NO

BASIC DESIGN STUDY REPORT
ON
THE FLOOD PROTECTION AND DRAINAGE IMPROVEMENT PROJECT IN THE MUNICIPALITY OF PHNOM PENH
IN
THE KINGDOM OF CAMBODIA

November 2001

JAPAN INTERNATIONAL COOPERATION AGENCY

CTI ENGINEERING INTERNATIONAL CO., LTD.

NIPPON KOEI CO., LTD

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PREFACE

In response to a request from the Government of the Kingdom of Cambodia, the Government of Japan decided to conduct a basic design study on The Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh in the Kingdom of Cambodia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cambodia a study team from March 29 to April 30, 2001.

The team held discussions with the officials concerned of the Government of Cambodia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Cambodia in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the teams.

November 2001

Takao Kawakami
President
Japan International Cooperation Agency

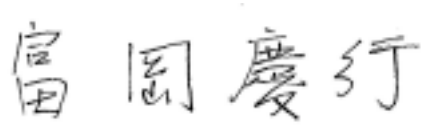
Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh in the Kingdom of Cambodia.

This study was conducted by the joint venture between CTI Engineering International Co., Ltd. and Nippon Koei Co., Ltd., under a contract to JICA, during the period from March, 2001 to October, 2001. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Cambodia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

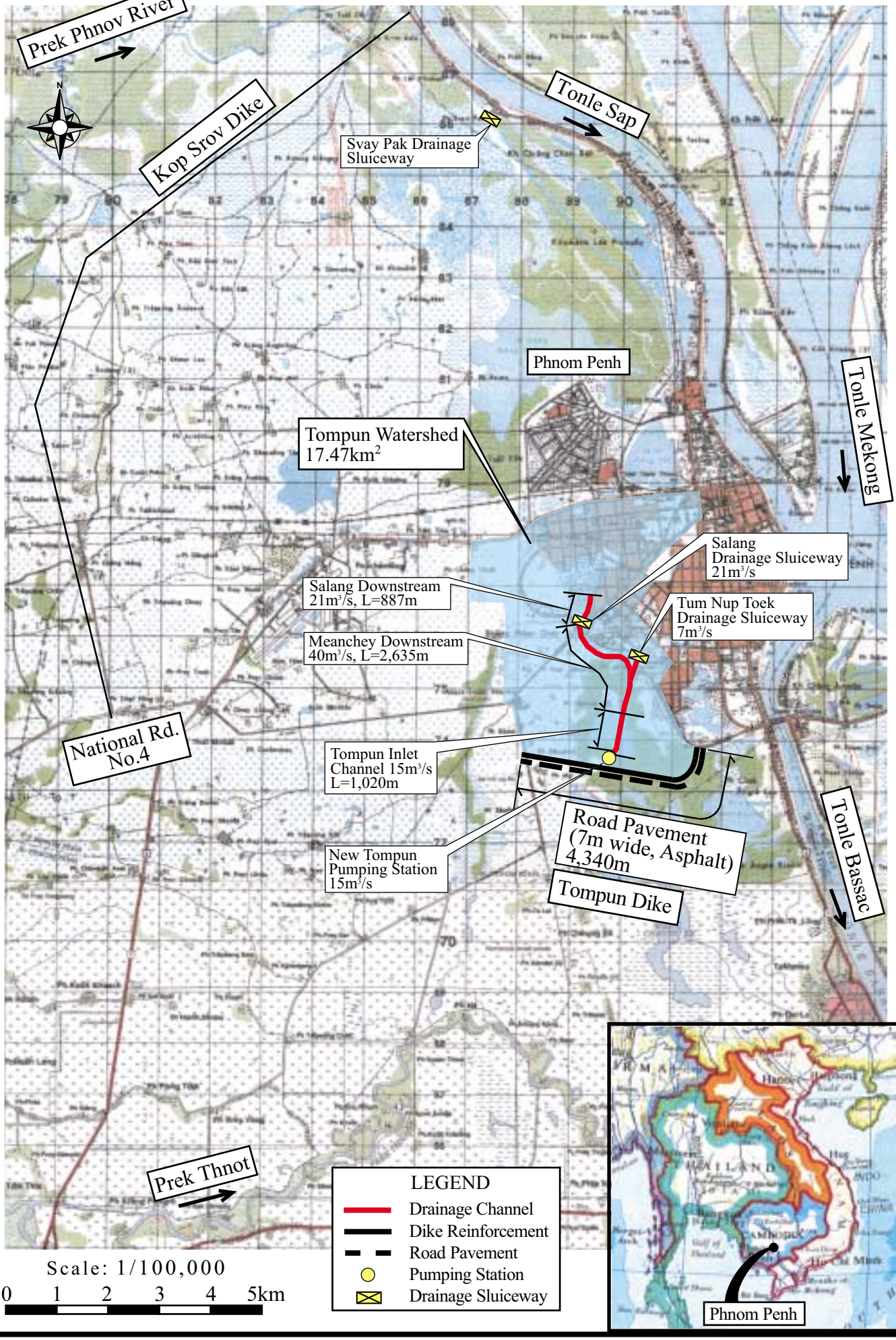


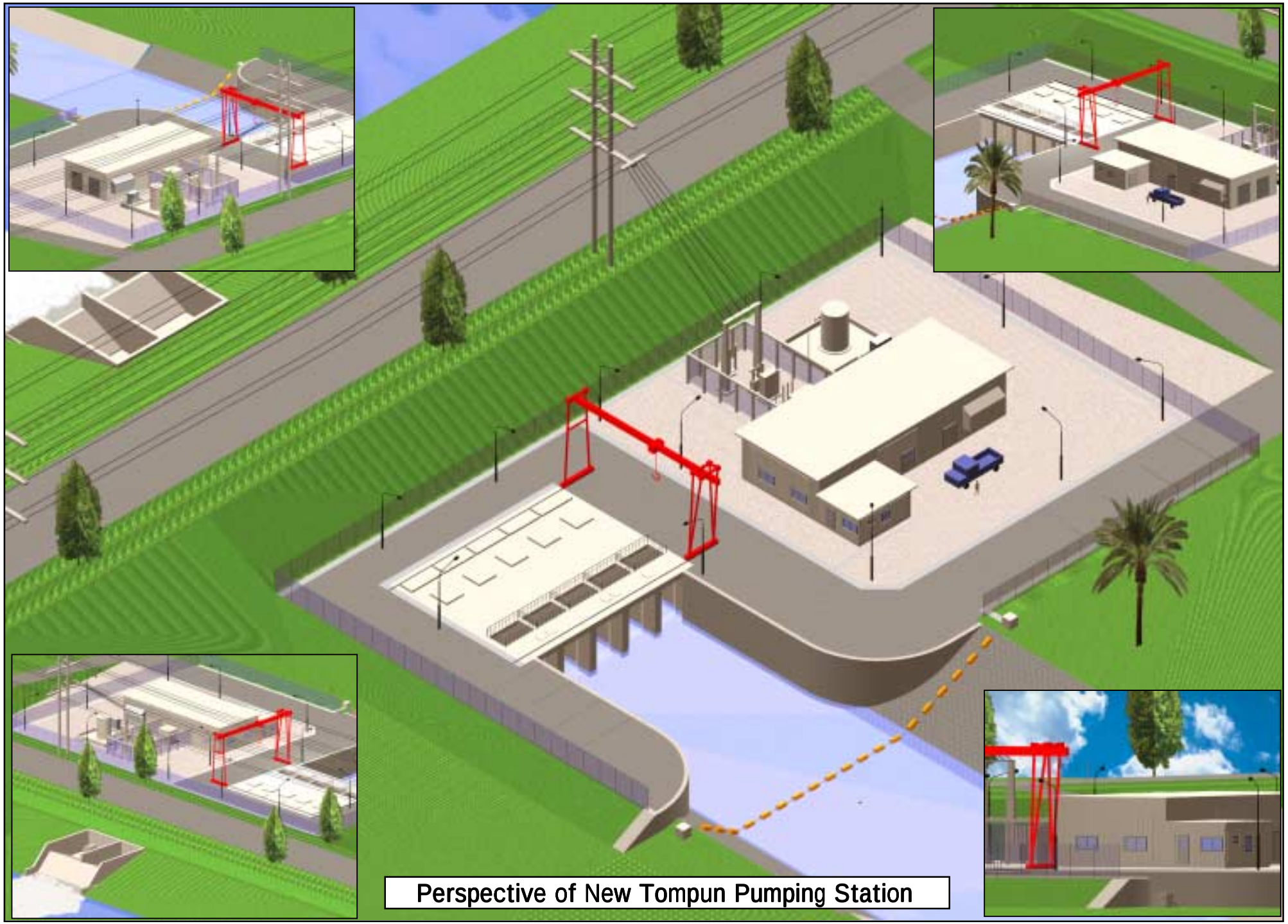
TOMIOKA Yoshiyuki
Project manager,

Basic design study team on
the Project for Flood Protection
and Drainage Improvement Project
in the Municipality of Phnom Penh
in the Kingdom of Cambodia

The joint venture between
CTI Engineering International Co., Ltd.
and Nippon Koei Co., Ltd.

LOCATION MAP





Perspective of New Tompun Pumping Station

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ABBREVIATIONS

1. ORGANIZATIONS

ADB	:	Asian Development Bank
APUR	:	Atelier Parisien d'urbanisme (Town Planning Agency for Paris)
BAU	:	Bureau des Affaires Urbaines (Bureau of Urban Affairs)
CATUC	:	Comité de l'Aménagement du Territoire, d'Urbanisme et de Construction (Committee for Planning, Urbanization and Construction)
CDC	:	Council for the Development of Cambodia
CNATUC	:	Comité National de l'Aménagement du Territoire, d'Urbanisme et de Construction (National Committee for Country Planning, Urbanization and Construction)
COM	:	Council of Ministers
CRDB	:	Cambodian Rehabilitation and Development Board
CTA	:	Cambodian Telecommunications Authority
DPWT	:	Department of Public Works and Transport
DSD	:	Drainage and Sewerage Division
EdC	:	Electricité du Cambodge
EU	:	European Union
GDIMH	:	General Directorate of Irrigation, Meteorology and Hydrology of MAFF
GOJ	:	Government of Japan
JICA	:	Japan International Cooperation Agency
MAFF	:	Ministry of Agriculture, Forestry and Fisheries
MEF	:	Ministry of Economy and Finance
MFAIC	:	Ministry of Foreign Affairs and International Cooperation
MOE	:	Ministry of Environment
MOP	:	Ministry of Planning
MPP	:	Municipality of Phnom Penh
MPWT	:	Ministry of Public Works and Transport
MWRM	:	Ministry of Water Resources and Meteorology
NORAD	:	Norwegian Agency for Development Cooperation
PMU	:	Project Management Unit
PPWSA	:	Phnom Penh Water Supply Authority
TdC	:	Telecommunication du Cambodge
UNCHS	:	United Nations Centre for Human Settlements
UNDP	:	United Nations Development Program
UNESCO	:	United Nations Educational, Scientific, and Cultural Organization
UNICEF	:	United Nations Children's Fund
UNTAC	:	United Nations Transitional Authority in Cambodia
USAID	:	United States Agency for International Development
WB	:	World Bank
WHO	:	World Health Organization

2. OTHER TERMS

BOD	:	Biochemical Oxygen Demand
BOT	:	Built, Operation and Transfer
COD	:	Chemical Oxygen Demand

CUDSS	:	Cambodian Urban Development Strategy Study
CUEIP	:	Cambodian Urban Environmental Improvement Project
DO	:	Oxygen Demand
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GRDP	:	Gross Regional Domestic Product
EPNRM	:	Law on Environmental Protection and Natural Resources Management
NR	:	National Road
PAP	:	Project Affected Persons
PIP	:	Public Investment Plan
SEDP	:	Socio-Economic Development Plan
SS	:	Suspended Solid
TA	:	Technical Assistance

3. UNITS OF MEASUREMENT

(Length)

mm	:	millimeter(s)
cm	:	centimeter(s)
m	:	meter(s)
km	:	kilometer(s)

(Weight)

mg	:	milligram(s)
g, gr	:	gram(s)
kg	:	kilogram(s)
ton	:	tonne(s)

(Area)

mm^2	:	square millimeter(s)
cm^2	:	square centimeter(s)
m^2	:	square meter(s)
km^2	:	square kilometer(s)
ha	:	hectare(s)

(Time)

s, sec	:	second(s)
min	:	minute(s)
h(hrs)	:	hour(s)
d(dys)	:	day(s)
y, yr(yrs)	:	year(s)

(Volume)

cm^3	:	cubic centimeter(s)
m^3	:	cubic meter(s)
ℓ	:	liter(s)

(Concentration)

mg/ℓ	:	milligram per liter

(Speed/Velocity)

cm/sec, cm/s	:	centimeter per second
m/sec, m/s	:	meter per second
km/hr, km/h	:	kilometer per hour

(Stress)

kg/cm^2	:	kilogram per square centimeter
ton/m^2	:	ton per square meter

(Flow/Discharge)

ℓ/sec, ℓ/s	:	liter per second
m^3/sec, m^3/s	:	cubic meter per second
m^3/yr, m^3/y	:	cubic meter per year

(Electrical Units)

W	:	watt(s)
kW	:	kilowatt(s)
MW	:	megawatt(s)
kWh	:	kilowatt-hour
MWh	:	megawatt-hour
GWh	:	gigawatt-hour
V	:	volt(s)
kV	:	kilovolt(s)

(Note: Other combined units may be constructed similarly as above)

4. MONETARY TERMS

¥	:	Japanese Yen
US$	:	United States Dollar
Riel	:	Cambodian Riels

5. CAMBODIAN TERMS

Boeng	:	Lake
Prek	:	River/Stream
Stoeng	:	River (medium)
Tonle	:	River (large)

SUMMARY

Phnom Penh City, the capital of the Kingdom of Cambodia, is located at the west side of the confluence of Mekong River and Tonle Sap River. Phnom Penh City is always at the risk of flooding in the rainy season and it habitually suffers from inundation and poor environmental conditions caused by stagnant wastewater in lowland areas.

In September 2000, the Mekong River marked the highest water level ever recorded in Phnom Penh City for the last 30 years and it nearly reached the top of Kop Srov Dike located along the northern perimeter of the city. The Government of Cambodia and the Municipality of Phnom Penh took every possible action to protect the city from flooding and thereby to maintain proper urban functions as the capital of Cambodia. As a result, the city was barely saved from a massive flood disaster because the river water did not overflow the dike. However, from the past flood fighting experience, it is understood that Phnom Penh City is vulnerable to floods by the Mekong River.

Under these circumstances, the Government of Cambodia has decided to undertake the reinforcement of Kop Srov Dike by raising the height. The work commenced in February 2001 with ADB financing and is still underway. For flood protection in the southern part of Phnom Penh City, Tompun Dike plays an important role in achieving its objective. The dike was in a critical condition in last year's flood as water level reached as high as 40 cm below the dike crown.

These two dikes form part of the ring levee surrounding the perimeter of Phnom Penh City and therefore recognized as flood control facilities. In this regard, further attention needs to be paid to the dikes in terms of maintenance and reinforcement.

With regard to storm water drainage facilities, which have been constructed in French colonial days, their functions have been extremely degraded due to the improper operation and maintenance. It should be noted that maintenance services could be hardly available during the 20-year long civil war since the 1970's. Consequently, flood and inundation occur recurrently in the capital in every rainy season resulting from insufficient drainage capacity.

As the river swells in the rainy season, storm water cannot be drained by the natural gravity system in lowland areas of the city so that pump drainage is essentially necessary in this case. At present, there are 11 pumping stations in Phnom Penh City. However, they are all antiquated and deteriorated to fulfill their due functions. In addition, drainage channels are full of garbage and sludge causing a decline in design flow capacity.

Boen Trabek drainage channel and pumping station, located east of this project area, is now in the process of improvement with ADB financing. Besides this, other drainage facilities need to be improved drastically.

From the above considerations, the Government of Cambodia urged that an integrated plan for urban drainage and flood control should be formulated to cope with rapid urbanization of Phnom Penh City and made a request to the Government of Japan for technical assistance. The Government of Japan dispatched a study team through the Japan International Cooperation Agency (JICA), the official agency implementing technical assistance programs of Japan. The study was conducted from March 1998 to August 1999 to establish a master plan and also to examine the feasibility of priority projects. An urgent project has been carefully selected in this connection.

As a result of the said study, the Government of Cambodia emphasized the necessity of early implementation of the urgent project and requested Japan's Grant Aid. In response to this request, the Government of Japan decided to conduct a Basic Design Study and JICA organized a study team to carry out the field survey from March 28 to May 1, 2001. The study output was compiled in the Draft Final Report and its outline was explained to the authorities concerned of the Municipality of Phnom Penh from July 22 to August 1 of the same year.

This Project aims to provide the Municipality of Phnom Penh with protection to make it highly safe against flooding of the Mekong River system and to minimize flood damage, and to minimize inundation by local rainfall in the Municipality of Phnom Penh and reduce inundation damage.

To achieve the objectives of the Project, the existing dike shall be reinforced to make it safe against the effect of the recorded highest water level of the Mekong and Sap rivers, which corresponds to about 30-year probability of planning scale. Drainage facilities shall also be improved with a planning scale of 5-year probability to be able to drain storm water from the Tompun watershed (Area: 17.47 km^2) to outside of the Tompun Ring Dike within 24 hours.

In discussing the Draft Final Report, both sides JICA and the Municipality of Phnom Penh mutually agreed on the general concept of the project as well as the basic design of components. These are summarized as follows:

(1) Improvement of Svay Pak Drainage Sluiceway
(3 wooden gate leaves to be replaced by steel ones)

The existing sluiceway located north of Phnom Penh City is designed to drain inland water to the Tonle Sap River. However, its wooden gates have worn-out to function properly, and steel ones should replace them to assure that water intrusion from the river is firmly prevented.

(2) Reinforcement of Tompun Ring Dike
(raising the height and asphalt paving for 4.34 km-long dike)

Judging from the fact that the dike surface is being used as public road and its height is lower than it should be in some portions, the dike needs to be reinforced by raising the height to the design level and paving it with asphalt. If these works are successfully done, Tompun Dike will be an important structure to facilitate public transportation and to smooth the way for flood fighting activities and maintenance works.

(3) Improvement of Meanchey Drainage Channel Downstream
(2.635 km of Meanchey channel downstream and 1.020 km of inlet channel including reconstruction of 3 bridges)

Meanchey drainage channel, covering 17.47 km^2 of catchment area, collects storm water in rainy season and domestic wastewater in dry season. Water collected as such is pumped to outside the ring dike at the existing Tompun pumping station. The design discharge is estimated at 40 m^3/s for Meanchey drainage channel downstream and 15 m^3/s for inlet channel on the basis of 5-year rainfall probability. However, it is important to note that the design discharge may increase to 75 m^3/s when the upstream stretch is to be improved in the future. As for the inlet channel, it remains unchanged at any case. Taking the above into consideration, the cross section of the channel downstream is designed to cope with upstream requirements so that basically no revetment is provided to facilitate future remodeling works. There are presently four (4) bridges over the drainage channel, and among them 3 bridges need to be reconstructed along with the channel improvement.

(4) Improvement of Salang Drainage Channel Downstream (0.887 km in length)

Salang drainage channel, a tributary of Meanchey channel, covers 2.75 km^2 of catchment area and the design discharge is calculated at 21 m^3/s for 5-year rainfall probability. In principle it is designed to be earth channel except for confluence and bridge sections. In this regard, a bridge crossing over the channel has to be removed and will be replaced by a box culvert.

(5) Construction of New Tompun Pumping Station (with a capacity of 15 m^3/s)

Although an existing pumping station is installed at the extreme end of Meanchey drainage channel, actual operation capacity seems to be far from the nominal capacity of 6 m^3/s due to mechanical desrepair. As a result, the channel overflows at the time of heavy rainfall and inundation occurs over an extensive area along the drainage channel. The project aims at constructing a new pumping station adjacent to the existing one to drain storm water to outside of the ring dike. From the economical point of view, an existing marsh stretching

down the channel can be used as a regulating pond in an effort to reduce the required pump capacity, and this idea will certainly help reduce construction cost.

(6) Construction of Tum Nup Toek Drainage Sluiceway (with a drain capacity of 7 m^3/s)

There is a pumping station to drain inland water collected in the left bank of Meanchey channel. However, the area is often inundated by torrential rain and superannuation of the pumping station so the situation looks the same as Tompun pumping station. From the topographical feature, inland water can be drained by the gravity system. Therefore, a new sluiceway is to be constructed instead of reconstruction of the existing pumping station. The sluiceway is designed to comply with requirements for the future road expansion plan which covers the sluiceway.

(7) Construction of Salang Drainage Sluiceway
(to be replaced by new one with a drain capacity of 21 m^3/s)

Salang drainage channel joins Meanchey channel after crossing the inner ring dike with two Hume concrete pipes. However, these drain pipes are hardly functioning due to insufficient diameter. In addition, they are filled up with sediment. In view of these situations, a box culvert is to be replaced with pipes as the most suitable type of sluiceway.

The request of the Government of Cambodia includes the reinforcement of 6.75-km long Kop Srov Dike and its connecting road (9.35 km long). However, both are not incorporated in the project because ADB is now providing financial assistance for the reinforcement of Kop Srov Dike. With regard to the connecting road, it seems to be no longer significant in terms of flood protection and drainage improvement.

The project begins with detailed design study that needs approximately 6.5 months including engineering design services, preparation of tender documents and tender administration. The total construction period will be 18 months including civil works, equipment procurement and installation.

The implementation of this project should bring following effects.

As the effect of the Tompun dike reinforcement, Phnom Penh City should be protected from flooding of 30-year probability. The 5,200 units of residential houses, 400 units of factories, shops and offices (1998 survey) or the Pochentong International Airport should be protected from enormous flood damage due to overtopping of floodwaters..

As the effect of the urban drainage improvement, the downstream area of both Meanchey and Salang drainage channels (7.87 km^2) should be protected from storm rainfall of less than 5-year

probability and remarkably reduced inundation damage caused by storm rainfall of more than 5-year probability. The implementation of the urban drainage improvement should bring the reduction of inundation damage by inland water to 34,000 units of residential houses, 1,200 units of factories, shops and offices (1998 survey) in the catchment area of both Meanchey and Salang drainage channels.

The facilities to be constructed by the project are to be managed by the Department of Public Works and Transport (DPWT) of Phnom Penh City, and DPWT has an organization and enough experience for operation and maintenance of such facilities. The annual operation and maintenance cost is estimated at 500,000 US dollars, which should be shouldered by the Municipality of Phnom Penh. The Municipality of Phnom Penh has enough budget of annual operation and maintenance cost of facilities to be constructed by the project

To evacuate houses before the commencement of the construction works and to acquire the project sites shall be given first priority. It is required of the responsible agency of the Municipality of Phnom Penh to establish a task force to expedite necessary procedures to accelerate land acquisition and house evacuation or to secure the necessary budget.

Flood is a serious threat to Phnom Penh City in every rainy season. It is certainly attributed to the overflow of the Mekong River and the Tonle Sap River, and poor inland drainage system, which may cause paralysis of urban function, thereby giving heavy damage to civic life. To break through this situation, project implementation is urgently required with the hope of mitigating flood and inundation disasters.

THE BASIC DESIGN STUDY REPORT ON
FLOOD PROTECTION AND DRAINAGE IMPROVEMENT PROJECT
IN THE MUNICIPALITY OF PHNOM PENH

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CHAPTER 1 BACKGROUND OF THE PROJECT

1.1 Background of the Project

Phnom Penh City, the capital of the Kingdom of Cambodia, is located at the west side of the confluence of Mekong River and Tonle Sap River. It is the political, economic and cultural center of the country and had the population of about one million in 1998.

The construction of outer ring dikes for the protection of Phnom Penh City from flooding of neighboring rivers, lakes and swamps had started since the 1960's, and urban drainage facilities with functions of draining storm water and domestic wastewater were improved gradually according to the development of the city. However, all of the drainage facilities, which have been constructed since the beginning of the 1900's, are not functioning well due to old age, as well as poor maintenance after the 1970's. As a result, the city suffers from habitual inundation and poor environmental conditions caused by stagnant wastewater in lowland areas. These are serious constraints to the residents' living environment as well as social and economic development, not only of Phnom Penh City but the whole country in general.

The Government of Cambodia had made a request for technical cooperation from the Government of Japan to formulate a Master Plan for the flood protection and urban drainage improvement in Phnom Penh City and suburbs. In response, the Government of Japan had dispatched a study team through the Japan International Cooperation Agency (JICA) to formulate the Master Plan and to conduct a Feasibility Study on priority projects selected from the Master Plan. That study was conducted from March 1998 to August 1999 and, as the result of the Feasibility Study, urgently necessary components of the priority projects were selected.

In June 1999, the Government of Cambodia further requested the Government of Japan to extend Grant Aid for the realization of the urgently necessary components of the priority projects. The Government of Japan subsequently decided to carry out this Basic Design Study from March to November 2001 to evaluate the possibility of executing the project components under the Grant Aid.

1.2 Contents of the Request

The Government of Cambodia had requested Grant Aid from the Government of Japan for the project components enumerated below:

(1) Reinforcement of Kop Srov and Tompun Ring Dikes

(a) Reinforcement of Kop Srov Ring Dike
(b) Pavement of the Access Road to Kop Srov Ring Dike
(c) Reinforcement of Tompun Ring Dike
(d) Improvement of Svay Pak Drainage Sluiceway
(e) Preparation of Relocation Site

(2) Tompun Watershed Drainage Improvement

(a) Construction of New Tompun Pumping Station and Inlet Channel
(b) Improvement of Meanchey Drainage Channel, Downstream Stretch
(c) Construction of Tum Nup Toek Drainage Sluiceway
(d) Improvement of Salang Drainage Channel, Downstream Stretch
(e) Preparation of Relocation Site

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

2.1.1 Objectives of the Project

Phnom Penh City tends to suffer from flooding because of its topography. In addition, flood protection and urban drainage facilities are not functioning well because of old age and poor maintenance. As a result, the city is always at the risk of flooding in the rainy season and it habitually suffers from inundation and poor environmental conditions caused by stagnant wastewater in lowland areas. These cause deterioration of the residents' living environment and pause a serious constraint to social and economic development.

To find a solution to these issues, the Government of Cambodia and the Municipality of Phnom Penh have been conducting various studies on flood protection and drainage improvement in line with the following overall goal:

(1) To stabilize the living conditions of people in the Municipality of Phnom Penh;

(2) To improve the water environment in the Municipality of Phnom Penh; and,

(3) To contribute to the development of the Municipality of Phnom Penh as well as the nation as a whole.

This Project aims at the following objectives under the overall goal mentioned above:

(1) To provide the Municipality of Phnom Penh with protection to make it highly safe against flooding of the Mekong River system and to minimize flood damage; and,

(2) To minimize inundation by local rainfall in the Municipality of Phnom Penh and reduce inundation damage.

To achieve the objectives of the Project, the existing dike shall be reinforced to make it safe against the effect of the recorded highest water level of the Mekong and Sap rivers, which corresponds to about 30-year probability of planning scale. Drainage facilities shall also be improved with a planning scale of 5-year probability to be able to drain storm water from the Tompun watershed (Area: 17.47 km^2) to outside of the Tompun Ring Dike within 24 hours.

2.1.2 Objective Facilities of the Basic Design

The objective works and facilities of the Basic Design Study that have been selected through previous discussions between JICA and the Municipality of Phnom Penh are as follows:

(1) Improvement of Svay Pak Drainage Sluiceway;
(2) Reinforcement of Tompun Ring Dike;
(3) Improvement of Meanchey Drainage Channel in the Downstream;
(4) Improvement of Tompun Inlet Channel;
(5) Improvement of Salang Drainage Channel in the Downstream;
(6) Construction of New Tompun Pumping Station;
(7) Construction of Tum Nup Toek Drainage Sluiceway; and,
(8) Construction of Salang Drainage Sluiceway.

2.2 Basic Design under the Requested Japanese Assistance

2.2.1 Design Policy

This subsection presents the policy of the Basic Design Study.

(1) Basic Design Policy

Since this Basic Design Study was requested by the Government of Cambodia based on the Urgent Projects proposed in the Final Report of "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh" conducted by the Study Team dispatched by Japan International Cooperation Agency (JICA) for the period from February 1998 to August 1999, the locations, dimensions and so on of the objective works/facilities in that final report should be followed, in principle.

However, Japan's Grant Aid is extended only for projects where grant aid is urgently necessary as in the present situation. Therefore, the requested facilities are to be reviewed from the viewpoint of Japan's Grant Aid.

Since the requested components of "Reinforcement of Kop Srov Ring Dike" and "Pavement of the Access Road to Kop Srov Ring Dike" have already been undertaken through assistance from the Asian Development Bank (ADB), those components were excluded from this Project.

(2) Policy on Natural Conditions

The design high water level and design discharge of inland storm water are to be reviewed to cover the additional meteorological and hydrological data after 1997.

(a) Design High Water Level at Tompun Ring Dike

The design high water level at Tompun Ring Dike is set at EL.9.30 m based on the recorded highest water level of EL.9.29 m in October 2000, as shown in Fig. 2.2.1.

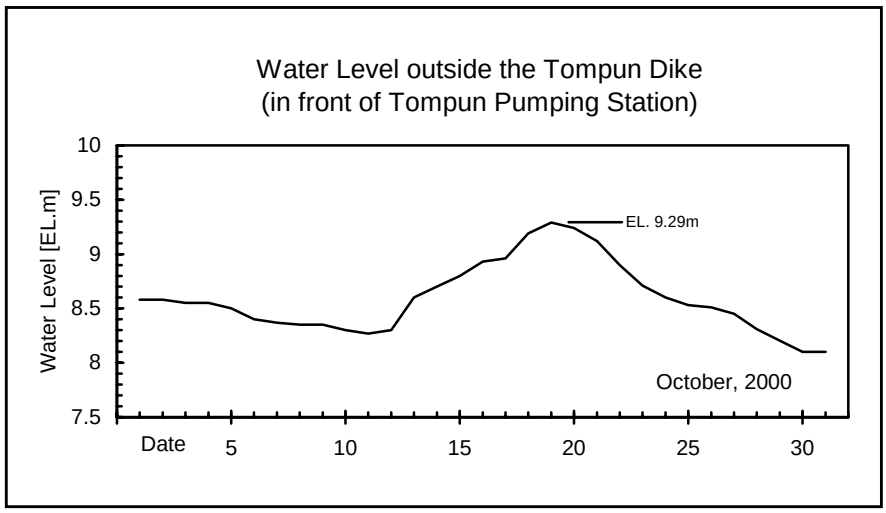


Fig. 2.2.1 Water Level Outside the Tompun Dike in October 2000

(b) Planning Scale of Drainage Facilities

Usually, the determination of planning scale depends on previous practices in similar projects. The planning scales applied to drainage improvement projects in capitals of Southeast Asian countries are shown in the Table 2.2.1.

Table 2.2.1 Planning Scale in Southeast Asia

City Name (Country Name)	Planning Scale (probability)
Bangkok (Thailand)	CA<0.2 km^2 : 1-year CA=0.2-1.0 km^2 : 2-year CA>1.0 km^2 : 5-year
Hanoi (Vietnam)	10-year
Jakarta (Indonesia)	CA<0.1 km^2 : 1 to 2-year CA=0.1-1.0 km^2 : 2 to 5-year CA>1.0 km^2 : 5 to 10-year
Manila (Philippines)	CA<5 km^2 : 3-year CA>5 km^2 : 5-year
Dhaka (Bangladesh)	2-year

Note: CA = Catchment Area

Since the catchment area of the Meanchey Drainage Channel is 17.47 km^2, the planning scale is set at 5-year probability.

(3) Policy on Social/Economic Conditions

To secure the Right-of-Way for the improvement of drainage channels and construction of new pumping station, it is impossible to avoid house relocation. However, land acquisition and house relocation attendant on the Project implementation often cause social conflicts. Therefore, the determination of alignment of drainage channel or layout of new pumping station shall be given particular attention to minimize the number of house relocation.

(4) Policy on Construction/Procurement

Since structural design standards in Cambodia have not been established yet, the Basic Design Study follows the Japanese design standard.

Main construction materials like cement, reinforcing bars, aggregates and so on are available in Cambodia, but the local availability of particular construction components like steel gate, drainage pump, electric facilities and so on is difficult. Locally available materials shall be used for the construction as much as possible to minimize the construction cost. The Basic Design Study shall consider the future improvement works to avoid the duplication of investment.

(5) Policy on the Applicability of Cambodian Company

There are some local contractors in Cambodia, and they have adequate skills on general construction works such as roads, drainage channels and simple concrete structures. Therefore, local contractors shall be used for the general construction components to reduce the construction cost.

(6) Policy on the Operation and Maintenance Condition of Implementing Agency

To determine the adequate specifications of the objective facilities, the capabilities and budget for operation and maintenance of the implementing agency shall be considered in the Basic Design Study.

(7) Policy on the Determination of Planning Scale of the Objective Facilities

To determine the planning scale of the objective facilities, it shall be considered that Japan's Grant Aid is extended only for projects where grant aid is urgently necessary as in the present situation.

Based on the design policies mentioned above and in order to achieve the objectives of the Project, the existing dike shall be reinforced to make it safe from the recorded highest water level of the Mekong and Sap rivers, which corresponds to about 30-year probability of planning scale. Drainage facilities shall also be improved with the planning scale of 5-year probability to be able to drain the storm water in the Tompun watershed (Area: 17.47 km^2) to outside of the Tompun Ring Dike within 24 hours.

(8) Policy on the Implementation/Procurement Plan and Implementation Schedule

The Project includes construction of a new pumping station, improvement of drainage channels, reinforcement of flood protection dike and so on, and the construction works are easily affected by rain and flooding. During the rainy season, work efficiency certainly becomes low and work progress will decline as a result. Therefore, it is important to consider the rainy season in the establishment of the implementation plan as well as the procurement plan.

In consideration of construction scale and work efficiency in rainy season, it is estimated that the term of construction would require two (2) dry seasons.

To establish the implementation schedule, the conditions mentioned above shall be considered.

2.2.2 Outline of the Objective Facilities

(1) Improvement of Svay Pak Drainage Sluiceway

The existing sluiceway structure is recognized to have enough stability to drain inland water to the Tonle Sap River and does not cause any serious inundation damage by storm rainfall under the present situation. However, its wooden floodgates have broke down by old age and it seems that the gates could not resist water pressure by flood of the Tonle Sap River. Therefore, the wooden gates shall be changed with steel gates with hoists.

(2) Reinforcement of Tompun Ring Dike

The existing Tompun Ring Dike has been constructed to protect Phnom Penh from floods, which may hit from south of the city. The existing dike crown is used as public road, but its condition has deteriorated very much. The pavement of the crown road of 4.34 km as well as its slopes shall be improved, if necessary. The design high water level of Tompun Ring Dike is set at EL 9.30 m based on the latest flood record at the Tompun area.

(3) Improvement of Meanchey Drainage Channel in the Downstream

The existing Meanchey Drainage Channel is not maintained well and the flow capacity has much deteriorated by mud deposit on the channel bed that low-lying areas along the channel are inundated at every heavy rain. The downstream channel of 2.635 km in length is to be improved to have enough flow capacity for the protection of areas along the stretch where inundation damage is concentrated and urgent improvement is required.

The planning scale of the channel improvement works is set at 5-year probability, and the design discharge is estimated at 40 m^3/s under the condition of improvement of only the downstream stretch, i.e., upper stretch remains unimproved.

(4) Improvement of Tompun Inlet Channel

The existing Tompun Inlet Channel of 1.02 km in total length runs through the Tompun Lake, which is to be used as the retarding pond for the New Tompun Pumping Station. This inlet channel is not also maintained well as the Meanchey Drainage Channel. Since the Tompun Lake is to serve as a retarding pond, excavation of the channel is to be carried out to the existing ground level. Embankment of both banks is not planned above the ground level even if the ground level is lower than the high water level so that floodwaters can overflow into the retarding pond.

(5) Improvement of Salang Drainage Channel in the Downstream

The existing Salang Drainage Channel is not maintained well and the flow capacity has much deteriorated by mud deposit on the channel bed. As a result, low-lying areas along the channel are inundated at every heavy rain. The downstream channel of 0.887 km in length is to be improved to have enough flow capacity for the protection of areas along the stretch where the inundation damage is concentrated and urgent improvement is required.

The design discharge of the channel is 21 m^3/s with the planning scale of 5-year probability.

(6) Construction of New Tompun Pumping Station

There exists a drainage pumping station at Tompun to drain inland water from the Meanchey Drainage Channel to the outside of the Tompun Ring Dike. The pumping station is superannuated and it is presumed that it already exceeded its economic life. Furthermore, it was observed that so much water leak from pipe joints of the pump system and it seems that

the pump does not have the design pump capacity of 6 m^3/s. A new pumping station with the drainage capacity of 15 m^3/s is to be constructed beside the existing pumping station.

(7) Construction of Tum Nup Toek Drainage Sluiceway

A drainage pumping station currently exists at the proposed site of the sluiceway where a secondary drainage channel joins the Meanchey Drainage Channel. The pumping station is already old and does not have enough capacity. Besides, it is possible to drain water by gravity. Therefore, the construction of a drainage sluiceway is planned instead of improvement of the existing pumping station.

(8) Construction of Salang Drainage Sluiceway

Two pipe culverts currently exist at the site of the sluiceway where the Salang Drainage Channel joins the Meanchey Drainage Channel. The discharge capacity of the pipe culverts is not enough. Therefore, the construction of a drainage sluiceway of box culvert type is planned instead of improvement of the existing pipe culverts.

2.2.3 Basic Plan of the Objective Facilities

(1) Improvement of Svay Pak Drainage Sluiceway

There exist a drainage sluiceway across National Road No.5 at the north of Phnom Penh City, which drain inland water to the Tonle Sap River. Even though the existing sluiceway is superannuated and does not have enough drainage sections, the structure itself seems to have enough stability and strength except the wooden gates.

Furthermore, based on the field reconnaissance by the Study Team conducted in April 2000, it is judged that presently there will be little inundation damage in the watershed area of the sluiceway.

Therefore, it is decided that the existing sluiceway will not be reconstructed, but the existing wooden gates shall be changed to steel gates with hoists and spindle rods, to protect Phnom Penh City from the intrusion of floods from Tonle Sap River through the gates.

The dimensions of the new gates are 1.675 m (height) x 1.700 m (width) x 3 gates.

(2) Reinforcement of Tompun Ring Dike

(a) Existing Condition and Design Requirements of the Dike

Tompun Ring Dike, which starts from the junction with Street No.271 (a part of the Inner Ring Dike) ending at Cheung Aek Road, has a length of about 4.34 km and was constructed to protect the city from flooding of the Prek Thnot River.

The crown of the dike, which has a width of 5.0 m to 7.5 m, is utilized as a public road as well as maintenance road of the dike, and many houses, factories and markets stand close to and along both sides of the road.

The elevation of the existing dike crown is EL.9.72 m to EL.10.63 m, and average elevation is EL.10.26 m. About 80% of the dike length is lower than EL.10.40 m, which is the design level of the dike, and raising the dike crown at this portion with embankment is necessary.

The existing road surface is not paved and undulated. Some sections are in very poor condition, having deep ruts and sub-grade failure. It is spoiling smooth traffic, besides obstructing maintenance work on the dike.

As the result of the travel time survey, the passage time on this section of about 4.34 km is about 20 minutes at the average speed of 13 km/hour.

On the other hand, dike body has been filled with sufficiently compacted soil that has high water-tightness, and non-existence of structural problems was confirmed by boring tests carried out on the dike during the field survey in Phnom Penh in April 2001.

Therefore, reinforcement of Tompun Ring Dike is planned to raise the dike crown to the design height of the dike (EL.10.40 m), and the crown road is to be paved for the following purposes:

- To secure easy operation of flood defense and maintenance of the dike;
- Prevention of overtopping of floods less than 30-year probability and;
- Protection of the dike body from heavy traffic.

Alignment of the dike shall follow the existing alignment to minimize the number of houses to be evacuated as much as possible.

The design requirements for the crown elevation of the dike are as follows:

Design High Water Level	:	E.L. 9.30 m
Design Freeboard	:	1.10 m
Design Height of Dike	:	E.L. 10.40 m

(b) Road Pavement Design

(i) General

Considering that the road on the dike may constitute a part of the proposed Outer Ring Road in the future, cross-sectional design of the road should follow the Cambodian National Road Standard; namely, a carriageway of 7.0 m with 1.5 m shoulder on both sides.

Thickness of pavement is designed in accordance with the "Manual for Asphalt Pavement, Japan Road Association," and based on the traffic survey and the sub-grade CBR test result carried out by the Basic Design Study Team.

(ii) Traffic Conditions

The summary of the daily traffic survey, which carried out on April 24, 2001 (Tuesday) at the east and west sides of the dike, is shown in the Table 2.2.2.

Table 2.2.2 Daily Traffic

Type of Vehicle	Daily Traffic	
	West Side	East Side
Passenger Car	299	179
Taxi	0	0
Light Bus, Van	74	108
Pick-up (Cargo Van)	258	58
Bus	0	0
Large Truck (Trailer)	276	193
Motoruno (Motorbike Trailer)	109	143
Motorbike	6,072	5,563
Cycro	11	12
Bicycle	737	619
Others	0	1
Total	7,836	6,876

Note: 1.20 represents 24/12h ratio.

The design traffic volume is calculated as one-way traffic volume of heavy vehicles. As for the lane distribution ratio, 0.5 is generally applied. The design traffic volume of each observation section is shown in the Table 2.2.3.

Table 2.2.3 Design Traffic Volume

Section	Daily Traffic volume of Heavy Vehicles	One-way Daily Traffic Volume of Heavy Vehicles
West Side	276	138
East Side	193	97

Road classification by design traffic volume is determined as Class A from the Table 2.2.4.

Table 2.2.4 Road Classification by Traffic Volume

Road Classification	One-way Daily Traffic Volume of Heavy Vehicles
L	100 or fewer
A	100 to 250
B	251 to 1000
C	1001 to 3000
D	More than 3000

(iii) Determination of Design CBR

The summary of the CBR test (laboratory and field tests) results is shown in the Table 2.2.5.

Table 2.2.5 Sub-grade CBR Test Results

Number	Station	Subgrade CBR (%)	
		Laboratory test	Field test
1	5+200	7.86	7.00
2	4+480	9.01	9.10
3	4+400	10.35	9.41 / 10.80 / 21.19
4	4+000	8.62	7.57 / 26.90
5	3+600	20.69	6.72 / 16.60 / 28.00
6	3+200	25.52 / 6.21	10.08 / 29.13
7	2+800	9.31 / 6.90	8.78 / 28.00
8	2+400	15.25	12.56 / 15.75 / 22.68
9	2+000	15.18	18.82 / 21.19 / 21.19
10	1+600	17.59	12.95 / 17.04
11	1+200	20.35	17.03 / 19.75 / 21.19
12	0+ 90	6.80	2.86 / 10.41

Two alternative cases have been studied for Design CBR. The alternative "Case-1" used all of the data and the alternative "Case-2" used only the laboratory test data. Since Design CBR is calculated at 6 in both cases, the Design CBR of 6 is applied for the Tompun Ring Dike.

The process of calculation is shown in the Table 2.2.6.

Table 2.2.6 Design CBR

Case	Case - 1		Case - 2	
Number of data	41		14	
Maximum CBR	29.13		25.52	
Minimum CBR	2.86		6.21	
Determining whether to ignore extreme values	29.13-28.00	=0.043	25.52-20.69	=0.250
	29.13-2.86	<0.300	25.52-6.21	<0.349
	6.21-2.86	=0.128	6.80-6.21	=0.031
	29.13-2.86	<0.300	25.52-6.21	<0.349
Determination of ignore	Not ignored		Not ignored	
Average CBR: CBRAVE	14.94		12.83	
Standard Deviation: STDEV	7.11		6.23	
CBRAVE - STDEV	7.82		6.60	
Design CBR	**6**		**6**	

(iv) Pavement Thickness Design

Using the Design CBR and the road classification given in Item (ii) and (iii), the pavement thickness of each layer is designed so that the desirable T_A value is assured. T_A represents the pavement thickness required if the entire depth of the pavement were to be constructed of hot asphalt mixture, used for the binder and surface course. As for the road of Tompun Ring Dike, 16 of T_A are required. (refer to Table 2.2.7)

Table 2.2.7 Value for T_A

Design CBR	Target Value (cm)				
	L	A	B	C	D
2	17	21	29	39	51
3	15	19	26	35	45
4	14	18	24	32	41
6	12	16	21	28	37
8	11	14	19	26	34
12	11	13	17	23	30
20	11	13	17	20	26

(v) Pavement Structure Determination

A tentative pavement structure is first selected based on the requirements for the minimum thickness of each layer shown in the Table 2.2.8, and then the value of T_A is calculated.

Table 2.2.8 Minimum Thickness of Layers

Road Classification	Minimum Combined Thickness of Binder and Surface Courses
L, A	5 cm
B	10 (5) cm
C	15 (10) cm
D	20 (15) cm

Construction Method/ Material	Minimum Thickness of One Layer of Base Course and Subbase Course
Bituminous Stabilization	Two times of a maximum grain size and 5 cm
Other Methods	Three times of a maximum grain size and 10 cm

Note: Parentheses show the value of case that uses bituminous stabilization method for base course.

The value of T_A is calculated by the following equation:

$$T_A = a_1 T_1 + a_2 T_2 + a_3 T_3 + \ldots\ldots a_n T_n$$

Where;

a_1, a_2, a_n: Conventional Coefficient shows in the table below.

T_1, T_2, T_n: Thickness of each layer (cm)

In consideration of the execution of road pavement works in Cambodia and for the sake of economy, granular materials shall be used for base and sub-base courses of this road. Thus, 0.35 is applied to base course and 0.25 is applied to sub-base course as conventional coefficients.

Table 2.2.9 Conventional Coefficient for the Calculation of T_A

Pavement Course	Method and Material of Construction	Conditions	Coefficient a
Surface and Binder Course	Hot Asphalt Mixture for Surface and Binder Course		1.00
Base Course	Bituminous Stabilization	Hot Mixing Stability= 3.43kN or more	0.80
		Cold Mixed Stability= 2.45kN or more	0.55
	Cement Bituminous Stabilization	Unconfined Compression Strength (7days)= 1.5 to 2.9 Mpa Primary Displacement= 5 to 30 (1/100cm) Residual Strength= More than 65%	0.65
	Cement Stabilization	Unconfined Compression Strength (7days)= 2.9 Mpa	0.55
	Lime Stabilization	Unconfined Compression Strength (10days)= 0.98 Mpa	0.45
	Crushed Stone for Mechanical Stabilization	Modified CBR= 80 or more	0.35
	Hydraulic Slug for Mechanical Stabilization	Modified CBR= 80 or more Unconfined Compression Strength (14days)= 1.2 Mpa	0.55
Sub-base Course	Crusher-run, Steel Slug, and Sand etc	Modified CBR= 30 or more	0.25
		Modified CBR= 20 to 30	0.20
	Cement Stabilization	Unconfined Compression Strength (7days)= 0.98 Mpa	0.25
	Lime Stabilization	Unconfined Compression Strength (10days)= 0.7 Mpa	0.25

The calculation results of pavement structure of Tompun Ring Dike are shown in the Table 2.210 and Table 2.2.11.

Table 2.2.10 Determination of Pavement Structure

	Surface Course	Base Course	Subbase Course	Total
Materials	Hot asphalt mixture	Mechanically Stabilized Crushed Stone	Crusher-run	
Condition		Modified CBR: 80 or more	Modified CBR: 30 or more	
Thickness (cm)	5.0	15.0	25.0	45.0
Coefficient	1.00	0.35	0.25	
T_A (cm)	5.0	5.25	6.25	16.5＞16.0

Table 2.2.11 Section of Pavement Structure

	Surface Course	t= 5 cm
	Base Course	t =15 cm
	Subbase Course	t =25 cm
	Total	t =45 cm

(c) Typical Section of the Road

The pavement shall be laid on the crown of dike body, and the design requirements for the road are as follows:

Design Crown Elevation of Dike	:	E.L.10.400 m	
Thickness of Pavement	:	0.450 m	
Super-elevation	:	0.070 m	(3.500 x 0.02)
Design Height of the Road	:	E.L.10.920 m	
Lane Number	:	2 Lanes	
Width of Carriageway	:	7.000 m	(3.500 x 2)
Width of Parking Lane	:	1.500 m	(Both sides)
Total Width of the Road	:	10.000 m	

A typical section of Tompun Ring Dike is shown in the Fig. 2.2.2.

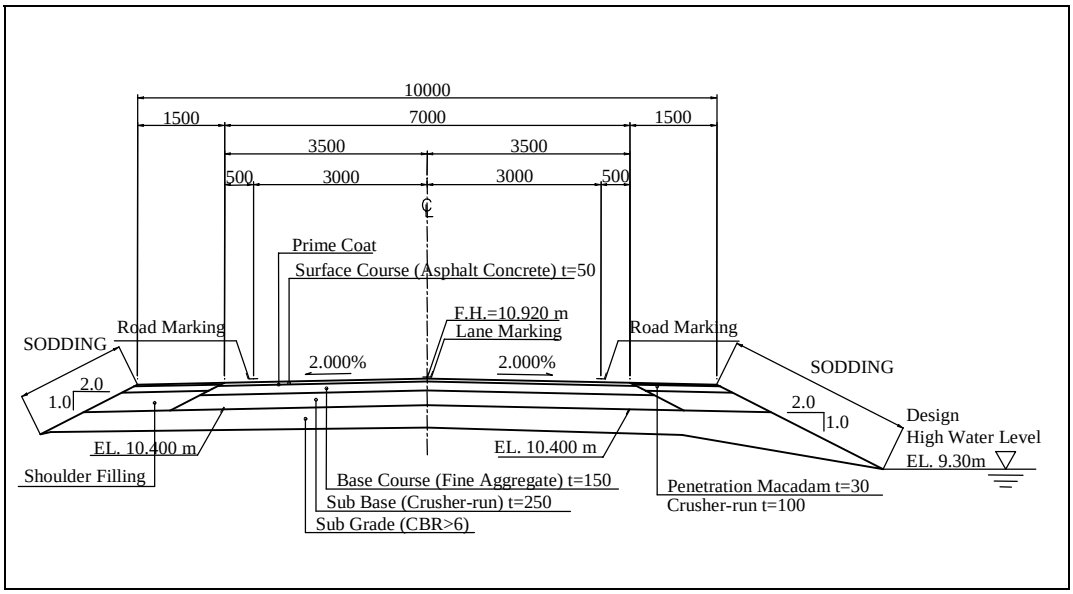


Fig. 2.2.2 Typical Section of Tompun Ring Dike

(3) Improvement of Meanchey Drainage Channel in the Downstream

(a) Review of Design Rainfall

The design rainfall at the planning scale of 5-year probability was estimated at 112.3 mm based on the rainfall data from 1981 to 1997 in the Feasibility Study (F/S). However, additional rainfall data from 1998 to 2000 were collected during the field reconnaissance of the Study Team.

The design rainfall was reviewed based on the additional rainfall data and the result is the same as the one estimated in the F/S, as shown in Fig. 2.2.3.

(b) Design Discharge

When the whole stretch of the Meanchey Drainage Channel is improved, the design discharge is estimated at 75 m^3/s at 5-year probability. However, only the downstream channel is to be improved in this project, and the design discharge of Meanchey Drainage Channel is estimated at 40 m^3/s under the condition that the downstream stretch of 2.675 km is to be improved in this project and the upper reaches remain unimproved, as shown in the Fig. 2.2.4.

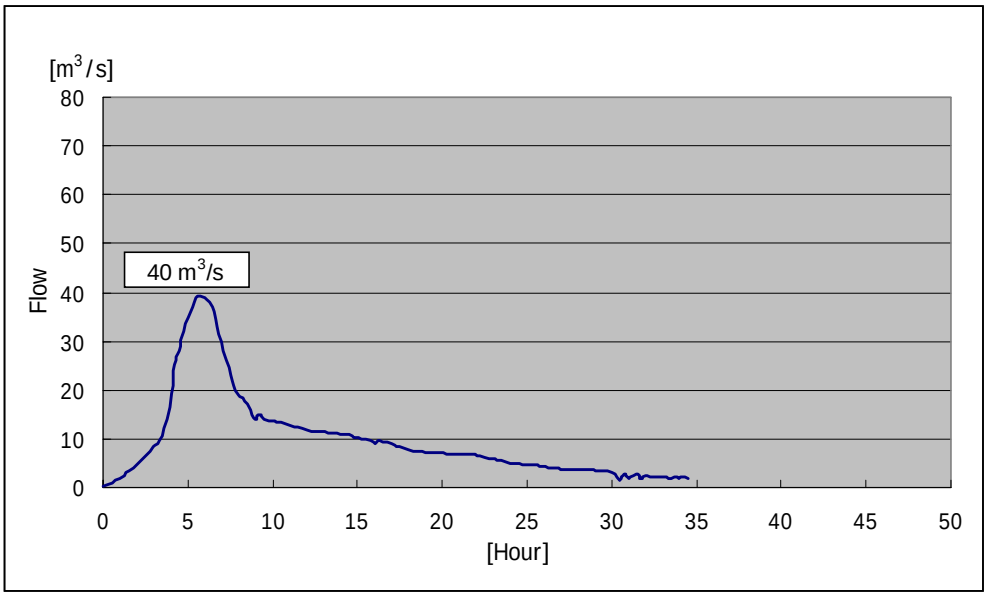
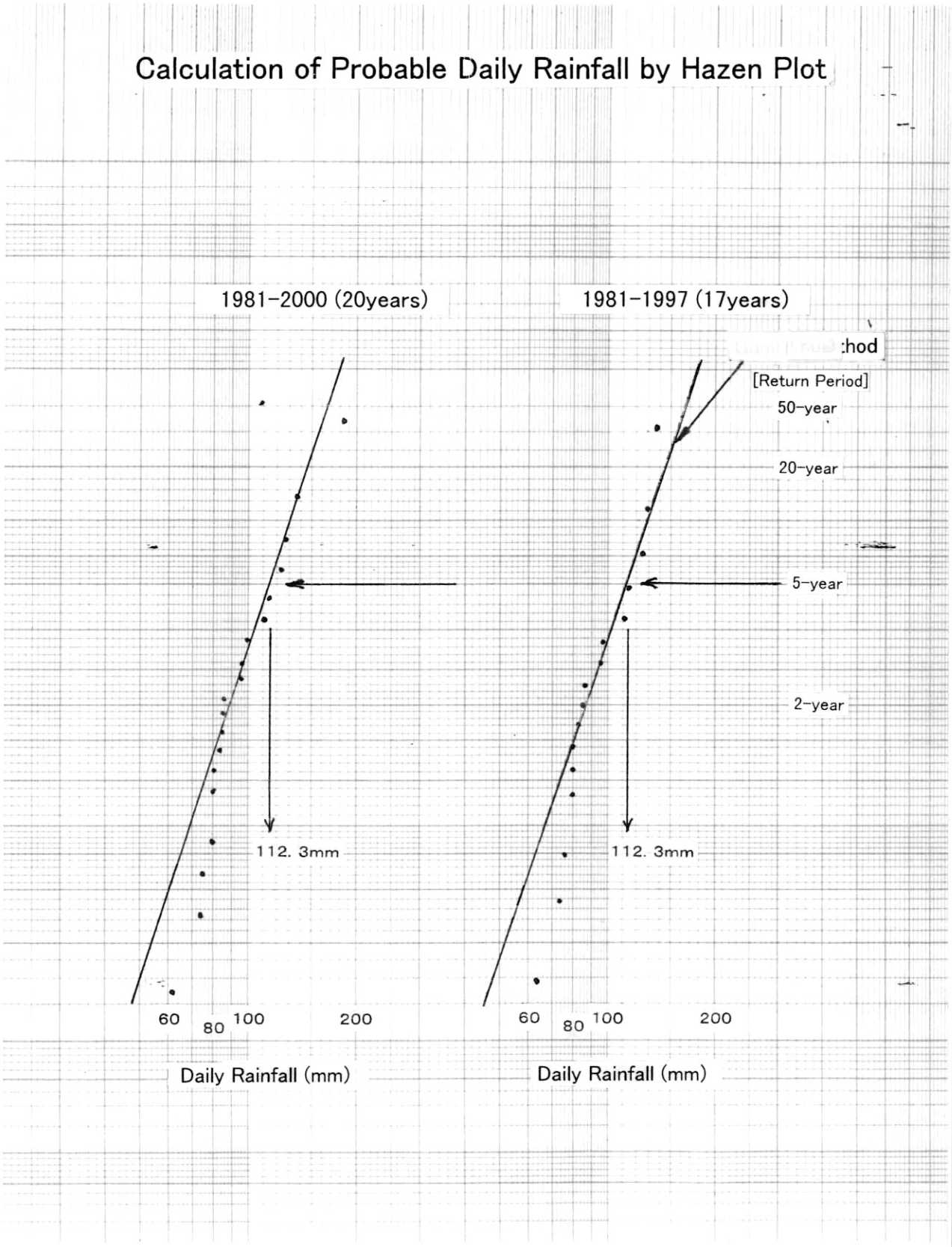


Fig. 2.2.4 Hydrograph of Meanchey Drainage Channel Downstream

(c) Comparative Study on Typical Cross Section

The typical cross section of Meanchey Drainage Channel at the design discharge of 40 m^3/s is decided based on the comparison of 2 alternatives.



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Fig. 2.2.3 Calculation of Probable Daily Rainfall by Hazen Plot
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	

The alternative cross sections are deduced from two viewpoints. The first one is based on the idea of adopting the same slope gradient as the one studied in the Master Plan and the other viewpoint is to adopt the same channel width as the one in the Master Plan so that the channel is secured to have enough width when the upper stretches of the channel is to be further improved. The cross sections of the Master Plan and the two alternatives are presented in the Fig. 2.2.5.

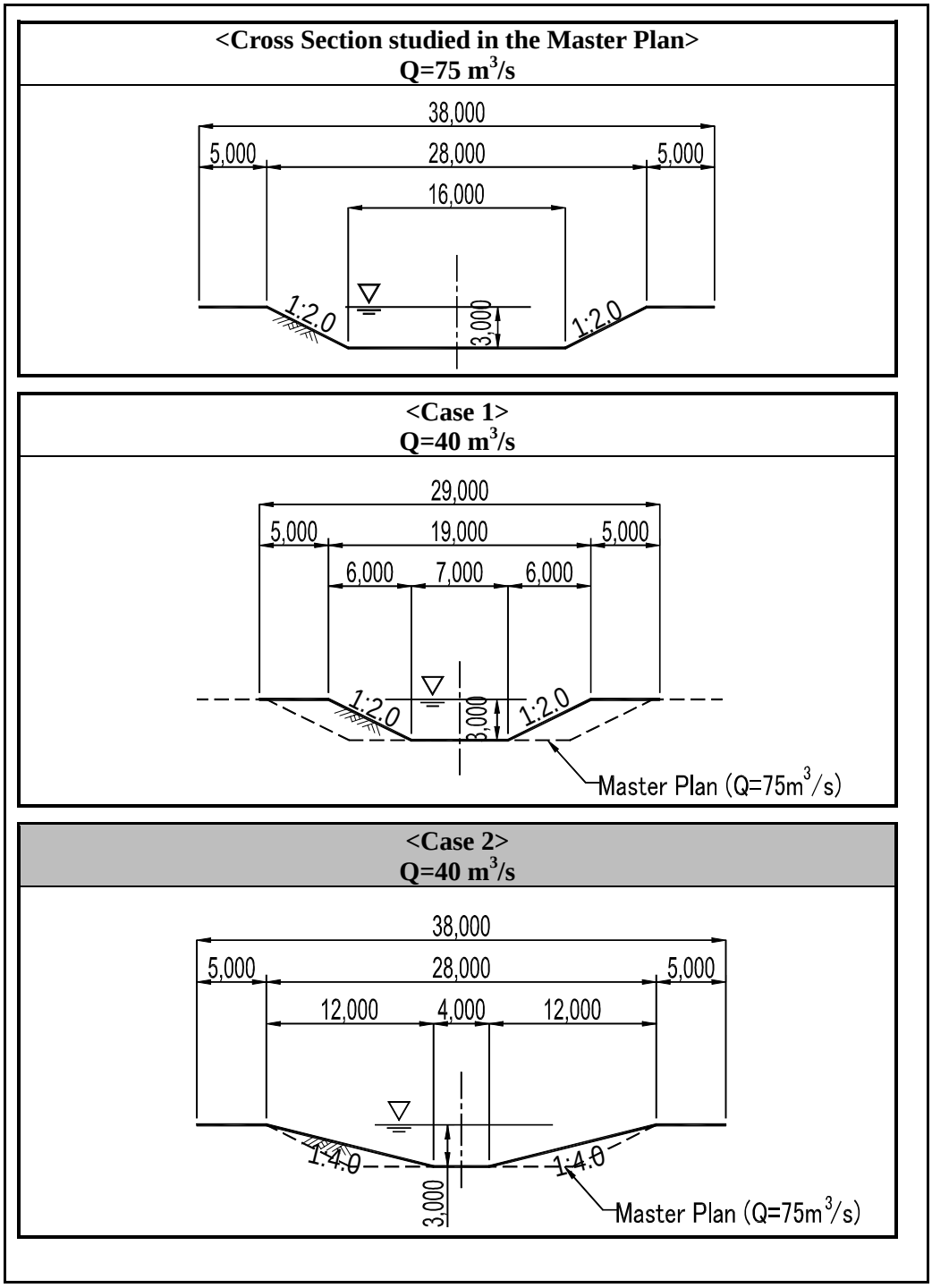


Fig. 2.2.5 Alternatives of Typical Cross Section of Meanchey Drainage Channel

The result of the comparative study is given in the Table 2.2.12.

Table 2.2.12 Comparison Table of Typical Cross Section of Meanchey Drainage Channel

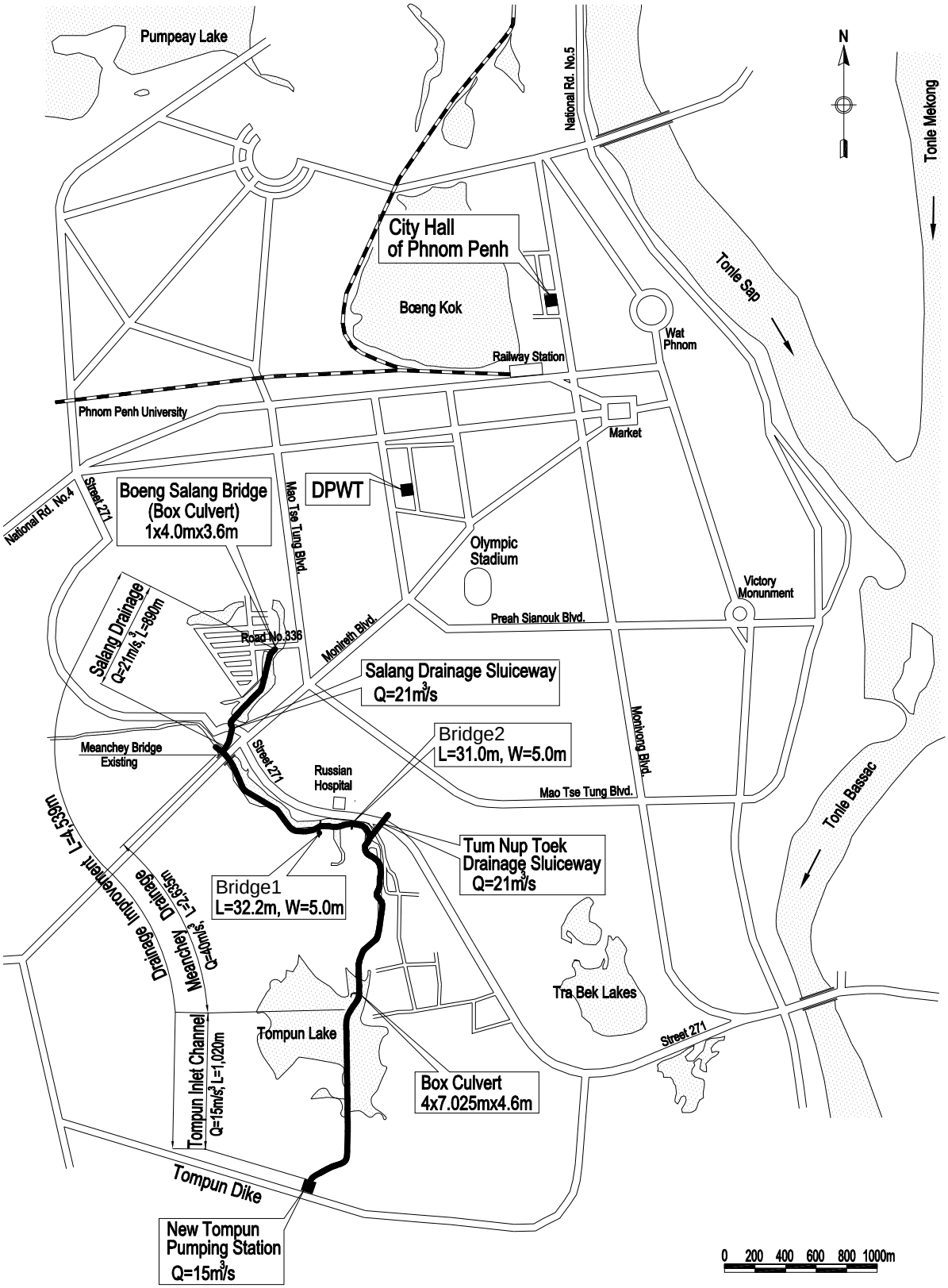
Item	Case 1	Case 2
Construction Cost	US$ 1,800,000	US$ 2,300,000
Merit	Cheaper cost	Project site is secured for the future improvement (whole width purchased is used in this project)
Demerit	Project site is not secured for the future improvement (whole width purchased is not used in this project)	Higher cost

Considering that securing the project site for future improvement is more important, **Case 2 is selected** as the typical cross section of the Meanchey Drainage Channel even though the construction cost is higher than in Case 1.

(d) Major Features of Meanchey Drainage Channel in the Downstream

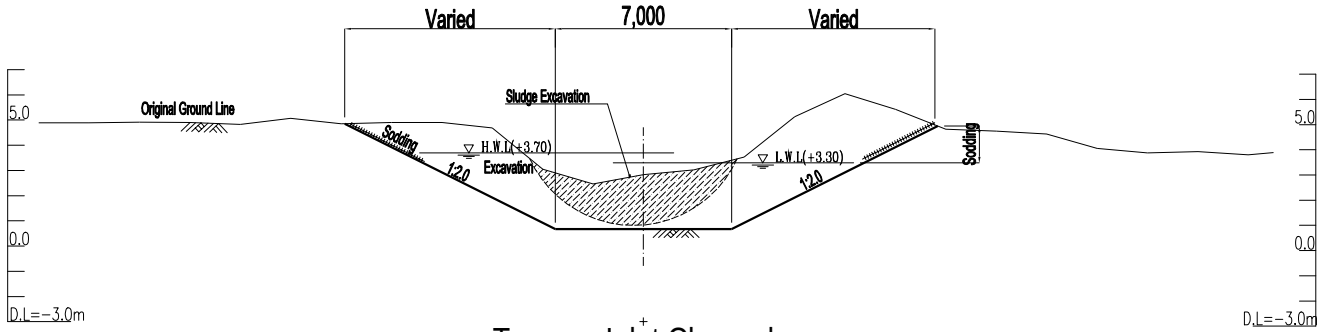
The Meanchey Drainage Channel in the downstream connects the Tompun Inlet Channel with the Salang Drainage Channel (refer to Fig.2.2.6). Major features of the downstream channel are decided based on the following reasons and are tabulated in the Table 2.2.13.

- The longitudinal profile of the channel, i.e. Design Bed Gradient (=1/2,500) and Bed Elevation, is determined from the result of the site investigation.
- Channel dimensions are decided from the result of uniform flow calculation with 0.030 of roughness coefficient.
- Because of the low flow velocity (0.9 m/sec), no revetment is provided at the side slopes of the channel, but sod is provided on the slopes of the channel and on both sides of maintenance roads.
- For the convenience of construction and maintenance of the channel, maintenance roads, 5m wide, are provided on both banks of the channel.
- The typical cross section of the channel is shown in Fig. 2.2.7 where the presumed sludge deposit on the channel bed is also indicated.
- With the provision of the above roads, lined ditches with 0.5m x 0.5m rectangular section are also provided along the roads to catch drain from the inland side and flow it into the channel through box culverts crossing the roads.

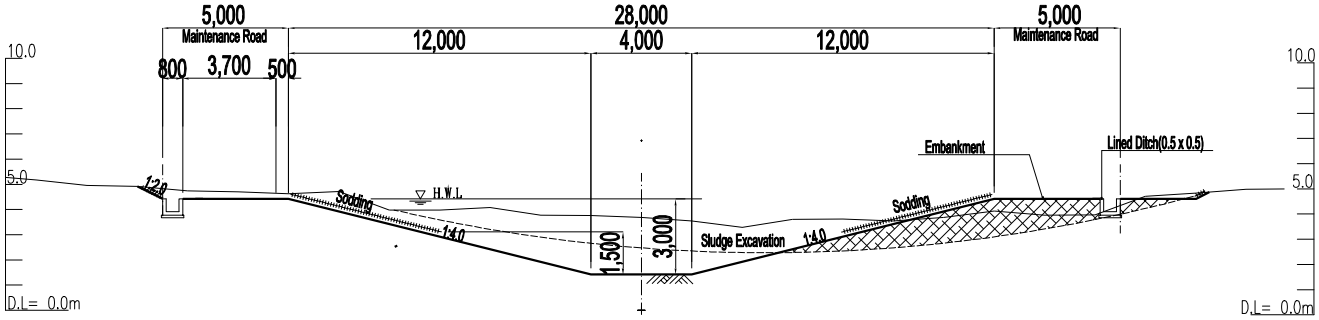


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Fig. 2.2.6 Drainage Improvement Location Map
CTIE International Co., Ltd.-Nippon Koei Co., Ltd.	

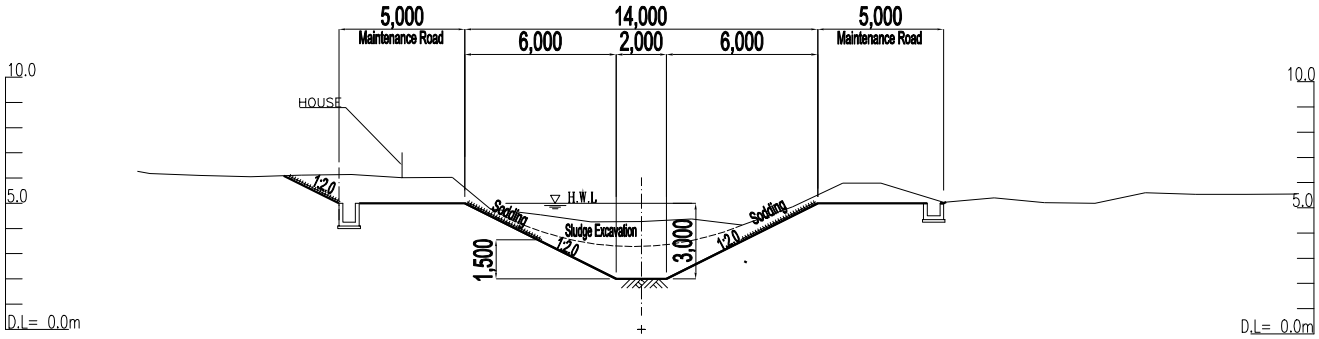
TYPICAL CROSS SECTION



Tompun Inlet Channel
(0+800)



Meanchey Drainage Channel
(1+800)



Salang Drainage Channel
(0+600)

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Fig.2.2.7 Typical Cross Section of Drainage Channels
CTIE International Co.,Ltd. - Nippon Koei Co.,Ltd.	

- In accordance with the result of the site investigation, two box culverts are proposed on the right bank at around Sta.1+800 and Sta.2+200 to drain existing local drains.
- Revetment with gabion mattress and boulder riprap are provided to protect bridge pier or abutment of the existing Meanchey Bridge.

Table 2.2.13 Major Features of Meanchey Drainage Channel Downstream

Type of Channel	Length (km)	Design Discharge (m^3/sec)	Bed Gradient	Bed Elevation (EL.m)		Channel Width (m)
				Sta.0+000	Sta.2+635	
Earth Channel	2.635	40.0	1/2,500	0.70	1.754	38

Note: Channel Width : Width in total, including the maintenance roads.

(e) Bridge Design

There are 3 bridges spanning the downstream Meanchey Drainage Channel to be reconstructed in accordance with the improvement of the channel.

The classification of crossing roads and the bridge locations are shown in the Table 2.2.14.

Table 2.2.14 List of Crossing Road and Bridge

Location	Road Function	Features of Structure		
STA.1+ 696	Local Street	Type of Structure	:	Girder Bridge
		Skew angle	:	75 degree
		Carriage way width	:	5 m
STA.1+ 480	Local Street	Type of Structure	:	Girder Bridge
		Skew angle	:	90 degree
		Carriage way width	:	5 m
STA.0+ 192	Pedestrian	Type of Structure	:	Box Culvert
		Skew angle	:	90 degree
		Carriage way width	:	3 m

(i) Structure Outline

The type of bridges was decided as 2 bridges of girder type and 1 bridge of box culvert type based on the comparative study. (Refer to Table 2.2.15 and Table 2.2.16)

STA. 1+696 (girder type) (Refer to Table 2.2.15)

- Bridge Length: L = 2.20m
- Bridge Width: Carriageway Width = 5.00m
- Design Live Load: A-Live Load (Japanese Standard)

Table2.2.15 Comparison of Bridge Type (Bridge No.1&2)

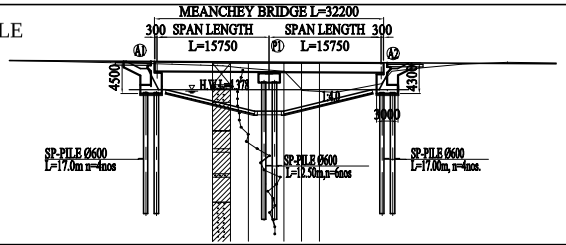
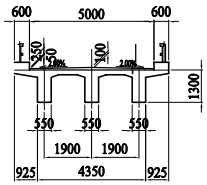
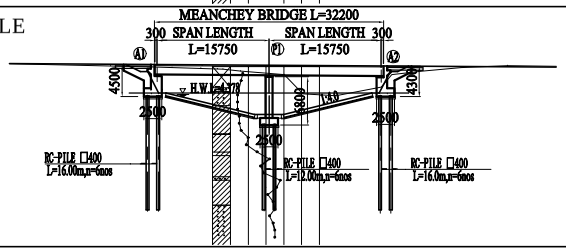
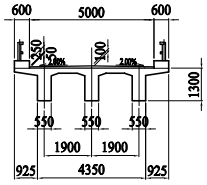
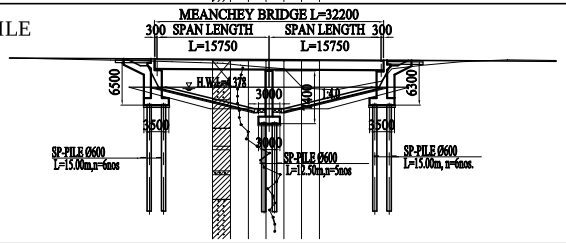
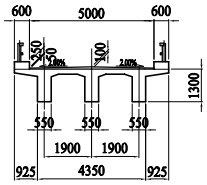
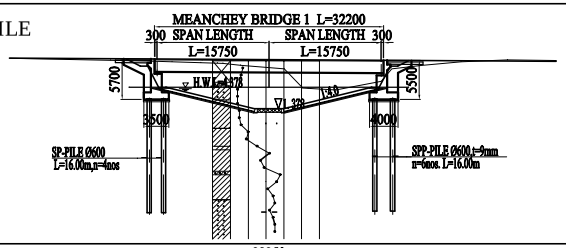
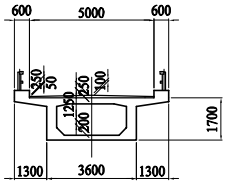
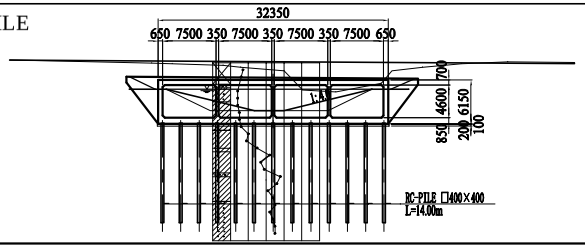
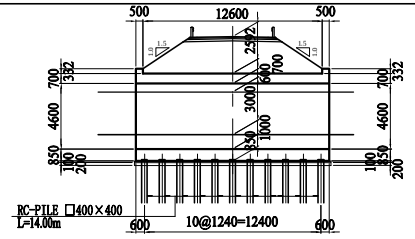
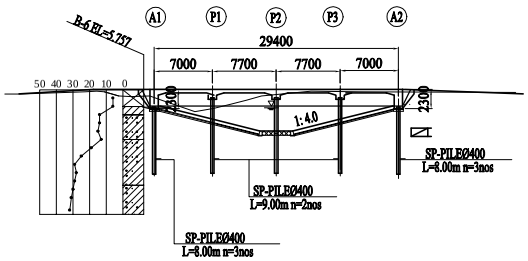
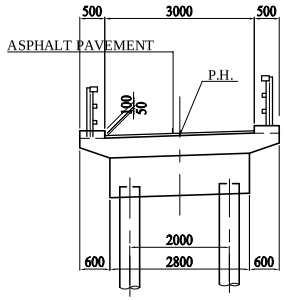
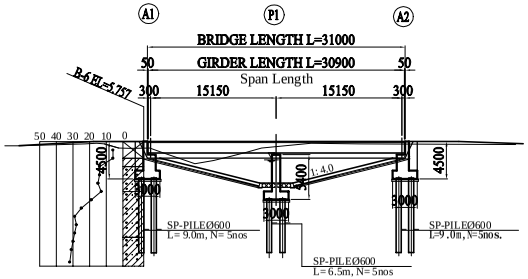
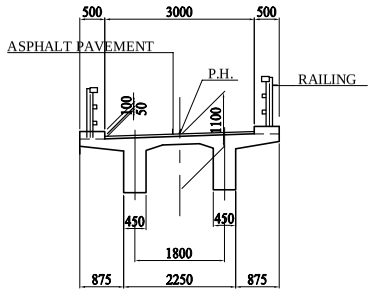
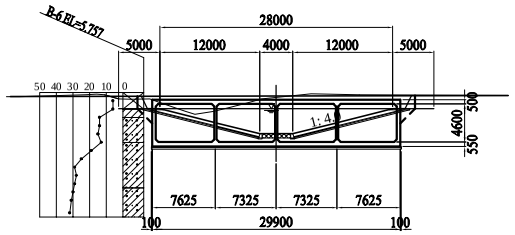
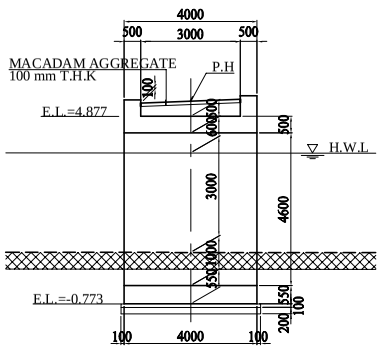
	Side View	Cross Section	Evaluation		
Alternative-1 2-Span Continuous Bridge for Pile Bent Style (RC-T Section Girder) Skew Angle 75 (R)	SP-PILE 	RC-T Section Girder 	Economy	・For a Steel Pipe Pile foundations, the foudation cost rate is high. 138,400 U.S.D(1.05)	○
			Structural Aspect	・For the Pile Bent Style, the stability of substructure is poor.	△
			Construction Aspect	・For a small scale of substructure, the temporary works is simple.	○
			Maintenance	・As the abutments and pier have bearings, and expansion joints are installed on the abutments, minor maintenance work will be required.	△
			Evaluation		○
Alternative-2 2-Span Continuous Bridge (RC-T Section Gieder) Skew Angle 75 (R)	RC-PILE 	RC-T Section Gieder 	Economy	・For a RC Pile foundations, cost of substructure is reduced, and is cheap. 131,800 U.S.D(1.00)	○
			Structural Aspect	・On the stability of substructure, this case is superior to the Pile Bent Style.	○
			Construction Aspect	・No problem for RC-structure.	○
			Maintenance	・As the abutments and pier have bearings, and expansion joints are installed on the abutments, minor maintenance work will be required.	△
			Evaluation		◎
Alternative-3 2-Span Continuous Brodge (RC-T Section Girder) Skew Angle 75 (R)	SP-PILE 	RC-T Section Gieder 	Economy	・For the large height on abutments, the cost of substructure is high. 152,000 U.S.D(1.16)	△
			Structural Aspect	・For the deep depth of embedment on a foundations, the good stability such as a scouring is obtained.	○
			Construction Aspect	・No problem for RC-structure.	○
			Maintenance	・As the abutments and pier have bearings, and expansion joints are installed on the abutments, minor maintenance work will be required.	△
			Evaluation		△
Alternative-4 Single Span Bridge (PC-Box Section Girder) Skew Angle 75 (R)	SP-PILE 	PC-Box Section Gieder 	Economy	・The superstructure of PC and the unit price is high. 225,900 U.S.D(1.72)	△
			Structural Aspect	・For the deep depth of embedment on foundations, the good stability such as a scouring is obtained.	○
			Construction Aspect	・The height of superstructure is low, accordingly the efficiency of girder inside works is bad.	△
			Maintenance	・As the abutments and pier have bearings, and expansion joints are installed on the abutments, minor maintenance work will be required.	△
			Evaluation		△
Alternative-5 Box Culvert Akew Angle 75 (R)	RC-PILE 		Economy	・Thich overburden was increasing the length of culvert and number of pile, thus, cost of construction of the culvert requires about 2 times of costs of the 2-span bridge. 362,600 U.S.D(2.77)	△
			Structural Aspect	・Thich overburden increases the length of culvert.	△
			Construction Aspect	・No problem for RC-structure.	△
			Maintenance	・No expansion joints and no barings will eliminate the maintenance in the future.	○
			Evaluation		△

Table 2.2.16 Comparison of Bridge Type (Bridge No.3)

	Side View	Cross Section	Evaluation		
Alternative-1 4-Span Series Slab Bridge	Skew Angle 90-00 	RC-SLAB 	Economy	・For a Steel Pipe Pile foundations, the foudation cost rate is high. 68500 U.S.D(1.07)	△
			Structural Aspect	・Construction is slab rigid-frame structure and makes substructure scale down.	○
			Construction Aspect	・The arrangement of reinforcing barof joints between the superstructure and pile are complicated	△
			Maintenance	・As no expansion joints and no barings, maintenace work is required on bridge deck.	○
			Evaliation	○	
Alternative-2 2-Span Continuous Bridge RC-T Section Series	Skew Angle 90-00 	RC-T桁橋 	Economy	・Since pile foundation is necessary, construction cost is expensive. 103,700 U.S.D(1.62)	△
			Structural Aspect	・Substructure had a depth of embedment on the ground is superior in stability.	○
			Construction Aspect	・No problem for RC-structure.	△
			Maintenance	・As the abutments and pie have bearings, and expansion joints are installed on the abutments, minor maintenance work will be required.	△
			Evaliation	△	
Alternative-3 Box Culvert	Skew Angle 90-00 	C-BOX 	Economy	・Since pile foundation is not necessary, construction cost is not expensive. 64,200 U.S.D(1.00)	○
			Structural Aspect	・Rigid structure is superior in stability such as scouring.	○
			Construction Aspect	・No problem for RC-structure.	△
			Maintenance	・No expansion joints and no barings will eliminate the maintenance in the future.	○
			Evaliation	◎	

- Type of Superstructure: 2-span-continuous RC-T-section Girder
- Type of Substructure: L-type Abutment and Wall-type Pier
- Type of Foundation: RC Pile, 400mm x 400mm

STA. 1+480 (girder type) (Refer to Table 2.2.15)

- Bridge Length: L = 31.00m
- Bridge Width: Carriageway Width = 5.00m
- Design Live Load: A-Live Load (Japanese Standard)
- Type of Superstructure: 2-span-continuous RC-T-section Girder
- Type of Substructure: L-type Abutment and Wall-type Pier
- Type of Foundation: RC Pile, 400mm x 400mm

STA. 0+192 (box culvert type) (Refer to Table 2.2.16)

- Structure Type: 4-barrel Box Culvert
- Road Width: Carriageway Width = 3.00m
- Design Live Load: Uniform Load (Japanese Standard)
- Type of Foundation: Spread Foundation

(ii) Design Criteria

- Standard and Specifications: Japanese Highway and Bridge Standard
- Material: Concrete - 28days Compressive Strength 24N/mm^2
- Reinforcement Steel: SD295A (Specified Yield Strength=295N/mm^2)
- Steel Pipe Pile: STK400 (Specified Yield Strength=400N/mm^2)
- Live Load: A-Live Load

Table 2.2.17 A-Live Load

Main Loading (loading width: max. 5.5m)						Sub-Loading
P1 (Uniform Load)			P2 (Uniform Load)			
Loading Length D(m)	Load Strength (kN/m^2)		Load Strength (kN/m^2)			
	For Bending Moment	For Shear Force	L≦ 80	80< L ≦130	130 <L	
6	10	12	3.5	4.3-0.01L	3.0	50%of main loading

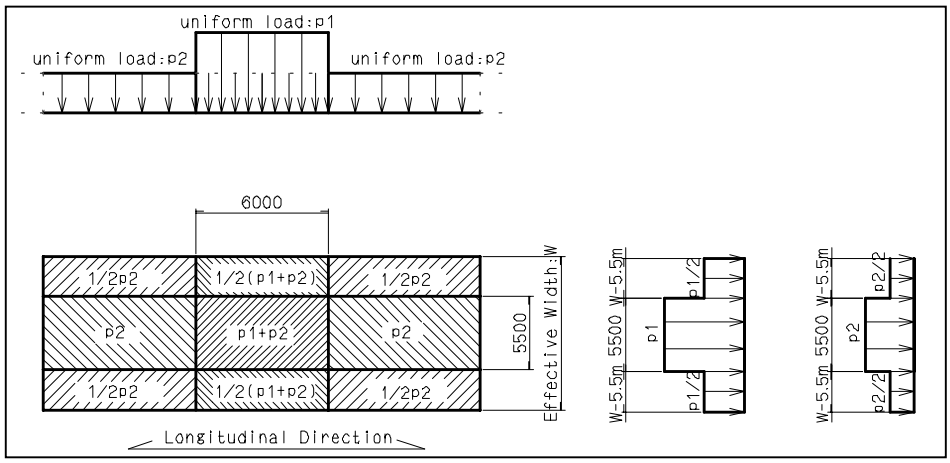


Fig. 2.2.8 Distribution of A-Live Load

- Impact Coefficient (I)

  I = 7/(20+L)

  where : I: Impact Coefficient

  L: Length in meter of the portion of the span that is loaded to produce the maximum stress in the member

- Design Seismic Coefficient

  Kh = 0.05, Kv = 0.00

- Thermal Effect

  Annual average air temperature: 27.8ºC

  Maximum air temperature: 42ºC

  Minimum air temperature: 11ºC

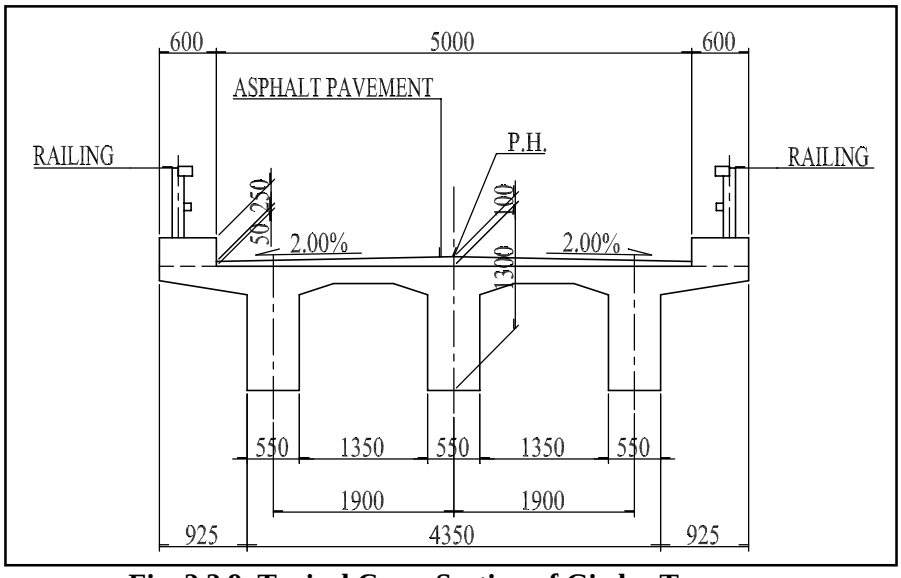


Fig. 2.2.9 Typical Cross Section of Girder Type

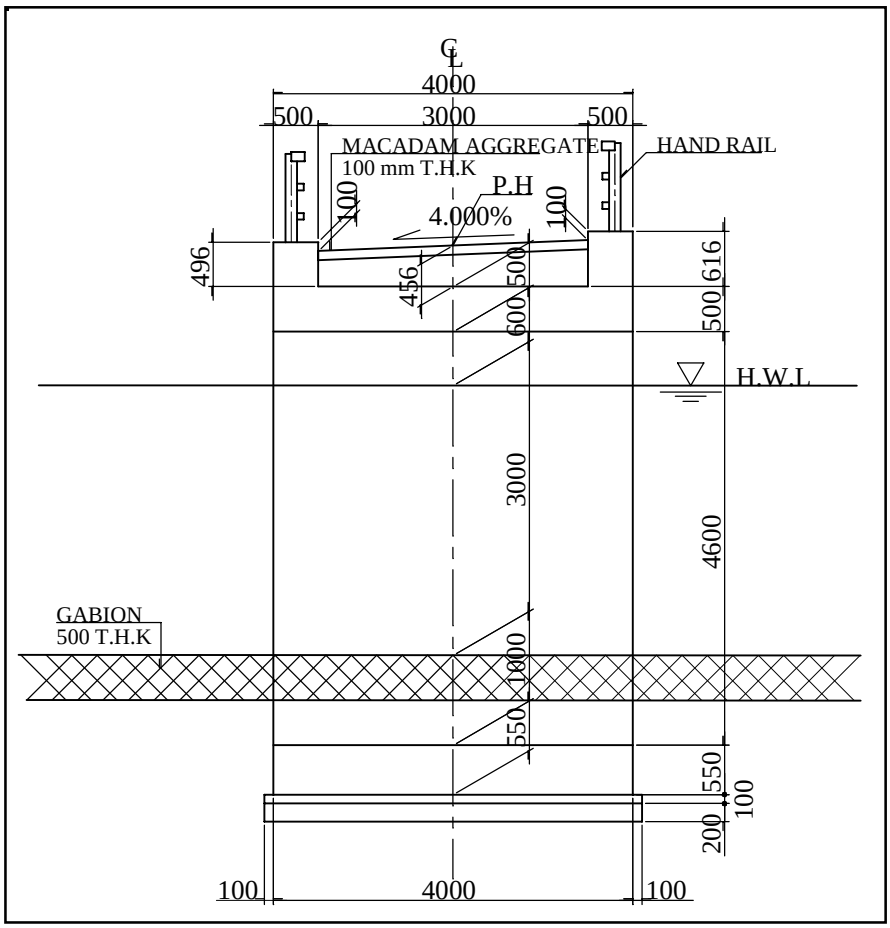


Fig. 2.2.10 Typical Cross Section of Box Culvert Type

(4) Improvement of Tompun Inlet Channel

The Tompun Inlet Channel located within the Tompun retarding pond connects the Tompun New Pumping Station with the downstream Meanchey Drainage Channel (refer to Fig. 2.2.6). Major features of the inlet channel are decided based on the following reasons and are tabulated in the Table 2.2.18.

- The discharge capacity of the channel is designed at $15m^3$/sec, same as the drainage capacity of the New Tompun Pumping Station.
- The longitudinal profile of the channel, i.e. Design Bed Gradient (=1/10,000) and Bed Elevation, is determined from the result of the site investigation.
- Channel dimensions are decided from the result of uniform flow calculation with 0.030 of roughness coefficient.
- Since the channel is located in the Tompun retarding pond, and considering the low flow velocity (0.4 m3/sec) at the design discharge, no revetment is provided at the side slopes of the channel.

- Sod is provided on the channel slopes above the Low Water Level (EL.3.300 m) of the pumping station.
- Considering construction and maintenance of the channel, maintenance road is provided on the left bank of the channel between Sta. 0+500 and Sta. 1+020 with a width of 5m.
- The typical cross section of the channel is shown in Fig 2.2.7 together with the presumed sludge deposit on the channel bed.

Table 2.2.18 Major Features of Tompun Inlet Channel

Type of Channel	Length (km)	Design Discharge (m^3/sec)	Bed Gradient	Bed Elevation (El.m)		Channel Width (m)
				Sta.0+000	Sta.1+020	
Earth Channel	1.020	15.0	1/10,000	0.600	0.700	About 21

Note: Channel Width : Width Bank to Bank

(5) Improvement of Salang Drainage Channel in the Downstream

(a) Major Features of Salang Drainage Channel in the Downstream

Salang Drainage Channel in the downstream is one of the tributaries of the Meanchey Drainage Channel joining at the upper end of the Meanchey Downstream Stretch (refer to Fig.2.2.6). Major features of the channel are decided based on the following reasons and are tabulated in the Table 2.2.19.

- The longitudinal profile of the channel, i.e. Design Bed Gradient (=1/2,500) and Bed Elevation, is determined from the result of the site investigation.
- Channel dimensions are decided from the result of uniform flow calculation with 0.030 of roughness coefficient.
- Because of the low flow velocity (0.9 m^3/sec) at the design discharge, no revetment is provided at the side slopes of the channel.
- Sod is provided on the slopes of the channel and on both sides of the maintenance roads.
- Considering construction and maintenance of the channel, roads, 5m wide, are provided on both banks of the channel.
- The typical cross section of the channel is shown in Fig 2.2.7 together with the presumed sludge deposit on the channel bed
- With the provision of the above roads, lined ditches with 0.5m x 0.5m rectangular section are also provided along the roads to catch drain from the inland side and flow it into the channel through box culverts crossing the roads.

- With the result of site investigation, 2 box culverts on the right bank at around Sta. 0+200 and left bank at around Sta. 0+300 are provided to drain the existing local drainage.
- To protect the abutments and piers of the existing Meanchey Bridge from scoring and to reinforce the channel slope of the confluence of Meanchey and Salang channels, revetment and channel bed protection with wet stone masonry and gabion mattress are provided for the portion from 10 m downstream of Meanchey Bridge to 80 m upstream of the bridge.
- Transition section with the length of 20.6 m is provided to connect Boeng Salang Bridge and Salang Drainage Channel Downstream.
- Revetment with stone masonry and bed protection works with gabion mattress are provided at the transition section to protect the Boeng Salang Bridge from scouring.

Table 2.2.19 Major Features of Salang Drainage Channel Downstream

Type of Channel	Length (km)	Design Discharge (m^3/sec)	Bed Gradient	Bed Elevation (EL.m)		Channel Width (m)
				Sta.0-220	Sta.0+667	
Earth Channel	0.887	13.0	1/2,500	1.754	2.109	24

Note: Channel Width : Width in total, including the maintenance roads.

(b) Design of Boeng Salang Bridge

Boeng Salang Bridge is along Road No.336 and spans the upper end of the Salang Drainage Channel Downstream (refer to Fig. 2.2.6). This bridge was not included in the original request of the Government of Cambodia.

The Muncipality of Phnom Penh plans to excavate or dredge the upstream stretch of Salang Drainage Channel in the future. On the other hand, the downstream stretch of Salang Drainage Channel will be improved in this project. In case of both sides of the bridge are improved, the bridge would become unstable.

Therefore, the Municipality of Phnom Penh requested JICA to include the reconstruction of the bridge in the scope of the Project, and JICA accepted the request.

The crossing road classification and the bridge location are shown in the Table 2.2.20.

Table 2.2.20 Road Classification and Bridge Location

Location	Road Function	Feature of Structure		
STA.0+ 667	Local Street	Type of Structure	:	Box Culvert
		Skew angle	:	90 degree
		Carriage way width	:	6 m

(i) Design Criteria

- Design Live Load: A-Live Load (Japanese Standard)
- Type of Foundation: RC Pile Foundation
- Standard and Specifications: Japanese Highway and Bridge Standard
- Material: Concrete – 28 days Compressive Strength = 21N/mm^2
- Reinforcement Steel: SD295A (Specified Yield Strength = 295N/mm^2)

(ii) Major Features of Boeng Salang Bridge

Major features of the bridge were decided based on the following reasons.

- The type of the bridge was decided as 1-barrel of box culvert type because of its structural simplicity and constructional easiness.
- Dimensions of the inner section of the box culvert were determined as the sections shown in the Fig. 2.2.11, considering flow area of the upstream stretch of Salang Drainage Channel in the future.

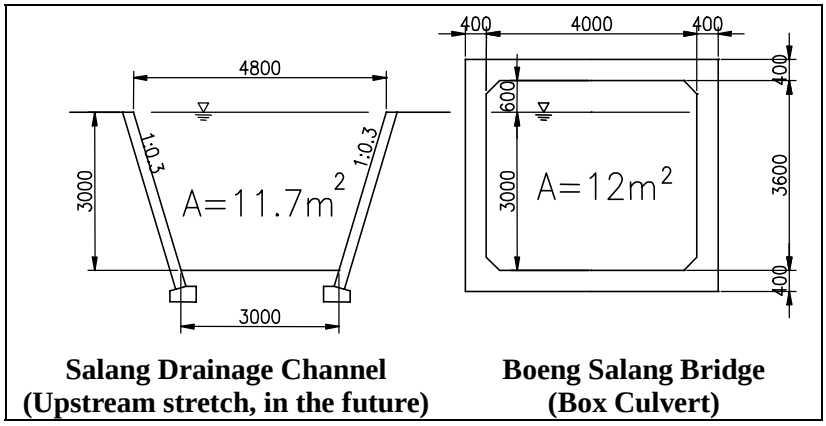


Fig. 2.2.11 Comparison of Cross Sections

- Considering the width of existing road, Carriageway Width of the road on the box culvert is 6.00m (3m x 2 lanes).
- The box culvert has an easily expandable structure to follow the widening of Road No.336 in the future. The 50cm of steel bars are stuck out of both ends of the box culvert for jointing, and covered with lean concrete of the same

quality as leveling concrete to avoid corrosion. Wheel guards are also provided with lean concrete.

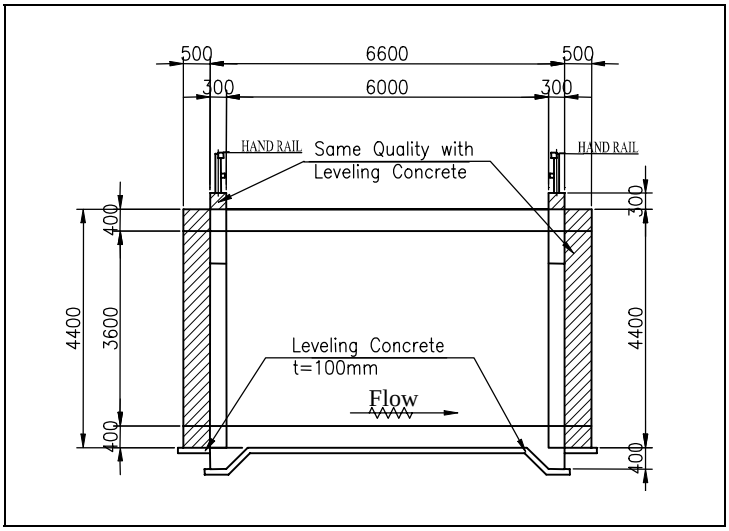


Fig. 2.2.12 Portion of Lean Concrete

(iii) Planning of Approach Road

Approach roads are provided to connect the existing road and bridge. For each approach road, width is 6m (3m x 2 lanes), length is 20m and gradient is 5%.

The sites of approach roads are dense residential areas and the right of way width is not sufficient. Hence, embankments with gravity type retaining walls are provided for both sides of approach roads.

(6) Construction of New Tompun Pumping Station

(a) Location of the Pumping Station

Since the New Tompun Pumping Station drains storm water from the Meanchey Drainage Channel, the new pumping station is located at the area beside the existing Tompun Pumping Station. (Refer to Fig. 2.2.6 and Fig. 2.2.13)

(b) Drainage Capacity

As mentioned before, the design discharge of the Meanchey Drainage Channel is set at 40 m^3/s. The necessary drainage capacity of the New Tompun Pumping Station is calculated under the conditions below:

(i) The peak discharge of Meanchey Drainage Channel is 40 m^3/s as the planning scale of 5-year probability.

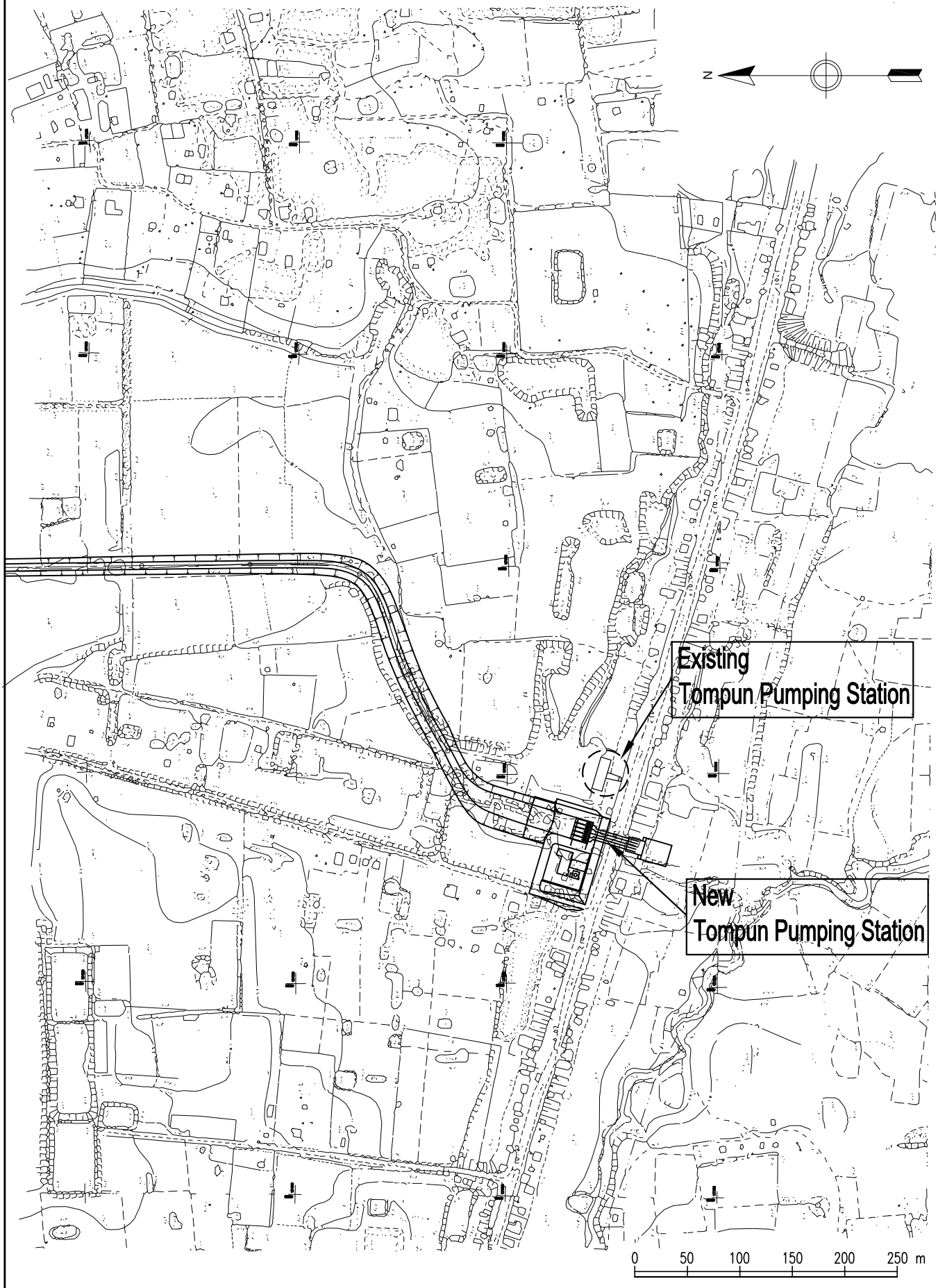


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Fig. 2.2.13

Location of New Tompun Pumping Station

(ii) Tompun Regulation Pond is not improved in this project and its present capacity is 299,000 m^3.

(iii) The storm water in the regulation pond is drained within 24 hours.

The analysis result is shown in the Fig. 2.2.14.

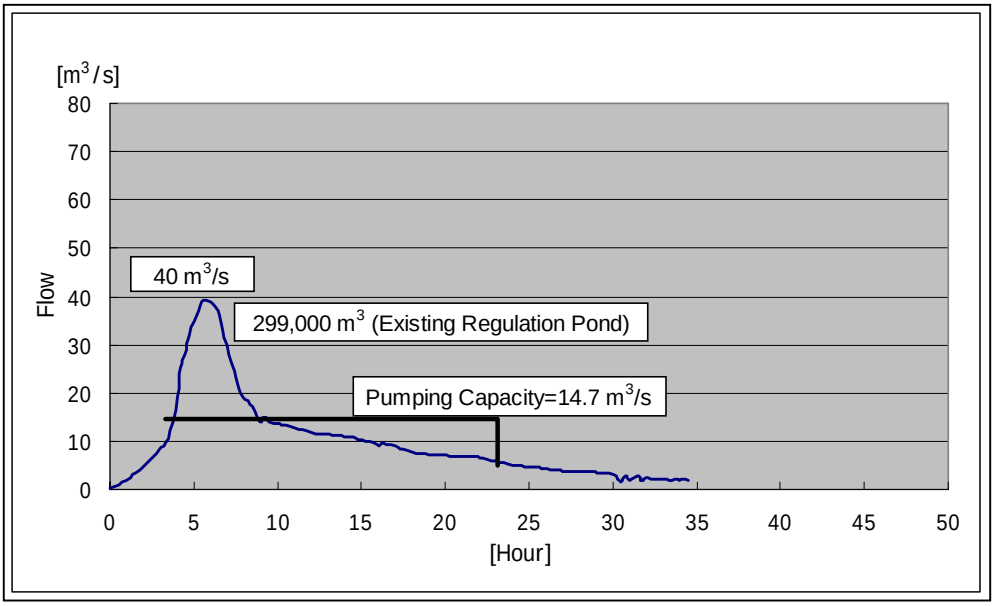


Fig. 2.2.14 Drainage Capacity Analysis of the New Tompun Pumping Station

From the result shown above, the drainage capacity of the New Tompun Pumping Station is decided at **15 m^3/s**.

(c) Number and Unit Capacity of Pumps

The number of pumps is decided to be **5 units** and accordingly, unit capacity of pumps is **3 m^3/s**, considering the following:

(i) Risk management at the time of breakdown;

(ii) To follow the change of discharge by unit;

(iii) Avoidance of frequent intermediate operation for small discharges; and

(iv) To use low voltage motor of less than 300 kW from the viewpoint of economy and easy maintenance (actual voltage is 260 kW with 5 pumps).

(d) Pump Type

In general 3 types of pumps are employed for storm water drain, namely, (1) Vertical shaft type, (2) Horizontal shaft type, and (3) Submergible type. Considering low cost of initial investment and operation and maintenance, **Submergible Type** is selected for

the New Tompun Pumping Station. The characteristics of these pumps are compared in Table 2.2.21.

(e) Basic Design of Civil Works

The layout of the pumping station is shown in Fig. 2.2.15. The major dimensions of the main structures of the New Tompun Pumping Station are as follows:

- Suction Pit: 5.8m (length) x 3.6m (width) x 3.0m (depth) x 5 (units)
- Discharge Pipe: 1,200 mm (diameter) x 5 (units) x 44m to 46m (length)
- Design High Water Level: EL.9.30 m at outside of Tompun Ring Dike
- Foundation for Suction Pit: Steel Pipe Pile Foundation (Dia.450mm to 600mm)
- Foundation for Discharge Pipe: PC Pile Foundation (400mm x 400mm)

Five discharge pipes are laid in Tompun Ring Dike, and reinforced by concrete and supported with PC piles. The structure of the pumping station and the suction pit are supported with steel pipe piles with the diameter of 450mm to 600mm

(f) Selection of Power Source

In general, the commercial electric line and diesel engine generator are compared as power sources. The best combination of power source is studied comparing the following 5 alternatives.

Case 1

In dry season, one pump operates intermediately by the commercial electric line to drain wastewater and, in rainy season, 4 pumps operate by the diesel engine generator to drain storm water.

Case 2

In dry season, one pump operates intermediately by the commercial electrical line to drain wastewater and, in rainy season, 5 pumps operate by the diesel engine generator to drain storm water.

Case 3

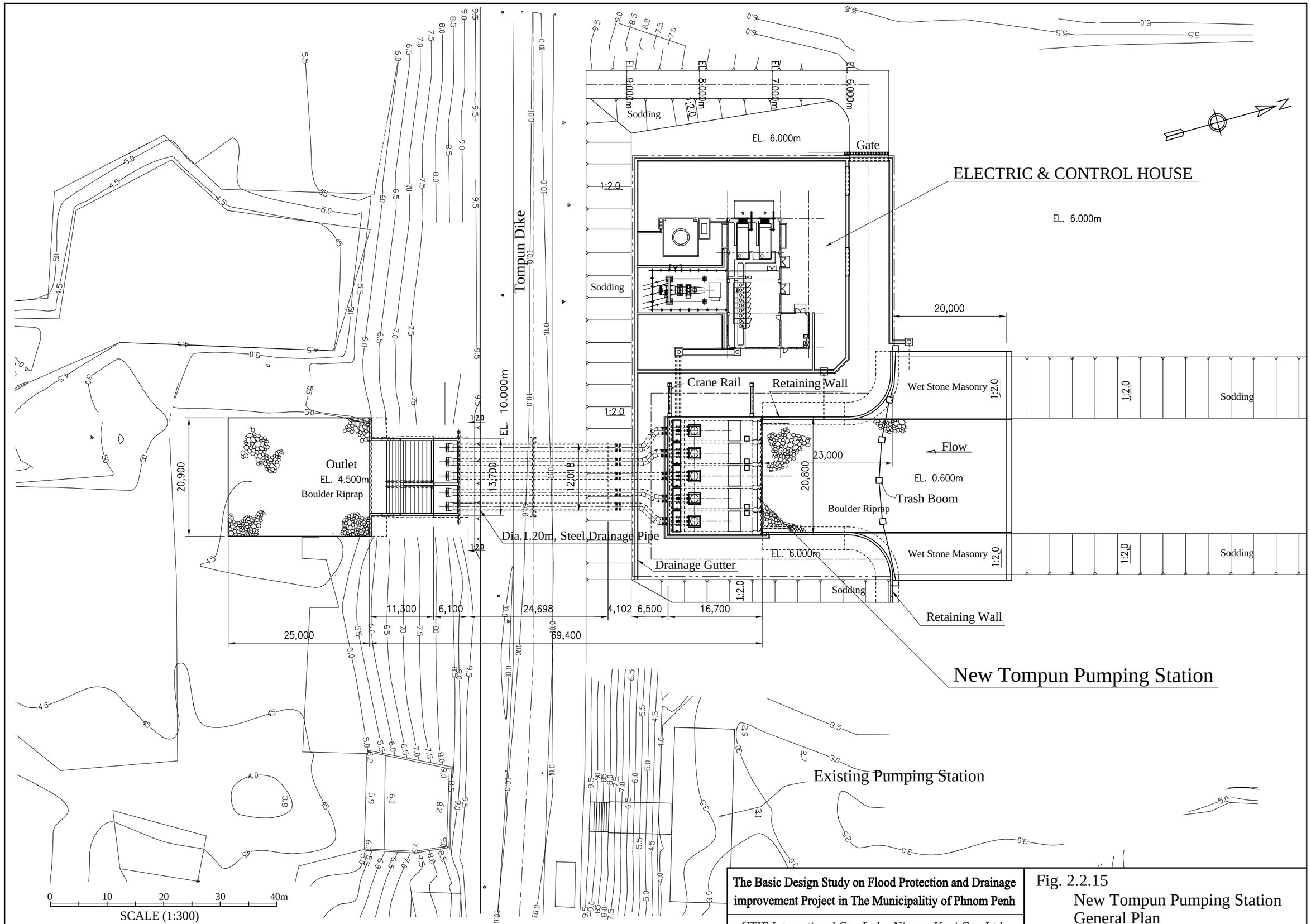
Both in dry and rainy seasons, all 5 pumps operate by the diesel engine generator.

Table 2.2.21(1/2) Comparison Table for Pump Types (1 of 2)

Item	Vertical Shaft		Horizontal Shaft		Submergible	
	Description	Judge	Description	Judge	Description	Judge
Prime Mover	Vertical-shaft mover is directly coupled in most cases. Horizontal-shaft mover requires bevel gear and larger space.	△	Horizontal-shaft mover, which is more popular than vertical mover, is used generally. No complex gear equipment is necessary even in case of engine driven type.	○	Submergible Motor is directly coupled. Special insulation will be applied for this type of motor	○
Area required	Less area is required.	○	Wider area is required than other types.	△	Less area is required	○
Building	Short Span, Higher	△	Long Span, Lower	△	No building is required.	○
Operation	Priming is not necessary.	○	Priming is necessary, unless positive suction condition. Therefore, automatic operation system needs complicated sequences.	△	Priming is not necessary.	○
Auxiliary equipment	Water supply equipment is necessary for water lubricated bearing type.	△	Vacuum pumps, Gland sealing pumps are necessary unless suction head is positive.	△	No special equipment is necessary for lubrication or priming.	○
Fresh Water	Very fresh water is necessary for water lubricated bearing.	△	Necessary for gland sealing water.	○	Not necessary	○
Suction Performance	Impeller is located below the suction water level. Cavitation does not occur in most cases.	○	Suction head and rotation speed are limited. Cavitation occurs in more cases than other types.	△	Impeller is located below the suction water level. Cavitation does not occur in most cases.	△

Table 2.2.21(2/2) Comparison Table for Pump Types (2 of 2)

Item	Vertical Shaft		Horizontal Shaft		Submergible	
	Description	Judge	Description	Judge	Description	Judge
Prime Mover protection from flood	Mover is located higher than the Horizontal Shaft Type. It is possible to design to set the mover higher than flood level.	○	Mover is located lower position than vertical shaft type. Mover might be needed protection from water flooding.	△	Motor is submersible type.	○
Anti-corrosion	Impeller and Casing are always in the water.	△	Impeller and Casing are above the water level and it is dry unless operated.	○	Impeller and Casing are always in the water.	△
Installation Works	It requires complicated works if the suction pipe length under the floor is long.	△	It requires complicated works if reduction gear and mover are to be coupled to pump after pump is settled.	△	Pump has been assembled with submergible motor before delivery. Installation is only to set down the pump unit.	○
Disassembling for maintenance	Pump is needed to be removed up on the floor for disassembling.	△	Pump can be disassembled without moving from the original position.	○	Pump is needed to be lifted up for disassembling. But lifting and re-setting works are very simple.	○
Maintenance	Pump maintenance situation cannot be checked easily since pump is under the floor.	△	Pump maintenance situation is can be checked easily by sight at anytime.	○	Frequent maintenance is not required. Insulation is to be checked once per month.	○
Noise	Pump noise is smaller than Horizontal shaft type. If engine driven type is applied, anti-noise measure might be necessary.	○	Pump noise is biggest among three types. If engine driven type is applied, noise protection is necessary.	△	Both pump and mover are set in the water, and noise is smallest among three types.	○
Evaluation	○		△		◎	



The Basic Design Study on Flood Protection and Drainage improvement Project in The Municipalitiy of Phnom Penh	Fig. 2.2.15 New Tompun Pumping Station General Plan
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Case 4

Both in dry and rainy seasons, all 5 pumps operate by the commercial electric line. Backup diesel engine generator is provided to operate 5 pumps.

Case 5

Both in dry and rainy seasons, all 5 pumps operate by the commercial electric line. Backup diesel engine generator is provided to operate 3 pumps.

The above 5 alternatives are compared in terms of initial cost and annual operation cost. Annual pump operation hours are estimated at 5,200 hours as a result of simulation of rainfall data from 1998 to 2000. The result of comparative study is shown in the Table 2.2.22.

Table 2.2.22 Comparison of Annual Operation Cost and Initial Cost

Cost	Case 1	Case 2	Case 3	Case 4	Case 5
Annual Operation Cost (x 10^3)	US$182.5	US$166.7	US$156.7	US$268.3	US$220.8
Initial Cost (x 10^3)	US$1,308	US$1,308	US$938	US$1,350	US$1,183

As a result, **Case 5 is selected** as the most preferable alternative from the viewpoint of easy operation and maintenance even though the operation cost is second highest among the 5 alternatives.

(7) Construction of Tum Nup Toek Drainage Sluiceway

Tum Nup Toek Drainage Sluiceway is located at Sta.1+300 on the right bank of the Downstream Meanchey Drainage Channel (refer to Fig.2.2.6). The purpose of this drainage sluiceway is to improve the present drainage condition maintained by the existing pumping station. With the above improvement, drainage capacity increases from 0.5 m^3/sec of the existing pumping station to 7 m^3/sec by gravity. Major features of the sluiceway are decided based on the following reasons and are tabulated in the Table 2.2.24.

- Design discharge of 7 m^3/sec is deduced from the run-off calculation with local secondary drainage system and the planning scale of 2-year probability rainfall.
- To minimize the number of houses to be evacuated, the location of the sluiceway is decided to be underneath the existing road (Street No. 183).
- The internal dimensions of the sluiceway are 1.75 m (width) x 3.60 m (height) x 1 lane.

Table 2.2.23 Comparison of Structure of Tum Nup Toek Drainage Sluiceway

No.	Structure Type	Design Condition	Items to be evaluated				Result
			Flood Protection	Adoptation of Plan in Future	Maintenance	Construction Cost	
			Evaluated by Safety against Flooding	Evaluated by Adoptation for Sewerage System	Evaluated by Possibility of Bed Erosion	(US$)	(No. of ◎)
1	Box Culvert 2.55 wide x 2.50 heigh x 1 lane	Design Discharge $7m^3$/sec from the result of run-off calculation with 2-year return period of the rainfall.	◎ (Slide Gate Type)	◎ Sill elevation is slightly high.	○ Possibility is high, Bed incline is not smooth.	200,000	2
2	Pipe Culvert 1.80 Dia. x 2 lanes		○ (Flap Gate Type)	○ Sill elevation is high.	○ Possibility is high, Bed incline is not smooth.	251,500	0
3	Box Culvert 1.65 wide x 1.65 heigh x 2 lanes		○ (Flap Gate Type)	○ Sill elevation is high.	○ Possibility is high, Bed incline is not smooth.	203,000	0
4	Box Culvert 1.75 x 3.60 x 1 1.75 wide x 3.60 heigh x 1 lane		◎ (Slide Gate Type)	◎ Sill elevation is low enough.	◎ Possibility is quite low, Bed incline is smooth.	180,400	3

- The proposed drainage sluiceway will be constructed at the site crossing the inner ring dike of Phnom Penh City, then a water gate is provided at the discharge side considering an emergency situation where the outer ring dike collapses.
- Pile foundation with RC piles is provided considering the result of soil investigation at the site.
- Based on the comparative study (Refer to Table.2.2.23), the structure of the sluiceway is decided as shown in the Table 2.2.24.

Table 2.2.24 Major Features of Tum Nup Toek Drainage Sluiceway

Design Discharge (m^3/sec)	Culvert Size	Longitudinal Gradient	Foundation Type
7.0 (2-year probability)	1.75m x 3.60m x 1-lane	1/2,500	RC Pile

(8) Construction of Salang Drainage Sluiceway

Salang Drainage Sluiceway is located at Sta.0-90 on the alignment of Downstream Salang Drainage Channel (refer to Fig.2.2.6). The purpose of this drainage sluiceway is to drain the design discharge of the channel instead of the existing drainage sluiceway at Sta. 0-100. Major features of the sluiceway are decided based on the following reasons and are tabulated in the Table 2.2.25.

- The proposed drainage sluiceway will be constructed at the site crossing the inner ring dike of Phnom Penh City, then water gates are provided considering an emergency situation where the outer ring dike collapses.
- The structural dimensions of the sluiceway are 4.5 m (width) x 3.6 m (height) x 1 lane.
- In consideration of operation of the proposed gates, 2.75m (width) x 3.60m (height) x 2-lane of gate leaves are provided at the outlet of the sluiceway instead of 4.5 m (width) x 3.60m (height) x 1-lane for the typical portion.
- Pile foundation is provided, considering the result of soil investigation at the site.

Table 2.2.25 Major Features of Salang Drainage Sluiceway

Design Discharge (m^3/sec)	Culvert Size	Longitudinal Gradient	Foundation Type
21.0	4.50m x 3.60m x 1-lane	1/2,500	RC Pile

2.2.4 Basic Design Drawing

This subsection describes drawings of the Basic Design for the Project. The list of drawings is shown in the Table below.

LIST OF DRAWINGS (1/2)

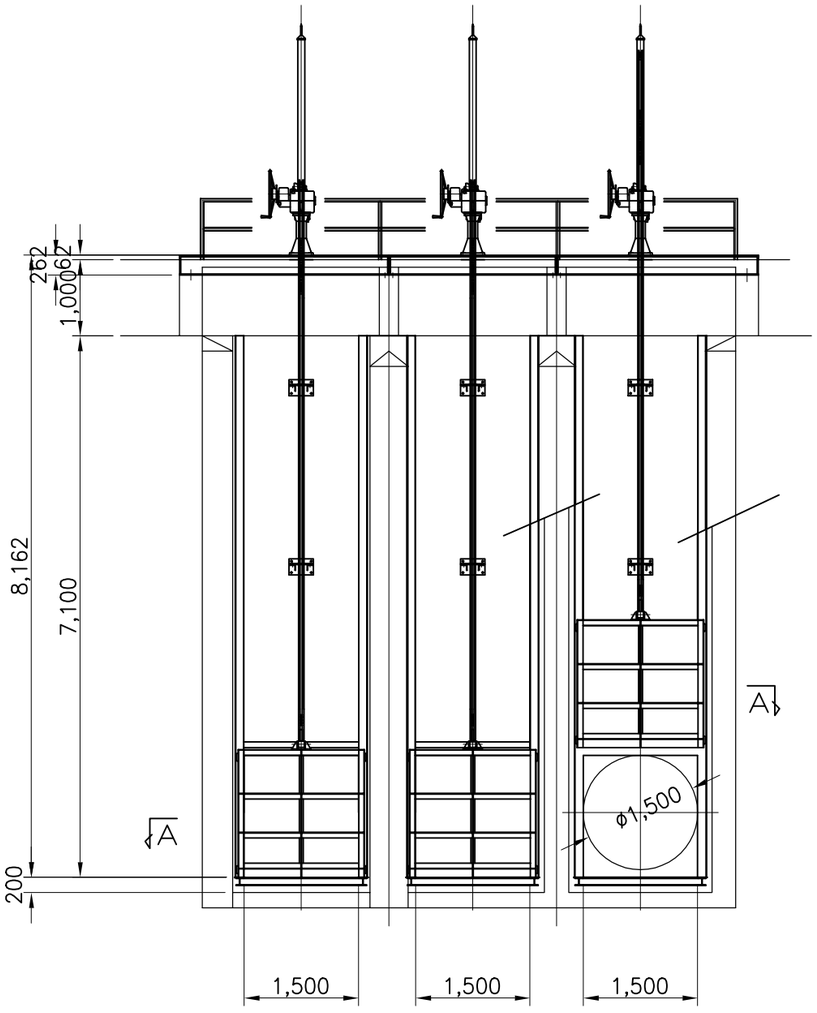
No.	Title of Drawings	Drawing No.
	FLOOD PROTECTION FACILITIES	
	SVAY PAK SLUICEWAY	
1	DETAIL OF GATE STRUCTURE	FP-SP-001
	TOMPUN DIKE ROAD	
2	PLAN AND PROFILE (1/3)	FP-TD-001
3	PLAN AND PROFILE (2/3)	FP-TD-002
4	PLAN AND PROFILE (3/3)	FP-TD-003
5	TYPICAL CROSS SECTION	FP-TD-004
6	CROSS SECTIONS (1/9)	FP-TD-005
7	CROSS SECTIONS (2/9)	FP-TD-006
8	CROSS SECTIONS (3/9)	FP-TD-007
9	CROSS SECTIONS (4/9)	FP-TD-008
10	CROSS SECTIONS (5/9)	FP-TD-009
11	CROSS SECTIONS (6/9)	FP-TD-010
12	CROSS SECTIONS (7/9)	FP-TD-011
13	CROSS SECTIONS (8/9)	FP-TD-012
14	CROSS SECTIONS (9/9)	FP-TD-013
	DRAINAGE IMPROVEMENT FACILITIES	
	GENERAL	
15	TYPICAL CROSS SECTIONS OF DRAINAGE CHANNELS	DI-GR-001
16	DRAINAGE FACILITIES VERTICAL DRAINAGE DITCH	DI-GR-002
17	CHANNEL STRUCTURE REVETMENT & BED PROTECTION	DI-GR-003
	MEANCHEY DRAINAGE CHANNEL	
18	PLAN (1/4)	DI-MC-001
19	PLAN (2/4)	DI-MC-002
20	PLAN (3/4)	DI-MC-003
21	PLAN (4/4)	DI-MC-004
22	PROFILE	DI-MC-005
23	CROSS SECTIONS (1/7)	DI-MC-006
24	CROSS SECTIONS (2/7)	DI-MC-007
25	CROSS SECTIONS (3/7)	DI-MC-008
26	CROSS SECTIONS (4/7)	DI-MC-009
27	CROSS SECTIONS (5/7)	DI-MC-010
28	CROSS SECTIONS (6/7)	DI-MC-011
29	CROSS SECTIONS (7/7)	DI-MC-012

LIST OF DRAWINGS (2/2)

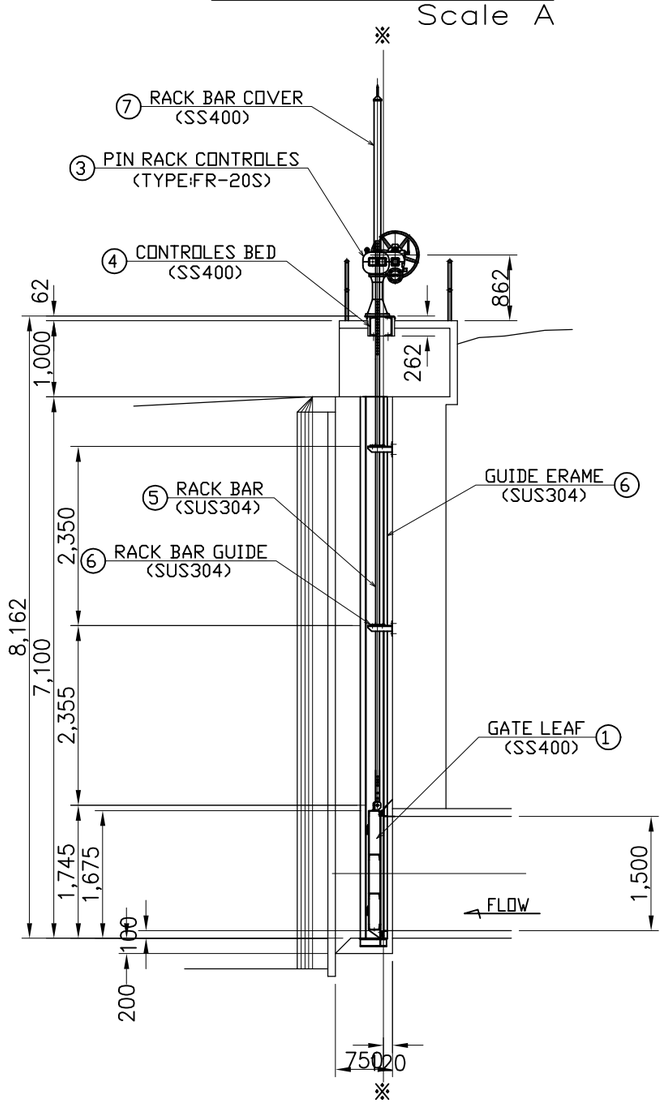
No.	Title of Drawings	Drawing No.
	MEANCHEY DRAINAGE CHANNEL	
30	BRIDGE-NO.1 (STA.1+696)	DI-MC-013
31	BRIDGE-NO.2 (STA.1+480)	DI-MC-014
32	BRIDGE-NO.3 BOX CULVERT (STA.0+192)	DI-MC-015
	TOMPUN INLET CHANNEL	
33	PLAN	DI-TC-001
34	PROFILE	DI-TC-002
35	CROSS SECTIONS (1/3)	DI-TC-003
36	CROSS SECTIONS (2/3)	DI-TC-004
37	CROSS SECTIONS (3/3)	DI-TC-005
	SALANG DRAINAGE CHANNEL	
38	PLAN (1/2)	DI-SC-001
39	PLAN (2/2)	DI-SC-002
40	PROFILE	DI-SC-003
41	CROSS SECTIONS (1/2)	DI-SC-004
42	CROSS SECTIONS (2/2)	DI-SC-005
43	BOENG SALANG BRIDGE (BOX CULVERT)	DI-SC-006
	NEW TOMPUN PUMPING STATION	
44	GENERAL PLAN	DI-TP-001
45	PLAN & PROFILE	DI-TP-002
46	CROSS SECTIONS	DI-TP-003
47	LAYOUT OF FOUNDATION PILE	DI-TP-004
	DRAINAGE SLUICEWAY	
48	TUM NUP TOEK DRAINAGE SLUICEWAY (1/2)	DI-SW-001
49	TUM NUP TOEK DRAINAGE SLUICEWAY (2/2)	DI-SW-002
50	SALANG DRAINAGE SLUICEWAY (1/2)	DI-SW-003
51	SALANG DRAINAGE SLUICEWAY (2/2)	DI-SW-004

NO.	DESCRIPTION	MATERIAL	DIMENTION	Q'TY	WEIGHT(kg)
1	GATE LEAF	SUS304	PL9, [150x75	3	1419.9
2	GUIDE FRAME	SUS304	PL6	3	1439.4
3	PIN RACK CONTROLES	-	FR-20S	3	739.8
4	CONTROLES BED	SS400	[250x90, PL12	1	459.5
5	RACK BAR	SUS304	FR-20S TYPE	3	404.1
6	RACK BAR GUIDE	SUS304	PL16,L75	6	116.4
7	RACK BAR COVER	SS400		3	55.5
			TOTAL		4634.6

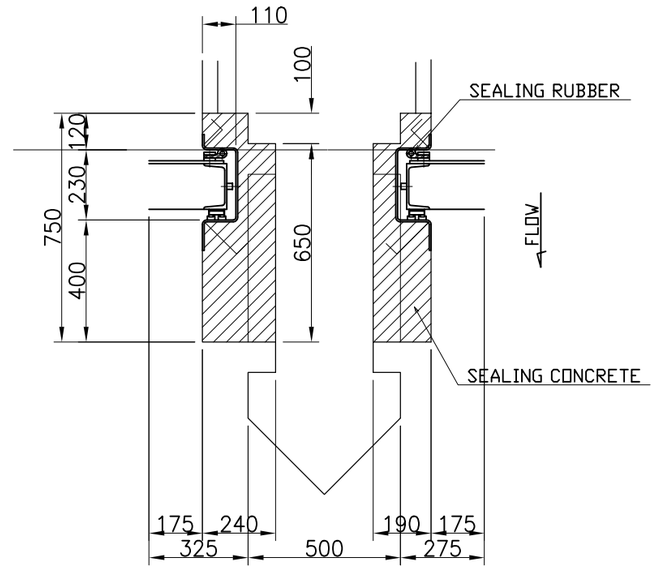
FRONT VIEW
Scale A



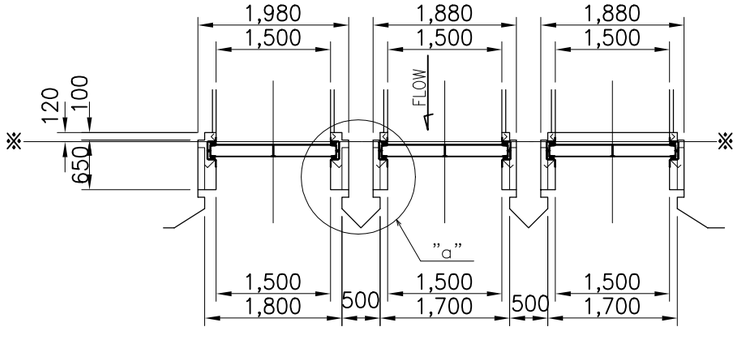
SIDE VIEW
Scale A



DETAIL "a"
Scale B



SECTION A—A
Scale A



Scale A 0 1 2 3 4 5m

Scale B 0 0.25 0.5 0.75 1.0 1.25m

DESIGN DATA

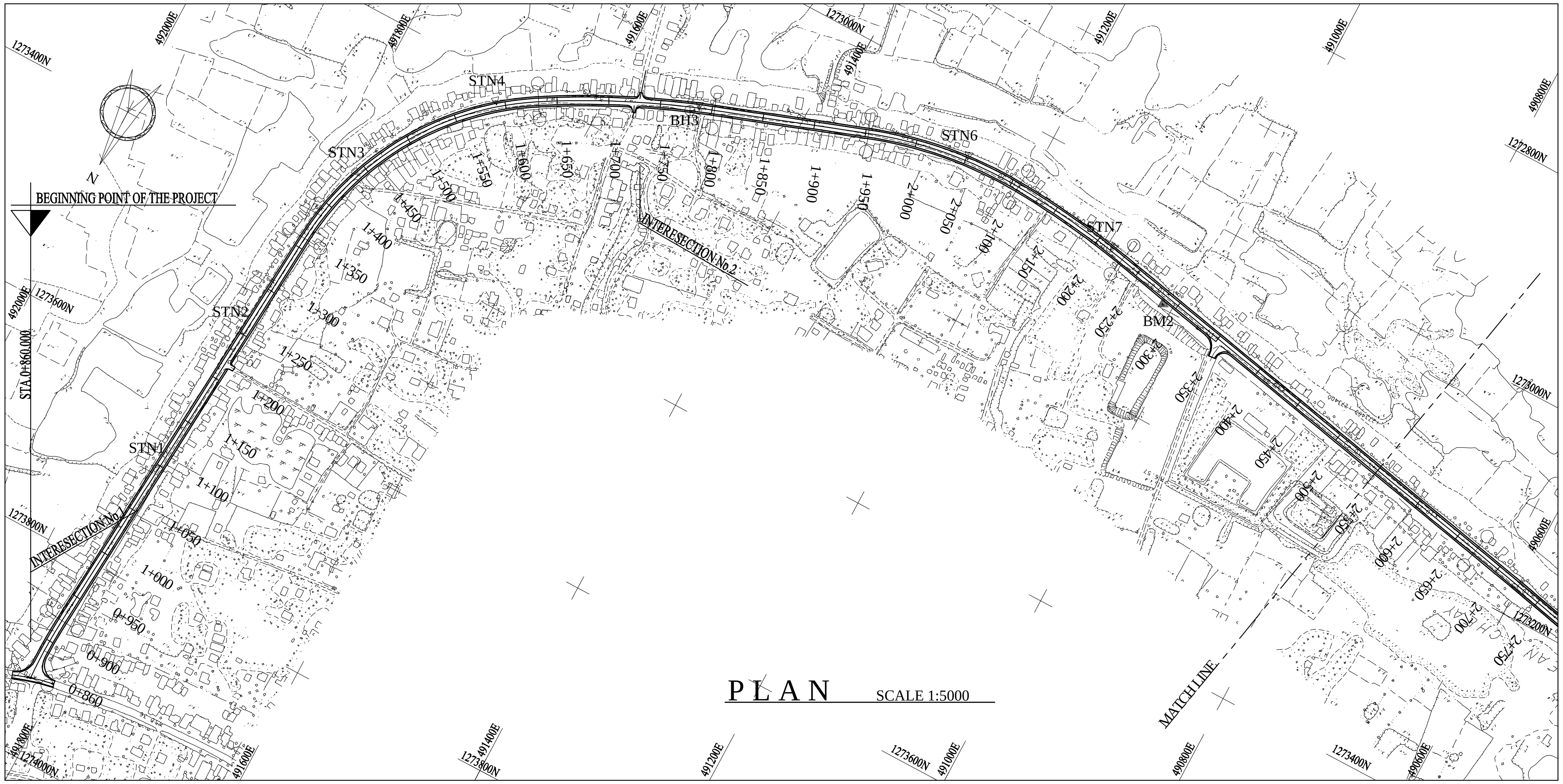
GATE LEAF	TYPE	SLIDE GATE	
	TUNNEL DIAMETER	ø1500 mm	
	QUANTITY	3 UNITS	
	DESIGN WATER HEAD	UPPER SIDE	0 mm
		LOWER SIDE	7220 mm
	OPERATING WATER HEAD (CASE OF OPEN)	UPPER SIDE	1500 mm
		LOWER SIDE	0 mm
	OPERATING WATER HEAD (CASE OF CLOSE)	UPPER SIDE	0 mm
		LOWER SIDE	1500 mm
	WATER TIGHTNESS	4 EDGES AT UPSTREAM SIDE	
CONTLOLES	TYPE	PIN RACK CONTROLES(FR-20S)	
	MOTIVE POWER	MAN'S POWER	
	HOISTING HEIGHT	1700 mm	
	HOISTING SPEED	0.191 m/min	

The Basic Design Study on Flood Protection and Drainage Improvement project in the Municipality of Phnom Penh

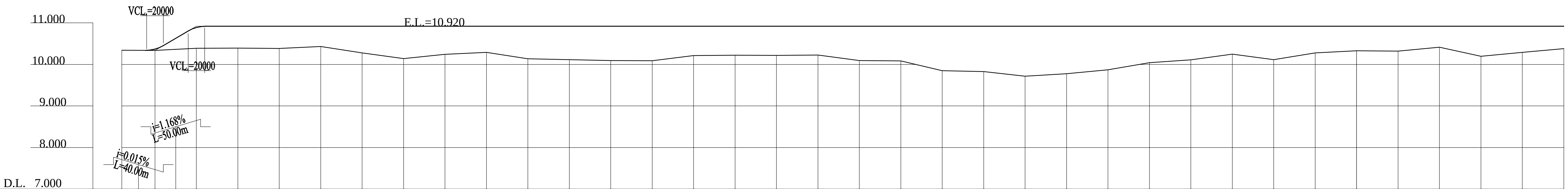
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.

Drawing No. FP-SP-001

SVAY PAK SLUICEWAY
DETAIL OF GATE STRUCTURE



PLAN SCALE 1:5000



GRADE: 10.342 | 10.336 | 10.920 | LEVEL E.L.=10.920

STATION	PROPOSED HIGHT	EXISTING GROUND LEVEL
0+860	10.342	10.342
0+900	10.366	10.336
0+950	10.891	10.390
1+000	10.920	10.394
1+050	10.920	10.382
1+100	10.920	10.431
1+150	10.920	10.278
1+200	10.920	10.141
1+250	10.920	10.244
1+300	10.920	10.288
1+350	10.920	10.135
1+400	10.920	10.114
1+450	10.920	10.094
1+500	10.920	10.088
1+550	10.920	10.212
1+600	10.920	10.223
1+650	10.920	10.216
1+700	10.920	10.226
1+750	10.920	10.093
1+800	10.920	10.084
1+850	10.920	9.847
1+900	10.920	9.827
1+950	10.920	9.716
2+000	10.920	9.775
2+050	10.920	9.872
2+100	10.920	10.040
2+150	10.920	10.111
2+200	10.920	10.248
2+250	10.920	10.113
2+300	10.920	10.279
2+350	10.920	10.328
2+400	10.920	10.321
2+450	10.920	10.416
2+500	10.920	10.196
2+550	10.920	10.288
2+600	10.920	10.381

PROFILE VERTICAL 1: 100 SCALE HORIZONTAL 1:5000

NOTES:

1. ALL CONTROL POINTS COODINATE ARE UTM ZONE GRID COORDINATES OF THAILAND (INDIAN DATUM 1975).
2. ALL DIMENSION ARE IN METERS.
3. VERTICAL REFERENCE IS THE MEAN SEA LEVEL AT HA TIEN.

BENCH MARKS & BOREHOLES COORDINATES

CODE	EASTING	NORTHING	LEVEL
BM2	491031.715	1273091.593	11.193
BH3	491522.149	1273142.607	9.920

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh

CTIE International Co., Ltd. - Nippon Koei Co., Ltd.

Drawing No. FP-TD-001

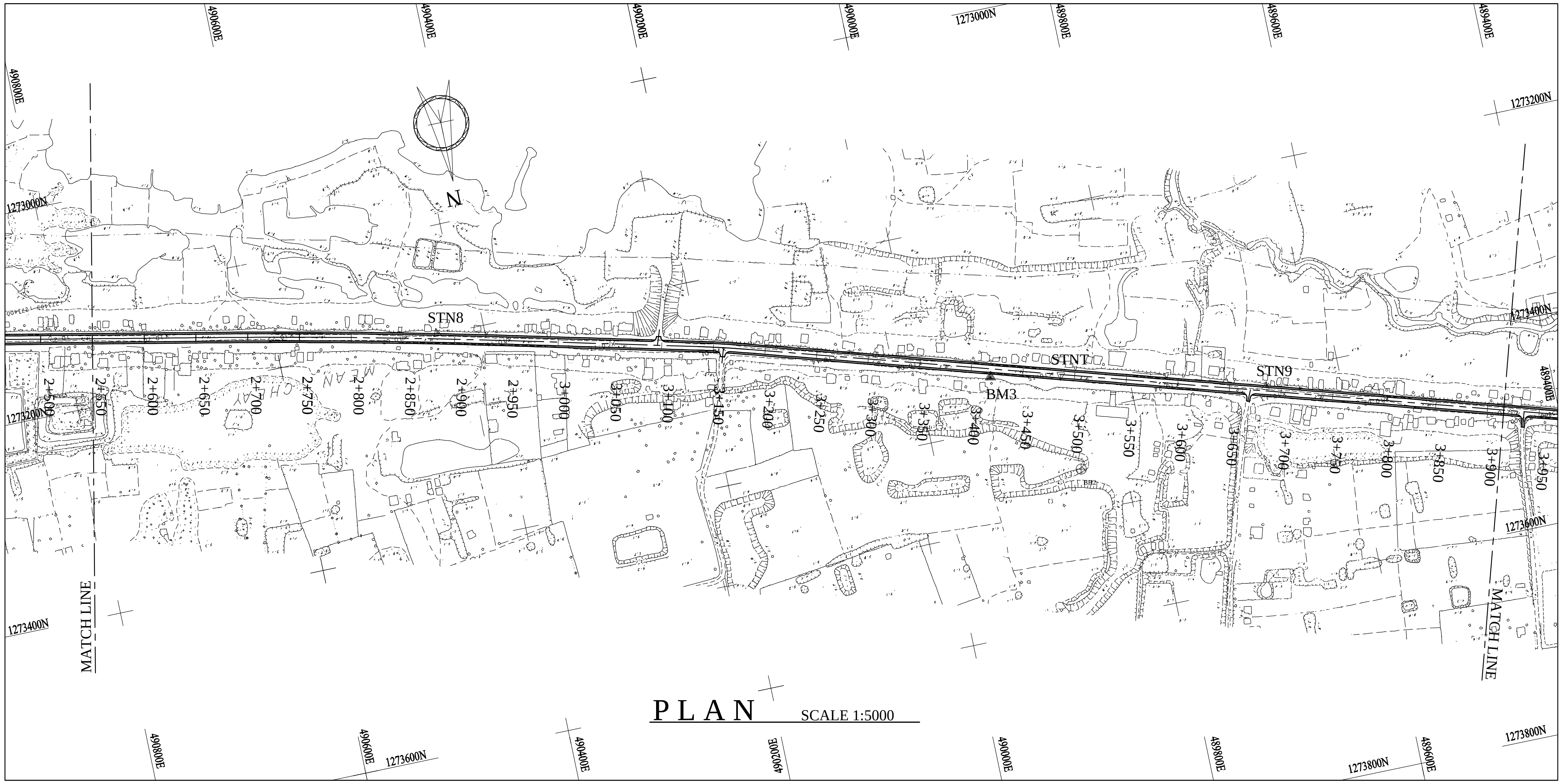
TOMPUN DIKE ROAD
PLAN AND PROFILE (1/3)

NOTES:

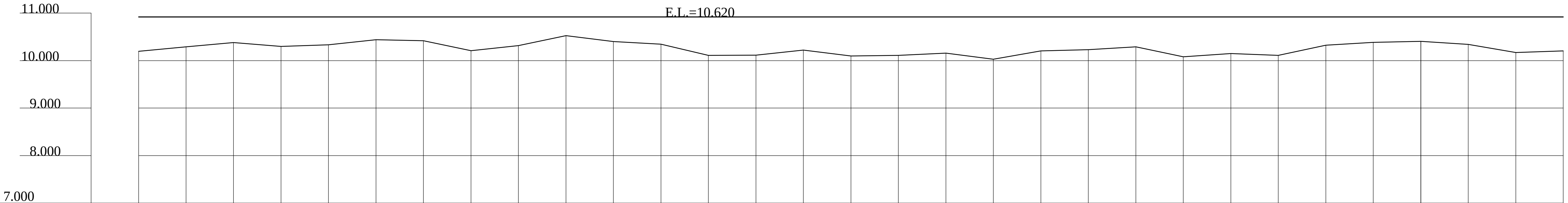
1. ALL CONTROL POINTS COODINATE ARE UTM ZONE GRID COORDINATES OF THAILAND (INDIAN DATUM 1975).
2. ALL DIMENSION ARE IN METERS.
3. VERTICAL REFERENCE IS THE MEAN SEA LEVEL AT HA TIEN.
   REFERENCE POINT: N.G.K. RN19 11.116m.

BENCH MARKS & BOREHOLES COORDINATES

CODE	EASTING	NORTHING	LEVEL
BM2	491031.715	1273091.593	11.193
BH3	491522.149	1273142.607	9.920



PLAN SCALE 1:5000

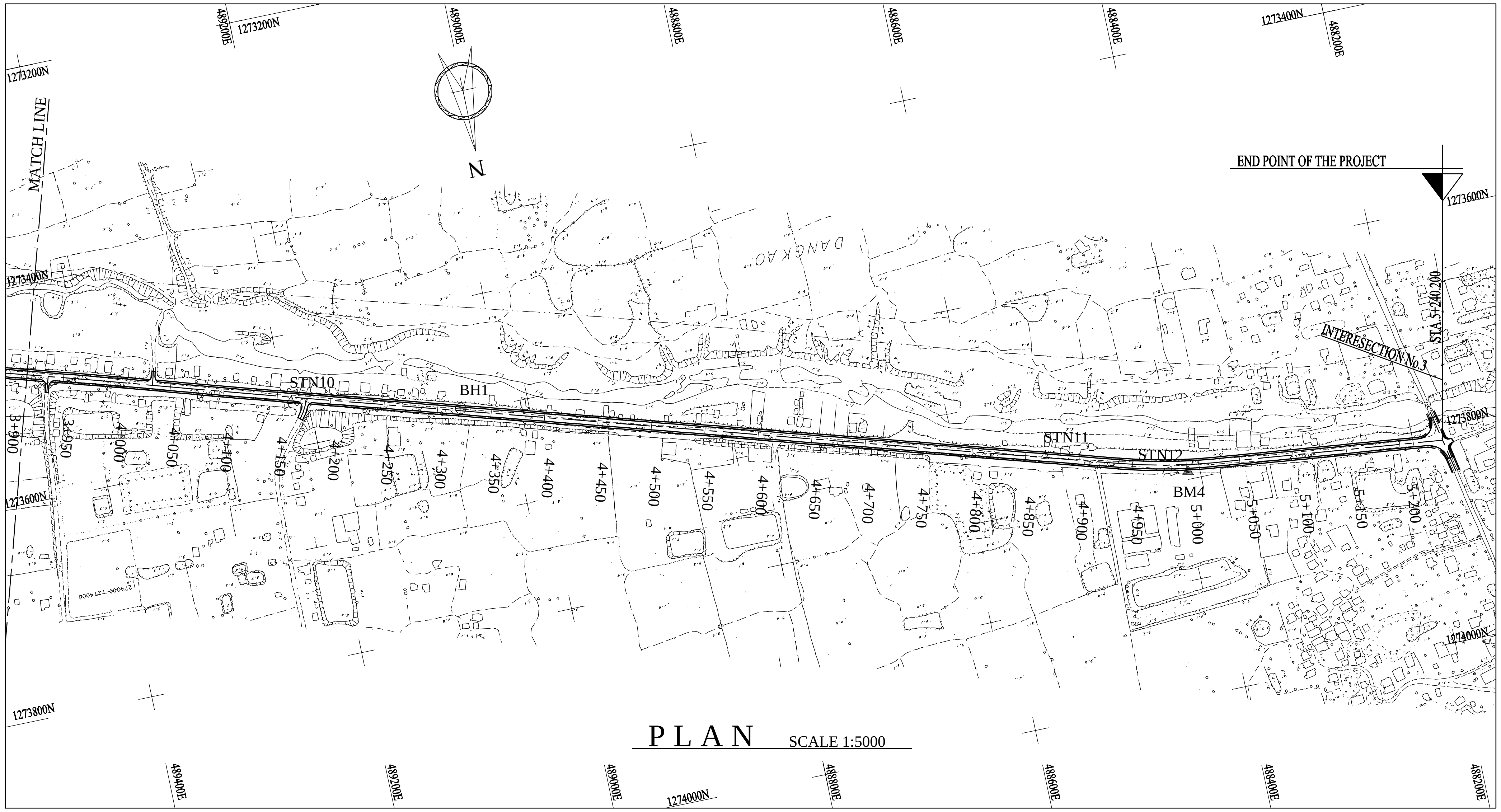


GRADE	LEVEL E.L.=10.920															
PROPOSED HEIGHT	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920
EXISTING GROUND LEVEL	10.196	10.288	10.381	10.299	10.332	10.441	10.417	10.207	10.316	10.524	10.399	10.345	10.110	10.113	10.222	10.097
STATION	2+500	2+550	2+600	2+650	2+700	2+750	2+800	2+850	2+900	2+950	3+000	3+050	3+100	3+150	3+200	3+250

PROPOSED HEIGHT	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920	10.920
EXISTING GROUND LEVEL	10.112	10.157	10.029	10.202	10.229	10.291	10.081	10.148	10.110	10.326	10.385	10.405	10.342	10.171	10.206
STATION	3+300	3+350	3+400	3+450	3+500	3+550	3+600	3+650	3+700	3+750	3+800	3+850	3+900	3+950	4+000

PROFILE SCALE VERTICAL 1: 100 HORIZONTAL 1:5000

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-002
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD PLAN AND PROFILE (2/3)



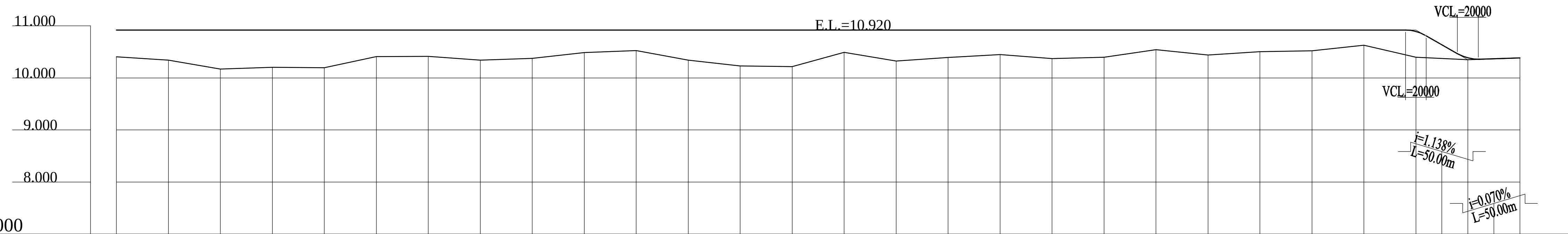
PLAN SCALE 1:5000

NOTES:

1. ALL CONTROL POINTS COODINATE ARE UTM ZONE GRID COORDINATES OF THAILAND (INDIAN DATUM 1975).
2. ALL DIMENSION ARE IN METERS.
3. VERTICAL REFERENCE IS THE MEAN SEA LEVEL AT HA TIEN. REFERENCE POINT: N.G.K. RN19 11.116m.

BENCH MARKS & BOREHOLES COORDINATES

CODE	EASTING	NORTHING	LEVEL
BM2	491031.715	1273091.593	11.193
BH3	491522.149	1273142.607	9.920



STATION	PROPOSED HEIGHT	EXISTING GROUND LEVEL
3+850	10.920	10.405
3+900	10.920	10.342
3+950	10.920	10.171
4+000	10.920	10.206
4+050	10.920	10.196
4+100	10.920	10.409
4+150	10.920	10.414
4+200	10.920	10.340
4+250	10.920	10.377
4+300	10.920	10.485
4+350	10.920	10.525
4+400	10.920	10.339
4+450	10.920	10.231
4+500	10.920	10.219
4+550	10.920	10.492
4+600	10.920	10.322
4+650	10.920	10.394
4+700	10.920	10.449
4+750	10.920	10.370
4+800	10.920	10.396
4+850	10.920	10.544
4+900	10.920	10.438
4+950	10.920	10.503
5+000	10.920	10.522
5+050	10.920	10.628
5+100	10.892	10.395
5+150	10.381	10.351
5+200	10.386	10.386

PROFILE VERTICAL 1: 100 SCALE HORIZONTAL 1:5000

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh

CTIE International Co., Ltd. - Nippon Koei Co., Ltd.

Drawing No. FP-TD-003

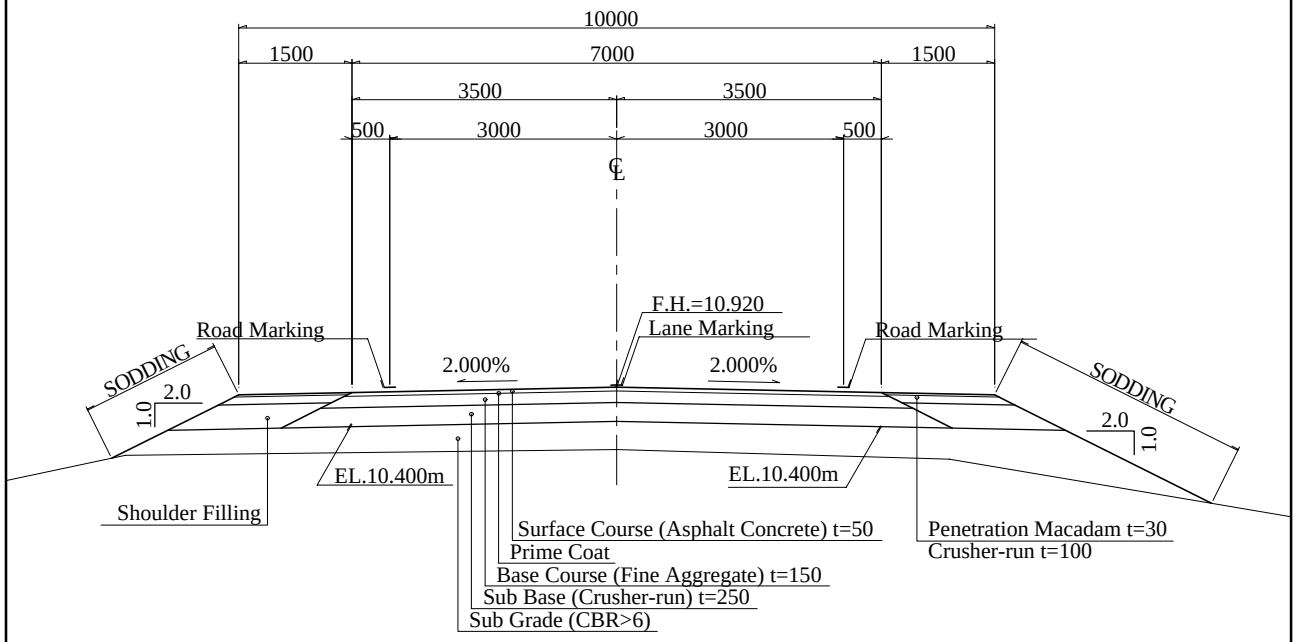
TOMPUN DIKE ROAD
PLAN AND PROFILE (3/3)

TYPICAL CROSS SECTION OF TOMPUN DIKE ROAD

SCALE 1:100

STA.1+500

P.H.=10.920
G.L.=10.094



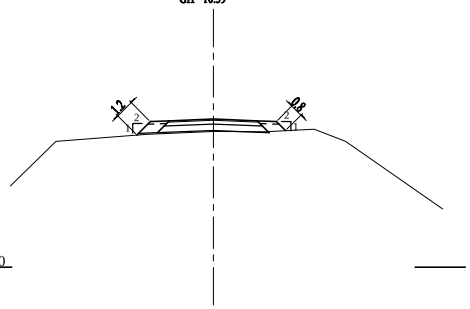
D.L.=5.00m

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-004
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD TYPICAL CROSS SECTION

CROSS SECTIONS (1)

SCALE V=1:100 H=1:200

STA.0+950.0
PH= 10.891
GH= 10.39



STA.1+100.0
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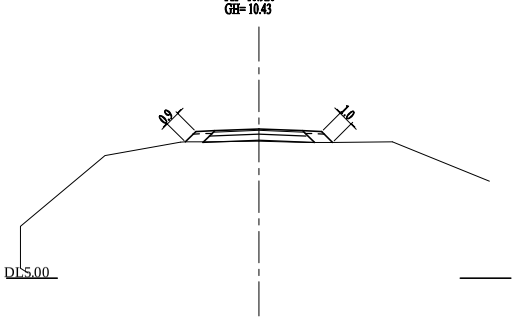
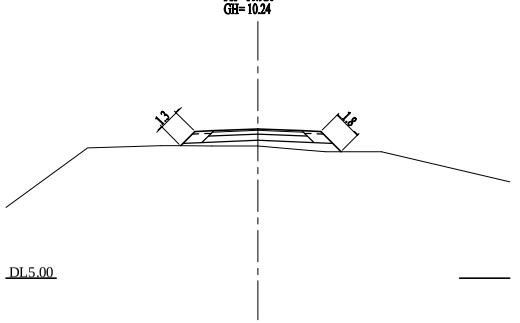
GH= 10.43



STA.1+250.0
PH= 10.920
GH= 10.24



STA.0+900.0
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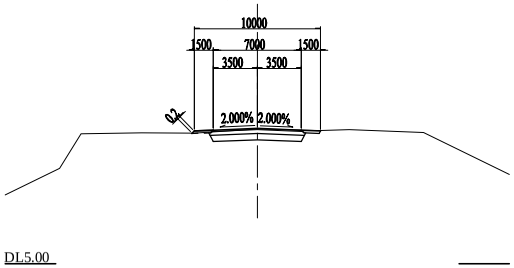
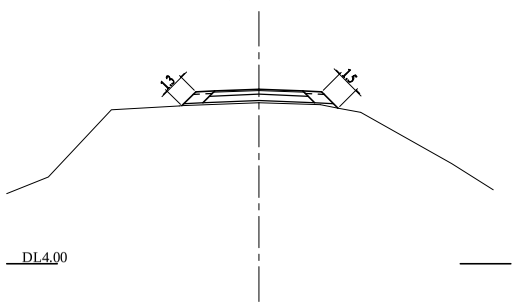
GH= 10.34



STA.1+050.0
PH= 10.920
GH= 10.38



STA.1+200.0
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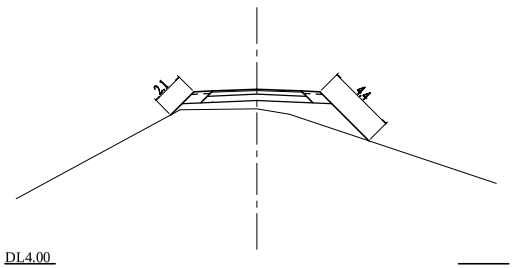
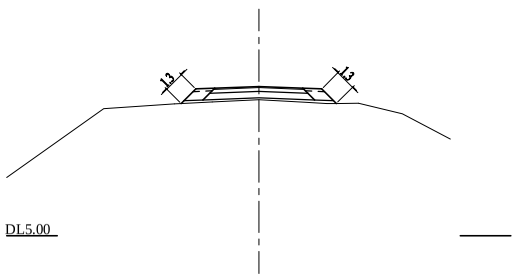
GH= 10.14



STA.0+860.0
PH= 10.342
GH= 10.34

STA.1+000.0
PH= 10.920
GH= 10.39



STA.1+150.0
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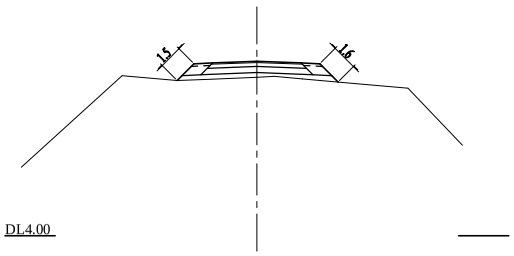
GH= 10.28

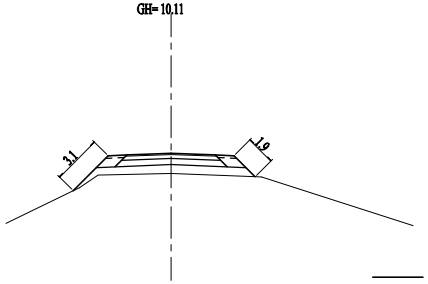


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-005
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD CROSS SECTIONS (1/9)

CROSS SECTIONS (2)

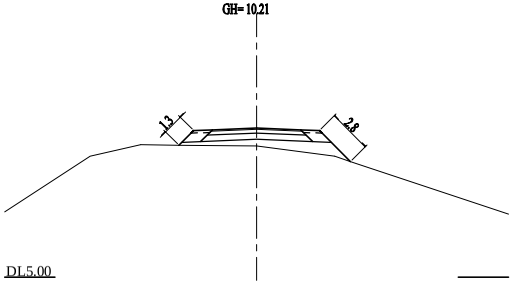
SCALE V=1:100 H=1:200

STA.1+400.0
PH= 10.920
GH= 10.11



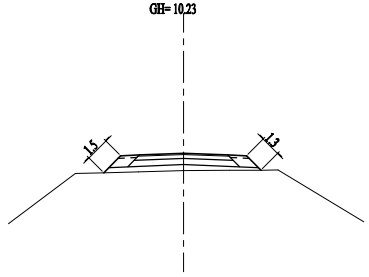
DL6.00

STA.1+550.0
PH= 10.920
GH= 10.21



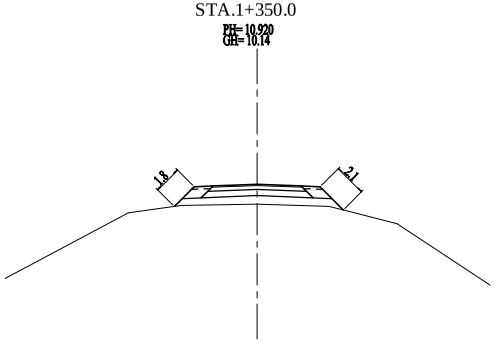
DL5.00

STA.1+700.0
PH= 10.920
GH= 10.23



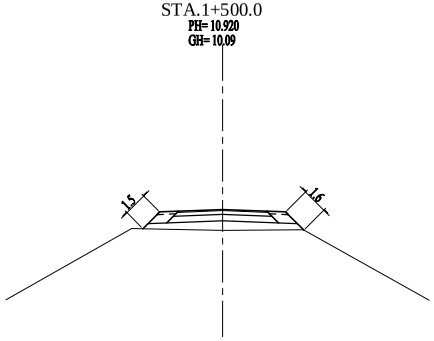
DL6.00

STA.1+350.0
PH= 10.920
GH= 10.14



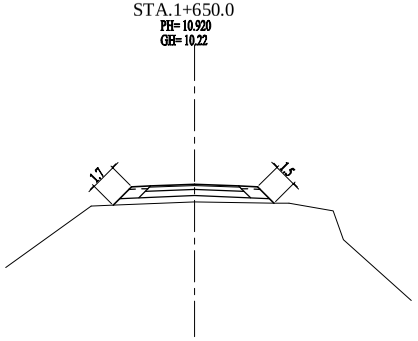
DL4.00

STA.1+500.0
PH= 10.920
GH= 10.09



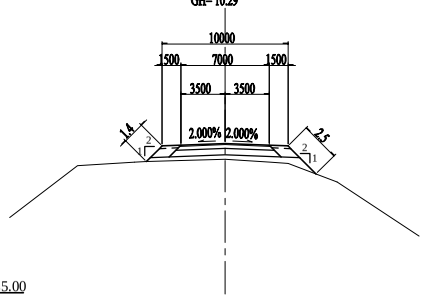
DL5.00

STA.1+650.0
PH= 10.920
GH= 10.22



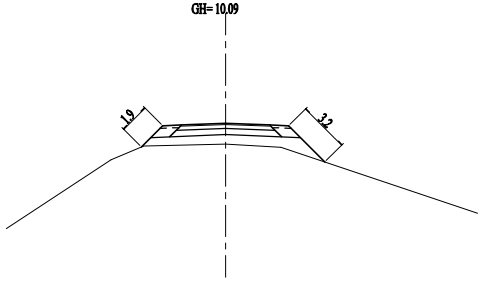
DL4.00

STA.1+300.0
PH= 10.920
GH= 10.29



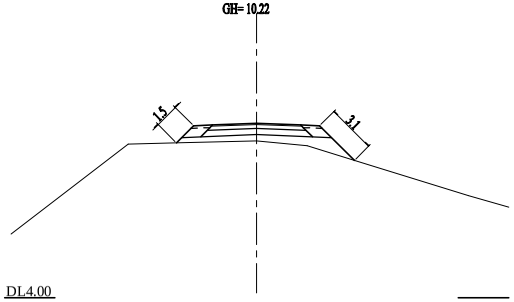
DL5.00

STA.1+450.0
PH= 10.920
GH= 10.09



DL4.00

STA.1+600.0
PH= 10.920
GH= 10.22



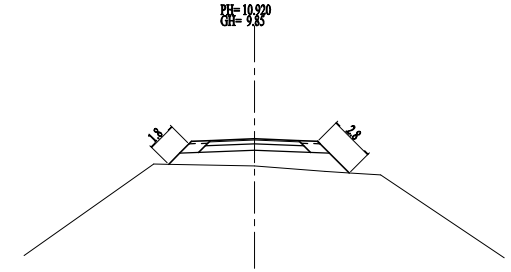
DL4.00

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-006
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD CROSS SECTIONS (2/9)

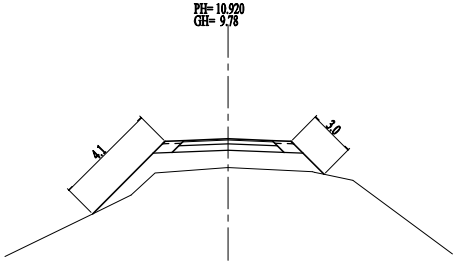
CROSS SECTIONS (3)

SCALE V=1:100 H=1:200

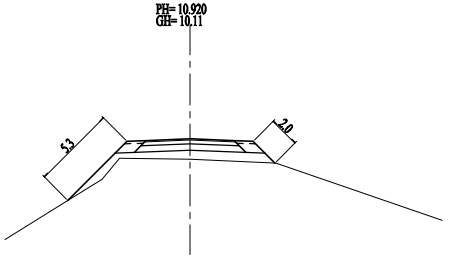
STA.1+850.0



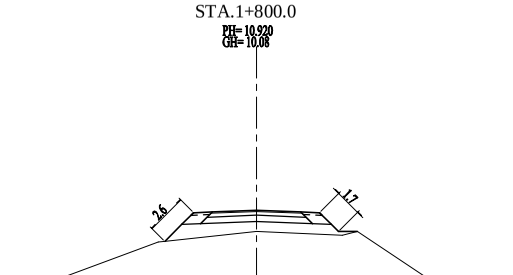
STA.2+000.0



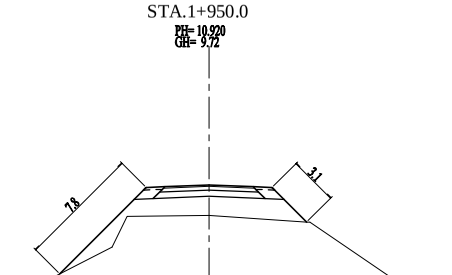
STA.2+150.0



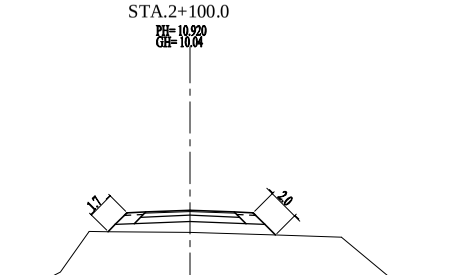
STA.1+800.0



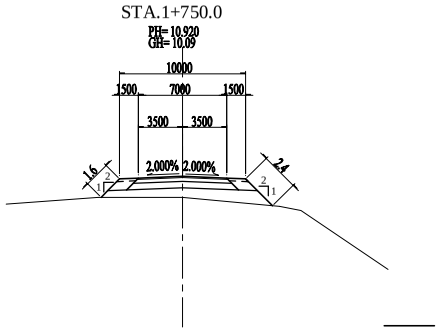
STA.1+950.0



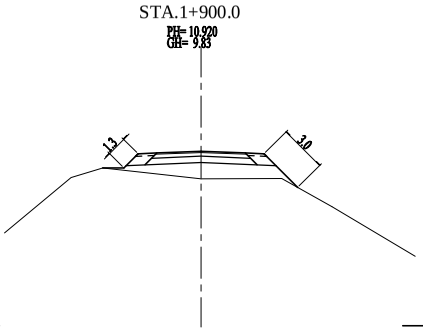
STA.2+100.0



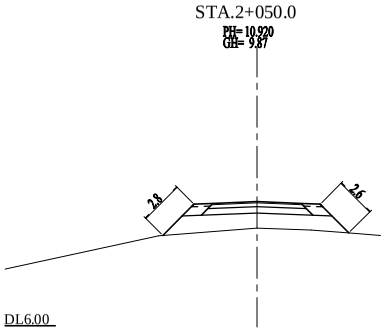
STA.1+750.0



STA.1+900.0



STA.2+050.0

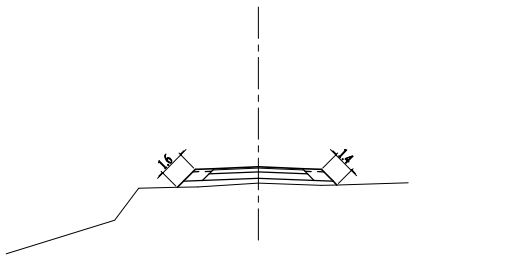


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-007
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD CROSS SECTIONS (3/9)

CROSS SECTIONS (4)

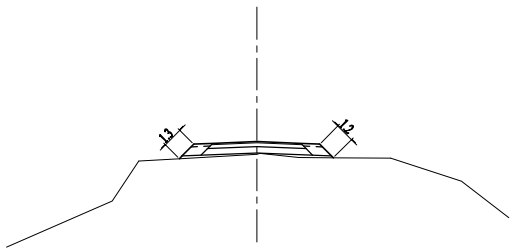
SCALE V=1:100 H=1:200

STA.2+300.0
PH= 10.920
GH= 10.28



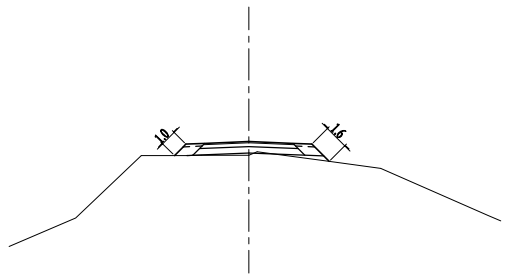
DL5.00

STA.2+450.0
PH= 10.920
GH= 10.42



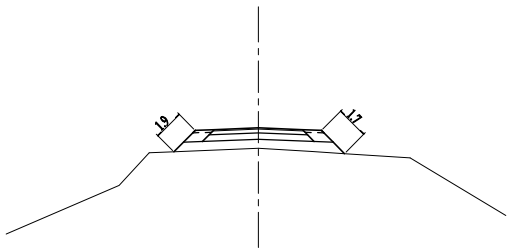
DL4.00

STA.2+600.0
PH= 10.920
GH= 10.38



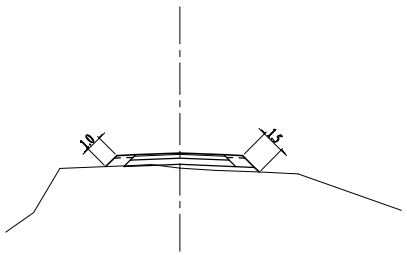
DL4.00

STA.2+250.0
PH= 10.920
GH= 10.11



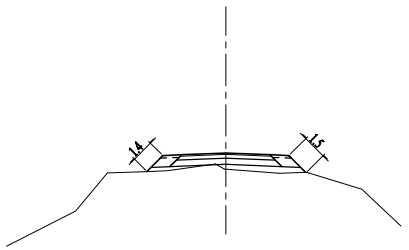
DL4.00

STA.2+400.0
PH= 10.920
GH= 10.32



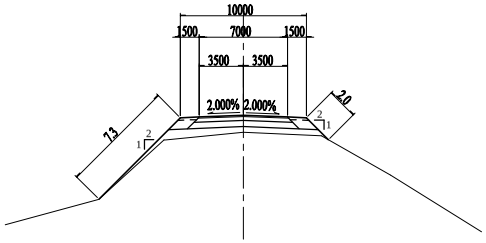
DL5.00

STA.2+550.0
PH= 10.920
GH= 10.29



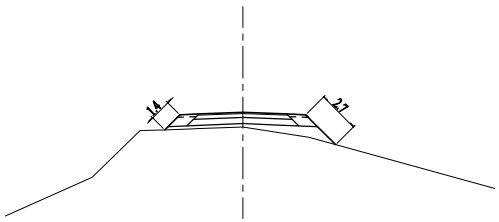
DL5.00

STA.2+200.0
PH= 10.920
GH= 10.25



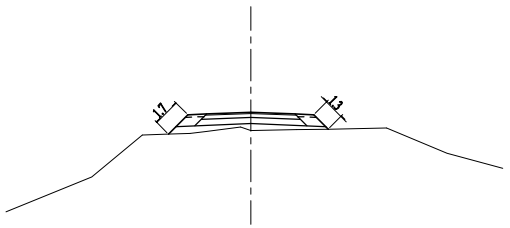
DL4.00

STA.2+350.0
PH= 10.920
GH= 10.33



DL4.00

STA.2+500.0
PH= 10.920
GH= 10.20



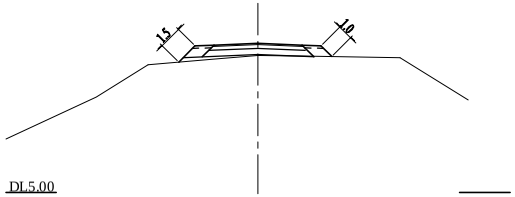
DL4.00

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. FP-TD-008 TOMPUN DIKE ROAD CROSS SECTIONS (4/9)

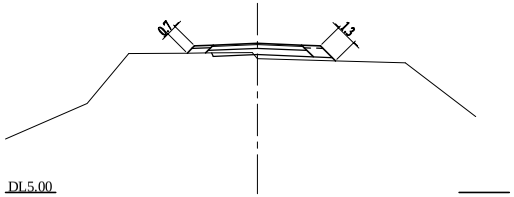
CROSS SECTIONS (5)

SCALE V=1:100 H=1:200

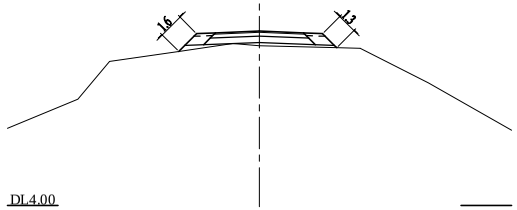
STA.2+750.0
PH= 10.920
GH= 10.44



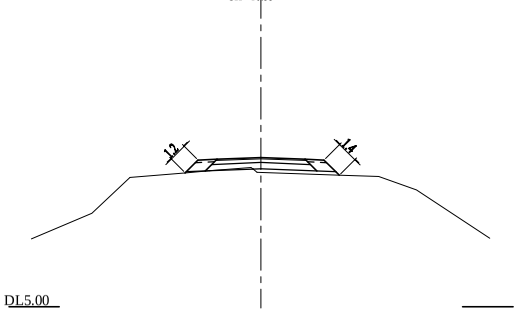
STA.2+900.0
PH= 10.920
GH= 10.32



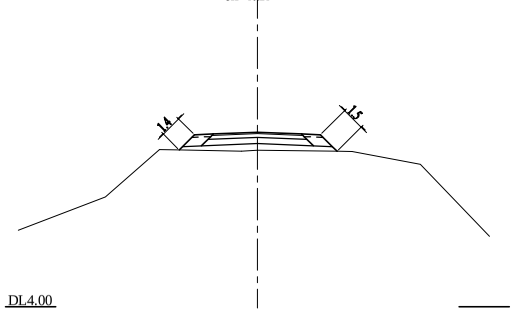
STA.3+050.0
PH= 10.920
GH= 10.35



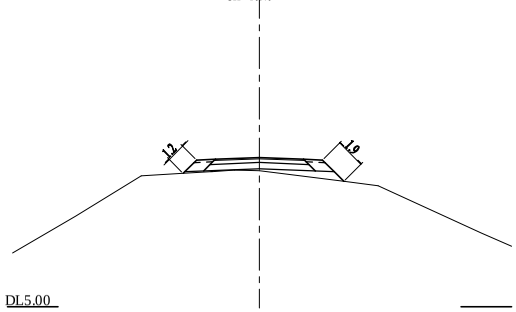
STA.2+700.0
PH= 10.920
GH= 10.33



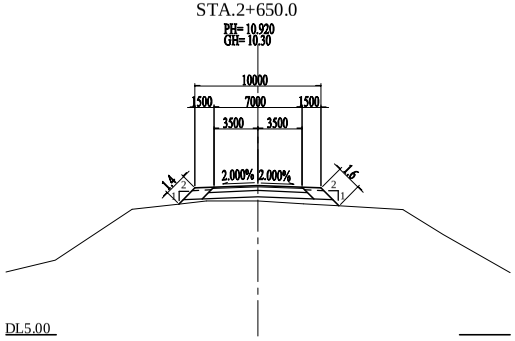
STA.2+850.0
PH= 10.920
GH= 10.21



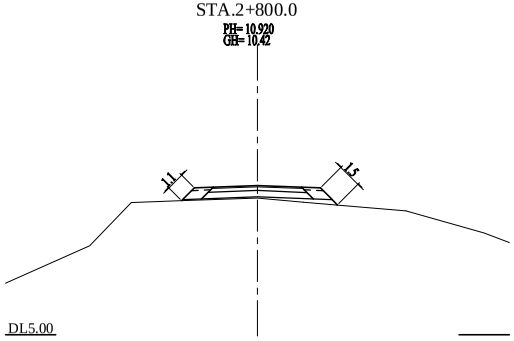
STA.3+000.0
PH= 10.920
GH= 10.40



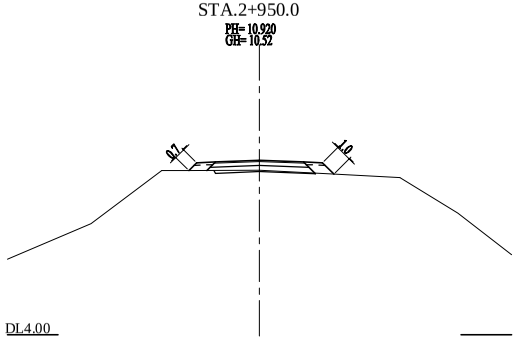
STA.2+650.0
PH= 10.920
GH= 10.30



STA.2+800.0
PH= 10.920
GH= 10.42



STA.2+950.0
PH= 10.920
GH= 10.52

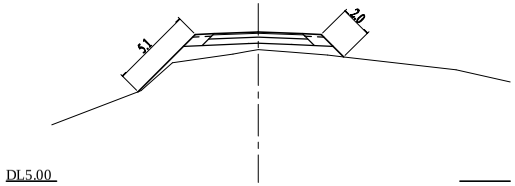


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-009
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD CROSS SECTIONS (5/9)

CROSS SECTIONS (6)

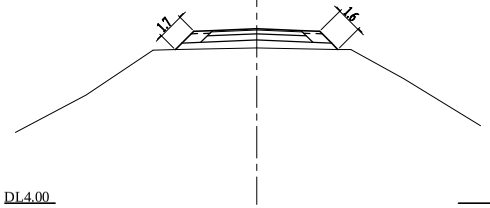
SCALE V=1:100 H=1:200

STA.3+200.0
PH= 10.920
GH= 10.22



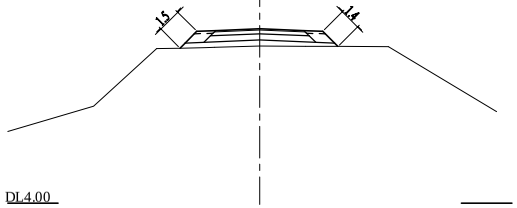
DL5.00

STA.3+350.0
PH= 10.920
GH= 10.16



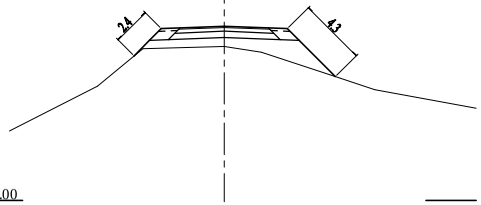
DL4.00

STA.3+500.0
PH= 10.920
GH= 10.23



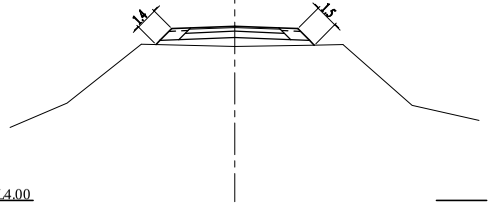
DL4.00

STA.3+150.0
PH= 10.920
GH= 10.11



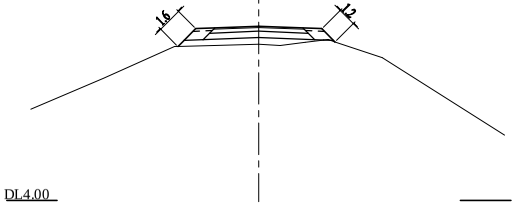
DL4.00

STA.3+300.0
PH= 10.920
GH= 10.11



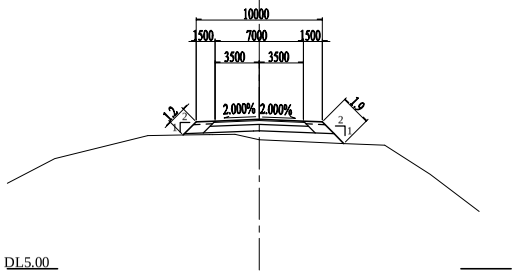
DL4.00

STA.3+450.0
PH= 10.920
GH= 10.15



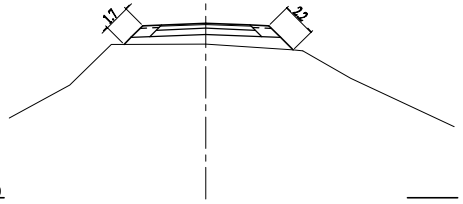
DL4.00

STA.3+100.0
PH= 10.920
GH= 10.11



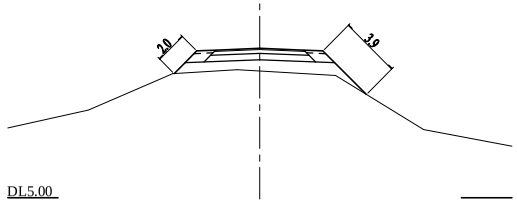
DL5.00

STA.3+250.0
PH= 10.920
GH= 10.10



DL4.00

STA.3+400.0
PH= 10.920
GH= 10.03



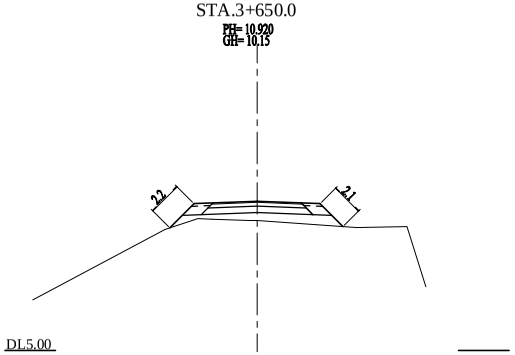
DL5.00

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-010
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD CROSS SECTIONS (6/9)

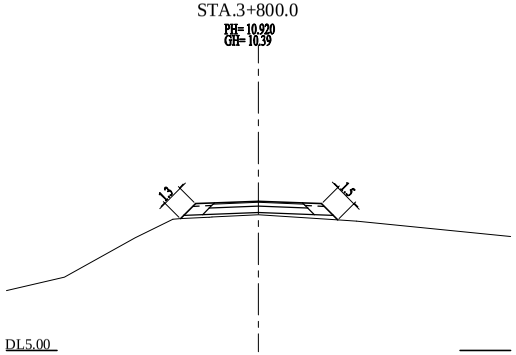
CROSS SECTIONS (7)

SCALE V=1:100 H=1:200

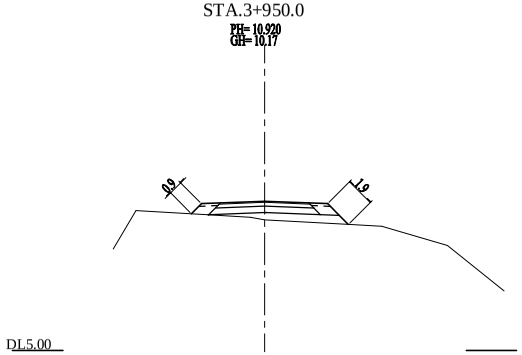
STA.3+650.0



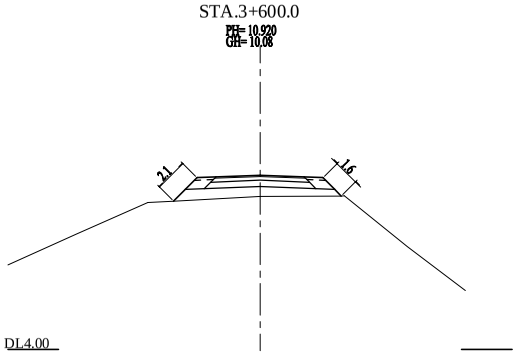
STA.3+800.0



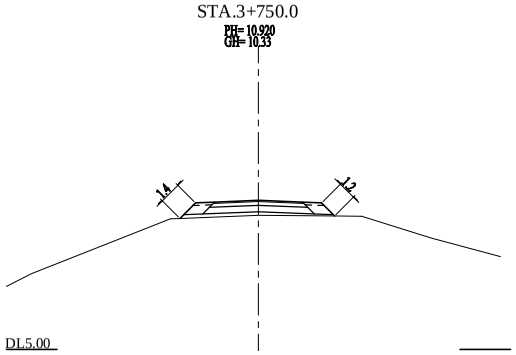
STA.3+950.0



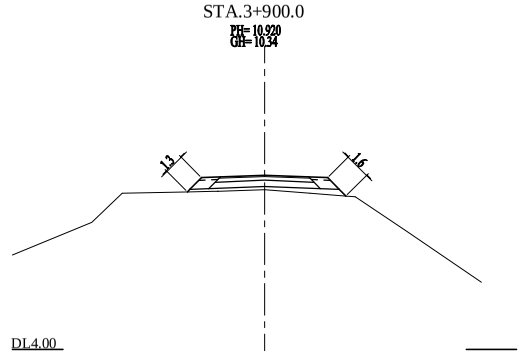
STA.3+600.0



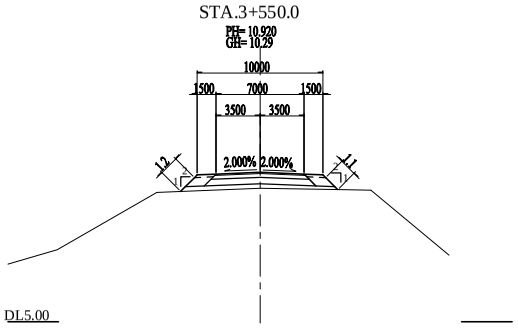
STA.3+750.0



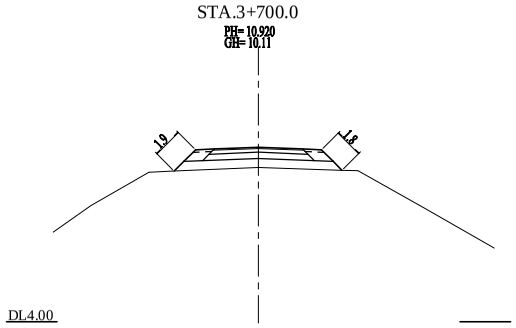
STA.3+900.0



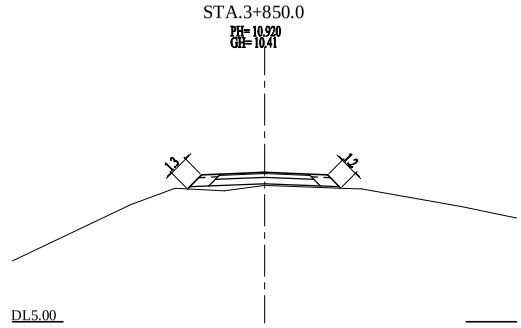
STA.3+550.0



STA.3+700.0



STA.3+850.0

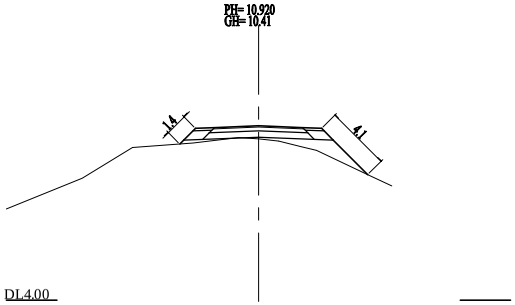


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-011
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD CROSS SECTIONS (7/9)

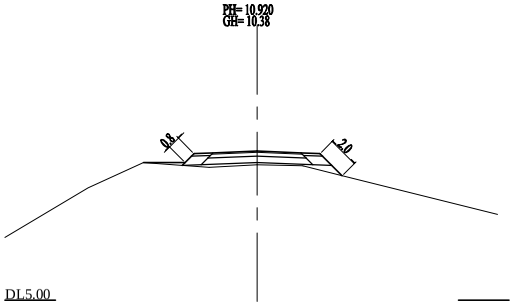
CROSS SECTIONS (8)

SCALE V=1:100 H=1:200

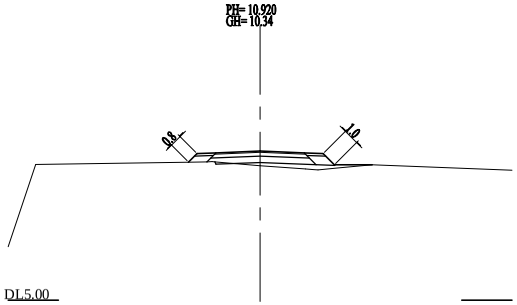
STA.4+100.0



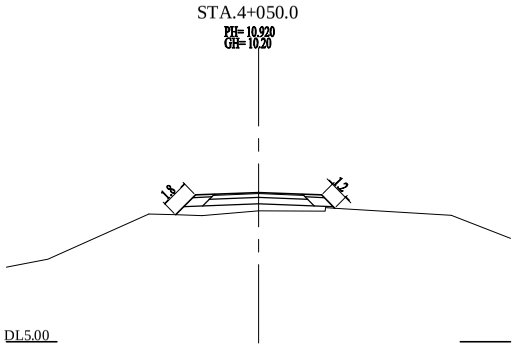
STA.4+250.0



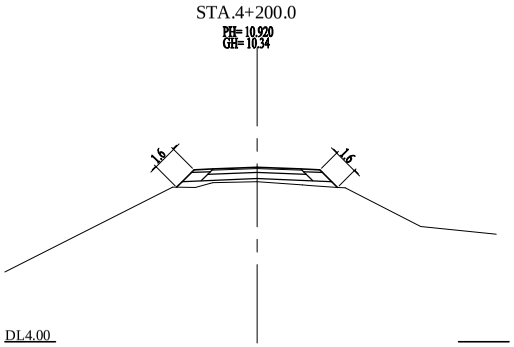
STA.4+400.0



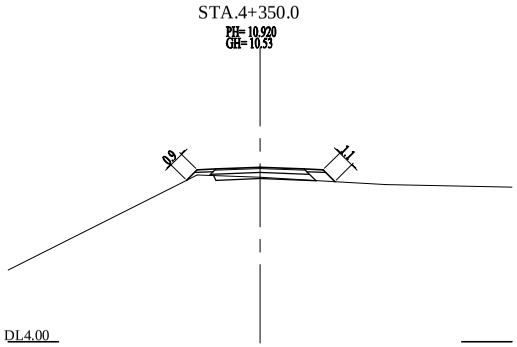
STA.4+050.0



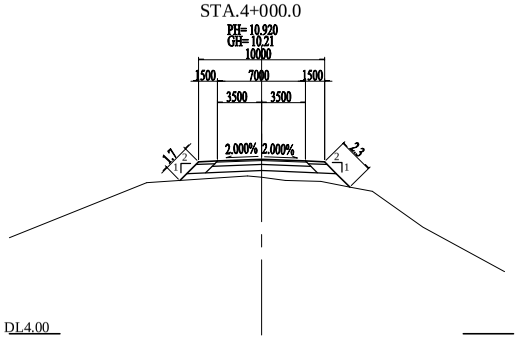
STA.4+200.0



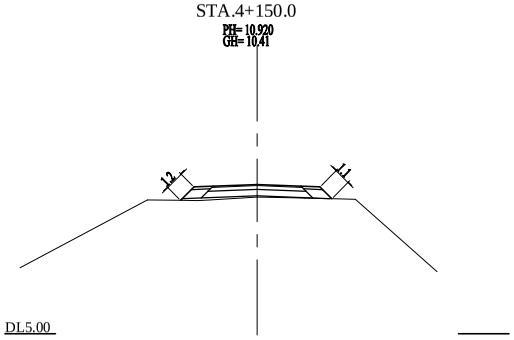
STA.4+350.0



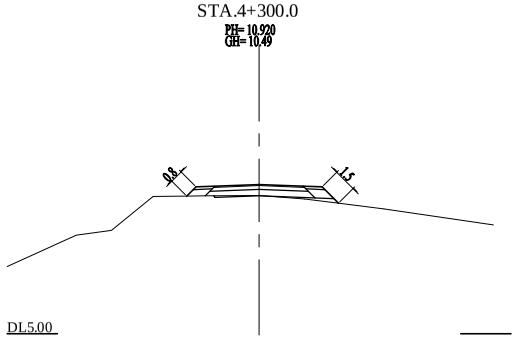
STA.4+000.0



STA.4+150.0



STA.4+300.0

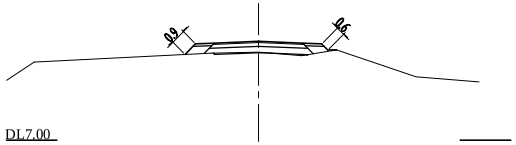


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-012
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD CROSS SECTIONS (8/9)

CROSS SECTIONS (9)

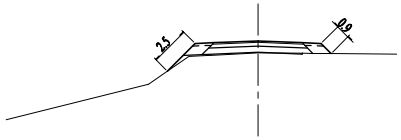
SCALE V=1:100 H=1:200

STA.4+550.0
PH= 10.920
GH= 10.49



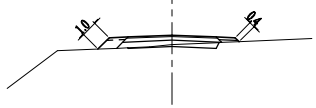
DL7.00

STA.4+700.0
PH= 10.920
GH= 10.45



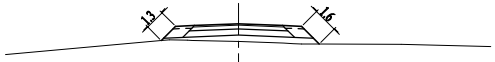
DL5.00

STA.4+850.0
PH= 10.920
GH= 10.54



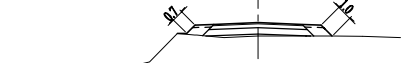
DL6.00

STA.4+500.0
PH= 10.920
GH= 10.22



DL7.00

STA.4+650.0
PH= 10.920
GH= 10.39

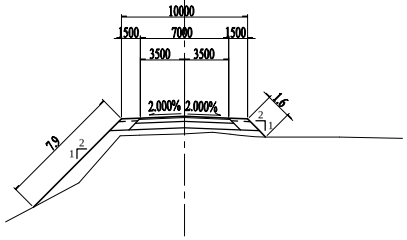


DL6.00

STA.4+800.0
PH= 10.920
GH= 10.40

DL4.00

STA.4+450.0
PH= 10.920
GH= 10.23

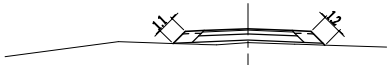


DL5.00

STA.4+600.0
PH= 10.920
GH= 10.32

DL6.00

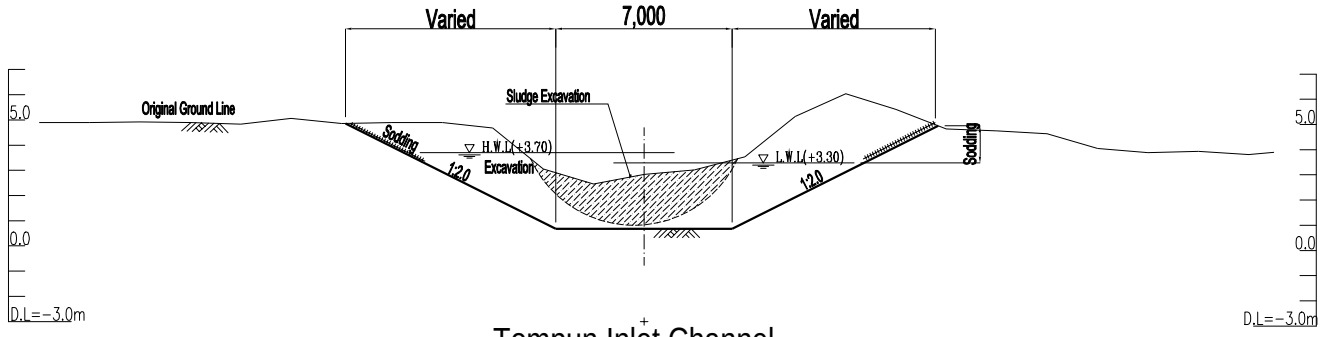
STA.4+750.0
PH= 10.920
GH= 10.37



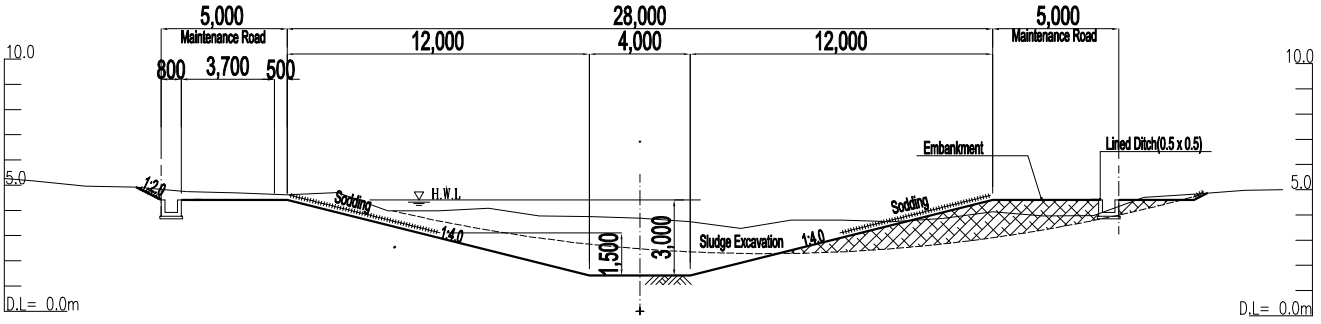
DL7.00

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. FP-TD-013
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TOMPUN DIKE ROAD CROSS SECTIONS (9/9)

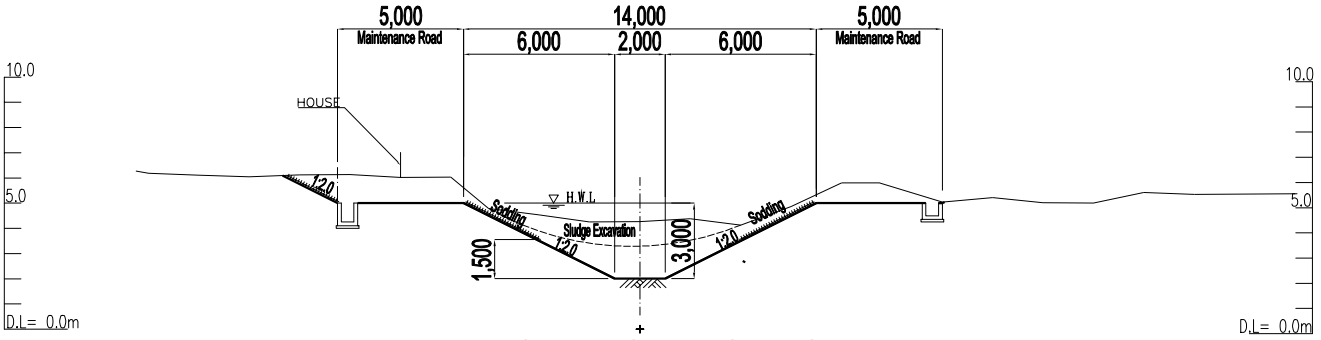
TYPICAL CROSS SECTION



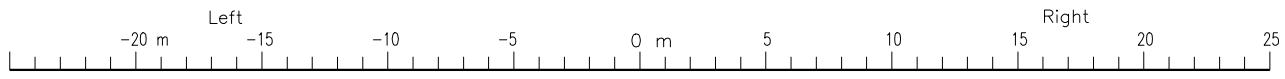
Tompun Inlet Channel
(0+800)



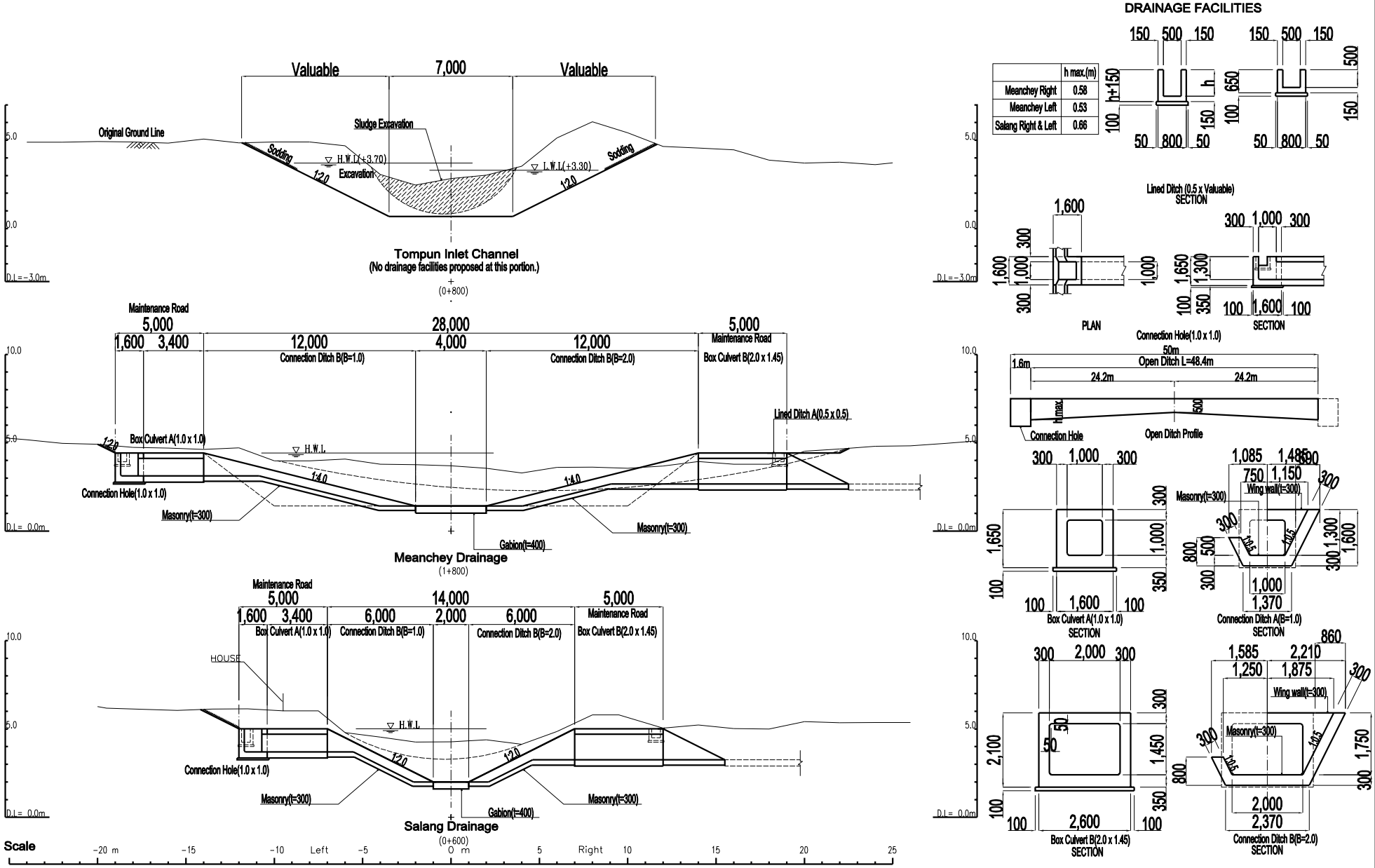
Meanchey Drainage Channel
(1+800)



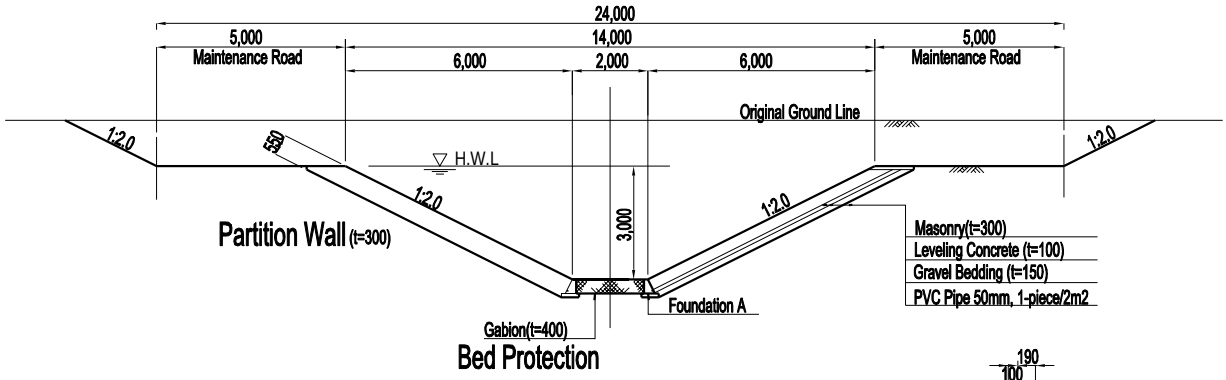
Salang Drainage Channel
(0+600)



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-GR-001
CTIE International Co.,Ltd. - Nippon Koei Co.,Ltd.	TYPICAL CROSS SECTIONS OF DRAINAGE CHANNELS

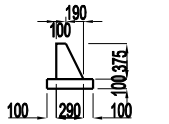


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-GR-002
CTIE International Co.,Ltd. - Nippon Koei Co.,Ltd.	DRAINAGE FACILITIES VERTICAL DRAINAGE DITCH



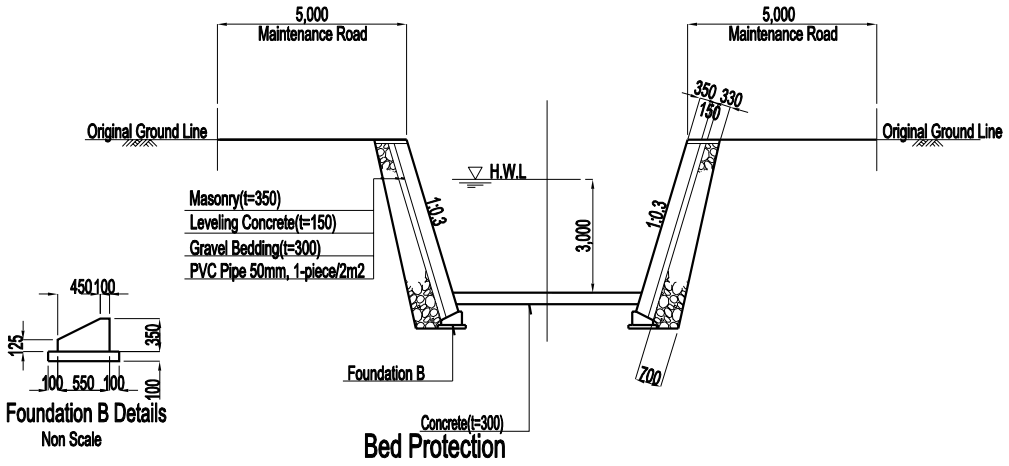
Revetment Type-I

Scale A



Foundation A Details

Non Scale



Revetment Type-II

Scale A

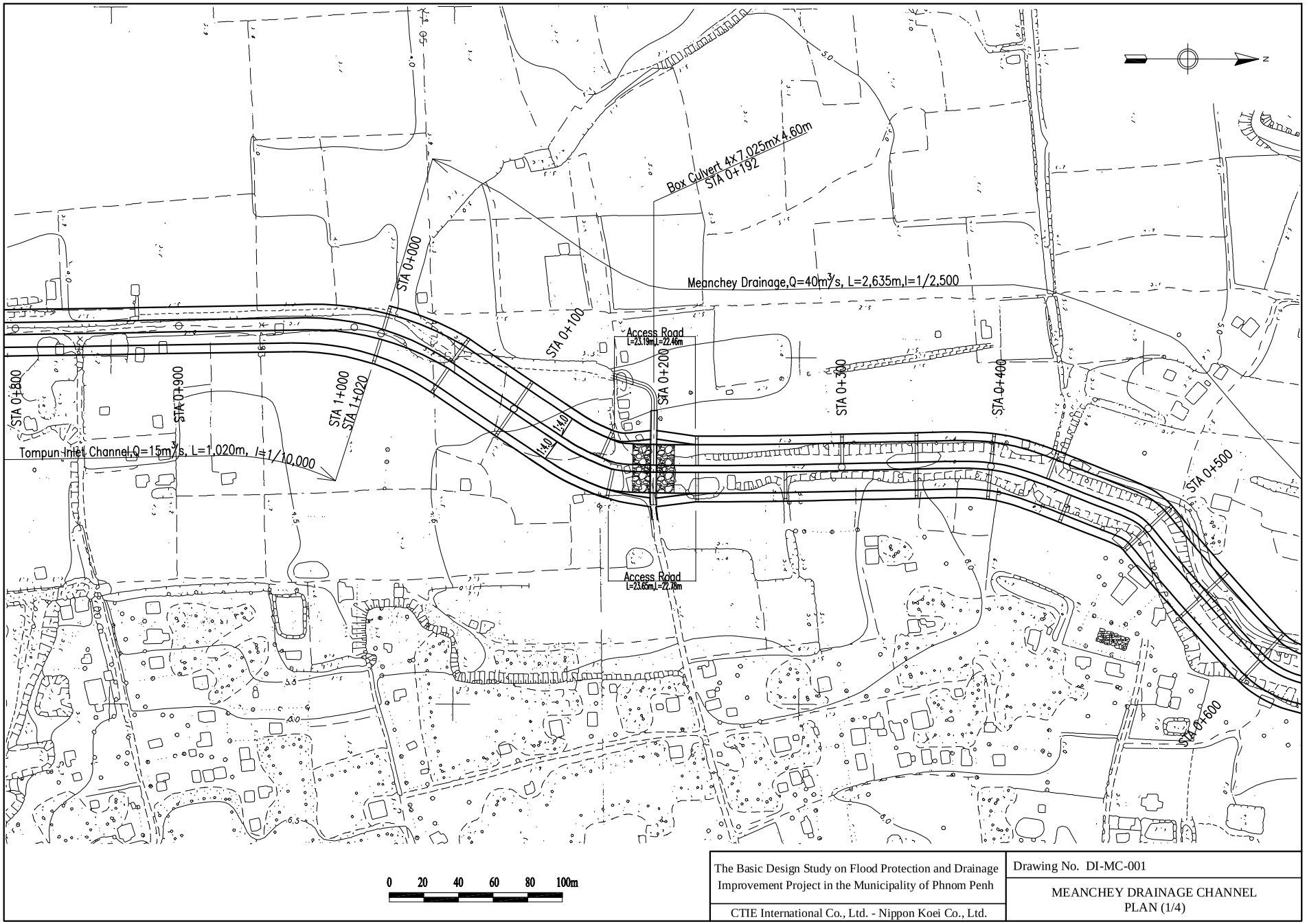
Quantity & Location

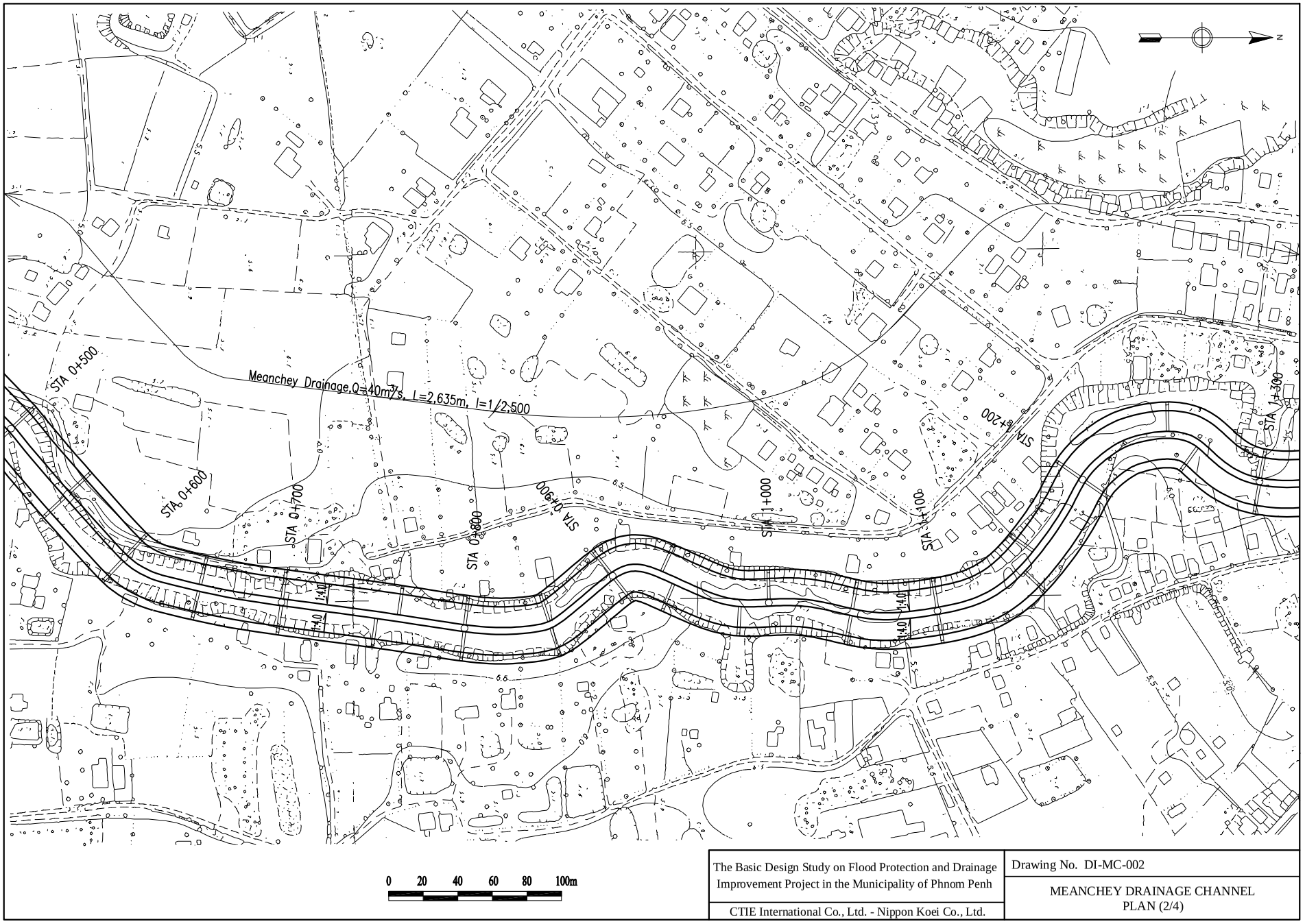
	Meanchey Channel	Salang Channel
Type I (m)	80	15
Type II (m)		5
Concrete (m)		10
Gabion (m)	80	10
	- Existing Meanchey Bridge - Confluence of Channels - around Meanchey 2+635	- Transition at upstream end - around Salang 0+640

Above quantity exclude Bridge and Sluiceway portion.

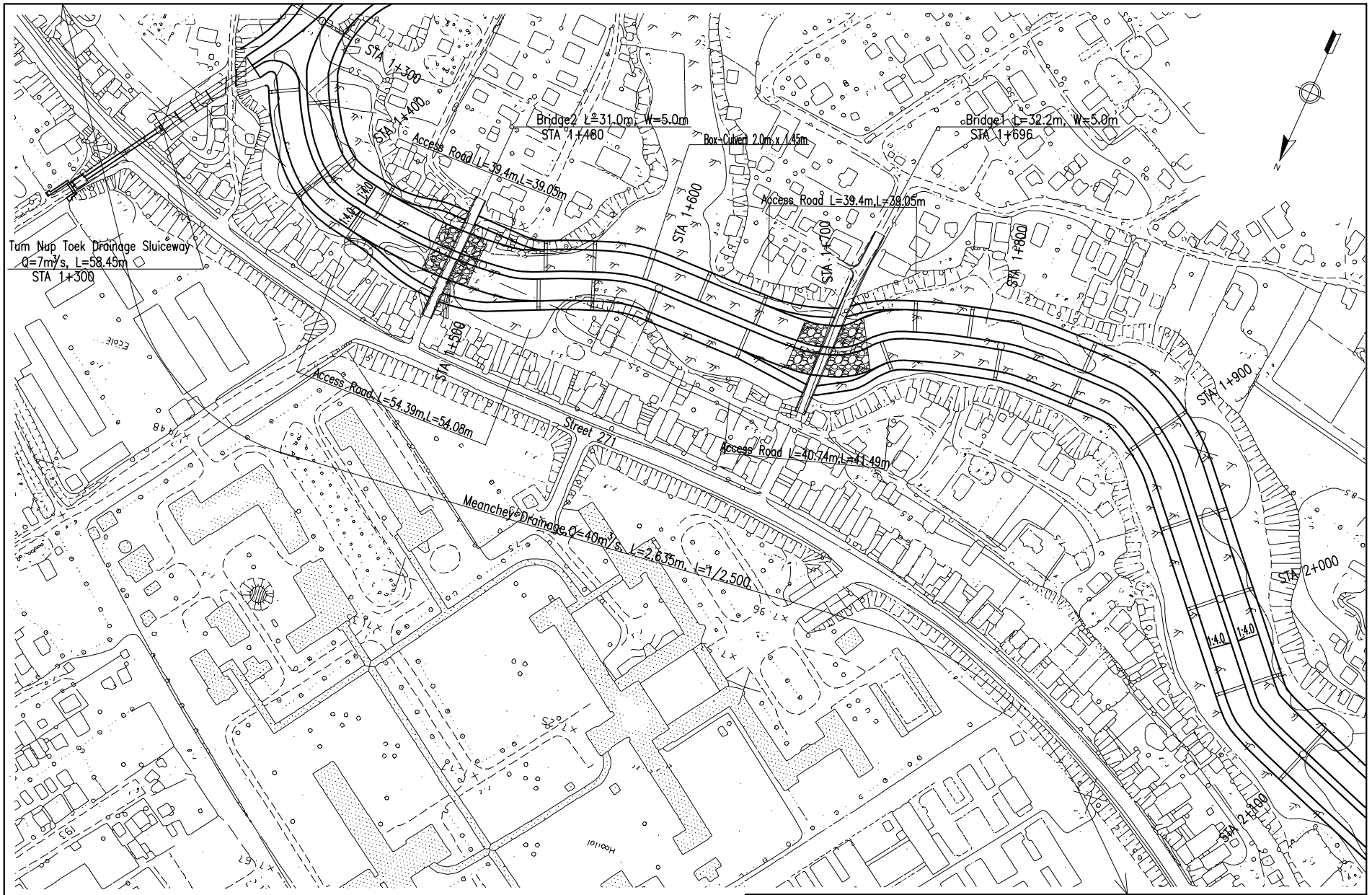
Scale A 0 5 10m

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-GR-003
CTIE International Co.,Ltd. - Nippon Koei Co.,Ltd.	CHANNEL STRUCTURE REVETMENT & BED PROTECTION

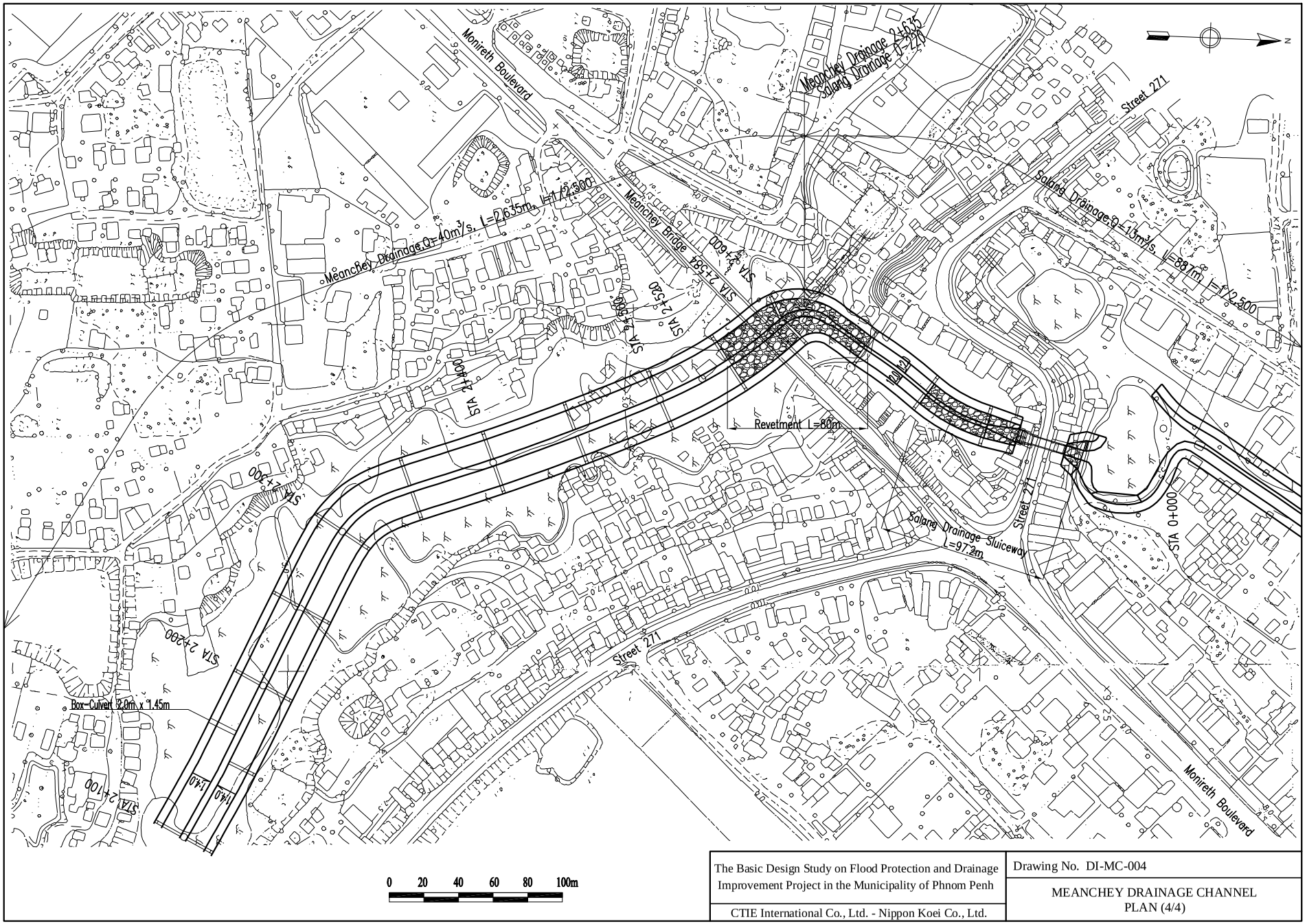

Box Culvert 4x7.025mx4.60m
STA 0+192
Meanchey Drainage,Q=40m³/s, L=2,635m,I=1/2,500
STA 0+000
STA 0+100
STA 0+200
STA 0+300
STA 0+400
STA 0+500
STA 0+600
STA 0+800
STA 0+900
STA 1+000
STA 1+020
Access Road
L=23.19m,L=22.46m
Access Road
L=23.65m,L=22.78m
1:4.0
1:4.0
Tompun Inlet Channel Q=15m³/s, L=1,020m, I=1/10,000
N
0 20 40 60 80 100m
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.
Drawing No. DI-MC-001
MEANCHEY DRAINAGE CHANNEL
PLAN (1/4)



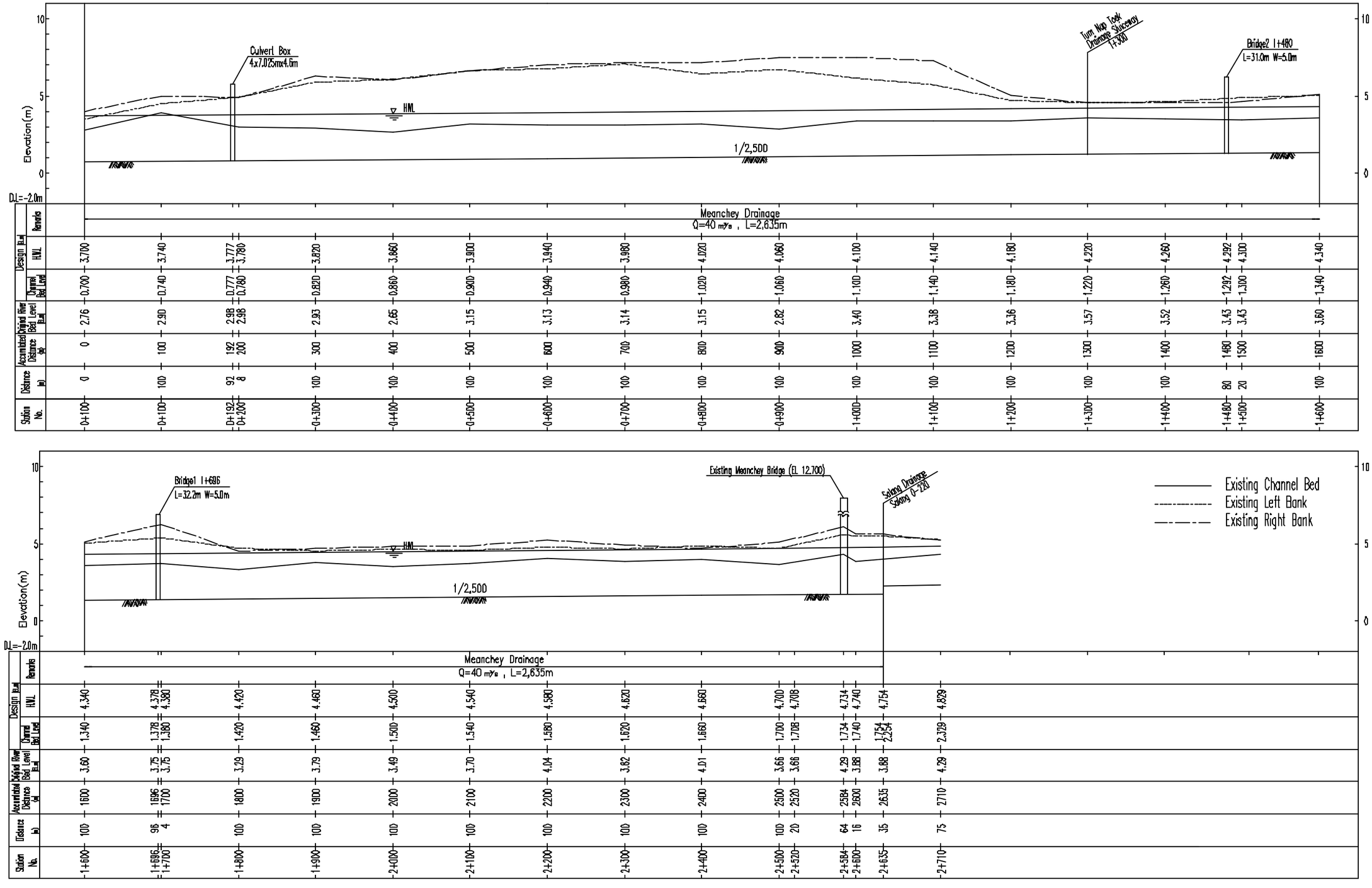
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-MC-002
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	MEANCHEY DRAINAGE CHANNEL PLAN (2/4)



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-MC-003
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	MEANCHEY DRAINAGE CHANNEL PLAN (3/4)



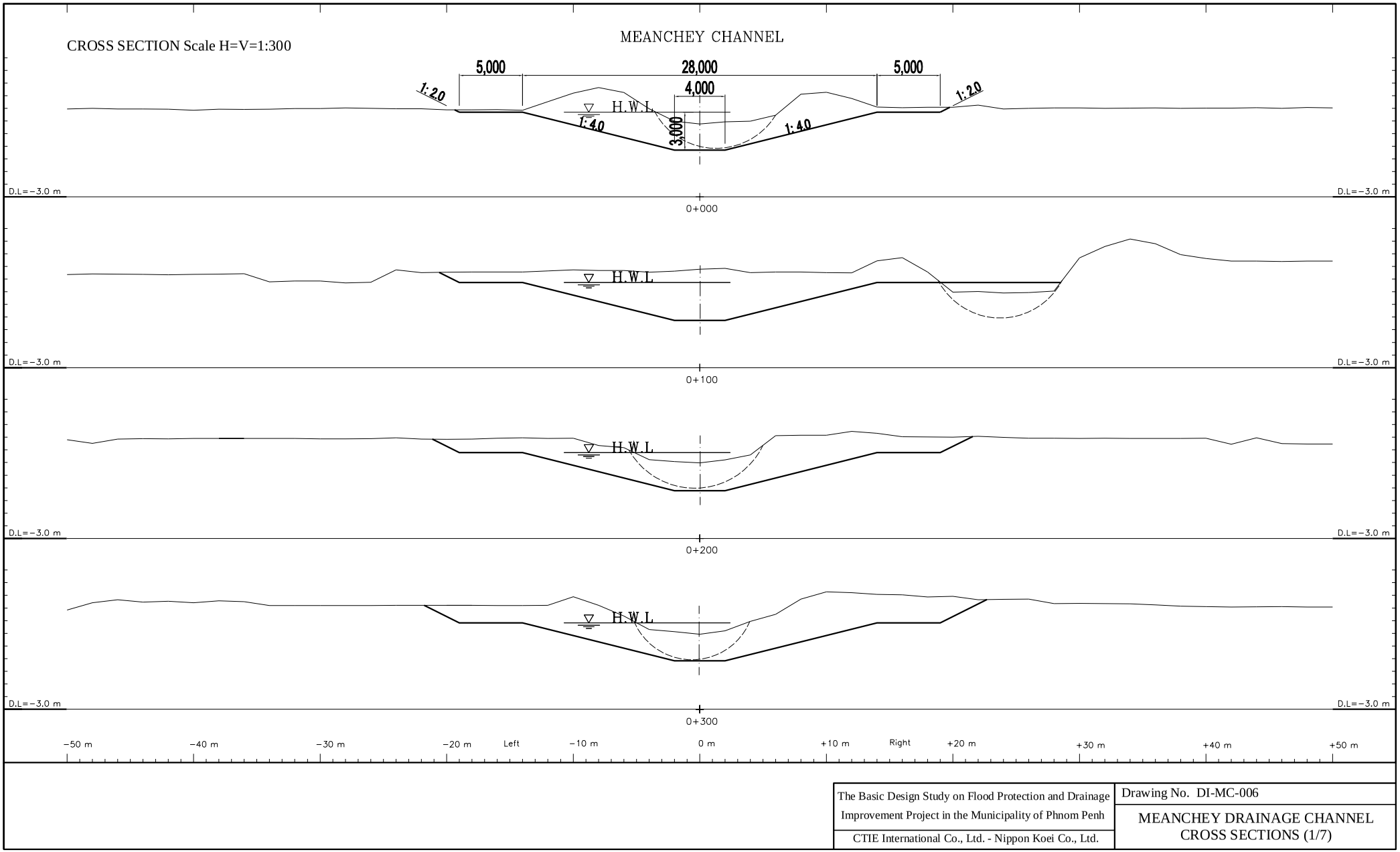
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-MC-004
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	MEANCHEY DRAINAGE CHANNEL PLAN (4/4)



SCALE (Vertical) 0 1 2 3 4 5m

SCALE (Horizontal) 0 20 40 60 80 100m

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-MC-005
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	MEANCHEY DRAINAGE CHANNEL PROFILE

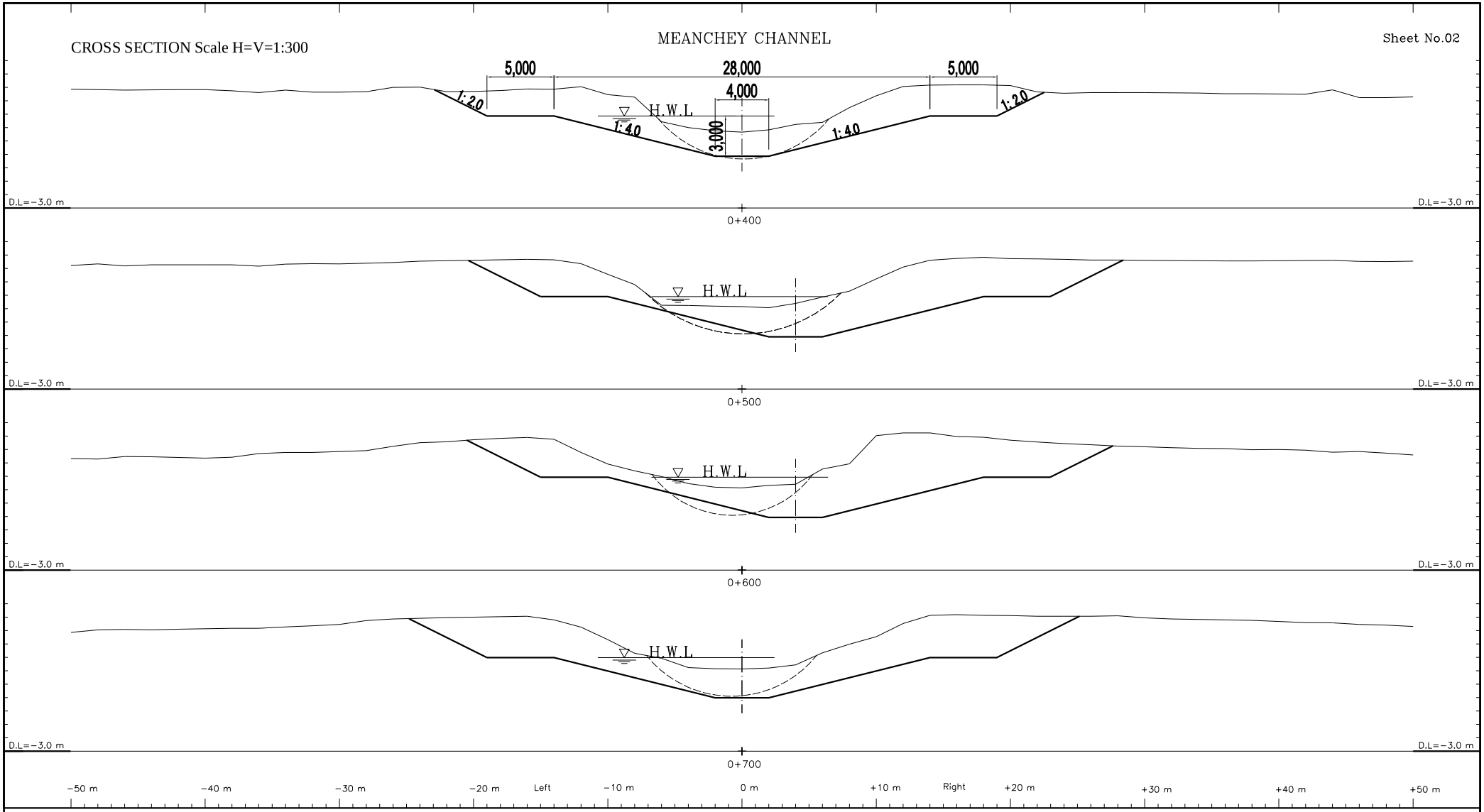


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-MC-006 MEANCHEY DRAINAGE CHANNEL CROSS SECTIONS (1/7)

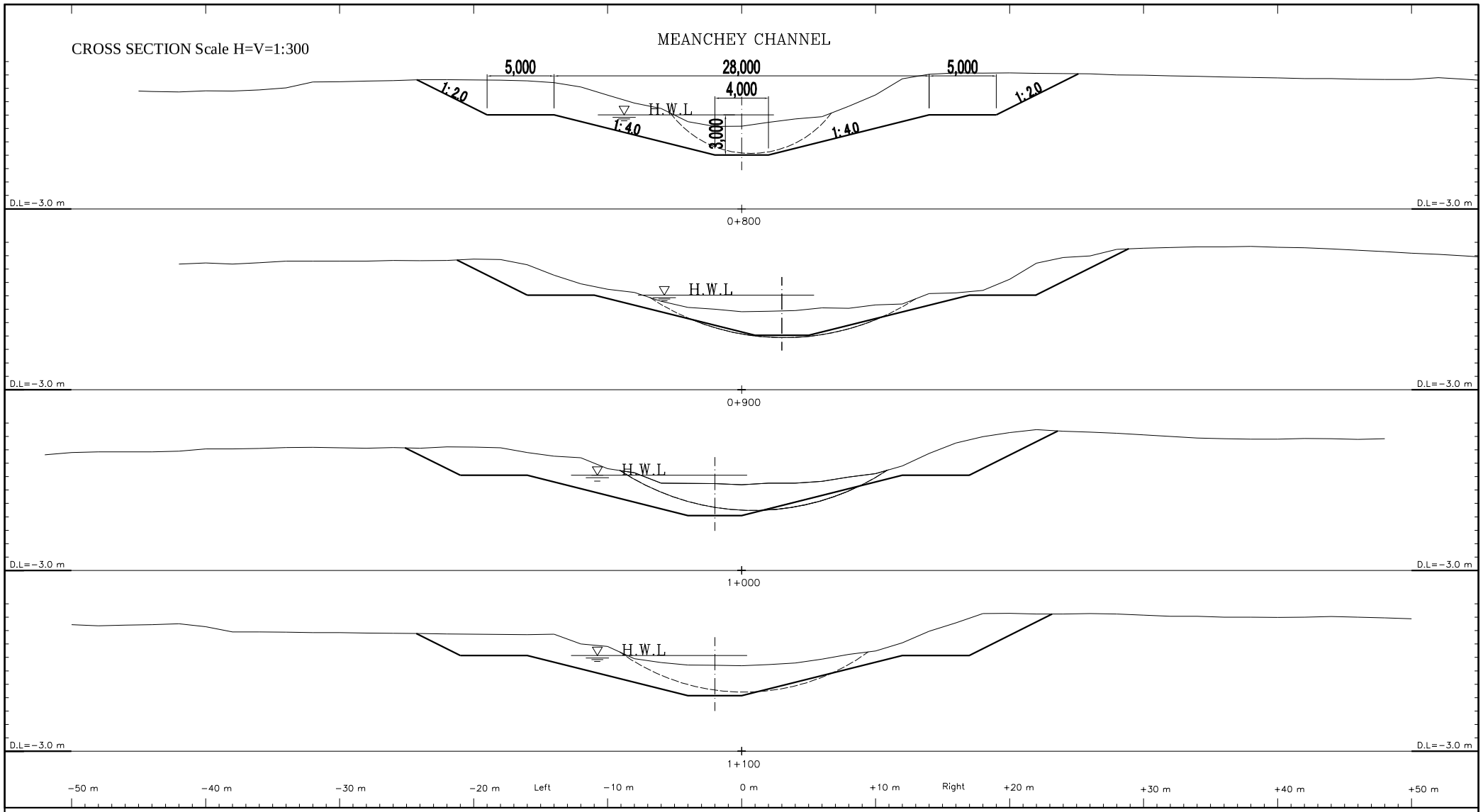
CROSS SECTION Scale H=V=1:300

MEANCHEY CHANNEL

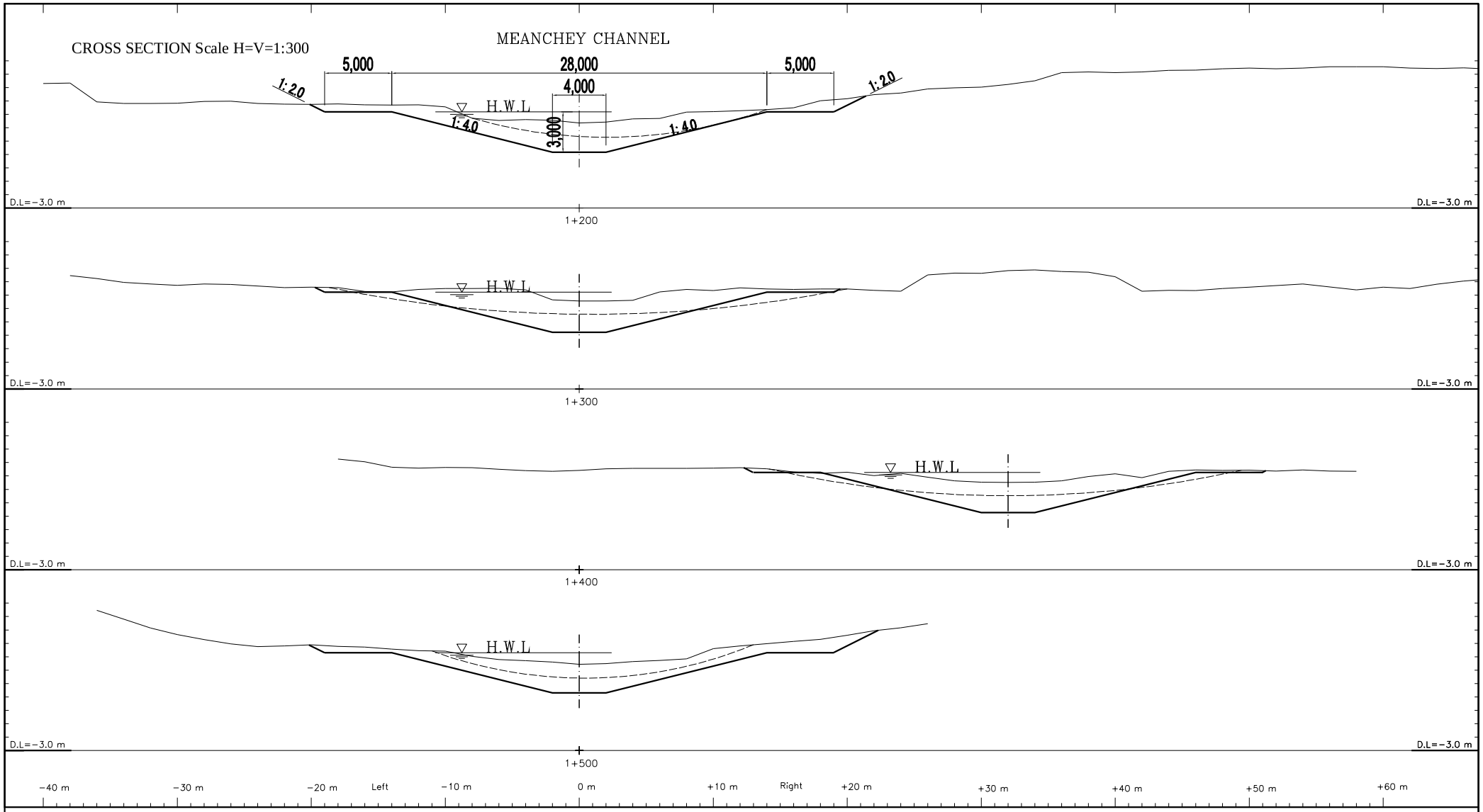
Sheet No.02



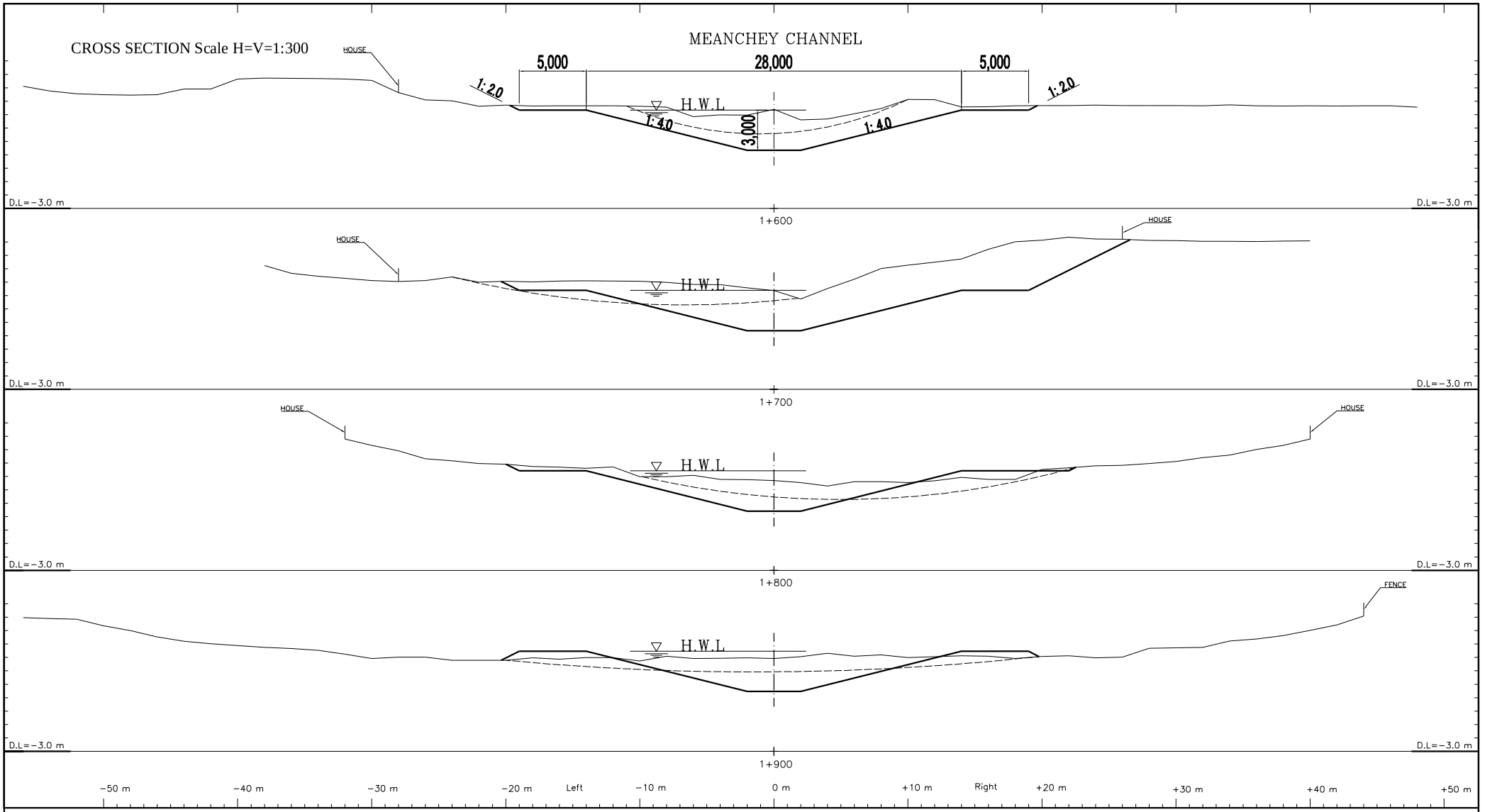
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-MC-007 MEANCHEY DRAINAGE CHANNEL CROSS SECTIONS (2/7)



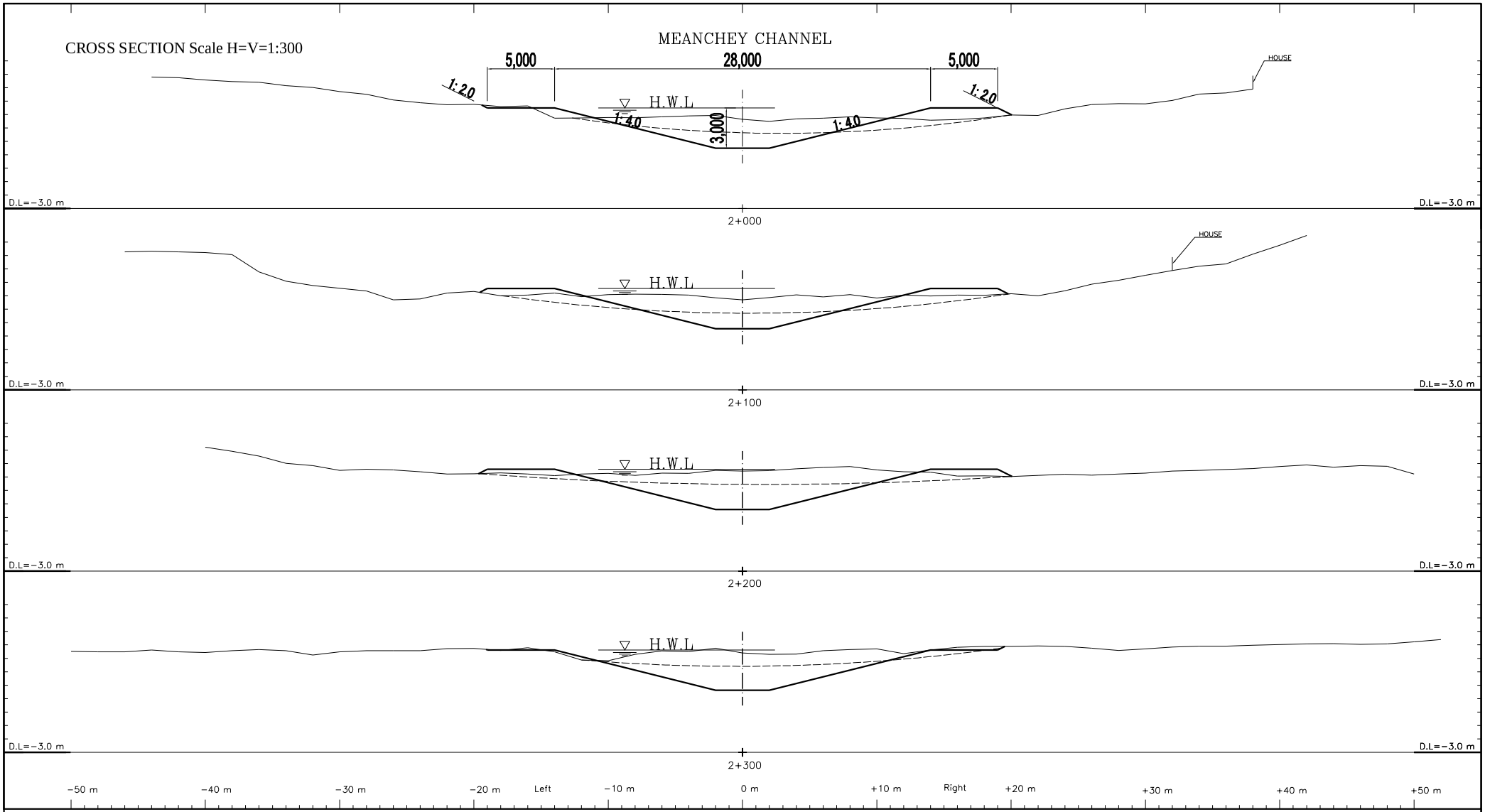
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-MC-008 MEANCHEY DRAINAGE CHANNEL CROSS SECTIONS (3/7)



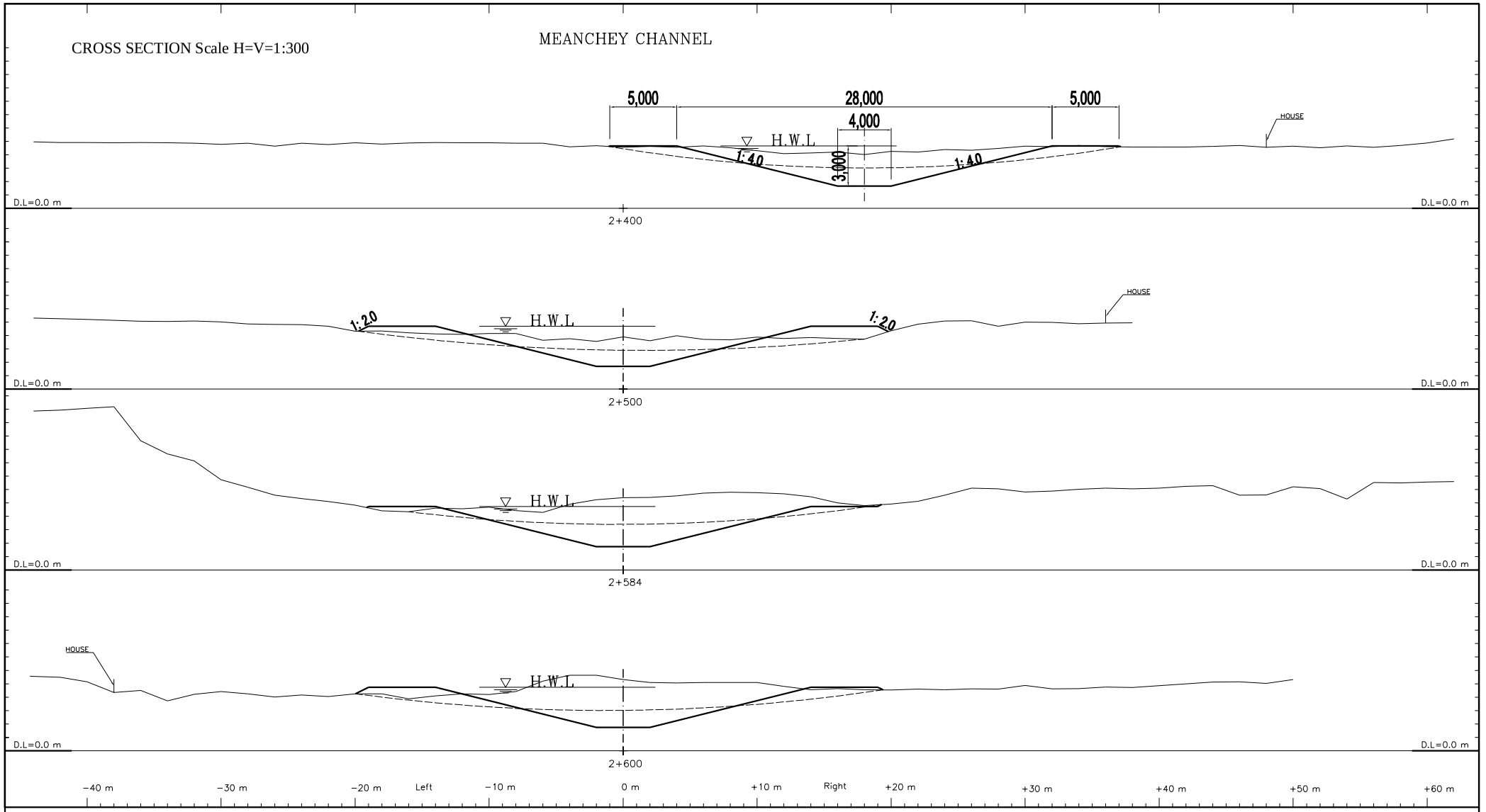
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-MC-009 MEANCHEY DRAINAGE CHANNEL CROSS SECTIONS (4/7)



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-MC-010
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	MEANCHEY DRAINAGE CHANNEL CROSS SECTIONS (5/7)



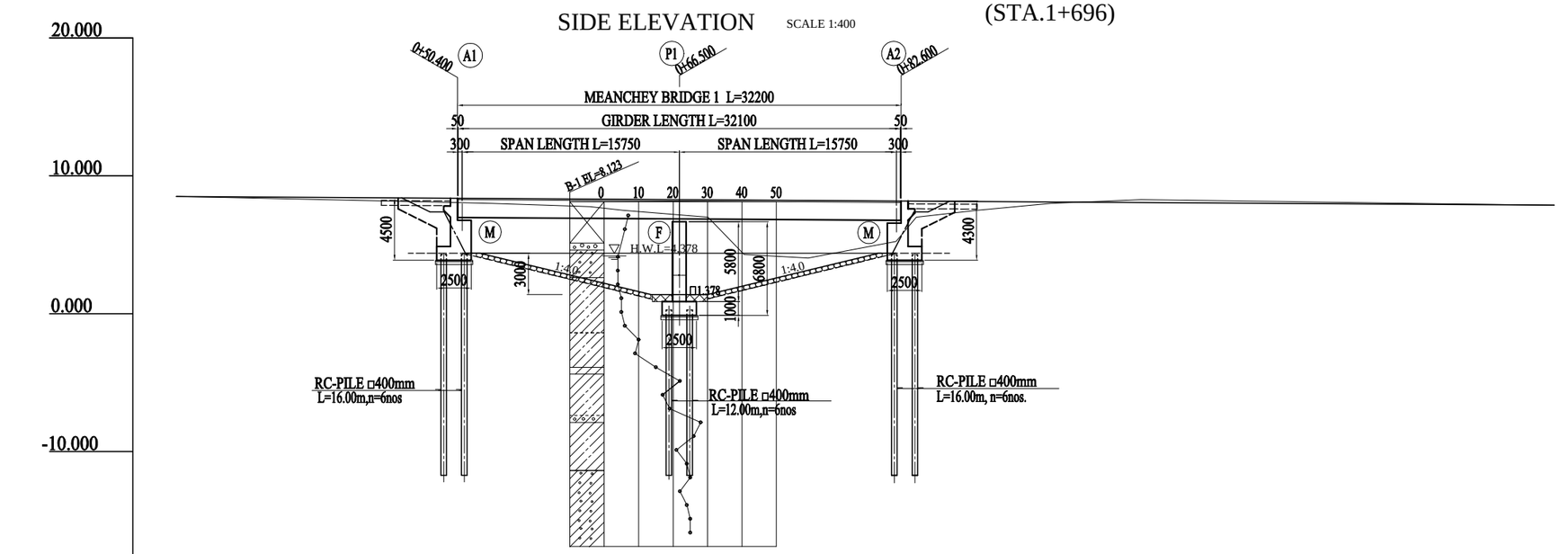
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-MC-011 MEANCHEY DRAINAGE CHANNEL CROSS SECTIONS (6/7)



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-MC-012 MEANCHEY DRAINAGE CHANNEL CROSS SECTIONS (7/7)

GENERAL VIEW OF MEANCHEY BRIDGE-1
(STA.1+696)

SIDE ELEVATION SCALE 1:400



GRADE	8.500 → I=0.630% L=100.000m → 7.870
PROPOSED HEIGHT	8.500 8.437 8.374 8.311 8.248 8.185 8.122 8.108 8.059 7.996 7.933 7.870
GROUND HEIGHT	8.51 8.30 8.08 7.77 5.53 4.83 7.68 8.21 8.27 8.14 8.00 7.87
STATION	0+030 +40 +50 +60 +70 +80 +90 +92.292 +100 +110 +120 +130
CURVE ELEMENT	R=500 L=45.864
SUPER ELEVATION	R= ∞ L=92.292 2.0% 2.0%

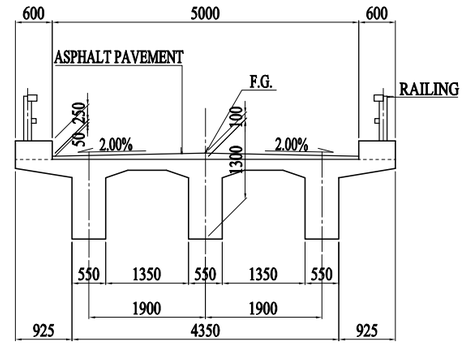
DESIGN CRITERIA

TYPE	2-SPANS CONTINUOUS T SECTION GIRDER
TOTAL BRIDGE LENGTH	L=32.200m
GIRDER LENGTH	L=32.100m
SPAN	2 x 15.750
WIDTH	CARRIAGE WAY WIDTH=5.00m
LIVE LOAD	A-LIVE LOAD
IMPACT COEFFICIENT	i=7/(20+L)
SEISMIC COEFFICIENT	Kh=0.05
ANGLE OF SKEW	75-00-00
HORIZONTAL CURVATURE	R= ∞
LONGITUDINAL SLOPE	i=0.630%

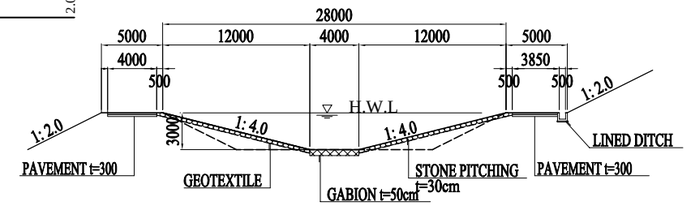
MATERIALS

CONCRETE	SUPERSTRUCTURE	σck=24N/mm²
	SUBSTRUCTURE	σck=24N/mm²
STEEL	REINFORCEMENT	SD295A
	PILE	RC PILE

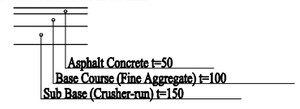
SUPERSTRUCTURE SCALE 1:100



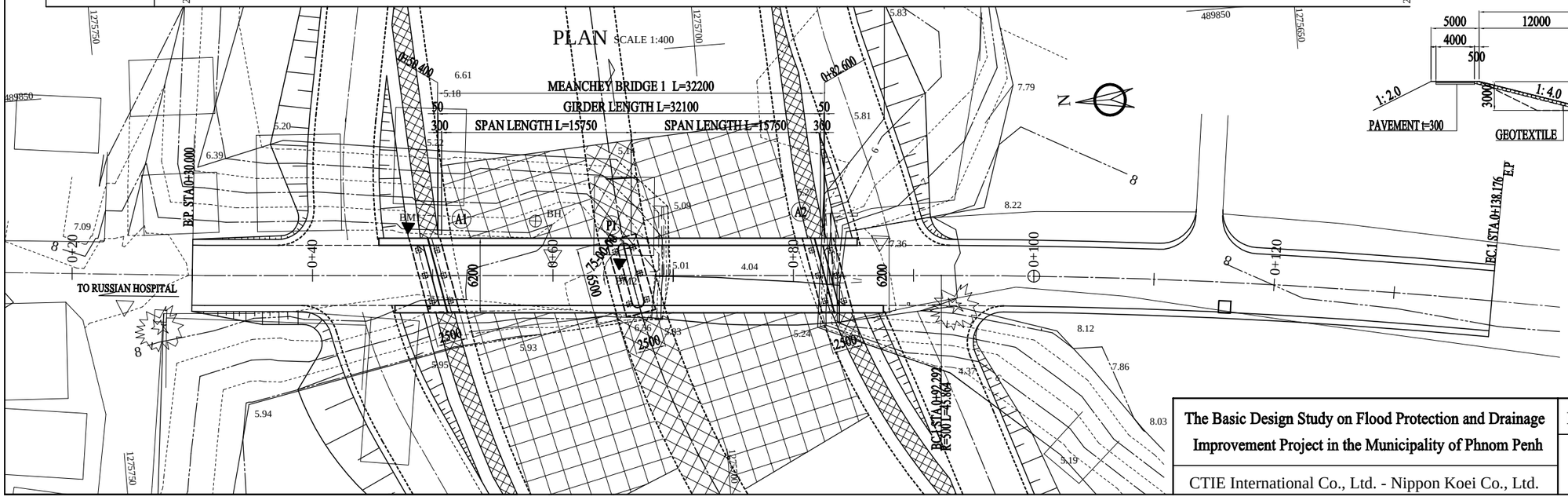
MEANCHEY CHANNEL SCALE 1:500



PAVEMENT DETAIL



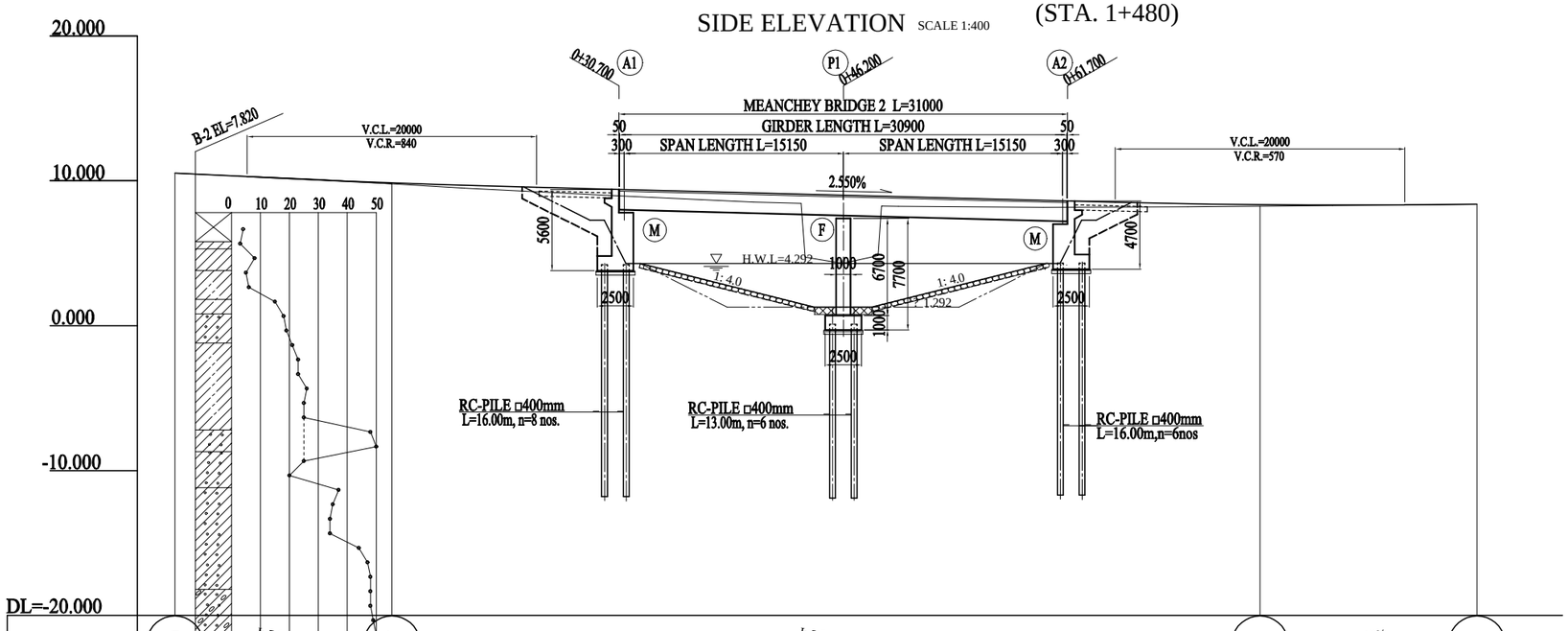
PLAN SCALE 1:400



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-MC-013
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	MEANCHEY DRAINAGE CHANNEL BRIDGE-NO.1 (STA.1+696)

GENERAL VIEW OF MEANCHEY BRIDGE-2

SIDE ELEVATION SCALE 1:400 (STA. 1+480)



DL=-20.000

GRADE	10.550	I=5.000% L=15.000m	9.800	I=2.550% L=60.000m			8.270	I=0.933% L=15.000m	8.410	
PROPOSED HEIGHT	10.540	10.062	9.687	9.418	9.163	8.908	8.653	8.419	8.338	8.410
GROUND HEIGHT	10.54	10.10	9.52	9.01	8.55	8.26	8.19	8.21	8.30	(8.41)
STATION	0+000	+ 10	+ 20	+ 30	+ 40	+ 50	+ 60	+ 70	+ 80	+ 90
CURVE ELEMENT	R= ∞ L=90.000									
SUPER ELEVATION	2.0%									2.0%

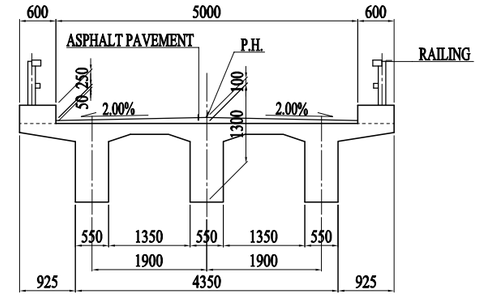
DESIGN CRITERIA

TYPE	2-SPANS CONTINUOUS T SECTION GIRDER
TOTAL BRIDGE LENGTH	L=31.000m
GIRDER LENGTH	L=30.900m
SPAN	2 x 15.150
WIDTH	CARRIAGE WAY WIDTH=5.00m
LIVE LOAD	A-LIVE LOAD
IMPACT COEFFICIENT	i=7/(20+L)
SEISMIC COEFFICIENT	Kh=0.05
ANGLE OF SKEW	90-00-00
HORIZONTAL CURVATURE	R= ∞
LONGITUDINAL SLOPE	i=2.550%

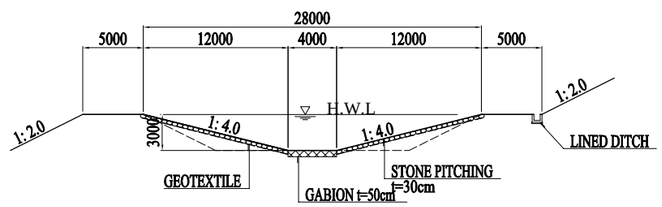
MATERIALS

CONCRETE	SUPERSTRUCTURE	σck=24N/mm²
	SUBSTRUCTURE	σck=24N/mm²
STEEL	REINFORCEMENT	SD295A
	PILE	RC-PILE

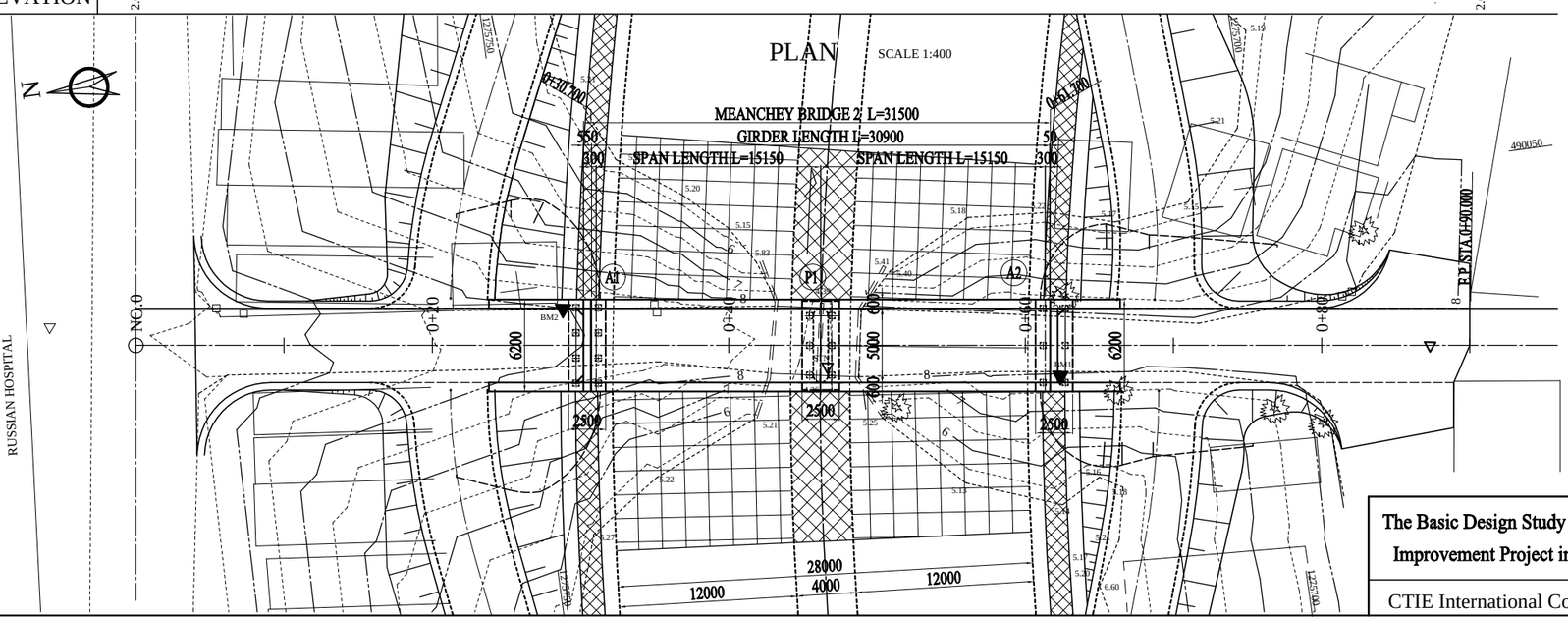
SUPERSTRUCTURE SCALE 1:100



MEANCHEY CHANNEL SCALE 1:500



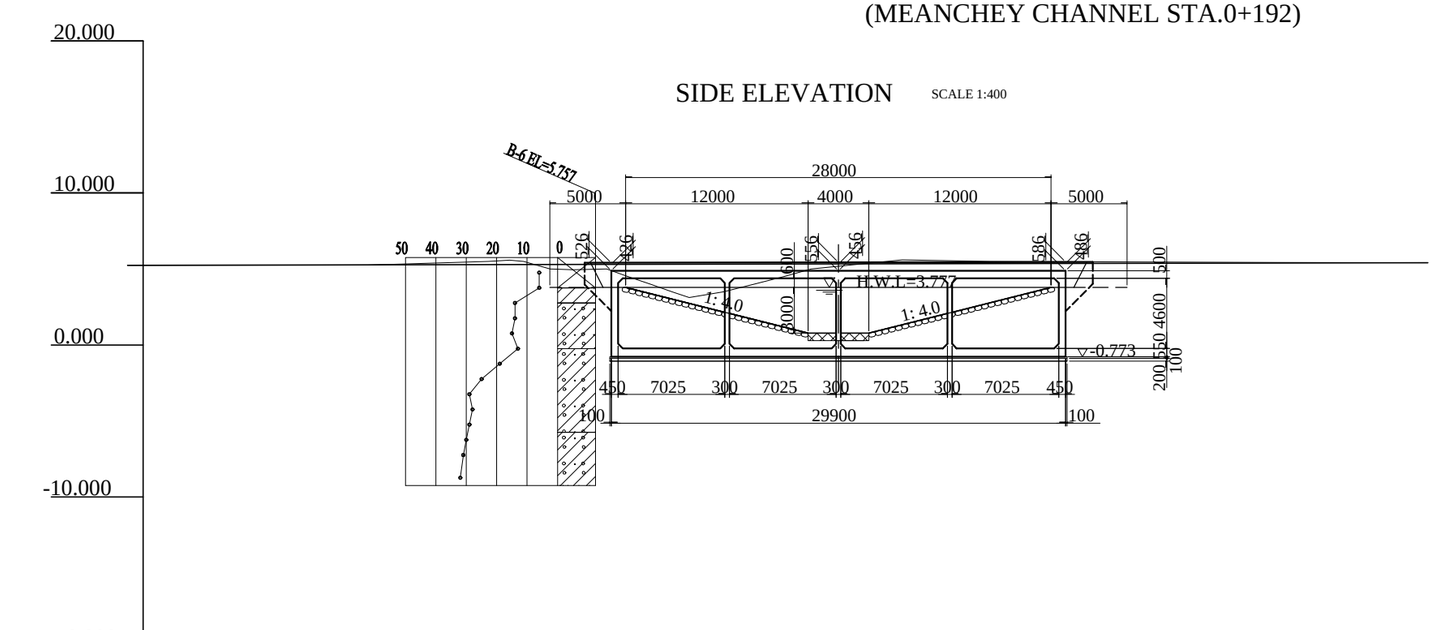
PLAN SCALE 1:400



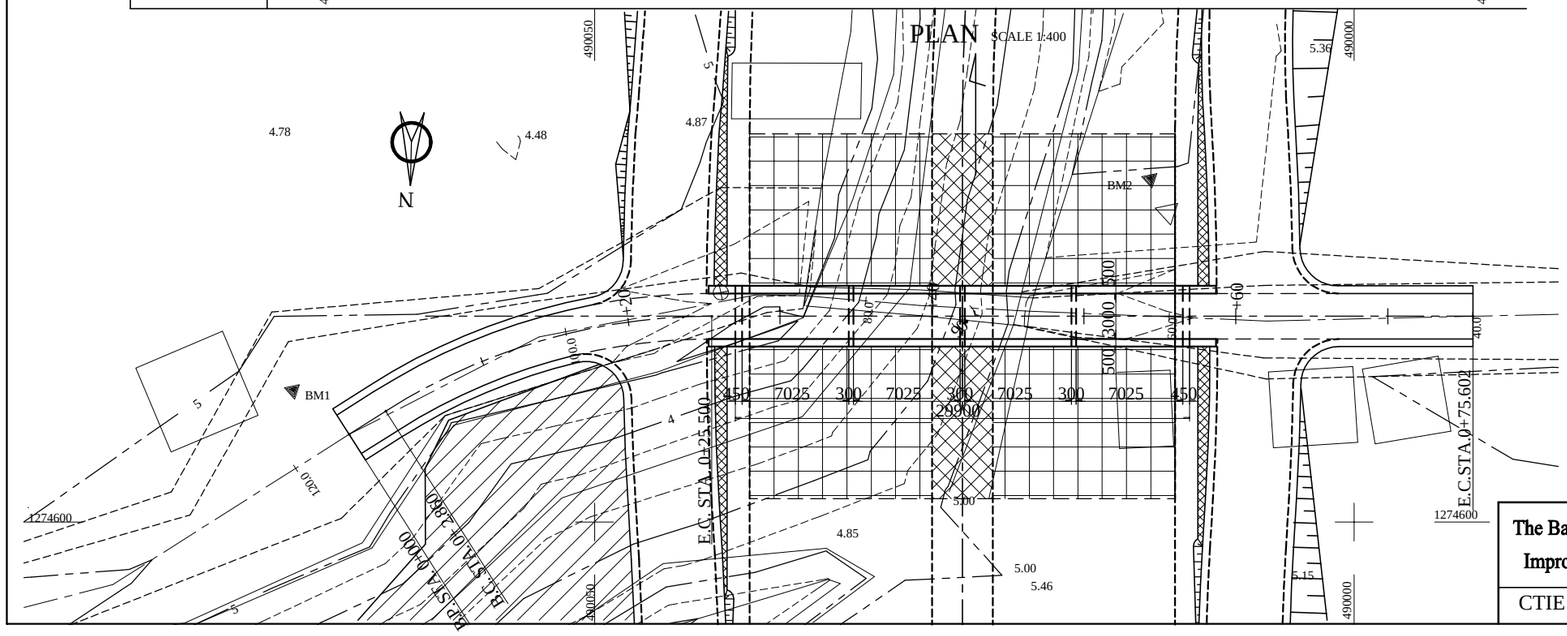
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-MC-014
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	MEANCHEY DRAINAGE CHANNEL BRIDGE-NO.2 (STA.1+480)

GENERAL VIEW OF BOX-CULVERT
(MEANCHEY CHANNEL STA.0+192)

SIDE ELEVATION SCALE 1:400



PLAN SCALE 1:400



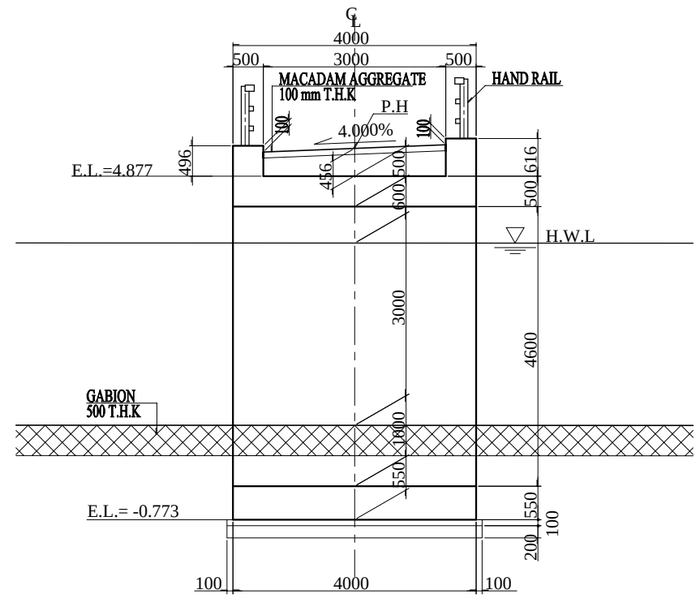
DESIGN CRITERIA

STRUCTURAL TYPE	4-BARREL BOX-CULVERT
TOTAL LENGTH	L=29.900m
WIDTH	CARRIAGE WAY WIDTH=3.00m
LIVE LOAD	SIDEWALK LIVE LOAD
ANGLE OF SKEW	90°00'00"
HORIZONTAL CURVATURE	R= ∞

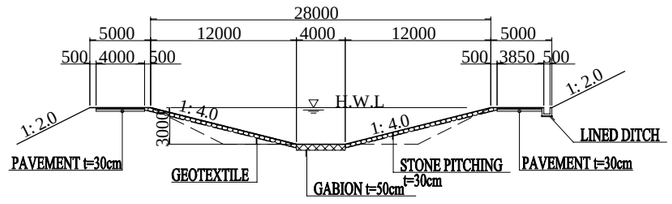
MATERIALS

CONCRETE		σck=24N/mm²
STEEL	REINFORCEMENT	SD295A

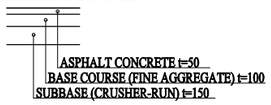
SECTION SCALE 1:100



MEANCHEY CHANNEL SCALE 1:500



PAVEMENT DETAIL

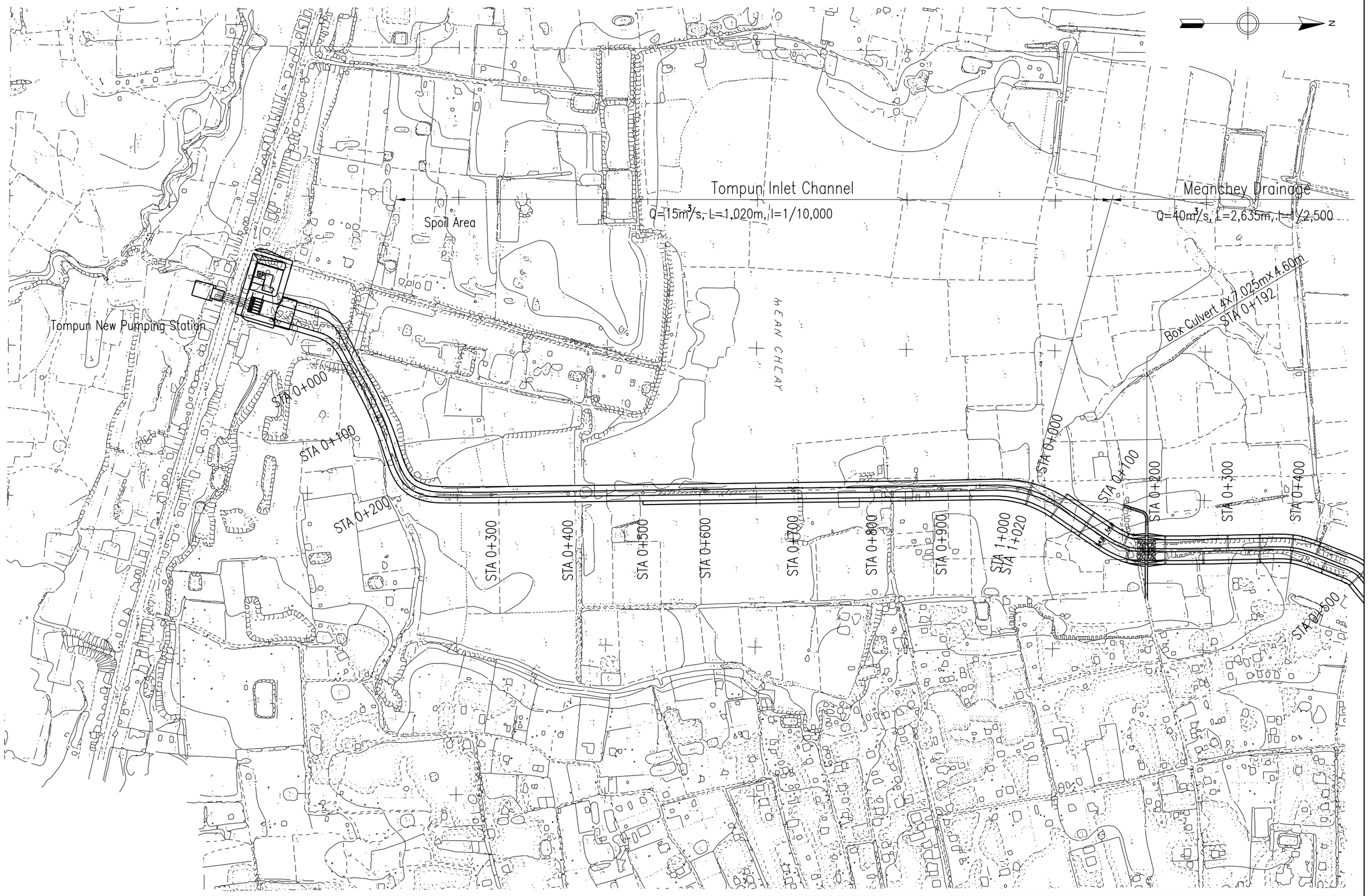


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh

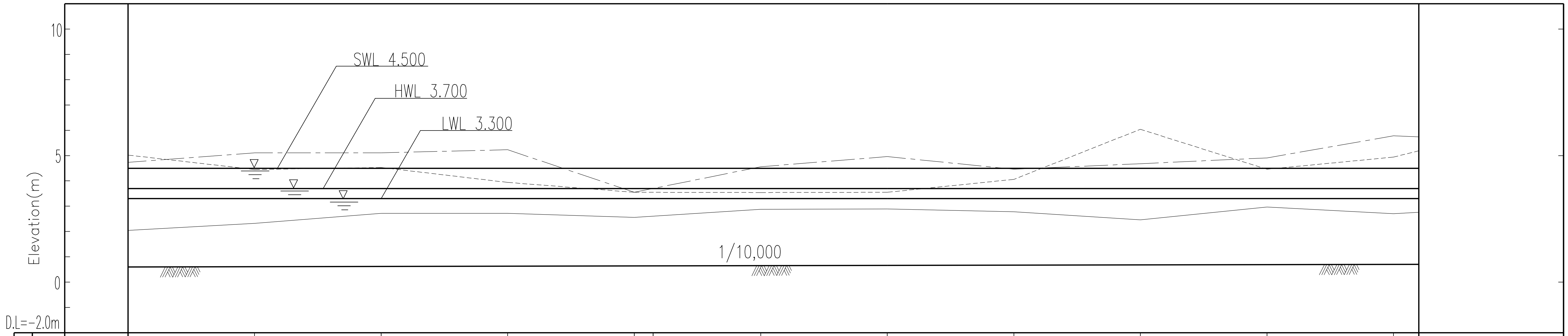
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.

Drawing No. DI-MC-015

MEANCHEY DRAINAGE CHANNEL
BRIDGE-NO.3
BOX-CULVERT(STA.0+192)



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-TC-001
CTIE International Co., Ltd.-Nippon Koei Co., Ltd.	TOMPUN INLET CHANNEL PLAN



Station No.	0+000	0+100	0+200	0+300	0+400	0+415	0+500	0+600	0+700	0+800	0+900	1+000	1+020 (0+000 of Meanchey Drainage)
Remarks	Tompun Inlet Channel Q=15 m³/s , L=1,020m												
Design (EL.m) H.W.L	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700
Design (EL.m) Channel Bed Level	0.600	0.608	0.618	0.628	0.638	0.640	0.648	0.658	0.668	0.678	0.688	0.698	0.700
Original River Bed Level (EL.m)	2.04	2.32	2.72	2.72	2.56		2.88	2.89	2.78	2.46	2.97	2.70	2.76
Accumulated Distance (m)	0	100	200	300	400	415	500	600	700	800	900	1000	1020
Distance (m)	0	100	100	100	100	15	85	100	33	100	100	100	20

Existing Channel Bed
Existing Left Bank
Existing Right Bank

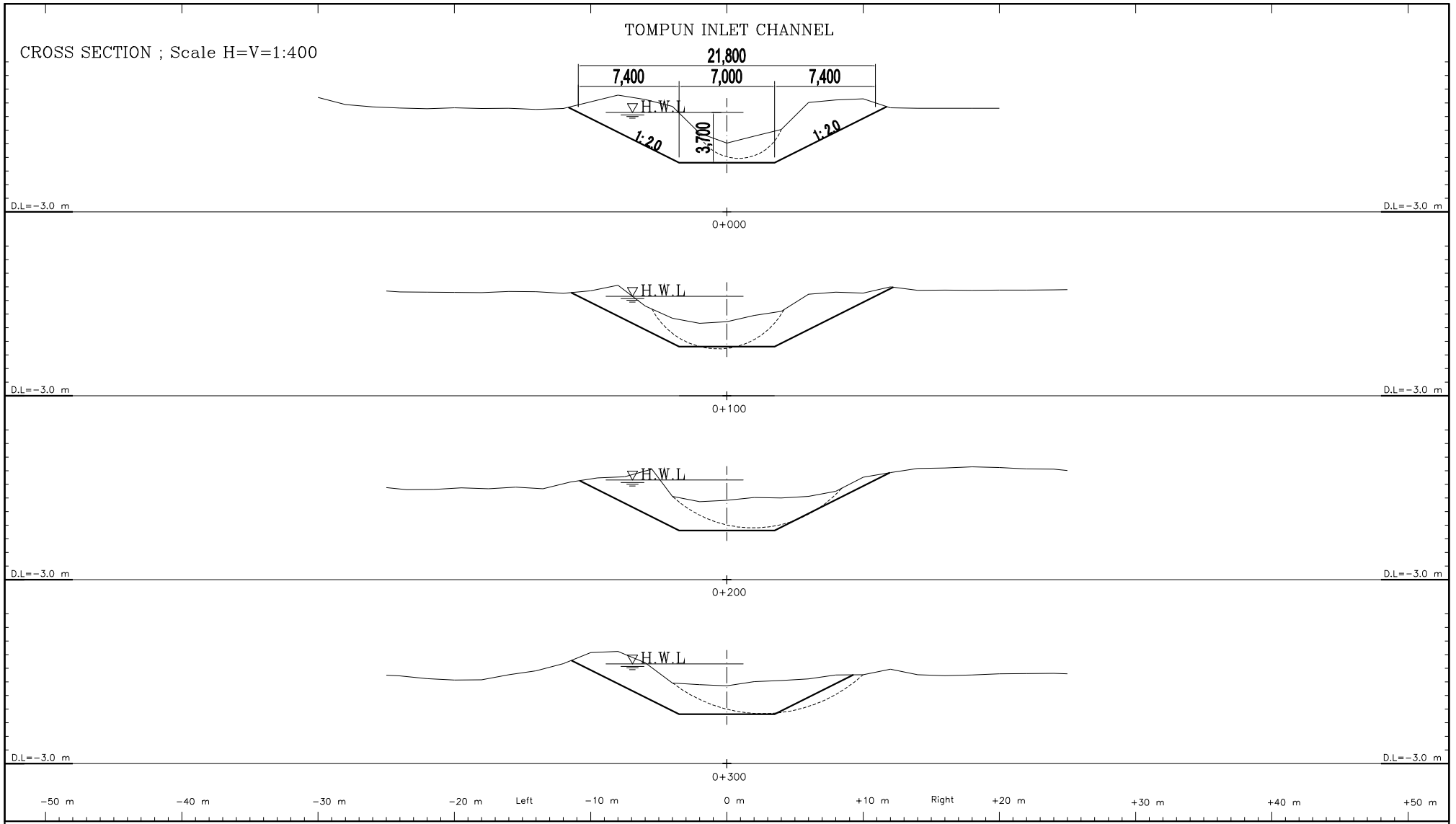
SCALE (Vertical) 0 1 2 3 4 5m

SCALE (Horizontal) 0 20 40 60 80 100m

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-TC-002
CTIE International Co., Ltd.-Nippon Koei Co., Ltd.	TOMPUN INLET CHANNEL PROFILE

TOMPUN INLET CHANNEL

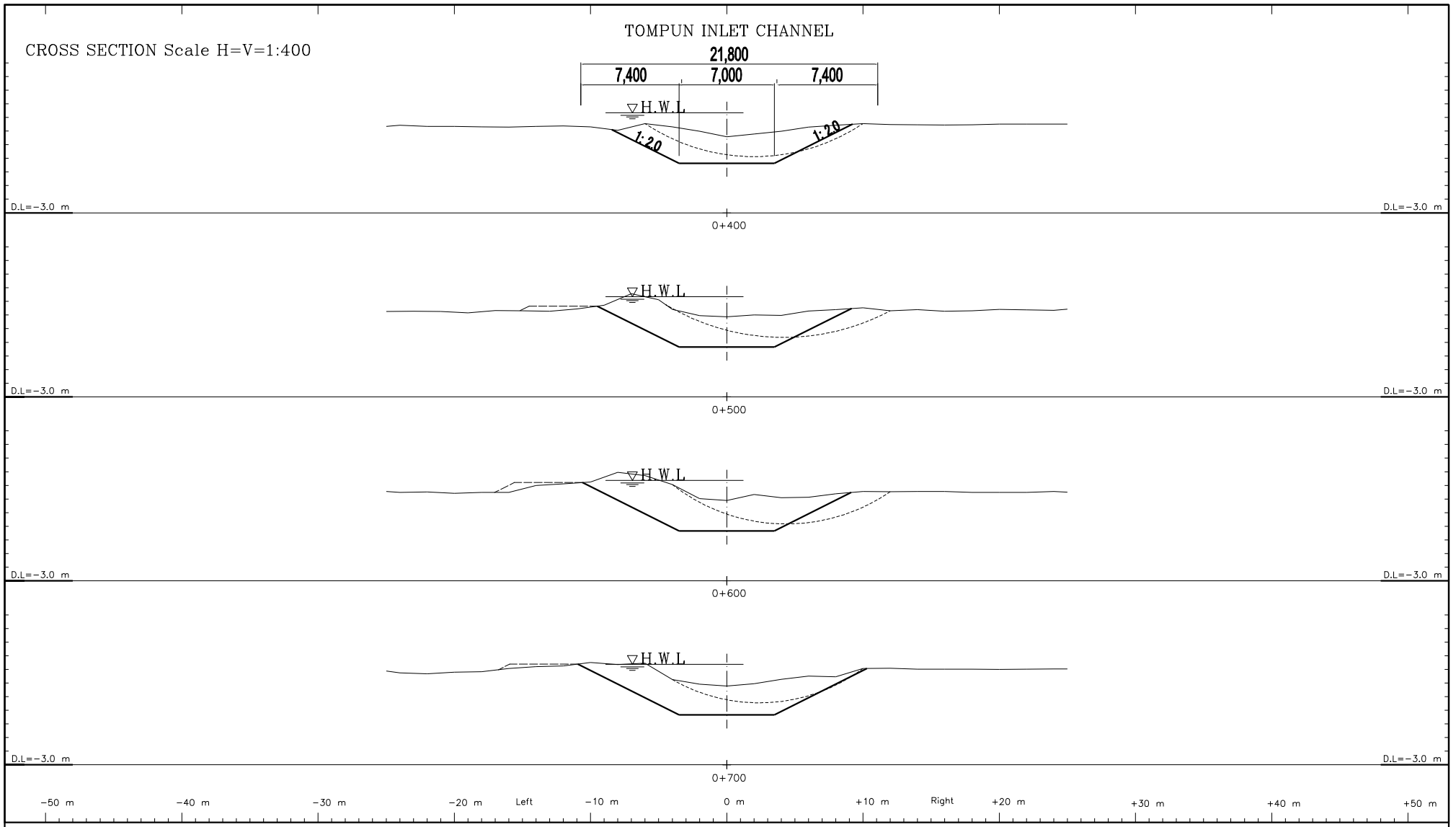
CROSS SECTION ; Scale H=V=1:400



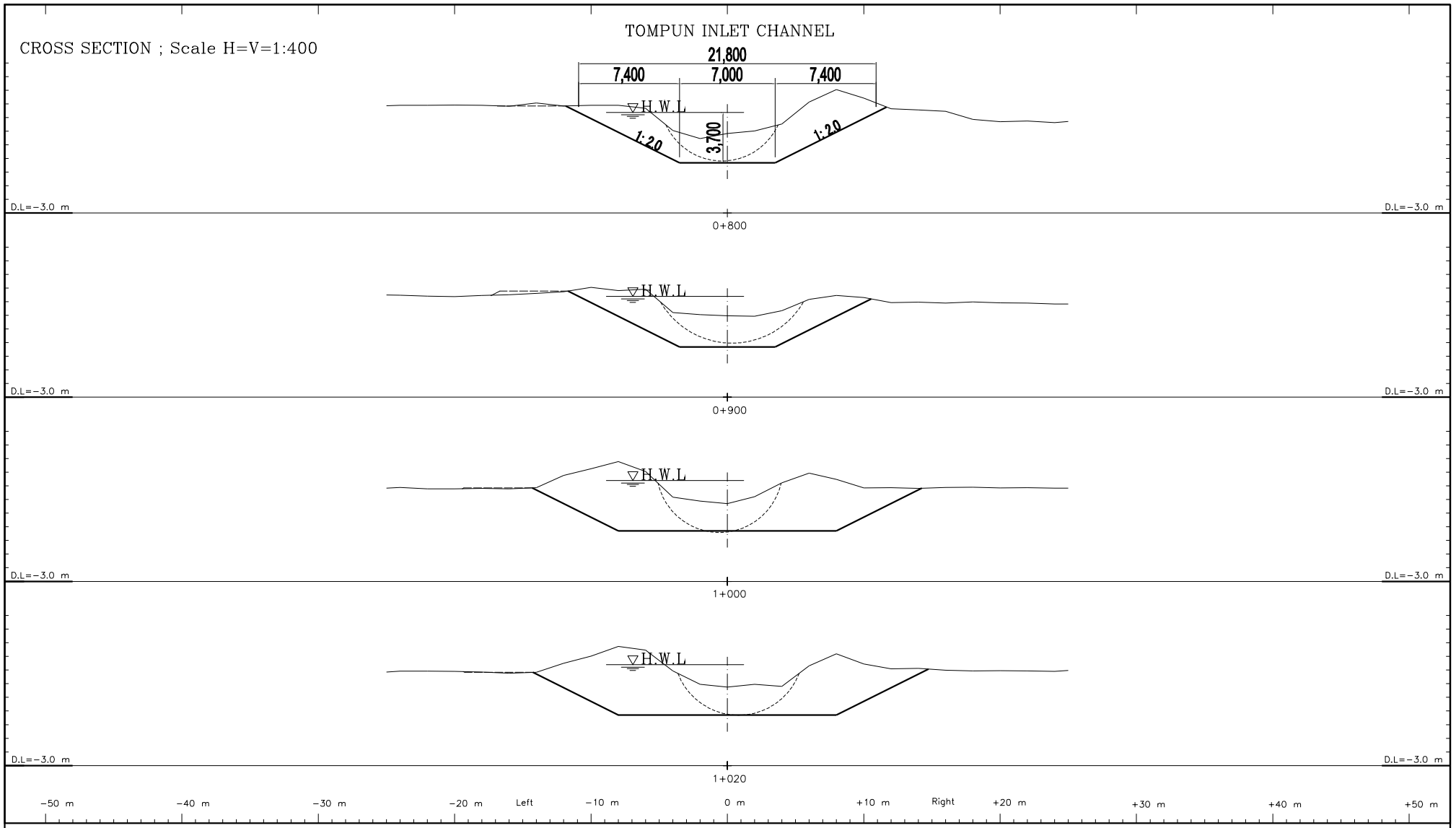
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-TC-003 TOMPUN INLET CHANNEL CROSS SECTIONS (1/3)

TOMPUN INLET CHANNEL

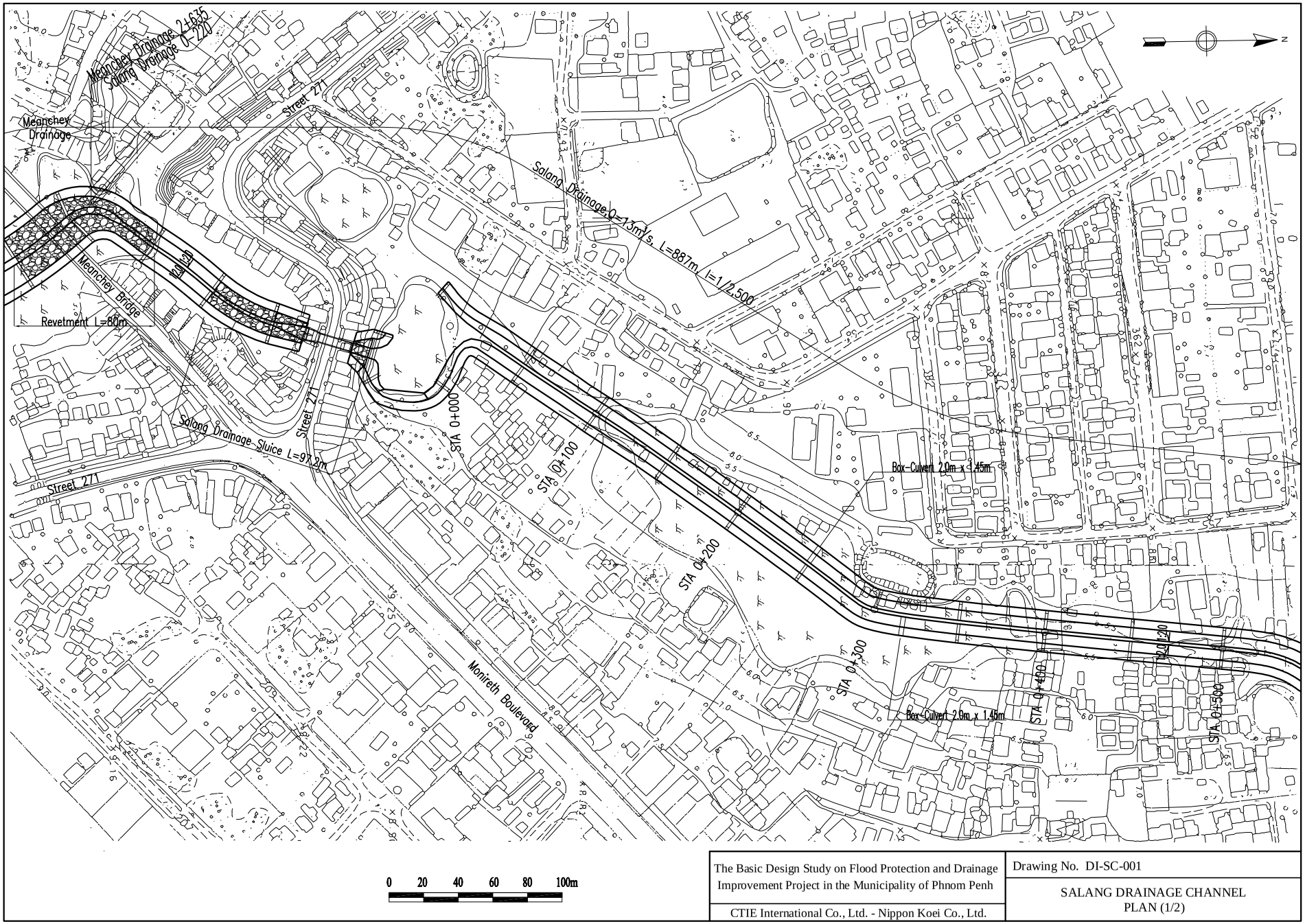
CROSS SECTION Scale H=V=1:400



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-TC-004 TOMPUN INLET CHANNEL CROSS SECTIONS (2/3)

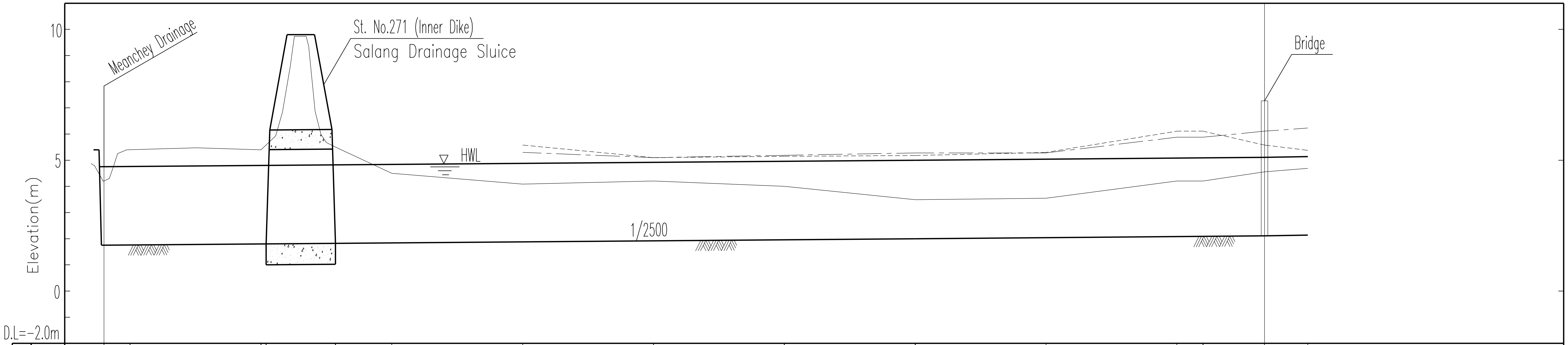


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-TC-005 TOMPUN INLET CHANNEL CROSS SECTIONS (3/3)



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-SC-001
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	SALANG DRAINAGE CHANNEL PLAN (1/2)

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-SC-002
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	SALANG DRAINAGE CHANNEL PLAN (2/2)

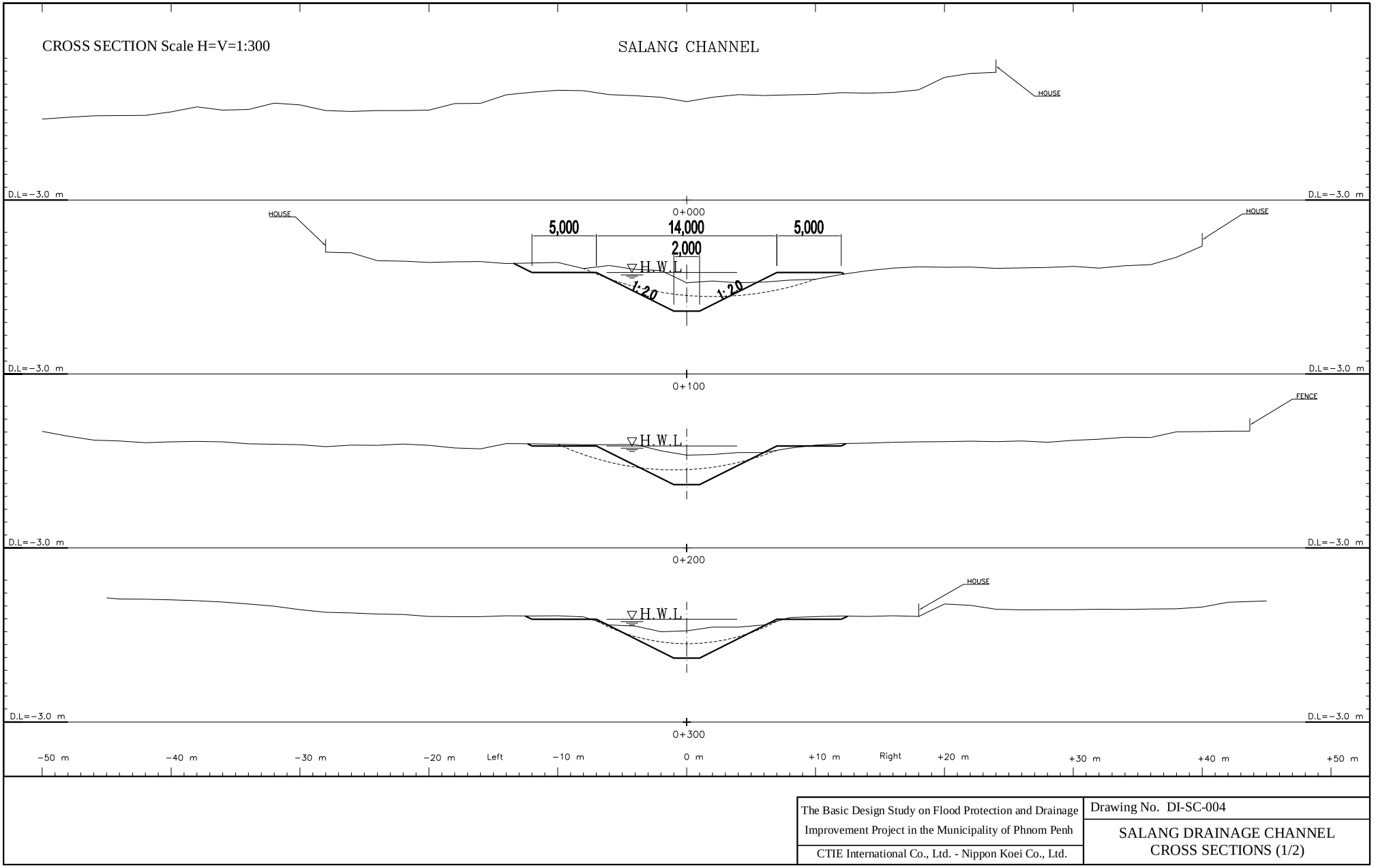


Station No.	Distance (m)	Accumlated Distance (m)	Original River Bed Level (EL.m)	Design (EL.m) Channel Bed Level	Design (EL.m) H.W.L	Remarks
0-220	0	0		1.754	4.754	Salang Drainage Q=13 m³/s , L=887m
0-200	20	20		1.762	4.762	
0-100	100	120		1.802	4.802	
0- 96	4	124		1.803	4.803	
0- 43	53	177		1.825	4.825	
0+000	43	220		1.842	4.842	
0+100	100	320	4.08	1.882	4.882	
0+200	100	420	4.21	1.922	4.922	
0+300	100	520	4.00	1.962	4.962	
0+400	100	620	3.49	2.002	5.002	
0+500	100	720	3.55	2.042	5.042	
0+600	100	820	4.21	2.082	5.082	
0+620	20	840	4.21	2.090	5.090	
0+667	47	887	4.56	2.109	5.109	
0+700	33	920	4.69	2.142	5.142	

Existing Channel Bed
Existing Left Bank
Existing Right Bank

SCALE (Vertical) 0 1 2 3 4 5m
SCALE (Horizontal) 0 20 40 60 80 100m

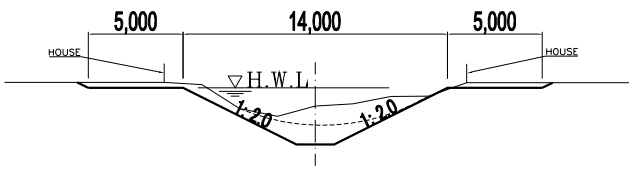
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-SC-003
CTIE International Co., Ltd.-Nippon Koei Co., Ltd.	SALANG DRAINAGE CHANNEL PROFILE



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-SC-004 SALANG DRAINAGE CHANNEL CROSS SECTIONS (1/2)

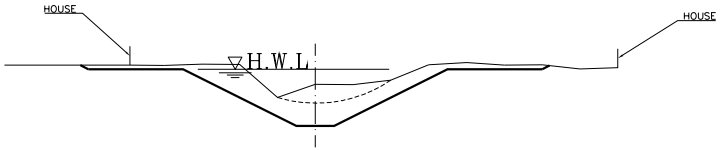
CROSS SECTION Scale H=V=1:300

SALANG CHANNEL



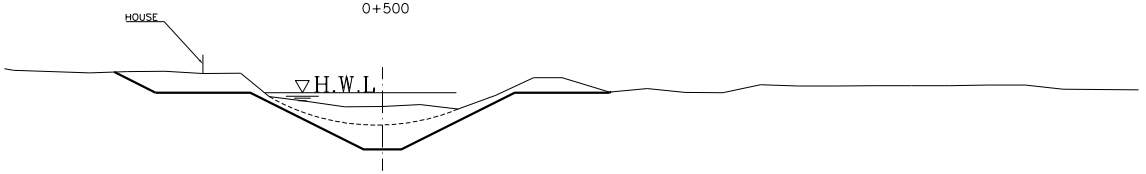
D.L=-3.0 m D.L=-3.0 m

0+400



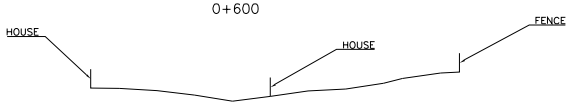
D.L=-3.0 m D.L=-3.0 m

0+500



D.L=-3.0 m D.L=-3.0 m

0+600



D.L=-3.0 m D.L=-3.0 m

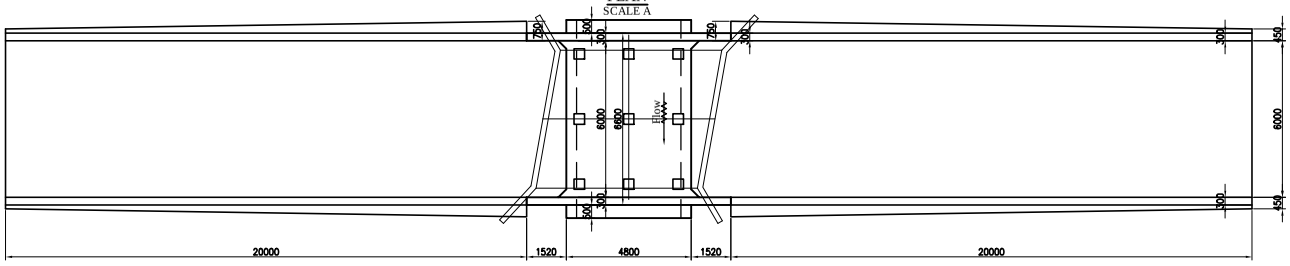
0+700

-50 m -40 m -30 m -20 m Left -10 m 0 m +10 m Right +20 m +30 m +40 m +50 m

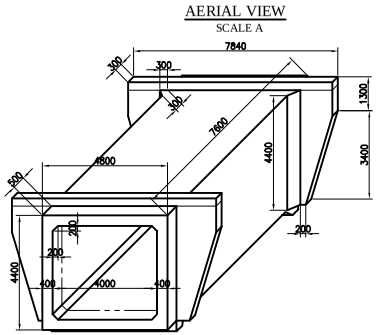
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-SC-005 SALANG DRAINAGE CHANNEL CROSS SECTIONS (2/2)

BOENG SALANG BRIDGE

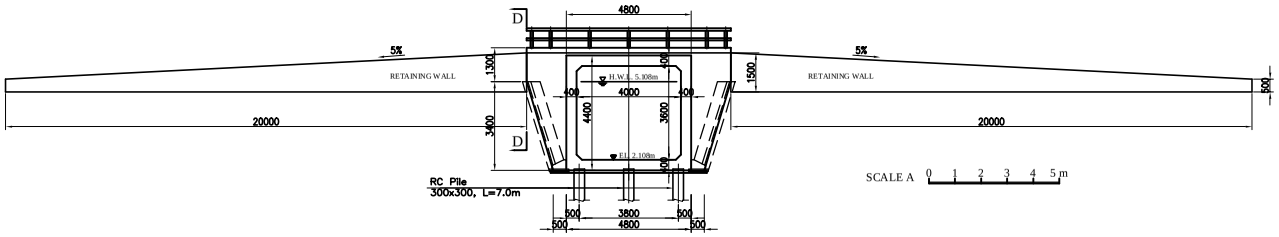
PLAN
SCALE A



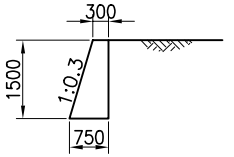
AERIAL VIEW
SCALE A



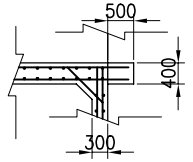
LONGITUDINAL PROFILE
SCALE A



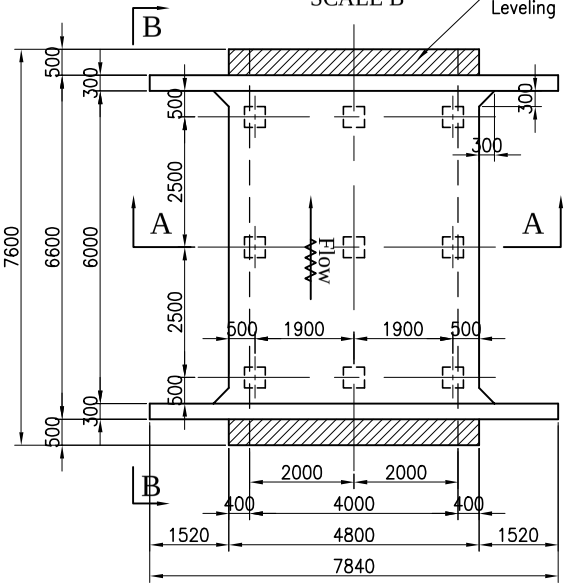
TYPICAL SECTION OF RETAINING WALL
Section D-D
SCALE B



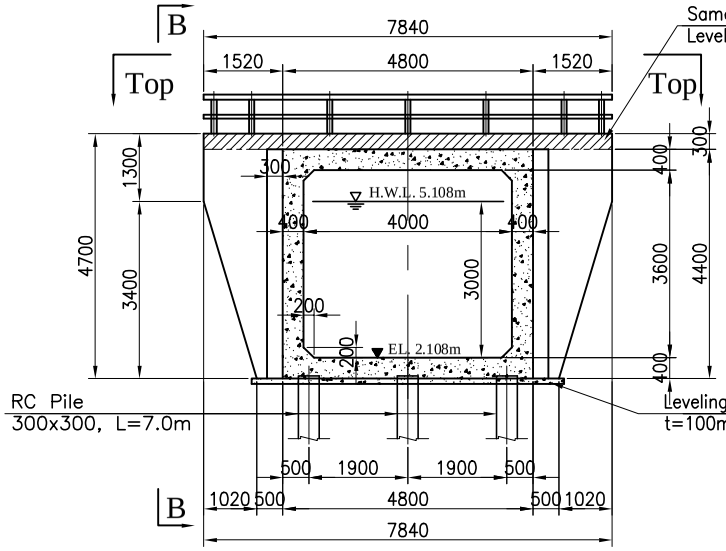
Section E-E
SCALE B



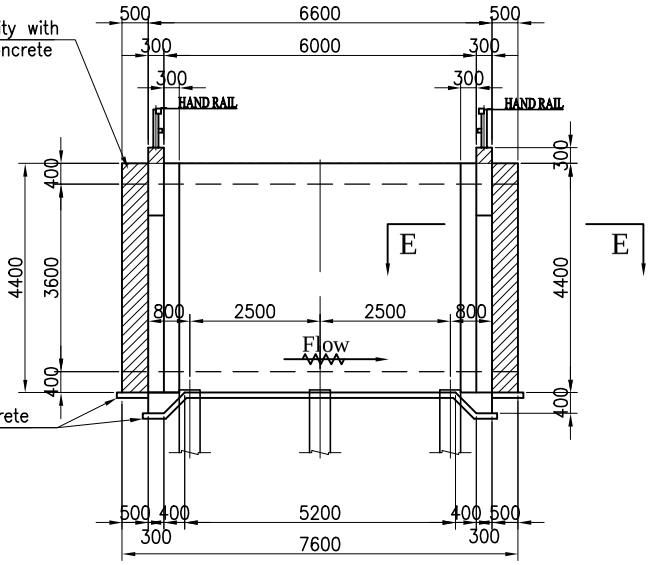
Top View
SCALE B



Section A-A
SCALE B



Section B-B
SCALE B



SCALE B 0 1 2 3 4 5m

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd.-Nippon Koei Co., Ltd.	Drawing No. DI-SC-006 SALANG DRAINAGE CHANNEL BOENG SALANG BRIDGE (BOX CULVERT)

ELECTRIC & CONTROL HOUSE

EL. 6.000m

Gate

Tompun Dike

EL. 10.000m

EL. 9.000m

EL. 8.000m

EL. 7.000m

EL. 6.000m

Sodding

1:2.0

Crane Rail

Retaining Wall

Wet Stone Masonry

Flow

EL. 0.600m

Trash Boom

Boulder Riprap

Outlet

EL. 4.500m

Boulder Riprap

Dia.1.20m, Steel Drainage Pipe

Drainage Gutter

20,000

23,000

20,800

20,900

13,700

12,018

11,300

6,100

24,698

4,102

6,500

16,700

25,000

69,400

New Tompun Pumping Station

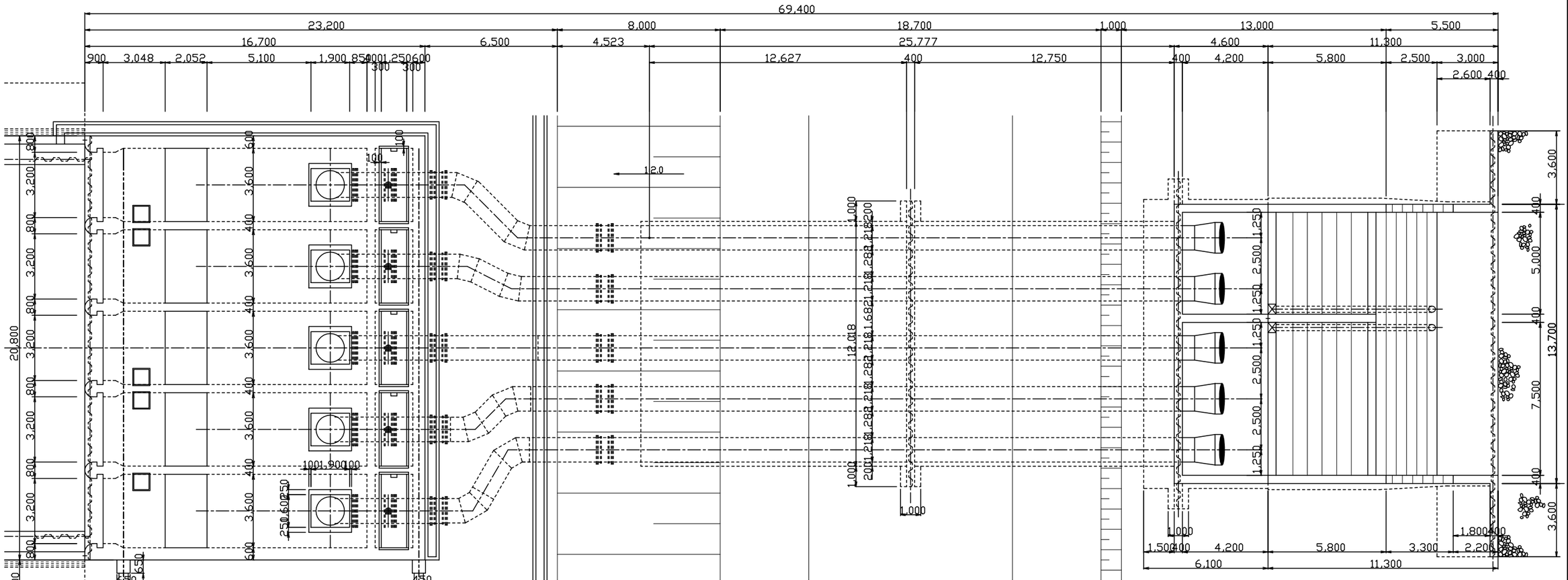
Existing Pumping Station

0 10 20 30 40m

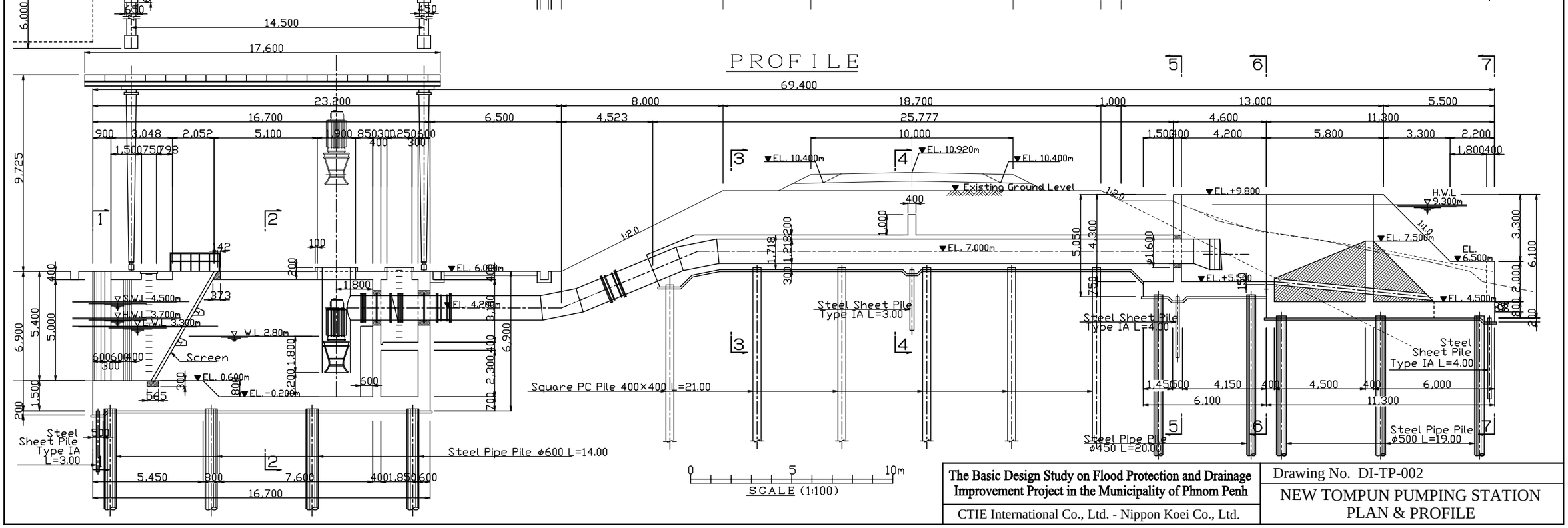
SCALE (1:300)

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-TP-001
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	NEW TOMPUN PUMPING STATION GENERAL PLAN

PLAN



PROFILE

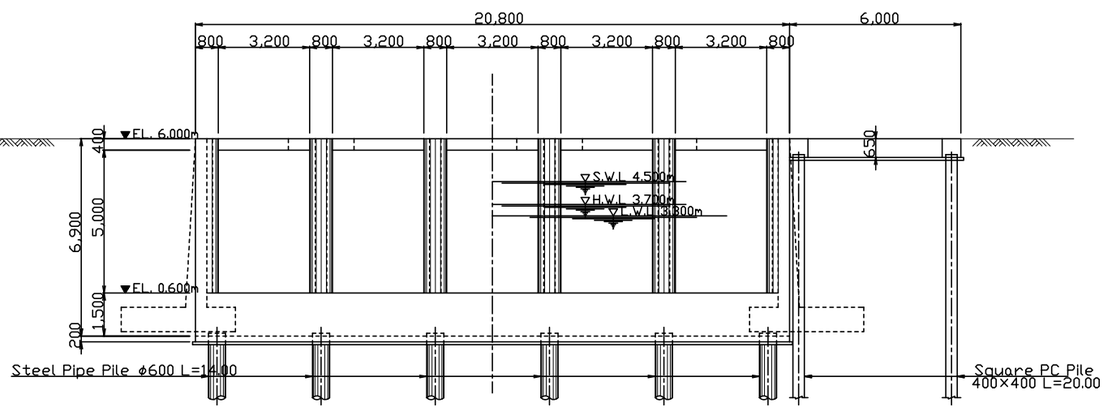


0 5 10m

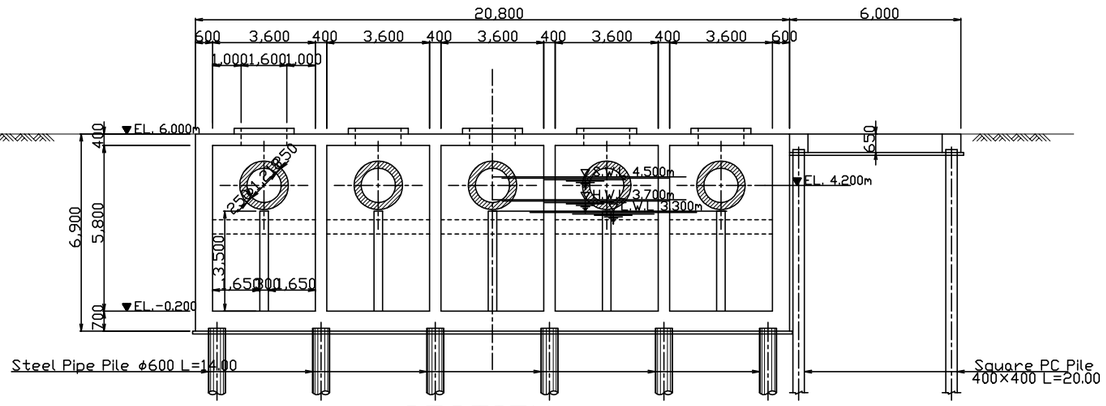
SCALE (1:100)

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-TP-002
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	NEW TOMPUN PUMPING STATION PLAN & PROFILE

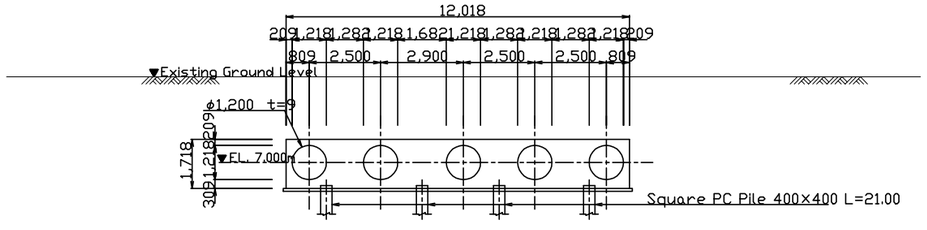
SECTION 1 - 1



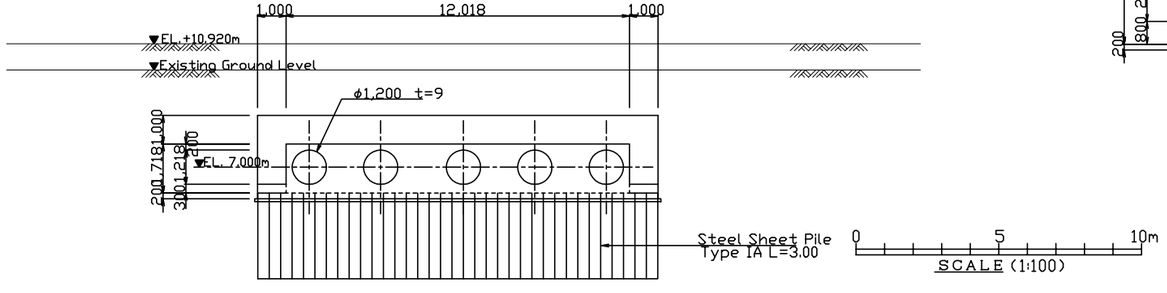
SECTION 2 - 2



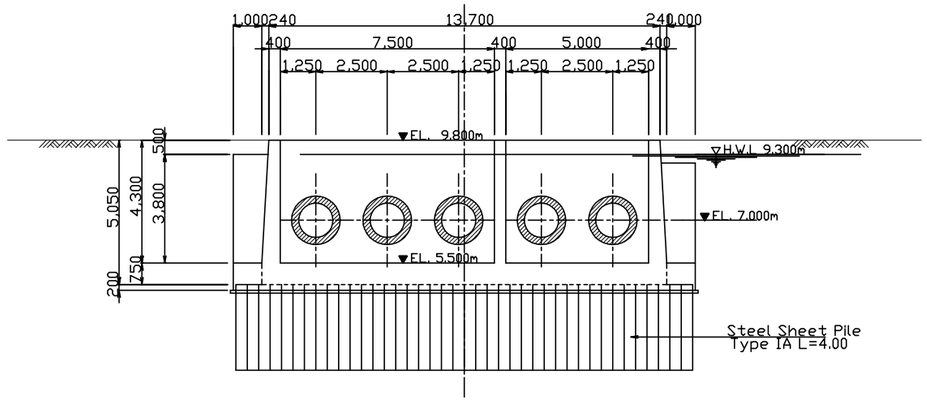
SECTION 3 - 3



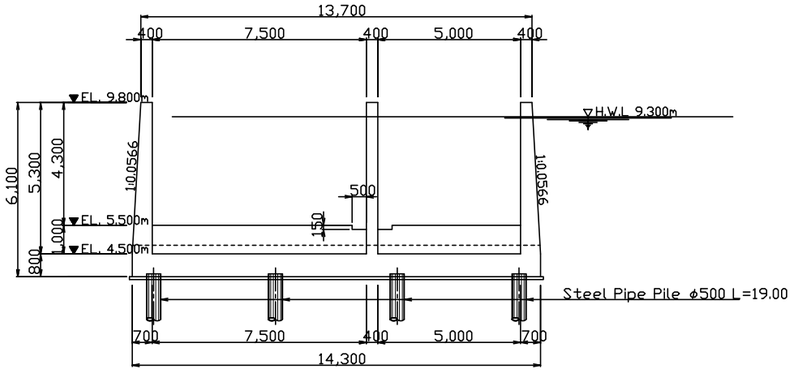
SECTION 4 - 4



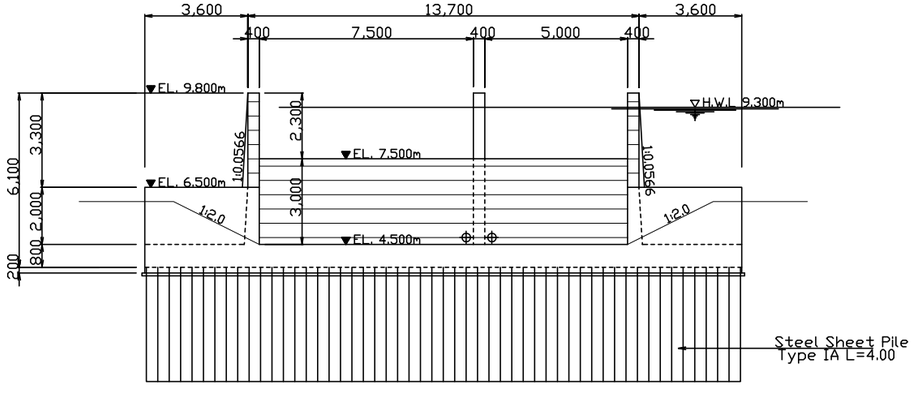
SECTION 5 - 5



SECTION 6 - 6

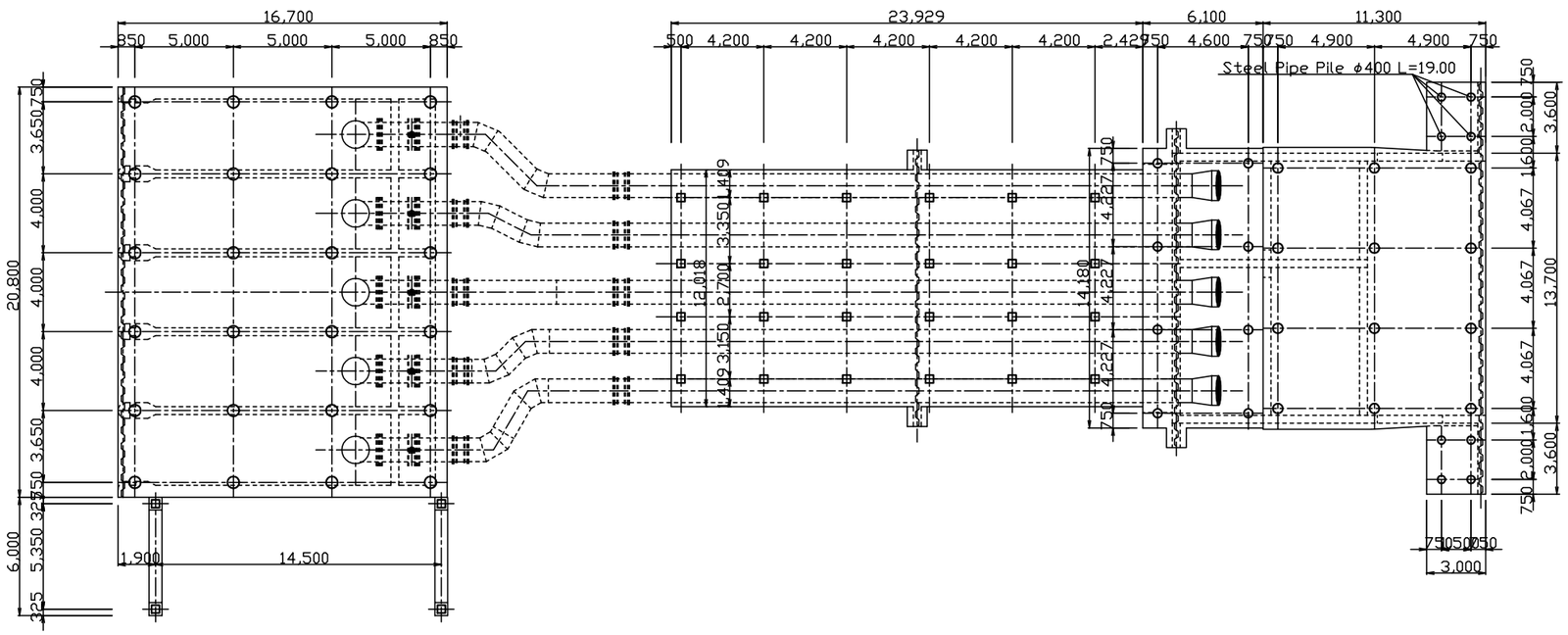


SECTION 7 - 7

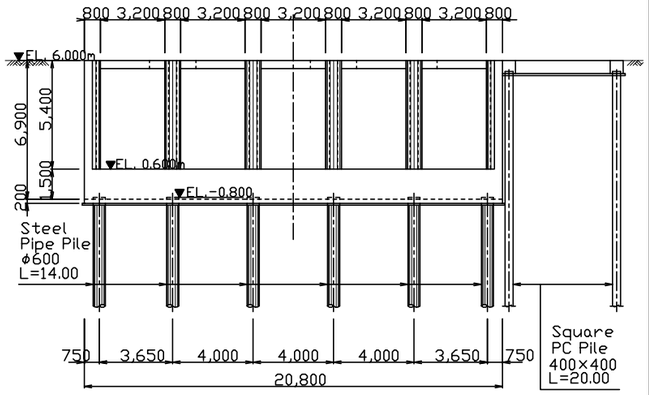


The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-TP-003
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	NEW TOMPUN PUMPING STATION CROSS SECTIONS

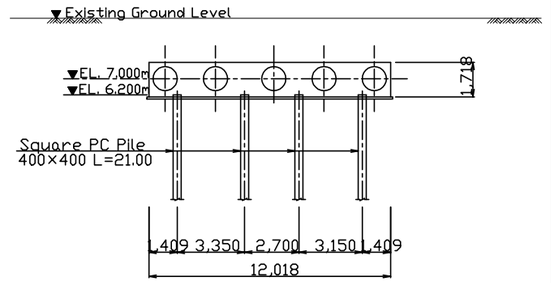
PLAN



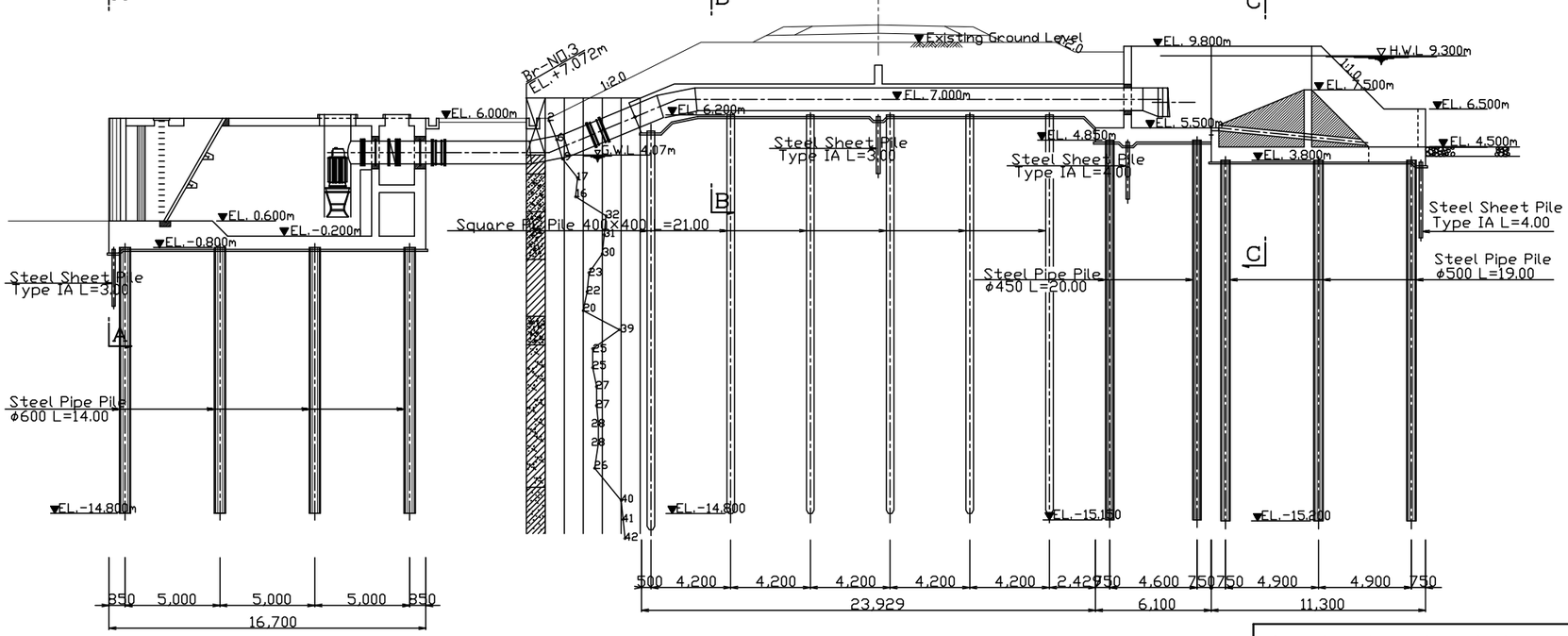
SECTION A－A



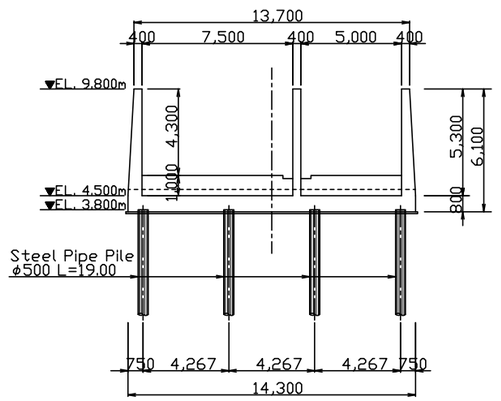
SECTION B－B



PROFILE

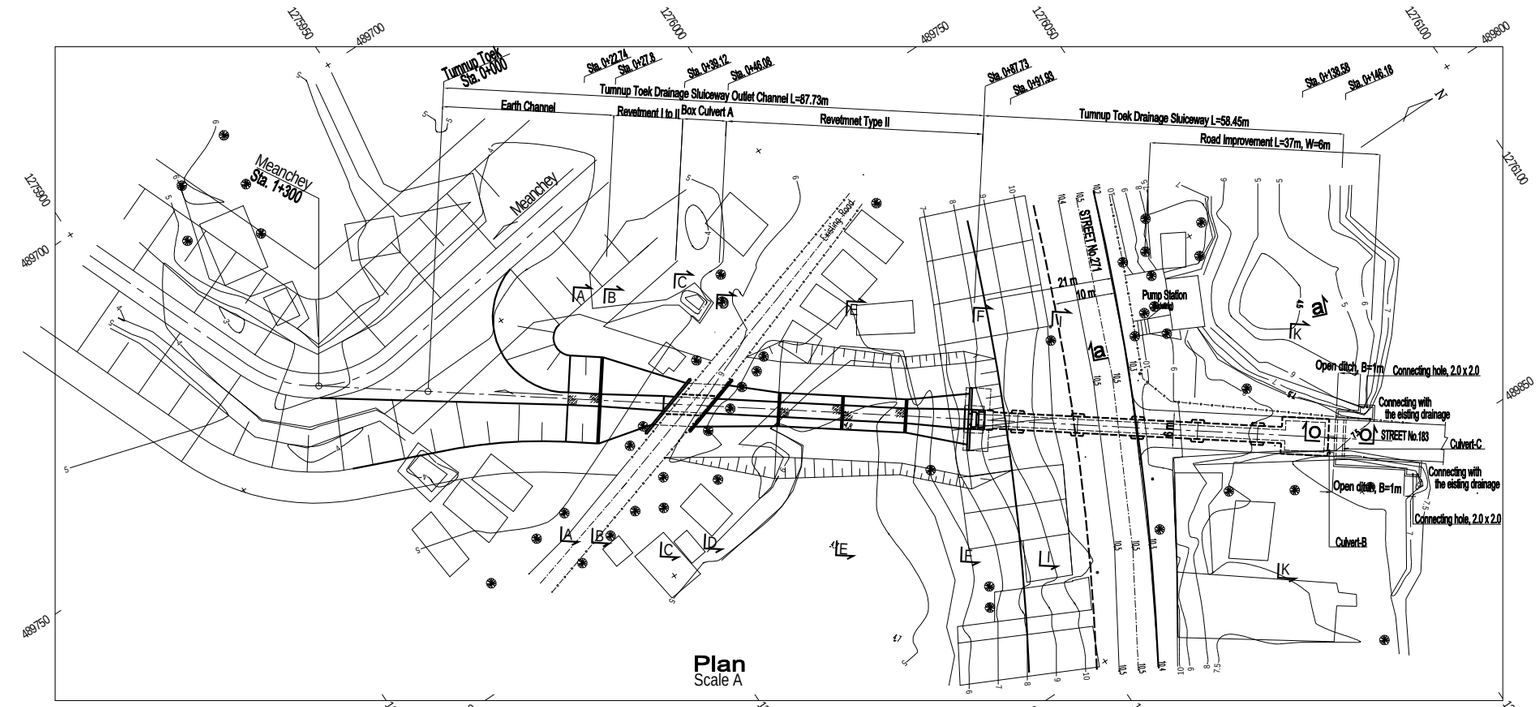


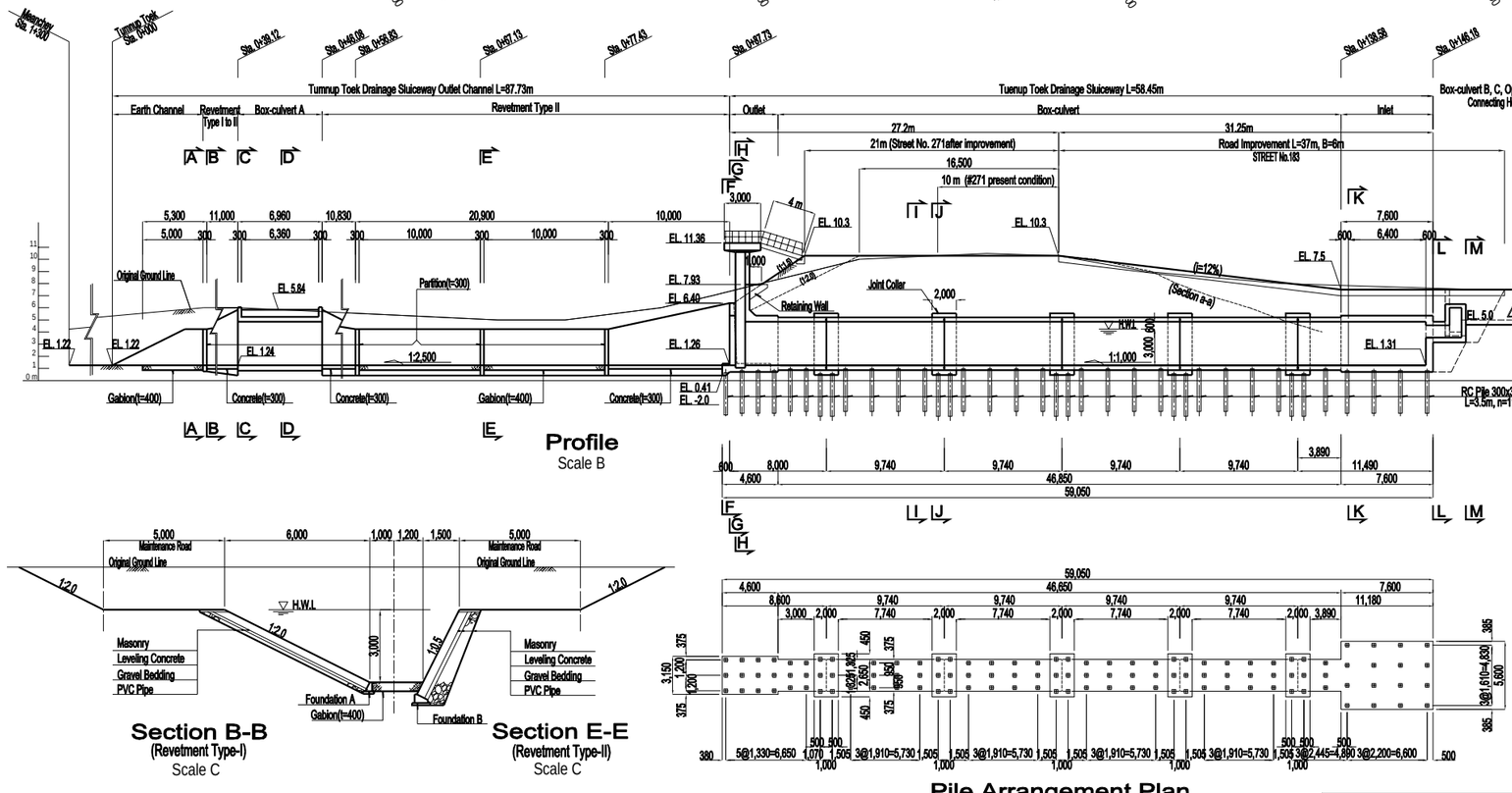
SECTION C－C



SCALE (1:150)

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Drawing No. DI-TP-004 NEW TOMPUN PUMPING STATION LAYOUT OF FOUNDATION PILE

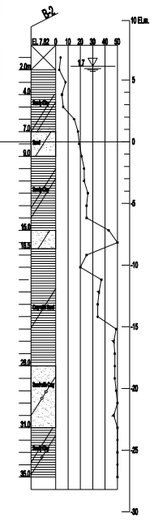


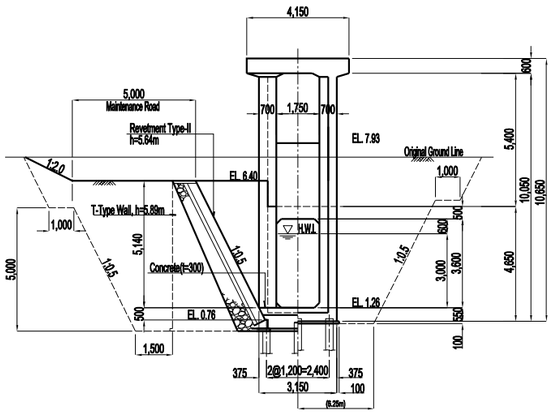


Section B-B
(Revetment Type-I)
Scale C

Section E-E
(Revetment Type-II)
Scale C

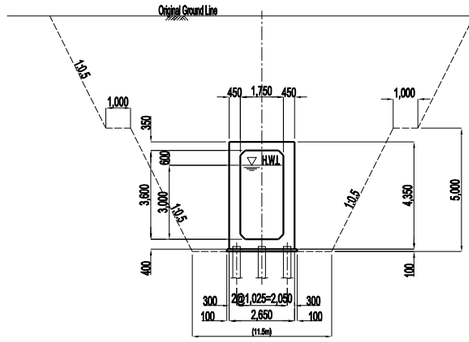
Pile Arrangement Plan
Scale B



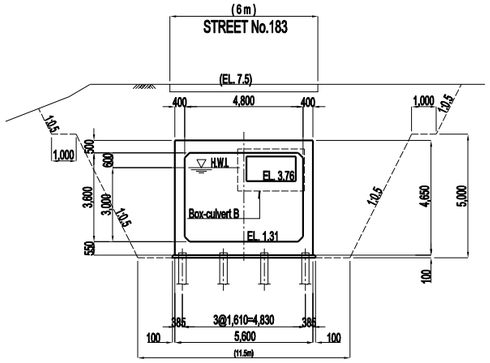


Section F-F
(Revetment Type-II)
Scale C

Section H-H
Scale C



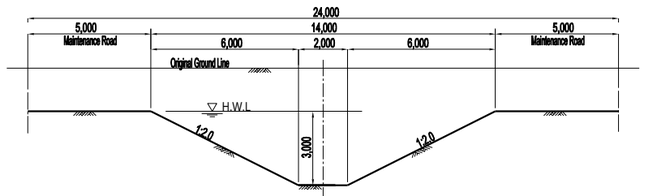
Section I-I
(Box-Culvert Typical)
Scale C



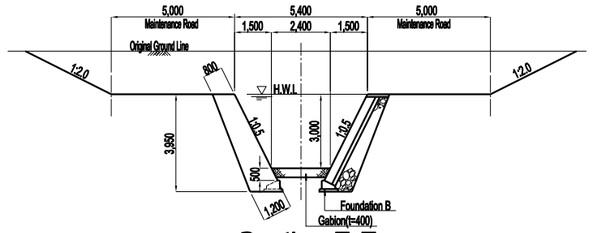
Section K-K
(Box-Culvert Inlet)
Scale C

Scale A 0 10 20 30 40m
Scale B 0 5 10 15 20m
Scale C 0 5 10m

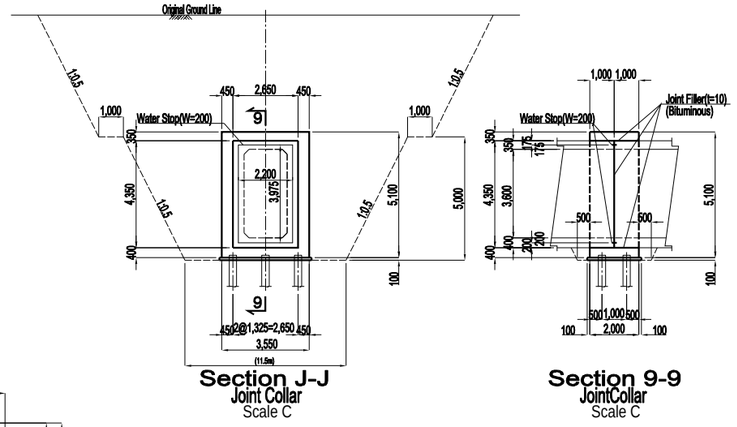
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-SW-001
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TUM NUP TOEK DRAINAGE SLUICEWAY (1/2)



Section A-A
Earth Channel
Scale C

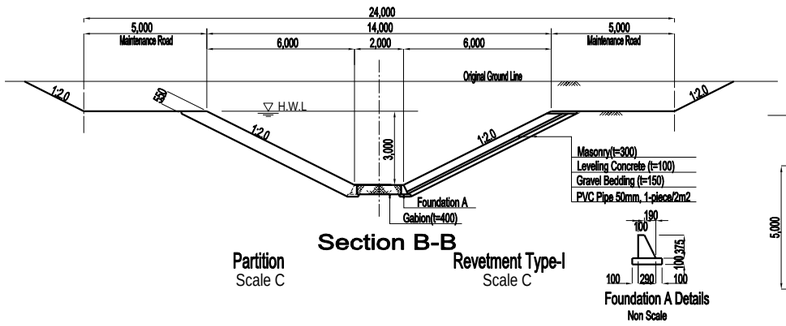


Section E-E
Partition Revetment Type-II
Scale C



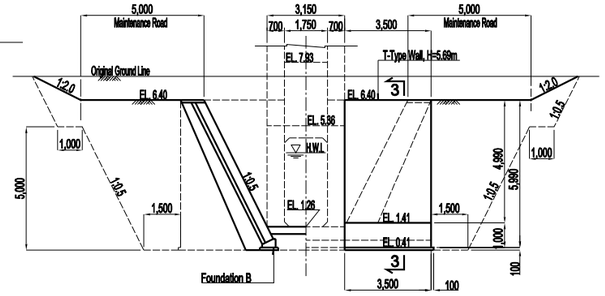
Section J-J
Joint Collar
Scale C

Section 9-9
JointCollar
Scale C

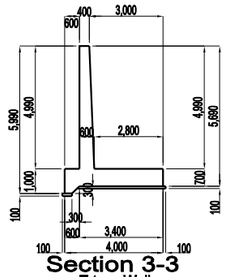


Section B-B
Partition Revetment Type-I
Scale C

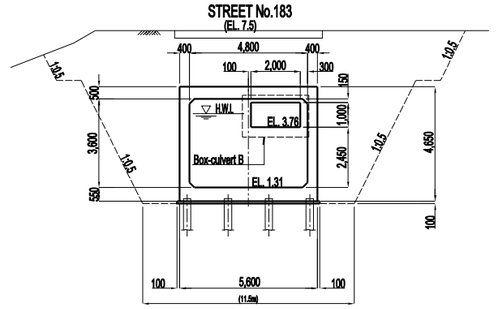
Foundation A Details
Non Scale



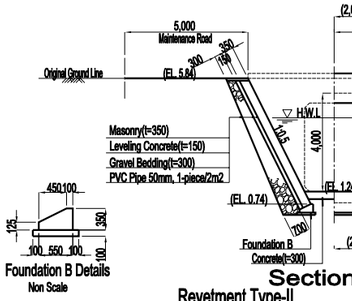
Section F-F
Revetment Type-II Wing Wall
Scale C



Section 3-3
T-type Wall
Scale C



Section K-K
Box-Culvert Inlet
Scale C



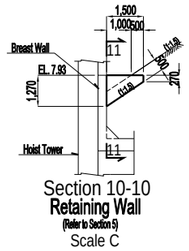
Foundation B Details
Non Scale

	w1		w2	
	d/s	u/s	d/s	u/s
Right	3,270	3,350	4,430	4,510
Left	4,050	3,470	5,210	4,630
	4,100	4,100	—	—
Total	11,420	10,920	9,640	9,140

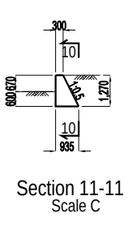
Section C-C
Revetment Type-II Wing Wall
Scale C

Section G-G Section H-H
Outlet, Hoist Tower
Scale C

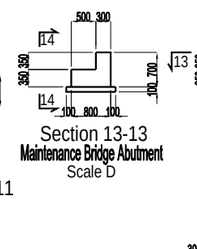
Section 4-4
Outlet, Hoist Tower
Scale C



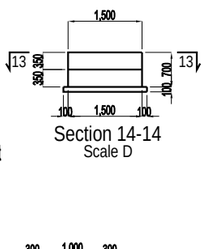
Section 10-10
Retaining Wall
(Refer to Section 5)
Scale C



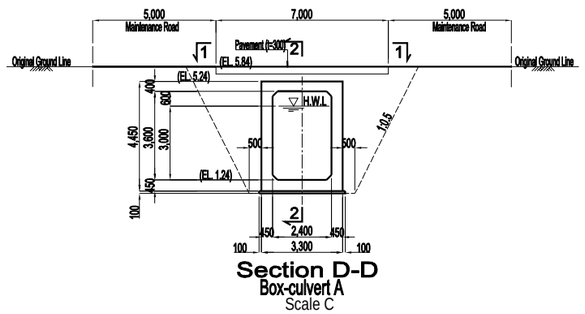
Section 11-11
Scale C



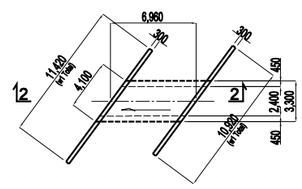
Section 13-13
Maintenance Bridge Abutment
Scale D



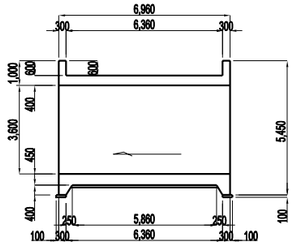
Section 14-14
Scale D



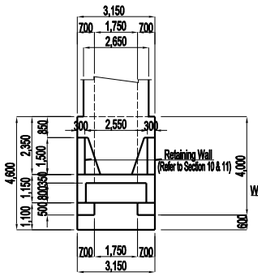
Section D-D
Box-culvert A
Scale C



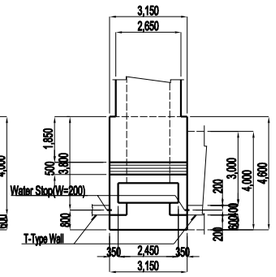
Section 1-1
Box-culvert A Plan
Scale B



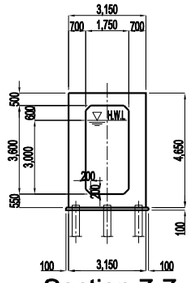
Section 2-2
Box-culvert A Profile
Scale C



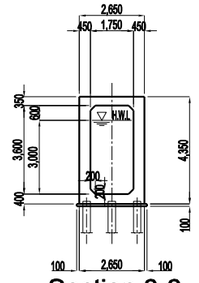
Section 5-5
Hoist Tower Plan
Scale C



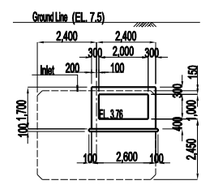
Section 6-6
Hoist Tower Plan
Scale C



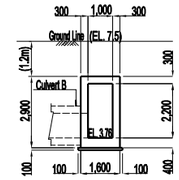
Section 7-7
Scale C



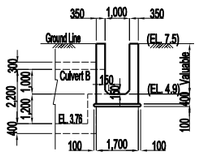
Section 8-8
Scale C



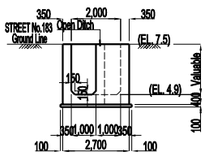
Culvert-B Section, L=1m
(Section L-L)
Scale C



Culvert-C Section
(Section O-O: Refer to Plan)
Scale C



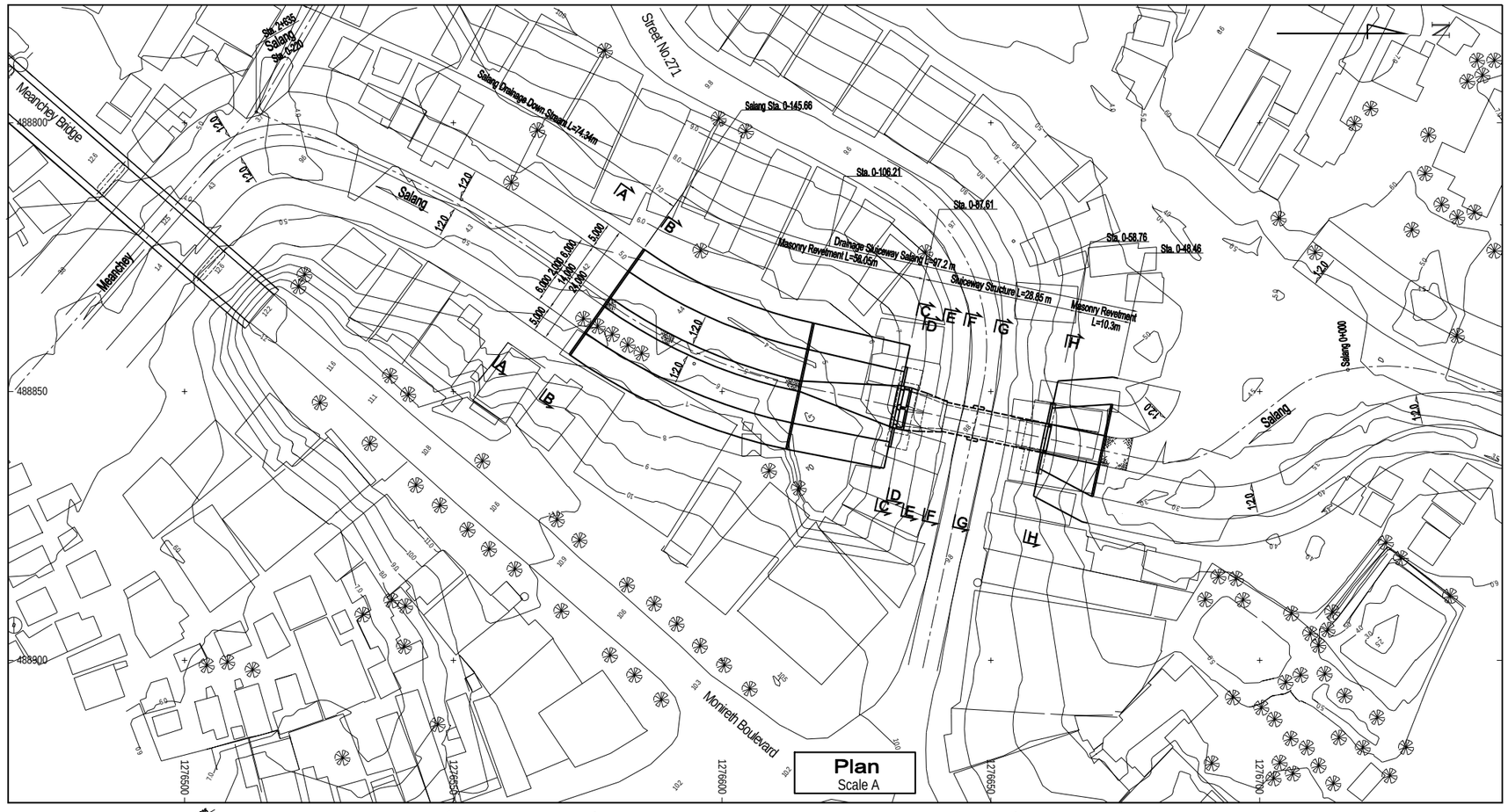
Open Ditch Section
(Section M-M)
Scale C

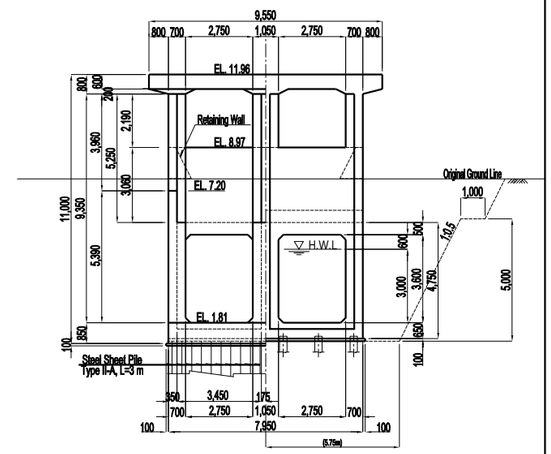


Connecting Hole(2.0 x 2.0) Section
(Section N-N)
Scale C

Scale A 0 10 20 30 40m
Scale B 0 5 10 15 20m
Scale C 0 5 10m
Scale D 0 1 2 3 4 5m

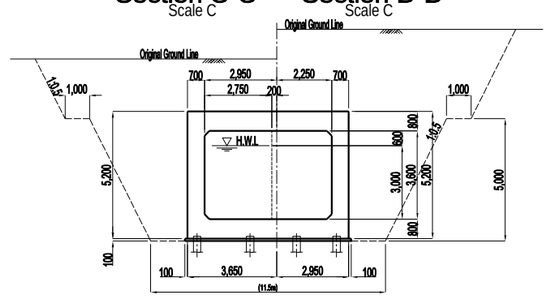
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-SW-002
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	TUM NUP TOEK DRAINAGE SLUICEWAY (2/2)





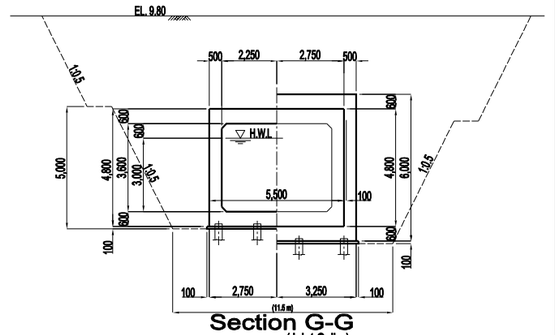
Section C-C Scale C

Section D-D Scale C

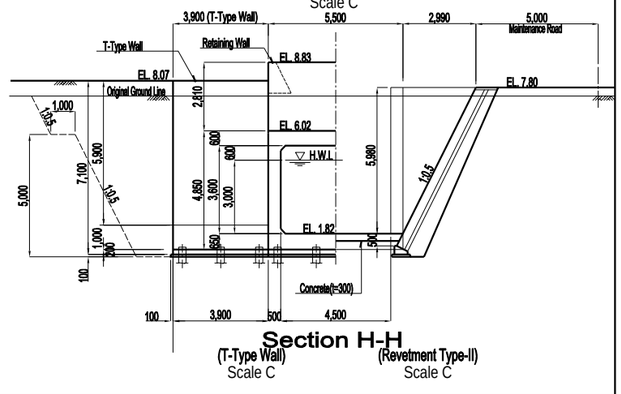


Section E-E Scale C

Section F-F Scale C

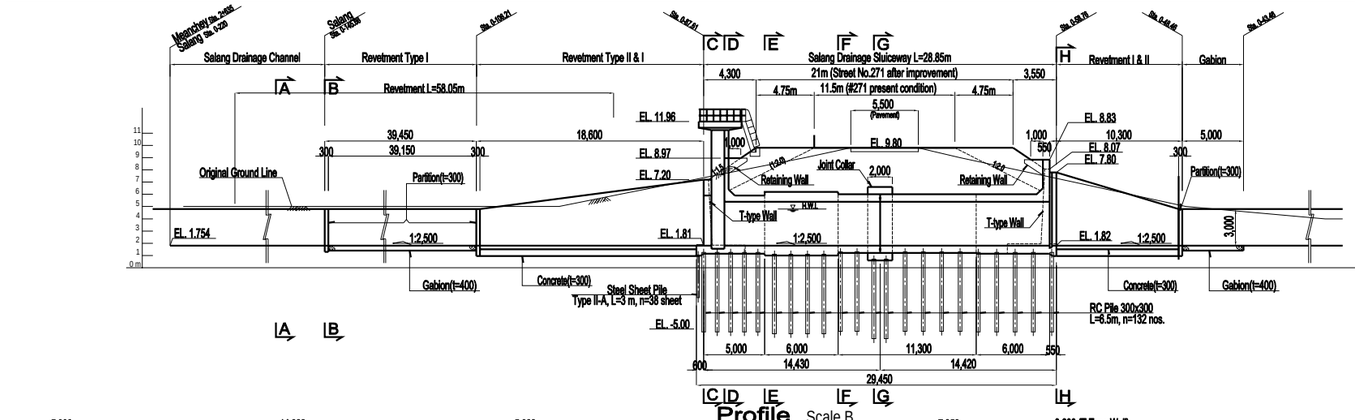


Section G-G (Joint Collar) Scale C

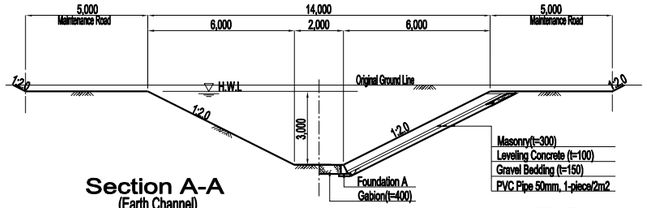


Section H-H (T-Type Wall) Scale C

(Revetment Type-II) Scale C

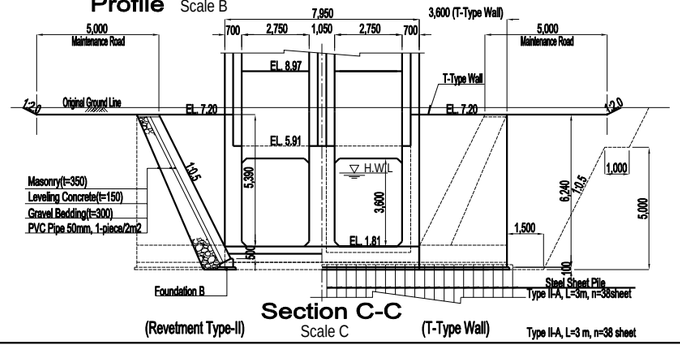


Profile Scale B

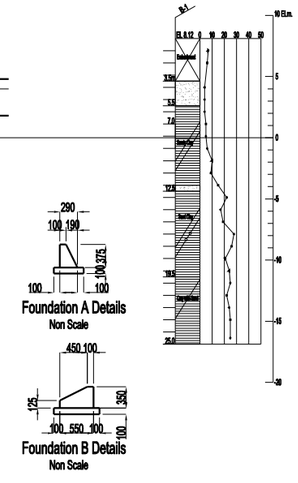


Section A-A (Earth Channel) Scale C

Section B-B (Revetment Type-I) Scale C

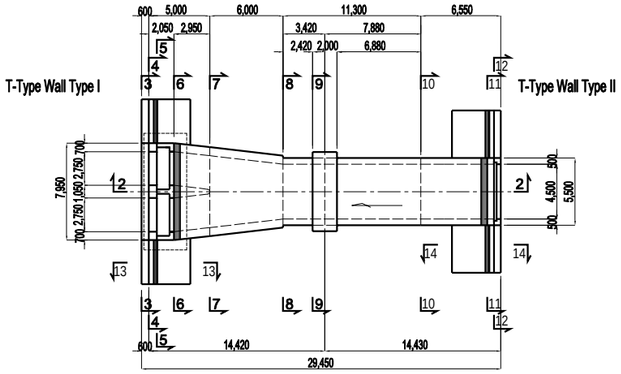


Section C-C (Revetment Type-II) Scale C (T-Type Wall) Type II-A, L=3 m, n=38 sheet

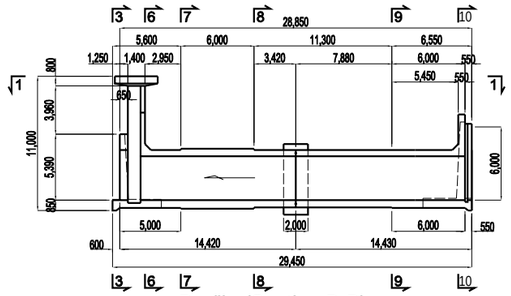


Scale A 0 10 20 30 40m
Scale B 0 5 10 15 20m
Scale C 0 5 10m

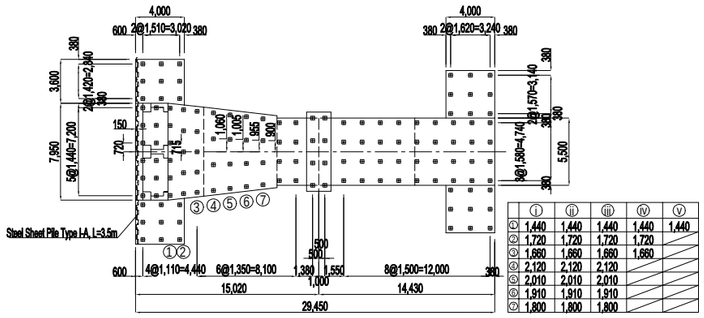
The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-SW-003
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	SALANG DRAINAGE SLUICEWAY (1/2)



Plan (Section A-A) Scale B

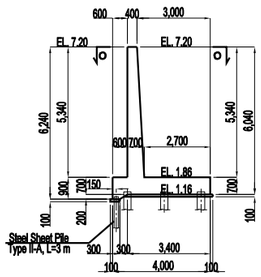


Profile (Section B-B) Scale B

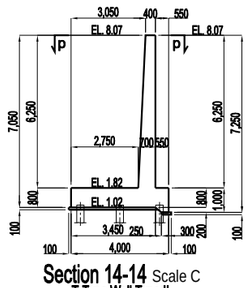


	①	⑪	⑩	⑨	⑧
①	1,440	1,440	1,440	1,440	1,440
②	1,720	1,720	1,720	1,720	
③	1,660	1,660	1,660	1,660	
④	2,120	2,120	2,120		
⑤	2,010	2,010	2,010		
⑥	1,910	1,910	1,910		
⑦	1,800	1,800	1,800		

Pile Arrangement Plan Scale B



Section 13-13 Scale C
T-Type Wall Type I



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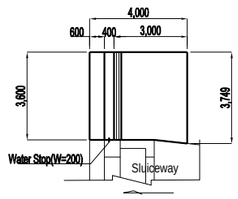
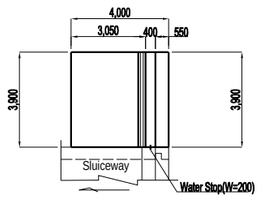
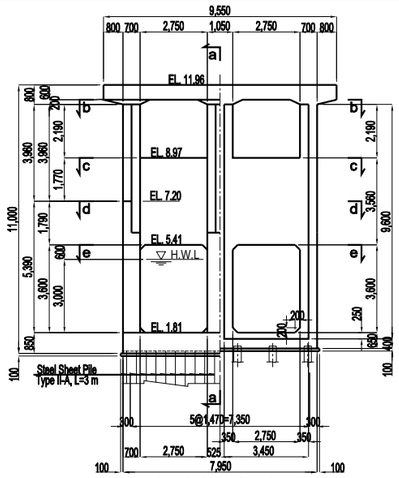


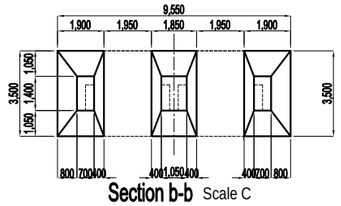
Section o - o Scale C



Section p-p Scale C



Section 3-3 Section 4-4 Scale C



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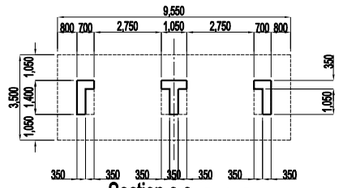

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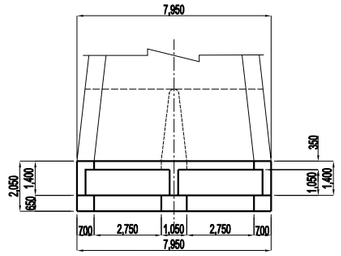

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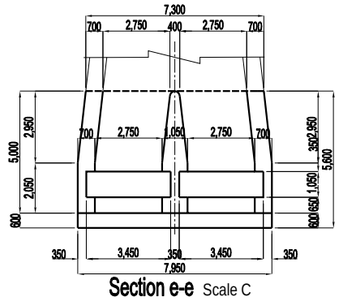

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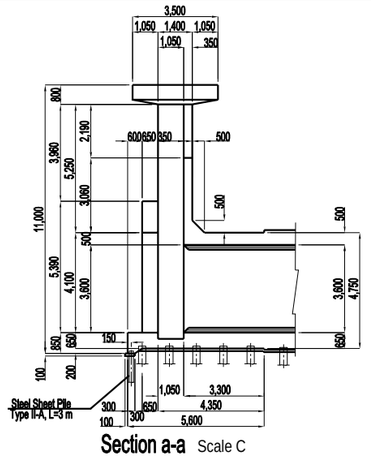
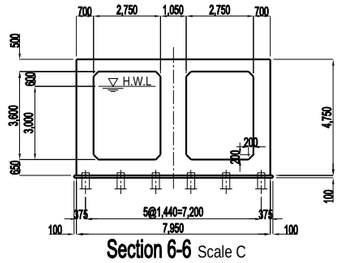


Section a-a Scale C



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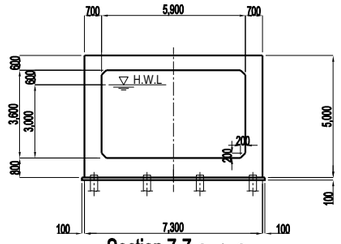

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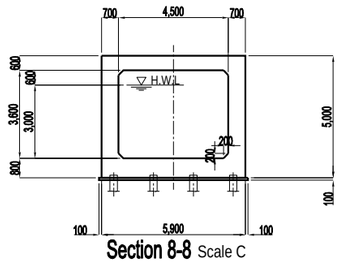
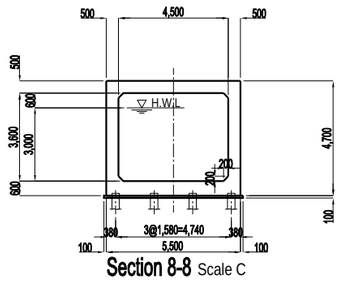


Section 8-8 Scale C



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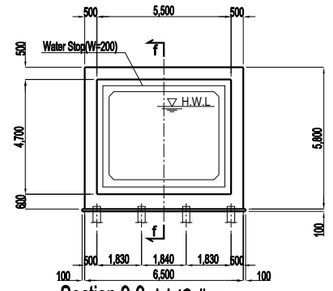
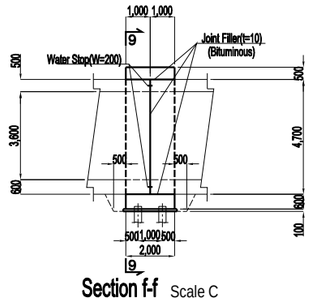


Section 9-9 JointCollar Scale C



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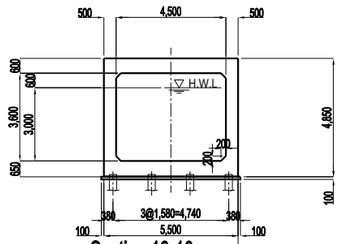
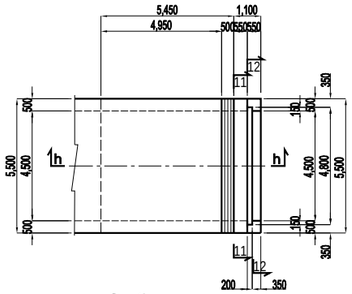


Section 10-10 Scale C



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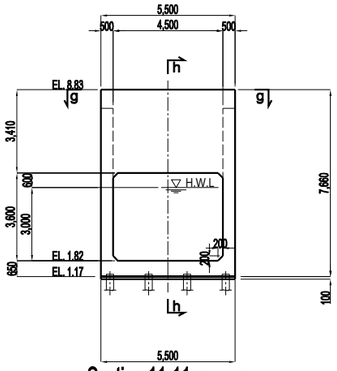
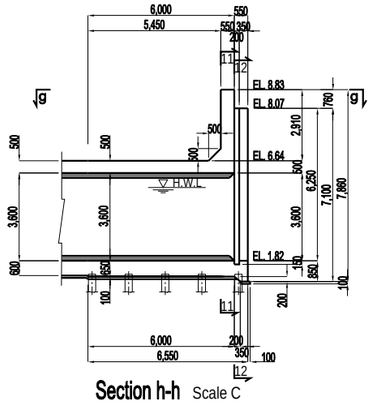
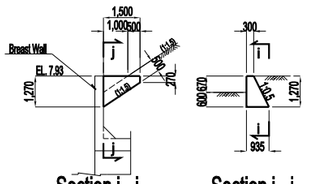


Section 11-11 Scale C

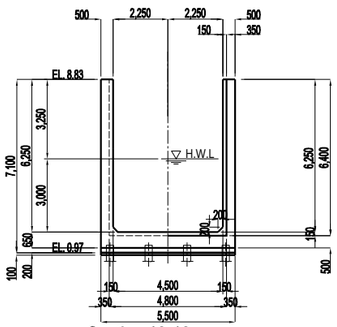


Section h-h Scale C

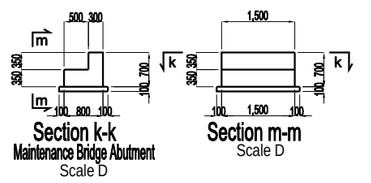


Section i - i
Retaining Wall
(2sets at Inlet & Outlet)
Scale C

Section j - j Scale C



Section 12-12 Scale C



Section k-k
Maintenance Bridge Abutment
Scale D

Section m-m Scale D

Scale A 0 10 20 30 40m
Scale B 0 5 10 15 20m
Scale C 0 5 10m
Scale D 0 1 2 3 4 5m

The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh	Drawing No. DI-SW-004
CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	SALANG DRAINAGE SLUICEWAY (2/2)

2.2.5 Implementation Plan

The issues to be clarified and taken into consideration so as to implement the Project under the Japan's Grant Aid Program are as presented below.

2.2.5.1 Implementation Policy

The implementing agency of the Project is the Department of Public Works and Transport (DPWT) in the Municipality of Phnom Penh and, practically, the Public Works Office will assume responsibility for project management during the construction period. With regard to operation and maintenance of facilities, the Drainage and Sewerage Division and the Flood Control Division will be in charge after the construction and equipment installation.

The construction period is estimated to be 18 months, therefore, if the project is implemented under the Japan's Grant Aid in fiscal year 2002, it should be completed by March 2004. To comply with the above schedule, it is important to note that detailed design work should be accomplished before June 2002 and the competent contractor needs to be selected through a fair and legal tendering process by August of the same year. The construction work will be able to start on condition that land acquisition and relocation of the project-affected people have been properly completed by the implementing agency.

The Project includes construction of a new pumping station, improvement of drainage channels, reinforcement of flood protection dike and so on. No special technique is required for such civil works so it seems to be not necessary to employ skilled workers from Thailand or other neighboring countries, because foreman, machine operators and other workmen to be engaged in road pavement may be locally available. In Phnom Penh, there are 14 to 15 local construction firms, which may be eligible to participate in the Project as subcontractors. However, they are not familiar with equipment installation and adjustment due to lack of experience. It will be, therefore, necessary to dispatch Japanese experts/engineers to Cambodia to ensure that works are properly performed in accordance with plan and design.

2.2.5.2 Implementation Conditions

Based on the implementation concept presented above, the following conditions should be fully considered for the smooth implementation of the Project.

(1) Relocation of Project-Affected Households

The relocation site for project-affected households is an unavoidable condition for the Project to be implemented in fiscal year 2001. Access road, water supply and other necessary infrastructures should be provided before the cabinet meeting for Grant Aid, which is scheduled in December, and eviction of people from the site should be in progress before the conclusion of Exchange of Notes, which may be in January 2002.

To implement the relocation plan, first of all a resettlement committee needs to be established by the departments and agencies concerned in the Municipality of Phnom Penh. Then, a working group shall be organized by DPWT and related districts to conduct a questionnaire as well as inventory survey with the affected households at an early stage possible. Thereby, information will be made available to evaluate public awareness and assets of each family for compensation.

According to the schedule submitted by the Municipality, compensation negotiation with residents will be conducted in July and November 2001. Based upon the above negotiation, the relocation plan should be approved without any delay, and it is expected that budget allocation will follow in November 2001 and March 2002, respectively. In view of the present situation, the Municipality intends to split the relocation period into three phases since it is considered as a more realistic measure for the implementation.

Relocation planning is hardly achievable without determining the boundary of land to be acquired. In addition, if financial capability of the Municipality is considered, it seems to be too difficult to extract fund from its annual budget for the compensation to the affected households. This situation will certainly cause the delay to realize house evacuation. Under the present circumstances, the project boundary can be pre-determined on the basis of existing aerial photos and topographic maps, and the study on public awareness as well as willingness can also be conducted by means of questionnaire. If the output of these works reflects successfully on acquisition of relocation site and budget allocation, some people can move from the required land within this fiscal year.

Needless to say, the relocation would be subject to the consent of each affected household. For the smooth negotiation with residents, it will be important to provide a compensation fund for their evacuation and the resettlement site with basic infrastructure. In this regard, the target people are the residents in and around the proposed pumping station and those living along the drainage channels to be improved. About 90% of them are likely to be squatters or illegal occupants.

With reference to the "Phnom Penh Water Supply and Drainage Project" that the Municipality is now undertaking with ADB financing, the project-affected people were required to relinquish their lands for the construction of the Boeng Trabek drainage channel and pumping station, and the following conditions were applied to the relocation compensation.

Households on canal and canal bank

- Relocation grant (US$100)
- Nuisance compensation, or family headed by a widow or having a disable person (US$200)
- Resettled house reconstruction (US$100)
- Land plot in resettlement site (8m x 18m)

Households in area required for pumping station

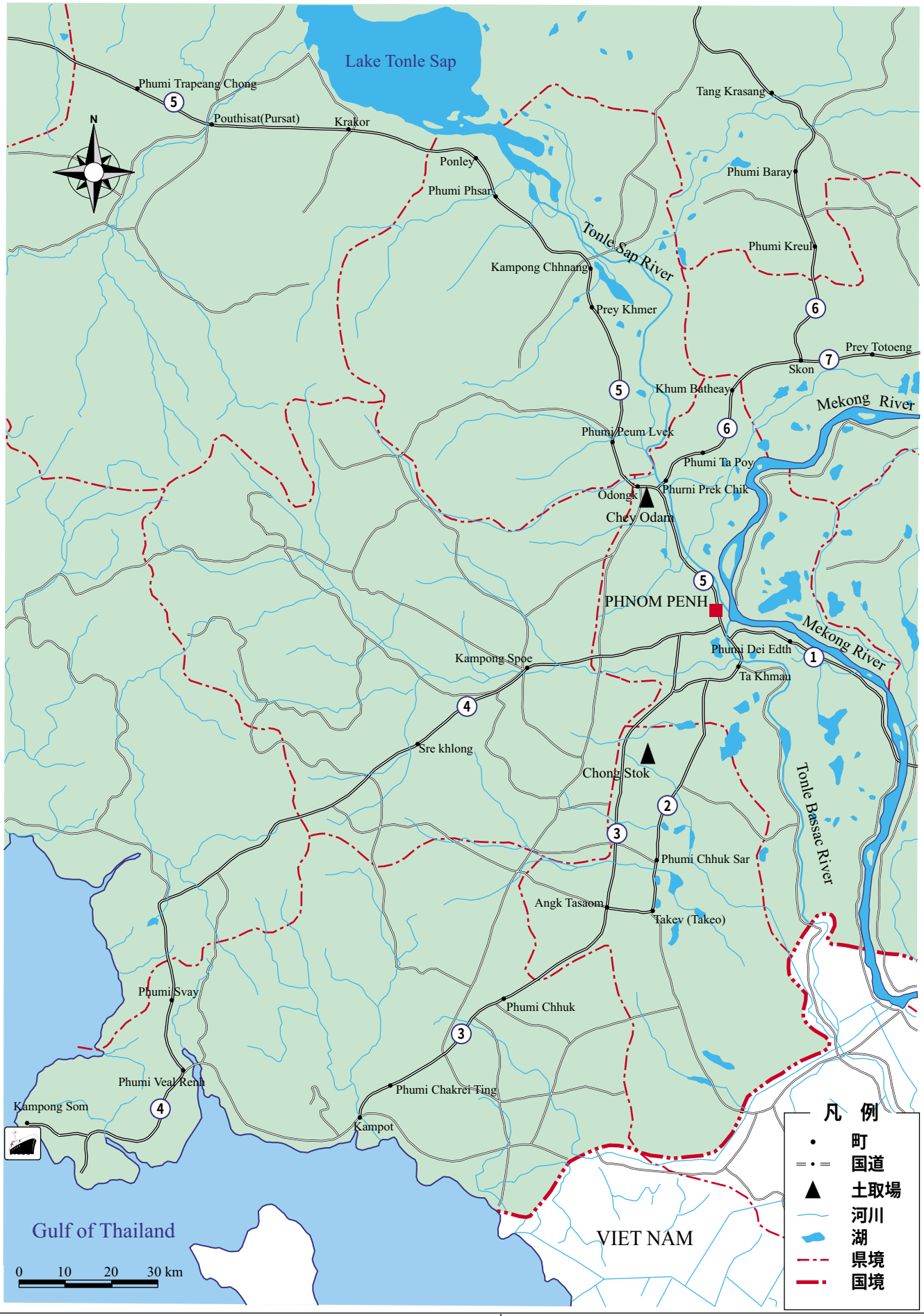
- Relocation grant (US$200)
- Nuisance compensation, or family headed by a widow or having a disabled person (US$200)
- Land acquisition compensation
- Residential property compensation (house, cash crop, trees, well, etc.)
- Land plot in resettlement site (8m x 18m)

Furthermore, the Municipality obtained the cooperation of UNCHS on the construction of communal wells and latrines in the resettlement site. it also undertook transport of household effects connected with the removal of affected families. The same conditions may be adopted in the relocation plan for this Project.

(2) Environmental Considerations

(a) Borrow Area

In selecting the appropriate location of the borrow area, the environmental impact to residents resulting from noise, dust and traffic needs to be considered. Two (2) sites have been chosen as indicated in Fig. 2.2.16, namely, Chey Odam located at about 50 km north on national route No.5 from Phnom Penh City, and Chong Stok located at about 50 km south on national route No.2 or No.3 from the capital.



The Basic Design Study on Flood Protection and Drainage Improvement Project in the Municipality of Phnom Penh

CTIE International Co.,Ltd.-Nippon Koei Co., Ltd.

Fig.2.2.16

Inland Route for Equipment and Construction Material

(b) Spoil Area

As mentioned in the feasibility study report, the spoil area will be the proposed reclaimed land over an extensive swampy area in the north of Tompun Pomping Station. The Municipality agreed that this area could be used as spoil area for excavated materials produced by the construction of required facilities. The total volume of spoil material is estimated at 230,000 m^3, which is just enough volume of soil to reclaim about 15 hectares of land, and part of this land will be used for resettlement site in the future.

It should be noted that the existing drainage channels are under undesirable environmental conditions due to domestic wastewater discharge and leachate from a garbage dumping site located on the left bank of Meanchey Drainage Channel. Sludge deposit in the channel bed contains a detectable quantity of heavy metals such as arsenic (As), cadmium (Cd) and organic phosphate. Although the sediment depth may vary depending upon the location, it is supposed to be 2 m at the deepest. Such sediment has to be removed and dumped into the spoil area as the result of the improvement work of existing channels. In this process, an environment-friendly measure needs to be considered for the treatment of sludge deposit. It should not be transported immediately after excavation but be placed on the side space temporarily in order to reduce water content, and after 5 to 7 days it can be dumped into the spoil area.

(3) Working Days

In Cambodia there are 20 national holidays in a year. If Sundays are additionally taken into account, the annual number of days off will be 72. It is also important to consider rainy days in calculating the total number of suspended days. In general, rainy season starts in May and continues until October. During this period, work efficiency certainly becomes low and work progress will decline as a result. In preparing a proper work schedule, it is absolutely necessary to estimate the reasonable number of work suspension days caused by rain. According to the rainfall data of Phnom Penh City in the last five years, it is figured up at 66 days, subject to the following conditions:

Daily rainfall	Judgment
0≦, < 3mm	Day-long work
3mm≦, <10mm	Half-day work
10mm≦	No work (suspension)

However, a rainy day may happen on Sunday or national holiday so that some adjustment should be required to make the figure justifiable. Thus, the number of annual working days is estimated at 240, accounting for 0.66 of work efficiency rate. This means that monthly-based work performance is expected for 20 days, and when 8 hours of work per day is taken into consideration, total working hours will amount to 160 a month.

(4) Temporary Works

Since temporary works will play a key role in the overall construction planning, careful attention should be given to the traffic conditions, natural and social conditions and environment in the planning and designing stage to facilitate construction works. From the above considerations, it is desirable to take the following measures as temporary works.

(a) Project Office and Yard

Due to the traffic congestion and difficulty in acquiring a suitable office space in the downtown area, the Project Office is planned at the backyard of operation room for the proposed Tompun Pumping Station. The proposed site is marshy at present, so it will be filled up with soil to provide 400 m^2 to 500 m^2 of land for temporary office for the Contractor as well as working yard for iron bar bending and carpentry. In this regard, a space for the Consultant's Office should be provided with the Contractor's one.

(b) Construction of Pumping Station

Since the proposed pumping station is located in marsh adjacent to the existing one, the construction site needs to be dried up in such a way that cofferdam and banking are provided to intercept water inflow. For the placing of drainage pipes, excavation will be required across the Tompun dike and therefore, the road will be cut off for a certain period. As a temporary measure, detour of about 6 m wide has to be built for passers-by during the construction.

(c) Improvement of Drainage Channels and Construction of Bridges

The existing road that connects to the bridge to be reconstructed under the Project can be used as access road to the drainage channel. A 5-m wide road will be provided on both sides of the channel to facilitate excavation and dredging works by machinery. Upon the completion of the work, the road shall be repaired and re-arranged in a proper way for use in channel management. During the construction of bridges over the Meanchey drainage channel, a detour for people shall be constructed by filling soil at

each site to mitigate traffic inconvenience, and concrete pipes need to be installed for the retrieval of drainage function in this connection.

(d) Construction of Sluiceway

When sluiceway is constructed across the dike road, either temporary bridge or detour has to be considered for people to pass. Traffic condition as well as proposed excavation width and depth will be the key points in making a choice of the idea. As a result, it is concluded from the cost and technical reasons that making a detour is a better choice. However, it will increase the number of relocation families even though the detour is temporarily used for the public.

2.2.5.3 Scope of Work

The scope of work for both Japanese and Cambodian sides needs to be clarified before the implementation of the Project. Each side shall assume responsibility for the work set forth in accordance with the principle of Japan's Grant Aid. The scope of work is summarized as follows:

(1) Undertaking of the Government of Japan

- Engineering services including preparation of tender documents, tendering and supervision of construction works;
- Construction and/or improvement of facilities (pumping station, earth dike, drainage canals and sluiceway);
- Procurement of equipment and materials (including sea and inland transportation);
- Equipment installation and test run; and
- Guideline services on operation and maintenance of the equipment procured under the Project.

(2) Undertaking of the Government of the Kingdom of Cambodia

- Relocation of project-affected people from the construction area;
- Land acquisition and preparation of resettlement site;
- Fencing around the pumping station for security reasons;
- Installation of a service electric line from the existing distribution line;
- Removal of unexploded bombs or mines if found before and during the construction;
- Tax exemption and smooth customs clearance for imported equipment and materials supplied under the Project; and

- Smooth procedures for immigration, tax exemption and safety assurance for Japanese experts assigned to the Project.

2.2.5.4 Consultant's Supervision

Since construction sites are dispersed in an extensive area, it is hardly expected that one Japanese engineer could provide supervision services satisfactory to the Client. Therefore, a supervising system needs to be enforced by employing some local civil engineers to ensure that time scheduling and quality control of the work can be achieved effectively. With regard to procurement and installation of the equipment, experts who are specialized in the field of mechanical and electrical engineering will be dispatched to Cambodia according to the implementation schedule.

(1) Main Issues to be Considered

It is definitely important to note that construction supervisors play an important role in handling the Project in a proper way; therefore, they should be competent enough to cope with their specialized field of engineering and technical judgment. In addition, since there are various tasks involved in the supervisory work, consulting engineers are expected to coordinate the Project by making close contact with the Implementing Agency. Major tasks of the supervisors are as follows:

(a) Meeting and Discussion with the Municipality of Phnom Penh and DPWT

Before the commencement of construction, the progress of works to be undertaken by the Cambodian side shall be confirmed through the meeting.

(b) Management of Works Entrusted to a Local Firm

Management and coordination are required for aerial photography, ground survey and other fieldworks, and work output has to be carefully examined to confirm the project boundary.

(c) Inspection for Facility Construction

Field inspection will be required at each construction stage to control work progress, quality of construction and schedule.

(d) Inspection of Equipment and Quality Control Test

Based on test data provided by manufacturer to certify the quality of equipment, mechanical inspection will be conducted according to the manual.

(e) Presence for Work Inspection

Inspection is required to confirm work achievement for the approval of interim payment. Before the completion of the work, instructions shall be given to the Contractor if some works need to be restored as the result of inspection. Furthermore, the supervisor is required to make procedures for the approval of completion of the work.

(f) Issuance of Certificate

Certificate shall be issued to the Contractor for the completion of works according to the payment schedule.

(g) Submission of Reports and Documents

Monthly report and as-built drawings shall be submitted to the Client.

(2) Engineers for the Supervision Services

Some qualified engineers shall be engaged in construction supervision to provide better engineering services for as long as 18 months of construction period. It is planned in such a way that one Japanese engineer will be placed in a position of long-term stay supervisor to maintain consistent services for the whole construction period, and two civil engineers will be locally employed as supporting staff of the Japanese engineer. In addition, some experts will be dispatched to the Project site from time to time according to the schedule for spot engineering services. The engineers for supervision services are proposed as follows:

(a) Team Leader

A team leader is required to attend meetings and negotiations with the Client and/or the Contractor at the commencement and completion of the works. If any problem is encountered, he will take every possible measure to solve it in collaboration with parties concerned. He will also be present in the Project site to provide spot engineering services at the key period in the schedule.

(b) Civil Engineer (1)

The major task is to supervise foundation works for such facilities as pumping station and bridges over the canal. Furthermore, after one (1) year from the completion of the Work he will be assigned to inspect equipment and facility to assure their operation and functions.

(c) Civil Engineer (2)

An engineer specialized in road construction needs to be assigned to the Project for a certain period, particularly, for keeping careful watch on the Tompun dike reinforcement work with asphalt pavement.

(d) Civil Engineer (3)

He will be assigned for a long-term stay as supervisor and is expected to dedicate himself to the quality control and management of schedule and other necessary works under the responsibility of the Consultant.

(e) Mechanical Engineer

The mechanical engineer will be dispatched to the Project site at the time of installation of pumps and shall give instructions to the Contractor on how to set up each equipment in a proper way. He will also be required to inspect test running and approval if the result is satisfactory.

(f) Architect

At the construction of the Pump Operation/Control House, an architect shall be present at the site to keep careful watch on work performance and quality. He is further required to give instructions to the Contractor on the installation of utilities.

2.2.5.5 Procurement Plan

Although there is no lease company dealing with construction machinery in Cambodia, machinery could be available from local contractors or foreign construction firms (Korean contractors, for instance). In case local availability is difficult, it can be procured from neighboring countries such as Thailand and Vietnam. In any case, there is no need to import machinery all the way from Japan.

A cement plant can be seen at Kampot located about 150 km south from Phnom Penh. However, the production capacity is limited to meet a large order. On the other hand, Siam cement, a Thai product, has a good reputation for both quality and quantity to satisfy the demands in Phnom Penh.

There are four (4) ready-mix concrete suppliers in the capital city (CPAC, GCM, CHZENG YI, UY HENG), all of which have been established with foreign investment. Under these circumstances, the ready-mix concrete would be commonly used in the construction site in Phnom Penh. Among the concrete suppliers mentioned above, CPAC established with Thai capital is considered to be the most reliable company covering nearly 70% of the local market.

With regard to reinforcing bars and steel material, the products of Thai origin are widely used in the country. Vietnamese iron bars are also available but used to be not guaranteed product for their quality. However, the quality has been improved in recent years since Japan-Vietnam Joint Corporation was established. Despite these facts, Thai-made products are still predominant over the country.

As for equipment procurement, it is important to realize that drainage pumps are not manufactured in Cambodia, and no agent of foreign manufacturer in this field exists in the country. Therefore, besides Japan, Europe, US and China will be considered as source countries. However, the quality cannot be assured on Chinese products, and there seems to be no difference in price and quality between the products of the other countries. If procurement is further discussed for the benefit of the Client, it will be of great advantage to procure the pumps from Japan in terms of availability of after-sales services, since a qualified engineer(s) can standby at anytime in a neighboring country.

Imported equipment will be unloaded at the Port of Kampong Som, the sole international port in Cambodia located about 250 km southwest from Phnom Penh. After customs clearance, it will be transported to the Project site through national road No.3 or No.4 (refer to Fig.2.2.16).

2.2.5.6 Quality Control Plan

The quality of main construction materials and construction works is controlled under the following conditions:

(1) Concrete

Concrete shall have the specified strength, durability and water tightness, and dispersion of quality of concrete shall be small. The standard strength of concrete shall be based on 28-day Compressive Strength. The method of compressive strength test shall satisfy JIS A1108, 1132.

The sample of mixed concrete shall be picked from every 50 m^3 of concrete, and the strength tests of 3 days, 7 days and 28 days shall be carried out for every sample. At the time of concrete placing, slump test shall be carried out in site and slump value shall be confirmed that it is less than the specified value. Since the concrete placing works is performed in the tropics, temperature control of concrete shall be performed adequately and temperature of pouring concrete at the time of placing shall be lower than the provided temperature.

(2) Placing and Curing of Concrete

Concrete shall be placed with the method that can possibly avoid the separation of materials, and adequately compacted with the vibrator at placing and immediately after placing. After the placing of concrete, the surface of concrete shall be kept wet for at least 5 days.

(3) Cement

Portland cement shall be used for construction and its quality shall conform the JIS R 5210.

(4) Aggregate

Aggregate shall be clean, strong and durable, and shall have adequate grain size. Aggregate shall be confirmed that it does not include contaminations such as dust, sludge, organic substance, salinity and so on. Especially, fine aggregate shall not include thin or slender piece of stone.

(5) Reinforcing Bar

Reinforcing bar shall have specified strength. Deformed bar shall be used as reinforcing bar in case of not specified. The material test of reinforcing bar shall be carried out according to instructions of the Engineer before using.

(6) Storage of Reinforced Concrete Material

In case of storing the materials of reinforced concrete, the storage method shall follow the Japanese Concrete Standard Specification.

(7) Embankment

Dike embankment shall be safe for not only stability but also filtration flow while flooding. Therefore, the material of dike embankment shall be compacted until specified hardness by the specified method.

2.2.5.7 Implementation Schedule

The Project will be implemented under the Japan's Grant Aid after the Exchange of Notes has been concluded between the Government of Japan and the Government of the Kingdom of Cambodia. The Project begins with detailed design study immediately after signing the contract for consulting services. It requires 6.5 months including engineering design service, preparation of tender documents and tender administration.

The total construction period will be 18 months including civil works, equipment procurement and installation. It should be noted that work efficiency for civil works may be lower during the six months of rainy season starting from May, and consequently, it is desirable to prepare the schedule in such a way that earthwork is minimized in the rainy season; instead, concrete placing and equipment installation works can be carried out.

As a precondition for the Project implementation, the Municipality of Phnom Penh shall take the initiative in removing people from the Project site before the commencement of construction works.

2.3 Obligations of Recipient Country

2.3.1 Resettlement of Inhabitants

The inhabitants living in the project site shall be relocated to resettlement areas before the commencement of the construction works in order to smoothly implement the project. Since the agency responsible for the project is the Municipality of Phnom Penh (MPP), the works related to relocation and resettlement are to be executed by MPP.

The relocation and resettlement work shall be done in accordance with the following procedures:

(1) Establishment of Resettlement Committee (established on May 17, 2001)

(2) Establishment of Relocation Plan (established in June, 2001)

(3) Preparation of Resettlement Areas

(4) Setting the Project Site and Publicity (started in July,2001)

(5) Questionnaire Survey (started in July,2001)

(6) Negotiation of Compensation (started in October,2001)

(7) Request of Budget for Compensation and Resettlement (requested on May 21,2001)

(8) Decision of Budget Allocation

(9) Payment of Compensation and Relocation

The compensation for relocation shall be decided in accordance with the standard of MPP and all relocation works mentioned above should be completed before the start of the project.

2.3.2 Land Acquisition

Almost all the project site is public land and only a small part is privately owned. After the setting of the project site, privately owned land shall be confirmed and purchased.

2.3.3 Cost Borne by the Recipient Country

The project cost borne by the recipient country is estimated at about 640,000 US dollars. The breakdown is presented in the Table 2.3.1.

Table 2.3.1 Project Cost Borne by the Recipient Country

Item	Cost (US$)
(a) Compensation and Relocation	370,000
(b) Purchase of Land for Resettlement	215,000
(c) Commission of Authorization to Pay	4,170
(d) Fence around New Tompun Pumping Station	30,000
(e) Construction Works for Lead of Power Line	20,000
Total	639,170

2.4 Project Operation Plan

Operation and maintenance (O&M) of facilities will be undertaken by the DPWT of the Municipality. The structure of each organization is presented in Fig.2.4.1 and Fig.2.4.2 respectively. There are four (4) deputy directors in DPWT, each managing its own responsible Office or Division(s). Particular attention should be paid to the Drainage and Sewerage Division, which will be directly concerned with the Project in terms of O&M of the city's drainage pumping stations. As of the end of March 2001, the number of personnel belonging to this Division is 98 accounting for about 20% of the total of DPWT. As far as Tompun pumping station is concerned, there are eleven (11) staff members at present being engaged in O&M, and there seems to be no need to increase the number of O&M staff for the post-construction stage. Although commercial electricity is currently used as a power source, generator was also used for a certain period in 1999, so they will be able to cope with either power supply system from their past experiences. However, it is absolutely necessary that after the equipment installation, the Contractor should provide technical guidance services to the local staff with the aim of transferring O&M technology.

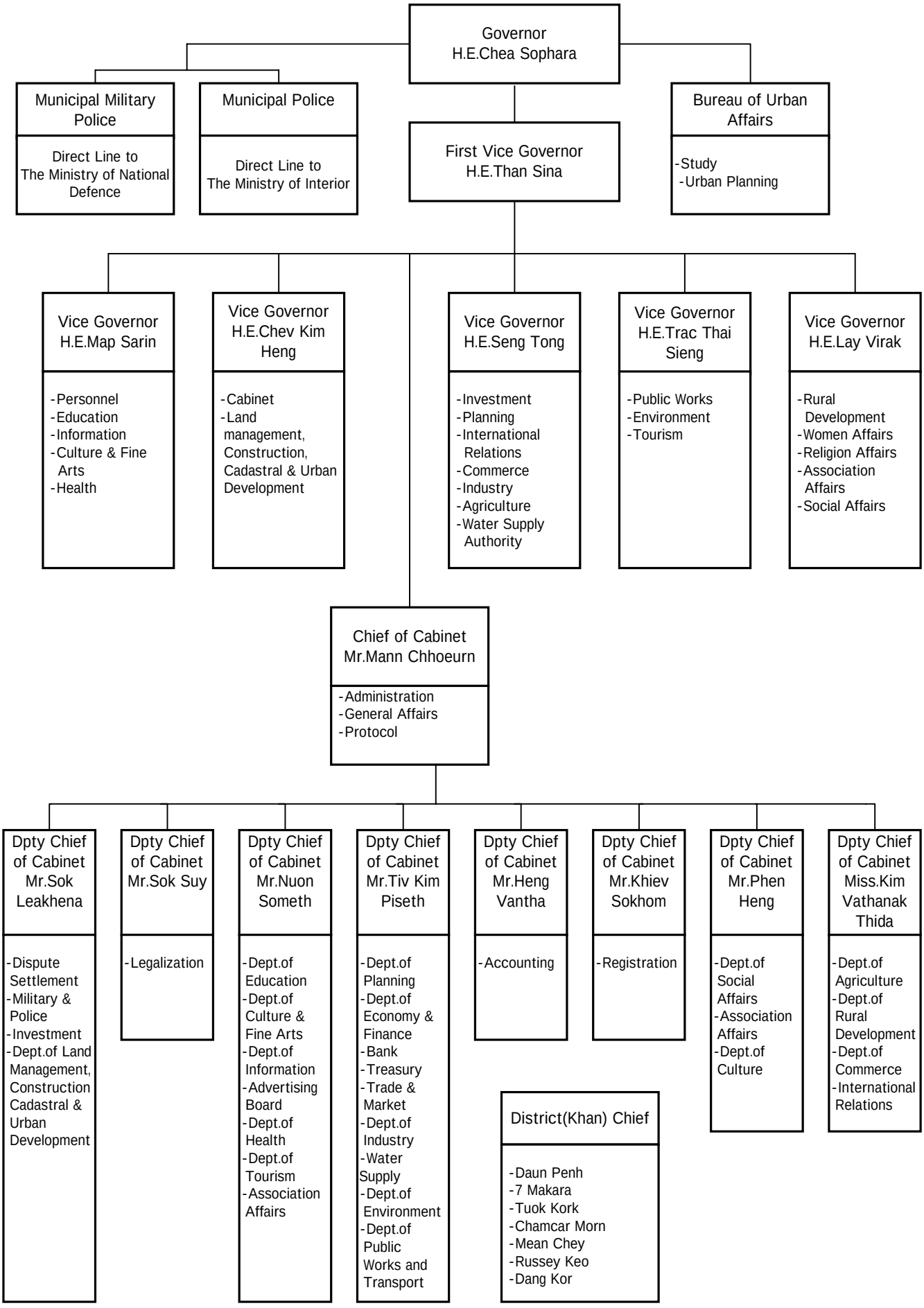


Fig. 2.4.1 ORGANIZATION CHART OF MUNICIPALITY OF PHNOM PENH

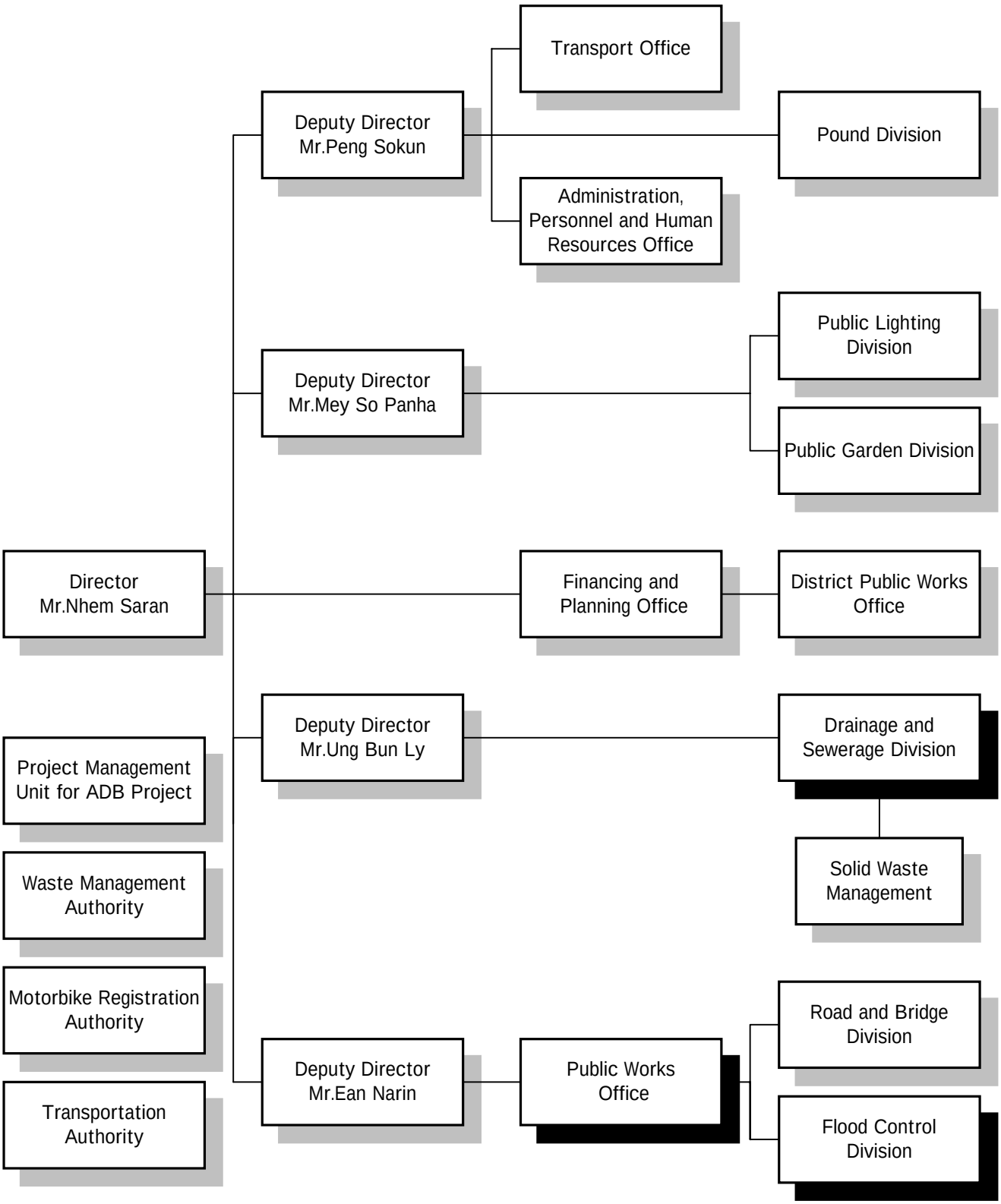


Fig. 2.4.2 ORGANIZATION CHART OF DEPARTMENT OF PUBLIC WORKS AND TRANSPO RT

This year, DPWT established the Flood Control Division to take charge of O&M for Kop Srov and Tompun flood protection dikes. It started with 15 personnel for the first year including three (3) engineers. The number of staff is still insufficient to deal with work that should be done properly, so it will be gradually increased to meet the requirements and may reach 30 personnel in total in the year 2004 when the construction is completed. The dikes provide double functions as a public road and flood protection for the inhabitants, but it also serves as a place of emergency evacuation from flood. From the above considerations, an appropriate O&M method needs to be discussed in cooperation with the Road and Bridge Division and other related agencies. The total number of DPWT personnel is 499 as of March 31, 2001. The details are given in the Table 2.4.1.

Table 2.4.1 DPWT Personnel

No.	Description	Total of Gov't. Staff	Engineer & Architect	Contractual Workers
1	Director of the Board	5	1	-
2	Admin. Personnel and H.R Office	22	-	-
3	Public Works Office	42	19	-
4	Financing and Planning Office	14	1	-
5	Transport Office	57	-	38
6	Districts Public Works Office	23	-	-
7	Pond Division	21	1	-
8	Public Lighting Division	31	1	-
9	Road and Bridge Division	77	7	136
10	Public Garden Division	94	3	426
11	Drainage and Sewerage Division	98	6	134
12	Flood Control Division	15	3	-
Total		499	42	734

Source: DPWT as of March 31, 2001

DPWT owns 24 units of heavy machinery such as bulldozer, loader, backhoe, grader, roller, dump truck and so on. These are in the custody of both Road and Bridge Division and Drainage and Sewerage Division and can be used for O&M services upon request. However, about half of them are said to be in unfavorable condition due to the expiration of service life. Particularly, 10 units of Russian equipment will need to be replaced by new ones because these were procured over 15 years ago, thereby having mechanical trouble frequently.

Although periodical inspection is an unavoidable task for the management and maintenance of flood protection dikes, DPWT has no vehicle of its own so that the staff is obliged to use privately owned cars for proper performance of their duties. In consideration of the importance of flood disaster prevention, the Flood Control Division is required to maximize its capability for O&M of facilities. In view of these circumstances, DPWT should take an appropriate measure to improve the O&M method emphasizing the necessity of renewal of the above machinery as well as procurement of vehicles for maintenance.

With regard to O&M cost, it is estimated at 500,000 US dollars a year, an increase of 191,000 US dollars over the 1999-based O&M cost. The breakdown is presented in the Table 2.4.2.

Table 2.4.2 Annual Operation and Maintenance Cost

(Unit: US Dollar)

Item	Before Project Implementation	After Project Implementation
Tompun Pumping Station	120,000	284,000
Other Pumping Stations in Phnom Penh	189,000	189,000
Maintenance Road along Channels	-	15,000
Drainage Channels	-	3,000
Tompun Road	-	9,000
Total	309,000	500,000

Note: O&M cost does not include personnel expenses and figures of "Before Project Implementation" are based on 1999-based record of DPWT

The increase in O&M cost is mainly attributable to the charge of electric power consumption in Tompun Pumping Station. For the maintenance road along drainage channels, O&M cost is calculated for 15 days of machinery work in connection with road maintenance and 10 days of manpower work for side ditch cleaning. As for drainage channels, it includes the cost of manpower for cleaning about 1 km of Meanchey channel and 400 to 500 m of Salang channel. This is based on the idea that the entire retrieved channel can be cleaned up in two or three years. The cost required for the maintenance of Tompun road is figured out to cover expenses for partial repair of slope and pavement.

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

3.1 Project Effect

The project effect concerning flood control, urban drainage improvement and dike crown road improvement are as summarized below.

3.1.1 Direct Effect

(1) Effect of Flood Control

The Tompun Dike was constructed to protect Phnom Penh City from floods of southern rivers. The lowest elevation of the crown level is EL.9.72 m. In October 2000, the rivers south of Tompun Dike flooded and the water level outside of the dike rose to EL.9.29 m with only about 40 cm to the dike crown.

Once floodwaters overtop Tompun Dike, the dike could collapse resulting in enormous flood damage including about 5,200 units of residential houses, 400 units of factories, shops and offices (1998 survey) or the Pochentong International Airport.

To prevent such damage, the crown level of the dike is to be raised to EL.10.40 m to have enough clearance of 1.10 m for the design high water level of EL.9.30 m, which is equivalent to about 30-year probability.

As a result, the safety against the flooding of 30-year probability should be secured.

(2) Effect of Urban Drainage Improvement

The catchment area of the Meanchey and Salang drainage channels is 17.47 km^2. The improvement of the downstream stretches of both Meanchey and Salang drainage channels and the construction of New Tompun Pumping Station will protect the downstream area of both drainage channels (7.87 km^2) from storm rainfall of less than 5-year probability and remarkably reduce inundation damage caused by storm rainfall of more than 5-year probability.

Further, as for the upstream area of both channels (9.60 km^2), inundation duration will become drastically shorter than without the project resulting in the reduction of inundation damage. The implementation of this project should bring the reduction of inundation damage

by inland water to 34,000 units of residential houses, 1,200 units of factories, shops and offices (1998 survey) in the catchment area of both Meanchey and Salang drainage channels.

(3) Effect of Dike Crown Road Improvement

Presently the crown road of Tompun Dike of about 4.3 km in length is not paved and the road is devastated. Even in dry season, it is almost impossible for any vehicle to pass on the road except four-wheel drive cars and large trucks. In rainy season, even large trucks could hardly pass. The crown road of Tompun Dike will be paved in this project to make it easier for any vehicle to pass.

Many factories are located along the crown road and a large number of workers commute through the road by motorcycle. Presently, it takes around 20 minutes for motorcycles to pass the road even in dry season. After the improvement works are completed, it will take only 4 or 5 minutes in either dry or rainy season to negotiate the road.

It is expected that the usefulness of the road would be improved by the implementation of the project resulting in remarkable increment of traffic volume.

3.1.2 Indirect Effect

(1) Economic Effect

As the indirect effect of improvement of flood control facilities, this project will contribute to protect the occurrence of economic damage by the closure of Pochentong International Airport, which is the international airport of the capital and the terminal airport for tourists to the Angkor Wat ruins.

As the indirect effect of improvement of urban drainage facilities, this project will contribute to reduce economic damage to be caused by storm water inundation.

(2) Health Effect

As the indirect effect of the project to urban drainage facilities, the prevention of occurrence and spread of epidemics due to long duration of inundation is expected.

3.2 Recommendations

3.2.1 Before the Commencement of the Construction Works

(1) Land Acquisition and House Evacuation

Presently there exist many houses in the project sites and almost all of them occupy the site irregularly. To evacuate these houses before the commencement of the construction works and to acquire the project sites shall be given first priority.

It is required of the responsible agency of the municipality of Phnom Penh to establish a task force to expedite necessary procedures to accelerate land acquisition and house evacuation or to secure the necessary budget.

(2) Preparation of Relocation Site

To implement house evacuation smoothly, it is important to secure relocation sites and to provide infrastructures (road, electric power supply system, water supply system, sanitary system, school, etc.) at the relocation sites. The Municipality of Phnom Penh should ask assistance of UNCHS (United Nations Centre for Human Settlements) for the provision of the infrastructures.

3.2.2 During Construction Works

(1) Countermeasure for Environmental Issue

Since the construction works are to be conducted in residential areas, noise, vibration or traffic accident by construction equipment during the construction period shall be prevented. To prevent spilling out during transportation to spoil banks, the excavated material loaded on dump trucks should be covered with sheets.

Excavated material from the existing drainage channels shall be deposited temporarily at the excavation site to reduce water content. Excavated material shall be transported to spoil banks after water content is confirmed reduced.

(2) Countermeasure for Flooding and Water Control

The construction work within drainage channels are to be conducted in dry season. However, flooding of drainage channels might take place even in dry season and wastewaters

always flow into the channels. Therefore, temporary facilities for dewatering or flood protection shall be planned.

(3) Construction Works within the Tompun Regulation Pond

For the construction work of Inlet Channel in Tompun Regulation Pond, a temporary road shall be constructed first. Since the regulation pond reserves water throughout the year and contains sludge deposit, the foundation soil condition is unsteady. Therefore, the construction work in the regulation pond can be done only in the dry season and the construction period is limited. Reliable temporary road shall be constructed in the regulation pond.

3.2.3 After Construction Works

(1) Operation, Maintenance and Management of Facilities

Appropriate operation, maintenance and management of the planned flood control and urban drainage facilities are indispensable to bring them into full function as designed. Enough numbers of staff and budget are important for that purpose. The facilities to be constructed by the project are to be managed by the Department of Public Works and Transport (DPWT) of Phnom Penh City, and DPWT has an organization and enough experience for operation and maintenance of such facilities. Further, a new section for management of flood control facilities was established this year 2001 in DPWT. Enough funds shall be provided for the relevant organizations.

(2) Revenue Source for Management of Facilities

The Municipality of Phnom Penh has two revenue sources: one is 10% of income of tariff of municipal water supply and the other is real estate tax, and car and motorbike tax, which are to be placed under municipality control from this year 2001. A part of such revenue shall be shared for the budget of management of facilities to be constructed by the project.