PART B DETAILED DESIGN REPORT
(VOLUME I-3: DESIGN REPORT)

CHAPTER 1 GENERAL DESCRIPTION

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1.1 General

This Design Report is a part of Interim Report (3) which consists of six volumes, such as Design Report, Construction Planning Report, Brief Project Implementation Plan Report and Operation and Maintenance Plan Report, Bill of Quantity and Drawings. The detailed information other than this reports shall be referred to other volumes of the reports.

The scope of this detailed design is limited only Stage I Water Conveyance Infrastructures as indicated in the following table and that of Stage II will be conducted by the NSDO in future.

1.2 Outline of Facilities in the Subject Design Section

Major facilities and its quantities for the conveyance canal design section are listed as following table.

Tender Package	Location	Major Facility	Length (m)	Appurtenant Structures
1st Package (KM86.50 – KM108.47)	KM86.50 – KM 94.30	-No.1 open canal	7,800	-8 units of sand settling box -1 unit of bridge
	KM94.30- KM 101.80	-Box culvert	7,500	-1 unit of sand settling box
	KM 101.80- KM108.47	-No.2 open canal	6,670	-1 unit of bridge -7 units of sand settling box
		-No.1 access road	1,000	
		-No.2 access road	2,800	
		-Spillway	100	-2 units radial gates -2,100m outlet channel -1,720m dyke
2nd Package (KM108.48 – KM118.56)	KM 108.48- KM108.86 (KM108.47)	-Sand settling basin	380	-Two units of roller gates
	KM108.86- KM108.99	-No.7 pumping station	130	-4 units of main pump and 13,000 kw motor

	KM108.99- KM118.36 KM118.36-KM118.56	-Delivery pressured pipelines -Discharge tank -No.3 access road	9,349 200 5,060	-2,100 sq.m building -4 units of flow meters -3rows of steel pipe with 2.400 mm and 3 unit x 2 place of one way surge tanks -1 unit of discharge tank
3rd Package (KM118.56 – KM132.50)	KM118.56-KM132.50	-3rd open canal	13,940	-3 units of bridge -14 units of sand settling box
4th Package (At KM108.97)		-Main Substation -Substation building -Administration building		-4 unit with 25MVA transformer -1,344 sq.m building -576 sq.m building
Total			46,000m (Canal length)	

1.3 Design Standards

Basic design standards applied in the detailed design are summarized as follows and detailed information shall be referred Interim Report (2) and respective sections of this reports.;

- Hydraulic design : Bureau of Reclamation, USA, Egyptian standards and Japanese standards
- Structural design for civil and building works : Bureau of Reclamation, USA, Egyptian standards as well as Egyptian Code of Practice 1994(ESS) and Japanese standards
- Structural design for mechanics : ISO (International Organization for Standardization) and IEC (International Electro-technical Commission)
- Structural design for electric : IEC

1.4 Contents of the Report

This report contain the six chapters, five appendixes and four annexes and, describe the results of computation and analysis for the detailed design of conveyance canal and appurtenant structures.

Chapter 1 describes general information of the study works including summary of facilities to be covered in the design section and applied design standards.

Chapter 2 and 3 are summarized the results of computation and analysis for hydraulic design of various facilities, stability analysis of the canal dyke and foundation design of No.7 pumping station.

Chapter 4 indicates structural design computation of civil and building facilities, and estimates suitable capacity and design of mechanical and electrical equipment. The optimum sizing of overall related facilities (conveyance canals, pumping station, delivery pressured pipeline, access road and substation and related mechanical and electrical equipment) also were discussed in this chapter.

Chapter 5 describes summarized main and appurtenant equipment list and capacity including appropriate size design of appurtenant equipment.

Chapter 6 indicates appropriate capacity designing of main, auxiliary substation and buildings including administration building. Implementation of this part will be taken by the authority of REA through NSDO request.

The appendixes was compiled dividing into five aspects, such as Appendix A of Hydraulics, Appendix B of Stability Analysis, Appendix C of Structures and Appendix D of Equipment describing detailed of the results of technical analysis and examinations. In addition to the above, Appendix E of Minutes of Meetings is included to clear process of the discussions.

The annexes consist of four(4) volumes are compiled as "data book" which binds the results of computation regarding Hydraulics (Annex A), Stability Analysis (Annex B), Structural Design (Annex C) and Equipment (Annex D). Copies of the annexes, however, will be made only limited volume (two volumes) as supplemental documents.

CHAPTER 2 HYDRAULIC DESIGN

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2.1 Hydraulic Design Conditions

2.1.1 Design Discharges

Based on the Stage Development Plan, the required discharges of each monthly and stage for the conveyance canal are given in the following table.

Table 2.1-1 Water Demand Projection (Unit : m^3/sec)

Month	Stage I			Stage II			Grand Total
	Irrigation	Industry	Total	Irrigation	Industry	Total	
Jan.	10.74	2.96	13.70	6.32	2.82	9.14	22.84
Feb.	12.69	2.96	15.65	7.46	2.82	10.28	25.93
Mar.	14.40	2.96	17.36	8.47	2.82	11.29	28.65
Apr.	12.42	2.96	15.38	7.30	2.82	10.12	25.50
May	11.95	2.96	14.91	7.03	2.82	9.85	24.76
Jun.	20.00	2.96	22.96	11.76	2.82	14.58	37.54
Jul.	**29.52**	**2.96**	**32.48**	**17.36**	**2.82**	**20.18**	**52.66**
Aug.	24.63	2.96	27.59	14.49	2.82	17.31	44.90
Sep.	12.42	2.96	15.38	7.30	2.82	10.12	25.50
Oct.	5.61	2.96	8.57	3.30	2.82	6.12	14.69
Nov.	5.13	2.96	8.09	3.02	2.82	5.84	13.93
Dec.	8.79	2.96	11.75	5.17	2.82	7.99	19.74
Average	**14.02**	**2.96**	**16.98**	**8.25**	**2.82**	**11.07**	**28.05**

Source: JICA F/S report 1997.

Table 2.1-2 Discharge by Stage (Unit : m^3/sec)

Discharge	Stage I	Stage II	Total
Irrigation Water (GIA)	29.52 (85,000 fed.)	17.36 (50,000 fed.)	46.88 (135,000 fed.)
Industrial Water	2.96	2.82	5.78
Required Discharge	32.48	20.18	52.66

Note; GIA: Gross irrigation area.

The beneficial area is to be developed in two stages. The design discharge of the Stage I is 32.48 m^3/sec and the design discharge of the full development in Stage II is 52.66 m^3/sec. The design discharge of the conveyance canal that is agreed upon and decided between NSDO and the Study Team are as follows:

Table 2.1-3 Design Discharge

Conveyance Canal	Stage I	Stage II
No.1, No.2 & No.3 Open Canal and Box Culvert Sections	52.66 m^3/sec	–
No.7 Pumping Station and Pipeline	32.48m^3/sec	52.66m^3/sec

Note : For location of open canals, box culvert, etc., see Figure 2.1-1

The increase of the design discharge of No.7 pumping station and pipeline will be coped with the development progress of the beneficial area.

The minimum design discharge is that of the minimum monthly water demand occurring in November and is given in the following table.

Table 2.1-4 Minimum Design Discharge (Unit : m^3/sec)

Discharge	Stage I	Stage II	Total
Irrigation Water	5.13	3.02	8.15
Industrial Water	2.96	2.82	5.78
Min. Design Discharge	8.09	5.84	13.93

The most frequent discharge could be defined as the mid-value of monthly discharges in descending or ascending order, and it occurs in April and September as follows;

Table 2.1-5 Most Frequent Discharge (Unit : m^3/sec)

Discharge	Stage I	Stage II	Total
Irrigation Water	12.42	7.30	19.72
Industrial Water	2.96	2.82	5.78
Most Frequent Discharge	15.38	10.12	25.50

2.1.2 Hydraulic Conditions

(1) Beginning Point

The beginning point was discussed at the commencement of the detailed design study and confirmed as the point of the KM86.5 on El Sheikh Gaber Canal from Suez Canal Siphon as follows;

Point : KM86.5 from Suez Canal Siphon
Latitude : 30° -59'-42" N
Longitude : 33° -07'-27" E
Full Water Supply Level : EL.13.64 m after Stage II development

This KM point coincides with the original plan made by the Egyptian side and the JICA F/S report followed this point. However, the modification of canal alignment of the preceding canal under construction in Bir El Abd Zone and the consequent change of the full supply water level has been made. Therefor, the coordinates and the full water supply level are different from the F/S report although the KM length is same as the report.

(2) End Point

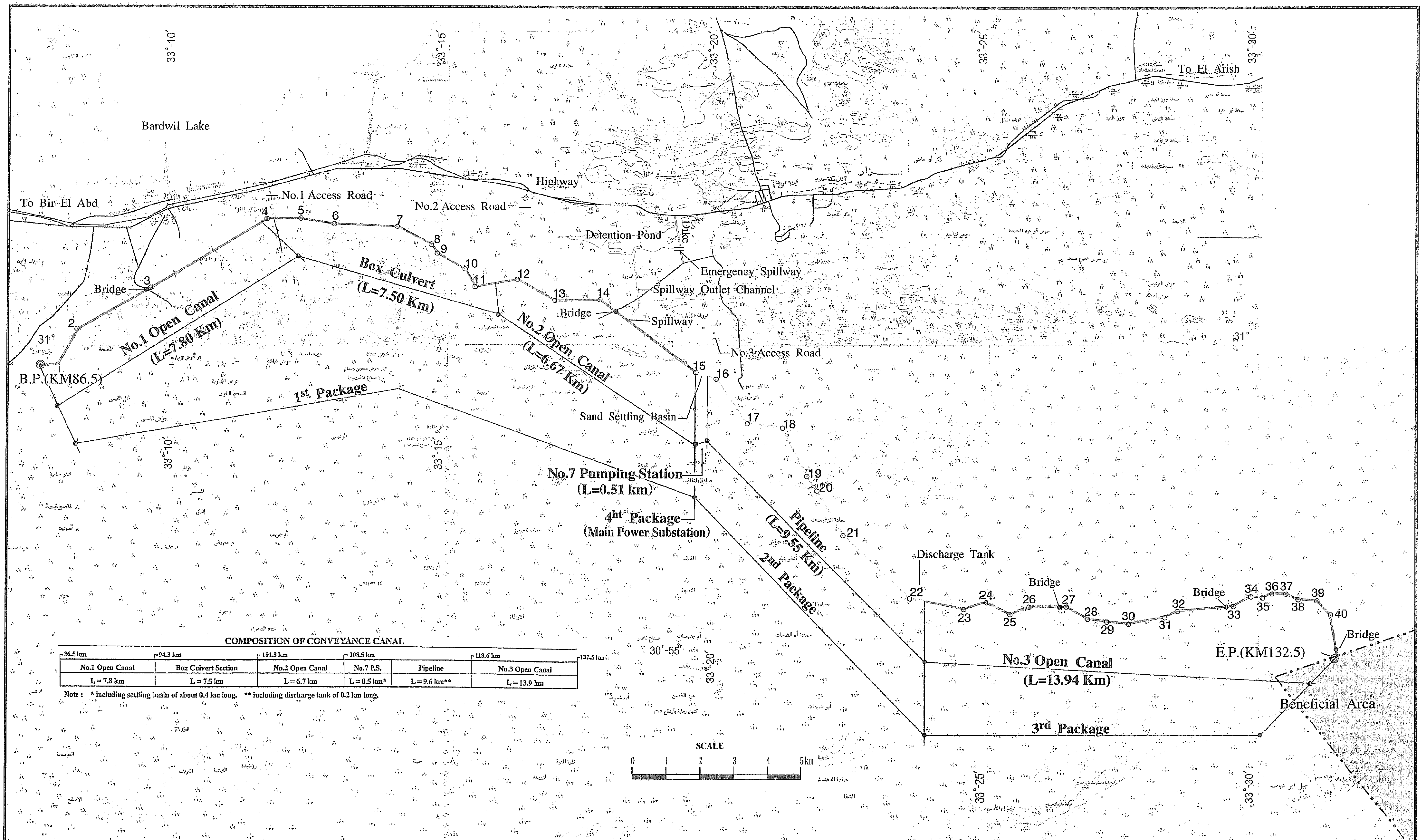
The full water supply level at the end point of the conveyance canal was determined at EL 90 m for Stage I development so as to guarantee the water supply to the gross irrigation area of 85,000 feddans partially with some small scale re-lifting pumps. The elevation of the ground surface at the end point was selected at the approximately same elevation of the full water supply level. Therefor, the end point of the conveyance canal was selected at the point of intersection of the elevation 90 m contour line and the northwestern boundary of the beneficial area.

End Point :	KM 132.50 from Suez Canal Siphon
Full Water Supply Level :	EL. 90 m for Stage I development

The surveyed coordination of the end point will be as shown below.

Latitude : 30° -55'-03" N

Longitude : 33° -31'-28" E



COMPOSITION OF CONVEYANCE CANAL

86.5 km	94.3 km	101.8 km	108.5 km		118.6 km – 132.5 km
No.1 Open Canal	Box Culvert Section	No.2 Open Canal	No.7 P.S.	Pipeline	No.3 Open Canal
L = 7.8 km	L = 7.5 km	L = 6.7 km	L = 0.5 km*	L = 9.6 km**	L = 13.9 km

Note : * including settling basin of about 0.4 km long. ** including discharge tank of 0.2 km long.

Figure 2.1-1 Route Map of the Conveyance Canal

2.2 Water Head Allotment of Conveyance Canal

(1) General Consideration

The profile of the conveyance canal shall be decided in due consideration of the following items;

1) The invert slope of the open canal between BP (Suez Canal) and KM 86.5 is 8 cm/km=1/12,500. The invert slope of the open canal (No.1, No.2 and No.3 Open Canal) shall ensue the velocity to avoid sand deposition in the canal bottom.
2) The velocity of the culvert box shall be more than 1.2 times of the velocity of the open canal to provide the economic conveyance canal system.
3) The profile of the conveyance canal shall cope with the topographic profile so as to minimize the construction cost.

(2) Invert Slope of the Open Canal

In order to prevent sand deposition in the open canal, the hydraulic gradient should be decided in consideration of the minimum velocity to ensure the transport capacity. The minimum discharge is given at 8.09 m^3/sec in Stage I development as described in '2.1 Hydraulic Design Conditions'.

The canal invert slope of 8 cm / km=1 / 12,500, which is applied in the upstream canal which is under construction now, could reasonably be applied in the design of the open canal section of the conveyance canal. A trapezoid shaped hydraulic cross section with bottom width of 12 m and side slope of 1 : 2 gives following hydraulic properties for the minimum discharge.

	for Stage I	for Stage II
Minimum Discharge	Q=8.09 m^3/sec	13.93 m^3/sec
Hydraulic Gradient	I=0.00008	0.00008
Roughness Coefficient	n=1/55	1/55
Water Depth	d=1.17 m	1.60 m
Flow Area	A=16.78 m^2	24.32 m^2
Wetted Perimeter	P=17.23 m	19.16 m
Hydraulic Radius	R=0.974 m	1.269 m
Velocity	V=0.483 m/sec	0.577 m/sec

The minimum transport capacity of the canal at Stage I development is expressed by the friction velocity and is given by the following formula.

$$U_{c1}=(g\ R\ I)^{1/2}$$

$=(9.8 x 0.974 x 0.00008)^{1/2}$
$=0.0276$ m/sec $=2.76$ cm/sec ($U_{c1}=3.15$ cm/sec after Stage II development)

The size of soil particles in the site ranges almost from 0.2mm to 0.8mm. According to IWAGAKI, the critical friction velocity to transport the particle size of 0.8 mm is given by the following formula.

$U_{c2}=(55\ d)^{1/2}$
$=(55 x 0.08)^{1/2}=2.10$cm/sec

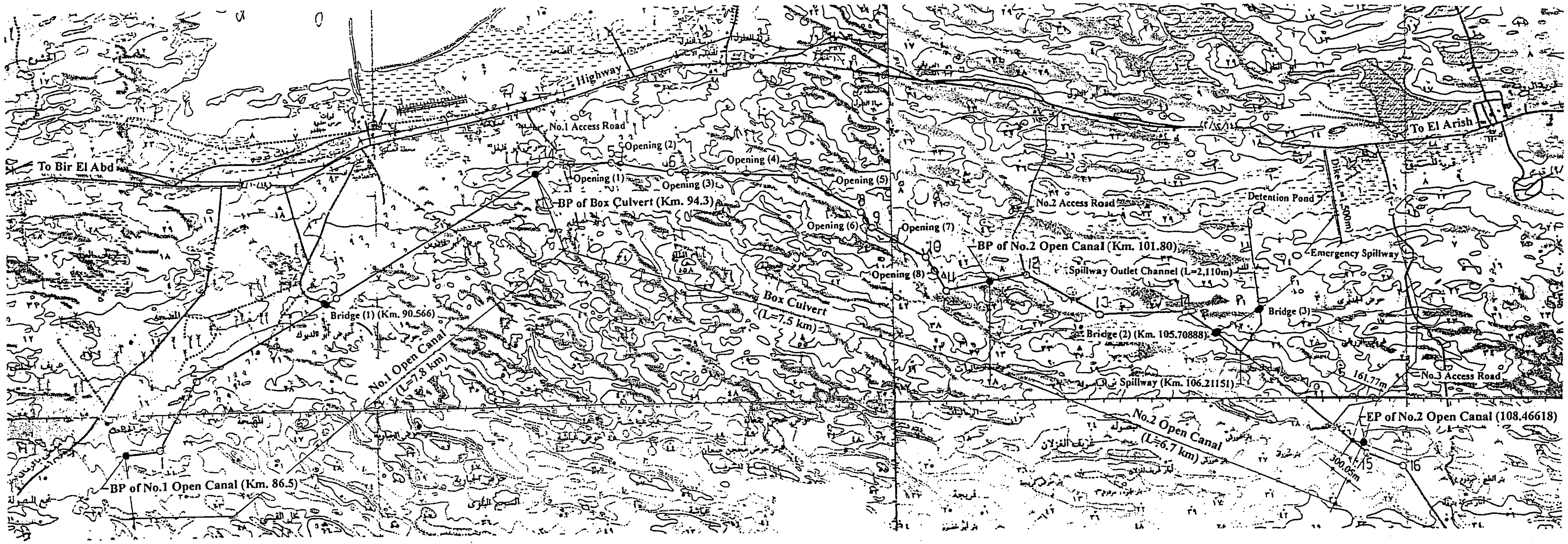
The transport capacity U_{c1} is 1.3 times larger than the critical friction velocity U_{c2} and the open canal has sufficient transport capacity for the maximum particle size of 0.8 mm in diameter. However, the stilling box having a size of 8 m wide, 1 m deep and 20 m long will be provided every 1 km on the open canal routes for easy maintenance.

(3) Invert Slope of the Box Culvert

In order to provide the economic conveyance canal system, the design velocity of the box culvert should be at more than 1.2 times of the open canal design velocity of 0.86 m/sec and should be more than 1.03 m/sec (=1.2 x 0.86 m/sec).
Based on the consideration mentioned above, the invert slope of the box culvert is decided to be 20 cm/km=1/5,000 that gives a velocity of 1.07 m/sec.

(4) Profile of the Conveyance Canal

The profile of the conveyance canal is shown in Figures 2.2-1, 2.2-2 and 2.2-3 based on the given hydraulic requirements, designed invert slope, topographic features on the canal route, etc. The water levels in No.1 Open Canal, box culvert and No.2 Open Canal are shown in DWG Nos. CCL-101 to CCL-109 and the water levels in No.3 Open Canal are shown in DWG Nos. CCL-301 to CCL-306. The calculation of head loss in the open transitions are shown in Appendix A.2.2-1.



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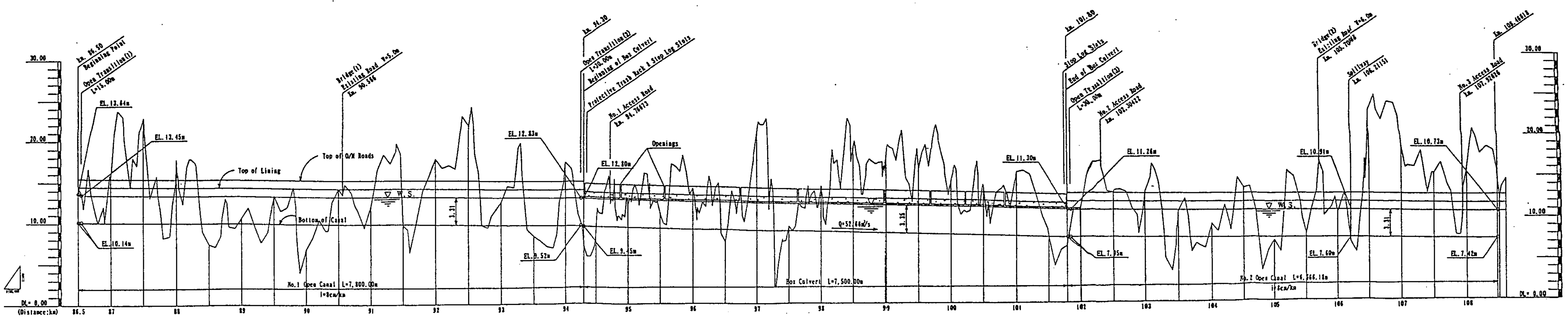


PROFILE

Figure 2.2-1 Plan and Profile of No.1 Open Canal, Box Culvert Conduit and No.2 Open Canal

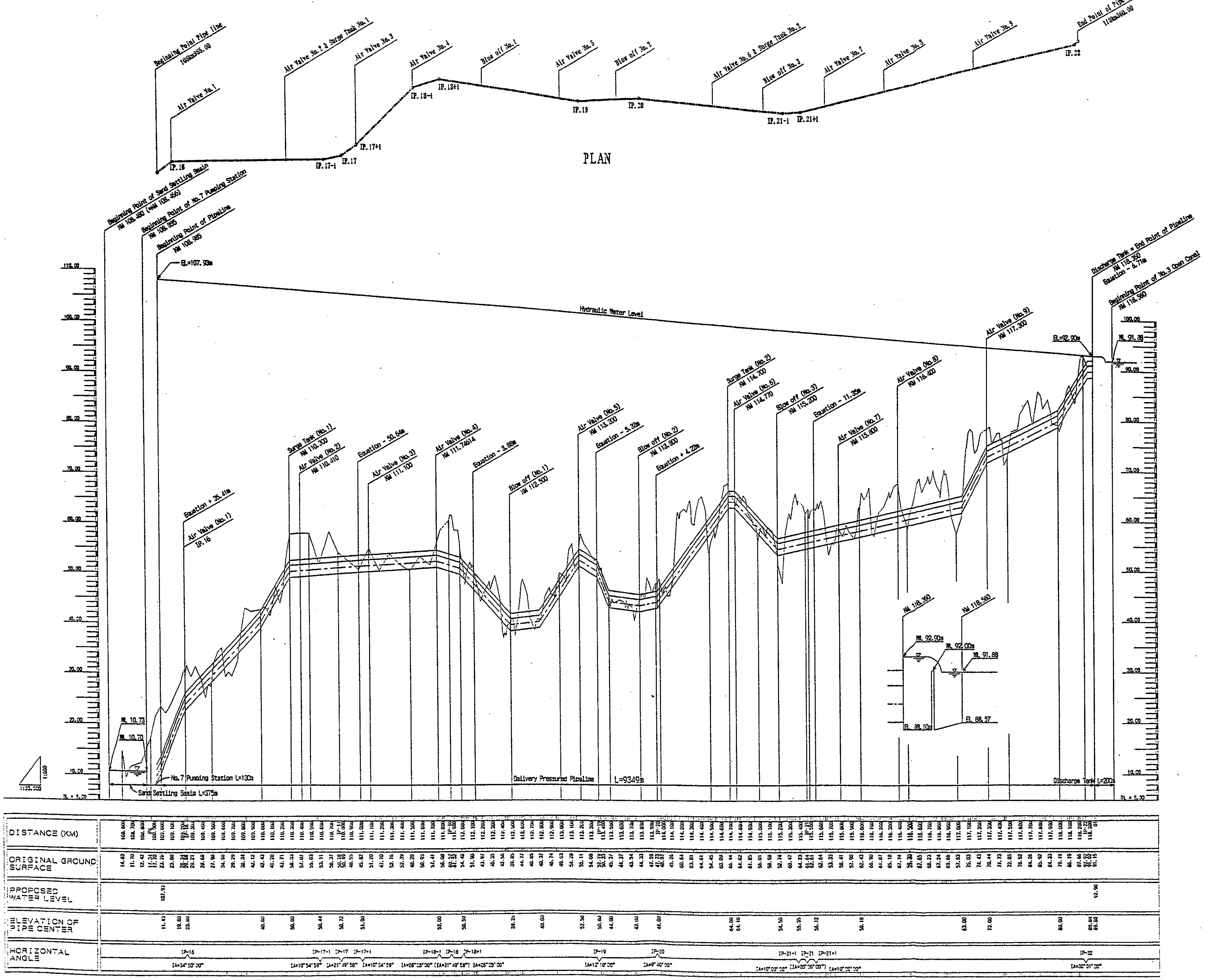
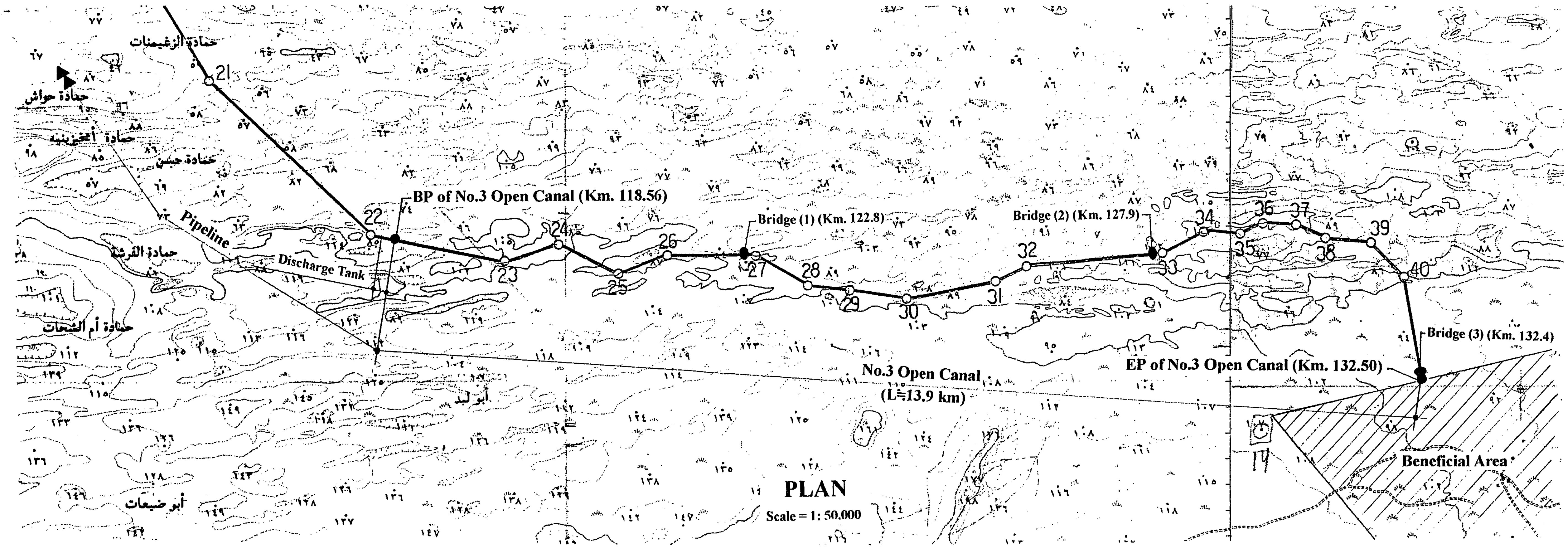
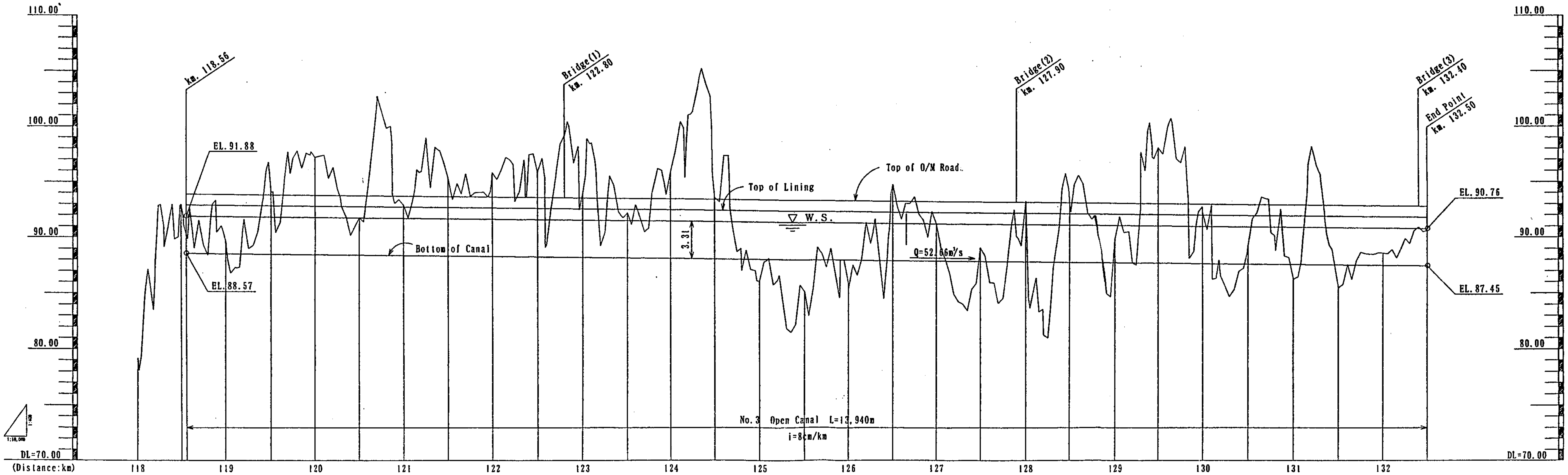


Figure 2.2-2 Plan and Profile of Pipeline





PROFILE

Figure 2.2-3 Plan and Profile of No.3 Open Canal

2.3 Hydraulic Design of Conveyance Canal

2.3.1 Open Canal Section

The concrete lined canal section has a 12 m base with 1 to 2 side slopes and a height of 4.5 m. The hydraulic properties of the concrete lined section is as follows (For detailed hydraulic properties, see Appendix A.2.3-1) :

Table 2.3-1 Hydraulic Properties of Open Canal

D	A	V	Q	Remarks
3.31 m	61.63 m^2	0.854 m/sec	52.66 m^3/sec	Design Discharge
2.55 m	43.61 m^2	0.745 m/sec	32.48 m^3/sec*	Flow in Stage I

Note : * = required maximum discharge at Stage I development,
1/n = 55, I = 1/12,500 (8cm/km)

2.3.2 Box Culvert Section

The 4-cell box culvert section (3.7 m x 3.7 m x 4) has been planned in the section 7.8 km – 15.3 km from the beginning point where drift sand dunes are prevailing. The hydraulic properties of the box culvert section is as follows (For detailed hydraulic properties, see Appendix A.2.3-2.) :

Table 2.3-2 Hydraulic Properties of 4-cell Box Culvert

D	A	V	Q	Remarks
3.35 m	12.395x4 m^2	1.062 m/sec	52.66 m^3/sec	Design Discharge
2.29 m	8.473x4 m^2	0.958 m/sec	32.48 m^3/sec*	Flow in Stage I

1/n = 67, I = 1/5,000 (20cm/km)

2.3.3 Delivery Pressured Pipeline Section

(1) Design Condition of Pipeline

(a) Discharge for one row of pipeline

Hydraulic conditions of delivery pressured pipeline connected with discharge header pipe, are to be correspond to the conditions of pump operation and pump lifting discharges. Hydraulic head loss of pipeline is closely related to actual pump lifting discharge for each other.

The discharges of pump are different from the number of pump operation as shown clause 2.6.6 Pump Operation Plan, and 12.900m^3/s for 1 unit of pump, 23.930m^3/s for 2 units of pump and 32.481m^3/s for 3 units of pump operation

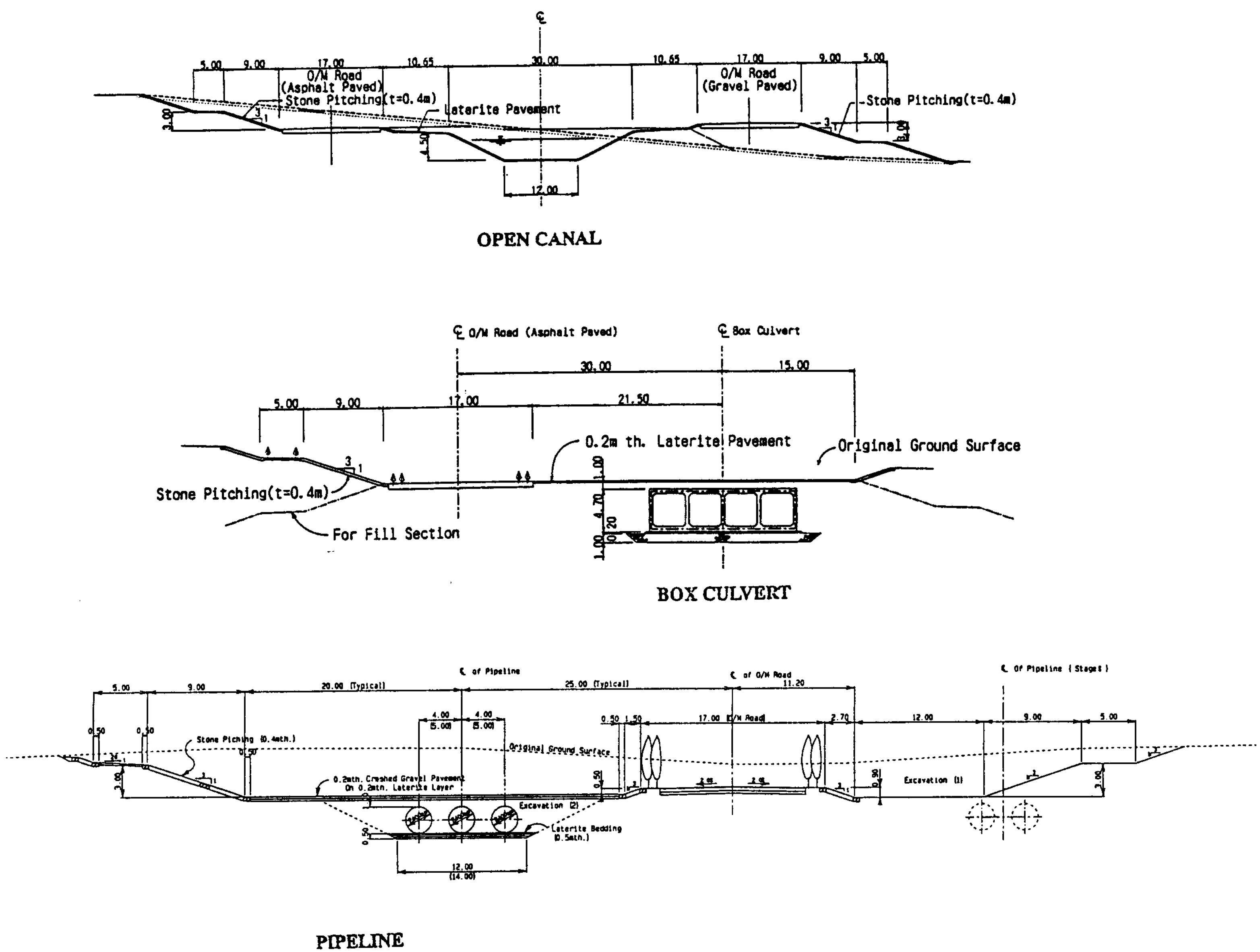


Figure 2.3-1 Typical Sections of Conveyance Canal

(b) The conditions of pipe real length, inter angles of horizontal and longitudinal

There are three pipelines and calculation of hydraulic head losses may be carried out based on the middle of three pipelines, and horizontal length of pipeline is 9354m between KM 108.98500 and KM 118.36000.

(2) Hydraulic Calculation of Pipeline

Hydraulic calculation of head losses of the pipeline was carried out by the following conditions;

(a) Discharge for one row of pipeline

Pump operation unit	Total lifting discharge (m^3/s)	Discharge for one row of pipeline (m^3/s)
3 units	32.481	10.827
2 units	23.930	7.977
1 unit	12.900	4.300

(b) Summary of the hydraulic calculation

The summary of hydraulic calculation is shown in the Table2.3-3 with major conditions and the detailed are tabulated in Appendix A 2.3-3.

- The calculation of hydraulic head loss is in generally adopted to use nominal diameter of 2,400mm with mortar lining.
- The pipe inter angle is adopted to use compound angle and length is estimated real pipe length for calculation of hydraulic head losses.

Table 2.3-3 Hydraulic Head Losses of the Main Pipelines

Discharge	Velocity	Velocity head	Hydraulic head losses (m)			
(m^3/s)	(m/s)	(m)	Friction	Bend	Discharge	Total
10.827	2.393	0.292	14.131	0.312	0.292	14.735
7.977	1.763	0.159	8.028	0.170	0.159	8.357
4.300	0.951	0.046	2.558	0.045	0.046	2.649

From the above table, total head losses of 14.735 m including pipe bend and discharge losses shall be used for determination of main pump specification and analysis of water hammer phenomenon.

2.4 Hydraulic Design of Spillway

2.4.1 Spillway System

(1) Necessity of Spillway

The purpose of this conveyance canal is to convey 52.66 m^3/sec of irrigation and industrial water from the location at 86.5 km on the Shikh Gaber El Sabah Canal to the beneficial area so called the El Sir and El Kawareer zone having a gross irrigation area of 135,000 feddan. This conveyance canal has a length of 46 km and No. 7 pumping station is planned to be constructed at the location about 22.36 km downstream from the beginning point of the conveyance canal. No. 6 pumping station is under construction at the location 40 km upstream from the beginning point of the conveyance canal, but no spillway is planned on this canal route. At the time of flowing the design discharges, water amount stored in the canal with a length of about 62.36 km between No. 6 pumping station and No. 7 pumping station is estimated at about 4.59 MCM (refer to Figure 2.4-1). Because possible storage capacity of the canal below the top of canal embankment at No. 7 pumping station is estimated at 2.38 MCM, overtopping of flow will occur from the canal section near No. 7 pumping station at the time of a power failure and pump shutdown. Therefore, the construction of spillway will be indispensable to prevent collapse of canal bank caused by overtopping of flow and to keep safety of life of people lived or stayed near the conveyance canal and of social infrastructure such as highways, houses, etc.

(2) Composition of Spillway System

There is no river around the site of the conveyance canal, and Bardawil lake and Mediterranean sea are far from No. 7 pumping station. Under such conditions, the lowland so called Sabkhet El Mustablq expanded both side of the highway located at 4.8 km north from No.7 pumping station will be only disposal point for the spillway of the conveyance canal.

The spillway system, as shown on Figure 2.4-2, consists of the following structures.

(1) Overflow type Spillway in combination with two gated sections in order to empty the canal for inspection, maintenance and emergency such as a canal bank failure.
(2) Spillway Outlet Channel to release excess water into the detention pond.
(3) Dike to create the detention pond and Emergency Spillway.

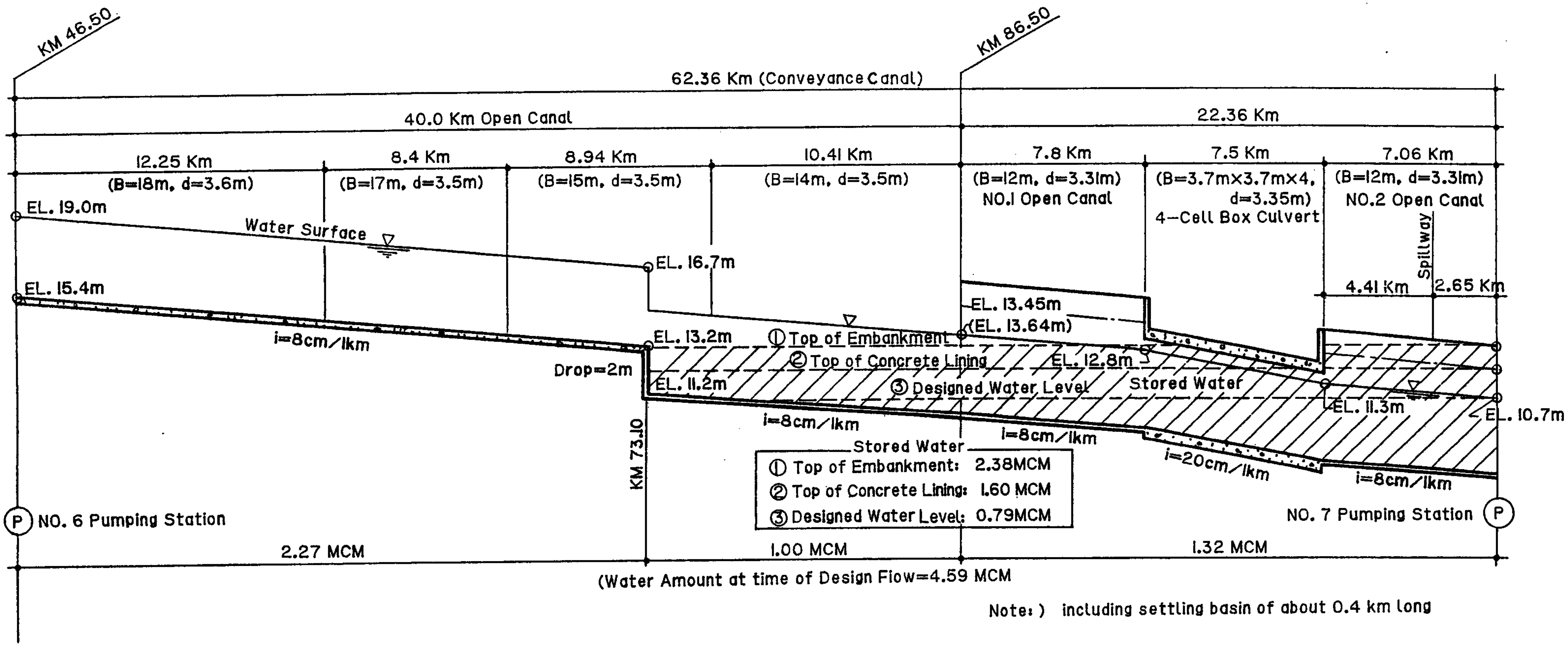


Figure 2.4-1 Profile of Conveyance Canal Between No.6 and No.7 Pumping Stations

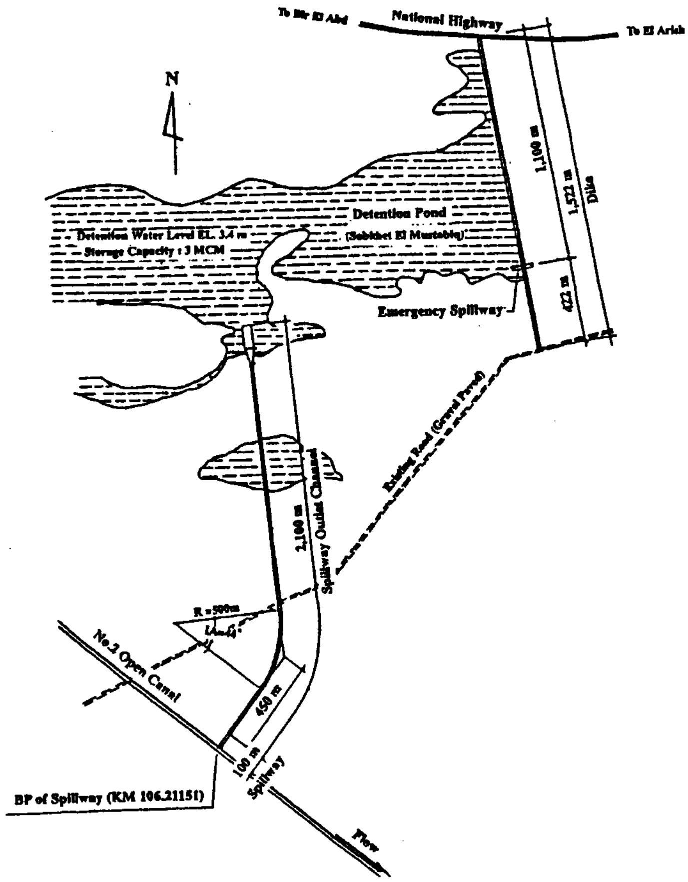


Figure 2.4-2 Plan of Spillway System

(3) Design of Spillway System

The spillway system will be designed under the condition that the conveyance canal flows designed discharges after completion of Stages I and II construction works. In the case that operation of No. 6 pumping station is stopped after three hours from the time of pump shutdown of No. 7 pumping station, water amount to be released from spillway can be calculated as shown below;

<u>Water Amount to be Released from Spillway</u>

(i) Inflow from No. 6 Pumping Station during 3 hours:	
52.66 cu.m/sec x 3 hr x 60 min x 60 sec =	0.57 MCM
(ii) Stored Water in Canal between No.6 and No.7 Pumping Station	4.59 MCM
(iii) Diverted Water through Turnouts: 3.27 MCM x 38.02 / 90.68 (m^3/sec) =	- 1.37 MCM
(iv) Stored Water below Spillway Crest	- 0.79 MCM
Total	3.00 MCM

(a) Spillway

The location of spillway should be selected near No.7 pumping station for releasing excess water as much as possible. However, it is selected at about 2.65 km upstream from the pumping station because the location of the pumping station is far from the disposal point and is surrounded with a hill of EL.20 m to 30 m high which will be request a high construction cost.

The spillway with the overflow crest of 38 m long (9.5m x 4 spans) is planned, in combination with two gated sections for emptying the canal. The water depth on the crest will be 0.84 m for draining the design discharge of 52.66 m^3/sec ($d= (Q/CB)^{2/3}=(52.66/1.8 \times 38)^{2/3}=0.84$ m). The spillway is shown on Figure 2.4-3.

The two gated sections are designed to release a flow almost same as the design discharge at the time of design depth of 3.31 m. The gated sections having a wide of 4 m x 2 can release a flow of 52.0 m^3/sec. (Refer to Appendix A.2.4-1.)

(b) Spillway Outlet Channel

The spillway outlet channel of 2.1 km long as shown on Figure 2.4-4, which consists of discharge canal, chute and stilling basin, riprap canal and excavated unlined canal, is planned to release the excess water from the spillway to the detention pond. The design discharge of the spillway outlet channel is 52.66 m^3/sec.

i) Discharge Canal

The discharge canal consists of flume and box culvert under the existing road. The flume has a 10 m base and a wall height of 2.7 m to 4.0 m as shown on Figure 2.4-5. (For detail of water depth in the discharge canal, see Appendix A.2.4-2.)

ii) Chute and Stilling Basin

- Critical Depth at Control Point (BP + 1,100.00)
  $dc = 0.467 \times q^{2/3} = 0.467 \times (52.66/10.00)^{2/3} = 1.41$ m

- Depth after the Hydraulic Jump
  $d_2 = (d_1/2) \times ((1+8 \times F_1^2)^{1/2} - 1)^{2/3} = 3.43$ m

  d_1 : depth before hydraulic jump = 0.42 m (Refer to Appendix A.2.4-3.)

  F_1 : Froude number = $V_1/(g \times d_1)^{1/2} = 12.42/(9.8 \times 0.42)^{1/2} = 6.12$ m
- Length of Stilling Basin
  $L \geqq 6 \times d_2 = 6 \times 3.43 = 20.6$ m
  Design Length of Stilling Basin (Net) = 12.0 m x 2 = 24 m

iii) Riprap Canal

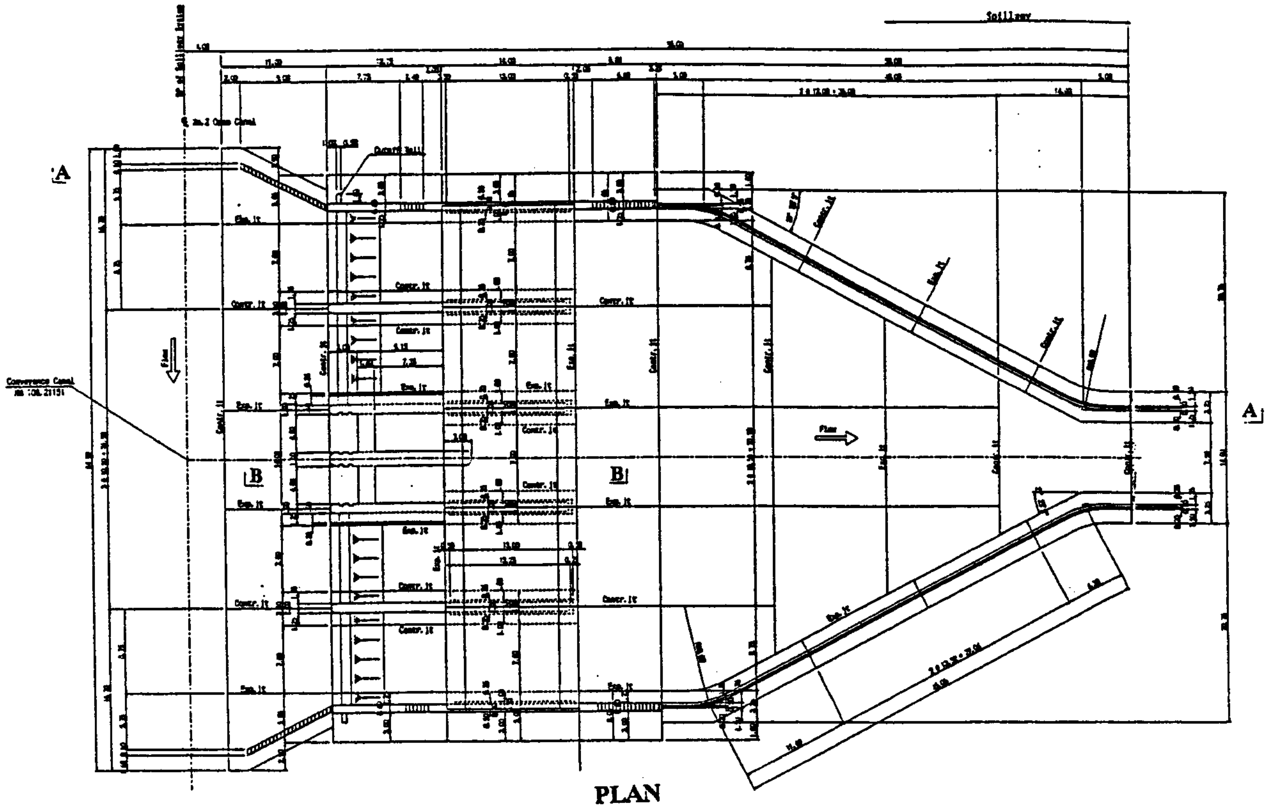
The riprap canal section has a 10 m base with 1 to 3 side slope and a height of 3.6 m. The hydraulic properties of riprap canal is as follows :

Table 2.4-1 Hydraulic Properties of Riprap Canal

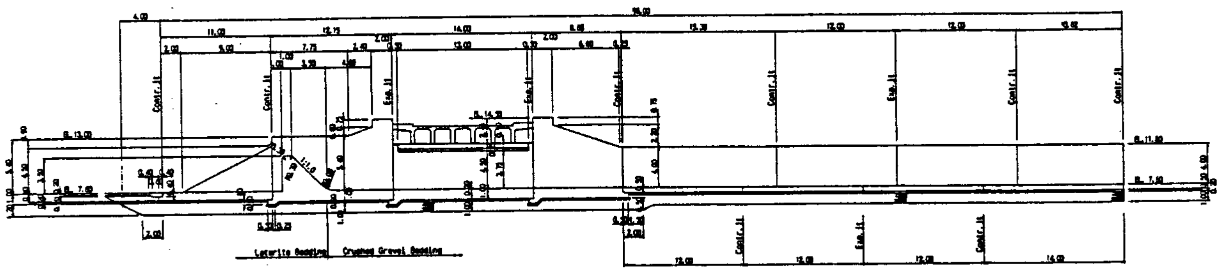
Q	D	A	V	Remarks
52.66 m^3/sec	**2.95 m**	**55.61 m^2**	**0.947 m/sec**	**n=0.03, I=1/3,000**

(c) Dike and Emergency Spillway

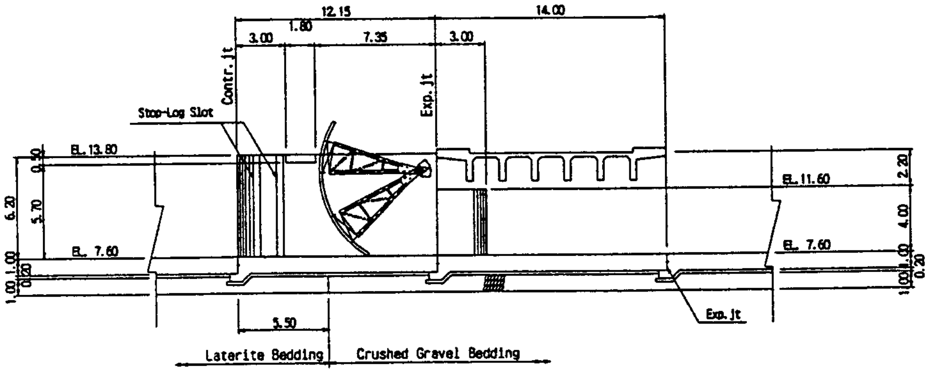
The dike construction is necessary to create a detention pond with a storage capacity of 3 million m^3, and an emergency spillway having a design head of 1.1 m (d= $(Q/CB)^{2/3}$=$(52.66/1.8 \times 9.5x3)^{2/3}$=1.02=1.1 m) should be also provided for keeping the safety of the dike. Typical section of the dike is shown on Figure 2.4-7 and the design of emergency spillway is shown on Figure 2.4-8. (For the detention pond capacity curve, see Appendix A.2.4-4.)



PLAN



SECTION A – A



SECTION B – B

Figure 2.4-3 Plan and Sections of Spillway

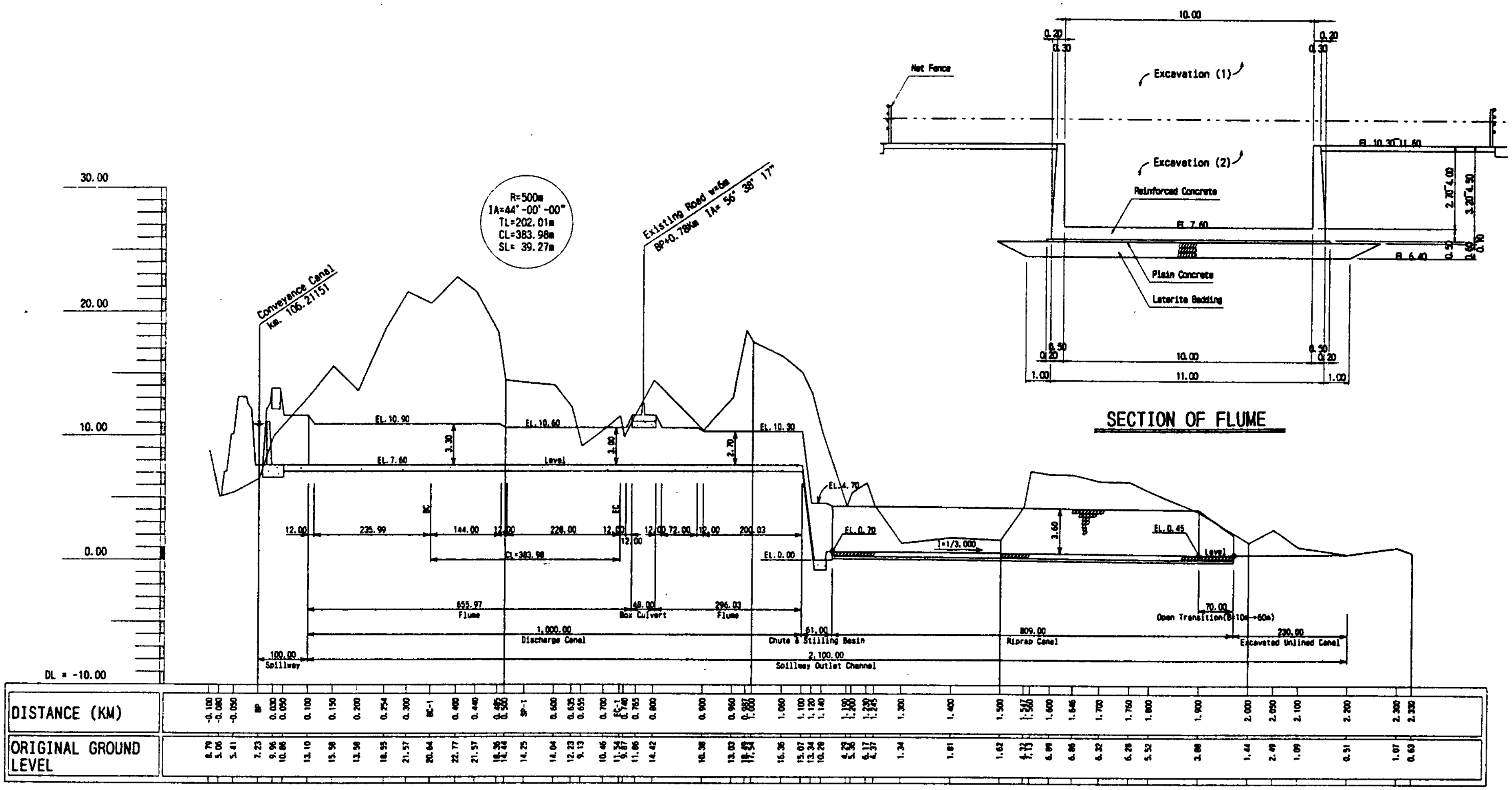


Figure 2.4-4 Profile and Sections of Spillway Outlet Channel

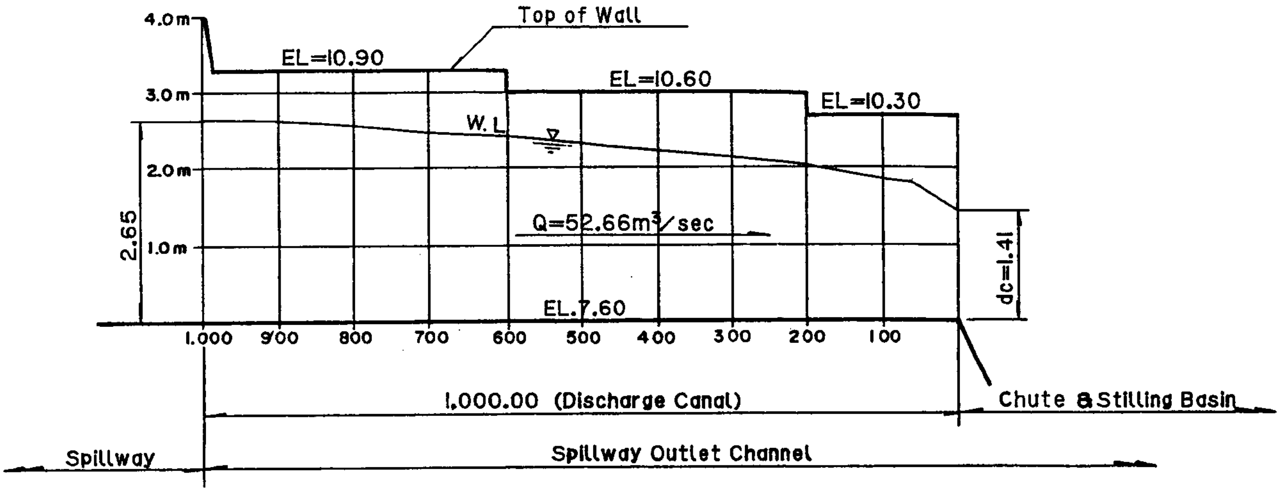


Figure 2.4-5 Profile of Discharge Canal

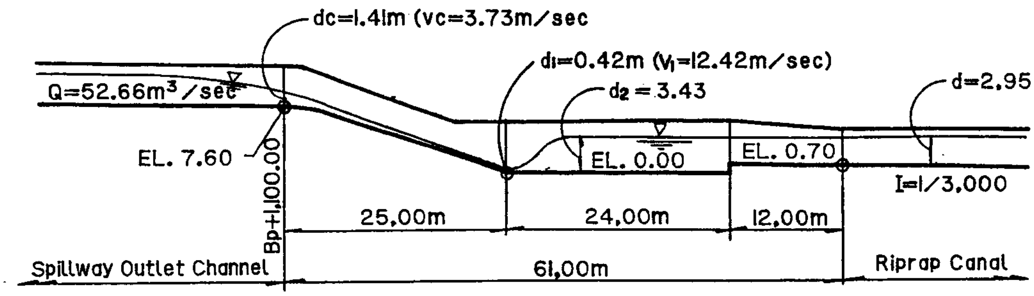


Figure 2.4-6 Profile of Chute and Stilling Basin

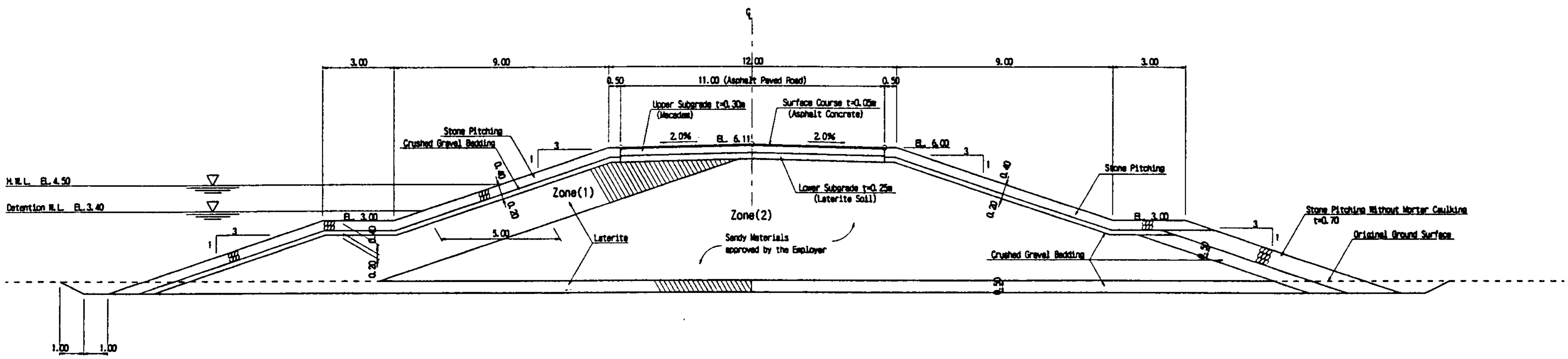
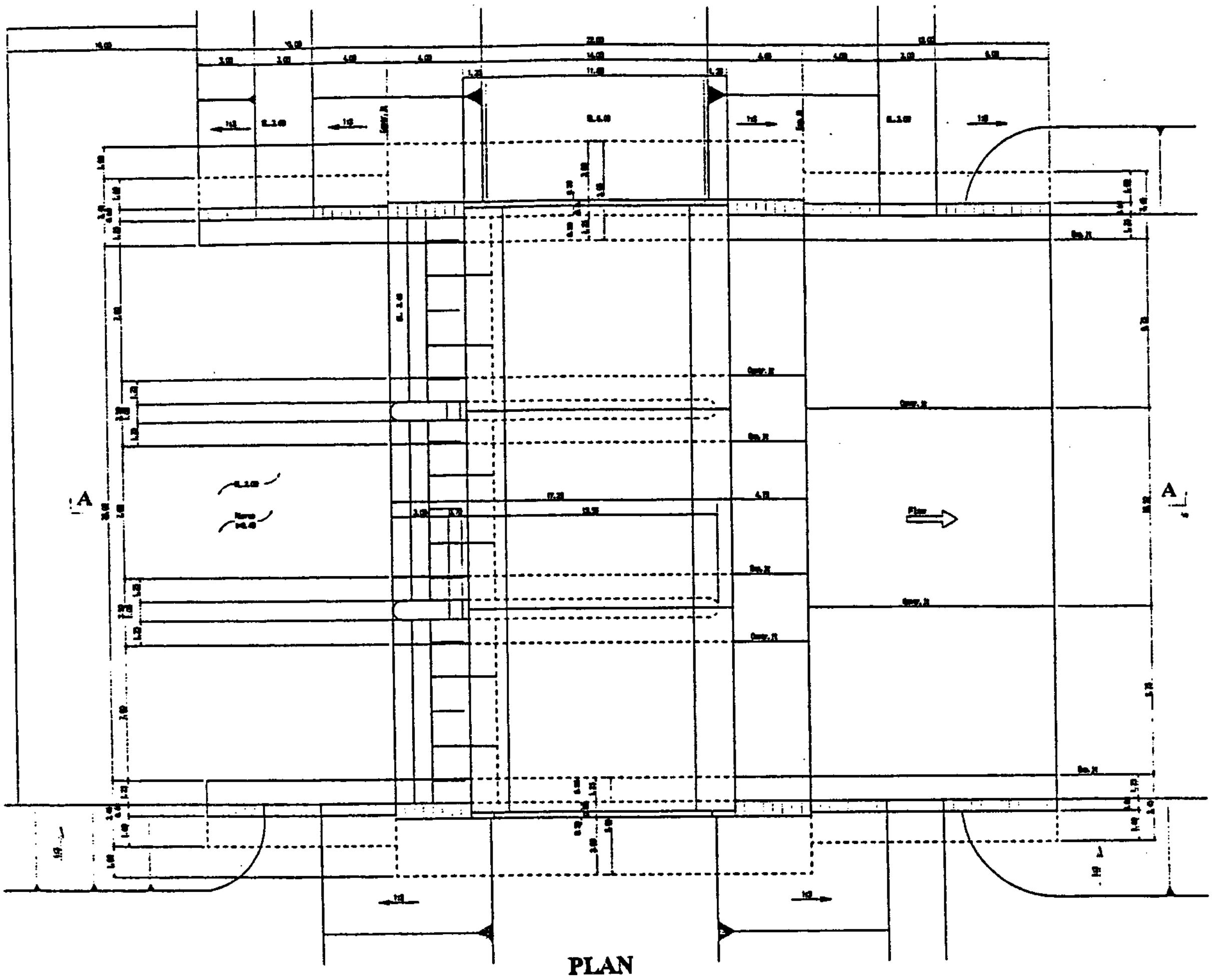


Figure 2.4-7 Typical Section of Dike to Create Detention Pond



PLAN

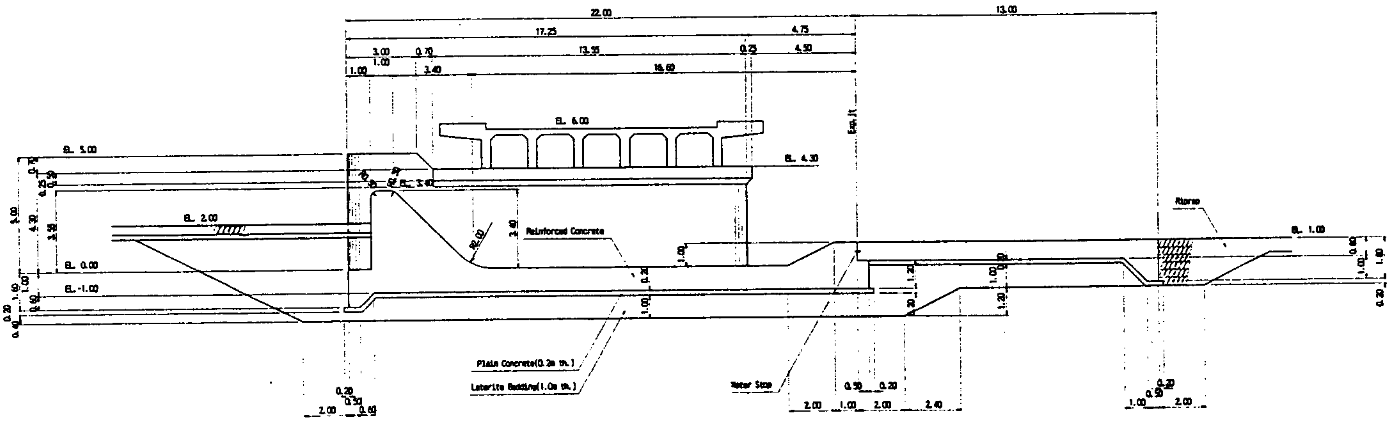


Figure 2.4-8 Plan and Section of Emergency Spillway