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PHASE 2

PRELIMINARY ENGINEERING AND COST ESTIMATES

FINAL REPORT

2/2

PART III : HIGH RISE LOCK CANAL

PART IV : SEA LEVEL CANAL

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ABBREVIATION

Abbreviation		Term
OCCE Study	:	Operating Characteristics and Capacity Evaluation Study
CTP Study	:	Commodity and Traffic Projections Study
ECE Study	:	Engineering and Cost Estimation Study
CAS	:	Commission for the Study of Alternatives to the Panama Canal
PCC	:	Panama Canal Commission
HRLC	:	High Rise Lock Canal
SLC	:	Sea Level Canal Route 10
AASHTO	:	American Association of State Highway and Transportation Officials
CALM	:	Catenary Anchor Leg Mooring
CAPAC	:	Camana Panamena De La Construction
IOCS	:	Inter Ocean Canal Studies
JAX	:	Department of the Army Jacksonville District, Corps of Engineers
JSSC	:	Japanese Society of Steel Construction
PIANC	:	Permanent International Association of Navigation Congress
SCADA	:	Supervising Control and Data Acquisition
SQ	:	Status Quo, Existing Panama Canal
Km	:	Kilometers
m	:	meters
mm	:	millimeters
ft	:	feet
in	:	inches

Abbreviation		Term
ha	:	hector
ϕ	:	diameter
KW	:	Kilowatts
Kg	:	Kilograms
DWT	:	Dead Weight Tonnage
HWL	:	High Water Level
MWL	:	Mean Water Level
LWL	:	Low Water Level
US$ or $	:	US dollars

PART III – HIGH RISE LOCK CANAL

PART III SECTION 1 ENGINEERING AND PRELIMINARY DESIGN

III.1 CHAPTER 1 - GENERAL

1.1 Basic Engineering Conditions

Two case studies were conducted for prospective ship sizes of 150,000 DWT and 200,000 DWT and for water levels, i.e. 85' and 90' were considered for Gatun Lake.

Basic engineering conditions used in "Engineering and Preliminary Design" are summarized in Table III.1.1-1.

Table III.1.1-1 Basic Engineering Conditions

Item	Description
1) Route	Ref. High Rise Lock Canal Layout Fig. III.1.1-1
2) Ship Size (Maximum)	150,000 DWT. (306 L x 46 B x 18 D) 200,000 DWT. (333 L x 50 B x 19 D)
3) Lane No.	Approach Channel 2-lanes, Canal 2-lanes
4) Canal Width	7 * B (150,000 DWT = 320 m, 200,000 DWT = 350 m)
5) Canal Depth	150,000 DWT = 21.0 m, 200,000 DWT = 22.0 m
6) Lock Dimensions	150,000 DWT, 390 * 50 * 20.0 m 200,000 DWT, 420 * 55 * 21.5 m
7) No. of Transits	150,000 DWT = 2,000 (2020), 4,600 (2060) 200,000 DWT = 2,000 (2020), 4,600 (2060) Existing Locks = 16,200 (2020), 20,000 (2060)
8) Lake Levels	85' and 90'
9) Tidal Levels	High Water Level = +3.6 m (Pacific) Lowest Water Level = -3.4 m (Pacific) High Water Level = +0.5 m (Atlantic) Lowest Water Level = -0.3 m (Atlantic)
10) Earthquake	Kh = 0.1, Kv = Kh * 2/3

1.2 Route

For the High Rise Lock system, a ship from the Pacific coast side follows the existing canal route, and changes direction to the west at a point 2 km north of the present port of Balboa where the ship diverts to the new 2-lift locks. The ship passes from the new locks into a new channel excavated 2.5 km west of Cerro Aguadulce, then joins the existing canal about 2.5 km north-west of the present Pedro Miguel locks.

After joining the existing canal, the ship transits the Culebra Cut section and then proceeds on Route-I through Gatun Lake following the existing route. The ship turns right about 3 km before Gatun dam and proceeds via the new Gatun Locks to the new canal which extends 1.5 km east from Gatun Locks and is parallel to the existing canal. The ship then rejoins the existing route at Limon Bay.

The High Rise Lock canal route with Pacific and Atlantic Lock locations is shown in Fig. III.1.1-1.

1.3 Water Levels

For the High Rise Lock system, the water level of Gatun Lake could be at the present water level (85'), but for the purpose of reducing the excavation volume, 90' water level cases (5' above the existing water level) have also been studied.

For the 90' water level cases, raising the water level of the lake by some 1.5m above the present level would cause problems from several aspects. The 90' study alternatives are discussed specifically in III.1. Chapter 11.

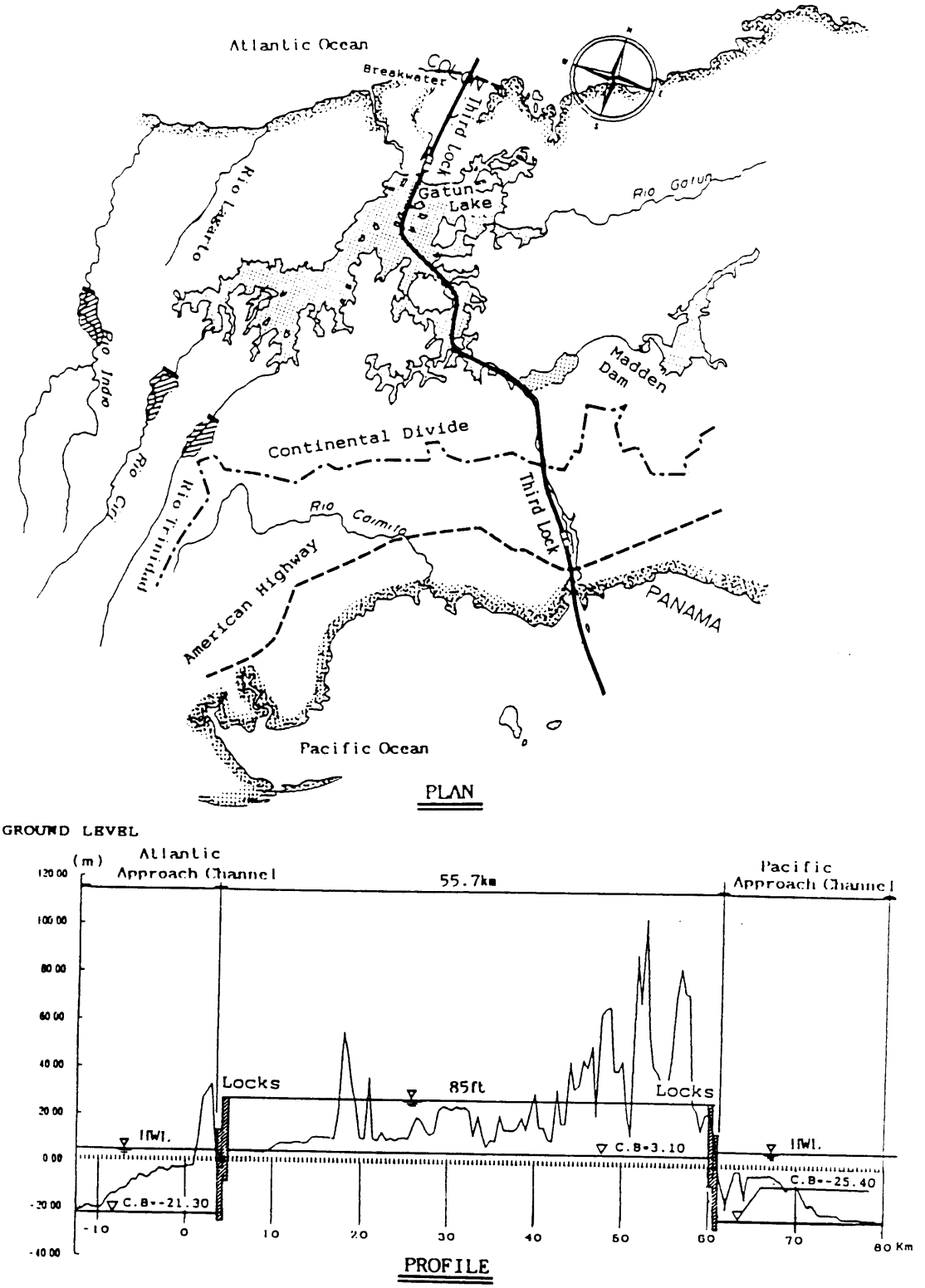


Fig. III.1.1-1 Layout of High Rise Canal (200,000 DWT)

III.1 CHAPTER 2 - WATER MANAGEMENT

2.1 Introduction

The water management plan is based on water conservation taking into consideration the new dams, including water from outside of the Gatun Lake catchment area. Pumping station requirements were developed to ensure that water requirements were still met. In order to evaluate the lockage capability of the present usable storage capacity, a computer simulation model was developed. Its concept is shown as a flowchart and as a schematic model in Fig. III.1.2-1 and Fig. III.1.2-2.

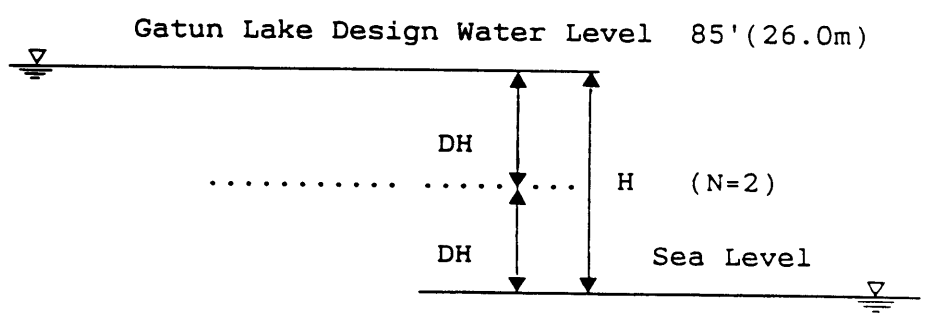
2.1.1 Basic conditions for Simulation Model

(1) Lockage Water

It was shown in II.1 Chapter 1.5 that the volume of water that will be required for one transit through the canal can be calculated from the formula given below:

V= B*L*(H/N)*2

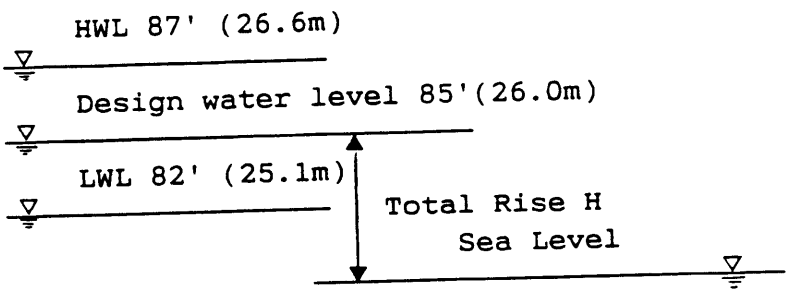
where, V= volume of water required for one transit
B= width of lock in meters
L= length " " " "
H= total rise " "
DH= height of one lift "
N= number of lifts (N=H/DH)
2= number of flushes including Pacific and Atlantic side (ie. one at each side)



III.1.2-1

(2) Operational Water Level

The operational water level at Gatun lake is between 26.6 meter(HWL) and 25.1 meter(LWL); the same as existing canal operations. A sketch of the water levels are shown below.



(3) Major Assumptions and Limitations

The major assumptions and limitations for the simulation are listed below:

1. Monthly discharge was calculated from average discharge for 51 years of record(1933-1983). For the last 10 years, 1982 is given as the dry year and 1981 is selected as the wet year. The simulation was performed for the following three different discharge cases (1) average, (2) dry, (3) wet year.

2. Gatun Lake operates between 82 feet and 87 feet.

3. Madden Lake operates between 200 and 252 feet. Water below 200 feet is reserved for future municipal use in Panama City.

4. Total volume of municipal water was estimated at about 274 million m^3 based on existing water use.

5. Evaporation loss calculations are in accordance with water level.

6. Miraflores Lake was not taken into consideration.

7. Total usable storage includes the sum of Gatun and Madden lakes.

8. No allowance has been made for the use of water for generation of hydroelectricity, ie use of water for lockages has been given a higher priority.

9. The simulation is based on the preference for avoiding spillage, thus allowing the most effective usage of available water. Spillage is only permitted where there is an excess of requirements after allowing for lockage water, municipal use and evaporation.

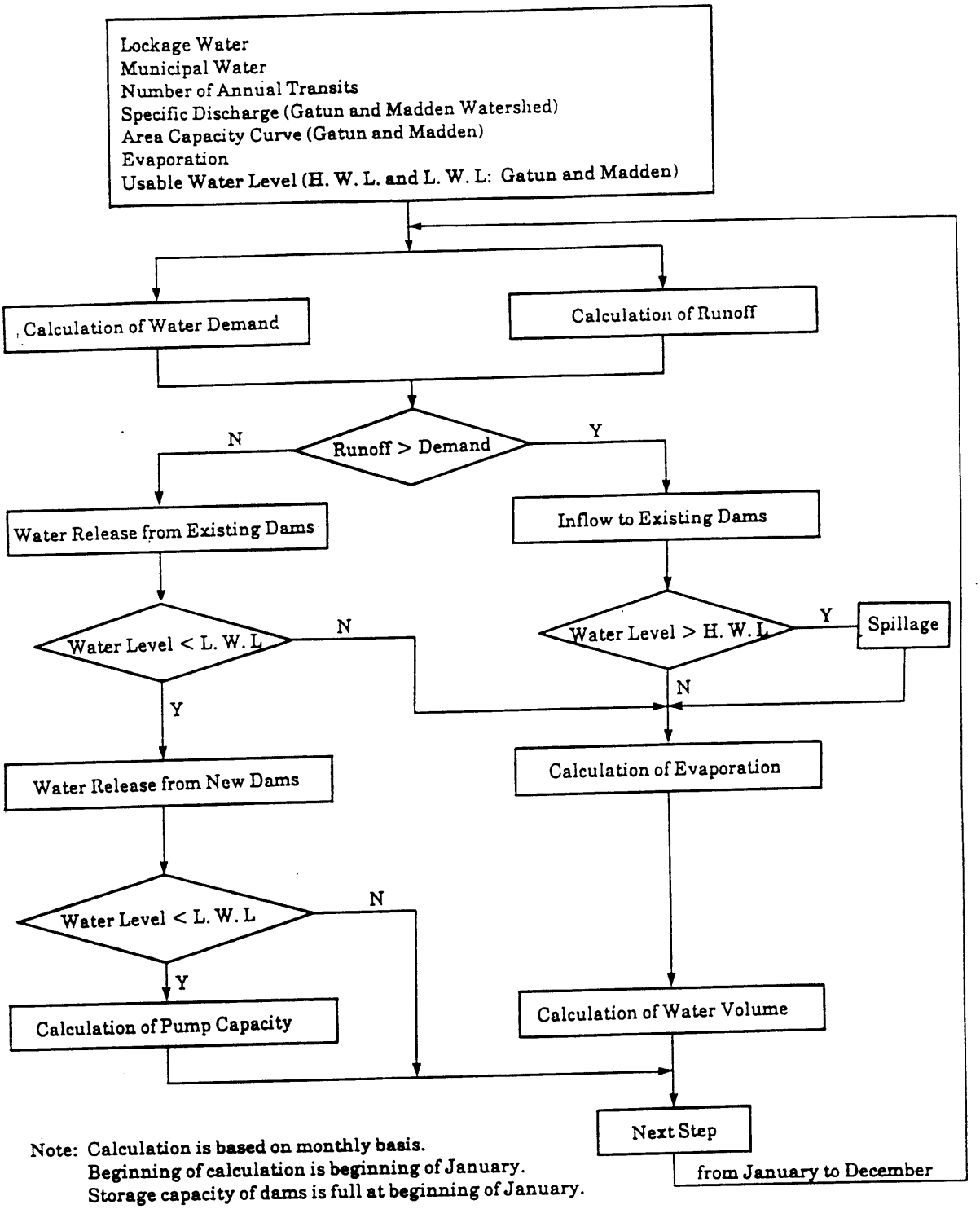


Fig. III.1.2-1 Flowchart for Water Balance Simulation

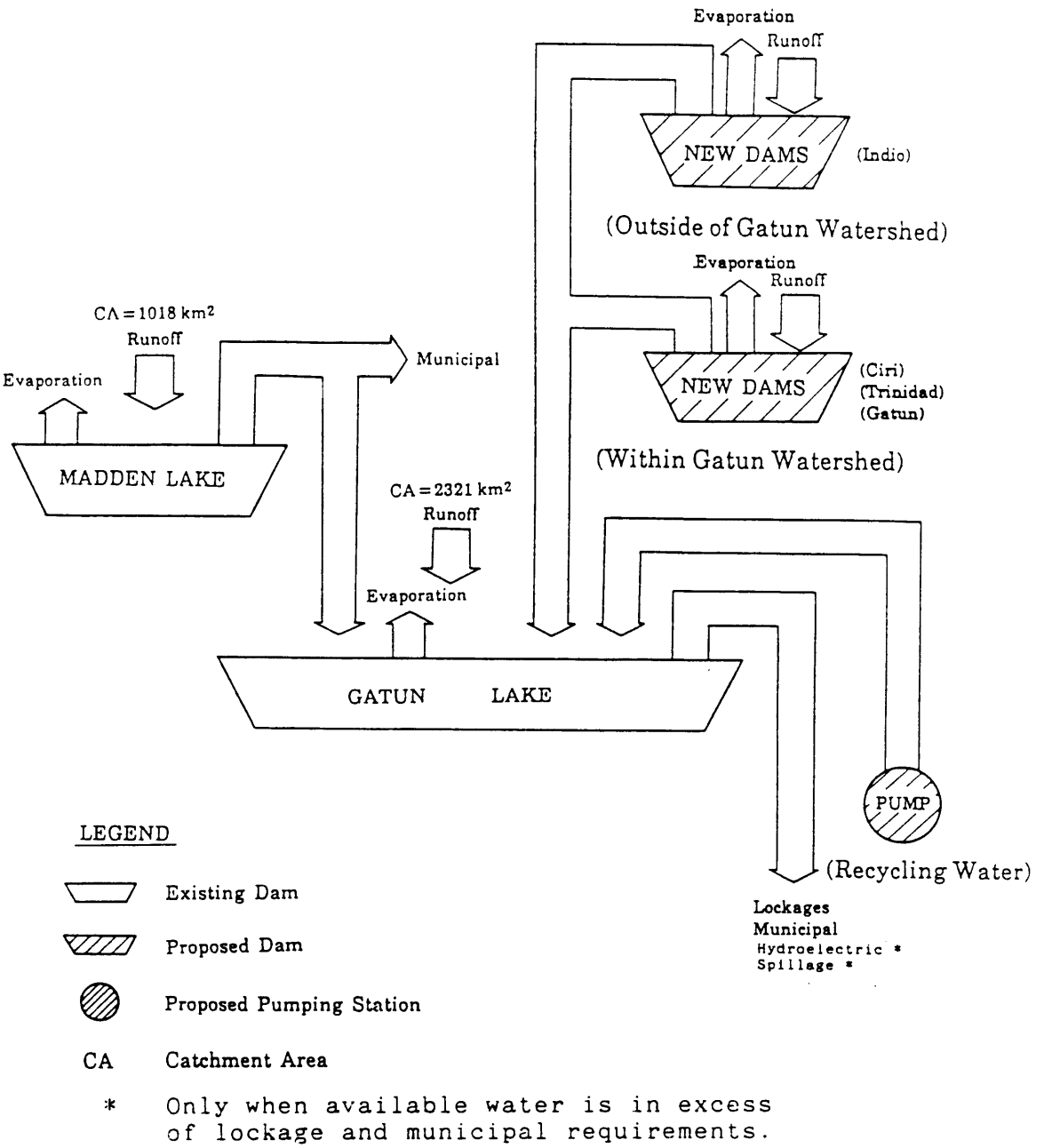


Fig.III.1.2-2 Simulation Model for Water Balance

(4) Selection of New Dams

Where the annual yield of the Gatun watershed is sufficient to provide the required lockage water, the existing storage capacity within the Gatun watershed must be compared to the volume determined from the water balance simulation to see if additional storage by means of regulating dams is necessary. The regulating dams serve the purpose of storing run-off during the wet season which would otherwise be spilled over Gatun Dam, and therefore making this water available for lockages. Suitable sites for regulating dams were identified in Phase 1 at Ciri, Trinidad and Upper Gatun. One or more of these sites are chosen according to the storage volume required.

Where the annual yield of the Gatun watershed is insufficient to provide the required lockage water, the shortage cannot be overcome regardless of how many dams are constructed within the Gatun watershed. The only ways of compensating are by constructing a new dam(s) outside the Gatun watershed, by recycling freshwater by pumping, or by a combination of both. In Phase 1 a suitable site for a new dam outside the Gatun watershed was identified on the Rio Indio. Water stored by this dam can be guided to the western and of Gatun Lake via an open channel. The catchment yield for the Indio dam was estimated in II.1 Chapter 4.3 as 591, 461 and 988 million m^3 for average, dry and wet years respectively. In cases where the Indio dam yield is insufficient to overcome the water shortage, any remaining water storage is overcome by recycling freshwater using pumping stations.

The locations of the four possible sites for new dams are shown in Fig. III.1.2-3. The main tributaries and the dam storage capacities are shown in Table III.1.2-1 below.

Table III.1.2-1 Storage Capacity of Proposed Dams

Name	Tributary	Catchment Area(km2)	Capacity (mill.m3)	Height (m)	Note
Ciri	Ciri Grande	190	120	60	Gatun Watershed
Trinidad	Trinidad	248	475	80	〃
Upper Gatun	Gatun	125	340	95	〃
Indio(Low)	Indio	323	550	80	Outside of Gatun
Indio(High)	Indio	323	710	90	〃

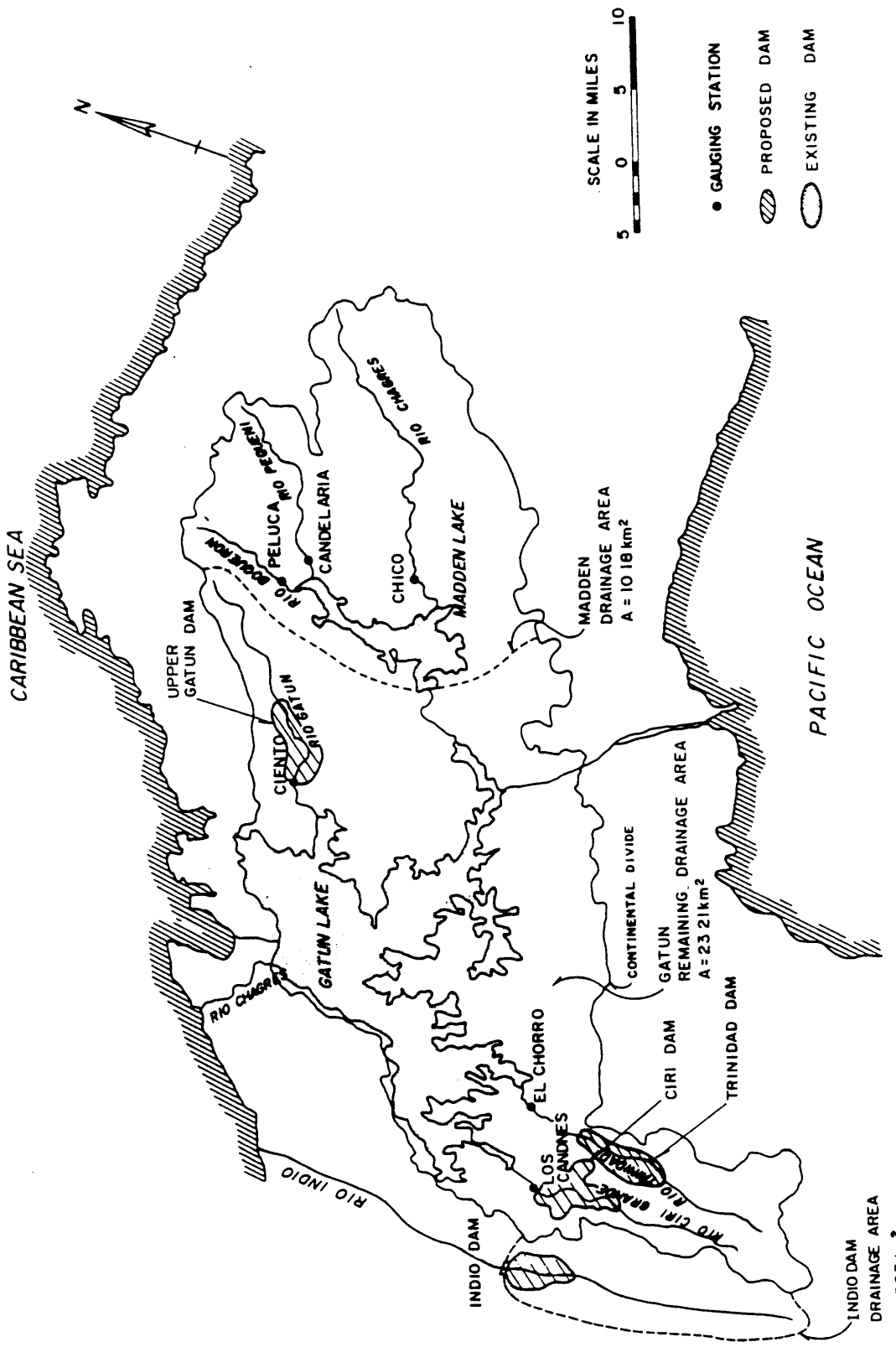


Fig. III.1.2-3 Location Map of Existing Dams and Proposed Dams

2.2 Water Management Plan

2.2.1 Lockage Water

(1) Lockage Water for One Transit

The dimension of the lock chambers for 65,000 DWT, 150,000 DWT and 200,000 DWT ships are shown in the Table III.1.2-2.

The rise, number of lifts, width and length of the lock chamber are the study variables affecting lockage water requirements. Appropriate combinations of the above mentioned variables were selected and the required lockage water per one transit was calculated using the equation in Chapter 2.1.1(1). The results of the calculations are presented in Table III.1.2-2.

Table III.1.2-2 Lockage Water for One Transit

Case		① Length	② Width	③ Lift	④Lockage
Rise(ft)	Size(DWT)	(m)	(m)	(step)	W.(1000m3)
85′	65,000	304.8	33.5	3	177
85′	150,000	390.0	50.0	2	507
85′	200,000	420.0	55.0	2	601
90′	65,000	304.8	33.5	3	187
90′	150,000	390.0	50.0	2	536
90′	200,000	420.0	55.0	2	635

Note:④(1000m3)=(Rise(m)*①*②/③)*2/1000

(2) Annual Transits and Lockage Water

Based on the above table, annual water requirements for the projected transits for different ship sizes were calculated. The results of these calculations and annual transits are shown in Table III.1.2-3.

Table III.1.2-3 Annual Transits and Lockage Water

Case	Existing Lock		New Lock		Total
Rise-DWT-Year	(Transits)	(MCM)	(Transits)	(MCM)	(MCM)
Case(1)85-150-2020	16200	2867	2000	1014	3881
85-150-2060	20000	3540	4600	2332	5872
Case(2)85-200-2020	16200	2867	2000	1201	4068
85-200-2060	20000	3540	4600	2763	6303
Case(3)90-150-2020	16200	3033	2000	1073	4105
90-150-2060	20000	3744	4600	2467	6211
Case(4)90-200-2020	16200	3033	2000	1271	4303
90-200-2060	20000	3744	4600	2922	6666

Note:Number of transits are based on Table II.1.1-5

2.2.2 Water Balance

(1) General

A mathematical simulation for the years 2020 and 2060 was performed for the following three different discharge cases (1) average year, (2) dry year, and (3) wet year in order to better determine the design capacity of new dams and pump stations. From the annual water requirement for existing, plus additional transits, additional water requirements were calculated.

In all cases there will be no water shortage except for special situations for the high rise cases. The water deficits may occur near 2060 and only during dry years. However with addition dams and/or pump stations there will be sufficient water for all situations.

Figures and tables have been prepared in order to explain the results of the water balance simulation. The purpose of each figure and table is shown below.

1. Fig. III.1.2-4 and III.1.2-5 show schematically the required capacity of dams and pumps in each case.

2. Fig. III.1.2-6 and III.1.2-7 show the relationship between cumulative water requirement and cumulative available water. The gap at the end of December between available water and requirement shows excess or deficiency of water.

3. Fig. III.1.2-8, III.1.2-9 and III.1.2-10 show the relationship between water requirement and monthly discharge in average, dry and wet years respectively. The dotted line designates the average discharge of Gatun watershed. The solid lines designate the water requirements for 200,000 DWT in the year 2060. The gap between the dotted line and the solid line represents the amount of water that has to be supplied by a new dam outside of Gatun watershed and/or simultaneous use of pumps.

   The volume beneath the dotted line represents the storage volume required for regulating dams within the Gatun catchment. The purpose of the regulating dams is that by avoiding spillage over the Gatun Dam in the wet season and water can be stored for use as lockage water during the dry season. In some cases the storage capacity of Gatun and Madden dams are sufficient, but in other cases new regulating dams are required. The Upper Gatun, Ciri or Trinidad dams are selected according to the required capacity.

4. Tables III.1.2-5 and III.1.2-6 show the summarized results of water balance simulation for 150,000 and 200,000 DWT ship sizes respectively.

5. APPENDIX 5 show the computer output of the monthly based water balance simulation. The figures in the table show the results of the water balance at the end of each month. The items in the table are explained in each table.

(2) 150,000 DWT Case

The results of this case are shown in Table III.1.2-5. Figure III.1.2-4, and Fig. III.1.2-6, are presented for a clearer understanding of the water balance in the years 2020 and 2060. For the year 2020 there is no water shortage, but for the year 2060 it will be necessary to construct dams within and outside the Gatun watershed with capacities of 102 MCM and 461 MCM respectively. A pump station with a capacity of 1459 MCM is also required to overcome the water shortage.

The results of the water balance analysis for a Gatun Lake level of 90' are summarised in Table III.1.2-7.

(3) 200,000 DWT Case

The results are shown in Table III.1.2-6. Figure III.1.2-5 and Fig. III.1.2-7 are presented for a clearer understanding of the water balance in the years 2020 and 2060. For the year 2020, it will be necessary to construct a dam on the Indio river able to supply 116 MCM in a dry year. For the year 2060, it will be necessary to construct dams within and outside Gatun watershed with capacities of 396 MCM and 591 MCM respectively. A pump station with a capacity of 1890 MCM is also required to eliminate water shortages.

The results of the water balance analysis for a Gatun Lake level of 90' are summarised in Table III.1.2-8.

2.2.3 Proposed Plan

In order to supply adequate lockage water for the increasing number of transits, it will be necessary to construct new dams and pump stations with the capacities mentioned previously. Required capacities of dams and pumps for 150,000 DWT and 200,000 DWT cases in Average, Dry and Wet year are shown in Table III.1.2-5 and III.1.2-6 respectively (85' case).

As previously described, selection of new dams and pumping stations is based on whether the annual yield of the Gatun watershed is sufficient to meet lockage water requirements and whether the storage volume within Gatun watershed is sufficient to allow full utilization of the annual yield for lockages:

i) Indio Dam and pumping stations

Where the annual yield of Gatun watershed is insufficient (ie. there is a water balance deficit), Indio dam is first selected as the new water source. If the water balance deficit also exceeds the yield of the Indio dam watershed, then pump stations are required to make up the remaining water deficit.

ii) Regulating Dams

Regulating dams are provided to ensure full utilization of runoff from the Gatun watershed. Based on the analysis made in III.1 Chapter 7.2.4 (Evaluation of Dam Potential), the optimum regulating dam locations are Ciri, Trinidad are Upper Gatun with capacities of 120,475 and 340 MCM respectively.

For the 150,000 DWT case, the existing water supply is adequate for the year 2020. For the year 2060 the annual yield of Gatun watershed is insufficient and Indio dam is required. The Indio dam yield in a dry year (461 MCM) is not sufficient to make up the water balance deficit and pump stations are also required to supply 1459 MCM annually. No pumping would be required in an average year.

An additional regulating dam to provide extra storage capacity within the Gatun watershed is also required for 2060 and the Ciri dam with a capacity of 102 MCM is proposed.

For the 200,000 DWT case in 2020, there is a small water balance deficit in a dry year (116 MCM) and construction of the Indio dam is proposed. For the year 2060, there is a significant deficit of 2351 MCM in a dry year, and construction of Indio dam is proposed. Since the annual yield of Indio dam in a dry year is 461 MCM, pumping stations are also required. They should recycle 1890 MCM of freshwater in a dry year. In an average year the yield from the Indio dam is almost sufficient to make up the water shortage and pumping requirements would be minimal. An additional regulating dam to provide extra storage capacity within the Gatun watershed is also required for 2060 and Trinidad dam is proposed to provide the required storage volume of 396 MCM in an average year.

Table III.1.2-4(1) summaries the proposed plan for the 85' case in the years 2020 and 2060.

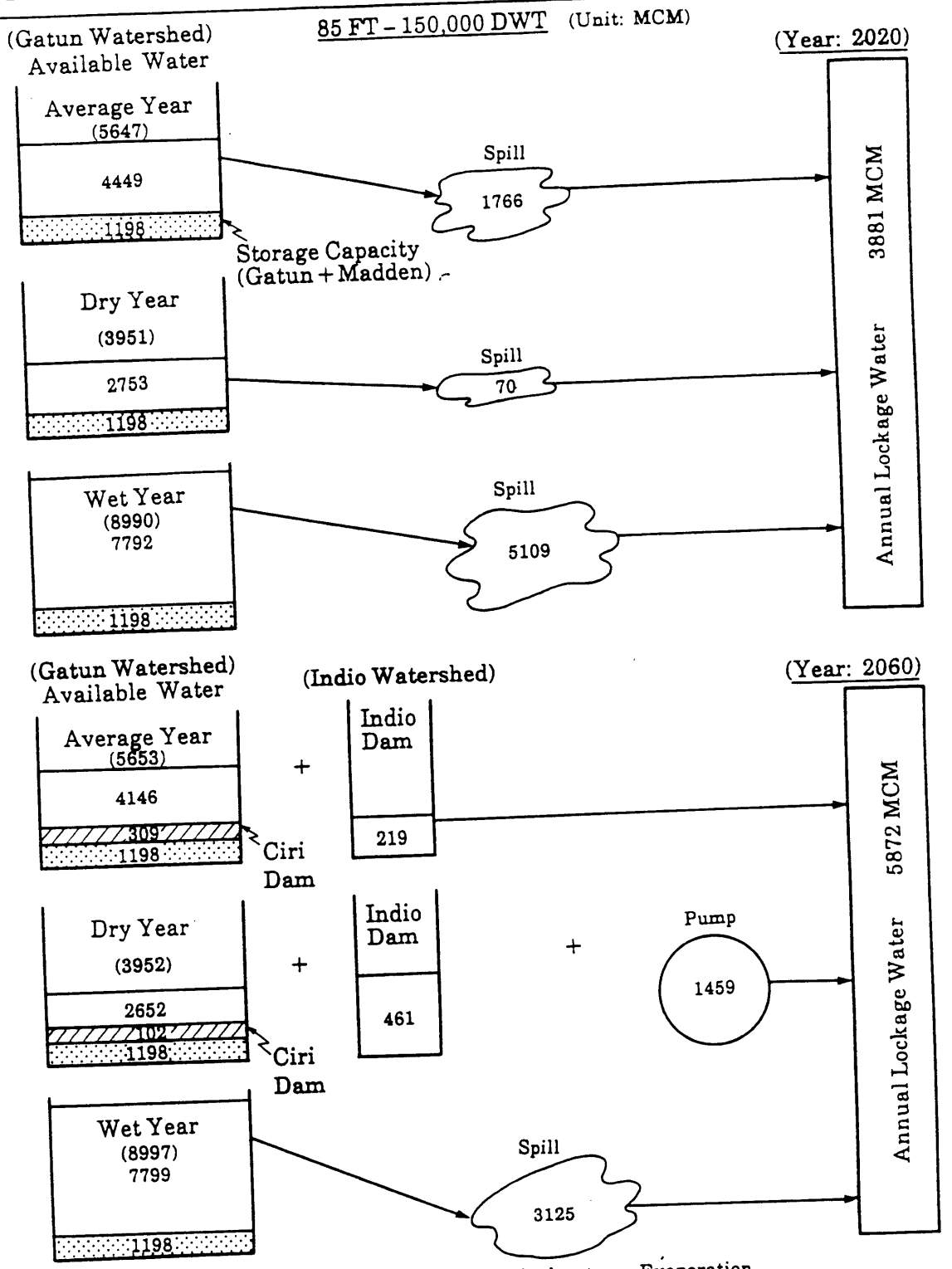
Table III.1.2-4(1) Proposed Plan(85Ft) (Unit mill.m^3)

Design ship	Dam & Pump	Year 2020	Year 2060
150,000	Ciri Dam	-	102
	Trinidad Dam	-	-
	U. Gatun Dam	-	-
	Indio Dam	-	461
	Pump St.	-	1459
200,000	Ciri Dam	-	-
	Trinidad Dam	-	396
	U. Gatun Dam	-	-
	Indio Dam	116	591
	Pump St.	-	1890

By following similar procedures for the 90' case the required capacities of dams and pump stations for 150,000 DWT and 200,000 DWT ships in Average, Dry and Wet years have been derived and are shown in Tables III.1.2-7 and III.1.2-8. The requirements are summarized in Table III.1.2-4(2) below.

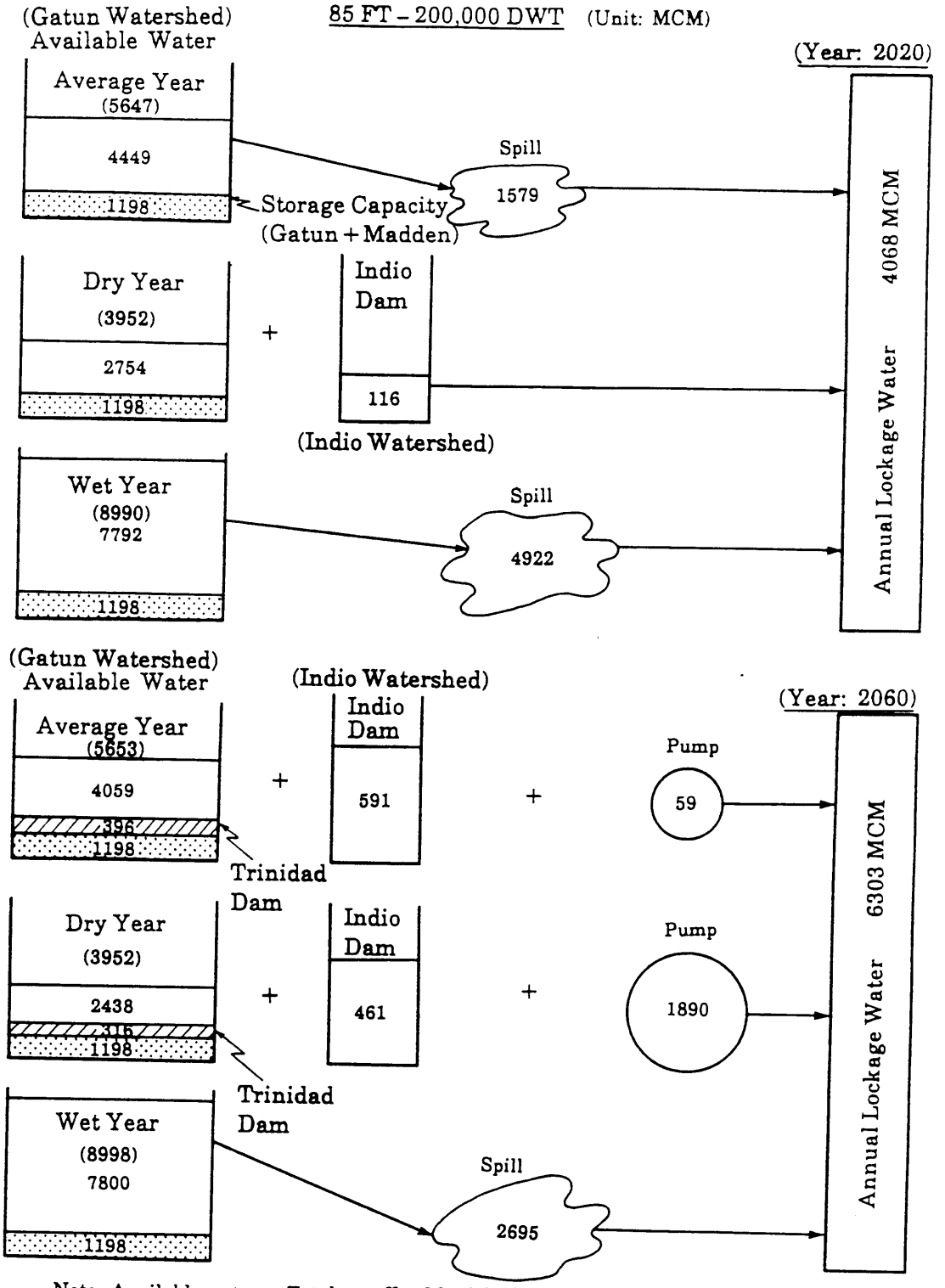
Table III.1.2-4(2) Proposed Plan(90Ft) (Unit mill.m^3)

Design ship	Dam & Pump	Year 2020	Year 2060
150,000	Ciri Dam	-	-
	Trinidad Dam	-	392
	U. Gatun Dam	-	-
	Indio Dam	190	558
	Pump St.	-	1798
200,000	Ciri Dam	-	102
	Trinidad Dam	-	466
	U. Gatun Dam	-	-
	Indio Dam	388	591
	Pump St.	-	2280



Note: Available water = Total runoff – Municipal water – Evaporation

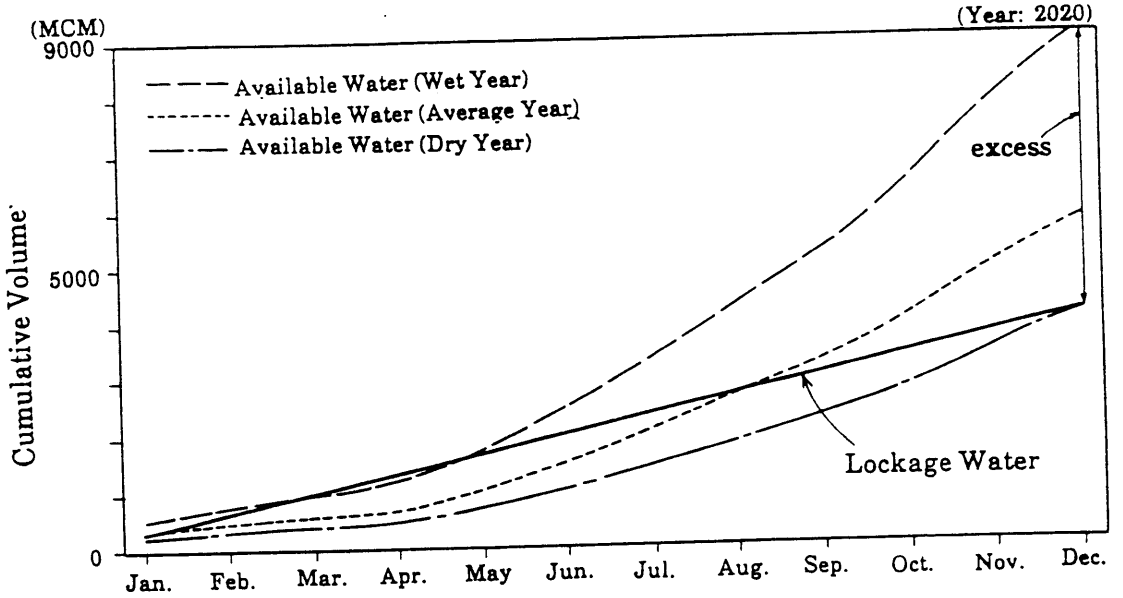
Fig. III.1.2-4 Water Balance for 150,000 DWT Case

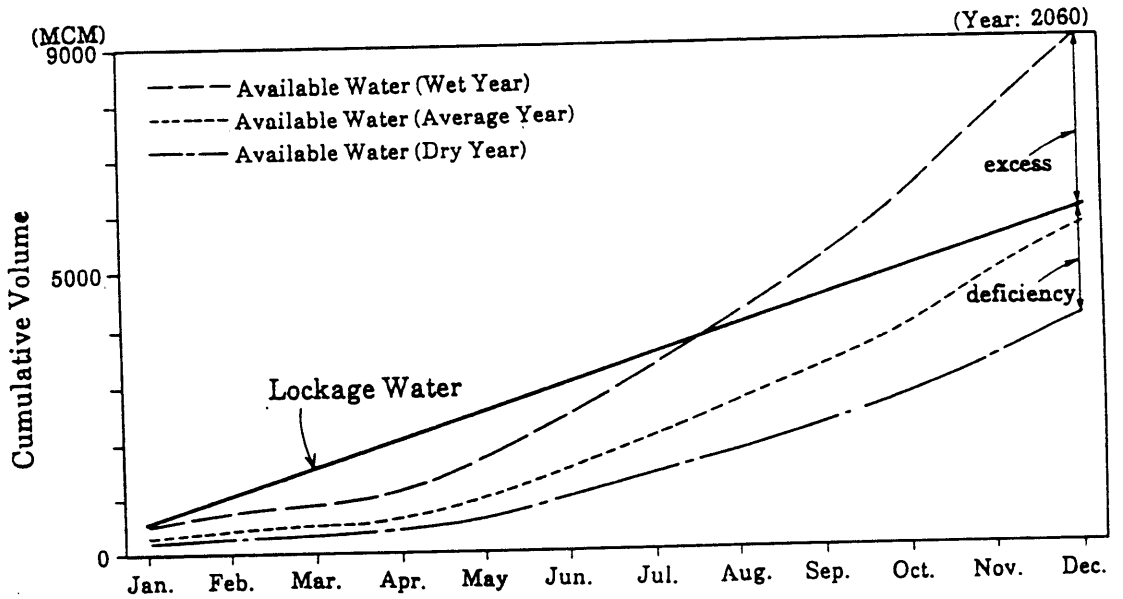


Note: Available water = Total runoff – Municipal water – Evaporation

Fig. III.1.2-5 Water Balance for 200,000 DWT Case

85 FT - 150,000 DWT

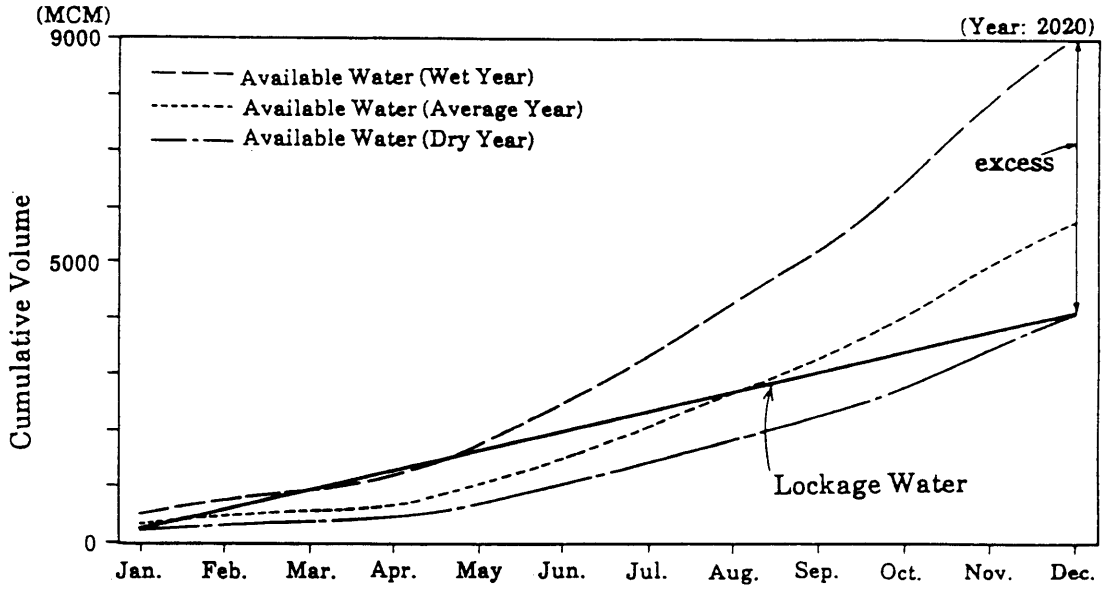


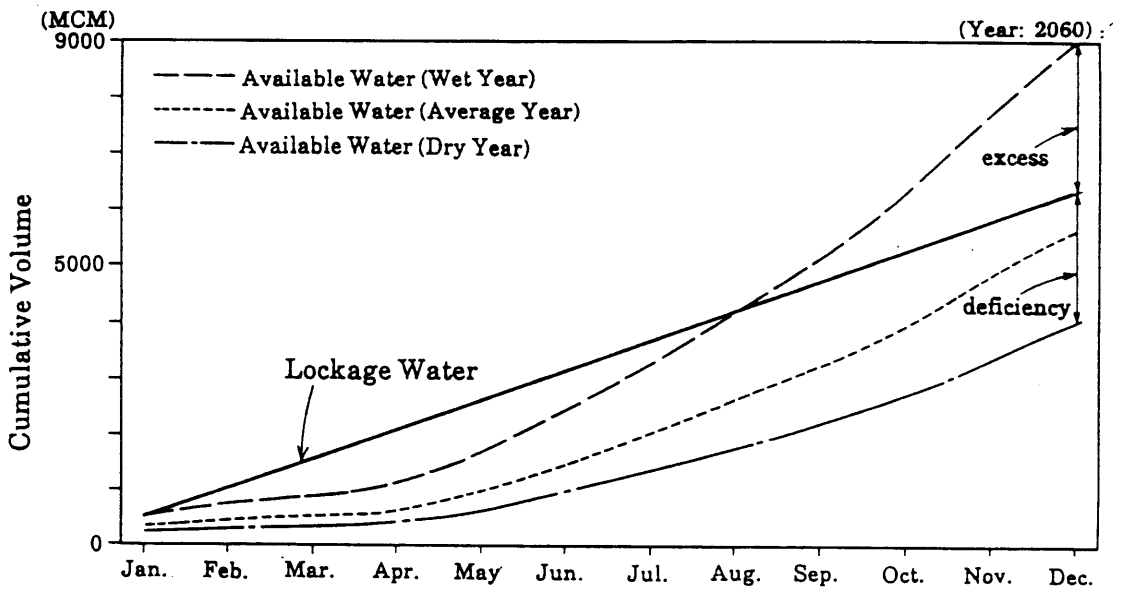


Note: Gap at end of December between available water and lockage water shows excess or deficiency of water

Fig. III.1.2-6 Cumulative Volume for 150,000 DWT Case

85 FT - 200,000 DWT





Note: Gap at end of December between available water and lockage water shows excess or deficiency of water

Fig. III.1.2-7 Cumulative Volume for 200,000 DWT Case

(CASE : 85 FT - 200,000 DWT - 2060 YEAR)

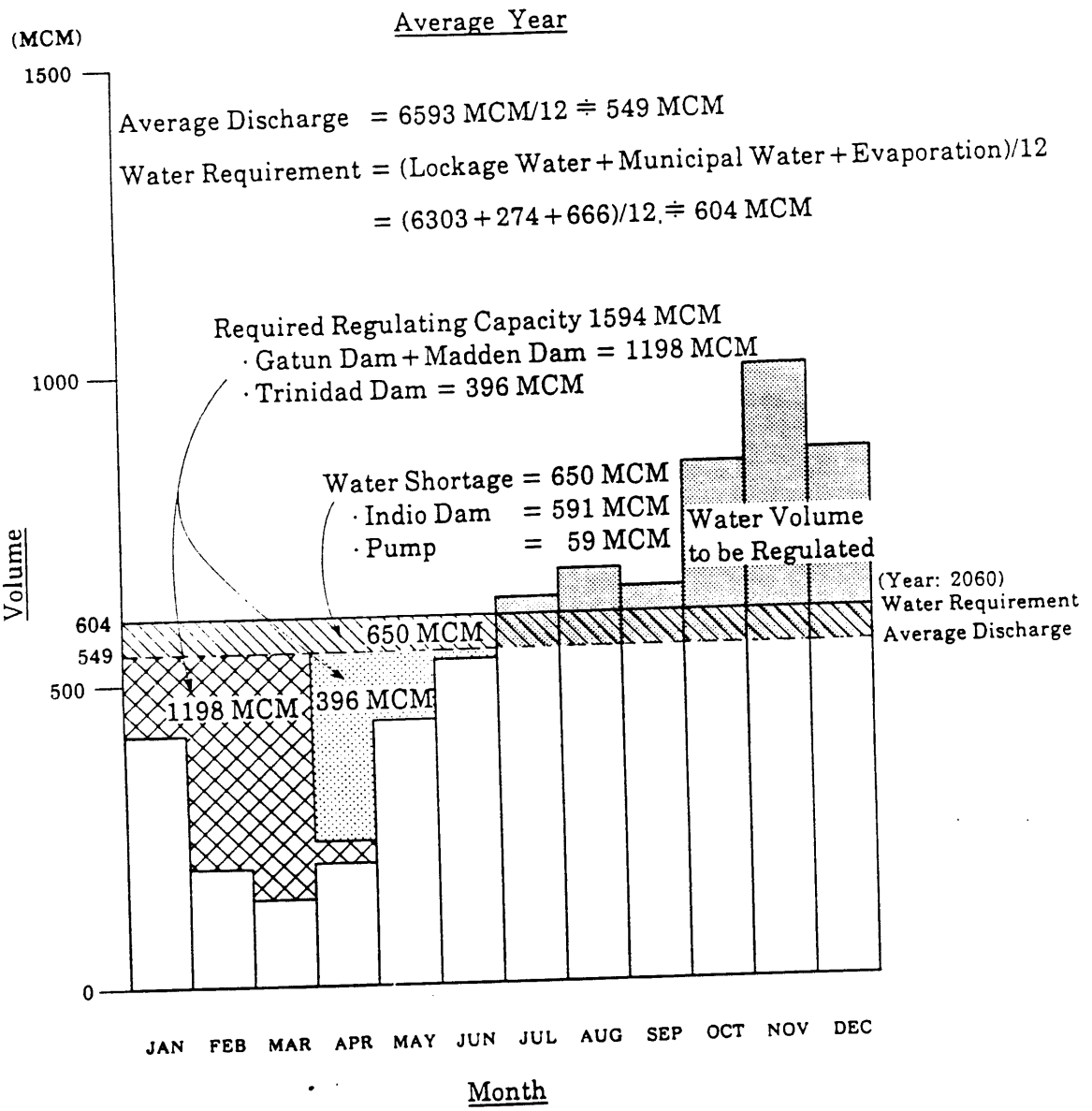


Fig. III. 1. 2-8 Relationship Between Monthly Discharge and Water Requirement

(CASE : 85 FT - 200,000 DWT - 2060 YEAR)

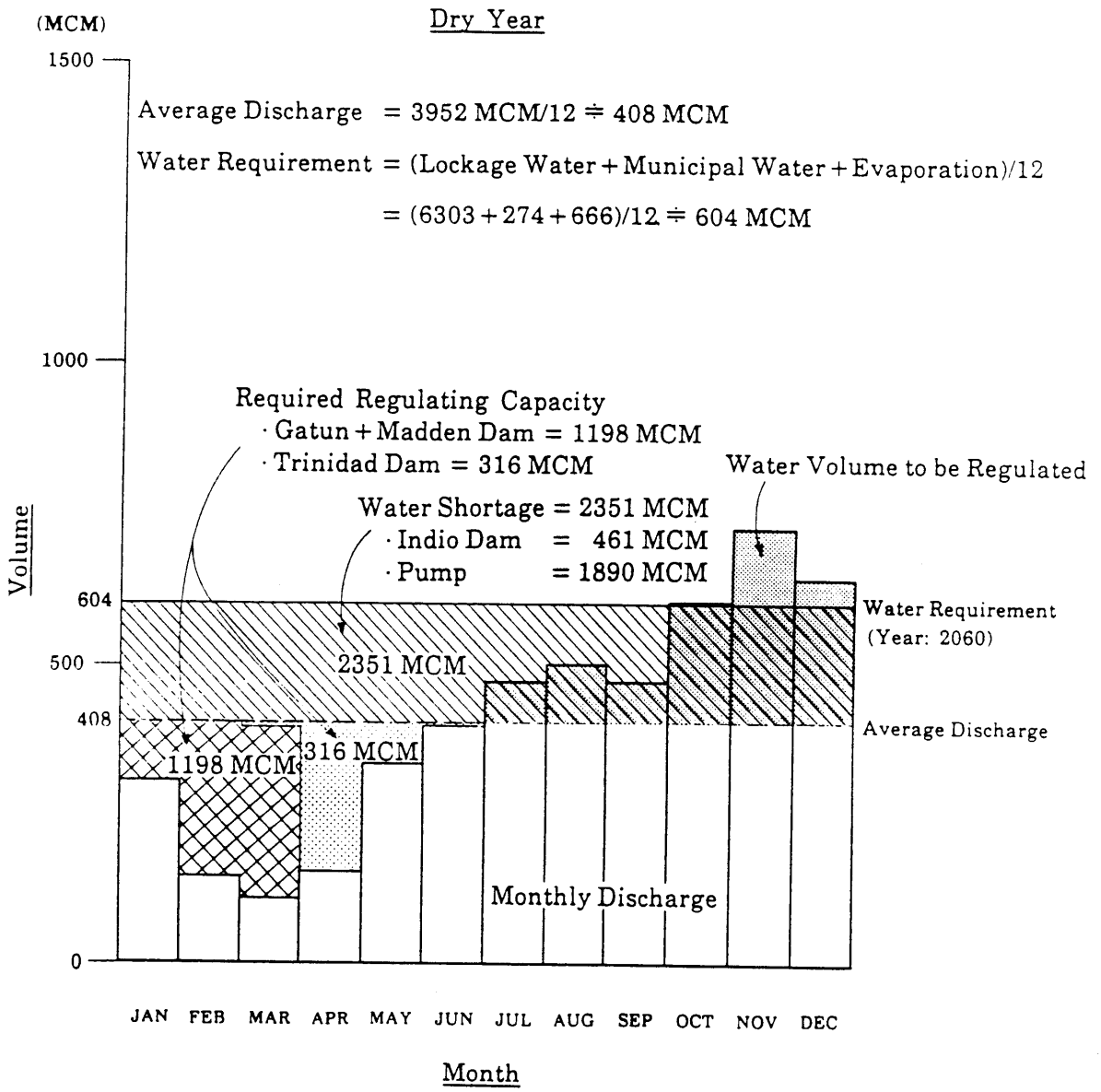


Fig. III. 1. 2-9 Relationship Between Monthly Discharge and Water Requirement

(CASE : 85 FT - 200,000 DWT - 2060 YEAR)

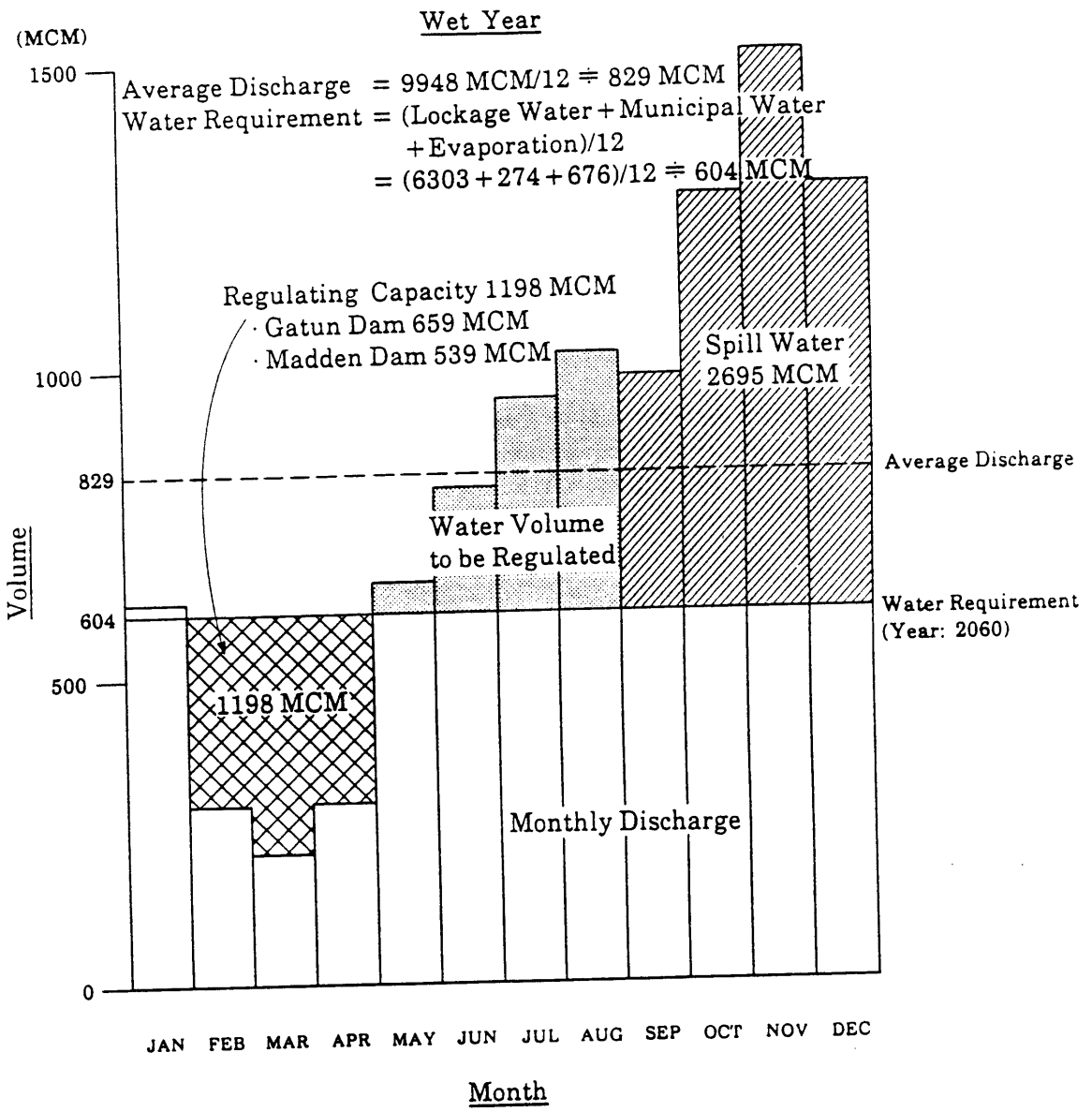


Fig. III.1.2-10 Relationship Between Discharge and Water Requirement (Wet Year)

Table III.1.2-5 Water Balance Table(85FT 150,000 DWT Case)

(1)2020 YEAR CASE

Transits through existing lock	16200		
Transits through new lock	2000		
Total	18200		
CASE NO.(Average,Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	6593	4892	9948
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	672	667	684
④Available water for lockage (①-②-③)(MCM)	5647	3951	8990
⑤Existing lock(MCM)	2867	2867	2867
⑥New lock(MCM)	1014	1014	1014
⑦Total lockage water(⑤+⑥)(MCM)	3881	3881	3881
⑧Water balance(④-⑦)(MCM)	1766	70	5109
Required new dam and pump capacity(MCM)			
⑨New regulating dam capacity(within Gatun watershed	0	0	0
⑩New dam capacity(outside of Gatun watershed)	0	0	0
⑪Pump capacity(⑧-⑩)	0	0	0
⑫Water balance(⑧-⑩-⑪)	1766	70	5109
Planned new dam and pump capacity(MCM)			
⑬New regulating dam capacity(within Gatun watershed)	0		
⑭Ciri dam	0		
⑮Trinidad dam	0		
⑯Upper Gatun dam	0		
⑰New dam capacity(Indio:outside of Gatun watershed)	0		
⑱Pump Capacity(cu.m/s)(⑪0.00/365day/86400sec)	0 (0 unit)		

(2)2060 YEAR CASE

Transits through existing lock	20000		
Transits through new lock	4600		
Total	24600		
CASE NO.(Average,Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	6593	4892	9948
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	666	666	677
④Available water for lockage (①-②-③)(MCM)	5653	3952	8997
⑤Existing lock(MCM)	3540	3540	3540
⑥New lock(MCM)	2332	2332	2332
⑦Total lockage water(⑤+⑥)(MCM)	5872	5872	5872
⑧Water balance(④-⑦)(MCM)	-219	-1920	3125
Required new dam and pump capacity(MCM)			
⑨New regulating dam capacity(within Gatun watershed	(*67) 309	102	0
⑩New dam capacity(outside of Gatun watershed)	(*461)219	461	0
⑪Pump capacity(⑧-⑩)	0	1459	0
⑫Water balance(⑧-⑩-⑪)	0	0	3125
Planned new dam and pump capacity(MCM)			
⑬New regulating dam capacity(within Gatun watershed)	102		
⑭Ciri dam	(102)		
⑮Trinidad dam	0		
⑯Upper Gatun dam	0		
⑰New dam capacity(Indio:outside of Gatun watershed)	461		
⑱Pump Capacity(cu.m/s)(⑪1459/365day/86400sec)	47 (2 unit)		

Note:(1)Pump capacity (1 unit) = 30 cu.m/sec
(2)Average year is the average for 51 years(1933～1983)
(3)Wet year is 1981
(4)Dry year is 1982
* To suite dry year requirements, Indio dam with a capacity of 461 MCM is Proposed. Therefore the required new regulating dam capacity is reduced from 309 to 67 MCM.

Table III.1.2-6 Water Balance Table(85FT 200,000 DWT Case)

(1)2020 YEAR CASE

Transits through existing lock	16200		
Transits through new lock	2000		
Total	18200		
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	2(Wet)
①Total runoff(MCM)	6593	4892	9948
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	672	666	684
④Available water for lockage (①-②-③)(MCM)	5647	3952	8990
⑤Existing lock(MCM)	2867	2867	2867
⑥New lock(MCM)	1201	1201	1201
⑦Total lockage water(⑤+⑥)(MCM)	4068	4068	4068
⑧Water balance(④-⑦)(MCM)	1579	-116	4922
Required new dam and pump capacity(MCM)			
⑨New regulating dam capacity(within Gatun watershed	0	0	0
⑩New dam capacity(outside of Gatun watershed)	0	116	0
⑪Pump capacity(⑧-⑩)	0	0	0
⑫Water balance(⑧-⑩-⑪)	0	0	0
Planned new dam and pump capacity(MCM)			
⑬New regulating dam capacity(within Gatun watershed)	0		
⑭Ciri dam	0		
⑮Trinidad dam	0		
⑯Upper Gatun dam	0		
⑰New dam capacity(Indio:outside of Gatun watershed)	116		
⑱Pump Capacity(cu.m/s)(⑪0.00/365day/86400sec)	0 (0 unit)		

(2)2060 YEAR CASE

Transits through existing lock	20000		
Transits through new lock	4600		
Total	24600		
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	6593	4892	9948
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	666	666	676
④Available water for lockage (①-②-③)(MCM)	5653	3952	8998
⑤Existing lock(MCM)	3540	3540	3540
⑥New lock(MCM)	2763	2763	2763
⑦Total lockage water(⑤+⑥)(MCM)	6303	6303	6303
⑧Water balance(④-⑦)(MCM)	-650	-2351	2695
Required new dam and pump capacity(MCM)			
⑨New regulating dam capacity(within Gatun watershed	*396	*316	*0
⑩New dam capacity(outside of Gatun watershed)	591	461	0
⑪Pump capacity(⑧-⑩)	59	1890	0
⑫Water balance(⑧-⑩-⑪)	0	0	2695
Planned new dam and pump capacity(MCM)			
⑬New dam capacity(within Gatun watershed)	396		
⑭Ciri dam	0		
⑮Trinidad dam	(396)		
⑯Upper Gatun dam	0		
⑰New dam capacity(Indio:outside of Gatun watershed)	591		
⑱Pump Capacity(cu.m/s)(⑪1890/365day/86400sec)	60 (2 unit)		

Note:(1)Pump capacity (1 unit) = 30 cu.m/sec
(2)Average year is the average for 51 years(1933～1983)
(3)Wet year is 1981
(4)Dry year is 1982
(*)See Fig.III.1.2-8,9&10

Table III.1.2-7 Water Balance Table(90FT 150,000 DWT Case)

(1)2020 YEAR CASE

Transits through existing lock	16200		
Transits through new lock	2000		
Total	18200		
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	6593	4892	9948
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	708	702	717
④Available water for lockage (①-②-③)(MCM)	5611	3916	8957
⑤Existing lock(MCM)	3033	3033	3033
⑥New lock(MCM)	1073	1073	1073
⑦Total lockage water(⑤+⑥)(MCM)	4106	4106	4106
⑧Water balance(④-⑦)(MCM)	1505	-190	4851
Required new dam and pump capacity(MCM)			
⑨New regulating dam capacity(within Gatun watershed	0	0	0
⑩New dam capacity(outside of Gatun watershed)	0	0	0
⑪Pump capacity(⑧-⑩)	0	0	0
⑫Water balance(⑧-⑩-⑪)	0	0	0
Planned new dam and pump capacity(MCM)			
⑬New dam regulating capacity(within Gatun watershed)	0		
⑭Ciri dam	0		
⑮Trinidad dam	0		
⑯Upper Gatun dam	0		
⑰New dam capacity(Indio:outside of Gatun watershed)	190		
⑱Pump Capacity(cu.m/s)(⑪0.00/365day/86400sec)	0 (0 unit)		

(2)2060 YEAR CASE

Transits through existing lock	20000		
Transits through new lock	4600		
Total	24600		
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	6593	4892	9948
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	666	666	710
④Available water for lockage (①-②-③)(MCM)	5653	3952	8964
⑤Existing lock(MCM)	3744	3744	3744
⑥New lock(MCM)	2467	2467	2467
⑦Total lockage water(⑤+⑥)(MCM)	6211	6211	6211
⑧Water balance(④-⑦)(MCM)	-558	-2259	2753
Required new dam and pump capacity(MCM)			
⑨New regulating dam capacity(within Gatun watershed	392	280	0
⑩New dam capacity(outside of Gatun watershed)	558	461	0
⑪Pump capacity(⑧-⑩)	0	1798	0
⑫Water balance(⑧-⑩-⑪)	0	0	0
Planned new dam and pump capacity(MCM)			
⑬New regulating dam capacity(within Gatun watershed)	392		
⑭Ciri dam	0		
⑮Trinidad dam	(392)		
⑯Upper Gatun dam	0		
⑰New dam capacity(Indio:outside of Gatun watershed)	558		
⑱Pump Capacity(cu.m/s)(⑪1798/365day/86400sec)	57 (2 unit)		

Note:(1)Pump capacity (1 unit) = 30 cu.m/sec
(2)Average year is the average for 51 years(1933～1983)
(3)Wet year is 1981
(4)Dry year is 1982

Table III.1.2-8 Water Balance Table(90FT 200,000 DWT Case)

(1)2020 YEAR CASE			
Transits through existing lock	16200		
Transits through new lock	2000		
Total	18200		
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	6593	4892	9948
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	706	702	715
④Available water for lockage (①-②-③)(MCM)	5613	3916	8959
⑤Existing lock(MCM)	3033	3033	3033
⑥New lock(MCM)	1271	1271	1271
⑦Total lockage water(⑤+⑥)(MCM)	4304	4304	4304
⑧Water balance(④-⑦)(MCM)	1309	-388	4655
Required new dam and pump capacity(MCM)			
⑨New regulating dam capacity(within Gatun watershed	0	0	0
⑩New dam capacity(outside of Gatun watershed)	0	388	0
⑪Pump capacity(⑧-⑩)	0	0	0
⑫Water balance(⑧-⑩-⑪)	0	0	0
Planned new dam and pump capacity(MCM)			
⑬New regulating dam capacity(within Gatun watershed)	0		
⑭Ciri dam	0		
⑮Trinidad dam	0		
⑯Upper Gatun dam	0		
⑰New dam capacity(Indio:outside of Gatun watershed)	388		
⑱Pump Capacity(cu.m/s)(⑪0.00/365day/86400sec)	0 (0 unit)		

(2)2060 YEAR CASE			
Transits through existing lock	20000		
Transits through new lock	4600		
Total	24600		
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	6593	4892	9948
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	702	702	710
④Available water for lockage (①-②-③)(MCM)	5617	3916	8964
⑤Existing lock(MCM)	3744	3744	3744
⑥New lock(MCM)	2922	2922	2922
⑦Total lockage water(⑤+⑥)(MCM)	6666	6666	6666
⑧Water balance(④-⑦)(MCM)	-1049	-2750	2298
Required new dam and pump capacity(MCM)			
⑨New regulating dam capacity(within Gatun watershed	396	568	0
⑩New dam capacity(outside of Gatun watershed)	591	461	0
⑪Pump capacity(⑧-⑩)	458	2289	0
⑫Water balance(⑧-⑩-⑪)	0	0	0
Planned new dam and pump capacity(MCM)			
⑬New regulating dam capacity(within Gatun watershed)	568		
⑭Ciri dam	(102)		
⑮Trinidad dam	(466)		
⑯Upper Gatun dam	0		
⑰New dam capacity(Indio:outside of Gatun watershed)	591		
⑱Pump Capacity(cu.m/s)(⑪2289/365day/86400sec)	72 (3 unit)		

Note:(1)Pump capacity (1 unit) = 30 cu.m/sec
(2)Average year is the average for 51 years(1933～1983)
(3)Wet year is 1981
(4)Dry year is 1982

III.1 CHAPTER 3 - GEOLOGY AND CANAL EXCAVATION

3.1 Geology

There are many references for the general geology around the Panama Canal area and those listed below are particularly useful to understand the geological characteristics of this area.

1) Mapa Geologico, Republica de Panama (1/250,000), 1991, Ministerio de Comercio E Industries

2) Geological Map of Panama Canal and Vicinity, Republic of Panama (1/100,000), 1980, R.H. and J.L. Stewart in collaboration with W.P. Wooding

3) Series of JAX reports (IOCS Memorandum), particularly JAX-46,78, 79, 85, 92, 94 and 96, etc.

4) IOCS Report - Annex V, Appendix 10

5) Technical Report S-70-9, Study of Clay Shale Slopes along the Panama canal, Report 2, R.J. Lutton

The geology of the Panama Canal area and its vicinity is outlines below using the above documents as references.

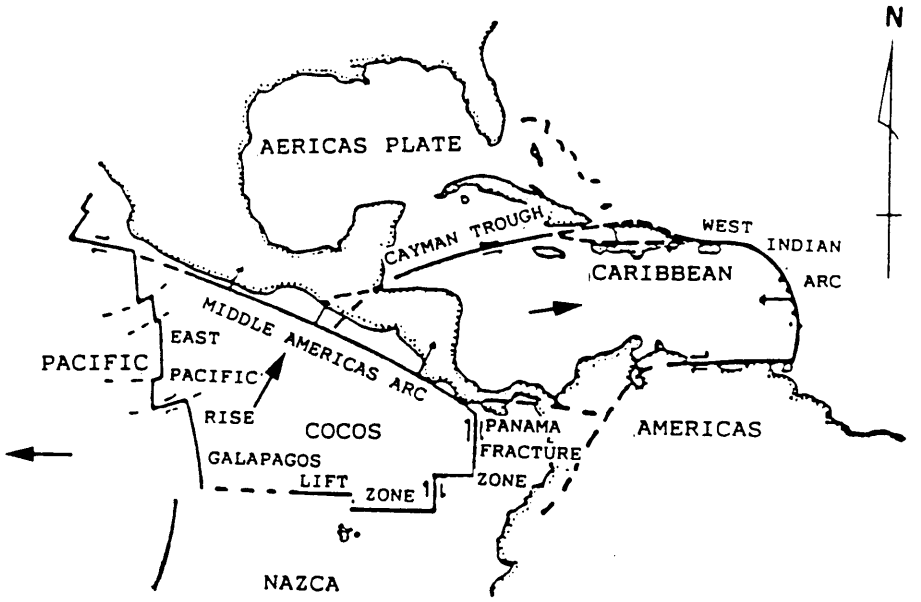
3.1.1 General Geology

The central isthmus linking the North and South American continents is located in an area characterised by complex geological conditions due to the overlapping of four plates, i.e. Cocos, Nazca, Caribbean and Americas, as explained by the plate tectonics theory.

The Panama Canal zone is located in the southwestern corner of the Caribbean Plate and the Cocos Plate is moving beneath it in the northeast direction from the southwest, causing a transform fault (Panama fracture zone) which runs along the north-south axis on the south side of Panama.

The Panama isthmus generally runs ENE-SWS near the canal zone with a north-south width of approximately 60km. The continental divide runs some 10-15km inside of and parallel to the Pacific coast located in the south of the isthmus. This divide has created very distinctive river systems. The topography near the canal zone vividly reflects the area's geological characteristics. On one hand, the highly altered, soft igneous rock region and the sedimentary rocks of the Tertiary have produced a hilly area with gentle slopes. On the other hand, the intrusive body of basalt or dacite has produced protruding tableland or a conical topography, showing a marked difference to the hilly area.

The bedrock of the canal zone consists of sedimentary rocks and extrusive or intrusive igneous rocks of the Tertiary. Although some pre-Tertiary rocks are distributed to the south of the canal zone (roughly to the south of the line linking Lake Maden and Colon), these rocks will not be directly involved in the canal work. Alluvial deposits of the Quaternary are distributed in the flat area along the Pacific and Caribbean. Coral reefs are found along the coast to the east of Colon facing the Caribbean. Furthermore, an active volcano of the Quaternary (Cerro Gaital) is located some 75km southwest of Panama but has no direct bearing on the canal work.



Source: JAX-93 Summary of Geology of Route 10 Panama (1969) by John C. Bowman Jr.

Fig. III.1.3-1 Lithospheric Plates of the Middle America Region

3.1.2 Geology Along High Rise Lock Route

The following three documents are useful to assist understanding of the geology along Route 1.

1) Geological Map of Gaillard Cut Area, Panama Canal, from Gamboa to Pedro Miguel (1/250,000)
Geological Map of Panama Canal and Vicinity, Republic of Panama (1/100,000), 1980, R.H. and J.L. Stewart in collaboration with W.P. Wooding

2) JAX-85 (IOCS Memorandum), 1969

3) Study of clay shale slopes along the Panama Canal Report I, II, III, Thechnical Report S-70-90 (R.J. Lotton, R.W. Hunt, etc. 1974)

The area along Route 1 is largely classified into four geological zones, i.e. (1) Caribbean coast zone, (2) Gatun Lake zone, (3) central divide zone and (4) Pacific coast zone, based on the bedrock formation. The geological characteristics of these zones are outlined below.

(1) Caribbean Coast Zone

This is the area between the Caribbean coast and the former excavation site for the 3rd Lock on the north bank of Gatun Lake. The bedrock of this zone consists of the Gatun Formation described below.

- Gatun Formation (Middle Miocene)
  - sandstone, siltstone, tuff and conglomerate
  - lithofacies: massive and medium hard
  - the excavation slope at the 3rd Lock is stable with little risk of a major landslide

The flat land along the Caribbean is very soft, consisting of alluvial deposits. At the bottom of the Caribbean, deposits of clayey materials called Atlantic Muck are found.

(2) Gatun Lake Zone

This is the area between the north bank of Gatun Lake and Gamboa at the confluence point with Chagres River. The main bedrock of this zone consists of three formations, i.e. Caimito, Bohio and Bas Obispo, with a minor distribution of the Caraba and Gatuntillo Formations.

- o Caimito Formation (Late Oligocene)
  - marine facies (Tcm) and volcanic facies (Tcv)
  - lithofacies: massive and medium hard
  - little risk of a major landslide

- o Bohio Formation (Early to Late Oligocene)
  - conglomerate and sandstone
  - lithofacies: massive and medium hard
  - little risk of a major landslide

- o Bas Obispo Formation (Oligocene)
  - aggromerate and hard tuff
  - lithofacies: massive and medium hard
  - little risk of a major landslide

Deposits of clayey materials and loose materials are found at the bottom of Gatun Lake.

(3) Central Divide Zone

This is the area between Gamboa and the Pedro Miguel Lock, crossing the continental divide which runs ENE-WSW at almost a right angle. The bedrock in this zone is divided into two sections by the Rio Limon fault running north-south and located 2km to the south of Gamboa. The northwestern side of the fault is represented by the formation in the north of Gatun Lake while the southeastern side of the fault is represented by formations of the early Miocene.

The geology of this zone is characterised by the following five formations and intrusive or extrusive basalt.

- Las Cascada Formation (Early Miocene)
  - agglomerate and tuff
  - lithofacies: massive and medium hard to soft
  - previous occurrences of small to medium-scale landslides

- La Boca Formation (Early Miocene)
  - mudstone, siltstone, sandstone and tuff
  - lithofacies: layered or massive and medium hard to soft
  - previous occurrences of small to medium-scale landslides

- Culebra Formation (Early Miocene)
  - sandstone and siltstone
  - lithofacies: massive or layered and medium hard to soft
  - previous occurrences of small to medium-scale landslides

- Cucaracha Formation (Early Miocene)
  - clay shale or tuff
  - lithofacies: layered and soft to very soft
  - previous occurrences of major landslides, the softest and most unstable area along the entire canal route, indepth examination deal with difficult excavation slopes

- Pedro Miguel Formation (Early Miocene)
  - fine to coarse grained agglomerate
  - lithofacies: medium hard to hard
  - little risk of a landslide due to the generally hard formation

- Basalt (generally Post Early Miocene)
  - extrusive or intrusive basalt
  - lithofacies: massive and soft to very hard
  - intrusive

The height of the excavation slopes in this zone may reach as high as 200m, because of the wide distribution of soft rocks, proper care must be taken in

preventing the occurrence of a landslide on these slopes.

(4) Pacific Zone

This is the area between the Pedro Miguel Lock and the Pacific coast which has a gentle hilly topography. The geology of this zone is characterised by the following formations.

- La Boca Formation (Early Miocene)
  - mudstone, siltstone, sandstone and tuff
  - lithofacies: massive or layered and medium hard to soft
  - previous occurrences of small to medium-scale landslides

- Panama Formation (Early to Late Oligocene)
  - agglomerate and tuff
  - Lithofacies: massive and medium hard to soft
  - Little risk of a major landslide

Deposits of clayey materials are found in the swamps distributed along the west bank of the existing canal and at the bottom of the Pacific Ocean.

3.2 Zoning

In view of the proposed canal structure, construction methods and excavation volume, the route is divided into five zones, i.e. (I) Atlantic Approach, (II) Gatun Lake, (III) Culebra, (IV) Miraflores and (V) Pacific Approach.

3.2.1 Atlantic Approach Zone (Zone I)

This is the 14.8km section between No.-12.80 (starting point of the Atlantic Approach) and No. 2.00 (Gatun Lock), and will be entirely excavated by the dredging method.

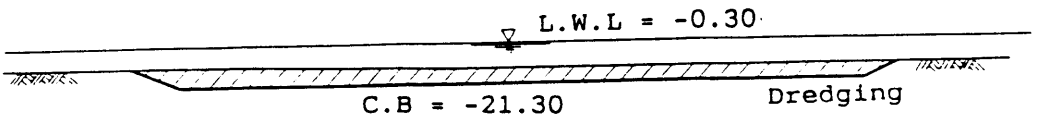


Fig. III.1.3-2 Typical Cross-Section of Zone I

3.2.2 Gatun Lake Zone (Zone II)

This is the 40km section between No. 2.00 (Gatun Lock) and No. 42.00 (Gamboa) and consists of Gatun Lake. In principle, the dredging method will be used except for ground excavation work at several small islands in the lake. For those islands where excavation machinery can be operated, dry excavation will be conducted at a ground level of EL 29m or above. The dredging method will be used below this elevation. For those islands where excavation machinery cannot be operated, or efficient operation is not expected, the dredging method will be used.

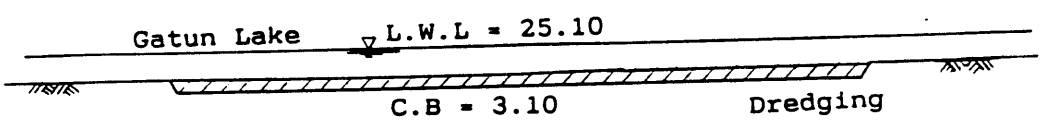


Fig. III.1.3-3 Typical Cross-Section of Zone II

3.2.3 Culebra Zone (Zone III)

This is the 10km section between No. 42.00 (Gamboa) and No. 52.00 (Contractor's Hill). Widening of the existing Culebra cut is planned here by expanding in the southwest direction while preserving the northeastern bank of the present canal. The dredging method will be used to excavate the existing canal while both the dredging and dry excavation methods will be used to widen the canal. In mixed excavation areas to widen the canal, dry excavation will be conducted in the first stage, and dredging will be conducted in the second stage to remove the remaining underwater excavation.

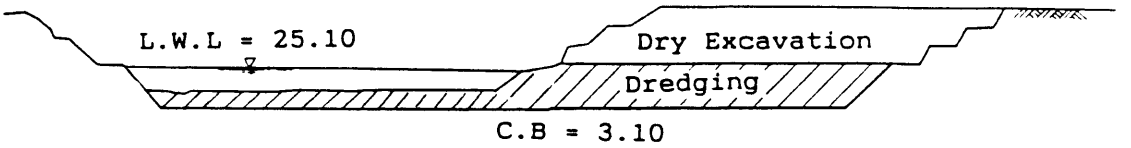


Fig. III.1.3-4 Typical Cross-Section of Zone III

3.2.4 Miraflores Zone (Zone IV)

This is the 8km section between No. 52.00 (Contractor's Hill) and No. 60.00 (Miraflores Lock). As the route in this zone avoids Miraflores Lake with the result of parting from the existing canal route, the entire excavation work will take place on the ground.

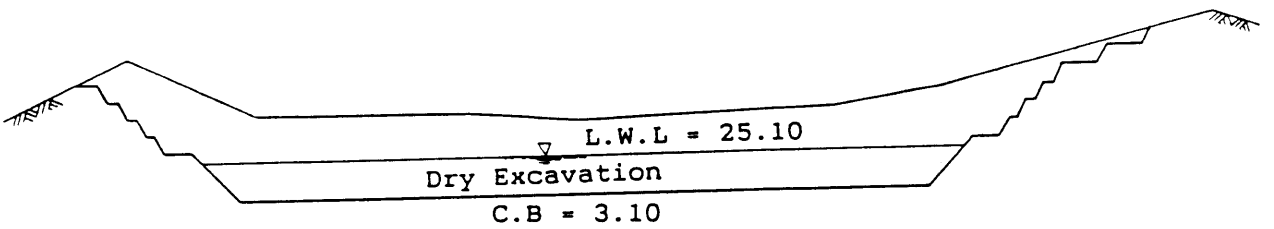


Fig. III.1.3-5 Typical Cross-Section of Zone IV

3.2.5 Pacific Approach Zone (Zone V)

This is the 19.2km section between No. 60.00 (Miraflores Lock) and No. 79.20 (end point of Pacific Approach) and the entire section will be dredged.

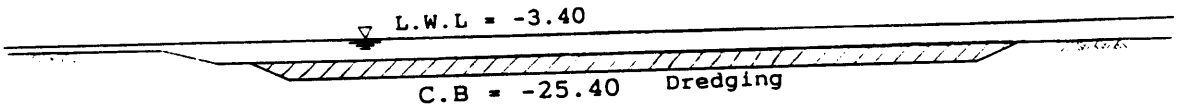


Fig. III.1.3-6 Typical Cross-Section of Zone V

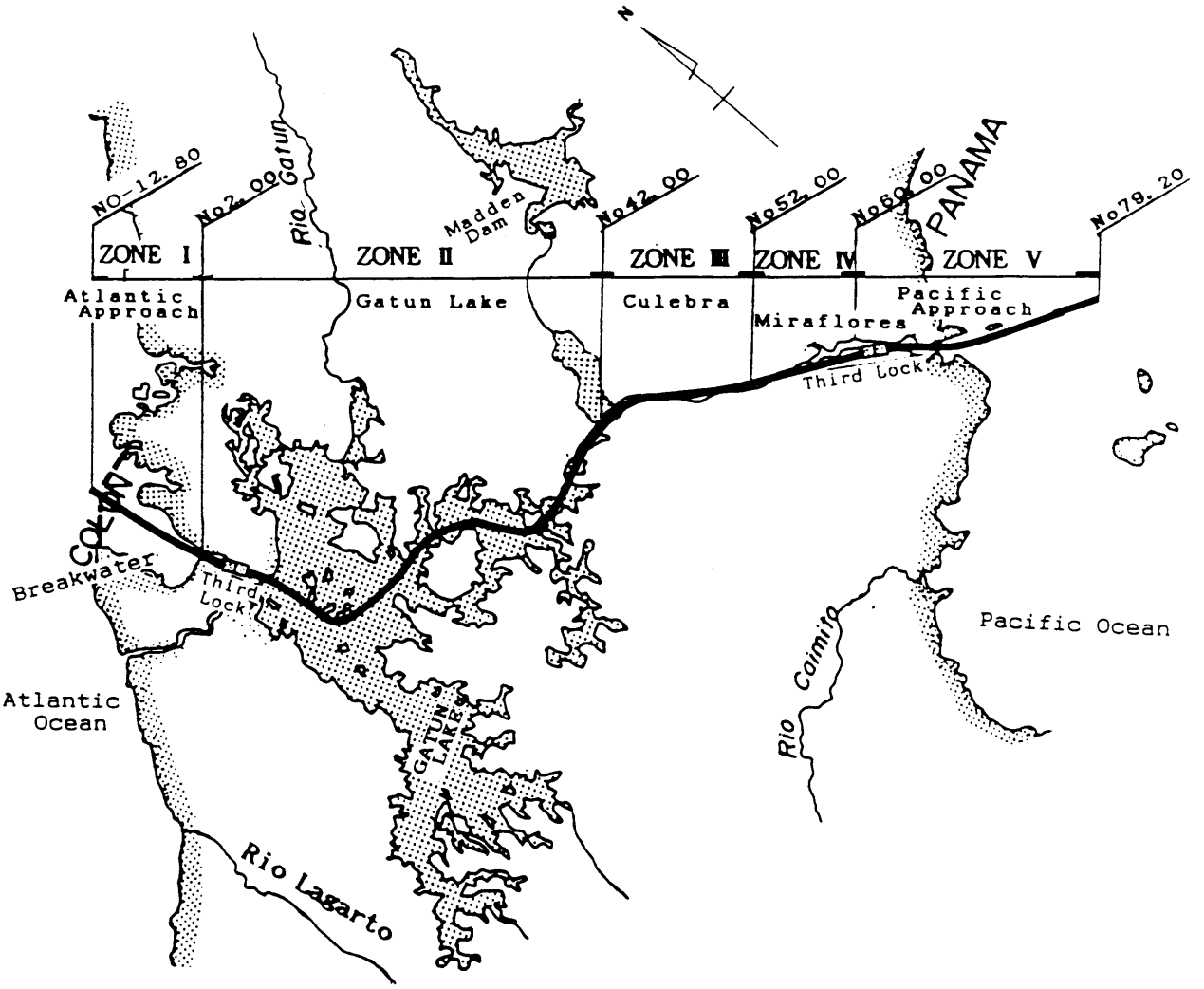


Fig. III.1.3-7 Zone Map for High Rise Lock Routes

3.3 Excavation Slopes

3.3.1 Standard Slope Configurations

Slope configuration selection will be based on the five slope categories of Type 1 to Type 5 described in Part II taking the rock and sediment types into consideration.

3.3.2 Slope Type Suitability for Route Alignment

The IOCS and Nagano Plan only describe slope type suitability in terms of the rock and sediment types and do not explain the geographical suitability of slope types. This aspect (geographical) of slope type suitability has now been proposed in the Study, Nevertheless, the proposal remains part of the Feasibility Study and slope type suitability for the detailed design and actual construction work must be determined based on the findings of a thorough soil engineering survey. The proposed slope types and their locations are shown in Table III.1.3-1.

The following documents were mainly used to decide the slope type at specific locations.

- Sediment Profiles (IOCS, 1970)
- Geological Map of Panama Canal and Vicinity (Republic of Panama, 1980)

Table III.1.3-1 Slope Type Suitability

Canal Station(km)	Section	Cordinates	Slope Type	Average Excavation Hight(m)
No. -12.80 to No. -1.50	Atlantic Ocean to the Coastline		5	6.8
		618.80E 1029.00N		
No. -1.50 to No. 43.00	The Coastline to Gamboa		1	13.0
		644.40E 1005.70N		
No. 43.00 to No. 50.50	Gamboa to Cerro Nitro		4	37.2
		648.30E 1000.00N		
No. 50.50 to No. 53.00	Cerro Nitro to Contractor's Hill		1	55.5
		649.80E 998.20N		
No. 53.00 to No. 61.00	Contractor's Hill to Miraflores Lock		3	38.0
		655.40E 992.40N		
No. 61.00 to No. 66.00	Miraflores Lock to the Coastline		2	19.4
		658.00E 988.10N		
No. 66.00 to No. 79.20	The Coastline to Pacific Ocean		5	9.0

3.4 Excavation Material Classification

3.4.1 Bedrock Classification for Excavation Work

Seven sediment types have been introduced to correspond to the construction work methods which have been decided based on the assumed thickness of the soil formations at each survey site. The assumed formation thickness is based on on-site observation findings and existing data such as that provided by past reports and geological plans. A schematic geological profile of each of the seven sediment types found along the High Rise Lock route is given in Fig. III.1.3-8 and the characteristics of the seven sediment types are summarised below:

The concept of common rock defined by the Study includes those rocks of which excavation will require blasting. The ratio of excavation work requiring blasting is assumed to be 0 and 30% depending on the rock types found along the route.

The excavation work is largely divided into dry excavation work on the ground and dredging work in the sea as shown in Table III.1.3-2. The dry excavation work is further divided into sediment excavation and rock excavation with the latter consisting of weathered rock excavation and common rock excavation.

The dredging work is also divided into rock excavation and sediment excavation with the latter consisting of clayey materials excavation and loose materials excavation based on grain size. The rock excavation work is divided into weathered rock excavation and common rock excavation as in the case of excavation work on the ground. However, the actual excavation method differs. Refer to the Construction Plan (Section 2) described later for details of the excavation methods.

Table III.1.3-3 gives the names of the formations and the quality of the rocks found along High rise lock Route. Table III.1.3-3 has been prepared based on various existing materials, particularly JAX-96 and the Geological Map of the Panama Canal and Vicinity (Republic of Panama, 1980).

Table III.1.3-2 Rock and Sediments Classification for Excavation

Excavation Area	Subsurface	Category of Excavation	Geological Features	Excavation Procedure
1. Dry Exc. (Open)	1.1 Sediments	(1) Earth common	- Holocene sediments	Bulldozer
	1.2 Rock	(2) Weathered Rock	- Weathered or altered, soft to med, hard rock - Semi-consolidated sedimentary rocks	Bulldozer with ripper
		(3) Common Rock	- Fresh to slightly weathered or altered rocks - Hard to med. hard	Bulldozer with ripper or blasting
2. Dredging (Under-water Exc.)	2.1 Sediments	(4) Clayey Materials	- Atlantic muck - Pacific muck (clay & silt)	Grub with trailer
		(5) Loose Materials	- Unconsolidated sediments (sand & gravel)	Grub with trailer
	2.2 Rock	(6) Weathered Rock	- Weathered or altered soft to med. hard rock - Semi-consolidated sedimentary rock	Cutter-suction pump
		(7) Common Rock	- Fresh to slightly weathered or altered rock	Large cutter suction pump
			- Hard to med. hard	Blasting & Large cutter suction pump

Table III.1.3-3 Classification of Rock Quality

Rock or Formation High Rise Lock		Category of Quality
Basalt (extrusive)	(Tb)	High Quality Rock
(intrusive)		
Dacite	(Td)	
Pedro Miguel F.	(Tpa)	
Bas Obispo F.	(Tba)	
Gatun F.	(Tg)	Intermediate Quality Rock
Caimito F.	(Tcm)	
Marine Rocks	(Tue)	
Bohio F.	(Tbm) & (Tbo)	
Las Cascadas F.	(Tlc)	Low Quality Rock
La Boca F.	(Tl)	
Panama F.	(TP)	
Cucaracha F.	(Tca)	Soft Rock
Severely altered agglomerate and tuff in (Tb) and (Tv)		
Culebra F.	(Tcb)	
Debris	(Overburden)	Earth
Atlantic Muck		
Pacific Muck		

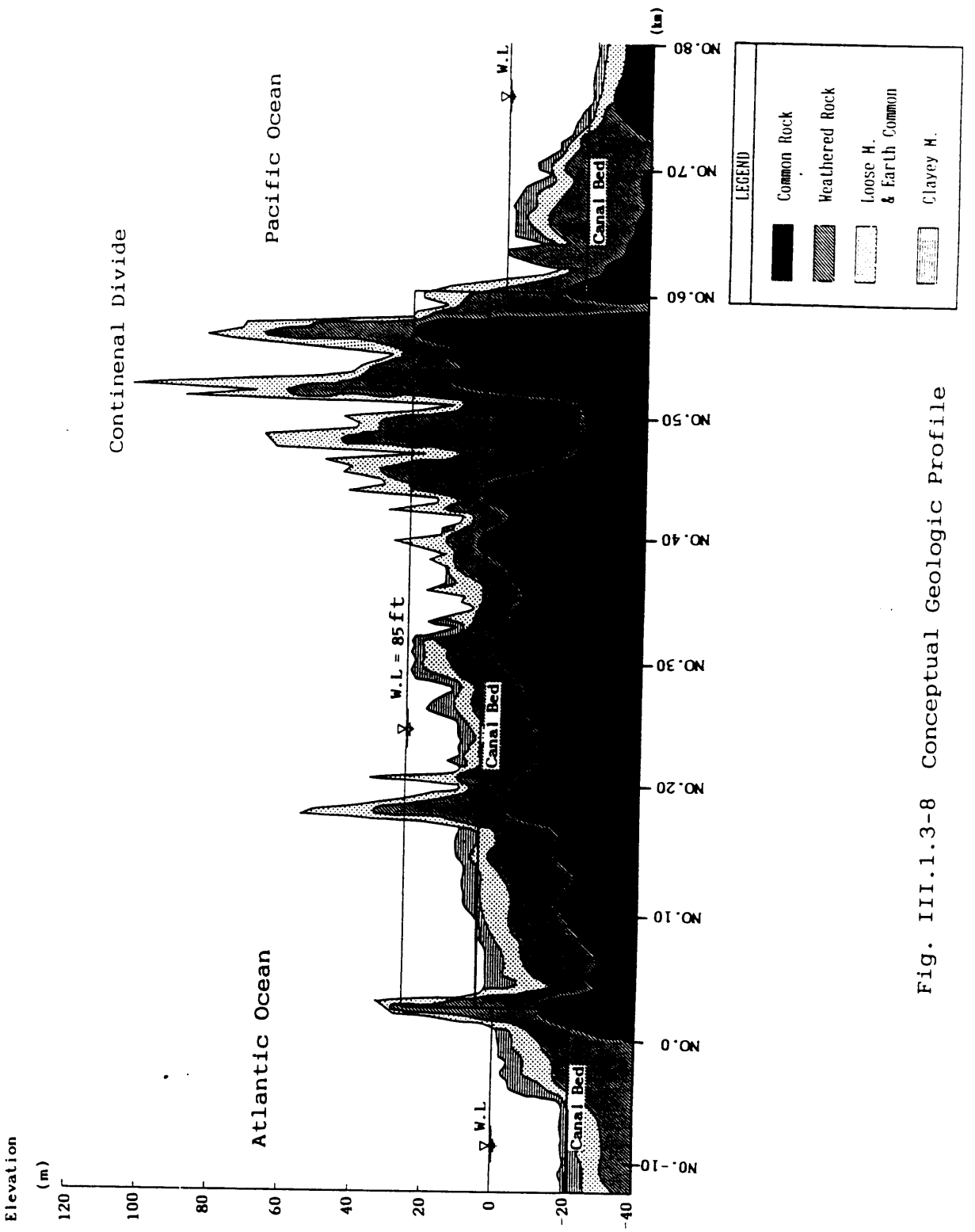


Fig. III.1.3-8 Conceptual Geologic Profile

3.4.2 Cross-Section Preparation

The scale of the topographical maps used for the ground section is 1:25,000. In the case of the sea and Gatun Lake sections, charts giving better details (scale:1/50,000) are used to prepare the cross-sections. The distance between the cross-section points is 0.5 km.

The required excavation volume has been computed and the relevant drawings made using a CAD system. Contours on the topographical maps were read by the digitizer and the design canal profile was input to compute the excavation volume. The sectional area was also computer based on the excavation volume. The software used to assist the construction plan was LAPLAS which is popularly used. A list of hardware is given below.

- Computer : SN-4330 (SUN Micro Systems)
- Personal Computer: PC-H98 model90-100 (NEC)
- Digitizer : DH8503 (SEIKO)
- Plotter : EP4010 (SEIKO)
- Printer : CH-5514 (SEIKO)

3.5 Excavation Volume

3.5.1 Excavation Volume of Each Alternative

The required excavation volume for the high rise lock canal route will be calculated for four separate cases, i.e. combinations of two different ship sizes of 150,000 DWT and 200,000 DWT, and two different water level of 85' and 90' for Gatun Lake.

Table III.1.3-4 given the excavation volume for each sediment type by zone for these four cases.

3.5.2 Consideration for Culebra Cut Widening Project Currently In-progress

"Culebra Cut Widening Project" (ref. I. Chapter 1.2.7) is now being carried out and the excavation volume is reported by PCC to be 34.9 mill. cu. yd. (26.7 mill. m^3) in total as shown below. This volume was deducted from excavation volume calculated for all high rise lock canal alternative.

The figures in zone III of Table III.1.3-5 are deducted volumes. The reduction was made with respect to each excavation materials (in seven categories) and the total amount deducted was 34.9 mill. cu. yd.

Memorandum of US Goverment dated May 3 1991

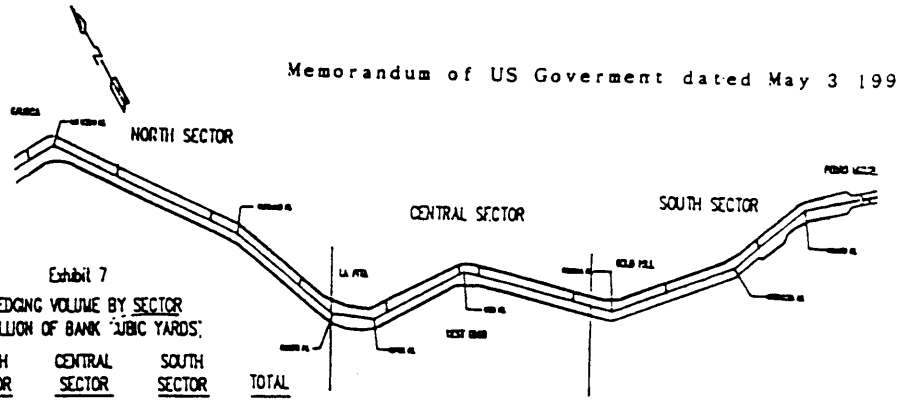


Exhibit 7

DREDGING VOLUME BY SECTOR
(IN MILLION OF BANK CUBIC YARDS)

MATERIAL	NORTH SECTOR	CENTRAL SECTOR	SOUTH SECTOR	TOTAL
DRY COLLUVION	1.8	4.3	3.2	9.3
DRY ROCK	2.0	6.5	5.5	14.0
DREDGING	3.4	5.0	3.2	11.6
TOTAL	7.2	15.8	11.9	34.9

Table III.1.3-4 Excavation Volume Tables

High Rise Look Canal 150.000 DWT. 85' Case

ZONES	STATION	Dry Excavation (1000m3)				Dredging (1000m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose M.	Clayey M.	Total
I	-12.50 - 2.00	0	195	127	322	52	23.510	16.189	6.862	46.613
II	2.00 - 42.00	5.677	6.373	904	12.954	14.592	37.268	35.526	34.480	121.866
III	42.00 - 52.00	15.782	41.952	11.379	69.113	25.403	25.040	3.232	2.382	56.057
IV	52.00 - 60.00	59.485	59.971	14.073	133.528	3.921	693	87	100	4.801
V	60.00 - 76.00	290	383	104	777	326	30.569	21.241	13.955	66.091
Total	88.50	81.234	108.873	26.587	216.694	44.294	117.080	76.275	57.779	295.423

High Rise Look Canal 150.000 DWT. 90' Case

ZONES	STATION	Dry Excavation (1000m3)				Dredging (1000m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose M.	Clayey M.	Total
I	-12.50 - 2.00	0	195	127	322	52	23.510	16.189	6.862	46.613
II	2.00 - 42.00	5.393	6.054	859	12.306	13.863	35.404	33.750	32.756	115.773
III	42.00 - 52.00	14.867	39.462	10.693	65.021	23.819	23.491	3.021	2.236	52.567
IV	52.00 - 60.00	56.510	56.972	13.369	126.852	3.725	659	82	95	4.561
V	60.00 - 76.00	290	383	104	777	326	30.568	21.241	13.954	66.088
Total	88.50	77.060	103.066	25.152	205.278	41.784	113.632	74.283	55.903	285.602

High Rise Look Canal 200.000 DWT. 85' Case

ZONES	STATION	Dry Excavation (1000m3)				Dredging (1000m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose M.	Clayey M.	Total
I	-12.80 - 2.00	0	217	141	358	58	27.194	18.687	7.908	53.847
II	2.00 - 42.00	6.291	7.000	996	14.288	17.344	43.667	42.097	42.856	145.964
III	42.00 - 52.00	17.640	47.544	13.006	78.190	28.945	28.984	3.765	2.725	64.419
IV	52.00 - 60.00	65.491	66.801	15.732	148.024	4.252	752	94	108	5.207
V	60.00 - 79.20	346	458	124	929	376	36.917	27.907	23.027	88.227
Total	92.00	89.769	122.019	30.000	241.788	50.975	137.514	92.550	76.625	357.664

High Rise Look Canal 200.000 DWT. 90' Case

ZONES	STATION	Dry Excavation (1000m3)				Dredging (1000m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose M.	Clayey M.	Total
I	-12.80 - 2.00	0	217	141	358	58	27.194	18.687	7.908	53.847
II	2.00 - 42.00	5.977	6.650	946	13.573	16.476	41.484	39.992	40.713	138.666
III	42.00 - 52.00	16.632	44.774	12.238	73.644	27.184	27.238	3.528	2.561	60.511
IV	52.00 - 60.00	62.216	63.461	14.946	140.623	4.040	715	89	103	4.947
V	60.00 - 79.20	346	458	124	929	376	36.917	27.907	23.027	88.227
Total	92.00	85.171	115.559	28.396	229.127	48.134	133.547	90.203	74.313	346.197

3.6 Sensibility Analysis

The slope criteria adopted by the Study are described in Part II. It is highly possible, however, that these slope criteria be modified for the actual excavation work on the basis of findings of the detailed soil engineering survey. In general, factors which largely affect excavation volume are slope gradient and canal width. Therefore, changes of excavation volume due to different slope gradient as well as different canal width were examined. The subject case was the ship size of 200,000 DWT and 85 feet lake level.

3.6.1 Excavation Slope

The adoption of gentler excavation slope than the slope criteria used by the Study was examined. The rate of increased excavation volume is shown in Fig. III.1.3-9.

The examination involved three cases where the adopted slope gradient under the Study be changed to a gentler slope of cotangent 0.2, 0.4 and 0.6. The examination results indicated that an increase of total excavation volume would be rather small even if the slope gradient be drastically changed to make the slope much gentler. The change of gradient to cotangent 0.6 would increase the total excavation volume by 10.5%. As the total excavation volume is roughly in proportion to the earth work cost, it is safe to assume that the latter would increase by the same proportion in case a gentler slope gradient being adopted.

3.6.2 Canal Width

Using the two-lane canal width of 7B (350m) adopted by the Study as the reference width, two cases of increased canal width, i.e. 8B (400m) and 10B (500m) were examined to determine an impact of wider canal width on excavation volume. The resulting increase of excavation volume is shown in Fig. III.1.3-10. The rate of increase is very large at 16% for the case 8B or 53% for the case 10B.

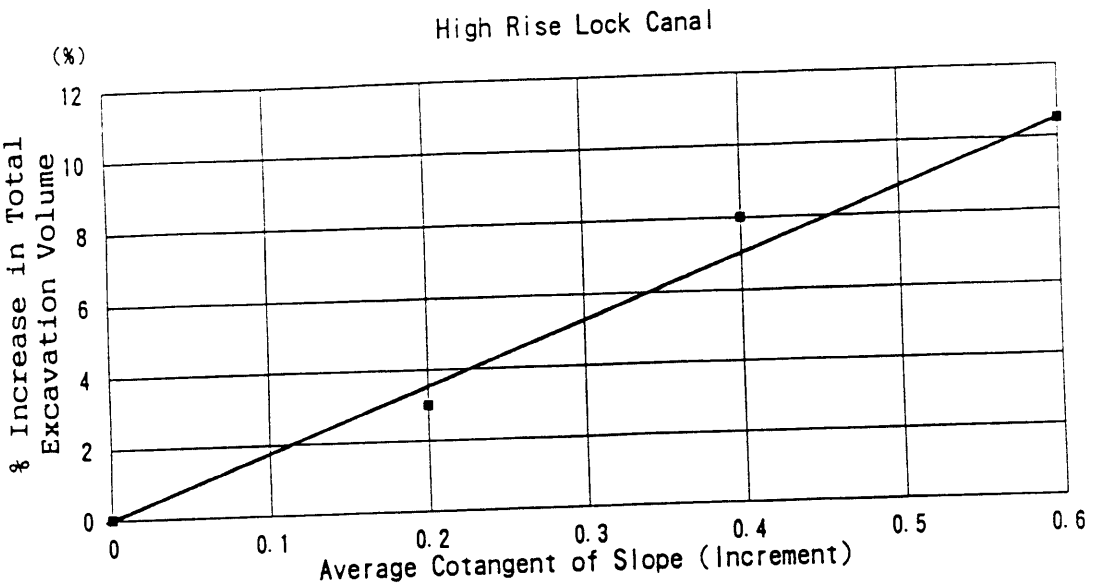


Fig. III.1.3-9 Effect of Canal Side Slope on Excavation Volume

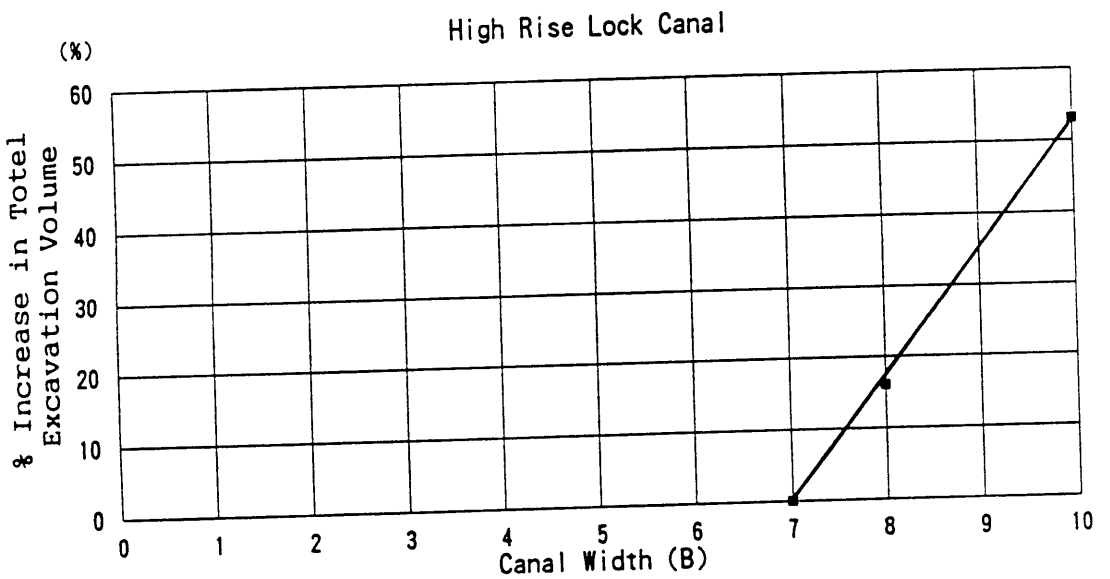


Fig. III.1.3-10 Effect of Canal Width on Excavation Volume

III.1 CHAPTER 4 - LOCK STRUCTURE

4.1 Design Criteria

Design criteria are shown in the Table III.1.4-1.

Table III.1.4-1 Design Criteria

Item	Description
1) Lake levels	85' and 90'
2) Tide levels	High water level = +3.6 m (Pacific) Lowest water level = -3.4 m (Pacific) High water level = +0.5 m (Atlantic) Lowest water level = -0.3 m (Atlantic)
3) Lock dimensions	150,000 DWT, 390 * 50 * 20.0 m 200,000 DWT, 420 * 55 * 21.5 m
4) Lock lift No.	2 lifts
5) Lock lane No.	1-lane
6) Canal lane No.	2-lanes (320m)
7) App. lane No.	2-lanes (320m)
8) Ship size	200,000 DWT, 333 x 50 x 19 m 150,000 DWT, 306 x 46 x 18 m
9) Earthquake	Kh = 0.1, Kv = Kh * 2/3

4.2 Lock Structure

4.2.1 Type of Structure

As shown in the Fig. III.1.4-1 various type of lock walls would be applicable in preliminary design.

(1) is gravity wall type and is used in existing locks. This type needs a lot of concrete but from a durability point of view it is thought to be superior to others.

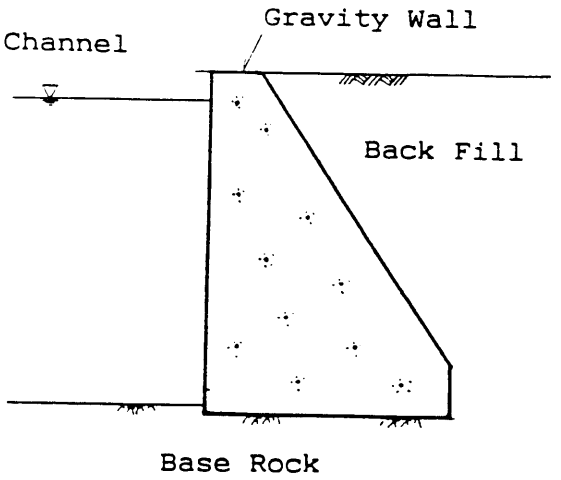
(2) is a buttress wall type and the concrete volume is less compared with (1) types but reinforcing bars are necessary.

(3) is a anchor type. A thin concrete wall is cast in place by an underground continual wall construction method and the wall is anchored into the ground with rock anchor system. The construction cost of this type would be more economical than that of gravity wall type, but more precise soil and rock investigation at the sites will be necessary.

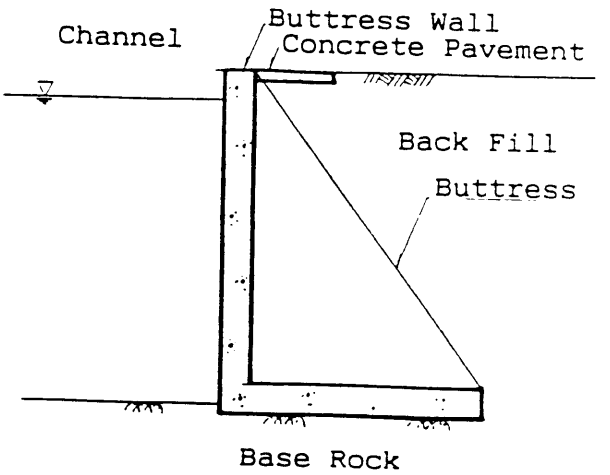
(4) is a jetty type. The ground is excavated at a slope and the slope surface is covered by concrete or mortar with rock bolt system, so that the excavated slope is stable and gives no lateral pressure to the jetty structure. The jetty top slabs are provided for mule operation and a ship guide line. Applying the type, more precise soil and rock investigation at the sites will be needed.

As a conclusion, the gravity wall type (1) is adopted in this preliminary design. Details of the structures are shown in DWG. No.1 - No.6.

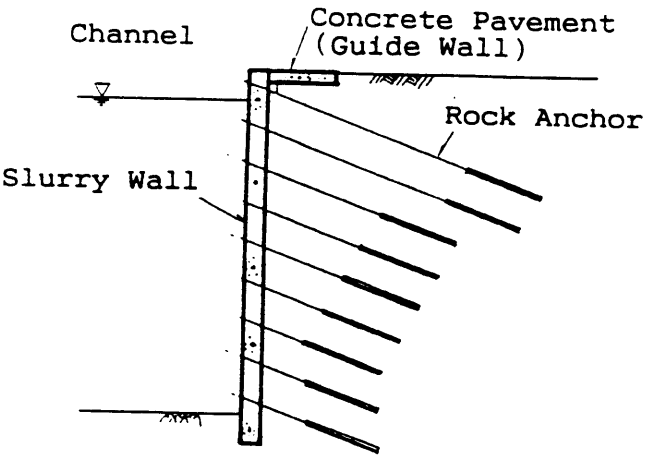
(1) Gravity Wall Type



(2) Buttress Wall Type



(3) Slurry Wall & Rock Anchor Type



(4) Jetty & Slope Protection (Rock Bolt) Type

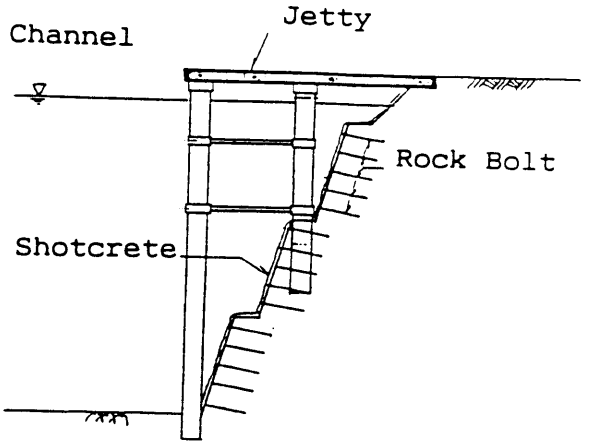


Fig. III.1.4-1 Various Type of Lock Wall

4.2.2 Location

In the Phase 1 study, the lock site on the Pacific was planned in the area previously identified for the third locks excavation (where excavation was conducted in the early 1940's).

In the Phase 2 study, the new lock site was slightly altered to the west as a result of changes to Route-I alignment. The new route provides small deflection angles on the centerline, to ensure smooth navigation, and avoid interference to ship navigation in Miraflores lake.

For the Atlantic the site is identical to that proposed in the Phase 1 study. The site lies approximately one kilometer east of Gatun lake within the excavated area identified as the Gatun third locks.

4.2.3 Geography

Generally, the hinter-land of the Pacific lock site is characterized by steep inclines and, igneous hills separated by narrow valleys. The elevation of the hills in this area range from approximately 50 to 150 meters. Elevation around the lock site area, is comparatively flat ranging from 5 meters to 20 meters. It was noted that various facilities could be located within proximity to the Cocoli residential area, Lacona residential area, the Bruja Road crossing at the existing Canal on the eastern side, and Boringuen highway.

For the Atlantic-side, low elevations are documented, ranging from 5 meters (the Atlantic approach area) to a maximum of 30 meters. But the terrain is abrupt and irregular at the Gatun lake side and the elevations there range from 70 meters to 90 meters. The source of Rio Agua Calera begins from here and flows down to the Atlantic approach channel area.

For existing facilities, there is Fort William Davis, a national road (no.836), Rail ways; Gatun residential area; and power stations adjacent to the site. Of particular importance is recognizing the need to replace this national road and railways.

4.2.4 Geology (Bearing capacity of structures)

The lock structures in the Pacific side will have a foundation of basalt that was classified as having allowable bearing capacities of more than 500 ton/sq.m according to prior studies accomplished for the third locks. The lock wing walls will rest in part on the La Boca Formation. The Boca formation consists of silty shales and sandstones of medium hardness, and as a whole is moderately strong. Allowable bearing capacity of the formation will be expected to be 160 ton/sq.m from the third locks study.

The Gatun lock site area is underlaid by fine grained sandstones and tuffs of the Gatun formation with only a few shallow pockets of Atlantic Muck near the northern approach walls. At this site the Gatun formation is more than 400m thick and bedding is massive and uniform, with the thickness of some strata in excess of 30m. The foundation rock at the site is correlated with the Gatun sandstone of existing Gatun locks. The formations were classified as having an allowable bearing capacity of more than 200 ton/sq.m. The bearing capacities mentioned above are considered sufficient to meet the requirements of structure foundations.

4.2.5 Lock Dimensions (High rise lock case)

Lock chamber dimensions used for 200,000 DWT and 150,000 DWT ships for high rise locks are as follows:

Ship Size	200,000 DWT	150,000 DWT
Chamber length	420 m	390 m
Chamber beam	55.0 m	50.0 m
Chamber draft	21.5 m	20.0 m

Note: Chamber length means the distance of hinge to hinge of the Gates.

Typical lock chamber cross section at a middle gate part is shown in Fig. III.1.4-2.

4.2.6 Water Level and Structure Level

Surface levels of lock wall structures such as the Pacific entrance side, No.1 chamber area, and No.2 chamber area are shown in Fig. III.1.4-3. The chamber sill top levels at each point are also schematically shown in Fig. III.1.4-3.

4.2.7 General Layout of Lock Structures

Fig. III.1.4-4 shows general layout of the lock facilities on the Atlantic side. The future lock construction area (second lane) excavation is included. Fig. III.1.4-5 shows the lock facilities arrangement on the Pacific side and the future excavation area is also included.DWG. No.1 and No.2 show the general layout of the high rise lock in the Pacific and Atlantic sides respectively.

4.3 Ancillary Facilities

4.3.1 Surge Basin

The hydro-dynamic impacts by surging phenomena may occur when the bypass channel water pours into the lock chamber in a short period of time because the locks at the Pacific Ocean side are directly connected to the bypass channel.

The occurrence of surging in the bypass channel may cause harmful pitching and rolling to vessels navigating in the area. In order to reduce the effects of such surge on vessels, a surge basin has been proposed in the area of the Rio Cocoli valley using the natural topography as much as possible. Since the lock at Atlantic Ocean side is connected to the open area of Gatun lake, the surging phenomena will not occur.

4.3.2 Recycling Basin and Pump Station

The introduction of a recycling pond is proposed on both the Pacific and Atlantic sides to store the spent lockage water (mainly fresh water) for subsequent recycling by pumping. A pump station with a capacity to $60m^3$/sec will also be provided between the recycling basin and surge basin.

4.3.3 Pump Stations

Pump station consists of three pumps (including one spare pump) and the characteristics of each pump are shown in Table III.1.4-2.

A schematic drawing is shown in Fig. III.1.4-6.

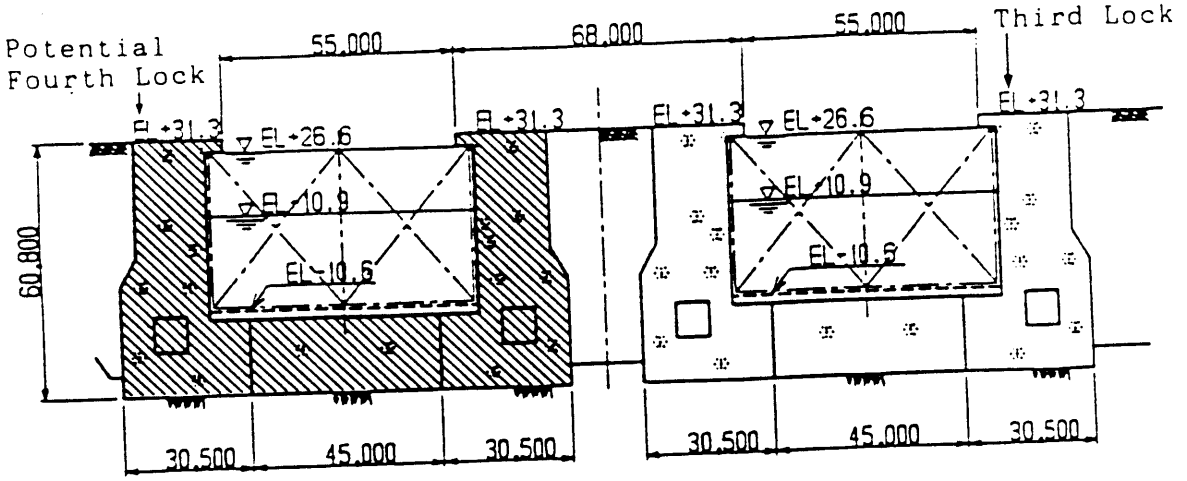


Fig. III.1.4-2 Typical Cross Section
(Pacific side, 200,000 DWT, 85')

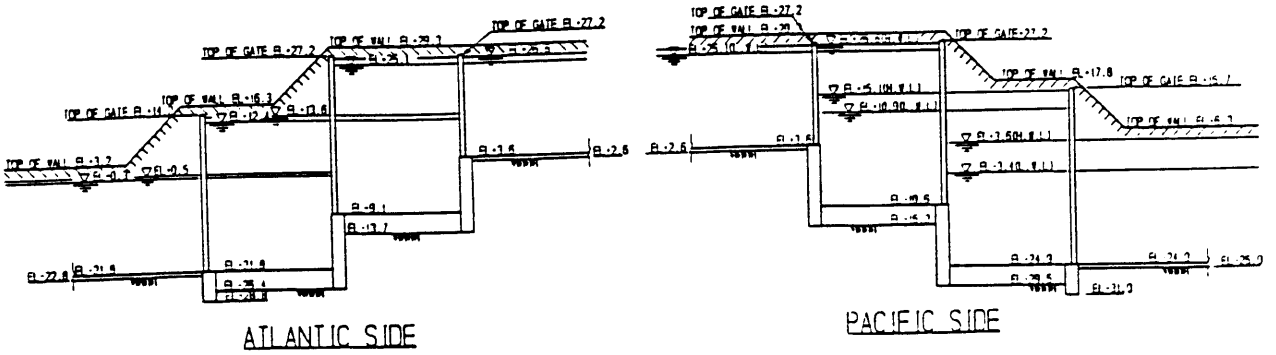


Fig. III.1.4-3 Levels of Structures and Water
(200,000 DWT, 85')

Table III.1.4-2 Pump Characteristics

Type	Vertical mixed flow centrifugal volume pump
Diameter	3,600 mm
Pressure head	27.3 meters
Volume	30 m^3/sec
Rotation ratio	190 r.p.m.
Motor	9,200 Kw
Number/pump station	Three (including spare pump)

One pump station (with three pumps) is needed in the alternatives as shown in Table III.1.4-3.

Table III.1.4-3 The Number of Pump Station

Item	2020		2060	
	150,000DWT	200,000DWT	150,000DWT	200,000DWT
Pumping Volume in (Mill M^3)	-	-	1459	1890
No. of P.Station	-	-	2	2

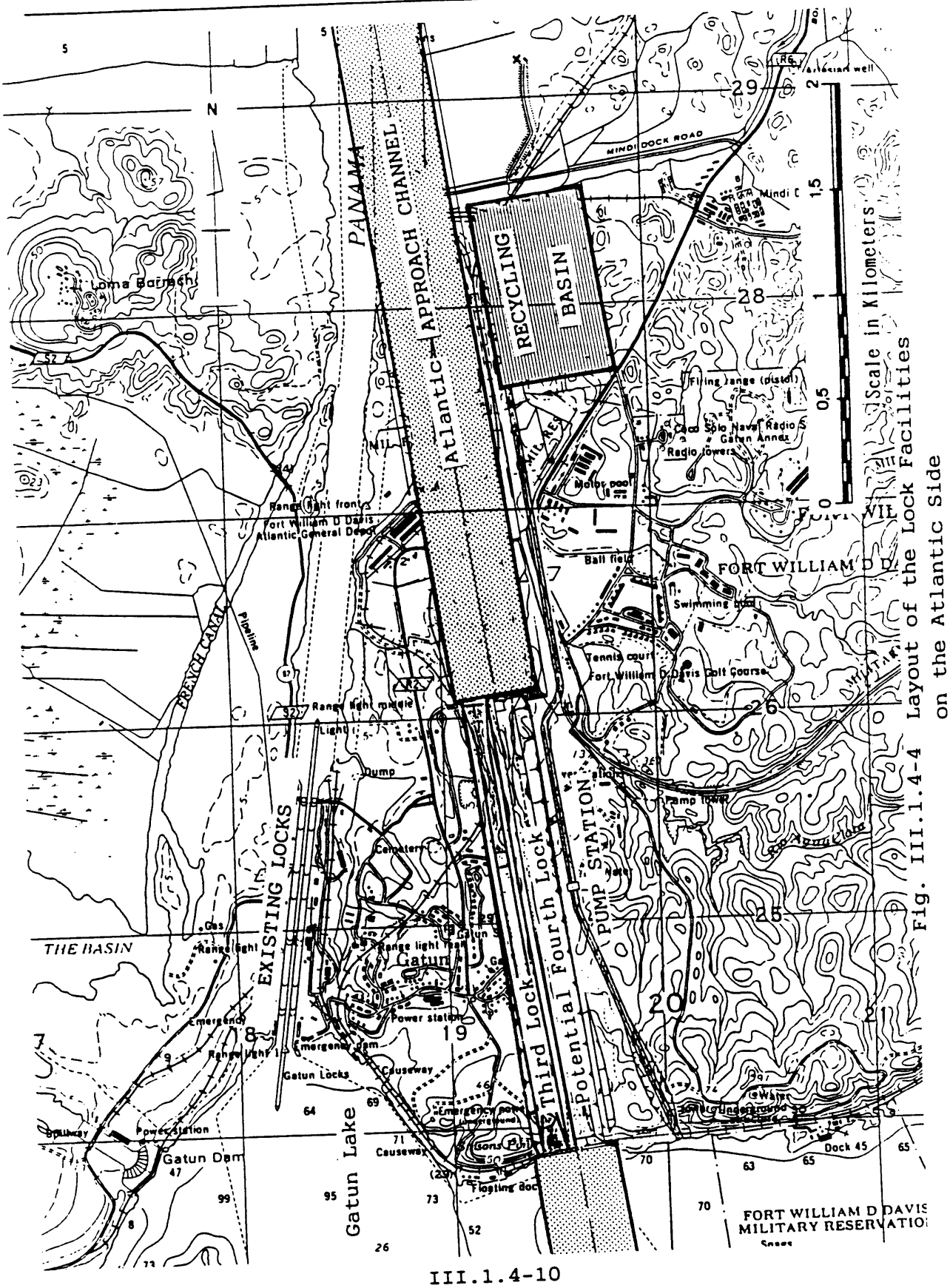


Fig. III.1.4-4 Layout of the Lock Facilities on the Atlantic Side

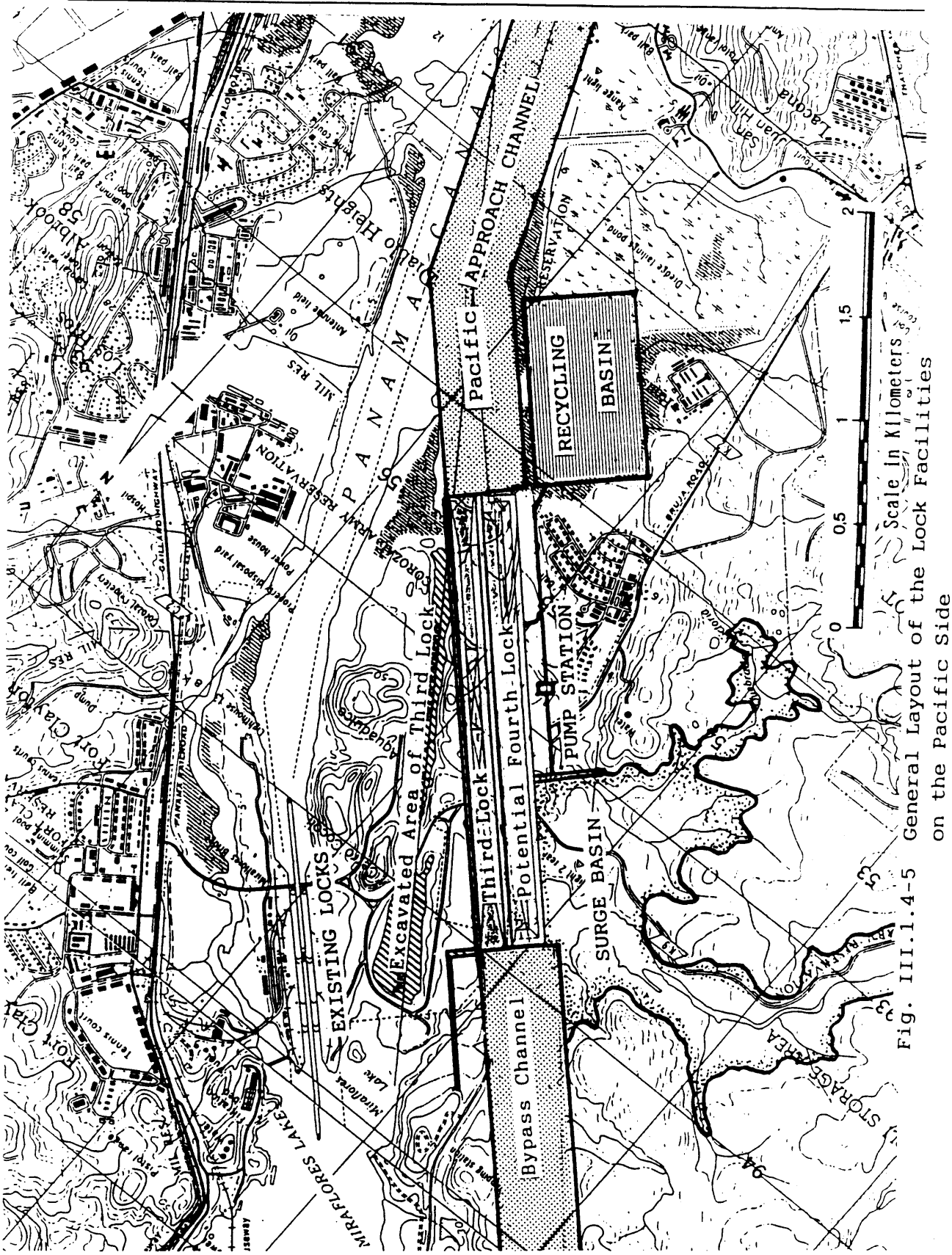
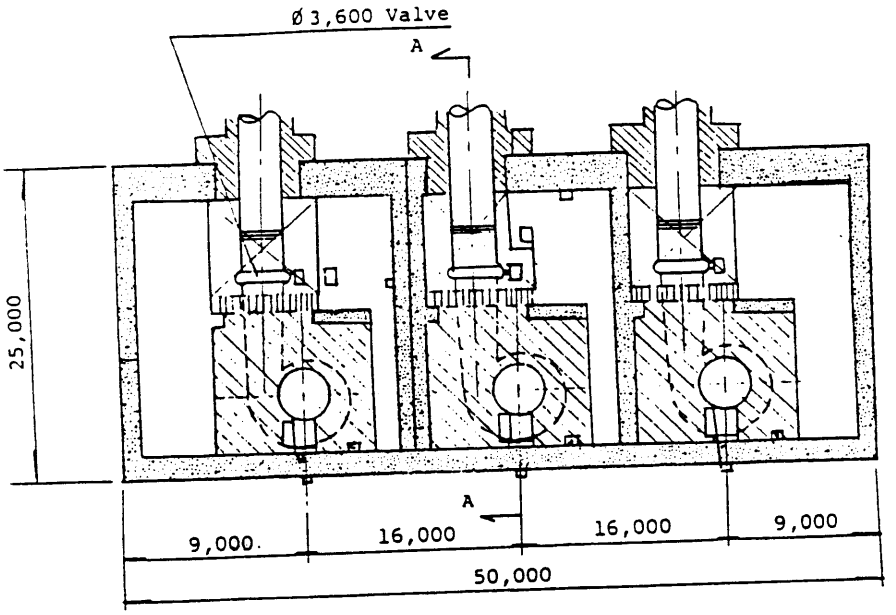


Fig. III.1.4-5 General Layout of the Lock Facilities on the Pacific Side

PLAN (Unit in mm)



A-A SECTION (Unit in mm)

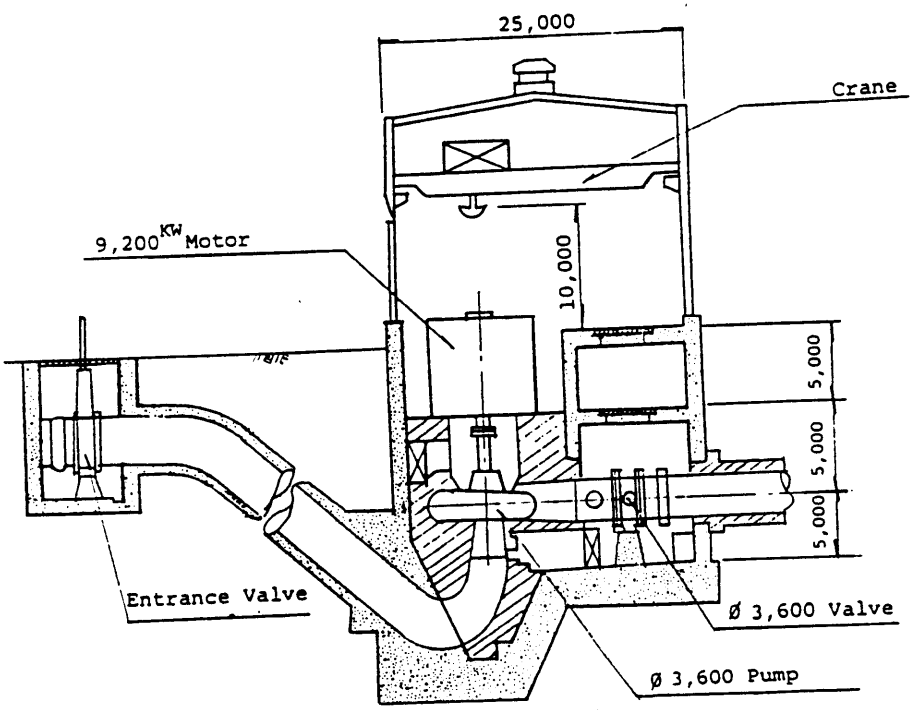


Fig. III.1.4-6 Pump Station

List of Drawings

DWG No. 1 General Dimensions of High Rise Lock (200,000 DWT)

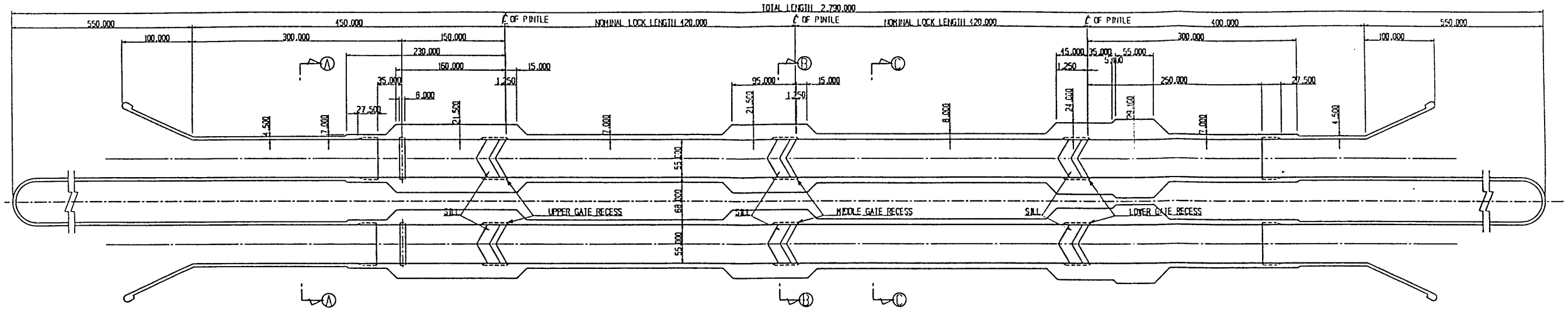
DWG No. 2 General Dimensions of High Rise Lock (150,000 DWT)

DWG No. 3 Chamber Wall Sections of High Rise Lock (200,000 DWT)

DWG No. 4 Chamber Wall Sections of High Rise Lock (200,000 DWT)

DWG No. 5 Filling and Emptying System of High Rise Lock (200,000 DWT)

DWG No. 6 Filling and Emptying System (Upper Chamber Detail) of High Rise Lock (200,000 DWT)



HIGH RISE LOCK PLAN
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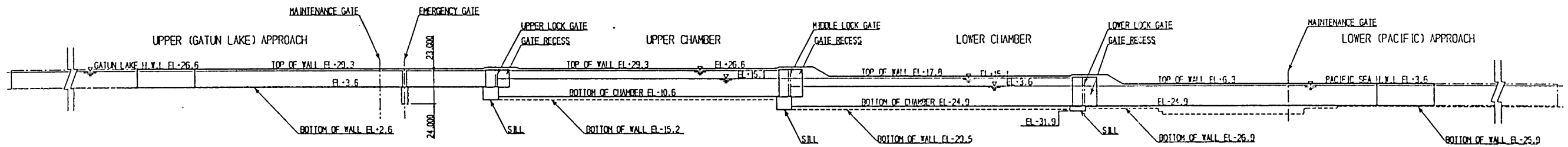

HIGH RISE LOCK PROFILE
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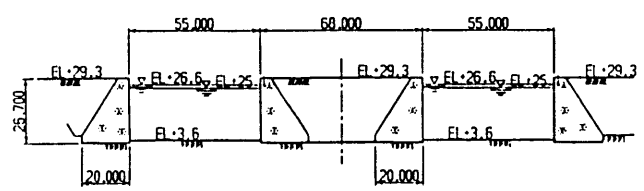

A - A UPPER APPROACH SECTION
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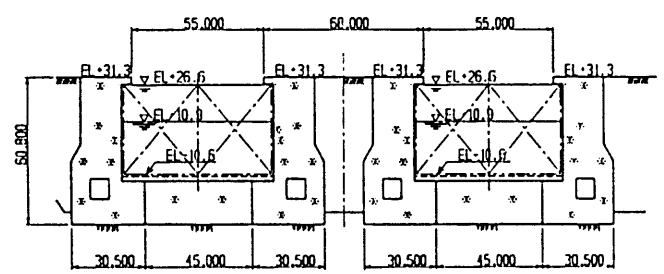

B - B MIDDLE GATE MONOLITH SECTION
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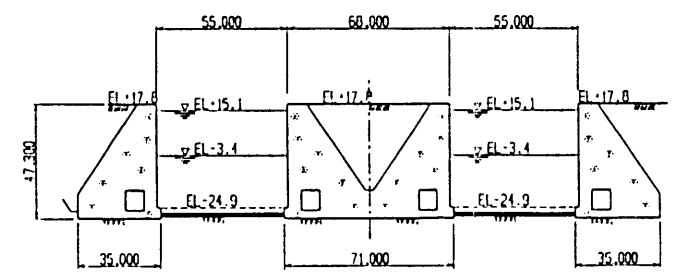

C - C LOWER CHAMBER WALL SECTION
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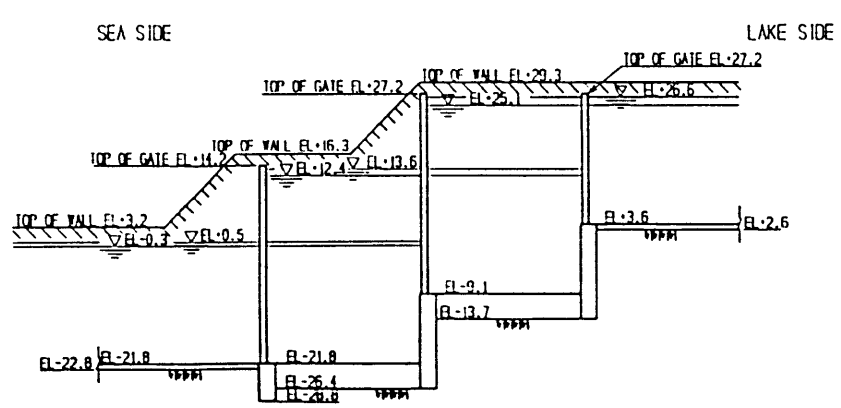
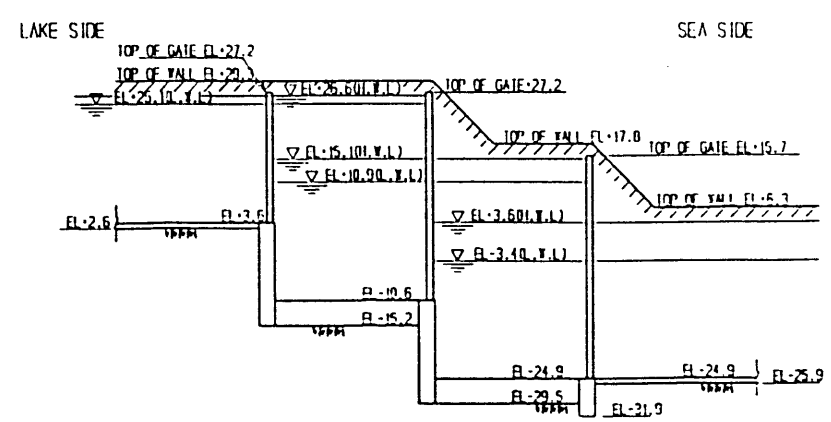


ATLANTIC SIDE
ELEVATION

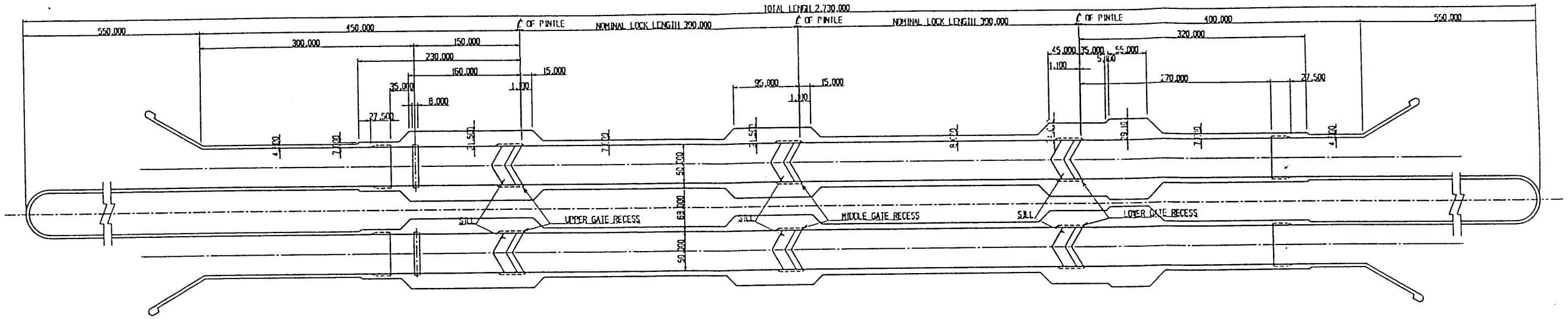


PACIFIC SIDE
ELEVATION

HIGH RISE LOCK (200,000 DWT)

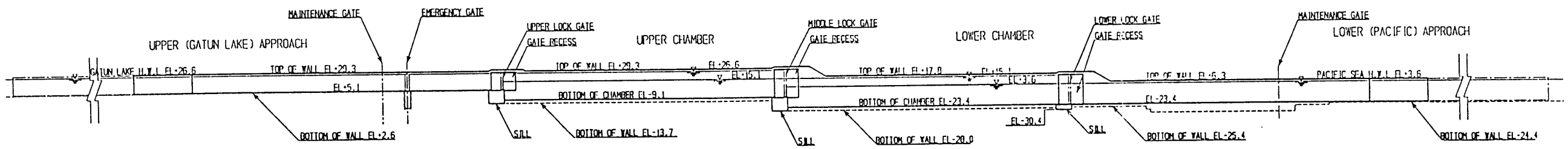
GENERAL DIMENSIONS

- DWG.No.1 -



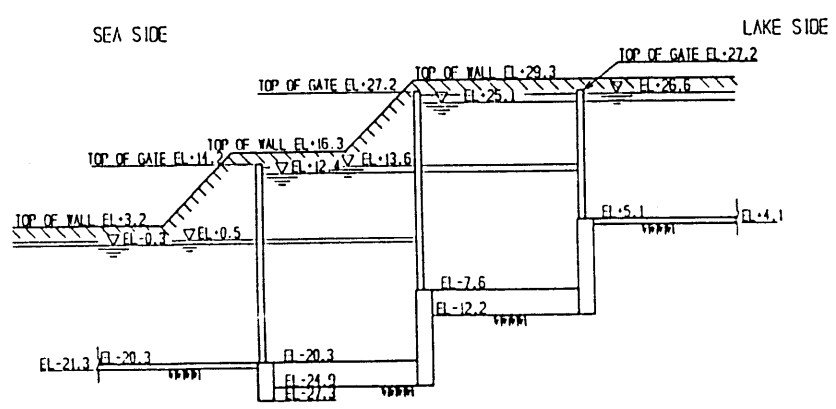
HIGH RISE LOCK PLAN

NONE SCALE



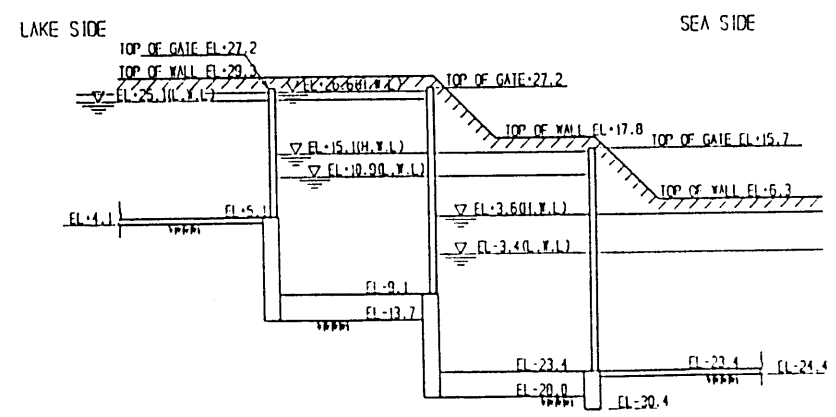
HIGH RISE LOCK PROFILE

NONE SCALE



ATLANTIC SIDE

ELEVATION



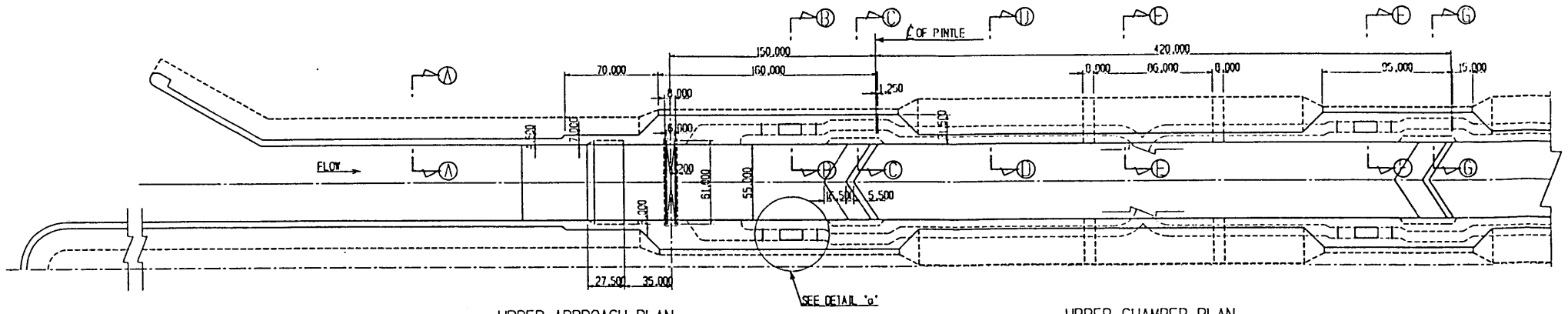
PACIFIC SIDE

ELEVATION

HIGH RISE LOCK (150,000 DWT)

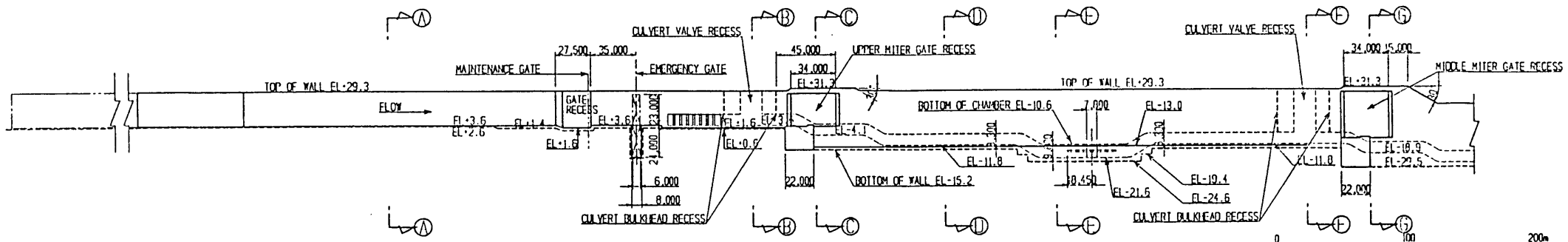
GENERAL DIMENSIONS

- DWG.No.2 -



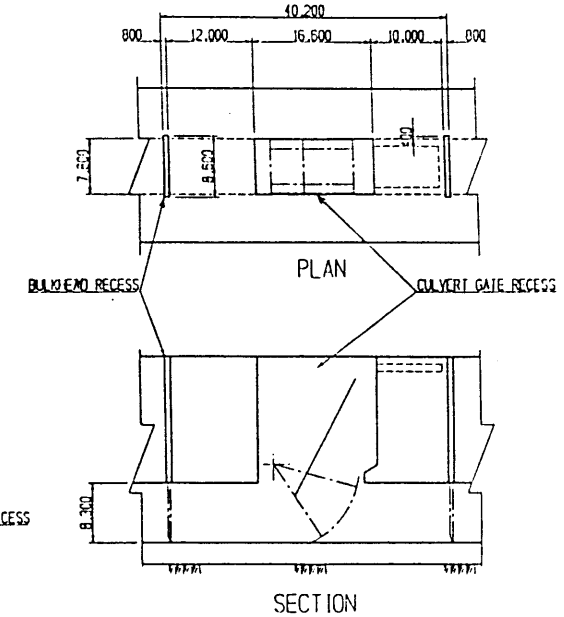
UPPER APPROACH PLAN

UPPER CHAMBER PLAN



UPPER APPROACH PLOFILE

UPPER CHAMBER PROFILE



DETAIL "a"

CULVERT VALVE RECESS

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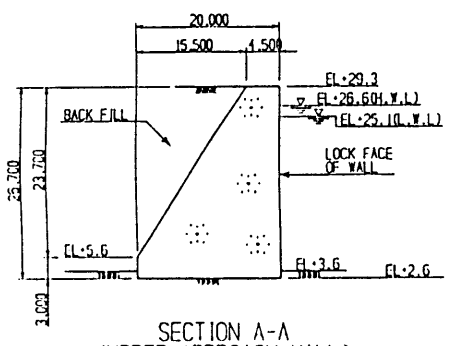
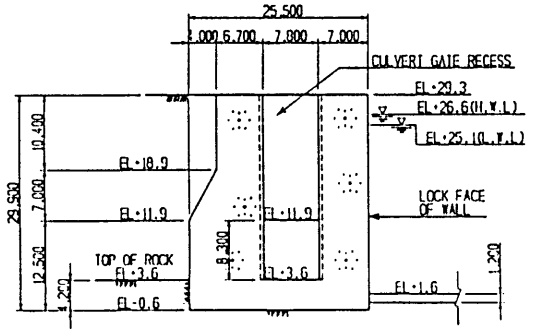
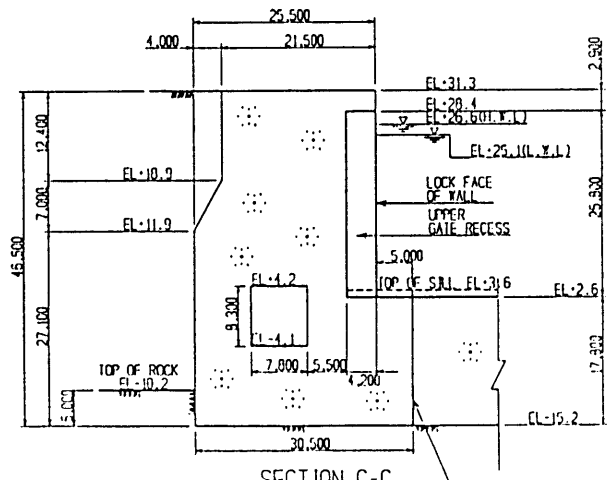


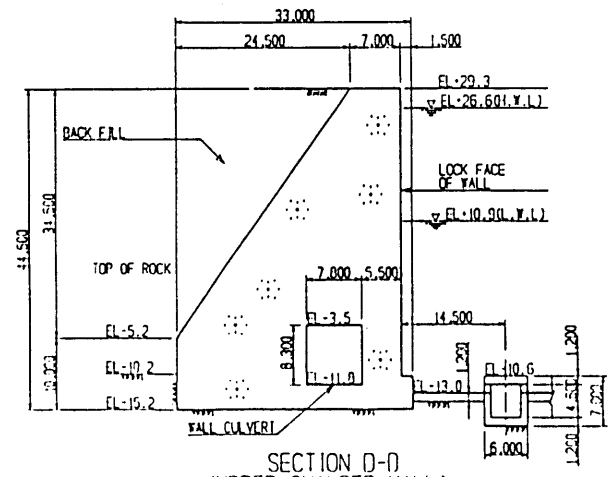
SECTION A-A
(UPPER APPROACH WALL)
SCALE 1:500



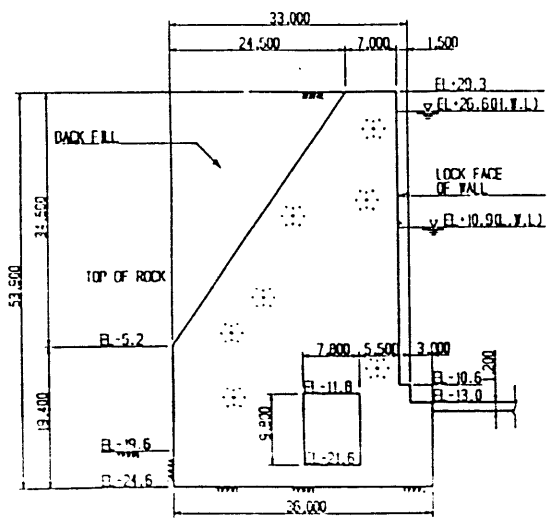
SECTION B-B
(UPPER CULVERT GATE MONOLITH)
SCALE 1:500



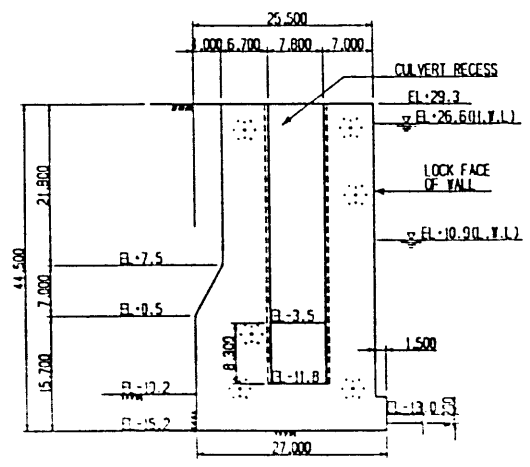
SECTION C-C
(UPPER GATE MONOLITH)
SCALE 1:500



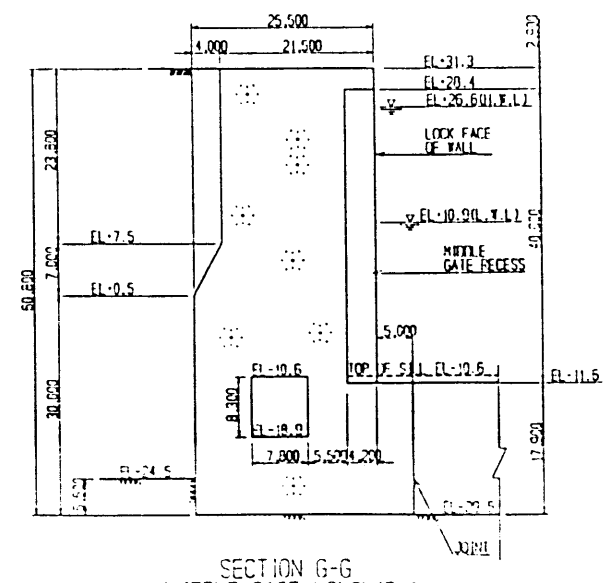
SECTION D-D
(UPPER CHAMBER WALL)
SCALE 1:500



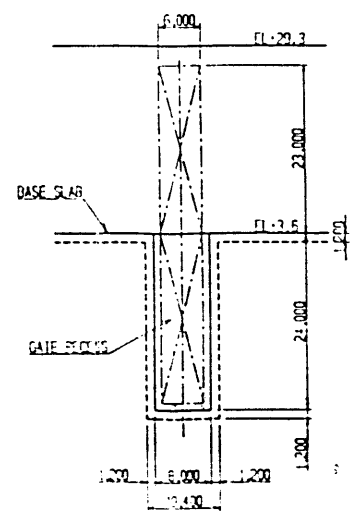
SECTION E-E
(UPPER CHAMBER WALL)
SCALE 1:500



SECTION F-F
(MIDDLE CULVERT GATE MONOLITH)
SCALE 1:500



SECTION G-G
(MIDDLE GATE MONOLITH)
SCALE 1:500



EMERGENCY GATE

S=1:500

III.1.4-16

HIGH RISE LOCK (200,000 DWT)

CHAMBER WALL SECTION (1/2)

- DWG.No.3 -

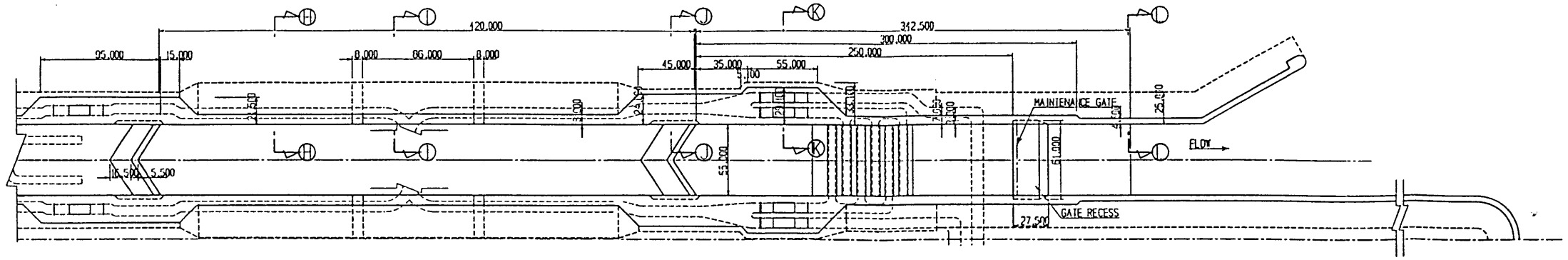
L.C.1. : DEAD LOAD , EARTH & WATER PRESSURE , UP-LIFT
L.C.2. : SEISMIC LOAD & ABOVE LOAD

DESIGN CRITERIA

1. UPPER POOL EL+15.1 , LOWER POOL EL-3.4
   GROUND WATER EL+5.9
2. UNIT WEIGHT OF CONCRETE : γc=2.35t/m³
3. UNIT WEIGHT OF DRY EARTH FILL : γt=1.8t/m³
4. UNIT WEIGHT OF SAT.EARTH FILL : γsat=2.0t/m³
5. SEISMIC COEFFICIENT : KH=0.1
   KV=0.067
6. COEFFICIENT OF ACTIVE EARTH PRESSURE L.C.1 - Ka=0.33
   L.C.2 - Ka=0.40
7. ALLOWABLE ECCENTRIC DISTANCE L.C.1-MIDDLE THIRD
   L.C.2-MIDDLE HALF
8. ALLOWABLE ROCK BEARING CAPACITY : qa=160t/m²
9. ALLOWABLE SAFETY FACTOR OF SLIDE L.C.1-1.5
   L.C.1-1.2

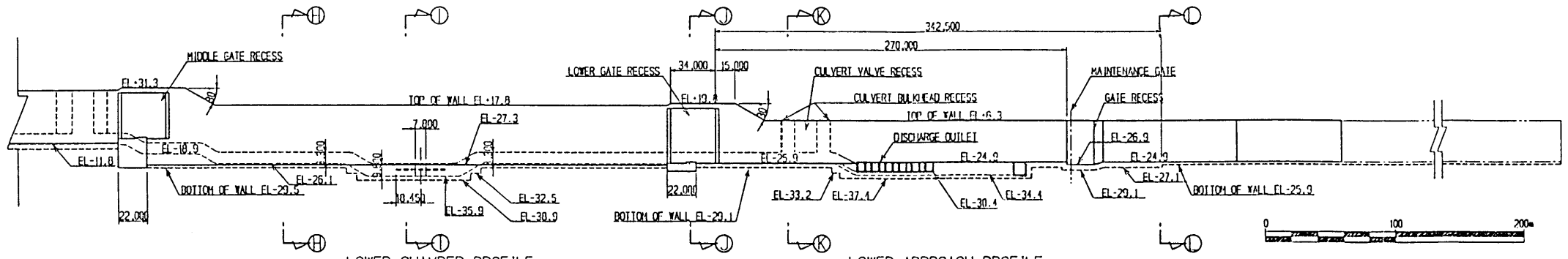
RESULTANT (LOWER CHAMBER WALL)

LOAD CASE	ECCENTRIC DISTANCE e(m)	ROCK REACTION q(t/m²)	SAFETY FACTOR OF SLIDE Fs
1.	5.1	128	2.02
2.	7.5	157	1.36



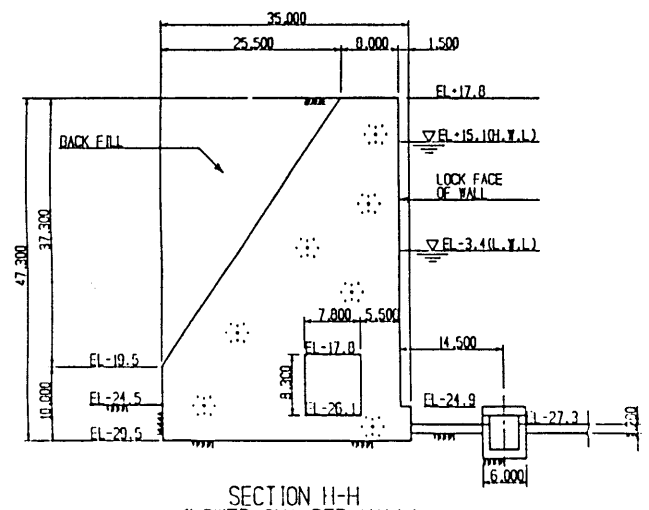
LOWER CHAMBER PLAN

LOWER APPROACH PLAN

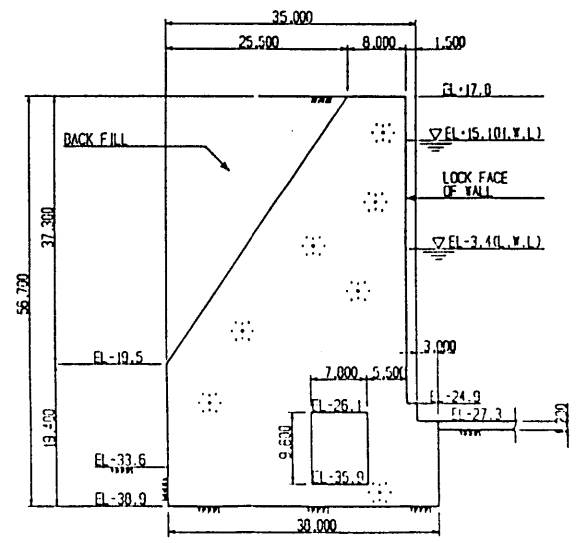


LOWER CHAMBER PROFILE

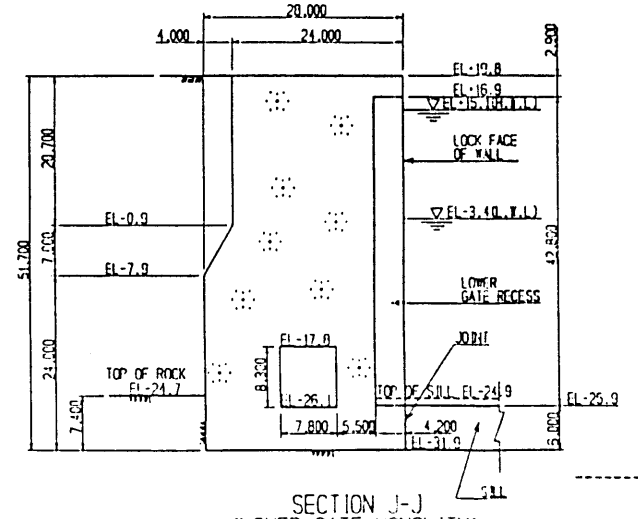
LOWER APPROACH PROFILE



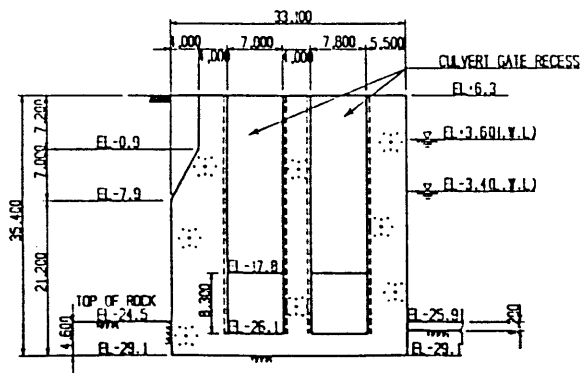
SECTION H-H
(LOWER CHAMBER WALL)
SCALE 1:500



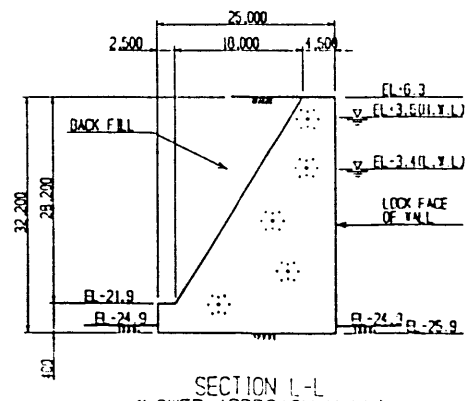
SECTION I-I
(LOWER CHAMBER WALL)
SCALE 1:500



SECTION J-J
(LOWER GATE MONOLITH)
SCALE 1:500

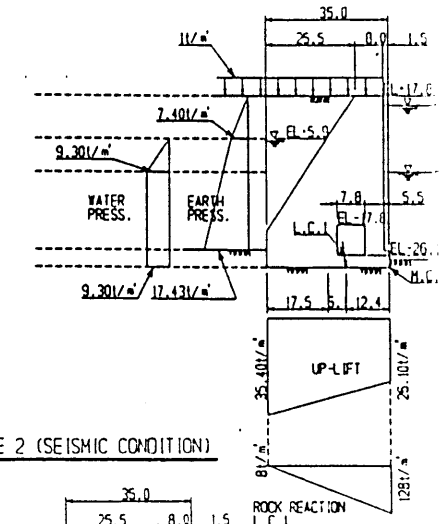


SECTION K-K
(LOWER CULVERT GATE MONOLITH)
SCALE 1:500

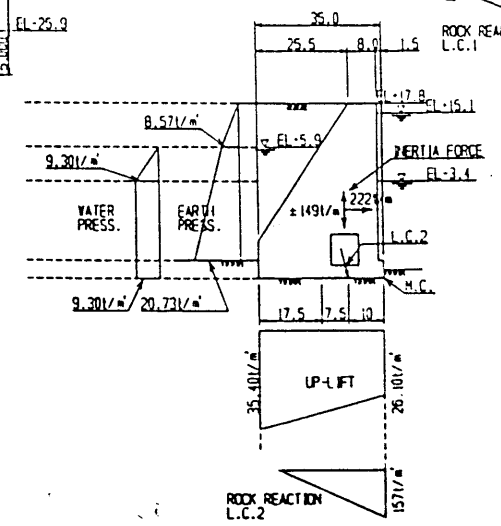


SECTION L-L
(LOWER APPROACH WALL)
SCALE 1:500

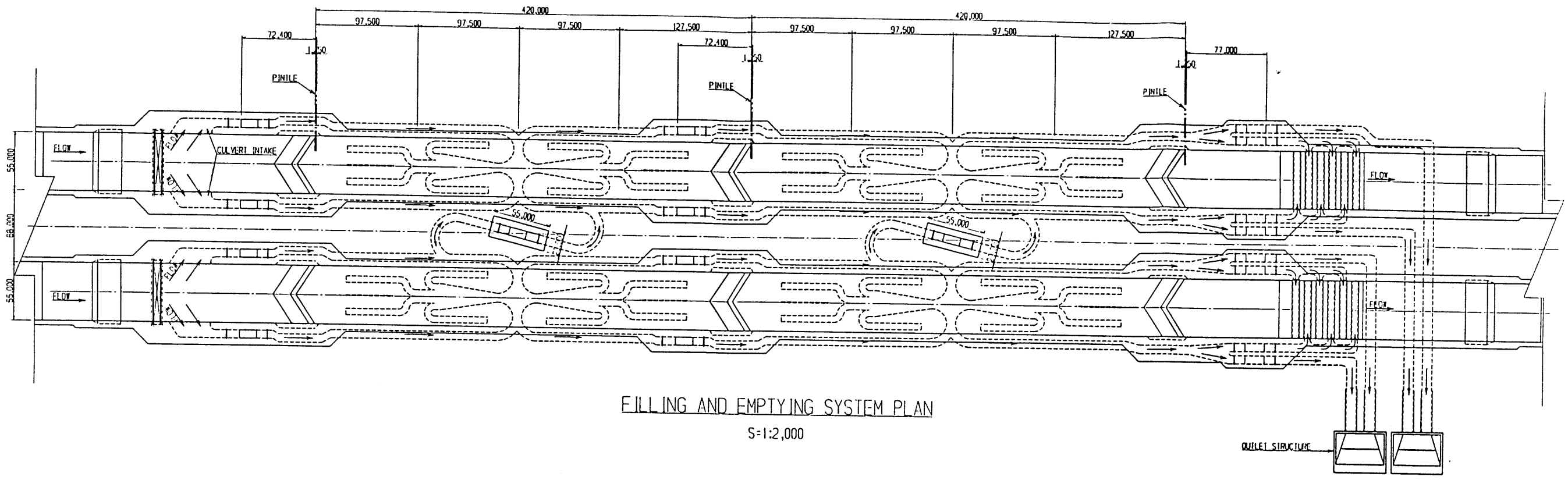
LOAD CASE 1 (NORMAL CONDITION)



LOAD CASE 2 (SEISMIC CONDITION)

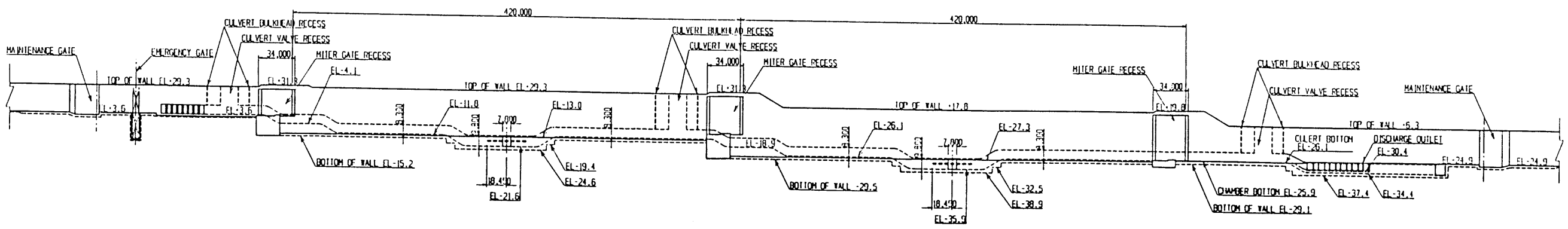


HIGH RISE LOCK (200,000 DWT)
CHAMBER WALL SECTION (2/2)
- DWG.No.4 -



FILLING AND EMPTYING SYSTEM PLAN

S=1:2,000



FILLING AND EMPTYING SYSTEM PROFILE

S=1:2.000

0 100 200m

NOTES

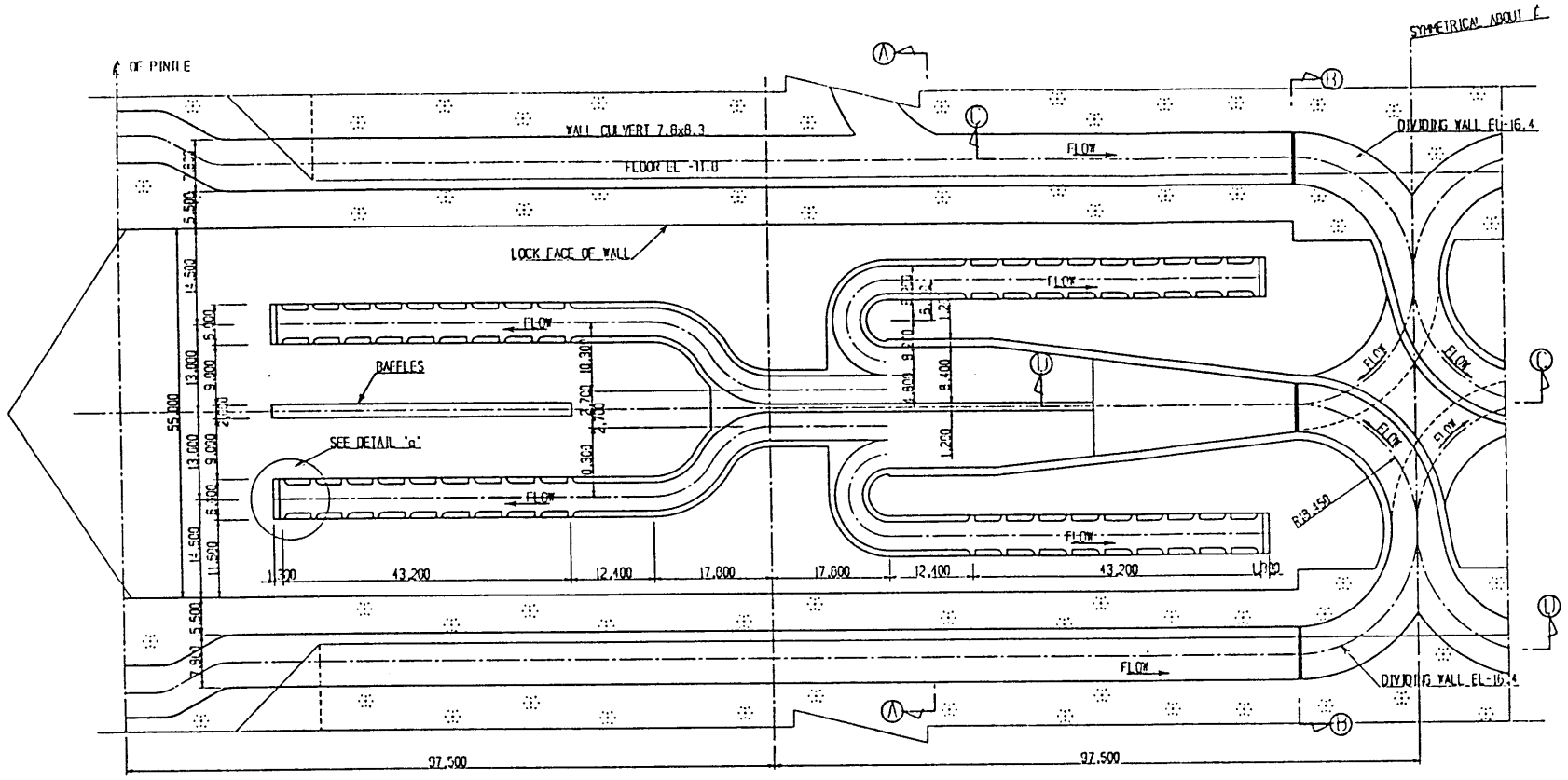
1. THE FILLING AND EMPTYING SYSTEMS ARE BASED ON IDCS (JAX 103 REPORT)

III.1.4-18

HIGH RISE LOCK (200,000 DWT)

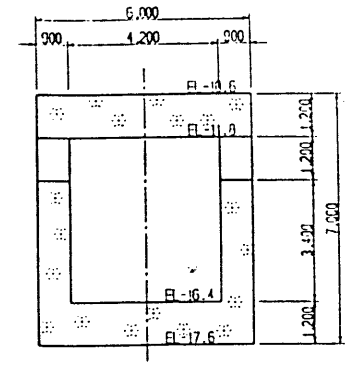
FILLING AND EMPTYING SYSTEM

- DWG.No.5 -

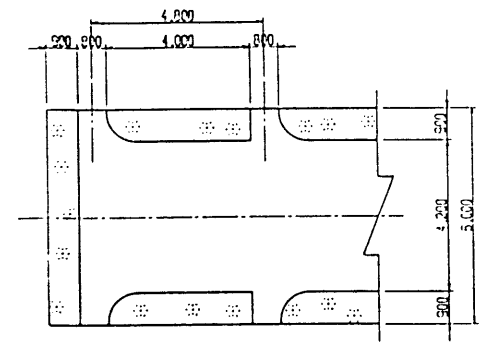


UPSTREAM HALF PLAN (UPPER CHAMBER)

S=1:500



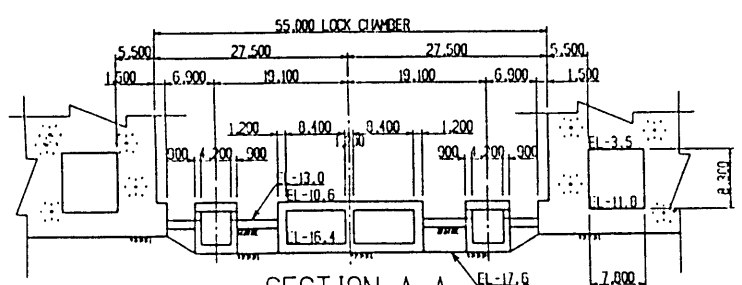
SECTION



PLAN

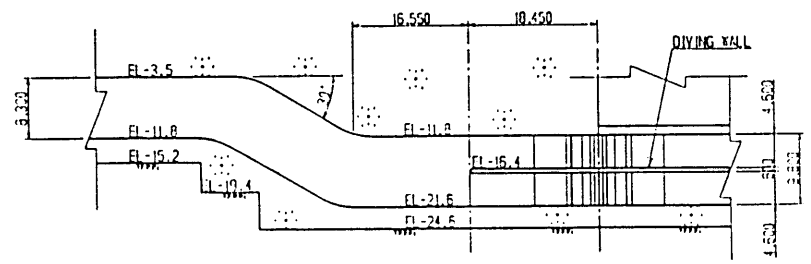
DETAIL 'a'

S=1:100



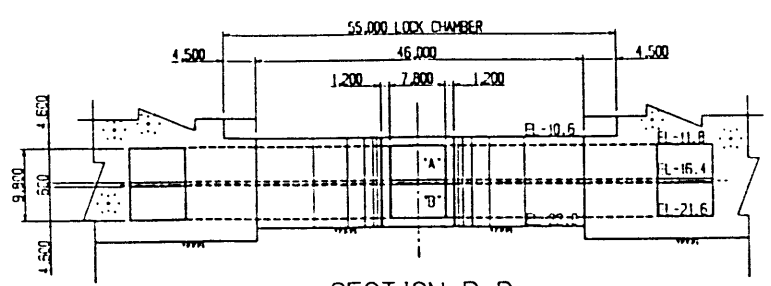
SECTION A-A

S=1:500



SECTION C-C

S=1:500



SECTION B-B

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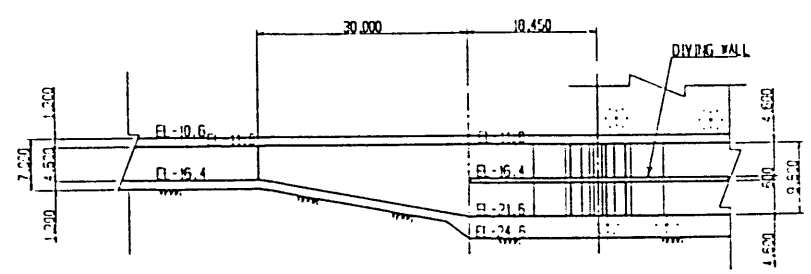


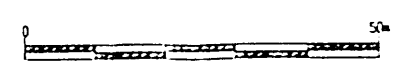
SECTION D-D

S=1:500

NOTES

1. THE FILLING AND EMPTYING SYSTEMS ARE BASED ON IOCS (JAX 103 REPORT)

2. FOR SECTION B-B
   AREA 'A' SUPPLIED BY TOP RIGHT WALL CULVERT
   AREA 'B' SUPPLIED BY BOTTOM LEFT WALL CULVERT



III.1.4-19

HIGH RISE LOCK (200,000 DWT

FILLING AND EMPTYING SYST
UPPER CHAMBER DETAIL

- DWG.No.6 -

III.1 CHAPTER 5 - LOCK GATES

5.1 Introduction

5.1.1 Description of Gates in the Lock

A lock has three Operating Gates, nine Culvert Gates, and an Emergency Gate to fulfill its lockage function. The three Operating Gates are named Upper Operating Gate which is located at the upstream end (=the lake side end) of the upper chamber, Middle Operating Gate, located at the downstream end (=the ocean side end) of the upper chamber, and Lower Operating Gate, located at the down stream end (=the ocean side end) of the lower chamber in the lock. The four Culvert Gates are installed in the culvert tunnel in each lock wall; i.e. one just upstream of the Upper Operating Gate, one just upstream of the Middle Operating Gate, and two just down stream of the Lower Operating Gate. One of the last two is for the culvert heading for the recycling pond and the other is for water discharge to the ocean. Besides these eight culvert gates in the both lock walls, the ninth culvert gate will be installed in the culvert tunnel connecting the third set of lock and the future forth lock. The Emergency Gate is located far ahead of the Upper Operating Gate.

The Operating Gates play a major role in canal lock functions and open or close the lock chamber entrances according to ship transits. The Culvert Gate also plays a major role. It opens or closes culvert tunnels in the lock walls and controls water flow in the tunnels running into or out of lock chambers and, eventually, lifts a ship in the chamber up or down according to the direction of ship transits. The Emergency Gate swiftly closes the lock in the event of an emergency; for example, fractures or collapses of the Operating Gate due to ship collisions, to prevent the areas surrounding the lock from disaster or reduce the level of damage.

Besides the gates described above, each lock has maintenance gate seats in the vicinity of both lock ends on the lake side and the sea side, and also has a pair of culvert gate maintenance gate slots on the upstream and downstream side of each Culvert Gate. These provisions enable either draining the whole lock or a Culvert Gate alone whenever it is necessary for lock maintenance work in a drained condition. For this purpose, a Maintenance Gate and four sets of the Culvert Gate Maintenance Gates are provided for the locks on both ocean sides.

5.1.2 General Information

This item intends to give design criteria common to all kinds of gates required for the high rise lock canal alternative.

(1) General Hydraulic Condition

The general hydraulic conditions for various gate designs are shown in Table III.1.5-1. The elevations shown are based upon P.L.D. and in the metric system and conform to the water levels of design criteria as given in II.1-Chapter 1.6.

Table III.1.5-1 Required Water Level in H.R.L. Canal

Location	Water Level	H.W.L.	L.W.L
Gatun Lake 85'	+26.0	+26.6	+25.1
Gatun Lake 90'	+27.5	+28.1	+26.6
Atlantic Side	+0.1(M.S.L.)	+0.5	-0.3
Pacific Side	+0.3(M.S.L.)	+3.6	-3.4

(2) Water Elevation during Lock Operation

The water elevation around and in the High Rise Locks during their operations are given in Table III.1.5-2.

Table III.1.5-2 Water Elevation During Operation in Meter Based upon P.L.D.

Location	Given Elevation		After Raised		After Lowered	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Atlantic Side						
Gatun Approach	+26.6	+25.1				
Upper Chamber			+26.6	+25.1	+13.6	+12.4
Lower Chamber			+13.6	+12.4	+0.5	-0.3
Sea Side App.	+0.5	-0.3				
Pacific Side						
Gatun Approach	+26.6	+25.1				
Upper Chamber			+26.6	+25.1	+15.1	+10.9
Lower Chamber			+15.1	+10.9	+3.6	-3.4
Sea Side App.	+3.6	-3.4				

The water levels in the Lower Chamber after raised are equal to the water levels in the Upper Chamber after lowered and their maximum and minimum elevations are equal to the mean value of the Gatun H.W.L. and respective ocean's H.W.L and the mean value of the Gatun L.W.L. and respective ocean's L.W.L respectively.

The maximum elevation of water in the Lower Chamber (=the underlined figures in the table) is directly bound to define the height of the lower chamber wall. This value can be reduced up to the minimum elevation by partially discharging the water in the upper chamber directly to the ocean. The less this value, the less the lower chamber cost is, but at the same time the greater the lockage water consumption. The above assumption corresponds to the minimum water consumption. Optimization of the maximum elevation will be left for the later stage of the design.

(3) Freeboard

Freeboard adopted are as follows.

Table III.1.5-3 Freeboard Allowances

Gate Name	Meter	Feet
Operating Gate	0.6	2*
Emergency Gate	0	0
Maintenance Gate	0.6	2*

Note: * marked value corresponds to the one used in Deep Draft Lock Plan Study in IOCS memorandum JAX 103.

(4) Structural Material and Allowable Stress Level

a) Structural Materials

Structural materials of the usual carbon steels, or low alloy carbon steels having good weldability, good notch ductility, and high resistance to brittle fracture are used. Steels that are classified in this category are presently widely available in mill markets. The strength range up to 100 Kg/mm^2 in fracture strength is applied in the design. Selection of the steels in various strength levels is made as follows.

1. Preference will be given to the higher strength steel only when it is advantageous for a facility's total cost including for material, fabrication, transportation, installation and operation and maintenance or when a canal study alternative can not be feasible without it. The cost study for selection of material specifications includes consideration of material sources and place of fabrication as discussed at II.2-Chapter 4.2.

2. The most preferable thickness from fabrication point of view is between 20 to 40 mm. In this sense, preference is given to thinner plates with higher tensile strength over thicker plates with lower tensile strength except when higher structural rigidity is required in preventing structures from excessive deformation or buckling.

3. Preference is given to quenched and tempered steels in the case of high tensile strength steel.

b) Allowable Stress Level based upon Yield Strength

The allowable stress levels applied are from the "Technical Standards for Gates and Penstocks", edited by the Hydraulic Gate and Penstock Association of Japan. Table III.1.5-4 shows allowable values for tensile and compressive stresses for various strength grades. The values shown are only for examples and applicable for plates thicker than 40 mm.

Table III.1.5-4 Allowable Stresses for Elastic Design

Strength Level	Yield P. Kg/mm^2	Fracture P. Kg/mm^2	Allowable Stress Kg/mm^2
SS400	22	41	11.0
SM400	22	41	11.0
SM490	30	50	15.0
SM570	43	58	20.4
H.T.70	60	70	26.0
H.T.80	70	80	29.1
H.T.100	90	97	34.6

Note: H.T.(steel) is abbreviation of high-tension (steel).

In addition to the preceding table, following allowable stress alleviation was added for the Phase 2 study.

Table III.1.5-5 Allowable Stress Alleviation

Applicable Case	Increased rate
1) When seismic load is added	150%
2) In case of emergency load	150%
3) Hydraulic Condition for maintenance	130%

c) Allowable Stress Level based upon Fatigue Strength

The life duration of the gates is assumed to be 80 years based upon the fact that the miter gates at the existing locks have worked since inception.

The number of new lockage operations per year is 9200 per both ocean sides. This frequency conforms to the value given in 1.5.2 of II.1-Chapter 1. Eventually the number of operation of each gate in each lock equals to 4600 per year.

Allowable stress levels based upon the above conditions are shown in Table III.1.5-6. These values were derived from the latest edition (1989) of Fatigue Design Guide issued by the Japanese Society of Steel Construction(JSSC). The study works for this edition have included comparisons of stress levels with various technical standards including AASHTO, BS5400 and ECCS.

The values derived are based on the premise that periodic inspections for fatigue damage and estimation of the remaining life are carried out.

Table III.1.5-6 Allowable Stress for Fatigue Design
(High Rise Lock)

Stress Status	Location	Allowable Stress
Tention	Mother Metal	34.1
	Finishec Butt & Seam Joint	27.8
	Fillet Weld Joint In Load Direction	22.4
	Fillet Weld Joint In Normal Direction	17.9
Compression	Mother Metal	44.3
	Finished Butt & Seam Joint	36.2
	Fillet Weld Joint In Load Direction	29.2
	Fillet Weld Joint In Normal Direction	23.3

Note: 1. The allowable stress shown is in Kg/mm^2
2. Frequency of operations per year is 4,600.
3. Gate life duration is 80 years.

d) Allowable Stress Application for Each Gates
The allowable stress show in b) and c) above are applied to each gate in the way shown in Table III.1.5-7.

Table III.1.5-7 Allowable Stress Application

Failure Mode	Gate Type				
	Operating Gate	Culvert Gate	Emergency Gate	Maintenance Gate	Culvert M. Gate
Yielding	Yes	Yes	Yes	Yes	Yes
Fatigue	Yes	Yes	No	No	No

(5) Seismic Design of Gate Structure
Seismic designs is applied to the gate structures based on the following.

1. Design seismic coefficient is 0.10 which was given in II.1.- Chapter 3.

2. Gate classification for the seismic coefficient application levels are as follows.

Table III.1.5-8 Seismic Coefficient Application

Gate Name	Application Rate in %
Lock Gate	100
Culvert Gate	50
Emergency Gate	50
Maintenance Gate	100
Bulkhead Gate	100

An Emergency Gate failure may cause a fatal catastrophe to the local area but is classified as 50 % because the probability of an earthquake during operation is deemed to be neglegible.

3. The following external forces to gate structures due to earthquakes are considered in the design. Fig. III.1.5-1 shows application of these forces schematically.

   1) Dynamic pressure increases in the water surrounding the gate leaves.

   2) Inertia forces of the gate leaves.

   3) Dynamic effect of water inside of gate leaves.

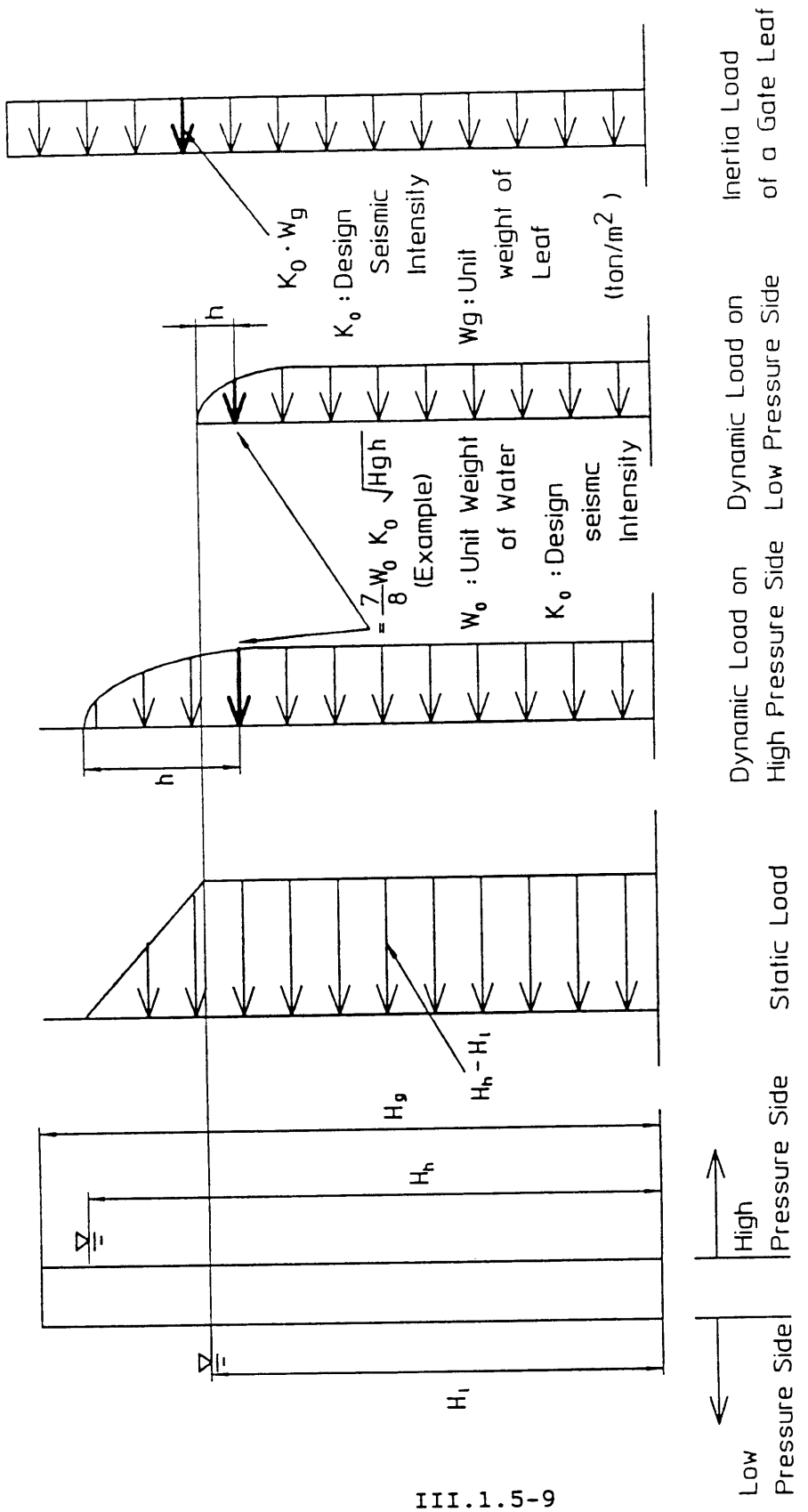


Fig.III.1.5-1 Load on Gate Leaf under Seismic Condition (ton/m²)

5.2 Operating Gate

5.2.1 General Information

(1) Gate Type

No alteration was made on the gate type since the Phase 1 study where the Miter Type with buoyant tanks was recommended. The Phase 1 recommendation was made because this type has long working records in the existing Panama canal, even though the best evaluation was given to the torsion type rolling gate. The study regarding the torsion type slide (=rolling in the Phase 1 study) gate for the Sea Level Canal option was likely to discover this type as feasible, and surely advantageous, and an alternative which was proposed in (3) of 4.6.1 in the Phase 1 Final Report has become more worth while to be considered and it is recommendable to make a comparative study effort on it at a detail design stage. It is anticipated that a substantial cost reduction rate will be achieved at the high rise lock rather than this gate type in the tidal gate in the Sea Level Canal option.

(2) Weight Estimation Procedure

Gate Leaf;The Middle Operating Gate for the 200,000DWT option was subject to a more detailed design study. The study work consisted of sizing the gate, arranging the structure member including the horizontal main girders, vertical diaphragms and horizontal auxiliary girders, computing the member loads, designing the major members and estimating the sizes of various other auxiliary members. The weight grasped by this process eventually covered approximately 80 % of the total leaf weight including all accessory on it. The residual weight was estimated according to a weight ratio established based upon the design experiences of the similar gate structures. Weight estimations for another Operating Gate leaves including for the 150,000DWT

option were made applying the curve in Fig. 4.2.1 of the Phase 1 study Final Report after the curve height was modified proportionally to the unit weight calculated for the Middle Operating Gate mentioned above. Fig. III.1.5-2 in this report is a copy of Fig. 4.2.1 with the Phase 2 unit weights plotted on it. The leaf weight reduction gained at the Phase 2 study was approximately 17.25 % excluding the gain due to the improvement of hydraulic load condition and Fig. III.1.5-2 shows the gate weights at the Phase 2 study are almost at the same level as those of the Deep Draft Lock Plan (=DDL on the figure).

Gate Frames and Drive Mechanisms;The Gate frames comprise various steel frames embedded in concrete structures and support the gate leaves and hydraulic load on them, provide seal surface on the concrete side and guide gate leaves during their opening and closure operations. The drive mechanisms are machinery to hoist gate leaves and sometimes referred to as "gate hoists" in this report. Their weights were estimated in proportion to their gate leaf weights using the relative ratios shown on Table III.1.5-9 which was established only for the purpose of cost estimations in this study.

Table III.1.5-9 Factors for Weight Estimation of Gate Frames and Drive Mechanisms (Weight Ratio to Gate Leaf)

Part	Operating Gate	Culvert Gate	Emergency Gate	Maintenance Gate
Gate Frame	0.2	0.8	0.4	0.1
Drive Mecha.	0.15	0.6	0.15	0.09

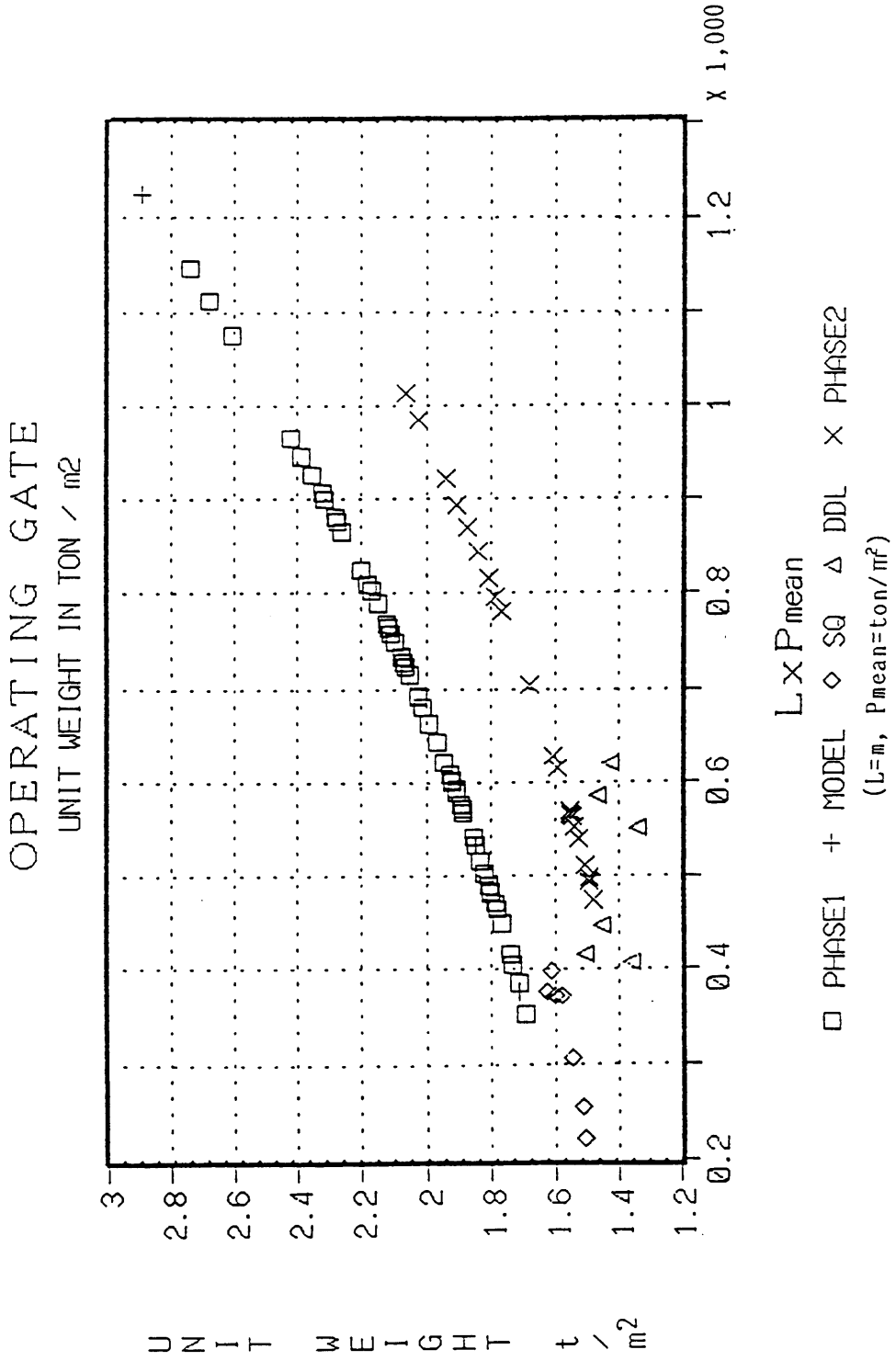


Fig. III.1.5-2 Unit Weight of Operating Gate for High Rise Lock Canal Option

5.2.2 200,000DWT Option

(1) Description of Gates

The height, width and weights of each Operating Gates are as shown in Table III.1.5-10. The width is that of the lock channel and not the leaf itself. The weight is for one lock wall and twice of the figures are required for one complete set of the Operating Gates. The Lower Operating Gate is supposed to be used as a road bridge for vehicular traffic crossing the lock chamber. The additional structural framing required for this purpose is approximately 60 tons which is included in the weights in the table and cost estimation.

Fig. III.1.5-3 shows the general arrangement of the Middle Operating Gate for the 200,000DWT option. The gate leaf is supported by embedments in concrete at two points; i.e. at top corner of the leaf by a gudgeon pin and at bottom corner of the leaf by a pintle. The leaf weight is supported by the pintle, and moment occurring due to the difference between the leaf weight center and the pintle reaction force center is supported by pulling force of the gudgeon pin and pushing force on the pintle. Water pressure acting upon the shell plate of the box type leaf is supported by bearing blocks arranged along the quoin end and the miter end of the gate leaf. There are two emergency stops; i.e. one located around the miter end for the leaf over-run and the other located around the quoin end for the pintle slip.

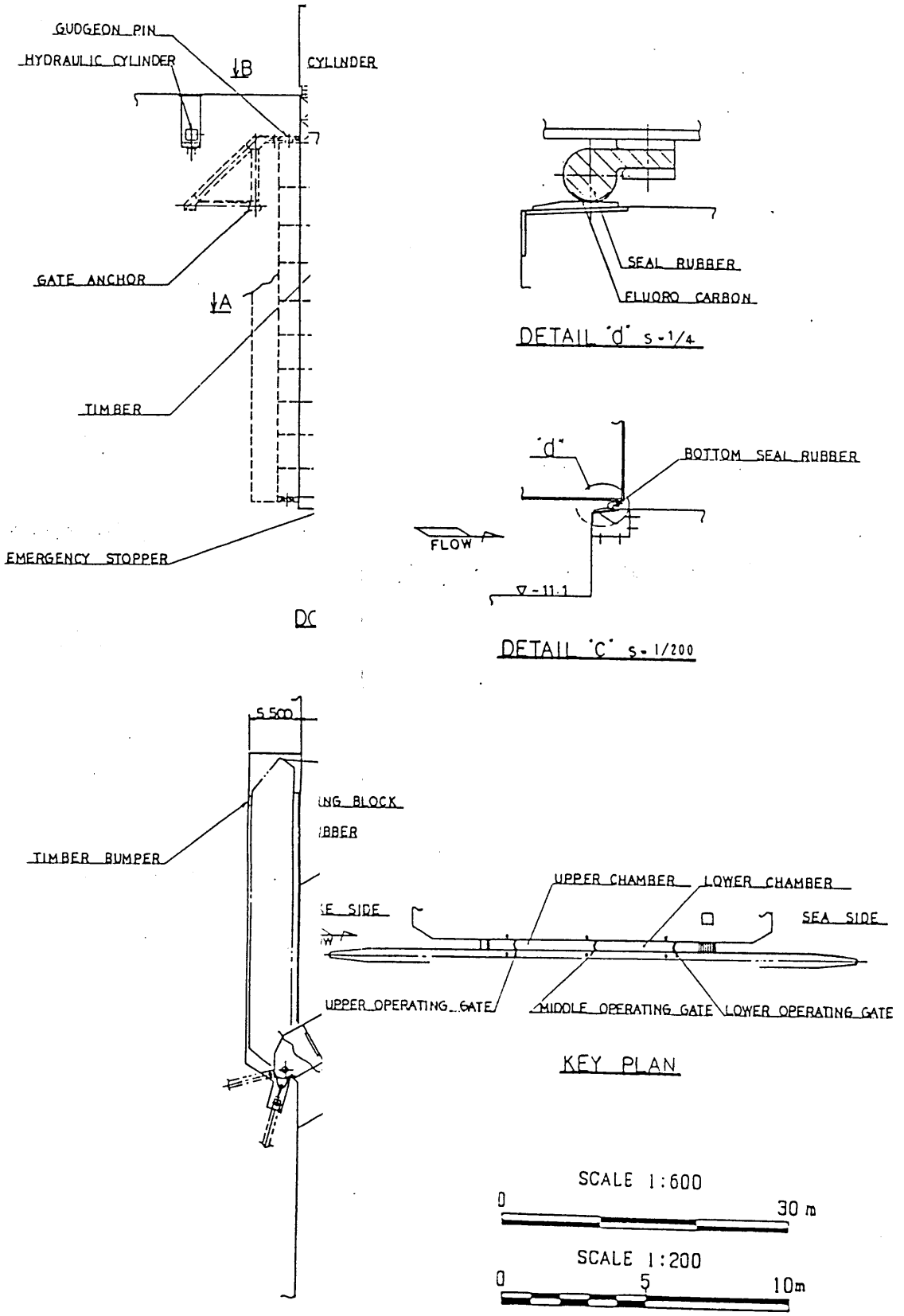
Each side, and the bottom of the gate leaf are sealed by a continuous "J" shaped rubber seal. This seal is located along the side and bottom edges of the downstream shell plate of the box type leaf. Dimensions of the rubber section are larger than normal to provide necessary self-adjustability for the Just-Set-In-Place Installation method which will be explained in detail at (3) of this 5.2.2. The bulb portion of the rubber will have proper hardness

to prevent excessive deformation in the bulb at high water pressure zone, and at the same time, maintain enough sealing ability at low water pressure zone.

The pintle sits rigidly on a base metal embedded in concrete floor, and a pintle bush mounted on the leaf bottom is movable in the direction of the gate width. The gudgeon is set rigidly to gudgeon anchors embedded in a concrete wall and a gudgeon pin mounted rigidly on the leaf top is supported by the gudg eon so that the pin together with the gate leaf may move in the direction of the gate width. As soon as the gate leaves start supporting the hydraulic load after a set of the two leaves is closed, the total leaf will move towards bearing blocks set on a gate frame embedded on a concrete wall until the bearing blocks mounted on the leaf quoin end hit the bearing blocks of the concrete side. This concept will release the pintle, gudgeon and quoin bearings from strict limitations for deviations from their designed relative positions and make the Just-Set-In-Place-Installation method useful. This will also contribute to decreased wearing on the quoin bearing blocks.

Most spaces in the box type leaf are assigned as float tanks. The buoyancy force compensates for the leaf weight so that the load on the pintle may be reduced to a greater extent during operational condition.

No spare gate leaf is included in the cost estimation.



III.1.5-15

General Arrangement of Middle Operating Gate
High Rise Lock 200000 DWT Canal Option

Table III.1.5-10 Dimensions and Weights of Operating Gate (200,000DWT)

Gate Name	Height in Meter	Width in Meter	Weight in Ton		
			Leaf G.	Frame G.	Hoist
Atlantic Side					
Upper Operating Gate	23.6	55(lock)	892	198	149
Middle Operating Gate	36.3	55(lock)	1935	387	290
Lower Operating Gate	36.0	55(lock)	1638	316	237
Pacific Side					
Upper Operating Gate	23.6	55(lock)	1008	202	151
Middle Operating Gate	37.8	55(lock)	2102	421	315
Lower Operating Gate	40.6	55(lock)	2033	395	296

(2) Design of Gates

Operating Gates are supposed to withstand hydraulic pressure force during lockage operation (=Operational Condition). In addition to this, the Middle and Upper Operating Gates are used during dewatering the Lower Chamber only or and the Upper Chamber for their maintenance work (=Maintenance Condition). Design heads in meter on the lake side and the sea side of each Operating Gate for these two conditions are shown in Table III.1.5-11. Concerning the Operational Condition, the lake side heads correspond to the maximum water elevations during the lock operation shown on the Table at III.1.5-2, and the sea side heads correspond to the minimum water elevations in the chamber or sea behind the gate of the same table. Concerning the Maintenance Condition, the lake side heads correspond to the maximum water elevation on the lake for the Upper Operating Gate and the maximum water elevation in the lower chamber for the Middle Operating Gate, and the sea side heads correspond to a drained condition. As long as the allowable stress for yielding is concerned, 100 % of it is allowed for the Operating Condition and 130 % for the Maintenance Condition.

Table III.1.5-11 Design Heads of Operating Gate in Meter (200,000DWT)

Gate Name	Operational Condition		Maintenance Condition	
	Lake Side	Sea Side	Lake Side	Sea Side
Atlantic Side				
Upper Operating Gate	23.0	8.8	23.0	0.0
Middle Operating Gate	35.7	8.8	22.7	0.0
Lower Operating Gate	35.4	21.5		
Pacific Side				
Upper Operating Gate	23.0	7.3	23.0	0.0
Middle Operating Gate	37.2	7.2	26.1	0.0
Lower Operating Gate	40.0	21.5		

(3) Installation and Removal of Gates

The Operating Gate leaf for the High Rise Lock is fabricated at shop in one piece and towed to Panama on a barge. They are set in place using a floating crane according to the steps shown in Fig.III.1.5-4. It is anticipated that the gate leaves fabricated and installed using these procedures will have bigger deviations from their drawing dimensions and from their relative positions to the gate frames or the hoist mechanisms installed in concrete structures before hand than gates installed using a conventional block erection method with which dimensional adjustment of gate leaves is possible during block erection either at shop or at site. Hence, gate seal mechanisms, bearing systems, support system etc, which interface on the leaf side to the equipment on concrete structures under water must be able to adapt to bigger dimensional deviations in gate leaves and embedded metals than ordinary gate designs. The proposed installation method is hereby named "Just-Set-In-Place Installation" versus "the conventional block erection installation ".

The Just-Set-In-Place Installation method also enables the gate leaves under water to be removed or reset for maintenance. Thus, elimination of overhaul outage of locks after starting which was one of the main study themes of the Third Lock Plan is realized.

Just-Set-In-Place Installation is an important idea of this conceptual design. However, all parts under water should also be adjustable in drained conditions.

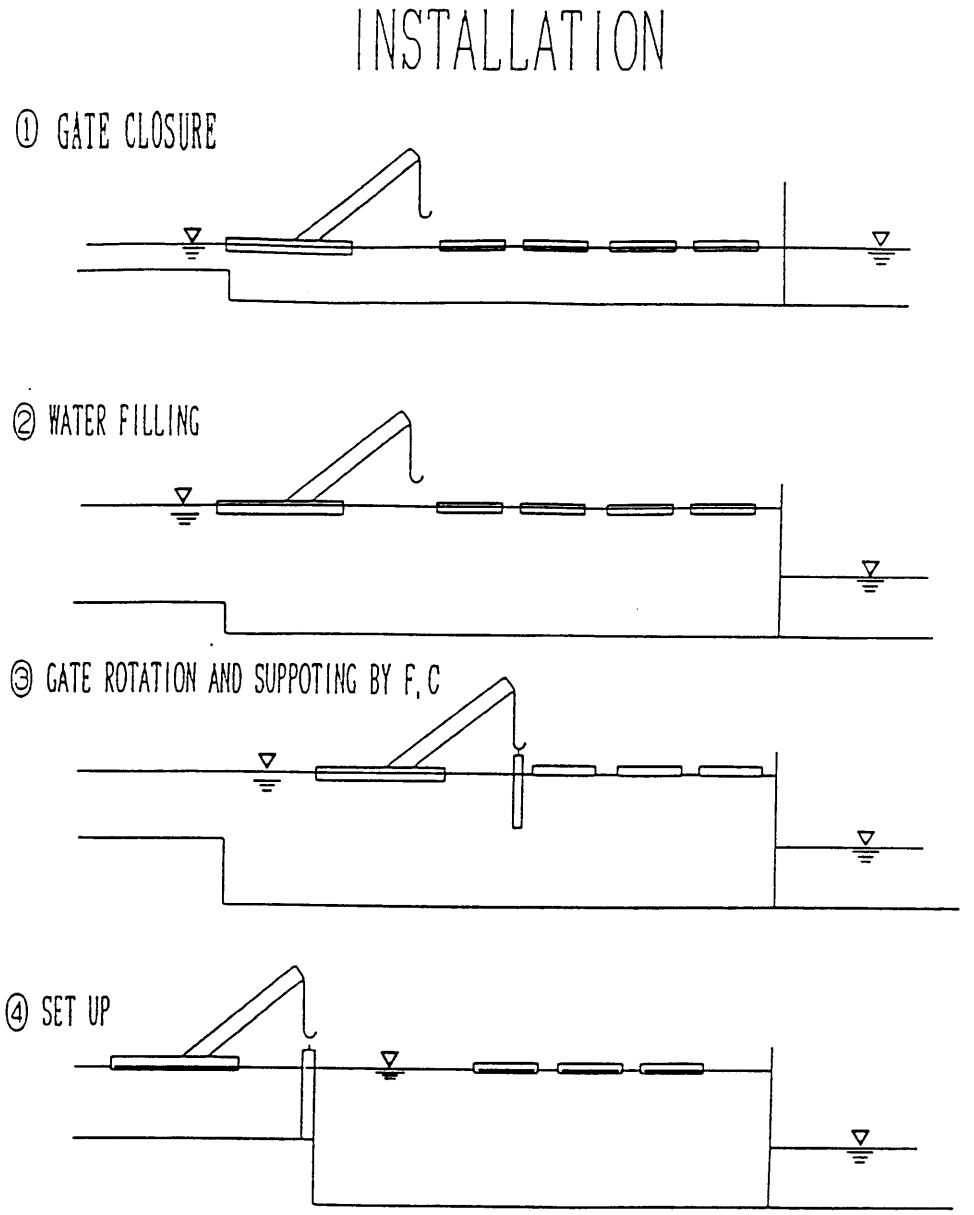


Fig.III.1.5-4 Installation Procedure

5.2.3 150,000DWT Option

(1) Description of Gates

The height, width and weights of each Operating Gates are as shown in Table III.1.5-12. The width is that of the lock channel and not the leaf. The weight is for one lock wall and twice of the figures are required for one complete set of the Operating Gates. The Lower Operating Gate is supposed to be used as a road bridge for vehicular traffic crossing the lock chamber. The additional structural framing required for this purpose is approximately 60 tons which is included in the weights in the table and in the cost estimation.

The drawing showing general arrangement of the Operating Gates for the 150,000DWT option was not made. The gate leaf is supported by embedments in concrete at two points; i.e. at top corner of the leaf by a gudgeon pin and at bottom corner of the leaf by a pintle. The leaf weight is supported by the pintle, and moment occurring due to the difference between the leaf weight center and the pintle reaction force center is supported by pulling force of the gudgeon pin and pushing force on the pintle. Water pressure acting upon the shell plate of the box type leaf is supported by bearing blocks arranged along the quoin end and the miter end of the gate leaf. There are two emergency stops; i.e. one located around the miter end for the leaf over-run and the other located around the quoin end for the pintle slip.

Each side, and the bottom of the gate leaf are sealed by a continuous "J" shaped rubber seal. This seal is located along the side and bottom edges of the downstream shell plate of the box type leaf. Dimensions of the rubber section are larger than normal to provide necessary self-adjustability for the Just-Set-In-Place Installation method which will be explained in detail at (3) of this 5.2.3. The

bulb portion of the rubber will have proper hardness to prevent excessive deformation in the bulb at high water pressure zone, and at the same time, maintain enough sealing ability at low water pressure zone.

The pintle sits rigidly on a base metal embedded in concrete floor, and a pintle bush mounted on the leaf bottom is movable in the direction of the gate width. The gudgeon is set rigidly to gudgeon anchors embedded in a concrete wall and a gudgeon pin mounted rigidly on the leaf top is supported by the gudg eon so that the pin together with the gate leaf may move in the direction of the gate width. As soon as the gate leaves start supporting the hydraulic load after a set of the two leaves is closed, the total leaf will move towards bearing blocks set on a gate frame embedded on a concrete wall until the bearing blocks mounted on the leaf quoin end hit the bearing blocks of the concrete side. This concept will release the pintle, gudgeon and quoin bearings from strict limitations for deviations from their designed relative positions and make the Just-Set-In-Place-Installation method useful. This will also contribute to decreased wearing on the quoin bearing blocks.

Most spaces in the box type leaf are assigned as float tanks. The buoyancy force compensates for the leaf weight so that the load on the pintle may be reduced to a greater extent during operational condition.

No spare gate leaf is included in the cost estimation.

Table III.1.5-12 Dimensions and Weights of Operating Gate (150,000DWT

Gate Name	Height in Meter	Width in Meter	Weight in Ton		
			Leaf G.	Frame G.	Hoist
Atlantic Side					
Upper Operating Gate	22.1	50(lock)	816	163	122
Middle Operating Gate	34.8	50(lock)	1571	314	236
Lower Operating Gate	34.5	50(lock)	1387	265	199
Pacific Side					
Upper Operating Gate	22.1	50(lock)	826	165	124
Middle Operating Gate	36.3	50(lock)	1698	340	255
Lower Operating Gate	39.1	50(lock)	1703	329	246

(2) Design of Gates

Design heads in meters of the lake side and the sea side of each Operating Gate are shown Table III.1.5-13. Concerning the Operational Condition, the lake side heads correspond to the maximum water elevations during the lock operation shown in the Table III.1.5-2, and the sea side heads correspond to the minimum water elevations in the chamber or sea behind the gate of the same table. Concerning the Maintenance Condition, the lake side heads correspond to the maximum water elevation on the lake for the Upper Operating Gate and the maximum water elevation in the lower chamber for the Middle Operating Gate, and the sea side heads correspond to a drained condition. As long as the allowable stress for yielding is concerned, 100 % of it is allowed for the Operating Condition and 130 % for the Maintenance Condition.

Table III.1.5-13 Design Heads of Operating Gate in Meter (150,000DWT)

Gate Name	Operational Condition		Maintenance Condition	
	Lake Side	Sea Side	Lake Side	Sea Side
Atlantic Side				
Upper Operating Gate	21.5	7.3	21.5	0.0
Middle Operating Gate	34.2	7.3	21.2	0.0
Lower Operating Gate	33.9	20.0		
Pacific Side				
Upper Operating Gate	21.5	5.8	21.5	0.0
Middle Operating Gate	35.7	5.7	24.2	0.0
Lower Operating Gate	38.5	20.0		

(3) Installation and Removal of Gates

The Operating Gate leaf for the High Rise Lock is fabricated at shop in one piece and towed to Panama on a barge. They are set in place using a floating crane according to the steps shown in Fig.III.1.5-4. It is anticipated that the gate leaves fabricated and installed using these procedures will have bigger deviations from their drawing dimensions and from their relative positions to the gate frames or the hoist mechanisms installed in concrete structures before hand than gates installed using a conventional block erection method with which dimensional adjustment of gate leaves is possible during block erection either at shop or at site. Hence, gate seal mechanisms, bearing systems, support system etc. which interface on the leaf side to the equipment on concrete structures under water must be able to adapt to bigger dimensional deviations in gate leaves and embedded metals than ordinary gate designs. The proposed installation method is hereby named "Just-Set-In-Place Installation" versus "the conventional block erection installation ".

The Just-Set-In-Place Installation method also enables the gate leaves under water to be removed or reset for maintenance. Thus, elimination of overhaul outage of locks after starting which was one of the main study themes of the Third Lock Plan is realized.

Just-Set-In-Place Installation is an important idea of this conceptual design. However, all parts under water should also be adjustable in drained conditions.

5.2.4 Operating Gate Machinery

The preliminary design adopted for the Operating Gates machinery generally followed the result of the study of the Deep Draft Lock Plan reported in IOCS Memorandum JAX-103. The machinery is of the crank and strut type driven by a hydraulic cylinder set on the floor at the same elevation as the Operating Gate top. Each machine is equipped with a hydraulic pump unit powered by two induction motors of 150 KW for the 200,000DWT option and 130 KW for the 150,000DWT option. Time restrictions did not afford us an opportunity to examine the possibility of cost saving with a hydraulic pumping station for each lock with the related controls and distribution system. The design consideration adopted in the latest locks on the Ohio River to prevent overloads on the machinery due to reverse heads on the gate should be considered at the detail design stage as it is recommended in the report mentioned above.

5.3 Culvert Gate

5.3.1 Culvert Gate Leaf

The gate type is the reversed Radial Gate as was recommended at the Phase 1 study. The gate in each lock has the same design for convenience of fabrication and maintenance. Height, width, radius of the leaf arm, weights and design heads are given in Table III.1.5-14 and Table III.1.5-15. The height and width were determined so that the same filling time as scheduled in the Deep Draft Lock Plan might be maintained. Data used in the calculation were for 250,000DWT ships in IOCS Memorandum JAX-103 and filling time was nine minutes with a three minute valve time. The weights for each part were estimated according to the leaf unit weights curve in Fig. 4.2.3 of the Phase 1 study Final Report and relative weight ratio coefficients shown on Table III.1.5-9. Fig. III.1.5-5 in this report is a copy of the Fig. 4.2.3 with the Phase 2 unit weights plotted on it. The design heads at the lake side correspond to the highest water elevation and at the sea side to the lowest water elevation of the corresponding ocean. The leaves are to be all welded construction and tension arms are connected to the trunnions installed in concrete. They are operated by machinery of the crank and strut type.

Table III.1.5-14 Dimensions and Weights of Culvert Gate

Lock Location	Height in Meter	Width in Meter	Radius in Meter	Weight in Ton		
				Leaf G.	Frame G.	Hoist
200,000DWT						
Atlantic Side	8.2	8.4	12.5	103	82	62
Pacific Side	8.2	8.4	12.5	105	84	63
150,000DWT						
Atlantic Side	7.5	8.1	11.5	90	72	54
Pacific Side	7.5	8.1	11.5	92	73	55

Table III.1.5-15 Design Heads in Meter of Culvert Gate

Lock Location	Lake Side	Sea Side
200,000DWT		
Atlantic Side	21.5	48.4
Pacific Side	21.5	51.5
150,000DWT		
Atlantic Side	20.0	46.9
Pacific Side	20.0	50.0

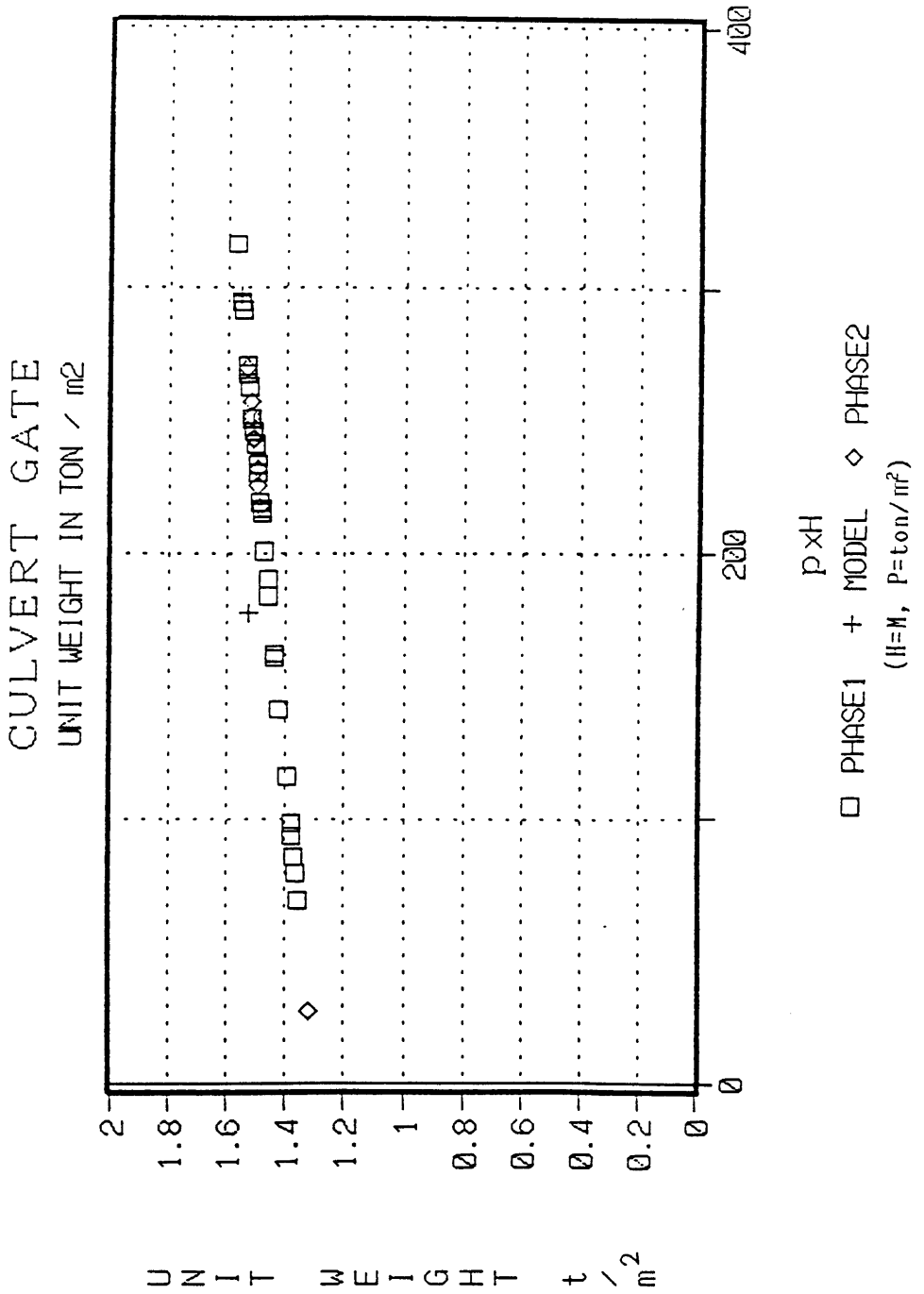


Fig. III.1.5-5 Culvert Gate Unit Weight

5.3.2 Culvert Gate Machinery

The preliminary design adopted for the Culvert Gate machinery generally follows the result of the study of the Deep Draft Lock Plan reported in IOCS Memorandum JAX-103. The machinery is the crank and strut type driven by a hydraulic cylinder and operating time is around three minutes. The machinery is equipped with a hydraulic pump unit powered by two induction motors of 70 KW for the 200,000DWT option and 60 KW for the 150,000DWT option. The following cost improvements proposed in the report mentioned above should be studied at the beginning stage of the detail design work.

1) Two smaller gates instead of one gate for a culvert tunnel width.

2) A longer operation time.

3) A central hydraulic pumping station system at each lock in conjunction with a hydraulic power source for the Operating Gate machineries.

Details of the these proposals are given on page 12 to 13 of the above report for the Deep Draft Lock Plan.

5.4 Emergency Gate

5.4.1 Emergency Gate Leaf

The Emergency Gate which is installed on the lake side approach channel is designed to close the channel automatically in the case of an emergency such as fracture or collapse and to prevent the water in the lake from escaping through the upper chamber, or down stream along the lock from natural disasters and keep the intensity of the damages to a minimum. Hence the role of this gate is substantial and its structures and mechanisms have to be very reliable. The gate type adopted is the drop type rolling gate as mentioned in the Phase 1 study. The general view of this gate is given on Fig. III.1.5-6. A

gate leaf consists of a box type main girder and vertical girders. The hydraulic load acting on the gate leaf during closing operation is supported by rollers arranged at both ends of the main girder and along the gate bottom edge. Two types of float tanks are provide in the leaf. One group is permanently empty and provides an amount of buoyancy force almost compensating for the gate weight and the other group is filled with water and will be drained by compressed air to give the gate leaf floating force in case of emergency. The gate top shape proposed is very similar to the bottom shape of emergency coaster gate as usually used for emergency closure of high pressure outlets in high dams. To develop definitive gate top shape, further study with hydraulic model tests will be necessary. No consideration was given to the compatibility of this gate for flood discharge spillway which was proposed in IOCS Memorandum JAX-103 for the Deep Draft Lock Plan because the need for such a consideration was vague.

The height, width, weights and design heads are given on Table III.1.5-16. The gate height corresponds to the gate top elevation equal to the maximum operational water elevation of the lake. The weights for each part were estimated according to the leaf unit weight curve in Fig. 4.2.4 in the Phase 1 Final Report and relative weight ratio coefficients shown on Table III.1.5-9. Fig. III.1.5-7 in this report is a copy of Phase 1 Fig. 4.2.4 with the Phase 2 unit weights plotted on it. The design heads correspond to the highest water elevation at the lake, and the sea side is in dry condition.

Table III.1.5-16 Dimensions, Weights and Design Head of Emergency Gate

Canal Option	Height in Meter	Width in Meter	Weight in Ton			Design Head in Meter
			Leaf G.	Frame G.	Hoist	
200,000DWT	23.0	55.0	2954	1181	443	23.0
150,000DWT	21.5	50.0	2467	987	370	21.5

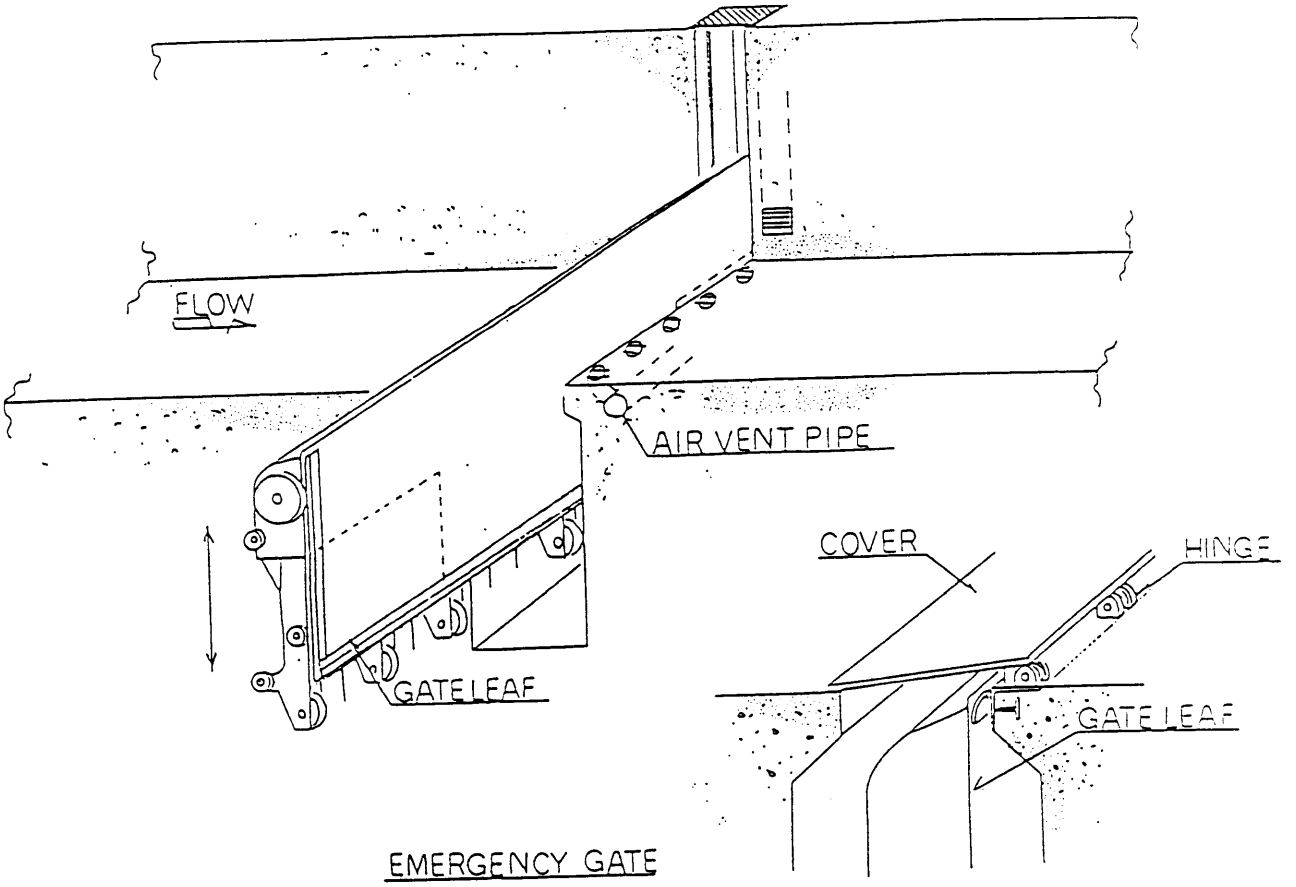


Fig. III.1.5-6 General View of Emergency Gate

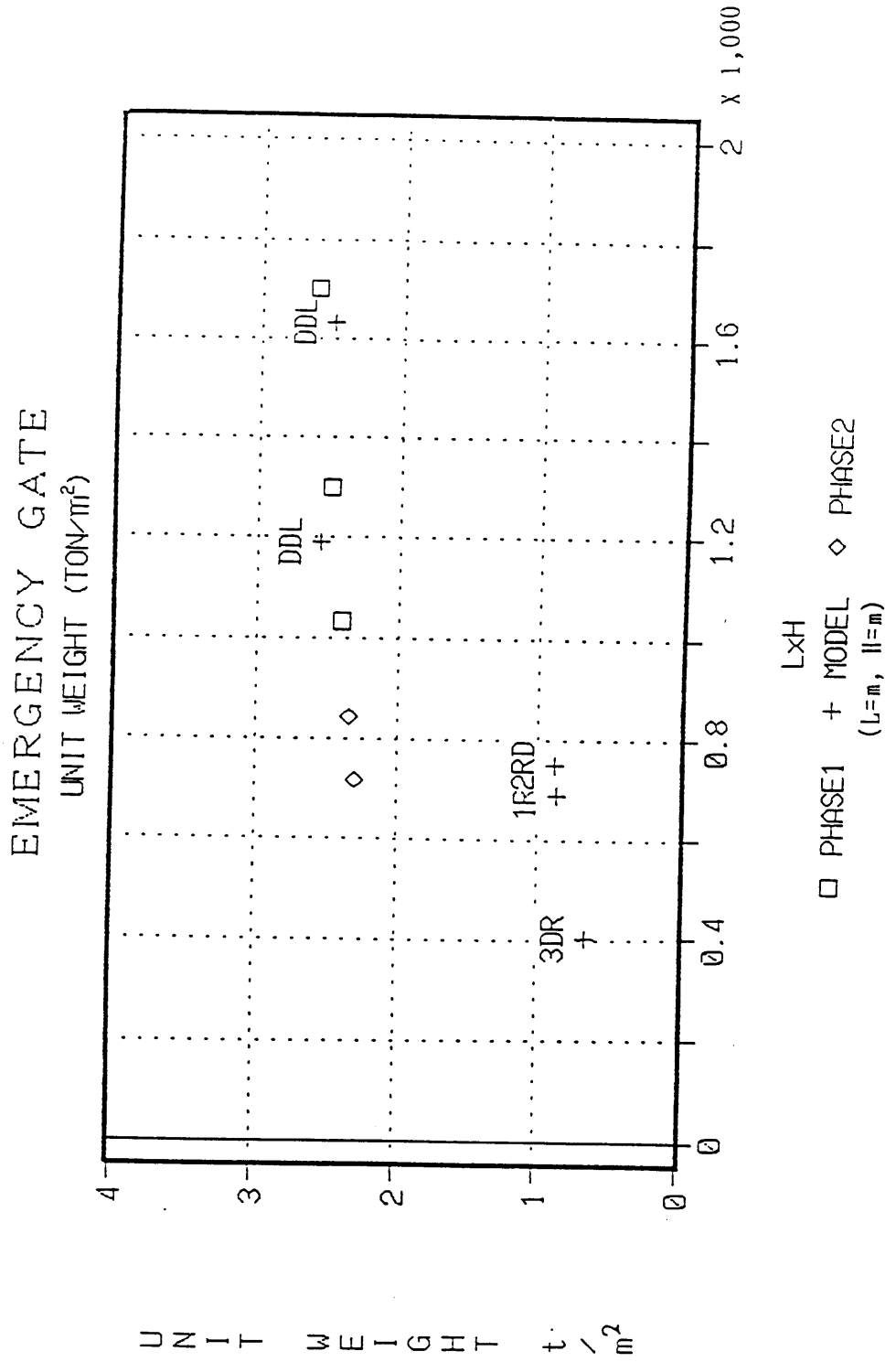


Fig. III.1.5-7 Emergency Gate Unit Weight

5.4.2 Emergency Gate Hoist Machine

Design of the hoist machine for emergency gate relied upon the recommendation made in IOCS Memorandum JAX NO 103 for the Deep Draft Lock Plan. A central jack type hoist machine, augmented by fire pump pressure and buoyancy tanks as used on the existing lock emergency gates in the States, is proposed for operating the Emergency Gate. The auxiliary hoists on each corner of the Emergency Gate to insure uniform rise of the gate leaf may be necessary to be studied at the detail design stage as was recommended in the said report above. Ordinary hydraulic power cylinders combined with a pulley system would also be applicable for this gate and it should be studied also in conjunction with the central hydraulic power station system mentioned in 5.3.2.

5.5 Maintenance Gate

Each lock is provided with recessed side seats and stepped bottom sills for the installation of the Maintenance Gate at the downstream side of the Lower Operating Gate in the lower chamber and at the upstream side of the Emergency Gate in the lake side approach. One floating type Maintenance Gate is provided for the locks on both ocean sides and is used when the lock chamber is dewatered for a maintenance operation in dry condition. For the upper and the lower chambers, the gate is set on the sea side sill and the water on the lake side is dammed either by the Upper Operating Gate or by the Middle Operating Gate according to the location to be maintained. For the maintenance operations in the lake side approach, the gate is set on the lake side sill and downstream side is left opened because the bottom elevation in the approach channel is equal or higher than the highest water elevation at the ocean side.

The gate type adopted is a floating type caisson as shown at Fig. III.1.5-8. Their height, width, weight and design heads are shown on the Table III.1.5-17. The weights for each part were estimated according to the leaf unit

weights curve in Fig. 4.2.5 in the Phase 1 Final Report and relative weight ratio coefficients shown on Table III.1.5-9. Fig. III.1.5-9 in this report is a copy of Phase 1 Fig. 4.2.5 with the Phase 2 unit weights plotted on it. The design heads correspond to the highest water elevation at the Pacific sea and the chamber side is in dry condition.

The gate is equipped with ballast tanks and submerged or re-floated by addition or removal of water ballast. Its structures are all welded construction and all other design aspects are fundamentally the same as the gates now in service except for being modernized.

Valves and pumps are provided in the gate to fill and drain water into, or out of the ballast tanks. This equipment is also used for water in the lock chambers, but covers only half the capacity required to fill or drain all chambers in a 24 hour period. The remaining half capacity is shared by drain pumps provided in the concrete walls on the seasides.

Table III.1.5-17 Dimensions, Weights and Design Head of Maintenance Gate

Canal Option	Height in Meter	Width in Meter	Weight in Ton			Design Head in Meter
			Leaf G.	Frame G.	Hoist	
200,000DWT	29.1	55.0	6700	670	603	28.5
150,000DWT	27.6	50.0	5632	563	507	27.0

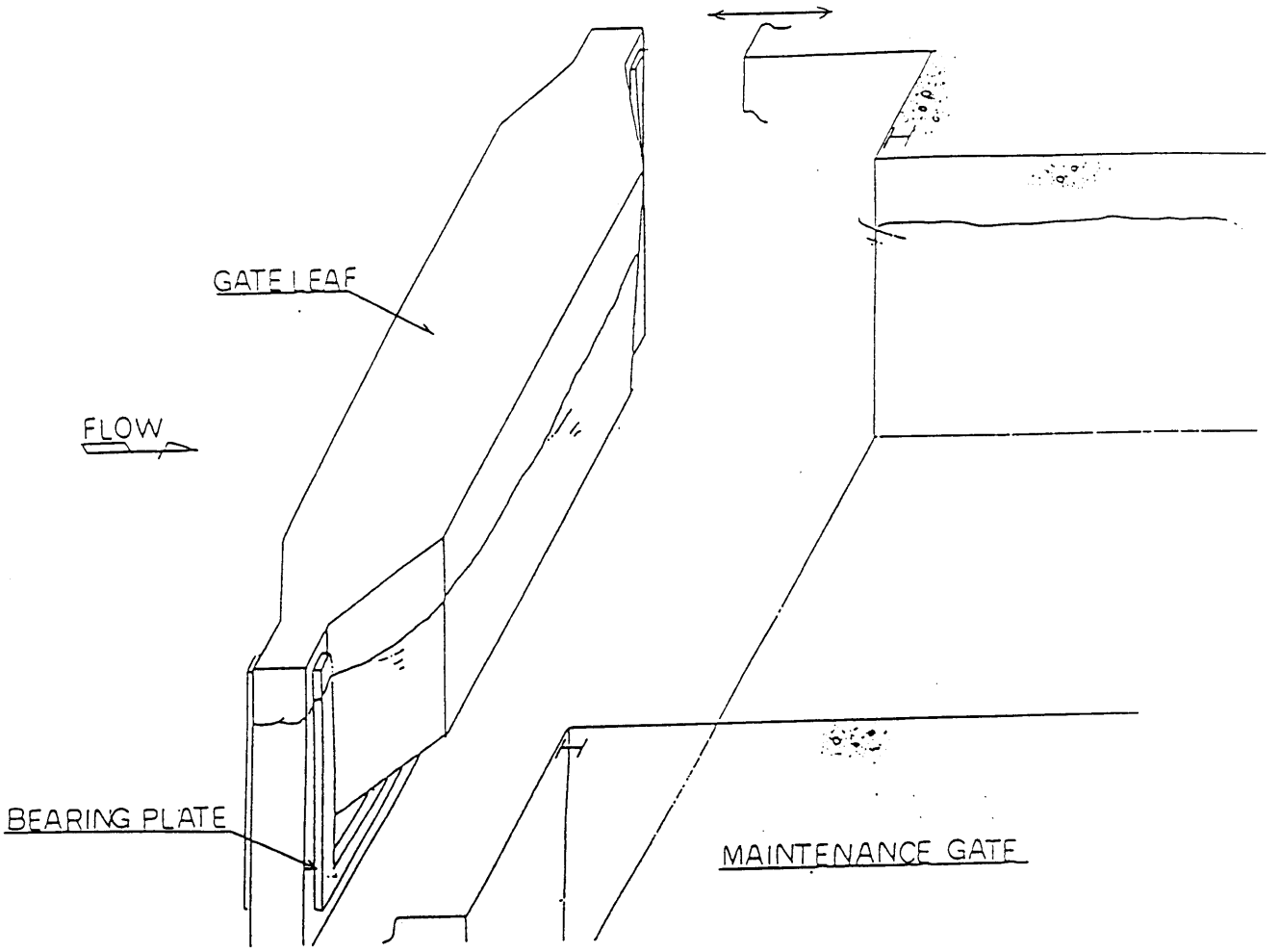


Fig. III.1.5-8 General View of Maintenance Gate

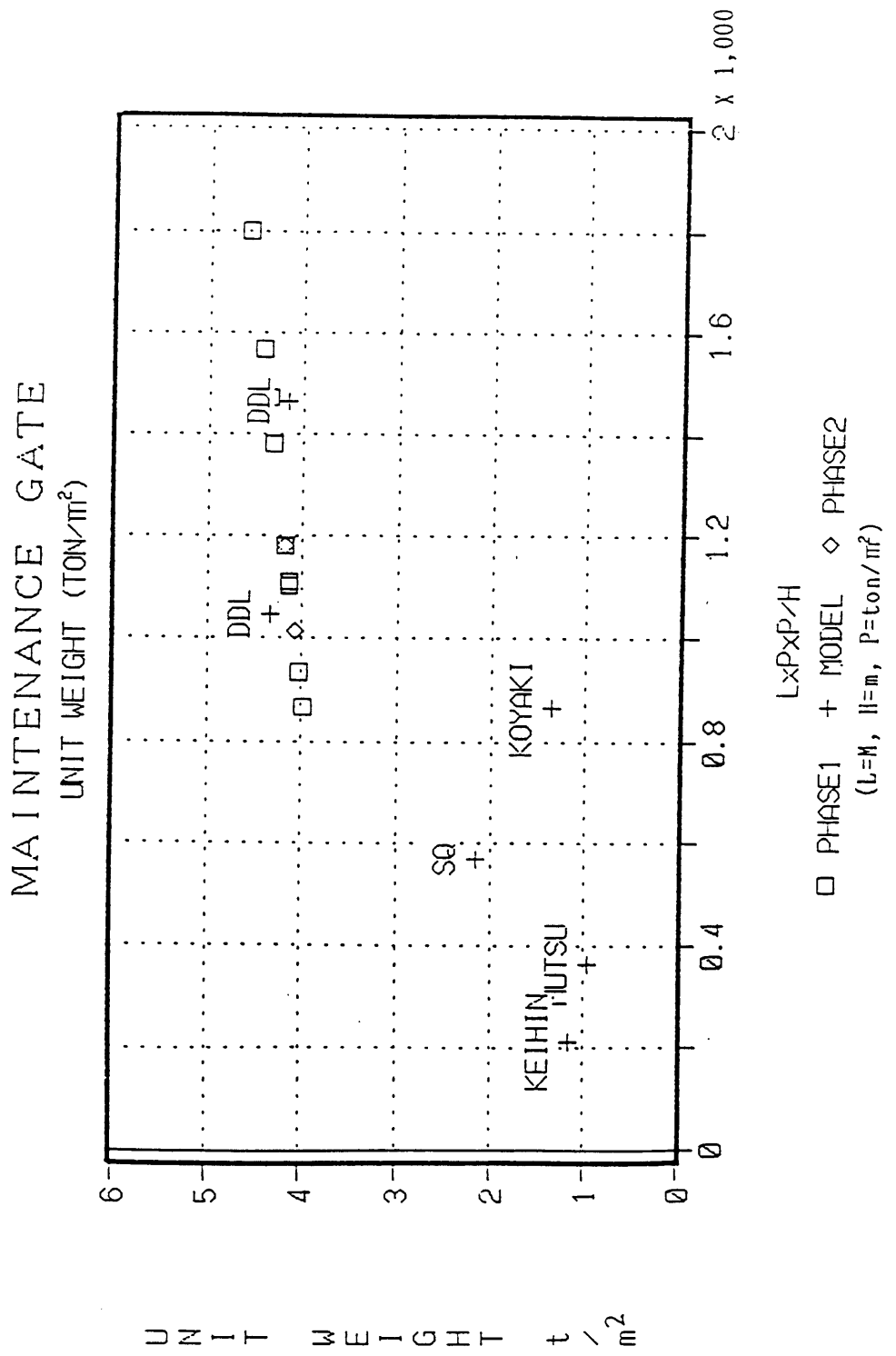


Fig. III.1.5-9 Maintenance Gate Unit Weight

5.6 Culvert Maintenance Gate

(1) Gate Design

The Culvert Bulkhead Gate type is a stop log made of steel. The gate leaf consists of four blocks, each having a box shape section and bearing plates. Fig. III.1.5-10 illustrates the Culvert Maintenance Gate. Their height, width, weight and design heads are shown in Table III.1.5-18. The design heads correspond to the highest water elevation at the Pacific Ocean while the chamber side is in dry condition.

(2) Number of Gate Sets

Four sets of gate leaves are provided which is adequate for draining the spaces for the two Culvert Gates in one lock wall of the lower chamber.

(3) Gate Installation

The gate leaf blocks stored in a separate location will be transported by vehicle and inserted into the gate slot with the aid of a movable crane.

Table III.1.5-18 Dimensions, Weights and Design Head of Culvert Maintenance Gate

Canal Option	Height in Meter	Width in Meter	Weight in Ton		Design Head in Meter
			Leaf	G. Frame	
200,000DWT	8.4	8.2	115	23	51.5
150,000DWT	8.1	7.5	90	18	50.0

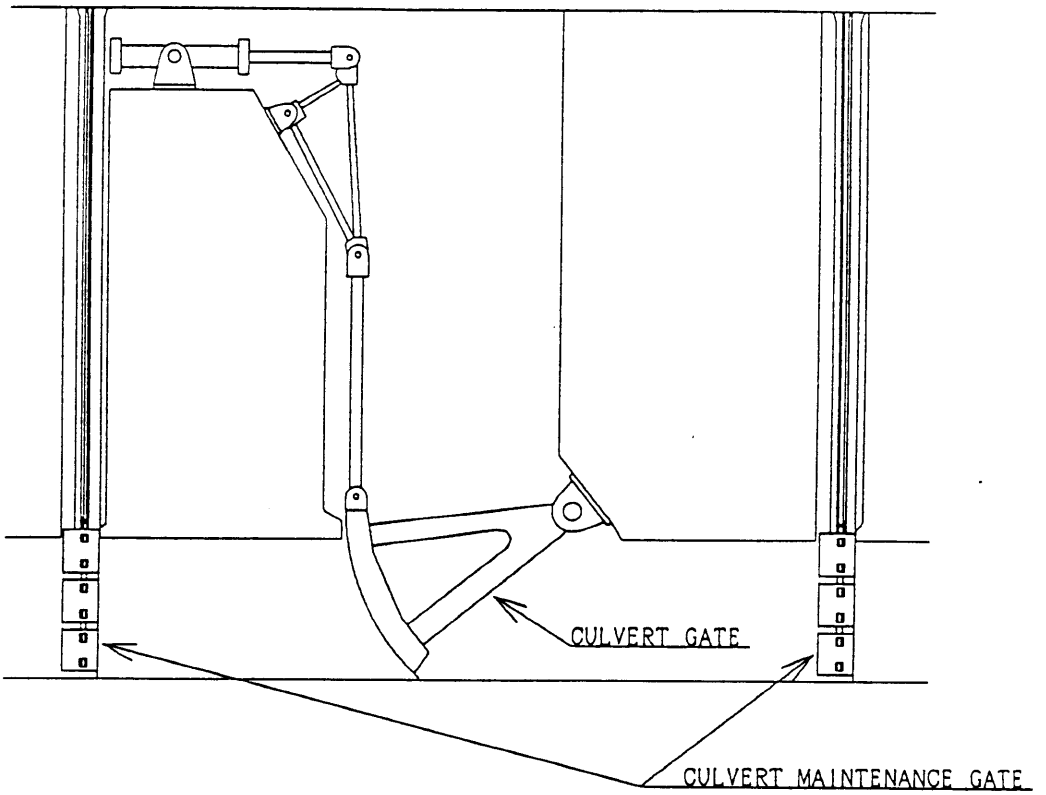


Fig. III.1.5-10 General View of Culvert Maintenance Gate

5.7 Corrosion Protection System

Corrosion protection systems including paint coating and cathodic protection anodes are required for each gate, gate frame and gate hoist according to the materials used and working or storage condition and circumstances. The system should also incorporate PCC maintenance experience and findings. It is not practical for the complete corrosion system to be established for each gate at this stage of preliminary design. The following table shows kinds of painting to be applied and status of cathodic protection anode provision on each gate. The present cost estimation is deemed to cover the cost level of including these types of corrosion protection procedures.

Table III.1.5-19 Recommendable Paint Coating and Cathodic Protection Application

Location	Coal Tar Enamel (Hot)	Special In-Organic Z.P. + Sealer	Coal Tar Epoxy	Polyamide Epoxy/ Vinyl	Cathodic Protect. Anodes
Operating Gate					
Submerged Area	Yes				Yes
Exposed Area		Yes			
Culvert Gate					
Gate Leaf	Yes				Yes
Gate Frame	Yes				Yes
Gate Hoist				Yes	
Emergency Gate					
Gate Leaf	Yes				Yes
Gate Frame	Yes				Yes
Gate Hoist	Yes				Yes
Maintenance Gate					
Gate Leaf			Yes		
Gate Frame	Yes				Yes
Culvert M. G.					
Gate Leaf			Yes		
Gate Frame	Yes				Yes

5.8 Electric Power Control

As a guide for conceptual design and estimating purposes the Deep Draft Lock Plan was generally used.

(1) Distribution System

The system consists of a radial type, double circuit, primary system encircling the lock complex, with a primary distribution voltage of 13.8 KV (12 KV nominal). Secondary distribution for power is at 3 phase 480 volt (460 volt nominal) with lighting and small auxiliary power loads supplied at 3 phase 120/208 volt. Three transformer substations and associated switch gear will be provided on each side of the lock. Substations will be located near each Operating Gate in the electrical equipment room at the operating gallery level below the local control stations. It is assumed for estimation purpose that commercial power is supplied to a point by the lock sites at 13.8 KV.

(2) Wire System

A cable tray system in an electrical gallery in each lock wall and in lock crossover tunnels provides the main raceway system for electric cables. Exposed conduits are provided in each local control station and its associated electrical equipment room below at the operating gallery level. These areas will have temperature and humidity control equipment. Embedded conduits will extend from the electrical equipment rooms to the lock operating machinery in the vicinity of miter gates and from galleries to utilization equipment in other locations. All electrical equipment for hoists and simple control boards set by the equipment for maintenance works is included in the estimate for mechanical equipment.

(3) Emergency Power Plant

The maximum plant load includes the power required by the lock guidance locomotives, the lock lighting system, including miscellaneous auxiliaries, and the lock operating equipment. The approximate power demands for two canal options are shown in Table III.1.5-20. Each gas turbine power plant set on both sides of the oceans is capable of supplying the amount of the total power demand on Pacific side. These emergency power sources could be used to supply more than 100 % of the power needed for the return of lockage water at 2060 A.D. section.

Table III.1.5-20 Approximate Electric Power Demands in KW for Lock Operation

Canal Option	Lock Site	Locomotive	Lighting	Gate Operation	Total Demand
200,000DWT	Atlantic Side	24,000	700	11,300	36,000
	Pacific Side	24,000	700	13,300	38,000
150,000DWT	Atlantic Side	24,000	600	9,400	34,000
	Pacific Side	24,000	600	10,400	35,000

(4) Lockage Guidance Equipment Power Supply

The guidance equipment motive power is provided by 16 A.C. operating guidance locomotives. Electrification rails and all electrical equipment for the locomotives are included in the estimate for mechanical equipment.

(5) Electrical Equipment for Gate Hoists and Locomotives

Weights and Costs of electrical equipment for gate hoists and locomotives are included in the gate hoists and locomotives which are classified as Mechanical Equipment in the Bill of Quantities at III.3-Chapter 2.

(6) Miscellaneous Electrical Equipment

Cost for miscellaneous electrical equipment for the electrical power and control were derived by adjusting the Deep Draft Lock Plan estimate including this item, in relation to the total cost for all other electrical power control equipment including for gate hoists and locomotives.

5.9 Miscellaneous Structures and System

As a guide for conceptual design and estimating purposes the Deep Draft Lock Plan was generally used.

(1) Lock Control System

A local control station is provided in the vicinity of each Operating Gate leaf on top of the lock wall and landward to the guidance system tracks. Operation of the Operating Gates and the Culvert Gates is controlled from these locations. Controls are supplemented by indication circuits of the selsyn type for continuous indication of the Culvert Gate position and lock water levels. Pilot lights and limit switches are used for miscellaneous control and position indication , and closed circuit TV monitoring equipment is provided for each Operating Gate, the Emergency Gate, and for the lake and sea side approach areas. The down stream lock entrance signal is controlled from the local control station associated with the Lower Operating Gate and the upstream entrance signal will be controlled from the control station associated with the Upper Operating

Gate. Costs for the items included here, as well as the other items included in the item "Others" on the Cost Content of Gate Leaves and Related Facilities in III.3-Chapter 2.1 were derived by adjusting the allowances in the Deep Draft Lock Plan estimate for these items, in relation to the gate leaf costs.

(2) Shops-Service Buildings-Gate Dry Dock

New facilities have not been included as it is assumed the existing Panama facilities could be used to provide such services.

(3) Ventilation System

A ventilation system is included to provide forced fresh air ventilation to the crossovers, emergency gate tunnel, operating galleries, and equipment rooms. Costs were derived by adjusting the allowances in the Deep Draft Lock Plan estimate for this item (=other mechanical component), in relation to the gate leaf costs.

(4) Pumping and Piping

Pumping and piping for raw water, potable water, dewatering locks and culverts, sump pumping, fire protection, and sewage disposal are included under these heading. Costs were derived by adjusting the allowances in the Deep Draft Lock Plan for this item (=other mechanical component), in relation to the gate leaf costs.

(5) Compressed Air System

Compressed air is to be provided for maintaining the buoyancy chambers of the Operating Gates, blowing the buoyancy tanks of the emergency gate and powering pneumatic equipment. Costs were derived by adjusting the allowances in the Deep Draft Lock Plan estimate for this item (=other mechanical component), in relation to the gate leaf costs.

III.1 CHAPTER 6 - LOCKAGE GUIDANCE SYSTEM

6.1 Ship Propulsion in a Lock Chamber by Ship's Power

Ships are guided by locomotives during lockage. The existing Panama Canal adopted this system when it was constructed. Prior to this time, serious accidents to the lock gates in locks used for large ships had been invariably caused by the misunderstanding of signals between the navigating officer and the engine room. For this reason it was concluded at the time the original canal was planned that ship's power should not be used for passage through the lock (Paper No.15 "Electrical and Mechanical Installation of the Panama Canal" of Transaction of the International Engineering Congress, 1915 held in USA). Lockage operation and the increased demands in both number and size of ships to transit the Panama canal have changed perceptions regarding locomotive usage and today usage of ship propulsion during lockage seems to be very common, especially in the case of larger ships. For reference purposes, listed below are documents in which there are statements concerning the usage of ship propulsion during lockage.

(1) The Panama Canal, Transaction of International Engineering Congress 1915.

(2) The Panama Canal Pilot, Panama Canal Commission Maritime Training.

(3) Pilot Hand Book, Panama Canal Commission, 1988.

In the Phase 2 study, the role of locomotives during lockage operations was reviewed according to the assumption that the ship's engines provide the primary power for navigation through the locks, while the locomotives are secondary.

6.2 Role of Guiding Locomotive

The role of locomotives during lockage operation was reviewed based upon the assumptions described in III.1 Chapter 6.1.

The first primary responsibility of the locomotive is ship position control in either the ship longitudinal direction or perpendicular to this direction. Elements disturbing to a ship's position are as follows.

(1) Wind force in either longitudinal, or lateral direction, or both

(2) Ship propulsion force

A single screwed ship has a tendency for its stern position to alter laterally however skillful the rudder operation. This tendency is more remarkable during full ahead or astern operations when ship's initial speed is zero or very minimal.

(3) Hydraulic force on ship hull under water

Existence of water flow in the lock during ship raising or lowering operations is inevitable even when the lock chamber is designed for homogeneous water filling or drawing. Therefore a ship hull under water may have resultant hydraulic force either in longitudinal or lateral direction, or both.

The secondary role shall be to support the ship braking function. Although astern operations by ship power are possible the locomotives shall provide braking functions to stop a lockage ship within a certain reach, or period, without ship power for emergencies such as a ship power failure.

The last role of the guidance system which will be of rather lesser importance for guiding the Design Ship is assistance in ship propulsion, including ship accelera-

tion to shorten lockage time. Being capable to tow a lockage ship by locomotives after the ship speed reaches green light speed (maximum guiding speeds established for various ship size) may be preferable for ship maneuvering in a lock, but it is not absolutely necessary. Nevertheless 8 locomotives, which is the maximum number for guiding a lockage ship, should probably be able to tow the majority of the smaller ships which transit the third set of locks.

6.3 Assumptions on Locomotive Function

Locomotives will be designed for pulling capacity and green light speed (maximum guiding speeds established for various ship size). These functions significantly relate to the lockage time which may control total capacity of the Canal Alternative. Fig. III.1.6-1 shows relationship between the lockage time and the locomotive function.

Fig.III.1.6-1; Ship Braking and Propulsion Assistance in this figure refer to the Role of Locomotives. Their engineering criteria are Braking Time(=necessary time for stopping a ship), Acceleration Time(=necessary time for accelerating a ship) and Green Light Speed, all of which are major elements of Lockage Time. These values relate to the Force on Pulling Cable of the locomotives as shown in the figure. The major functions of the locomotives are Pulling Capacity and Green Light Speed. Hence, the finalization of locomotive functions should consider the canal capacity study, which is a major subject of another component study for the Panama Alternatives Study.

Table III.1.6-1 gives the assumed locomotive function for preliminary design in the Phase 2 study. The assumption is twice the pulling capacity of the existing locomotive for the existing Panama canal. The pulling capacity shown on the table is large enough for a ship being maneuvered under wind velocity of 13 m/sec.

Table III.1.6-1 Assumed Guiding Locomotive Functions

Function Name	Assumption
Pulling Capacity per One Cable in Ton	; 32
Number of Cable	; 2
Total Pulling Capacity in ton	; 64
Green Light Speed in knot (Note 1)	; 0.5, 1, 2 & 3
Light Speed in knot (Note 2)	; 6 & 9
Cable Length in Meter	; 300

Note: 1. Green Light Speed in the table means the maximum guiding speeds established for various ship size.
2. Light Speed in the table is the speed used for a return or running "light".

Table III.1.6-2 shows Braking Time, Braking Length(= ship travel distance after a braking operation started), and ship speeds, which can be achieved with the assumed locomotive functions applied to the Design Ship in the lock chamber of each canal option. All values have been given for different drafts which are expressed in the amounts of draft decrease. The sea level canal option is also included here just for the sake of comparison. Ship Speed for 150,000DWT option is unexpectedly low which has resulted from the smallest ratio of the lock transversal sectional area to the Design Ship midship sectional area. The Braking Time or the Braking Length increases as the ship draft decreases in this calculation but they will finally start decreasing with a much smaller ship draft. The ship speed of 2 knots in the table means 2 knots or more. The calculation made to find these values covers the ship speed up to 2 knots. The Braking Time and the Braking Length correspond to a starting ship speed of 2 knots. The configulation of the Design Ship is simplified in the calculation such that the ship sides are parallel for the middle 50% of the ship and then taper linearly towards the stem and the stern. The angles of inclination of the pulling cable from the locomotives adopted in

the calculation are 40 degrees from vertical when projected on a vertical plane including the midship section and 45 degrees from the locomotive rail direction when angle was projected on a horizontal plane. The 40 degrees angle was adopted in the Third Lock study for a two lift type lock. The calculation includes several simplifications, yet it's accuracy is reliable enough to show relations between locomotive function and lock function.

Table III.1.6-2 Braking Time, Braking Length and Ship Speed in Lock Chamber

	S. Speed in Kt			B. Time in sec(3)			B. Length in M(3)		
C. Option	0.0	0.5	1.0	0.0	0.5	1.0	0.0	0.5	1.0
150,000DWT	1.7	2.0	2.0	63	68	72	28	32	35
200,000DWT	2.0	2.0	2.0	89	94	97	41	44	46
250,000DWT	1.5	1.9	2.0	103	110	115	46	50	53

Note: 1. Abbreviations; S.=Ship, B.=Braking, M=Meter, C.=Canal
2. The parameter on the table is a draft decrease of ship in meter.
3. Braking Operation started with ship speed at 2 knots.

6.4 Description of Locomotive and Track Rails

Twenty locomotive units are provided at each set of locks. The guiding track and related equipment will be similar to that proposed for the Deep Draft Lock Plan. The guiding system is identical for both lock schemes and includes turntables at the middle of each level and a return track connecting them to each other, and to a locomotive service building. Specifications of the locomotive are shown in Table III.1.6-3. Cost estimation for the locomotives was based upon a quotation followed by verification assisted with the PCC purchasing records.

Table III.1.6-3 Specification of Locomotive

Item Name	Specification
Type of Locomotive	Rack and Pinion Traction Type
Towing Capacity	140,000 Lbs (max) and 100,000 Lbs (one hour rated)
Dimensions in Meters	L15.0 W3.3 H4.5
Weight in tons	88
Number of Drive Motors	2
Drive Motor	6 Pole Induction Motor (brushless) 340 Hp 440V 40Hz
Cable Size	1-1/4"
Rail Gauge in Meters	1.676
Power Source	3 Phase Alternative Current 460 V 60Hz
Speed Control	Inverter Control

6.5 Power Supply

The power supply for the locomotive is discussed in section 5.8, with the power supply for gates.

6.6 Improvements on Guidance System in Future

Site tours were made on the Panamax class transit ships during the Phase 1 and 2 study. Following items which were disclosed during the tours may be helpful for study on improvements of Lockage Guidance system in future.

(1) A ship approaches a lock entrance by much less than the dead slow speed. This is inevitable way to avoid for the ship to hit the lock wall and achieve safety mating with guidance locomotives. The importance is the fact that majority of lockage time is spent for a transit ship approaching a lock entrance and a big possibility of improving lockage time may exist only in this event.

(2) Almost twenty line handlers a ship are on board for locomotive cable line setting. They are well trained and their movement are efficient with full of precaution for their safety works although their work site is with full of dangers such as fully tensioned cables, handling of moving cables towed by locomotives, embarkation to a moving ship etc. Nevertheless of this, it is very important from long term point of view to make continual efforts to eliminate any physical risks existing at work sites.

(3) Three pilots a ship are on board for ship maneuvering at lock sites. A chief pilot on the main bridge gives instructions to a rudder operator and an engineer of the transit ship, and two tug boats or 6 locomotives. He carries out his duty with assistance of two other pilots, one at the other end of the main bridge and one at the ship bow. A ship of more than 30 m beam width and almost 250 m length passes through the lock chambers whose width has only 60 cm margin at each side of the ship beam. Although a part of ship maneuvering duty is shared by the bow pilot and the locomotive operators, the chief pilot's duty is still very heavy. He has to speak to four radio phones during his ship maneuvering. The pilots now on duty are well experienced and their skill is almost state of art. Nevertheless of this, it is very important to make continual efforts to decrease their heavy duty for their next generation.

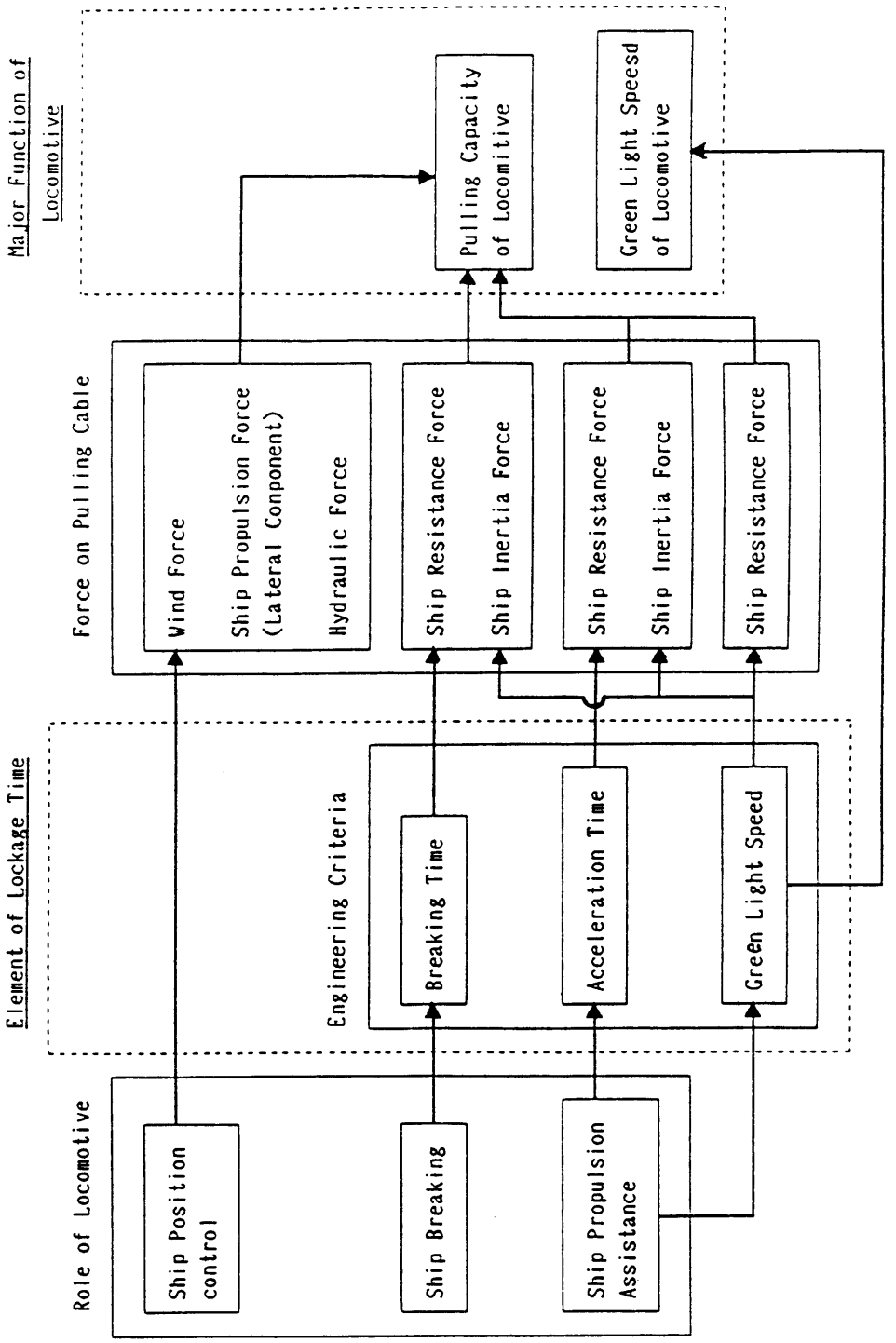


Fig. III.1.6-1 Relation Between Lockage Time and Locomotive Function

III.1 CHAPTER 7 - NEW DAMS

7.1 Introduction

Considering the large volume of lockage water required for existing and new locks, new dams to regulate the runoff within the Gatun watershed are to be planned. Also a new dam as a new water source is thought to be necessary and the dam has been planned at Indio river outside the Gatun watershed.

As shown in Fig. III.1.7-1, Main rivers flowing down into Maden lake are Rio Chagres, Rio Pequeni, and Rio Boqueron. Rio Gatun flows down into the northern part of the Gatun lake, Rio Chiri and Rio Trinidad flow down into the western part of the Gatun lake.

Rio Indio located at outside of the Gatun watershed flows down into the Atlantic ocean directly. Those seven rivers are target sites of new dam construction and studied in the following pages.

7.2 Design Condition

7.2.1 Rivers for Potential Dam Sites

The target rivers with their catchment areas are listed in Table III.1.7-1.

Table III.1.7-1 Catchment Area of Target Rivers

Dam	River	Catchment Area (km)
(1) Trancado	Rio Chagres	425
(2) Pequeni	Rio Pequeni	135
(3) Boqueron	Rio Boqueron	95
(4) Upper Gatun	Rio Gatun	125
(5) Trinidad	Rio Trinidad	165
(6) Ciri	Rio Ciri Grande	190
(7) Indio	Rio Indio	323

Each Candidate dam sites of the rivers are described as follows:

(1) Trancado

A dam site was selected in a relatively narrow part of the valley approximately 2 km upstream from where the Rio Chagres flows into Madden Lake. Chico gauging station is situated approximately 4 km upstream from this site. This site was the farthest downstream of the dam sites considered on the Chagres river.

Approximately 1 km further upstream of this site there is another potential site, however the lower site was preferable considering the effective use of water resources on the river.

(2) Pequeni

A dam site was selected in a relatively narrow part of the valley approximately 2 km upstream from where the Rio Pequeni flow into Madden lake, and is located near Candeleria gauging station. This site is located the farthest downstream among the candidate dam sites on the Pequeni river, but 2 km upstream there is another potential site.

(3) Boqueron

A dam site was selected in a relatively narrow part of the valley approximately 3 km upstream from where the Rio Boqueron flows into Madded Lake, and is located near Pellica gauging station. This site is located the farthest downstream among the candidate dam-sites on the Rio Boqueron.

(4) Upper Gatun

A dam site was selected in a relatively narrow part of the valley approximately 6 km upstream from where the Rio Gatun flows into Gatun Lake, and is located near Ciento Gauging station. Approximately 2 km farther downstream from this site there are other potential sites, whoever relative heights between the river bed and ridge are comparatively small and thus, these were not selected.

(5) Trinidad

A dam site was selected in a relatively narrow part of the valley approximately 9 km upstream from where the Rio trinidado flows into Gatun take, and is located approximately 4 km upstream from Chorro gauging station. Approximately 3 km further downstream from this site there are other potential sites, but relative heights between the river bed and ridge are comparatively small and hence, the sites were not selected.

(6) Ciri

A dam site was selected in a narrow part of the valley approximately 3 km upstream from where the Rio Ciri Grande flows into Gatun Lake, and is located near Loss Canones gauging station. The valley is quite narrow for approximately 2 km, including the gauging station site, and is a suitable site. The topography upstream from the dam site area is relatively flat and, the left bank ridge is low, thus a

saddle dam could be constructed.

(7) Indio

A dam site was selected approximately 25 km upstream in a straight line from where the Rio Indio flows into the Atlantic ocean, and is located approximately 1 km upstream from Boca De Uracillo gauging station. Suitable sites for a dam meeting proposed sizes on this river seem very limited. If water is conveyed from the Indio reservoir into Gatun Lake using gravity water flow a supply conduit about 10 km long would be required.

In order to make more effective usage of the basin's water resources, the reservoir's low water level could be reduced by moving the dam site downstream. An alternative plan would be to move the dam site upstream so that the reservoirs low water level could be raised. Water could then be conveyed to Rio Ciri Grande instead of Gatun Lake, making it possible to shorten the required length of the conduit.

7.2.3 Type of Dam

The most suitable type of dam is chosen by considering the topographical, geological and hydrological conditions at the dam site. From a topographical point of view, the shape of the valley is the most important factor. On the other hand, economical considerations such as the distribution of construction materials are also very important factors.

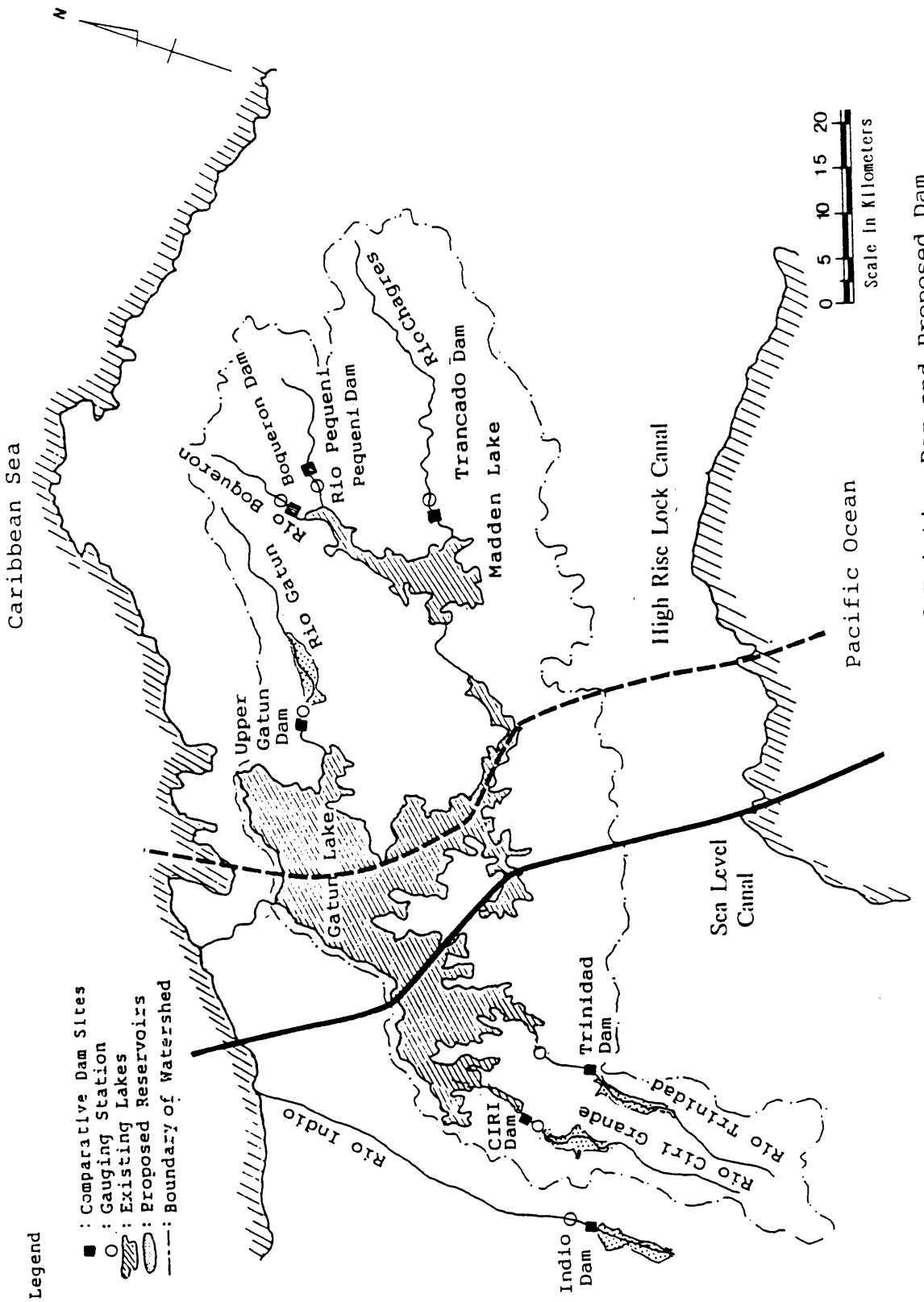


Fig. III.1.7-1 Location Map of Existing Dam and Proposed Dam

7.2.4 Evaluation of the Development Potential

Analyses of the dam site possibilities has been carried out for the seven river sites mentioned above.

Fig. III.1.7-2 shows the relation between dam height (H) and effective storage capacities per unit dam embankment volume (Ratio R) for each dam site.

The Figure shows Ciri, Trinidad, upper Gatun and Indio river dam sites are favorable dam construction sites.

The following procedures and methodology are then applied to determine reservoir water surface levels and dam crest elevations.

- Water Demand (less than Annual Water Production)
  ↓
- Net Storage Capacity
  ↓ ← Sediment
- Gross Storage Capacity
  ↓ ← * H-V (Height-Volume) Curve
- Normal Water Level (NWL)
  ← Spillway overflow depth
  ↓ (ungated spillway)
- High Water Level (NWL)
  ↓ ← Freeboard
- Dam Crest Elevation

The selection of optimum dams are to be confirmed in the future, studying the detail of geological conditions such as the thickness of river deposits and weathered rock foundation, the strength and permeability of the bedrock and the distribution of construction materials.

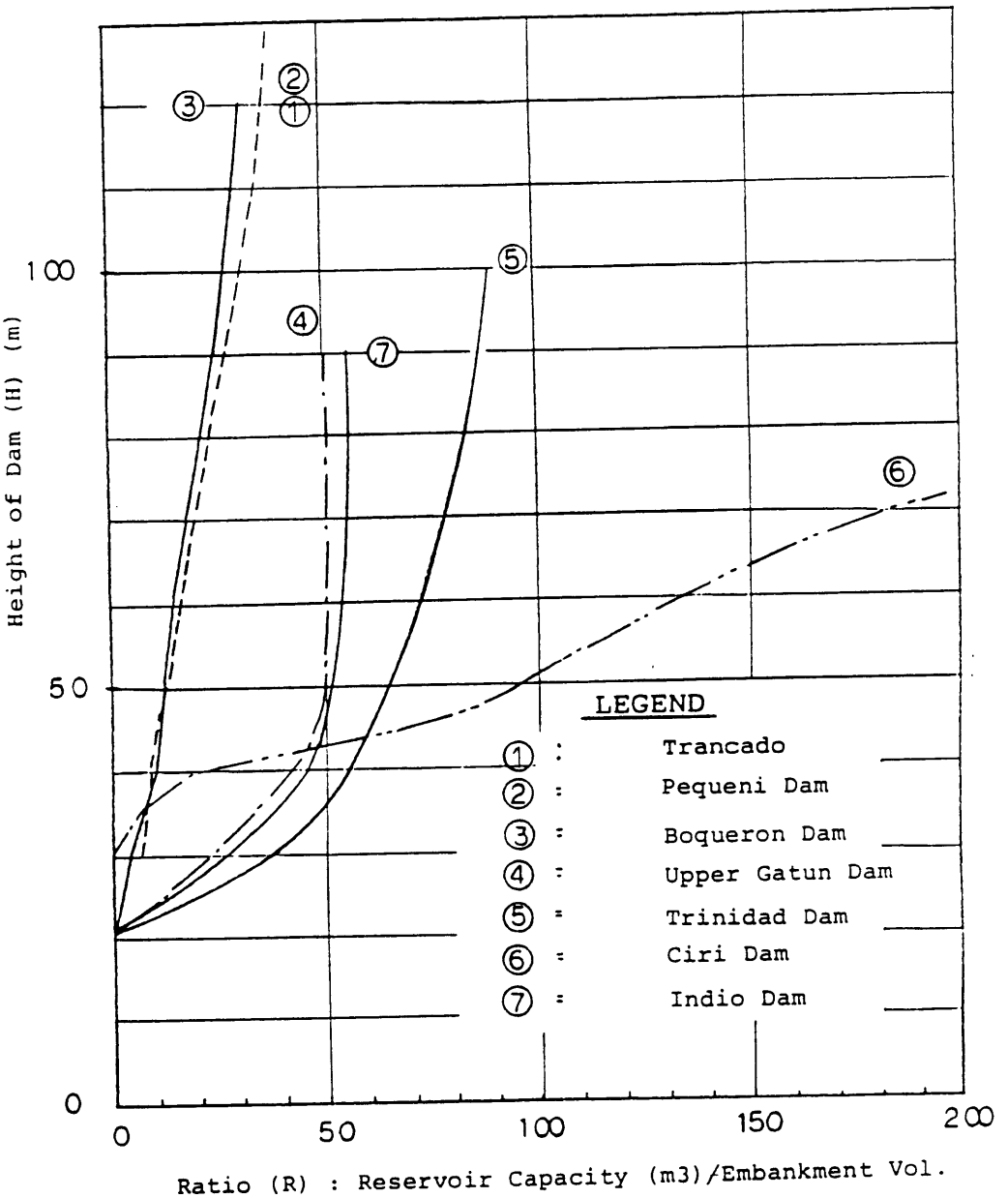


Fig. III.1.7-2 Relation between Dam Height (H) and Effective Storage Ratio(R)per unit Dam Embankment Volume

7.2.5 Required Dam Capacities

Results of water management plan described in III.1 Chapter 2 are summarized with proposed dams in Table III.1.7-2.

Table III.1.7-2 Required Water Volume and Dam

Ship Size (DWT)	Water Volume Required (Mill M3)	Proposed Dam	Description
200,000	396	Trinidad	as regulating dam
	591	Indio (H)	as new water source
150,000	102	Ciri	as regulating dam
	461	Indio (L)	as new water source
Sea Level	285	Upper Gatun	as regulating dam

7.2.6 Pore Pressure and Seismic Loading

To decide the side slopes of a dam, pore pressures and seismic loadings are considered as shown in Table III.1.7-3.

Table III.1.7-3 Design Conditions

Case	Pore Pressure	Seismic Load
N.W.L	Steady seapage	0.1
H.W.L	ditto	0.05
Rapid drawdown	Seapage Pressure in core at N.W.L	0.05
End of Construction	Hypothetical instantanous construction	0.1

7.3 Dam and Incidental Structures

7.3.1 Main Features of Dam and Reservoir

Dams proposed to the study alternatives are listed in Table III.1.7-2 and these dams are designed in detail. The design results of these dams are summarized in Table III.1.7-4.

Table III.1.7-4 Main Features of Dams and Reservoirs

(Dam)	(200,000 DWT)		(150,000 DWT)		(Sea Level)
Item	Trinidad	Indio (H)	Ciri	Indio (L)	Upper Gatun
Type	Earth and rockfill				
Crest EL (m)	145	95	125	85	120
Foundation EL (m)	65	5	65	5	25
Height (m)	80	90	60	80	95
Crest length (m)	800	1,630	190	1,560	830
Crest width (m)	15	15	15	15	15
Core volume (mill m3)	0.9	2.0	0.23	1.5	0.9
Fitter volume (mill m3)	0.8	1.7	0.21	1.3	0.8
Rockfill volume (mill m3)	4.4	10.0	0.96	7.0	4.5
Total	6.1	13.7	1.40	9.8	6.2

(Reservoir)

Catchment area (km3)	248	323	190	323	125
Capacity total (mill m3)	485	730	130	770	350
Effective volume (mill m3)	475	710	120	550	340
Sediment volume (mill m3)	10	20	10	20	10
Reservoir surface (km2)	17	22	13	19	11
L.W.L (m)	90	40	100	40	50
N.W.L (m)	140	90	120	80	115
H.W.L (m)	142.5	92.5	122.5	82.5	117.5

Note: L.W.L - Low Water Level
N.W.L - Normal Water Level
H.W.L - High Water Level

7.3.2 Type of Dam

The standard dam section is shown in Fig. III.1.7-3. All dams are earth and rockfill type dam consisting of three zones, ie, a core, filter layers and rockfill layers. Drawings for Trinidad, Indio, Ciri and upper Gatun dam are shown in Fig. III.1.7-4(1)-(4).

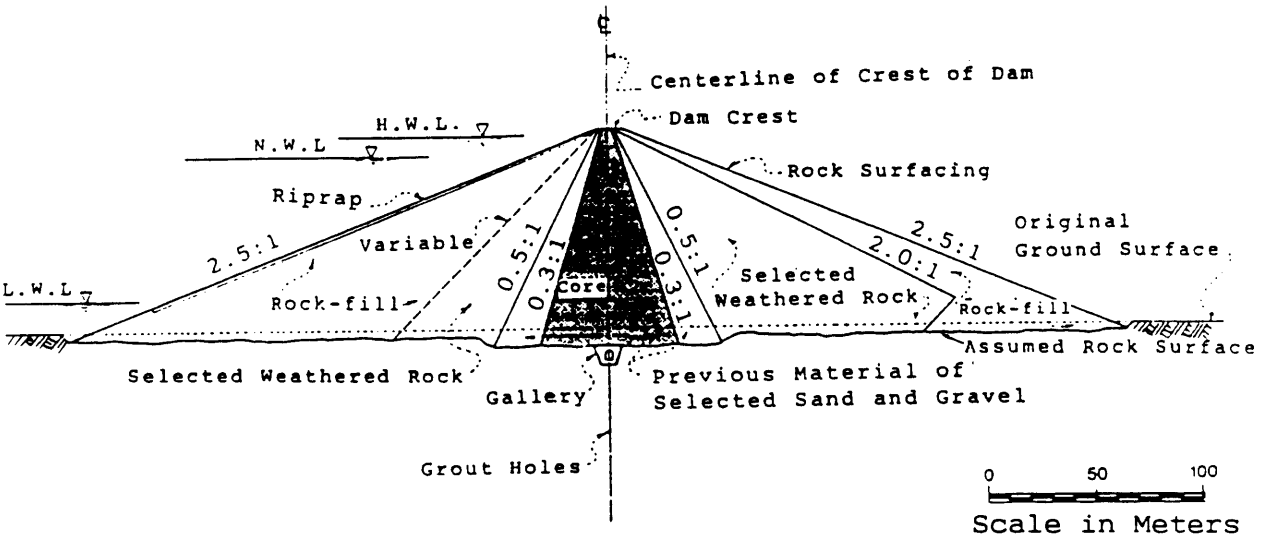


Fig. III.1.7-3 Standard Section of Dam

7.3.3 Spillway and Outlet

Main features of spillways and outlets are shown in Table III.1.7-5. Spillway control structures are designed for the design flood discharge with the reservoir at high water level.

Outlet control structures are considered for the capacity of annual mean discharge with the reservoir at low water level.

Table III.1.7-5 Main Features of Spillway and Outlet

(Spillway)

Item	Trinidad	Indio (H)	Ciri	Indio (L)	Upper Gatun
Type		Ungated			
Design discharge (m3/s)	470	920	540	920	360
Crest EL (m)	140	90	120	80	115
Crest length (m)	60	120	70	120	50

(Outlet)

Type	Intake: shaft, submerged upstream intake Discharge control: valve				
Design discharge (m3/s)	7	20	11	20	7
Valve ϕ(m)	0.70	1.30	0.90	1.30	0.80

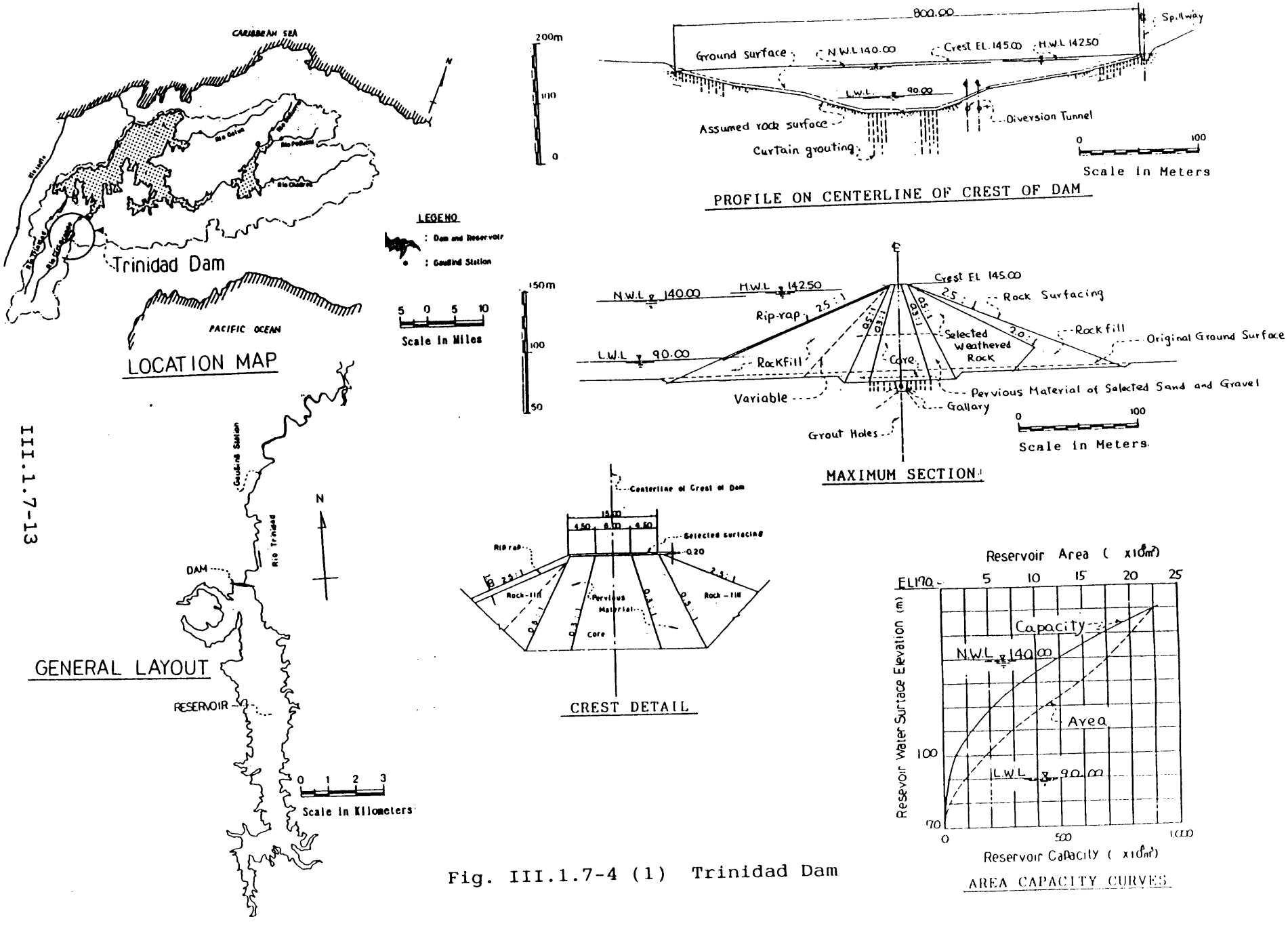


Fig. III.1.7-4 (1) Trinidad Dam

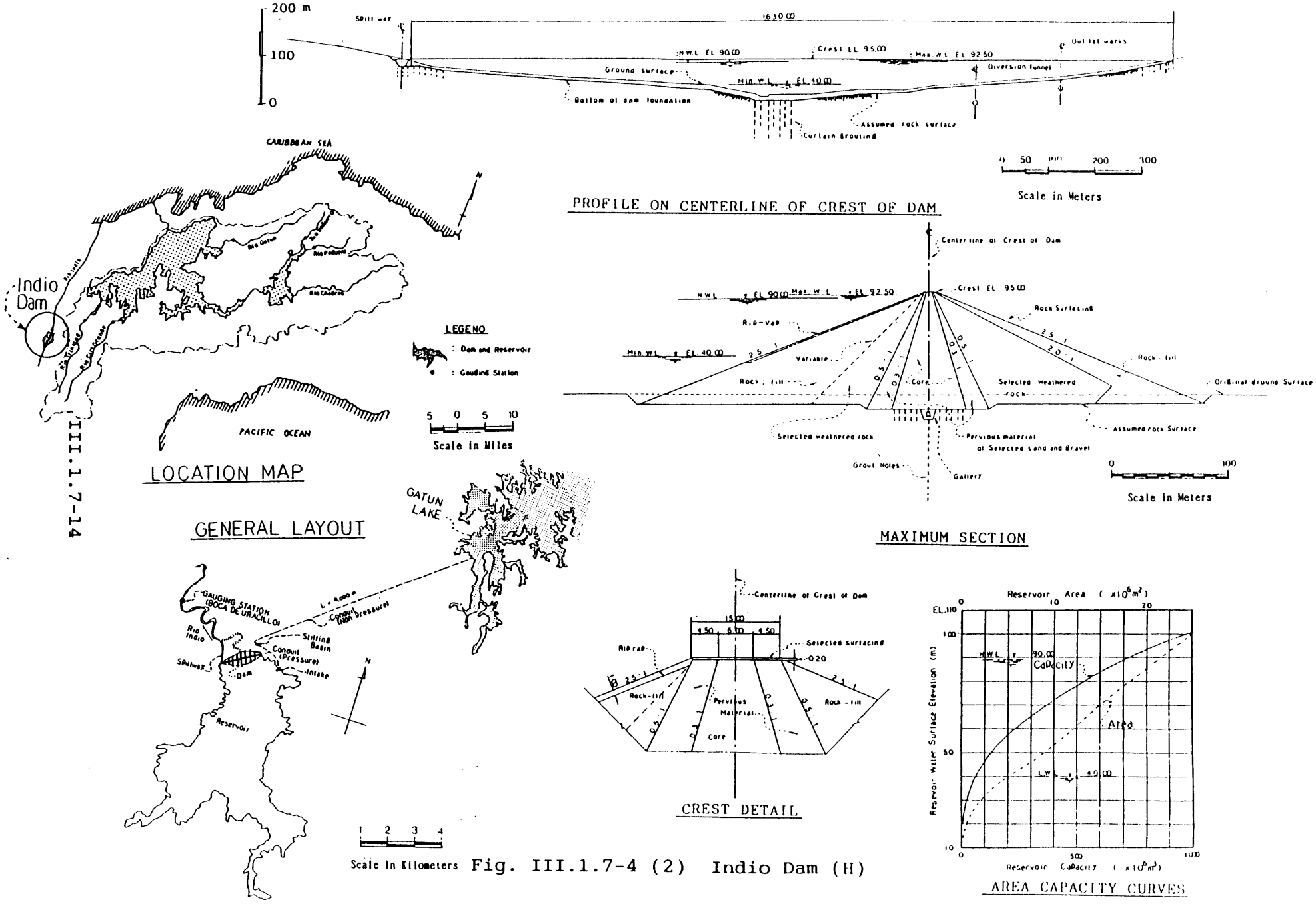
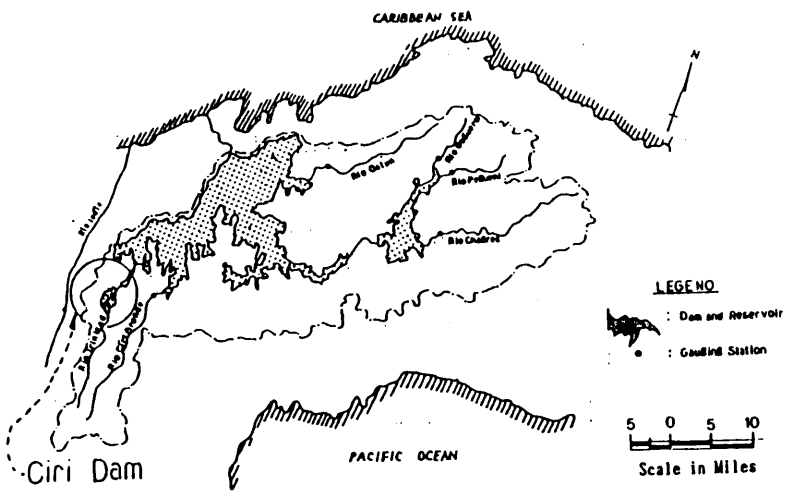
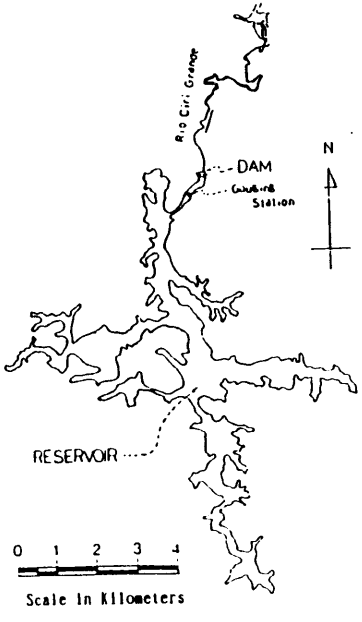


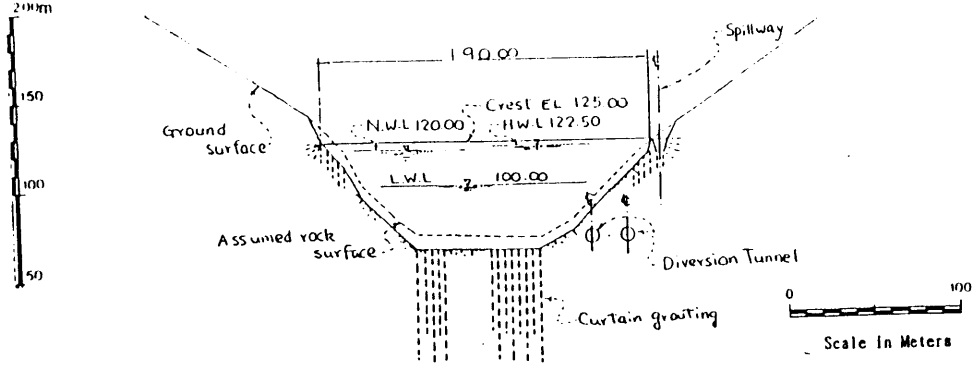
Fig. III.1.7-4 (2) Indio Dam (H)



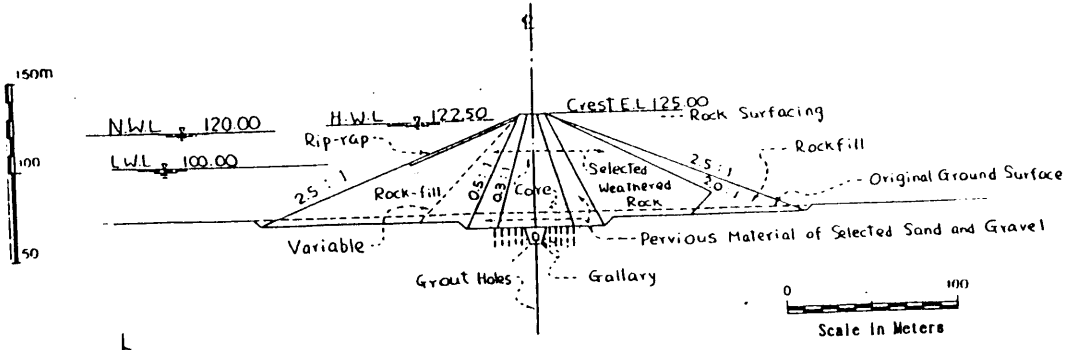
LOCATION MAP



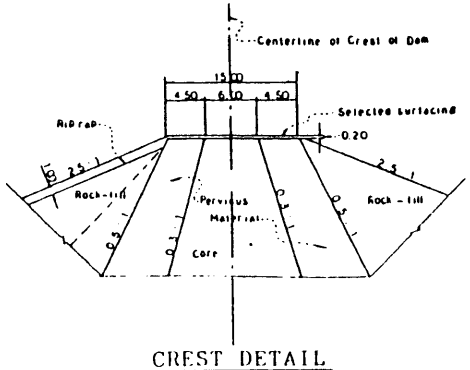
GENERAL LAYOUT



PROFILE ON CENTERLINE OF CREST OF DAM



MAXIMUM SECTION



CREST DETAIL

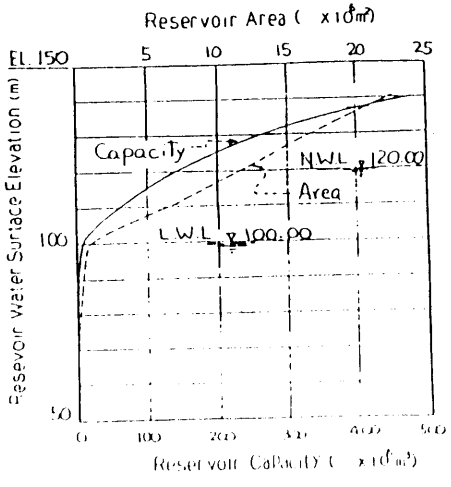


Fig. III.1.7-4 (3) Ciri Dam

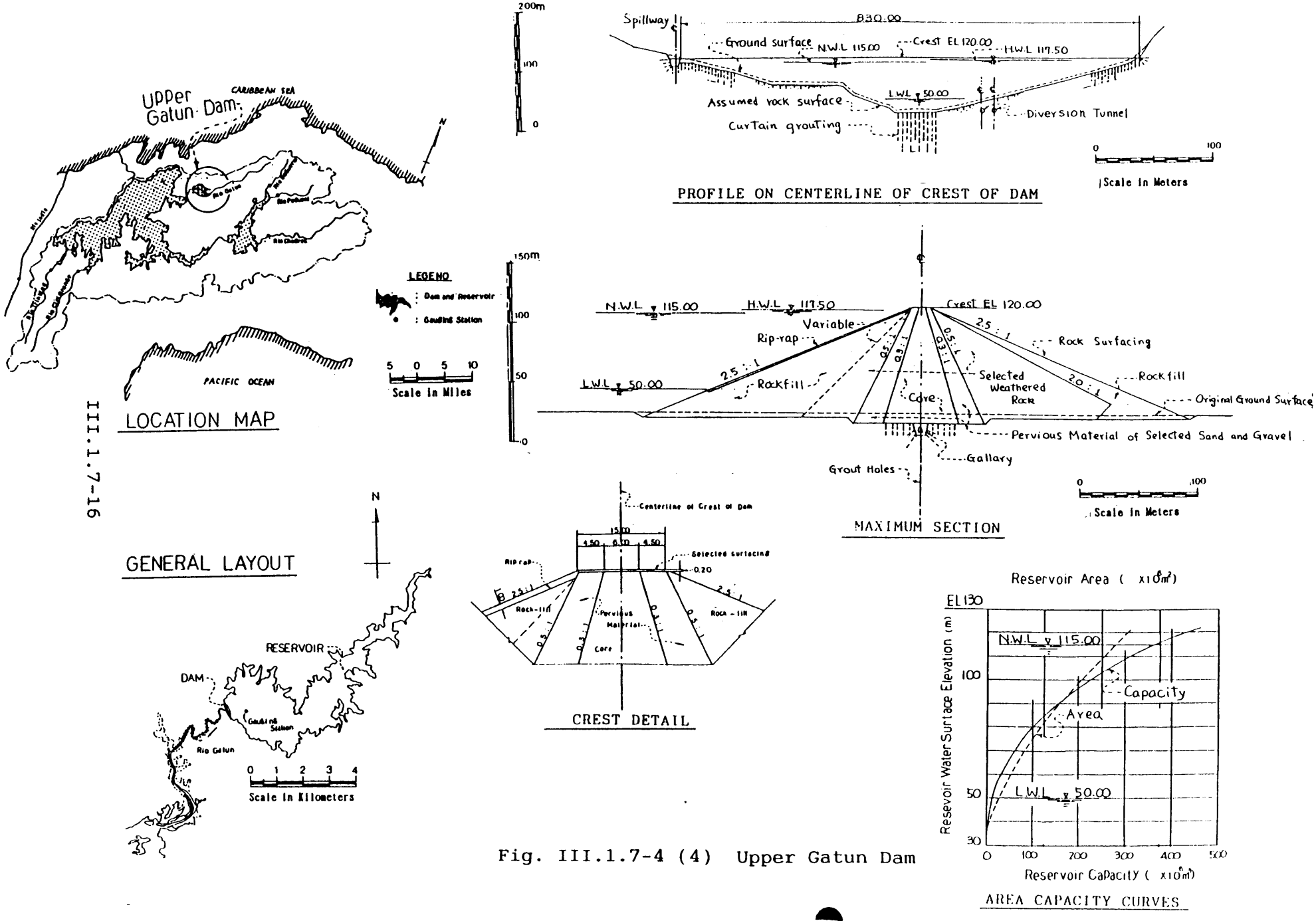


Fig. III.1.7-4 (4) Upper Gatun Dam

III.1 CHAPTER 8 - INCIDENTAL FACILITIES

8.1 Anchorage Area

8.1.1 Introduction

Vessels wanting to use the new canal may have to temporarily anchor offshore while awaiting permission to proceed to the new canal. The assumed anchorage area for this purpose is at the ocean end of the approach channel as in the case of the present canal. No dredging work is required as the designated anchorage area has a sufficient depth. Mooring facilities are also unnecessary as the vessels will use their own anchors.

8.1.2 Numbers of Vessels Anchoring

Prediction by the OCCE sub-contractor of queue lengths to be expected at the Atlantic and Pacific entrances have been provided by the Secretariat. These figures formed part of the OCCE Phase 1 study report. They have been used to determine the area of anchorage requirement but certain features of the later OCCE Phase 2 Interim report diverge widely from experience reported from the only canal now providing passage for very large tankers and bulk carriers. In particular the quoted stopping distances without tug assistance are less than those observed in full scale trials with the assistance of two stern tugs. Separation distances given in the OCCE report are, for the larger ships, less than 30% of those required in the Suez Canal. Amendment of the assumptions of the OCCE report will affect canal capacity and mooring requirements.

Maximum queue lengths at the locks, taken from OCCE Phase 1 Report are listed in Table III.1.8-1. Average queue lengths are given in brackets:

Table III.1.8-1 Queues at Locks

Year	2020		2060	
Direction/Location	South	North	South	North
Gatun (existing)	16 (1.0)	14 (0.9)	25 (2.9)	20 (2.6)
Gatun (new)	4 (0.1)	2 (0)	15 (1.5)	8 (0.8)
Pedro Miguel	5 (0.1)	6 (0.1)	7 (0.3)	6 (0.2)
Miraflores (existing)	8 (0.3)	9 (0.3)	12 (0.6)	14 (0.6)
Miraflores (new)	3 (0.1)	3 (0)	6 (0.6)	6 (0.4)

Although predicted maximum queue lengths at the canal entrances are large, the time each ship occupies an anchorage is, on average, 11 hours (OCCE Phase 2, Interim Report Tables 2.3 and 2.4). If a peaking factor of 30% is allowed for irregular arrivals the numbers of anchorages in the Atlantic and Pacific become 12 and 7 respectively for 2020 and 24 and 11 in 2060.

Within the canal either anchoring in the lake sections, at the emergency tie-up stations, or near to the locks is possible. At the approach to each lock, two moorings will be provided. No details of waiting periods at the locks are given in the OCCE report and, in practice, it is likely that mooring will be avoided wherever possible because of the associated delays. The recommended numbers of anchorages and moorings are listed in Table III.1.8-2.

Table III.1.8-2 Numbers of Anchorages and Moorings

Location/Year	2020	2060
Atlantic Anchorages	12	24
Gatun lake	2*	2*
Pedro Miguel (North)	2*	2*
Pedro Miguel (South)	2*	2*
Miraflores (North)	2*	2*
New Miraflores (North)	2*	2*
Pacific Anchorages	7	11

* Used also for emergency mooring at locks

8.1.3 Fleet Grouping for Anchorages

The approximate proportions of the three mooring groups described in II.1 chapter 1.7 have been estimated from the predicated fleet given in the CTP Study Phase 1 report as amended by TAMS (in their facsimile to M.S. Bronzini on 20th November, 1992), as follows:

Table III.1.8-3 Fleet Grouping for Anchorage

Group/Year	2020		2060	
	Colon	Balboa	Colon	Balboa
A (<40,000 DWT)	74%	80%	74%	79%
B (<100,000 DWT)	21%	19%	22%	20%
C (>100,000 DWT)	5%	1%	4%	1%

Table III.1.8-4 Numbers of Anchorages

Group/Year	2020		2060	
	Colon	Balboa	Colon	Balboa
A (<40,000 DWT)	9	6	18	9
B (<100,000 DWT)	2	-	5	1
C (>100,000 DWT)	1	1	1	1

8.1.4 Atlantic Anchorage

At least fifteen Group A vessels can anchor in designated areas within the harbour. Some of these anchorages will be required for non-canal traffic but the size of that traffic is not known. Six locations are tentatively allocated to this traffic leaving nine for vessels waiting to transit the canal. In practice more ships than fifteen will be able to anchor within the harbour as the moorings shown on Fig. III.1.8-1 are for the largest vessels which could anchor in the available depths of water.

The sea anchorage now designated is approximately 4500m wide and extends 3600m seawards. An expansion anchorage extends a further 1700m seawards. The area of the main anchorage beyond the 21m contour is about 875 ha with a further 765 ha in the expansion anchorage. These anchorages extend into deeper water (44m) than is needed for safe anchorage, even of the largest ships envisaged. As numbers of ship anchoring at sea increase it might be found more convenient to re-orient the anchorage to be parallel to the sea bed contours as shown in Fig. III.1.8-2.

In 2020, all Group A vessels should be able to anchor in the harbour. The number of larger vessels is predicted to be small (3 No) requiring about 175 ha each. The existing anchorage will accommodate these without difficulty.

By 2060, the numbers of Group A vessels will have increased to 18, of which 9, together with 6 larger ships, will need to anchor outside the breakwater. The area required for 15 ships will be about 1583 ha, which can be accommodated within the total are now designated. With that number of ships regularly anchoring offshore, the re-orientation of the anchorage shown on Fig. III.1.8-2 could become more attractive. The new area shown contains about 2000 ha.

8.1.5 Pacific Anchorage

The existing canal anchorage is an area of 1950 ha south east of Flamenco Island and to the east of the dredged channel leading to the canal. Depths vary from 13 to 22m so that only ships of Group C would be excluded. Depths sufficient for Group C are not to be found closer than 7.5 km (4nm) from the whistle buoy at the entrance to the dredged channel. For operational efficiency, an area immediately adjacent to the dredged channel and south of the existing anchorage should be deepened to a minimum of 26.5m.

In 2020 the predicted requirements are for 6 Group A and 1 Group C anchorages. These would require areas of 520 and 190 ha respectively. All Group A could anchor in the existing designated anchorage and the anchorage for the largest vessels should be sited alongside the channel, its north west boundary about 600m from the present whistle buoy position. (Fig. III.1.8-3).

No extension of anchorage areas will be necessary beyond 2020 as the increased number of ships are all in Groups A and B which can anchor within the existing area. The total area required by Groups A and B by 2060 is estimated to be 780 ha which is less than half the available area.

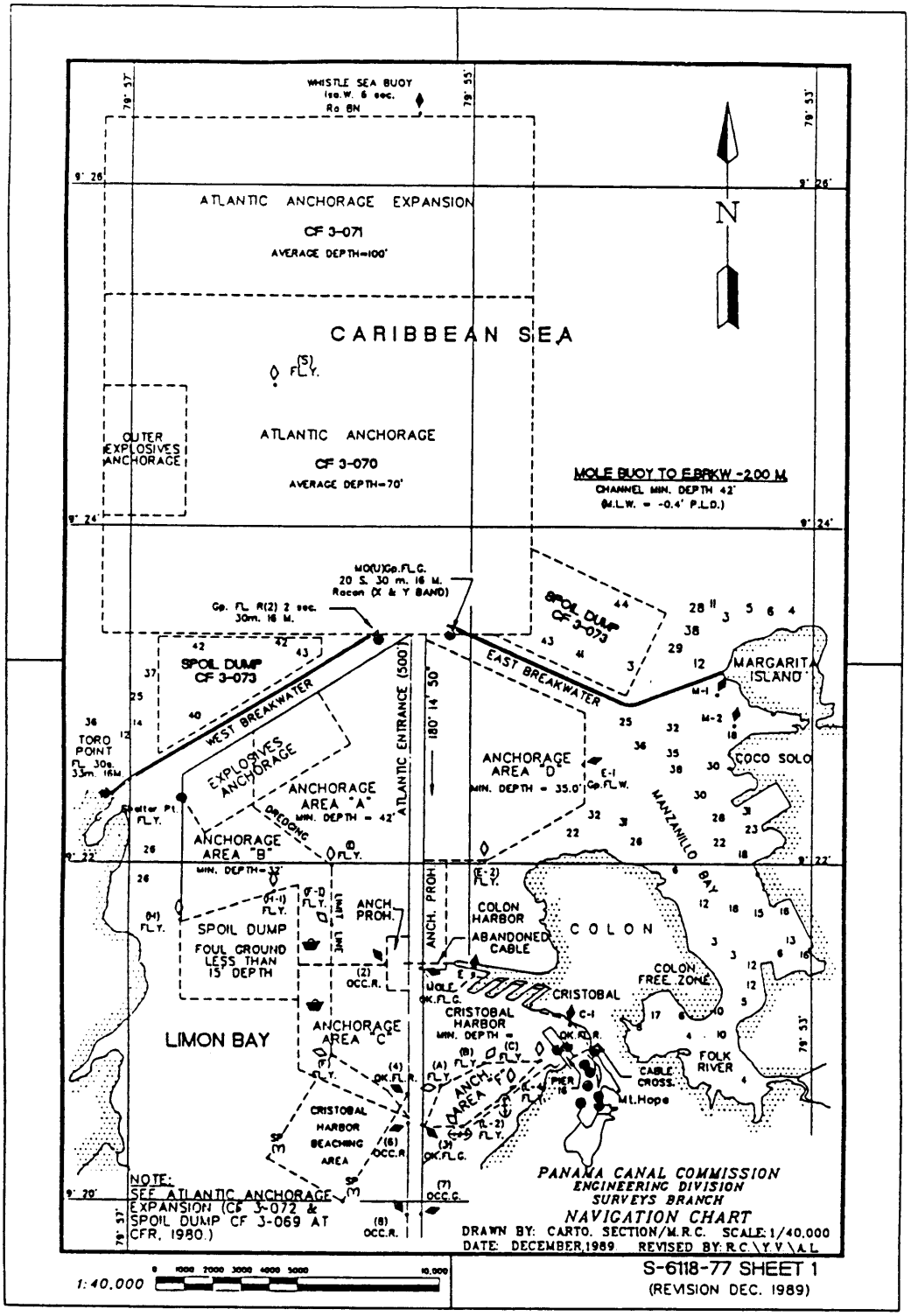


Fig. III.1.8-1 Limon Anchorage

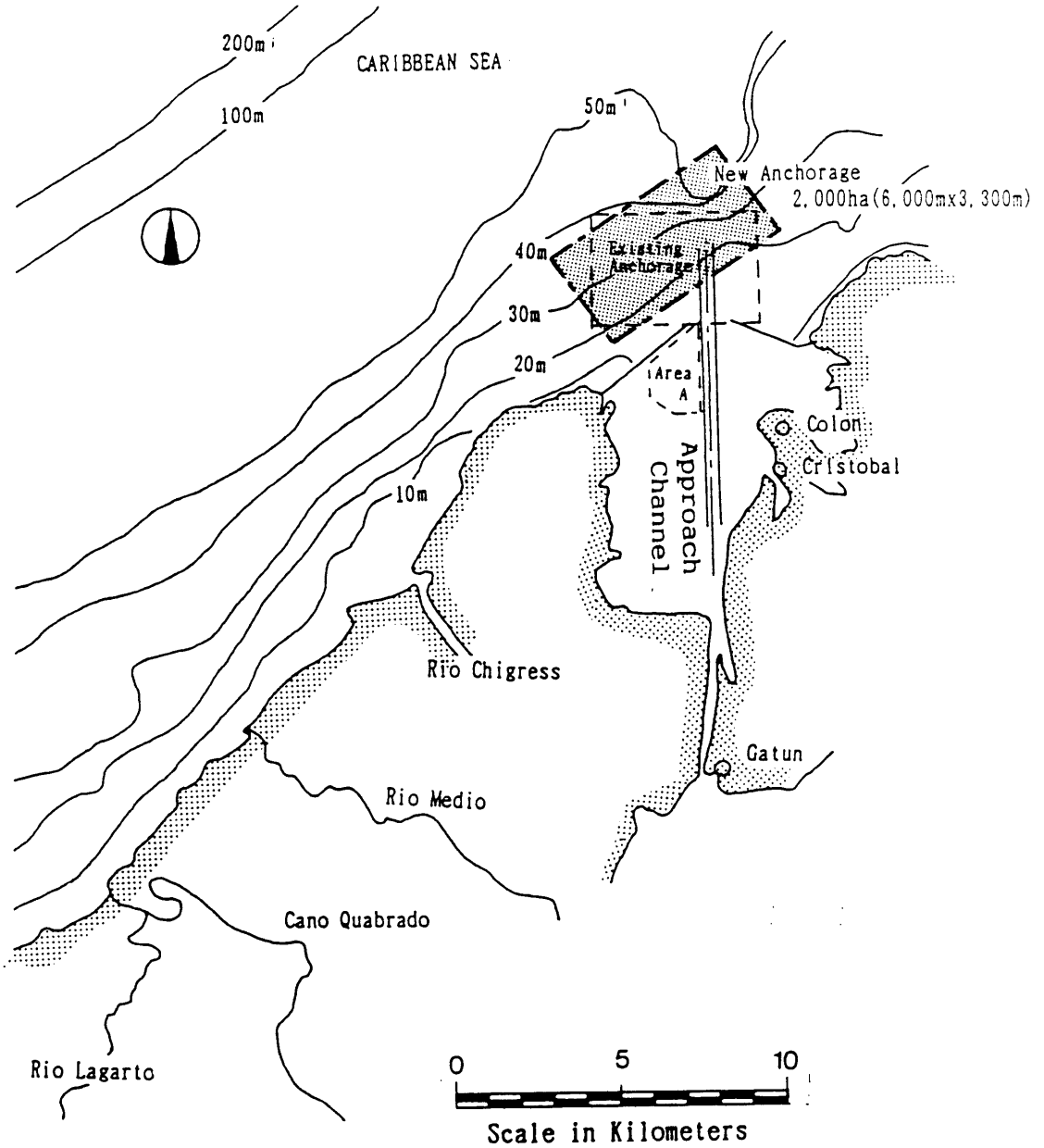


Fig. III.1.8-2 Northern Anchorage

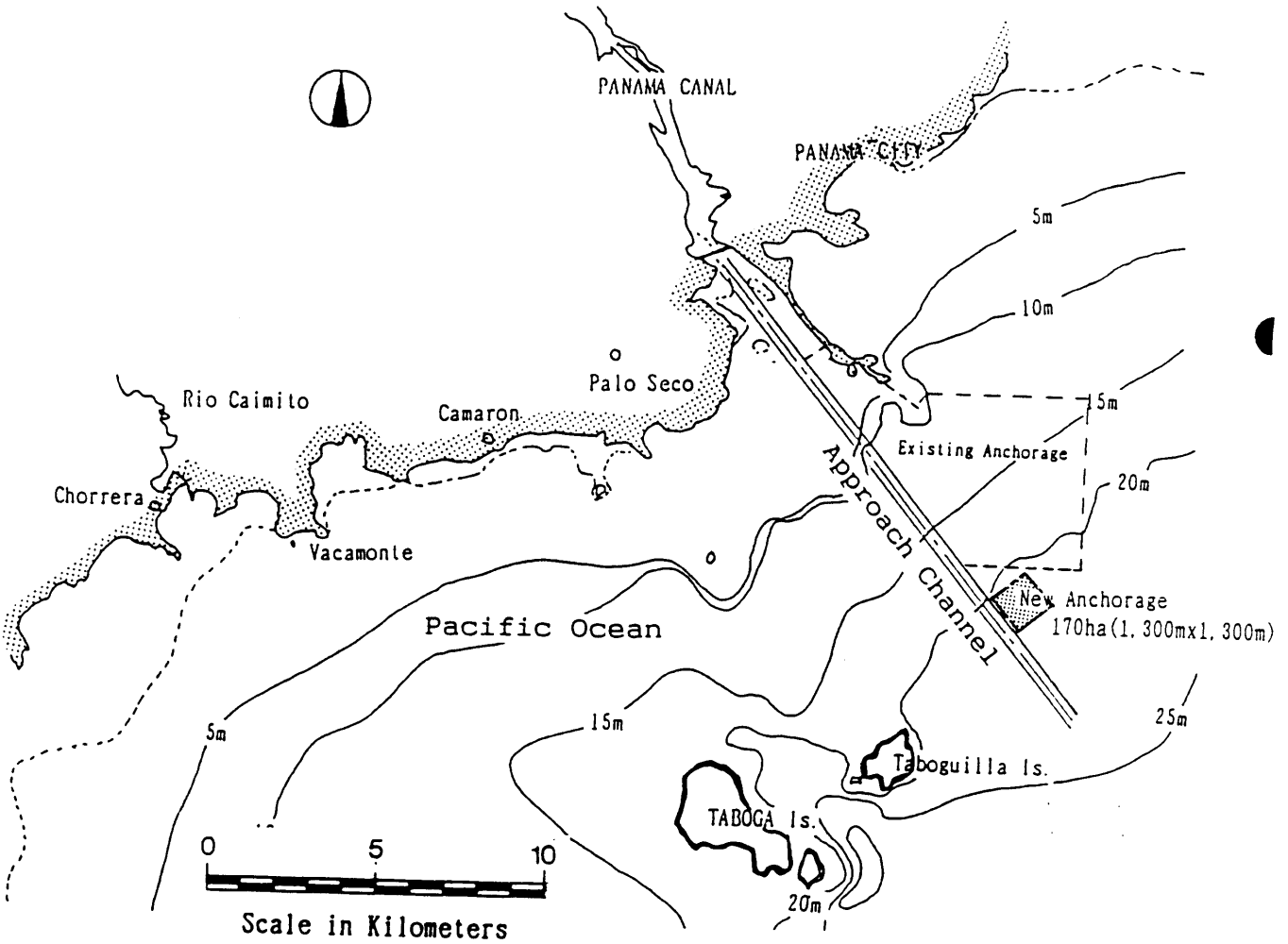


Fig. III.1.8-3 Balboa Anchorage

8.1.6 Emergency Tie-Up Stations

Two tie-up stations will be introduced at Gatun Lake and near New Miraflores lock for disabled ships. The layout would be as described in II.1 Chapter 1.7.2. The mooring facilities adjacent to the locks (see 8.1.2) could also be used as emergency tie-up stations, although this would create some disruption to passing ships.

8.2 Breakwaters

8.2.1 General

The existing breakwaters on the Atlantic side can be used by the New High Rise Lock Canal. On the Pacific side, the three islands of Naos, Perico and Falmenco are connected by a road, forming a natural breakwater. There is no other man-made breakwater. It is judged that no new breakwater is necessary for the new canal.

8.2.2 Opening Width of Breakwaters

Present opening width of breakwaters on the Atlantic side is approximately 500 meters.

Considering the approach channel width of 320 m (150,000 DWT case) and 350 m (200,000 DWT case), any widening works for the present opening of breakwaters will be unnecessary.

If enlargement of the approach channel beyond the planned 7B (B: Beam of the largest vessel) is required in the future detail design stage it should be noted that the present opening in the breakwaters should also be widened. In such a case adverse effects on waves and currents inside the breakwaters should be checked carefully.

8.3 Berthing Facilities for Small Boats

Jetties will be required to provide berthing facilities for tug boats, launch boats and barges. 12 tug boats will be required to tug vessels between the Pacific lock and Gatun Lake and an additional 8 tug boats will be required to assist the navigation of vessels through the Atlantic lock. Including 3 reserve boats, a total of 23 tug boats will be required. The ship sizes and berth dimensions are shown in Table III.1.8-5 and III.1.8-6 respectively.

Table III.1.8-5 Size of Small Boats

Kind of Ships	Tonnage	Overall Length (m)	Moulded Breadth (m)	Fill Load Draft (m)
Tugboat	100 G.T.	26.1	7.6	2.5
	200 G.T.	33.5	9.0	3.1
	300 G.T.	38.7	10.0	3.5
Barge	200 D.W.T	34.5	8.6	2.7
	300 D.W.T	38.2	9.4	3.0
	500 D.W.T	47.1	10.2	3.6

(Technical Standards for Port and Harbour Facilities in Japan, 1991, The Overseas Coastal Area Development Institute of Japan)

Table III.1.8-6 Dimension of Berth for Small Boats

Kind of Ships	Tonnage	Length of Berth (m)	Water Depth of Breadth (m)
Tugboat	100 G.T.	35	3.0
	200 G.T.	45	3.5
	300 G.T.	50	4.0
Barge	200 D.W.T	45	3.0
	300 D.W.T	50	3.5
	500 D.W.T	60	4.0

(Technical Standards for Port and Harbour Facilities in Japan, 1991, The Overseas Coastal Area Development Institute of Japan)

A total of 5 jetties will be constructed and each jetty will be 50m in length and 10m wide with a pile foundation and concrete slabs.

The standard jetty dimensions are shown in Fig. III.1.8-4 while the jetty locations are shown in Fig. III.1.8-5. The required number of small boats and berthing facilities are listed in Table III.1.8-7.

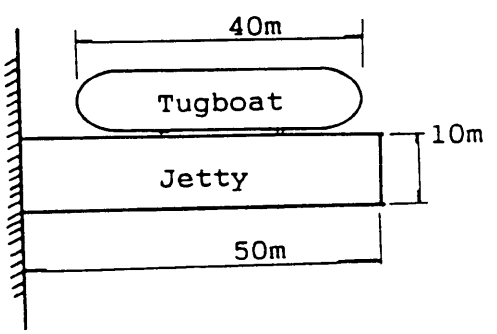


Fig. III.1.8-4 Plan of Jetty for Small Boats

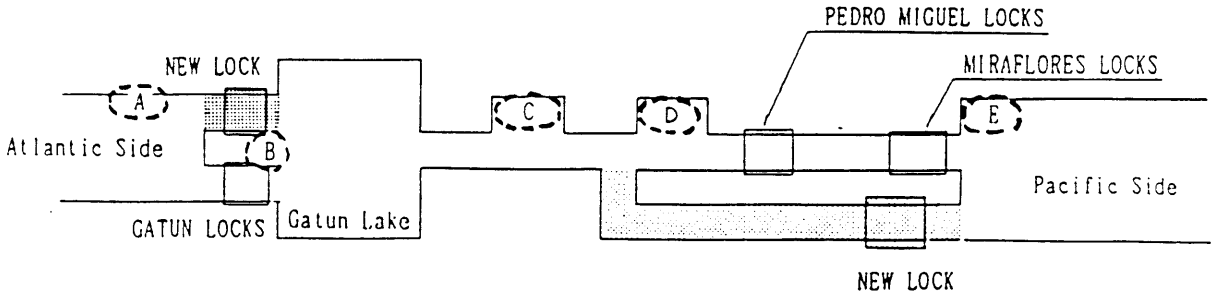


Fig. III.1.8-5 Areas of Port Facilities for Small Boats

Table III.1.8-7 Number of Small Boats and Jetties

	A (Colon)	B (Gatun)	C (Gamboa)	D (Pedro Miguel)	E (Diablo)
Tugboats	6	6	-	4	7
Launchs					
- Pilots	3	-	-	-	3
- Line handlers	2	2	-	2	2
Barges	-	-	2	-	-
Tugboats for Barges	-	-	2	-	-
Jetties	2	2	1	1	2

III.1 CHAPTER 9 - TRANSPORTATION PLAN

9.1 Introduction

This Chapter identifies the improvements and modifications to the existing road network which become necessary due to the permanent works associated with the High Rise Lock Canal improvements. Access requirements for operation and maintenance of the canal are also included. The existing road network was described in II.1 Chapter 5.

Temporary access roads or diversions which are required only during construction of the canal and not for the permanent works are considered as temporary works and are described and costed in Sections 2 and 3 of Part III. In some cases, access roads necessary for the construction works can be located and designed to become part of the road network improvements required in any case to provide permanent access to both sides of the canal and/or for operation and maintenance of the canal. This helps to reduce costs and also reduces disturbance to the environment.

Wherever possible, the construction works are phased so that continuous access is maintained to all areas. This would normally be achieved by cutting existing roads only after the alternative access or crossing has been provided. In some cases however temporary traffic diversions or road closures may be necessary for periods during construction.

Since the High Rise Lock Canal closely follows the alignment of the existing canal, access roads generally already exist and the extent of new permanent roads is much less than for the Sea Level Canal. The Boyd Roosevelt highway for example provides convenient access across the isthmus but there are no roads across the isthmus near the Sea Level Canal. Except for the new bridges, relatively minor realignments or modifications to existing roads will be sufficient to ensure that comparable access

is available to the canal and associated facilities.

The allowances for permanent access roads and bridges for the High Rise Lock Canal are described below.

9.2 Permanent Access Roads

The access road proposals aim to provide at least a similar level of service and convenience after implementation of the canal improvements as is now available. In most cases this objective can be achieved and access is in fact enhanced by the additional bridges which have been proposed. However some loss of convenience is inevitable since the canal bridges represent a significant proportion of the overall cost and the number provided is necessarily limited. Where new permanent access roads are proposed, they are shown on Fig. III.1.9-1 and are described below. Roads required only for construction purposes are described in III.2.

The proposals for canal crossings take into consideration site observations, an assessment of the existing road network shown in Fig. II.1.5-3, the extent to which users would be inconvenienced if a canal crossing was not provided, and possible future improvements in the road network. A rigorous analysis based on existing and future traffic volumes was not possible because of the limited traffic data available (refer II.1 Chapter 5.2.2). Traffic data was available for some major roads only and future traffic data was unavailable.

Following discussions with the Secretariat after submission of the Interim Report, it was agreed that four bridges would be provided across the High Rise Lock Canal. The roads and canal crossings are shown on Fig. III.1.9-1 and are described below for each section of the canal.

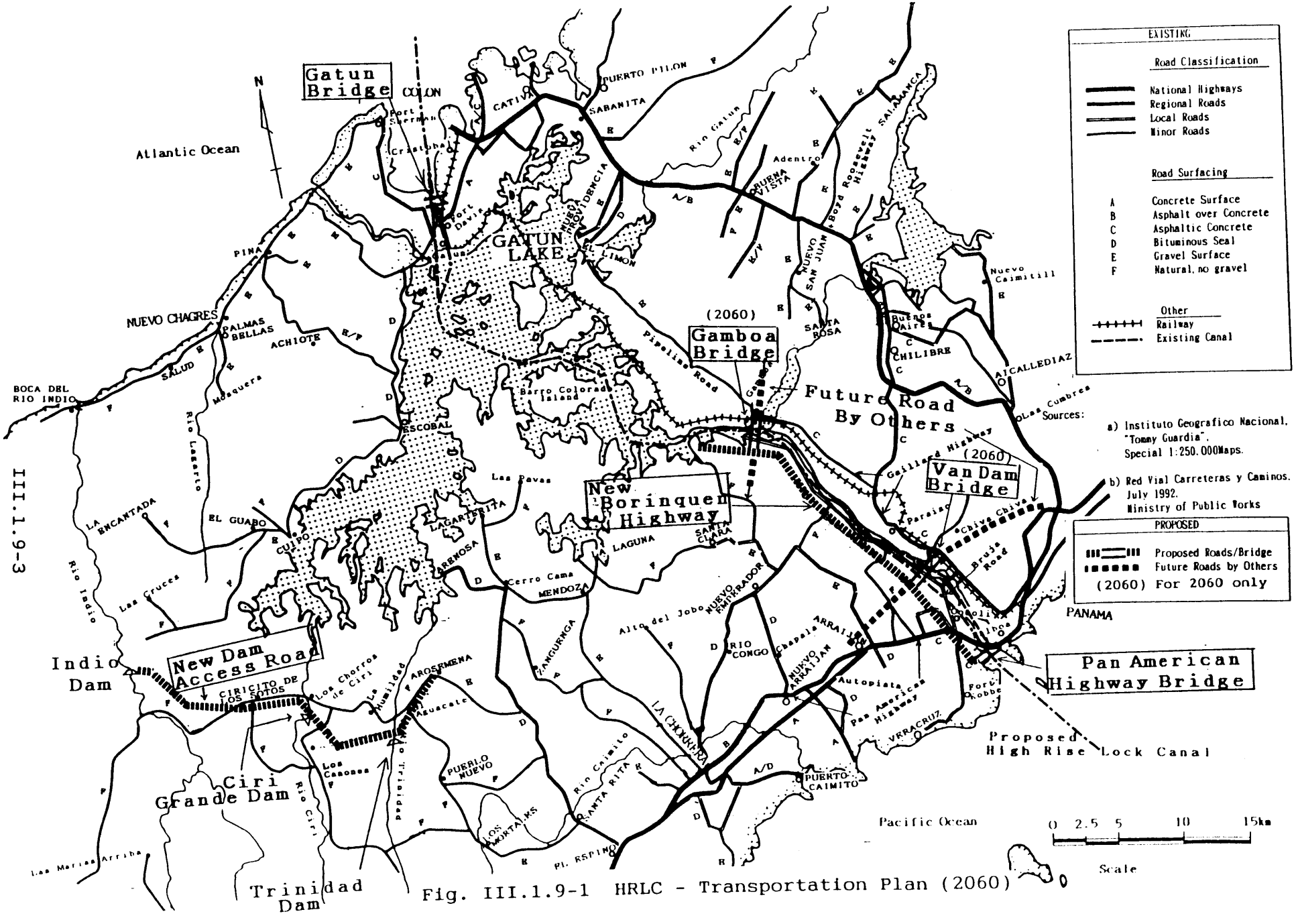


Fig. III.1.9-1 HRLC - Transportation Plan (2060)

(1) Gatun Township Area

Construction of the new Gatun locks and the approach channel from Limon Bay will cut off the existing access road from Colon to Fort Sherman and also the roads to Escobal and Nuevo Chagres on the Atlantic Coast.

Gatun township itself will become isolated in a triangle of land framed by Gatun Lake, the existing locks and the new locks. The adjacent military establishment of Fort William D. Davis will also be adversely affected by the new locks and approach channel, and acquisition of part of the Military Reservation will be necessary.

New roads and a new bridge are proposed for the area and are shown on the attached Fig. III.1.9-2. Access to Fort Sherman, Escobal and Nuevo Chagres will be improved under the proposed arrangements since traffic will no longer be obliged to wait for passing ships at the movable bridge below the existing Gatun Locks. The length of the new road, including the bridge length, is about 3 km. The diversion road would be two-lanes wide and paved, as shown in Fig. III.1.9-3.

Access to the Gatun township is provided by way of the new high level bridge and the existing movable bridge immediately below the existing locks. This system has disadvantages compared to existing access in terms of time taken and distance traveled, and also because of the width (14' max.) and weight (20 tons max.) restrictions on use of the movable bridge. The inconvenience and restrictions could be reduced by provision of a tunnel under the new locks, but the ramps down would be long and difficult to position within the limited space available.

On the eastern side of the new locks, road access to Fort William Davis and Dock 45 on Gatun Lake should be maintained clear of the locks and water recycling

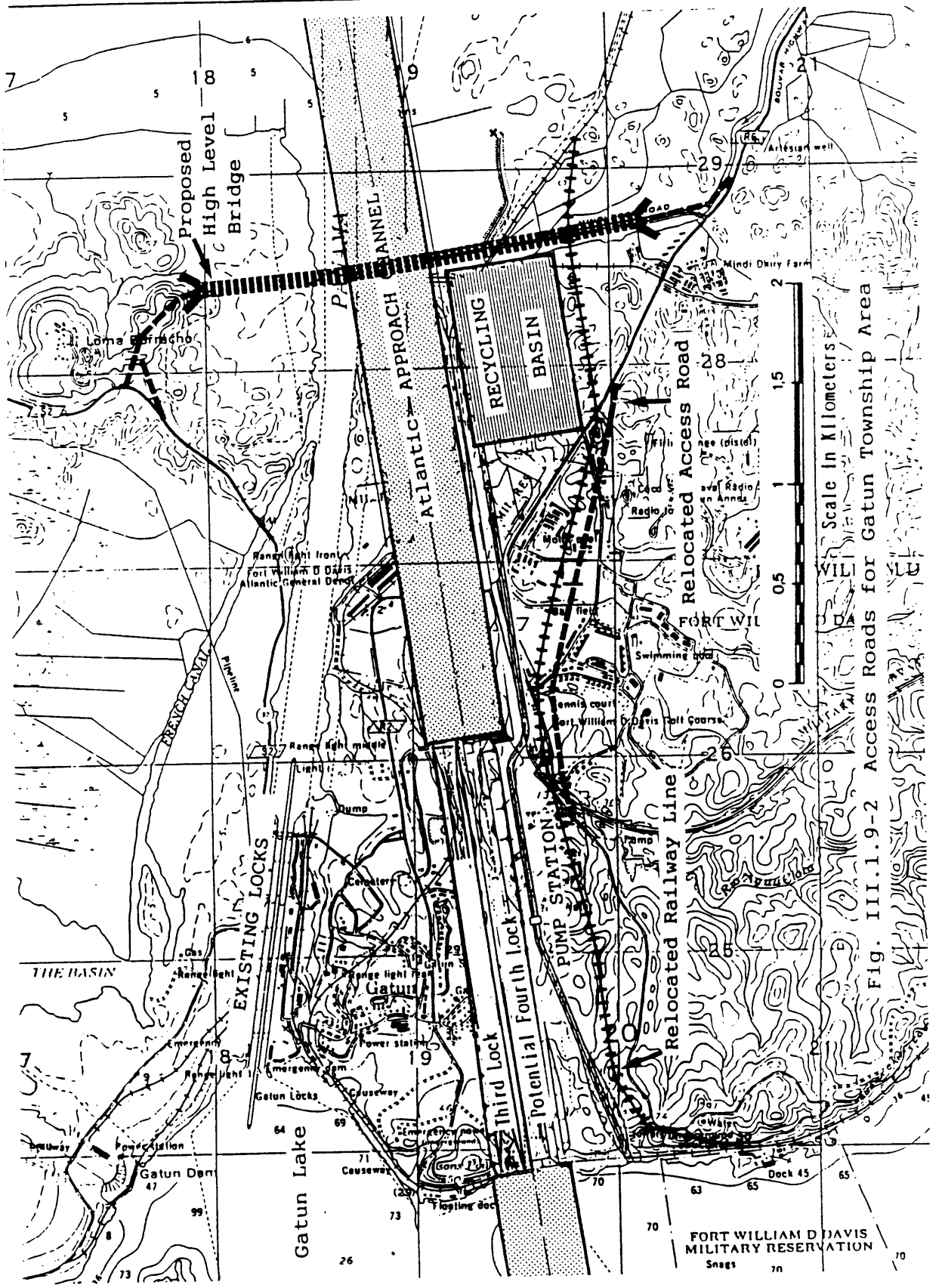


Fig. III.1.9-2 Access Roads for Gatun Township Area

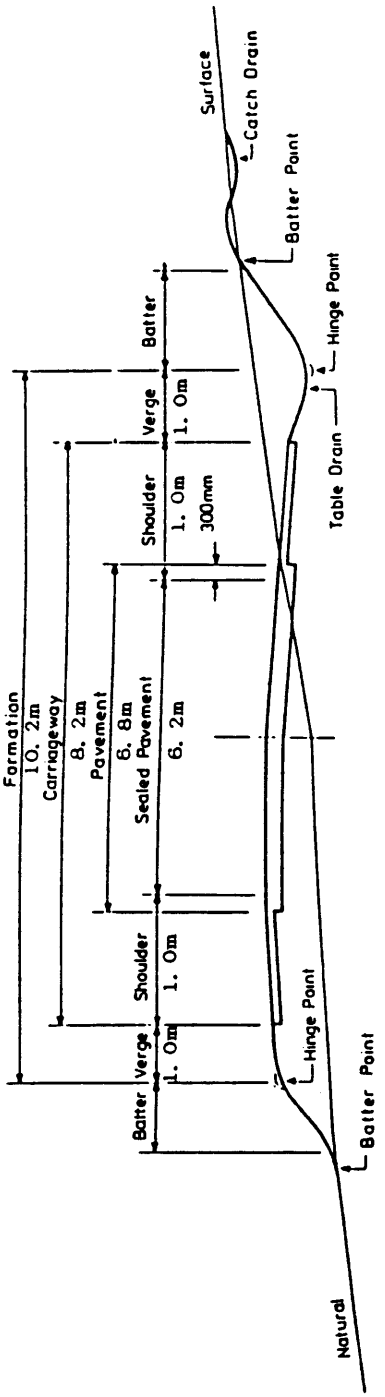


Fig. III.1.9-3 Typical Section for Two-Lane Paved Roads

system, as shown on Fig. III.1.9-2. The length required is about 3 km and the typical cross section would be similar to that shown in Fig. III.1.9-3.

(2) Gatun Lake

Much of the Gatun Lake shoreline in the vicinity of the canal is inaccessible by road and is undisturbed rainforest. Access for operation and maintenance of the existing canal across the lake is mainly from the lake itself and it is proposed that the widened canal be operated and maintained in the same way. Road access for construction is also not necessary since most work involves dredging from the lake.

On the eastern side of the Lake Gatun between Gamboa and Nueva Providencia or El Limon, road access to the eastern shore of the existing lake/canal is not available. This area is rainforest apart from the Panama/Colon railway and the pipeline road which is several kilometers from the lake shore. Road access to the widened canal on this part of the eastern side is not considered necessary either during or after construction and there are no access road proposals in this area. On Bohio Peninsula some land based excavation will be necessary on the outside of the bend. Access to this area by road would be difficult to provide and environmentally undesirable, so the construction planning proposes to transport the necessary excavation and hauling equipment via Lake Gatun.

For environmental reasons, road access to the west side of the canal is also not proposed; access will be from the lake itself as described above.

(3) Gamboa Reach

Existing infrastructure on the northern side of Gamboa Reach is substantial and includes the railway line, Gatun township and PCC canal maintenance center, and road and rail bridges across the en-

trance of the Chagres River. To avoid disturbing this infrastructure the canal widening is proposed on the south side of Gamboa Reach.

Access to Gamboa will be unaffected and no access roadworks are required on this side. Road access to the opposite side of Gamboa Reach is required for construction purposes and will be retained for operation and maintenance on completion. Access will be provided by extending the road from Miraflores on the west/south side of the widened canal. The proposed location and extent of the new road is shown on Fig. III.1.9-1 as the New Borinquen Highway and is further described in (4) below.

As agreed with the CAS Secretariat, an allowance has been included in the cost estimates for an additional high level bridge in the vicinity of Gamboa. This bridge would provide a fourth high level crossing of the canal, supplementing those proposed at Gatun, Miraflores and Panama City. No roadway crossing of the canal mid-way across the isthmus has been shown in any planning studies but the allowance for an additional crossing is prudent considering the life of the canal. Therefore the bridge cost has been included in the estimates for 2060. The cost of the future connecting road would not be affected by the canal width and has not been costed. For the Sea Level Canal alternative, the costs of a mid-isthmus bridge across both the Sea Level Canal and the existing canal will be included for comparative purposes.

(4) Gaillard Cut

All works required for the High Rise Lock Canal are on the south/west side of the existing canal so that disturbance to the existing canal and infrastructure on the north/east side is minimized. The existing Gaillard Highway between Balboa and Gamboa will continue to provide access for operation and maintenance of the improved canal.

On the south/west side of the canal the Borinquen Highway follows the existing canal alignment from Miraflores and extends past the end of the Culebra Cut, to a point just beyond Gamboa. Significant portions of this road will be lost during construction of the canal bypass on the Gatun Lake side of the new Miraflores locks, and by the widening of the existing canal through the Culebra Cut. As proposed in III.2, a construction road for access and hauling of spoil will be required along this section. Since a new permanent road is also necessary, the construction road will be located and designed for conversion to a permanent road for canal operation and maintenance on completion of construction.

The terrain is not difficult over the alignment and a design speed of 80 km/hr can easily be achieved. The proposed route of the New Borinquen Highway is shown on Fig. III.1.9-1 and a typical cross section is shown in Fig. III.1.9-4. The proposed alignment is within about 1 km of the new canal and is about 28 km long.

(5) Miraflores

At present, the autopista extends between La Chorrera and Arraijan only but an extension of the autopista from Arraijan to Panama City north (Van Dam Bypass) may be constructed in the future. The approximate alignment of the Van Dam Bypass was shown for example in the General Map of the Lands and Waters of the Panama Canal Treaty as attached to the 1977 Agreement, and was also shown in the Transport Masterplan produced by JICA in Phase 1 of the Urban Transport Study in Panama Metropolitan Area (ESTAMPA I, 1982).

The alignment crosses the canal at Miraflores Lake, about 500m upstream of the Miraflores Dam. While the cost of the bypass roadway is not considered as part of the canal improvements, the cost of a new bridge at Miraflores will be included in both the

High Rise and Sea Level Canals to ensure that comparisons are equitable. The cost included for this bridge is higher in the case of the High Rise Lock Canal since the bridge must extend over the new locks as well as Miraflores Lake. Because of uncertainty regarding the implementation and timing of construction of the Van Dam bypass the costing assumes that the bridge is only required for the target year 2060.

At Miraflores Locks the existing movable bridge is not open to public use and a similar bridge or tunnel across the new locks has not been proposed. Alternative access to the other side of the new locks will be available via the proposed bridge at Panama City and an additional bridge is not considered necessary.

(6) Panama/Balboa

The Bridge of the Americas has a width of four lanes and a main span of 344m. However, the available clearance envelope with the full 60m vertical clearance is only about 260m, well short of the width necessary for the two way canal for either 150,000 DWT (350m) or 200,000 DWT ships (380m). Therefore replacement of the bridge is necessary for the High Rise Lock Canal alternatives and is included in the cost estimates.

The existing bridge would be required to carry traffic until the replacement is completed, so the new bridge would be built beside the existing one. In addition to the bridge structure length it is estimated that the length of realigned road approaches to the new bridge would be about 2 km.

(7) Access to New Dams

The Upper Gatun Dam is not required for any of the variations of the High Rise Lock Canal, and no allowance has been made for an access road.

Access to dams proposed at Rio Indio, Rio Ciri Grande and Rio Trinidad will be required for some of the High Rise Lock Canal variations and the proposed route is shown on Fig. III.1.9-1. There are no established roads in this area. As proposed in III.2, a construction road for access and hauling of quarry materials will be required along this section. Since a new permanent road is also necessary, the construction road will be located and designed for conversion to a permanent road for dam operation and maintenance on completion of construction. The proposed road is about 27 km long and is located to pass adjacent to the proposed quarry areas. In its permanent form it would be two lanes wide and sealed.

The number of dams varies according to the ship size and the year (2020 or 2060), so construction of the new road is adjusted accordingly.

(8) Access for Operation and Maintenance

The existing road network will in most cases continue to provide adequate access to the widened canal and new locks for operation and maintenance of the High Rise Lock Canal.

The new lock structures at Gatun and Miraflores are accessible from both sides of the canal under the proposed access road arrangements and bridges across the canal will be available in the vicinity. While vehicular crossing facilities are not considered essential at the locks themselves, the additional cost of providing a crossing for use when the gates are closed is relatively small. Therefore an allowance has been included in the cost estimates to allow vehicles to cross over one pair of gates at each new facility. Pedestrian traffic could use the bridge as well, and it would be convenient for operation and maintenance. The crossings would not generally be open for public usage.

As discussed in (3) and (4) above, a new Borinquen Highway will be constructed on the south-west side of the High Rise Lock Canal, and will be available primarily for operation and maintenance of the High Rise Lock Canal.

Proposed access roads to the new dams at Rio Indio, Rio Ciri Grande and Rio Trinidad will provide the necessary access for operating and maintaining the dams and associated spillway structures.

For monitoring and maintenance within the canal excavation a gravel road will be provided on the lower berm in areas where access from existing or proposed roads can be provided. Access to the maintenance road would be provided at regular intervals where the topography is suitable.

(9) Summary of New Roads

The requirements for new permanent access roads are summarized for convenience in Table III.1.9-1 below.

Table III.1.9-1 HRLC - Summary of New Access Roads

Location	No. of Lanes	Typical X-section	Approximate Length	Comments
Gatun				
1. Approaches to new bridge	2	Paved	1 km *	Provides access to west of canal.
2. Access to New Locks & Fort Davis	2	Paved	3 km	Also serves Dock 45 on Gatun Lake.
Gaillard Cut				
3. Borinquen Highway	2	Paved	27 km	Replaces existing Borinquen Highway
Panama				
4. Pan American Highway	4	Undivided, paved	2 km *	Approaches to new bridge.
Access to New Dams				
5. Rio Indio, Ciri Grande, and Trinidad	2	Paved	27 km	No existing roads
Total			60 km	

* Excludes length of bridge structure (Refer Table III.1.9-2).

9.3 Summary of Canal Bridges

9.3.1 Phasing of Bridge Construction

As described above, new bridges across the High Rise Lock Canal are proposed at (1) Gatun, (2) Gamboa, (3) Van Dam Bypass and (4) Pan American Highway.

As agreed with the CAS Secretariat, construction of the above bridges will be phased for the years 2020 and 2060. The proposed phasing and number of lanes to be provided are as follows:

Table III.1.9-2 HRLC - Phasing of Bridge Construction

Location of bridge	Traffic Count over 24 hours	Year 2020	Year 2060
Atlantic	N.A.	1 (2 lane) →	
Gamboa	-	-	1 (2 lane)
Van Dam Bypass	-	-	1 (4 lane)
Pan American	30502 (1992)	1 (4 lane) →	
Total		2 bridges	2 bridges

N.A.: Traffic Counts Not Available
Note: Refer to Table II.1.5-2 for source of traffic data.

9.3.2 Bridge Structures

The bridge crossings must provide a main span clearance envelope about 350-380m wide and 60m high and long approach spans will be necessary to achieve the required vertical clearance above the water level. For the span lengths required, the most economic solution for the main spans is a cable stayed bridge. For the approach spans, steel box girders with 60m spans are proposed. Bridge requirements are summarized in Table III.1.9-3. A typical elevation view is shown in Fig. III.1.9-4 and typical cross sections are shown in Fig. III.1.9-5.

It would be possible for the roads to be taken under rather than over the canal, using sunken tubes or boring machines for example. However, preliminary comparisons indicated that the cable stayed/steel box solution would be more cost effective and involve less risk under the conditions.

Table III.1.9-3 - Summary of Bridges over HRLC

(a) 150,000 DWT

Location of Bridge	Canal Width (m)	Bridge Lanes No	Bridge Width (m)	Main Spans Bridge Length (m) L	L1	L2	L3	Approach Length L4
Atlantic	320	2	10.0	740	410	165	165	1500
Middle (Gamboa)	320	2	10.0	850	470	190	190	600
Van Dam(1)	320	4	20.5	850	470	190	190	490
Van Dam(2)	Exist.	4	20.5	900	500	200	200	430
Pacific	320	4	20.5	810	450	180	180	850

(b) 200,000 DWT

Location of Bridge	Canal Width (m)	Bridge Lanes No	Bridge Width (m)	Main Spans Bridge Length (m) L	L1	L2	L3	Approach Length L4
Atlantic	350	2	10.0	770	430	170	170	1500
Middle (Gamboa)	350	2	10.0	900	500	200	200	600
Van Dam(1)	350	4	20.5	900	500	200	200	490
Van Dam(2)	Exist.	4	20.5	900	500	200	200	430
Pacific	350	4	20.5	860	480	190	190	800

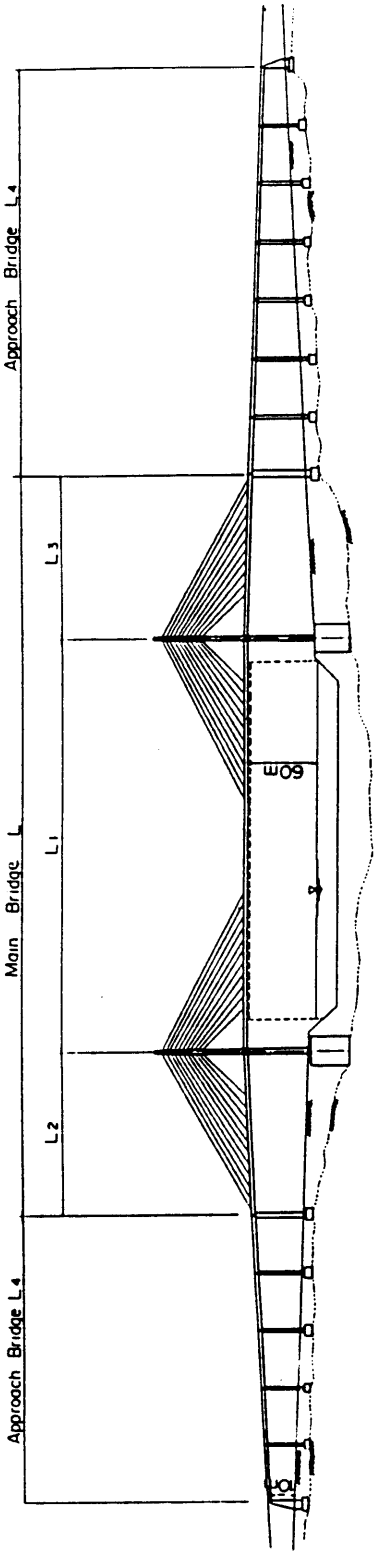
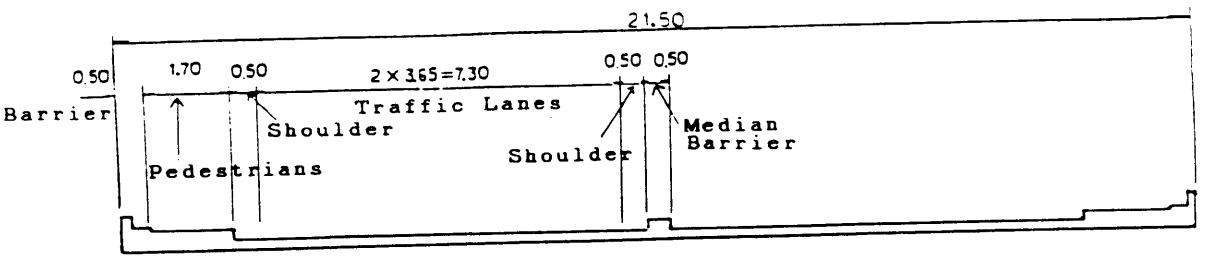
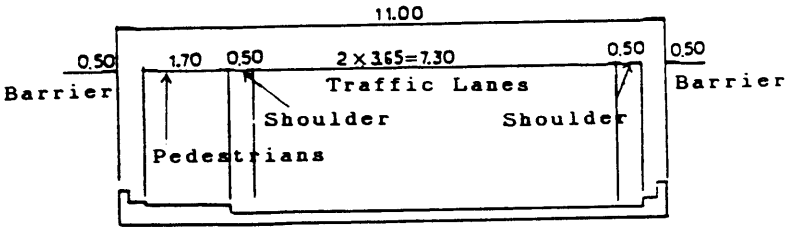


Fig. III.1.9-4 Typical Elevation for Canal Bridges

Note: All Dimensions in Meters



(a) Four-Lane



(b) Two-Lane

Fig. III.1.9-5 Typical Sections for Canal Bridges

9.4 Railways

The railway line between Colon and Panama is cut at Gatun and a diversion is necessary. The proposed diversion follows the adjacent road diversion, as shown in Fig. III.1.9-2. The length of the required diversion is approximately 5.5 km.

9.5 Pedestrian Access

The Terms of Reference require that consideration be given to the provision of pedestrian access. No figures were available for pedestrian volumes using existing roads but site observations suggested that the number of pedestrians using the existing bridge crossings is not large.

The new bridges proposed for the High Rise Lock Canal include provision for pedestrian usage, but the height and length of the bridges would discourage most pedestrians. The walkway shown on the typical bridge sections would be primarily for emergency usage.

At the lock structures it would be relatively simple to provide a pedestrian crossing facility which would be available only when ships were not passing. This facility would be convenient for operation and maintenance personnel and could possibly be made available for public usage. As described in III.1 Chapter 9.2(8), a crossing facility suitable for pedestrians and vehicles would not add significantly to costs and has been allowed for in the cost estimates. One crossing facility over the lower pair of lock gates has been included at the new Gatun and new Miraflores locks.

III.1 CHAPTER 10 - REVIEW OF IMPACTS

10.1 General

The construction works discussed in this study will have significant ecological, socioeconomic and cultural impacts.

In this chapter concerns related to the design and construction schemes are identified and listed without resolution.

10.2 Impact on Existing Canal

The environmentally sensitive areas and Canal routes are shown in Fig. III.1.10-1. The following items have been carefully considered during the planning and costing of construction works.

(1) Dredging works in the Gatun Lake must be executed while maintaining the safety of ships transiting along the existing Gatun Lake route. Therefore, construction methods and schedules have been carefully planned.

(2) Removed of earthwork plugs and flooding on new canal excavation areas will require the existing canal to be shut down for a period of about 30 days.

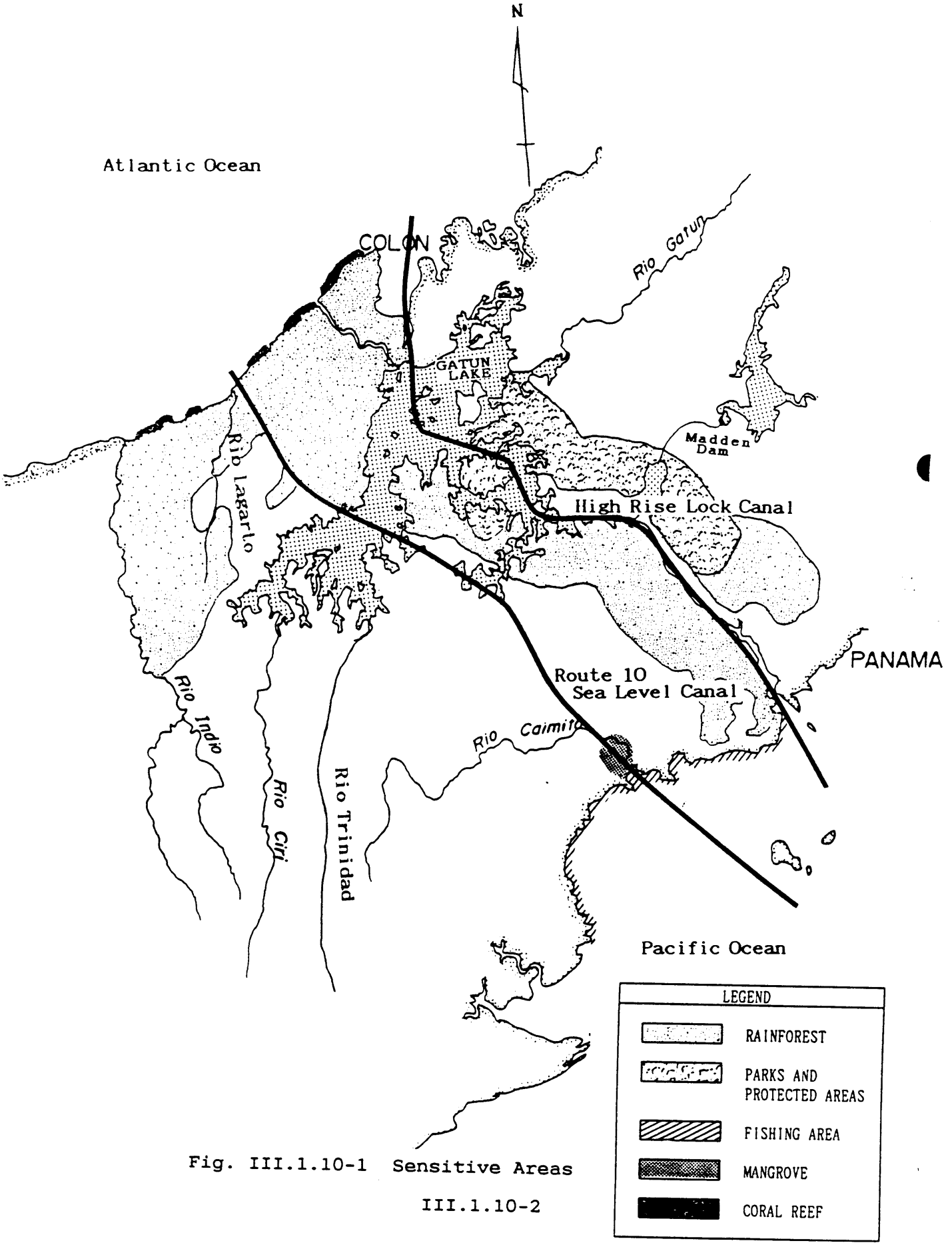


Fig. III.1.10-1 Sensitive Areas

10.3 Environmental Impact

(1) The lockage water supply is insufficient for the new locks operation in the year 2060 and a water pumping system would be required. Direct pumping of sea water into Gatun Lake would result in increased salinity in the Gatun Lake water and changes to the lake ecology would result. Hence recycling of lockage water only using a freshwater recycling pond has been proposed. While the effect on salinity in Gatun Lake would be much less, survey and analysis would still be required.

(2) To increase the available lockage water, new dams are also proposed at Rio Trinidad and Rio Ciri Grande approximately 3 and 9 km respectively upstream from where these rivers flow into Gatun Lake.

The construction works of these dams and new lakes made as the result of completion of these dams will generate an environmental impact.

(3) Some alternatives consider increasing the Gatun Lake level from 85' to 90'. This increased lake level might cause some environmental impact in the surrounding area and on aquatic creatures.

(4) Access channels 14.0-17.5km long in both Ocean sides and 21-24m deep are planned.

The environmental impact during construction and after completion of the work will need to be studied later.

(5) If excavated material were disposed in adjacent stream and river valleys, diversion and artificial reconstruction would be required. This will have an environmental impact. Natural areas will also be affected locally by spoil placement and recovery could take some time. Plant and animal life will be affected and further studies of this aspect are required.

(6) Blasting may also have environmental impacts as described in 10.4 below.

10.4 Blasting Effects

Blasting operations will be substantial for any of the canal alternatives and the environmental effects of the blasting must be fully considered. Blasting has the potential to cause adverse effects on:

- residences
- commercial or industrial facilities
- new or existing lock facilities
- electronic equipment and controls
- new or existing dams
- new or existing roads, railways, bridges etc
- passing ships (underwater blasting)
- marine organisms (underwater blasting)

Fortunately most blasting will be carried out at some distance from existing facilities and, even when this is not the case, the technology exists to predict blasting effects and to modify blasting procedures as necessary so that adverse environmental effects can be kept to a minimum.

The main causes of environmental effects due to blasting are briefly described below, including alleviation measures that can be taken.

a) Ground Vibrations from Blasting

Ground vibrations caused by blasting can be predicted at any given distance from the blast by considering the weight and characteristics of the explosives, degree of confinement, soil and rock conditions, spatial and timing distributions of the detonation process, and the like.

Criteria is also available for ground vibration limits for mass concrete, structural concrete, fresh concrete and formwork, residences and buildings etc, as well as likely reactions of people to various ground vibration levels.

The blasting plan can be adjusted as necessary during the detail design stage so the predicted ground vibrations will be within appropriate limits according to the location.

b) Water Pressures Generated by Blasting

In addition to those vibrations which are carried under the water by the bedrock, underwater blasting will generate pressure waves within the water itself.

The magnitude of the peak pressure is highly dependent on the "depth of burial" of the charges, that is how deeply they are placed within the rock below the surface. If it develops that water pressures are a matter of some concern, it is advisable to terminate the explosives charge within each hole a meter or so below the rock/water contact rather than to follow the common practice of loading blast holes to the very top of the rock surface.

It is customary to avoid blasting when passing ships are within a few hundred meters of the blasting operations.

For the large scale blasting operations proposed it would be difficult and expensive to enforce special precautions for the protection of fish and other marine organisms (such as the installation of air curtains). During the detail design stage this issue should be further considered based on PCC experience, but the most practicable procedure would be to exercise some control over the depth of burial of the explosives charges.

c) Airblast Overpressures

In typical down-hole blasting operations, it is very rare for air waves to cause any damage to structures. Where blasting operations take place near inhabited areas, the secondary sound effects generated by air waves from land-based blasting are of interest not because they cause damage but because they usually are responsible for the adverse reactions of persons in occupied residences. In turn, such sound effects often are the reasons why persons then examine their homes to search for defects that they might judge to be related to blasting "vibrations". Such adverse reactions can be mitigated through public relations efforts, providing information to the public, and making careful inspections of selected properties prior to the beginning of the project.

III.1 CHAPTER 11 - 90' STUDY ALTERNATIVE

11.1 Description

The alternative water level for Gatun lake designed at 90' (EL 87'-92') is examined here. By raising the water level of the lake, the bottom of the canal can also be raised by some 1.5m, making this alternative more advantageous than the 85' Alternative (EL 81'-87') in terms of the required volume of canal excavation. Nevertheless, raising the water level of the lake by some 1.5m above the present level can cause problems from several aspects as described below.

1) adverse effects on the environment
2) reduced land availability around the lake
3) erosion and collapse of land around the lake
4) adverse effects on the existing railway line
5) adverse effects on the existing power cable line
6) necessity to raise the Gatun dam height and to re-install gates
7) necessity to raise the existing lock height, to repair gates and to restrict use of the canal during repair work
8) increased time required to pass through the canal

A detailed technical examination of each of the above is essential as part of the examination process of the 90' Alternative.

11.2 Examination of Problematic Issues

11.2.1 Environmental Problems

The Smithsonian Institute of Fauna and Flora located on Colorado island at the centre of Gatun lake has long been engaged in the study of natural animal and plant ecologies. The raised water level of Gatun lake will have a significant impact on the ecological environment on and around the island. The retreatment of the waterfront due

to the increased water level may also have a serious impact on the environment in areas around the lake.

11.2.2 Reduced Land Around Lake

The aggregate length of the shoreline is several hundred kilometers and the rise of the water level by some 1.5m means that several hundred hectares of land along the shore will be submerged. This issue must be thoroughly examined in view of serious implications.

11.2.3 Land Erosion and Collapse Around Lake

In addition to the reduced land availability around the lake, land erosion and collapse may occur due to the rise in the lake's water level. At present, the land around the lake is fairly stable following a long period of time since the initial formation of the lake. Slope collapse on a small-scale has occurred from time to time due to waves and the raising of the lake's water level to 90' calls for further examination in view of the implication of new erosion and collapse.

11.2.4 Reinforcement of Existing Railway Tracks

The railway line currently runs along the eastern shore of Gatun lake, linking Panama City and Gatun lock. The track is very near the shore around Gamboa and part of it actually crosses Gatun lake. This section which stretches some 30km must be reinforced in some way against the possible dangers associated with the rise of the water level. Replacement of the existing bridge near Gamboa is also required.

11.2.5 Power Transmission Line

A power cable is laid long the existing railway track and improvement or reinforcement measure are required for this power cable.

11.2.6 Raising of Gatun Dam Height

It is necessary to raise the height of the Gatun dam. The question of the safety of the entire dam must be carefully examined prior to the commencement of any improvement work. Simply raising the dam's crown height will not be sufficient and the safety of the entire dam, including its foundations, must be taken into consideration. The gate will also require replacement as part of the work to raise the dam height.

11.2.7 Raising of Existing Lock Height

The height of the concrete structure forming part of the Gatun lock and Pedro Miguel lock will require raising if the lake's water level is raised by more than 1.5m. In particular, the gates currently in use will require repair and remodeling. During the work to raise the lock height and repair the gates, it is likely that the number of vessels passing through the canal will have to be substantially reduced.

11.2.8 Navigation Time to Pass Locks

In the case of the 90' Alternative, the raised water level will lengthen the navigation time through the locks compared to the 85' Alternative, reducing the number of vessels able to pass through the locks.

11.3 Conclusions

The 90' Alternative which envisages the raising of the water level of Gatun lake to 90' has the advantage of reducing the required excavation volume by some 35 million m^3 (200,000 DWT case) but it has been concluded that this is an unsuitable alternative due to its many disadvantages. The cost necessary to solve these disadvantages has been roughly estimated and listed in Table III.1.11-1. The results are also mentioned in the Summation Table as other works. Consequently, only 2 cases, i.e. the

150,000 DWT case and 200,000 DWT case, for the 85' Alternative are discussed in this Report, and no detailed examination of the 90' Alternative is made.

Table III.1.11-1 Cost of Other Works

Item	Cost in Mill US$	Note
1. Gatun Dam		
1) Steel Gate Repair	14.0	
2) Concrete Dam Repair	20.0	
2. Miraflores Dam	10.0	Additional one gate
3. Gatun & Pedro Miguel Locks		
1) Operating Gates	230	20 pairs
2) Lock Concrete	100	
4. Land Aquisition	10	For submerged areas
5. Erosion Protection	20	
6. Railway		
1) Embankment	10	
2) Bridges	60	
3) Power line	10	
Total	474.0	

PART-III Section-2 CONSTRUCTION PLANS

III.2 Chapter 1. Canal Excavation

1.1 Excavation Method

(1) Clearing and Grubbing of Excavation Area

- Before commencing dry excavation, clearing and grubbing shall be performed.

- Quantity

Table III. 2.1.1 - 1
Clearing and Grubbing

Case	200,000 DWT	150,000 DWT
Zone I	743,000 m^2	683,500 m^3
Zone II	2,228,000 m^2	2,049,000 m^3
Zone III	3,590,000 m^2	3,302,500 m^3
Zone IV	4,353,000 m^2	4,004,500 m^3
Zone V	408,000 m^2	374,500 m^3
Total	11,322,000 m^2	10,414,000 m^3

(2) Vegetation

- The surface of slopes shall be protected by spraying seeds of vegetation.

- Quantity

Table III. 2.1.1 - 2 Vegetation

Case	200,000 DWT & 150,000 DWT
Zone I	215,000 m^2
Zone II	459,000 m^2
Zone III	1,294,000 m^2
Zone IV	1,223,000 m^2
Zone V	65,000 m^2
Total	3,256,000 m^2

(3) Placing Area

- The location of placing area are shown in the Base Map (scale 1:100,000) together with ecologically sensitive areas.

- Capacities of each placing area are shown in the Table III. 2.1.1 - 3(a) to 3(d).

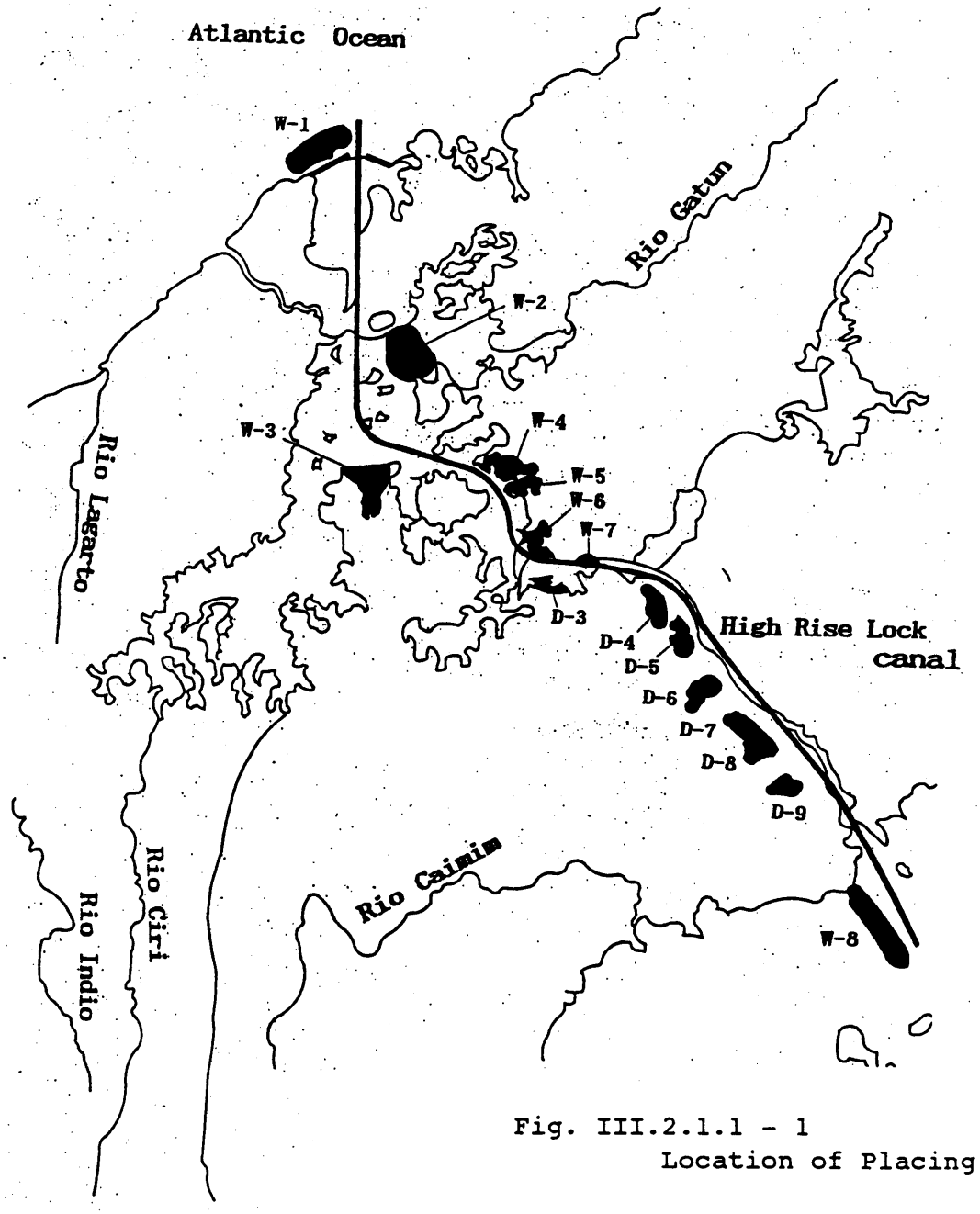


Fig. III.2.1.1 - 1
Location of Placing Area

TABLE III.2.1.1-3(a)

CASE : HIGH RISE LOCK CANAL-200,000 D.W.T.-85' Case

File Name PLCH2085

DRY EXCAVATION					DREDGING				
PLACING -AREA	AREA OF PLACING AREA	PLACING AREA			PLACING -AREA	AREA OF PLACING AREA	PLACING AREA		
		PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION			PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION
	(km2)	(m3)	(m)	E.L. (m)		(km2)	(m3)	(m)	E.L. (m)
D-1	0.2	382,070	1.9	50.0	W-1	5.2	53,846,820	10.4	-4.0
D-2	1.2	13,217,364	11.0	50.0	W-2	14.7	103,968,646	7.1	21.0
D-3	0.4	1,046,008	2.6	50.0	W-3	3.9	16,323,746	4.2	21.0
D-4	3.3	11,609,875	3.5	50.0	W-4	2.6	8,023,496	3.1	21.0
D-5	3.2	38,183,048	11.9	100.0	W-5	4.4	32,076,287	7.3	21.0
D-6	3.5	40,263,366	11.5	130.0	W-6	4.3	43,521,405	10.1	21.0
D-7	2.3	50,017,750	21.7	100.0	W-7	1.0	11,676,269	11.7	21.0
D-8	4.6	82,833,500	18.0	80.0	W-8	7.5	88,227,050	11.8	-4.0
D-9	1.5	4,234,950	2.8	60.0					
	20.2	241,787,931	9.4			43.6	357,663,719	8.2	

TABLE III. 2. 1. 1-3(b)

CASE : HIGH RISE LOCK CANAL-200,000 D. W. T. -90' Case

File Name PLCH2090

DRY EXCAVATION					DREDGING				
PLACING -AREA	AREA OF PLACING AREA	PLACING AREA			PLACING -AREA	AREA OF PLACING AREA	PLACING AREA		
		PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION			PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION
	(km2)	(m3)	(m)	E. L. (m)		(km2)	(m3)	(m)	E. L. (m)
D-1	0. 2	380, 829	1. 9	50. 0	W-1	5. 2	53, 846, 820	10. 4	-4. 0
D-2	1. 2	12, 556, 491	10. 5	50. 0	W-2	14. 7	98, 768, 960	6. 7	21. 0
D-3	0. 4	993, 718	2. 5	50. 0	W-3	3. 9	15, 507, 391	4. 0	21. 0
D-4	3. 3	10, 934, 502	3. 3	50. 0	W-4	2. 6	7, 622, 391	2. 9	21. 0
D-5	3. 2	35, 962, 033	11. 2	100. 0	W-5	4. 4	30, 319, 104	6. 9	21. 0
D-6	3. 5	38, 021, 011	10. 8	120. 0	W-6	4. 3	40, 883, 883	9. 5	21. 0
D-7	2. 3	47, 516, 250	20. 7	100. 0	W-7	1. 0	11, 019, 967	11. 0	21. 0
D-8	4. 6	78, 692, 250	17. 1	80. 0	W-8	7. 5	88, 227, 050	11. 8	-4. 0
D-9	1. 5	4, 069, 700	2. 7	60. 0					
	20. 2	229, 126, 784	9. 0			43. 6	346, 195, 566	7. 9	

TABLE III.2.1.1-3(c)

CASE : HIGH RISE LOCK CANAL-150,000 D.W.T.-85' Case

File Name PLCH1585

DRY EXCAVATION					DREDGING				
PLACING -AREA	AREA OF PLACING AREA	PLACING AREA			PLACING -AREA	AREA OF PLACING AREA	PLACING AREA		
		PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION			PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION
	(km2)	(m3)	(m)	E.L. (m)		(km2)	(m3)	(m)	E.L. (m)
D-1	0.2	325,128	1.6	50.0	W-1	5.2	46,613,400	9.0	-4.0
D-2	1.2	12,078,355	10.1	50.0	W-2	14.7	87,120,168	5.9	21.0
D-3	0.4	872,123	2.2	50.0	W-3	3.9	13,379,189	3.4	21.0
D-4	3.3	9,818,723	3.0	50.0	W-4	2.6	6,609,689	2.5	21.0
D-5	3.2	33,842,216	10.6	100.0	W-5	4.4	26,749,671	6.1	21.0
D-6	3.5	36,366,270	10.4	130.0	W-6	4.3	38,221,918	8.9	21.0
D-7	2.3	44,626,250	19.4	100.0	W-7	1.0	10,643,703	10.6	21.0
D-8	4.6	75,174,000	16.3	80.0	W-8	7.5	66,092,200	8.8	-4.0
D-9	1.5	3,591,300	2.4	60.0					
	20.2	216,694,365	8.4			43.6	295,429,938	6.9	

TABLE III.2.1.1-3(d)

CASE : HIGH RISE LOCK CANAL-150,000 D.W.T.-90' Case

File Name PLCH1590

DRY EXCAVATION					DREDGING				
PLACING -AREA	AREA OF PLACING AREA	PLACING AREA			PLACING -AREA	AREA OF PLACING AREA	PLACING AREA		
		PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION			PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION
	(km2)	(m3)	(m)	E.L. (m)		(km2)	(m3)	(m)	E.L. (m)
D-1	0.2	324,951	1.6	50.0	W-1	5.2	46,613,400	9.0	-4.0
D-2	1.2	11,474,373	9.6	50.0	W-2	14.7	82,764,127	5.6	21.0
D-3	0.4	828,548	2.1	50.0	W-3	3.9	12,709,976	3.3	21.0
D-4	3.3	9,237,482	2.8	50.0	W-4	2.6	6,279,226	2.4	21.0
D-5	3.2	31,837,929	9.9	100.0	W-5	4.4	25,264,923	5.7	21.0
D-6	3.5	34,314,541	9.8	120.0	W-6	4.3	35,840,699	8.3	21.0
D-7	2.3	42,394,750	18.4	100.0	W-7	1.0	10,041,926	10.0	21.0
D-8	4.6	71,415,000	15.5	80.0	W-8	7.5	66,088,200	8.8	-4.0
D-9	1.5	3,450,550	2.3	60.0					
	20.2	205,278,124	8.0			43.6	285,602,477	6.6	

(4) Quantity of Excavation and Hauling Distance

- The volume and hauling distances of excavated materials and dredged materials to each placing area, are as shown in the Table III.2.1.1-4, -5.

Table III. 2.1.1 - 4 Hauling Distance and Quantity of Excavation (200,000 DWT)

	200,000 DWT (85')			
	Dry Excavation		Dredging	
	Hauling Distance	Quantity	Hauling Distance	Quantity
		m^3		m^3
Zone I	2.5 km	358,000	12.0 km	53,847,000
Zone II	2.0 km	14,287,000	18.5 km	145,964,000
Zone III	4.0 km	78,192,000	22.5 km	64,419,000
Zone IV	4.0 km	148,024,000	22.0 km	5,206,000
Zone V	6.0 km	929,000	7.5 km	88,227,000
		m^3		m^3
Total		241,790,000		357,663,000

Table III. 2.1.1 - 5 Hauling Distance and Quantity of Excavation (150,000 DWT)

	150,000 DWT (85')			
	Dry Excavation		Dredging	
	Hauling Distance	Quantity	Hauling Distance	Quantity
		m^3		m^3
Zone I	2.5 km	332,000	12.0 km	46,613,000
Zone II	2.0 km	12,954,000	18.5 km	121,866,000
Zone III	4.0 km	69,133,000	22.5 km	56,057,000
Zone IV	4.0 km	133,529,000	22.0 km	4,801,000
Zone V	6.0 km	777,000	8.0 km	66,093,000
		m^3		m^3
Total		216,695,000		295,430,000

- The locations of placing area are shown in Fig. III. 2.1.1 - 1.

Table III.2.1.1-6(a) Quantity of Excavation and Hauling Distance

HIGH RISE LOCK CANAL-200,000 D.W.T.-85'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH2085

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
-12.80		0		0		W-1	0		0	
-12.50		0		0		W-1	6,600	3.0	19,800	
-12.00		0		0		W-1	33,000	2.5	82,500	
-11.50		0		0		W-1	176,250	2.0	352,500	
-11.00		0		0		W-1	344,250	2.0	688,500	
-10.50		0		0		W-1	299,000	2.5	747,500	
-10.00		0		0		W-1	208,750	3.0	626,250	
-9.50		0		0		W-1	200,750	3.5	702,625	
-9.00		0		0		W-1	221,750	4.0	887,000	
-8.50		0		0		W-1	248,250	4.5	1,117,125	
-8.00		0		0		W-1	236,000	5.0	1,180,000	
-7.50		0		0		W-1	243,250	5.5	1,337,875	
-7.00		0		0		W-1	278,750	6.0	1,672,500	
-6.50		0		0		W-1	254,500	6.5	1,654,250	
-6.00		0		0		W-1	218,000	7.0	1,526,000	
-5.50		0		0		W-1	224,250	7.5	1,681,875	
-5.00		0		0		W-1	283,500	8.0	2,268,000	
-4.50		0		0		W-1	1,350,750	8.5	11,481,375	
-4.00		0		0		W-1	2,707,750	9.0	24,369,750	
-3.50		0		0		W-1	3,105,500	9.5	29,502,250	
-3.00		0		0		W-1	3,356,500	10.0	33,565,000	
-2.50		0		0		W-1	3,539,500	10.5	37,164,750	
-2.00		0		0		W-1	3,655,000	11.0	40,205,000	
-1.50		0		0		W-1	3,846,250	11.5	45,381,875	
-1.00		0		0		W-1	4,146,750	12.0	49,761,000	
-0.50		0		0		W-1	4,401,750	12.5	55,021,875	
0.00		0		0		W-1	4,483,000	13.0	58,279,000	
0.50		0		0		W-1	4,297,250	13.5	58,012,875	
1.00		0		0		W-1	4,382,250	14.0	61,351,500	
1.50		0		0		W-1	5,615,750	14.5	81,428,375	
2.00	D-1	357,780	2.5	894,450		W-1	1,381,970	15.0	20,729,550	
Zone I		357,780	2.5	894,450			53,846,820	11.6	622,798,475	
									0	
2.00	D-1	0	2.5	0		W-1	0	15.0	0	
2.50	D-1	0	2.5	0		W-1	0	15.5	0	
3.00	D-1	0	2.0	0		W-1	0	16.0	0	TOTAL W-1
3.50	D-1	0	2.5	0	TOTAL D-1	W-1	0	16.5	0	53,846,820
4.00	D-1	24,290	2.5	60,725	382,070	W-2	41,010	4.0	164,040	
4.50		0		0		W-2	62,000	4.0	248,000	
5.00		0		0		W-2	1,500	4.0	6,000	
5.50		0		0		W-2	0	4.5	0	
6.00		0		0		W-2	0	5.0	0	
6.50		0		0		W-2	0	5.5	0	
7.00		0		0		W-2	0	6.0	0	
7.50		0		0		W-2	0	6.5	0	
8.00		0		0		W-2	0	7.0	0	
8.50		0		0		W-2	85,750	7.5	643,125	
9.00		0		0		W-2	188,750	8.0	1,510,000	
9.50		0		0		W-2	327,000	8.5	2,779,500	
10.00		0		0		W-2	637,000	9.0	5,733,000	
10.50		0		0		W-2	821,750	9.5	7,806,625	
11.00		0		0		W-2	843,250	10.0	8,432,500	
11.50		0		0		W-2	864,250	10.5	9,074,625	
12.00		0		0		W-2	882,500	11.0	9,707,500	
12.50		0		0		W-2	959,750	12.0	11,517,000	
13.00		0		0		W-2	985,750	12.5	11,829,000	
13.50		0		0		W-2	929,750	13.0	11,621,875	
14.00		0		0		W-2	979,750	13.5	12,736,750	
14.50		0		0		W-2	1,187,500	14.0	16,031,250	
15.00		0		0		W-2	1,316,750	7.5	18,434,500	
15.50		0		0		W-2	1,331,750	8	10,654,000	
16.00		0		0		W-2	1,689,250	8.0	14,358,625	
16.50		0		0		W-2	1,701,500	8.5	15,313,500	
17.00		0		0		W-2	1,202,500	9.0	11,423,750	
17.50		0		0		W-2	1,859,250	9.5	18,592,500	
18.00		0		0		W-2	5,258,500	10.0	55,214,250	
18.50	D-2	3,723,140	1.5	5,584,710		W-2	4,361,860	10.5	47,980,457	
19.00	D-2	6,608,682	2.0	13,217,364	TOTAL D-2	W-2	1,041,318	11.0	11,975,157	
19.50	D-2	2,885,542	2.5	7,213,854	13,217,364	W-2	2,407,208	11.5	28,886,499	

HIGH RISE LOCK CANAL-200,000 D.W.T.-85'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH2085

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
20.00		0		0		W-2	3,186,750	12.0	39,834,375	
20.50		0		0		W-2	2,112,500	12.5	27,462,500	
21.00		0		0		W-2	3,296,500	13.0	44,502,750	
21.50		0		0		W-2	3,195,750	13.5	44,740,500	
22.00		0		0		W-2	1,212,000	14.0	17,574,000	
22.50		0		0		W-2	1,730,750	14.5	25,095,875	
23.00		0		0		W-2	1,767,250	15.0	26,508,750	
23.50		0		0		W-2	1,700,250	15.5	26,353,875	
24.00		0		0		W-2	1,685,500	16.0	26,968,000	
24.50		0		0		W-2	1,300,500	16.5	21,458,250	
25.00		0		0		W-2	1,434,000	17.0	24,378,000	
25.50		0		0		W-2	1,376,250	17.5	24,084,375	
26.00		0		0		W-2	1,857,500	18.0	33,435,000	
26.50		0		0		W-2	2,691,750	18.5	49,797,375	
27.00		0		0		W-2	2,900,000	19.0	55,100,000	
27.50		0		0		W-2	2,544,750	19.5	49,622,625	
28.00		0		0		W-2	2,113,000	20.0	42,260,000	
28.50		0		0		W-2	2,434,750	20.5	49,912,375	
29.00		0		0		W-2	3,120,750	21.0	65,535,750	
29.50		0		0		W-2	4,072,500	21.5	87,558,750	
30.00		0		0		W-2	4,276,750	22.0	94,088,500	
30.50		0		0		W-2	3,654,250	22.5	82,220,625	
31.00		0		0		W-2	3,729,000	23.0	85,767,000	
31.50		0		0		W-2	3,818,250	23.5	89,728,875	
32.00		0		0		W-2	3,949,500	24.0	94,788,000	
32.50		0		0		W-2	3,897,500	24.5	95,488,750	TOTAL W-2
33.00		0		0		W-2	2,943,250	25.0	73,581,250	103,968,646
33.50		0		0		W-3	3,232,000	24.0	77,568,000	
34.00		0		0		W-3	2,855,000	24.5	72,397,500	
34.50		0		0		W-3	1,767,000	25.0	44,175,000	
35.00		0		0		W-3	1,921,750	25.5	49,004,625	
35.50		0		0		W-3	1,880,000	26.0	48,880,000	
36.00		0		0		W-3	2,351,500	26.5	62,314,750	TOTAL W-3
36.50	D-3	523,004	2.5	1,307,509	TOTAL D-3	W-3	2,216,496	27.0	59,845,399	16,323,746
37.00	D-3	523,004	3.0	1,569,011	1,046,008	W-4	1,703,496	18.0	30,662,933	
37.50		0		0		W-4	1,928,250	18.5	35,672,625	
38.00		0		0		W-4	1,940,250	19.0	36,864,750	TOTAL W-4
38.50		0		0		W-4	2,451,500	19.5	47,804,250	8,023,496
39.00		0		0		W-5	2,412,500	17.5	42,218,750	
39.50		0		0		W-5	2,420,000	18.0	43,560,000	
40.00		0		0		W-5	3,569,750	18.5	66,040,375	
40.50		0		0		W-5	3,085,750	19.0	58,629,250	
41.00		0		0		W-5	1,999,750	20.0	39,995,000	
41.50		0		0		W-5	1,951,750	20.5	40,010,875	
42.00	D-4	0	3.0	0		W-5	2,208,500	21.0	46,378,500	
Zone II		14,287,662	2.0	28,953,175			145,963,888	18.1	2,642,542,734	
									0	
42.00	D-4	0	3.0	0			0	21.5	0	
42.50	D-4	1,034,427	3.5	3,620,495		W-5	2,210,938	22.0	48,640,636	
43.00	D-4	1,713,181	4.0	6,852,724		W-5	1,942,521	22.5	43,706,723	
43.50	D-4	678,754	3.5	2,375,639		W-5	2,714,051	23.0	62,423,173	
44.00	D-4	562,231	4.0	2,248,924		W-5	3,160,447	23.5	74,270,505	
44.50	D-4	1,182,307	4.5	5,365,382		W-5	2,298,628	24.0	55,167,072	TOTAL W-5
45.00	D-4	2,022,841	5.0	10,114,205	TOTAL D-4	W-5	2,101,702	24.5	51,491,698	32,076,287
45.50	D-4	4,406,134	4.0	17,624,536	11,609,875	W-6	2,460,537	19.5	47,980,472	
46.00	D-5	4,848,428	2.5	12,121,070		W-6	2,603,876	20.0	52,077,520	
46.50	D-5	3,795,133	2.0	7,590,266		W-6	2,861,591	20.5	58,662,616	
47.00	D-5	4,254,853	2.5	10,637,133		W-6	3,745,077	21.0	78,646,617	
47.50	D-5	4,432,658	3.0	13,297,974		W-6	4,431,263	21.5	95,272,155	
48.00	D-5	4,545,719	3.5	15,910,017		W-6	4,540,677	22.0	99,894,894	
48.50	D-5	6,797,166	2.5	16,992,915		W-6	2,581,442	22.5	58,082,445	
49.00	D-5	6,029,340	3.0	18,088,020	TOTAL D-5	W-6	2,048,579	23.0	47,117,317	
49.50	D-5	3,479,751	3.5	12,179,129	38,183,048	W-6	3,223,717	23.5	75,757,350	
50.00	D-6	4,707,901	4.5	21,185,555		W-6	3,055,142	24.0	73,323,408	
50.50	D-6	5,344,445	4.0	21,377,780		W-6	2,709,129	24.5	66,373,661	
51.00	D-6	6,400,320	4.5	28,801,440		W-6	4,173,575	25.0	104,339,375	TOTAL W-6
51.50	D-6	7,062,276	5.0	35,311,380		W-6	5,086,800	22.5	114,453,000	43,521,405
52.00	D-6	4,881,964	5.5	26,850,802		W-7	6,469,229	21.0	135,853,809	
Zone III		78,189,829	3.7	288,545,383			64,418,921	22.4	1,443,534,444	
									0	

HIGH RISE LOCK CANAL-200,000 D.W.T.-85'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH2085

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
52.00	D-6	0	5.5	0	TOTAL D-6	W-7	0	21.5	0	TOTAL W-7
52.50	D-6	11,866,460	5.5	65,265,530	40,263,366	W-7	5,207,040	22.0	114,554,880	11,676,269
53.00	D-7	16,284,500	4.5	73,280,250			0		0	
53.50	D-7	11,075,750	4.0	44,303,000			0		0	
54.00	D-7	8,485,500	3.5	29,699,250			0		0	
54.50	D-7	7,846,500	4.0	31,386,000	TOTAL D-7		0		0	
55.00	D-7	6,325,500	4.5	28,464,750	50,017,750		0		0	
55.50	D-8	5,514,500	3.0	16,543,500			0		0	
56.00	D-8	9,739,250	2.5	24,348,125			0		0	
56.50	D-8	14,661,500	3.0	43,984,500			0		0	
57.00	D-8	18,049,750	3.5	63,174,125			0		0	
57.50	D-8	17,166,000	4.0	68,664,000			0		0	
58.00	D-8	9,991,750	3.5	34,971,125			0		0	
58.50	D-8	4,652,500	4.0	18,610,000	TOTAL D-8		0		0	
59.00	D-8	3,058,250	4.5	13,762,125	82,833,500		0		0	
59.50	D-9	3,306,000	4.5	14,877,000			0		0	
60.00	D-9	0	4.0	0			0		0	
Zone IV		148,023,710	3.9	571,333,280			5,207,040	22.0	114,554,880	
									0	
60.00	D-9	0	4.0	0			0		0	
60.50	D-9	0	4.5	0			0		0	
61.00	D-9	0	5.0	0			0		0	
61.50	D-9	0	5.5	0	TOTAL D-9		0		0	
62.00	D-9	928,950	6.0	5,573,700	4,234,950	W-8	473,100	13.5	6,386,850	
62.50		0		0		W-8	2,586,250	13.0	33,621,250	
63.00		0		0		W-8	4,210,250	12.5	52,628,125	
63.50		0		0		W-8	4,900,250	12.0	58,803,000	
64.00		0		0		W-8	3,623,750	11.5	41,673,125	
64.50		0		0		W-8	3,198,000	11.0	35,178,000	
65.00		0		0		W-8	4,088,250	10.5	42,926,625	
65.50		0		0		W-8	4,079,000	10.0	40,790,000	
66.00		0		0		W-8	4,093,500	9.5	38,888,250	
66.50		0		0		W-8	4,077,250	9.0	36,695,250	
67.00		0		0		W-8	4,348,750	8.5	36,964,375	
67.50		0		0		W-8	4,521,500	8.0	36,172,000	
68.00		0		0		W-8	4,289,750	7.5	32,173,125	
68.50		0		0		W-8	3,998,000	7.0	27,986,000	
69.00		0		0		W-8	3,419,500	6.5	22,226,750	
69.50		0		0		W-8	2,673,750	6.0	16,042,500	
70.00		0		0		W-8	2,720,250	2.5	6,800,625	
70.50		0		0		W-8	3,159,000	2.5	7,897,500	
71.00		0		0		W-8	2,815,250	2.5	7,038,125	
71.50		0		0		W-8	2,422,250	2.5	6,055,625	
72.00		0		0		W-8	2,497,000	2.5	6,242,500	
72.50		0		0		W-8	2,288,250	2.5	5,720,625	
73.00		0		0		W-8	1,926,250	2.5	4,815,625	
73.50		0		0		W-8	1,787,250	2.5	4,468,125	
74.00		0		0		W-8	1,656,250	2.5	4,140,625	
74.50		0		0		W-8	1,485,000	2.5	3,712,500	
75.00		0		0		W-8	1,310,000	2.5	3,275,000	
75.50		0		0		W-8	1,147,500	2.5	2,868,750	
76.00		0		0		W-8	1,066,500	2.5	2,666,250	
76.50		0		0		W-8	975,750	2.5	2,439,375	
77.00		0		0		W-8	806,000	2.5	2,015,000	
77.50		0		0		W-8	638,250	2.5	1,595,625	
78.00		0		0		W-8	472,750	2.5	1,181,875	
78.50		0		0		W-8	309,250	2.5	773,125	
79.00		0		0		W-8	147,750	2.5	369,375	TOTALW-8
79.20		0		0		W-8	15,700	2.5	39,250	88,227,050
Zone V		928,950	6.0	5,573,700			88,227,050	7.2	633,270,725	
Zone I		357,780					53,846,820			
Zone II		14,287,662					145,963,888			
Zone III		78,189,829					64,418,921			
Zone IV		148,023,710					5,207,040			
Zone V		928,950					88,227,050			
Total=		241,787,931			241,787,931		357,663,719			357,663,719

Table III.2.1.1-6(b) Quantity of Excavation and Hauling Distance

HIGH RISE LOCK CANAL-200,000 D.W.T.-90'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH2090

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
-12.80		0		0		W-1	0		0	
-12.50		0		0		W-1	6,600	3.0	19,800	
-12.00		0		0		W-1	33,000	2.5	82,500	
-11.50		0		0		W-1	176,250	2.0	352,500	
-11.00		0		0		W-1	344,250	2.0	688,500	
-10.50		0		0		W-1	299,000	2.5	747,500	
-10.00		0		0		W-1	208,750	3.0	626,250	
-9.50		0		0		W-1	200,750	3.5	702,625	
-9.00		0		0		W-1	221,750	4.0	887,000	
-8.50		0		0		W-1	248,250	4.5	1,117,125	
-8.00		0		0		W-1	236,000	5.0	1,180,000	
-7.50		0		0		W-1	243,250	5.5	1,337,875	
-7.00		0		0		W-1	278,750	6.0	1,672,500	
-6.50		0		0		W-1	254,500	6.5	1,654,250	
-6.00		0		0		W-1	218,000	7.0	1,526,000	
-5.50		0		0		W-1	224,250	7.5	1,681,875	
-5.00		0		0		W-1	283,500	8.0	2,268,000	
-4.50		0		0		W-1	1,350,750	8.5	11,481,375	
-4.00		0		0		W-1	2,707,750	9.0	24,369,750	
-3.50		0		0		W-1	3,105,500	9.5	29,502,250	
-3.00		0		0		W-1	3,356,500	10.0	33,565,000	
-2.50		0		0		W-1	3,539,500	10.5	37,164,750	
-2.00		0		0		W-1	3,655,000	11.0	40,205,000	
-1.50		0		0		W-1	3,946,250	11.5	45,381,875	
-1.00		0		0		W-1	4,146,750	12.0	49,761,000	
-0.50		0		0		W-1	4,401,750	12.5	55,021,875	
0.00		0		0		W-1	4,483,000	13.0	58,279,000	
0.50		0		0		W-1	4,297,250	13.5	58,012,875	
1.00		0		0		W-1	4,382,250	14.0	61,351,500	
1.50		0		0		W-1	5,615,750	14.5	81,428,375	
2.00	D-1	357,780	2.5	894,450		W-1	1,381,970	15.0	20,729,550	
Zone I		357,780	2.5	894,450			53,846,820	11.6	622,798,475	
									0	
2.00	D-1	0	2.5	0		W-1	0	15.0	0	
2.50	D-1	0	2.5	0		W-1	0	15.5	0	
3.00	D-1	0	2.0	0		W-1	0	16.0	0	TOTAL W-1
3.50	D-1	0	2.5	0	TOTAL D-1	W-1	0	16.5	0	53,846,820
4.00	D-1	23,049	2.5	57,623	380,829	W-2	38,951	4.0	155,804	
4.50		0		0		W-2	59,000	4.0	236,000	
5.00		0		0		W-2	1,500	4.0	6,000	
5.50		0		0		W-2	0	4.5	0	
6.00		0		0		W-2	0	5.0	0	
6.50		0		0		W-2	0	5.5	0	
7.00		0		0		W-2	0	6.0	0	
7.50		0		0		W-2	0	6.5	0	
8.00		0		0		W-2	0	7.0	0	
8.50		0		0		W-2	81,500	7.5	611,250	
9.00		0		0		W-2	179,250	8.0	1,434,000	
9.50		0		0		W-2	310,500	8.5	2,639,250	
10.00		0		0		W-2	605,000	9.0	5,445,000	
10.50		0		0		W-2	780,500	9.5	7,414,750	
11.00		0		0		W-2	801,000	10.0	8,010,000	
11.50		0		0		W-2	821,000	10.5	8,620,500	
12.00		0		0		W-2	838,250	11.0	9,220,750	
12.50		0		0		W-2	911,750	12.0	10,941,000	
13.00		0		0		W-2	936,500	12.5	11,238,000	
13.50		0		0		W-2	883,250	13.0	11,040,625	
14.00		0		0		W-2	930,750	13.5	12,099,750	
14.50		0		0		W-2	1,128,000	14.0	15,228,000	
15.00		0		0		W-2	1,250,750	7.5	17,510,500	
15.50		0		0		W-2	1,265,000	8	10,120,000	
16.00		0		0		W-2	1,604,750	8.0	13,640,375	
16.50		0		0		W-2	1,616,500	8.5	14,548,500	
17.00		0		0		W-2	1,142,500	9.0	10,853,750	
17.50		0		0		W-2	1,766,250	9.5	17,662,500	
18.00		0		0		W-2	4,995,500	10.0	52,452,750	
18.50	D-2	3,536,950	1.5	5,305,425		W-2	4,143,800	10.5	45,581,803	
19.00	D-2	6,278,246	2.0	12,556,491	TOTAL D-2	W-2	989,255	11.0	11,376,427	
19.50	D-2	2,741,296	2.5	6,853,239	12,556,491	W-2	2,286,954	11.5	27,443,451	

HIGH RISE LOCK CANAL-200,000 D.W.T.-90'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH2090

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
20.00		0		0		V-2	3,027,500	12.0	37,843,750	
20.50		0		0		V-2	2,006,750	12.5	26,087,750	
21.00		0		0		V-2	3,131,500	13.0	42,275,250	
21.50		0		0		V-2	3,036,000	13.5	42,504,000	
22.00		0		0		V-2	1,151,500	14.0	16,696,750	
22.50		0		0		V-2	1,644,250	14.5	23,841,625	
23.00		0		0		V-2	1,679,000	15.0	25,185,000	
23.50		0		0		V-2	1,615,250	15.5	25,036,375	
24.00		0		0		V-2	1,601,250	16.0	25,620,000	
24.50		0		0		V-2	1,235,500	16.5	20,385,750	
25.00		0		0		V-2	1,362,250	17.0	23,158,250	
25.50		0		0		V-2	1,307,500	17.5	22,881,250	
26.00		0		0		V-2	1,764,750	18.0	31,765,500	
26.50		0		0		V-2	2,557,250	18.5	47,309,125	
27.00		0		0		V-2	2,755,000	19.0	52,345,000	
27.50		0		0		V-2	2,417,500	19.5	47,141,250	
28.00		0		0		V-2	2,007,250	20.0	40,145,000	
28.50		0		0		V-2	2,313,000	20.5	47,416,500	
29.00		0		0		V-2	2,964,750	21.0	62,259,750	
29.50		0		0		V-2	3,868,750	21.5	83,178,125	
30.00		0		0		V-2	4,062,750	22.0	89,380,500	
30.50		0		0		V-2	3,471,500	22.5	78,108,750	
31.00		0		0		V-2	3,542,500	23.0	81,477,500	
31.50		0		0		V-2	3,627,250	23.5	85,240,375	
32.00		0		0		V-2	3,752,000	24.0	90,048,000	
32.50		0		0		V-2	3,702,500	24.5	90,711,250	TOTAL V-2
33.00		0		0		V-2	2,796,000	25.0	69,900,000	98,768,960
33.50		0		0		V-3	3,070,500	24.0	73,692,000	
34.00		0		0		V-3	2,807,250	24.5	68,777,625	
34.50		0		0		V-3	1,678,500	25.0	41,962,500	
35.00		0		0		V-3	1,825,500	25.5	46,550,250	
35.50		0		0		V-3	1,786,000	26.0	46,436,000	
36.00		0		0		V-3	2,234,000	26.5	59,201,000	TOTAL V-3
36.50	D-3	496,859	2.5	1,242,147	TOTAL D-3	V-3	2,105,641	27.0	56,852,314	15,507,391
37.00	D-3	496,859	3.0	1,490,576	993,718	V-4	1,618,391	18.0	29,131,043	
37.50		0		0		V-4	1,832,000	18.5	33,892,000	
38.00		0		0		V-4	1,843,250	19.0	35,021,750	TOTAL V-4
38.50		0		0		V-4	2,328,750	19.5	45,410,625	7,622,391
39.00		0		0		V-5	2,291,750	17.5	40,105,625	
39.50		0		0		V-5	2,299,000	18.0	41,382,000	
40.00		0		0		V-5	3,391,250	18.5	62,738,125	
40.50		0		0		V-5	2,931,500	19.0	55,698,500	
41.00		0		0		V-5	1,899,750	20.0	37,995,000	
41.50		0		0		V-5	1,854,000	20.5	38,007,000	
42.00	D-4	0	3.0	0		V-5	2,098,000	21.0	44,058,000	
Zone II		13,573,258	2.0	27,505,501			138,663,993	18.1	2,510,384,466	
42.00	D-4	0	3.0	0					0	
42.50	D-4	974,275	3.5	3,409,963			0	21.5	0	
43.00	D-4	1,613,508	4.0	6,454,032		V-5	2,076,958	22.0	45,693,076	
43.50	D-4	639,233	3.5	2,237,316		V-5	1,824,780	22.5	41,057,550	
44.00	D-4	529,517	4.0	2,118,068		V-5	2,549,512	23.0	58,638,776	
44.50	D-4	1,122,862	4.5	5,053,329		V-5	2,968,878	23.5	69,768,633	
45.00	D-4	1,905,217	5.0	9,526,085	TOTAL D-4	V-5	2,159,340	24.0	51,824,160	TOTAL V-5
45.50	D-4	4,149,780	4.0	16,599,160	10,934,502	V-5	1,974,386	24.5	48,372,457	30,319,104
46.00	D-5	4,566,311	2.5	11,415,778		V-6	2,311,410	19.5	45,072,495	
46.50	D-5	3,574,368	2.0	7,148,736		V-6	2,446,031	20.0	48,920,620	
47.00	D-5	4,007,385	2.5	10,018,463		V-6	2,688,175	20.5	55,107,588	
47.50	D-5	4,174,833	3.0	12,524,499		V-6	3,518,149	21.0	73,881,129	
48.00	D-5	4,281,300	3.5	14,984,550		V-6	4,162,739	21.5	89,498,889	
48.50	D-5	6,401,795	2.5	16,004,488		V-6	4,265,507	22.0	93,841,154	
49.00	D-5	5,678,646	3.0	17,035,938	TOTAL D-5	V-6	2,425,003	22.5	54,562,568	
49.50	D-5	3,277,395	3.5	11,470,883	35,962,033	V-6	1,924,446	23.0	44,262,258	
50.00	D-6	4,434,063	4.5	19,953,284		V-6	3,028,407	23.5	71,167,565	
50.50	D-6	5,033,458	4.0	20,133,836		V-6	2,870,021	24.0	68,880,504	
51.00	D-6	6,027,910	4.5	27,125,595		V-6	2,544,899	24.5	62,350,026	
51.50	D-6	6,651,439	5.0	33,257,195		V-6	3,920,587	25.0	98,014,675	TOTAL V-6
52.00	D-6	4,600,900	5.5	25,304,950		V-6	4,778,509	22.5	107,516,453	40,883,883
						V-7	6,073,207	21.0	127,537,347	
Zone III		73,644,306	3.7	271,776,145			60,510,944	22.4	1,355,967,920	

HIGH RISE LOCK CANAL-200,000 D.W.T.-90°Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH2090

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
									0	
52.00	D-6	0	5.5	0	TOTAL D-6	W-7	0	21.5	0	TOTAL W-7
52.50	D-6	11,273,240	5.5	62,002,820	38,021,011	W-7	4,946,760	22.0	108,828,720	11,019,967
53.00	D-7	15,470,250	4.5	69,616,125			0		0	
53.50	D-7	10,521,750	4.0	42,087,000			0		0	
54.00	D-7	8,061,000	3.5	28,213,500			0		0	
54.50	D-7	7,454,000	4.0	29,816,000	TOTAL D-7		0		0	
55.00	D-7	6,009,250	4.5	27,041,625	47,516,250		0		0	
55.50	D-8	5,238,750	3.0	15,716,250			0		0	
56.00	D-8	9,252,250	2.5	23,130,625			0		0	
56.50	D-8	13,928,500	3.0	41,785,500			0		0	
57.00	D-8	17,147,250	3.5	60,015,375			0		0	
57.50	D-8	16,307,750	4.0	65,231,000			0		0	
58.00	D-8	9,492,250	3.5	33,222,875			0		0	
58.50	D-8	4,420,000	4.0	17,680,000	TOTAL D-8		0		0	
59.00	D-8	2,905,500	4.5	13,074,750	78,692,250		0		0	
59.50	D-9	3,140,750	4.5	14,133,375			0		0	
60.00	D-9	0	4.0	0			0		0	
Zone IV		140,622,490	3.9	542,766,820			4,946,760	22.0	108,828,720	
									0	
60.00	D-9	0	4.0	0			0		0	
60.50	D-9	0	4.5	0			0		0	
61.00	D-9	0	5.0	0			0		0	
61.50	D-9	0	5.5	0	TOTAL D-9		0		0	
62.00	D-9	928,950	6.0	5,573,700	4,069,700	W-8	473,100	13.5	6,386,850	
62.50		0		0		W-8	2,586,250	13.0	33,621,250	
63.00		0		0		W-8	4,210,250	12.5	52,628,125	
63.50		0		0		W-8	4,900,250	12.0	58,803,000	
64.00		0		0		W-8	3,623,750	11.5	41,673,125	
64.50		0		0		W-8	3,188,000	11.0	35,178,000	
65.00		0		0		W-8	4,088,250	10.5	42,926,625	
65.50		0		0		W-8	4,079,000	10.0	40,790,000	
66.00		0		0		W-8	4,093,500	9.5	38,888,250	
66.50		0		0		W-8	4,077,250	9.0	36,695,250	
67.00		0		0		W-8	4,348,750	8.5	36,964,375	
67.50		0		0		W-8	4,521,500	8.0	36,172,000	
68.00		0		0		W-8	4,289,750	7.5	32,173,125	
68.50		0		0		W-8	3,998,000	7.0	27,986,000	
69.00		0		0		W-8	3,419,500	6.5	22,226,750	
69.50		0		0		W-8	2,673,750	6.0	16,042,500	
70.00		0		0		W-8	2,720,250	2.5	6,800,625	
70.50		0		0		W-8	3,159,000	2.5	7,897,500	
71.00		0		0		W-8	2,815,250	2.5	7,038,125	
71.50		0		0		W-8	2,422,250	2.5	6,055,625	
72.00		0		0		W-8	2,497,000	2.5	6,242,500	
72.50		0		0		W-8	2,288,250	2.5	5,720,625	
73.00		0		0		W-8	1,926,250	2.5	4,815,625	
73.50		0		0		W-8	1,787,250	2.5	4,468,125	
74.00		0		0		W-8	1,656,250	2.5	4,140,625	
74.50		0		0		W-8	1,485,000	2.5	3,712,500	
75.00		0		0		W-8	1,310,000	2.5	3,275,000	
75.50		0		0		W-8	1,147,500	2.5	2,868,750	
76.00		0		0		W-8	1,066,500	2.5	2,666,250	
76.50		0		0		W-8	975,750	2.5	2,439,375	
77.00		0		0		W-8	806,000	2.5	2,015,000	
77.50		0		0		W-8	638,250	2.5	1,595,625	
78.00		0		0		W-8	472,750	2.5	1,181,875	
78.50		0		0		W-8	309,250	2.5	773,125	
79.00		0		0		W-8	147,750	2.5	369,375	TOTALW-8
79.20		0		0		W-8	15,700	2.5	39,250	88,227,050
Zone V		928,950	6.0	5,573,700			88,227,050	7.2	633,270,725	
Zone I		357,780					53,846,820			
Zone II		13,573,258					138,663,993			
Zone III		73,644,306					60,510,944			
Zone IV		140,622,490					4,946,760			
Zone V		928,950					88,227,050			
Total=		229,126,784			229,126,784		346,195,567			346,195,567

Table III.2.1.1-6(c) Quantity of Excavation and Hauling Distance

HIGH RISE LOCK CANAL-150,000 D.W.T.-85'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH1585

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
-12.80		0		0		W-1	0		0	
-12.50		0		0		W-1	0	3.0	0	
-12.00		0		0		W-1	19,500	2.5	48,750	
-11.50		0		0		W-1	154,500	2.0	309,000	
-11.00		0		0		W-1	301,250	2.0	602,500	
-10.50		0		0		W-1	261,750	2.5	654,375	
-10.00		0		0		W-1	182,750	3.0	548,250	
-9.50		0		0		W-1	175,750	3.5	615,125	
-9.00		0		0		W-1	184,250	4.0	777,000	
-8.50		0		0		W-1	217,250	4.5	977,625	
-8.00		0		0		W-1	206,500	5.0	1,032,500	
-7.50		0		0		W-1	213,000	5.5	1,171,500	
-7.00		0		0		W-1	244,250	6.0	1,465,500	
-6.50		0		0		W-1	223,000	6.5	1,449,500	
-6.00		0		0		W-1	190,750	7.0	1,335,250	
-5.50		0		0		W-1	196,250	7.5	1,471,875	
-5.00		0		0		W-1	248,250	8.0	1,986,000	
-4.50		0		0		W-1	1,181,750	8.5	10,044,875	
-4.00		0		0		W-1	2,369,250	9.0	21,323,250	
-3.50		0		0		W-1	2,717,750	9.5	25,818,625	
-3.00		0		0		W-1	2,937,750	10.0	29,377,500	
-2.50		0		0		W-1	3,084,000	10.5	32,382,000	
-2.00		0		0		W-1	3,156,000	11.0	34,716,000	
-1.50		0		0		W-1	3,399,500	11.5	39,094,250	
-1.00		0		0		W-1	3,575,500	12.0	42,906,000	
-0.50		0		0		W-1	3,772,750	12.5	47,159,375	
0.00		0		0		W-1	3,832,250	13.0	49,819,250	
0.50		0		0		W-1	3,689,750	13.5	49,811,625	
1.00		0		0		W-1	3,738,750	14.0	52,342,500	
1.50		0		0		W-1	4,894,000	14.5	70,963,000	
2.00	D-1	321,701	2.5	804,251		W-1	1,235,400	15.0	18,530,993	
Zone I		321,701	2.5	804,251			46,613,400	11.6	538,733,993	
									0	
2.00	D-1	0	2.5	0		W-1	0	15.0	0	
2.50	D-1	0	2.5	0		W-1	0	15.5	0	
3.00	D-1	0	2.0	0		W-1	0	16.0	0	TOTAL W-1
3.50	D-1	0	2.5	0	TOTAL D-1	W-1	0	16.5	0	46,613,400
4.00	D-1	3,428	2.5	8,570	325,128	W-2	10,272	4.0	41,089	
4.50		0		0		W-2	19,750	4.0	79,000	
5.00		0		0		W-2	0	4.0	0	
5.50		0		0		W-2	0	4.5	0	
6.00		0		0		W-2	0	5.0	0	
6.50		0		0		W-2	0	5.5	0	
7.00		0		0		W-2	0	6.0	0	
7.50		0		0		W-2	0	6.5	0	
8.00		0		0		W-2	0	7.0	0	
8.50		0		0		W-2	5,500	7.5	41,250	
9.00		0		0		W-2	8,500	8.0	68,000	
9.50		0		0		W-2	83,750	8.5	711,875	
10.00		0		0		W-2	351,000	9.0	3,159,000	
10.50		0		0		W-2	561,500	9.5	5,334,250	
11.00		0		0		W-2	609,250	10.0	6,092,500	
11.50		0		0		W-2	631,000	10.5	6,625,500	
12.00		0		0		W-2	646,000	11.0	7,106,000	
12.50		0		0		W-2	715,250	12.0	8,583,000	
13.00		0		0		W-2	741,250	12.5	8,895,000	
13.50		0		0		W-2	690,750	13.0	8,634,375	
14.00		0		0		W-2	731,500	13.5	9,509,500	
14.50		0		0		W-2	925,500	14.0	12,494,250	
15.00		0		0		W-2	1,052,000	7.5	14,728,000	
15.50		0		0		W-2	1,065,000	8	8,520,000	
16.00		0		0		W-2	1,367,500	8.0	11,623,750	
16.50		0		0		W-2	1,370,000	8.5	12,330,000	
17.00		0		0		W-2	938,000	9.0	8,911,000	
17.50		0		0		W-2	1,569,250	9.5	15,692,500	
18.00		0		0		W-2	4,781,250	10.0	50,203,125	
18.50	D-2	3,361,922	1.5	5,042,883		W-2	4,011,578	10.5	44,127,361	
19.00	D-2	6,039,177	2.0	12,078,355	TOTAL D-2	W-2	955,073	11.0	10,983,337	
19.50	D-2	2,677,256	2.5	6,693,139	12,078,355	W-2	2,151,995	11.5	25,823,934	

HIGH RISE LOCK CANAL-150,000 D.W.T.-85'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH1585

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
20.00		0		0		W-2	2,670,000	12.0	33,375,000	
20.50		0		0		W-2	1,647,000	12.5	21,411,000	
21.00		0		0		W-2	2,898,250	13.0	39,126,375	
21.50		0		0		W-2	2,823,250	13.5	39,525,500	
22.00		0		0		W-2	944,500	14.0	13,695,250	
22.50		0		0		W-2	1,410,500	14.5	20,452,250	
23.00		0		0		W-2	1,443,750	15.0	21,656,250	
23.50		0		0		W-2	1,374,000	15.5	21,297,000	
24.00		0		0		W-2	1,359,000	16.0	21,744,000	
24.50		0		0		W-2	1,019,750	16.5	16,825,875	
25.00		0		0		W-2	1,140,500	17.0	19,388,500	
25.50		0		0		W-2	1,090,000	17.5	19,075,000	
26.00		0		0		W-2	1,527,250	18.0	27,490,500	
26.50		0		0		W-2	2,293,250	18.5	42,425,125	
27.00		0		0		W-2	2,490,250	19.0	47,314,750	
27.50		0		0		W-2	2,157,000	19.5	42,061,500	
28.00		0		0		W-2	1,759,000	20.0	35,180,000	
28.50		0		0		W-2	2,058,750	20.5	42,204,375	
29.00		0		0		W-2	2,692,250	21.0	56,537,250	
29.50		0		0		W-2	3,538,500	21.5	76,077,750	
30.00		0		0		W-2	3,722,500	22.0	81,895,000	
30.50		0		0		W-2	3,189,500	22.5	71,763,750	
31.00		0		0		W-2	3,262,500	23.0	75,037,500	
31.50		0		0		W-2	3,331,750	23.5	78,296,125	
32.00		0		0		W-2	3,417,500	24.0	82,020,000	
32.50		0		0		W-2	3,369,750	24.5	82,558,875	TOTAL W-2
33.00		0		0		W-2	2,497,500	25.0	62,437,500	87,120,168
33.50		0		0		W-3	2,751,750	24.0	66,042,000	
34.00		0		0		W-3	2,539,750	24.5	62,223,875	
34.50		0		0		W-3	1,397,750	25.0	34,943,750	
35.00		0		0		W-3	1,469,000	25.5	37,459,500	
35.50		0		0		W-3	1,445,750	26.0	37,589,500	
36.00		0		0		W-3	1,912,500	26.5	50,681,250	TOTAL W-3
36.50	D-3	436,061	2.5	1,090,153	TOTAL D-3	W-3	1,862,689	27.0	50,292,596	13,379,189
37.00	D-3	436,061	3.0	1,308,184	872,123	W-4	1,403,439	18.0	25,261,898	
37.50		0		0		W-4	1,579,750	18.5	29,225,375	
38.00		0		0		W-4	1,580,250	19.0	30,024,750	TOTAL W-4
38.50		0		0		W-4	2,046,250	19.5	39,901,875	6,609,689
39.00		0		0		W-5	2,032,250	17.5	35,564,375	
39.50		0		0		W-5	2,082,000	18.0	37,476,000	
40.00		0		0		W-5	3,133,000	18.5	57,960,500	
40.50		0		0		W-5	2,655,250	19.0	50,449,750	
41.00		0		0		W-5	1,662,000	20.0	33,240,000	
41.50		0		0		W-5	1,482,250	20.5	30,386,125	
42.00	D-4	0	3.0	0		W-5	1,710,500	21.0	35,920,500	
Zone II		12,953,905	2.0	26,221,282			121,866,295	18.2	2,215,833,214	
									0	
42.00	D-4	0	3.0	0			0	21.5	0	
42.50	D-4	870,547	3.5	3,046,915		W-5	1,831,769	22.0	40,298,918	
43.00	D-4	1,430,413	4.0	5,721,652		W-5	1,609,575	22.5	36,215,438	
43.50	D-4	559,865	3.5	1,959,528		W-5	2,267,909	23.0	52,161,907	
44.00	D-4	473,865	4.0	1,895,460		W-5	2,655,024	23.5	62,393,064	
44.50	D-4	982,386	4.5	4,420,737		W-5	1,884,219	24.0	45,221,256	TOTAL W-5
45.00	D-4	1,716,014	5.0	8,580,070	TOTAL D-4	W-5	1,743,925	24.5	42,726,163	26,749,671
45.50	D-4	3,785,633	4.0	15,142,532	9,818,723	W-6	2,100,695	19.5	40,963,553	
46.00	D-5	4,172,320	2.5	10,430,800		W-6	2,226,052	20.0	44,521,040	
46.50	D-5	3,285,941	2.0	6,571,882		W-6	2,457,589	20.5	50,380,575	
47.00	D-5	3,608,671	2.5	9,021,678		W-6	3,151,458	21.0	66,180,618	
47.50	D-5	3,860,097	3.0	11,580,291		W-6	3,847,681	21.5	82,725,142	
48.00	D-5	4,171,081	3.5	14,598,784		W-6	4,130,742	22.0	90,876,324	
48.50	D-5	6,221,995	2.5	15,554,988		W-6	2,363,898	22.5	53,187,705	
49.00	D-5	5,441,162	3.0	16,323,486	TOTAL D-5	W-6	1,805,499	23.0	41,526,477	
49.50	D-5	3,080,949	3.5	10,783,322	33,842,216	W-6	2,831,979	23.5	66,551,507	
50.00	D-6	4,212,314	4.5	18,955,413		W-6	2,708,368	24.0	65,000,832	
50.50	D-6	4,753,948	4.0	19,015,792		W-6	2,391,491	24.5	58,591,530	
51.00	D-6	5,649,898	4.5	25,424,541		W-6	3,658,686	25.0	91,467,150	TOTAL W-6
51.50	D-6	6,366,907	5.0	31,834,535		W-6	4,547,780	22.5	102,325,050	38,221,918
52.00	D-6	4,469,233	5.5	24,580,782		W-7	5,842,023	21.0	122,701,383	
Zone III		69,113,239	3.7	255,443,185			56,057,262	22.4	1,256,015,629	

HIGH RISE LOCK CANAL-150,000 D.W.T.-85°Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH1585

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
52.00	D-6	0	5.5	0	TOTAL D-6	W-7	0	21.5	0	
52.50	D-6	10,913,970	5.5	60,026,835	36,366,270	W-7	4,800,780	22.0	105,617,160	TOTAL W-7
53.00	D-7	14,871,250	4.5	66,920,625			0		0	10,643,703
53.50	D-7	9,992,500	4.0	39,970,000			0		0	
54.00	D-7	7,631,750	3.5	26,711,125			0		0	
54.50	D-7	6,759,500	4.0	27,038,000	TOTAL D-7		0		0	
55.00	D-7	5,371,250	4.5	24,170,625	44,626,250		0		0	
55.50	D-7	4,917,250	3.0	14,751,750			0		0	
56.00	D-8	8,807,000	2.5	22,017,500			0		0	
56.50	D-8	13,414,000	3.0	40,242,000			0		0	
57.00	D-8	16,644,500	3.5	58,255,750			0		0	
57.50	D-8	15,768,750	4.0	63,075,000			0		0	
58.00	D-8	8,963,250	3.5	31,371,375			0		0	
58.50	D-8	4,033,250	4.0	16,133,000	TOTAL D-8		0		0	
59.00	D-8	2,626,000	4.5	11,817,000	75,174,000		0		0	
59.50	D-8	2,814,000	4.5	12,663,000			0		0	
60.00	D-9	0	4.0	0			0		0	
Zone IV		133,528,220	3.9	515,163,585			4,800,780	22.0	105,617,160	
60.00	D-9	0	4.0	0			0		0	
60.50	D-9	0	4.5	0			0		0	
61.00	D-9	0	5.0	0			0		0	
61.50	D-9	0	5.5	0	TOTAL D-9		0		0	
62.00	D-9	777,300	6.0	4,663,800	3,591,300	W-8	352,950	13.5	4,764,825	
62.50		0		0		W-8	2,118,250	13.0	27,537,250	
63.00		0		0		W-8	3,652,000	12.5	45,650,000	
63.50		0		0		W-8	4,310,000	12.0	51,720,000	
64.00		0		0		W-8	3,144,000	11.5	36,156,000	
64.50		0		0		W-8	2,761,000	11.0	30,371,000	
65.00		0		0		W-8	3,577,250	10.5	37,561,125	
65.50		0		0		W-8	3,558,500	10.0	35,585,000	
66.00		0		0		W-8	3,571,500	9.5	33,929,250	
66.50		0		0		W-8	3,566,750	9.0	32,100,750	
67.00		0		0		W-8	3,815,500	8.5	32,431,750	
67.50		0		0		W-8	3,972,750	8.0	31,782,000	
68.00		0		0		W-8	3,758,750	7.5	28,190,625	
68.50		0		0		W-8	3,489,500	7.0	24,425,500	
69.00		0		0		W-8	2,956,750	6.5	19,218,875	
69.50		0		0		W-8	2,272,000	6.0	13,632,000	
70.00		0		0		W-8	2,314,750	2.5	5,786,875	
70.50		0		0		W-8	2,717,000	2.5	6,792,500	
71.00		0		0		W-8	2,402,000	2.5	6,005,000	
71.50		0		0		W-8	1,754,250	2.5	4,385,625	
72.00		0		0		W-8	1,546,250	2.5	3,865,625	
72.50		0		0		W-8	1,319,250	2.5	3,298,125	
73.00		0		0		W-8	926,250	2.5	2,315,625	
73.50		0		0		W-8	776,500	2.5	1,941,250	
74.00		0		0		W-8	636,000	2.5	1,590,000	
74.50		0		0		W-8	453,000	2.5	1,132,500	
75.00		0		0		W-8	267,000	2.5	667,500	
75.50		0		0		W-8	93,500	2.5	233,750	
76.00		0		0		W-8	7,500	2.5	18,750	
76.50		0		0		W-8	1,500	2.5	3,750	
77.00		0		0		W-8	0	2.5	0	
77.50		0		0		W-8	0	2.5	0	
78.00		0		0		W-8	0	2.5	0	
78.50		0		0		W-8	0	2.5	0	
79.00		0		0		W-8	0	2.5	0	TOTALW-8
79.20		0		0		W-8	0	2.5	0	66,092,200
Zone V		777,300	6.0	4,663,800			66,092,200	7.9	523,093,825	
Zone I		321,701					46,613,400			
Zone II		12,953,905					121,866,295			
Zone III		69,113,239					56,057,262			
Zone IV		133,528,220					4,800,780			
Zone V		777,300					66,092,200			
Total=		216,694,364			216,694,364		295,429,937			295,429,937

Table III.2.1.1-6(d) Quantity of Excavation and Hauling Distance

HIGH RISE LOCK CANAL-150,000 D.W.T.-90°Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH1590

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
-12.80		0		0		W-1	0		0	
-12.50		0		0		W-1	0	3.0	0	
-12.00		0		0		W-1	19,500	2.5	48,750	
-11.50		0		0		W-1	154,500	2.0	309,000	
-11.00		0		0		W-1	301,250	2.0	602,500	
-10.50		0		0		W-1	261,750	2.5	654,375	
-10.00		0		0		W-1	182,750	3.0	548,250	
-9.50		0		0		W-1	175,750	3.5	615,125	
-9.00		0		0		W-1	194,250	4.0	777,000	
-8.50		0		0		W-1	217,250	4.5	977,625	
-8.00		0		0		W-1	206,500	5.0	1,032,500	
-7.50		0		0		W-1	213,000	5.5	1,171,500	
-7.00		0		0		W-1	244,250	6.0	1,465,500	
-6.50		0		0		W-1	223,000	6.5	1,449,500	
-6.00		0		0		W-1	190,750	7.0	1,335,250	
-5.50		0		0		W-1	196,250	7.5	1,471,875	
-5.00		0		0		W-1	248,250	8.0	1,986,000	
-4.50		0		0		W-1	1,181,750	8.5	10,044,875	
-4.00		0		0		W-1	2,369,250	9.0	21,323,250	
-3.50		0		0		W-1	2,717,750	9.5	25,818,625	
-3.00		0		0		W-1	2,937,750	10.0	29,377,500	
-2.50		0		0		W-1	3,084,000	10.5	32,382,000	
-2.00		0		0		W-1	3,156,000	11.0	34,716,000	
-1.50		0		0		W-1	3,399,500	11.5	39,094,250	
-1.00		0		0		W-1	3,575,500	12.0	42,906,000	
-0.50		0		0		W-1	3,772,750	12.5	47,159,375	
0.00		0		0		W-1	3,832,250	13.0	49,819,250	
0.50		0		0		W-1	3,689,750	13.5	49,811,625	
1.00		0		0		W-1	3,738,750	14.0	52,342,500	
1.50		0		0		W-1	4,894,000	14.5	70,963,000	
2.00	D-1	321,701	2.5	804,251		W-1	1,235,400	15.0	18,530,993	
Zone I		321,701	2.5	804,251			46,613,400	11.6	538,733,993	
									0	
2.00	D-1	0	2.5	0		W-1	0	15.0	0	
2.50	D-1	0	2.5	0		W-1	0	15.5	0	
3.00	D-1	0	2.0	0		W-1	0	16.0	0	TOTAL W-1
3.50	D-1	0	2.5	0	TOTAL D-1	W-1	0	16.5	0	46,613,400
4.00	D-1	3,251	2.5	8,126	324,951	W-2	9,750	4.0	38,998	
4.50		0		0		W-2	18,750	4.0	75,000	
5.00		0		0		W-2	0	4.0	0	
5.50		0		0		W-2	0	4.5	0	
6.00		0		0		W-2	0	5.0	0	
6.50		0		0		W-2	0	5.5	0	
7.00		0		0		W-2	0	6.0	0	
7.50		0		0		W-2	0	6.5	0	
8.00		0		0		W-2	0	7.0	0	
8.50		0		0		W-2	5,250	7.5	39,375	
9.00		0		0		W-2	8,000	8.0	64,000	
9.50		0		0		W-2	79,500	8.5	675,750	
10.00		0		0		W-2	333,500	9.0	3,001,500	
10.50		0		0		W-2	533,500	9.5	5,068,250	
11.00		0		0		W-2	578,750	10.0	5,787,500	
11.50		0		0		W-2	599,250	10.5	6,292,125	
12.00		0		0		W-2	613,500	11.0	6,748,500	
12.50		0		0		W-2	679,500	12.0	8,154,000	
13.00		0		0		W-2	704,250	12.5	8,451,000	
13.50		0		0		W-2	656,250	13.0	8,203,125	
14.00		0		0		W-2	685,000	13.5	9,035,000	
14.50		0		0		W-2	879,250	14.0	11,869,875	
15.00		0		0		W-2	999,500	7.5	13,993,000	
15.50		0		0		W-2	1,011,750	8	8,094,000	
16.00		0		0		W-2	1,299,000	8.0	11,041,500	
16.50		0		0		W-2	1,301,500	8.5	11,713,500	
17.00		0		0		W-2	891,250	9.0	8,466,875	
17.50		0		0		W-2	1,491,000	9.5	14,910,000	
18.00		0		0		W-2	4,542,250	10.0	47,693,625	
18.50	D-2	3,183,815	1.5	4,790,722		W-2	3,810,935	10.5	41,920,291	
19.00	D-2	5,737,187	2.0	11,474,373	TOTAL D-2	W-2	997,314	11.0	10,434,105	
19.50	D-2	2,543,372	2.5	6,358,430	11,474,373	W-2	2,044,378	11.5	24,532,536	

HIGH RISE LOCK CANAL-150,000 D.W.T.-90'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH1590

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
20.00		0		0		W-2	2,536,500	12.0	31,706,250	
20.50		0		0		W-2	1,564,750	12.5	20,341,750	
21.00		0		0		W-2	2,753,500	13.0	37,172,250	
21.50		0		0		W-2	2,682,250	13.5	37,551,500	
22.00		0		0		W-2	897,250	14.0	13,010,125	
22.50		0		0		W-2	1,339,750	14.5	19,426,375	
23.00		0		0		W-2	1,371,500	15.0	20,572,500	
23.50		0		0		W-2	1,305,250	15.5	20,231,375	
24.00		0		0		W-2	1,291,000	16.0	20,656,000	
24.50		0		0		W-2	968,750	16.5	15,984,375	
25.00		0		0		W-2	1,083,500	17.0	18,419,500	
25.50		0		0		W-2	1,035,500	17.5	18,121,250	
26.00		0		0		W-2	1,450,750	18.0	26,113,500	
26.50		0		0		W-2	2,178,500	18.5	40,302,250	
27.00		0		0		W-2	2,365,750	19.0	44,949,250	
27.50		0		0		W-2	2,049,250	19.5	39,960,375	
28.00		0		0		W-2	1,671,000	20.0	33,420,000	
28.50		0		0		W-2	1,955,750	20.5	40,092,875	
29.00		0		0		W-2	2,557,750	21.0	53,712,750	
29.50		0		0		W-2	3,361,750	21.5	72,277,625	
30.00		0		0		W-2	3,536,500	22.0	77,803,000	
30.50		0		0		W-2	3,030,000	22.5	68,175,000	
31.00		0		0		W-2	3,099,250	23.0	71,282,750	
31.50		0		0		W-2	3,165,000	23.5	74,377,500	
32.00		0		0		W-2	3,246,500	24.0	77,916,000	
32.50		0		0		W-2	3,201,250	24.5	78,430,625	TOTAL W-2
33.00		0		0		W-2	2,372,750	25.0	59,318,750	82,764,127
33.50		0		0		W-3	2,614,250	24.0	62,742,000	
34.00		0		0		W-3	2,412,750	24.5	59,112,375	
34.50		0		0		W-3	1,327,750	25.0	33,193,750	
35.00		0		0		W-3	1,395,500	25.5	35,585,250	
35.50		0		0		W-3	1,373,500	26.0	35,711,000	
36.00		0		0		W-3	1,816,750	26.5	48,143,875	TOTAL W-3
36.50	D-3	414,274	2.5	1,035,684	TOTAL D-3	W-3	1,769,476	27.0	47,775,859	12,709,976
37.00	D-3	414,274	3.0	1,242,821	828,548	W-4	1,333,226	18.0	23,998,073	
37.50		0		0		W-4	1,500,750	18.5	27,763,875	
38.00		0		0		W-4	1,501,250	19.0	28,523,750	TOTAL W-4
38.50		0		0		W-4	1,944,000	19.5	37,908,000	6,279,226
39.00		0		0		W-5	1,930,750	17.5	33,788,125	
39.50		0		0		W-5	1,978,000	18.0	35,604,000	
40.00		0		0		W-5	2,976,500	18.5	55,065,250	
40.50		0		0		W-5	2,522,500	19.0	47,927,500	
41.00		0		0		W-5	1,578,750	20.0	31,575,000	
41.50		0		0		W-5	1,408,000	20.5	28,864,000	
42.00	D-4	0	3.0	0		W-5	1,625,000	21.0	34,125,000	
Zone II		12,306,171	2.0	24,910,157			115,772,829	18.2	2,105,035,611	
42.00	D-4	0	3.0	0					0	
42.50	D-4	819,004	3.5	2,866,514			0	21.5	0	
43.00	D-4	1,345,760	4.0	5,383,040		W-5	1,717,708	22.0	37,789,576	
43.50	D-4	526,756	3.5	1,843,646		W-5	1,509,362	22.5	33,960,645	
44.00	D-4	445,772	4.0	1,783,088		W-5	2,126,653	23.0	48,913,019	
44.50	D-4	924,206	4.5	4,158,927		W-5	2,489,534	23.5	58,504,049	
45.00	D-4	1,614,456	5.0	8,072,280	TOTAL D-4	W-5	1,766,814	24.0	42,403,536	TOTAL W-5
45.50	D-4	3,561,528	4.0	14,246,112	9,237,482	W-5	1,635,352	24.5	40,066,124	25,264,923
46.00	D-5	3,925,292	2.5	9,813,230		W-6	1,969,870	19.5	38,412,465	
46.50	D-5	3,091,369	2.0	6,182,738		W-6	2,087,399	20.0	41,747,980	
47.00	D-5	3,395,009	2.5	8,487,523		W-6	2,304,498	20.5	47,242,209	
47.50	D-5	3,631,538	3.0	10,894,614		W-6	2,955,162	21.0	62,058,402	
48.00	D-5	3,924,012	3.5	13,734,042		W-6	3,608,005	21.5	77,572,108	
48.50	D-5	5,853,405	2.5	14,633,513		W-6	3,873,349	22.0	85,213,678	
49.00	D-5	5,118,819	3.0	15,356,457	TOTAL D-5	W-6	2,216,570	22.5	49,872,825	
49.50	D-5	2,898,485	3.5	10,144,698	31,837,929	W-6	1,692,960	23.0	38,938,080	
50.00	D-6	3,962,850	4.5	17,832,825		W-6	2,655,533	23.5	62,405,026	
50.50	D-6	4,472,330	4.0	17,889,320		W-6	2,539,648	24.0	60,951,552	
51.00	D-6	5,315,318	4.5	23,918,931		W-6	2,242,457	24.5	54,940,197	
51.50	D-6	5,989,896	5.0	29,949,480		W-6	3,430,765	25.0	85,769,125	TOTAL W-6
52.00	D-6	4,205,807	5.5	23,131,939		W-6	4,264,483	22.5	95,950,868	35,840,699
Zone III		65,021,612	3.7	240,322,915		W-7	5,481,266	21.0	115,106,586	
							52,567,388	22.4	1,177,818,048	

HIGH RISE LOCK CANAL-150,000 D.V.T.-90'Case

QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE

File Name HAUH1590

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
									0	
52.00	D-6	0	5.5	0	TOTAL D-6	W-7	0	21.5	0	TOTAL W-7
52.50	D-6	10,368,340	5.5	57,025,870	34,314,541	W-7	4,560,660	22.0	100,334,520	10,041,926
53.00	D-7	14,127,750	4.5	63,574,875			0		0	
53.50	D-7	9,492,750	4.0	37,971,000			0		0	
54.00	D-7	7,250,000	3.5	25,375,000			0		0	
54.50	D-7	6,421,500	4.0	25,686,000	TOTAL D-7		0		0	
55.00	D-7	5,102,750	4.5	22,962,375	42,394,750		0		0	
55.50	D-8	4,671,500	3.0	14,014,500			0		0	
56.00	D-8	8,366,750	2.5	20,916,875			0		0	
56.50	D-8	12,743,250	3.0	38,229,750			0		0	
57.00	D-8	15,812,250	3.5	55,342,875			0		0	
57.50	D-8	14,980,250	4.0	59,921,000			0		0	
58.00	D-8	8,515,000	3.5	29,802,500			0		0	
58.50	D-8	3,831,500	4.0	15,326,000	TOTAL D-8		0		0	
59.00	D-8	2,484,500	4.5	11,225,250	71,415,000		0		0	
59.50	D-9	2,673,250	4.5	12,029,625			0		0	
60.00	D-9	0	4.0	0			0		0	
Zone IV		126,851,340	3.9	489,403,495			4,560,660	22.0	100,334,520	
									0	
60.00	D-9	0	4.0	0			0		0	
60.50	D-9	0	4.5	0			0		0	
61.00	D-9	0	5.0	0			0		0	
61.50	D-9	0	5.5	0	TOTAL D-9		0		0	
62.00	D-9	777,300	6.0	4,663,800	3,450,550	W-8	352,950	13.5	4,764,825	
62.50		0		0		W-8	2,118,250	13.0	27,537,250	
63.00		0		0		W-8	3,652,000	12.5	45,650,000	
63.50		0		0		W-8	4,310,000	12.0	51,720,000	
64.00		0		0		W-8	3,144,000	11.5	36,156,000	
64.50		0		0		W-8	2,761,000	11.0	30,371,000	
65.00		0		0		W-8	3,576,000	10.5	37,548,000	
65.50		0		0		W-8	3,557,250	10.0	35,572,500	
66.00		0		0		W-8	3,571,500	9.5	33,929,250	
66.50		0		0		W-8	3,566,750	9.0	32,100,750	
67.00		0		0		W-8	3,815,500	8.5	32,431,750	
67.50		0		0		W-8	3,972,750	8.0	31,782,000	
68.00		0		0		W-8	3,758,750	7.5	28,190,625	
68.50		0		0		W-8	3,489,500	7.0	24,426,500	
69.00		0		0		W-8	2,956,750	6.5	19,218,875	
69.50		0		0		W-8	2,272,000	6.0	13,632,000	
70.00		0		0		W-8	2,314,750	2.5	5,786,875	
70.50		0		0		W-8	2,717,000	2.5	6,792,500	
71.00		0		0		W-8	2,402,000	2.5	6,005,000	
71.50		0		0		W-8	1,754,250	2.5	4,385,625	
72.00		0		0		W-8	1,546,250	2.5	3,865,625	
72.50		0		0		W-8	1,319,250	2.5	3,298,125	
73.00		0		0		W-8	926,250	2.5	2,315,625	
73.50		0		0		W-8	776,500	2.5	1,941,250	
74.00		0		0		W-8	636,000	2.5	1,590,000	
74.50		0		0		W-8	453,000	2.5	1,132,500	
75.00		0		0		W-8	267,000	2.5	667,500	
75.50		0		0		W-8	93,500	2.5	233,750	
76.00		0		0		W-8	7,500	2.5	18,750	
76.50		0		0		W-8	0	2.5	0	
		0		0		W-8	0	2.5	0	
		0		0		W-8	0	2.5	0	
		0		0		W-8	0	2.5	0	
		0		0		W-8	0	2.5	0	
		0		0		W-8	0	2.5	0	TOTAL W-8
		0		0		W-8	0	2.5	0	66,088,200
Zone V		777,300	6.0	4,663,800			66,088,200	7.9	523,064,450	
Zone I		321,701					46,613,400			
Zone II		12,306,171					115,772,829			
Zone III		65,021,612					52,567,388			
Zone IV		126,851,340					4,560,660			
Zone V		777,300					66,088,200			
Total=		205,278,124			205,278,124		285,602,477			285,602,477

(5) Excavation Method

1) Atlantic Approach Zone (Zone I 14.8 km)

a. Sequence of dredging 1 ——> 2

b. Shifting of navigation channel

A (Existing) ——> B ——> A

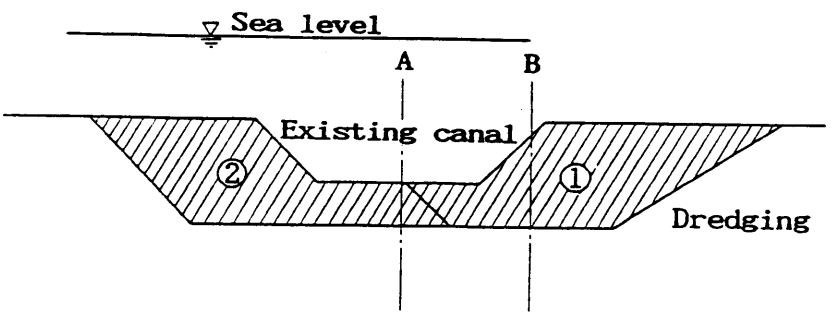


Fig. III.2.1.1 - 1(a)Excavation of Zone I

c. Dredging

- Clayey	Trailing Hopper	19,000 HP
	Grab Dredger	$50m^3$
- Loose	Trailing Hopper	19,000 HP
	Grab Dredger	$50m^3$
- Weathered Rock	Cutter Suction Dredger	27,500 HP

2) Gatun Lake Zone (Zone II 40 km)

a. Sequence of dredging 1 ——> 2

b. Shifting of navigation channel

a (Existing) ——> b ——> c

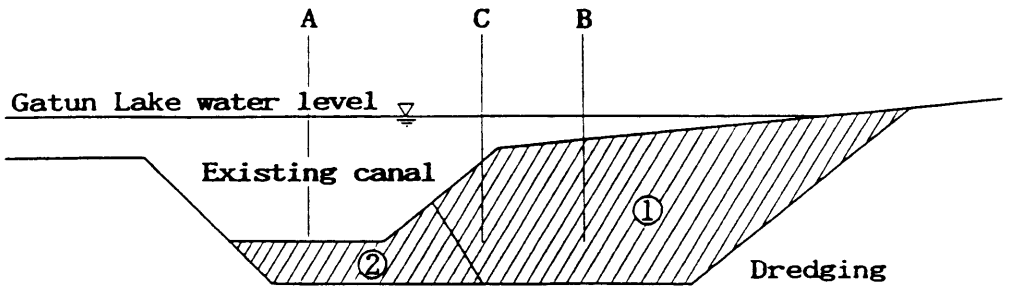


Fig. III. 2.1.1 - 2 Excavation of Zone II

c. Dredging

- Clayey	Grab Dredger	($50m^3$)
- Loose	Cutter Suction Dredger	27,500 HP
- Weathered Rock	Cutter Suction Dredger	27,500 HP
- Medium Hard Rock	Cutter Suction Dredger	27,500 HP

3) Culebura Cut Zone (Zone III 10 km)

a. Sequence of Excavation
1 (Dry) ——> 2, 3 (Dry-Blasting) ——> 3, 4 (Dredging)

- After completion of overburden excavation, areas 1, 2, 3 (Hard Rock) are blasted.

- Excavation 2 is carried out by excavator down to a level where a dredging vessel can pass through.

- Excavation 3 (first) and 4 (second) are done by dredging.

b. Shifting of navigation channel

A (Existing) ——> B ——> C

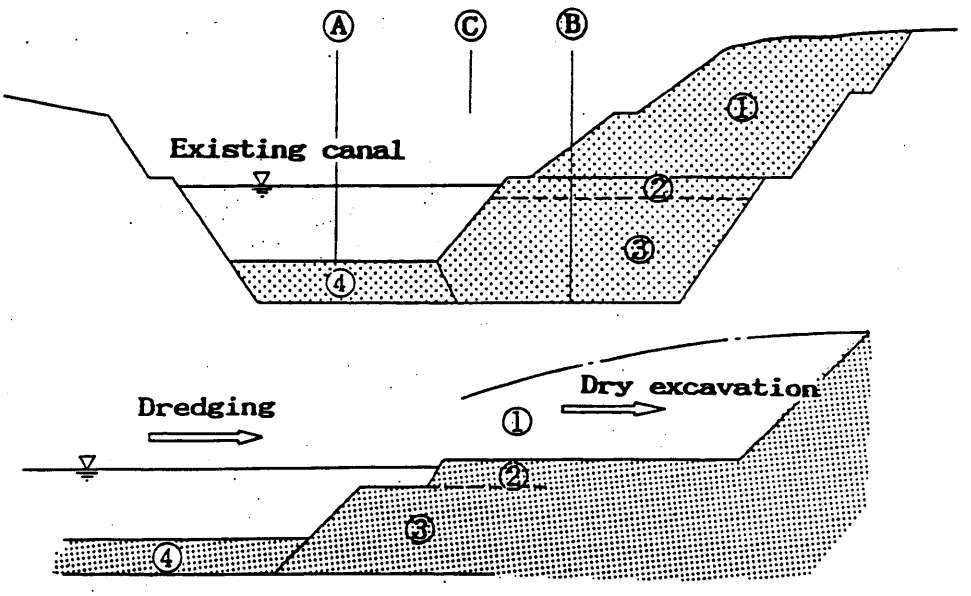


Fig. III. 2.1.1 - 3 Excavation of Zone III

c. Dredging

- Clayey	Grab Dredger	($50m^3$)
- Loose	Cutter Suction Dredger 27,500 HP	
- Weathered Rock	Cutter Suction Dredger 27,500 HP	
- Medium Hard Rock	Cutter Suction Dredger 27,500 HP	
- Hard Rock	Grab Dredger Blasting Barge	($50m^3$)

4) Miraflores Zone (Zone IV 8 km)

a. Sequence of Dredging 1 (Dry)

b. Shifting of Navigation Cannel

New canal is separated from existing canal. (No shifting is required)

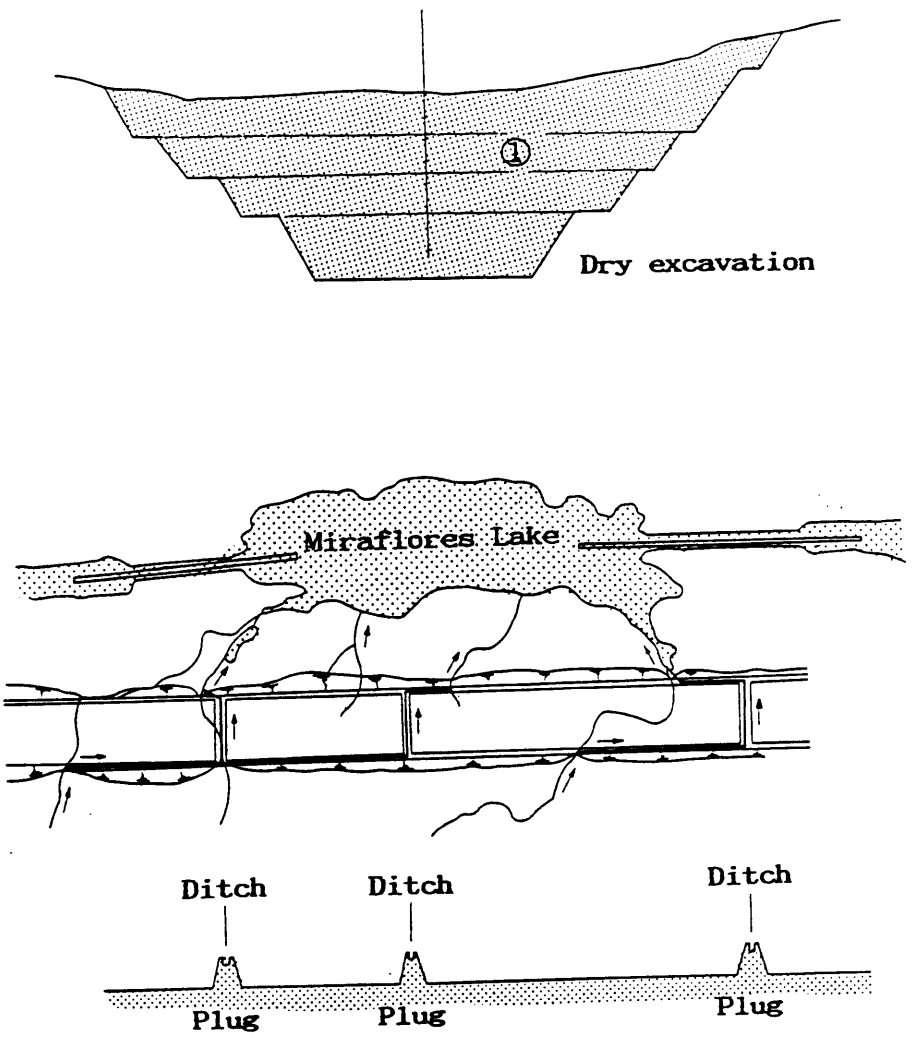


Fig. III. 2.1.1. - 4 Excavation of Zone IV

5) Pacific Approach (Zone I 19.2 km)

a. Sequence of dredging 1 ——> 2

b. Shifting of navigation channel

A (Existing) ——> B ——> C

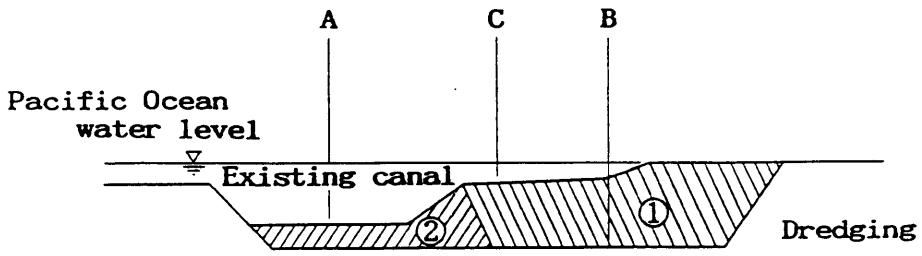


Fig. III. 2.1.1. - 5 Excavation of Zone V

c. Dredging

- Clayey	Trailing Hopper 19,000 HP Grub Dredger 50 m^3
- Loose	Trailing Hopper 19,000 HP Grub Dredger 50 m^3
- Weathered Rock	Cutter Suction Dredger 27,500 HP
- Medium Hard Rock	Cutter Suction Dredger 27,500 HP

(6) Construction Scheme for Excavation

Following Table III. 2.1.1 - 7(a) to III.2.1.1 - 8(d) show construction scheme for respective type of excavation.

Table No.	Description	Type of Excavation
III. 2.1.1 - 7(a)	200,000 DWT - 85'	Dry
III. 2.1.1 - 7(b)	200,000 DWT - 85'	Dredging
III. 2.1.1 - 7(c)	150,000 DWT - 85'	Dry
III. 2.1.1 - 7(d)	150,000 DWT - 85'	Dredging
III. 2.1.1 - 8(a)	200,000 DWT - 90'	Dry
III. 2.1.1 - 8(b)	200,000 DWT - 90'	Dredging
III. 2.1.1 - 8(c)	150,000 DWT - 90'	Dry
III. 2.1.1 - 8(d)	150,000 DWT - 90'	Dredging

Table III. 2. 1. 1-7(a)
CONSTRUCTION SCHEME FOR EXCAVATION
HIGH RISE LOCK CANAL 200,000 D. W. T. -85'

File:PLANHIGH

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DRY EXCAVATION	COMMON	Q'TY(m3)	m3	141,000	996,000	13,006,000	15,732,000	125,000	30,000,000
		HAULING DISTANCE(km)	km	2.5	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	2	2	2	4	1	
		BULLDOZER(98Ton)	nos.	10.46	10.46	10.46	20.92	5.23	
		SHOVEL(30m3)	nos.	2.00	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240Ton)	nos.	18.32	15.38	27.10	54.20	19.40	
		BULLDOZER(98Ton)	nos.	5.30	5.30	5.30	10.60	2.65	
		CAPACITY(m3/hr.)	m3/hr.	5,258	5,258	5,258	10,516	2,629	
		CAPACITY(m3/day)	m3/day	94,644	94,644	94,644	189,288	47,322	
		REQUIRED DAYS	days	2	11	138	84	3	
		REQUIRED YEARS(254days/year)	years	0.1	0.1	0.6	0.4	0.1	
	WEATHERED ROCK	Q'TY(m3)	m3	216,000	7,000,000	47,544,000	66,801,000	458,000	122,019,000
		HAULING DISTANCE(km)	km	2.5	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	2	2	2	4	1	
		BULLDOZER(98Ton)	nos.	18.12	18.12	18.12	36.24	9.06	
		SHOVEL(30m3)	nos.	2.00	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	16.30	13.74	23.98	47.96	17.11	
		BULLDOZER(98Ton)	nos.	5.54	5.54	5.54	11.08	2.71	
		CAPACITY(m3/hr.)	m3/hr.	3,714	3,714	3,714	7,428	1,857	
		CAPACITY(m3/day)	m3/day	66,852	66,852	66,852	133,704	33,426	
		REQUIRED DAYS	days	4	105	712	500	14	
		REQUIRED YEARS(254days/year)	years	0.1	0.5	2.9	2	0.1	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	0	6,291,000	15,876,000	45,844,000	346,000	68,357,000
		HAULING DISTANCE(km)	km	0	2.0	4.0	3.0	6.0	
		EQUIPMENT	group	0	2	2	4	1	
		BULLDOZER(98Ton)	nos.	0	18.12	18.12	36.24	9.06	
		SHOVEL(30m3)	nos.	0	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240Ton)	nos.	0	13.74	23.98	47.96	17.11	
		BULLDOZER(98Ton)	nos.	0	5.42	5.42	10.84	2.71	
		CAPACITY(m3/hr.)	m3/hr.	0	3,714	3,714	7,428	1,857	
		CAPACITY(m3/day)	m3/day	0	66,852	66,852	133,704	33,426	
		REQUIRED DAYS	days	0	95	238	343	11	
		REQUIRED YEARS(254days/year)	years	0	0.4	1	1.4	0.1	
	HARD ROCK	Q'TY(m3)	m3	0	0	1,764,000	19,647,000	0	21,411,000
		HAULING DISTANCE(km)	km	0	0	4.0	4.0	0	
		EQUIPMENT	group	0	0	2	4	0	
		CRAWLER DRILL(32Ton-225mm)	nos.	0	0	4.20	8.40	0	
		BULLDOZER(98Ton)	nos.	0	0	11.08	22.16	0	
		SHOVEL(30m3)	nos.	0	0	2.00	4.00	0	
		DUMP TRUCK(240ton)	nos.	0	0	20.88	41.76	0	
		BULLDOZER(98Ton)	nos.	0	0	5.56	11.12	0	
		CAPACITY(m3/hr.)	m3/hr.	0	0	2,804	5,608	0	
		CAPACITY(m3/day)	m3/day	0	0	50,472	100,944	0	
		REQUIRED DAYS	days	0	0	35	195	0	
		REQUIRED YEARS(254days/year)	years	0	0	0.2	0.8	0	
	TOTAL VOL. OF DRY EXCAVATION		m3	357,000	14,287,000	78,190,000	148,024,000	929,000	241,787,000
	TOTAL OF REQUIRED YEARS		years	0.2	1.0	4.7	4.6	0.3	

Table III.2.1.1-7(b)
CONSTRUCTION SCHEME FOR EXCAVATION
HIGH RISE LOCK CANAL 200,000 D.W.T.-85'

File:PLNEXCHW

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DREDGING	COMMON (CLAYEY)	Q'TY(m3)	m3	3,954,000	42,856,000	2,725,000	108,000	11,514,000	61,157,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	7.5	
		EQUIPMENT	group	1	2	1	1	1	
		GRAB(50m3)	fleet	1.0	2.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	2.0	6.0	3.0	3.0	2.0	
		PUSHER TUG(3,200HP)	unit	1.0	4.0	2.0	2.0	1.0	
		REQUIRED PERIOD	year	0.6	3.4	0.6	0.0	1.8	
		CAPACITY(m3/hr)	m3/hr	1,200	2,400	840	840	1,200	
		CAPACITY(m3/year)	m3/year	6,384,000	12,768,000	4,468,800	4,468,800	6,384,000	
		Q'TY(m3)	m3	3,954,000				11,514,000	15,468,000
		HAULING DISTANCE(km)	km	17.0				12.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000m3)	unit	1.0				1.0	
		REQUIRED PERIOD	year	0.4				1.0	
		CAPACITY(m3/hr)	m3/hr	1,657				2,077	
		CAPACITY(m3/year)	m3/year	8,815,240				11,049,640	
	COMMON (LOOSE)	Q'TY(m3)	m3	9,343,500	42,097,000	3,765,000	94,000	13,953,500	69,253,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	7.5	
		EQUIPMENT	group	1	2	1	1	1	
		CUTTER(18,000HP)	fleet	1.0	2.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	3.0	6.0	3.0	3.0	2.0	
		PUSHER TUG(3,200HP)	unit	2.0	4.0	2.0	2.0	1.0	
		REQUIRED PERIOD	year	1.0	2.3	0.6	0.0	1.5	
		CAPACITY(m3/hr)	m3/hr	1,755	3,510	1,229	1,229	1,755	
		CAPACITY(m3/year)	m3/year	9,336,600	18,673,200	6,535,620	6,535,620	9,336,600	
		Q'TY(m3)	m3	9,343,500				13,953,500	23,297,000
		HAULING DISTANCE(km)	km	17.0				12.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000m3)	unit	1.0				1.0	
		REQUIRED PERIOD	year	1.0				1.2	
		CAPACITY(m3/hr)	m3/hr	1,827				2,270	
		CAPACITY(m3/year)	m3/year	9,719,640				12,076,400	
	WEATHERED ROCK	Q'TY(m3)	m3	27,194,000	43,667,000	28,984,000	752,000	36,917,000	137,514,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	7.5	
		EQUIPMENT	group	1	2	1	1	2	
		CUTTER(27,500HP)	fleet	1.0	2.0	1.0	1.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	6.0	3.0	3.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	4.0	2.0	2.0	2.0	
		REQUIRED PERIOD	year	3.8	3.0	5.8	0.1	2.6	
		CAPACITY(m3/hr)	m3/hr	1,350	2,700	945	945	2,700	
		CAPACITY(m3/year)	m3/year	7,182,000	14,364,000	5,027,400	5,027,400	14,364,000	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	58,000	17,344,000	26,050,000	2,976,000	376,000	46,804,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	7.5	
		EQUIPMENT	group	2	2	2	1	1	
		CUTTER(27,500HP)	fleet	2.0	2.0	2.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	4.0	4.0	4.0	2.0	2.0	
		PUSHER TUG(3,200HP)	unit	2.0	2.0	2.0	1.0	1.0	
		REQUIRED PERIOD	year	0.0	2.4	5.2	1.2	0.1	
		CAPACITY(m3/hr)	m3/hr	1,350	1,350	945	472	675	
		CAPACITY(m3/year)	m3/year	7,182,000	7,182,000	5,027,400	2,513,700	3,591,000	
	HARD ROCK	Q'TY(m3)	m3			2,895,000	1,276,000	0	4,171,000
		HAULING DISTANCE(km)	km	0.0	0.0	22.5	22.0	0.0	
		EQUIPMENT	group	0	0	1	1	0	
		BLASTING BARGE	fleet	0.0	0.0	1.0	1.0	0.0	
		GRAB(50m3)	fleet	0.0	0.0	1.0	1.0	0.0	
		SPLIT BARGE(1,500m3)	unit	0.0	0.0	3.0	2.0	0.0	
		PUSHER TUG(1,300HP)	unit	0.0	0.0	2.0	1.0	0.0	
		REQUIRED PERIOD	year	0.0	0.0	2.7	1.2	0.0	
		CAPACITY(m3/hr)	m3/hr	0	0	203	203	0	
		CAPACITY(m3/year)	m3/year	0	0	1,079,960	1,079,960	0	
	TOTAL VOL. OF DREDGING		m3	53,847,000	145,964,000	64,419,000	5,206,000	88,228,000	357,664,000
	TOTAL OF REQUIRED YEARS		years	4.3	3.9	6.3	1.7	3.1	

Table III. 2. 1. 1-7(c)
CONSTRUCTION SCHEME FOR EXCAVATION
HIGH RISE LOCK CANAL 150,000 D.W.T. -85'

File:PLANHIGH

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DRY EXCAVATION	COMMON	Q'TY(m3)	m3	181,000	984,000	11,979,000	14,073,000	184,000	26,647,000
		HAULING DISTANCE(km)	km	2.5	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	2	2	2	4	1	
		BULLDOZER(98ton)	nos.	10.46	10.46	10.46	20.92	5.23	
		SHOVEL(30m3)	nos.	2.00	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	18.32	15.38	27.10	54.20	19.40	
		BULLDOZER(98ton)	nos.	5.30	5.30	5.30	10.60	2.65	
		CAPACITY(m3/hr.)	m3/hr.	5,258	5,258	5,258	10,516	2,629	
		CAPACITY(m3/day)	m3/day	94,644	94,644	94,644	189,288	47,322	
		REQUIRED DAYS	days	2	10	121	75	3	
		REQUIRED YEARS(254days/year)	years	0.1	0.1	0.5	0.3	0.1	
	WEATHERED ROCK	Q'TY(m3)	m3	195,000	6,373,000	41,952,000	59,971,000	383,000	108,874,000
		HAULING DISTANCE(km)	km	2.5	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	2	2	2	4	1	
		BULLDOZER(98ton)	nos.	18.12	18.12	18.12	36.24	9.06	
		SHOVEL(30m3)	nos.	2.00	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	16.30	13.74	23.98	47.96	17.11	
		BULLDOZER(98ton)	nos.	5.54	5.54	5.54	11.08	2.71	
		CAPACITY(m3/hr.)	m3/hr.	3,714	3,714	3,714	7,428	1,857	
		CAPACITY(m3/day)	m3/day	66,852	66,852	66,852	133,704	33,426	
		REQUIRED DAYS	days	3	96	628	449	12	
		REQUIRED YEARS(254days/year)	years	0.1	0.4	2.5	1.8	0.1	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	0	5,677,000	14,204,000	41,640,000	290,000	61,811,000
		HAULING DISTANCE(km)	km	0	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	0	2	2	4	1	
		BULLDOZER(98ton)	nos.	0	18.12	18.12	36.24	9.06	
		SHOVEL(30m3)	nos.	0	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	0	13.74	23.98	47.96	17.11	
		BULLDOZER(98ton)	nos.	0	5.42	5.42	10.84	2.71	
		CAPACITY(m3/hr.)	m3/hr.	0	3,714	3,714	7,428	1,857	
		CAPACITY(m3/day)	m3/day	0	66,852	66,852	133,704	33,426	
		REQUIRED DAYS	days	0	85	213	312	9	
		REQUIRED YEARS(254days/year)	years	0	0.4	0.9	1.3	0.1	
	HARD ROCK	Q'TY(m3)	m3	0	0	1,578,000	17,845,000	0	19,423,000
		HAULING DISTANCE(km)	km	0	0	4.0	4.0	0	
		EQUIPMENT	group	0	0	2	4	0	
		CRAWLER DRILL(32ton-225mm)	nos.	0	0	4.20	8.40	0	
		BULLDOZER(98ton)	nos.	0	0	11.08	22.16	0	
		SHOVEL(30m3)	nos.	0	0	2.00	4.00	0	
		DUMP TRUCK(240ton)	nos.	0	0	20.88	41.76	0	
		BULLDOZER(98ton)	nos.	0	0	5.56	11.12	0	
		CAPACITY(m3/hr.)	m3/hr.	0	0	2,804	5,608	0	
		CAPACITY(m3/day)	m3/day	0	0	50,472	100,944	0	
		REQUIRED DAYS	days	0	0	32	177	0	
		REQUIRED YEARS(254days/year)	years	0	0	0.2	0.7	0	
	TOTAL VOL. OF DRY EXCAVATION		m3	322,000	12,954,000	69,113,000	133,529,000	777,000	216,695,000
	TOTAL OF REQUIRED YEARS		years	0.2	0.9	4.1	4.1	0.3	

Table III.2.1.1-7(d)
CONSTRUCTION SCHEME FOR EXCAVATION
HIGH RISE LOCK CANAL 150,000 D.W.T.-85'

File:PLNEXCHW

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DREDGING	COMMON (CLAYEY)	Q'TY(m3)	m3	3,431,000	34,480,000	2,382,000	100,000	6,978,000	47,371,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	8.0	
		EQUIPMENT	group	1	2	1	1	1	
		GRAB(50m3)	fleet	1.0	2.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	2.0	6.0	3.0	3.0	2.0	
		PUSHER TUG(3,200HP)	unit	1.0	4.0	2.0	2.0	1.0	
		REQUIRED PERIOD	year	0.5	2.7	0.5	0.0	1.1	
		CAPACITY(m3/hr)	m3/hr	1,200	2,400	840	840	1,200	
		CAPACITY(m3/year)	m3/year	6,384,000	12,768,000	4,468,800	4,468,800	6,384,000	
		Q'TY(m3)	m3	3,431,000				6,978,000	10,409,000
		HAULING DISTANCE(km)	km	17.0				12.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000m3)	unit	1.0				1.0	
		REQUIRED PERIOD	year	0.4				0.6	
		CAPACITY(m3/hr)	m3/hr	1,657				2,077	
		CAPACITY(m3/year)	m3/year	8,815,240				11,049,640	
	COMMON (LOOSE)	Q'TY(m3)	m3	8,094,500	35,526,000	3,232,000	87,000	10,621,000	57,560,500
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	8.0	
		EQUIPMENT	group	1	2	1	1	1	
		CUTTER(18,000HP)	fleet	1.0	2.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	3.0	6.0	3.0	3.0	2.0	
		PUSHER TUG(3,200HP)	unit	2.0	4.0	2.0	2.0	1.0	
		REQUIRED PERIOD	year	0.9	1.9	0.5	0.0	1.1	
		CAPACITY(m3/hr)	m3/hr	1,755	3,510	1,229	1,229	1,755	
		CAPACITY(m3/year)	m3/year	9,336,600	18,673,200	6,535,620	6,535,620	9,336,600	
		Q'TY(m3)	m3	8,094,600				10,621,000	18,715,500
		HAULING DISTANCE(km)	km	17.0				12.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000m3)	unit	1.0				1.0	
		REQUIRED PERIOD	year	0.8				0.9	
		CAPACITY(m3/hr)	m3/hr	1,827				2,270	
		CAPACITY(m3/year)	m3/year	9,719,640				12,076,400	
	WEATHERED ROCK	Q'TY(m3)	m3	23,610,000	37,268,000	25,040,000	693,000	30,569,000	117,080,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	8.0	
		EQUIPMENT	group	1	2	1	1	2	
		CUTTER(27,500HP)	fleet	1.0	2.0	1.0	1.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	6.0	3.0	3.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	4.0	2.0	2.0	2.0	
		REQUIRED PERIOD	year	3.3	2.6	5.0	0.1	2.1	
		CAPACITY(m3/hr)	m3/hr	1,350	2,700	945	945	2,700	
		CAPACITY(m3/year)	m3/year	7,182,000	14,364,000	5,027,400	5,027,400	14,364,000	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	52,000	14,592,000	22,863,000	2,745,000	326,000	40,578,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	8.0	
		EQUIPMENT	group	1	2	2	1	1	
		CUTTER(27,500HP)	fleet	1.0	2.0	2.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	2.0	4.0	4.0	2.0	2.0	
		PUSHER TUG(3,200HP)	unit	1.0	2.0	2.0	1.0	1.0	
		REQUIRED PERIOD	year	0.0	2.0	4.5	1.1	0.1	
		CAPACITY(m3/hr)	m3/hr	675	1,350	945	472	675	
		CAPACITY(m3/year)	m3/year	3,591,000	7,182,000	5,027,400	2,513,700	3,591,000	
	HARD ROCK	Q'TY(m3)	m3	0	0	2,540,000	1,176,000	0	3,716,000
		HAULING DISTANCE(km)	km	0.0	0.0	22.5	22.0	0.0	
		EQUIPMENT	group	0	0	1	1	0	
		BLASTING BARGE	fleet	0.0	0.0	1.0	1.0	0.0	
		GRAB(50m3)	fleet	0.0	0.0	1.0	1.0	0.0	
		SPLIT BARGE(1,500m3)	unit	0.0	0.0	3.0	2.0	0.0	
		PUSHER TUG(1,300HP)	unit	0.0	0.0	2.0	1.0	0.0	
		REQUIRED PERIOD	year	0.0	0.0	2.4	1.1	0.0	
		CAPACITY(m3/hr)	m3/hr	0	0	203	203	0	
		CAPACITY(m3/year)	m3/year	0	0	1,079,960	1,079,960	0	
	TOTAL VOL. OF DREDGING		m3	46,613,000	121,866,000	56,057,000	4,801,000	66,093,000	295,430,000
	TOTAL OF REQUIRED YEARS		years	3.8	3.2	5.5	1.6	2.6	

Table III.2.1.1-8(a)
CONSTRUCTION SCHEME FOR EXCAVATION
HIGH RISE LOCK CANAL 200,000 D.W.T. -90'

File:PLANHIGH

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DRY EXCAVATION	COMMON	Q'TY(m3)	m3	141,000	946,000	12,238,000	14,946,000	124,000	28,395,000
		HAULING DISTANCE(km)	km	2.5	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	1	2	2	4	1	
		BULLDOZER(98ton)	nos.	5.23	10.46	10.46	20.92	5.23	
		SHOVEL(30m3)	nos.	1.00	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	9.16	15.38	27.10	54.20	19.40	
		BULLDOZER(98ton)	nos.	2.65	5.30	5.30	10.60	2.65	
		CAPACITY(m3/hr.)	m3/hr.	2,629	5,258	5,258	10,516	2,629	
		CAPACITY(m3/day)	m3/day	47,322	94,644	94,644	189,288	47,322	
		REQUIRED DAYS	days	3	10	130	79	3	
		REQUIRED YEARS(254days/year)	years	0.1	0.1	0.6	0.4	0.1	
	WEATHERED ROCK	Q'TY(m3)	m3	217,000	6,650,000	44,774,000	63,461,000	458,000	115,560,000
		HAULING DISTANCE(km)	km	2.5	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	1	2	2	4	1	
		BULLDOZER(98ton)	nos.	9.06	18.12	18.12	36.24	9.06	
		SHOVEL(30m3)	nos.	1.00	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	8.15	13.74	23.98	47.96	17.11	
		BULLDOZER(98ton)	nos.	2.77	5.54	5.54	11.08	2.71	
		CAPACITY(m3/hr.)	m3/hr.	1,857	3,714	3,714	7,428	1,857	
		CAPACITY(m3/day)	m3/day	33,426	66,852	66,852	133,704	33,426	
		REQUIRED DAYS	days	7	100	670	475	14	
		REQUIRED YEARS(254days/year)	years	0.1	0.4	2.7	1.9	0.1	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	0	5,977,000	14,969,000	43,551,000	346,000	64,843,000
		HAULING DISTANCE(km)	km	0	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	0	2	2	4	1	
		BULLDOZER(98ton)	nos.	0	18.12	18.12	36.24	9.06	
		SHOVEL(30m3)	nos.	0	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	0	13.74	23.98	47.96	17.11	
		BULLDOZER(98ton)	nos.	0	5.42	5.42	10.84	2.71	
		CAPACITY(m3/hr.)	m3/hr.	0	3,714	3,714	7,428	1,857	
		CAPACITY(m3/day)	m3/day	0	66,852	66,852	133,704	33,426	
		REQUIRED DAYS	days	0	90	224	326	11	
		REQUIRED YEARS(254days/year)	years	0	0.4	0.9	1.3	0.1	
	HARD ROCK	Q'TY(m3)	m3	0	0	1,663,000	18,665,000	0	20,328,000
		HAULING DISTANCE(km)	km	0	0	4.0	4.0	0	
		EQUIPMENT	group	0	0	2	4	0	
		CRAWLER DRILL(32ton-225mm)	nos.	0	0	4.20	8.40	0	
		BULLDOZER(98ton)	nos.	0	0	11.08	22.16	0	
		SHOVEL(30m3)	nos.	0	0	2.00	4.00	0	
		DUMP TRUCK(240ton)	nos.	0	0	20.88	41.76	0	
		BULLDOZER(98ton)	nos.	0	0	5.56	11.12	0	
		CAPACITY(m3/hr.)	m3/hr.	0	0	2,804	5,608	0	
		CAPACITY(m3/day)	m3/day	0	0	50,472	100,944	0	
		REQUIRED DAYS	days	0	0	33	185	0	
		REQUIRED YEARS(254days/year)	years	0	0	0.2	0.8	0	
	TOTAL VOL. OF DRY EXCAVATION		m3	358,000	13,573,000	73,644,000	140,623,000	928,000	229,126,000
	TOTAL OF REQUIRED YEARS		years	0.2	0.9	4.4	4.4	0.3	

Table III.2.1.1-8(b)
CONSTRUCTION SCHEME FOR EXCAVATION
HIGH RISE LOCK CANAL 150,000 D.W.T.-90'

File:PLNEXCHW

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DREDGING	COMMON (CLAYEY)	Q'TY(m3)	m3	3,431,000	32,756,000	2,236,000	95,000	6,977,000	45,495,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	8.0	
		EQUIPMENT	group	1	2	1	1	1	
		GRAB(50m3)	fleet	1.0	2.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	2.0	6.0	3.0	3.0	2.0	
		PUSHER TUG(3,200HP)	unit	1.0	4.0	2.0	2.0	1.0	
		REQUIRED PERIOD	year	0.5	2.6	0.5	0.0	1.1	
		CAPACITY(m3/hr)	m3/hr	1,200	2,400	840	840	1,200	
		CAPACITY(m3/year)	m3/year	6,384,000	12,768,000	4,468,800	4,468,800	6,384,000	
		Q'TY(m3)	m3	3,431,000				6,977,000	10,408,000
		HAULING DISTANCE(km)	km	17.0				12.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000m3)	unit	1.0				1.0	
		REQUIRED PERIOD	year	0.4				0.6	
		CAPACITY(m3/hr)	m3/hr	1,657				2,077	
		CAPACITY(m3/year)	m3/year	8,815,240				11,049,640	
	COMMON (LOOSE)	Q'TY(m3)	m3	8,094,500	33,750,000	3,021,000	82,000	10,620,500	55,568,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	8.0	
		EQUIPMENT	group	1	2	1	1	1	
		CUTTER(18,000HP)	fleet	1.0	2.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	3.0	6.0	3.0	3.0	2.0	
		PUSHER TUG(3,200HP)	unit	2.0	4.0	2.0	2.0	1.0	
		REQUIRED PERIOD	year	0.9	1.8	0.5	0.0	1.1	
		CAPACITY(m3/hr)	m3/hr	1,755	3,510	1,229	1,229	1,755	
		CAPACITY(m3/year)	m3/year	9,336,600	18,673,200	6,535,620	6,535,620	9,336,600	
		Q'TY(m3)	m3	8,094,500				10,620,500	18,715,000
		HAULING DISTANCE(km)	km	17.0				12.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000m3)	unit	1.0				1.0	
		REQUIRED PERIOD	year	0.8				0.9	
		CAPACITY(m3/hr)	m3/hr	1,827				2,270	
		CAPACITY(m3/year)	m3/year	9,719,640				12,076,400	
	WEATHERED ROCK	Q'TY(m3)	m3	23,510,000	35,404,000	23,491,000	659,000	30,568,000	113,632,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	8.0	
		EQUIPMENT	group	1	2	1	1	2	
		CUTTER(27,500HP)	fleet	1.0	2.0	1.0	1.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	6.0	3.0	3.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	4.0	2.0	2.0	2.0	
		REQUIRED PERIOD	year	3.3	2.5	4.7	0.1	2.1	
		CAPACITY(m3/hr)	m3/hr	1,350	2,700	945	945	2,700	
		CAPACITY(m3/year)	m3/year	7,182,000	14,364,000	5,027,400	5,027,400	14,364,000	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	62,000	13,863,000	21,437,000	2,608,000	326,000	38,286,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	8.0	
		EQUIPMENT	group	1	2	2	1	2	
		CUTTER(27,500HP)	fleet	1.0	2.0	2.0	1.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	4.0	4.0	2.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	2.0	2.0	1.0	2.0	
		REQUIRED PERIOD	year	0.0	1.9	4.3	1.0	0.0	
		CAPACITY(m3/hr)	m3/hr	675	1,350	945	472	1,350	
		CAPACITY(m3/year)	m3/year	3,591,000	7,182,000	5,027,400	2,513,700	7,182,000	
	HARD ROCK	Q'TY(m3)	m3	0	0	2,382,000	1,117,000	0	3,499,000
		HAULING DISTANCE(km)	km	0.0	0.0	22.5	22.0	0.0	
		EQUIPMENT	group	0	0	1	1	0	
		BLASTING BARGE	fleet	0.0	0.0	1.0	1.0	0.0	
		GRAB(50m3)	fleet	0.0	0.0	1.0	1.0	0.0	
		SPLIT BARGE(1,500m3)	unit	0.0	0.0	3.0	2.0	0.0	
		PUSHER TUG(1,300HP)	unit	0.0	0.0	2.0	1.0	0.0	
		REQUIRED PERIOD	year	0.0	0.0	2.2	1.0	0.0	
		CAPACITY(m3/hr)	m3/hr	0	0	203	203	0	
		CAPACITY(m3/year)	m3/year	0	0	1,079,960	1,079,960	0	
	TOTAL VOL. OF DREDGING		m3	46,613,000	115,773,000	52,567,000	4,561,000	66,089,000	285,603,000
	TOTAL OF REQUIRED YEARS		years	3.8	3.1	5.2	1.5	2.6	

Table III. 2. 1. 1-8(c)
CONSTRUCTION SCHEME FOR EXCAVATION
HIGH RISE LOCK CANAL 150,000 D.W.T. -90'

File:PLANHIGH

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DRY EXCAVATION	COMMON	Q'TY(m3)	m3	127,000	859,000	10,693,000	13,369,000	104,000	25,152,000
		HAULING DISTANCE(km)	km	2.5	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	1	2	2	4	1	
		BULLDOZER(98ton)	nos.	5.23	10.46	10.46	20.92	5.23	
		SHOVEL(30m3)	nos.	1.00	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	9.16	15.38	27.10	54.20	19.40	
		BULLDOZER(98ton)	nos.	2.65	5.30	5.30	10.60	2.65	
		CAPACITY(m3/hr.)	m3/hr.	2,629	5,258	5,258	10,516	2,629	
		CAPACITY(m3/day)	m3/day	47,322	94,644	94,644	189,288	47,322	
		REQUIRED DAYS	days	3	10	113	71	3	
		REQUIRED YEARS(254days/year)	years	0.1	0.1	0.5	0.3	0.1	
	WEATHERED ROCK	Q'TY(m3)	m3	195,000	6,054,000	39,462,000	56,972,000	383,000	103,066,000
		HAULING DISTANCE(km)	km	2.5	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	1	2	2	4	1	
		BULLDOZER(98ton)	nos.	9.06	18.12	18.12	36.24	9.06	
		SHOVEL(30m3)	nos.	1.00	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	8.15	13.74	23.98	47.96	17.11	
		BULLDOZER(98ton)	nos.	2.77	5.54	5.54	11.08	2.71	
		CAPACITY(m3/hr.)	m3/hr.	1,857	3,714	3,714	7,428	1,857	
		CAPACITY(m3/day)	m3/day	33,426	66,852	66,852	133,704	33,426	
		REQUIRED DAYS	days	6	91	591	427	12	
		REQUIRED YEARS(254days/year)	years	0.1	0.4	2.4	1.7	0.1	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	0	5,393,000	13,380,000	39,557,000	290,000	58,620,000
		HAULING DISTANCE(km)	km	0	2.0	4.0	4.0	6.0	
		EQUIPMENT	group	0	2	2	4	1	
		BULLDOZER(98ton)	nos.	0	18.12	18.12	36.24	9.06	
		SHOVEL(30m3)	nos.	0	2.00	2.00	4.00	1.00	
		DUMP TRUCK(240ton)	nos.	0	13.74	23.98	47.96	17.11	
		BULLDOZER(98ton)	nos.	0	5.42	5.42	10.84	2.71	
		CAPACITY(m3/hr.)	m3/hr.	0	3,714	3,714	7,428	1,857	
		CAPACITY(m3/day)	m3/day	0	66,852	66,852	133,704	33,426	
		REQUIRED DAYS	days	0	81	201	296	9	
		REQUIRED YEARS(254days/year)	years	0	0.4	0.8	1.2	0.1	
	HARD ROCK	Q'TY(m3)	m3	0	0	1,487,000	16,953,000	0	18,440,000
		HAULING DISTANCE(km)	km	0	0	4.0	4.0	0	
		EQUIPMENT	group	0	0	2	4	0	
		CRAWLER DRILL(32ton-225mm)	nos.	0	0	4.20	8.40	0	
		BULLDOZER(98ton)	nos.	0	0	11.08	22.16	0	
		SHOVEL(30m3)	nos.	0	0	2.00	4.00	0	
		DUMP TRUCK(240ton)	nos.	0	0	20.88	41.76	0	
		BULLDOZER(98ton)	nos.	0	0	5.56	11.12	0	
		CAPACITY(m3/hr.)	m3/hr.	0	0	2,804	5,608	0	
		CAPACITY(m3/day)	m3/day	0	0	50,472	100,944	0	
		REQUIRED DAYS	days	0	0	30	168	0	
		REQUIRED YEARS(254days/year)	years	0	0	0.2	0.7	0	
	TOTAL VOL. OF DRY EXCAVATION		m3	322,000	12,306,000	65,022,000	126,851,000	777,000	205,278,000
	TOTAL OF REQUIRED YEARS		years	0.2	0.9	3.9	3.9	0.3	

Table III.2.1.1-8(d)
CONSTRUCTION SCHEME FOR EXCAVATION
HIGH RISE LOCK CANAL 200,000 D.W.T.-90'

File:PLNEXCH#

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DREDGING	COMMON (CLAYEY)	Q'TY(m3)	m3	3,954,000	40,713,000	2,561,000	103,000	11,514,000	58,845,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	7.5	
		EQUIPMENT	group	1	2	1	1	1	
		GRAB(50m3)	fleet	1.0	2.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	2.0	6.0	3.0	3.0	2.0	
		PUSHER TUG(3,200HP)	unit	1.0	4.0	2.0	1.0	1.0	
		REQUIRED PERIOD	year	0.6	3.2	0.6	0.0	1.8	
		CAPACITY(m3/hr)	m3/hr	1,200	2,400	840	840	1,200	
		CAPACITY(m3/year)	m3/year	6,384,000	12,768,000	4,468,800	4,468,800	6,384,000	
		Q'TY(m3)	m3	3,954,000				11,514,000	15,468,000
		HAULING DISTANCE(km)	km	17.0				12.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000m3)	unit	1.0				1.0	
		REQUIRED PERIOD	year	0.4				1.0	
		CAPACITY(m3/hr)	m3/hr	1,657				2,077	
		CAPACITY(m3/year)	m3/year	8,815,240				11,049,640	
	COMMON (LOOSE)	Q'TY(m3)	m3	9,343,500	39,992,000	3,528,000	89,000	13,953,500	66,906,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	7.5	
		EQUIPMENT	group	1	2	1	1	1	
		CUTTER(18,000HP)	fleet	1.0	2.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	3.0	6.0	3.0	3.0	2.0	
		PUSHER TUG(3,200HP)	unit	2.0	4.0	2.0	2.0	1.0	
		REQUIRED PERIOD	year	1.0	2.1	0.5	0.0	1.5	
		CAPACITY(m3/hr)	m3/hr	1,755	3,510	1,229	1,229	1,755	
		CAPACITY(m3/year)	m3/year	9,336,600	18,673,200	6,535,620	6,535,620	9,336,600	
		Q'TY(m3)	m3	9,343,500				13,953,500	23,297,000
		HAULING DISTANCE(km)	km	17.0				12.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000m3)	unit	1.0				1.0	
		REQUIRED PERIOD	year	1.0				1.2	
		CAPACITY(m3/hr)	m3/hr	1,827				2,270	
		CAPACITY(m3/year)	m3/year	9,719,640				12,076,400	
	WEATHERED ROCK	Q'TY(m3)	m3	27,194,000	41,484,000	27,238,000	715,000	36,917,000	133,548,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	7.5	
		EQUIPMENT	group	1	2	1	1	2	
		CUTTER(27,500HP)	fleet	1.0	2.0	1.0	1.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	6.0	3.0	3.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	4.0	2.0	2.0	2.0	
		REQUIRED PERIOD	year	3.8	2.9	5.4	0.1	2.6	
		CAPACITY(m3/hr)	m3/hr	1,350	2,700	945	945	2,700	
		CAPACITY(m3/year)	m3/year	7,182,000	14,364,000	5,027,400	5,027,400	14,364,000	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	58,000	16,476,000	24,466,000	2,828,000	376,000	44,204,000
		HAULING DISTANCE(km)	km	12.0	18.5	22.5	22.0	7.5	
		EQUIPMENT	group	1	2	2	1	1	
		CUTTER(27,500HP)	fleet	1.0	2.0	2.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	2.0	4.0	4.0	2.0	2.0	
		PUSHER TUG(3,200HP)	unit	1.0	2.0	2.0	1.0	1.0	
		REQUIRED PERIOD	year	0.0	2.3	4.9	1.1	0.1	
		CAPACITY(m3/hr)	m3/hr	675	1,350	945	472	675	
		CAPACITY(m3/year)	m3/year	3,591,000	7,182,000	5,027,400	2,513,700	3,591,000	
	HARD ROCK	Q'TY(m3)	m3	0	0	2,718,000	1,212,000	0	3,930,000
		HAULING DISTANCE(km)	km	0.0	0.0	22.5	22.0	0.0	
		EQUIPMENT	group	0	0	1	1	0	
		BLASTING BARGE	fleet	0.0	0.0	1.0	1.0	0.0	
		GRAB(50m3)	fleet	0.0	0.0	1.0	1.0	0.0	
		SPLIT BARGE(1,500m3)	unit	0.0	0.0	3.0	2.0	0.0	
		PUSHER TUG(1,300HP)	unit	0.0	0.0	2.0	1.0	0.0	
		REQUIRED PERIOD	year	0.0	0.0	2.5	1.1	0.0	
		CAPACITY(m3/hr)	m3/hr	0	0	203	203	0	
		CAPACITY(m3/year)	m3/year	0	0	1,079,960	1,079,960	0	
	TOTAL VOL. OF DREDGING		m3	53,847,000	138,665,000	60,511,000	4,947,000	88,228,000	346,198,000
	TOTAL OF REQUIRED YEARS		years	4.3	3.7	5.9	1.6	3.1	

1.2 Dewatering

(1) Volume of Water to be Pumped Up

Table III. 2.1.2 - 1 Volume of Water to be Pumped Up

Zone	Drainage Area	Drainage Volume	Location and Daily Rainfall
Zone I	0.74 km^2	101,000 m^3/day	Atlantic side
Zone II	0.23 km^2	31,000 m^3/day	130 mm/day
Zone III	3.59 km^2	490,000 m^3/day	
Zone IV	4.35 km^2	457,000 m^3/day	Pacific side
Zone V	0.41 km^2	43,000 m^3/day	100 mm/day
Total		1,122,000 m^3/day	

Note: The volume of water to be pumped up includes leakage and spring water.

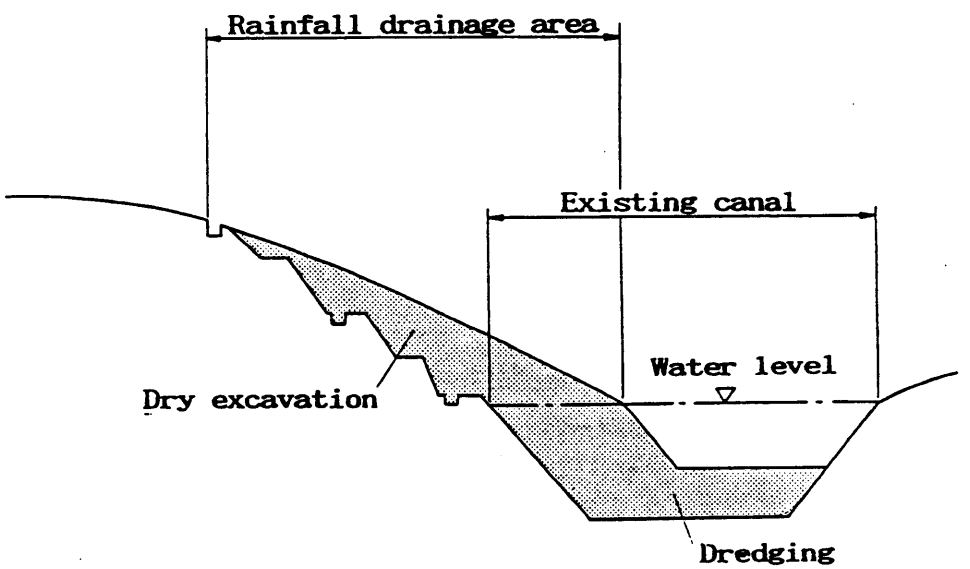


Fig. III. 2.1.2 - 1 Rainfall Drainage Area

(2) Pumps to be used for Dewatering

Table III. 2.1.2 - 2 Specification for and Number of Pumps to be used

Type	Stationary Pump	Portable Pump
Specification		
Bore	300 mm	200 mm
Head	30~40m	20m
Displacement	$12m^3$/min	$4m^3$/min
Output	95 kW	22 kW
Number used		
Zone I	8	20
Zone II	3	9
Zone III	42	126
Zone IV	40	120
Zone V	3	9
Total	97 sets	284 sets

Note: Numbers of portable pumps will be 2 - 3 sets per one set of fixed location pumps. Generators are used as power sources.

III.2 Chapter 2. Lock Construction

2.1 Excavation

(1) After the construction yard is dried out by the dewatering system, excavation work will be commenced.

(2) The equipment to be used for lock excavation will be the same as for dry excavation.

(3) Dewatering

Prior to commencing excavation, small rivers and streams that flow into the excavation area will be diverted by open ditches. At a suitable location outside the excavation area, a sedimentation pond will be provided. Supernatant from the pond will be dislodged. A temporary cut off wall will be constructed for the third lock and the third lock will be dewatered. Excavation is to be carried out deeper while drainage pumps are relocated to the deepest part of the excavation. Drainage pumps will be constantly used even during the placing of concrete.

Table III. 2.2.1 - 1 Pumps required

	Atlantic Side Lock		Pacific Side Lock	
	Fixed Location Pump	Portable Pump	Fixed Location Pump	Portable Pump
Specification				
Base	300 mm	200 mm	300 mm	200 mm
Head	30 - 40m	20m	30 - 40m	20m
Pumping Capacity	12 m^3/min	4 m^3/min	12 m^3/min	4 m^3/min
Output	95 kW	22 kW	95 kW	22 kW
Number used	8 sets	24 sets	6 sets	18 sets

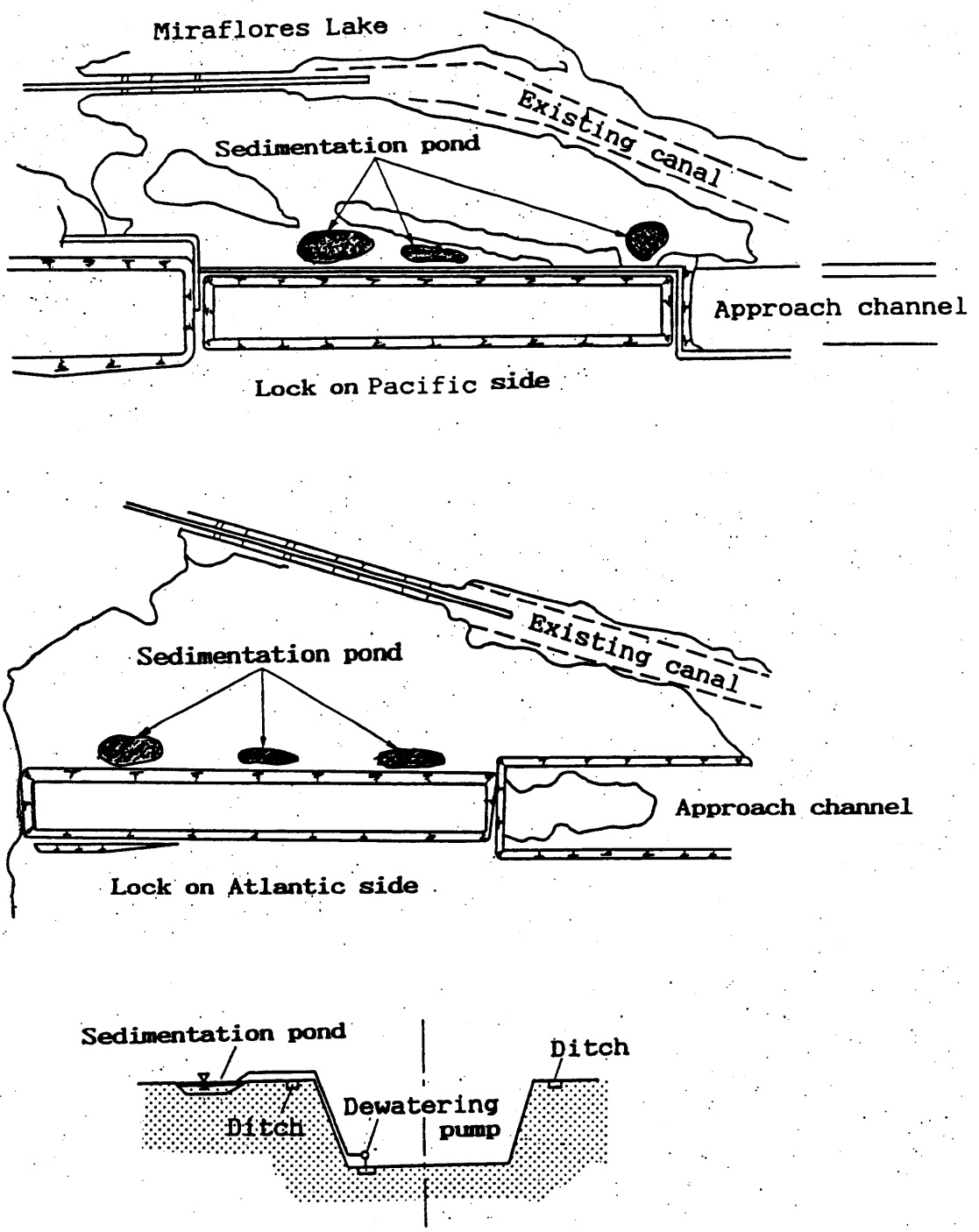


Fig. III. 2.2.1 - 1 Location of Locks and Sedimentation Pond

2.2 Concrete Works

(1) Quantity of Concrete

Table III. 2.2.2 - 1

Quantity of Concrete for 200,000 DWT

Case	200,000 DWT (85')	
Location	Atlantic	Pacific
Volume	3,600,000m^3	3,600,000m^3

Table III. 2.2.2 - 2

Quantity of Concrete for 150,000 DWT

Case	150,000 DWT (85')	
Location	Atlantic	Pacific
Volume	3,200,000m^3	3,200,000m^3

(2) Method of Concrete Placing

1) Concrete produced by the batching plant located near the Lock is transported to the placing area.

2) Concrete is placed at the designated block by means of travelling-jib-crane installed at the Lock.

3) A steel sliding forms with 1.5m-lift are used for concrete placing.

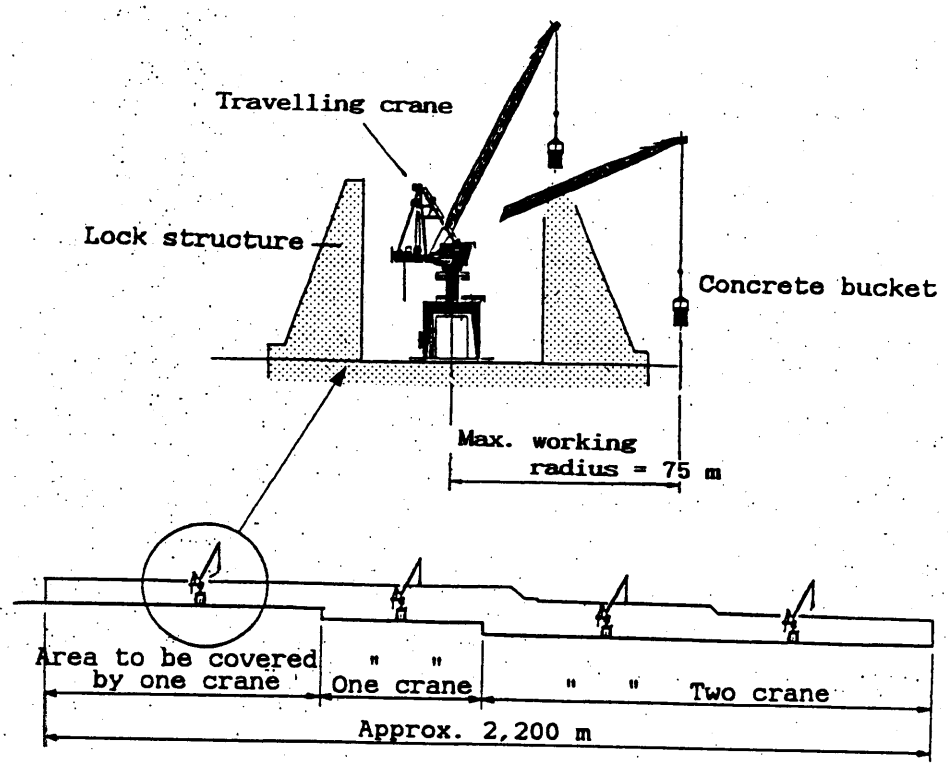


Fig. III. 2.2.2 - 1 Lock Concrete Placing Scheme

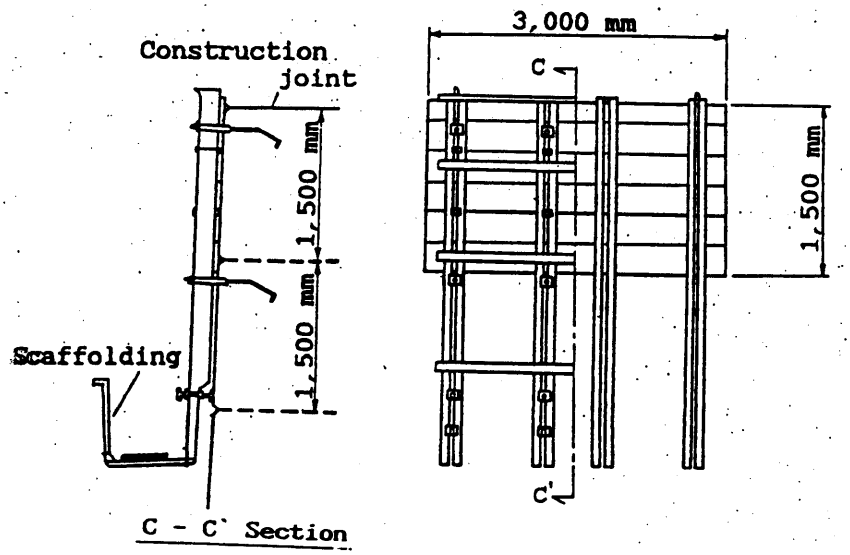


Fig. III. 2.2.2 - 2 Slidingform

(3) Work Description of Lock Concrete

Table III. 2.2.2 - 3
Work description of Lock Concrete

Case	200,000 DWT (85')	150,000 DWT (85')
Depreciation	Atlantic Side and Pacific Side	Atlantic Side and Pacific Side
Concrete Volume	3,600,000m^3	3,200,000m^3
Concrete construction period	4 years	4 years
Working Days per year	249 days	249 days
Total Work Days	996 days	996 days
Work hrs per Day	18 hrs	18 hrs
Total work hrs	17,928 hrs	17,928 hrs
Average hourly Rates of concrete	200 m^3/hr	180 m^3/hr
Concrete Mixing Capacity of Batcher Plant	70 m^3/hr	70 m^3/hr
No. of Plants to be employed	3 Units	3 Units
Concrete Transportation No. of Agitating/Mixer Trucks to be employed	21 Units	21 Units
Concrete Placing No. of Cranes to be employed	4 Units	4 Units
No. of concrete Buckets to be provided	8 Units	8 Units

III.2 Chapter 3. Lock Gate Installation

3.1 Introduction

This chapter covers gate leaves and related facilities for the high rise locks. Also it refers partially to valves and pipes for the new dams. Major components included in the related facilities are as follows.

- Gate Frames
- Gate Hoists
- Locomotives and it's rails and power supply lines
- Electric Power and Control Equipments including lighting on the lock wall
- Emergency Power Plant
- Local control building and their electrical equipments
- Cathodic protection around the lock
- Monitoring & surveillance equipments for the lock
- Communication equipments for the lock
- Ground system

3.2 Constructability

Constructability of all major facilities included in the preliminary designs made for the High Rise Lock Canal has been reviewed and it has been concluded that a possibility of all their installation is positive at least from the feasibility study point of view. Nevertheless the same effort has to be made for the more detail portions of designs at a detail design stage.

3.3 Inland Transportation

The fabricated materials which have been classified as "Packed" at 4.5 of Section II.2 in this reports are transported from landing ports or fabrication factories in local domains upto storage yards which will be provided near the ports on each side of the oceans. They will be transported to their installation sites according to

site work progress. Other items listed at the 4.5 will arrive at their landing ports according to their installation schedule and transferred to the site directly from the port through the canal and the lock already completed and will be installed accordingly.

3.4 Storage Procedures

Storage procedures at the storage yards near the landing ports are classified as below.

Table III.2.3-1 Storage Procedure

Classification	Example of Application
(1) Storage at open yard	Fabricated big material with less possibility of deterioration due to climatic exposure to, for in stance, direct sunshine, rain, wind or high temperature.
(2) Storage under a roof	Fabricated big material with possibility of deterioration due to climatic exposure to, for instance, direct sunshine or rain.
(3) Storage in a warehouse	Small or valuable parts which will be easily lost.
(4) Storage in an air conditioned warehouse	Equipments which dislike high temperature or high humidity.

The all materials to be stored at the yards shall be classified according to an established classification before hands.

3.5 Installation Procedures

(1) Gate leaves

1) Operating Gate, Emergency Gate and Maintenance Gate for Lock

Operating Gate, Emergency Gate and Maintenance Gate for High Rise Lock are set in place using a floating crane according to the steps shown in Fig. III.1.5-4 of this report. In case of the Operating Gate, the pintle axis adjustment work will follow. The Operating Gate and the Emergency Gate are connected to their drive mechanisms, then all gates installed are ready to work.

2) Culvert Gates for Locks and Outlet Pipes for New Dams

Culvert Gate for High Rise Locks and Outlet Pipes for New Dams are transported to the site in blocks and erected by a truck crane, a tower crane or other available means. The blocks are joined either by high tension bolts or welding.

3) Culvert Maintenance Gate for Lock

Culvert Maintenance Gates for High Rise Lock are transported to the site in four blocks. There is no need of further erection for them except to be inserted to each gate slots just for confirmation of good mating with the metals already embedded in concrete.

(2) Locomotives

Locomotives are transported to site through the canal on barges. They are lifted up by a floating crane and put on their rails on the lock wall tops.

(3) Electric Power Equipments, Emergency Power Plant

Installation cost estimation for Electric Power and control Equipments, and Emergency Power Plant was made based upon conventional installation procedures using a truck crane or something. A possibility of cost reduction may exist in idea of packaged system in which all parts are mounted on a frame rest at shop, transported to site as a whole and mounted by a floating crane at once.

3.6 Possibility of Installing Gate Leaves by Firms in Panama and Immediate Region

Possibility of gate leaf field installation by local firms in Panama or immediate regions were evaluated on both technical ability and competitiveness of cost and concluded that the answers to all gates would be positive with contract conditions given in Table III.2.3-2 The immediate region includes Colombia, Ecuador, Peru, Costa Rica, Nicaragua, El Salvador, Guatemala and Honduras.

Table III. 2.3-2 Condition for Installation by Local Firm

Gate Name	Condition for Installation by Local Firm
Lock Gate	
1) Operating Gate	To be done as a sub-contractor
2) Culvert Gate	To be supervised by others
3) Emergency Gate	To be done as a sub-contractor
4) Maintenance Gate	To be done as a sub-contractor
5) Culvert Maintenance Gate	To be supervised by others
Dam Gate	
1) Outlet Valve*	To be supervised by others
2) Outlet Pipe*	To be supervised by others

Note 1. The installation by local firms means installation of gate leaves by local firms in Panama or immediate regions.

2. * shows for new dams which are necessary to be constructed as a part of the High Rise Canal Alternative.

III.2 Chapter 4. New Dams

4.1 Location of New Dams

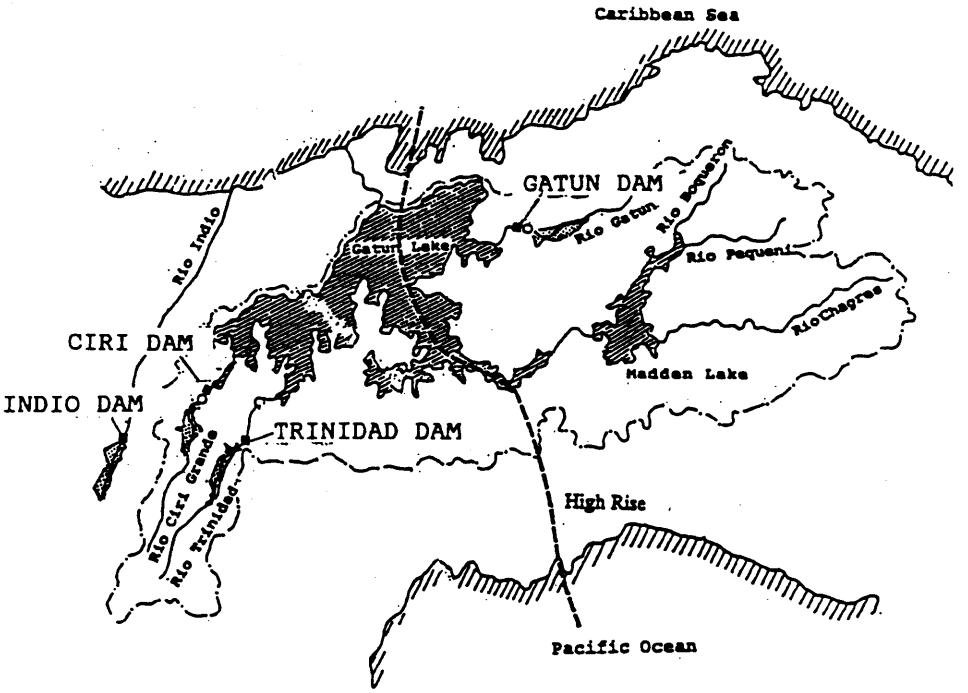


Fig. III. 2.4.1 - 1 Location of New Dams

Table III. 2.4.1 - 1 Latest Year - Dam Required

High Rise Lock Canal Case	200,000 DWT	150,000 DWT
Ciri	-	2,060
Up.Gatun	-	-
Trinidado	2,060	-
Indio	2,020	2,060
Total	2 Dams	2 Dams

4.2 Construction Plans

(1) Type of dam

Each new dam will be a center core rockfill type dam.

(2) Filling Materials

For core material, ordinary soil obtained from foundation excavation will primarily be used. Rock and filter materials will be supplied from quarry sites.

(3) Construction Sequence

a. Diversion Tunnel

After diversion tunnel is constructed, the Ciri River is diverted into the tunnel and after dam embankment is complete, the tunnel is plugged and impoundment begins.

b. Foundation Excavation

For core zone, the trench cut method will be used as standard. After completion of the excavation, the finishing will be performed manually.

c. Foundation Treatment

After completion of foundation excavation, blanket grouting and curtain grouting will be performed. The curtain grouting will be performed from the gallery also.

d. Embankment

After completion of the blanket grouting, the embankment core will be constructed.

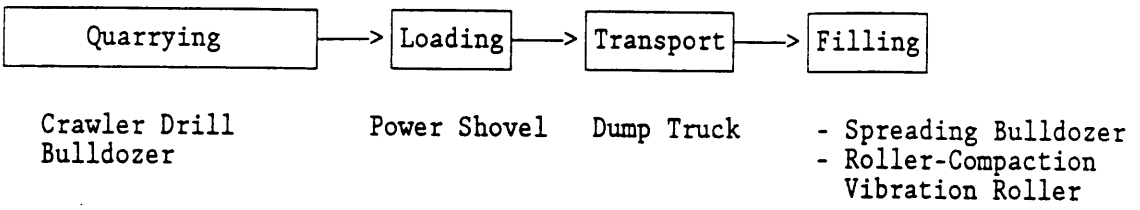
(4) Embankment Materials

a. Rock and filter materials will be taken from the quarry sites.

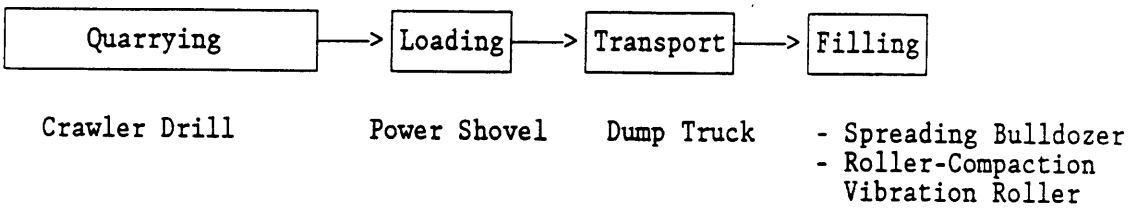
b. Core material will be obtained from the foundation excavation, and blended with suitable material in order to obtain optimum water content and highest impervious characteristics.

(5) Flow of Dam Embankment

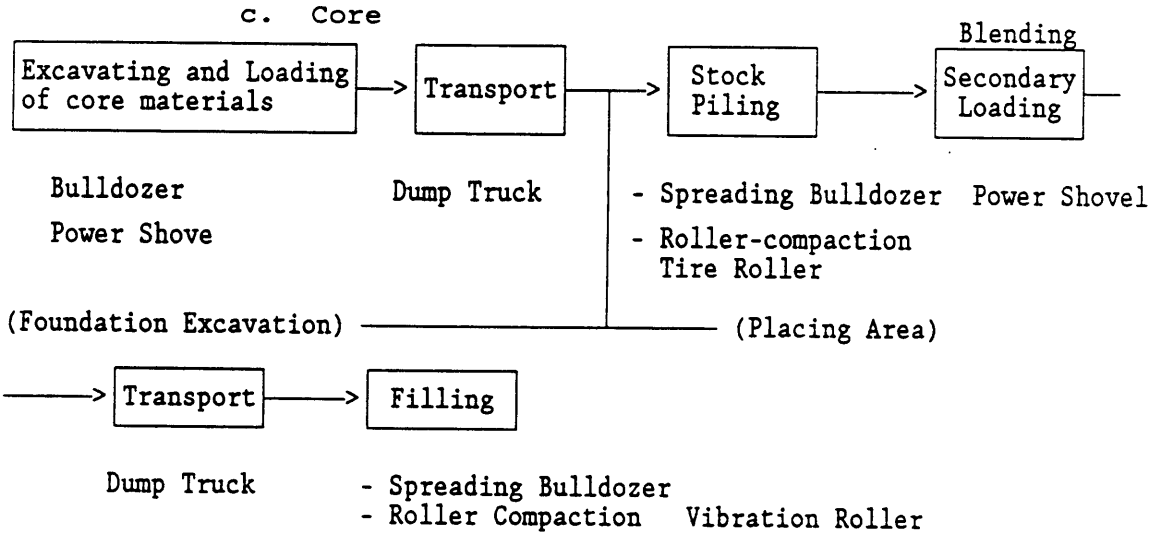
a. Rock



b. Filter



c. Core



III.2 Chapter 5. Pumping Station

5.1 Quantities

Table III. 2.5.1-1 Quantity for Pumping Station

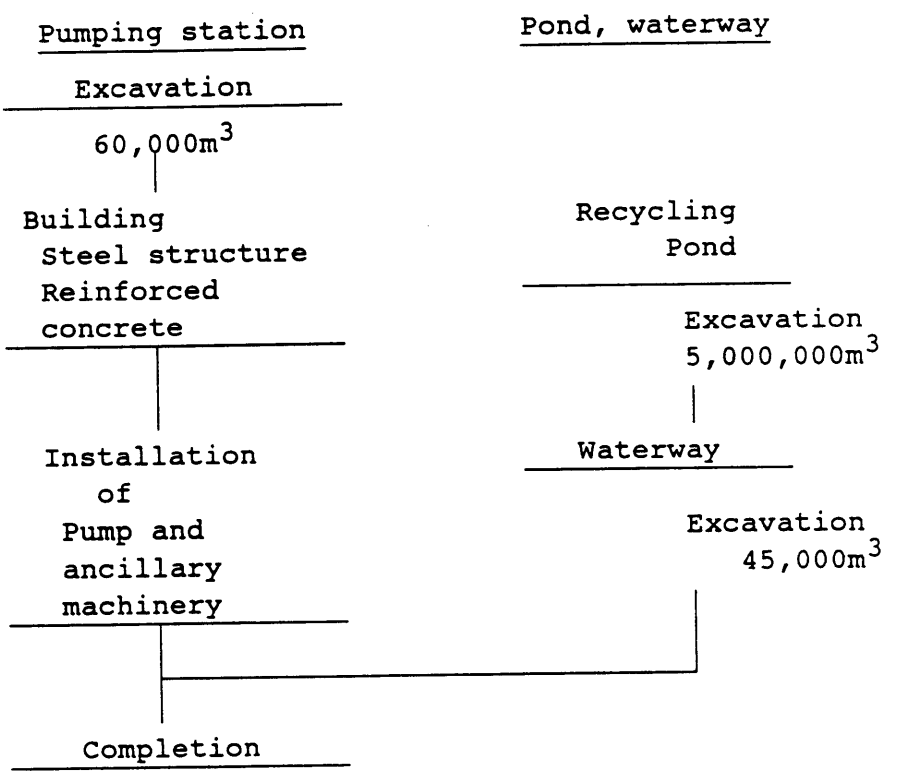
Case	2060 Year	
Side Pumping Station	Atlantic 1	Pacific 1

No pumping station is required until year 2060.

5.2 Construction Method for Pumping Station

(1) Construction Procedure

Construction procedure for Pumping station is as follows:



(2) Earthwork Equipment

a. The combination of earthwork equipment used for excavation of pumping station, pond and waterway will be shovel and dump truck.

b. Excavated material from stations, ponds and waterways will be used for the dikes for waterways and ponds. Surplus material will be transported to the placing area for Canal Excavation.

(3) Pumping Station Construction

a. Ready-mixed concrete produced at the Concrete Plant will be used for the lock construction. The concrete will be transported by mixer/agitator trucks, and a mobile crane with bucket will be used for concrete placing.

b. Reinforcing steel, structural steel and iron pipes, pumps, machinery, etc., which are to be embedded in concrete, will be lifted and set in place by the mobile crane.

III.2 Chapter 6. Canal Crossing

6.1 Location of Canal Crossing

Table III. 2.6.1-1 Canal Crossing

Location	New Bridge	Remarks
Atlantic Entrance	1 (2 lanes)	the year of 2,020
Middle	1 (2 lanes)	" 2,060
Vam Dam (1)	1 (4 lanes)	" 2,060
Vam Dam (2)	1 (4 lanes)	" 2,060
Pacific Entrance	1 (4 lanes)	" 2,020
Total	5 Bridges	

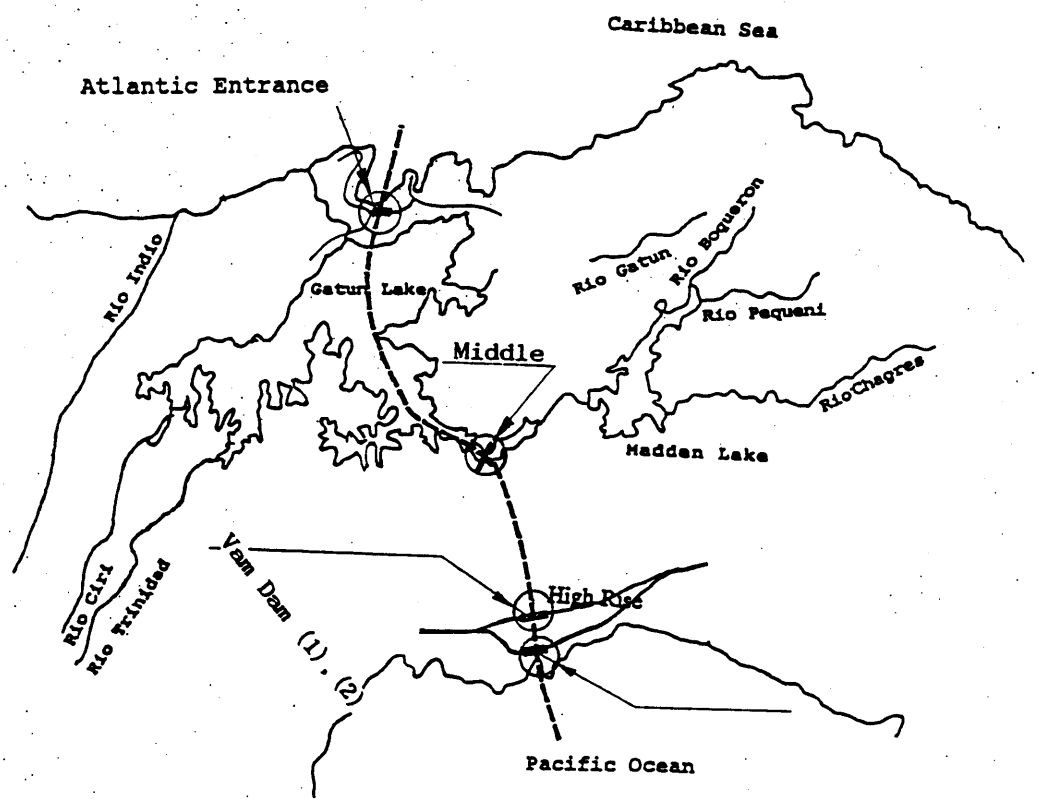


Fig. III. 2.6.1-1 Location of Canal Crossing

6.2 Construction Plans

(1) The existing American Bridge is to be demolished after a new bridge is constructed.

(2) Other new bridges are to be built during the construction of the Canal.

III.2 Chapter 7. Supporting Construction

7.1 Construction Village and Camps

(1) General

2 construction village and 5 labor camps will be constructed for accommodating approx. 10,000* workers, 800 staff and their families.
Construction villages will be handed over to the client for permanent use after completion of construction work.
Labor camps will be removed after completion of the work.

(2) Description of Village and Camps

Table III. 2.7.1 shows description and quantities to build houses and facilities for village and camps.

Table III. 2.7.1-1 Houses and Facilities

Description	Village	Labor Camps
Detached House A	2 places x 5 nos. x 400m^2	-
" " B	2 places x 50 nos. x 300m^2	
" " C	2 places x 200 nos. x 200m^2	
Dormitory	2 places x 7,000m^2	5 x 2,000m^2
Condominium	-	5 x 16,000m^2
Resthouse	2 places x 2,000m^2	-
Canteen	2 places x 1,000m^2	5 x 1,000m^2
Mess Hall	2 places x 1,000m^2	5 x 1,000m^2
Supermarket	2 places x 1,000m^2	5 x 1,000m^2
Retail Shop	2 places x 1,500m^2	5 x 1,500m^2
Bottle Shop	2 places x 200m^2	5 x 200m^2
Bank	2 places x 200m^2	5 x 200m^2
Post Office	2 places x 200m^2	5 x 200m^2
Camp Office	2 places x 200m^2	5 x 200m^2
Security/Body Corporate Office	2 places x 100m^2	5 x 100m^2
School	2 places x 2,500m^2	5 x 2,500m^2
Church	2 places x 500m^2	5 x -

(continued)

Description	Village	Labor Camps
Library	2 places x 200m^2	5 x -
Sports Center	2 places x 2,000m^2	5 x -
Recreation Center	2 places x 1,000m^2	5 x -
Movie Theater	2 places x 2,000m^2	5 x -
Hospital/Clinic	2 places x 2,000m^2	5 x 1,200m^2
Fire Station	2 places x 500m^2	5 x 500m^2
Fuel Station	2 places x 500m^2	5 x 500m^2
Playground	2 places x 10,100m^2	5 x 10,000m^2
Marinas	LS	-
Heliport	LS	-
Bus Terminal	Shuttle Bus/Commuting	Commuting
Telecommunication System	LS	LS
Power Generation System	2 places x 6 nos. x 800 kVA	5 x 3 nos. x 800 kVA
Sewage Treatment System	2 places x 1,000m^3/Day	5 x 1,000m^3/Day
Water Supply System	2 places x 200ton/Day	5 x 400ton/Day
Incineration/ Garbage Treatment	LS	LS

* Refer to Table III.2.10.3 - 1 and Table III.2.10.3 - 2

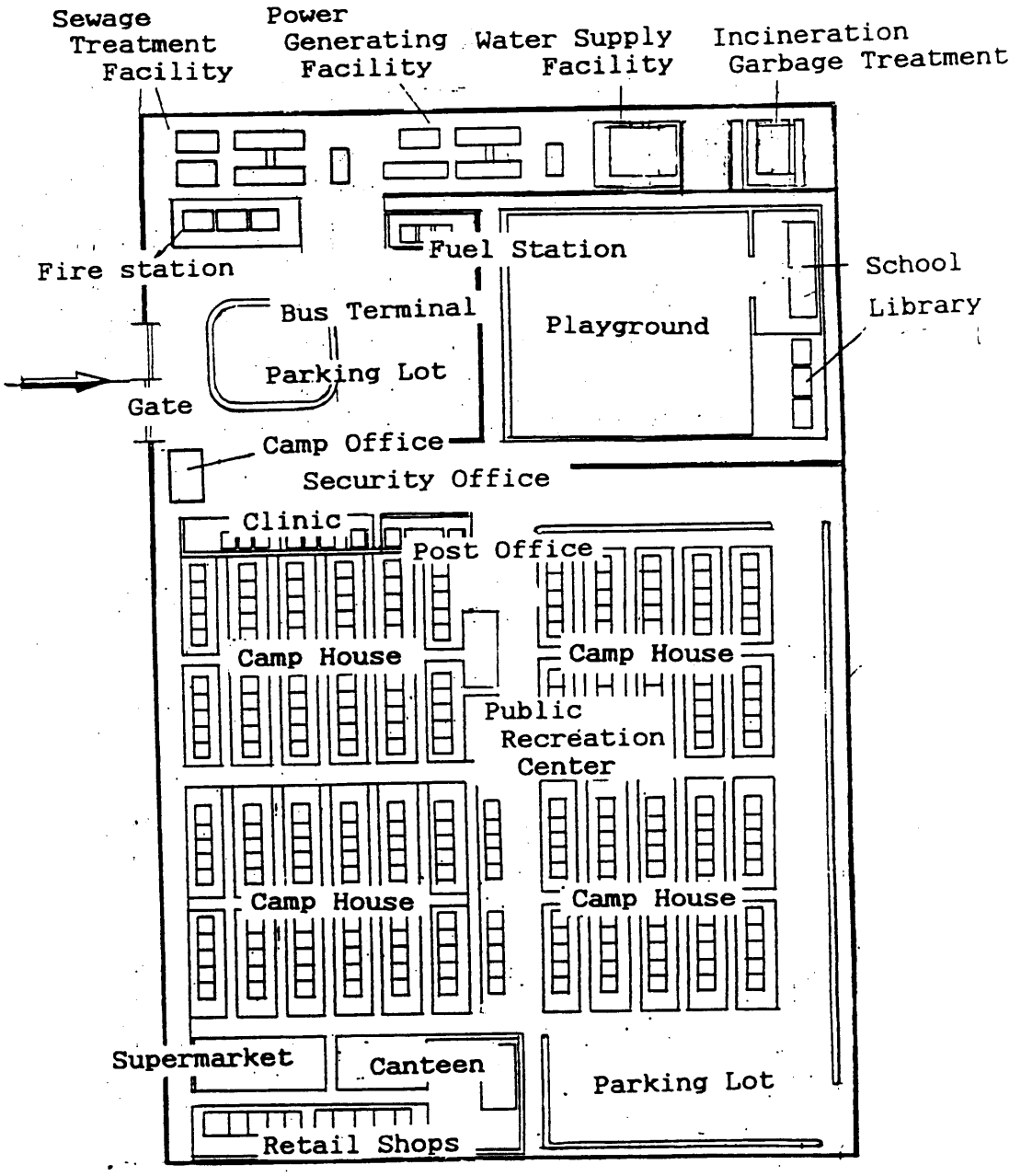


Fig. III. 2.7.1 - 1 Layout of Construction Camp

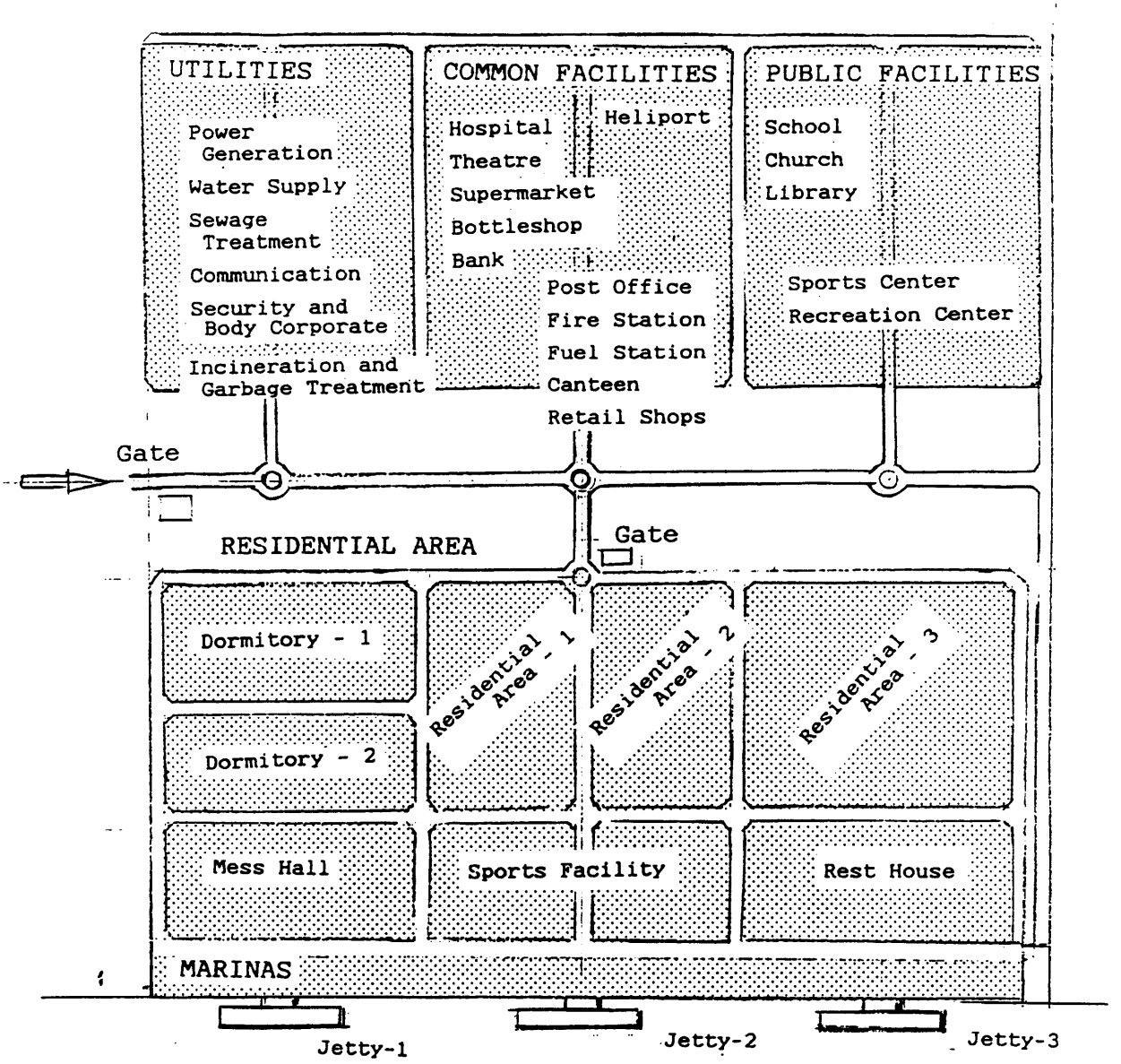


Fig. III. 2.7.1 - 2 Layout of Village

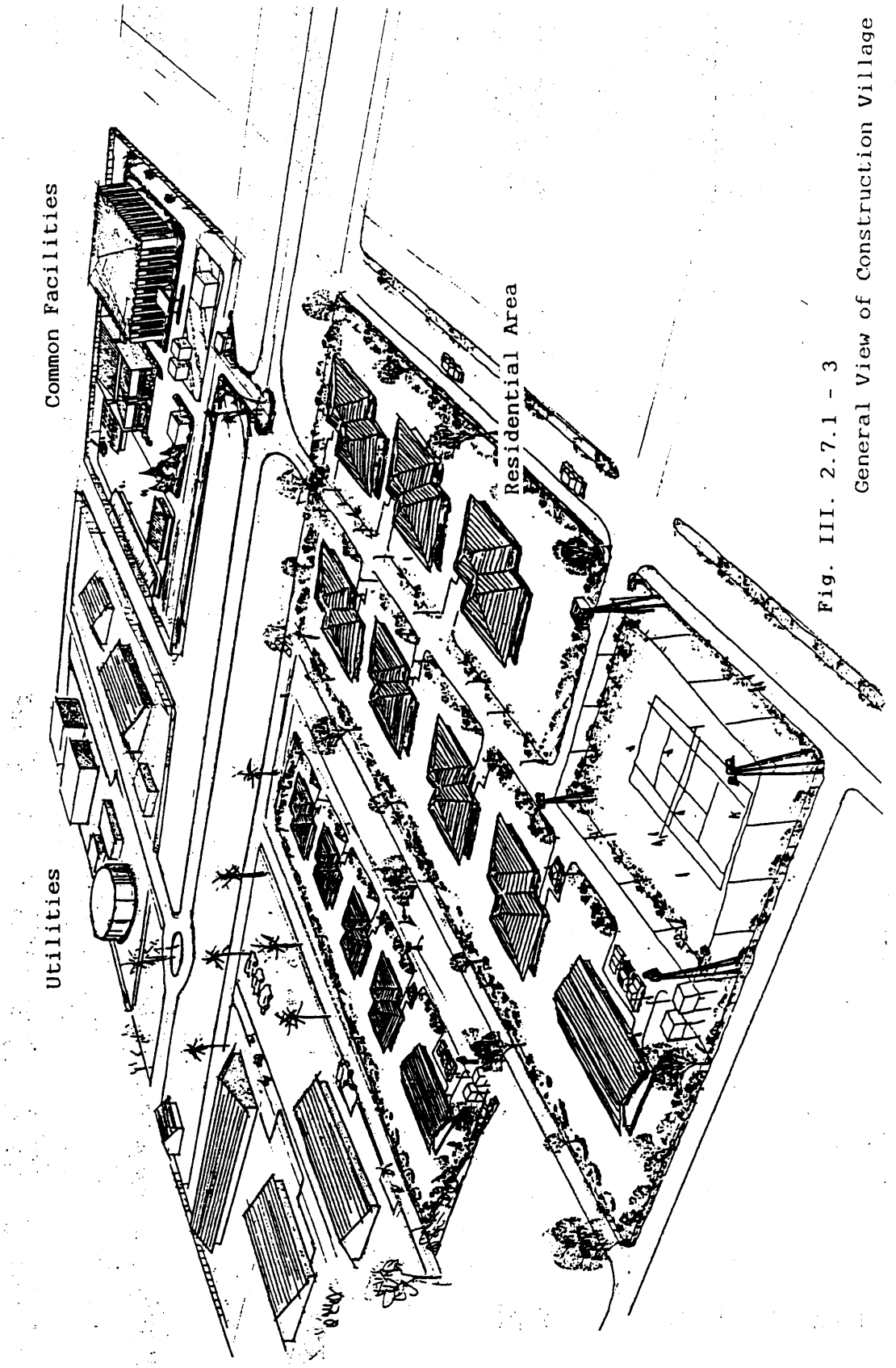


Fig. III. 2.7.1 - 3
General View of Construction Village

7.2 Main Haul Road

(1) Main haul road will be constructed along the Canal prior to commencing the Construction work.

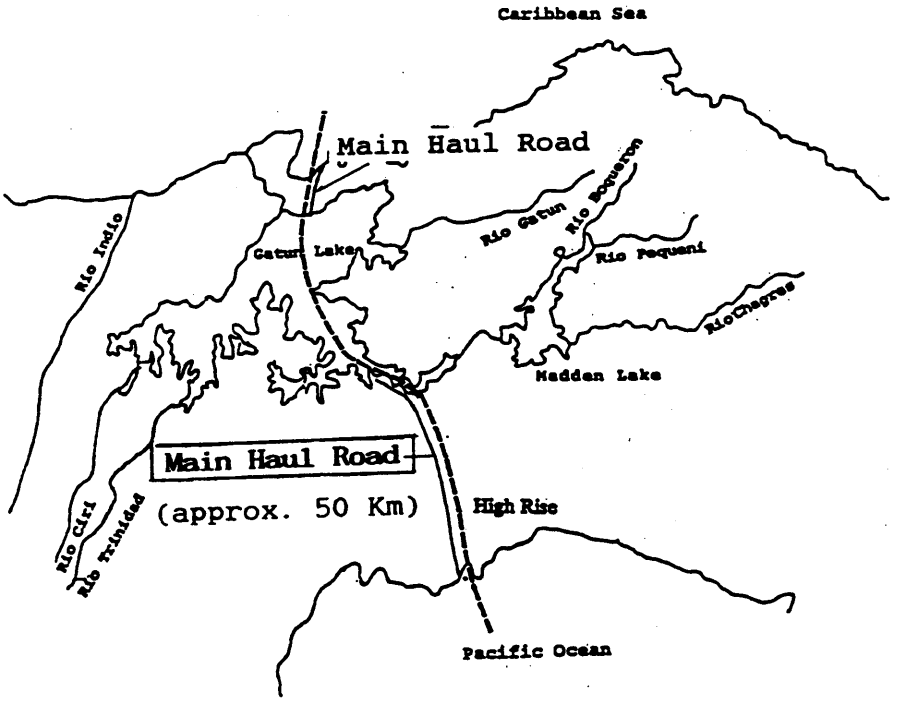


Fig. III. 2.7.2 - 1 Layout of Main Haul Road

The main access road will be used for transport of excavated material, liaison between each construction site, moving and transporting construction materials/equipment. Taking into account a 240 ton dump truck, the width of the road shall be at least 22m.

Actual thickness of sub-bars is to be determined depending on soil conditions at site.

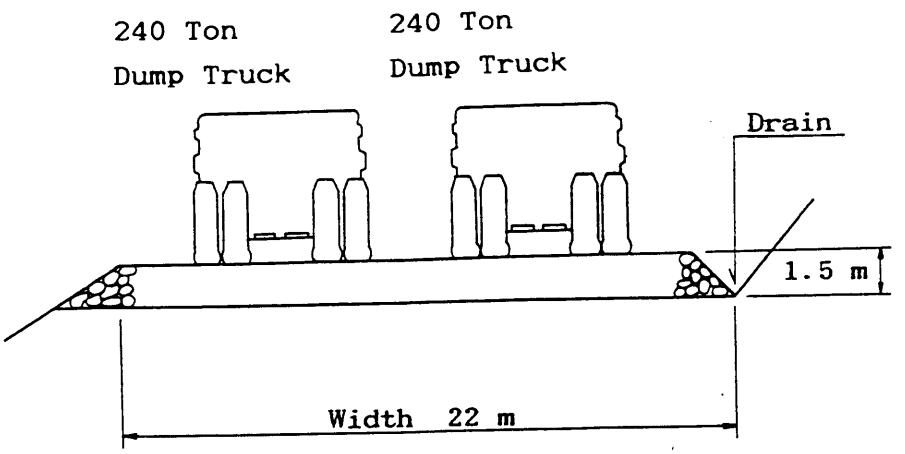


Fig. III. 2.7.2 - 2
Typical Section of Main Haul Road

(2) With the addition of pavement, the Main Haul Road will become the permanent maintenance road for the Canal after the completion of construction work.

(3) For subbase course, excavated materials (soft rock, hard rock) will be used.

(4) The length of haul road construction will be 50 km in total.

7.3 Access Road connecting Quarry Sites and Logistic Base Facilities

(1) For transport of aggregates and rock materials connecting Quarry Sites and logistic base facilities, access roads of 15m in width will be constructed. Actual thickness of sub-base is to be determined depending on soil condition at site.

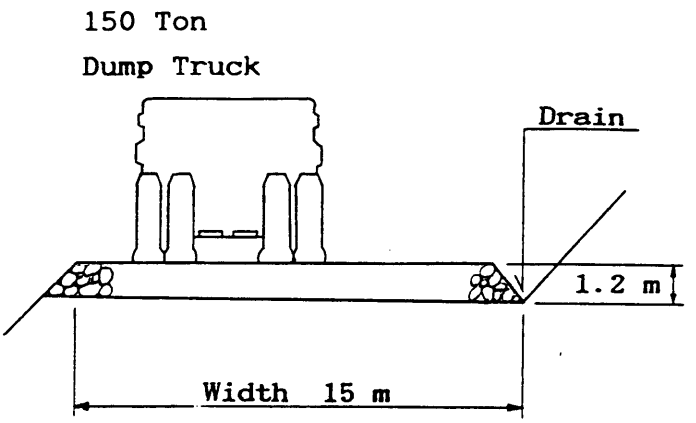


Fig. III. 2.7.3-1 Typical Section of Access Road

(2) Distance of respective Access Road

Table III. 2.7.3-1 Distance and Purpose of Access Road

Section		Distance	Purpose
Temporary Port Puerto Pilon	Quarry	9 km	Transport of aggregate

7.4 Logistic Base Facilities

(1) Purpose

The facilities required for construction work are as follows:

Table III. 2.7.4 - 1 Logistic Base Facilities - 1

	Location of Wharf	Number	Purpose
Atlantic Side	Puerto Pilon	1	Shipping of aggregate
	Colon	1	Unloading and storage of cement, unloading of aggregate unloading of lubricants and fuel and storage
Pacific Side	Panama City	1	Unloading of cement Unloading and storage of lubricants and fuel
Total		3	

(2) Capacity of Facility

1) Cement

Cement will be imported from abroad.
Approx. 15-day stock of cement will be stored at the Logistic Base Facilities.

Table III. 2.7.4 - 2 Logistic Base Facilities - 2

	Atlantic Side	Pacific Side
a. Temporary Wharf	Colon	Panama City
Concrete placing volume per day	3,500 m^3/day	3,500m^3/day *
Cement consumption per 15 days	15,000 ton	15,000 ton **
b. Storage Facility		
Cement silo	1,500 ton 10 silos	1,500 ton 10 silos

* Concrete Placing Volume per day
3,600,000m^3 / 4 years x 249 days = 3,500 m^3/day approx.

** Cement Consumption per 15 days
3,500m^3/day x 0.295 ton/m^3 x 15 days = 15,000 ton approx.

2) Fuel, lubricants

Fuel, oil, etc., for construction equipment used for dry excavation, etc., will be imported from abroad.
A 20-day supply of fuel, lubricants, etc., will be stored at the Logistc Base Facilities.

Table III. 2.7.4 - 3 Logistic Base Facilities - 3

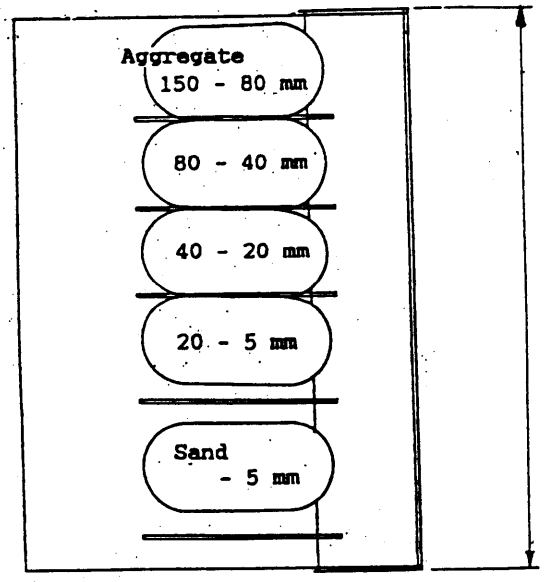
	Atlantic Side		Pacific Side	
a. Logistc Base Facilities	Colon		Panama City	
b. Storage Facility				
Tanks for fuel	1,600 kl	8 tanks	1,600 kl	8 tanks
Tanks for oil	100 kl	2 tanks	100 kl	2 tanks

3) Aggregate

A 10-day supply of aggregate (15,000m^3) for lock concrete on the Atlantic side will be stored at the Logistic Base Facilities located at Puerto Pilon. An aggregate shipping facility will be provided.
An unloading yard will be provided at the Logistic Base Facilities at Colon.

4) Others

Warehouses, sheds, etc., for construction equipment, parts, etc., and construction materials will be provided at each Logistic Base Facility.



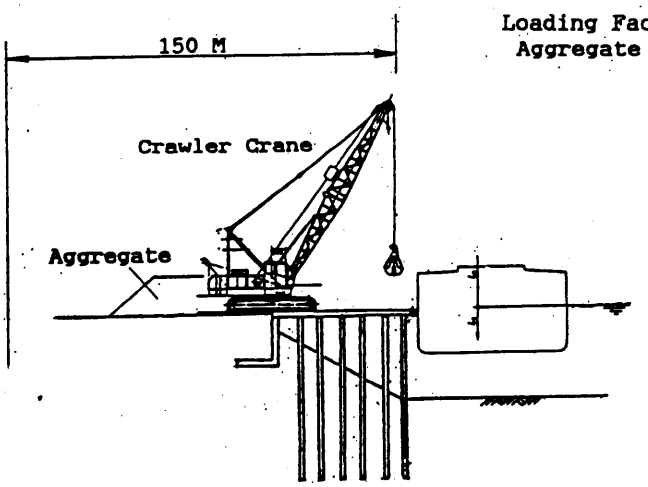


Fig. III. 2.7.4 - 1 Puerto Pilon

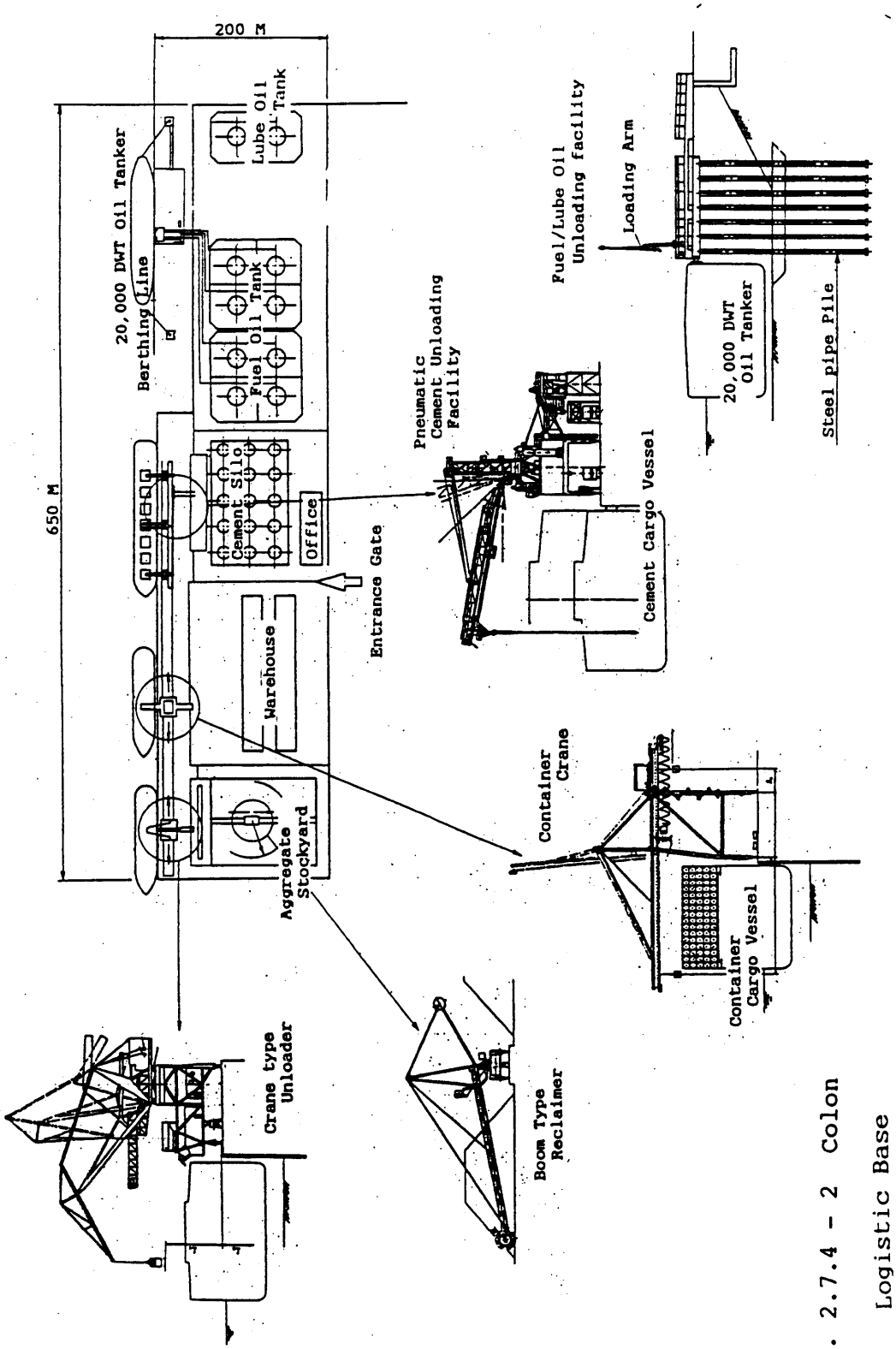


Fig. III. 2.7.4 - 2 Colon Logistic Base Facilities

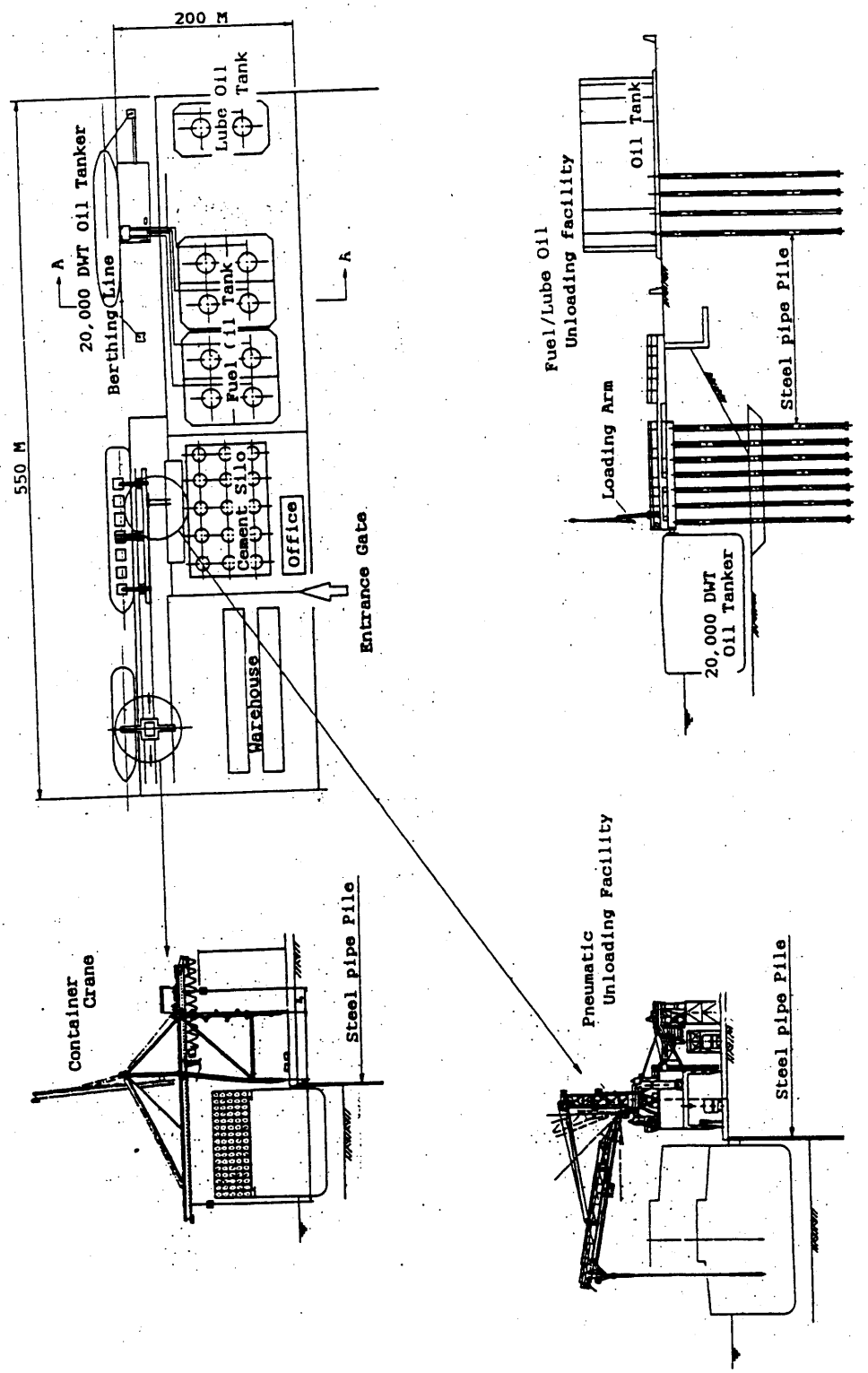


Fig. III. 2.7.4 - 3 Panama City Logistic Base Facilities

III.2 Chapter 8. Constructabilities

There may be difficulties encountered on several points in the execution of construction works, which will be overcome by taking the following measures:

8.1 Excavation of Points along the Existing Canal

In the case of High Rise Lock Canal, most of the points of excavation are located adjacent to the existing canal. To minimize the effect on navigation of vessels through the existing canal and to attain a smooth progress of the excavation work, it is necessary that the procedure of the work should be thoroughly examined and the work be proceeded in a systematic manner.

The construction procedure is planned basically such that the work of the widening portion will be completed first, the navigation channel to be shifted thereto and the bottom of the existing canal dredged.

By doing so, the overlap of the excavation work and the navigation of vessels through the existing canal can be reduced to a negligible degree making it possible to achieve smooth progress of the work. However, the hauling of excavated material may have to be held up occasionally, as the passage of vessels is to take precedence over others. This problem is planned to be solved by adjusting the cycle time and by increasing the number of Hopper Barges.

8.2 Deep Underwater Blasting Method

When making the existing canal of the Culebra Cut deeper, it is assumed that difficulties may be encountered in the work as hard rock exists in large quantities at that location. To proceed quickly with operations such as drilling, charging with explosives and blasting, it is considered preferable to use S.E.P. (Self-elevated Platform). By adopting the S.E.P., the positioning will be made easier and by equipping the Platform with multiple overburden drills, a number of charging holes may be drilled simultaneously, which will result in improved

efficiency. Also the stability of the equipment during drilling will be improved reducing accidents.

8.3 Source Rock of Aggregate

A large quantity of concrete aggregate will be required for construction of locks. To reduce the construction cost, it is essential that the aggregate be procured inexpensively. Although it is desirable to produce aggregate at the location of construction as much as possible, the geology at the vicinity of the lock on the Atlantic side consists of sandstone strata of the diluvial epoch. This is not suitable for aggregate because of insufficient consolidation. As it is not possible to obtain source rock for aggregate in the vicinity of con struction, it is necessary to procure source rock from the granite stratum behind Puerto Pilon, produce aggregate there, and transport by land and by sea to the construction site of the lock for use.

As regards the lock on the Pacific side, there will be no problem concerning raw material for aggregate as there is an outcrop of basalt in the vicinity.

8.4 Shifting of Navigation Channel from Zone-III to Zone-VI

While in Zone-III the excavation method for the navigation channel is composed mainly of dredging, it is planned to excavate the navigation channel using dry excavation in Zone-IV as many basalt strata exist here.

Between Zone-III and Zone-IV, natural ground is planned to be left as a coffer dam without excavating it so as to prevent the inflow of water from Gatun Lake into the site of excavation.

At the point in time when excavation operations of Zone-III and Zone-IV have been completed, the coffer dam is to be removed. To enable the removal work to continue without interrupting passage of vessels through existing canal, selection of the position of the coffer dam becomes important.

By selecting the position of the coffer dam at the point about 200 - 300m into the new navigation channel from the junction, the removal work of the coffer dam could be carried out without regard to the passage of vessels through the existing canal.

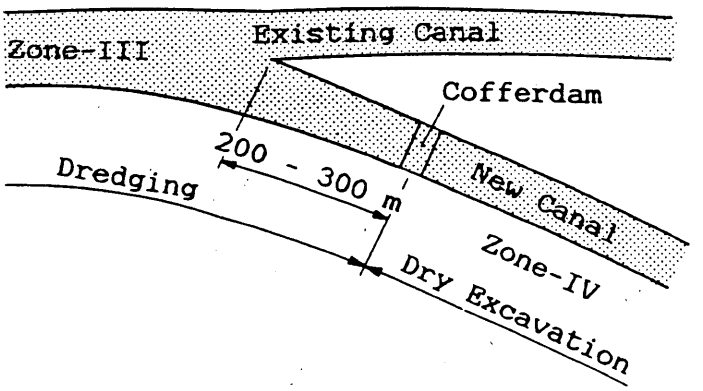


Fig. III.2.8.1-1 Confluent Point of Zone III & IV

The procedure for removal of the coffer dam will be as follows:

(1) Completion of canal excavation (both Zone-III and Zone-IV).

(2) Impounding of Zone-IV.

(3) Blasting of coffer dam using the Land Based Blasting method.

(4) Dredging using a grab dredger.

III.2 Chapter 9. Interference with Existing Canal Navigation

At present there is the passage of approx. 40 - 50 vessels per day through the existing canal. It is assumed that during the period of construction of the alternative canal, this number will be approximately the same or slightly more.

Since the estimate of construction schedule and construction cost has been made based on the principle that the canal navigation has priority over the construction work, the case where the passage of vessels is affected by the construction work need not be considered so greatly.

As the only conceivable case may be that the fragments of blasting of the widening portion of the Culebra Cut of Zone-III could scatter over the navigation channel, it is necessary to detect whether or not there are any obstacles within the navigation channel before allowing the passage of vessels after the blasting has taken place, using sonar detecting. In the case where there are obstacles, they will have to be removed before resuming the passage of vessels. As the blasting is the underwater blasting, it is not considered that scattering of fragments will be much, but there may be cases where resuming of passage of vessels will be delayed pending a safety check by sonar sounding.

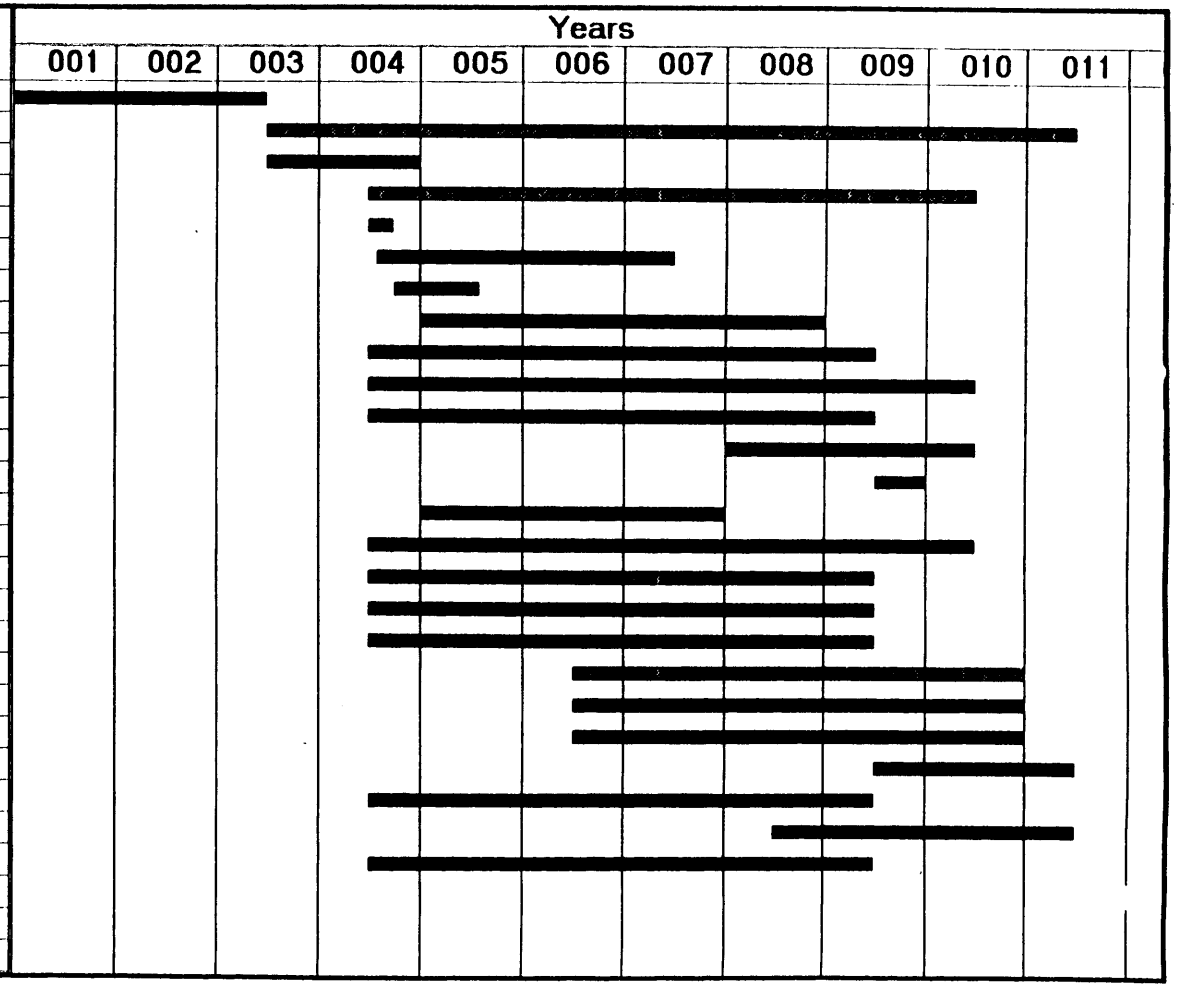
III.2 Chapter 10. Construction Schedule

10.1 Overall Work Schedule

a.	High Rise Lock Canal	200,000 DWT the year of 2,020
b.	High Rise Lock Canal	150,000 DWT the year of 2,020

Overall Work Schedule
High Rise Lock Canal
200,000 DWT, 85' (A.D. 2,020)

Task Name	Q'ty
Engineering,Design&Tender	
Construction	
Supporting construction	
Canal Excavation	
Zone I Dry Excavation	358,000m3
Zone I Dredging	53,847,000m3
Zone II Dry Excavation	14,287,000m3
Zone II Dredging	145,964,000m3
Zone III Dry Excavation	78,192,000m3
Zone III Dredging	64,419,000m3
Zone IV Dry Excavation	148,024,000m3
Zone IV Dredging	5,206,000m3
Zone V Dry Excavation	929,000m3
Zone V Dredging	88,227,000m3
Placing Area	22.5 km2
Lock Structure	
Atlantic Side	3,600,000m3
Pacific Side	3,600,000m3
Gate Leaves, etc.	
Atlantic Side	1 ls
Pacific Side	1 ls
New Permanent Road	32 km
Canal Crossing(Bridges)	2 Bridges
Navigation System	1 ls
New Dam	1 ls



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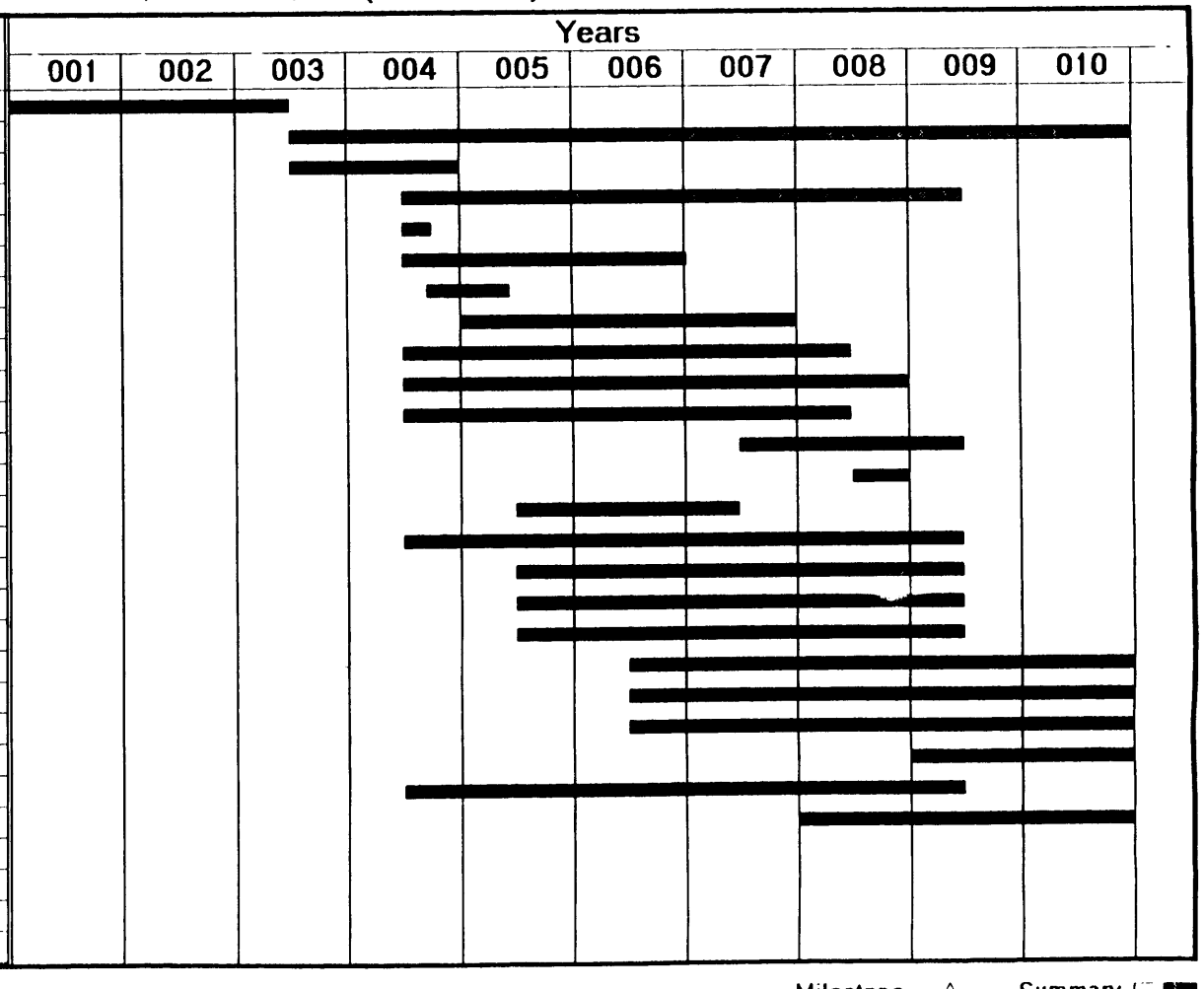
Page 1

Milestone △ Summary

Overall Work Schedule
High Rise Lock Canal
150,000 DWT, 85' (A.D. 2,020)

Task Name	Q'ty
Engineering,Design&Tender	
Construction	
Supporting construction	
Canal Excavation	
Zone I Dry Excavation	322,000m3
Zone I Dredging	46,613,000m3
Zone II Dry Excavation	12,954,000m3
Zone II Dredging	121,866,000m3
Zone III Dry Excavation	69,113,000m3
Zone III Dredging	56,057,000m3
Zone IV Dry Excavation	133,529,000m3
Zone IV Dredging	4,801,000m3
Zone V Dry Excavation	777,000m3
Zone V Dredging	66,093,000m3
Placing Area	22.5 km2
Lock Structure	
Atlantic Side	3,200,000m3
Pacific Side	3,200,000m3
Gate Leaves, etc.	
Atlantic Side	1 ls
Pacific Side	1 ls
New Permanent Road	32 km
Canal Crossing(Bridges)	2 Bridges
Navigation System	1 ls



Milestone △ Summary

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10.2 Schedule for Equipment and Vessel Requirements

	Description	D.W.T.	Table No.
1.	Schedule for Equipment and Vessels - 85′	200,000	III.2.10.2 - 1
2.	Schedule for Equipment and Vessels - 85′	150,000	III.2.10.2 - 2

Table III.2.10.2-1
SCHEDULE FOR EQUIPMENT AND VESSELS
HIGH RISE LOCK CANAL 200,000 D.W.T.-85'

File:EQSH2002

DESCRIPTION	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PRICE CIF PANAMA ($/unit)
Canal Excavation(Dry)																		
Crawler Drill(32ton-225mm)						3	3	3	3									734,760
Bulldozer(98ton)				83	83	71	71	71	71									1,002,340
Shovel(30m3)				7	7	6	6	6	6									7,521,696
Dump Truck(240ton)				80	80	72	72	72	72									1,621,807
Canal Excavation(Dredging)																		
Grab(50m3)				2	3	3	2	2	1	2								13,314,286
Split Barge(5000m3)				13	25	39	35	21	10	9								3,850,000
Split Barge(1500m3)								3	3	5								2,652,857
Pusher Tug(3200HP)				8	15	23	21	13	6	5								3,646,429
Pusher Tug(1300HP)								2	2	3								2,088,571
Trailer(10000m3)				1	2	1												82,557,143
Cutter(18000HP)				2	3	3	2	2										27,485,714
Cutter(27500HP)				1	4	10	10	6	4	4								40,771,429
Blasting Barge w/t Assisting Vessels								1	1	2								26,196,343
Lock Construction																		
Crawler Drill(32ton-225mm)				8														734,760
Bulldozer(98ton)				82														1,002,340
Shovel(30m3)				7														7,521,696
Dump Truck(240ton)				77														1,621,807
Batching Plant(70m3/hr)					6	6	6	6										1,191,240
Genarator(450KVA)					6	6	6	6										175,160
Jib Crane(13.5ton-75m)					8	8	8	8										5,230,000
Genarator(800KVA)					4	4	4	4										270,960
Agitating Car(4.5m3)					42	42	42	42										81,440
Aggregate Production																		
Crawler Drill(32ton-225mm)					1	1	1	1										734,760
Bulldozer(98ton)					1	1	1	1										1,002,340
Shovel(3.3m3)					2	2	2	2										946,194
Dump Truck(32ton)					5	5	5	5										430,505
Crushing Plant(500ton/hr)					2	2	2	2										14,909,332
Genarator(800KVA)					8	8	8	8										270,960
Shovel(3.3m3)					2	2	2	2										946,194
Dump Truck(32ton)					34	34	34	34										430,505

Table III.2.10.2-2
SCHEDULE FOR EQUIPMENT AND VESSELS
HIGH RISE LOCK CANAL 150,000 D.W.T.-85'

File:EQSH1502

DESCRIPTION	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PRICE CIF PANAMA ($/unit)
Canal Excavation(Dry)																		
Crawler Drill(32ton-225mm)						3	3	3										734,760
Bulldozer(98ton)				83	83	71	71	71										1,002,430
Shovel(30m3)				7	7	6	6	6										7,521,696
Dump Truck(240ton)				80	80	72	72	72										1,621,807
Canal Excavation(Dredging)																		
Grab(50m3)				2	3	2	2	2	1									13,314,286
Split Barge(5000m3)				16	22	35	30	13										3,850,000
Split Barge(1500m3)							3	3	2									2,652,857
Pusher Tug(3200HP)				10	13	21	18	8										3,646,429
Pusher Tug(1300HP)							2	2	1									2,088,571
Trailer(10000m3)				1	2	1												82,557,143
Cutter(18000HP)				2	1	2	2	1										27,485,714
Cutter(27500HP)				2	5	10	9	4										40,771,429
Blasting Barge w/t Assisting Vessels							1	1	1									26,196,343
Lock Construction																		
Crawler Drill(32ton-225mm)																		734,760
Bulldozer(98ton)				82														1,002,340
Shovel(30m3)				7														7,521,696
Dump Truck(240ton)				77														1,621,807
Batching Plant(70m3/hr)					6	6	6	6										1,191,240
Generator(450KVA)					6	6	6	6										175,160
Jib Crane(13.5ton-75m)					8	8	8	8										5,230,000
Generator(800KVA)					4	4	4	4										270,960
Agitating Car(4.5m3)					42	42	42	42										81,400
Aggregate Production																		
Crawler Drill(32ton-225mm)					1	1	1	1										734,760
Bulldozer(98ton)					1	1	1	1										1,002,340
Shovel(3.3m3)					2	2	2	2										946,194
Dump Truck(32ton)					5	5	5	5										430,505
Crushing Plant(500ton/hr)					2	2	2	2										14,909,332
Generator(800KVA)					8	8	8	8										270,960
Shovel(3.3m3)					2	2	2	2										946,194
Dump Truck(32ton)					34	34	34	34										430,505

10.3 Manpower Schedule

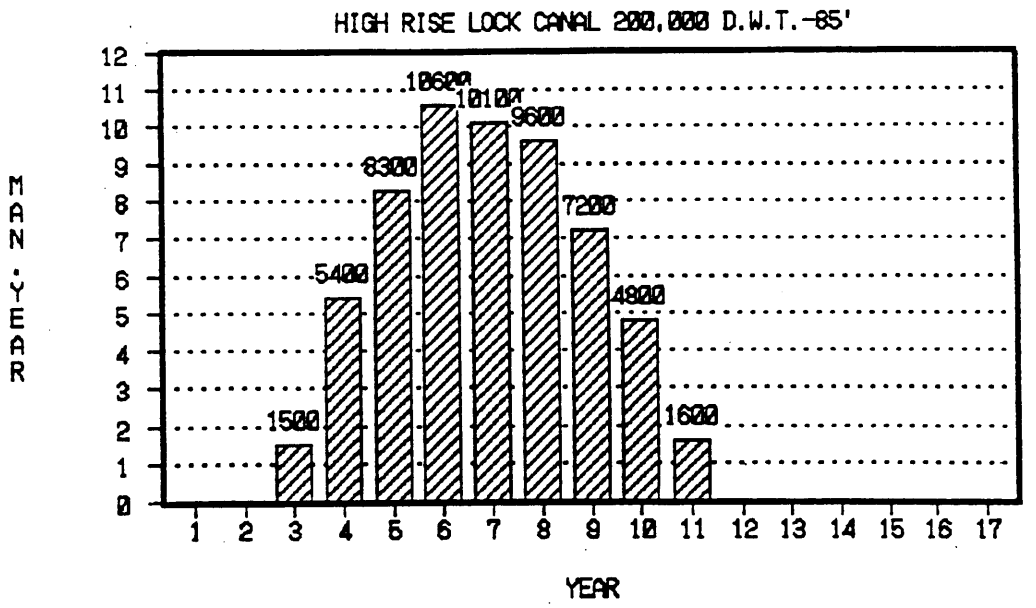


Fig. III.2.10.3-1 Manpower Schedule

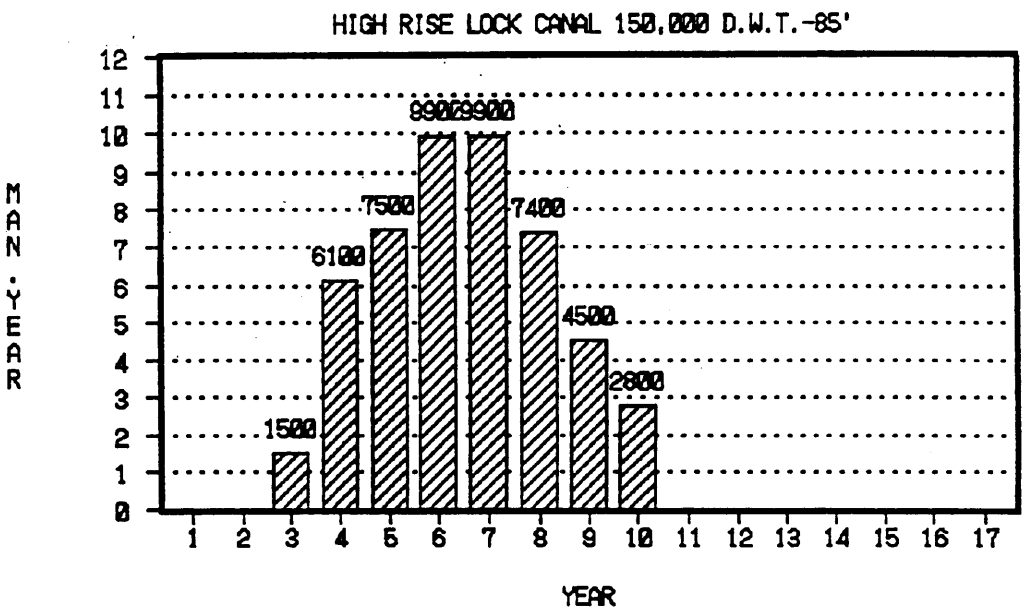


Fig. III.2.10.3-2 Manpower Schedule

Note: These schedules are based on preliminary construction schedule and require levelizing.

PART III SECTION 3 COST ESTIMATES

III.3 Chapter 1. Project Cost Summary

1.1 Project Cost Summary for High Rise Lock Canal

Table III.3.1.1 indicates the project costs estimated for following cases listed below:

1)-1	200,000 D.W.T.(85')	the year of 2,020
1)-2	200,000 D.W.T.(85')	the year of 2,060
2)-1	150,000 D.W.T.(85')	the year of 2,020
2)-2	150,000 D.W.T.(85')	the year of 2,060

The project costs mainly comprise Construction costs and Indirect costs

Note: Costs estimates for lake water level 90' case to be referred to III-1 Chapter II "90' Study Alternatives"

Table III.3.1.1-1 Project Cost Summary, High Rise Lock Canal

(Currency in US dollars) (File : SUMHRLC)

	Description	200,000 DWT			150,000 DWT		
		Rise 85'			Rise 85'		
		the year of 2,020 ($)	the year of 2,060 ($)	Total ($)	the year of 2,020 ($)	the year of 2,060 ($)	Total ($)
I	CONSTRUCTION COSTS						
(A)	CIVIL WORKS						
1	Canal Excavation	3,477,383,640	-	3,477,383,640	3,011,946,860	-	3,011,946,860
2	Placing Area	87,794,350	-	87,794,350	87,794,350	-	87,794,350
3	Lock Construction	1,127,257,294	-	1,127,257,294	991,170,516	-	991,170,516
5	New Dams	236,998,948	92,605,538	329,604,486	-	201,134,249	201,134,249
6	Pump Station	-	149,374,284	149,374,284	-	149,374,284	149,374,284
7	New Permanent Roads	8,752,280	-	8,752,280	8,752,280	-	8,752,280
8	New Canal Crossing	501,187,820	839,491,140	1,340,678,960	450,199,285	776,534,190	1,226,733,475
10	Barrier Dams	-	-	-	-	-	-
11	Breakwater	-	-	-	-	-	-
12	Diversion Scheme	-	-	-	-	-	-
13	Supporting Construction	425,434,300	84,586,000	510,020,300	425,434,300	88,150,000	513,584,300
	Subtotal	5,864,808,632	1,166,056,962	7,030,865,594	4,975,297,591	1,215,192,723	6,190,490,314
(B)	PLANT FORMING A PART OF PERMANENT WORKS						
4	Gate Leaves and Related Facilities	1,011,237,350	-	1,011,237,350	888,887,500	-	888,887,500
9	Navigation Support System	414,209,530	-	414,209,530	414,209,530	-	414,209,530
	Subtotal	1,425,446,880	-	1,425,446,880	1,303,097,030	-	1,303,097,030
	CONSTRUCTION COSTS, TOTAL(I)	7,290,255,512	1,166,056,962	8,456,312,474	6,278,394,621	1,215,192,723	7,493,587,344
I I	INDIRECT COSTS						
1	Administrative Costs	89,542,200	14,322,000	103,864,200	77,114,100	14,925,500	92,039,600
2	Headquarter's Costs	152,853,000	24,448,400	177,301,400	131,637,600	25,478,600	157,116,200
3	Construction Supervision	179,283,000	28,675,800	207,958,800	154,399,200	29,884,200	184,283,400
4	Land Aquisition & Rights	-	-	-	-	-	-
5	Compensation Costs	105,000,000	-	105,000,000	105,000,000	-	105,000,000
6	Contingency	729,026,000	116,606,000	845,632,000	627,839,000	121,519,000	749,358,000
	INDIRECT COSTS, TOTAL(II)	1,255,704,200	184,052,200	1,439,756,400	1,095,989,900	191,807,300	1,287,797,200
	PROJECT COSTS,GRAND TOTAL(I+II)	8,545,959,712	1,350,109,162	9,896,068,874	7,374,384,521	1,407,000,023	8,781,384,544

III.3 Chapter 2. Construction Costs

2.1 Bill of Quantities for Case - I (200,000 DWT)

(1) High Rise Lock Canal the year of 2020 (85')

1) Summary
2) Direct Construction Costs
3) Supporting Construction
4) General Conditions

(2) Additional Costs of phased Construction the year of 2060 (85')

1) Summary
2) Additional Direct Construction Costs
3) Supporting Construction
4) General Conditions

2.2 Bill of Quantities for Case - II (150,000 DWT)

(1) High Rise Lock Canal the year of 2020 (85')

1) Summary
2) Direct Construction Costs
3) Supporting Construction
4) General Conditions

(2) Additional Costs of phased Construction the year of 2060 (85')

1) Summary
2) Direct Construction Costs
3) Supporting Construction
4) General Conditions

2.1 Bill of Quantities for Case-I-1 (200,000DWT)
(1) High Rise Lock Canal, the Year of 2,020 (85')
1) Summary

HIGH RISE LOCK CANAL CASE-I-1
(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	General Cond.	D. Const. Cost	Project Costs
			$	$	$
			(II)	(I)	(I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	Canal Excavation	ls	435,053,000	3,042,330,640	3,477,383,640.00
2	Placing Area	ls	10,984,000	76,810,350	87,794,350.00
3	Lock Construction	ls	153,805,000	973,452,294	1,127,257,294.00
5	New Dams	ls	29,651,000	207,347,948	236,998,948.00
6	Pump Station(to be provided in AC2,060)		nil	nil	nil
7	New Permanent Roads	ls	1,095,000	7,657,280	8,752,280.00
8	New Canal Crossing	ls	inclusive	501,187,820	501,187,820.00
10	Barrier Dams	ls	nil	nil	nil
11	Breakwater	ls	nil	nil	nil
12	Diversion Scheme	ls	nil	nil	nil
13	Supporting Construction	ls	53,226,000	372,208,300	425,434,300.00
	Subtotal		683,814,000	5,180,994,632	5,864,808,632.00
(B)	PLANT FORMING A PART OF PERMANENT WORK				
4	Gate Leaves and Related Facilities	ls	inclusive	1,011,237,350	1,011,237,350.00
9	Navigation Support System	ls	56,516,000	357,693,530	414,209,530.00
	Subtotal		56,516,000	1,368,930,880	1,425,446,880.00
	CONSTRUCTION COSTS, TOTAL		740,330,000	6,549,925,512	7,290,255,512.00
I I I	INDIRECT COSTS				
1	Administrative Costs	ls	-	-	89,542,200.00
2	Headquarter's Costs	ls	-	-	152,853,000.00
3	Construction Supervision	ls	-	-	179,283,000.00
4	Land Aquisition & Rights	ls	-	-	-
5	Compensation Costs	ls	-	-	105,000,000.00
6	Contingency(10% of Const. Costs)	ls	-	-	729,026,000.00
	Subtotal				1,255,704,200.00
	GRAND TOTAL(PROJECT COSTS)				8,545,959,712.00

BILL NO. : 1 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
					0.00
I	DIRECT CONSTRUCTION COSTS				
1	CANAL EXCAVATION				
(1)	Grubbing & clearing in the Canal Area				
1)	ZONE 1	m2	743,000	0.21	156,030.00
2)	ZONE 2	m2	2,228,000	0.21	467,880.00
3)	ZONE 3	m2	3,590,000	0.21	753,900.00
4)	ZONE 4	m2	4,353,000	0.21	914,130.00
5)	ZONE 5	m2	408,000	0.21	85,680.00
	Grubbing & Clearingn Total m2		11,322,000		
(2)	Dry Excavation				
1)	ZONE 1				
	Average hauling distance 2.5km				
1)-1	Common	m3	141,000	1.82	256,620.00
1)-2	Weathered rock (using ripper)	m3	217,000	2.76	598,920.00
1)-3	Medium Hard rock (using ripper)	m3	-	2.76	0.00
1)-4	Hard rock (using blasting)	m3	-	4.59	0.00
2)	ZONE 2				
	Average hauling distance 2.0km				
2)-1	Common	m3	996,000	1.67	1,663,320.00
2)-2	Weathered rock (using ripper)	m3	7,000,000	2.58	18,060,000.00
2)-3	Medium Hard rock (using ripper)	m3	6,291,000	2.58	16,230,780.00
2)-4	Hard rock (using blasting)	m3	-	4.38	0.00
	Subtotal this Sheet				39,187,260.00

BILL NO. : 2 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	ZONE 3				
	Average hauling distance 4.0km				
3)-1	Common	m3	13,008,000	2.27	29,528,160.00
3)-2	Weathered rock (using ripper)	m3	47,544,000	3.32	157,846,080.00
3)-4	Medium Hard rock (using ripper)	m3	15,876,000	3.32	52,708,320.00
3)-5	Hard rock (using blasting)	m3	1,764,000	5.22	9,208,080.00
4)	ZONE 4				
	Average hauling distance 4.0km				
4)-1	Common	m3	15,732,000	2.27	35,711,640.00
4)-2	Weathered rock (using ripper)	m3	66,801,000	3.32	221,779,320.00
4)-3	Medium Hard rock (using ripper)	m3	45,844,000	3.32	152,202,080.00
4)-4	Hard rock (using blasting)	m3	19,647,000	5.22	102,557,340.00
5)	ZONE 5				
	Average hauling distance 6km				
5)-1	Common	m3	125,000	2.87	358,750.00
5)-2	Weathered rock (using ripper)	m3	458,000	4.06	1,859,480.00
5)-3	Medium Hard rock (using ripper)	m3	346,000	4.06	1,404,760.00
5)-4	Hard rock (using blasting)	m3	0	6.06	0.00
	Dry Excavation Total m3		241,790,000		
	Subtotal this Sheet				765,164,010.00

BILL NO. : 3 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(3)	Dredging				
	ZONE 1				
	Average hauling distance 12km				
1)-1	Clayey material(clay, silt)	m3	7,908,000	2.47	19,532,760.00
1)-2	Loose material(sand, gravel)	m3	18,687,000	2.84	53,071,080.00
1)-3	Weathered rock	m3	27,194,000	4.34	118,021,960.00
1)-4	Medium Hard rock	m3	58,000	9.02	523,160.00
1)-5	Hard rock (using blasting)	m3	-	70.60	0.00
2)	ZONE 2				
	Average hauling distance 18.5km				
2)-1	Clayey material(clay, silt)	m3	42,856,000	3.33	142,710,480.00
2)-2	Loose material(sand, gravel)	m3	42,097,000	2.88	121,239,360.00
2)-3	Weathered rock	m3	43,667,000	5.11	223,138,370.00
2)-4	Medium Hard rock	m3	17,344,000	9.05	156,963,200.00
2)-5	Hard rock (using blasting)	m3	-	70.65	0.00
3)	ZONE 3				
	Average hauling distance 22.5km				
3)-1	Clayey material(clay, silt)	m3	2,725,000	4.79	13,052,750.00
3)-2	Loose material(sand, gravel)	m3	3,765,000	4.14	15,587,100.00
3)-3	Weathered rock	m3	28,984,000	7.33	212,452,720.00
3)-4	Medium Hard rock	m3	26,050,000	12.95	337,347,500.00
3)-5	Hard rock (using blasting)	m3	2,895,000	104.10	301,369,500.00
4)	ZONE 4				
	Average hauling distance 22km				
4)-1	Clayey material(clay, silt)	m3	108,000	4.79	517,320.00
4)-2	Loose material(sand, gravel)	m3	94,000	4.14	389,160.00
4)-3	Weathered rock	m3	752,000	7.33	5,512,160.00
4)-4	Medium Hard rock	m3	2,976,000	12.95	38,539,200.00
4)-5	Hard rock (using blasting)	m3	1,276,000	100.95	128,812,200.00
5)	ZONE 5				
	Average hauling distance 7.5km				
5)-1	Clayey material(clay, silt)	m3	23,027,000	2.45	56,416,150.00
5)-2	Loose material(sand, gravel)	m3	27,907,000	2.26	63,069,820.00
5)-3	Weathered rock	m3	36,917,000	4.32	159,481,440.00
5)-4	Medium Hard rock	m3	376,000	9.00	3,384,000.00
5)-5	Hard rock (using blasting)	m3	-	70.55	0.00
	Wet Excavation Total m3		357,663,000		
	Subtotal this Sheet				2,171,131,390.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Vegetation(Seeding) of Canal Slope				
1)	ZONE 1	m2	215,300.00	0.75	161,475.00
2)	ZONE 2	m2	459,300.00	0.75	344,475.00
3)	ZONE 3	m2	1,293,600.00	0.75	970,200.00
4)	ZONE 4	m2	1,222,700.00	0.75	917,025.00
5)	ZONE 5	m2	65,500.00	0.75	49,125.00
	Total Area, m2		3,256,400.00		
(5)	Temporary Works				
1)	Access Roads (W = 22 m, t=1.5m) Starting from excavating spot in the Canal to main construction road which is lying along the Canal	m	16,000	1,002.98	16,047,680.00
2)	Dewatering for Dry Excavation	m3	241,790,000	0.20	48,358,000.00
	Subtotal this Sheet				66,847,980.00
	Total-Item No. 1 Canal Excavation				3,042,330,640.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	Placing Areas for Surplus Material				
(1)	Grubbing & Clearing for Placing Areas				
1)	D-01 Area	m2	2,800,000.0	0.21	588,000.00
2)	D-02 Area	m2	1,700,000.0	0.21	357,000.00
3)	D-03 Area	m2	1,200,000.0	0.21	252,000.00
4)	D-04 Area	m2	100,000.0	0.21	21,000.00
5)	D-05 Area	m2	800,000.0	0.21	168,000.00
6)	D-06 Area	m2	700,000.0	0.21	147,000.00
7)	D-07 Area	m2	3,300,000.0	0.21	693,000.00
8)	D-08 Area	m2	1,600,000.0	0.21	336,000.00
9)	D-09 Area	m2	2,600,000.0	0.21	546,000.00
10)	D-10 Area	m2	2,300,000.0	0.21	483,000.00
11)	D-11 Area	m2	1,900,000.0	0.21	399,000.00
12)	D-12 Area	m2	1,100,000.0	0.21	231,000.00
13)	D-13 Area	m2	2,400,000.0	0.21	504,000.00
	Total Area, m2		22,500,000.0		
(2)	Placing Area Preparation including Surface drainage (open ditch) Vegetation Underground Drainage	km2	22.5	2,535,140.00	57,040,650.00
(3)	Access Roads (W = 22 m, t=1.5m) starting from placing area to the main construction road	m	15,000.0	1,002.98	15,044,700.00
	Subtotal this Sheet				76,810,350.00
	Total-Item No. 2 Placing Areas for Surplus Material				76,810,350.00

BILL NO. : 6 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	LOCK CONSTRUCTION				
(1)	ATLANTIC SIDE				
1)	Excavation, Hauling Distance 5.0km				
1)-1	Common	m3	15,500,000	2.57	39,835,000.00
1)-2	Weathered Rock	m3	9,300,000	3.69	34,317,000.00
1)-3	Hard Rock	m3	6,200,000	5.64	34,968,000.00
	Total Volume		31,000,000		
1)-4	Dewatering	ls	1	13,849,447.00	13,849,447.00
2)	Backfill	m3	8,500,000	3.85	32,725,000.00
3)	Grouting				
3)-1	Bore Hole	m	226,000	20.05	4,531,300.00
3)-2	Consolidation Groutiong	m	226,000	66.80	15,096,800.00
4)	Concrete including form works, etc (Atlantic side cost)	m3	3,600,000	87.68	315,648,000.00
5)	Reinforcing Bar(Deformed)	ton	36,000	804.10	28,947,600.00
(2)	PACIFIC SIDE				
1)	Excavation				
1)-1	Common	m3	15,500,000	2.57	39,835,000.00
1)-2	Weathered Rock	m3	9,300,000	3.69	34,317,000.00
1)-3	Hard Rock	m3	6,200,000	5.64	34,968,000.00
	Total Volume		31,000,000		
1)-4	Dewatering	ls	1	13,849,447.00	13,849,447.00
2)	Backfill	m3	8,500,000	3.85	32,725,000.00
3)	Grouting				
3)-1	Bore Hole	m	226,000	20.05	4,531,300.00
3)-2	Consolidation Grouting	m	226,000	66.80	15,096,800.00
4)	Concrete including form works, etc (Pacific side cost)	m3	3,600,000	69.24	249,264,000.00
5)	Reinforcing Bar(Deformed)	ton	36,000	804.10	28,947,600.00
	Subtotal this Sheet				973,452,294.00
	Total-Item No. 3 Lock Construction				973,452,294.00

BILL NO. : 7 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	GATE LEAVES AND RELATED FACILITIES				
(1)	GATE LEAVES AT ATLANTIC ENTRANCE LOCK				
1)	Gate Leaves	ton	12,786	9,820	125,558,520.00
2)	Machinery & Equipment				
2)-1	Gate Frame	ton	5,349	11,110	59,427,390.00
2)-2	Gate Hoist	ton	2,289	15,910	36,417,990.00
2)-3	Locomotives	unit	20	3,600,000	72,000,000.00
2)-4	Rails and Racks for Locomotive	ton	3,631	8,140	29,556,340.00
2)-5	Power Supply Line for Locomotives	set	1	5,000,000	5,000,000.00
2)-6	Other Mechanical Component (Compressed Air System, Drainage Pumps Piping and Misc. Mechanical Equip.)	set	1	37,676,000	37,676,000.00
3)	Electrical Power & Control				
3)-1	Electrical Power & Control Equipment (38000KW)	set	1	35,700,000	35,700,000.00
3)-2	Emergency Power Plant	kw	38,000	770	29,260,000.00
3)-3	Misc. Electrical Equip.	set	1	8,000,000	8,000,000.00
3)-4					
4)	Others				
4)-1	Local Control Buildings	set	1	400,000	400,000.00
4)-2	Their electrical equipment	set	1	100,000	100,000.00
4)-3	Cathodic Protection	set	1	1,600,000	1,600,000.00
4)-4	Monitoring & Surveillance Equipments, Communication System	set	1	1,900,000	1,900,000.00
4)-5	Grounding System	set	1	400,000	400,000.00
4)-6	Other Electric works and Consumables	set	1	700,000	700,000.00
	Subtotal this Sheet				443,696,240.00

BILL NO. : 8 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	GATE LEAVES AT PACIFIC ENTRANCE LOCK				
1)	Gate Leaves	ton	21,114	9,800	206,917,200.00
2)	Machinery & Equipment				
2)-1	Gate Frame	ton	5,591	11,110	62,116,010.00
2)-2	Gate Hoist	ton	3,073	15,720	48,307,560.00
2)-3	Locomotives	unit	20	3,600,000	72,000,000.00
2)-4	Rails and Racks for Locomotive	ton	3,631	8,140	29,556,340.00
2)-5	Power Supply Line for Locomotives	set	1	5,000,000	5,000,000.00
2)-6	Other Mechanical Component (Compressed Air System, Drainage Pumps Piping and Misc. Mechanical Equip.)	set	1	62,084,000	62,084,000.00
3)	Electrical Power & Control				
3)-1	Electrical Power & Control Equipment (38000KW)	set	1	35,700,000	35,700,000.00
3)-2	Emergency Power Plant	kw	38,000	770	29,260,000.00
3)-3	Misc. Electrical Equip.	set	1	8,000,000	8,000,000.00
4)	Others				
4)-1	Local Control Buildings	set	1	700,000	700,000.00
4)-2	Their electrical equipment	set	1	200,000	200,000.00
4)-3	Cathodic Protection	set	1	2,700,000	2,700,000.00
4)-4	Monitoring & Surveillance Equip. Communication System	set	1	3,100,000	3,100,000.00
4)-5	Systems, Grounding System	set	1	700,000	700,000.00
4)-6	and Other Electric works and Consumables	set	1	1,200,000	1,200,000.00
	Subtotal this Sheet				567,541,110.00
	Total-Item No. 4 Gate Leaves and Related Structure				1,011,237,350.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	NEW DAMS				
(1)	INDIO DAM (H=90M)				
1)	Earthwork Excavation for Dam Foundation				
1)-1	Top Soil Removal	m2	776,100	1.59	1,233,999.00
	Excavation(Hauling Distance 5km) Shovel(3.0m3), Dump Truck(32t)				
1)-1	Common	m3	850,000	4.77	4,054,500.00
1)-2	Weathered Rock	m3	850,000	6.68	5,678,000.00
	Total m3		1,700,000		
1)-3	Foundation Preparation (Finish excavation, t=0.5m) Foundation Area, 776,100m2*20%	m2	156,000	34.28	5,347,680.00
1)-4	Foundation Preparation by Washing	m2	156,000	30.50	4,758,000.00
1)-5	Excavation for Diversion tunnel	m3	152,000	120.00	18,240,000.00
	Excavation for Spillway				
1)-6	Common	m3	59,500	4.77	283,815.00
1)-7	Weathered Rock	m3	35,700	6.68	238,476.00
1)-8	Hard Rock	m3	23,800	8.46	201,348.00
	Total m3		119,000		
	Embankment(Hauling Distance 10.0km)				
1)-9	Core	m3	2,000,000	11.69	23,380,000.00
1)-10	Filter	m3	1,700,000	11.70	19,890,000.00
1)-11	Rock	m3	10,000,000	8.46	84,600,000.00
	Total m3		13,700,000		
	Subtotal this Sheet				167,905,818.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2)	Grouting(Curtain)				
	Curtain Grouting				
2)-1	Drilling Grouting Hole	m	83,000	73.09	6,066,470.00
2)-2	Pressure Grouting	m	83,000	71.50	5,934,500.00
	Blanket Grouting				
2)-3	Drilling Grouting Hole	m	44,100	19.99	881,559.00
2)-4	Pressure Grouting	m	44,100	34.07	1,502,487.00
3)	Concrete Works including Formworks etc				
3)-1	Concrete for Spillway	m3	83,000	100.00	8,300,000.00
3)-2	Concrete for Diversion Tunnel	m3	26,000	120.00	3,120,000.00
3)-3	Concrete for Outlet	m3	50,000	100.00	5,000,000.00
	Total m3		159,000		
3)-4	Reinforcing Bars(Deformed)	t	9,540	804.10	7,671,114.00
4)	Steel Works & Equipment				
4)-1	Outlet Penstock	t	30	7,200.00	216,000.00
4)-2	Hollow-jet Valve Φ=1.3m	set	1	470,000.00	470,000.00
4)-3	Spare Valve Φ=1.3m	set	1	280,000.00	280,000.00
(2)	TRINIDADO DAM (H=80M) to be provided in the year of AC 2,060		-	-	-
(3)	CIRI DAM		nil	-	-
(4)	UPPER GATUN DAM		nil	-	-
	Subtotal this Sheet				39,442,130.00
	Total-Item No.5 New Dams				207,347,948.00

BILL NO. : 11 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6	PUMP STATIONS				
(1)	PUMP STATION AT ATATLANTIC LOCK to be provided in the year of 2,060		-	-	-
(2)	PUMP STATION AT PACIFIC LOCK to be provided in the year of 2,060		-	-	-
	Subtotal this Sheet				0.00
	Total-Item No. 6 Pump Stations				-

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
7	NEW PERMANENT ROADS				
(1)	ROADS FOR INSPECTION (NEW ROADS) W =6.8m				
1)	Subgrade, Base Course(t = 0.4m)	km	32.0	110,490.00	3,535,680.00
2)	Asphalt Paving(t=70mm)	m2	320,000.0	12.88	4,121,600.00
	Subtotal this Sheet				7,657,280.00
	Total-Item No.7 New Permanent Roads				7,657,280.00

BILL NO. : 13 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
8	NEW CANAL CROSSINGS				
(1)	BRIDGES				
1)	Bridges Over The Canal on Pacific Side				
1)-1	Cable Stayed Bridge Canal Width 350m Span = L1(Main)+L2+L3=480+190+190=860m Width = 20.5m (Four Lane)	m2	17,630	15,834.00	279,153,420.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 800m (One Span 60m) Width = 20.5m (Four Lane)	m2	16,400	2,956.00	48,478,400.00
2)	Bridges Over the Canal for Van Dam Bypass(1) (To be provided in the year of 2,060)		-	-	-
3)	Bridges Over the Canal for Van Dam Bypass(2) (To be provided in the year of 2,060)				
	Subtotal this Sheet				327,631,820.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4)	Bridges Over the Canal at Middle Gamboa		-	-	-
	(To be provided in the year of 2,060)				
5)	Bridges Over The Canal on Atlantic Side				
5)-1	Cable Stayed Bridge Canal Width 350m Span = L1(Main)+L2+L3=430+170+170=770m Width = 10.0m (Two Lane)	m2	7,700	13,680.00	105,336,000.00
5)-2	Approaching Bridges(Steel Box Girder) Total Length = 1,500m (One Span 60m) Width = 10.0m (Two Lane)	m2	15,000	2,980.00	44,700,000.00
(2)	Demolition of Existing Bridge				
1)	Balboa bridge(Bridge of the Americas)				
1)-1	Super-structure	t	14,000	1,120.00	15,680,000.00
1)-2	Sub-Structure	ls	1	7,840,000	7,840,000.00
	Subtotal this Sheet				173,556,000.00
	Total-Item No.8 New Canal Crossings				501,187,820.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
9	NAVIGATION SUPPORT SYSTEMS				
(1)	Navigation Lights and Leading Channel Range Marker Lights				
	For Two-Way Newly Excavated Canal				
1)	Navigation Lights 10 w, Lens Type Light Range : Three Nautical miles Power supply : Solar Battery				
1)-1	Pacific Ocean Navigation Light(Buoy) For 11km (Interval 927m) 11,000 / 927 m = 12 * 2 sides	sets	24	121,506.00	2,916,144.00
1)-2	Atlantic Ocean Navigation For 11km (Interval 927m)	sets	24	121,506.00	2,916,144.00
1)-3	At turning points, S and T 2 points x 2 sets	sets	4	121,506.00	486,024.00
1)-4	At turning points, B, C and D 3 points x 2 sets	sets	6	121,506.00	729,036.00
1)-5	Leading Channel Range Marker Light 4 points x 2 lanes x 2 sets	sets	16	473,496.00	7,575,936.00
	For Two-way widened-portion of the Canal, 30 km				
1)-6	Relocation of existing Navigation Lights (Buoys) (specification)	sets	-	12,874.00	0.00
1)-7	Leading Channel Range Marker Light 30 points x 2	sets	60	473,496.00	28,409,760.00
	Subtotal this Sheet				43,033,044.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	TUG STATION				
1)	Provide Tug Boats, 6,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	23	6,649,286	152,933,578.00
2)	Provide/Supply Tug Boats, 3,000 HP-4,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	2	4,652,857	9,305,714.00
3)	Lunches(for 10 persons) Twin Screw (maintenance/running Cost not included)	unit	14	163,571	2,289,994.00
(3)	EMERGENCY TIE UP STATION (Mooring Dolphin Type)				
1)	Located at the north end of the new Pacific Locks	nos	1	14,043,200	14,043,200.00
2)	Located at Gatun Lake	nos	1	14,043,200	14,043,200.00
3)	Excavation				
	Dry Excavation(Hauling distance 4.0km)				
3)-1	Common	m3	1,600,000	2.27	3,632,000.00
3)-2	Weathered Rock	m3	960,000	3.32	3,187,200.00
3)-3	Hard Rock	m3	640,000	5.22	3,340,800.00
	Dredging(Hauling Distance 22km)				
3)-4	Clayey material(clay, silt)	m3	1,600,000	4.79	7,664,000.00
3)-5	Weathered Rock	m3	960,000	7.33	7,036,800.00
3)-6	Hard Rock	m3	640,000	100.95	64,608,000.00
	Total Excavation m3		6,400,000		
	Subtotal this Sheet				282,084,486.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Jetty(10m x 50m)				
	Five(5) Locations for Tug Jetty				
1)	Colon	nos	2	4,072,000	8,144,000.00
2)	Gatun Lake	nos	2	4,072,000	8,144,000.00
3)	Gamboa	nos	1	4,072,000	4,072,000.00
4)	Pedro Miguel	nos	1	4,072,000	4,072,000.00
5)	Diablo	nos	2	4,072,000	8,144,000.00
	Subtotal this Sheet				32,576,000.00
	Total-Item No.9 Navigation Support Systems				357,693,530.00

BILL NO. : 18 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
10	Barrier Dam (not applicable for the H.R.L Canal)		nil	-	-
11	Break Water (not applicable for the H.R.L Canal)		nil	-	-
12	Diversion Scheme (not applicable for the H.R.L Canal)		nil	-	-
	Subtotal this Sheet				-

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 3	SUPPORTING CONSTRUCTION				
(1)	CONSTRUCTION VILLAGE AND CAMPS				
1)	Site Preparation				
	5 site*140000m2 + 2 village*1000000m2	m2	2,700,000	1.72	4,644,000.00
2)	Housing and Building				
2)-1	Office and Warehouse		Estimated in General Conditions		0.00
2)-2	Detached House A 400m2/house	Nos	5	80,000	400,000.00
2)-3	Detached House B 300m2/house	Nos	50	60,000	3,000,000.00
2)-4	Detached House C 200m2/house	Nos	200	40,000	8,000,000.00
2)-5	Dormitory 2 village*120psn*100m2	m2	24,000	150	3,600,000.00
2)-6	Resthouse 2 village*2000m2	m2	4,000	200	800,000.00
2)-7	Canteen/Messhouse 1000m2*2 1000m2*5	m2	7,000	150	1,050,000.00
2)-8	Labor Camp 5 site*2000psn*50m2/psn	m2	500,000	120	60,000,000.00
2)-9	Supermarket 2village*1000m2 5site*200	m2	3,000	120	360,000.00
2)-10	School 2 village*2500m2	m2	5,000	150	750,000.00
2)-11	Theatre 2 village*5000m2	m2	10,000	150	1,500,000.00
2)-12	Sports/Recreation Center	m2	10,000	150	1,500,000.00
2)-13	Church 2 village*1000m2	m2	2,000	150	300,000.00
2)-14	Fire Station 7 places*500m2	m2	3,500	120	420,000.00
2)-15	Hospital 2 village*5000m2	m2	10,000	200	2,000,000.00
3)	Facilities and Services				
3)-1	Road W=6M 5site*600m 2village*2000m	m2	42,000	13	546,000.00
3)-2	Sewage 1 unit 2 village 5 site				
	Sewage Plant 5000t/day	unit	7	1,000,000	7,000,000.00
	Piping	m	20,000	50	1,000,000.00
	Operation Cost	yrs	8	60000	480,000.00
3)-3	Water Supply				
	Pump for Well (20m3/h)	Nos	7	10,000	70,000.00
	Water Treatment	Nos	7	500,000	3,500,000.00
	Piping 3000m*7	m	21000	8	168,000.00
3)-4	Power Supply Generator 800kVA*3Nos*7				
	Power Distribution 3000m*7	m	21000	20	420,000.00
	Operation 11unit*24h*365*8	Hrs	770,880	58	44,711,040.00
3)-5	Fuel Supply Station	site	7	100,000	700,000.00
3)-6	Communication(Telephone/Fax/Radio/TV)	site	7	200,000	1,400,000.00
3)-7	Landscaping	m2	2,700,000	4	10,800,000.00
	Subtotal this Sheet				159,119,040.00

BILL NO. : 20 HIGH RISE LOCK 159,119,040

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4)	Maintenance Cost Personnel Cost for Maintenance				
4)-1	Camp Manager 1psn*2site*96mo	M.Mo	192	3,000	576,000.00
4)-2	Guardman 20psn*7site*96mo	M.Mo	13,440	1,000	13,440,000.00
4)-3	Medical Doctor 2psn*2Hosp*96	M.Mo	384	10,000	3,840,000.00
4)-4	Nurse 8psn*2*96 4psn*5*96	M.Mo	3,456	1,500	5,184,000.00
4)-5	Catering Staff 10psn*7*96	M.Mo	6,720	1,200	8,064,000.00
4)-6	Housekeeper 20*7*96	M.Mo	13,440	700	9,408,000.00
4)-7	Chief Driver 2psn*96mo	M.Mo	192	1,200	230,400.00
4)-8	Bus Driver 30Nos*96	M.Mo	2,880	1,000	2,880,000.00
4)-9	School Teacher 2 village*4*96mo	M.Mo	768	7,000	5,376,000.00
4)-10	Gardener 2psn*7site*96	M.Mo	1,334	1,000	1,334,000.00
4)-11	Supermarket Staff 4psn*7site*96	M.Mo	2,688	1,200	3,225,600.00
5)	Vehicles				
5)-1	Buses 30Nos*96mo	M.Mo	2,880	3,800	10,944,000.00
5)-2	Ambulance 2Nos*7*96	M.Mo	1,344	1,000	1,344,000.00
5)-3	Patrol Vehicle 2Nos*7*96	M.Mo	1,344	1,500	2,016,000.00
5)-4	Fire Engine 1No*7*96	M.Mo	672	2,500	1,680,000.00
	Subtotal this Sheet				69,542,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Main Construction Roads				
1)	Cut, fill, subgrade, Base Course, etc. (W = 22.0m, t=1.2m)	m	50,000	1,002.98	50,149,000.00
(3)	Access Roads to Quarries				
1)	Cut, fill, subgrade, Base Course, etc. (W = 22.0m, t=1.2m)	m	9,000	1,002.98	9,026,820.00
	Subtotal this Sheet				59,175,820.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Logistic Base				
1)	Puerto Pilon on Atlantic Side				
1)-1	Embankment, Grading	m3	30,000	12.00	360,000.00
1)-2	Jetty for Aggregates	m	240	2,800.00	672,000.00
1)-3	Control House	m2	100	400.00	40,000.00
1)-4	Guard House	m2	9	160.00	1,440.00
1)-5	Rest House	m2	100	240.00	24,000.00
1)-6	Roads	m2	7,000	20.00	140,000.00
1)-7	Fence	m	700	24.00	16,800.00
1)-8	Gate	set	1	8,000.00	8,000.00
1)-9	Drainage Way	m	700	104.00	72,800.00
1)-10	Operation of Generator	year	6	162,000.00	972,000.00
2)	Colon on Atlantic Side				
1)-1	Embankment, Grading	m3	110,500	12.00	1,326,000.00
1)-2	Sea Wall (Conc.)	m	490	270.00	132,300.00
1)-3	Jetty for Aggregates	m	200	2,800.00	560,000.00
1)-4	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
	Storage Facilities				
1)-5	Cement Silo(1,500t/No.)	no.	10	240,000.00	2,400,000.00
1)-6	Tank for Fuel (1,600kl/no.)	no.	8	520,000.00	4,160,000.00
1)-7	Tank for Oil (100kl/no.)	no.	2	80,000.00	160,000.00
1)-8	Warehouse	m2	8,000	240.00	1,920,000.00
1)-9	Control House	m2	1,000	400.00	400,000.00
1)-10	Guard House	m2	27	160.00	4,320.00
1)-11	Rest House	m2	500	240.00	120,000.00
1)-12	Roads w=12m	m2	39,360	20.00	787,200.00
1)-13	Fence	m	990	24.00	23,760.00
1)-14	Gate	set	3	8,000.00	24,000.00
1)-15	Drainage Way	m	3,280	104.00	341,120.00
1)-16	Operation of Generator	year	6	252,000.00	1,512,000.00
	Subtotal this Sheet				43,777,740.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	Panama City on Pacific Side				
1)-1	Embankment, Grading	m3	93,500	12.00	1,122,000.00
1)-2	Sea Wall	m	590	270.00	159,300.00
1)-3	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
	Strage Facilities				
1)-4	Cement Silo(1,500t/No.)	no.	10	240,000.00	2,400,000.00
1)-5	Tank for Fuel (1,600kl/no.)	no.	8	520,000.00	4,160,000.00
1)-6	Tank for Oil (100kl/no.)	no.	2	80,000.00	160,000.00
1)-7	Warehouse	m2	8,000	240.00	1,920,000.00
1)-8	Control House	m2	1,000	400.00	400,000.00
1)-9	Guard House	m2	27	160.00	4,320.00
1)-10	Rest House	m2	500	240.00	120,000.00
1)-11	Roads	m2	34,560	20.00	691,200.00
1)-12	Fence	m	890	24.00	21,360.00
1)-13	Gate	set	3	8,000.00	24,000.00
1)-14	Drainage Way	m	2,880	104.00	299,520.00
1)-15	Operation of Generator	year	6	252,000.00	1,512,000.00
	Subtotal this Sheet				40,593,700.00
	Total-Item No. 13 Supporting Construction				372,208,300.00

BILL NO. : 24 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
14	GENERAL CONDITIONS				
(1)	Canal Excavation, (14.3%, Item Total)	ls	1		435,053,000.00
(2)	Placing Area, (14.3%, Item Total)	ls	1		10,984,000.00
(3)	Lock Construction (15.8%, Item Total)	ls	1		153,805,000.00
(4)	Gate Leaves and Related Facilities		-		-inclusive-
(5)	New Dams, (14,3%, Item Total)	ls	1		29,651,000.00
(6)	Pump Station		nil		-
(7)	New Parmanent Roads, (14.3%, Total Item)	ls	1		1,095,000.00
(8)	New Canal Crossing		-		-inclusive-
(9)	Navigation Support System(15.8%, T. Item)	ls	1		56,516,000.00
(10)	Barrier Dams		nil		-
(11)	Breakwater		nil		-
(12)	Diversion Scheme		nil		-
(13)	Supporting Construction(14.3%, T. Item)	ls	1		53,226,000.00
	Subtotal this Sheet				740,330,000.00
	Total-Item No.14 General Conditions				740,330,000.00

2.1 Bill of Quantities for Case-I-1 (200,000DWT)

(2) Additional Costs of Phased Construction High Rise Lock Canal, the Year of 2,060 (85')

1) Summary

HIGH RISE LOCK CANAL CASE-I-1

(2,060) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	General Cond. $	D. Const. Cost $	Project Costs $
			(II)	(I)	(I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	New dams	ls	11,586,000	81,019,538	92,605,538.00
2	Pump Station	ls	20,381,000	128,993,284	149,374,284.00
3	New Canal Crossing	ls	-inclusive-	839,491,140	839,491,140.00
4	Supporting Construction	ls	10,582,500	74,003,500	84,586,000.00
	CONSTRUCTION COSTS, TOTAL		42,549,500	1,123,507,462	1,166,056,962.00
I I I	INDIRECT COSTS (*1)				
1	Administrative Costs	ls	-	-	14,322,000.00
2	Headquarter's Costs	ls	-	-	24,448,400.00
3	Construction Supervision	ls	-	-	28,675,800.00
4	Land Aquisition & Rights	ls	-	-	-
5	Compensation Costs	ls	-	-	-
6	Contingency(10% of Const. Costs)	ls	-	-	116,606,000.00
	Subtotal				184,052,200.00
	(*1):to be assigned as percentage of Construction Costs				
	GRAND TOTAL(PROJECT COSTS)				1,350,109,162.00

BILL NO. : 1 HIGH RISE LOCK CANAL CASE-I-1

(2,060) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1	NEW DAMS				
(1)	TRINIDADO DAM (H=80M)				
1)	Earthwork Excavation for Dam Foundation				
1)-1	Top Soil Removal	m2	336,000	1.59	534,240.00
	Excavation(Hauling Distance 5km) Shovel(3.0m3), Dump Truck(32t)				
1)-2	Common	m3	400,000	4.77	1,908,000.00
1)-3	Weathered Rock	m3	400,000	6.68	2,672,000.00
	Total m3		800,000		
	Foundation Preparation				
1)-4	(Finish excavation, t=0.5m) Foundation Area, 336,000m2*20%	m2	67,200	34.28	2,303,616.00
1)-5	Foundation Preparation by Washing	m2	67,200	30.50	2,049,600.00
1)-6	Excavation for Diversion tunnel	m3	26,000	120.00	3,120,000.00
	Excavation for Spillway				
1)-7	Common	m3	37,000	4.77	176,490.00
1)-8	Weathered Rock	m3	22,200	6.68	148,296.00
1)-9	Hard Rock	m3	14,800	8.46	125,208.00
	Total m3		74,000		
	Embankment(Hauling Distance 10.0km)				
1)-10	Core	m3	900,000	11.69	10,521,000.00
1)-11	Filter	m3	800,000	11.70	9,360,000.00
1)-12	Rock	m3	4,400,000	8.46	37,224,000.00
	Total m3		6,100,000		
	Subtotal this Sheet				70,142,450.00

BILL NO. : 2 HIGH RISE LOCK CANAL CASE-I-1

(2,060) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2)	Grouting(Curtain)				
	Curtain Grouting				
2)-1	Drilling Grouting Hole	m	38,000	73.09	2,777,420.00
2)-2	Pressure Grouting	m	38,000	71.50	2,717,000.00
	Blanket Grouting				
2)-3	Drilling Grouting Hole	m	19,400	19.99	387,806.00
2)-4	Pressure Grouting	m	19,400	34.07	660,958.00
3)	Concrete Works including Formworks etc				
3)-1	Concrete for Spillway	m3	15,000	100.00	1,500,000.00
3)-2	Concrete for Diversion Tunnel	m3	8,000	120.00	960,000.00
3)-3	Concrete for Outlet	m3	1,000	100.00	100,000.00
	Total m3		24,000		
3)-4	Reinforcing Bars(Deormed)	t	1,440	804.10	1,157,904.00
4)	Steel Works & Equipment				
4)-1	Outlet Penstock	t	30	7,200.00	216,000.00
4)-2	Hollow-jet Valve Φ=0.7m	set	1	250,000.00	250,000.00
4)-3	Spare Valve Φ=0.7m	set	1	150,000.00	150,000.00
	Subtotal this Sheet				10,877,088.00
	Total-Item No.1 New Dams				81,019,538.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	PUMP STATIONS				
(1)	PUMP STATION AT ATATLANTIC LOCK				
1)	Excavation, Hauling Distance 5.0km (Shovel 3.0m3, Dump Truck 32t)				
1)-1	Common	m3	30,000	4.77	143,100.00
1)-2	Weathered	m3	18,000	6.68	120,240.00
1)-3	Hard Rock	m3	12,000	8.86	106,320.00
	Total m3		60,000		
2)	Concrete Work				
2)-1	Concrete including form works, etc.	m3	14,680	100.00	1,468,000.00
2)-2	Reinforcing Bars(Deformed)	t	1,170.00	804.10	940,797.00
3)	Building	m2	1,750	1,000.00	1,750,000.00
4)	Pumps & ancillary equipment				
4)-1	Pumps & Valves including installation 3 units of pumps, 30 m3/sec-unit	units	3	7,350,000	22,050,000.00
4)-2	Machinery including piping, etc.	units	3	4,410,000	13,230,000.00
4)-3	Electrical Equipment and Wiring	units	3	2,940,000	8,820,000.00
4)-4	Others	ls	1	-	0.00
5)	Water Way				
5)-1	Embankment(Excavated Materials) Hauling Distance 10.0km	m3	33,000	11.69	385,770.00
	Excavation, Hauling Distance 0.5km				
5)-2	Common	m3	22,500	1.82	40,950.00
5)-3	Weathered Rock	m3	13,500	3.03	40,905.00
5)-4	Hard Rock	m3	9,000	4.72	42,480.00
	Total m3		45,000		
	Subtotal this Sheet				49,138,562.00

BILL NO. : 4 HIGH RISE LOCK CANAL CASE-I-1

(2,060) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6)	Recycle Pond				
6)-1	Embankment(Excavated Materials) Hauling Distance 10.0km	m3	132,000	11.69	1,543,080.00
	Excavation, Hauling Distance 0.5km				
6)-2	Common	m3	2,500,000	1.82	4,550,000.00
6)-3	Weathered Rock	m3	1,500,000	3.03	4,545,000.00
6)-4	Hard Rock	m3	1,000,000	4.72	4,720,000.00
	Total m3		5,000,000		
6)-5	Concrete Structures	m3	-		0.00
	Subtotal this Sheet				15,358,080.00

BILL NO. : 5 HIGH RISE LOCK CANAL CASE-I-1

(2,060) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	PUMP STATION AT PACIFIC LOCK				
1)	Excavation, Hauling Distance 5.0km (Shovel 3.0m3, Dump Truck 32t)				
1)-1	Common	m3	30,000	4.77	143,100.00
1)-2	Weathered	m3	18,000	6.68	120,240.00
1)-3	Hard Rock	m3	12,000	8.86	106,320.00
	Total m3		60,000		
2)	Concrete Work				
2)-1	Concrete including form works, etc.	m3	14,680	100.00	1,468,000.00
2)-2	Reinforcing Bars(Deformed)	t	1,170.00	804.10	940,797.00
3)	Building	m2	1,750	1,000.00	1,750,000.00
4)	Pumps & ancillary equipment				
4)-1	Pumps & Valves including installation 3 units of pumps, 30 m3/sec-unit	units	3	7,350,000	22,050,000.00
4)-2	Machinery including piping, etc.	units	3	4,410,000	13,230,000.00
4)-3	Electrical Equipment and Wiring	units	3	2,940,000	8,820,000.00
4)-4	Others	ls	1	-	0.00
5)	Water Way				
5)-1	Embankment(Excavated Materials) Hauling Distance 10.0km	m3	33,000	11.69	385,770.00
	Excavation, Hauling Distance 0.5km				
5)-2	Common	m3	22,500	1.82	40,950.00
5)-3	Weathered Rock	m3	13,500	3.03	40,905.00
5)-4	Hard Rock	m3	9,000	4.72	42,480.00
	Total m3		45,000		
	Subtotal this Sheet				49,138,562.00

BILL NO. : 6 HIGH RISE LOCK CANAL CASE-I-1

(2,060) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6)	Recycle Pond				
6)-1	Embankment(Excavated Materials) Hauling Distance 10.0km	m3	132,000	11.69	1,543,080.00
	Excavation, Hauling Distance 0.5km				
6)-2	Common	m3	2,500,000	1.82	4,550,000.00
6)-3	Weathered Rock	m3	1,500,000	3.03	4,545,000.00
6)-4	Hard Rock	m3	1,000,000	4.72	4,720,000.00
	Total m3		5,000,000		
	Subtotal this Sheet				15,358,080.00
	Total-Item No.2 Pump Stations				128,993,284.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	New Canal Crossing				
(1)	BRIDGES				
1)	Bridges Over the Canal for Van Dam Bypass(1)				
1)-1	Cable Stayed Bridge Canal Width 350m Span = L1(Main)+L2+L3=500+200+200=900m Width = 20.5m (Four Lane)	m2	18,450	16,679.00	307,727,550.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 490m (One Span 60m) Width = 20.5m (Four Lane)	m2	10,045	2,964.00	29,773,380.00
2)	Bridges Over the (Existing) Canal for Van Dam Bypass(2)				
2)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=500+200+200=900m Width = 20.5m (Four Lane)	m2	18,450	16,679.00	307,727,550.00
2)-2	Approaching Bridges(Steel Box Girder) Total Length = 430m (One Span 60m) Width = 20.5m (Four Lane)	m2	8,815	2,964.00	26,127,660.00
3)	Bridges Over the Canal at Middle Gamboa				
3)-1	Cable Stayed Bridge Canal Width 350m Span = L1(Main)+L2+L3=500+200+200=900m Width = 10.0m (Two Lane)	m2	9,000	16,695.00	150,255,000.00
3)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Two Lane)	m2	6,000	2,980.00	17,880,000.00
	Subtotal this Sheet				839,491,140.00
	Total-Item No. 3 New Canal Crossing				839,491,140.00

BILL NO. : 8 HIGH RISE LOCK CANAL CASE-I-1

(2,060) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	SUPPORTING CONSTRUCTION to be assigned as percentage of Construction Costs(Civil Works)	ls	1		74,003,500.00
	Subtotal this Sheet				74,003,500.00
	Total-Item No. 4 Supporting Construction				74,003,500.00

BILL NO. : 9 HIGH RISE LOCK CANAL CASE-I-1

(2,060) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	GENERAL CONDITIONS				
(1)	New dams (14.3% of Item Total)	ls	1		11,586,000.00
(2)	Pump Station(15.8% of Item Total)	ls	1		20,381,000.00
(3)	New Canal Crossing	ls	-		-inclusive-
(3)	Supporting Construction(14.3%, I.Total)	ls	1		10,582,500.00
	Total carried to summary				42,549,500.00
	Tota Item No.5 General Conditions				42,549,500.00

2.2 Bill of Quantities for Case-II-1(150,000DWT)

(1) High Rise Lock Canal, the Year of 2,020(85')

1) Summary

HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	General Cond. $	D. Const. Cost $	Project Costs $
			(II)	(I)	(I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	Canal Excavation	ls	376,823,000	2,635,123,860	3,011,946,860.00
2	Placing Area	ls	10,984,000	76,810,350	87,794,350.00
3	Lock Construction	ls	135,237,000	855,933,516	991,170,516.00
5	New Dams(to be provided in AC 2,060)		-	-	-
6	Pump Station(- '-)		nil	nil	nil
7	New Permanent Roads	ls	1,095,000	7,657,280	8,752,280.00
8	New Canal Crossing	ls	inclusive	450,199,285	450,199,285.00
10	Barrier Dams	ls	nil	nil	nil
11	Breakwater	ls	nil	nil	nil
12	Diversion Scheme	ls	nil	nil	nil
13	Supporting Construction	ls	53,226,000	372,208,300	425,434,300.00
				-	
	Subtotal		577,365,000	4,397,932,591	4,975,297,591.00
(B)	PLANT FORMING A PART OF PERMANENT WORK				
4	Gate Leaves and Related Facilities	ls	inclusive	888,887,500	888,887,500.00
9	Navigation Support System	ls	56,516,000	357,693,530	414,209,530.00
	Subtotal		56,516,000	1,246,581,030	1,303,097,030.00
	CONSTRUCTION COSTS, TOTAL		633,881,000	5,644,513,621	6,278,394,621.00
I I I	INDIRECT COSTS(*1)				
1	Administrative Costs	ls	-	-	77,114,100.00
2	Headquarter's Costs	ls	-	-	131,637,600.00
3	Construction Supervision	ls	-	-	154,399,200.00
4	Land Aquisition & Rights	ls	-	-	-
5	Compensation Costs	ls	-	-	105,000,000.00
6	Contingency(10% of Const. Costs)	ls	-	-	627,839,000.00
	Subtotal				1,095,989,900.00
	(*1): to be assigned as percentage of Construction Costs				
	GRAND TOTAL(PROJECT COSTS)				7,374,384,521.00

BILL NO. : 1 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
					0.00
I	DIRECT CONSTRUCTION COSTS				
1	CANAL EXCAVATION				
(1)	Grubbing & clearing in the Canal Area				
1)	ZONE 1	m2	683,500	0.21	143,535.00
2)	ZONE 2	m2	2,049,000	0.21	430,290.00
3)	ZONE 3	m2	3,302,500	0.21	693,525.00
4)	ZONE 4	m2	4,004,500	0.21	840,945.00
5)	ZONE 5	m2	374,500	0.21	78,645.00
	Grubbing & Clearingn Total m3		10,414,000	0.21	
(2)	Dry Excavation				
	ZONE 1				
	Average hauling distance 2.5km				
1)-1	Common	m3	127,000	1.82	231,140.00
1)-2	Weathered rock (using ripper)	m3	195,000	2.76	538,200.00
1)-3	Medium Hard rock (using ripper)	m3	-	2.76	0.00
1)-4	Hard rock (using blasting)	m3	-	4.59	0.00
2)	ZONE 2				
	Average hauling distance 2.0km				
2)-1	Common	m3	904,000	1.67	1,509,680.00
2)-2	Weathered rock (using ripper)	m3	6,373,000	2.58	16,442,340.00
2)-3	Medium Hard rock (using ripper)	m3	5,677,000	2.58	14,646,660.00
2)-4	Hard rock (using blasting)	m3	-	4.38	0.00
	Subtotal this Sheet				35,554,960.00

BILL NO. : 2 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	ZONE 3				
	Average hauling distance 4.0km				
3)-1	Common	m3	11,379,000	2.27	25,830,330.00
3)-2	Weathered rock (using ripper)	m3	41,952,000	3.32	139,280,640.00
3)-4	Medium Hard rock (using ripper)	m3	14,204,000	3.32	47,157,280.00
3)-5	Hard rock (using blasting)	m3	1,578,000	5.22	8,237,160.00
4)	ZONE 4				
	Average hauling distance 4.0km				
4)-1	Common	m3	14,073,000	2.27	31,945,710.00
4)-2	Weathered rock (using ripper)	m3	59,971,000	3.32	199,103,720.00
4)-3	Medium Hard rock (using ripper)	m3	41,640,000	3.32	138,244,800.00
4)-4	Hard rock (using blasting)	m3	17,845,000	5.22	93,150,900.00
5)	ZONE 5				
	Average hauling distance 6.0km				
5)-1	Common	m3	104,000	2.87	298,480.00
5)-2	Weathered rock (using ripper)	m3	383,000	4.06	1,554,980.00
5)-3	Medium Hard rock (using ripper)	m3	290,000	4.06	1,177,400.00
5)-4	Hard rock (using blasting)	m3	0	6.06	0.00
	Dry Excavation Total m3		216,695,000		
	Subtotal this Sheet				685,981,400.00

BILL NO. : 3 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(3)	Dredging				
1)	ZONE 1				
	Average hauling distance 12km				
1)-1	Clayey material(clay, silt)	m3	6,862,000	2.47	16,949,140.00
1)-2	Loose material(sand, gravel)	m3	16,189,000	2.84	45,976,760.00
1)-3	Weathered rock	m3	23,510,000	4.34	102,033,400.00
1)-4	Medium Hard rock	m3	52,000	9.02	469,040.00
1)-5	Hard rock (using blasting)	m3	-	70.6	0.00
2)	ZONE 2				
	Average hauling distance 18.5km				
2)-1	Clayey material(clay, silt)	m3	34,480,000	3.33	114,818,400.00
2)-2	Loose material(sand, gravel)	m3	35,526,000	2.88	102,314,880.00
2)-3	Weathered rock	m3	37,268,000	5.11	190,439,480.00
2)-4	Medium Hard rock	m3	14,592,000	9.05	132,057,600.00
2)-5	Hard rock (using blasting)	m3	-	70.65	0.00
3)	ZONE 3				
	Average hauling distance 22.5km				
3)-1	Clayey material(clay, silt)	m3	2,382,000	4.79	11,409,780.00
3)-2	Loose material(sand, gravel)	m3	3,232,000	4.14	13,380,480.00
3)-3	Weathered rock	m3	25,040,000	7.33	183,543,200.00
3)-4	Medium Hard rock	m3	22,863,000	12.95	296,075,850.00
3)-5	Hard rock (using blasting)	m3	2,540,000	104.10	264,414,000.00
4)	ZONE 4				
	Average hauling distance 22km				
4)-1	Clayey material(clay, silt)	m3	100,000	4.79	479,000.00
4)-2	Loose material(sand, gravel)	m3	87,000	4.14	360,180.00
4)-3	Weathered rock	m3	693,000	7.33	5,079,690.00
4)-4	Medium Hard rock	m3	2,745,000	12.95	35,547,750.00
4)-5	Hard rock (using blasting)	m3	1,176,000	100.95	118,717,200.00
5)	ZONE 5				
	Average hauling distance 8km				
5)-1	Clayey material(clay, silt)	m3	13,956,000	2.45	34,192,200.00
5)-2	Loose material(sand, gravel)	m3	21,242,000	2.26	48,006,920.00
5)-3	Weathered rock	m3	30,569,000	4.32	132,058,080.00
5)-4	Medium Hard rock	m3	326,000	9.00	2,934,000.00
5)-5	Hard rock (using blasting)	m3	-	70.55	0.00
	Wet Excavation Total m3		295,430,000		
	Subtotal this Sheet				1,851,257,030.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Vegetation(Seeding) of Canal Slope				
1)	ZONE 1	m2	215,300	0.75	161,475.00
2)	ZONE 2	m2	459,300	0.75	344,475.00
3)	ZONE 3	m2	1,293,600	0.75	970,200.00
4)	ZONE 4	m2	1,222,700	0.75	917,025.00
5)	ZONE 5	m2	65,500	0.75	49,125.00
	Total Area, m2		3,256,400		
(5)	Temporary Works				
1)	Access Roads (W = 22 m, t=1.5m) starting from excavating spot in the Canal to the main construction road which is lying along the Canal	km	16,500.00	1,002.98	16,549,170.00
2)	Dewatering for Dry Excavation	m3	216,695,000	0.20	43,339,000.00
	Subtotal this Sheet				62,330,470.00
	Total-Item No.1 Canal Excavation				2,635,123,860.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	Placing Areas for Surplus Material				
(1)	Grubbing & Clearing for Placing Areas				
1)	D-01 Area	m2	2,800,000.0	0.21	588,000.00
2)	D-02 Area	m2	1,700,000.0	0.21	357,000.00
3)	D-03 Area	m2	1,200,000.0	0.21	252,000.00
4)	D-04 Area	m2	100,000.0	0.21	21,000.00
5)	D-05 Area	m2	800,000.0	0.21	168,000.00
6)	D-06 Area	m2	700,000.0	0.21	147,000.00
7)	D-07 Area	m2	3,300,000.0	0.21	693,000.00
8)	D-08 Area	m2	1,600,000.0	0.21	336,000.00
9)	D-09 Area	m2	2,600,000.0	0.21	546,000.00
10)	D-10 Area	m2	2,300,000.0	0.21	483,000.00
11)	D-11 Area	m2	1,900,000.0	0.21	399,000.00
12)	D-12 Area	m2	1,100,000.0	0.21	231,000.00
13)	D-13 Area	m2	2,400,000.0	0.21	504,000.00
	Total Area, km2		22,500,000.0		
(2)	Placing Area Preparation including Surface Drainage(Open Ditch) Vegetation Underground Drainage	km2	22.5	2,535,140.00	57,040,650.00
(3)	Access Roads (W = 22 m, t=1.5m)	m	15,000.0	1,002.98	15,044,700.00
	Subtotal this Sheet				76,810,350.00
	Total-Item No. 2 Placing Areas for Surplus Materials				76,810,350.00

BILL NO. : 6 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	LOCK CONSTRUCTION				
(1)	ATLANTIC SIDE				
1)	Excavation, Hauling Distance 5.0km				
1)-1	Common	m3	13,200,000	2.57	33,924,000.00
1)-2	Weathered Rock	m3	7,920,000	3.69	29,224,800.00
1)-3	Hard Rock	m3	5,280,000	5.64	29,779,200.00
	Total m3		26,400,000		
1)-4	Dewatering	ls	1	13,849,447.00	13,849,447.00
2)	Backfill	m3	7,000,000	3.85	26,950,000.00
3)	Grouting				
3)-1	Bore Hole	m	200,900	20.05	4,028,045.00
3)-2	Consolidation Groutiong	m	200,900	66.68	13,396,012.00
4)	Concrete including form works, etc.	m3	3,200,000	87.68	280,576,000.00
5)	Reinforcing Bar(Deformed)	ton	32,000	804.10	25,731,200.00
(2)	PACIFIC SIDE				
1)	Excavation				
1)-1	Common	m3	13,200,000	2.57	33,924,000.00
1)-2	Weathered Rock	m3	7,920,000	3.69	29,224,800.00
1)-3	Hard Rock	m3	5,280,000	5.64	29,779,200.00
	Total m3		26,400,000		
1)-4	Dewatering	ls	1	13,849,447.00	13,849,447.00
2)	Backfill	m3	7,000,000	3.85	26,950,000.00
3)	Grouting				
3)-1	Bore Hole	m	200,900	20.05	4,028,045.00
3)-2	Consolidation Grouting	m	200,900	66.80	13,420,120.00
4)	Concrete including form works, etc.	m3	3,200,000	69.24	221,568,000.00
5)	Reinforcing Bar(Deformed)	ton	32,000	804.10	25,731,200.00
	Subtotal this Sheet				855,933,516.00
	Total-Item No.3 Lock Construction				855,933,516.00

BILL NO. : 7 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	GATE LEAVES AND RELATED FACILITIES				
(1)	GATE LEAVES AT ATLANTIC ENTRANCE LOCK				
1)	Gate Leaves	ton	10,619	9,830	104,384,770.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	4,467	11,120	49,673,040.00
2)-2	Gate Hoists	ton	1,918	15,970	30,630,460.00
2)-3	Locomotives	unit	20	3,600,000	72,000,000.00
2)-4	Rails and Racks for Locomotives	ton	3,371	8,140	27,439,940.00
2)-5	Power Supply Line for Locomotives	set	1	5,000,000	5,000,000.00
2)-6	Other Mechanical Component (Compressed Air System, Piping and Misc. Mechanical Equipments)	set	1	31,315,000	31,315,000.00
3)	Electrical Power & Control				
3)-1	Electrical Power & Control Equipment (35000KW)	set	1	32,900,000	32,900,000.00
3)-2	Emergency Power Plant	kw	35,000	770	26,950,000.00
3)-3	Misc. Electrical Equip.	set	1	7,000,000	7,000,000.00
4)	Others				
4)-1	Local Control Buildings	set	1	400,000	400,000.00
4)-2	Their Electrical Equipment	set	1	100,000	100,000.00
4)-3	Cathodic Protection	set	1	1,400,000	1,400,000.00
4)-4	Monitoring & Surveillance Equip. Communication System	set	1	1,600,000	1,600,000.00
4)-5	Grounding System	set	1	400,000	400,000.00
4)-6	Other Electric works and Consumable	set	1	600,000	600,000.00
	Subtotal this Sheet				391,793,210.00

BILL NO. : 8 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	GATE LEAVES AT PACIFIC ENTRANCE LOCK				
1)	Gate Leaves	ton	17,619	9,810	172,842,390.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	4,730	11,130	52,644,900.00
2)-2	Gate Hoists	ton	2,622	15,730	41,244,060.00
2)-3	Locomotives	unit	20	3,600,000	72,000,000.00
2)-4	Rails and Racks for Locomotives	ton	3,371	8,140	27,439,940.00
2)-5	Power Supply Line for Locomotives	set	1	5,000,000	5,000,000.00
2)-6	Other Mechanical Component (Compressed Air System, Piping and Misc. Mechanical Equipments)	set	1	51,873,000	51,873,000.00
3)	Electrical Power & Control				
3)-1	Electrical Power & Control Equipment (35000KW)	set	1	32,900,000	32,900,000.00
3)-2	Emergency Power Plant	kw	35,000	770	26,950,000.00
3)-3	Misc. Electrical Equip.	set	1	7,000,000	7,000,000.00
4)	Others				
4)-1	Local Control Buildings	set	1	600,000	600,000.00
4)-2	Their Electrical Equipment	set	1	100,000	100,000.00
4)-3	Cathodic Protection	set	1	2,300,000	2,300,000.00
4)-4	Monitoring & Surveillance Equip. Communication System	set	1	2,600,000	2,600,000.00
4)-5	Grounding System	set	1	600,000	600,000.00
4)-6	Other Electric works and Consumable	set	1	1,000,000	1,000,000.00
	Subtotal this Sheet				497,094,290.00
	Total-Item No. 4 Gate Leaves and Related Structure				888,887,500.00

BILL NO. : 9 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	NEW DAMS				
(1)	CIRI DAM(H=80M) will be provided in the year of 2,060		-	-	-
(2)	UPPER GATUN DAM(H= M)		nil	-	-
(3)	TRINIDADO DAM(H= M)		nil	-	-
(4)	INDIO DAM(H=80M) will be provided in the year of 2,060		-	-	-
	Subtotal this Sheet				-
	Total-Item No. 5 Lock Construction				-

BILL NO. : 10 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6	PUMP STATIONS				
(1)	PUMP STATION AT ATLANTIC LOCK to be provided in the year of 2,060		-	-	-
(2)	PUMP STATION AT PACIFIC LOCK to be provided in the year of 2,060		-	-	-
	Subtotal this Sheet				-
	Total-Item No. 6 Pump Stations				-

BILL NO. : 11 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
7	NEW PERMANENT ROADS				
(1)	ROADS FOR INSPECTION (NEW ROADS) W =6.8m				
1)	Subgrade, Base Course(t = 0.4m)	km	32.0	110,490.00	3,535,680.00
2)	Asphalt Paving(t=70mm)	m2	320,000.0	12.88	4,121,600.00
	Subtotal this Sheet				7,657,280.00
	Total-Item No. 7 New Permanent Roads				7,657,280.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
8	NEW CANAL CROSSINGS				
(1)	BRIDGES				
1)	Bridges Over The Canal on Pacific Side				
1)-1	Cable Stayed Bridge Canal Width 320m Span = L1(Main)+L2+L3=450+180+180=810m Width = 20.5m (Four Lane)	m2	16,605	14,387.00	238,896,135.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 850m (One Span 60m) Width = 20.5m (Four Lane)	m2	16,605	2,950.00	48,984,750.00
2)	Bridges Over the Canal for Van Dam Bypass(1) (to be provided in the year of 2,060)		-	-	-
3)	Bridges Over the (Existing) Canal for Van Dam Bypass(2) (to be provided in the year of 2,060)		-	-	-
	Subtotal this Sheet				287,880,885.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4)	Bridges Over the Canal at Middle Gamboa (to be provided in the year of 2,060)		-	-	-
5)	Bridges Over The Canal on Atlantic Side				
5)-1	Cable Stayed Bridge Canal Width 320m Span = L1(Main)+L2+L3=410+165+165=740m Width = 10.0m (Two lane)	m2	7,400	12,716.00	94,098,400.00
5)-2	Approaching Bridges(Steel Box Girder) Total Length = 1,500m (One Span 60m) Width = 10.0m (Two lane)	m2	15,000	2,980.00	44,700,000.00
(2)	Demolition of Existing Bridge				
1)	Balboa Bridge(Bridge of the Americas)				
1)-1	Super-structure	t	14,000	1,120.00	15,680,000.00
1)-2	Sub-structure	ls	1	7,840,000	7,840,000.00
	Subtotal this Sheet Total-Item No.8 New Canal Crossings				エラー 450,199,285.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
9	NAVIGATION SUPPORT SYSTEMS				
(1)	Navigation Lights and Leading Channel Range Marker Lights				
	For Two-Way Newly Excavated Canal				
1)	Navigation Lights 10 w, Lens Type Light Range : Three Nautical miles Power supply : Solar Battery				
1)-1	Pacific Ocean Navigation Light(Buoy) For 11km (Interval 927m) 11,000 / 927 m = 12 * 2 sides	sets	24	121,506.00	2,916,144.00
1)-2	Atlantic Ocean Navigation For 11km (Interval 927m)	sets	24	121,506.00	2,916,144.00
1)-3	At turning points, S and T 2 points x 2 sets	sets	4	121,506.00	486,024.00
1)-4	At turning points, B, C and D 3 points x 2 sets	sets	6	121,506.00	729,036.00
1)-5	Leading Channel Range Marker Light 4 points x 2 lanes x 2 sets	sets	16	473,496.00	7,575,936.00
	For Two-way widened-portion of the Canal, 30 km				
1)-6	Relocation of existing Navigation Lights (Buoys) (specification)	sets	-	12,874.00	0.00
1)-7	Leading Channel Range Marker Light 30 points x 2	sets	60	473,496.00	28,409,760.00
	Subtotal this Sheet				43,033,044.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	TUG STATION				
1)	Provide Tug Boats, 6,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	23	6,649,286	152,933,578.00
2)	Provide/Supply Tug Boats, 3,000 HP-4,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	2	4,652,857	9,305,714.00
3)	Lunches(for 10 persons) Twin Screw (maintenance/running Cost not included)	unit	14	163,571	2,289,994.00
(3)	EMERGENCY TIE UP STATION (Mooring Dolphin Type)				
1)	Located at the north end of the new Pacific Locks	nos	1	14,043,200	14,043,200.00
2)	Located at Gatun Lake	nos	1	14,043,200	14,043,200.00
3)	Excavation				
	Dry Excavation(Hauling distance 4.0km)				
3)-1	Common	m3	1,600,000	2.27	3,632,000.00
3)-2	Weathered Rock	m3	960,000	3.32	3,187,200.00
3)-3	Hard Rock	m3	640,000	5.22	3,340,800.00
	Dredging(Hauling Distance 22km)				
3)-4	Clayey material(clay, silt)	m3	1,600,000	4.79	7,664,000.00
3)-5	Weathered Rock	m3	960,000	7.33	7,036,800.00
3)-6	Hard Rock	m3	640,000	100.95	64,608,000.00
	Total Excavation m3		6,400,000		
	Subtotal this Sheet				282,084,486.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Jetty(10m x 50m)				
	Five(5) Locations for Tug Jetty				
1)	Colon	nos	2	4,072,000	8,144,000.00
2)	Gatun Lake	nos	2	4,072,000	8,144,000.00
3)	Gamboa	nos	1	4,072,000	4,072,000.00
4)	Pedro Miguel	nos	1	4,072,000	4,072,000.00
5)	Diablo	nos	2	4,072,000	8,144,000.00
	Subtotal this Sheet				32,576,000.00
	Total-Item No.9 Navigation Support System				357,693,530.00

BILL NO. : 17 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
10	Barrier Dam (not applicable for the H.R.L. Canal)		nil	-	-
11	Break Water (not applicable for the H.R.L. Canal)		nil	-	-
12	Diversion Scheme (not applicable for the H.R.L. Canal)		nil	-	-
	Subtotal this Sheet				-

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 3	SUPPORTING CONSTRUCTION				
(1)	CONSTRUCTION VILLAGE AND CAMPS				
1)	Site Preparation				
	5 site*140000m2 + 2 village*1000000m2	m2	2,700,000	1.72	4,644,000.00
2)	Housing and Building				
2)-1	Office and Warehouse	Estimated in General Conditions			0.00
2)-2	Detached House A 400m2/house	Nos	5	80,000	400,000.00
2)-3	Detached House B 300m2/house	Nos	50	60,000	3,000,000.00
2)-4	Detached House C 200m2/house	Nos	200	40,000	8,000,000.00
2)-5	Dormitory 2 village*120psn*100m2	m2	24,000	150	3,600,000.00
2)-6	Resthouse 2 village*2000m2	m2	4,000	200	800,000.00
2)-7	Canteen/Messhouse 1000m2*2 1000m2*5	m2	7,000	150	1,050,000.00
2)-8	Labor Camp 5 site*2000psn*50m2/psn	m2	500,000	120	60,000,000.00
2)-9	Supermarket 2village*1000m2 5site*200	m2	3,000	120	360,000.00
2)-10	School 2 village*2500m2	m2	5,000	150	750,000.00
2)-11	Theatre 2 village*5000m2	m2	10,000	150	1,500,000.00
2)-12	Sports/Recreation Center	m2	10,000	150	1,500,000.00
2)-13	Church 2 village*1000m2	m2	2,000	150	300,000.00
2)-14	Fire Station 7 places*500m2	m2	3,500	120	420,000.00
2)-15	Hospital 2 village*5000m2	m2	10,000	200	2,000,000.00
3)	Facilities and Services				
3)-1	Road W=6M 5site*600m 2village*2000m	m2	42,000	13	546,000.00
3)-2	Sewage 1 unit 2 village 5 site				
	Sewage Plant 5000t/day	unit	7	1,000,000	7,000,000.00
	Piping	m	20,000	50	1,000,000.00
	Operation Cost	yrs	8	60000	480,000.00
3)-3	Water Supply				
	Pump for Well (20m3/h)	Nos	7	10,000	70,000.00
	Water Treatment	Nos	7	500,000	3,500,000.00
	Piping 3000m*7	m	21000	8	168,000.00
3)-4	Power Supply Generator 800kVA*3Nos*7				
	Power Distribution 3000m*7	m	21000	20	420,000.00
	Operation 11unit*24h*365*8	Hrs	770,880	58	44,711,040.00
3)-5	Fuel Supply Station	site	7	100,000	700,000.00
3)-6	Communication(Telephone/Fax/Radio/TV)	site	7	200,000	1,400,000.00
3)-7	Landscaping	m2	2,700,000	4	10,800,000.00
	Subtotal this Sheet				159,119,040.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4)	Maintenance Cost Personnel Cost for Maintenance				
4)-1	Camp Manager 1psn*2site*96mo	M. Mo	192	3,000	576,000
4)-2	Guardman 20psn*7site*96mo	M. Mo	13,440	1,000	13,440,000
4)-3	Medical Doctor 2psn*2Hosp*96	M. Mo	384	10,000	3,840,000
4)-4	Nurse 8psn*2*96 4psn*5*96	M. Mo	3,456	1,500	5,184,000
4)-5	Catering Staff 10psn*7*96	M. Mo	6,720	1,200	8,064,000
4)-6	Housekeeper 20*7*96	M. Mo	13,440	700	9,408,000
4)-7	Chief Driver 2psn*96mo	M. Mo	192	1,200	230,400
4)-8	Bus Driver 30Nos*96	M. Mo	2,880	1,000	2,880,000
4)-9	School Teacher 2 village*4*96mo	M. Mo	768	7,000	5,376,000
4)-10	Gardener 2psn*7site*96	M. Mo	1,334	1,000	1,334,000
4)-11	Supermarket Staff 4psn*7site*96	M. Mo	2,688	1,200	3,225,600
5)	Vehicles				
5)-1	Buses 30Nos*96mo	M. Mo	2,880	3,800	10,944,000
5)-2	Ambulance 2Nos*7*96	M. Mo	1,344	1,000	1,344,000
5)-3	Patrol Vehicle 2Nos*7*96	M. Mo	1,344	1,500	2,016,000
5)-4	Fire Engine 1No*7*96	M. Mo	672	2,500	1,680,000
	Subtotal this Sheet				69,542,000.00

BILL NO. : 20 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Main Construction Roads				
1)	Cut, fill, subgrade, Base Course, etc. (W = 22.0m, t=1.2m)	m	50,000	1,002.98	50,149,000.00
(3)	Access Roads to Quarries				
1)	Cut, fill, subgrade, Base Course, etc. (W = 22.0m, t=1.2m)	m	9,000	1,002.98	9,026,820.00
	Subtotal this Sheet				59,175,820.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Logistic Base				
1)	Puerto Pilon on Atlantic Side				
1)-1	Embankment, Grading	m3	30,000	12.00	360,000.00
1)-2	Jetty for Aggregates	m	240	2,800.00	672,000.00
1)-3	Control House	m2	100	400.00	40,000.00
1)-4	Guard House	m2	9	160.00	1,440.00
1)-5	Rest House	m2	100	240.00	24,000.00
1)-6	Roads	m2	7,000	20.00	140,000.00
1)-7	Fence	m	700	24.00	16,800.00
1)-8	Gate	set	1	8,000.00	8,000.00
1)-9	Drainage Way	m	700	104.00	72,800.00
1)-10	Operation of Generator	year	6	162,000.00	972,000.00
2)	Colon on Atlantic Side				
1)-1	Embankment, Grading	m3	110,500	12.00	1,326,000.00
1)-2	Sea Wall (Conc.)	m	490	270.00	132,300.00
1)-3	Jetty for Aggregates	m	200	2,800.00	560,000.00
1)-4	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
	Storage Facilities				
1)-5	Cement Silo(1,500t/No.)	no.	10	240,000.00	2,400,000.00
1)-6	Tank for Fuel (1,600kl/no.)	no.	8	520,000.00	4,160,000.00
1)-7	Tank for Oil (100kl/no.)	no.	2	80,000.00	160,000.00
1)-8	Warehouse	m2	8,000	240.00	1,920,000.00
1)-9	Control House	m2	1,000	400.00	400,000.00
1)-10	Guard House	m2	27	160.00	4,320.00
1)-11	Rest House	m2	500	240.00	120,000.00
1)-12	Roads w=12m	m2	39,360	20.00	787,200.00
1)-13	Fence	m	990	24.00	23,760.00
1)-14	Gate	set	3	8,000.00	24,000.00
1)-15	Drainage Way	m	3,280	104.00	341,120.00
1)-16	Operation of Generator	year	6	252,000.00	1,512,000.00
	Subtotal this Sheet				43,777,740.00

BILL NO. : 22 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	Panama City on Pacific Side				
1)-1	Embankment, Grading	m3	93,500	12.00	1,122,000.00
1)-2	Sea Wall	m	590	270.00	159,300.00
1)-3	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
	Strage Facilities				
1)-4	Cement Silo(1,500t/No.)	no.	10	240,000.00	2,400,000.00
1)-5	Tank for Fuel (1,600kl/no.)	no.	8	520,000.00	4,160,000.00
1)-6	Tank for Oil (100kl/no.)	no.	2	80,000.00	160,000.00
1)-7	Warehouse	m2	8,000	240.00	1,920,000.00
1)-8	Control House	m2	1,000	400.00	400,000.00
1)-9	Guard House	m2	27	160.00	4,320.00
1)-10	Rest House	m2	500	240.00	120,000.00
1)-11	Roads	m2	34,560	20.00	691,200.00
1)-12	Fence	m	890	24.00	21,360.00
1)-13	Gate	set	3	8,000.00	24,000.00
1)-14	Drainage Way	m	2,880	104.00	299,520.00
1)-15	Operation of Generator	year	6	252,000.00	1,512,000.00
	Subtotal this Sheet				40,593,700.00
	Total-Item No. 13 Supporting Construction				372,208,300.00

BILL NO. : 23 HIGH RISE LOCK CANAL CASE-II-1

(2,020) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
14	GENERAL CONDITIONS				
(1)	Canal Excavation, (14.3%, Item Total)	ls	1		376,823,000.00
(2)	Placing Area	ls	1		10,984,000.00
(3)	Lock Construction (15.8%, Item Total)	ls	1		135,237,000.00
(4)	Gate Leaves and Related Facilities		-		-inclusive-
(5)	New Dams(to be provided in 2,060)		-		-
(6)	Pump Station		-		-
(7)	New Parmanent Roads, (14.3%, Item Total)	ls	1		1,095,000.00
(8)	New Canal Crossing		-		-inclusive-
(9)	Navigation Support System(15.8%T. Item)	ls	1		56,516,000.00
(10)	Barrier Dams		nil		-
(11)	Breakwater		nil		-
(12)	Diversion Scheme		nil		-
(13)	Supporting Construction(14.3%, T. Item)	ls	1		53,226,000.00
	Subtotal this Sheet				633,881,000.00
	Total-Item No. 14 General Conditions				633,881,000.00

2.2 Bill of Quantities for Case-II-1(150,000DWT)
(2) Additional Costs of Phased Construction High Rise Lock Canal, the Year of 2,060(85')
1) Summary

HIGH RISE LOCK CANAL CASE-II-1
(2,060) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	General Cond.	D. Const. Cost $	Project Costs $
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	New dams	ls	25,164,000	175,970,249	201,134,249.00
2	Pump Station	ls	20,381,000	128,993,284	149,374,284.00
3	New Canal Crossings	ls	-inclusive-	776,534,190	776,534,190.00
4	Supporting Construction	ls	11,028,000	77,122,000	88,150,000.00
	CONSTRUCTION COSTS, TOTAL		56,573,000	1,158,619,723	1,215,192,723.00
I I I	INDIRECT COSTS (*1)				
1	Administrative Costs	ls	-	-	14,925,500.00
2	Headquater's Cost	ls	-	-	25,478,600.00
3	Construction Supervision	ls	-	-	29,884,200.00
4	Land Aquisition & Rights	ls	-	-	-
5	Compensation Costs	ls	-	-	-
6	Contingency(10% of Const. Costs)	ls	-	-	121,519,000.00
	Subtotal				191,807,300.00
	(*1): to be assigned as percentage of Construction costs				
	GRAND TOTAL(PROJECT COSTS)				1,407,000,023.00

BILL NO. : 1 HIGH RISE LOCK CANAL CASE-II-1

(2,060) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1	NEW DAMS				
(1)	CIRI DAM(H=60m)				
1)	Earthwork Excavation for Dam Foundation				
1)-1	Top Soil Removal	m2	60,800	1.59	96,672.00
	Excavation (Hauling Distance 5km) Shovel(3.0m3), Dump Truck(32t)				
1)-2	Common	m3	95,000	4.77	453,150.00
1)-3	Weathered Rock	m3	95,000	6.68	634,600.00
	Total m3		190,000		
	Foundation Preparation				
1)-4	(Finish excavation, t=0.5m) Foundation Area, 60,800m2*20%	m2	12,200	34.28	418,216.00
1)-5	Foundation Preparation by Washing	m2	12,200	30.50	372,100.00
1)-6	Excavation for Diversion tunnel	m3	24,000	120.00	2,880,000.00
	Excavation for Spillway				
1)-7	Common	m3	41,500	4.77	197,955.00
1)-8	Weathered Rock	m3	24,900	6.68	166,332.00
1)-9	Hard Rock	m3	16,600	8.86	147,076.00
	Total m3		83,000		
	Embankment(Hauling Distance 10.0km)				
1)-10	Core	m3	230,000	11.69	2,688,700.00
1)-11	Filter	m3	210,000	11.70	2,457,000.00
1)-12	Rock	m3	960,000	8.46	8,121,600.00
	Total m3		1,400,000		
	Subtotal this Sheet				18,633,401.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2)	Grouting(Curtain)				
	Curtain Grouting				
2)-1	Drilling Grouting Hole	m	8,000	73.09	584,720.00
2)-2	Pressure Grouting	m	8,000	71.50	572,000.00
	Blanket Grouting				
2)-3	Drilling Grouting Hole	m	3,500	19.99	69,965.00
2)-4	Pressure Grouting	m	3,500	34.07	119,245.00
3)	Concrete Works including Formworks etc				
3)-1	Concrete for Spillway	m3	18,000	100.00	1,800,000.00
3)-2	Concrete for Diversion Tunnel	m3	7,000	120.00	840,000.00
3)-3	Concrete for Outlet	m3	1,000	100.00	100,000.00
	Total m3		26,000		
3)-4	Reinforcing Bar(Deformed)	t	1,740.00	804.10	1,399,134.00
4)	Steel Works & Equipment				
4)-1	Outlet Penstock	t	30	7,200.00	216,000.00
4)-2	Hollow-jet Valve φ=0.9m	set	1	290,000.00	290,000.00
4)-3	Spare Valve φ=0.9m	set	1	170,000.00	170,000.00
	Subtotal this Sheet				6,161,064.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	INDIO DAM(H=80M)				
1)	Earthwork (Hauling Distance 5km) Excavation for Dam Foundation				
1)-1	Top Soil Removal	m2	655,200	1.59	1,041,768.00
	Excavation(Hauling Distance 5km) Shovel(3.0m3), Dump Truck(32t)				
1)-2	Common	m3	600,000	4.77	2,862,000.00
1)-3	Weathered Rock	m3	600,000	6.68	4,008,000.00
	Total m3		1,200,000		
	Foundation Preparation				
1)-4	(Finish excavation, t=0.5m) Foundation Area, 655,200m2*20%	m2	131,100	34.28	4,494,108.00
1)-5	Foundation Preparation by Washing	m2	131,100	30.50	3,998,550.00
1)-6	Excavation for Diversion tunnel	m3	149,000	120.00	17,880,000.00
	Excavation for Spillway				
1)-7	Common	m3	58,000	4.77	276,660.00
1)-8	Weathered Rock	m3	34,800	6.68	232,464.00
1)-9	Hard Rock	m3	23,200	8.86	205,552.00
	Total m3		116,000		
	Embankment(Hauling Distance 10.0km)				
1)-10	Core	m3	1,500,000	11.69	17,535,000.00
1)-11	Filter	m3	1,300,000	11.70	15,210,000.00
1)-12	Rock	m3	7,000,000	8.46	59,220,000.00
	Total m3		9,800,000		
	Subtotal this Sheet				126,964,102.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2)	Grouting(Curtain)				
	Curtain Grouting				
2)-1	Drilling Grouting Hole	m	63,000	73.09	4,604,670.00
2)-2	Pressure Grouting	m	63,000	71.50	4,504,500.00
	Blanket Grouting				
2)-3	Drilling Grouting Hole	m	37,700	19.99	753,623.00
2)-4	Pressure Grouting	m	37,700	34.07	1,284,439.00
3)	Concrete Works including Formworks etc				
3)-1	Concrete for Spillway	m3	25,000	100.00	2,500,000.00
3)-2	Concrete for Diversion Tunnel	m3	49,000	120.00	5,880,000.00
3)-3	Concrete for Outlet	m3	1,000	100.00	100,000.00
	Total m3		75,000		
3)-4	Reinforcing Bars(Deormed)	t	4,500	804.10	3,618,450.00
4)	Steel Works & Equipment				
4)-1	Outlet Penstock	t	30	7,200.00	216,000.00
4)-2	Hollow-jet Valve φ=1.3m	set	1	470,000	470,000.00
4)-3	Spare Valve φ=1.3m	set	1	280,000	280,000.00
	Subtotal this Sheet				24,211,682.00
	Total-Item No.1 New Dams				175,970,249.00

BILL NO. : 5 HIGH RISE LOCK CANAL CASE-II-1

(2,060) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	PUMP STATIONS				
(1)	PUMP STATION AT ATATLANTIC LOCK				
1)	Excavation, Hauling Distance 5.0km (Shovel 3.0m3, Dump Truck 32t)				
1)-1	Common	m3	30,000	4.77	143,100.00
1)-2	Weathered	m3	18,000	6.68	120,240.00
1)-3	Hard Rock	m3	12,000	8.86	106,320.00
	Total m3		60,000		
2)	Concrete Work				
2)-1	Concrete including form works, etc.	m3	14,680	100.00	1,468,000.00
2)-2	Reinforcing Bars(Deformed)	t	1,170.00	804.10	940,797.00
3)	Building	m2	1,750	1,000.00	1,750,000.00
4)	Pumps & ancilary equipment				
4)-1	Pumps & Valves including installation 3 units of pumps, 30 m3/sec-unit	units	3	7,350,000	22,050,000.00
4)-2	Machinery including piping, etc.	units	3	4,410,000	13,230,000.00
4)-3	Electrical Equipment and Wiring	units	3	2,940,000	8,820,000.00
4)-4	Others	ls	1	-	0.00
5)	Water Way				
5)-1	Embankment(Excavated Materials) Hauling Distance 10.0km	m3	33,000	11.69	385,770.00
	Excavation, Hauling Distance 0.5km				
5)-2	Common	m3	22,500	1.82	40,950.00
5)-3	Weathered Rock	m3	13,500	3.03	40,905.00
5)-4	Hard Rock	m3	9,000	4.72	42,480.00
	Total m3		45,000		
5)-5	Concrete Structures	m3	-		0.00
	Subtotal this Sheet				49,138,562.00

BILL NO. : 6 HIGH RISE LOCK CANAL CASE-II-1

(2,060) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6)	Recycle Pond				
6)-1	Embankment(Excavated Materials) Hauling Distance 10.0km	m3	132,000	11.69	1,543,080.00
	Excavation, Hauling Distance 0.5km				
6)-2	Common	m3	2,500,000	1.82	4,550,000.00
6)-3	Weathered Rock	m3	1,500,000	3.03	4,545,000.00
6)-4	Hard Rock	m3	1,000,000	4.72	4,720,000.00
	Total m3		5,000,000		
6)-5	Concrete Structures	m3	-		0.00
	Subtotal this Sheet				15,358,080.00

BILL NO. : 7 HIGH RISE LOCK CANAL CASE-II-1

(2,060) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	PUMP STATION AT PACIFIC LOCK				
1)	Excavation, Hauling Distance 5.0km (Shovel 3.0m3, Dump Truck 32t)				
1)-1	Common	m3	30,000	4.77	143,100.00
1)-2	Weathered	m3	18,000	6.68	120,240.00
1)-3	Hard Rock	m3	12,000	8.86	106,320.00
	Total m3		60,000		
2)	Concrete Work				
2)-1	Concrete including form works, etc.	m3	14,680	100.00	1,468,000.00
2)-2	Reinforcing Bars(Deformed)	t	1,170.00	804.10	940,797.00
3)	Building	m2	1,750	1,000.00	1,750,000.00
4)	Pumps & ancilary equipment				
4)-1	Pumps & Valves including installation 3 units of pumps, 30 m3/sec-unit	units	3	7,350,000	22,050,000.00
4)-2	Machinery including piping, etc.	units	3	4,410,000	13,230,000.00
4)-3	Electrical Equipment and Wiring	units	3	2,940,000	8,820,000.00
4)-4	Others	ls	1	-	0.00
5)	Water Way				
5)-1	Embankment(Excavated Materials) Hauling Distance 10.0km	m3	33,000	11.69	385,770.00
	Excavation, Hauling Distance 0.5km				
5)-2	Common	m3	22,500	1.82	40,950.00
5)-3	Weathered Rock	m3	13,500	3.03	40,905.00
5)-4	Hard Rock	m3	9,000	4.72	42,480.00
	Total m3		45,000		
5)-5	Concrete Structures	m3	-		0.00
	Subtotal this Sheet				49,138,562.00

BILL NO. : 8 HIGH RISE LOCK CANAL CASE-II-1

(2,060) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6)	Recycle Pond				
6)-1	Embankment(Excavated Materials) Hauling Distance 10.0km	m3	132,000	11.69	1,543,080.00
	Excavation, Hauling Distance 0.5km				
6)-2	Common	m3	2,500,000	1.82	4,550,000.00
6)-3	Weathered Rock	m3	1,500,000	3.03	4,545,000.00
6)-4	Hard Rock	m3	1,000,000	4.72	4,720,000.00
	Total m3		5,000,000		
	Subtotal this Sheet				15,358,080.00
	Total-Item No.2 Pump Station				128,993,284.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	NEW CANAL CROSSINGS				
1)	Bridges Over the Canal for Van Dam Bypass(1)				
1)-1	Cable Stayed Bridge Canal Width 320m Span = L1(Main)+L2+L3=470+190+190=850m Width = 20.5m (Four Lane)	m2	17,425	15,232.00	265,417,600.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 490m (One Span 60m) Width = 20.5m (Four Lane)	m2	10,045	2,964.00	29,773,380.00
2)	Bridges Over the (Existing) Canal for Van Dam Bypass(2)				
2)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=500+200+200=900m Width = 20.5m (Four Lane)	m2	18,450	16,679.00	307,727,550.00
2)-2	Approaching Bridges(Steel Box Girder) Total Length = 430m (One Span 60m) Width = 20.5m (Four Lane)	m2	8,815	2,964.00	26,127,660.00
3)	Bridges Over the Canal at Middle Gamboa				
3)-1	Cable Stayed Bridge Canal Width 320m Span = L1(Main)+L2+L3=470+190+190=850m Width = 20.5m (Four Lane)	m2	8,500	15,248.00	129,608,000.00
3)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 20.5m (Four Lane)	m2	6,000	2,980.00	17,880,000.00
	Subtotal this Sheet				776,534,190.00
	Total-Item No. 3 New Canal Crossings				776,534,190.00

BILL NO. : 10 HIGH RISE LOCK CANAL CASE-II-1

(2,060) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	SUPPORTING CONSTRUCTION to be assigned as percentage of Construction Costs(Cvil Works)	ls	1		77,122,000.00
	Subtotal this Sheet				77,122,000.00
	Total-Item No. 4 Supporting Construction				77,122,000.00

BILL NO. : 11 HIGH RISE LOCK CANAL CASE-II-1

(2,060) 150,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	GENRERAL CONDITIONS				
(1)	New Dams (14.3%, Item Total)	ls	1		25,164,000
(2)	Pump Station(15.8%, Item Total)	ls	1		20,381,000
(3)	New Canal Crossings	ls	-		-inclusive-
(4)	Supporting Construction(14.3%, I.Total)	ls	1		11,028,000
	Subtotal this Sheet				56,573,000.00
	Total-Item No.5 General Conditions				56,573,000.00

III.3 Chapter 3. Indirect Costs

3.1 Bill of Quantities for Case - I (200,000 DWT)

A. High Rise Lock Canal the year of 2020 (85')

Indirect costs for the cases mentioned below are to be assigned a percentage of construction costs.

- **Bill of Quantities for Case - I (200,000 DWT)**

B. Additional Costs of phased Construction the year of 2060

- **Bill of Quantities for Case - II (150,000 DWT)**

A. High Rise Lock Canal the year of 2020

B. Additional Costs of phased Construction the year of 2060

3.1 Indirect Costs
Bill of Quantities for Case-I-1(200,000DWT)
High Rise Lock Canal, the Year of 2,020 (85')

BILL NO. : 25 HIGH RISE LOCK CANAL CASE-I-1
(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
I I	INDIRECT COSTS				
1	ADMINISTRATIVE COSTS (For Five Sites Administration)				
(1)	Salaries/Wages for Personnel Staff				
	Man-Month				
1)	Project Manager 1per *12mon. *9y	m-m	108	12,000	1,296,000.00
2)	Duputy Project Manager 1per *12mon. *8.5y	m-m	102	10,000	1,020,000.00
3)	Admi. Manager 1per *12mon. *8.5y	m-m	102	9,000	918,000.00
4)	Engineer Senior 4per *12mon. *9y	m-m	432	9,000	3,888,000.00
5)	Chief, Project Site 4per *12mon. *8.5y	m-m	408	7,000	2,856,000.00
6)	Site Engineer 7per *12mon. 8.5y	m-m	714	6,000	4,284,000.00
7)	Assist. Labo. etc 9per *12mon. *8.5y	m-m	918	5,000	4,590,000.00
8)	Quantity Surveyor, 2per*12mon. *8.5y	m-m	204	8,000	1,632,000.00
9)	Accountant, 1per*12mon. *8.5y	m-m	102	5,000	510,000.00
10)	Land Surveyor, 9per*12mon. *8.5y	m-m	918	3,000	2,754,000.00
11)	Technician/Drafter, 14per*12mon. *8.5y	m-m	1,428	2,500	3,570,000.00
12)	Office Clark, 18per*12mon. *8.5y	m-m	1,836	2,000	3,672,000.00
13)	Inspector, 4per*12mon. *8.5y	m-m	408	3,000	1,224,000.00
14)	Store/Time keeper, 2per*12mon. *8.5y	m-m	204	1,500	306,000.00
15)	Survey Helper/Clerk, 36per*12mon. *8.5y	m-m	3,672	1,000	3,672,000.00
16)	Secretary/Typist, 18per*12mon. *8.5y	m-m	1,836	1,500	2,754,000.00
17)	Driver, 36per*12mon. *8.5y	m-m	3,672	1,000	3,672,000.00
18)	Office Boy, 14*12mon. *8.5y	m-m	1,428	700	999,600.00
19)	Watchman, 45per*12mon. *8.5y	m-m	4,590	700	3,213,000.00
					46,830,600.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Office Equipment and Engineering Supply (12mon*9y)	mon	108	23,000.00	2,484,000.00
(3)	Utilities Consumption (Water, Power, Etc.) 12mon. *9y	mon	108	16,500.00	1,782,000.00
(4)	Communications (Telephone, Fax, Telex, Etc.) 12mon. *9y	mon	108	18,400.00	1,987,200.00
(5)	Traveling expenses				
	EXPATRIATE (3p*2t*8y)	trip	48	5,000.00	240,000.00
	LOCAL (4p*4t*12m*8y)	trip	1,536	800.00	1,228,800.00
(6)	Welfare Expenses	mon	108	9,200.00	993,600.00
(7)	Medical Expenses	mon	108	11,000.00	1,188,000.00
(8)	Board of Consultanats (5p*8times)	times	8	200,000.00	1,600,000.00
(9)	Staff Transportation				
	Vehicles (18*12mon. *8y)	u-m	1,728	2,000.00	3,456,000.00
	Landcruiser (18*12mon. *8y)	u-m	1,728	2,500.00	4,320,000.00
	Pilot Boat (2*12mon. *8y)	u-m	192	25,000.00	4,800,000.00
	Helicopter (1*12mon. *8y)	u-m	96	50,000.00	4,800,000.00
(10)	Legal Fee (Allowance)	ls	1	4,200,000.00	4,200,000.00
(11)	Accomodation & Building				
	Offices (5sites * 900m2)	m2	4,500	200.00	900,000.00
	Warehouse (2sites * 1800m2)	m2	3,600	100.00	360,000.00
	Shops ans Sheds (2 *450m2)	m2	900	80.00	72,000.00
	Yards (2 * 4600m2)	m2	9,200	100.00	920,000.00
	Canteens and Messrooms (5sites*180m2)	m2	900	200.00	180,000.00
	Houses	no	180	40,000.00	7,200,000.00
	Subtotal this Sheet				42,711,600.00
	Total-Item No.1 Administrative Costs				89,542,200.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	HEADQUARTER'S COSTS				
(1)	SITE SURVEY/INVESTIGATIONS				
1)	Salaries/Wages 20per*12mon.*2.5y	m-m	600	7,000.00	4,200,000.00
2)	Travel Expenses 24per*4trips*2.5y	trip	240	5,000.00	1,200,000.00
3)	Communications (TEL, FAX)	mon	30	18,400.00	552,000.00
4)	Office Equipment & Supply	mon	30	9,200.00	276,000.00
5)	Site Transport	mon	30	27,500.00	825,000.00
6)	Geological Boring	ls	1	920,000.00	920,000.00
7)	Mapping/Documentations	ls	1	18,300,000.00	18,300,000.00
(2)	ENGINEERING AND DESIGN				
1)	SALARIES/wages				
1)-1	Project Director	m-m	96	10,000.00	960,000.00
1)-2	Senior Design Engineer (4.5per*12mon.*8y)	m-m	432	9,000.00	3,888,000.00
1)-3	Design Engineer (18per*12mon.*8y)	m-m	1,728	8,000.00	13,824,000.00
1)-4	Technician (18per*12mon.*8y)	m-m	1,728	2,500.00	4,320,000.00
1)-5	Drafter (46per*12mon.*8y)	m-m	4,416	2,500.00	11,040,000.00
1)-6	Computer Specialist (23per*12mon.*8y)	m-m	2,208	2,500.00	5,520,000.00
1)-7	Chief Geologist (3per*12mon.*8y)	m-m	288	9,000.00	2,592,000.00
1)-8	Senior Geologist (9per*12mon.*8y)	m-m	864	8,000.00	6,912,000.00
	Subtotal this Sheet				75,329,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1)-9	Administration Manager	m-m	96	9,000.00	864,000.00
1)-10	Accountant	m-m	96	5,000.00	480,000.00
1)-11	Office Clerk (9per*12mon.*8y)	m-m	864	2,000.00	1,728,000.00
1)-12	Secretary/Typist (14per*12mon.*8y)	m-m	1,344	1,500.00	2,016,000.00
1)-13	Driver (36per*12mon.*8y)	m-m	3,456	1,000.00	3,456,000.00
1)-14	Office Boy 4.5*6*12mon.*8y	m-m	2,592	700.00	1,814,400.00
1)-15	Watchman 46per*12mon.*8y	m-m	4,416	700.00	3,091,200.00
2)	Report/Documentations	ls	1	14,000,000.00	14,000,000.00
3)	Travel Expense 36per*2t*8y	trip	576	5,000.00	2,880,000.00
4)	Communications (TEL, FAX)	mon	96	18,400.00	1,766,400.00
5)	Office Equipment & Supply	mon	96	27,500.00	2,640,000.00
6)	Staff Transpsortation				
6)-1	Vehicles 28*12mon.*8y	u-m	2,688	2,000.00	5,376,000.00
6)-2	Land Cruiser 36*12mon.*8y	u-m	3,456	2,500.00	8,640,000.00
	Subtotal this Sheet				48,752,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
7)	Accomodation & Buildings				
7)-1	Office	m2	4,500	200.00	900,000.00
7)-2	Messroom	m2	280	200.00	56,000.00
7)-3	Houses	no.	45	40,000.00	1,800,000.00
(3)	TENDER PREPARATION/EVALUATION/CONTRACT				
1)	Salaries/Wages (3.5per*12mon.*2.5y)	m-m	105	7,000.00	735,000.00
2)	Travel Expense (3.5*6trips*2.5y)	trip	53	5,000.00	265,000.00
3)	Communications	mon	30	18,000.00	540,000.00
4)	Office Equipment & Supply	mon	30	9,200.00	276,000.00
5)	Documentations	ls	1	13,500,000.00	13,500,000.00
(4)	HOME OFFICE OVERHEAD (7% of Item Total)	ls	1	10,700,000.00	10,700,000.00
	Subtotal this Sheet				28,772,000.00
	Total-Item No.2 Headquarter's Costs				152,853,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	CONSTRUCTION SUPERVISION				
(1)	Salaries/Wages for Personnel Staff				
1)	Chief Superviser 1per *12mon. *8.5y	m-m	102	12,000	1,224,000.00
2)	Senior Superviser 5sites*2per *12mon. *8.5y	m-m	1,020	10,000	10,200,000.00
3)	Superviser 5sites*4per *12mon. *8.5y	m-m	2,040	8,000	16,320,000.00
4)	Inspector 5sites*8per *12mon. *8.5y	m-m	4,080	3,000	12,240,000.00
5)	Checker 5sites*32per *12mon. *8.5y	m-m	16,320	1,000	16,320,000.00
6)	Land Surveyor 5sites*4per *12mon. *8.5y	m-m	2,040	2,500	5,100,000.00
7)	Surveyor Helper 5sites*16per *12mon. *8.5y	m-m	8,160	1,000	8,160,000.00
8)	Driver, 40per*102mon. 5sites*8per *12mon. *8.5y	m-m	4,080	1,000	4,080,000.00
9)	Secretary/Typist (5sites*4per+1per) *12mon. *8.5y	m-m	2,142	1,500	3,213,000.00
10)	Office Boy 5sites*4per *12mon. *8.5y	m-m	2,040	700	1,428,000.00
	Subtotal this Sheet				78,285,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Office Equip. and Engineering Supply(Equipment) 5sites*12mon. *8.5year	mon	510	12,000	6,120,000.00
(3)	Utilities Consumption (Water, Power, Etc.)	mon	510	10,000	5,100,000.00
(4)	Communications (Telephone, Fax, Telex, Etc.)	mon	510	12,000	6,120,000.00
(5)	Traveling expenses				
1)	EXPATRIATE(5sites*4per+1)*2time*8.5y	trip	357	10,000	3,570,000.00
2)	LOCAL Travel(5sites*10times*12m*8.5y)	trip	5,100	1,000	5,100,000.00
(6)	Welfare Expenses	mon	102	14,000	1,428,000.00
(7)	Staff Transportation				
1)	Vehicles (5sites* 15unit * 8.5years) (5sites* 15unit*12m * 8.5years)	u-m	7,650	2,000	15,300,000.00
2)	Pilot Boat (2units*12*9) (5sites* 1unit*12m * 8.5years)	u-m	510	30,000	15,300,000.00
3)	Helicopter(Suppervision/First Aids) (3unit*12m * 8.5years)	u-m	306	75,000	22,950,000.00
(8)	Accomodation and Buildings for superviser				
1)	Offices, 5sites*1 unit* 1000m2	m2	5,000	1,200	6,000,000.00
2)	Warehouse, 5sites*1unit* 500m2	m2	2,500	1,000	2,500,000.00
3)	Shops and Sheds, 5sites*1units*1000m2	m2	5,000	1,000	5,000,000.00
4)	Yards, 5sites*1unit*1000m2	m2	5,000	100	500,000.00
5)	Canteens and Messrooms 5sites*1units *360m2	m2	1,800	1,200	2,160,000.00
6)	Houses 5sites*20houses	nos	100	38,500.00	3,850,000.00
	Subtotal this Sheet				100,998,000.00
	Total-Item No.3 Construction Supervision				179,283,000.00

BILL NO. : 32 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	LAND AQUISITION & RIGHTS	ls	1	-	-
	Subtotal this Sheet				-
	Total-Item No. 4 Land Aquisition & Rights				-

BILL NO. : 33 HIGH RISE LOCK CANAL CASE-I-1

(2,020) 200,000 DWT (W. LEVEL 85 FEET)

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	COMPENSATION COSTS	ls	1	105,000,000	105,000,000.00
	Subtotal this Sheet				105,000,000.00
	Total-Item No. 5 Compensation Costs				105,000,000.00

III.3 Chapter 4. Project Cost Distribution by year

4.1 Project Cost Distribution by year

Case 200,000 DWT the year of 2020

4.2 Project Cost Distribution by year

Case 150,000 DWT the year of 2020

Table III.3.4.1-1

4.1 Project Cost Distribution by Year
High Rise Lock Canal
Case : 200,000 DWT Rise 85' (the Year of 2,020)

File:FLOWHRL

	Major Cost Component	Amount	Year of Expenditure (unit:millions of dollars)															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	CONSTRUCTION COSTS																	
(A)	CIVIL WORKS																	
1	Canal Excavation	3,477.38				869.35	469.45	469.45	469.45	469.45	469.45	260.80						
2	Placing Area	87.79				21.95	13.17	5.71	5.71	6.15	21.95	13.17						
3	Lock Construction	1,121.26				281.81	186.00	186.00	186.00	186.00	101.45							
5	New Dams	237.00				59.25	23.70	38.39	38.39	38.39	38.87							
6	Pump Station	-																
7	New Permanent Roads	8.75									2.19	3.94	2.63					
8	New Canal Crossing	501.19				125.30	82.70	82.70	82.70	82.70	45.11							
10	Barrier Dams	-																
11	Breakwater	-																
12	Diversion Scheme	-																
13	Supporting Construction	425.43			170.17	255.26												
	Subtotal	5,864.81			170.17	1,612.92	775.01	782.24	782.24	782.68	679.01	277.91	2.63					
(B)	PLANT FORMING A PART OF PERMANENT WORKS																	
4	Gate Leaves and and Related Facilities	1,011.24						252.81	187.08	187.08	187.08	197.19						
9	Navigation Support System	414.21								103.55	124.26	124.26	62.13					
	Subtotal	1,425.45						252.81	187.08	290.63	311.34	321.45	62.13					
	CONSTRUCTION COSTS TOTAL	7,290.26			170.17	1,612.92	775.01	1,035.05	969.32	1,073.31	990.35	599.37	64.76					
I I	INDIRECT COSTS																	
1	Administrative Costs	89.54	4.03	4.03	8.06	9.85	9.85	9.85	9.85	9.85	9.85	9.85	4.48					
2	Headquarter's Costs	152.85	37.45	37.45	37.45	5.35	5.35	5.35	5.35	5.35	5.35	5.35	3.06					
3	Construction Supervision	179.28	4.93	4.93	14.34	20.62	20.62	20.62	20.62	20.62	20.62	20.62	10.76					
4	Land Aquisition & Rights	-																
5	Compensation Costs	105.00	42.00	42.00	21.00													
6	Contingency	729.03				54.68	54.68	54.68	54.68	145.81	145.81	145.81	72.90					
	INDIRECT COSTS TOTAL	1,255.70	88.41	88.41	80.85	90.49	90.49	90.49	90.49	181.62	181.62	181.62	91.19					
	ANNUAL DISTRIBUTION	8,545.96	88.41	88.41	251.02	1,703.41	865.50	1,125.54	1,059.81	1,254.93	1,171.98	780.99	155.95					

Table III.3.4.2-1

4.2 Project Cost Distribution by Year
High Rise Lock Canal
Case : 150,000 DWT Rise 85' (the Year of 2,020)

File:FLOWHRL

	Major Cost Component	Amount	Year of Expenditure (unit:millions of dollars)															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	CONSTRUCTION COSTS																	
(A)	CIVIL WORKS																	
1	Canal Excavation	3,011.95				752.99	496.97	496.97	496.97	496.97	271.08							
2	Placing Area	87.79				21.95	13.17	8.78	8.78	21.95	13.17							
3	Lock Construction	991.17					247.79	208.15	208.15	208.15	118.94							
5	New Dams	-																
6	Pump Station	-																
7	New Permanent Roads	8.75									5.47	3.28						
8	New Canal Crossing	450.20				112.55	74.28	74.28	74.28	74.28	40.52							
10	Barrier Dams	-																
11	Breakwater	-																
12	Diversion Scheme	-																
13	Supporting Construction	425.43			212.72	212.72												
	Subtotal	4,975.30			212.72	1,100.20	832.22	788.18	788.18	801.35	449.17	3.28						
(B)	PLANT FORMING A PART OF PERMANENT WORKS																	
4	Gate Leaves and and Related Facilities	888.89						222.22	164.44	164.44	164.44	173.33						
9	Navigation Support System	414.21								207.10	103.55	103.55						
	Subtotal	1,303.10						222.22	164.44	371.55	268.00	276.89						
	CONSTRUCTION COSTS TOTAL	6,278.39			212.72	1,100.20	832.22	1,010.40	952.62	1,172.90	717.17	280.17						
I I	INDIRECT COSTS																	
1	Administrative Costs	77.11	3.86	3.86	7.33	8.87	8.87	8.87	8.87	8.87	8.87	8.87						
2	Headquarter's Costs	131.64	31.59	31.59	31.59	5.27	5.27	5.27	5.27	5.27	5.27	5.27						
3	Construction Supervision	154.40	4.63	4.63	12.20	18.99	18.99	18.99	18.99	18.99	18.99	18.99						
4	Land Aquisition & Rights	-																
5	Compensation Costs	105.00	42.00	42.00	21.00													
6	Contingency	627.84				62.78	62.78	62.78	62.78	125.57	125.57	125.57						
	INDIRECT COSTS TOTAL	1,095.99	82.08	82.08	72.12	95.91	95.91	95.91	95.91	158.69	158.69	158.69						
	ANNUAL DISTRIBUTION	7,374.38	82.08	82.08	284.83	1,196.11	928.12	1,106.31	1,048.53	1,331.59	875.86	438.86						

III.3 Chapter 5. Operation and Maintenance Costs

Refer to Part II.3 Chapter 3
"Operation and Maintenance Costs"

PART IV – SEA LEVEL CANAL

PART IV SECTION 1 ENGINEERING AND PRELIMINARY DESIGN

IV.1 CHAPTER 1 - GENERAL

1.1 Introduction

The Sea Level Canal is designed to accommodate 250,000 DWT class vessels. The case variations include tidal locks on the Pacific side, a tidal gate on the Atlantic side and combinations of these. The configurations of these different cases are shown in Fig. IV.1.1-1.

There is a possibility that the Sea Level Canal will cause an environmental problem on a global scale because of the movement of seawater between the Pacific and Atlantic. The introduction of a freshwater barrier has been examined as a method of solving this potential problem. The Report also examines the possible volume of freshwater to be poured into the canal and by what method but the likely effects of this have not yet been studied. A more detailed examination is, therefore, required in the future prior to the official acceptance of the freshwater barrier.

1.2 Basic Engineering Conditions

Basic engineering conditions used in "Engineering and Preliminary Design" are summarized in Table IV.1.1-1.

Table IV.1.1-1 Basic Engineering Conditions

Item	Description
1) Route	Ref. Sea Level Canal layout Fig. IV.1.1-1
2) Ship Size	250,000 DWT. (356 L x 54 B x 21 D)
3) Lane No.	Approach Channel 2-lanes, Canal 1-lane
4) Canal Width	3.5 * B = 190 m Canal depth = 24.0 m 7.0 * B = 380 m (Approach Channel)
5) Lock Dimensions & No. of Lane	250,000 DWT, 420 m * 60 m * 23.0 m 3-lanes. Plus additional one lane [Case (a)]
6) Tidal Gate Dimension & No. of Lane	Gate width = 190 m Draft = 23 m Tidal Gates at both Ocean sides [Case (b), (c)] One lane
7) No. of Transits	Existing Locks = 10,866 (2020) 12,078 (2060) Sea Level = 2,100 (2020) 5,100 (2060)
8) Tidal Levels	High Water Level = +3.6 m (Pacific) Lowest Water Level = -3.4 m (Pacific) High Water Level = +0.5 m (Atlantic) Lowest Water Level = -0.3 m (Atlantic)
9) Earthquake	Kh = 0.1, Kv = Kh * 2/3

1.3 Route

The study cases follow Route 10 located 16 km west of and parallel to the existing canal as shown in Fig. IV.1.1-2.

The Pacific terminal of the route is at the town of Puerto Caimito at the mouth of the Caimito River. The route follows the river north-westward for 8 km, crossing the Pan American Highway about 4.8 km north-east of La Chorrera. It continues to the north through generally open and rolling terrain; crosses the Continental Divide through the Chorrera Gap; and parallels the Pescado River until it reaches an arm of Gatun Lake at La Laguna. Turning in a more westerly direction, the route continues over relatively flat terrain and crosses the Trinidad arm of Gatun Lake, to Escobal. From there it changes direction to the north through low ridges that become more open towards the coast. It enters the Atlantic at the town of Nuevo Chagres. Atlantic approach channel would be only 3.2 km long; however, that on the Pacific would require 24.1 km of underwater excavation, extending past Taboga Island.

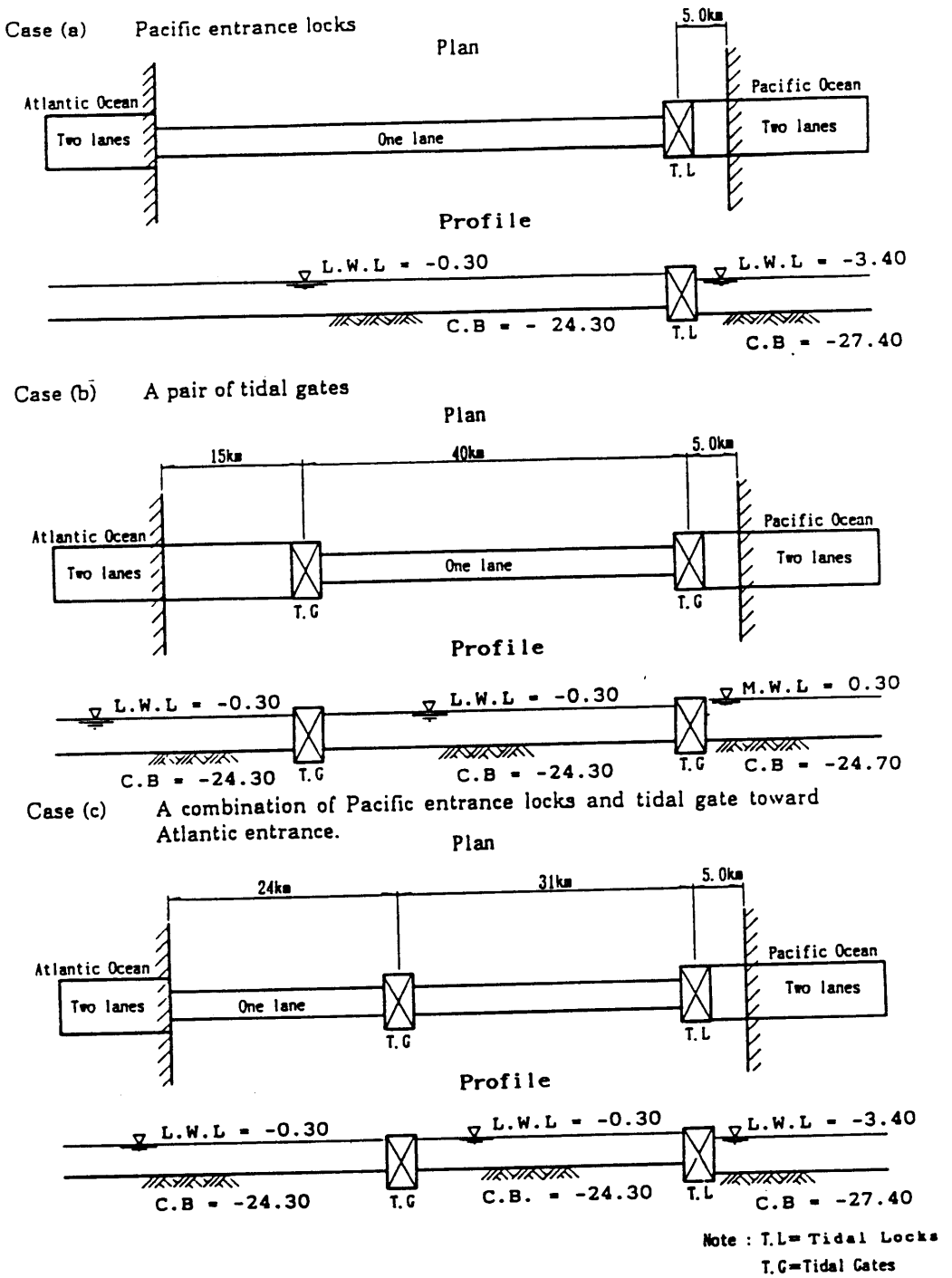
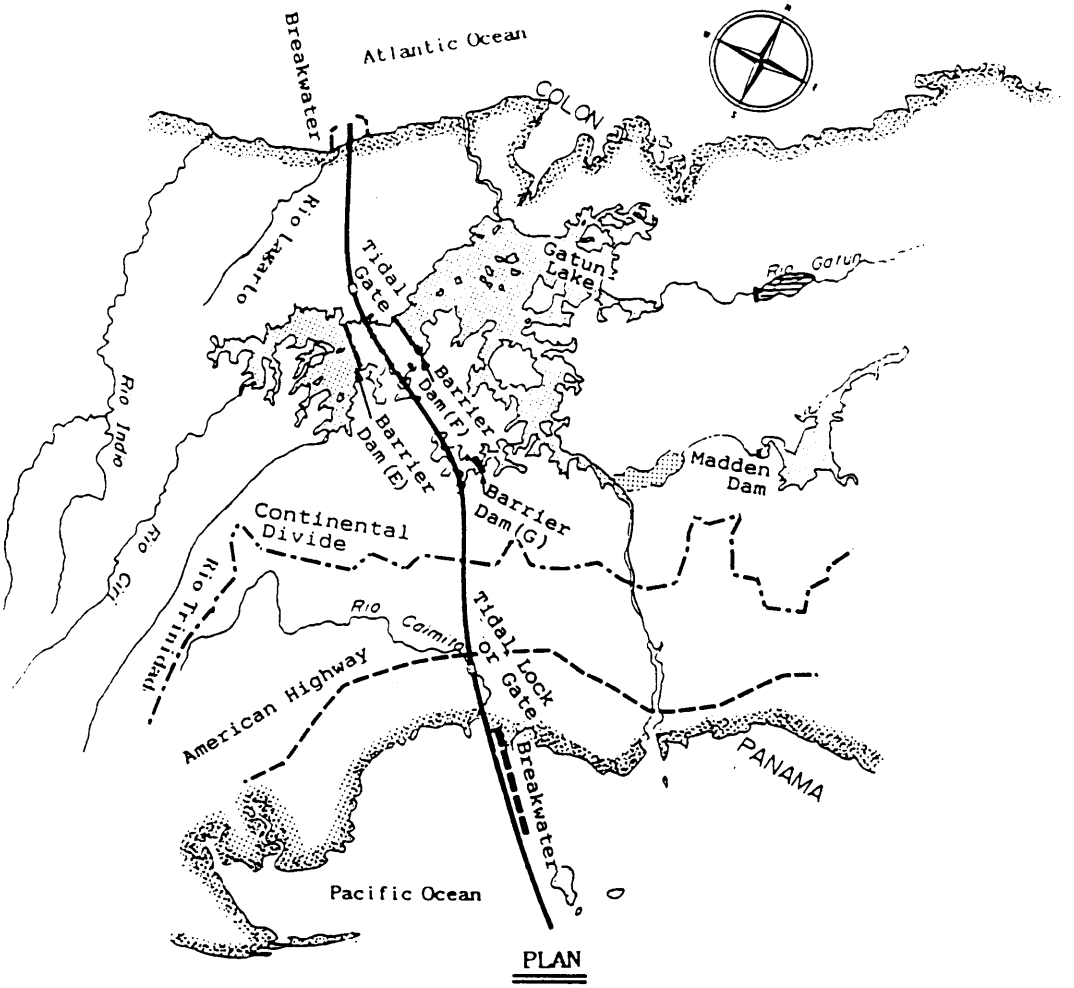


Fig. IV.1.1-1 Case of the Sea Level Canal



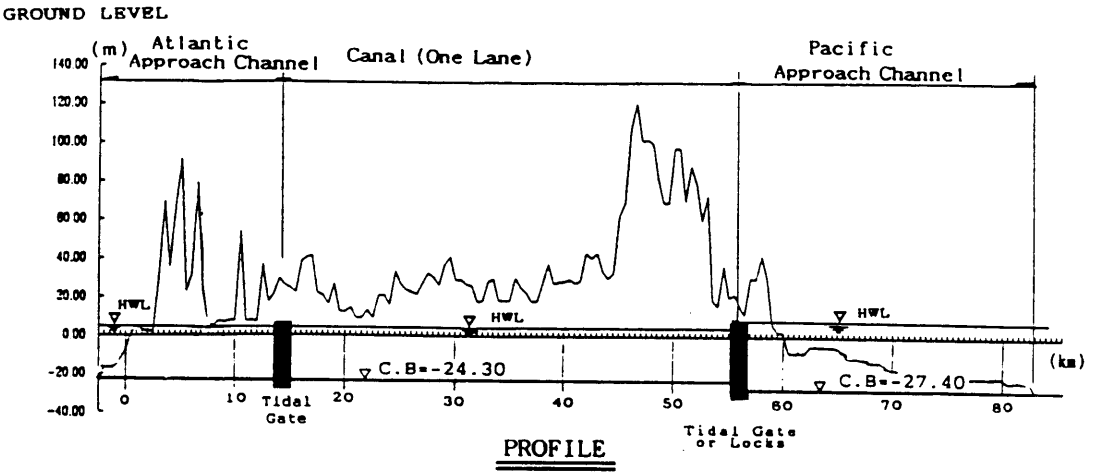


Fig. IV.1.1-2 Layout of Sea Level Canal [Case (a)]

IV.1 CHAPTER 2 - WATER MANAGEMENT

2.1 Introduction

In the case of the high rise lock, some 4,000 million m^3 of lockage water is required to operate the new and existing locks, making calculation of the water balance extremely important. In contrast, the question of lockage water for the new high rise locks does not arise in the case of the Sea Level Canal although lockage water is still required for the existing locks.

The main water management item in the case of the Sea Level Canal is, therefore, examination of the available water volume for the existing locks in view of the reduced size of Gatun lake (due to the construction of a barrier dam) upon completion of the Sea Level Canal. The examination results show that sufficient lockage water is available from the remaining catchment for the existing locks even in dry years, although an additional regulating dam at Upper Gatun is required for the year 2060.

The freshwater barrier system proposed here to solve the problem of seawater movement between the two oceans involves the collection of rainwater, mainly from the watershed at the west side of the canal. As much freshwater as possible is then discharged into the canal or tidal lock chambers to form a freshwater barrier to restrict the movement of seawater. However, it is questionable whether or not the movement of seawater between the two oceans will be successfully prevented by the freshwater barrier system alone.

Only the possible volume of water to be used by the freshwater barrier system and the water collection and discharge method are examined in the Report. In other words, no detailed analysis of the possible effects of the proposed freshwater barrier system has been conducted. The main analysis item is the amount of freshwater that can be made available in addition to the lockage water for the existing canal. In short, the amount of

water available for the freshwater barrier from reservoir (E) is approximately 1,200 million m^3/year in an average year, plus about 700 million m3 from Rio Caimito and others that can be directly discharged to the canal instead of being stored in reservoir (E).

2.2 Water Management Plan

2.2.1 Projected Annual Transits

Based on the OCCE and CTP study, the number of transits in the years 2020 and 2060 are given in the table below.

	Number of Transits	
Year	Through Existing Canal	Through New Canal
2020	16200	2100
2060	19400	5100

2.2.2 Water Balance for Existing Canal

After construction of barrier dam "E", the storage capacity of Gatun Lake will change as shown in Fig. IV.1.2-1. The storage capacity and catchment area will be reduced 20 and 30 percent respectively. Water balance simulations in the years 2020 and 2060 were performed for the following three cases (1) average, (2) dry and (3) wet year. The results are shown in Table IV.1.2-2. For the three cases in 2020, there was no water shortage, but for the dry year case in 2060, a water shortage of 285 MCM was predicted.

Although an overall water balance deficit is predicted, no new dams outside the Gatun watershed have been proposed. Since there is a considerable water balance excess in an average year, the construction of an additional regulating dam within the Gatun watershed will be sufficient to ensure the availability of lockage water

during a dry year. The additional regulating dam capacity required is 285 MCM and it is expected that this dam will be filled in the wet season prior to a dry year (See Appendix 5).

The regulating dam chosen in the case of the Sea Level Canal is the Upper Gatun dam, since the other regulating dam sites at Ciri and Trinidad are separated from the remaining Gatun watershed by the Sea Level Canal. The required storage capacity of the Upper Gatun dam is 285 MCM and this storage capacity can be provided at the site.

2.2.3 Available Water for Freshwater Barrier

Reservoir (E) will be used as one source of freshwater for the barrier system. Water from Rio Ciri and Rio Trinidad flows into reservoir (E) directly, and water from Rio Los Hules, Rio Chica and Rio Cano also flows down into reservoir (E) via diversion channels. The catchment areas of those rivers become 850 sq.km in total (refer IV.1 Chapter 7.5) and the water volume becomes 1159, 720, and 1909 million m^3 in an average, dry and wet year respectively as shown in Table IV.1.2-2(3).

Freshwater from Rio Lagart (Atlantic side), Rio Caimito and Rio Sanchez (Pacific side) can be discharged into the canal directly and can contribute usefully to the freshwater barrier. Of these rivers, only Rio Caimito can be discharged in the central portion of the canal between the tidal lock/gate structures.

The discharge of those three rivers is 736, 482 and 1,174 million m^3 in average, dry and wet years respectively.

The total volume of freshwater awaitable from Reservoir (E) and the other rivers is listed below:

Table IV.1.2-1 Available Water Volume

Item	Average	Dry	Wet
Reservoir (E)	1159	720	1909
Rio Lagarto	321	208	503
Rio Caimito	376	248	608
Rio Sanchez	39	26	63
Sub Total	736	482	1174

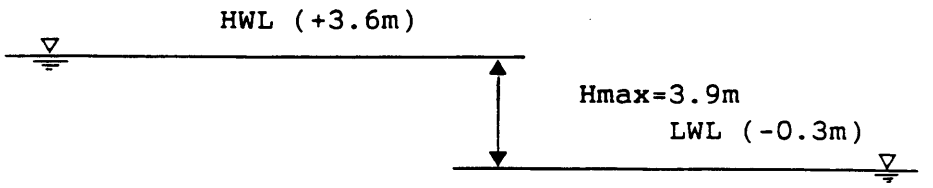
Note:
1) Rivers flowing into reservoir (E) are Rio Ciri, Rio Trinidad, Rio Hules, Rio Chica, Rio Cano.
2) Reservoir (E) and Rio Caimito only can be discharged in the central portion of the canal between tidal gate/lock structures.
3) Water volume in million m^3

2.2.4 Water Volume Necessary for Tidal Lock Chamber

In Case (a) and Case (b), it would be possible to discharge freshwater directly into the tidal lock chambers to raise the lock water level during lockage operations. The water volume necessary for the year 2020 and 2060 is calculated as follows:

$$V = L \times B \times H \times 0.5 \times N$$

where,
- V = water volume per one transit
- L = length of lock
- B = width of lock
- H = rise (HWL-LWL)
- 0.5H = average rise
- N = number of transits



V(Year 2020) = 430m*60m*3.9m*0.5*2,100 = 110 MCM
V(Year 2060) = 430m*60m*3.9m*0.5*5,100 = 260 MCM

2.2.5 Freshwater Barrier using Tidal Lock Chambers

(1) Freshwater Pouring into Lock Chambers (A)

Freshwater to act as a barrier could potentially be poured directly into the Tidal Lock Chambers. The water volume necessary for raising the water level in the lock chambers is 110 and 260 million m^3 in 2020 and 2060 year respectively, therefore sufficient water is available from Rio Caimito or reservoir (E) even in a dry year. No details for this option are discussed for the following reasons:

- A huge volume of water must be injected into the lock chamber in a very short period of time.
- The involvement of three lock chambers makes the system very complicated.
- The positive effects of such a freshwater barrier system have not been clearly demonstrated.

(2) Freshwater Pouring into Lock Chambers (B)

The freshwater pouring method mentioned above is sufficient only to raise the water level in the chambers for ship transit. Therefore sea water would still remain in the lower parts of the chambers and the effectiveness of the barrier would be doubtful. If all the water in the chambers is replaced by freshwater, the effectiveness of the barrier would improve significantly. The water volume needed for this method is calculated for reference as follows:

V_1 = (Year 2020)
= 430 L x 60 W x 23 D x 2,100 Transit
= 1,246 MCM + 110 MCM = 1,356 MCM

V_2 = (Year 2060)
= 430 L x 60 W x 23 D x 5,100 Transit
= 3,026 MCM + 260 MCM = 3,286 MCM

Considering the available freshwater volume and the volume needed it might be concluded that this idea is not practical.

2.2.6 Freshwater Discharge Between Tidal Gates/Locks

In this case, water is injected into the canal via the intake of dams W-3-D, W-4-D, W-6-D and W-7-D described later in IV.1. Chapter 8.

Generally, in this case the ratio A defined in the formula below might be used as an indication of whether the freshwater barrier would work effectively or not.

$$\text{Ratio A} = \frac{\text{annual freshwater added}}{\text{storage capacity between gates/locks}}$$

(Density Flow Hydraulics, Page 149-151 : Edited Japanese Civil Engineering Society in 1980 : Dr. Tamai)

If the value of A is less than 10, it is said that water in the channel is not effectively mixed. Accordingly when A is less than 10, it is unlikely that the freshwater barrier would be effective.

The results for Case (c) of the Sea Level Canal are shown in the table below:

Case	Inflow* (MCM)	Capacity** (MCM)	Ratio A
Average	1159 + 376 = 1535	160	10
Dry	720 + 248 = 968	160	6
Wet	1909 + 608 = 2517	160	16

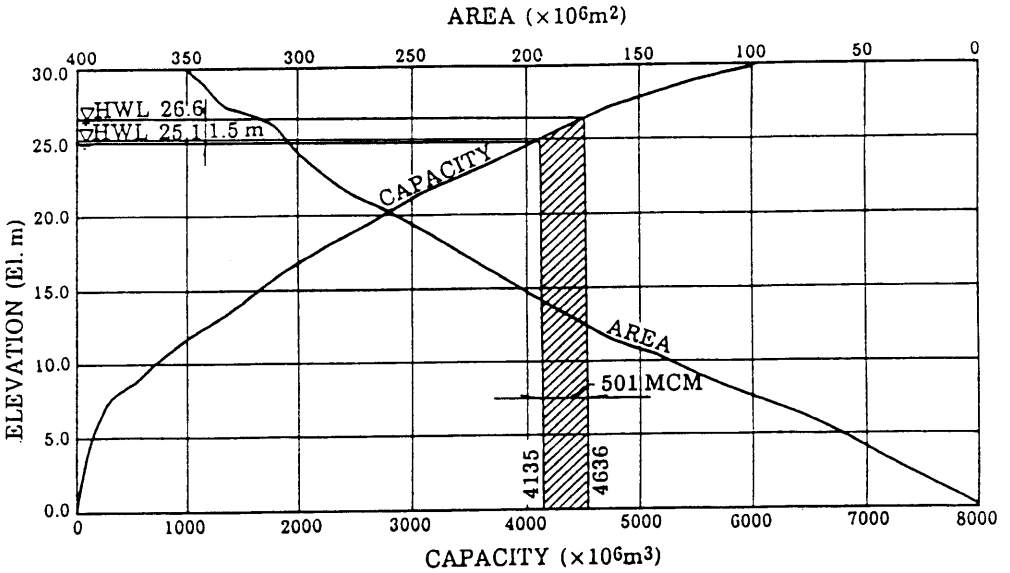
Note: * Inflow includes Reservoir (E) plus Rio Caimito
** Capacity is the water volume between tidal lock and tidal gate
Capacity=(190+238)*0.5*24*31,000(length)=160 MCM

For Case (b) of the Sea Level Canal the Ratio A would be considerably reduced since the gate separation is increased from 31 km to 40 km.

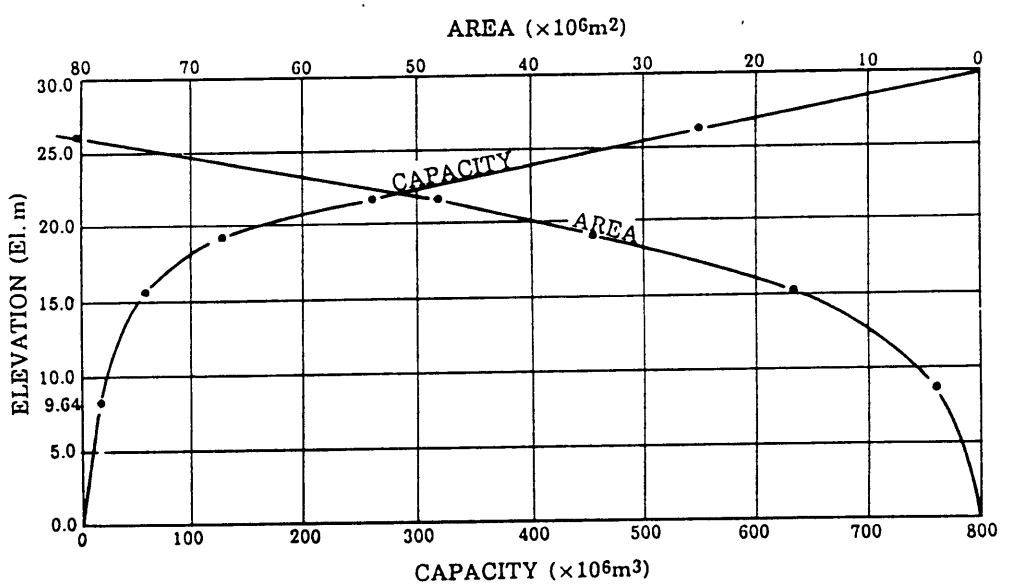
In Case (a), the Atlantic entrance is open at all times and the Ratio A is no longer applicable.

The simple analysis of Ratio A may be valid as a preliminary indication of the likely effectiveness of a freshwater barrier but it must be emphased that a detailed study is required. An evaluation of the effectiveness of the freshwater barrier was not part of the Scope of Works for this study.

(1) GATUN LAKE AREA CAPACITY CURVE (SEA LEVEL CASE)



(2) BARRIER DAM "E" AREA CAPACITY CURVE



Data Source: YEC based on topographic map (scale 1 : 50,000)

Fig. IV.1.2-1 Area Capacity Curve of Revised Gatun Lake and Barrier Dam "E"

Table IV.1.2-2 Water Balance Table (Sea Level Case)

(1)2020 Year Case

Water Resource Catchment area(sq.km)	Revised Gatun Lake 2365.0		
Design Ship		65000	
Transits through existing lock		16200	
Transits through sea level canal		—	
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	5117	3931	7629
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	512	509	520
④Available water for lockage(①-②-③)(MCM)	4331	3148	6835
⑤Existing Lock(MCM)	2867	2867	2867
⑥Water Balance(④-⑤)(MCM)	1464	281	3968

(2)2060 Year Case

Water Resource Catchment area(sq.km)	Revised Gatun Lake 2365.0		
Desin Ship		65000	
Transits through existing lock		19400	
Transits through sea level canal		—	
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	5117	3931	7629
②Municipal water(MCM)	274	274	274
③Evaporation(MCM)	510	508	518
④Available water for lockage(①-②-③)(MCM)	4333	3149	6837
⑤Existing Lock(MCM)	3434	3434	3434
⑥Water Balance(④-⑤)(MCM)	899	-285	3403

(3)Available Water for Freshwater barrier

Water Resource Catchment area(sq.km)	Reservoir 'E' 846.5		
Design Ship		250000	
Transits through existing lock		—	
Transits through sea level canal		5100	
CASE NO.(Average, Dry and Wet Years)	1(Ave)	2(Dry)	3(Wet)
①Total runoff(MCM)	1268	829	2018
②Municipal water(MCM)	0	0	0
③Evaporation(MCM)	109	109	109
④Available water for freshwater (①-②-③)(MCM)	1159	720	1909

Note:(1)Average year is the average for 51 years(1933～1983)
(2)Wet year is 1981
(3)Dry year is 1982
(4)By constructing diversion channel, the catchment area of Reservoir 'E' will have an additional catchment area of 161.5 sq.km (685+161.5=846.5) (See Chapter 7.5)

IV.1 CHAPTER 3 - GEOLOGY AND CANAL EXCAVATION

3.1 Geology

The following documents are useful to assist understanding of the geology along Route 10.

1) Geological Map of Panama Canal and Vicinity, Republic of Panama (1/100,000), 1980, R.H. and J.L. Stewart in collaboration with W.P. Wooding

2) JAX-92 (IOCS Memorandum), 1969

3) JAX-93 (IOCS Memorandum), 1969

In general, geological data on Route 10 are scarce compared to data on High Rise Lock Route. The geological conditions are particularly unclear in the continental divide area which has a tableland topography with few outcrops.

The geology along Route 10 is outlined in the following section using the field survey findings for the Phase II Study and the descriptions given by the above documents.

3.1.1 Geology Along Route 10

The area along Route 10 is largely classified into four geological zones, i.e. (1) Caribbean coast zone, (2) Gatun Lake zone, (3) central divide zone and (4) Pacific coast zone, as in the case of High Rise Lock Route based on the bedrock formation. The geological characteristics of these zones are outlines below.

(1) Caribbean Coast Zone

This is the area between the Caribbean coast and the north bank of Lake Gatun which has a hilly topography with Lagarto River meandering throughout the zone. This zone has two main formations.

- o Gatun Formation (Middle Miocene)
  - sandstone, siltstone and conglomerate
  - lithofacies: massive and medium hard to soft
  - natural slopes are stable with little risk of a medium to large-scale landslide
  - the Gatun Formation is located below the Chagres Formation

- o Chagres Formation
  (Late Miocene or Early Pliocene)
  - sandstone
  - lithofacies: massive and medium hard to soft
  - stable slopes with little risk of a landslide

Deposits of unconsolidated gravel and clayey materials are found near the mouth of Ragarto River. Moreover, deposits of clayey materials called Atlantic Muck are found at the bottom of the Caribbean.

(2) Gatun Lake Zone

This is the area between the north bank of Gatun Lake and the 2km northwest point of the mouth of Pescado River. A large part of this zone is under Gatun Lake and the small land area consists of low hills and swamps. This zone has two main formations.

- o Marine Rocks (Late Eocene)
  - sandstone and siltstone
  - lithofacies: massive and medium hard to soft
  - stable slopes with little risk of a landslide

- o Caimito Formation (Late Oligocene)
  - marino sandstone, silstone and tuff
  - lithofacies: massive to layered and medium hard
  - stable slopes with little risk of a landslide

Deposits of unconsolidated gravel or clayey materials are found in the lowland area adjacent to Gatun Lake, Deposits of clayey materials are found at the bottom of Gatun Lake.

(3) Central Divide Zone

This is the area between the 2km northwest point of the mouth of Pescado River and the Interamerican Highway and is part of the continental divide. The central area forms a plateau of 200-300m in elevation. The geology is characterised by highly altered igneous rocks. Details of the geological structure are as yet unknown although a very complicated picture is expected.

One-third of the zone in the north consists of volcanic rocks of the early Miocene which have become soft due to alteration. The remaining two-thirds of the zone in the south mainly consist of soft basalt due to alteration although the intercalation of hard intrusive or extrusive rocks is also found in parts. Careful examination of the stability of the slopes is required as the excavated slopes are expected to be high and the ground generally soft.

(4) Pacific Coast Zone

This is the area between the Interamerican Highway and the mouth of Camito River. A large part of this zone belongs to the flood plain of Camito River which meanders through the zone. The bedrock of this zone is altered, soft basalt and deposits of unconsolidated gravel and clayey materials are found in the lowland area along Caimito River.

3.1.2 Additional Geotechnical Investigation

Geological information on Route 10 at the Feasibility Study stage was fairly scarce compared to the availability of essential data for the High Rise Lock route. An additional geotechnical investigation is, therefore, required to make the data for both routes of a comparable level. This additional geotechnical investigation on Route 10 will consist of the following three components. It will then be necessary to conduct a geotechnical

evaluation of the entire Route 10 based on the new data obtained through the additional investigation. The cost breakdown of the investigation is mentioned in Appendix 4.

(1) Boring

Boring will be conducted at three points at an average interval of 3km. The boring depth will be the excavated bottom level of the canal.

(2) Soil Test

A soil sample will be collected at every 20m boring interval.

(3) Field Reconnaissance and Geological Analysis

Field reconnaissance using the topographical map (scale: 1/25,000) will be conducted to prepare a geological map (scale: 1/25,000).

3.2 Zoning

In view of the proposed canal structure, construction methods and excavation volume, the route is divided into five zones, i.e. (I) Atlantic Approach, (II) Queblado, (III) Gatun Lake, (IV) Continental Divide and (V) Pacific Approach.

3.2.1 Atlantic Approach Zone (Zone I)

This is 3.3km section between No.-2.80 (starting point of Atlantic Approach Zone) and No. 0.50 (mouth of Lagaruto River), the entire section will be dredged.

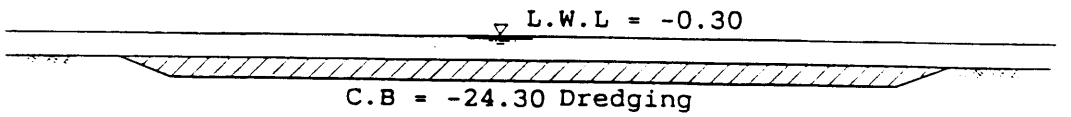


Fig. VI.1.3-1 Typical Cross-Section of Zone I

3.2.2 Queblado Zone (Zone II)

This is the 16.50km section between No. 0.50 (mouth of Lagaruto River on the Atlantic coast) and No. 17.00 (Cano Las Cruces on the shore of Gatun Lake). The sub-section between No. 0.50 and No. 14.50 will be excavated by the mixed method of dry excavation and dredging. The ground above sea level (EL 0m) will be excavated in the first stage. The dredging method will be used for areas below this level. Dry excavation will be conducted for the remaining sub-section between No. 14.50 and No. 17.00.

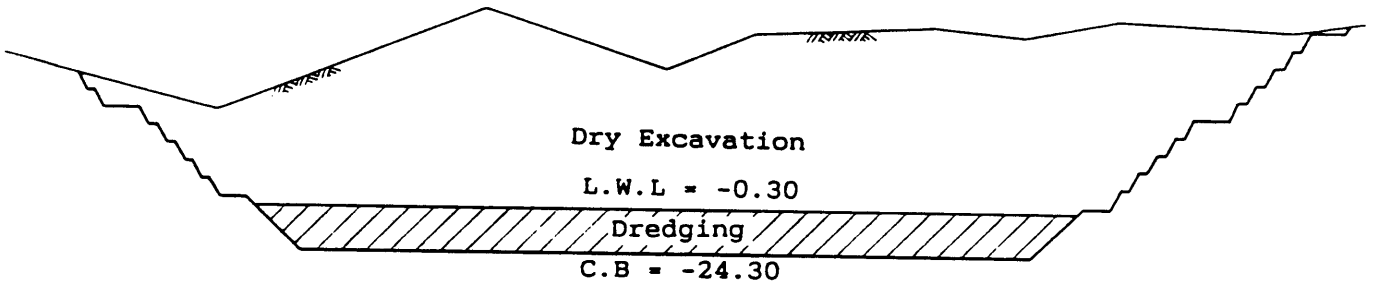


Fig. IV.1.3-2 Typical Cross-Section of Zone II

3.2.3 Gatun Lake Zone (Zone III)

This is the 21km section between No. 17.00 (Cano Las Cruces on the shore of Gatun Lake) and No. 38.00 (mouth of Pescado River) and consists of Gatun Lake. Dredging and dry excavation will be conducted at the sub-section between No. 17.00 and No. 22.50. Dredging work will firstly be conducted below sea level while barrier dams are constructed. With the completion of the barrier dams, water inside the barrier dams will be drained, followed by dry excavation above sea level. Work for the sub-section between No. 22.50 and No. 33.00 will entirely consists of dry excavation. Barrier dams will be erected for the sub-section between No. 33.00 and No. 38.00. Dry excavation will be conducted in this sub-section after the water has been drained. In view of the inflow of four large rivers (Los Hules, Qubruado de Chica, Pescado and Cano), diversion cofferdams will be erected to guide the flow to Gatun Lake via diversion channels.

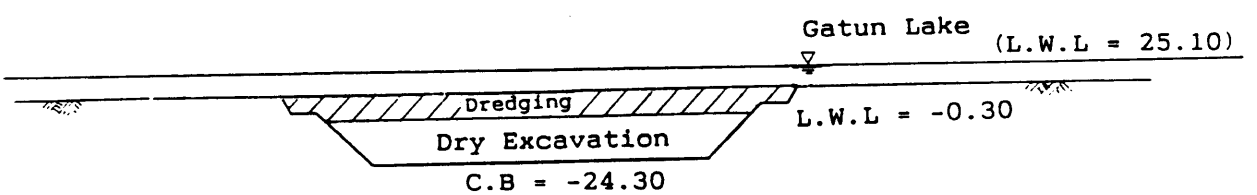


Fig. IV.1.3-3 Typical Cross-Section of Zone III

3.2.4 Continental Divide (Zone IV)

This is the 22.50km section between No. 38.00 (mouth of Pescado River) and No. 60.50 (mouth of Caimito River on the Pacific coast). Mixed excavation consisting of dry excavation and dredging will be conducted at the sub-section between No. 38.00 and No.59.00. Dry excavation above sea level will firstly be conducted, followed by dredging below sea level. The sub-section between No. 59.00 and No. 60.50 which is a swamp zone will be completely dredged.

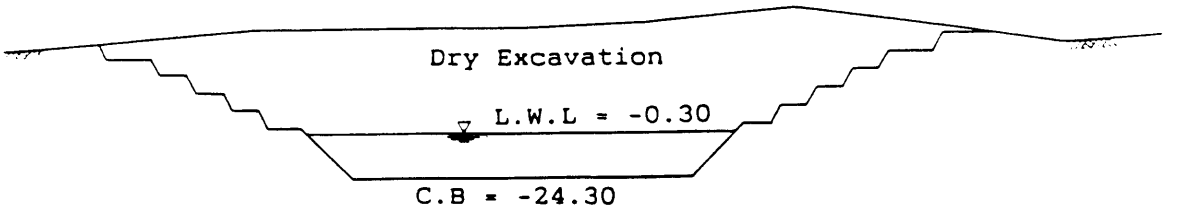


Fig. IV.1.3-4 Typical Cross-Section of Zone IV

3.2.5 Pacific Approach Zone (Zone V)

This is the 25.1km section between No. 60.50 (mouth of Caimito River on the Pacific coast) and No. 85.60 (end point of the Pacific Approach) and will be dredged throughout.

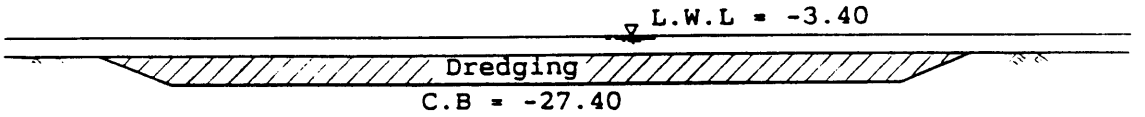


Fig. IV.1.3-5 Typical Cross-Section of Zone V

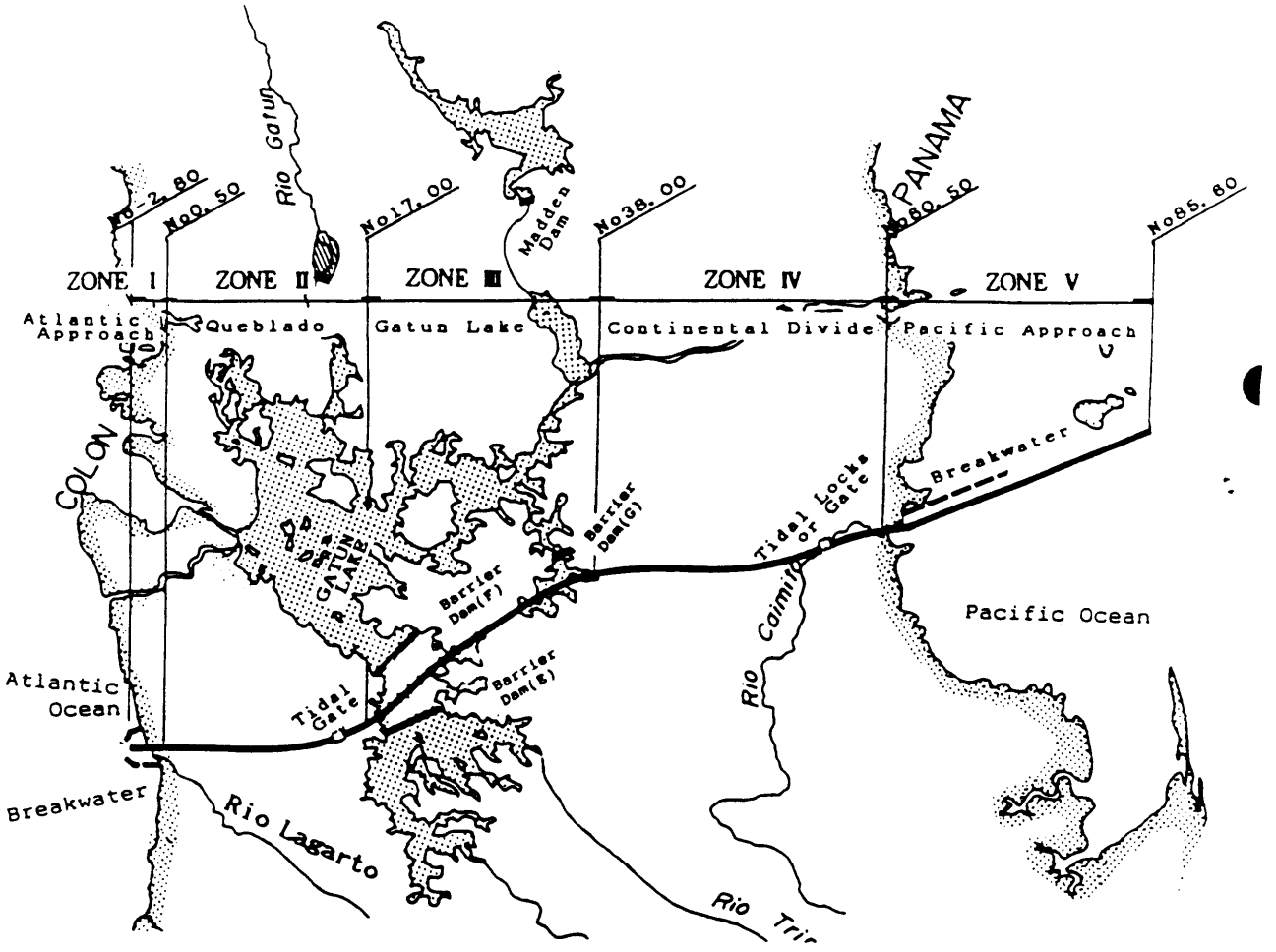


Fig. IV.1.3-6 Zone Map for Sea Level Canal Route

3.3 Excavation Slopes

3.3.1 Standard Slope Configurations

Slope configuration selection will be based on the five slope categories of Type 1 to Type 5 described in Part II taking the rock and sediment types into consideration.

3.3.2 Slope Type Suitability for Route Alignment

The IOCS and Nagano Plan only describe slope type suitability in terms of the rock and sediment types and do not explain the geographical suitability of slope types. This geographical of slope type suitability has now been proposed in the Study. Nevertheless, the proposal remains part of the Feasibility Study and slope type suitability for the detailed design and actual construction work must be determined based on the findings of a thorough soil engineering survey. The proposed slope types and their locations are shown in Table IV.1.3-1.

The following documents were mainly used to decide the slope type at specific locations.

- Sediment Profiles (IOCS, 1970)
- Geological Map of Panama Canal and Vicinity (Republic of Panama, 1980)

Table IV.1.3-1 Slope Type Suitability

Canal Station(km)	Section	Cordinates	Slope Type	Average Excavation Hight(m)
No. -2.80 to No. 0.50	Atlantic Ocean to the Coastline	600.80E 1021.70N	5	11.5
No. 0.50 to No. 17.00	The Coastline to the North Shore of Gatun Lake	610.80E 1008.70N	2	50.0
No. 17.00 to No. 38.00	North Shore of Gatun Lake to the Mouth of Pescado River	629.00E 998.80N	1	47.2
No. 38.00 to No. 42.00	The Mouth of Pescado River to the Upper Stream	631.30E 995.60N	4	55.5
No. 42.00 to No. 43.00	The Upper Stream of Pescado River to Continental Divide(1)	631.70E 994.70N	1	66.3
No. 43.00 to No. 50.00	Continental Dive(1) to Continental Divide(2)	634.60E 988.30N	4	98.6
No. 50.00 to No. 52.00	Continental Divide(2) to Continental Divide(3)	635.80E 986.70N	1	110.3
No. 52.00 to No. 60.50	Continental Divide(3) to the Mouth of Caimito River	641.60E 982.30N	4	57.0
No. 60.50 to No. 85.60	The Mouth of Caimito River to Pacific Ocean		5	13.4

3.4 Excavation Material Classification

3.4.1 Bedrock Classification for Excavation Work

Seven sediment types have been introduced to correspond to the construction work methods which have been decided based on the assumed thickness of the soil formations at each survey site. The assumed formation thickness is based on-site observation findings and existing data such as that provided by past reports and geological plans. A schematic geological profile of each of the seven sediment types found along the High Rise Lock route is given in Figs. IV.1.3-7.

The concept of common rock defined by the Study includes those rocks of which excavation will require blasting. The ratio of excavation work requiring blasting is assumed to be 0 and 30% depending on the rock types found along the route.

Table VI.1.3-2 Classification of Rock Quality

Rock or Formation of Route-10		Category of Quality
Basalt (extrusive) (intrusive)	(Tb)	High Quality Rock
Volcanic rocks undifferentiated	(Tv)	
Chagres F.	(Tc)	Intermediate Quality Rock
Toro limestone	(Tct)	
Gatun F.	(Tg)	
Marine rocks	(Tue)	
Caimito F.	(Tcm)	
		Low Quality Rock
Severely altered agglomerate and tuff in (Tb) and (Tv)		Soft Rock
Debris (Overburden) Atlantic Muck Pacific Muck		Earth

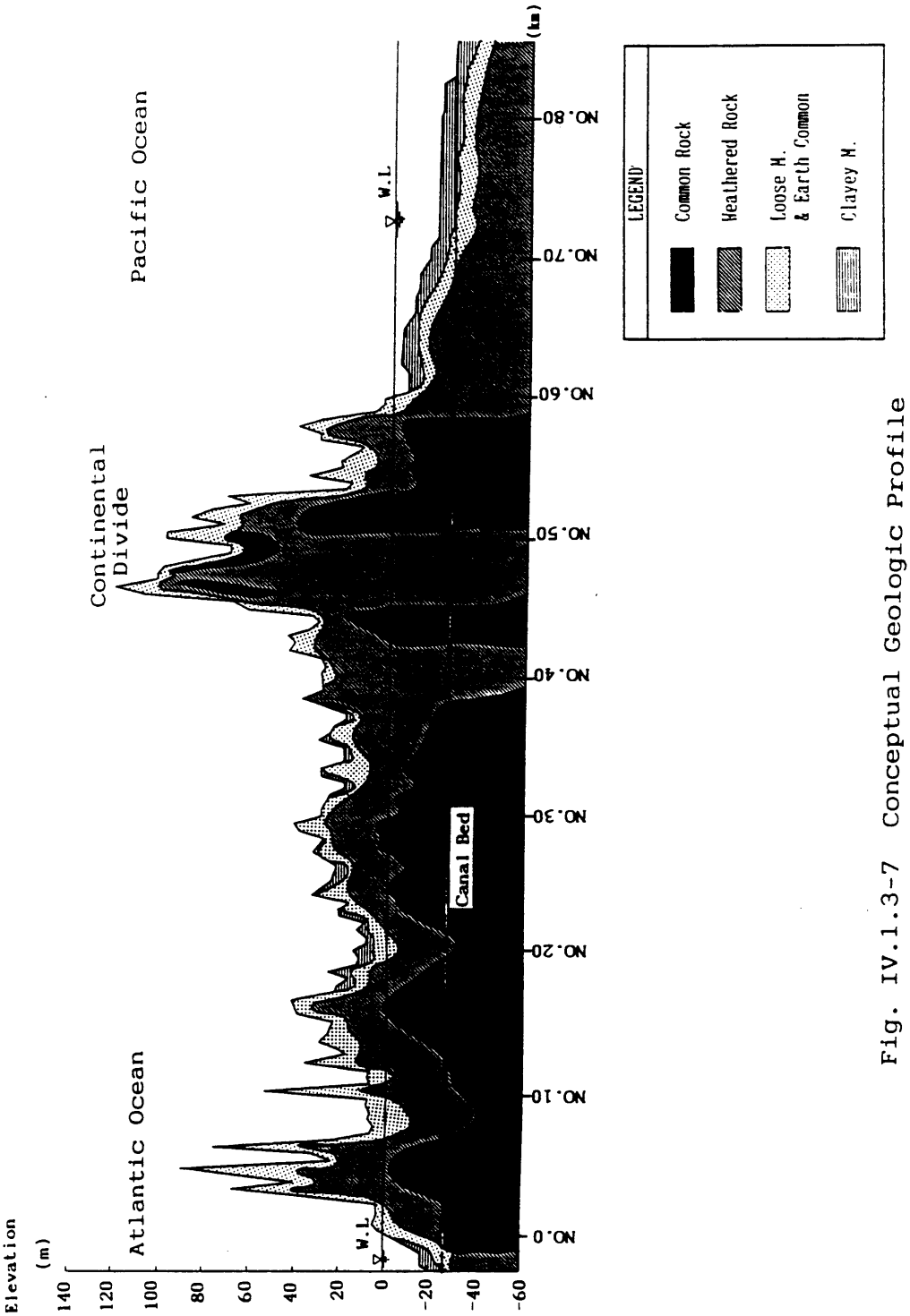


Fig. IV.1.3-7 Conceptual Geologic Profile

3.4.2 Cross-Section Preparation

The scale of the topographical maps used for the ground section is 1:25,000. In the case of the sea and Gatun Lake sections, charts giving better details (scale:1/50,000) are used to prepare the cross-sections. The distance between the cross-section points is 0.5 km.

The required excavation volume has been computed and the relevant drawings made using a CAD system. Contours on the topographical maps were read by the digitizer and the design canal profile was input to compute the excavation volume. The sectional area was also computer based on the excavation volume. The software used to assist the construction plan was LAPLAS which is popularly used. A list of hardware is given below.

- Computer : SN-4330 (SUN Micro Systems)
- Personal Computer: PC-H98 model90-100 (NEC)
- Digitizer : DH8503 (SEIKO)
- Plotter : EP4010 (SEIKO)
- Printer : CH-5514 (SEIKO)

3.5 Excavation Volume

In the case of the Sea Level Canal route, the required excavation volume will be calculated for three separate cases, i.e. cases (a), (b) and (c), for the same ships size of 250,000 DWT.

Table IV.1.3-3 gives the excavation volume for each sediment type by zone for these three cases.

Table IV.1.3-3 Excavation Volume

Sea Level Route 10, 250,000 DWT, Case (a), (c)

ZONES	STATION	Dry Excavation (1000m3)				Dredging (1000m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose M.	Clayey M.	Total
I	-2.80 - 0.50	0	0	0	0	0	2.242	5.163	8.857	16.262
II	0.50 - 17.00	49.987	84.678	14.851	149.517	38.900	27.935	18.104	0	84.940
III	17.00 - 38.00	68.196	117.992	23.229	209.416	0	10.386	6.612	7.755	24.754
IV	38.00 - 60.50	173.656	373.581	41.967	589.204	14.902	33.888	8.579	0	57.369
V	60.50 - 85.60	0	0	0	0	0	31.086	39.840	50.094	121.020
Total	88.40	291.839	576.251	80.047	948.137	53.803	105.537	78.298	66.706	304.344

Sea Level Route 10, 250,000 DWT, Case (b)

ZONES	STATION	Dry Excavation (1000m3)				Dredging (1000m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose M.	Clayey M.	Total
I	-2.80 - 0.50	0	0	0	0	0	3.123	5.515	8.857	17.494
II	0.50 - 17.00	78.206	136.983	24.392	239.581	67.492	54.902	36.378	0	158.773
III	17.00 - 38.00	68.196	117.992	23.229	209.416	0	10.386	6.612	7.755	24.754
IV	38.50 - 60.50	173.005	370.149	41.419	584.573	13.979	30.946	7.657	0	52.582
V	60.50 - 83.20	0	0	0	0	0	26.820	32.824	38.132	97.777
Total	86.00	319.407	625.124	89.040	1.033.571	81.471	126.178	88.986	54.744	351.379

3.6 Sensitivity Analysis

The slope criteria adopted by the Study are described in Part II. It is highly possible, however, that these slope criteria be modified for the actual excavation work on the basis of findings of the detailed soil engineering survey. In general, factors which largely affect excavation volume are slope gradient and canal width. Therefore, changes of excavation volume due to different slope gradient as well as different canal width were examined. The subject case was A and B of 250,000 DWT.

3.6.1 Excavation Slope

The adoption of gentler excavation slope gradient that the gradient of the slope criteria used by the Study resulted into an increased excavation volume, of which rate of increase is shown in Fig. IV.1.3-8.

The examination involved three cases where the adopted slope gradient under the Study be changed to a gentler slope of cotangent 0.2, 0.4 and 0.6. The examination results indicated that an increase of total excavation volume would be rather small even if the slope gradient be drastically changed to make the slope much gentler. The change of gradient to cotangent 0.6 would increase the total excavation volume by 19.5%. As the total excavation volume is roughly in proportion to the earth work cost, it is safe to assume that the latter would increase by the same proportion in case a gentler slope gradient being adopted.

3.6.2 Canal Width

Using the two-lane canal width of 7B (380m) adopted by the Study as the reference width, two cases of increased canal width, i.e. 8B (430m) and 10B (540m) were examined to determine an impact of wider canal width on excavation volume. In conducting the examination, the canal width was widened only in the two-lane approach section, while the single-lane section (3.5B: 190m) was left unchanged. The resulting increase of excavation volume is shown in

Fig. IV.1.3-9. The rate of increase is 2% for the case 8B or 5% for the case 10B.

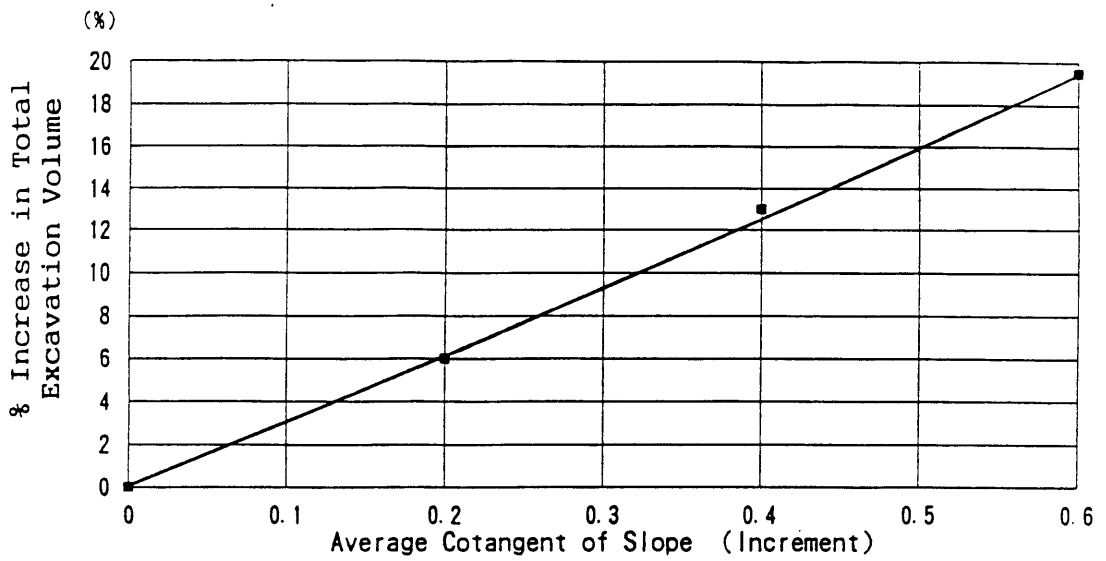


Fig. IV.1.3-8 Effect of Canal Side Slope on Excavation Volume

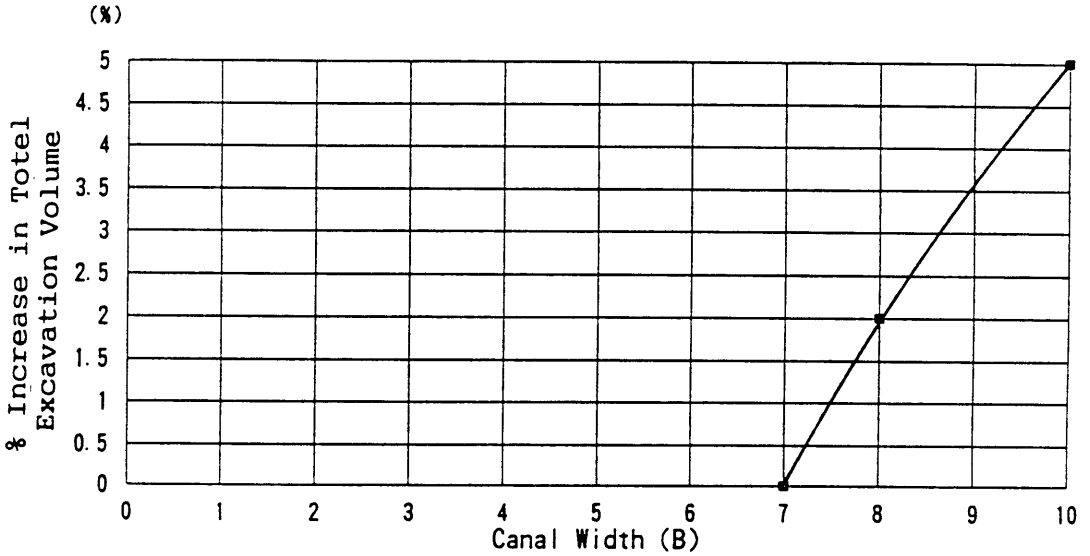


Fig. IV.1.3-9 Effect of Canal Width on Excavation Volume

IV.1 CHAPTER 4 - TIDAL LOCK AND TIDAL GATE (CIVIL)

4.1 Design Criteria

The Sea Level Canal is designed to accommodate 250,000 DWT class vessels. The case variations include tidal locks on the Pacific side, a tidal gate on the Atlantic side and combinations of these. The configurations of these different cases are shown in Fig. IV.1.4-1. Design Criteria used in the Sea Level Canal are summarized in Table IV.1.4-1.

4.2 Tidal Lock and Tidal Gate

4.2.1 Arrangement of Structures

There are three study cases for the Tidal gates and Tidal locks arrangement plan regarding the Sea level canal along Route-10 as shown in the Fig. IV.1.4-1.

Case (a) One Tidal Lock structure only on the Pacific side. For the Canal lane, there are two lanes on the Pacific and Atlantic approaches; and one lane between them.

Case (b) Two Tidal Gates on both ocean sides. For the Canal lane, there are two lanes from both Oceans to the Tidal Lock and Tidal Gate; and one lane between them.

Case (c) One Tidal Lock on the Pacific side and one Tidal gate on the Atlantic side. For the Canal lane, there are two lanes from the Pacific Ocean to the Tidal Lock, two lanes from the Atlantic Ocean to the Atlantic coast line, and one lane between them.

4.2.2 Freshwater Barrier

There is a possibility that the Sea Level Canal will cause an environmental problem on a global scale because of the movement of seawater between the Pacific and

Atlantic. The introduction of a freshwater barrier has been examined as a method of solving this potential problem. The Report also examines the possible volume of freshwater to be poured into the canal and by what method but the likely effects of this have not yet been studied. A more detailed examination is, therefore, required in the future prior to the official acceptance of the freshwater barrier.

4.3 Tidal Lock Structure

4.3.1 Location of Case (a) and (c)

The Tidal lock construction site is located at an inland area of 5-kilometers from the "Bahia Chorrera" in the Pacific side. The site is located from an angle off a hill ranging about 50 to 60 meters to nearby Rio Caimito. The towns of "La Chorrera" in the south-west, "Nueva Guarare" in the north-east, and "Puerto Caimito" near the Caimito river mouth are located here. There is a National highway (k5), an autopista tollway, and a local road (70) in the vicinity.

4.3.2 Tidal Lock Dimensions

Ship size	250,000 DWT
Chamber length	430 M
Chamber beams	60 M
Chamber draft	23 M

Tidal Lock dimensions are decided assuming ships are guided by Mule system.

4.3.3 Layout of the Facilities

The Tidal Lock facilities for the study cases (a) and (c) are shown in Fig. IV.1.4-2.

The tidal locks consist of three lanes arranged in parallel with each other. One additional Lock lane will be constructed in the future. The canal width is 190m and

approach channel is 380m basically but both widths are enlarged near the facilities to 810m.

The tidal locks have two rolling gates at each lock head (four rolling gates in total per one lock structure) respectively. Maintenance and operation yards are provided on both sides of the lock chamber. Water levels on the Pacific, on the canal and surface levels of structures with sill levels are also shown in Section A-A in Fig. IV.1.4 -2.

4.3.4 Lock Structure

All locks and approach walls will be of a gravity type. All walls will be proportioned so that at the intersection of the base and the foundation, the resultant forces fall within the middle third of the base under normal operating conditions and within the middles half of the base under emergency conditions. Structure details are shown in DWG. No.7 and DWG. No.8.

Table IV.1.4-1 Design Criteria

Item	Description
1) Route	Ref. Sea Level Canal layout Fig. IV.1.1-2
2) Ship size	250,000 DWT. (356 x 54 x 21 m)
3) Lane No.	Approach Channel 2 lanes, Canal 1 lane
4) Canal width	3.5 * B = 190 m
5) Lock dimension & No. of lane	250,000 DWT. 430m * 60m * 23.0m 3 lanes plus additional one lane [Case (a)]
6) Tidal gate dimension & No. of lane	Gate width = 190m, Draft = 23m Tidal Gates at both Ocean sides [Case (b), (c)] One lane
7) Tide levels	High water level = +3.6m (Pacific) Lowest water level = -3.4m (Pacific) High water level = +0.5m (Atlantic) Lowest water level = -0.3m (Atlantic)
8) Earthquake	Kh = 0.1, Kv = Kh * 2/3

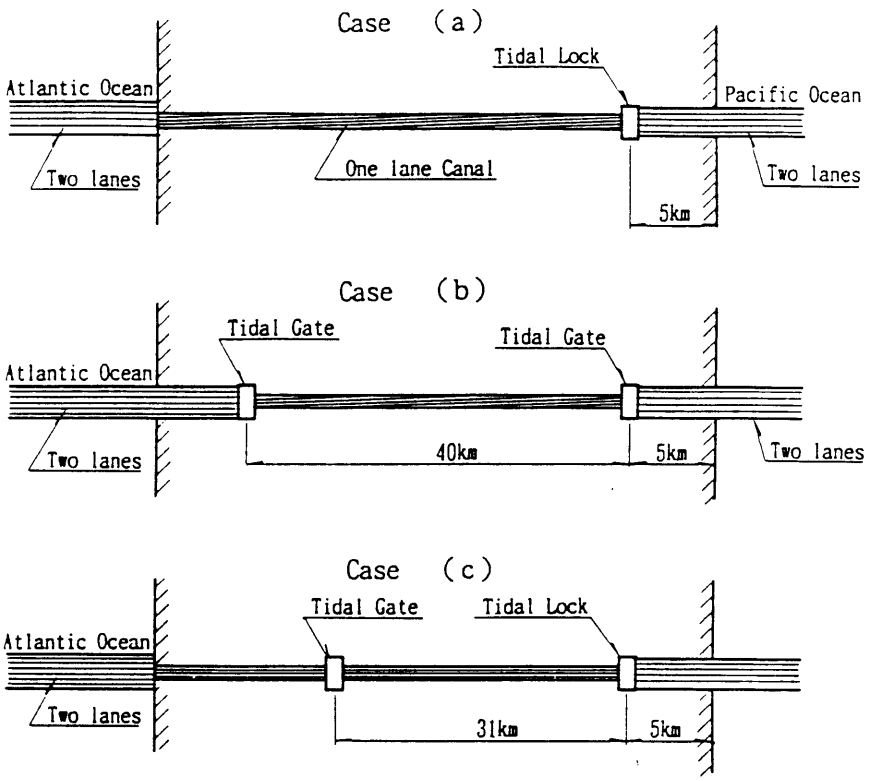


Fig. IV.1.4-1 Tidal Lock and Gates Arrangement Plan

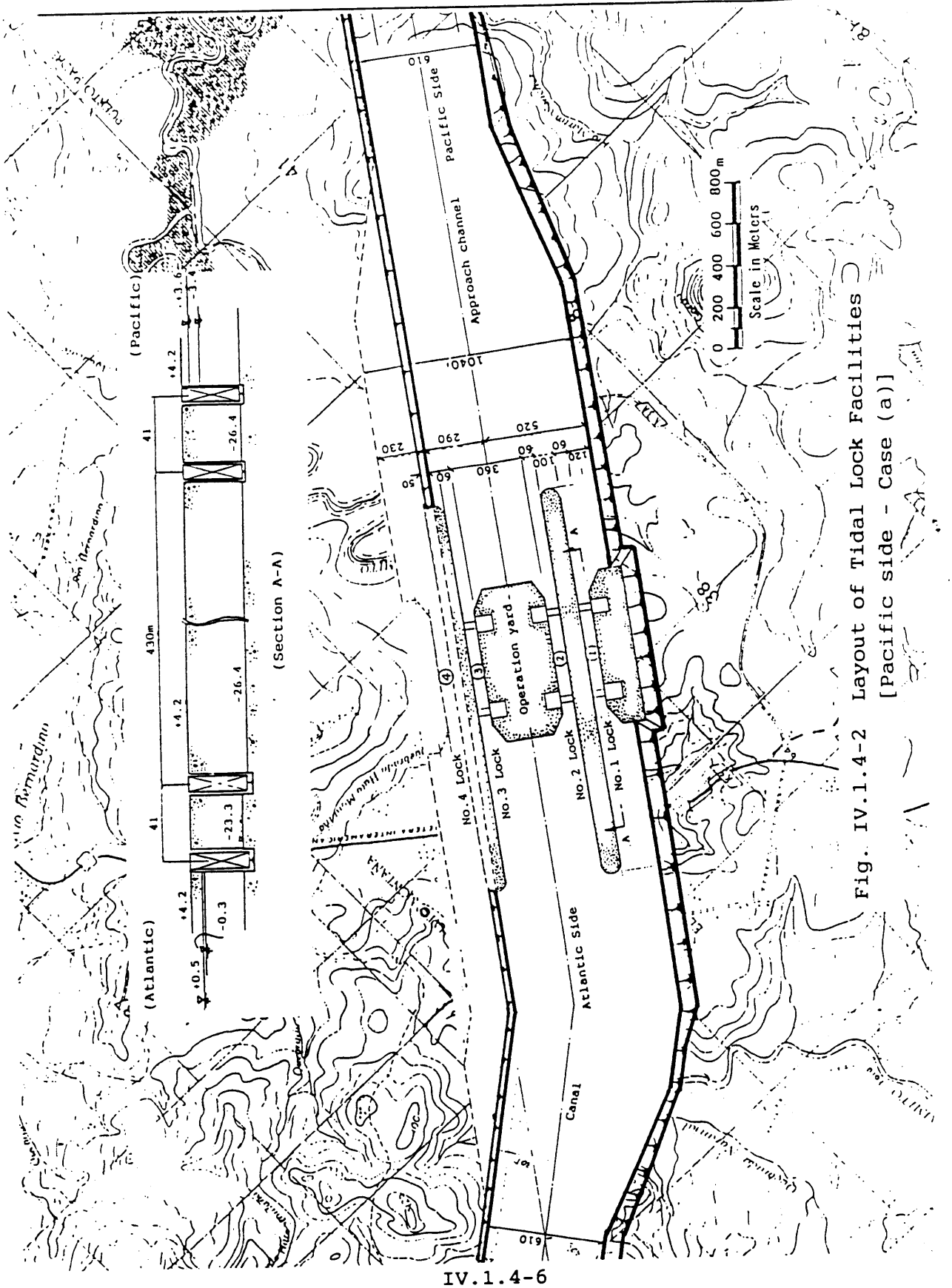


Fig. IV.1.4-2 Layout of Tidal Lock Facilities [Pacific side - Case (a)]

4.4 Tidal Gates

4.4.1 Location

For study case (b), a pair of tidal gates shall be installed on both Ocean sides. A tidal gate on the Pacific side is located at the same site where the tidal lock is Planned. (Ref. Fig. IV.1.4-3) Another tidal gate is planned at a site 15-kilometer southeast from the Atlantic coast. The village "Escobal" is located 6-kilometers east of the site. The area is generally flat ranging from 20 to 30 meters, with Rio Brazit and Rio Arileos, located near the site. The distance between the two tidal gates is 40 kilometers.

For study (c), a tidal lock of the same structure located on the Pacific side as mentioned for study case (a) and a tidal gate is planned at site N-617.5 and E-1005 km adjacent to the village "Largarterita". The distance between the tidal gate and tidal locks is 31 kilometers.

4.4.2 Tidal Gate Dimensions

Ship size	250,000 DWT
Gate width	190 M
Chamber depth	23 M
Gates (with a emergency)	

4.4.3 Water Levels and Structure Levels

	Pacific	Atlantic
T.Gate (b)	+3.6 or -3.4 M	+0.5 or -0.3 M
T.Gate (c)	+1.1 or -0.3 M	+0.5 or -0.3 M
Structure	+6.3 M	+4.2 M

4.4.4 Structures

Tidal gate structures include a gate recess abutments and basements with rails. The tidal gate has two rolling triangular type gates with one for emergencies. Maintenance and operation yards are also provided in both sides of the canal.

Abutments, gate recess walls and basements are made of concrete. Detailed structures are shown in DWG. No.9. The construction works of these facilities would be conducted in dry conditions, so there are no special problems. There would be some difficulties in maintenance works on the rail tracks due to siltation which would disturb smooth operation of the gate. Therefore specially designed cleaning equipment using a pump dredging system would be necessary.

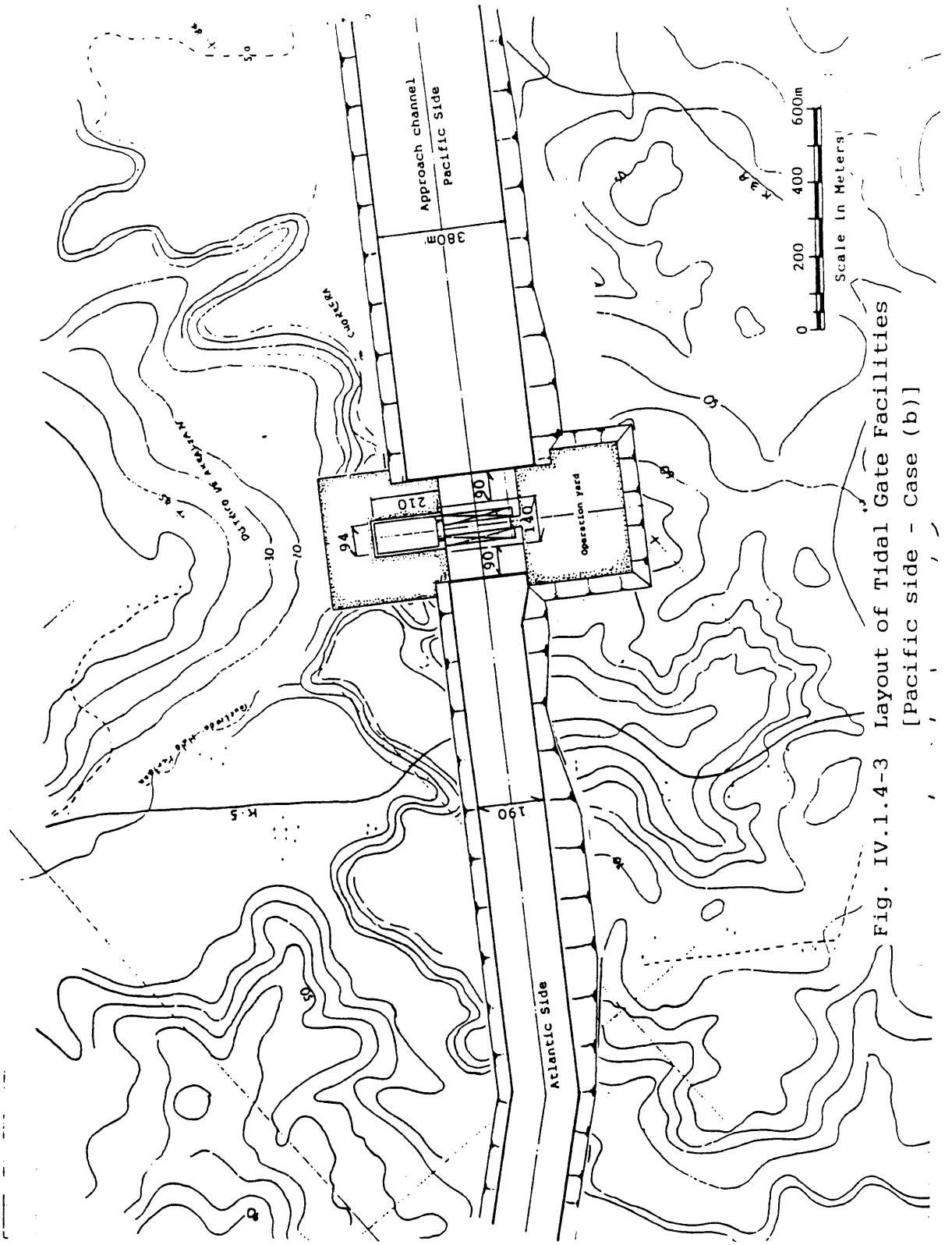


Fig. IV.1.4-3 Layout of Tidal Gate Facilities
[Pacific side - Case (b)]

4.4.5 Freshwater Barrier System

The freshwater barrier system proposed here to solve the problem of seawater movement between the two oceans intends the collection of rain water, mainly from the watershed at the west side of the canal, and pouring into the canal or tidal lock chambers as much freshwater as possible for form a freshwater barrier to restrict the movement of seawater. However, it is questionable whether or not the movement of seawater between the two oceans will be successfully prevented by the freshwater barrier system alone.

Only the possible volume of water to be used by the freshwater barrier system and the water collection method are examined in the Report. In other words, no detailed analysis of the possible effects of the proposed freshwater barrier system has been conducted. The main analysis item is how much freshwater is available in addition to the lockage water for the existing canal. In short, the amount of water available as the freshwater barrier to be stored at the reservoir (E) is approximately 1,200 million m^3/year. In the case of Rio Caimito and others, the water is directly injected to the canal instead of being stored by a reservoir.

4.4.6 Freshwater Supply System

Freshwater to act as a barrier can be injected either directly into the tidal lock chamber or between the Pacific side tidal gate and Atlantic side tidal gate.

1) Direct Discharge to Tidal Lock Chamber

No details and only the concept of this option are examined in the Report due to the following reasons.

- A huge volume of water must be injected into the lock chamber in a very short period of time. It means an elevated reservoir with some one million m^3 capacity is necessary adjacent to the tidal locks and water supply pipes are needed

connecting between the elevated reservoir and the tidal locks.

- The involvement of three lock chambers makes the system very complicated.

- The positive effects of a freshwater barrier system have not been clearly demonstrated.

2) Injection Between Tidal Gates

In this case, water is injected into the canal consecutively via reservoir (E) or the intake of dams W-3-D, W-4-D, W-6-D and W-7-D described later in IV.1.8 Diversion Scheme. In the case of other rivers, the water naturally flows into the canal.

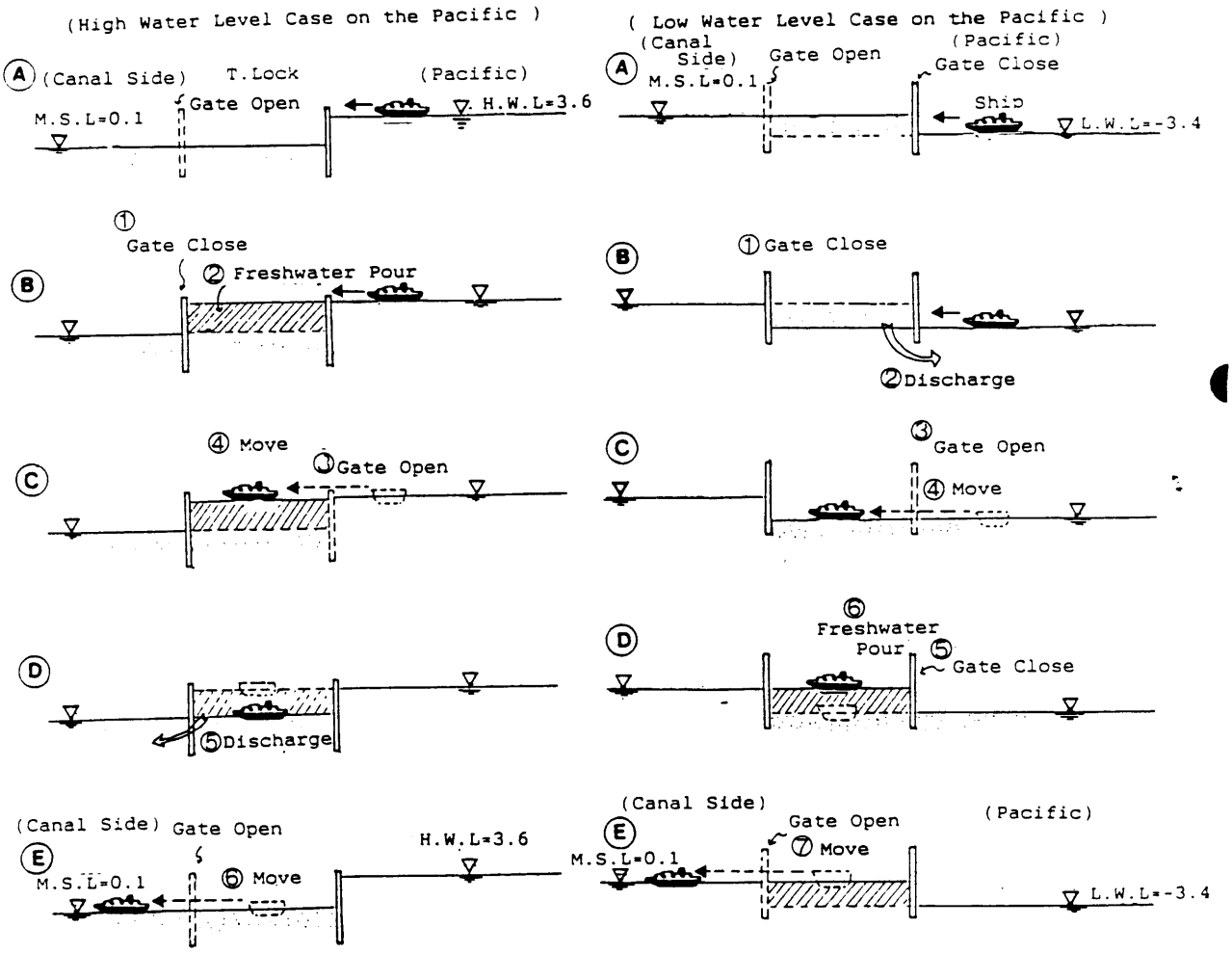
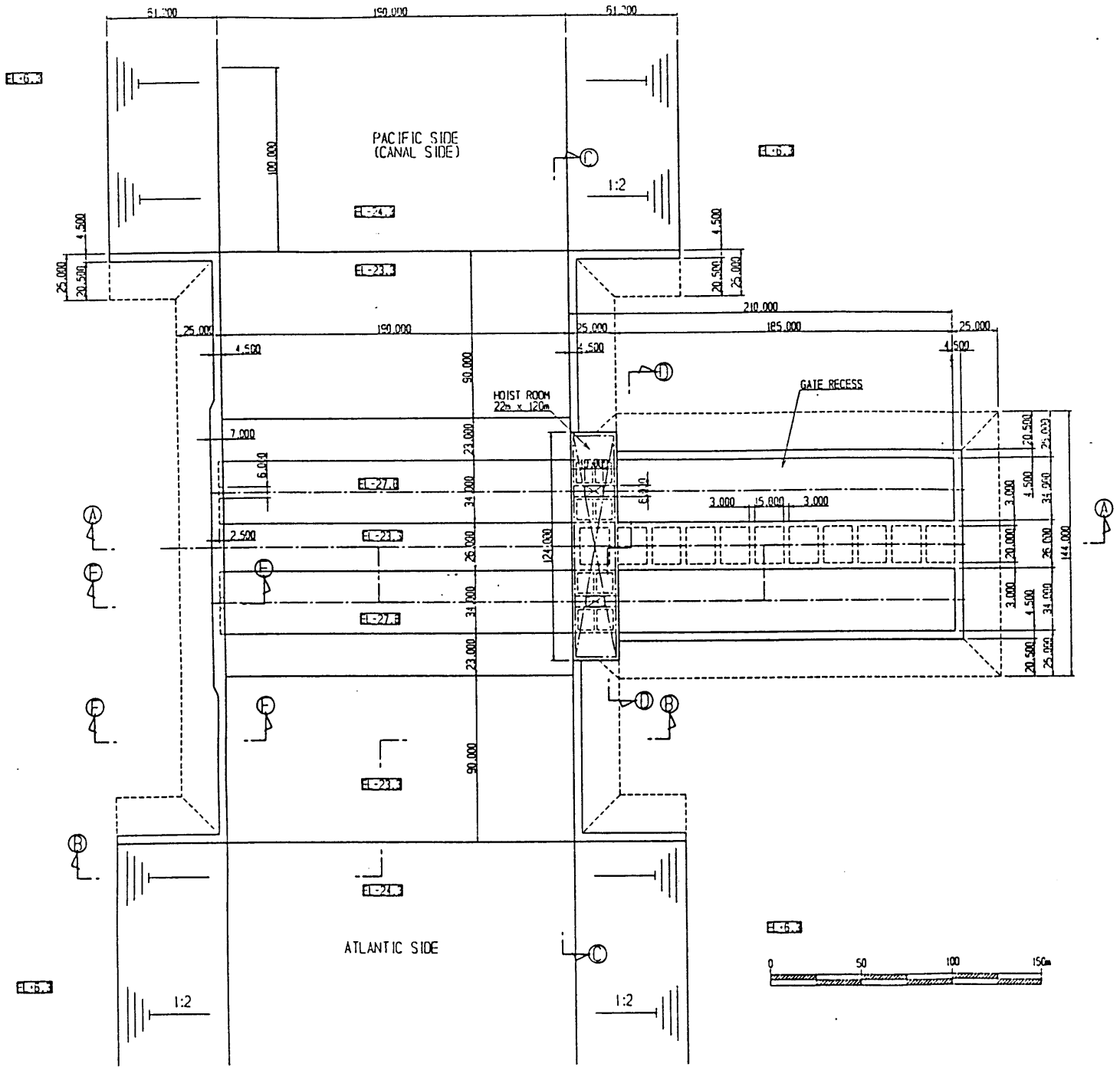


Fig. IV.1.4-4 Freshwater & Lock Gate Operation

Fig. IV.1.4-4 illustrates the procedures for lock gate operations, freshwater pouring, lock chamber water discharging and ship transits when Pacific tidal levels are high or low.

List of Drawings

DWG No. 7	General Dimension Tidal Lock (250,000 DWT)
DWG No. 8	General Recess & Chamber Wall Tidal Lock for Case (c) (250,000 DWT)
DWG No. 9	General Dimention Tidal Gate for Case (b) (250,000 DWT)



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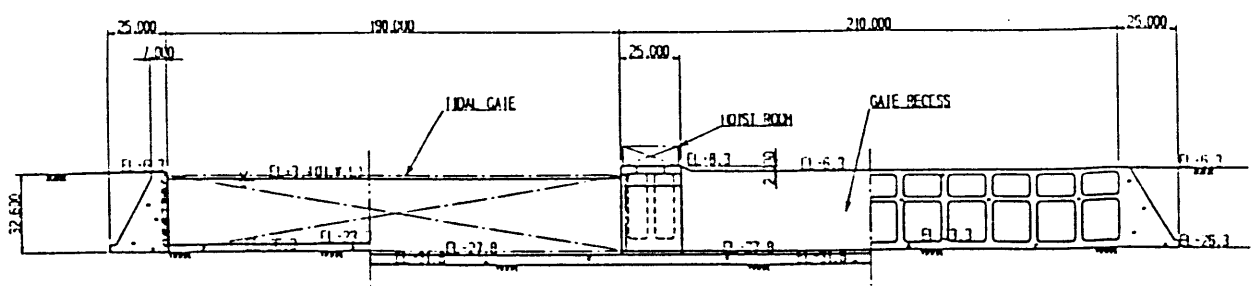

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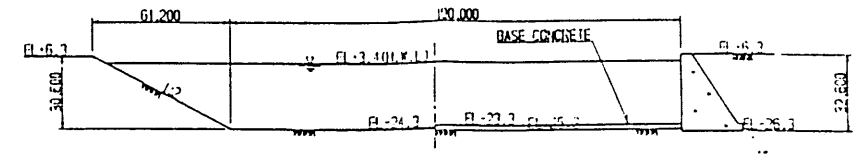

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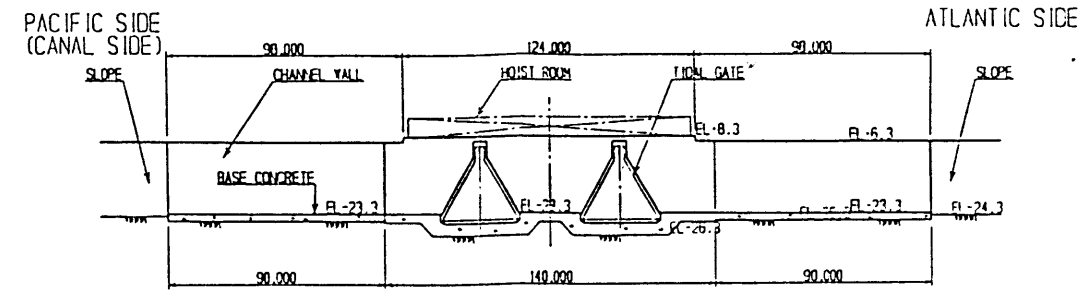

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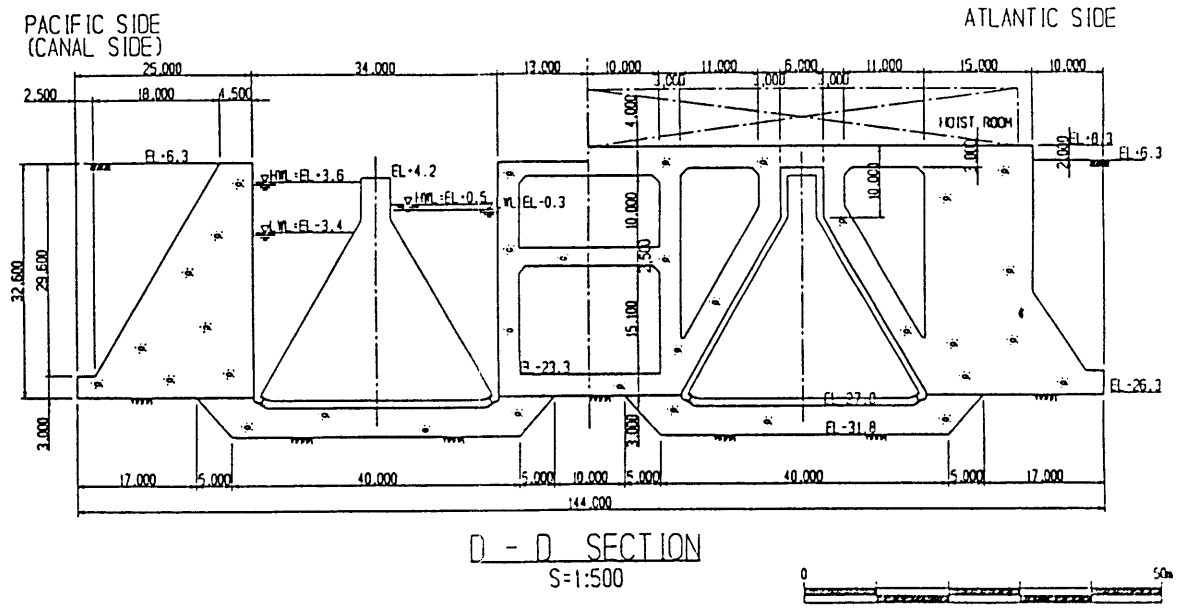

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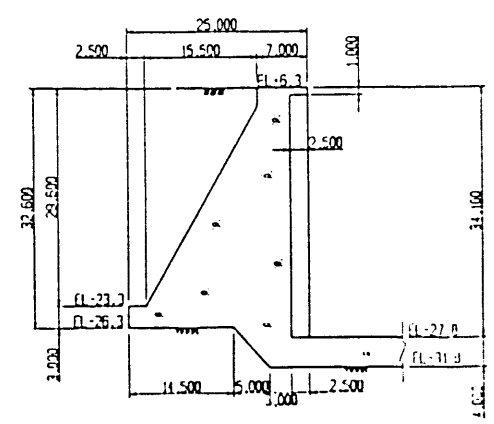

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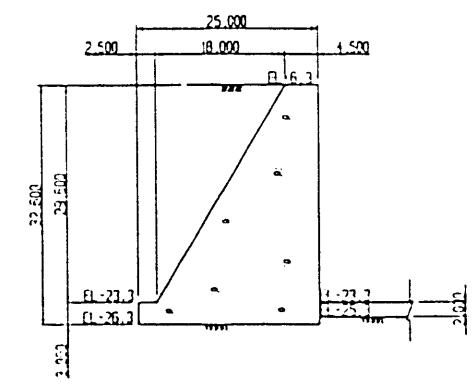

F - F SECTION
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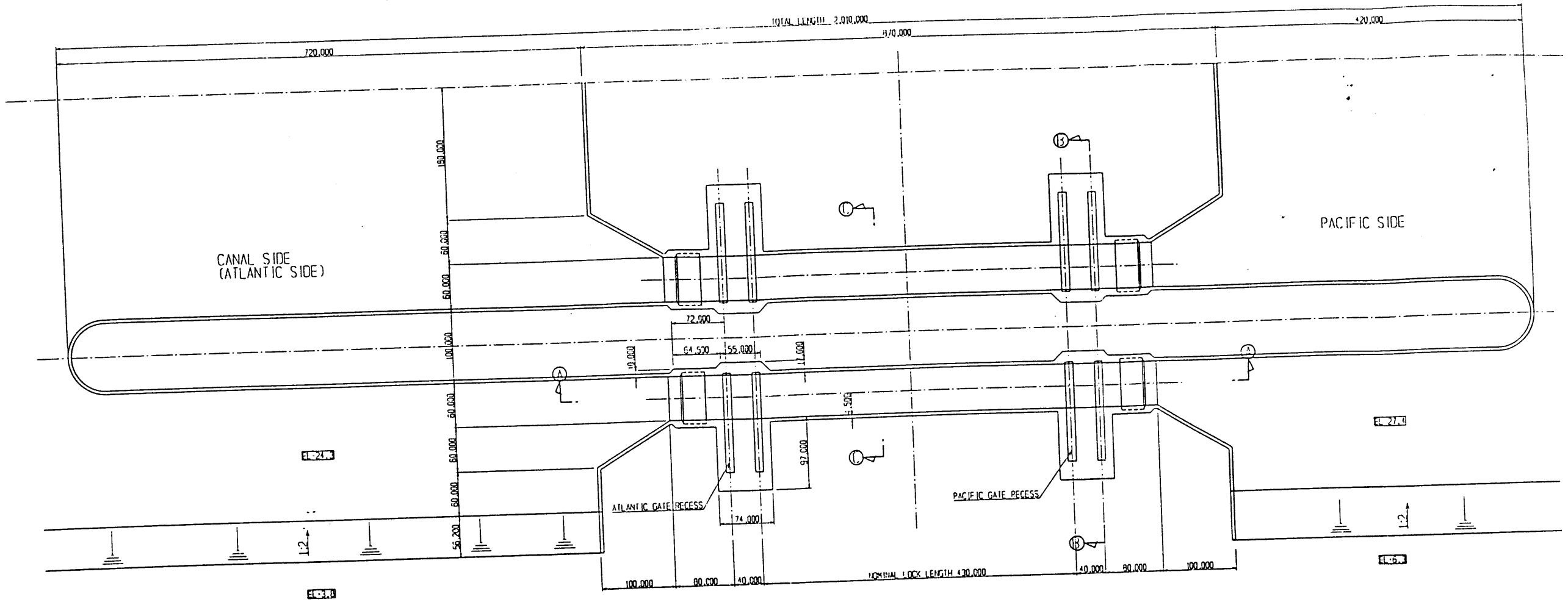
IV.1.4-14

TIDAL GATE FOR CASE B
(250,000 DWT)

GENERAL DIMENSION

-DWG.No.9-



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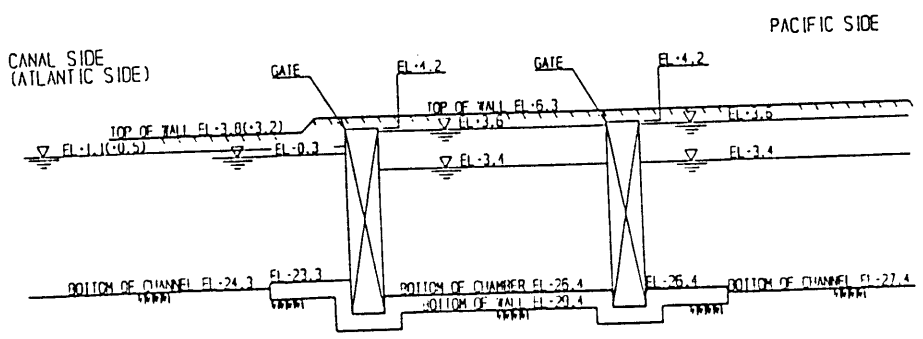
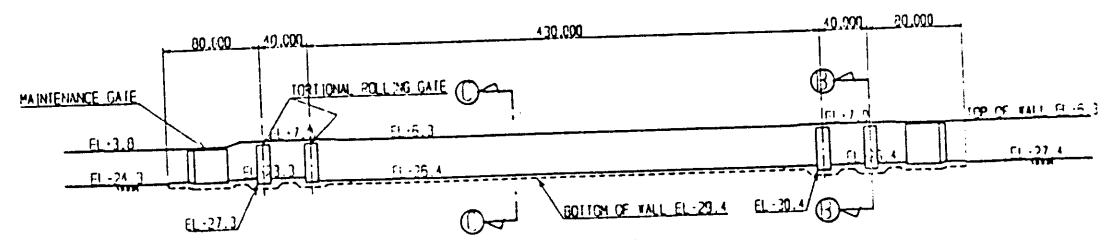


ELEVATION ( ):FOR CASE A



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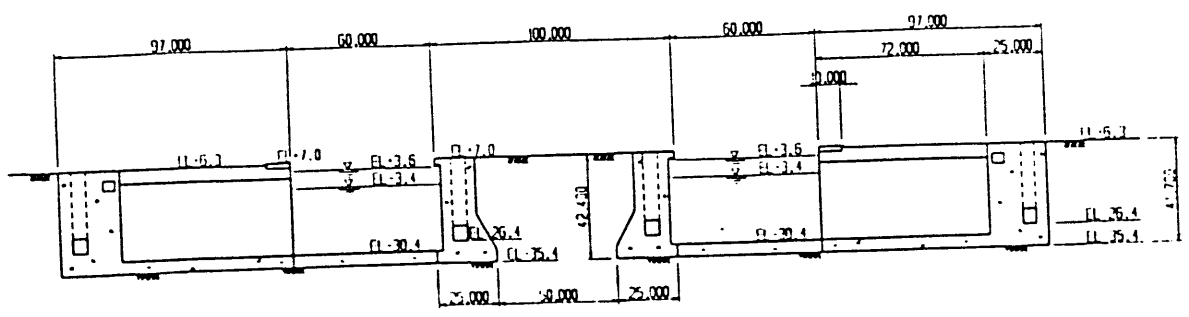

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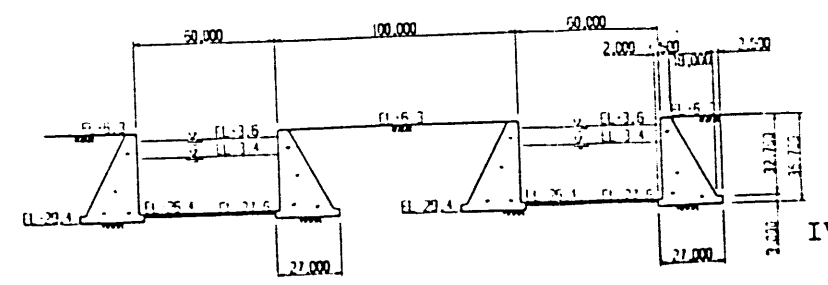

C - C SECTION
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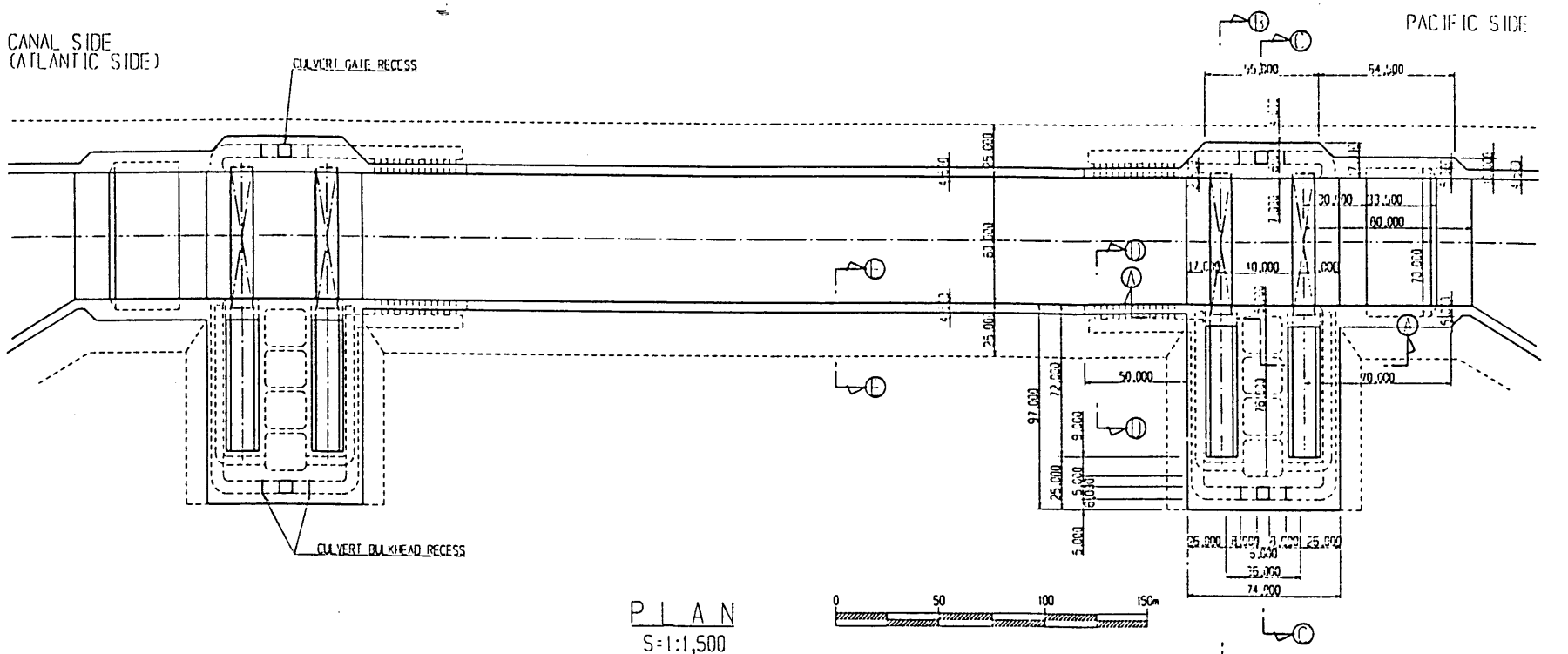
IV.1.4-15

TIDAL LOCK (250.000)
GENERAL DRAWING
-DWG.No.7-



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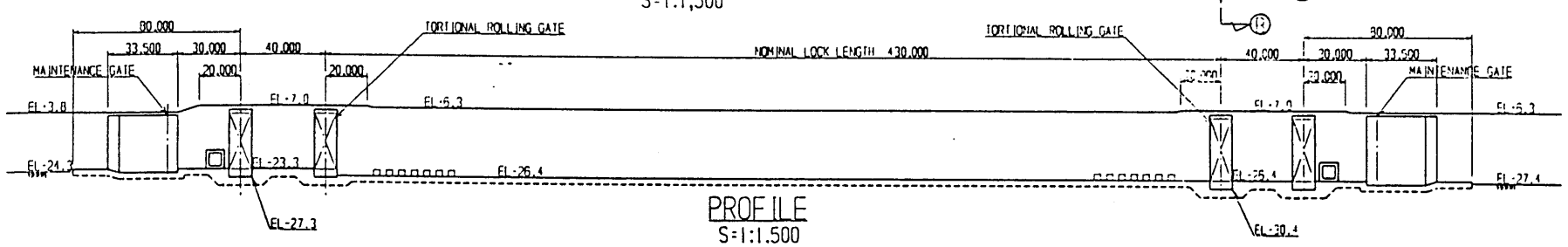

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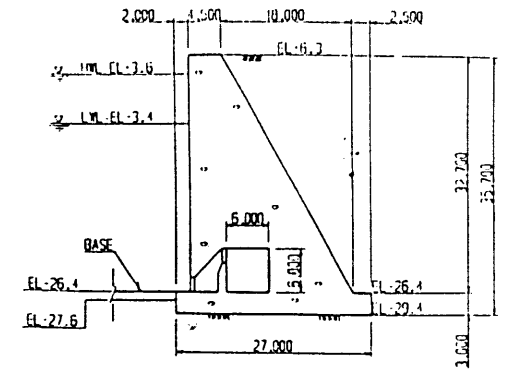

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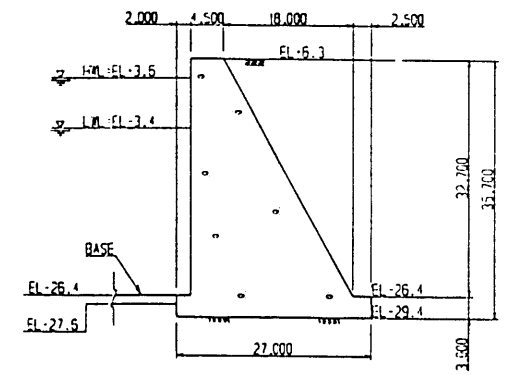

E - E SECTION
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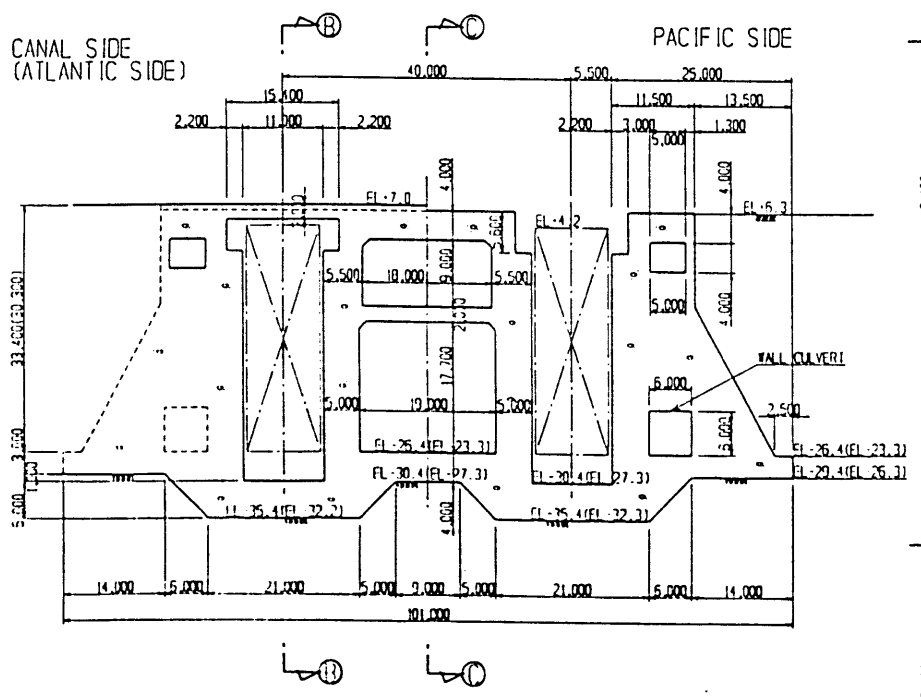

A - A SECTION (PACIFIC SIDE GATE)
( ) : FOR CANAL SIDE GATE
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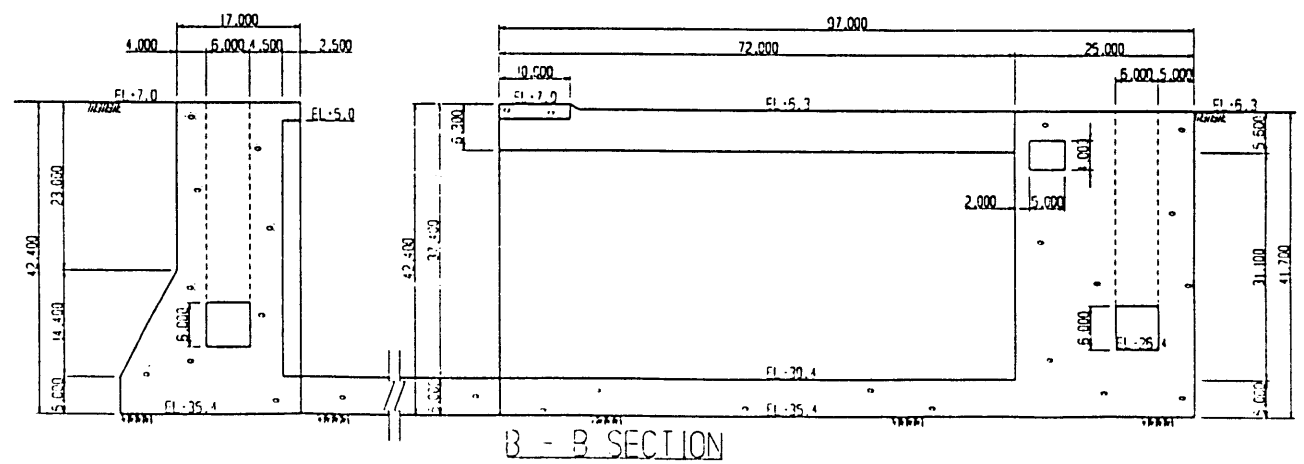

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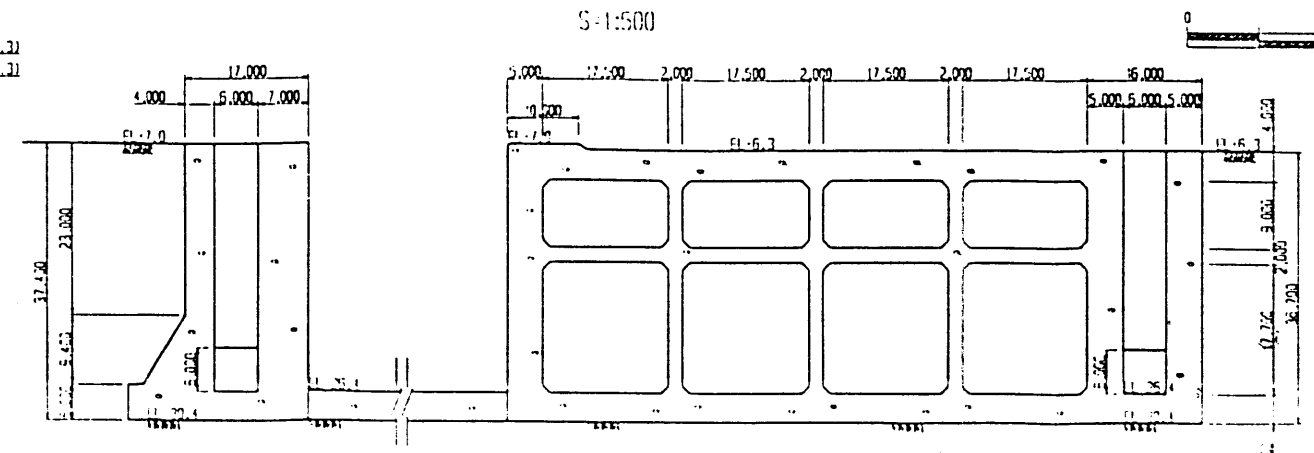

SECTION
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IV.1.4-16

TIDAL LOCK FOR CASE C
(250,000 DWT)

GATE RECESS & CHAMBER

-DWG.No.8-

IV.1 CHAPTER 5 - TIDAL LOCK GATES AND TIDAL GATES (MECHANICAL)

5.1 Introduction

Two kinds of structure, tidal locks and tidal gates, which intend to restrict tidal currents as well as help to create a fresh water barrier within the Route 10 Sea Level Canal alternative are differently combined in the three study cases established in the TOR (Terms of Reference). The combination for each case is shown on Table IV.1.5-1.

Table IV.1.5-1 Combination of Tidal Lock and Tidal Gate (Sea Level Canal)

Study Case	Location	Tidal Lock	Tidal Gate
Case (a)	Atlantic Side		
	Pacific Side	Yes	
Case (b)	Atlantic Side		Yes
	Pacific Side		Yes
Case (c)	Atlantic Side		Yes
	Pacific Side	Yes	

Various gate leaves and their related facilities are provided in these structures. Major components included in the related facilities are gate frames, gate hoists, guidance locomotives, electric power and control equipments and emergency power plant. This chapter presents the results of the engineering and preliminary design for all the gate leaves and related facilities except for the locomotives which are given at next chapter.

In addition to the content in this chapter, study efforts were made on alternative proposals for the Tidal Lock and Tidal Gate and their results are presented in Appendix 3 to the Volume I of this report.

(1) Tug boat guided Tidal Lock

(2) Torsion type Tidal Gate

5.2 Tidal Lock Gates

5.2.1 Description of Gates in the Tidal Lock

A lock has two Operating Gates, four Culvert Gates, and two Emergency Gates to fulfill its lockage function. The Operating Gate which is located on the Pacific side in the lock is named the Sea Side Operating Gate and the other which is located on the canal side in the lock is named Canal Side Operating Gate. The two Operating Gates are not identical. The two Culvert Gates are installed in the culvert tunnel in each lock wall, one by each Operating Gate. The Emergency Gate is the same type as the Operating Gate, and installed as a pair.

The Operating Gates play a major role in tidal lock functions and open or close the lock chamber entrances according to ship transits. The Culvert Gate also plays a major role. It opens or closes culvert tunnels in the lock walls and controls water flow in the tunnels running into or out of lock chambers and, eventually, lift up or lower a ship in the chamber so that the water elevation in the lock reaches the same level as the water level in the canal. The Emergency Gate is a kind of guard gate. It is operated together with the Operating Gate, and will take over the role of the Operating Gate in the event of an emergency; for example, fractures or collapses of the Operating Gate due to ship collisions or when the Operating Gate is inoperable due to machinery failure. It also works in place of the Operating Gate during maintenance periods.

In addition to the gates described above, each lock has a maintenance gate seat in the vicinity of the lock ends on the canal side and Pacific side, and also has a pair of of culvert gate maintenance gate slots on the upstream

and downstream side of each Culvert Gate. These provisions enable the emptying of the lock or a Culvert Gate alone whenever it is necessary for lock maintenance work. For this purpose, the two Emergency Gates are removable and can be set at the Maintenance Gate seats and four sets of the Culvert Gate Maintenance Gates are provided for each lock.

5.2.2 General Information to All Lock Gates

This sub-section gives design criteria common to all kinds of gates required for tidal locks for the sea level canal alternative.

(1) General Hydraulic Condition

1) Sea Water Level

Sea water levels for a various gate design base are shown in Table IV.1.5-2. The elevations shown are based upon P.L.D. and in the metric system and conform to the water levels of design criteria as given in II.1-Chapter 1.6.

Table IV.1.5-2 Required Water Level

Location	Water Level	H.W.L.	L.W.L
Atlantic Side	+0.1(M.S.L.)	+0.5	-0.3
Pacific Side	+0.3(M.S.L.)	+3.6	-3.4

2) Freeboard

Freeboards adopted are as follows.

Table IV.1.5-3 Freeboard Allowances

Gate Name	Meter	Feet
Operating Gate	0.6	2*
Emergency Gate (Maintenance)	0.6	2*

Note:
1. * marked values correspond to those used in Deep Draft Lock Plan Study in IOCS memorandum JAX 103.

3) The tide range at the closed end of a stub canal (=a canal blocked at a certain distance from its opening to the sea so that waves coming from the sea can not go further, just like a stub in which the water coming up through its root can not go further) increases due to the resonance of the tide wave. Water elevations just in front of the tidal locks after considering this phenomena are shown on Table IV.1.5-4. These values were obtained through a modification[1] of the sea water levels given in preceding 1), using the calculation results of wave height amplifications in a stub canal of 24 miles in length, which was reported on page 8 in the IOCS Memorandum JAX 67. The shorter the canal length, the shorter the amplification will be, and vice versa.

Note 1. Modification Basis
The modification of the tidal level was made in such a way that the ratios of high tide increase and low tide decrease to the total tidal amplitude are constant between the computer analyzed case in the IOCS report and the present case.

Table IV.1.5-4 Water Elevation at Tidal Lock (P.L.D)

Pacific Side		Atlantic Side		Difference	
Max.	Min.	Max.	Min.	P(A	A(P
4.0	-3.8	0.5	-0.3	4.3	4.3

4) Water elevation between the Tidal Lock and the Tidal Gate

As defined under Case (c), the space between the Tidal Lock and the Tidal Gate is supposed to be a fresh water barrier. The water elevation in this zone is not directly controlled by ocean tides, but has to be maintained within a range fixed by operation of water-control structures and the navigation limits through the locks and the tidal gate structures. Table IV.1.5-5 shows proposed water elevation between the Tidal Lock and the Tidal Gate and should be reflected in the design.

Table IV.1.5-5 Water Elevations between Tidal Lock and Tidal Gate

Limit	Elevation (P.L.D)	Reference
Maximum	1.1	= Atlantic H.W.L + 0.6m
Minimum	-0.3	= Atlantic L.W.L

(2) Structural Material and Allowable Stress Level

a) Structural Materials

Structural materials of the usual carbon steel, or low alloy carbon steels having good weldabil-

ity, good notch ductility, and high resistance to brittle fracture are used. Steels that are classified in this category are presently widely available in mill markets. The strength range up to 100 Kg/mm^2 in fracture strength is applied in the design. Selection of the steels in various strength levels shall be done as followings.

1. Preference will be given to the higher strength steel only when it is advantageous for a facility's total cost including for material, fabrication, transportation, installation and operation and maintenance or when a canal study alternative can not be feasible without it. The cost study for selection of material specifications includes consideration of material sources and place of fabrication as discussed in II.2 Chapter 4.2 in this report.

2. The most preferable thickness from fabrication point of view is between 20 to 40 mm. In this sense, preference is given to thinner plates with higher tensile strength over thicker plates with lower tensile strength except when higher structural rigidity is required in preventing structures from excessive deformation or buckling.

3. Preference is given to quenched and tempered steels in the case of high tensile strength steel.

b) Allowable Stress Level based upon <u>Yield Strength</u>

The allowable stress levels applied are from the "Technical Standards for Gates and Penstocks", edited by the Hydraulic Gate and Penstock Association of Japan. Table IV.1.5-6 shows allowable values for tensile and compressive stresses for various strength grades. The values shown are only for examples and applicable for plates

Table IV.1.5-6 Allowable Stresses for Elastic Design

Strength Level	Yield P. Kg/mm^2	Fracture P. Kg/mm^2	Allowable Stress Kg/mm^2
SS400	22	41	11.0
SM400	22	41	11.0
SM490	30	50	15.0
SM570	43	58	20.4
H.T.70	60	70	26.0
H.T.80	70	80	29.1
H.T.100	90	97	34.6

In addition to the above, the following allowable stress alleviation was added for the Phase 2 study.

Table IV.1.5-7 Allowable Stress Alleviation

Applicable Case	Increased rate
1) When seismic load is added	150%
2) In case of emergency load	150%
3) Hydraulic Condition for maintenance	130%

c) Allowable Stress Level based upon <u>Fatigue Strength</u>

The life duration of the gates is assumed to be 80 years based upon the fact that the gates at the existing locks have worked since their inception.

The number of lockage operations per year for three tidal locks is 5100. This frequency conforms to the value given in II.1-Chapter 1.5.2. Eventually the number of operations of each gate in a tidal lock equals to 1700 per year.

Allowable stress levels are based upon the above conditions and are shown in Table IV.1.5-8. These values were derived from the latest edition (1989) of Fatigue Design Guide issued by the Japanese Society of Steel Construction(JSSC). The study works for this edition have included comparisons of stress levels with various technical standards including AASHTO, BS5400 and ECCS.

The values derived are based on the premise that periodic inspections for fatigue damage and estimation of the remaining life are conducted.

Table IV.1.5-8 Allowable Stress for Fatigue Design (Sea Level Lock)

Stress Status	Location	Allowable Stress
Tension	Mother Metal	47.5
	Finished Butt & Seam Joint	38.7
	Fillet Weld Joint In Load Direction	31.2
	Fillet Weld Joint In Normal Direction	25.0
Compression	Mother Metal	61.7
	Finished Butt & Seam Joint	50.4
	Fillet Weld Joint In Load Direction	40.6
	Fillet Weld Joint In Normal Direction	32.5

Note: 1. The allowable stress shown is in Kg/mm^2
2. Frequency of operations per year is 1,700.
3. Gate life duration is 80 years.

d) Allowable Stress Application for Each Gate
The allowable stress show in b) and c) above are applied to each gate in the way shown in Table IV.1.5-9.

Table IV.1.5-9 Allowable Stress Application

	Gate Type				
Failure Mode	Operating Gate	Culvert Gate	Emergency Gate	Maintenance Gate	Culvert M. Gate
Yielding	Yes	Yes	Yes	Yes	Yes
Fatigue	Yes	Yes	No	No	No

(4) Seismic Design of Gate Structure

Seismic designs is applied to the gate structures based on the following.

1. Design seismic coefficient is 0.10 which was given in II.1.- Chapter 3.
2. Gate classification for the seismic coefficient application levels are as follows.

Table IV.1.5-10 Seismic Coefficient Application

Gate Name	Application Rate in %
Lock Gate	50
Culvert Gate	50
Emergency Gate	50
Maintenance Gate	100
Culvert Maintenance Gate	100

The Emergency Gate was classified as 50 % although the probability of an earthquake during operation is deemed to be negligible because it will function as an Operating Gate during absence of the Operating Gate.

3. The following external forces to gate structures due to earthquakes are considered in the design. Fig. III.1.5-1 shows application of these schematically:
   1) Dynamic pressure increases in the water surrounding gate leaves.

   2) Inertia forces of gate leaves.

   3) Dynamic effect of water inside of gate leaves.

5.2.3 Operating Gate, Emergency Gate and Maintenance Gate

(1) Gate Type

Table IV.1.5-11 shows a comparison of the Operating Gate type whose sketch are shown on Fig.IV.1.5-1. The evaluation of gate types was made with respect to fundamental technical and economical elements relevant to the Operating Gate for the Tidal Lock. The elements selected are as shown below.

a) Functions
   The major functions to be satisfied are
   1. Height of clearance above water is 62 m.
   2. To support hydraulic loads in either direction.

b) Lock length
   Lock efficiency is one of fundamental elements.

c) Initial cost of gate itself

d) Cost of sand and silt removal
   High sand and silt contamination in canal water is predicted.

e) Maintenance costs other than d) above

f) Possibility to remove and reset gate leaves
This is a fundamental condition required for installation and maintenance of the gates.

g) Hoist load
This greatly affects operation costs

The gate type proposed is the Torsion Type Slide Gate which moves laterally on wheels mounted along the leaf bottoms. The leaf body is a box structure similar to the Operating Gate at Berendrecht in the port of Antwerp, but its torsional rigidity, instead of its bending rigidity, is the main strength element resisting hydraulic water pressures on the gate leaf. Fig. IV.1.5-2 shows the general arrangement of this gate.

Table IV.1.5-11 Comparison of Gate Types for Operating Gate for Tidal Lock

Movement	Direction	No	Structural Type	Function	Initial Cost	Lock Length	Cost of Sand & Silt Removal	Maintenance Cost	Removal & Reset	Hoist Load
Rotation	Vertical	1	Radial(Double)	○	△	△	△	×	×	○
		2	Miter	×						
	Horizontal	3	Flap(Torsional)	○	◎	△	○	△	○	△
		4	Flap(Bending)	○	△	△	○	○	○	△
		5	Radial(Sink)	○	×	○	○	◎	×	○
Linear	Vertical	6	Roller(Drop)	○	△	○	△	△	△	○
	Hoirzontal	7	Triangle	○	○	△	○	△	○	○
		8	Torsional	○	◎	○	◎	○	○	○
		9	Bending Type	○	○	○	○	○	○	○

NOTE 1.Number in the table corresponds to the number in Fig. IV.1.5.-1.

2.EVALUATION MARKS

×;NOT ACCEPTABLE, △;JUST AT ACCEPTABLE LEVEL, ○ACCEPTABLE WITHOUT ANY CONDITIONS,

◎;STRONGLY RECOMENDABLE

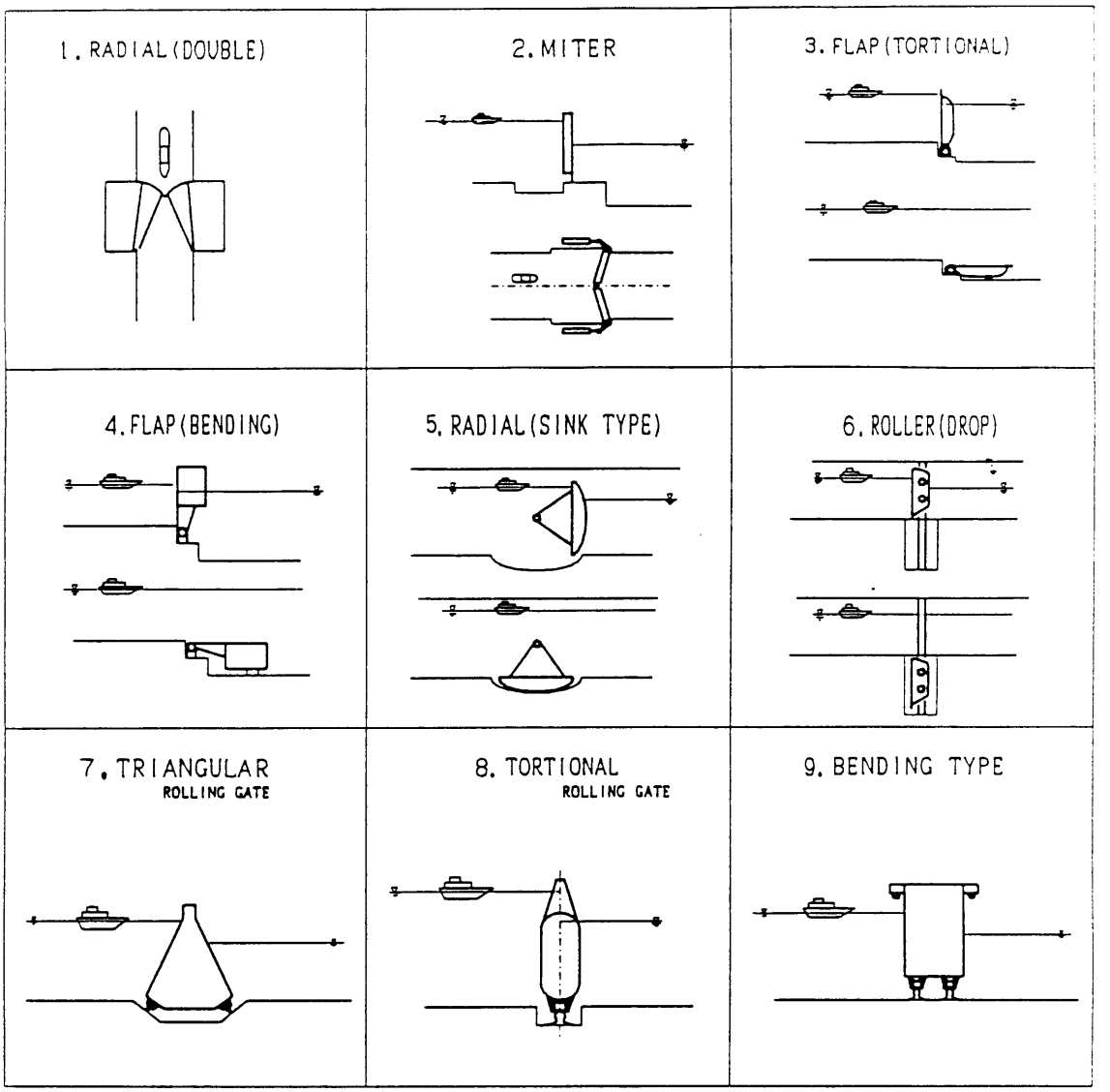


Fig. IV.1.5-1 Various Gate Types for Operating Gate in Tidal Lock

(2) Weight Estimation Procedure

Gate Leaf; The weight of the gate leaf was estimated using, as a model, the torsion type tidal gate which is the alternative proposal to the Tidal Gate and whose weight was calculated on the drawing base. Following technical items were considered in the weight conversion from the model to the prototype.

(a) Gate widths
(b) Gate heights
(c) The amount of torsional moment in leaves
(d) The minimum thickness rule
(e) The maximum thickness rule

Gate Frames and Drive Mechanisms; The Gate frames comprise various steel frames embedded in concrete structures and support the gate leaves and hydraulic load on them, provide seal surface on the concrete side and guide gate leaves during their opening and closure operations. The drive mechanisms are machinery to hoist gate leaves and sometimes referred to as "gate hoists" in this report. Weights were estimated in proportion to their gate leaf weights using the relative ratios given in Table IV.1.5-12.

Table IV.1.5-12 Factors for Weight Estimation of Gates in Tidal Lock

Part Name	Operating Gate	Emergency Gate	Maintenance Gate	Culvert Gate
Gate Frame	0.3	0.3	0.15	0.8
Drive Mechanism	0.1	0.1	0.09	0.6

(3) Description of Gates

The height, width and weights of the Operating Gate and the Emergency Gate, are given in the following table. The width is nominal and equal to the lock

chamber width. The sea side Operating Gate could be used as a road bridge for vehicular traffic crossing the lock chamber. The additional structural framing required for this purpose is approximately 130 ton which is included in the weights on the table and in the cost estimation. No spare gate is required for the Operating Gate.

Fig. IV.1.5-2 shows the general arrangement of the Operating Gate. The whole gate leaf is a box section which resists a torsional moment whose magnitude is equal to the couple of a hydraulic force and roller reaction forces on the gate leaf. The leaf is supported at both ends by a couple of forces, one at the top on the downstream side and another at the bottom on the upstream side of the leaf. The hull (=skin plate) which is subject to hydraulic water pressure is supported by vertical auxiliary girders, which are supported by horizontal girders, which are finally supported by vertical diaphragms arranged at every 10 meters throughout the length of the gate leaf. Each diaphragm is supported by two rollers having roundly concaved tread surfaces which will run on a round steel rail. Eventually, most of the hydraulic force on the gate leaf will be supported by the rollers arranged along the bottom of the gate leaf and only torsional moment will be carried to the leaf ends. The inside of the leaf is separated into several compartments some of which are assigned as buoyant tanks used when the leaf is removed for maintenance work. The buoyant tank ~~has~~ a longitudinal bulkhead but will have no bottom.

The Emergency Gate can be used as a maintenance gate after it can be removed to the maintenance gate seats. Pump units to pour or draw water into or out of the buoyancy compartments in the gate leaf for removal or reseting for this purpose are installed in the leaf. This pump unit is used also to dewater from the lock chamber for maintenance work during dry conditions. There will be no other differences between the Emergency Gate and the Operating Gate.

Table IV.1.5-13 Dimensions and Weights of
Operating Gate, Emergency Gate and Maintenance Gate

Gate Name	Side	Height in Meter	Width in Meter	Weight in Ton		
				Leaf G.	Frame G.	Hoist
Operating Gate	Canal	27.5	60	1452	436	145
	Sea	30.6	60	1775	494	165
Emergency Gate	Canal	27.5	60	3141	436	145
	Sea	30.6	60	4275	494	165
Maintenance Gate	Canal	24.4	60		471	385
	Sea	30.6	60		641	385

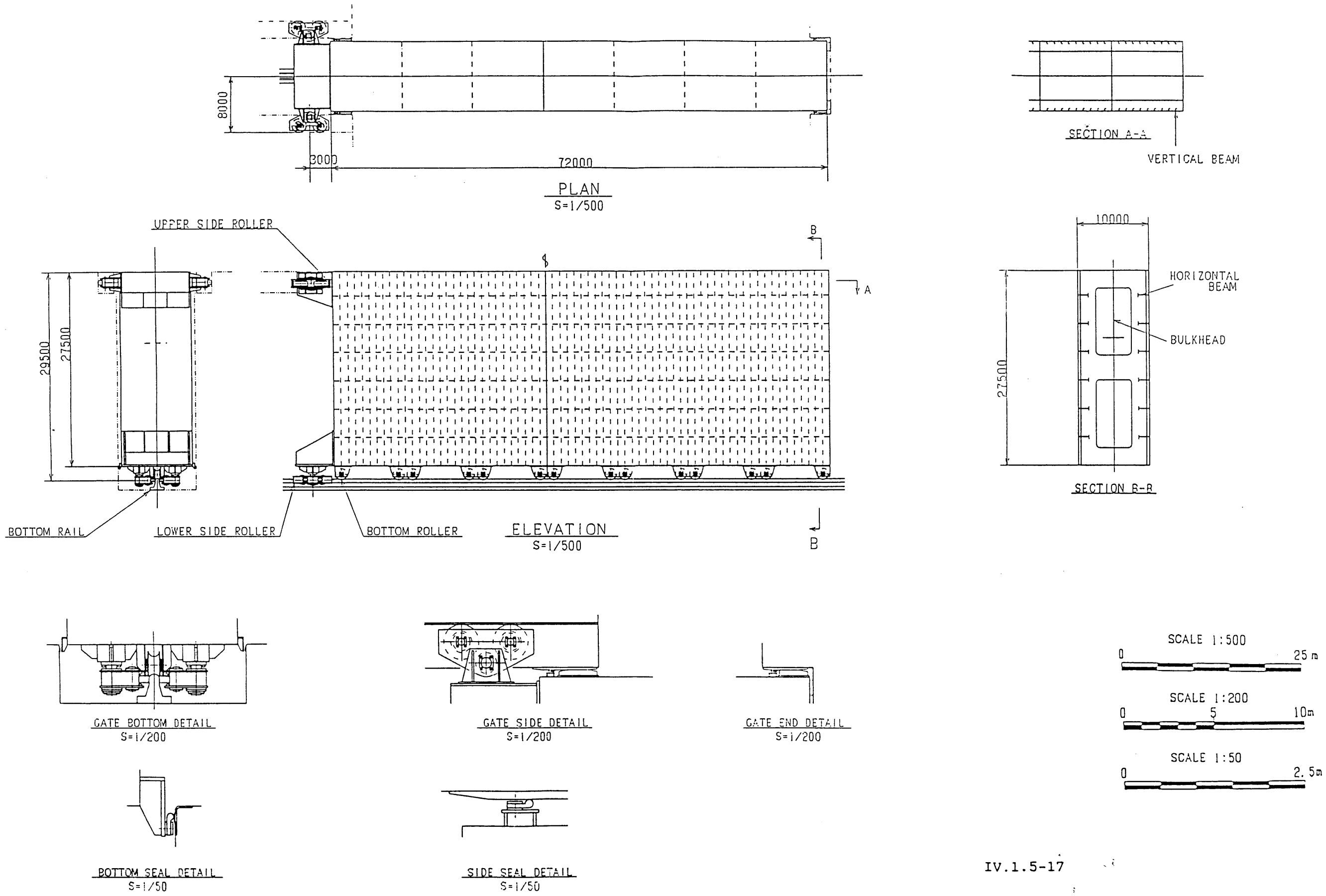


Fig.IV.1.5-2 General Arrangement of Operating Gate
Sea Level Tidal Lock 250000 DWT Canal Option

(4) Design of Gates

Design heads in meters for the canal side and the sea side of each gate are given in Table IV.1.5-14. Concerning Operational Condition, the canal side heads correspond to the minimum water elevations on the Atlantic side and the sea side heads correspond to the maximum water elevations on the Pacific ocean. Concerning Maintenance Conditions, the canal side head of the canal side gate corresponds to the maximum water elevations on the Atlantic ocean, and the sea side head of the sea side gate is the maximum water elevation of the Pacific ocean, and the chamber side is at dry condition. As long as the allowable stress for yielding is concerned, 100 % of it is allowed for the Operating Condition, and 130 % for the Maintenance Condition. The Emergency Gate is also subject to the design heads for the Maintenance Gate.

Table IV.1.5-14 Design Heads in Meter of Operating Gate, Emergency Gate and Maintenance Gate

		Operational Cond.		Maintenance Cond.	
Gate Name	Side	Canal Side	Sea Side	Canal Side	Sea Side
Operating Gate	Canal	23.0	27.3		
	Sea	26.1	30.4		
Emergency Gate	Canal	23.0	27.3		
	Sea	26.1	30.4		
Maintenance Gate	Canal			23.8	0.0
	Sea			0.0	30.4

(5) Installation and Removal of Gates

The Operating Gate and the Emergency Gate for the Tidal Lock fabricated at shop including all accessories are towed to Panama on a barge. They are set in place using a floating crane according to the steps shown in Fig.III.1.5-4. It is anticipated that gate leaves fabricated and installed using these procedures will have bigger deviations from their drawing dimensions and from their relative drawing positions to the gate frames or the hoist mechanisms installed in concrete structures before hand than gates installed using a conventional block erection method with which dimensional adjustment of gate leaves is possible during block erection either at shop or at site. Hence, gate seal mechanisms, roller systems, support system etc. which interface on the leaf side to the equipment on concrete structures under water must be able to adapt to bigger dimensional deviations in gate leaves and embedded metals than ordinary gate designs. The proposed installation method is hereby named "Just-Set-In-Place Installation" versus "the conventional block erection installation ".

The Just-Set-In-Place Installation method also enables the gate leaves under water to be removed or reset for maintenance. Thus, elimination of overhaul outage of locks after starting which was one of the main study themes of the Third Lock Plan is realized.

Just-Set-In-Place Installation is an important idea of this conceptual design. However, all parts under water should also be adjustable in drained conditions.

The gate leaf is shipped in two blocks to enable the Just-Set-In-Place installation. Both blocks are joined to each other after they are set on their rail.

(6) Machinery for Operating Gate and Emergency Gate

The machinery type adopted for the Operating Gate and for the Emergency Gate for the tidal lock is a looped wire cable and hydraulic motor type as used in guiding small vessels at a tidal lock. A looped wire cable in a pulley system is driven by hydraulic oil motors with the assistance of a small hydraulic cylinder to give proper tension in the continuous cable. At least four cables are used to pull each leaf. The machinery is capable of opening or closing the lock in 5 minutes. Each gate is equipped with two hydraulic power units each of which is powered by two induction motors of 120 KW for the canal side Operating Gate, 140 KW for the sea side Operating Gate, 250 KW for the canal side Emergency Gate, and 340 KW for the sea side Emergency Gate. Because of time limitations, the possibility of cost savings with a hydraulic pumping station for each lock with the related controls and distribution system were not studied.

(7) Sand and Silt Flushing Equipment

Since contamination by sand and silt is predicted in water around the tidal locks, the gates must be provided with equipment to flush sediment on or in the vicinity of the rail on the canal floor. A water jet flushing system as is working in similar facilities or a combination of a flushing system with a mechanically sweeping system or any other type would be applicable.

5.2.4 Culvert Gate

(1) Culvert Gate Leaf

The gate type is the reversed Radial Gate as was recommended for the High Rise Lock Canal Alternative. All gates in a lock have the same design for convenience of fabrication and maintenance. Height, width, radius of the leaf arm, weights and design

heads are given on Table IV.1.5-15. The height and width were determined so that the same filling time is scheduled as in the tidal locks in Belgium. Data used in the calculation was from the Berendrecht lock at the port of Antwerp for 150000 DWT ships, where the filling time is fifteen minutes, including three minutes for valve time. The weights for each part were estimated according to the leaf unit weights curve in Fig. 4.2.3 of the Phase 1 study Final Report and relative weight ratio coefficients shown on Table IV.1.5-12. Fig. III.1.5-5 in this report is a copy of Phase 1 Fig. 4.2.3 with the Phase 2 unit weights plotted on it. The design head at the canal side corresponds to the lowest water elevation at the Atlantic ocean and the sea side corresponds to the Highest water elevation of the Pacific ocean. The leaves are to be all welded construction and tension arms are connected to the trunnions installed in concrete. They are operated by machinery of the crank and strut type powered by hydraulic cylinders.

Table IV.1.5-15 Dimensions, Weights and Design Head of Culvert Gate in Tidal Lock

Dimension in Meter			Weight in Ton			Design Head in M	
Height	Width	Radius	Leaf	G. Frame	G. Hoist	Canal Side	Sea Side
6.0	6.0	9.0	48	38	29	26.1	30.4

(2) Culvert Gate Machinery

The preliminary design adopted for the Culvert Gate machinery generally follows the results of the study of the Deep Draft Lock Plan reported in IOCS Memorandum JAX-103. The machinery is the crank and strut type driven by a hydraulic cylinder and operating time is around three minutes. Each machine is equipped with a hydraulic pump unit powered by two

induction motors of 37.5 KW. The following cost improvements proposed in the report mentioned above should be studied at the beginning of the detail design work.

1) Two smaller gates in place of one gate for a culvert tunnel width.

2) A longer operation time than originally adopted.

3) A central hydraulic pumping station system at each lock in conjunction with a hydraulic power source for the Operating Gate and Emergency Gate machineries.

Details of these proposals are given on page 12 and 13 of the report for the Deep Draft Lock Plan.

5.2.5 Culvert Maintenance Gate

(1) Gate Design

The Culvert Bulkhead Gate type is a stop log made of steel. The gate leaf consists of two blocks, each having a box shape section and bearing plates. Fig. III.1.5-2 illustrates the Culvert Maintenance Gate. Height, width, weight and design head are given on Table IV.1.5-16. The design head corresponds to the highest water elevation on the Pacific Ocean while the chamber side is in dry condition.

(2) Number of Gate Sets

The number of gate leaves provided are four sets which are adequate enough to dry up the spaces for the two Culvert Gates.

(3) Gate Installation

The gate leaf blocks stored in a separate location will be transported by vehicle and inserted into the gate slot with the aid of a movable crane.

Table IV.1.5-16 Dimensions, Weights and Design Head of Culvert Maintenance Gate

Height in Meter	Width in Meter	Weight in Ton		Design Head in Meter
		Leaf	G. Frame	
6.0	6.0	54	11	30.4

5.2.6 Corrosion Protection System

Corrosion protection systems, including paint coating and cathodic protection anodes, are required for each gate, gate frame and gate hoist according to materials used and working or storage condition and circumstances. The system should also incorporate PCC maintenance experience and findings. It is not practical for the complete corrosion system to be established for each gate at this stage of preliminary design. The following table provides the kinds of painting to be applied, and the status of cathodic protection anode provision on each gate. The present cost estimation is deemed to cover the cost level of including these types of corrosion protection procedures.

Table IV.1.5-17 Recommendable Paint Coating and Cathodic Protection Application

Location	Coal Tar Enamel (Hot)	Special In-Organic Z.P. + Sealer	Coal Tar Epoxy	Polyamide Epoxy/ Vinyl	Cathodic Protect. Anodes
Operating Gate					
Submerged Area	Yes				Yes
Exposed Area		Yes			
Culvert Gate					
Gate Leaf	Yes				Yes
Gate Frame	Yes				Yes
Gate Hoist				Yes	
Emergency Gate					
Submerged Areas	Yes				Yes
Exposed Area		Yes			
Culvert M. G.					
Gate Leaf			Yes		
Gate Frame	Yes				Yes

5.2.7 Electric Power Control

As a guide for conceptual design and estimating purposes, the Deep Draft Lock Plan was employed.

(1) Distribution System

The system consists of a radial type, double circuit, primary system encircling the lock complex, with a primary distribution voltage of 13.8 KV (12 KV nominal). Secondary distribution for power is at 3 phase 6000(nominal) volt and 480 volt (460 volt nominal) with lighting and small auxiliary power loads supplied at 3 phase 120/208 volt. Two transformer substations and associated switch gear will be provided on each side of the lock. Substations will be located near each Operating Gate in the electrical equipment room at the operating gallery

level below the local control stations. It is assumed for estimation purposes that commercial power is supplied to a point by the lock sites at 13.8 KV.

(2) Wire System

A cable tray system in an electrical gallery in each lock wall and in lock crossover tunnels provides the main raceway system for electric cables. Exposed conduits are provided in each local control station and its associated electrical equipment room below at the operating gallery level. These areas will have temperature and humidity control equipment. Embedded conduits will extend from the electrical equipment rooms to the lock operating machinery in the vicinity of the Operating Gates and from galleries to utilization equipment in other locations. All electrical equipment for hoists and simple control boards set by the equipment for maintenance works is included in the estimate for mechanical equipment.

(3) Emergency Power Plant

The maximum plant load includes the power required by the lock guidance locomotives, the lock lighting system, including miscellaneous auxiliaries, and the lock operating equipment. The approximate power demands is shown on the following table. A gas turbine power plant is capable of supplying the amount of the total power demand for three tidal locks.

Table IV.1.5-18 Approximate Electric Power Demands in KW for Three Tidal Locks

Locomotive	Lighting	Gate Operation	Total Demand
72,000	1,600	10,400	84,000

(4) Lockage Guidance Equipment Power Supply

The guidance equipment motive power is provided by eight A.C. operating guidance locomotives per lock. Electrification rails and all electrical equipment for the locomotives are included in the estimate for mechanical equipment.

(5) Electrical Equipment for Gate Hoists and Locomotives

Weights and costs of electrical equipments for gate hoists and locomotives are included in gate hoists and locomotives which are classified as Mechanical Equipment in the Bill of Quantities at IV.3-Chapter 2.

(6) Miscellaneous Electrical Equipment

Cost for miscellaneous electrical equipment for electrical power and control were derived by adjusting the allowance in the Deep Draft Lock Plan estimate including this item, in relation to the total cost for all other electrical power control equipments including for gate hoists and locomotives.

5.2.8 Miscellaneous Structures and System

As a guide for conceptual design and estimating purposes, the Deep Draft Lock Plan was employed.

(1) Lock Control System

A local control station is provided in the vicinity of each Operating Gate leaf on top of the lock wall and landward of the guidance system tracks. Operation of the Operating Gates, the Emergency Gates and the Culvert Gates is controlled from these locations. Controls are supplemented by indication circuits of the selsyn type for continuous indication of the Culvert Gate position and lock water levels. Pilot lights and limit switches are used for miscellaneous control and position indication, and

closed circuit TV monitoring equipment is provided for each Operating Gate, the Emergency Gate, and for the canal and sea side approach areas. The down stream lock entrance signal is controlled from the local control station associated with the sea side Operating Gate and the upstream entrance signal will be controlled from the control station associated with the canal side Operating Gate. Costs for the items included here, as well as the other items included in the item "Others" in the Cost Content of Gate Leaves and Related Facilities in IV.3-Chapter 2.1, were derived by adjusting the allowances in the Deep Draft Lock Plan estimate for these items, in relation to the gate leaf costs.

(2) Shops-Service Buildings-Gate Dry Dock

New facilities have not been included as it is assumed the existing Panama facilities could be used to provide such services.

(3) Ventilation System

A ventilation system is included to provide forced fresh air ventilation to the crossovers, operating galleries, and equipment rooms. Costs were derived by adjusting the allowances in the Deep Draft Lock Plan estimate for this item (=other mechanical components), in relation to the gate leaf costs.

(4) Pumping and Piping

Pumping and piping for raw water, potable water, dewatering locks and culverts, sump pumping, fire protection, and sewage disposal are included under this heading. Costs were derived by adjusting the allowances in the Deep Draft Lock Plan for this item(=other mechanical components), in relation to the gate leaf costs.

(5) Compressed Air System

Compressed air is to be provided for maintaining the buoyancy chambers of the Operating Gates and powering pneumatic equipment. Costs were derived by adjusting the allowances in the Deep Draft Lock Plan estimate for this item (=other mechanical components), in relation to the gate leaf costs.

5.3 Tidal Gate

5.3.1 Description of Gates in the Tidal Regulating Structure

Tidal Gates provided in the Tidal Regulating Structure consist of one Operating Gate and one Emergency Gate. Both gates are identical and are installed in parallel.

The Operating Gate is not opened during the tide height in the ocean stay below around the Mean Sea Level and shuts down the tidal flow between the canal and both oceans. The Emergency Gate swiftly closes the canal in the event of an emergency; for example, fractures or collapses of the Operating Gate due to ship collisions or when the Operating Gate is inoperative due to machinery failures. It also works in place of the Operating Gate during maintenance.

In addition to the gates described above, the Tidal Regulating Structures provides a set of Maintenance Equipment with which the rail and the seal seat embedded in the canal floor can be maintained in a dry condition.

5.3.2 General Hydraulic Condition

(1) Sea Water Level

Sea water levels for a gate design base are shown in Table IV.1.5-19. The elevations shown are based upon P.L.D. and in meters and conform to the water levels of design criteria as given in II.1-Chapter 1.6.

Table IV.1.5-19 Required Sea Water Level to be Considered

Location	Water Level	H.W.L.	L.W.L
Atlantic Side	+0.1(M.S.L.)	+0.5	-0.3
Pacific Side	+0.3(M.S.L.)	+3.6	-3.4

(2) Freeboard

Freeboards adopted are as follows.

Table IV.1.5-20 Freeboard Allowances

Gate Name	Meter	Feet
Operating Gate	0.6	2
Emergency Gate	0.6	2

(3) Water Elevation at Tidal Gate

The tide range at the closed end of a stub canal (=a canal blocked at a certain distance from its opening to the sea so that waves coming from the sea can not go further, just like a stub in which the water coming up through its root can not go further) increases due to the resonance of the tide wave. Water elevations just in front of the tidal locks after considering this phenomena are as shown in following Table IV.1.5-21. These values were ob-

tained through a modification[1] of the sea water levels given in preceding (1), using the calculation result of wave height amplifications in a canal of 24 miles in length, which was reported on page 8 in the IOCS Memorandum JAX 67. The shorter the canal length, the shorter the amplification will be, and vice versa.

Note 1. Modification Basis

The modification of the tidal level was made in such a way that the ratios of high tide increases and low tide decreases to the total tidal amplitude are constant between the computer analyzed case in the IOCS report and the present case.

Table IV.1.5-21 Water Elevation at Tidal Gate (P.L.D)

Pacific Side		Atlantic Side		Difference	
Max.	Min.	Max.	Min.	P(A	A(P
4.0	-3.8	0.5	-0.3	4.3	4.3

(4) Water elevation between the Tidal Lock and the Tidal Gate

As defined under Case (c), the space between the Tidal Lock and the Tidal Gate is supposed to be a fresh water barrier. The water elevation in this zone is not directly controlled by ocean tides, but has to be maintained within a range fixed by operation of water-control structures and navigation limits through the Tidal Lock and the Tidal Gate Structure. The following Table IV.1.5-22 is the proposed water elevations between the Tidal Lock and the Tidal Gate and should be reflected in the design.

Table IV.1.5-22 Water Elevation between the Tidal Lock and the Tidal Gate

Limit	Elevation (P.L.D)	Reference
Maximum	1.1	= Atlantic H.W.L + 0.6m
Minimum	-0.3	= Atlantic L.W.L

5.3.3 Structural Material and Allowable Stress Level

(1) Structural Materials

Structural materials of the usual carbon steel, or low alloy carbon steels having good weldability, good notch ductility, and high resistance to brittle fracture are used. Steels that are classified in this category are presently widely available in mill markets. The strength range up to 100 Kg/mm^2 in fracture strength is applied in the design. Selection of the steels in various strength levels shall be done as followings.

1. Preference will be given to the higher strength steel only when it is advantageous for a facility's total cost including for material, fabrication, transportation, installation and operation and maintenance or when a canal study alternative can not be feasible without it. The cost study for selection of material specifications includes consideration of material sources and place of fabrication as discussed in II.2-Chapter 4.2.

2. The most preferable thickness from fabrication point of view is between 20 to 40 mm. In this sense, preference is given to thinner plates with higher tensile strength over thicker plates with lower tensile strength except when higher structural rigidity is required in preventing

structures from excessive deformation or buckling.

3. Preference is given to quenched and tempered steels in the case of high tensile strength steel.

(2) Allowable Stress Level based upon Yield Strength

The allowable stress levels applied are from the "Technical Standards for Gates and Penstocks", edited by the Hydraulic Gate and Penstock Association of Japan. Table IV.1.5-23 gives the allowable values for tensile and compressive stresses for various strength grades. The values shown are only for examples and applicable for plates thicker than 40 mm.

Table IV.1.5-23 Allowable Stresses for Elastic Design

Strength Level	Yield P. Kg/mm^2	Fracture P. Kg/mm^2	Allowable Stress Kg/mm^2
SS400	22	41	11.0
SM400	22	41	11.0
SM490	30	50	15.0
SM570	43	58	20.4
H.T.70	60	70	26.0
H.T.80	70	80	29.1
H.T.100	90	97	34.6

Note
1. H.T.(steel) is abbreviation of high-tension (steel).

In addition to the above, the following allowable stress alleviation was added for the Phase 2 study.

Table IV.1.5-24 Allowable Stress Alleviation

Applicable Case	Increased rate
1) When seismic load is added	150%
2) Hydraulic Condition for maintenance	130%

(3) Allowable Stress Level based upon Fatigue Strength
Not applicable to the Tidal Gate.

5.3.4 Seismic Design of Gate Structure

Seismic designs is applied to the gate structures based on the following.

(1) Design seismic coefficient is 0.10 which was given in II.1-Chapter 3

(2) Gate classification for the seismic coefficient application levels are as follows.

Table IV.1.5-25 Seismic Coefficient Application

Gate Name	Application Rate in %
Operating Gate	50
Emergency Gate	50
Maintenance Equipment	100

An Emergency Gate was classified as 50 % although the probability of an earthquake during operation is deemed to be negligible because the Emergency Gate is supposed to be identical to the Operating Gate.

(3) The following external forces to gate structures due to earthquakes are considered in the design. Fig. III.1.5-1 shows application of these forces schematically.

1) Dynamic pressure increases in the water surrounding gate leaves.
2) Inertia forces of gate leaves.
3) Dynamic effect of water inside of gate leaves.

5.3.5 Operating Gate and Emergency Gate

(1) Gate Type

The gate type adopted for a cost estimation is a triangular leaf rolling gate which was a result of optimization studies performed during the Phase 1 stage.

(2) Weight Estimation Procedure

The weight of the gate leaf was estimated according to the leaf unit weight curve in Fig. 4.2.6 of the Phase 1 study Final Report. Fig. IV.1.5-3 in this report is a copy of Phase 1 Fig. 4.2.6 with the Phase 2 unit weights plotted on it. A validity of the leaf weight obtained for Case (b) was confirmed with the calculated weight on a drawing base.

The weights of Gate Frames and Drive Mechanisms were estimated in proportion to their gate leaf weights using the relative ratios in Table IV.1.5-26.

Table IV.1.5-26 Factors for Weight Estimation of Tidal Gates

Part Name	Operating Gate	Emergency Gate	Maintenance Equipment
Gate Frame	0.3	0.3	0
Drive Mechanism	0.1	0.1	0

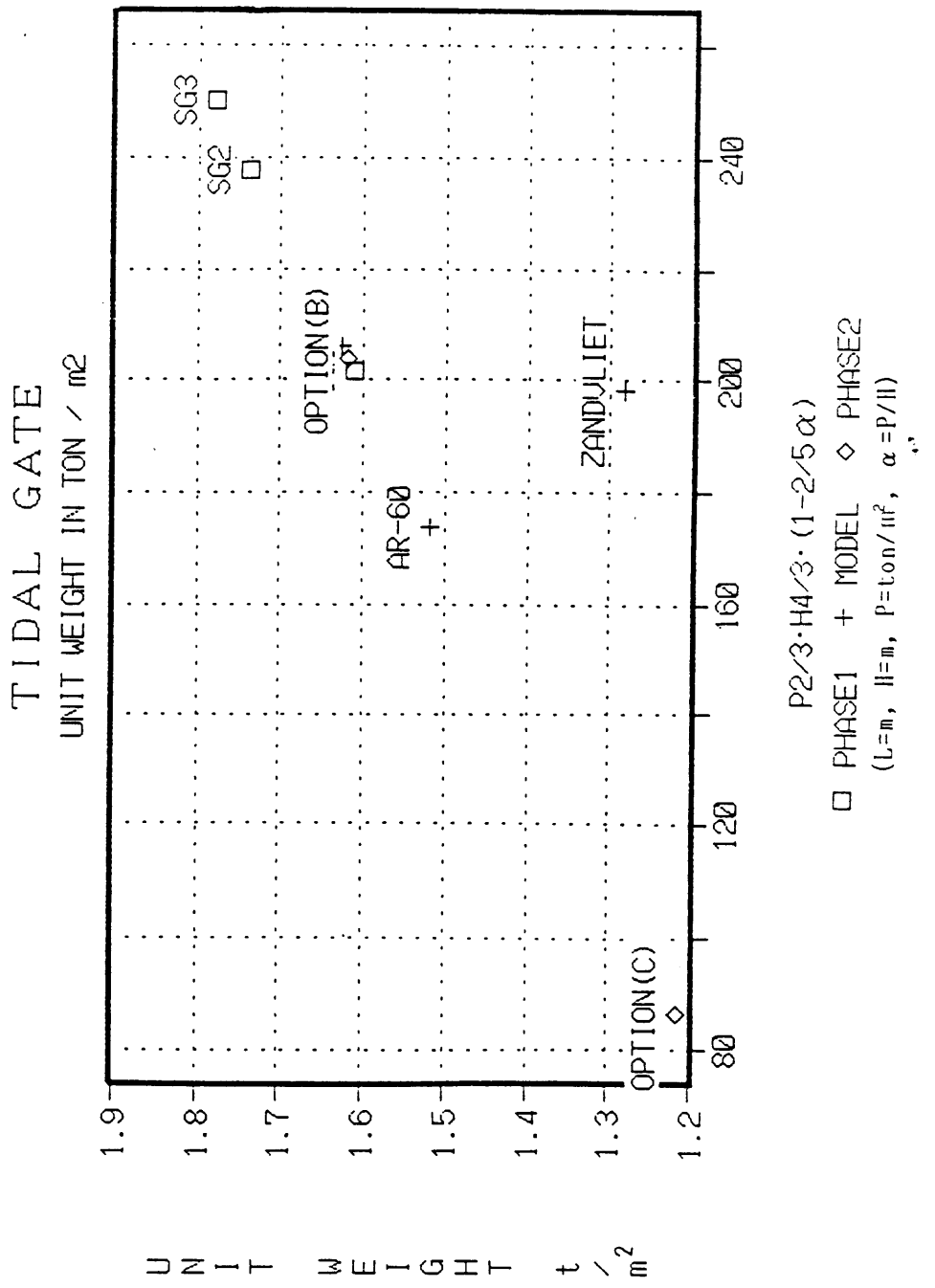


Fig. IV.1.5-3 Tidal Gate Unit Weight

(3) Description of Gates

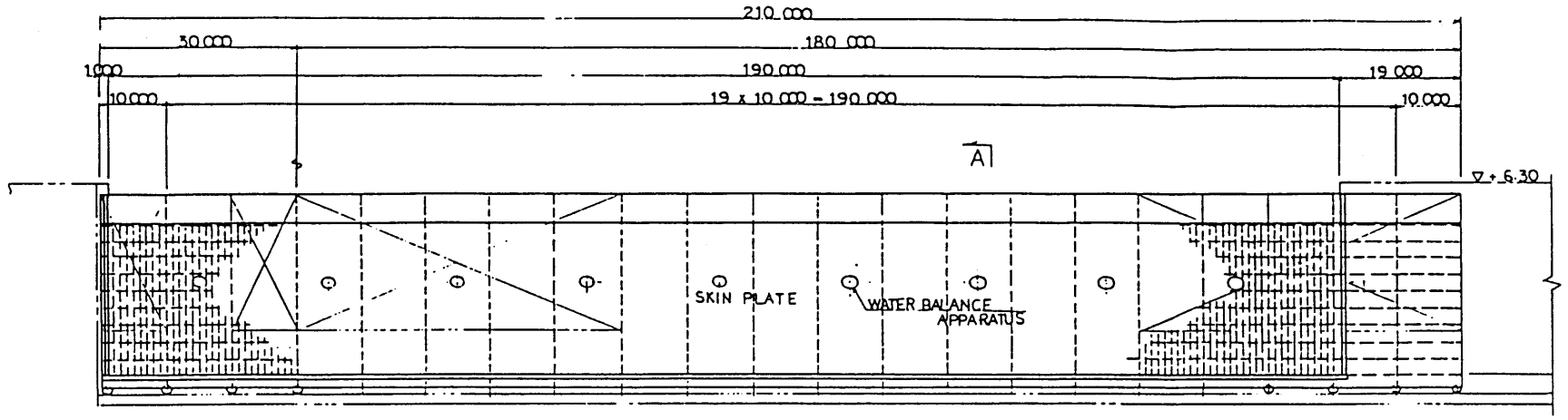
The height, width and weights of the Operating Gate and the Emergency Gate are given on Table IV.1.5-27. The width is nominal and equal to the canal navigation channel width. No spare gate is required for the Operating Gate.

Fig. IV.1.5-4 shows the general arrangement of the Operating Gate. The whole gate leaf is a right triangular section. The hull (=skin plate) which is subject to hydraulic water pressure is supported by vertical auxiliary girders, which are supported by horizontal girders, which are finally supported by vertical triangular main frames arranged at every 10 meters throughout the length of the gate leaf. Each main frame is supported by two rollers having a flat tread surface with a rim which will run on a flat steel rail with a round corner edge. Eventually all hydraulic force on the gate leaf will be supported by the rollers arranged along the bottom of the gate leaf and also a moment produced by hydraulic load on the leaf and reaction forces of the roller is balanced in each vertically sliced 10 m block, which can be a dynamically independent system. The inside of the leaf is separated into several compartments some of which are assigned as buoyant tanks to be used when the leaf is removed for maintenance work. The buoyant tank has a longitudinal bulkhead but will have no bottom. The roller contact surface is in a plane normal to a main frame axis.

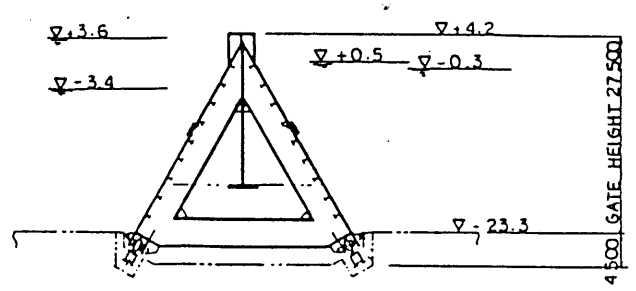
The Emergency Gate is exactly identical to the Operating Gate.

Table IV.1.5-27 Dimensions and Weights of Operating Gate and Emergency Gate

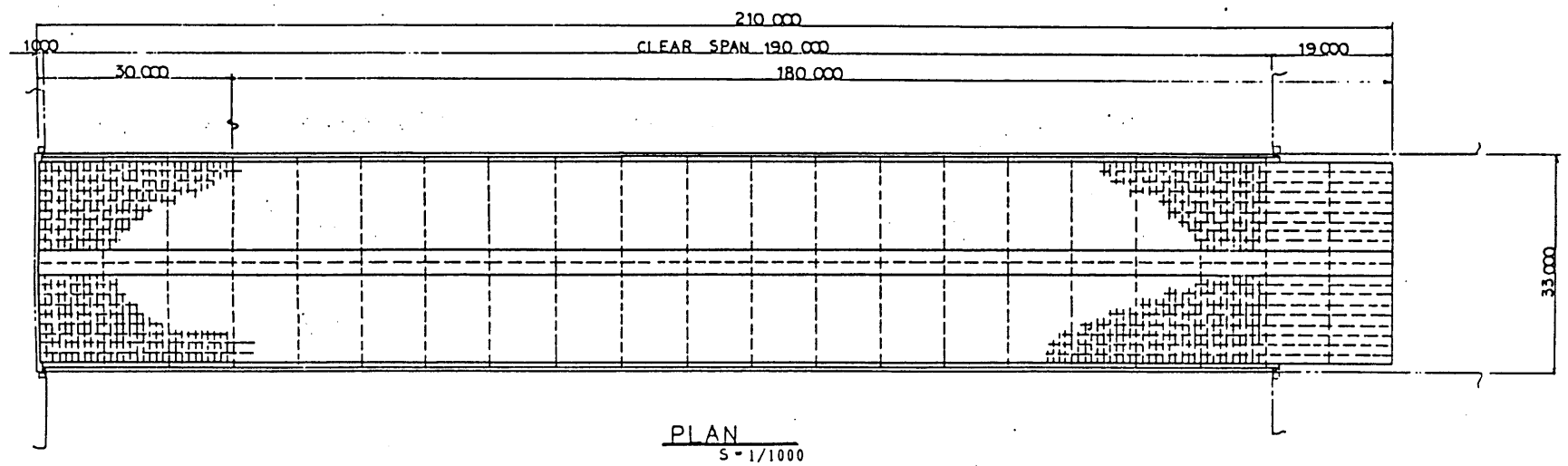
Case	Side	Gate Name	Height in Meter	Width in Meter	Weight in Ton		
					Leaf	Frame	Hoist
(B)	Atlantic	Operating Gate	27.5	190	8461	2538	846
		Emergency Gate	27.5	190	8461	2538	846
	Pacific	Operating Gate	27.5	190	8461	2538	846
		Emergency Gate	27.5	190	8461	2538	846
(C)	Atlantic	Operating Gate	25.0	190	5778	1733	578
		Emergency Gate	25.0	190	5778	1733	578



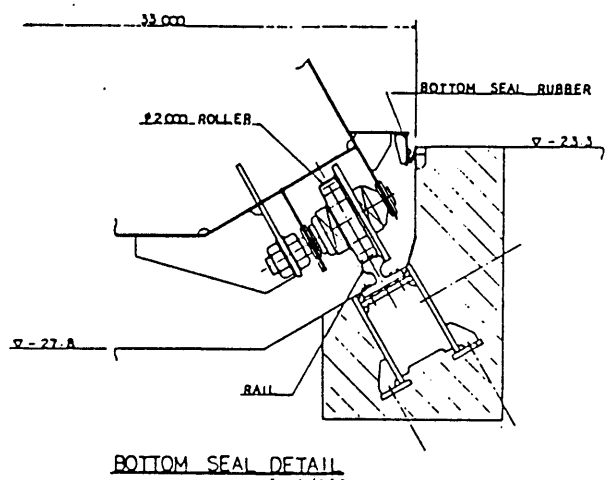
ELEVATION
S = 1/1000



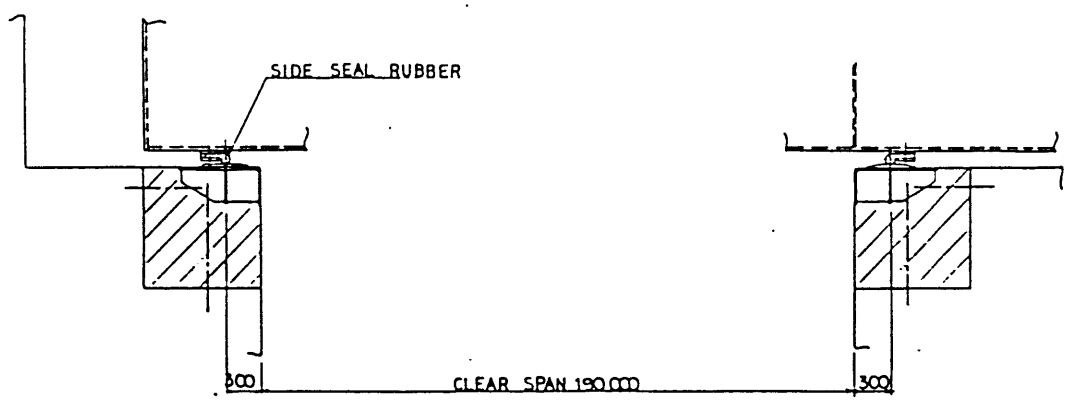
A - A SECTION
S = 1/1000



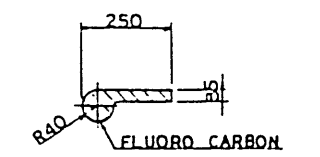
PLAN
S = 1/1000



BOTTOM SEAL DETAIL
S = 1/150



SIDE SEAL DETAIL
S = 1/60



SEAL RUBBER DETAIL
S = 1/20

SCALE 1:1000
0 50 m

SCALE 1:150
0 2.5 5 7.5m

SCALE 1:60
0 3 m

SCALE 1:20
0 1 m

Fig.IV.1.5-4 General Arrangement of Tidal Gate (Triangular Type)
Sea Level Canal 250000 DWT Canal Option

(4) Design of Gates

Design heads in meters for the Atlantic side and Pacific side of each gate are shown on Table IV.1.5-28. Concerning Case (b), Atlantic side heads correspond to the minimum water elevations of the Atlantic ocean and the sea side heads correspond to the maximum water elevations of the Pacific Ocean. Concerning Case (c), Atlantic side head corresponds to the minimum water elevations on the Atlantic ocean, and the Pacific side head is the maximum water elevation in the canal.

Table IV.1.5-28 Design Head in Meter of Operating Gate and Emergency Gate

Case	Side	Gate Name	Atlantic Side	Pacific Side
(b)	Atlantic	Operating Gate	23.0	27.3
		Emergency Gate	23.0	27.3
	Pacific	Operating Gate	23.0	27.3
		Emergency Gate	23.0	27.3
(c)	Atlantic	Operating Gate	23.0	24.4
		Emergency Gate	23.0	24.4

(5) Result of Engineering Analysis

Engineering analysis was made on the Tidal Gate for Case (b)

1) Leaf Deformation as a whole

This type of structure deforms only in a vertical plane including flow direction. A structural analysis was made on a vertically sliced 10 m section including a main frame at the middle of slice ends, using a program for a plane frame. The deflection in the horizontal direction at the top of the gate was approximately 5 mm and

at the center of the pressurized member, approximately 12 mm under the design heads. Nothing wrong can be seen with this level of deformation except at both ends of the leaf where water seal rubbers for the leaf side sealing are mounted. The leaf ends shall consist of a plate instead of the main frame to restrict displacement on the seal rubber seat face. A rotation at the roller mounted corner of the triangular is approximately 1.0×10^{-6}, which suggests no consideration is necessary in roller assembly.

2) Stability when Totally Closed

Stability of the leaf totally closed and being subject to various hydraulic conditions was analyzed and the conclusions below were obtained.

a. The leaf which was designed to be stable against hydraulic pressure load in Atlantic-ward direction can not be stable under Pacific-ward load and vice versa, not withstanding the massive weight of the leaf. It suggests that water elevation in the leaf has always to be equal to the lower water elevation outside of the leaf. When Pacific side is higher, the inside water elevation is supposed to be equal to Atlantic side and vise versa. To realize this condition, a water balancing apparatus is necessary as it was proposed in the Phase 1 study Final Report.

b. Wheel load;approximate values are 900 tons normal to the tread surface and 600 tons parallel to the tread surface.

3) Stability during Opening or Closure Operation

Stability of the leaf during moving operation while subject to a 0.9 m water head difference was analyzed and the conclusions below were obtained.

a. The leaf is stable throughout all hydraulic conditions.

b. Wheel load during gate movement;
Approximate values are 330 tons normal to the tread surface and 210 tons parallel to the tread surface. It can be seen that a roller designed for the maximum load with a gate leaf totally closed will also be stable during the gate movements.

(6) Installation and Removal of Gates

The Operating Gate and the Emergency Gate for the Tidal Regulating Structure fabricated at shop including all accessories are towed to Panama by tug boats. They are set in place using a floating crane according to the steps shown in Fig.III.1.5-4. It is anticipated that gate leaves fabricated and installed using these procedures will have bigger deviations from their drawing dimensions and from their relative drawing positions to the gate frames or the hoist mechanisms installed in concrete structures before hand than gates installed using conventional block erection method with which dimensional adjustment of gate leaves is possible during block erection either at shop or at site. Hence, gate seal mechanisms, roller systems, support system etc. which interface on the leaf side to the equipment on concrete structures under water must be able to adapt to bigger dimensional deviations in gate leaves and embedded metals than ordinary gate designs. The proposed installation method is hereby named "Just-Set-In-Place Installation" versus "the conventional block erection installation ".

The Just-Set-In-Place Installation method also enables the gate leaves under water to be removed or reset for maintenance. It is worth while to note that all gate parts under water can not be adjustable in drainage conditions.

The gate leaf is shipped in two blocks to enable the Just-Set-In-Place installation. Both blocks are joined to each other after being set on the rails.

(7) Machinery for Operating Gate and Emergency Gate

The machinery type adopted for the Operating Gate and for the Emergency Gate in the Tidal Regulating Structure, is a rack and pinion gear mechanism as proposed in IOCS Memorandum JAX-67 except that the pinion gears are powered by hydraulic oil motors. Dual racks mounted on the gate top are pushed by multiple pinions installed in the machine house set on the concrete wall. These pinions are driven independently by multiple hydraulic motors. The machinery is capable of opening or closing the canal channel in 20 minutes. Each gate is equipped with two hydraulic power units each of which are powered by two induction motors of 450 KW for the Case (b), and 350 KW for the Case (c). Time limitations restricted further study of cost savings with a hydraulic pumping station for each Tidal Regulating Structure with the related controls and distribution system.

(8) Sand and Silt Flushing Equipment

Substantial contamination of sand and silt is predicted in water around the Tidal Regulating Structures. Therefore, the gates must be provided with equipment to flush sediment on or in the vicinity of the rails on the canal floor. A water jet flushing system as is working in similar facilities or a combination of a flushing system with a mechanically sweeping system or some other type would be applicable.

5.3.6 Maintenance Equipment

A set of maintenance equipment for the embedded metals of the Operating Gate and Emergency Gate is included in the estimate. It consists of many blocks and each block has approximately half circular sectional shape. The blocks are set on the embedded metals by a floating crane with assistance of divers. The joint of each block is sealed by specially shaped rubbers. The insides of the equipment set on the canal floor including gate recess in the side concrete walls and gate shelter is dewatered to enable maintenance work of the embedded metals in dry condition. This kind of equipment was used in the UK for maintenance works of miter gate sills in concrete. Time limitations restricted more detailed study.

5.3.7 Corrosion Protection System

Corrosion protection systems including paint coating and cathodic protection anodes are required for each gate, gate frame and gate hoist according to the materials used and working or storage conditions and circumstances. The system should also incorporate PCC maintenance experience and findings. It is not practical for the complete corrosion system to be established for each gate at this stage of preliminary design. The following table shows the kinds of painting to be applied and status of cathodic protection anode provision on each gate. The present cost estimation is deemed to cover the cost level of including these types of corrosion protection procedures.

Table IV.1.5-29 Recommendable Paint Coating and Cathodic Protection Application

Location	Coal Tar Enamel (Hot)	Special In-Organic Z.P. + Sealer	Coal Tar Epoxy	Polyamide Epoxy/ Vinyl	Cathodic Protect. Anodes
Operating Gate					
Submerged Area	Yes				Yes
Exposed Area		Yes			
Emergency Gate					
Submerged Areas	Yes				Yes
Exposed Area		Yes			
Maintenance Eq.					
Gate Leaf			Yes		
Gate Frame	Yes				Yes

5.3.8 Electric Power Control

As a guide for conceptual design and estimating purposes the Deep Draft Lock Plan was generally used.

(1) Distribution System

The system consists of a radial type, double circuit, primary system encircling the tidal regulating structure complex, with a primary distribution voltage of 13.8 KV (12 KV nominal). Secondary distribution for power is at 3 phase 6000 (nominal) volt and 480 volt (460 volt nominal) with lighting and small auxiliary power loads supplied at 3 phase 120/208 volt. Two transformer substations and associated switch gear will be provided in the concrete wall under the machine room. Substations will be located near each gate in the electrical equipments room at the operating gallery level below the local control stations. It is assumed for estimation purposes that commercial power is supplied to a point by the lock sites at 13.8 KV.

(2) Wire System

A cable tray system in an electrical gallery in each concrete wall and in a canal crossover tunnel provides the main raceway system for electric cables. Exposed conduits are provided in a local control station and its associated electrical equipment room below at the operating gallery level. These areas will have temperature and humidity control equipment. Embedded conduits will extend from the electrical equipment rooms to the gate operating machinery in the vicinity of each gate and from galleries to utilization equipment in other locations. All electrical equipment for hoists and simple control boards set by the equipment for maintenance works is included in the estimate for mechanical equipment.

(3) Emergency Power Plant

The maximum plant load includes the power required by the lighting system, including miscellaneous auxiliaries, and the gate operating equipment. The approximate power demand is shown on Table IV.1.5-30. A diesel turbine power plant set on each structure is capable of supplying the total power demand.

Table IV.1.5-30 Approximate Electric Power Demands in KW for Tidal Regulating Structure

Lighting	Gate Operation	Total Demand
400	5,600	6,000

(4) Electrical Equipments for Gate Hoists

Weights and costs of electrical equipments for gate hoists are included in the gate hoists which are classified as Mechanical Equipment in the Bill of Quantities at Chapter IV.3.2.

(5) Miscellaneous Electrical Equipment

Cost for miscellaneous electrical equipment for electrical power and control were derived by adjusting the allowances in the Deep Draft Lock Plan estimate including this item, in relation to the total cost for all other electrical power control equipments including the gate hoists.

5.3.9 Miscellaneous Structures and System

As a guide for the conceptual design and for estimating purposes, the Deep Draft Lock Plan was used.

(1) Gate Control System

A local control station is provided in the vicinity of the gate leaves on top of the concrete wall. Operation of the Operating Gate and the Emergency Gate is controlled from this location. Controls are supplemented by indication circuits of the selsyn type for continuous indication of the gates position. Pilot lights and limit switches are used for miscellaneous control and position indication, and closed circuit TV monitoring equipment is provided for the Operating Gate, the Emergency Gate, and for the canal and sea side approach areas. Passage signals for both side are controlled from the local control station. Costs for the items included here, as well as the other items included in the item "Others" in the Cost Content of Gate Leaves and Related Facilities in IV.3-Chapter 2.2, were derived in this report by adjusting the allowances in the Deep Draft Lock Plan estimate for these items, in relation to the gate leaf costs.

(2) Shops-Service Buildings

New facilities have not been included as it is assumed the existing Panama facilities could be used to provide such services.

(3) Repair facility

Repair facilities are not included in the estimate.

(4) Ventilation System

A ventilation system is included to provide forced fresh air ventilation to a canal crossing tunnel, operating galleries and equipment rooms. Costs were derived by adjusting the allowances in the Deep Draft Lock Plan estimate for this item (=other mechanical components), in relation to the gate leaf costs.

(5) Pumping and Piping

Pumping and piping for raw water, potable water, dewatering gate shelter and sump pumping, fire protection, and sewage disposal are included under this heading. Costs were derived by adjusting allowances in the Deep Draft Lock Plan estimate for this item (=other mechanical components), in relation to the gate leaf costs.

(6) Compressed Air System

Compressed air is to be provided for maintaining the buoyancy chambers of gates and powering pneumatic equipment. Costs were derived by adjusting allowances in the Deep Draft Lock Plan estimate for this item (=other mechanical components), in relation to the gate leaf costs.

IV.1 CHAPTER 6 - LOCKAGE GUIDANCE SYSTEM

6.1 Ship Propulsion in a Lock Chamber by Ship's Own Power

Ships are guided by locomotives during lockage. The existing Panama canal adopted this system when it was constructed. Prior to this time, serious accidents to the lock gates in locks used for large ships had been invariably caused by the misunderstanding of signals between the navigating officer and the engine room. For this reason it was concluded at the time the original canal was planned that ship's power should not be used for passage through the lock (Paper No.15 "Electrical and Mechanical Installation of the Panama Canal" of Transaction of the International Engineering Congress, 1915 held in USA). Lockage operation and the increased demands in both number and size of ships to transit the Panamá Canal have changed perceptions regarding locomotive usage, and today usage of ship propulsion during lockage seems to be very common, especially in the case of larger ships. For reference purposes, listed below are documents in which there are statements concerning the usage of ship propulsion during lockage.

(1) The Panama Canal, Transaction of International Engineering Congress 1915.

(2) The Panama Canal Pilot, Panama Canal Commission Maritime Training.

(3) Pilot Hand Book, Panama Canal Commission, 1988.

In the Phase 2 study, the role of locomotives during lockage operations was reviewed according to the assumption that the ship's engines provide the primary power for navigation through the locks, while the locomotives are secondary.

6.2 Role of Guiding Locomotive

The role of the locomotives during lockage operations was reviewed based upon the assumptions described in Chapter 6.1 above.

The primary role of the locomotive is ship position control in either the ship longitudinal direction or in the lateral direction. Elements disturbing a ship's position are as follows.

(1) Wind force in either longitudinal or lateral direction or both.

(2) Ship propulsion force.

A single screwed ship has a tendency for its stern position to alter laterally however skillful the rudder operation. This tendency is more remarkable during full ahead or astern operations when the ship's initial speed is zero, or minimal.

(3) Hydraulic force on ship hull under water.

Existence of water flow in the lock during ship raising or lowering operations is inevitable even when every effort is made in designing the lock chamber water filling and draining system to achieve homogeneous water filling or drawing. Eventually a ship hull under water may have resultant hydraulic forces either in the longitudinal or the lateral direction, or both.

The secondary role shall be to support the ship braking function. Although astern operations by ship power are possible, the locomotives shall provide braking functions to stop a lockage ship within a certain reach or period, without the ship's power for emergencies such as a ship power failure.

The last role which will be of rather lesser importance for guiding the Design Ship is assistance in ship propul-

sion including ship acceleration to shorten lockage time. Being capable to tow a lockage ship by the locomotives alone after the ship speed gets at her green light speed (maximum guiding speeds established for various ship size) may be preferable for ship maneuvering in a lock but it is not absolutely necessary. Nevertheless 8 locomotives, which is the maximum number for guiding a lockage ship, should be able to tow, without ship power, the majority of the smaller ships which transit the tidal locks.

6.3 Assumptions on Locomotive Function

Major functions of locomotives to be determined for design are pulling capacity and green light speed (maximum guiding speeds established for various ship size). These functions relate to the lockage time which may control total capacity of the Canal Alternative. Fig. III.1.6-1 shows the relationship between the lockage time and the locomotive function.

Fig.III.1.6-1; Ship Braking and Propulsion Assistance in the figure demonstrate the Role of Locomotives. Engineering criteria are Braking Time(=necessary time for stopping a ship), Acceleration Time(=necessary time for accelerating a ship) and Green Light Speed, all of which are major elements of Lockage Time. These values relate to the Force on Pulling Cable of the locomotives in the ways shown in the figure. The major functions of the locomotives are Pulling Capacity and Green Light Speed as shown on the figure. Hence, the finalization of locomotive functions should consider the canal capacity study which is a major subject of another component study for the Panama Alternatives Study.

Table IV.1.6-1 gives the assumed locomotive function for preliminary design in the Phase 2 study. The assumption is twice the pulling capacity of the existing locomotives for the existing Panama canal. The pulling capacity shown on the table is large enough for a ship being maneuvered under wind velocity of 13 m/sec.

Table IV.1.6-1 Assumed Guiding Locomotive Functions

Function Name	Assumption
Pulling Capacity per One Cable in Ton	; 32
Number of Cable	; 2
Total Pulling Capacity in ton	; 64
Green Light Speed in knot	; 0.5, 1, 2 & 3
Light Speed in knot	; 6 & 9
Cable Length in Meter	; 300

Note: 1. Green Light Speed in the table means the maximum guiding speeds established for various ship size.
2. Free Speed in the table is the speed used for a return or running "light".

Table IV.1.6-2 shows Braking Time, Braking Length(= ship travel distance after a braking operation started), and ship speeds, which can be achieved with the assumed locomotive functions applied to the Design Ship in the lock chamber of each canal option. All values have been given for different drafts which are expressed in the amounts of draft decrease. The high rise lock canal option is also included here just for the sake of comparison. Ship Speed for 200,000 DWT option alone is quite high which has been resulted from the largest ratio of the lock transversal sectional area to the Design Ship midship sectional area. The Braking Time or the Braking Length increases as the ship draft decreases in this calculation but they will finally start decreasing with a much smaller ship draft. The ship speed of 2 knots in the table means 2 knots or more. The calculation made to find these values covers the ship speed up to 2 knots. The Braking Time and the Braking Length correspond to a starting ship speed of 2 knots. The configuration of the Design Ship is simplified in the calculation such that the ship sides are parallel for the middle 50% of the ship and then taper linearly towards the stem and the stern. The angles of inclination of the pulling cable

from the locomotives adopted in the calculation are 40 degrees from the vertical when projected on a vertical plane including the midship section and 45 degrees from the locomotive rail direction when projected on a horizontal plane. The 40 degrees angle was adopted in the Third Lock study for a two lift type lock. The calculation includes several simplification, yet it's accuracy is good enough to show relations between locomotive function and lock function.

Table IV.1.6-2 Braking Time, Braking Length and Ship Speed in Lock Chamber

	S. Speed in Kt			B. Time in sec(3)			B. Length in M(3)		
C. Option	0.0	0.5	1.0	0.0	0.5	1.0	0.0	0.5	1.0
150,000DWT	1.7	2.0	2.0	63	68	72	28	32	35
200,000DWT	2.0	2.0	2.0	89	94	97	41	44	46
250,000DWT	1.5	1.9	2.0	103	110	115	46	50	53

Note: 1. Abbreviations; S.=Ship, B.=Braking, M=Meter, C.=Canal
2. The parameter on the table is a draft decrease of ship in meter.
3. Braking Operation started with ship speed at 2 knots.

6.4 Description of Locomotive and Track Rails

Thirty locomotive units are provided for three tidal locks. The guiding track and related equipment will be similar to that proposed for the Deep Draft Lock Plan. The guiding system is identical for both lock schemes and includes turntables at the middle, the lock, and a return track connecting them to each other and to a locomotive service building. Specifications of the locomotive are shown in Table IV.1.6-3. Cost estimation for the locomotives was based upon a quotation followed by verification assisted with the PCC purchasing records.

Table IV.1.6-3 Specification of Locomotive

Item Name	Specification
Type of Locomotive	Rack and Pinion Traction Type
Towing Capacity	140,000 Lbs (max) and 100,000 Lbs (one hour rated)
Dimensions in Meter	L15.0 W3.3 H4.5
Weight in tons	88
Number of Drive Motor	2
Drive Motor	6 Pole Induction Motor (brushless) 340 Hp 440V 40Hz
Cable Size	1-1/4"
Rail Gauge in Meters	1.676
Power Source	3 Phase Alternative Current 460 V 60Hz
Speed Control	Inverter Control

6.5 Power Supply

The power supply for the locomotive is discussed in section 5.2.8 with the power supply for gates.

IV.1 CHAPTER 7 - BARRIER DAMS AND RESERVOIR

7.1 Introduction

The main barrier dam consists of two almost parallel dams to be constructed in Gatun lake. These dams will ensure the present water level of Gatun lake while allowing the lowering of the water level between them to the seawater level. The Sea Level Canal passing between these two dams can be construction with hardly any adverse effects on Gatun lake. These barrier dams will start near Escobal village at the southern tip of Gatun lake towards Cano Gigante situated on the opposite side of the lake. Apart from these main barrier dams, another barrier dam is planned on the opposite coast of La Lagunda village to bring the total number of barrier dams to 3.

A western area of the main barrier dam will be separated from Gatun lake to form a reservoir which will be used as a freshwater supply source for the Freshwater barrier. The water level of the reservoir will be 85' same as that of Gatun lake. The reservoir surface area will be about 80 km^2 and the storage volume will be approximately 500 million m^3. The watershed serving this reservoir has an area of 685 km^2 and rainwater will mainly flow into the reservoir via Rio Ciri and Rio Trinidad.

Freshwater of the reservoir will flow down into the Canal via a freshwater conveyance structure ordinarily. Available freshwater from the reservoir will be 1,225 million m^3 a year and 740 million m^3 from other rivers outside of the Gatun watershed.

7.2 Design Condition

7.2.1 Location

The location of the Barrier dams for the Sea Level canal is shown in Fig. IV.1.7-1.

The following three sites have been considered based on the shape of the old valley and topography of Gatun Lake, keeping the safe distance from the Sea level canal alignment.

Gatun lake is divided into two reservoirs (New Gatun Lake and Reservoir E) by three Barrier dams (E, F and G). The axes of the barrier dams are located nearer the proposed canal alignment compared with the axes of IOCS and Nagano Plans, because of the need to have larger reservoir capacities on both sides.

The barrier dam sites are as follows:

(1) Barrier Dam (E)

The dam site is selected at a location where the valley is at a relatively narrow part of the old Rio Trinidad, approximately 1 km south of the proposed alignment. Los Negros and Esperanza islands in the lake would be closed off by barrier dam.

The barrier dam has a spillway to ensure the safety of the dam, and a waterway from the spillway to Rio Lagarto is also proposed in order to reduce the water level increase of the Lake during floods.

(2) Barrier Dam (F)

The dam site F is selected at a location downstream of the dam site E and north of the canal alignment. The axis of the dams are almost parallel and the dams are separated by approximately 3 kms. La Punta de Ramon and Bajo Island in the Lake would be closed off by this barrier dam.

(3) Barrier Dam (G)

The dam site is selected at a location where the valley is very narrow, and downstream of the old Rio Pescado approximately 7 kms south of the existing canal, and about 2 km away to north of the proposed canal alignment.

7.2.2 Type of Barrier Dam

From an economical point of view, considering the huge crest length, relatively small differential water head from upstream to downstream of dam, and the fact that dam foundation treatment are almost entirely underwater, the fill-type dam has therefore been adopted.

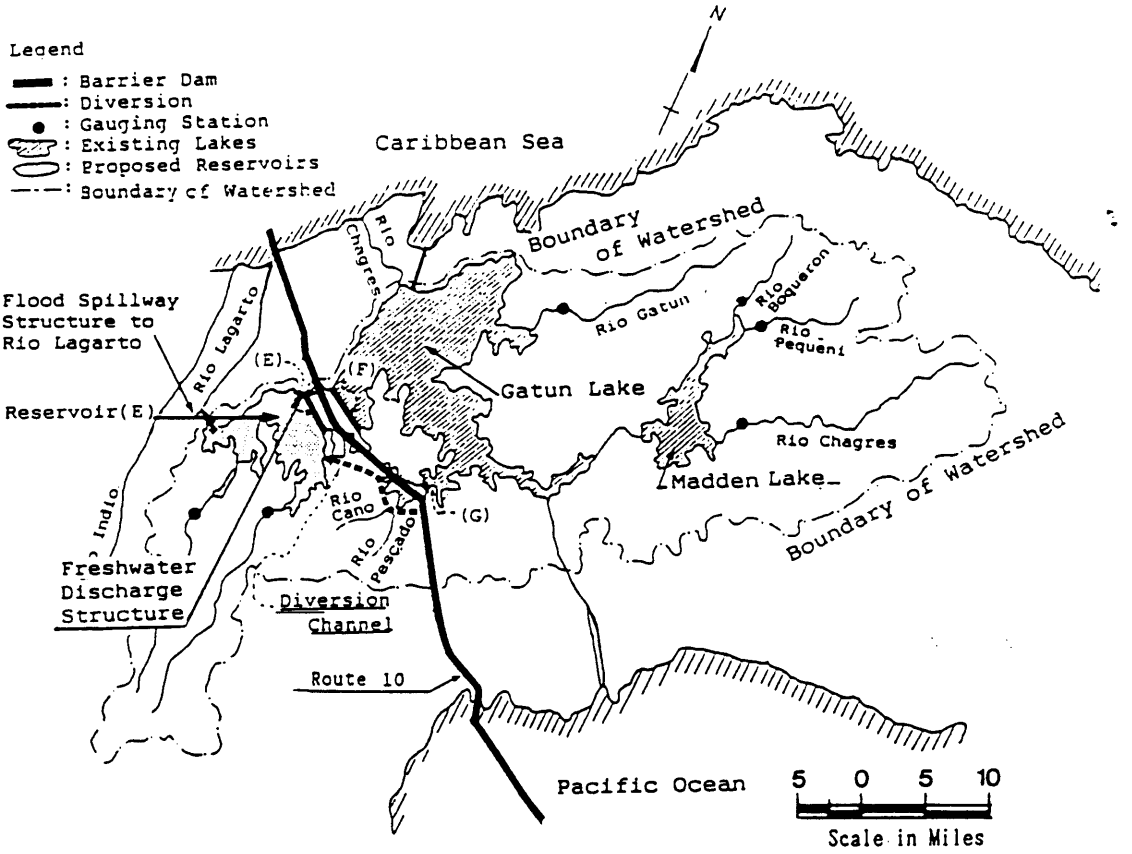


Fig. IV.1.7-1 Barrier Dam Locations

7.2.3 Pore Pressure and Seismic Load

The conditions of pore pressures and Seismic load is listed Table IV.1.7-1.

Table IV.1.7-1 Design Conditions of Barrier Dam

Case	Slope	Conditions Pore Pressure	Seismic Loading
During Construction (each construction stage)	both U/S and D/S	Remains some excess pore pressure in core	0.05
Slow drawdown (from H.W.L to sea level)	D/S	ditto	0.05
Rapid drawdown (from N.W.L to L.W.L)	U/S	Remains in core at N.W.L seepage pressure	0.05
Reservoir at N.W.L	both U/S and D/S	Steady seepage pressure	0.10
Reservoir at H.W.L	ditto	ditto	0.05

7.2.4 Design Procedure

The following procedures and methodology are applied to determine reservoir water surface levels and dam crest elevations.

Water Demand
↓ ← H-V Curve
Normal Water Level
↓ ← Spillway overflow depth (Gated spillway)
High Water Level
↓ ← Freeboard
Dam Crest Elevation

7.2.5 Other Items to be Considered in Design

(1) Selection of materials to increase the impermeability in the core is important.

(2) The impermeability shall be also increased using banking loads effectively.

(3) Sand drain layers at the core zones to reduce a excess pore water pressure is required

(4) Blanket layers toward up stream are effective in order to reduce the seepage water through the dam foundation.

(5) Down stream side rock zone should have a enough section considering the water level will be lowered when the dam is completed.

(6) Barrier dams should be equipped with a spillway to reduce the water level in the reservoir and to keep safety.

(7) Enough usable materials are available from the canal excavation and quarry site upstream of Rio Ciri Grande, but some blending and separation will be necessary.

7.3 Dam Structures

7.3.1 Main Features of Dam

Main features of dams are summarized in Table IV.1.7-2, and drawings of barrier dams are shown in Fig. IV.7.1-3(1) - (3).

Table IV.1.7-2 Main Features of Dams

Barrier Dam		(E)	(F)	(G)
Dam Crest EL	(m)	32	32	32
Dam Foundation EL	(m)	2	0	7
Dam Height	(m)	30	32	25
Dam Crest Length	(m)	4,700	5,100	900
Dam Crest Width	(m)	20	20	20
Core Volume	(mill m3)	4.3	4.65	0.65
Filter Volume	(mill m3)	3.9	4.25	0.65
Rock-fill Volume	(mill m3)	4.8	5.3	0.70
Total	(mill m3)	13.0	14.2	2.0

7.3.2 Cross Section of Barrier Dam

The typical section of barrier dam is shown in Fig. IV.1.7-2. The dam embankment sectional zones are consist of core, filter and rockfill.

The main features of the cross section are as follows:

(1) a "core" of impervious soil is classified as silty and silty clayed sand, and low to medium plasticity;

(2) a blanket layer of impervious soil to seal the foundation;

(3) three more layers of impervious soil alternating with horizontal sand drains to help dissipate excess pore pressures;

(4) filter layers consist of well graded sand and gravel to prevent movement of particles from soil to another;

(5) filter materials do not suffer segregation during placement in the water;

(6) a rockfill zone with bedded filter layers to control against slope sliding;

(7) rip-rap facing on the rockfill zone to stabilize the slopes against wave action; and

(8) a wave wall and road along the crest of the dam.

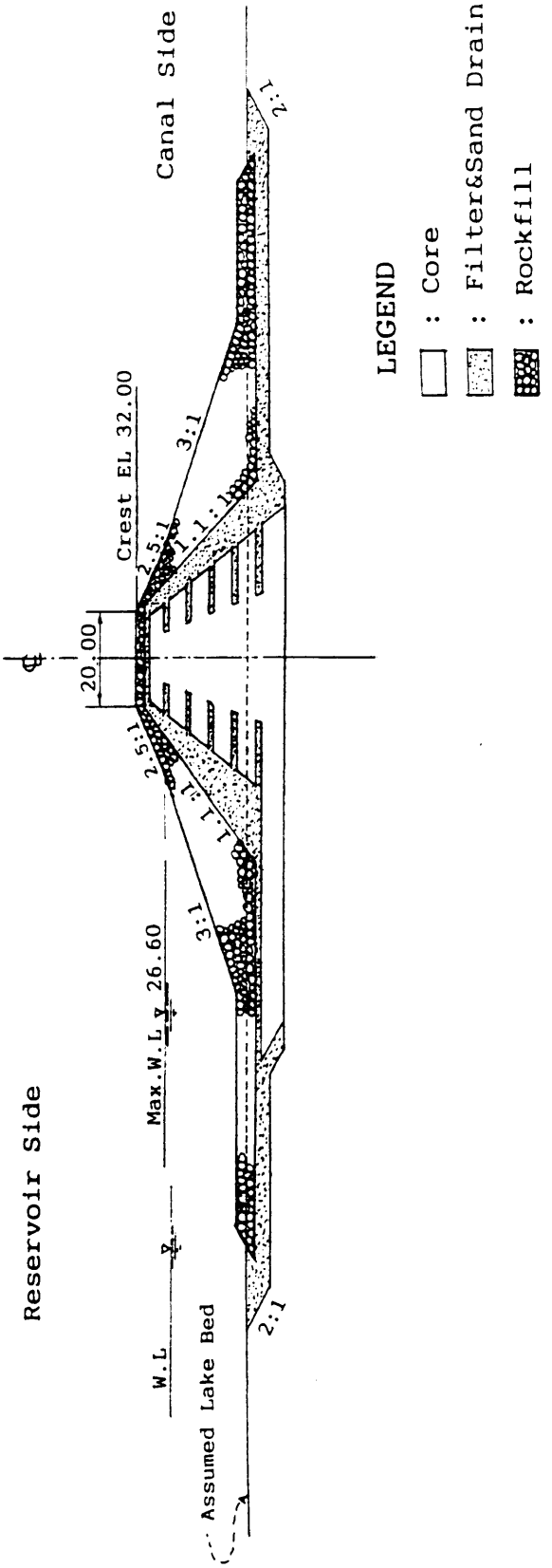


Fig. IV.1.7-2 Typical Section of Barrier Dams

7.4 Spillway

A spillway is located at about 12 km upstream from the left abutment of the barrier dam (E) (as shown in Fig. IV.1.7-1).

The spillway control structures has a capacity of 100 m3/s when the reservoir water level is 26.00m.

The spillway is equipped with two 6 x 3 meters rectangular gates with sills at elevation 24.00m.

A orifice at the lower part of main sills is equipped one 3 x 2 meters radial gate with a sill at elevation 22.00m, and it is capable of discharging the annual mean discharge volume of 37 m^3/s with the reservoir water level is 26.00m.

The overfall and orifice spillway are both used for reservoir releases of the designed discharge volume. The drawing of the spillway is shown in Fig. IV.1.7-4.

Main features of spillway are shown in Table IV.1.7-3 and Typical section and profile of the spillway is shown in Fig. IV.1.7-3.

Table IV.1.7-3 Main Features of Spillway

	Design water level (m)	Design discharge (m3/s)	Wide (m)	Height (m)	No.	Sill EL
Crest gate	26.00	100	6	3	2	24.00
Conduit gate			3	2	1	22.00

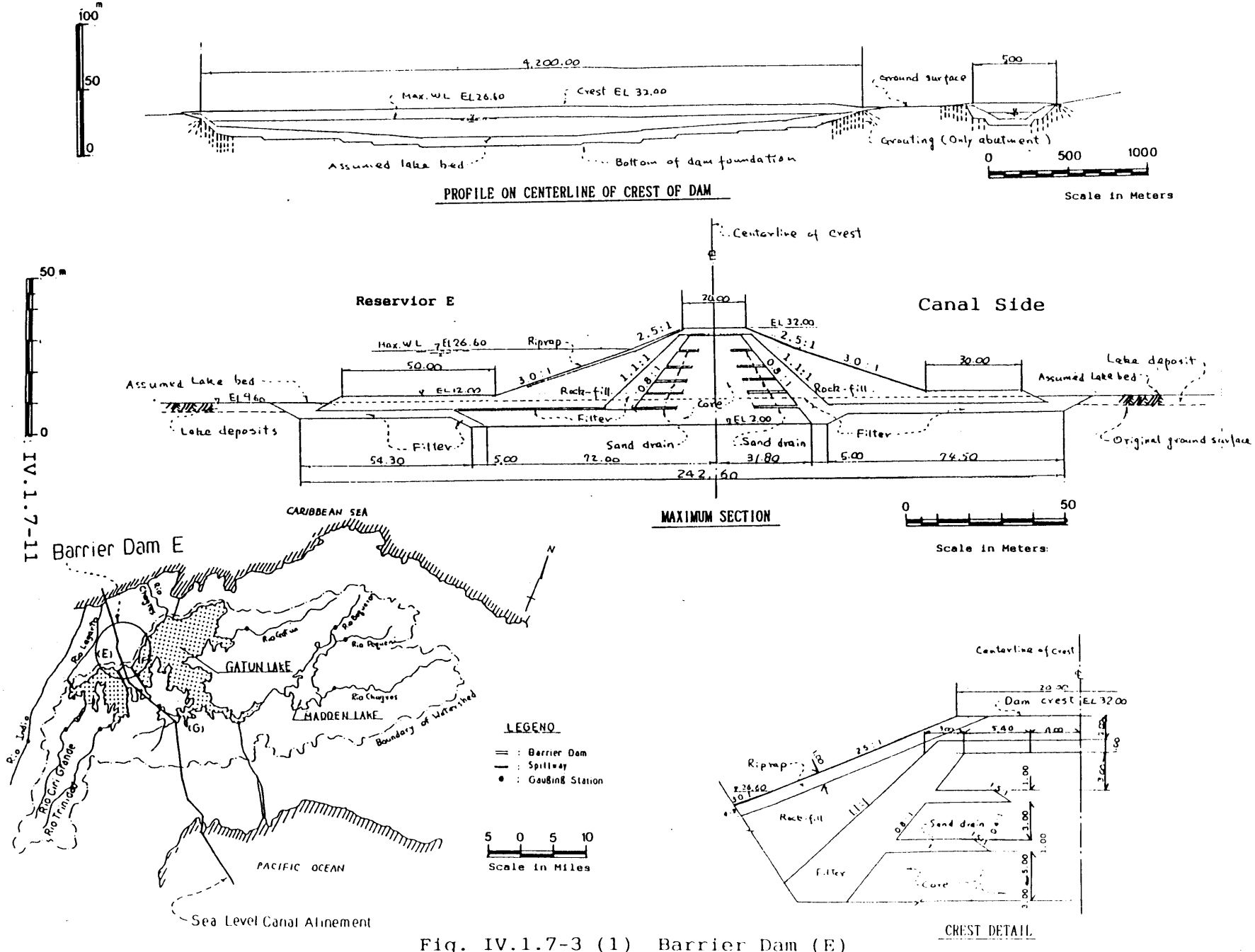
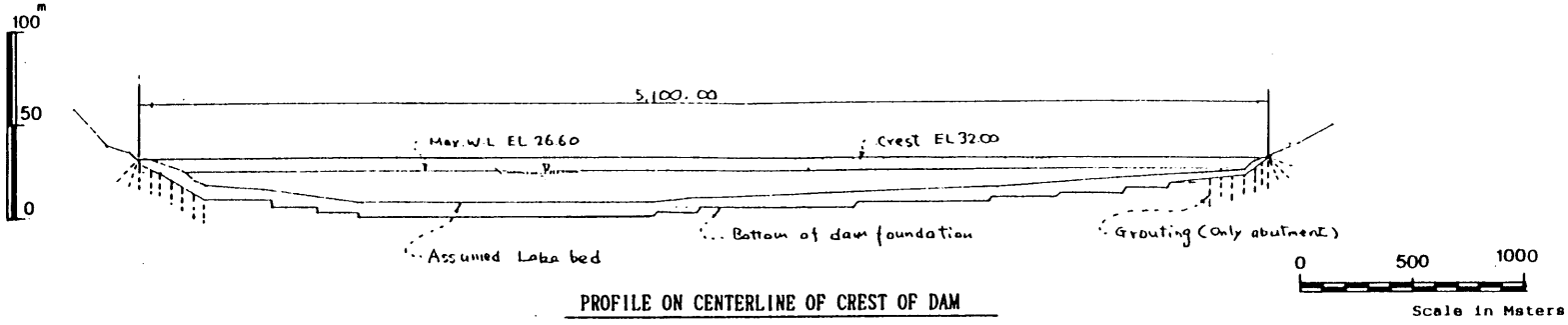
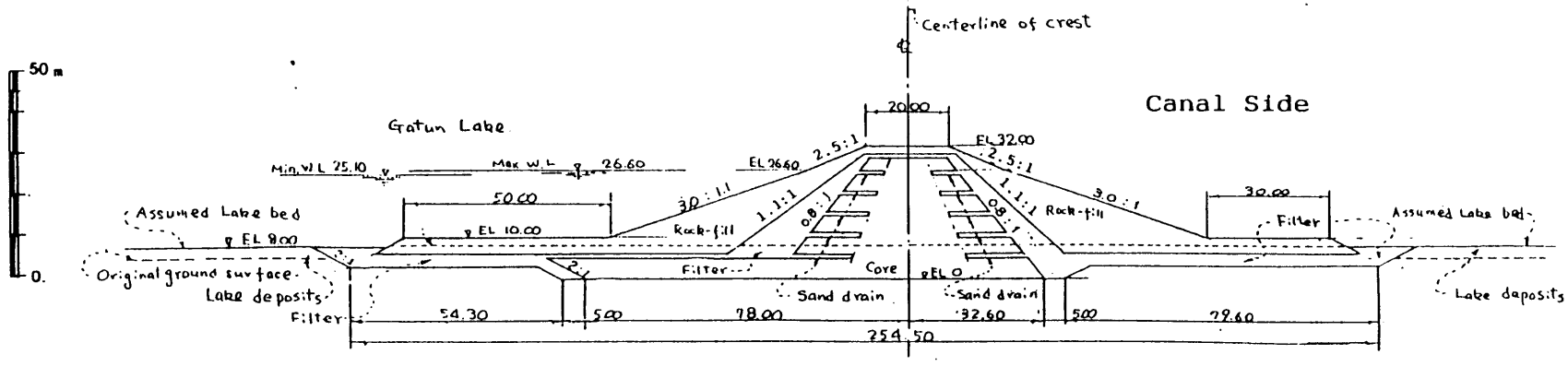


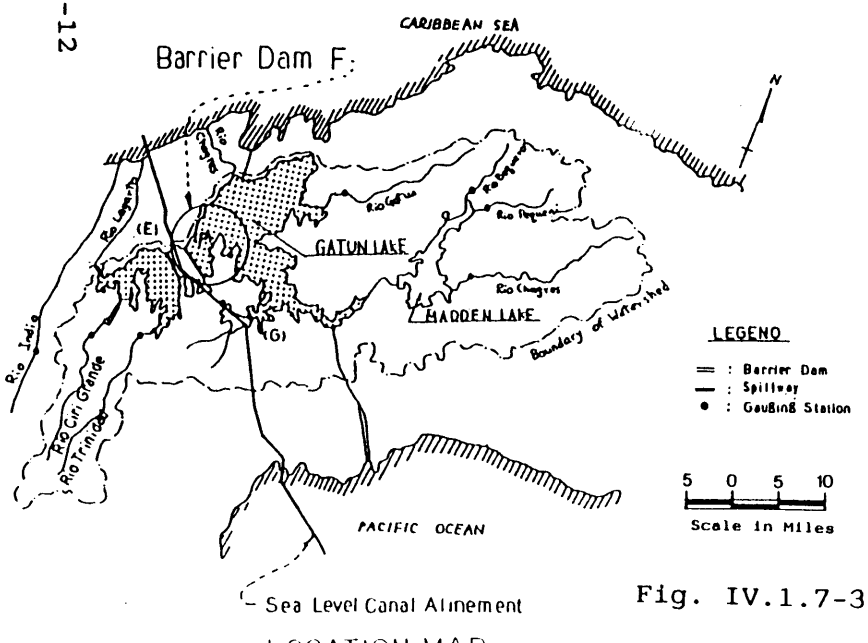
Fig. IV.1.7-3 (1) Barrier Dam (E)



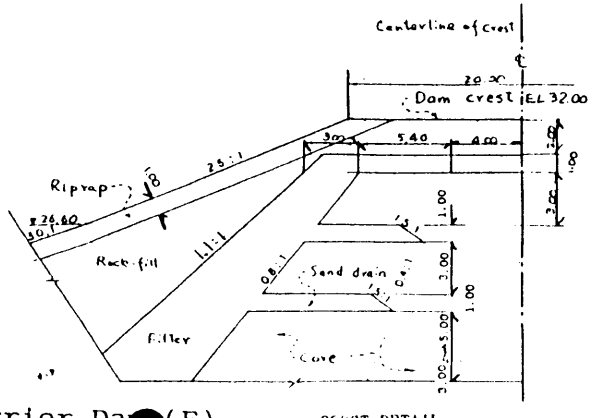
PROFILE ON CENTERLINE OF CREST OF DAM



MAXIMUM SECTION

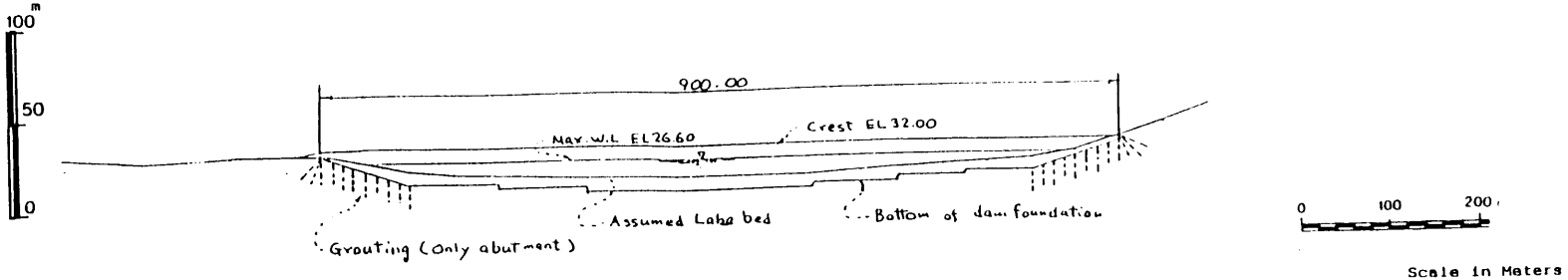


LOCATION MAP

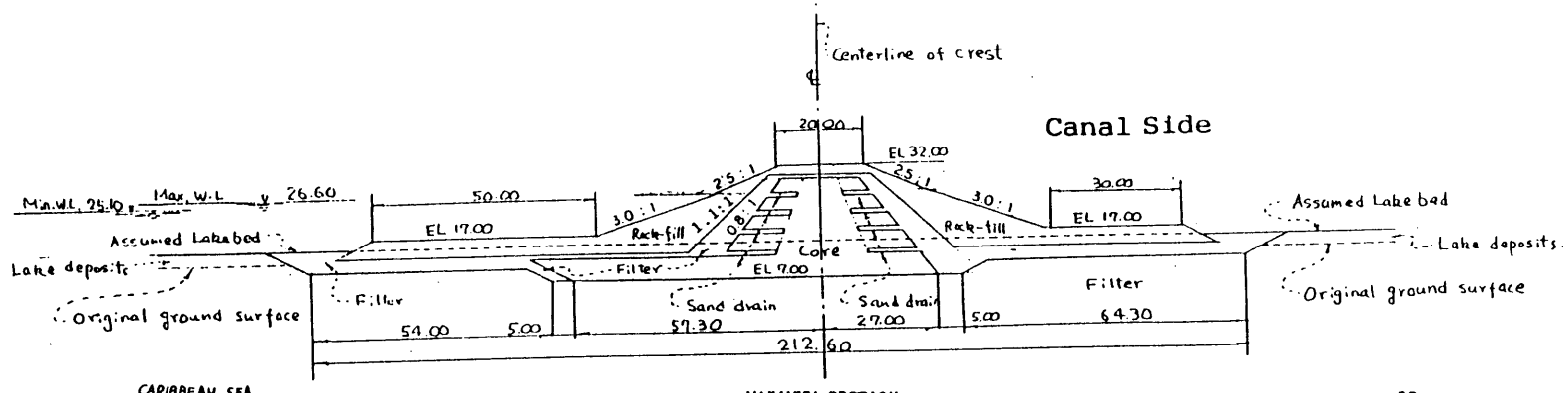


CREST DETAIL

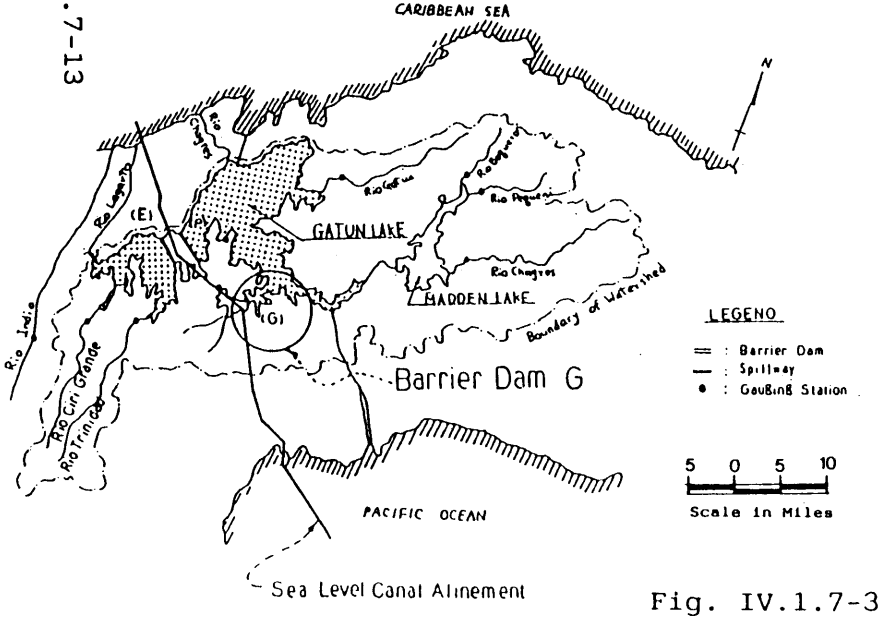
Fig. IV.1.7-3 (2) Barrier Dam (F)



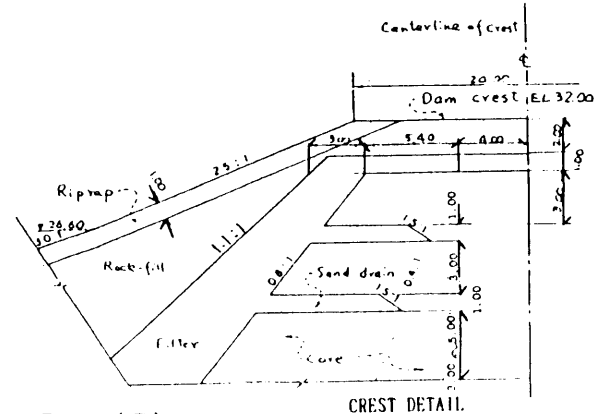
PROFILE ON CENTERLINE OF CREST OF DAM



MAXIMUM SECTION

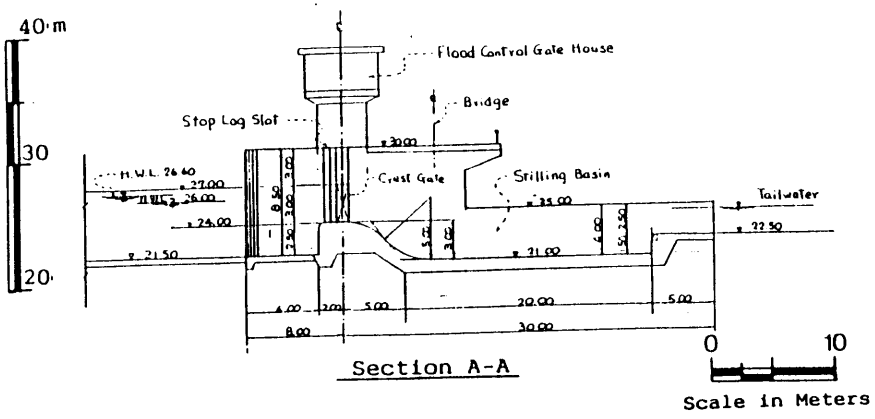


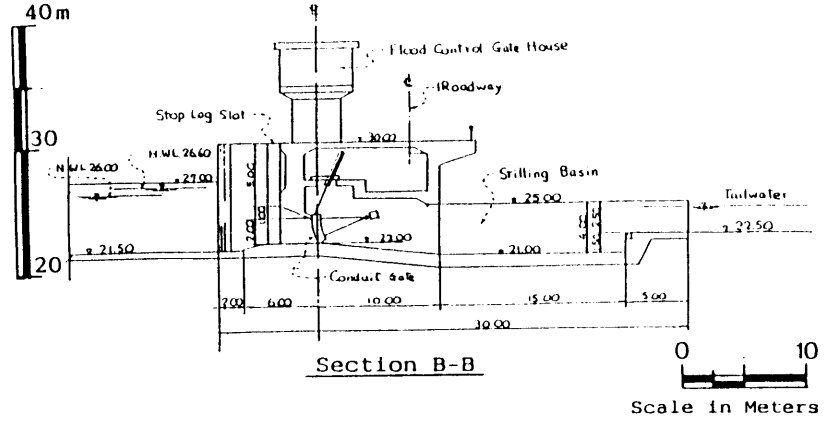
LOCATION MAP

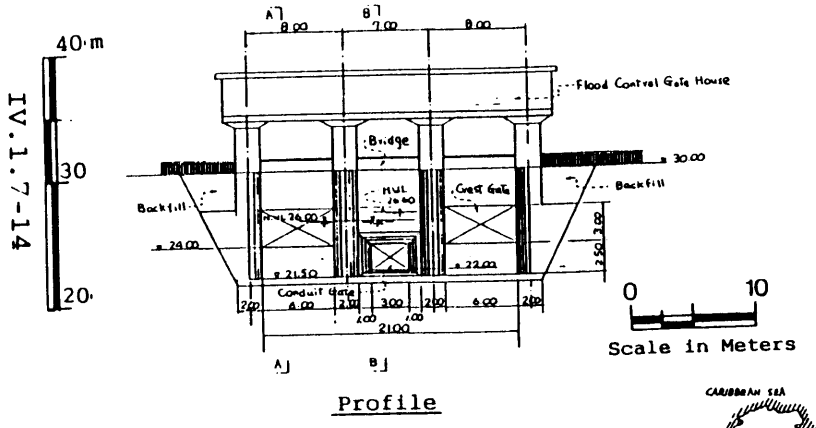


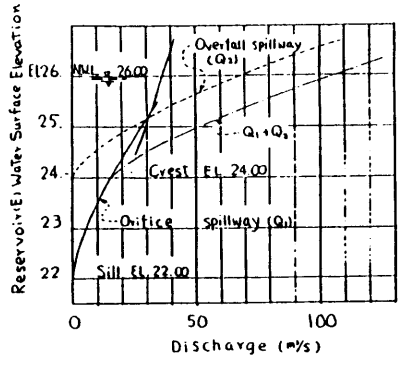
CREST DETAIL

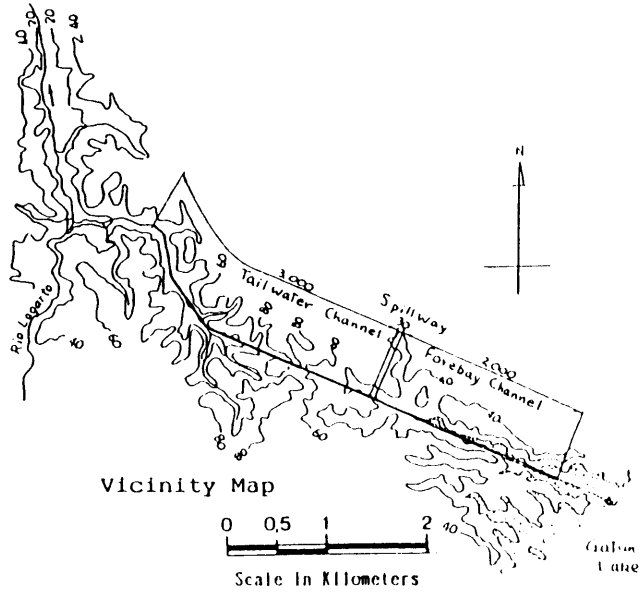
Fig. IV.1.7-3 (3) Barrier Dam (G)











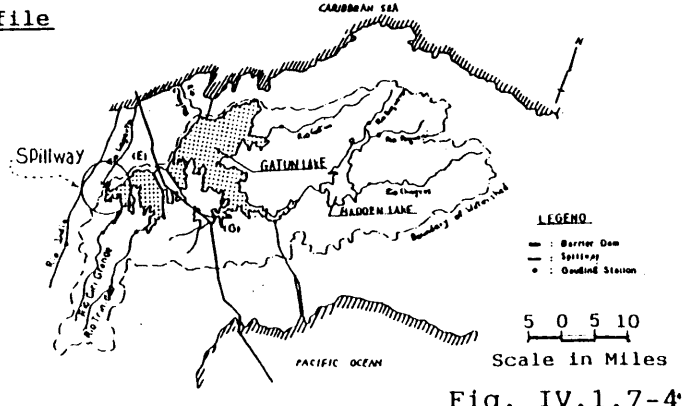


Fig. IV.1.7-4 Typical Spillway and Inlet Structure

7.5 Freshwater Supply Facilities

7.5.1 Freshwater Discharge Structure

A freshwater discharge structure which discharges water to the canal from the reservoir is located at the south-east end of barrier dam (E) and designed for a discharge capacity of 37 m^3/sec. Water levels of the reservoir are planned to be 26.0 m at normal water level and 21.1 m at low water level respectively. A profile of the structure is shown in Fig. IV.1.7-6.

7.5.2 Discharge Culverts

Box type culverts, through which river water (as a fresh-water) can flow down directly into the canal, are planned in the diversion dams (Ref: IV.1 Chapter 8 Diversion Scheme). These culverts are closed during construction and opened after the completion of the construction works. A schematic figure is shown in Fig. IV.1.7-5.

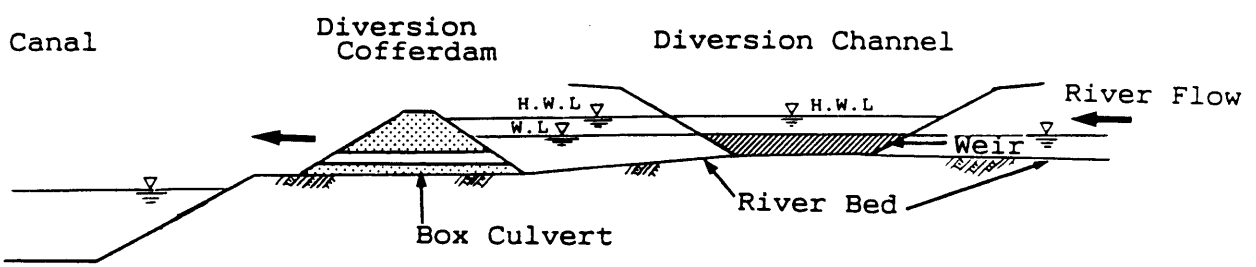


Fig. IV.1.7-5 Discharge Culvert

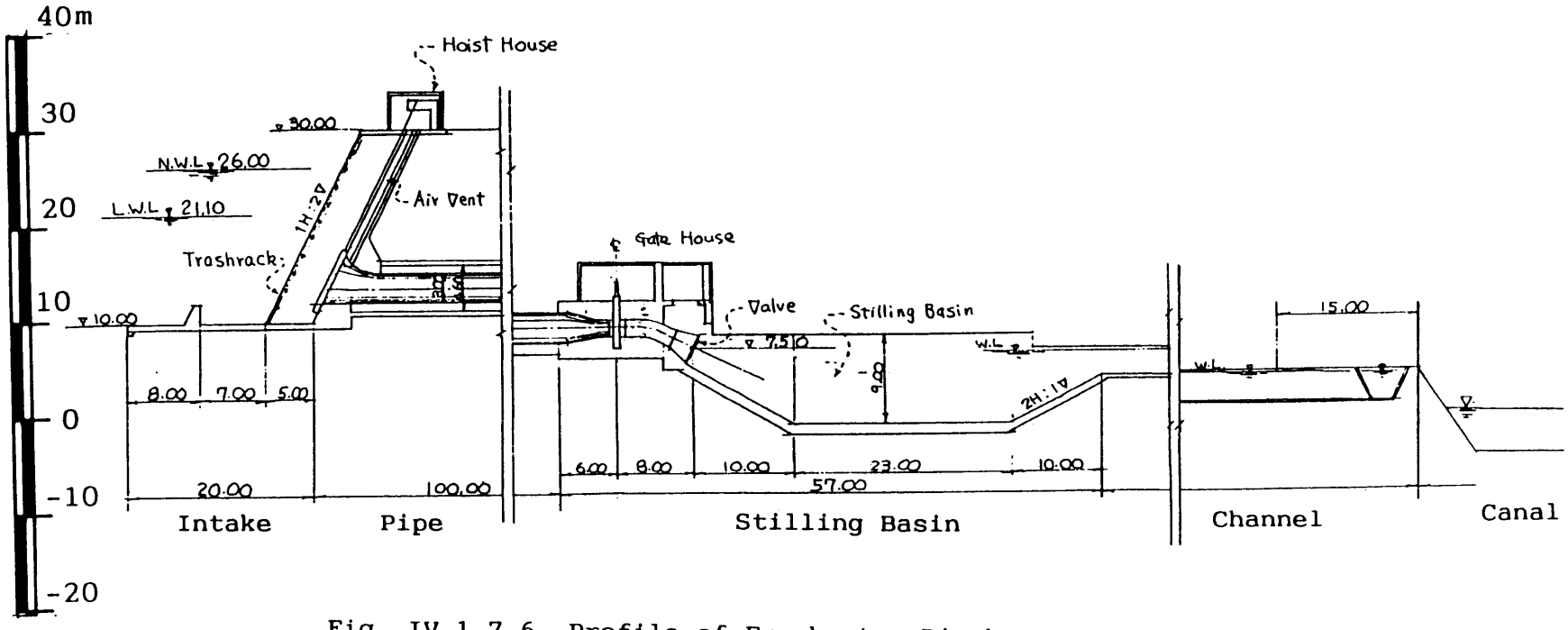


Fig. IV.1.7-6 Profile of Freshwater Discharge Structure

IV.1 CHAPTER 8 - DIVERSION SCHEME

8.1 Introduction

In view of the requirement to inject a huge amount of water into the tidal lock chamber, it is necessary to temporarily store freshwater from rivers in a reservoir and other facilities so that freshwater can function as a barrier system. Reservoir (E) is proposed for this purpose. Freshwater is obtainable from Rio Trinidad and Rio Ciri, both of which directly flow into Reservoir (E). In addition, the use of Rio Los Hules, Rio Chico and Rio Cano is proposed to provide water for Reservoir (E) via diversion channels.

Rio Caimito, the watershed of which differs from the Gatun watershed, also has a large runoff which can be used by the freshwater barrier system. As it is difficult to guide water from Rio Caimito to Reservoir (E) due to topographical reasons, water from Rio Caimito will be independently used. Any water discharge into the canal on the Pacific and Atlantic sides will come directly from rivers without using a reservoir. Major rivers flowing into the Sea Level Canal are listed below for reference purposes.

1) Rio Lagarto (East)
2) Rio Lagarto (West)
3) Rio Trinidad
4) Rio Ciri
5) Rio Los Hules
6) Rio Quebrada Chica
7) Rio Cano
8) Rio Pescado
9) Rio Caimito (East)
10) Rio Caimito (West)
11) Rio Martin Sanchez

The concept of how to use these rivers to create the freshwater barrier are explained above but these rivers would flow into the canal during excavation. The excavation method in main part of the canal is now planned in dry. (Because it is considered that there exist a hard rock layer in the main parts of the canal in Route-10, and the excavation of this hard rock is thought to be very difficult and very expensive if it is dredged.)

For this dry excavation purpose, these rivers should be temporarily diverted so that their runoff does not flow into the canal area directly.

Rio Caimito (west) diversion channel will be filled in and restored and others will be used as permanent diversion channels when the canal is completed.

8.2 Catchment Area of Rivers

There are many rivers in the proposed canal area. The catchment areas of the rivers associated with the construction of the canal is about 970 km^2 (excluding Rio Trinidad and Rio Chiri). The main rivers and their catchment areas are listed in Table IV.1.8-1.

Table IV.1.8-1 Component of Catchment Area

River	Catchment Area (km^2)
Rio Lagarto	243.5
Rio Los Hules	81.3
Quebrada de Chico	8.8
Quebrada la Mendoza	8.0
Rio Cano	75.0
Rio Pescado	32.0
Rio Caimito	472.0
Other	49.5
Total	970.1

8.3 Diversion Dams and Channels

8.3.1 Layout of Dams and Channels

Diversion dams and channels are arranged as shown in Fig. IV.1.8-2(1) - (3).

Dams and channels are listed with their catchment areas to be diverted and non diverted in Table IV.1.8-2.

Table IV.1.8-2 Diversion Dam and Channel

River	Watershed	Catchment Area (km^2)	Divert Area (km^2)	Non Divert Area (km^2)	Dam	Diversion Channel
Rio Lagart	W-1	110.9	105.0	5.9	W-1-D	W-1-C
	W-2	40.8	-	40.8	-	-
	E-1	91.8	76.0	15.8	E-1-D	E-1-C
Others		4.5	-	4.5	-	-
Reservoir F		21.0	-	21.0	-	-
Rio Los Hules	W-3	81.3	79.0	2.3	W-3-D	W-3-C
Quebrada De Chico	W-4	8.8	4.5	4.3	W-4-D	W-4-C
Quebrada La Mendoze	W-5	8.0	5.0	3.0	-	W-6-C
Rio Cano	W-6	75.0	73.0	2.0	W-6-D	
Reservoir G		11.0	-	11.0	-	-
Others		13.0	-	13.0	-	-
Rio Pescado	EW-1	32.0	-	32.0	-	-
Rio Caimito	W-7	303.7	297.0	6.7	W-7-D	W-7-C
	W-8	31.0	-	31.0	-	-
	E-2	137.3	116.0	21.3	E-2-D	E-2-C
Total		970.1	755.5 (77.9%)	214.6 (22.1%)		

8.3.2 Diversion Cofferdam

Diversion Cofferdam sites have been selected in relatively narrow parts of the valley. In order to divert as much of the river discharge as possible, the location of dam sites shall be selected in the lower reaches of the rivers.

The cofferdams are planned considering the topographical, geological and hydrological conditions at the dam sites. The cofferdams are the embankment type and made from excavated material.

Main features of dams are shown in Table IV.1.8-3.

Table IV.1.8-3 Main Features of Diversion Dams

Dam	H.W.L EL (m)	Dam Crest EL (m)	Dam Crest Length (m)	Dam Height (m)
W-1-D	-	10	200	7
E-1-D	10	12	200	10
W-3-D	37.5	40	420	16
W-4-D	43.5	46	500	20
W-6-D	52.0	54	420	30
W-7-D	30.0	32	760	25
E-2-D	-	8	5,000	5

Note: H.W.L = High water level of the reservoir.

8.3.3 Diversion Channel

The channels are cut and filled in the ground of average loam or gravelly loam and unlined earthen channels. Channel side slopes is determined 1-1/2:1 considering stability of the bank materials. The limiting velocity of discharge is considered comparatively low, and hydraulic slope S=0.0002 is selected.

Typical trapezoidal channel section is shown in Fig. IV.1.8-1.

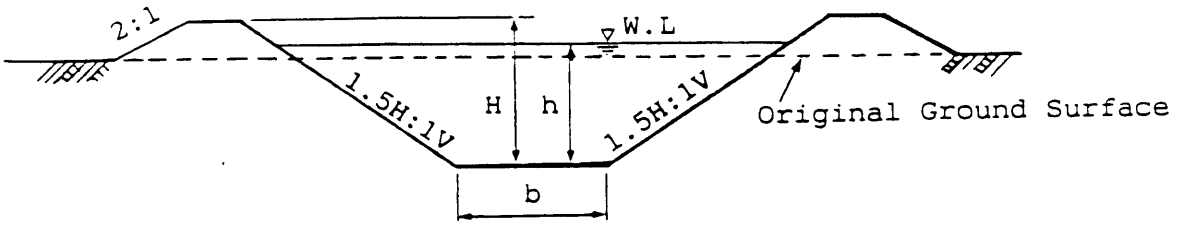


Fig. IV.1.8-1 Typical Channel Section

Main features of diversion channel are shown in Table IV.1.8-4.

Table IV.1.8-4 Proposed Diversion Channels

Diversion Channel	Design Discharge (m3/S)	Channel Length (m)	Bottom Width b (m)	Hydraulic Depth h (m)	H (m)
W-1-C	400*	950	20	7.00	7.50
E-1-C	220	1,300	15	5.50	6.00
W-3-C	460	14,400	25	6.00	6.50
W-4-C	235	1,850	15	5.50	6.00
W-6-C	210	11,750	15	5.50	6.00
W-7-C	850	4,500	30	5.00	5.50
E-2-C	330	4,000	40	5.00	5.50

* Discharge includes 100 m^3/s from spillway of reservoir (E)

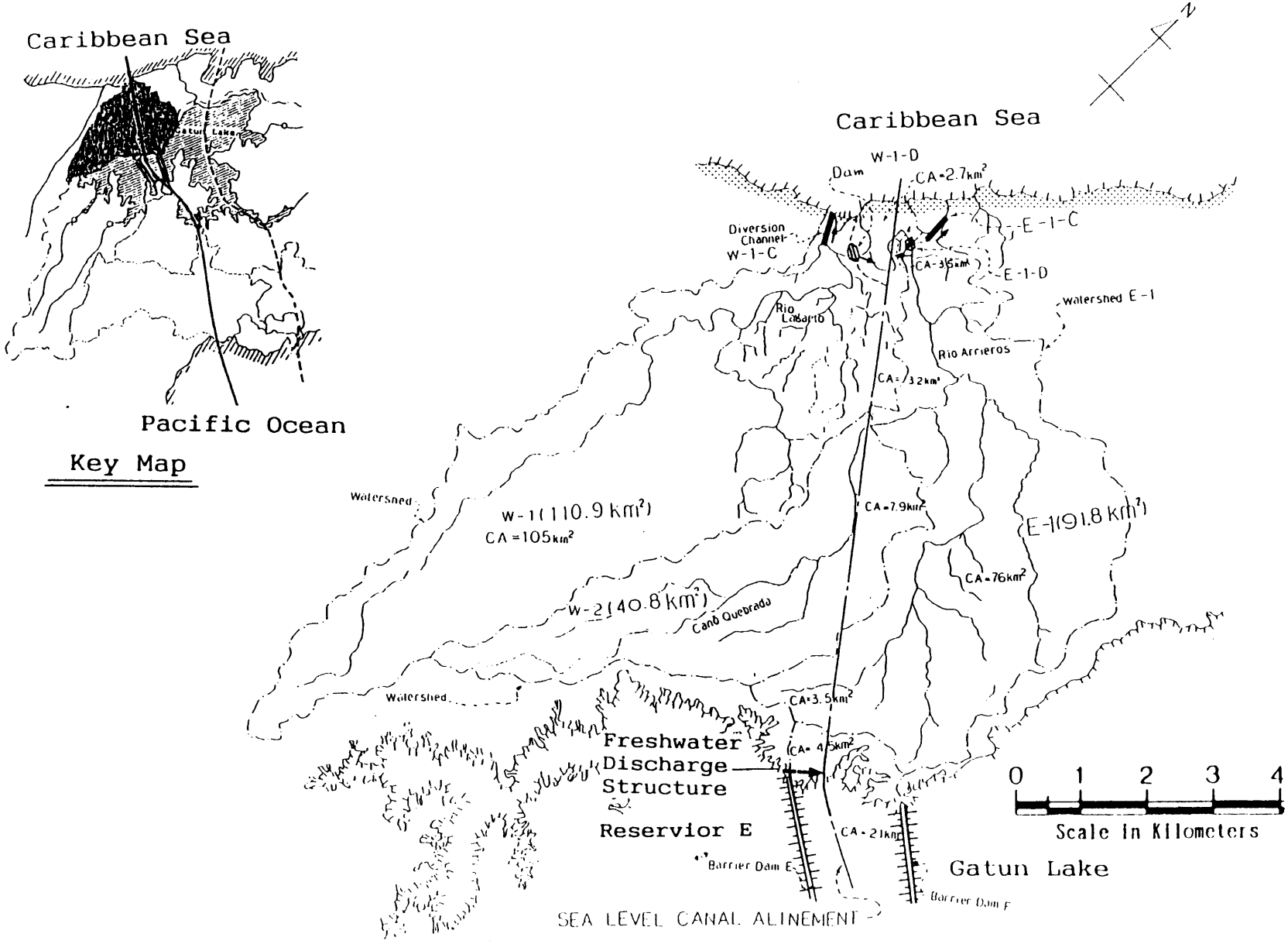


Fig. IV.1.8 2 (1) Diversion Scheme

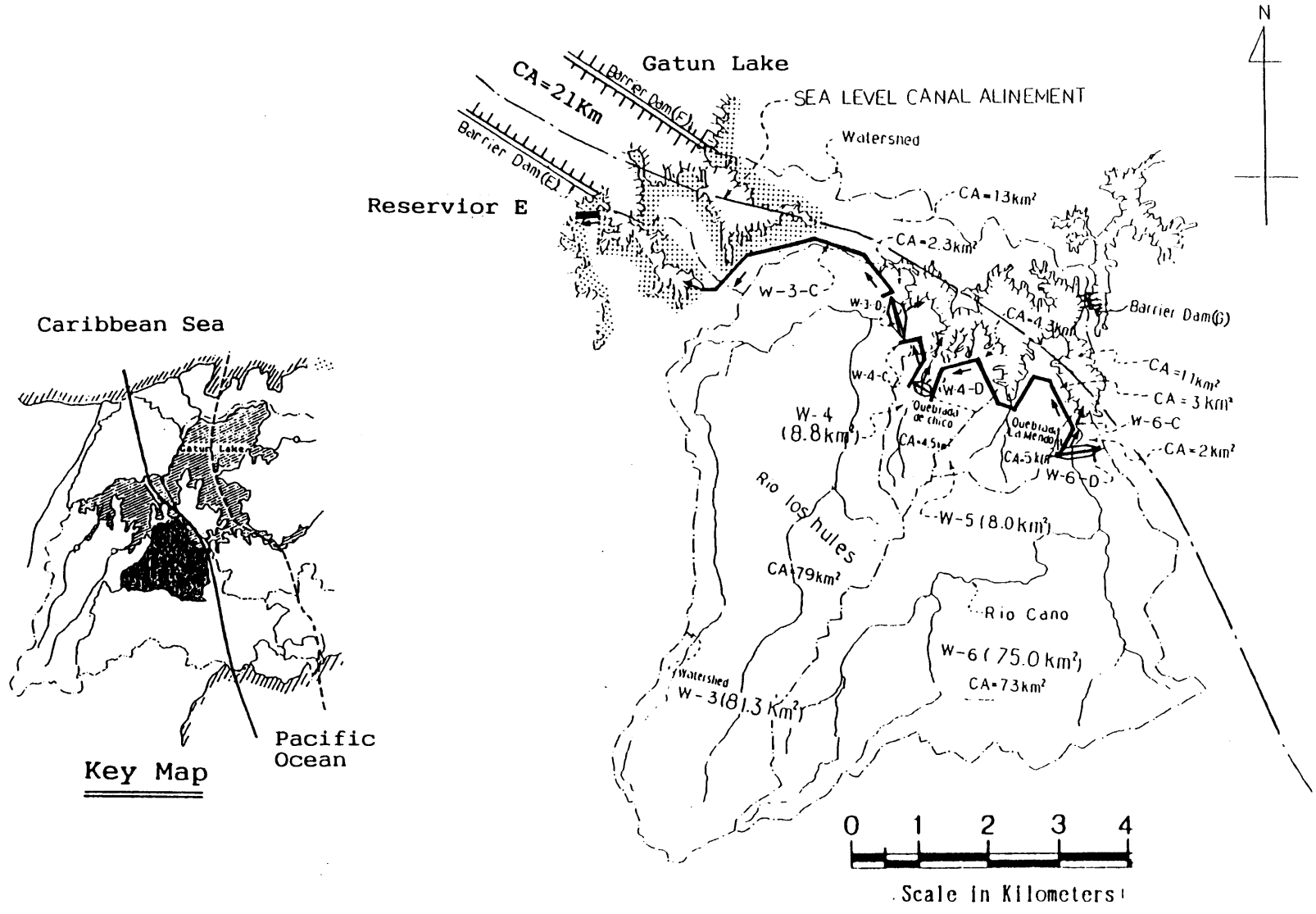


Fig. IV.1.8-2 (2) Diversion Scheme

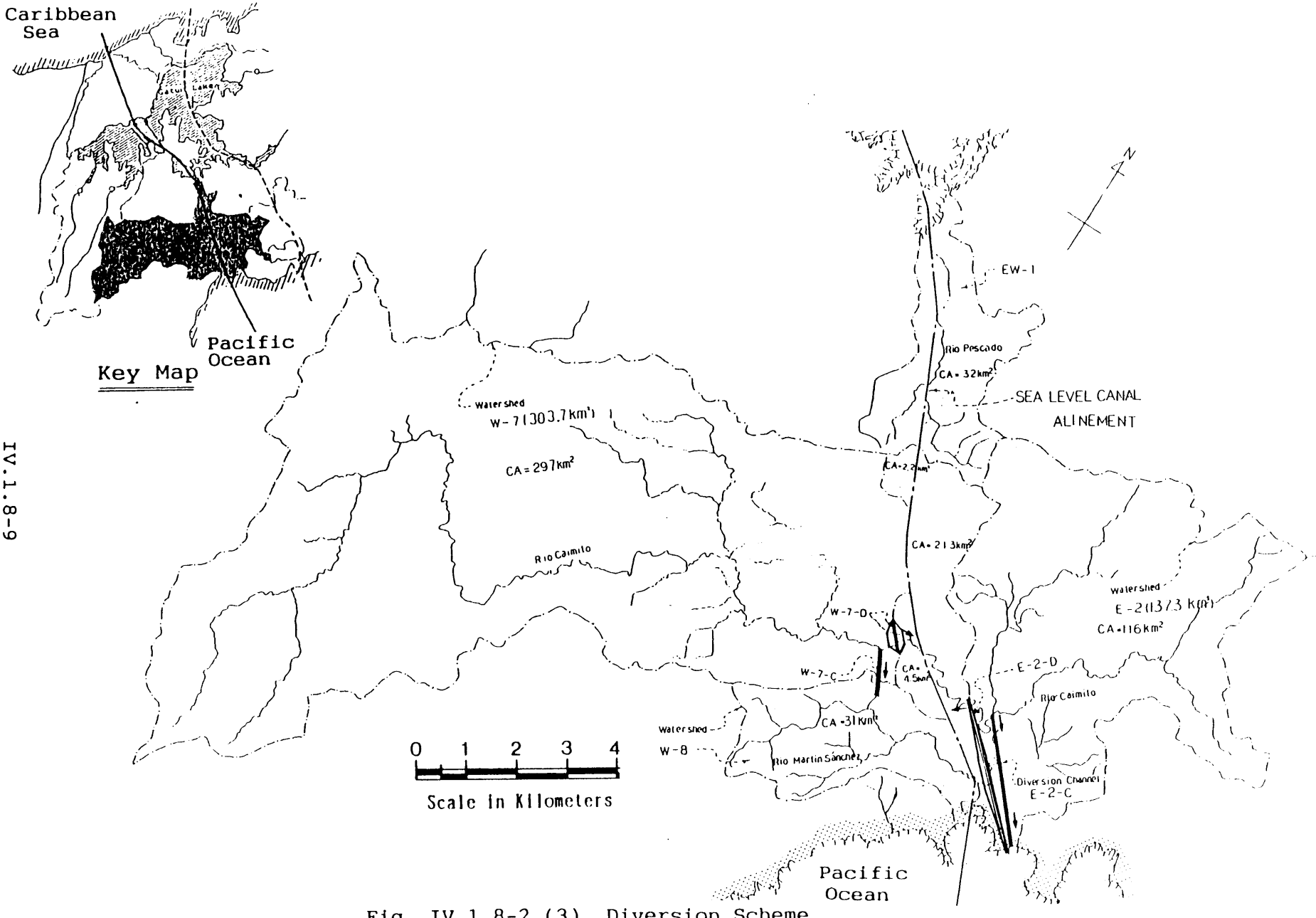


Fig. IV.1.8-2 (3) Diversion Scheme

IV.1 CHAPTER 9 - INCIDENTAL FACILITIES

9.1 Anchorage Area

The OCCE Phase 1 Report gives details of queue length and waiting times for the existing but not for the sea level canal. Anchorage requirements for the latter have therefore been based upon the average number of ships predicted to use the sea level canal increased by a peaking factor of 30%, together with the assumption that all the vessels will arrive in the period when the canal is in use by ships proceeding in the opposite direction and will wish to anchor.

CAS have supplied projected figures for the number of ships using the existing and sea level canals. These figures have been used to estimate the size of anchorages required although they imply there is little transfer of traffic from the existing canal, operating at full capacity to the underused sea level canal. On this basis, the number of ships using each canal is:

Table IV.1.9-1 Canal Transits

	2020		2060	
Direction	North	South	North	South
Existing	8,390	8,090	10,462	8,914
Sea Level	1,440	648	3,433	1,615

The division between north and south bound traffic is on the basis of the WEFA predictions for vessels greater and less than 65,000 DWT.

The OCCE values of queue length and average present waiting times result in the demand for anchorage shown in Table IV.1.9-2. Also included in this table is the demand for anchorage at the sea level canal based on the assumptions given above:

Table IV.1.9-2 Anchorage Requirements

Direction	2020 Atlantic	2020 Pacific	2060 Atlantic	2060 Pacific
Existing	10	4	9	7
Sea Level	5	3	12	6

On the basis of these figures no changes will be required to the present anchorages at both ends of the existing canal.

Ships using the sea level canal will be in the two larger groups for anchorage. The number of Group C vessels (over 100,000 DWTR) expected per year are given in Table III.1.9-3 and will require 2 anchorages in the Atlantic and 1 in the Pacific. (The basics ideas for grouping ships are described in III.1.8.1)

Table IV.1.9-3 Sea Level Transits over 100,000 DWT

	2020	2060
Southbound	542	595
Northbound	109	156

The division of anchorages between the groups is shown in Table IV.1.9-4.

Table IV.1.9-4 Sea Level Canal: Anchorages Provided

	2020		2060	
	Group B	Group C	Group B	Group C
Atlantic	3	2	10	2
Pacific	2	1	5	1

Neither anchorage, as shown in Fig. IV.1.9-1 and IV.1.9-2 requires dredging. So, for both, an area is shown which will satisfy the predicted 2060 demands.

The assumed anchorage area for this purpose is at the ocean end of the approach channel as in the case of the present canal. No dredging work is required as the designated anchorage area has sufficient depth. Mooring facilities are also unnecessary as the vessels will use their own anchors. The main disadvantage of the anchorage area location on the Pacific side is the greater distance. Pilots and boarding officers are required to travel. However, the establishment and maintenance of an inshore location will require dredging as the bay receives a considerable amount of silt from Rio Caimito and these costs must be offset against any operation saving.

A small area of shoal water to the north east of the Rio Lagarto anchorage is shown on the Admiralty chart. If confirmed, it is recommended that this be reduced to give a minimum depth of 27m (15 fathoms).

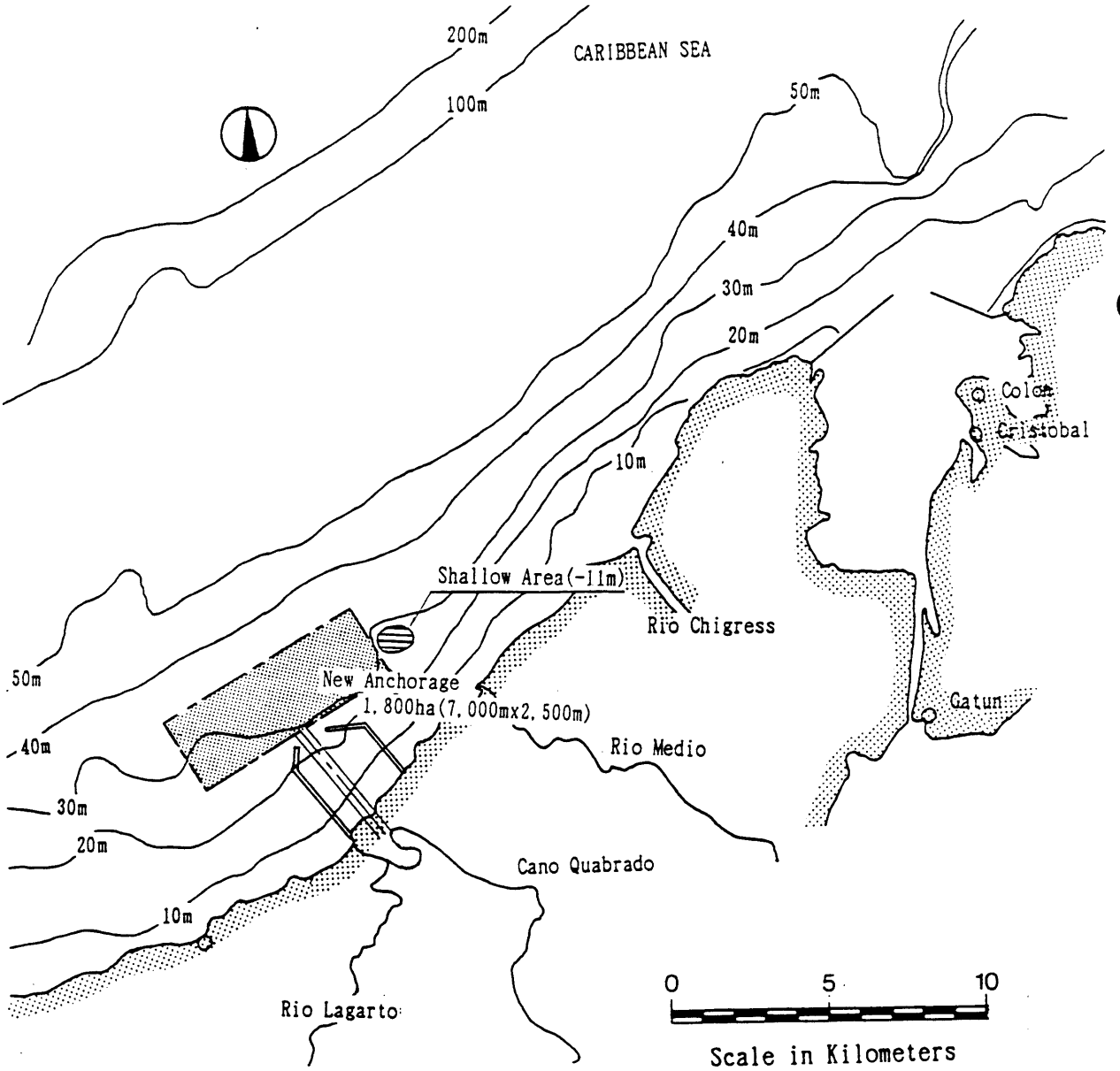


Fig. IV.1.9-1 Anchorage Area of Atlantic Side

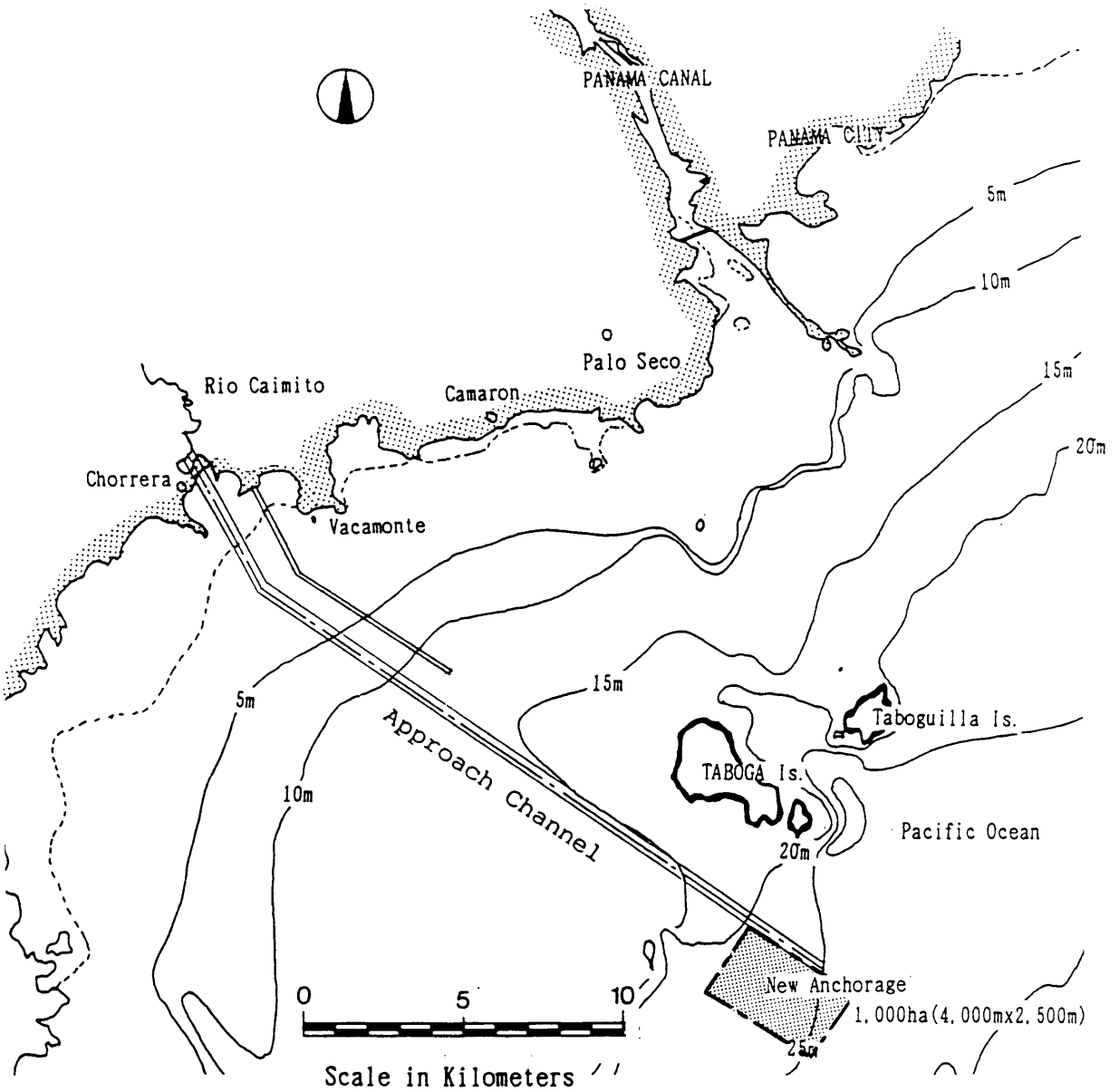


Fig. IV.1.9-2 Anchorage Area of Pacific Side

9.1.2 Tie-Up Stations

Two tie-up stations will be introduced, near barrier dams (E) and (G), and near the Pacific side lock (or gate). They will be available for the mooring of vessels in the canal at the time of an emergency. A dolphin structure will be adopted as in the case of the existing tie-up station.

9.2 Breakwaters

9.2.1 General

It is judged that no new breakwaters are necessary in the case of the High Rise Lock in view of the existing breakwaters on the Colon side and the presence of natural breakwaters formed by Naos, Perico, Falmenco and the road connecting them on the Pacific side. However, the Sea Level Canal requires new breakwaters on both the Atlantic and Pacific sides.

9.2.2 Wave Conditions

The only data available on wave conditions around Panama are the Global Wave Statistics prepared by British Maritime Technology Limited. Data on Area 55 (latitude range: 0°N-10°N and longitude range: 80°W-90°W) are used as they show the wave conditions around Panama. Based on Fig. IV.1.9-3, offshore wave with a 90% appearance coverage is H: 3.0m and T: 8.0 sec. Changes in the wave height caused by the sea depth are shown in Table IV.1.9-5.

Latitude Range 0°N - 10°N
Longitude Range 80°W - 90°W

ALL DIRECTIONS

PERCENTAGE OF OBS = 100.00%
(INCLUDING 5.00% DIRECTION UNKNOWN)

SIGNIFICANT WAVE HEIGHT (m)	<4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	>13	TOTAL
TOTAL	26	153	299	276	155	62	20	5	1	-	-	1000
>14	-	-	-	-	-	-	-	-	-	-	-	-
13-14	-	-	-	-	-	-	-	-	-	-	-	-
12-13	-	-	-	-	-	-	-	-	-	-	-	-
11-12	-	-	-	-	-	-	-	-	-	-	-	-
10-11	-	-	-	-	-	-	-	-	-	-	-	-
9-10	-	-	-	-	-	-	-	-	-	-	-	-
8-9	-	-	-	-	-	-	-	-	-	-	-	-
7-8	-	-	-	-	-	-	-	-	-	-	-	-
6-7	-	-	-	-	-	-	-	-	-	-	-	-
5-6	-	-	-	-	-	-	-	-	-	-	-	1
4-5	-	-	1	1	2	1	1	-	-	-	-	6
3-4	-	1	6	12	11	7	3	1	-	-	-	41
2-3	1	10	42	63	48	23	8	2	1	-	-	196
1-2	6	64	159	153	79	28	7	2	-	-	-	498
0-1	20	79	92	48	15	3	1	-	-	-	-	258

ZERO CROSSING PERIOD (s)

Source: Area 55, Global Wave Statistics, edited by British Maritime Technology Ltd.

Fig. IV.1.9-3 Wave Statistics

Table IV.1.9-5 Wave Height

	Water Depth (m)	Wave Height (m)
Atlantic Side (Slope of Seabottom 1/150)	25	2.8
	20	2.8
	15	2.7
	10	2.8
	5	2.8
Pacific Side (Slope of Seabottom 1/1,000)	25	2.8
	20	2.8
	15	2.7
	10	2.8
	5	2.8

* Deeper Wave Height = 3.0m, Wave Period = 8 sec.

9.2.3 Weights of Armour Stones

The weight of rubble stone covering the slope surface of a structure receiving the action of wave force may be calculated by formula.

$$W = \frac{\Gamma_r H^3}{K_D (S_r - 1)^3 \cot\alpha} \quad \text{..... (5.1)}$$

W: Minimum weight of rubble or concrete blocks (ton)
Γ_r: Unit weight or rubble or block in air (ton/m^3)
S_r: Specific gravity of rubble or block to sea water
α: Angle of the slope to horizontal plane (degrees)
H: Wave height (m)
K_D: Stability coefficient determined by the armouring material and damage rate.

(Applicable to a slope gradient of between 2/3 and 1/5)

(Technical Standards for Port and Harbor Facilities in Japan, 1991, the Overseas Coastal Area Development Institute of Japan)

1) Atlantic Side

Γ_r = 2.65 (ton)
α : $\tan\alpha$ = 1/3
H = 3 (m)
K_D = 2

$$W = \frac{2.65 \times 3^3}{2 \times (2.65/1.03-1)^3 \times 3}$$

$$= 3.0 \text{ (ton)}$$

The weight of rubble (3 ton/rock) is adopted for both the Pacific and Atlantic Ocean.

9.2.3 Alignment of Breakwaters

(1) Atlantic Side

Breakwaters are arranged to shelter the canal approach basin as shown Fig. IV.1.9-4, referring to the existing breakwaters in Cristobal Port.

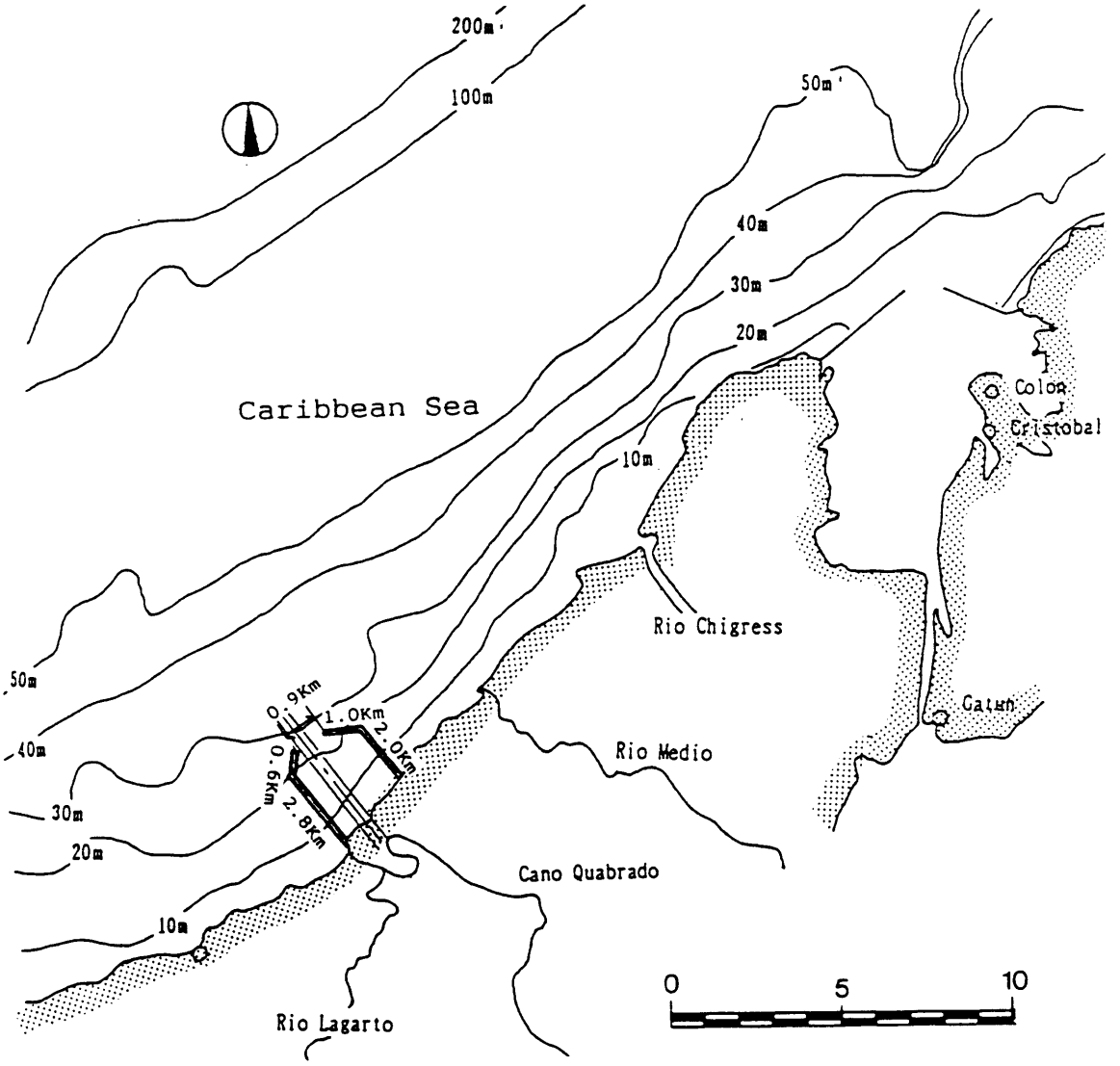


Fig. IV.1.9-4 Layout of Breakwater (Atlantic Side)

(2) Pacific Side

Breakwaters are arranged from the shore line to the point of -12m depth behind Taboga Island, considering sea bottom contour lines and the SE wave direction. The rivermouth of Rio Caimito will be relocated outside the breakwaters in order to prevent sediment inflow from Rio Caimito. In this area the water depth is comparativly shallow with a 1:1000 slope.

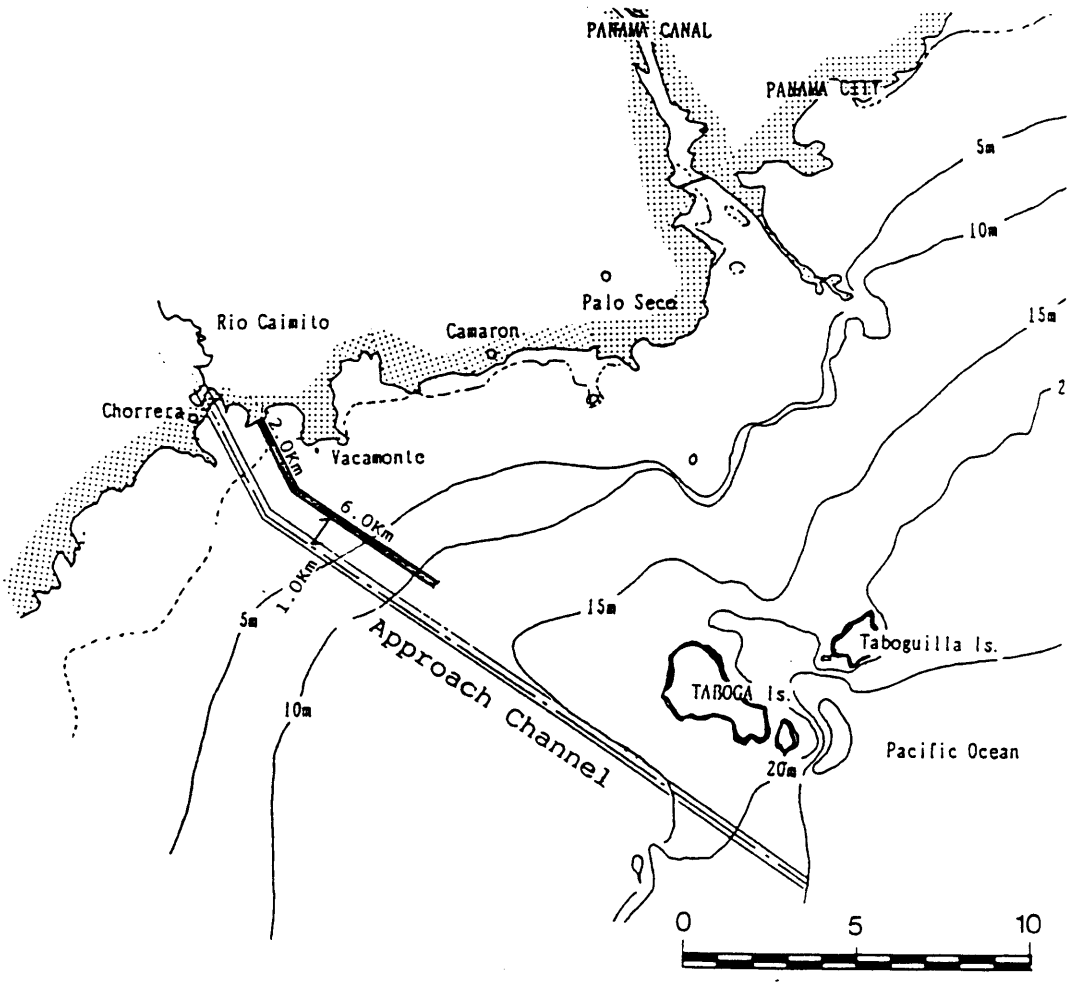


Fig. IV.1.9-5 Layout of Breakwater (Pacific Side)

(2) Standard Section of the Breakwater

Standard Section of the Breakwaters is shown in Fig. IV.1.9-6 and Fig. IV.1.9-7.

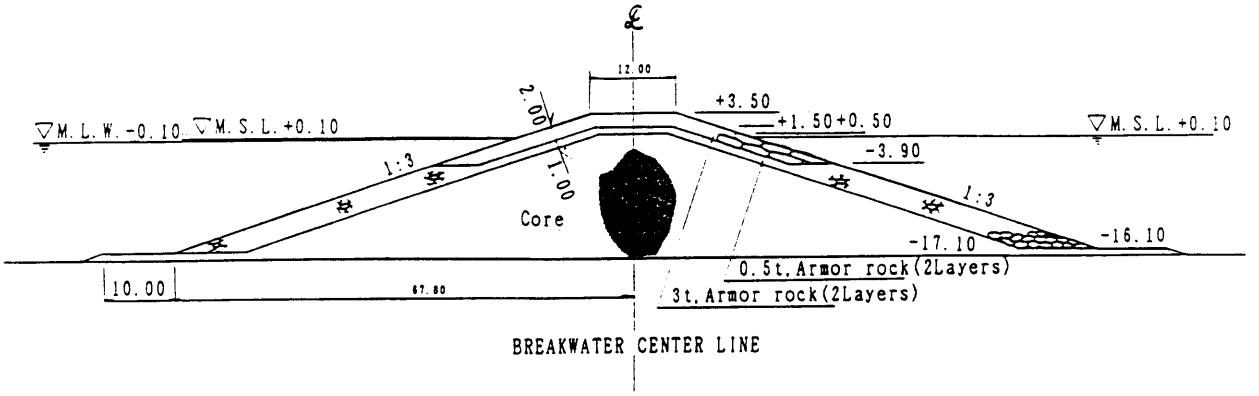


Fig. IV.1.9-6 Standard Section of Breakwater (Atlantic Side)

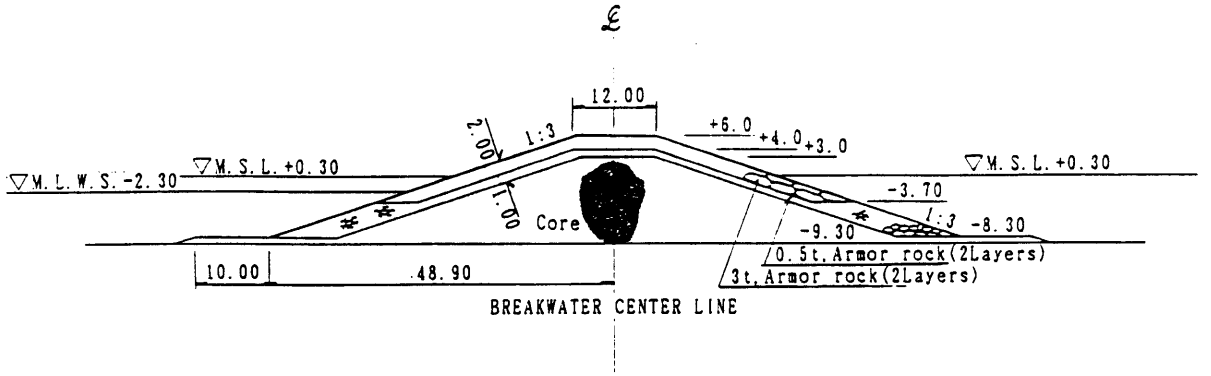


Fig. IV.1.9-7 Standard Section of Breakwater (Pacific Side)

(3) Dimension of Breakwaters

Dimensions and quantities of breakwaters are shown in Table IV.1.9-6 and Table IV.1.9-7.

Table IV.1.9-6 Length and Mean Depth of Breakwaters

		Length			Mean Depth
Atlantic Side	East	3,000 m	Total	6,400 m	-17.0 m
	West	3,400 m			-17.0 m
Pacific Side		8,000 m	Total	8,000 m	- 7.0 m

Table IV.1.9-7 Quantities of Breakwater Materials

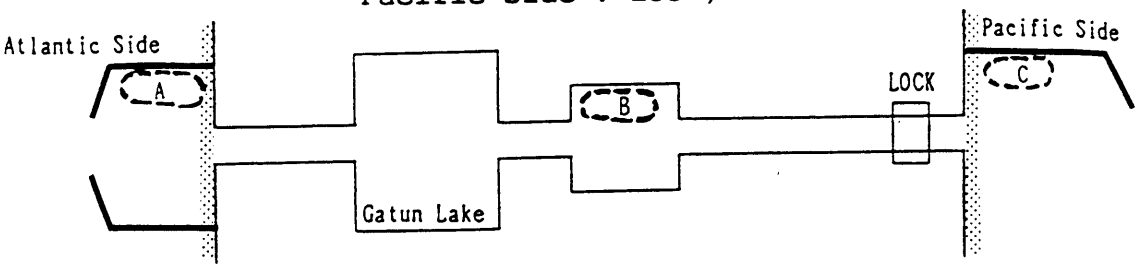
Materials	Atlantic Side	Pacific Side
Core	7,500,000 m^3	6,400,000 m^3
Armor Rock	(0.5 ton/rock) 1,600,000 m^3	(0.5 ton/rock) 1,200,000 m^3
	(3.0 ton/rock) 700,000 m^3	(3.0 ton/rock) 700,000 m^3
Total	9,800,000 m^3	8,300,000 m^3

9.3 Berthing Facilities for Small Boats

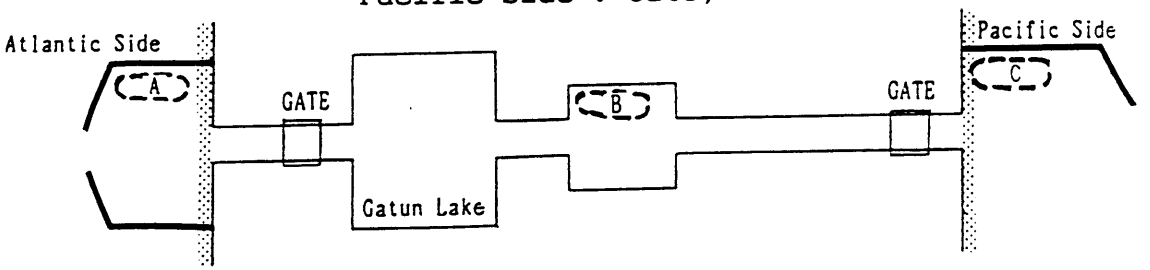
The introduction of jetties for use as berthing facilities for small boats, including tug boats assisting vessels passing through the canal, is planned. A total of 3 jetties will be constructed and each jetty will be 50m in length and 10m wide with a pile foundation and concrete slabs.

A jetty type port facility has been planned at each location in each case. Dimension of jetty and small Boats is same to the High rise lock case.

(1) Case A (Atlantic Side: No Lock nor gate, Pacific Side : Lock)



(2) Case B (Atlantic Side: Gate, Pacific Side : Gate)



(3) Case C (Atlantic Side: Gate, Pacific Side: Lock)

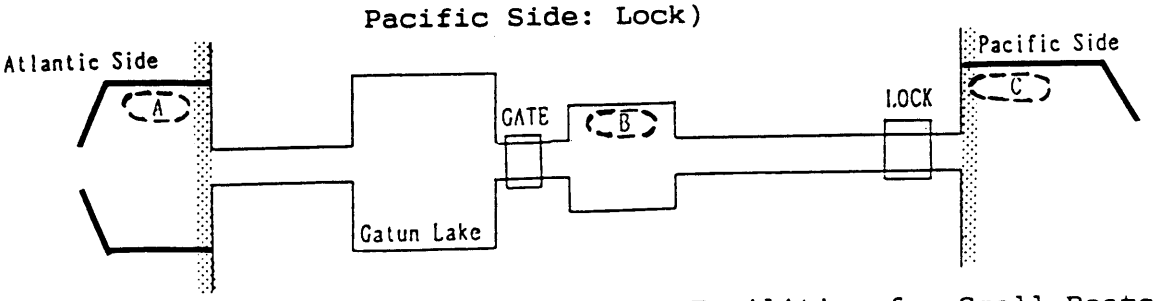


Fig. IV.1.9-8 Areas of Port Facilities for Small Boats

A total of 23 tug boats are required in Case (a), i.e. 8 to assist the navigation of vessels through the canal, 7 to assist the passing of vessels through the lock, 4 for emergencies and 4 as reserves. In contrast, 15 tug boats are required in Case (b), i.e. 8 to assist the navigation of vessels through the canal, 4 for emergencies and 3 as reserves. As in Case (a), Case (c) requires 23 tug boats. The number of small boats to be moored at each station and the number of planned jetties are shown in Table IV.1.9-8.

Table IV.1.9-8 Number of Small Boats and Jetties

(1) Case (a) (Atlantic Side: No Lock nor gate, Pacific Side : Lock)

	A Atlantic Side	B	C Pacific Side
Tugboats	5	5	13
Launches			
- Pilots	4	-	4
- Line handlers	-	3	3
Barges	-	2	-
Tugboats for Barges	-	2	-
Jetties	2	2	3

(2) Case (b) (Atlantic Side: Gate,
Pacific Side : Gate)

	A Atlantic Side	B	C Pacific Side
Tugboats	5	2	8
Launches			
- Pilots	4	-	4
- Line handlers	-	-	-
Barges	-	2	-
Tugboats for Barges	-	2	-
Jetties	2	1	2

(3) Case (c) (Atlantic Side: Gate,
Pacific Side: Lock)

	A Atlantic Side	B	C Pacific Side
Tugboats	5	5	13
Launches			
- Pilots	4	-	4
- Line handlers	-	3	3
Barges	-	2	-
Tugboats for Barges	-	2	-
Jetties	2	2	3

IV.1 CHAPTER 10 - TRANSPORTATION PLAN

10.1 Introduction

This Chapter identifies the improvements and modifications to the existing road network which become necessary due to the permanent works associated with the Sea Level Canal. Access requirements for operation and maintenance of the canal are also included. The existing road network was described in II.1 Chapter 5.

Temporary access roads or diversions which are required only during construction of the canal and not for the permanent works are considered as temporary works and are described and costed in Sections IV.2 and 3. In some cases, access roads necessary for the construction works can be located and designed to become part of the road network improvements required in any case to provide permanent access to both sides of the canal and/or for operation and maintenance of the canal. This helps to reduce costs and also reduces disturbance to the environment.

Wherever possible, the construction works are phased so that continuous access is maintained to all areas. This would normally be achieved by cutting existing roads only after the alternative access or crossing has been provided. In some cases however temporary traffic diversions or road closures may be necessary for periods during construction.

The area traversed by the Sea Level Canal is sparsely populated with the exception of quite heavy corridor development along the Pan American Highway (refer Fig. II.1.5-2). The population densities elsewhere are very low and the road network is not well developed. Many of the roads identified on Fig. II.1.5-3 are minor one-lane roads which are passable only in dry weather. However, permanent access road requirements are more significant for the Sea Level Canal than for the High Rise Lock Canal since there are more existing roads crossing the Route 10

alignment. Access to the areas on both sides of the canal reached by these roads should be maintained.

The allowances for permanent access roads and bridges for the Sea Level Canal are described below.

10.2 Permanent Access Roads

The access road proposals aim to provide at least a similar level of service and convenience after canal construction as is now available. However some loss of convenience is inevitable since the canal bridges represent a significant proportion of the overall cost and the number provided is necessarily limited. Where new permanent access roads are proposed, they are shown on Fig. IV.1.10-1 and are described below. Roads required only for construction purposes are described in IV.2.

Proposals for canal crossings take into consideration observations on site, an assessment of the existing road network shown in Fig. II.1.5-3, the extent to which users would be inconvenienced if a canal crossing was not provided, and possible future improvements in the road network. A rigorous analysis based on existing and future traffic volumes was not possible because of the limited traffic data available (refer II.1 Chapter 5.2.2). Traffic data was available for some major roads only and future traffic data was unavailable.

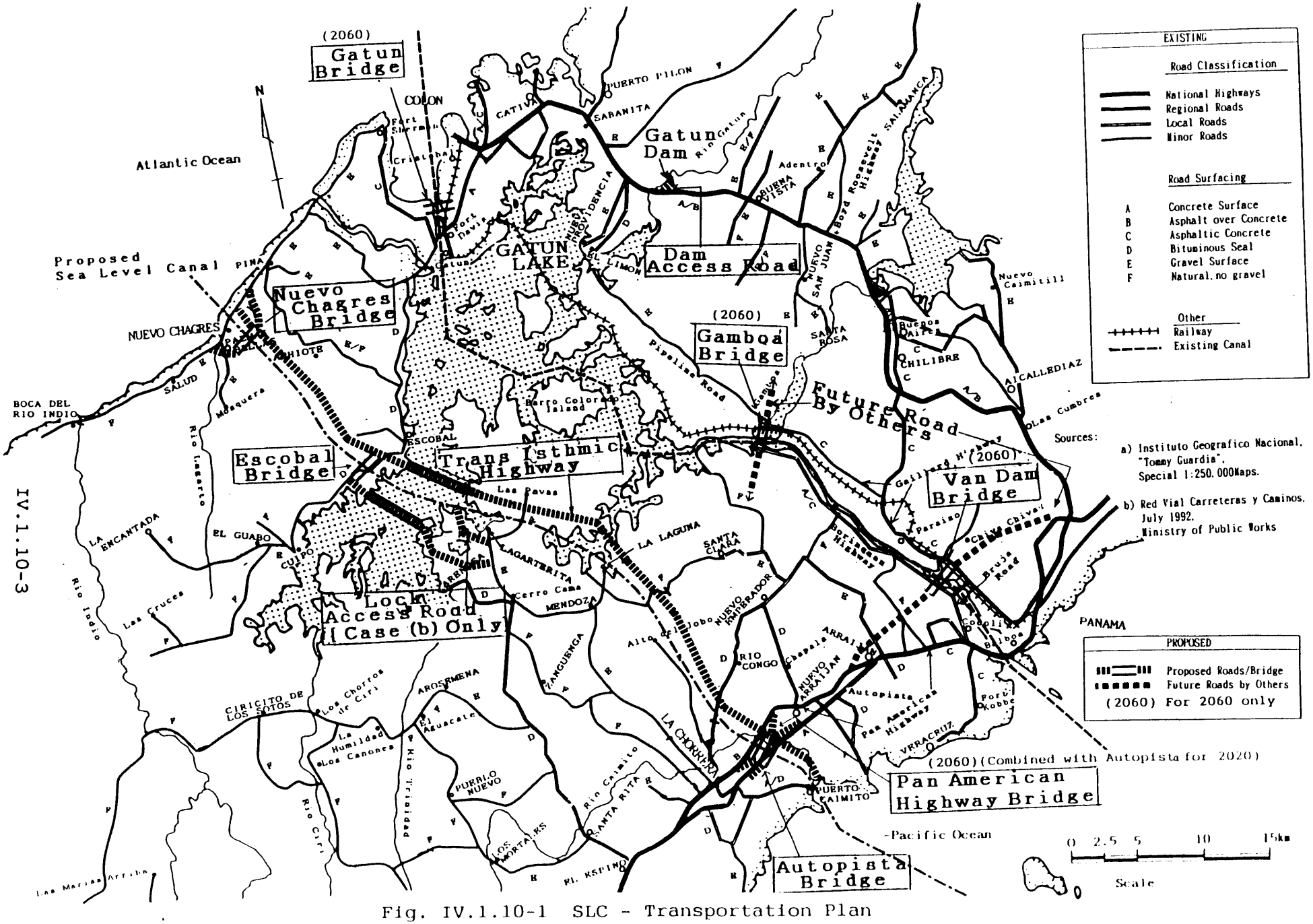


Fig. IV.1.10-1 SLC - Transportation Plan

Four bridges across the Sea Level Canal have been proposed, as described below. Four bridges were also proposed in Part III for the High Lock Canal alternative, across the enlarged canal. However, construction of a Sea Level Canal would effectively create two barriers to the movement of traffic, compared to one in the case of the High Rise Lock Canal. It was therefore agreed with the CAS Secretariat that the cost estimates for the Sea Level Canal would reflect the resulting duplication of bridge requirements and would include bridges over both canals.

Consequently the Sea Level Canal estimates include, in addition to the four bridges over the Sea Level Canal, three bridges over the existing canal at Gatun, Gamboa and Miraflores (Van Dam Bypass). The fourth bridge over the existing canal for the Pan American Highway is not included since the existing canal is not widened and the existing Bridge of the Americas can remain. The costs of the bridges at Gatun, Gamboa and Miraflores, while included, are less than in the case of the High Rise Lock Canal. For the Sea Level Canal these bridges must span across the existing canal only, not the widened canal of the High Rise Lock Canal.

As also agreed with CAS, the construction of the above bridges will be phased, with some bridges provided for the target year 2020 and the remainder included in the works for the target year 2060. Further details of the phasing of bridge crossings are described in IV.1 Chapter 10.3 below.

(1) Trans-Isthmic Road

For the High Rise Lock Canal, road access across the isthmus is conveniently available via the Boyd Roosevelt Highway. In the case of the Sea Level Canal there is no existing trans-isthmic road and the Boyd Roosevelt Highway which crosses the isthmus on the other side of the existing canal is too distant to be practical as the sole road access to the Atlantic side.

A new trans-isthmic road is considered essential for construction of the Sea Level Canal and would be highly desirable for efficient operation and maintenance of the canal after completion. Therefore it has been proposed that the construction access/haul road be designed and located for conversion to a public road on completion of the Sea Level Canal. The trans-isthmic road would be used to provide access for operation and maintenance of the canal but would be open to the public for general usage and tourism.

This proposal is consistent with the IOCS Study which also proposed a new trans-isthmic highway for construction use and as a permanent Highway (Refer IOCS Study, Annexure V, pages V-237 and V-238). The Nagano Plan proposed a road beside the canal but did not specify that the road should be retained as a permanent road.

The proposed alignment of the access road is shown on Fig. IV.1.10-1 and follows the eastern side of the canal alignment, usually between one and two kilometers from the centerline of the canal. The access road has been located on the eastern side for more convenient access to both the canal excavation and the spoil areas which are generally located on the eastern side of the canal. The IOCS Study also proposed that the trans-isthmic road should follow this alignment. Gatun Lake is crossed on the new barrier dam and the total length from coast to coast is about 62.5 km. The terrain is not difficult over most of the alignment and a design speed of 100 km/hr could be achieved. A typical cross section is shown on Fig. IV.1.10-2.

An at-grade connection of the trans-isthmic road to the Pan American Highway will be provided but an interchange with the autopista is not proposed. Access to the autopista is available via the Pan American Highway to interchanges on the autopista within 4 and 5 km to the west and east respectively.

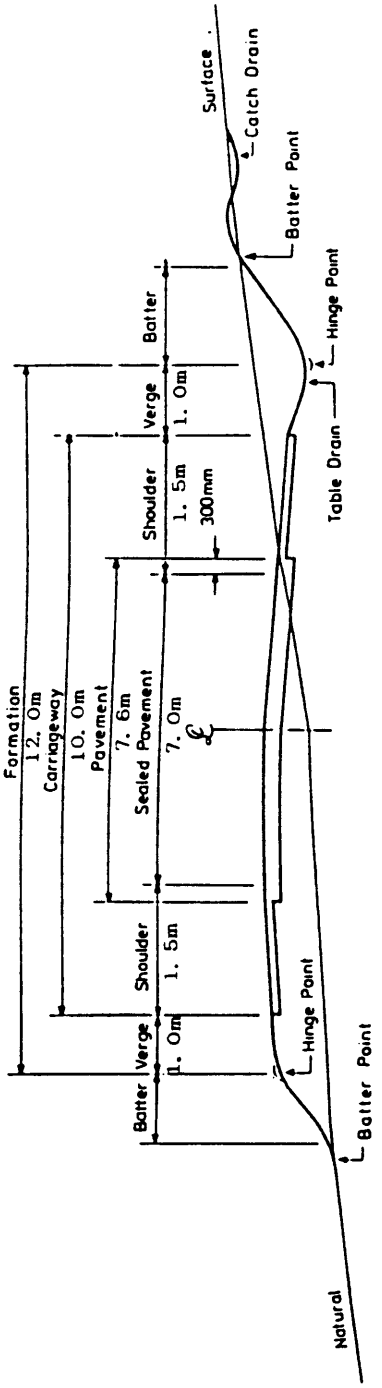


Fig. IV.1.10-2 Typical Section for Trans-Isthmic Road

(2) Atlantic Ocean to Gatun Lake

Although the villages on the Atlantic coast to the west of the Route 10 alignment are small, a canal crossing is necessary to maintain continuity of the regional coast road since alternative access is not available. To reduce the length of the structure required, the proposed crossing location is about 1.5 km inland where the hills provide a convenient approach on either side. The bridge length depends on the canal width at this location; 190m for Case (a) and Case (c), 380m for Case (b). The length of diversion road required is about 4 km and the typical road cross-section is shown on Fig. IV.1.10-3.

The road between Escobal and Cuipo on the north side of Gatun Lake will also be cut by the alignment. Based on available data and site observations, this road is more important and carries more traffic than other roads north of the La Chorrera - Nuevo Emperador road. A bridge crossing has therefore been proposed at this location. The road cross section would be similar to that shown on Fig. IV.1.10-3.

The Escobal bridge will cross a single lane canal in all variations of the Sea Level Canal and the proposed crossing point is near the existing Escobal road; a diversion length of 2 km has been allowed.

(3) Gatun Lake Region

The small village of Las Pavas is now accessed from the road between Cerro Cama and Lagarterita. This access road will be cut off by the Sea Level Canal and alternative access is provided by connecting the village access road to the new trans-isthmic road as shown on Fig. IV.1.10-1.

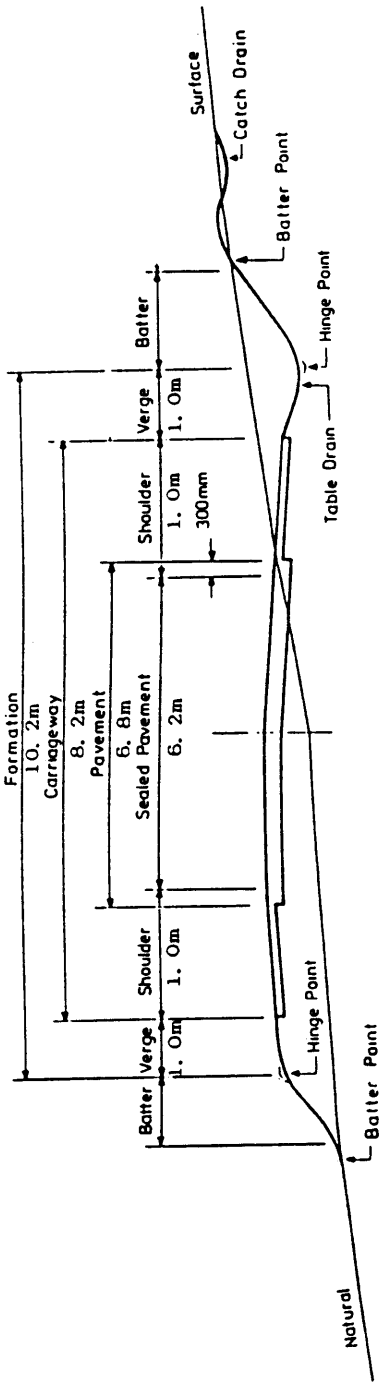


Fig. IV.1.10-3 Typical Section for Minor Paved Roads

A permanent road across the barrier dam to the west of the canal is also proposed. It will be required for maintenance of the dam and will also serve to improve the road network on the west side of the canal. The road cross section would be similar to that shown on Fig. IV.1.10-3.

The villages of Lagarterita and La Laguna are accessed by roads from the south and access is not affected by the canal construction. Minor works will be required where the proposed diversion dikes cross these access roads.

(4) Gatun Lake to Rio Caimito

The existing road between La Laguna and Santa Clara will be cut by the Sea Level Canal. This road is very minor and alternative access is available to this road from both sides of the canal. On the north/east side of the canal the road can be connected to the proposed trans-isthmic road.

The existing regional road between La Chorrera and Neuvo Emperador through Rio Congo will also be cut by the canal alignment but a crossing is not required since a connection to the new trans-isthmic road on the east side of the canal will be provided. Alternative access between La Chorrera and Neuvo Emperador is also available via the road through Chapala. The road would be cut on the west side only with minor inconvenience.

(5) Rio Caimito to Pacific Ocean

In this section the Sea Level Canal crosses two major roads, the Pan American Highway and the autopista toll road which provides alternative access between La Chorrera and Arraijan. Both roads carry considerable traffic volumes and a bridge(s) over the canal is considered essential to carry the traffic using these roads.

Both roads cross the canal alignment very close to the tidal locks in Cases (a) and (c) or the tidal gates in Case (b). The proposed crossing point for all cases is at the tidal structure, allowing effective use of hills on either side to reduce the length of approach structures. For Cases (a) and (c), crossing at the tidal locks also minimizes the required length of the main spans. The approach widening on either side of the tidal locks extends about 6 km in each direction and the cost of the long spans which would be necessary within this 12 km zone would be prohibitive other than at the lock structures.

Short diversions of the autopista and the Pan American Highway are necessary to connect to the new bridge(s). It has been assumed that the two structures are combined for target year 2020 but that a separate additional structure will be provided for 2060. Cost savings might be possible if future planning shows that the two structures could be combined for the target year 2060.

An at-grade connection of the trans-isthmic road to the Pan American Highway will be provided but an interchange with the autopista is not proposed. Access to the autopista is available via the Pan American Highway to interchanges on the autopista within 4 and 5 km to the west and east respectively.

The diversion of the autopista and Pan American Highway will match the existing roads, ie. divided four lanes for the autopista and two lane undivided for the Pan American Highway.

(6) Access to New Dams

The Upper Gatun Dam is required for the year 2060 in the case of the Sea Level Canal to maintain an adequate supply of lockage water for the continued operation of the existing canal. A construction access road is required between the new dam site and

the Boyd Roosevelt Highway and the road would be retained as a paved two-lane road for operation and maintenance purposes after construction.

The proposed road is about 3 km long and the location is shown on Fig. IV.1.10-1.

(7) Access for Operation and Maintenance

The proposed trans-isthmic road will provide the main access for operation and maintenance of the Sea Level Canal. It passes adjacent to each of the tidal lock/tidal gate structures and also connects to the port facilities proposed inside the breakwaters on the Atlantic and Pacific sides.

Proposed roads across all three barrier dams will provide the necessary access for maintaining the dams and associated spillway structures.

For monitoring and maintenance within the canal excavation a gravel road will be provided on the lower berm on each side of the canal. Access to this maintenance road would be provided from existing or proposed roads at regular intervals where the topography is suitable. Access to the maintenance road would also be provided from the operation and maintenance yards adjacent to the tidal lock and tidal gate structures.

With the exception of the Atlantic side tidal gate in Case (c), all of the tidal lock/tidal gate structures are located close to proposed bridges across the Sea Level Canal. While vehicular crossing facilities are not essential at the locks/gates themselves, the additional cost of providing a crossing for use when the gates are closed is relatively small. Therefore an allowance has been included in the cost estimates to allow vehicles to cross over one of the gates at each facility. This facility would allow pedestrian traffic as well and will be convenient for operation and maintenance.

The crossings would not generally be open for public usage.

(8) Summary of New Roads

The proposals for new permanent access roads are summarized for convenience in Table IV.1.10-1 below.

Table IV.1.10-1 SLC - Summary of New Access Roads

Location	No. of Lanes	Typical X-section	Approximate Length	Comments
1.Trans-Isthmic Road	2	Paved	62.5 km	
Nuevo Chagres				
2. Approaches to new bridge	2	Paved	4 km *	Provides access to west of canal.
Escobal Road				
3. Approaches to new bridge	2	Paved	2 km *	Provides access to west of canal
La Chorrera				
4. Pan American Highway	2	Undivided, paved	3 km *	Approaches to new bridge.
5. Autopista	4	Divided, paved	3 km *	Approaches to new bridge.
Access to New Dams				
6. Rio Gatun	2	Paved	3 km	No existing road
Total			77.5 km	

* Excludes length of bridge structure (refer Table IV.1.10-2).

10.3 Summary of Canal Bridges

10.3.1 Phasing of Bridge Construction

As described above, new bridges are proposed at the following locations for the Sea Level Canal:

(a) Bridges across the Sea Level Canal
- (1) Atlantic Coast Road at Neuvo Chagres
- (2) Escobal Road
- (3) Pan American Highway
- (4) Autopista

(b) Bridges across the Existing Canal
- (1) Gatun
- (2) Gamboa
- (3) Van Dam Bypass (Miraflores)

As agreed with the CAS Secretariat, construction of the above bridges will be phased for the years 2020 and 2060. The proposed phasing and number of lanes are as follows:

Table IV.1.10-2 SLC - Phasing of Bridge Construction

Location of bridge	Traffic Count over 24 hours	Year 2020	Year 2060
Over the Sea Level Canal:			
Atlantic	N.A.	1(2 lane) →	
Escobal Rd.	132 (1992)	1(2 lane) →	
Autopista	5501 (1992)]	1(4 lane) →	
Pan American	8114 (1992)]		1(4 lane)
Over the Existing Canal:			
Atlantic	N.A.	-	1(2 lane)
Gamboa	-	-	1(2 lane)
Van Dam Bypass	-	-	1(4 lane)
Pan American	30502 (1992)	- (existing → 3-4 lane)	
Total		3 bridges	4 bridges

N.A. : Traffic Counts Not Available
Note : Refer to Table II.1.5-2 for source of traffic data.

For the year 2020, the autopista and Pan American Highway will share the same 4-lane crossing over the Sea Level Canal. An alternative option for 2020 with similar costs would be to defer construction of the Escobal Road Bridge until the second stage. Access to the villages served by the Escobal Road bridge would be possible across barrier dam (E), and the cost savings could be used to provide additional lanes (ie. more than 4) on the autopista/Pan American highway crossing for the target year 2020.

10.3.2 Bridge Structures

For crossing the open canal the bridge crossings must provide a main span clearance envelope at least 200 m wide and 60 m high. In addition to requiring a substantial central span, the bridge approaches must also be long to achieve the required vertical clearance above the water level. For the span lengths required, the most economic solution for the main spans is a cable stayed bridge. For the approach spans, steel box girders with 60 m spans are proposed. A typical elevation view is shown in Fig. IV 1.10-4 and typical sections are shown in Fig. IV.1.10-5.

For crossing the Sea Level Canal the option of cut and cover tunnels instead of bridges was considered. Reinforced concrete tunnels using a box section could be constructed in the dry by the cut and cover technique. Cost comparisons were carried out but it was found that bridges were more cost effective after considering lighting, ventilation and drainage costs.

For crossing the existing canal, tunnels would also be possible using sunken tubes or boring machines for example. As described for the High Rise Lock Canal, preliminary comparisons indicated that the cable stayed/steel box solution would cost less and involve less risk under the conditions.

Details for each bridge are shown in Table IV.1.10-3 below.

Table IV.1.10-3 SLC - Summary of Bridges

Sea Level Canal - Case (a) and Case (c)

Location of Bridge	Canal Width (m)	Bridge: Lanes No	Bridge: Width (m)	Main Spans Bridge Length (m) L	L1	L2	L3	Approach Length L4
Over the Sea Level Canal:								
Atlantic	190	2	10.0	430	250	90	90	1600
Escobal Rd.	190	2	10.0	630	350	140	140	600
Autopista	190	4	20.5	430	250	90	90	600
Pan American	190	4	20.5	430	250	90	90	600
Over the Existing Canal:								
Atlantic	Exist.	2	10.0	410	230	90	90	1140
Gamboa	Exist.	2	10.0	360	200	80	80	600
Van Dam	Exist.	4	20.5	900	500	200	200	950

Sea Level Canal - Case (b)

Location of Bridge	Canal Width (m)	Bridge: Lanes No	Bridge: Width (m)	Main Spans Bridge Length (m) L	L1	L2	L3	Approach Length L4
Over the Sea Level Canal:								
Atlantic	380	2	10.0	800	440	180	180	1600
Escobal	190	2	10.0	630	350	140	140	600
Autopista	190	4	20.5	430	250	90	90	600
Pan American	190	4	20.5	430	250	90	90	600
Over the Existing Canal:								
Atlantic	Exist.	2	10.0	410	230	90	90	1140
Gamboa	Exist.	2	10.0	360	200	80	80	600
Van Dam	Exist.	4	20.5	900	500	200	200	950

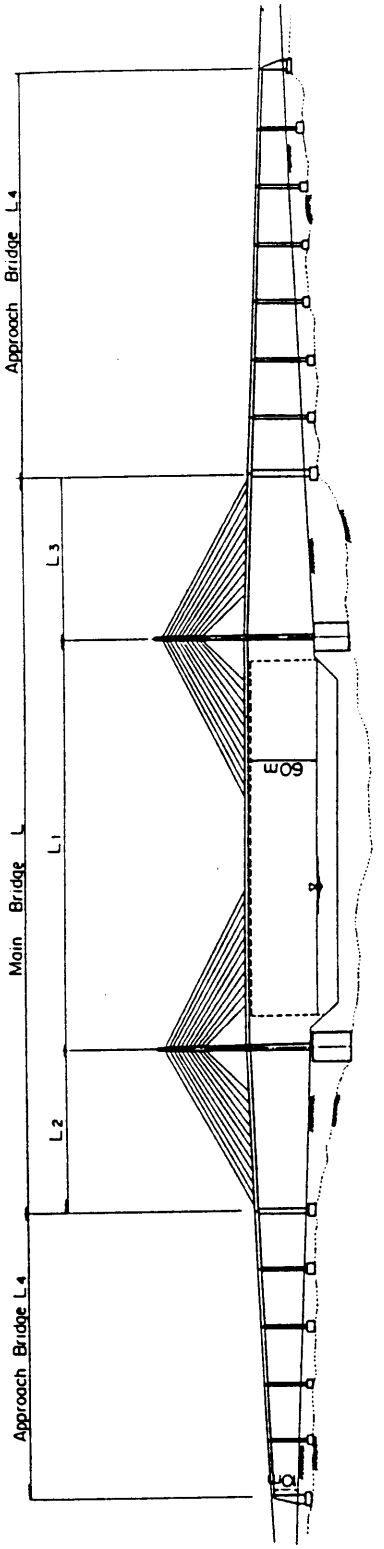
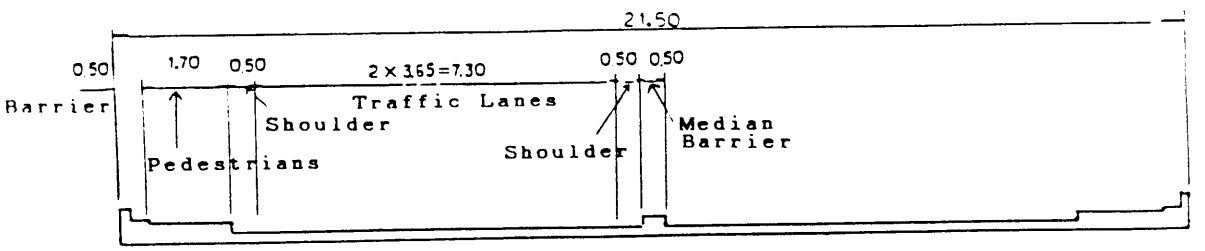
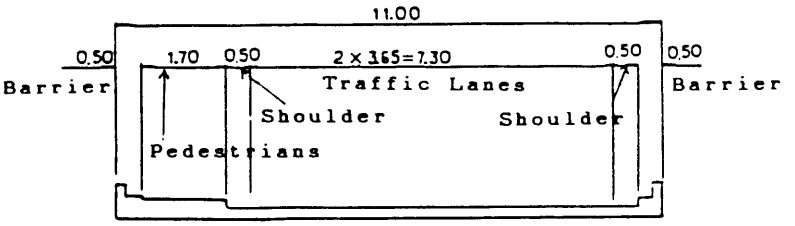


Fig. IV.1.10-4 Typical Elevation for Canal Bridges

Note: All Dimensions in Meters



(a) Four-Lane



(b) Two-Lane

Fig. IV.1.10-5 Typical Sections for Canal Bridges.

10.4 Pedestrian Access

The Terms of Reference require that consideration be given to the provision of pedestrian access. No figures were available for pedestrian volumes using existing roads but site observations suggested that volumes were low.

The bridge crossings proposed for the Sea Level Canal alternative include provision for pedestrian usage, but the height and length of the bridges would discourage most pedestrians. The walkway shown on the typical bridge sections would be primarily for emergency usage.

At the tidal lock and tidal gate structures it would be relatively simple to provide a pedestrian crossing facility which would be available only when ships were not passing. This facility would be convenient for operation and maintenance personnel and could possibly be made available for public usage. The tidal gates will operate on a 6.25 hour cycle and the crossing would not be available for several hours while each convoy passes. The delay for a crossing attached to the tidal lock gates would be considerably less. As described in IV.1 Chapter 10.2 (7), a crossing facility suitable for pedestrians and vehicles would not add significantly to costs and has been allowed for in the cost estimates. One crossing facility has been allowed at each tidal lock or tidal gate facility.

IV.1 CHAPTER 11 - REVIEW OF IMPACT

11.1 Impact on the Existing Canal

The canal route begins in the bay of Chorrera at the mouth of Rio Caimito and reaches the Atlantic Coast side near the mouth of Rio Lagarto via plains, Gatun Lake, and the continental divide.

Route 10 is about 16km from the existing canal route, so the Sea Level Canal construction works would not directly affect the existing canal operations.

11.2 Environmental Impacts

(1) The first and biggest problem is the potential for sea water to flow from the Pacific Coast side to Atlantic Coast side, the direction of net flow. Marine and estuarine plants and animals could be transferred from the Pacific Coast to the Atlantic Coast and the resulting impact could be of the first magnitude.

This potential requires serious study and examination before the construction works begin.

(2) The excavation volume is tremendous. The valleys in the upper reaches of the Rio Caimito on the Pacific Coast side and Rio Los Hules, Rio Pescado, and Rio Chica in the central section of the Canal and Rio Lagarto and Rio Quebrado in the Atlantic Coast side will be used as placing areas for the excavated material. Significant environmental impacts would occur.

The small upstream rivers and streams of these main rivers would be diverted and partially realigned to artificial culverts.

The filling operation and the water way diversions would cause significant changes to the ecology of these areas.

(3) A diversion channel (for flood discharge only) connecting the western part of Gatun lake to Rio Lagarto is planned and this will cause an impact in the surrounding area and to the aquatic creatures in the lake.

(4) The planned breakwaters on both Ocean coast sides will create an impact.

(5) Dredging in both oceans and Gatun Lake will create an impact on marine animals and organisms.

(6) Environmental effects of blasting (Refer III.1 Chapter 10.4)

11.3 Socioeconomic Impact

(1) Dwellings and inhabitants from a village near Puerto Caimito on the Pacific Coast side will be impacted because the village site is at the entrance of the sea level canal.

(2) Dwellings and inhabitants from Nuevo Chagres village located near the mouth of Rio Lagarto in the Atlantic Coast side would be impacted in part.

(3) Transportation infranstructure will also be affected by the new canal. Impacts are described separately in IV.1 Chapter 10.

11.4 Impacts on Real Estate

As an inevitable result of Route 10 canal construction, real estate in and along the canal route must be acquired. As a reference, data on the number of buildings in various villages and/or towns and their areas have been examined and are listed in Table IV.1.11-1.

Agriculture lands, forest areas, swamps and industries areas are also listed in Table IV.1.11-2.

Real estate outside the canal zone required as placing areas for excavated materials from the canal are shown in Table IV.1.11-3 and Table IV.1.11-4.

Table IV.1.11-1 Buildings and Their Areas (in Canal Zone)

TOWN NAME	HOUSE	INDUSTRY	RESTRANT	AREA(M2)	LAND COST($/M2)
Punta Grande	0			0	
Paulino	3			147.060	0.15
Nuevo Chagres	5			36.560	0.15
Llano Bonito	4			105.625	0.15
Vino Tinto	1			8.125	0.15
Cano Quebrado	0			147.875	0.15
La Chunga	1			47.940	0.15
La Tagua	3			13.810	0.25
El Portachuelo	1			26.000	0.25
Quebraon	14			96.680	1.00
Los Negros	1			17.875	1.50
Cano Del Gigant	5			57.680	1.00
La Laguna	7			29.250	1.00
Canito	4			29.250	1.50
Calabacito	6			20.310	1.50
Rio Pescadado	6			49.560	2.00
La Celestina	9			205.725	2.00
Rio Congo Abajo	4			30.875	2.00
Loma Alta	7			371.310	3.00
El Limon	15	1	1	745.065	7.00
Rio Caimito	39	1		34.125	8.00
TOTAL	135	2	1	2.220.700	

Table IV.1.11-2 Various Areas (1) - (4)
(in Canal Zone)

(1) AGRICULTURE		
NO	AREA(M2)	LAND COST($/M2)
1	27.625	0.10
2	649.190	0.08
3	337.190	0.08
4	502.125	0.05
5	946.560	0.10
6	1.785.875	0.10
7	478.560	0.05
8	101.575	0.03
9	288.440	0.03
10	2.669.070	0.10
11	1.009.125	0.15
12	1.464.935	0.15
13	2.179.930	0.15
Total	12.440.200	

(2) FOREST		
NO	AREA(M2)	LAND COST($/M2)
1	2.548.000	0.08
2	426.560	0.05
3	594.750	0.10
4	333.620	0.10
5	340.430	0.05
6	710.930	0.05
7	779.180	0.05
8	284.375	0.05
9	914.060	0.03
10	548.440	0.10
11	284.400	0.15
12	300.655	0.15
TOTAL	8.065.400	

(3) INDUSTRY		
NO	AREA(M2)	COST($/M2)
1	121.900	12.00
2		
3		
4		
TOTAL	121.900	

(4) SWAMP		
NO	AREA(M2)	COST($/M2)
1	44.675	0.80
2	625.625	0.80
3		
4		
TOTAL	670.300	

Table IV.1.11-3 Buildings and Their Areas (in Placing Area)

TOWN NAME	HOUSE	INDUSTRY	RESTRANT	AREA(M2)	LAND COST($/M2)
Paulino	7			250.000	0.15
La Mara Nona	8			99.000	0.15
Cano Quebrado	13			484.000	0.15
La Chunga	2			30.000	0.15
Alto Frijolito	2			30.000	0.15
Las Pavas	65			1.493.500	1.00
Cerro Canito	18			282.000	1.00
La Celestina	12			191.000	2.00
Moscu	0			110.000	2.00
El Limon	3			160.000	2.00
Total	130	0	0	3.129.500	

Table IV.1.11-4 Various Areas (1) - (2) (in Placing Area)

(1) AGRICULTURE		
NO	AREA(M2)	COST($/M2)
1	738.000	0.05
2	2.590.000	0.10
3	1.370.000	0.10
4	3.362.000	0.05
5	1.570.000	0.05
6	3.055.000	0.03
7	4.650.000	0.07
8	6.953.000	0.10
9	7.002.200	0.15
10	1.147.000	8.00
Total	32.437.200	

(2) FOREST		
NO	AREA(M2)	COST($/M2)
1	13.804.000	0.05
2	398.000	0.10
3	490.000	0.10
4	11.000	0.05
5	332.000	0.03
6	253.000	0.07
7	120.000	0.10
TOTAL	15.408.000	

PART-IV Section-2 CONSTRUCTION PLANS

IV.2 Chapter 1. Canal Excavation

1.1 Excavation Method

(1) Clearing and Grubbing of Excavation Area

- Prior to commencing dry excavation, clearing and grubbing is carried out inside the excavation area.
- Quantity

Table IV. 2.1.1 -1 Clearing and Grubbing

Case	a,c	b
Zone I	0	0
Zone II	5,878,000 m^2	9,118,000 m^2
Zone III	2,073,000 m^2	2,073,000 m^2
Zone IV	11,910,000 m^2	11,910,000 m^2
Zone V	0	0
Total	19,861,000 m^2	23,101,000 m^2

(2) Vegetation

- The surface of slopes are sprayed with seeds of vegetation.
- Quantity

Table IV. 2.1.1 - 2 Vegetation

Case	a,b,c
Zone I	12,000m^2
Zone II	2,687,000m^2
Zone III	2,199,000m^2
Zone IV	7,327,000m^2
Zone V	0
Total	12,225,000m^2

(3) Placing Area

- Location of placing areas are shown in the Base Map (scale 1:100,000) together with ecologically sensitive areas.

- Capacity of placing areas is shown in the Table IV. 2.1.1 - 3(a), 3(b).

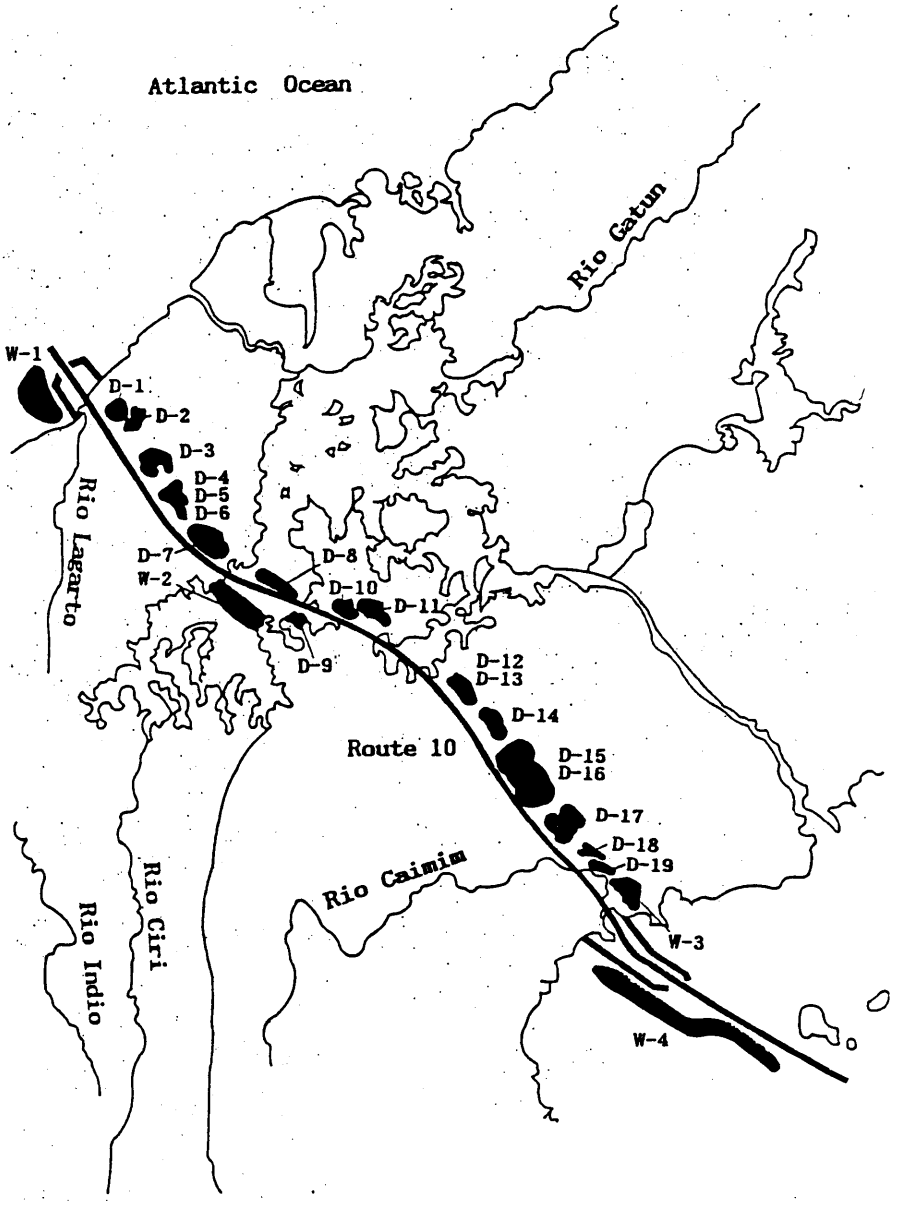


Fig. IV.2.1.1-1 Location of Placing Area

TABLE IV.2.1.1-3(a) PLACING VOLUME AT EACH PLACING AREA

CASE : SEA LEVEL CANAL-250,000 D.W.T.-CASE A & C

File Name PLCS25AC

DRY EXCAVATION					DREDGING				
PLACING -AREA	AREA OF PLACING AREA	PLACING AREA			PLACING -AREA	AREA OF PLACING AREA	PLACING AREA		
		PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION			PLACING VOLUME	AV. HEIGHT OF PLACING	TOP ELEVATION
	(km2)	(m3)	(m)	E.L. (m)		(km2)	(m3)	(m)	E.L. (m)
D-1	2.1	8,603,470	4.1	50.0	W-1	8.8	101,201,486	11.5	-4.0
D-2	2.2	38,078,425	17.3	80.0	W-2	2.6	24,753,501	9.5	21.0
D-3	3.7	39,728,285	10.7	50.0	W-3	5.4	69,931,552	13.0	21.0
D-4	0.2	534,802	2.7	50.0	W-4	17.6	108,457,200	6.2	-4.0
D-5	0.4	2,175,815	5.4	50.0					
D-6	2.2	9,365,063	4.3	50.0					
D-7	4.6	56,990,493	12.4	50.0					
D-8	2.4	38,111,661	15.9	30.0					
D-9	1.6	29,484,000	18.4	70.0					
D-10	1.6	24,840,250	15.5	70.0					
D-11	2.3	56,468,250	24.6	50.0					
D-12	2.1	44,271,500	21.1	50.0					
D-13	2.3	59,795,250	26.0	80.0					
D-14	2.7	52,141,000	19.3	100.0					
D-15	5.3	136,278,250	25.7	130.0					
D-16	8.3	171,789,500	20.7	150.0					
D-17	4.7	124,455,000	26.5	120.0					
D-18	1.3	26,825,528	20.6	60.0					
D-19	1.0	28,200,671	28.2	30.0					
	51.0	948,137,213				34.4	304,343,739		

TABLE IV.2.1.1-3(b) PLACING VOLUME AT EACH PLACING AREA

CASE : SEA LEVEL CANAL-250,000 D.W.T.-CASE B

File Name PLCS25B

DRY EXCAVATION					DREDGING				
PLACING -AREA	AREA OF PLACING AREA (km2)	PLACING AREA			PLACING -AREA	AREA OF PLACING AREA (km2)	PLACING AREA		
		PLACING VOLUME (m3)	AV. HEIGHT OF PLACING (m)	TOP ELEVATION E.L. (m)			PLACING VOLUME (m3)	AV. HEIGHT OF PLACING (m)	TOP ELEVATION E.L. (m)
D-1	2.1	17,492,727	8.3	50.0	W-1	8.8	176,267,553	20.0	-4.0
D-2	2.2	61,627,918	28.0	80.0	W-2	2.6	24,753,501	9.5	21.0
D-3	3.7	69,596,726	18.8	50.0	W-3	5.4	63,237,503	11.7	21.0
D-4	0.2	1,484,127	7.4	50.0	W-4	17.6	87,120,600	5.0	-4.0
D-5	0.4	4,263,101	10.7	50.0					
D-6	2.2	16,836,790	7.7	50.0					
D-7	4.6	74,239,398	16.1	50.0					
D-8	2.4	38,111,661	15.9	30.0					
D-9	1.6	29,484,000	18.4	70.0					
D-10	1.6	24,840,250	15.5	70.0					
D-11	2.3	56,468,250	24.6	50.0					
D-12	2.1	44,271,500	21.1	50.0					
D-13	2.3	59,795,250	26.0	80.0					
D-14	2.7	52,141,000	19.3	100.0					
D-15	5.3	136,278,250	25.7	130.0					
D-16	8.3	171,789,500	20.7	150.0					
D-17	4.7	123,412,000	26.3	120.0					
D-18	1.3	24,989,624	19.2	60.0					
D-19	1.0	26,448,873	26.4	30.0					
	51.0	1,033,570,945	20.3			34.4	351,379,157	10.2	

(4) Quantity of Excavation and Hauling Distance

1) Quantity of excavated and dredged materials and hauling distance, are shown in Tables below.

Table No.	Case No.
IV. 2.1.1 - 4a-1	a & c
IV. 2.1.1 - 4a-2	"
IV. 2.1.1 - 4a-3	"
IV. 2.1.1 - 4b-1	b
IV. 2.1.1 - 4b-2	"
IV. 2.1.1 - 4b-3	"

2) Average Hauling Distance and Quantity for Each Zone

Table IV. 2.1.1 - 4(a) Hauling Distance and Quantity of Excavation

	Case a & c			
	Dry Excavation		Dredging	
	Hauling Distance	Quantity	Hauling Distance	Quantity
		m^3		m^3
Zone I	-	0	2.5 km	16,262,000
Zone II	4.5 km	149,517,000	10.5 km	84,940,000
Zone III	3.5 km	209,416,000	2.0 km	24,754,000
Zone IV	4.0 km	589,204,000	2.5 km	57,369,000
Zone V	-	0	2.5 km	121,020,000
		m^3		m^3
Total		948,137,000		304,345,000

Table IV. 2.1.1 - 4(b) Hauling Distance and Quantity of Excavation

	Case b			
	Dry Excavation		Dredging	
	Hauling Distance	Quantity	Hauling Distance	Quantity
		m^3		m^3
Zone I	-	0	2.5 km	17,494,000
Zone II	4.5 km	239,581,000	10.5 km	158,773,000
Zone III	3.5 km	209,416,000	2.0 km	24,754,000
Zone IV	4.0 km	584,573,000	2.5 km	52,582,000
Zone V	-	0	2.5 km	97,777,000
		m^3		m^3
Total		1,033,570,000		351,380,000

Table IV.2.1.1-5(a)
QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE
SEA LEVEL CANAL - CASE A & C

File Name HAUS25AC

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
-2.80				0						
-2.00		0		0		W-1	1,728,000	2.5	4,320,000	
-1.50		0		0		W-1	2,154,250	2.5	5,385,625	
-1.00		0		0		W-1	2,140,000	2.5	5,350,000	
-0.50		0		0		W-1	2,877,750	2.5	7,194,375	
0.00		0		0		W-1	3,796,500	2.5	9,491,250	
0.50		0		0		W-1	3,565,250	2.5	8,913,125	
Zone I		0		0			16,261,750	2.5	40,654,375	
0.50	D-1	0	3.5	0		W-1	0	2.5	0	
1.00	D-1	884,975	3.0	2,654,925		W-1	2,970,775	3.0	8,912,325	
1.50	D-1	1,500,854	3.5	5,252,989		W-1	2,329,396	4.0	9,317,584	
2.00	D-1	1,626,723	4.0	6,506,892		W-1	1,887,527	4.5	8,493,872	
2.50	D-1	1,762,785	4.5	7,932,533	TOTAL D-1	W-1	1,653,465	5.0	8,267,325	
3.00	D-1	2,828,133	5.5	15,554,732	8,603,470	W-1	2,517,117	5.5	13,844,144	
3.50	D-2	7,898,999	5.0	39,494,993		W-1	3,285,752	6.0	19,714,509	
4.00	D-2	9,048,905	5.5	49,768,979		W-1	2,999,095	6.5	19,494,116	
4.50	D-2	8,574,242	6.0	51,445,454	TOTAL D-2	W-1	4,053,508	7.0	28,374,554	
5.00	D-2	12,556,279	6.5	81,615,810	38,078,425	W-1	4,004,722	7.5	30,035,411	
5.50	D-3	9,404,403	3.0	28,213,209		W-1	2,472,347	8.0	19,778,776	
6.00	D-3	6,329,509	3.5	22,153,282		W-1	2,329,991	8.5	19,804,924	
6.50	D-3	10,717,703	4.0	42,870,813		W-1	2,560,297	8.5	21,762,522	
7.00	D-3	9,663,165	2.5	24,157,913	TOTAL D-3	W-1	3,374,585	9.0	30,371,263	
7.50	D-3	3,613,505	3.0	10,840,514	39,728,285	W-1	3,344,245	9.5	31,770,330	
8.00	D-4	534,802	1.5	802,203	TOTAL D-4	W-1	2,822,698	10.0	28,226,983	
8.50	D-5	0	2.5	0	534,802	W-1	3,409,000	10.5	35,794,500	
9.00	D-5	766,513	2.0	1,533,026	TOTAL D-5	W-1	3,065,237	11.0	33,717,607	
9.50	D-5	1,409,302	2.5	3,523,255	2,175,815	W-1	2,519,698	11.5	28,976,527	
10.00	D-6	1,283,441	5.5	7,058,923		W-1	2,469,310	12.0	29,631,714	
10.50	D-6	3,247,052	5.0	16,235,260		W-1	2,679,698	12.5	33,496,225	
11.00	D-6	3,720,486	5.5	20,462,670		W-1	2,336,765	13.0	30,377,939	
11.50	D-6	1,114,085	6.0	6,684,510	TOTAL D-6	W-1	2,679,665	13.5	36,175,478	
12.00	D-6	0	6.5	0	9,365,063	W-1	3,541,000	14.0	49,574,000	
12.50	D-7	3,889,337	5.5	21,391,351		W-1	3,308,914	14.5	47,979,246	
13.00	D-7	4,630,529	5.0	23,152,643		W-1	3,592,722	15.0	53,890,823	
13.50	D-7	1,581,641	4.5	7,117,386		W-1	4,342,109	15.5	67,302,686	
14.00	D-7	2,927,401	4.0	11,709,605		W-1	3,812,349	16.0	60,997,580	
14.50	D-7	3,791,850	3.5	13,271,473		W-1	3,041,401	16.5	50,183,108	W-1
15.00	D-7	4,718,148	4.0	18,872,590		W-1	1,536,353	17.0	26,117,993	101,201,486
15.50	D-7	5,901,000	4.0	23,604,000		W-2	0	4.5	0	
16.00	D-7	6,709,250	3.5	23,482,375		W-2	0	4.0	0	
16.50	D-7	8,225,500	4.0	32,902,000		W-2	0	3.5	0	
17.00	D-7	8,656,000	4.5	38,952,000		W-2	0	3.5	0	
Zone II		149,516,514	4.4	659,218,305			84,939,736	10.4	882,384,060	
17.00	D-7	0	4.5	0	TOTAL D-7	W-2	0	3.5	0	
17.50	D-7	5,959,838	5.0	29,799,190	56,990,493	W-2	1,570,162	3.0	4,710,486	
18.00	D-8	3,251,040	5.0	16,255,200		W-2	2,988,960	2.5	7,472,400	
18.50	D-8	2,771,981	4.5	12,473,912		W-2	2,548,520	2.0	5,097,039	
19.00	D-8	2,564,041	4.0	10,256,164		W-2	2,761,709	2.0	5,523,418	
19.50	D-8	2,244,150	3.5	7,854,525		W-2	2,742,850	2.0	5,485,700	
20.00	D-8	1,823,551	3.0	5,470,654		W-2	2,206,449	2.0	4,412,898	
20.50	D-8	1,897,691	2.5	4,744,228		W-2	2,273,059	2.0	4,546,118	
21.00	D-8	1,980,751	2.0	3,961,502		W-2	1,990,499	2.0	3,980,999	
21.50	D-8	2,010,186	1.5	3,015,279		W-2	1,638,064	2.0	3,276,129	
22.00	D-8	2,212,145	2.0	4,424,289		W-2	1,679,606	2.0	3,359,211	
22.50	D-8	2,251,904	2.5	5,629,760		W-2	1,604,096	2.0	3,208,192	W-2
23.00	D-8	3,814,472	3.0	11,443,416		W-2	749,528	2.0	1,499,056	24,753,501
23.50	D-8	5,571,000	3.5	19,498,500	TOTAL D-8			3.0	0	
24.00	D-8	5,718,750	4.0	22,875,000	38,111,661			3.5	0	
24.50	D-9	6,273,250	1.0	6,273,250				4.0	0	
25.00	D-9	6,441,250	1.5	9,661,875				1.5	0	
25.50	D-9	5,827,500	2.0	11,655,000				1.0	0	
26.00	D-9	5,529,250	2.5	13,823,125	TOTAL D-9			1.0	0	
26.50	D-9	5,412,750	3.0	16,238,250	29,484,000			1.0	0	
27.00	D-10	5,610,250	2.0	11,220,500				1.5	0	

Table IV.2.1.1-5(b)
QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE
SEA LEVEL CANAL - CASE A & C

File Name HAUS25AC

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
27.50	D-10	6,204,250	1.5	9,306,375				2.0	0	
28.00	D-10	6,608,250	2.0	13,216,500	TOTAL D-10			2.5	0	
28.50	D-10	6,417,500	2.5	16,043,750	24,840,250			3.0	0	
29.00	D-11	6,553,000	5.5	36,041,500				3.5	0	
29.50	D-11	7,691,250	4.5	34,610,625				4.0	0	
30.00	D-11	7,624,750	4.0	30,499,000				4.5	0	
30.50	D-11	6,664,750	4.5	29,991,375				3.5	0	
31.00	D-11	6,317,000	5.0	31,585,000				3.0	0	
31.50	D-11	5,966,250	5.5	32,814,375				2.5	0	
32.00	D-11	5,254,000	6.0	31,524,000				2.0	0	
32.50	D-11	4,838,000	5.5	26,609,000	TOTAL D-11			1.5	0	
33.00	D-11	5,559,250	5.5	30,575,875	56,468,250			1.5	0	
33.50	D-12	6,319,250	3.0	18,957,750				1.5	0	
34.00	D-12	5,620,000	2.5	14,050,000				1.5	0	
34.50	D-12	4,827,250	2.0	9,654,500				2.0	0	
35.00	D-12	4,830,000	2.5	12,075,000				1.5	0	
35.50	D-12	5,519,250	3.0	16,557,750				1.5	0	
36.00	D-12	6,096,000	3.5	21,336,000				2.5	0	
36.50	D-12	5,818,500	4.0	23,274,000	TOTAL D-12			3.0	0	
37.00	D-12	5,241,250	4.5	23,585,625	44,271,500			3.5	0	
37.50	D-13	4,828,000	2.5	12,070,000				4.0	0	
38.00	D-13	5,453,000	2.0	10,906,000				4.5	0	
Zone III		209,416,499	3.4	711,857,618			24,753,501	2.1	52,571,644	
38.00	D-13	0	2.0	0					0	
38.50	D-13	7,234,500	2.0	14,469,000					0	
39.00	D-13	7,576,500	2.5	18,941,250					0	
39.50	D-13	6,763,750	3.0	20,291,250					0	
40.00	D-13	6,895,750	3.5	24,135,125					0	
40.50	D-13	7,019,750	3.0	21,059,250					0	
41.00	D-13	6,885,000	3.0	20,655,000	TOTAL D-13				0	
41.50	D-13	7,139,000	3.5	24,986,500	59,795,250				0	
42.00	D-14	7,700,000	4.5	34,650,000					0	
42.50	D-14	7,989,750	4.0	31,959,000					0	
43.00	D-14	8,716,250	4.5	39,223,125					0	
43.50	D-14	8,812,000	5.0	44,060,000					0	
44.00	D-14	8,622,500	5.5	47,423,750	TOTAL D-14				0	
44.50	D-14	10,300,500	4.5	46,352,250	52,141,000				0	
45.00	D-15	12,644,250	6.0	75,865,500					0	
45.50	D-15	17,656,500	6.5	114,767,250					0	
46.00	D-15	29,498,750	4.5	132,744,375					0	
46.50	D-15	38,775,750	4.0	155,103,000	TOTAL D-15				0	
47.00	D-15	37,703,000	4.5	169,663,500	136,278,250				0	
47.50	D-16	32,918,000	5.0	164,590,000					0	
48.00	D-16	29,608,750	4.5	133,239,375					0	
48.50	D-16	26,950,750	4.0	107,803,000					0	
49.00	D-16	23,857,750	4.5	107,359,875					0	
49.50	D-16	20,958,250	5.0	104,791,250					0	
50.00	D-16	19,208,000	5.5	105,644,000	TOTAL D-16				0	
50.50	D-16	18,288,000	6.0	109,728,000	171,789,500				0	
51.00	D-17	16,094,750	4.5	72,426,375					0	
51.50	D-17	14,922,750	3.5	52,229,625					0	
52.00	D-17	18,441,500	3.0	55,324,500					0	
52.50	D-17	18,097,000	2.5	45,242,500					0	
53.00	D-17	13,987,500	3.0	41,962,500					0	
53.50	D-17	9,230,000	3.5	32,305,000					0	
54.00	D-17	4,991,500	4.0	19,966,000					0	
54.50	D-17	7,874,250	4.5	35,434,125					0	
55.00	D-17	10,472,500	5.0	52,362,500	TOTAL D-17				0	
55.50	D-17	10,343,250	5.5	56,887,875	124,455,000				0	
56.00	D-18	8,897,060	3.0	26,691,180		W-3	2,417,940	4.5	10,880,730	
56.50	D-18	5,420,240	2.5	13,550,599		W-3	4,748,010	4.0	18,992,041	
57.00	D-18	5,433,352	3.0	16,300,055	TOTAL D-18	W-3	4,756,898	3.5	16,649,144	
57.50	D-18	7,074,877	3.5	24,762,068	26,825,528	W-3	5,095,624	3.0	15,286,871	
58.00	D-19	10,522,828	1.0	10,522,828		W-3	6,257,173	2.5	15,642,931	
58.50	D-19	12,352,983	1.5	18,529,475		W-3	7,123,517	2.0	14,247,034	
59.00	D-19	5,324,860	2.0	10,649,720		W-3	7,398,890	1.5	11,098,335	

Table IV.2.1.1-5(c)
QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE
SEA LEVEL CANAL - CASE A & C

File Name HAUS25AC

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
59.50	D-19	0	2.5	0		W-3	7,259,250	1.5	10,888,875	
60.00	D-19	0	3.0	0	TOTAL D-19	W-3	6,806,750	1.5	10,210,125	
60.50	D-19	0	3.5	0	28,200,671	W-3	5,505,000	2.0	11,010,000	
Zone IV		589,204,199	4.2	2,454,651,550			57,369,052	2.4	134,906,086	
60.50		0		0		W-3	0	2.0	0	
61.00		0		0		W-3	4,187,500	2.5	10,468,750	
61.50		0		0		W-3	4,187,500	3.0	12,562,500	W-3
62.00		0		0		W-3	4,187,500	3.5	14,656,250	69,931,552
62.50		0		0		W-4	4,627,250	4.0	18,509,000	
63.00		0		0		W-4	5,052,500	3.0	15,157,500	
63.50		0		0		W-4	5,015,000	3.0	15,045,000	
64.00		0		0		W-4	4,992,000	2.5	12,480,000	
64.50		0		0		W-4	4,992,000	2.5	12,480,000	
65.00		0		0		W-4	4,932,000	2.5	12,330,000	
65.50		0		0		W-4	4,653,500	2.5	11,633,750	
66.00		0		0		W-4	4,022,500	2.5	10,056,250	
66.50		0		0		W-4	3,651,750	2.5	9,129,375	
67.00		0		0		W-4	3,693,250	2.5	9,233,125	
67.50		0		0		W-4	3,586,000	2.5	8,965,000	
68.00		0		0		W-4	3,340,250	2.5	8,350,625	
68.50		0		0		W-4	3,198,250	2.5	7,995,625	
69.00		0		0		W-4	3,195,250	2.5	7,988,125	
69.50		0		0		W-4	2,928,000	2.5	7,320,000	
70.00		0		0		W-4	2,562,500	2.5	6,406,250	
70.50		0		0		W-4	2,467,250	2.5	6,168,125	
71.00		0		0		W-4	2,406,000	2.5	6,015,000	
71.50		0		0		W-4	2,024,750	2.5	5,061,875	
72.00		0		0		W-4	1,739,250	2.5	4,348,125	
72.50		0		0		W-4	1,771,000	2.5	4,427,500	
73.00		0		0		W-4	1,761,500	2.0	3,523,000	
73.50		0		0		W-4	1,703,000	1.5	2,554,500	
74.00		0		0		W-4	1,655,000	1.5	2,482,500	
74.50		0		0		W-4	1,656,000	1.5	2,484,000	
75.00		0		0		W-4	1,656,000	1.5	2,484,000	
75.50		0		0		W-4	1,656,000	1.5	2,484,000	
76.00		0		0		W-4	1,664,750	1.5	2,497,125	
76.50		0		0		W-4	1,664,750	1.5	2,497,125	
77.00		0		0		W-4	1,656,000	1.5	2,484,000	
77.50		0		0		W-4	1,656,000	1.5	2,484,000	
78.00		0		0		W-4	1,656,000	1.5	2,484,000	
78.50		0		0		W-4	1,656,000	1.5	2,484,000	
79.00		0		0		W-4	1,656,000	1.5	2,484,000	
79.50		0		0		W-4	1,656,000	1.5	2,484,000	
80.00		0		0		W-4	1,659,250	1.5	2,488,875	
80.50		0		0		W-4	1,428,500	1.5	2,142,750	
81.00		0		0		W-4	1,200,250	1.5	1,800,375	
81.50		0		0		W-4	1,206,500	1.5	1,809,750	
82.00		0		0		W-4	1,207,000	1.5	1,810,500	
82.50		0		0		W-4	1,221,250	1.5	1,831,875	
83.00		0		0		W-4	768,250	1.5	1,152,375	
83.50		0		0		W-4	310,250	1.5	465,375	
84.00		0		0		W-4	332,000	1.5	498,000	
84.50		0		0		W-4	346,000	1.5	519,000	
85.00		0		0		W-4	356,000	1.5	534,000	W-4
85.60		0		0		W-4	218,700	1.5	328,050	108,457,200
Zone V		0		0			121,019,700	2.4	288,078,925	
Zone I		0					16,261,750			
Zone II		149,516,514					84,939,736			
Zone III		209,416,499					24,753,501			
Zone IV		589,204,199					57,369,052			
Zone V		0					121,019,700			
Total=		948,137,212			948,137,212		304,343,739			304,343,739

Table IV.2.1.1-6(a)
QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE
SEA LEVEL CANAL - CASE B

File Name HAUS25B

Station No.	DRY EXCAVATION PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	DREDGING PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
-2.80				0						
-2.00		0		0		W-1	1,728,000	2.5	4,320,000	
-1.50		0		0		W-1	2,154,250	2.5	5,385,625	
-1.00		0		0		W-1	2,140,000	2.5	5,350,000	
-0.50		0		0		W-1	2,877,750	2.5	7,194,375	
0.00		0		0		W-1	3,796,500	2.5	9,491,250	
0.50		0		0		W-1	4,797,750	2.5	11,994,375	
Zone I		0		0			17,494,250	2.5	43,735,625	
0.50	D-1	0	3.5	0		W-1	0	2.5	0	
1.00	D-1	1,886,455	3.0	5,659,367		W-1	5,776,295	3.0	17,328,884	
1.50	D-1	3,193,058	3.5	11,175,701		W-1	4,955,943	4.0	19,823,770	
2.00	D-1	3,766,503	4.0	15,066,012		W-1	4,300,247	4.5	19,351,112	
2.50	D-1	3,869,871	4.5	17,414,420	TOTAL D-1	W-1	3,629,879	5.0	18,149,395	
3.00	D-1	4,776,840	5.5	26,272,620	17,492,727	W-1	4,260,660	5.5	23,433,630	
3.50	D-2	12,775,689	5.0	63,878,445		W-1	5,319,811	6.0	31,918,866	
4.00	D-2	14,659,866	5.5	80,629,260		W-1	4,864,135	6.5	31,616,874	
4.50	D-2	14,024,066	6.0	84,144,396	TOTAL D-2	W-1	6,629,934	7.0	46,409,538	
5.00	D-2	20,168,297	6.5	131,093,931	61,627,918	W-1	6,481,453	7.5	48,610,898	
5.50	D-3	16,088,126	3.0	48,264,377		W-1	4,462,125	8.0	35,696,996	
6.00	D-3	12,425,216	3.5	43,488,256		W-1	4,623,784	8.5	39,302,164	
6.50	D-3	18,173,977	4.0	72,695,907		W-1	4,440,273	8.5	37,742,323	
7.00	D-3	15,933,445	2.5	39,833,612	TOTAL D-3	W-1	5,776,805	9.0	51,991,247	
7.50	D-3	6,975,963	3.0	20,927,889	69,596,726	W-1	7,151,037	9.5	67,934,852	
8.00	D-4	1,484,127	1.5	2,226,191	TOTAL D-4	W-1	6,411,373	10.0	64,113,730	
8.50	D-5	0	2.5	0	1,484,127	W-1	6,360,750	10.5	66,787,875	
9.00	D-5	1,515,822	2.0	3,031,644	TOTAL D-5	W-1	5,805,428	11.0	63,859,708	
9.50	D-5	2,747,279	2.5	6,868,196	4,263,101	W-1	4,906,472	11.5	56,424,422	
10.00	D-6	2,735,145	5.5	15,043,298		W-1	5,262,355	12.0	63,148,260	
10.50	D-6	5,267,168	5.0	26,335,838		W-1	4,982,583	12.5	62,282,281	
11.00	D-6	6,298,978	5.5	34,644,379		W-1	4,114,272	13.0	53,485,536	
11.50	D-6	2,535,499	6.0	15,212,994	TOTAL D-6	W-1	5,853,751	13.5	79,025,639	
12.00	D-6	0	6.5	0	16,836,790	W-1	7,125,500	14.0	99,757,000	
12.50	D-7	5,922,451	5.5	32,573,483		W-1	5,668,799	14.5	82,197,578	
13.00	D-7	7,345,428	5.0	36,727,140		W-1	6,278,822	15.0	94,182,330	
13.50	D-7	2,992,469	4.5	13,466,112		W-1	8,215,281	15.5	127,336,852	
14.00	D-7	5,303,289	4.0	21,213,157		W-1	7,001,461	16.0	112,023,372	
14.50	D-7	6,741,859	3.5	23,596,507		W-1	5,403,391	16.5	89,155,952	W-1
15.00	D-7	8,251,813	4.0	33,007,250		W-1	2,710,688	17.0	46,081,688	176,267,553
15.50	D-7	8,131,500	4.0	32,526,000		W-2	0	4.5	0	
16.00	D-7	6,709,250	3.5	23,482,375		W-2	0	4.0	0	
16.50	D-7	8,225,500	4.0	32,902,000		W-2	0	3.5	0	
17.00	D-7	8,656,000	4.5	38,952,000		W-2	0	3.5	0	
Zone II		239,580,947	4.4	1,052,352,754			158,773,303	10.4	1,649,172,769	
17.00	D-7	0	4.5	0	TOTAL D-7	W-2	0	3.5	0	
17.50	D-7	5,959,838	5.0	29,799,190	74,239,398	W-2	1,570,162	3.0	4,710,486	
18.00	D-8	3,251,040	5.0	16,255,200		W-2	2,988,960	2.5	7,472,400	
18.50	D-8	2,771,981	4.5	12,473,912		W-2	2,548,520	2.0	5,097,039	
19.00	D-8	2,564,041	4.0	10,256,164		W-2	2,761,709	2.0	5,523,418	
19.50	D-8	2,244,150	3.5	7,854,525		W-2	2,742,850	2.0	5,485,700	
20.00	D-8	1,823,551	3.0	5,470,654		W-2	2,206,449	2.0	4,412,898	
20.50	D-8	1,897,691	2.5	4,744,228		W-2	2,273,059	2.0	4,546,118	
21.00	D-8	1,980,751	2.0	3,961,502		W-2	1,990,499	2.0	3,980,999	
21.50	D-8	2,010,186	1.5	3,015,279		W-2	1,638,064	2.0	3,276,129	
22.00	D-8	2,212,145	2.0	4,424,289		W-2	1,679,606	2.0	3,359,211	
22.50	D-8	2,251,904	2.5	5,629,760		W-2	1,604,096	2.0	3,208,192	W-2
23.00	D-8	3,814,472	3.0	11,443,416		W-2	749,528	2.0	1,499,056	24,753,501
23.50	D-8	5,571,000	3.5	19,498,500	TOTAL D-8			3.0	0	
24.00	D-8	5,718,750	4.0	22,875,000	38,111,661			3.5	0	
24.50	D-9	6,273,250	1.0	6,273,250				4.0	0	
25.00	D-9	6,441,250	1.5	9,661,875				1.5	0	
25.50	D-9	5,827,500	2.0	11,655,000				1.0	0	
26.00	D-9	5,529,250	2.5	13,823,125	TOTAL D-9			1.0	0	
26.50	D-9	5,412,750	3.0	16,238,250	29,484,000			1.0	0	
27.00	D-10	5,610,250	2.0	11,220,500				1.5	0	

Table IV.2.1.1-6(b)
QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE
SEA LEVEL CANAL - CASE B

File Name HAUS25B

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
27.50	D-10	6,204,250	1.5	9,306,375				2.0	0	
28.00	D-10	6,608,250	2.0	13,216,500	TOTAL D-10			2.5	0	
28.50	D-10	6,417,500	2.5	16,043,750	24,840,250			3.0	0	
29.00	D-11	6,553,000	5.5	36,041,500				3.5	0	
29.50	D-11	7,691,250	4.5	34,610,625				4.0	0	
30.00	D-11	7,624,750	4.0	30,499,000				4.5	0	
30.50	D-11	6,664,750	4.5	29,991,375				3.5	0	
31.00	D-11	6,317,000	5.0	31,585,000				3.0	0	
31.50	D-11	5,966,250	5.5	32,814,375				2.5	0	
32.00	D-11	5,254,000	6.0	31,524,000				2.0	0	
32.50	D-11	4,838,000	5.5	26,609,000	TOTAL D-11			1.5	0	
33.00	D-11	5,559,250	5.5	30,575,875	56,468,250			1.5	0	
33.50	D-12	6,319,250	3.0	18,957,750				1.5	0	
34.00	D-12	5,620,000	2.5	14,050,000				1.5	0	
34.50	D-12	4,827,250	2.0	9,654,500				2.0	0	
35.00	D-12	4,830,000	2.5	12,075,000				1.5	0	
35.50	D-12	5,519,250	3.0	16,557,750				1.5	0	
36.00	D-12	6,096,000	3.5	21,336,000				2.5	0	
36.50	D-12	5,818,500	4.0	23,274,000	TOTAL D-12			3.0	0	
37.00	D-12	5,241,250	4.5	23,585,625	44,271,500			3.5	0	
37.50	D-13	4,828,000	2.5	12,070,000				4.0	0	
38.00	D-13	5,453,000	2.0	10,906,000				4.5	0	
Zone III		209,416,499	3.4	711,857,618			24,753,501	2.1	52,571,644	
38.00	D-13	0	2.0	0			0		0	
38.50	D-13	7,234,500	2.0	14,469,000			0		0	
39.00	D-13	7,576,500	2.5	18,941,250			0		0	
39.50	D-13	6,763,750	3.0	20,291,250			0		0	
40.00	D-13	6,895,750	3.5	24,135,125			0		0	
40.50	D-13	7,019,750	3.0	21,059,250			0		0	
41.00	D-13	6,885,000	3.0	20,655,000	TOTAL D-13		0		0	
41.50	D-13	7,139,000	3.5	24,986,500	59,795,250		0		0	
42.00	D-14	7,700,000	4.5	34,650,000			0		0	
42.50	D-14	7,989,750	4.0	31,959,000			0		0	
43.00	D-14	8,716,250	4.5	39,223,125			0		0	
43.50	D-14	8,812,000	5.0	44,060,000			0		0	
44.00	D-14	8,622,500	5.5	47,423,750	TOTAL D-14		0		0	
44.50	D-14	10,300,500	4.5	46,352,250	52,141,000		0		0	
45.00	D-15	12,644,250	6.0	75,865,500			0		0	
45.50	D-15	17,656,500	6.5	114,767,250			0		0	
46.00	D-15	29,498,750	4.5	132,744,375			0		0	
46.50	D-15	38,775,750	4.0	155,103,000	TOTAL D-15		0		0	
47.00	D-15	37,703,000	4.5	169,663,500	136,278,250		0		0	
47.50	D-16	32,918,000	5.0	164,590,000			0		0	
48.00	D-16	29,608,750	4.5	133,239,375			0		0	
48.50	D-16	26,950,750	4.0	107,803,000			0		0	
49.00	D-16	23,857,750	4.5	107,359,875			0		0	
49.50	D-16	20,958,250	5.0	104,791,250			0		0	
50.00	D-16	19,208,000	5.5	105,644,000	TOTAL D-16		0		0	
50.50	D-16	18,288,000	6.0	109,728,000	171,789,500		0		0	
51.00	D-17	16,094,750	4.5	72,426,375			0		0	
51.50	D-17	14,922,750	3.5	52,229,625			0		0	
52.00	D-17	18,441,500	3.0	55,324,500			0		0	
52.50	D-17	18,097,000	2.5	45,242,500			0		0	
53.00	D-17	13,987,500	3.0	41,962,500			0		0	
53.50	D-17	9,230,000	3.5	32,305,000			0		0	
54.00	D-17	4,991,500	4.0	19,966,000			0		0	
54.50	D-17	7,874,250	4.5	35,434,125			0		0	
55.00	D-17	10,138,500	5.0	50,692,500	TOTAL D-17		0		0	
55.50	D-17	9,634,250	5.5	52,988,375	123,412,000		0		0	
56.00	D-18	8,244,473	3.0	24,733,419		W-3	2,229,777	4.5	10,033,997	
56.50	D-18	4,996,463	2.5	12,491,157		W-3	4,376,037	4.0	17,504,149	
57.00	D-18	5,080,350	3.0	15,241,049	TOTAL D-18	W-3	4,432,900	3.5	15,515,151	
57.50	D-18	6,668,339	3.5	23,339,186	24,989,624	W-3	4,802,911	3.0	14,408,734	
58.00	D-19	9,895,946	1.0	9,895,946		W-3	5,886,554	2.5	14,716,384	
58.50	D-19	11,576,947	1.5	17,365,421		W-3	6,673,803	2.0	13,347,606	
59.00	D-19	4,975,980	2.0	9,951,959		W-3	6,773,521	1.5	10,160,281	

Table IV.2.1.1-6(c)
QUANTITY OF EXCAVATION (DRY & WET) AND THE HAULING DISTANCE
SEA LEVEL CANAL - CASE B

File Name HAUS25B

Station No.	DRY EXCAVATION					DREDGING				
	PLACING AREA NO.	(1)VOLUME (m3)	(2)HAULING DISTANCE (km)	(3)=(1)*(2) (m3.km)	PLACED VOL. (m3)	PLACING AREA NO.	(4)VOLUME (m3)	(5)HAULING DISTANCE (km)	(6)=(4)*(5) (m3.km)	PLACED VOL. (m3)
59.50	D-19	0	2.5	0		W-3	6,504,750	1.5	9,757,125	
60.00	D-19	0	3.0	0	TOTAL D-19	W-3	6,080,000	1.5	9,120,000	
60.50	D-19	0	3.5	0	26,448,873	W-3	4,821,250	2.0	9,642,500	
Zone IV		584,573,497	4.2	2,441,094,262			52,581,503	2.4	124,205,926	
60.50		0		0		W-3	0	2.0	0	
61.00		0		0		W-3	3,552,000	2.5	8,880,000	
61.50		0		0		W-3	3,552,000	3.0	10,656,000	W-3
62.00		0		0		W-3	3,552,000	3.5	12,432,000	63,237,503
62.50		0		0		W-4	3,997,500	4.0	15,990,000	
63.00		0		0		W-4	4,429,500	3.0	13,288,500	
63.50		0		0		W-4	4,394,250	3.0	13,182,750	
64.00		0		0		W-4	4,372,500	2.5	10,931,250	
64.50		0		0		W-4	4,372,500	2.5	10,931,250	
65.00		0		0		W-4	4,316,000	2.5	10,790,000	
65.50		0		0		W-4	4,054,250	2.5	10,135,625	
66.00		0		0		W-4	3,461,000	2.5	8,652,500	
66.50		0		0		W-4	3,112,250	2.5	7,780,625	
67.00		0		0		W-4	3,151,250	2.5	7,878,125	
67.50		0		0		W-4	3,050,250	2.5	7,625,625	
68.00		0		0		W-4	2,819,000	2.5	7,047,500	
68.50		0		0		W-4	2,685,500	2.5	6,713,750	
69.00		0		0		W-4	2,683,000	2.5	6,707,500	
69.50		0		0		W-4	2,431,500	2.5	6,078,750	
70.00		0		0		W-4	2,087,250	2.5	5,218,125	
70.50		0		0		W-4	1,997,750	2.5	4,994,375	
71.00		0		0		W-4	1,940,250	2.5	4,850,625	
71.50		0		0		W-4	1,581,250	2.5	3,953,125	
72.00		0		0		W-4	1,312,500	2.5	3,281,250	
72.50		0		0		W-4	1,342,500	2.5	3,356,250	
73.00		0		0		W-4	1,333,500	2.0	2,667,000	
73.50		0		0		W-4	1,278,250	1.5	1,917,375	
74.00		0		0		W-4	1,233,000	1.5	1,849,500	
74.50		0		0		W-4	1,234,000	1.5	1,851,000	
75.00		0		0		W-4	1,234,000	1.5	1,851,000	
75.50		0		0		W-4	1,234,000	1.5	1,851,000	
76.00		0		0		W-4	1,242,250	1.5	1,863,375	
76.50		0		0		W-4	1,242,250	1.5	1,863,375	
77.00		0		0		W-4	1,234,000	1.5	1,851,000	
77.50		0		0		W-4	1,234,000	1.5	1,851,000	
78.00		0		0		W-4	1,234,000	1.5	1,851,000	
78.50		0		0		W-4	1,234,000	1.5	1,851,000	
79.00		0		0		W-4	1,234,000	1.5	1,851,000	
79.50		0		0		W-4	1,234,000	1.5	1,851,000	
80.00		0		0		W-4	1,237,000	1.5	1,855,500	
80.50		0		0		W-4	1,019,500	1.5	1,529,250	
81.00		0		0		W-4	804,500	1.5	1,206,750	
81.50		0		0		W-4	810,500	1.5	1,215,750	
82.00		0		0		W-4	811,000	1.5	1,216,500	
82.50		0		0		W-4	824,500	1.5	1,236,750	
83.20		0		0		W-4	586,600	1.5	879,900	
		0		0		W-4	0	1.5	0	
		0		0		W-4	0	1.5	0	
		0		0		W-4	0	1.5	0	
		0		0		W-4	0	1.5	0	W-4
		0		0		W-4	0	1.5	0	87,120,600
Zone V		0		0			97,776,600	2.4	237,315,525	
Zone I		0					17,494,250			
Zone II		239,580,947					158,773,303			
Zone III		209,416,499					24,753,501			
Zone IV		584,573,497					52,581,503			
Zone V		0					97,776,600			
Total=		1,033,570,943			1,033,570,943		351,379,157			351,379,157

(5) Construction Sequence of Canal Excavation

1) Preceding Construction of Diversion Scheme

a. Prior to commencing dry excavation in each zone, rivers that cross the excavation area are to be diverted. Excavated material obtained from the canal excavation is used for dam embankments.

b. Dams and channels related to each zone are as shown in the table below.

Table IV. 2.1.1 - 7 Diversion Scheme

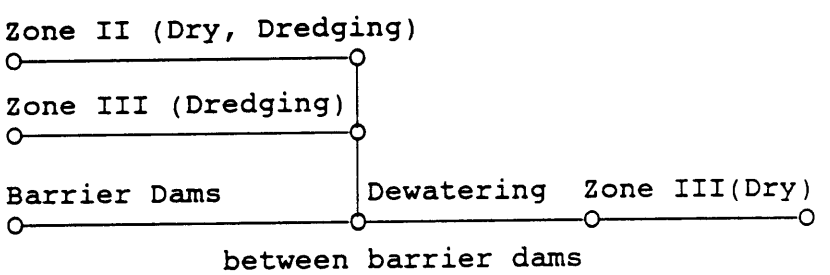
Zone	Dams (Embankment Volume)		Channels (Excavation Volume)	
Zone II	E-1	50,000m^3	E-1	350,000m^3
			W-1	750,000m^3
Zone III	W-3	23,000m^3	W-3	5,200,000m^3
	W-4	22,000m^3	W-4	300,000m^3
	W-6	25,000m^3	W-6	1,800,000m^3
Zone IV	W-7	78,000m^3	W-7	3,000,000m^3
Total		828,000m^3		12,400,000m^3

5 dams and 6 channels in total.

2) Barrier Dams and Canal Excavation

a. Canal Excavation (Zone III) between barrier dams is to be performed by dredging and dry excavation.

b. Construction Sequence



(6) Excavation Method

1) Atlantic Approach Zone (Zone I 4.4 km)

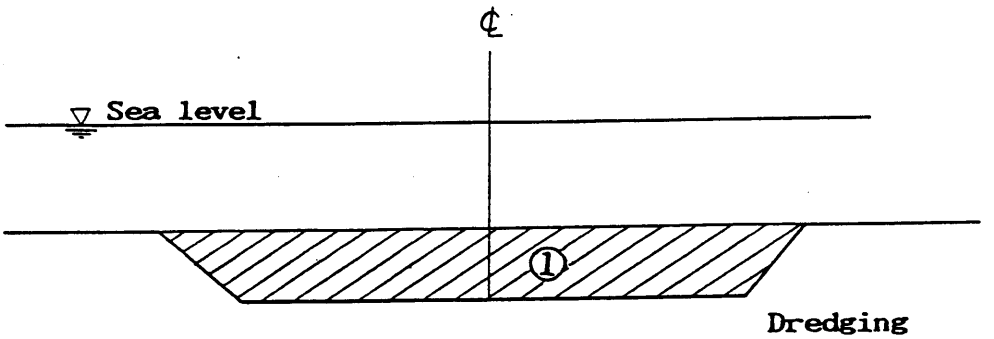


Fig. IV. 2.1.1 - 1(a) Excavation of Zone I

Dredging

- Clayey	Trailing Hopper Grab Dredger	19,000 HP $50m^3$
- Loose	Trailing Hopper Grab Dredger	19,000 HP $50m^3$
- Weathered Rock	Cutter Suction Dredger	27,500 HP

2) Queblado Zone (Zone II 16.5 km)

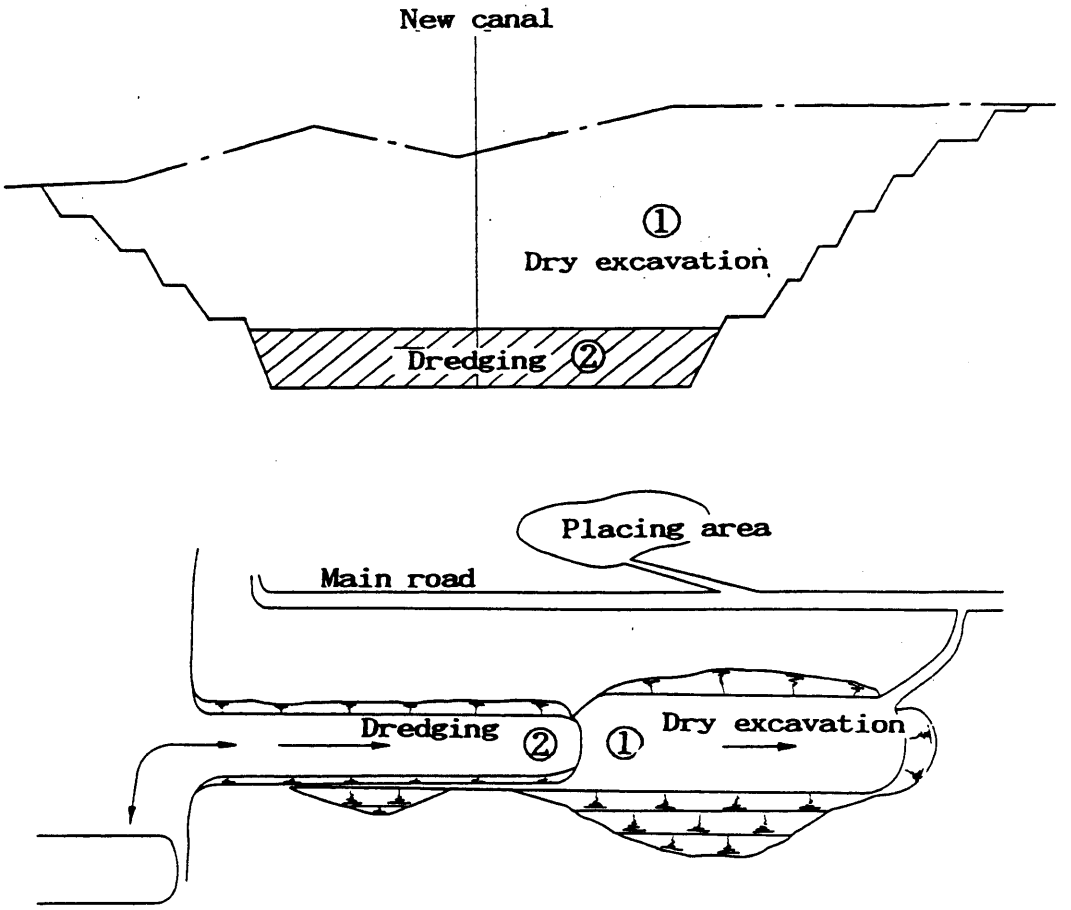


Fig. IV. 2.1.1 - 2 Excavation of Zone II

Dredging

- Clayey		
- Loose	Cutter Suction Dredger	27,500 HP
- Weathered Rock	Cutter Suction Dredger	27,500 HP
- Medium Hard Rock	Cutter Suction Dredger	27,500 HP
- Hard Rock	Blasting Barge Grab Dredger	 $50m^3$

3) Gatun Lake Zone (Zone III 21 km)

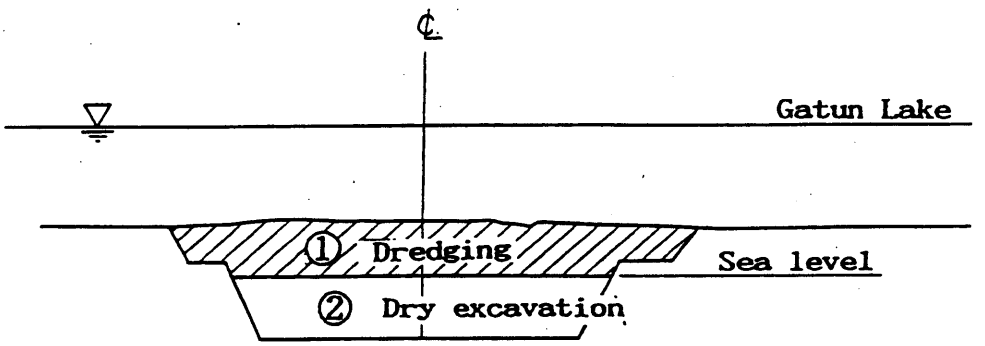


Fig. IV. 2.1.1 - 3 Excavation of Zone III

Sequence of excavation

1 (Dredging) ——> Barrier Dams ——> 2 (Dry)

Dredging

- Clayey	Grab Dredger	$50m^3$
- Loose	Cutter Suction Dredger	27,500 HP
- Weathered Rock	Cutter Suction Dredger	27,500 HP

4) Continental Divide (Zone IV 22.5 km)

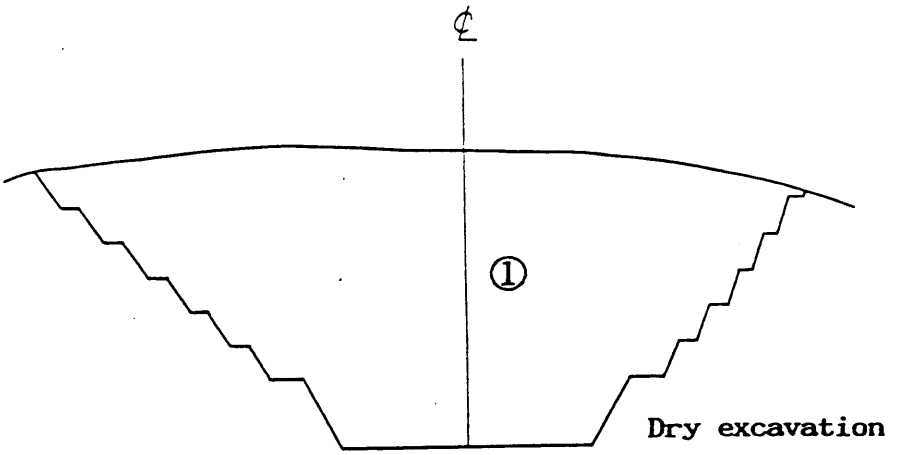


Fig. IV. 2.1.1 - 4 Excavation of Zone IV

- Excavation work between No.38 and No.56 is to be carried out by dry excavation.

- The section between No.56 and No.60.5 consists of swamp and is to be excavated by dredging.
  Dredging work commences from the Pacific Ocean.

Dredging

- Loose	Cutter Suction Dredger	27,500 HP
- Weathered Rock	Cutter Suction Dredger	27,500 HP
- Medium Hard Rock	Cutter Suction Dredger	27,500 HP
- Hard Rock	Blasting Barge Grab Dredger	 $50m^3$

5) Pacific Approach Zone (Zone V 25.1 km)

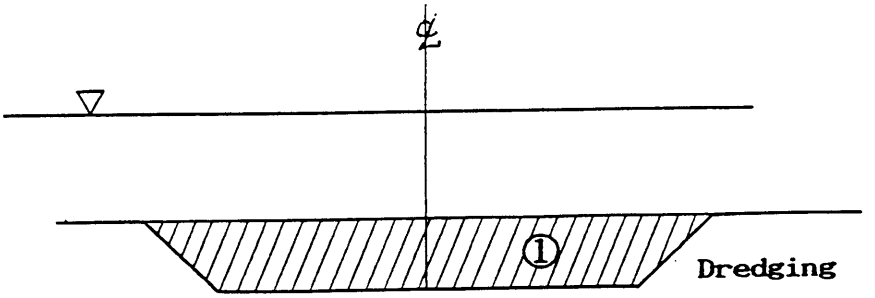


Fig. IV. 2.1.1 - 5 Excavation of Zone V

Dredging

- Clayey	Trailing Hopper	19,000 HP
	Grab Dredger	$50m^3$
- Loose	Trailing Hopper	19,000 HP
	Grab Dredger	$50m^3$
- Weathered Rock	Cutter Suction Dredger	27,500 HP

(7) Construction Scheme for Excavation

Following Table IV. 2.1.1 - 8 to 11 show construction scheme for respective type of excavation.

Table No.	DWT	Case	Type of Excavation	Excavation Volume m^3
IV. 2.1.1 - 8	250,000	a & c	Dry	948,137,000
IV. 2.1.1 - 9	250,000	a & c	Dredging	304,343,000
IV. 2.1.1 -10	250,000	b	Dry	1,033,572,000
IV. 2.1.1 -11	250,000	b	Dredging	351,378,000

Table IV.2.1.1-8
CONSTRUCTION SCHEME FOR EXCAVATION
SEA LEVEL CANAL 250,000 D.W.T. CASE A & C

File:PLANSEAC

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DRY EXCAVATION	COMMON	Q'TY(m3)	m3	0	14,851,000	23,229,000	41,967,000	0	80,047,000
		HAULING DISTANCE(km)	km	0	4.5	3.5	4.0	0	
		EQUIPMENT	group	0	4	5	7	0	
		BULLDOZER(98ton)	nos.	0	20.92	26.15	36.61	0	
		SHOVEL(30m3)	nos.	0	4.00	5.00	7.00	0	
		DUMP TRUCK(240ton)	nos.	0	60.04	60.40	94.85	0	
		BULLDOZER(98ton)	nos.	0	10.60	13.25	18.55	0	
		CAPACITY(m3/hr.)	m3/hr.	0	10,516	13,145	18,403	0	
		CAPACITY(m3/day)	m3/day	0	189,288	236,610	331,254	0	
		REQUIRED DAYS	days	0	79	99	127	0	
		REQUIRED YEARS(254days/year)	years	0	0.4	0.4	0.6	0	
	WEATHERED ROCK	Q'TY(m3)	m3	0	84,678,000	117,992,000	373,581,000	0	576,251,000
		HAULING DISTANCE(km)	km	0	4.5	3.5	4.0	0	
		EQUIPMENT	group	0	4	5	7	0	
		BULLDOZER(98ton)	nos.	0	36.24	45.30	63.42	0	
		SHOVEL(30m3)	nos.	0	4.00	5.00	7.00	0	
		DUMP TRUCK(240ton)	nos.	0	52.92	53.55	83.93	0	
		BULLDOZER(98ton)	nos.	0	10.84	13.55	18.97	0	
		CAPACITY(m3/hr.)	m3/hr.	0	7,428	9,285	12,999	0	
		CAPACITY(m3/day)	m3/day	0	133,704	167,130	233,982	0	
		REQUIRED DAYS	days	0	634	706	1,597	0	
		REQUIRED YEARS(254days/year)	years	0	2.5	2.8	6.3	0	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	0	39,990,000	54,557,000	121,559,000	0	216,106,000
		HAULING DISTANCE(km)	km	0	4.5	3.5	4.0	0	
		EQUIPMENT	group	0	4	5	7	0	
		BULLDOZER(98ton)	nos.	0	36.24	45.30	63.42	0	
		SHOVEL(30m3)	nos.	0	4.00	5.00	7.00	0	
		DUMP TRUCK(240ton)	nos.	0	52.92	53.55	83.93	0	
		BULLDOZER(98ton)	nos.	0	10.84	13.55	18.97	0	
		CAPACITY(m3/hr.)	m3/hr.	0	7,428	9,285	12,999	0	
		CAPACITY(m3/day)	m3/day	0	133,704	167,130	233,982	0	
		REQUIRED DAYS	days	0	300	327	520	0	
		REQUIRED YEARS(254days/year)	years	0	1.2	1.3	2.1	0	
	HARD ROCK	Q'TY(m3)	m3	0	9,997,000	13,639,000	52,097,000	0	75,733,000
		HAULING DISTANCE(km)	km	0	4.5	3.5	4.0	0	
		EQUIPMENT	group	0	4	5	7	0	
		CRAWLER DRILL(32ton-225mm)	nos.	0	8.40	10.50	14.70	0	
		BULLDOZER(98ton)	nos.	0	22.16	27.70	38.78	0	
		SHOVEL(30m3)	nos.	0	4.00	5.00	7.00	0	
		DUMP TRUCK(240ton)	nos.	0	46.16	46.70	73.08	0	
		BULLDOZER(98ton)	nos.	0	11.12	13.90	19.46	0	
		CAPACITY(m3/hr.)	m3/hr.	0	5,608	7,010	9,814	0	
		CAPACITY(m3/day)	m3/day	0	100,944	126,180	176,652	0	
		REQUIRED DAYS	days	0	100	109	295	0	
		REQUIRED YEARS(254days/year)	years	0	0.4	0.5	1.2	0	
	TOTAL VOL. OF DRY EXCAVATION		m3	0	149,516,000	209,417,000	589,204,000	0	948,137,000
	TOTAL OF REQUIRED YEARS		years	0.0	4.5	5.0	10.2	0.0	

Table IV.2.1.1-9
CONSTRUCTION SCHEME FOR EXCAVATION
SEA LEVEL CANAL 250,000 D.W.T- A & C

File:PLNEYCSV

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DREDGING	COMMON (CLAYEY)	Q'TY(m3)	m3	4,428,500	0	7,755,000	0	25,047,000	37,230,500
		HAULING DISTANCE(km)	km	2.5	0.0	2.0	0.0	2.5	
		EQUIPMENT	group	1	0	1	0	2	
		GRAB(50m3)	fleet	1.0	0.0	1.0	0.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	0.0	2.0	0.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	0.0	1.0	0.0	2.0	
		REQUIRED PERIOD(year)	year	1.1	0.0	1.2	0.0	2.9	
		CAPACITY(m3/hr)	m3/hr	740	0	1,200	0	1,606	
		CAPACITY(m3/year)	m3/year	3,936,000	0	6,384,000	0	8,544,000	
		Q'TY(m3)	m3	4,428,500				25,047,000	29,475,500
		HAULING DISTANCE(km)	km	2.5				2.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000ton)	unit	1.0				1.0	
		REQUIRED PERIOD(year)	year	0.3				1.4	
		CAPACITY(m3/hr)	m3/hr	2,874				3,278	
		CAPACITY(m3/year)	m3/year	15,289,680				17,438,960	
	COMMON (LOOSE)	Q'TY(m3)	m3	2,581,500	18,104,000	6,612,000	8,579,000	19,920,000	55,796,500
		HAULING DISTANCE(km)	km	2.5	10.5	2.0	2.5	2.5	
		EQUIPMENT	group	1	1	1	1	1	
		CUTTER(18,000HP)	fleet	1.0	1.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	2.0	2.0	2.0	2.0	2.0	
		PUSHER TUG(3,200HP)	unit	1.0	1.0	1.0	1.0	1.0	
		REQUIRED PERIOD(year)	year	0.4	1.9	0.7	0.9	3.2	
		CAPACITY(m3/hr)	m3/hr	1,082	1,755	1,755	1,755	1,174	
		CAPACITY(m3/year)	m3/year	5,756,400	9,336,600	9,336,600	9,336,600	6,247,800	
		Q'TY(m3)	m3	2,581,500				19,920,000	22,501,500
		HAULING DISTANCE(km)	km	2.5				2.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000ton)	unit	1.0				1.0	
		REQUIRED PERIOD(year)	year	0.2				1.1	
		CAPACITY(m3/hr)	m3/hr	3,090				3,494	
		CAPACITY(m3/year)	m3/year	16,438,800				18,588,080	
	WEATHERED ROCK	Q'TY(m3)	m3	2,242,000	27,935,000	10,386,000	33,888,000	31,086,000	105,537,000
		HAULING DISTANCE(km)	km	2.5	10.5	2.0	2.5	2.5	
		EQUIPMENT	group	1	1	1	2	2	
		CUTTER(27,500HP)	fleet	1.0	1.0	1.0	2.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	2.0	2.0	4.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	1.0	1.0	2.0	2.0	
		REQUIRED PERIOD(year)	year	0.5	3.9	1.4	2.4	3.2	
		CAPACITY(m3/hr)	m3/hr	832	1,350	1,350	2,700	1,807	
		CAPACITY(m3/year)	m3/year	4,428,000	7,182,000	7,182,000	14,364,000	9,612,000	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	0	31,120,000	0	10,431,000	0	41,551,000
		HAULING DISTANCE(km)	km	0.0	10.5	0.0	2.5	0.0	
		EQUIPMENT	group	0	2	0	2	0	
		CUTTER(27,500HP)	fleet	0.0	2.0	0.0	2.0	0.0	
		SPLIT BARGE(5,000m3)	unit	0.0	4.0	0.0	4.0	0.0	
		PUSHER TUG(3,200HP)	unit	0.0	2.0	0.0	2.0	0.0	
		REQUIRED PERIOD(year)	year	0.0	3.9	0.0	1.3	0.0	
		CAPACITY(m3/hr)	m3/hr	0	1,500	0	1,500	0	
		CAPACITY(m3/year)	m3/year	0	7,980,000	0	7,980,000	0	
	HARD ROCK	Q'TY(m3)	m3	0	7,780,000	0	4,471,000	0	12,251,000
		HAULING DISTANCE(km)	km	0.0	10.5	0.0	2.5	0.0	
		EQUIPMENT	group	0	2	0	2	0	
		BLASTING BARGE	fleet	0.0	2.0	0.0	2.0	0.0	
		GRAB(50m3)	fleet	0.0	2.0	0.0	2.0	0.0	
		SPLIT BARGE(1,500m3)	unit	0.0	4.0	0.0	4.0	0.0	
		PUSHER TUG(1,300HP)	unit	0.0	2.0	0.0	2.0	0.0	
		REQUIRED PERIOD(year)	year	0.0	2.5	0.0	1.4	0.0	
		CAPACITY(m3/hr)	m3/hr	0	580	0	580	0	
		CAPACITY(m3/year)	m3/year	0	3,085,600	0	3,085,600	0	
	TOTAL VOL. OF WET EXCAVATION		m3	16,262,000	84,939,000	24,753,000	57,369,000	121,020,000	304,343,000
	TOTAL OF REQUIRED YEARS		years	1.6	4.4	1.9	2.9	3.7	

Table IV.2.1.1-10
CONSTRUCTION SCHEME FOR EXCAVATION
SEA LEVEL CANAL 250,000 D.W.T. CASE B

File:PLANSEAC

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DRY EXCAVATION	COMMON	Q'TY(m3)	m3	0	24,392,000	23,229,000	41,419,000	0	89,040,000
		HAULING DISTANCE(km)	km	0	4.5	3.5	4.0	0	
		EQUIPMENT	group	0	6	6	7	0	
		BULLDOZER(98ton)	nos.	0	31.38	31.38	36.61	0	
		SHOVEL(30m3)	nos.	0	6.00	6.00	7.00	0	
		DUMP TRUCK(240ton)	nos.	0	90.06	72.48	94.85	0	
		BULLDOZER(98ton)	nos.	0	15.90	15.90	18.55	0	
		CAPACITY(m3/hr.)	m3/hr.	0	15,774	15,774	18,403	0	
		CAPACITY(m3/day)	m3/day	0	283,932	283,932	331,254	0	
		REQUIRED DAYS	days	0	86	82	126	0	
		REQUIRED YEARS(254days/year)	years	0	0.4	0.4	0.5	0	
	WEATHERED ROCK	Q'TY(m3)	m3	0	136,983,000	117,992,000	370,149,000	0	625,124,000
		HAULING DISTANCE(km)	km	0	4.5	3.5	4.0	0	
		EQUIPMENT	group	0	6	6	7	0	
		BULLDOZER(98ton)	nos.	0	54.36	54.36	63.42	0	
		SHOVEL(30m3)	nos.	0	6.00	6.00	7.00	0	
		DUMP TRUCK(240ton)	nos.	0	79.38	64.26	83.93	0	
		BULLDOZER(98ton)	nos.	0	16.26	16.26	18.97	0	
		CAPACITY(m3/hr.)	m3/hr.	0	11,142	11,142	12,999	0	
		CAPACITY(m3/day)	m3/day	0	200,556	200,556	233,982	0	
		REQUIRED DAYS	days	0	684	589	1,582	0	
		REQUIRED YEARS(254days/year)	years	0	2.7	2.4	6.3	0	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	0	62,565,000	54,557,000	121,103,000	0	238,225,000
		HAULING DISTANCE(km)	km	0	4.5	3.5	4.0	0	
		EQUIPMENT	group	0	6	6	7	0	
		BULLDOZER(98ton)	nos.	0	54.36	54.36	63.42	0	
		SHOVEL(30m3)	nos.	0	6.00	6.00	7.00	0	
		DUMP TRUCK(240ton)	nos.	0	79.38	64.26	83.93	0	
		BULLDOZER(98ton)	nos.	0	16.26	16.26	18.97	0	
		CAPACITY(m3/hr.)	m3/hr.	0	11,142	11,142	12,999	0	
		CAPACITY(m3/day)	m3/day	0	200,556	200,556	233,982	0	
		REQUIRED DAYS	days	0	312	273	518	0	
		REQUIRED YEARS(254days/year)	years	0	1.3	1.1	2.1	0	
	HARD ROCK	Q'TY(m3)	m3	0	15,641,000	13,639,000	51,903,000	0	81,183,000
		HAULING DISTANCE(km)	km	0	4.5	3.5	4.0	0	
		EQUIPMENT	group	0	6	6	7	0	
		CRAWLER DRILL(32ton-225mm)	nos.	0	12.60	12.60	14.70	0	
		BULLDOZER(98ton)	nos.	0	33.24	33.24	38.78	0	
		SHOVEL(30m3)	nos.	0	6.00	6.00	7.00	0	
		DUMP TRUCK(240ton)	nos.	0	69.24	56.04	73.08	0	
		BULLDOZER(98ton)	nos.	0	16.68	16.68	19.46	0	
		CAPACITY(m3/hr.)	m3/hr.	0	8,412	8,412	9,814	0	
		CAPACITY(m3/day)	m3/day	0	151,416	151,416	176,652	0	
		REQUIRED DAYS	days	0	104	91	294	0	
		REQUIRED YEARS(254days/year)	years	0	0.5	0.4	1.2	0	
	TOTAL VOL. OF DRY EXCAVATION		m3	0	239,581,000	209,417,000	584,574,000	0	1,033,572,000
	TOTAL OF REQUIRED YEARS		years	0.0	4.9	4.3	10.1	0.0	

Table IV.2.1.1-11
CONSTRUCTION SCHEME FOR EXCAVATION
SEA LEVEL CANAL 250,000 D.W.T- B

File:PLNEXCS

METHOD	CLASSIFICATION	DESCRIPTION	UNIT	ZONE-I	ZONE-II	ZONE-III	ZONE-IV	ZONE-V	TOTAL
DREDGING	COMMON (CLAYEY)	Q'TY(m3)	m3	4,428,500	0	7,755,000	0	19,066,000	31,249,500
		HAULING DISTANCE(km)	km	2.5	0.0	2.0	0.0	2.5	
		EQUIPMENT	group	1	0	1	0	2	
		GRAB(50m3)	fleet	1.0	0.0	1.0	0.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	0.0	2.0	0.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	0.0	1.0	0.0	2.0	
		REQUIRED PERIOD(year)	year	1.1	0.0	1.2	0.0	2.2	
		CAPACITY(m3/hr)	m3/hr	740	0	1,200	0	1,606	
		CAPACITY(m3/year)	m3/year	3,936,000	0	6,384,000	0	8,544,000	
		Q'TY(m3)	m3	4,428,500				19,066,000	23,494,500
		HAULING DISTANCE(km)	km	2.5				2.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000ton)	unit	1.0				1.0	
		REQUIRED PERIOD(year)	year	0.3				1.1	
		CAPACITY(m3/hr)	m3/hr	2,874				3,278	
		CAPACITY(m3/year)	m3/year	15,289,680				17,438,960	
	COMMON (LOOSE)	Q'TY(m3)	m3	2,757,500	36,378,000	6,612,000	7,657,000	16,412,000	69,816,500
		HAULING DISTANCE(km)	km	2.5	10.5	2.0	2.5	2.5	
		EQUIPMENT	group	1	1	1	1	1	
		CUTTER(18,000HP)	fleet	1.0	1.0	1.0	1.0	1.0	
		SPLIT BARGE(5,000m3)	unit	2.0	2.0	2.0	2.0	2.0	
		PUSHER TUG(3,200HP)	unit	1.0	1.0	1.0	1.0	1.0	
		REQUIRED PERIOD(year)	year	0.5	3.9	0.7	0.8	2.6	
		CAPACITY(m3/hr)	m3/hr	1,082	1,755	1,755	1,755	1,174	
		CAPACITY(m3/year)	m3/year	5,756,400	9,336,600	9,336,600	9,336,600	6,247,800	
		Q'TY(m3)	m3	2,757,500				16,412,000	19,169,500
		HAULING DISTANCE(km)	km	2.5				2.5	
		EQUIPMENT	group	1				1	
		TRAILER(10,000ton)	unit	1.0				1.0	
		REQUIRED PERIOD(year)	year	0.2				0.9	
		CAPACITY(m3/hr)	m3/hr	3,090				3,494	
		CAPACITY(m3/year)	m3/year	16,438,800				18,588,080	
	WEATHERED ROCK	Q'TY(m3)	m3	3,123,000	54,902,000	10,386,000	30,946,000	26,820,000	126,177,000
		HAULING DISTANCE(km)	km	2.5	10.5	2.0	2.5	2.5	
		EQUIPMENT	group	1	2	1	2	2	
		CUTTER(27,500HP)	fleet	1.0	2.0	1.0	2.0	2.0	
		SPLIT BARGE(5,000m3)	unit	2.0	4.0	2.0	4.0	4.0	
		PUSHER TUG(3,200HP)	unit	1.0	2.0	1.0	2.0	2.0	
		REQUIRED PERIOD(year)	year	0.7	3.8	1.4	2.2	2.8	
		CAPACITY(m3/hr)	m3/hr	832	2,700	1,350	2,700	1,807	
		CAPACITY(m3/year)	m3/year	4,428,000	14,364,000	7,182,000	14,364,000	9,612,000	
	MEDIUM HARD ROCK	Q'TY(m3)	m3	0	53,994,000	0	9,785,000	0	63,779,000
		HAULING DISTANCE(km)	km	0.0	10.5	0.0	2.5	0.0	
		EQUIPMENT	group	0	4	0	1	0	
		CUTTER(27,500HP)	fleet	0.0	4.0	0.0	1.0	0.0	
		SPLIT BARGE(5,000m3)	unit	0.0	8.0	0.0	2.0	0.0	
		PUSHER TUG(3,200HP)	unit	0.0	4.0	0.0	1.0	0.0	
		REQUIRED PERIOD(year)	year	0.0	3.4	0.0	2.5	0.0	
		CAPACITY(m3/hr)	m3/hr	0	3,000	0	750	0	
		CAPACITY(m3/year)	m3/year	0	15,960,000	0	3,990,000	0	
	HARD ROCK	Q'TY(m3)	m3	0	13,498,000	0	4,194,000	0	17,692,000
		HAULING DISTANCE(km)	km	0.0	10.5	0.0	2.5	0.0	
		EQUIPMENT	group	0	3	0	2	0	
		BLASTING BARGE	fleet	0.0	3.0	0.0	2.0	0.0	
		GRAB(50m3)	fleet	0.0	3.0	0.0	2.0	0.0	
		SPLIT BARGE(1,500m3)	unit	0.0	6.0	0.0	4.0	0.0	
		PUSHER TUG(1,300HP)	unit	0.0	3.0	0.0	2.0	0.0	
		REQUIRED PERIOD(year)	year	0.0	2.9	0.0	1.4	0.0	
		CAPACITY(m3/hr)	m3/hr	0	870	0	580	0	
		CAPACITY(m3/year)	m3/year	0	4,628,400	0	3,085,600	0	
	TOTAL VOL. OF WET EXCAVATION		m3	17,495,000	158,772,000	24,753,000	52,582,000	97,776,000	351,378,000
	TOTAL OF REQUIRED YEARS		years	1.6	4.4	1.9	3.0	3.3	

1.2 Excavation at Canal in/between Barrier Dams

(1) After completion of Barrier Dams, dewatering of the area between the Barrier Dams is carried out by discharge channels. During the dewatering, digging down of discharge channels is to be continued while lowering the water level. This is to prevent sudden outflows of encountered water from occurring.

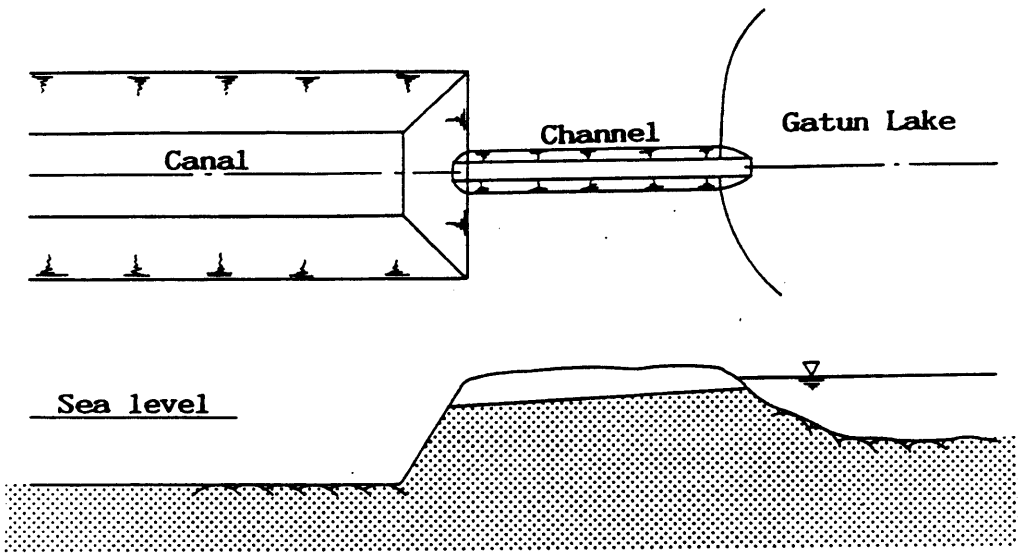


Fig. IV. 2.1.2-1 Construction Procedure on Dewatering of Encountered Water

1.3 Dewatering for Canal Excavation

1) Prior to excavation, water that flows into the excavation area from small rivers and streams is diverted to outside through open channels.

2) Rainfall on slopes and benches (at every 20m) is collected in open ditches on both sides during the excavation.
At the bottom of excavation areas, drainage water is dewatered by pumps.

3) With the progress of excavation, the pumps are relocated to the lower positions.

4) Leakage water from barrier dams is dewatered to the ocean side by providing open channels on both sides of the canal, and rain water on excavation slopes and benches is pumped to open ditches.

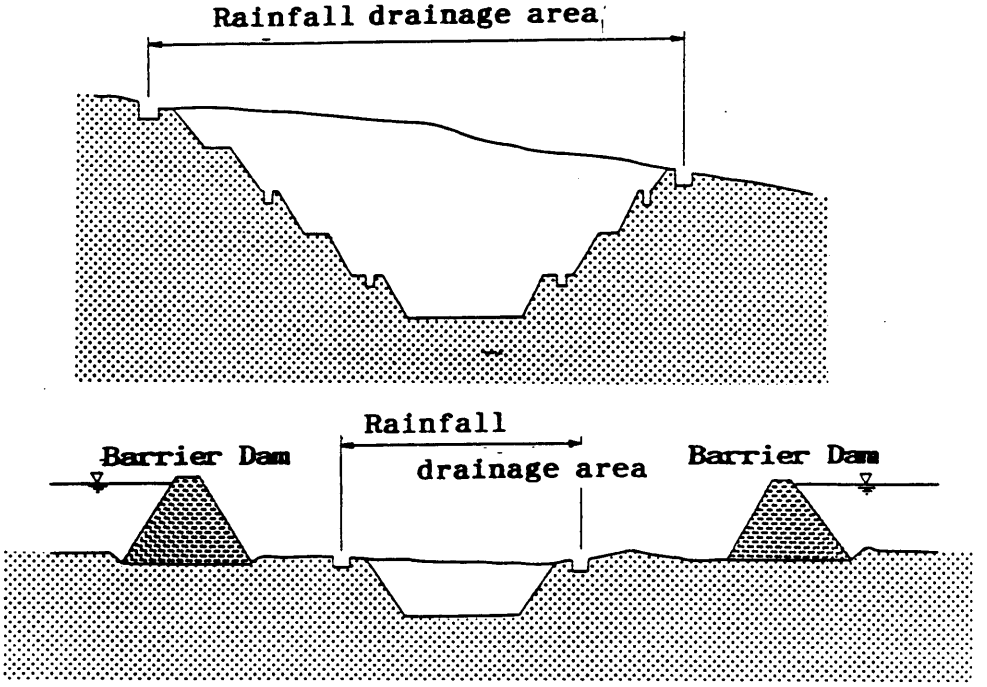


Fig. IV. 2.1.3-1 Dewatering for Canal Excavation

5) Pumps to be used for Construction

Table IV. 2.1.3-1 Specification and Number of Pumps to be used

Case	a	b
Type of Pumps	Fixed Location Type	Portable Type
	Number Used	
Zone I	0 set	0
Zone II	56	168
Zone III	79	237
Zone IV	87	261
Zone V	0	0
Total	222	666

Note: - Specification of Fixed Location Type Pump

Bore	300 mm
Head	100 - 150m
Pumping Volume	12 m^3/min
Rated Capacity	240 kW

- Specification of Portable Type Pump

Bore	200 mm
Head	20m
Pumping Volume	4 m^3/min
Rated Capacity	22 kW

- Generators are used as a power sources.

IV.2 Chapter 2. Tidal Lock Construction

2.1 Excavation and Dewatering

(1) Canal excavation and tidal lock construction areas are divided with temporary plugs.

(2) Open ditches are provided around the tidal lock construction area where drainage water is pumped during the construction period.

(3) Pumped water is led to a small stream near the construction area.

(4) Temporary plugs are to be removed after the completion of Lock Construction.

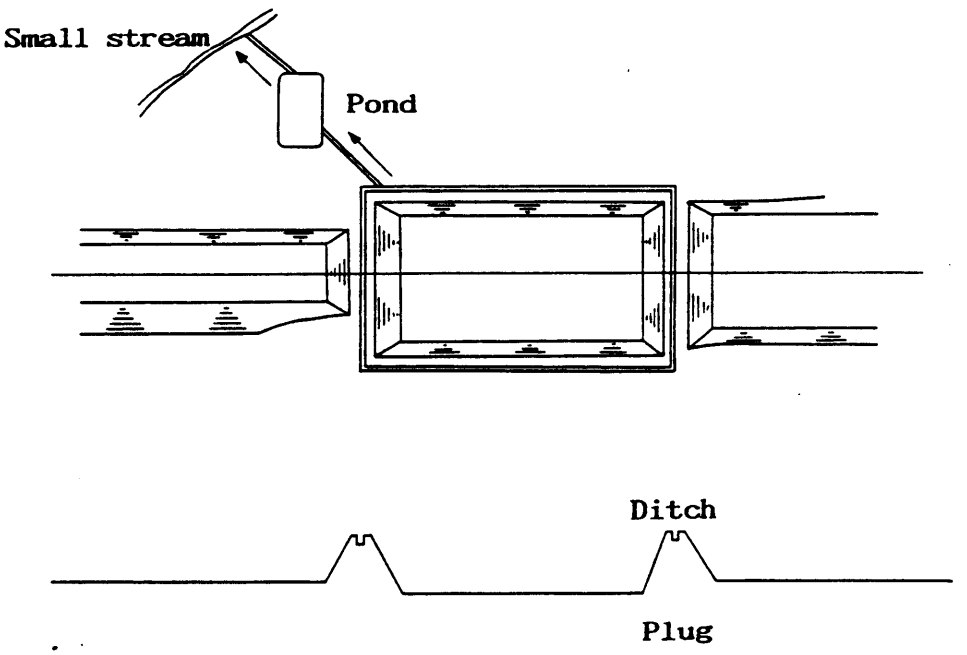


Fig. IV. 2.2.1-1 Excavation

(5) Dewatering

1) During the construction, drainage water is pumped to open ditches by pumps.

2) Drainage pumps used for construction

Table IV. 2.2.1-1 Drainage Pumps used for Construction

Case	a		b		c	
	Atlantic	Pacific	Atlantic	Pacific	Atlantic	Pacific
Tidal Lock/Gate	Nil	Lock	Gate	Gate	Gate	Lock
Type of Pumps						
Fixed Location Type	-	22 sets	11 sets	9 sets	11 sets	22 sets
Portable Type	-	66 sets	33 sets	27 sets	33 sets	66 sets

Note-1: Fixed Location Pumps

Bore	300 mm
Head	40m
Pumping Volume	12 m^3/min
Rated Capacity	95 kW

Portable Pumps

Bore	200 mm
Head	20m
Pumping Volume	4 m^3/min
Rated Capacity	22 kW

Note-2: Rainfall Atlantic Side 130 mm/day (Max.)
Pacific Side 100 mm/day (Max.)

The number of pumps required was determined based on 105% of expected discharge. (rainfall per day)

2.2 Concrete Structure

(1) Concrete Volume Required for Each Case

Table IV. 2.2.2-1 Concrete Volume

Case	a		b		c	
Side	Atlantic	Pacific	Atlantic	Pacific	Atlantic	Pacific
Tidal Lock/Gate	Nil	Lock	Gate	Gate	Gate	Lock
Concrete Volume	-	m^3 6,000,000	m^3 980,000	m^3 980,000	m^3 980,000	m^3 6,000,000

(2) Supply of Aggregate and Cement

Concrete production plants are installed for each Tidal Lock/Gate.

Aggregate: Aggregate production located at quarry site ——> Concrete Production Plant

Cement : Cement Silo located at logistic base facilities ——> Concrete Production Plant

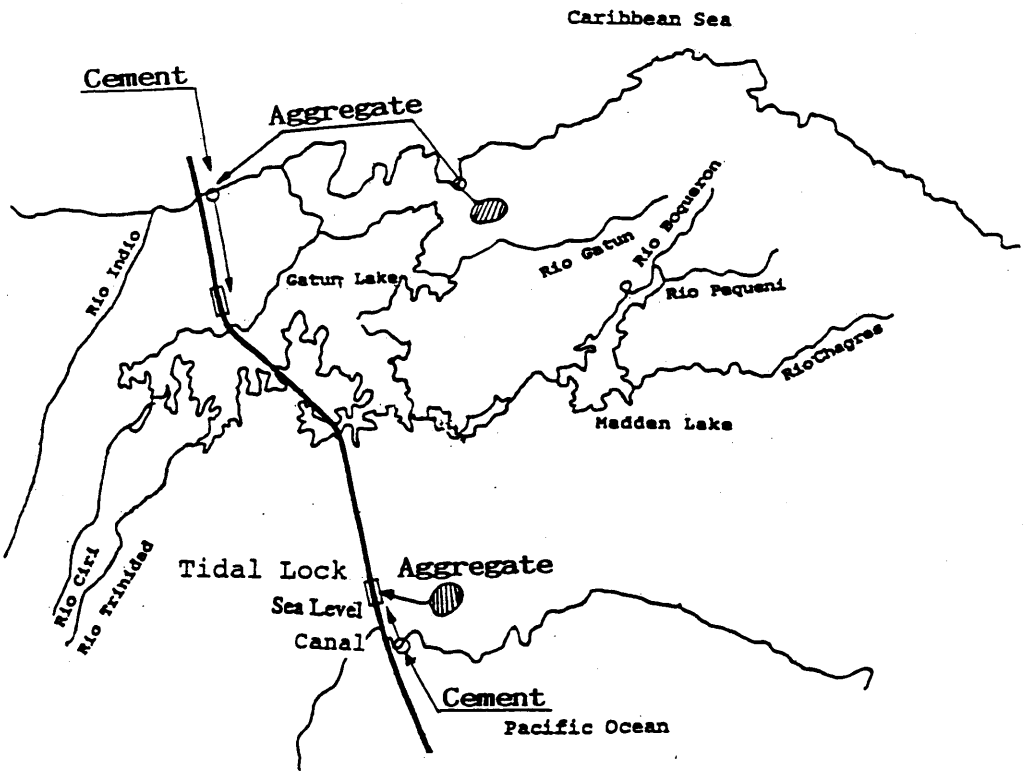


Fig. IV. 2.2.2 - 1 Supply of Aggregate and Cement

(3) Concrete producing, transporting and placing

1) Traveling type jib cranes are installed at the proposed site of Tidal Lock/Gate.

2) Mixer/Agitator trucks are used to transport concrete from the concrete production plants to the jib cranes at the location of concrete placing.

Production of Concrete ——>	Transport ——>	Placing of Concrete
Concrete Plant	Mixer/Agitator Truck	Traveling type jib crane Concrete and bucket

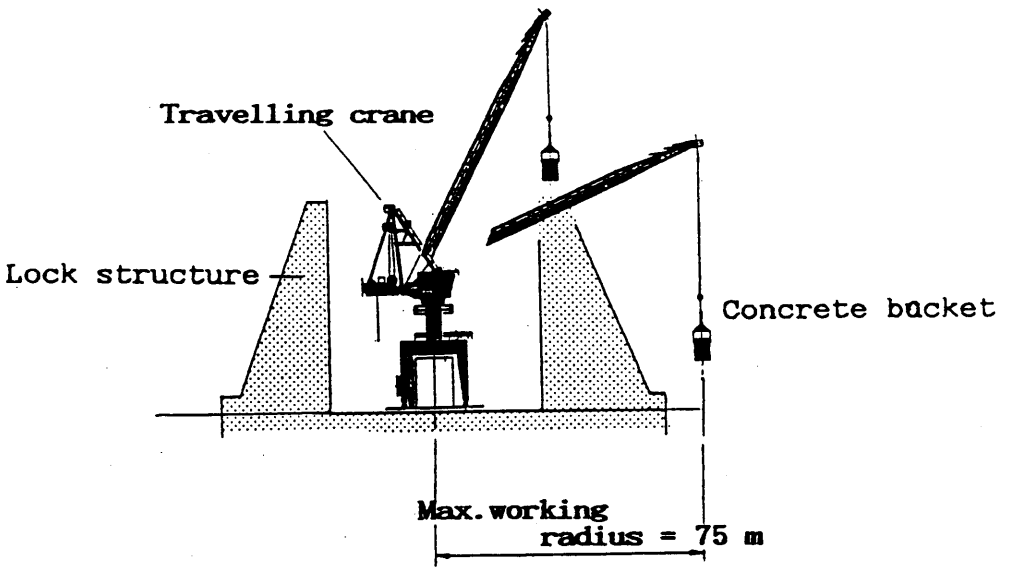


Fig. IV. 2.2.2 - 2 Method of Concrete Placing
(Tidal Lock)

(4) Method of Concrete Placing and Formwork

a. Construction joints are provided at every 15m in longitudinal section and height of one lift is 1.5m. The surface of the concrete at the joint is "green cut" before the pouring of the next lift.

b. Formwork

Steel sliding forms with a 1.5m lift are used. The form provides scaffolding.

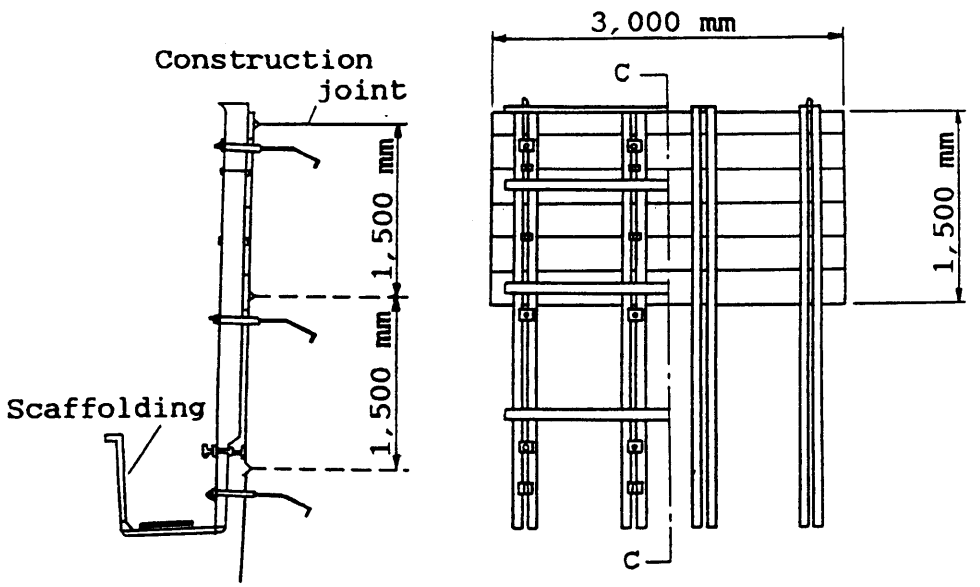


Fig. IV. 2.2.2 - 3 Sliding Form

IV.2 Chapter 3. Gate Installation

3.1 Introduction

This chapter covers gate leaves and related facilities not only for the tidal locks but also for the tidal regulating structures. In addition, it refers partially to valves and pipes for the new dam and small gates for the barrier dams. Major components included in the related facilities are as follows.

- Gate Frames
- Gate Hoists
- Locomotives and it's rails and power supply lines for the tidal lock
- Electric Power and Control Equipments including lighing on the lock wall tops and the tidal regulating structures
- Emergency Power Plant
- Local control building and their electrical equipments
- Cathodic protection around the lock and the tidal regulating structure
- Monitoring & surveillance equipments for the lock and tidal regulating structure
- Communication equipments for the lock and tidal requlating structure
- Ground system

3.2 Constructability

Constructability of all major facilities included in the preliminary designs made for the Tidal Lock and the Tidal Regulating Structures has been reviewed and it has been concluded that a possibility of all their installation is positive at least from the feasibility study point of view. Nevertheless the same effort has to be made for the more detail portions of designs at a detail design stage.

3.3 Inland Transportation

The fabricated materials which have been classified as "Packed" at II.2-Chapter 4.5 in this report are transported from landing ports or fabrication factories in local domains upto storage yards which will be provided near the ports on each side of the oceans. They will be transported to their installation sites according to site work progress. Other items listed at the Chapter 4.5 will arrive at their landing ports according to their installation schedule and transferred to the site directly from the port through the canal and the lock already completed and will be installed accordingly.

3.4 Storage Procedures

Storage procedures at the storage yards near the landing ports are classified as below.

Table IV. 2.3-1 Storage Procedures

Classification	Example of Application
(1) Storage at open yard	Fabricated big material with less possibility of deterioration due to climatic exposure to, for in stance, direct sunshine, rain, wind or high temperature.
(2) Storage a under roof	Fabricated big material with possibility of deterioration due to exposure to, for instance, direct sunshine or rain.
(3) Storage in a warehouse	Small or valuable parts which will be easily lost.
(4) Storage in an air conditioned warehouse	Equipments which dislike high temperature or high humidity.

The all materials to be stored at the yards shall be classified according to an established classification before hands.

3.5 Installation Procedures

(1) Gate leaves

1) Operating Gate and Emergency Gate for Lock and Tidal Regulating Structures

Operating Gate and Emergency Gate for Tidal Lock and Tidal Regulating Structures are consist of a pair of blocks respectively and each block is set in place using a floating crane according to the steps shown in Fig. III.1.5-4 of this report. Two blocks of each gate installed are connected mechanically and the gates will be ready to work after they are connected to their drive mechanisms.

2) Culvert Gate for Lock and Outlet Pipes for New Dams and Spillway Radial Gate for Barrier Dam

Culvert Gate for Tidal Lock and Outlet Pipes for New Dams and Spillway Radial Gate for Barrier Dams are transported to the site in blocks and erected by a truck crane, a tower crane or other available means. The blocks are joined either by high tension bolts or welding.

3) Culvert Maintenance Gate for Lock and Spillway Slide Gate for Barrier Dam

Culvert Maintenance Gates for Tidal Lock and Spillway Slide Gate for Barrier Dam are transported to the site in blocks. There is no need of further erection for them except to be inserted to each gate slots just for confirmation of good mating with the metals already embedded in concrete.

(2) Locomotives

Locomotives are transported to site through the canal on barges. They are lifted up by a floating crane and put on their rails on the lock wall tops.

(3) Electric Power Equipments, Emergency Power Plant

Installation cost estimation for Electric Power and control Equipments, and Emergency Power Plant was made based upon conventional installation procedures using a truck crane or something. A possibility of cost reduction may exist in idea of package system in which all parts are mounted on a frame rest at shop, transported to site as a whole and mounted by a floating crane at once.

3.6 Possibility of Installing Gate Leaves by firms in Panama and Immediate Region

Possibility of gate leaf field installation by local firms in Panama or immediate regions were evaluated on both technical ability and competitiveness of cost and concluded that the answers to all gates would be positive with contract conditions given in Table IV.2.3-2 The immediate region includes Colombia, Ecuador, Peru, Costa Rica, Nicaragua, El Salvador, Guatemala and Honduras.

Table IV. 2.3-2 Condition for Installation by Local Firms

Gate Name	Condition for Installation by Local Firm
Tidal Gate	To be done as a sub-contractor
Lock Gate	
1) Operating Gate	To be done as a sub-contractor
2) Culvert Gate	To be supervised by others
3) Emergency Gate	To be done as a sub-contractor
4) Maintenance Gate	To be done as a sub-contractor
5) Culvert Maintenance Gate	To be supervised by others
Dam Gate	
1) Crest Gate**	To be supervised by others
2) Outlet Valve*	To be supervised by others
3) Outlet Pipe*	To be supervised by others

Note 1. The installation by local firms means installation of gate leaves by local firms in Panama or immediate regions.

2. * shows for the new dam and ** shows for the barrier dams.

IV.2 Chapter 4. Barrier Dams

4.1 Quantities for Barrier Dams

Table IV. 2.4.1 -1 Quantities for Barrier Dams
(Cases a, b and c)

Dam	Foundation Excavation	Core	Sand	Filler	Rock	Riprap
	m^3	m^3	m^3	m^3	m^3	m^3
Dam E	5,900,000	4,300,000	300,000	3,600,000	4,800,000	260,000
Dam F	6,500,000	4,650,000	350,000	3,900,000	5,300,000	260,000
Dam G	1,000,000	650,000	50,000	600,000	100,000	45,000
Sub Total		9,600,000	700,000	8,100,000		
Total	13,400,000		18,400,000		10,800,000	565,000

4.2 Embankment Materials and Transport

- Materials obtained from Zone II are mainly used for embankments.

- Materials suitable for embankments are selected at the time of excavation and loading. These materials are collected at temporary stockyards and transported by ship from the loading jetty to the proposed site.

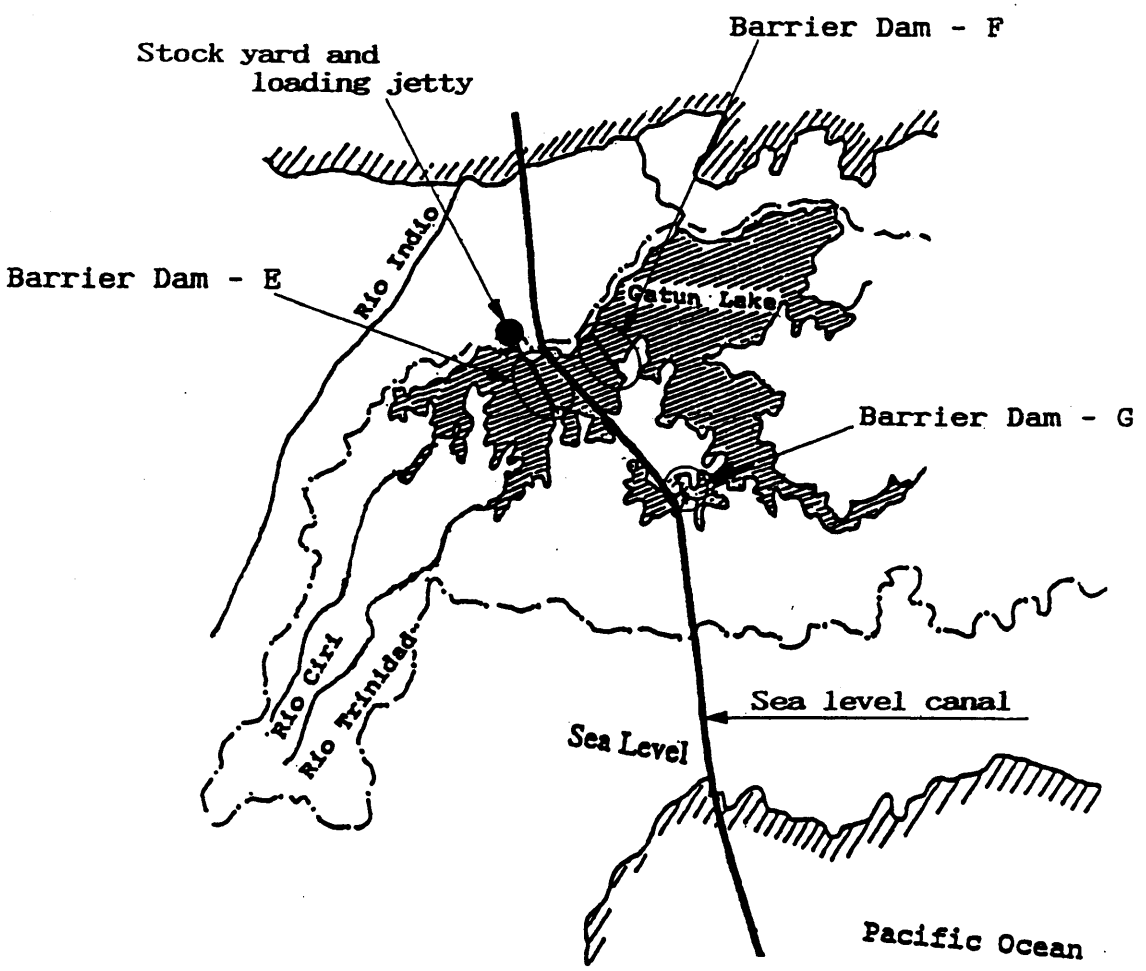


Fig. IV. 2.4.2-1 Location of Stock Yard and Jetty

Stockyard and Loading jetty are to be provided near northern part of the Barrier Dam - E.

4.3 Construction Method

(1) Construction Sequence

Foundation Excavation ——> Embankment
└——> Drilling and Grouting

(2) Excavation

The surface of the lake bed (clay, loose materials) is to be excavated using a grab dredger, to make the foundation of the Barrier Dam.

(3) Embankment

At Gatun Lake, the construction method and equipment used above EL-4.00 are different from those used below EL-4.00.

a. Below -4.0m

- Core, filter and sand or rock materials are transported using a stone barge. These materials are dumped from the barge at the designated location.

- Core and filter are placed first. In order to prevent slope erosion, rock materials are placed later on.

b. Above -4.0m

- Core, filter and rock materials are transported to designated location by flat top barge and unloaded using a backhoe barge.

- Riprap materials are unloaded using a crane barge.

c. Drilling and Grouting

- Drilling and grouting is carried out at the abutment of the Barrier Dam. Grouting is performed at the top of the Dam.

Table IV.2.4-3-1
CONSTRUCTION SCHEME FOR BARRIER DAM

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LOCATION	FILL MATERIAL	DESCRIPTION	UNIT	BARRIER DAM "E"	BARRIER DAM "F"	BARRIER DAM "G"	TOTAL
DREDGING		WORKING DAYS	days/year	266	266	266	
		HAULING DISTANCE	km	10	15	10	
	CLAYEY MATERIAL	Q'TY(m3)	m3	2,900,000	3,000,000	500,000	6,400,000
		EQUIPMENT	group	1	1	1	
		GRAB DREDGER(50m3)	unit	1	1	1	
		SPLIT BARGE(5,000m3)	unit	2.0	2.0	2.0	
		PUSHER TUG(3,200 HP)	unit	1.0	1.0	1.0	
		REQUIRED PERIOD	years	0.5	0.6	0.1	
		CAPACITY(m3/hr)	m3/hr	1020	1020	1020	
		CAPACITY(m3/year)	m3/year	5,426,400	5,426,400	5,426,400	
	LOOSE MATERIAL	Q'TY(m3)	m3	3,000,000	3,500,000	500,000	7,000,000
		EQUIPMENT	group	1	1	1	
		GRAB DREDGER(50m3)	unit	1	1	1	
		SPLIT BARGE(5,000m3)	unit	2.0	2.0	2.0	
		PUSHER TUG(3,200 HP)	unit	1.0	1.0	1.0	
		REQUIRED PERIOD	years	0.6	0.6	0.1	
		CAPACITY(m3/hr)	m3/hr	1020	1020	1020	
		CAPACITY(m3/year)	m3/year	5,426,400	5,426,400	5,426,400	
	DREDGING TOTAL		m3	5,900,000	6,500,000	1,000,000	13,400,000
	TOTAL TIME REQUIRED		years	1.6	1.6	1.1	
BARRIER DAM	CORE MATERIAL FILTER MATERIAL SAND (BELOW -4.0m)	Q'TY(m3)	m3	7,320,000	7,950,000	1,140,000	16,410,000
		EQUIPMENT	group	6	6	2	
		STONE BARGE(2,000ton)	unit	6.0	6.0	2.0	
		CRAWLER CRANE(70 ton)	unit	12.0	12.0	4.0	
		REQUIRED PERIOD	years	1.9	2.1	0.9	
		CAPACITY(m3/hr)	m3/hr	1,456	1,456	485	
		CAPACITY(m3/year)	m3/year	3,871,920	3,871,920	1,290,640	
	CORE MATERIAL FILTER MATERIAL SAND (ABOVE -4.0m)	Q'TY(m3)	m3	880,000	950,000	160,000	1,990,000
		EQUIPMENT	group	1	1	1	
		BACKHOE BARGE(8 m3)	unit	1.0	1.0	1.0	
		FLAT TOP BARGE(2,000ton)	unit	3.0	3.0	3.0	
		PUSHER TUG(1,300 HP)	unit	3.0	3.0	3.0	
		CRAWLER CRANE(70 ton)	unit	2.0	2.0	2.0	
		REQUIRED PERIOD	years	1.1	1.2	0.2	
		CAPACITY(m3/hr)	m3/hr	302	302	302	
		CAPACITY(m3/year)	m3/year	803,320	803,320	803,320	
	ROCK (BELOW -4.0m)	Q'TY(m3)	m3	4,415,000	4,880,000	630,000	9,925,000
		EQUIPMENT	group	6	6	2	
		STONE BARGE(2,000ton)	unit	6.0	6.0	2.0	
		CRAWLER CRANE(70 ton)	unit	12.0	12.0	4.0	
		REQUIRED PERIOD	years	1.1	1.3	0.5	
		CAPACITY(m3/hr)	m3/hr	1456	1456	485	
		CAPACITY(m3/year)	m3/year	3,871,920	3,871,920	1,290,640	
	ROCK (ABOVE -4.0m)	Q'TY(m3)	m3	385,000	420,000	70,000	875,000
		EQUIPMENT	group	1	1	1	
		BACKHOE BARGE(8 m3)	unit	1.0	1.0	1.0	
		FLAT TOP BARGE(2,000ton)	unit	2.0	2.0	2.0	
		PUSHER TUG(1,300 HP)	unit	2.0	2.0	2.0	
		CRAWLER CRANE(70 ton)	unit	2.0	2.0	2.0	
		REQUIRED PERIOD	years	1.2	1.3	0.2	
		CAPACITY(m3/hr)	m3/hr	125	125	125	
		CAPACITY(m3/year)	m3/year	331,280	331,280	331,280	
	RIPRAP (BELOW -4.0m)	Q'TY(m3)	m3	120,000	120,000	20,000	260,000
		EQUIPMENT	group	1	1	1	
		STONE BARGE(1,000ton)	unit	1.0	1.0	1.0	
		CRAWLER CRANE(70 ton)	unit	2.0	2.0	2.0	
		REQUIRED PERIOD	years	0.6	0.6	0.1	
		CAPACITY(m3/hr)	m3/hr	70	70	70	
		CAPACITY(m3/year)	m3/year	186,760	186,760	186,760	
	RIPRAP (ABOVE -4.0m)	Q'TY(m3)	m3	140,000	140,000	25,000	305,000
		EQUIPMENT	group	2	2	2	
		CRANE BARGE(50tx2)	unit	2.0	2.0	2.0	
		FLAT TOP BARGE(1,000ton)	unit	4.0	4.0	4.0	
		PUSHER TUG(1,300 HP)	unit	4.0	4.0	4.0	
		CRAWLER CRANE(70 ton)	unit	8.0	8.0	8.0	
		REQUIRED PERIOD	years	0.9	0.9	0.2	
		CAPACITY(m3/hr)	m3/hr	56	56	56	
		CAPACITY(m3/year)	m3/year	148,960	148,960	148,960	
	TOTAL VOL. OF FILL MATERIAL		m3	13,260,000	14,460,000	2,045,000	29,765,000
	TOTAL TIME REQUIRED		years	2.9	3.1	1.9	

IV.2 Chapter 5. Breakwaters

5.1 Quantities

Table IV. 2.5.1-1 Quantities of Breakwater Materials (Cases a, b and c)

Material	Atlantic Side	Pacific Side
Core	7,500,000m^3	6,400,000m^3
Armour Rock	(0.5 ton/piece) 1,600,000m^3	(0.5 ton/piece) 1,200,000m^3
	(3.0 ton/piece) 700,000m^3	(3.0 ton/piece) 700,000m^3
Total	9,800,000m^3	8,300,000m^3

5.2 Filling Materials

(1) Atlantic Side

1) Basically, material obtained from Canal excavation Zone II (Dry) is used for core. Material suitable for filling is selected at the time of excavation.

2) Armor rock is extracted at the quarry site.

(2) Pacific Side

1) Excavated material at Zone V (dredging) of Canal is used as core material.

2) Armor rock is extracted at the quarry site.

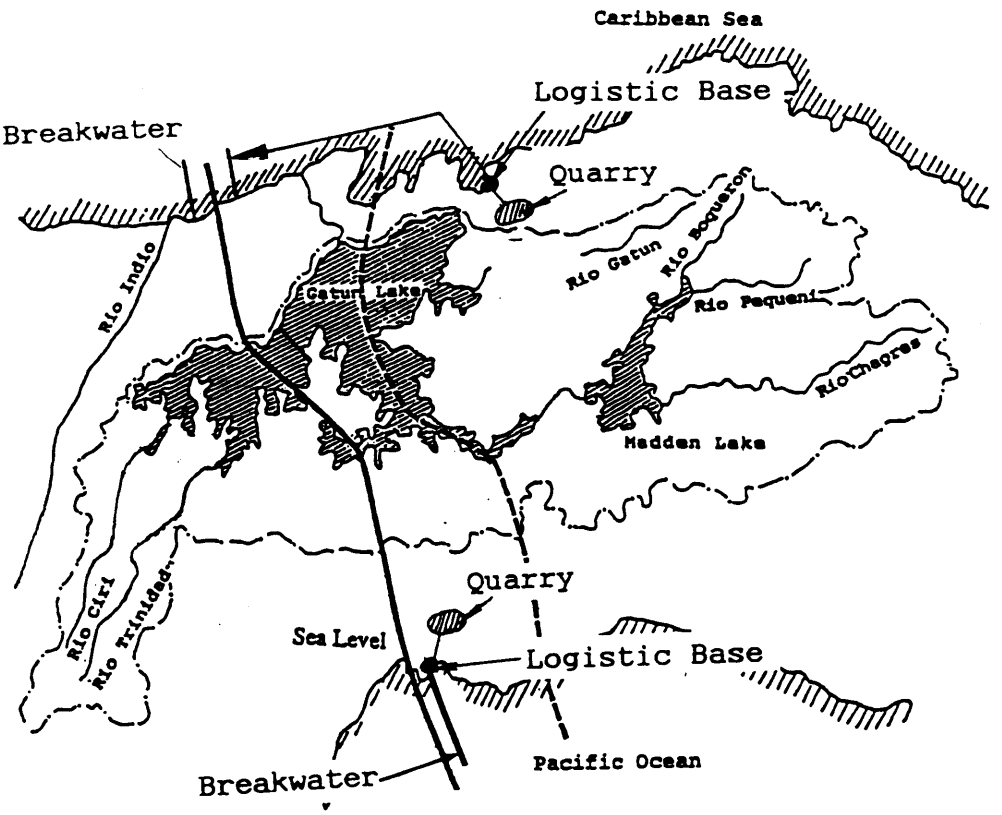


Fig. IV. 2.5.2-1 Location of Quarry for Armor Rock

5.3 Construction Method

(1) Seabed site is to be dredged before breakwater is constructed.

(2) Construction method and equipment usage are both planned separately for above EL-4.00 and below EL-4.00.

Table IV.2.5.3-1
CONSTRUCTION SCHEME FOR BREAKWATER

File:PLANBW

LOCATION	FILL MATERIAL	DESCRIPTION	UNIT	ATLANTIC OCEAN SIDE	PACIFIC OCEAN SIDE	TOTAL
BREAKWATER		WORKING DAYS	days/year	164	178	
		HAULING DISTANCE	km	44	15	
	CORE MATERIAL (BELOW -4.0m)	Q'TY(m3)	m3	6,705,000	4,774,000	11,479,000
		EQUIPMENT	group	1	1	
		SPLIT BARGE(5,000m3)	unit	2	3	
		PUSHER TUG(3,200HP)	unit	1.0	2.0	
		CRAWLER CRANE(70 ton)	unit	4.0		
		CUTTER SUCTION(18,000HP)	unit		1.0	
		REQUIRED PERIOD	years	1.72	0.79	
		CAPACITY(m3/hr)	m3/hr	1,190	1,700	
		CAPACITY(m3/year)	m3/year	3,903,200	6,052,000	
	CORE MATERIAL (ABOVE -4.0m)	Q'TY(m3)	m3	795,000	1,626,000	2,421,000
		EQUIPMENT	group	1.0	1.0	
		BACKHOE BARGE(8 m3)	unit	1	1	
		FLAT TOP BARGE(2,000ton)	unit	3.0	3.0	
		PUSHER TUG(1,300 HP)	unit	3.0	3.0	
		CRAWLER CRANE(70 ton)	unit	2.0	2.0	
		REQUIRED PERIOD	years	1.61	3.02	
		CAPACITY(m3/hr)	m3/hr	302	302	
		CAPACITY(m3/year)	m3/year	495,280	537,560	
	ARMOR ROCK(0.5t) (BELOW -4.0m)	Q'TY(m3)	m3	1,488,000	928,000	2,416,000
		EQUIPMENT	group	6.0	2.0	
		STONE BARGE(2,000ton)	unit	6	2	
		CRAWLER CRANE(70 ton)	unit	12.0	4.0	
		REQUIRED PERIOD	years	1.36	1.26	
		CAPACITY(m3/hr)	m3/hr	668	413	
		CAPACITY(m3/year)	m3/year	1,095,192	735,852	
	ARMOR ROCK(0.5t) (ABOVE -4.0m)	Q'TY(m3)	m3	112,000	272,000	384,000
		EQUIPMENT	group	1.0	1.0	
		BACKHOE BARGE(8 m3)	unit	1	1	
		FLAT TOP BARGE(2,000ton)	unit	2.0	2.0	
		PUSHER TUG(1,300 HP)	unit	2.0	2.0	
		CRAWLER CRANE(70 ton)	unit	2.0	2.0	
		REQUIRED PERIOD	years	0.34	0.76	
		CAPACITY(m3/hr)	m3/hr	202	202	
		CAPACITY(m3/year)	m3/year	331,280	359,560	
	ARMOR ROCK(3.0t) (BELOW -4.0m)	Q'TY(m3)	m3	0	0	0
		EQUIPMENT	group	0.0	0.0	
		STONE BARGE(1,000ton)	unit	0	0	
		CRAWLER CRANE(70 ton)	unit	0.0	0.0	
		REQUIRED PERIOD	years	0.00	0.00	
		CAPACITY(m3/hr)	m3/hr	0	0	
		CAPACITY(m3/year)	m3/year	0	0	
	ARMOR ROCK(3.0t) (ABOVE -4.0m)	Q'TY(m3)	m3	700,000	700,000	1,400,000
		EQUIPMENT	group	4.0	4.0	
		CRANE BARGE(50tx2)	unit	4	4	
		FLAT TOP BARGE(1,000ton)	unit	8.0	8.0	
		PUSHER TUG(1,300 HP)	unit	8.0	8.0	
		CRAWLER CRANE(70 ton)	unit	8.0	8.0	
		REQUIRED PERIOD	years	3.81	3.51	
		CAPACITY(m3/hr)	m3/hr	112	112	
		CAPACITY(m3/year)	m3/year	183,680	199,360	
	TOTAL VOL. OF FILL MATERIAL		m3	9,800,000	8,300,000	18,100,000
	TOTAL TIME REQUIRED		years	4.81	4.51	

IV.2 Chapter 6. Diversion Scheme

6.1 Quantities

(1) Coffer Dams

Table IV. 2.6.1 - 1 Quantities required for Diversion Scheme

Canal Excavation Zone Division	Coffer Dams	Concrete	Excavation	*Embank-ment	Foundation Treatment	
					Drilling	Grouting
Zone II	E-1	-	20,000m^3	50,000m^3	-	-
Zone III	W-3	2,000m^3	50,000m^3	230,000m^3	2,000m	2,000m
Zone III	W-4	500m^3	55,000m^3	220,000m^3	2,000m	2,000m
Zone III	W-6	1,000m^3	50,000m^3	250,000m^3	2,500m	2,500m
Zone IV	W-7	-	120,000m^3	780,000m^3	5,000m	5,000m
Total		3,500m^3	295,000m^3	1,530,000m^3	11,500m	11,500m

* Quantities of Core, Filter and Rock.

(2) Channel

Table IV.2.6.1 - 2 Excavation Quantity for respective channel

Canal Excavation Zone Division	Channel	Excavation	Remarks
Zone II	E-1	350,000m^3	
	W-1	750,000m^3	
Zone III	W-3	5,200,000m^3	
Zone III	W-4	300,000m^3	
Zone II	W-6	1,800,000m^3	
Zone IV	W-7	3,000,000m^3	
Zone IV	E-3	1,000,000m^3	Dredging
Total		12,400,000m^3	

6.2 Construction Method

(1) Construction Sequence

Coffer dams and diversion channels are to be constructed preceding canal excavation at each canal zone.

Channel, Dams in the zone ——> Canal Excavation in the zone

(2) Construction of Channels

1) Excavated material is heaped on both sides of the channel as dikes.

(3) Construction of Coffer Dams

1) Embankment materials (core, filter, rock)

- A temporary stock yard for filling materials (core, filter) is prepared at the placing area.

- Materials obtained from canal excavation are to be used.
  Materials suitable for core, filter, rock, etc., are selected at the time of excavation and transported to the temporary stock yard.

- Core material is blended with suitable granular material in the temporary stock yard.

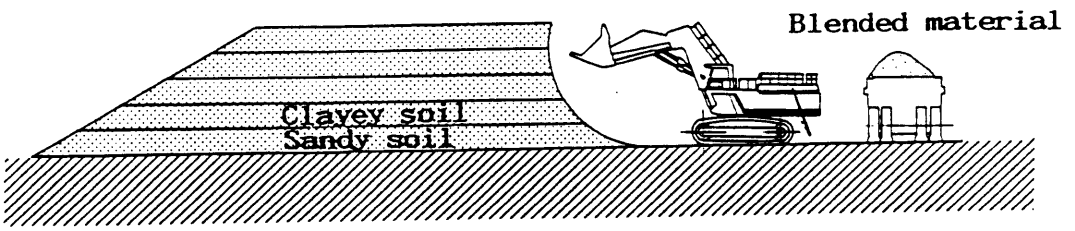


Fig. IV. 2.6.2-1 Method of Blending to make Core Material

2) Construction Sequence of Coffer Dams

- Foundation excavation ___ Foundation Treatment Drilling and Grouting ___ Embankment

- Embankment compaction of each coffer dam is carried out horizontally by thorough roller-compacting after completion of foundation treatment.

IV.2 Chapter 7. New Dam (Upper Gatun Dam)

7.1 Location of New Dam

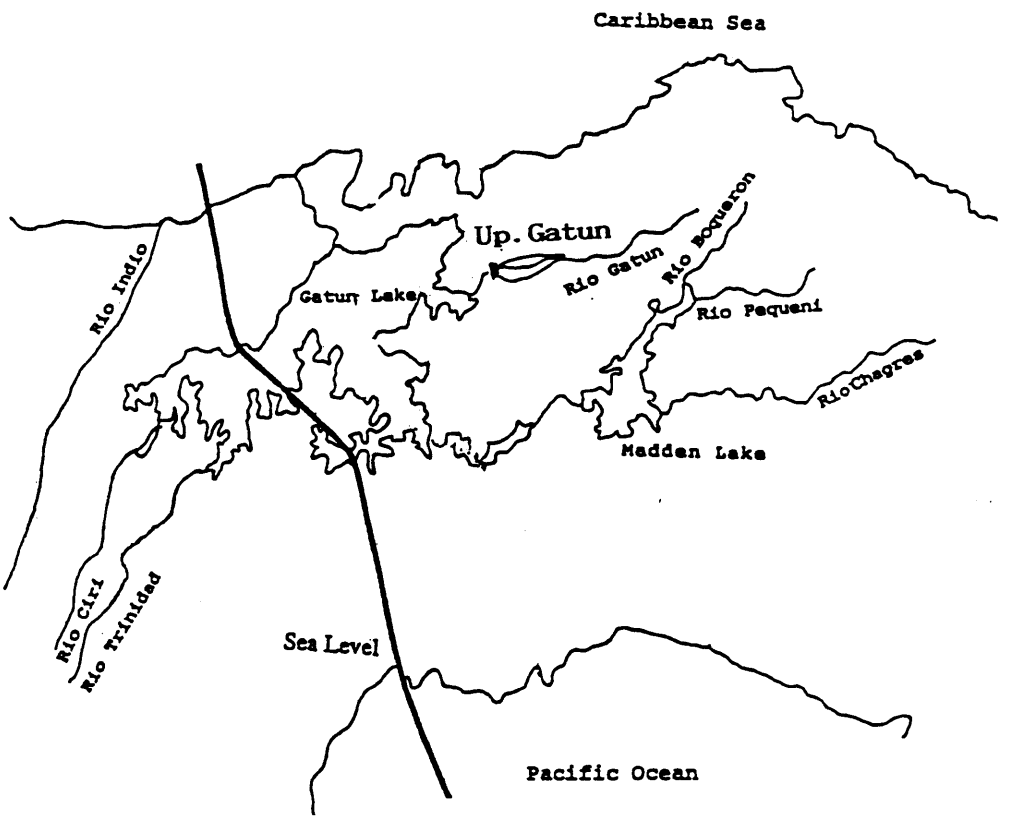


Fig. IV. 2.7.1 - 1 Location of New Dam

Sea Level Canal	2060 year
Case	a, b, c
Upper Gatun Dam	

Upper Gatum Dam is required in the year of 2060.

7.2 Construction Plans

(1) Type of dam

The new dam will be a center core type rockfill dam.

(2) Embankment Materials

For core material, ordinary soil obtained from foundation excavation will primarily be used. Rock and filter materials will be supplied from quarry sites.

(3) Construction Sequence

1) Diversion Tunnel

After diversion tunnel is constructed, the Gatun River is diverted into the tunnel. After dam embankment is completed the tunnel is plugged and then impoundment begins.

2) Foundation Excavation

For the core zone, the trench cut method will be used as standard. After completion of the excavation, the finish excavation will be performed manually.

3) Foundation Treatment

After completion of foundation excavation, blanket grouting and curtain grouting will be performed. Curtain grouting will be performed from the gallery also.

4) Embankment

After completion of the blanket grouting, core and rock embankment will be constructed.

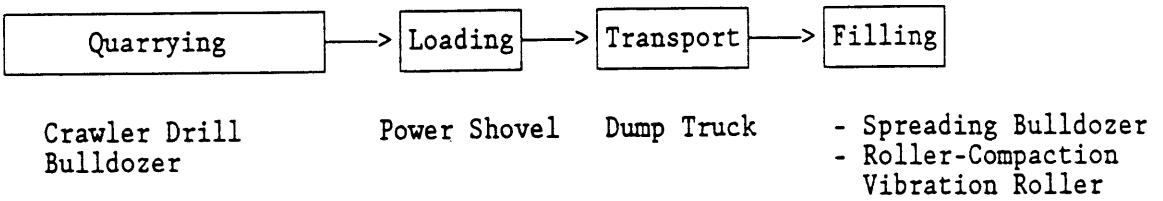
(4) Embankment Materials

1) Rock and filter materials will be taken from the quarry sites.

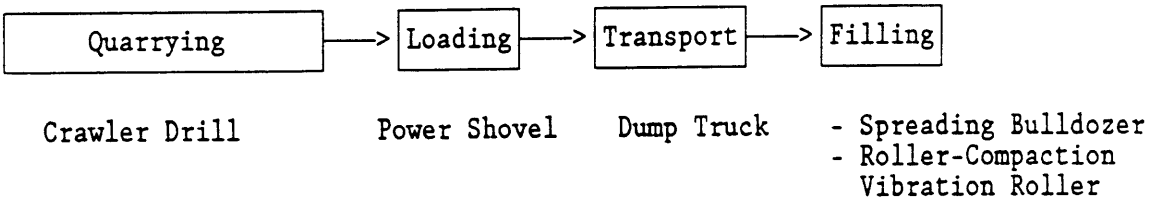
2) Core materials will be obtained from the foundation excavation. These material are blended with suitable materials in order to get lower water content and impervious zone.

(5) Flow of Dam Embankment Construction

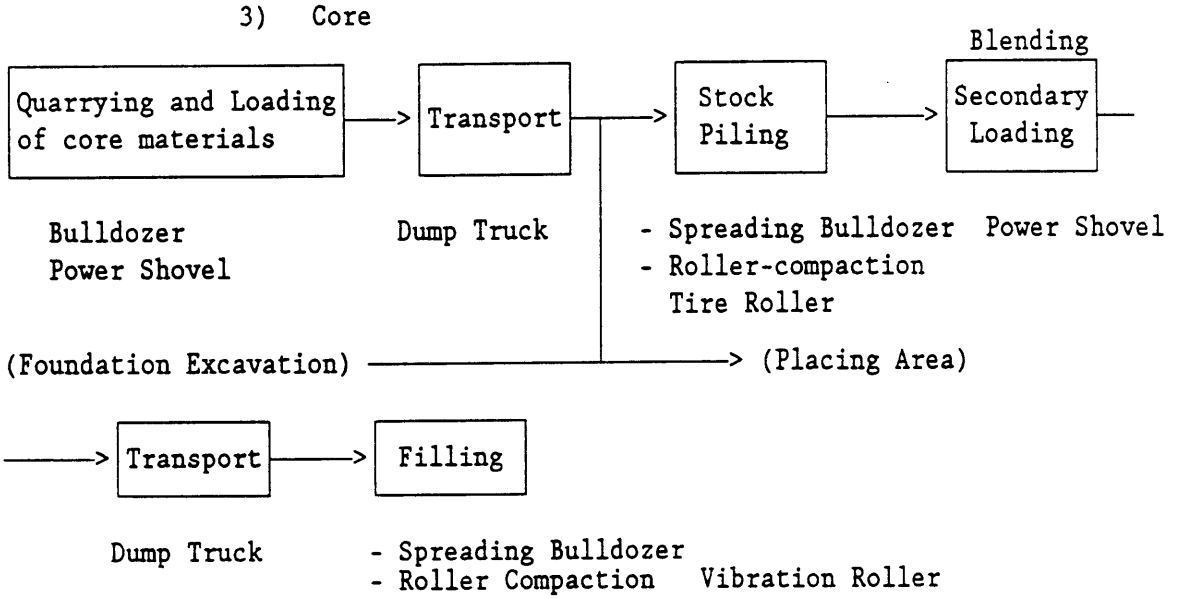
1) Rock



2) Filter



3) Core



IV.2 Chapter 8. Canal Crossing

8.1 Location

(1) New canal is to be crossed by new bridges.

Table IV. 2.8.1-1 New Bridges

Location	Route 10	Existing Canal (Route I)
Pacific	1 (4 lanes)	
Vam Dam	1 (4 lanes)*	1 (4 lanes)*
Middle	1 (2 lanes)	1 (2 lanes)*
Atlantic	1 (2 lanes)	1 (2 lanes)*
Total	7 Bridges	

* To be constructed by 2060

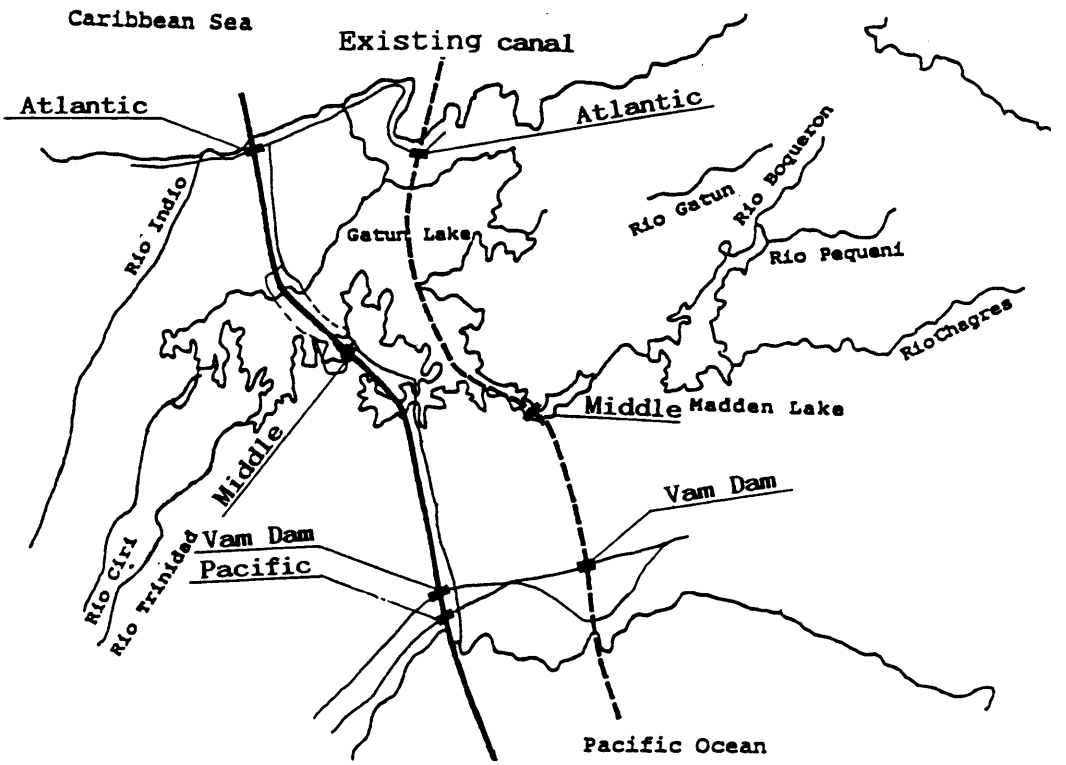


Fig. IV. 2.8.1 - 1 Location of Canal Crossing

8.2 Construction Plans

(1) The construction of these new bridges is to proceed without regard to the canal construction.

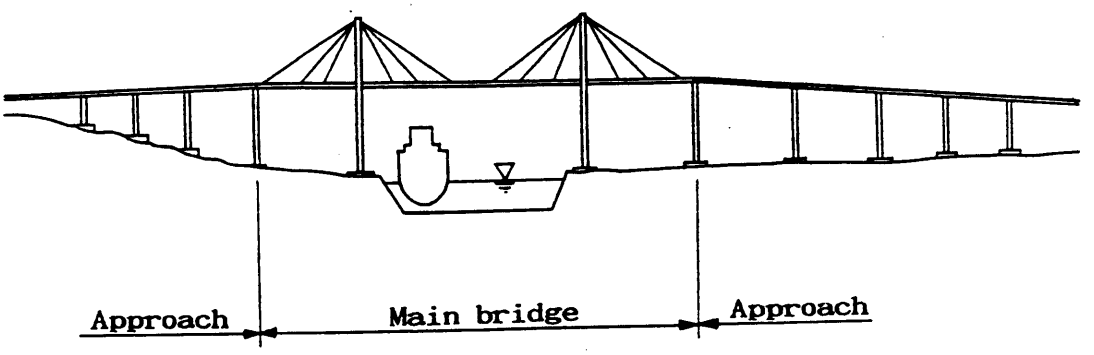


Fig. IV. 2.8.2 -1 Typical Side View of New Bridge

IV.2 Chapter 9. Supporting Construction

9.1 Construction Villages and Camps

(1) General

2 construction village and 5 labor camps will be constructed for accommodating approx. 10,000* workers, 800 staff and their families.
Construction villages will be handed over to the client for permanent use after completion of construction work.
Labor camp will be removed after completion of the work.

(2) Description of Village and Camps

Table IV. 2.9.1 shows description and quantities to build houses and facilities for village and camps.

Table IV. 2.9.1-1 Houses and Facilities

Description	Village	Labor Camps
Detached House A	2 places x 5 nos. x 400m^2	-
" " B	2 places x 50 nos. x 300m^2	
" " C	2 places x 200 nos. x 200m^2	
Dormitory	2 places x 7,000m^2	5 x 4,000m^2
Condominium	-	5 x 32,000m^2
Resthouse	2 places x 2,000m^2	-
Canteen	2 places x 1,000m^2	5 x 1,000m^2
Mess Hall	2 places x 1,000m^2	5 x 1,000m^2
Supermarket	2 places x 1,000m^2	5 x 1,000m^2
Retail Shop	2 places x 1,500m^2	5 x 1,500m^2
Bottle Shop	2 places x 200m^2	5 x 200m^2
Bank	2 places x 200m^2	5 x 200m^2
Post Office	2 places x 200m^2	5 x 200m^2
Camp Office	2 places x 200m^2	5 x 200m^2
Security/Body Corporate Office	2 places x 100m^2	5 x 100m^2
School	2 places x 2,500m^2	5 x 2,500m^2
Church	2 places x 500m^2	5 x -

(continued)

Description	Village	Labor Camps
Library	2 places x 200m^2	5 x -
Sports Center	2 places x 2,000m^2	5 x -
Recreation Center	2 places x 1,000m^2	5 x -
Movie Theater	2 places x 2,000m^2	5 x -
Hospital/Clinic	2 places x 2,000m^2	5 x 1,200m^2
Fire Station	2 places x 500m^2	5 x 500m^2
Fuel Station	2 places x 500m^2	5 x 500m^2
Playground	2 places x 10,100m^2	5 x 10,000m^2
Marinas	LS	-
Heliport	LS	-
Bus Terminal	Shuttle Bus/Commuting	Commuting
Telecommunication System	LS	LS
Power Generation System	2 places x 6 nos. x 800 kVA	5 x 3 nos. x 800 kVA
Sewage Treatment System	2 places x 1,000m^3/Day	5 x 1,000m^3/Day
Water Supply System	2 places x 200ton/Day	5 x 400ton/Day
Incineration/ Garbage Treatment	LS	LS

* Refer to Table IV.2.11.3 Manpower Schedule

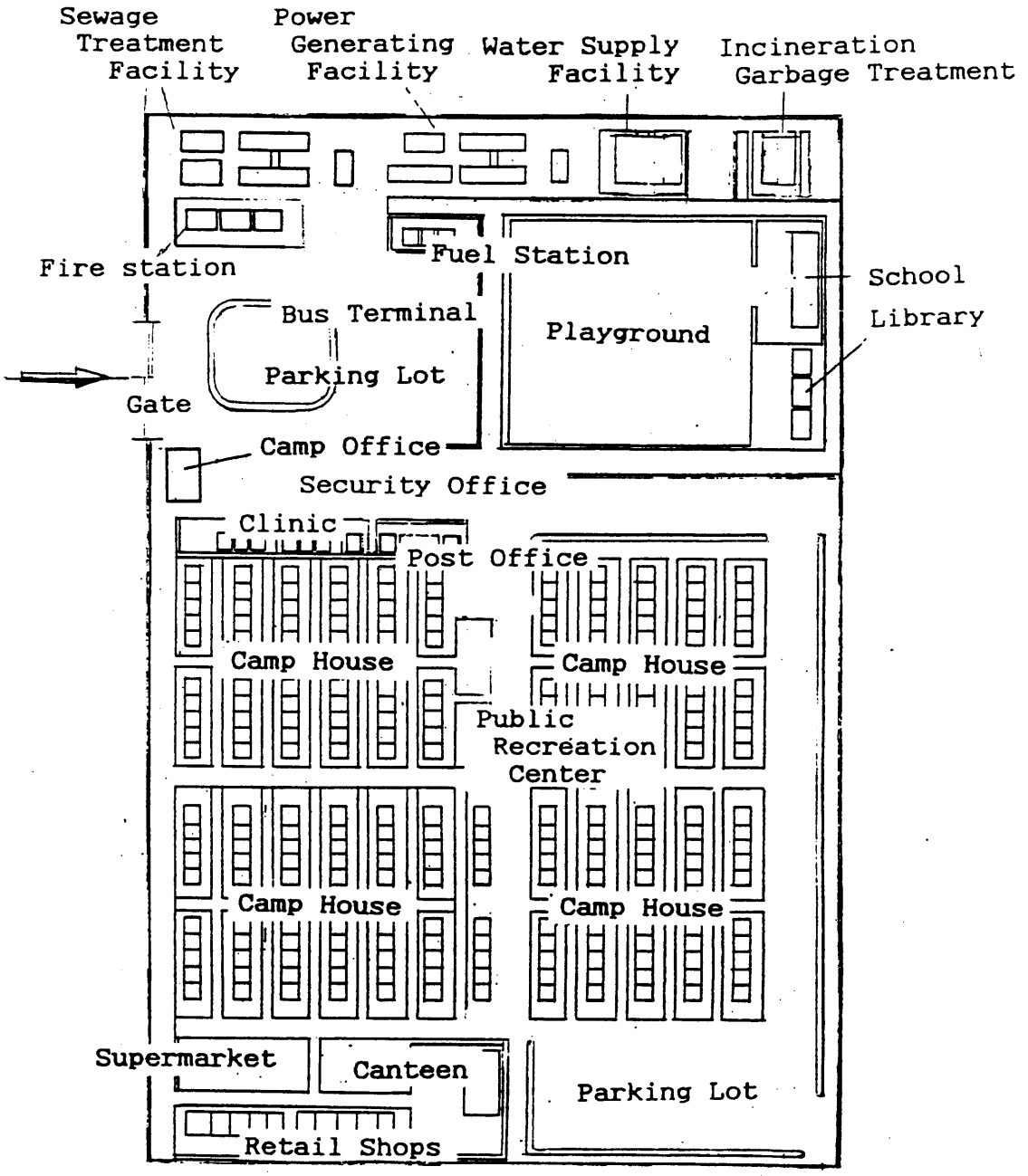


Fig. IV. 2.9.1 - 1 Layout of Camp

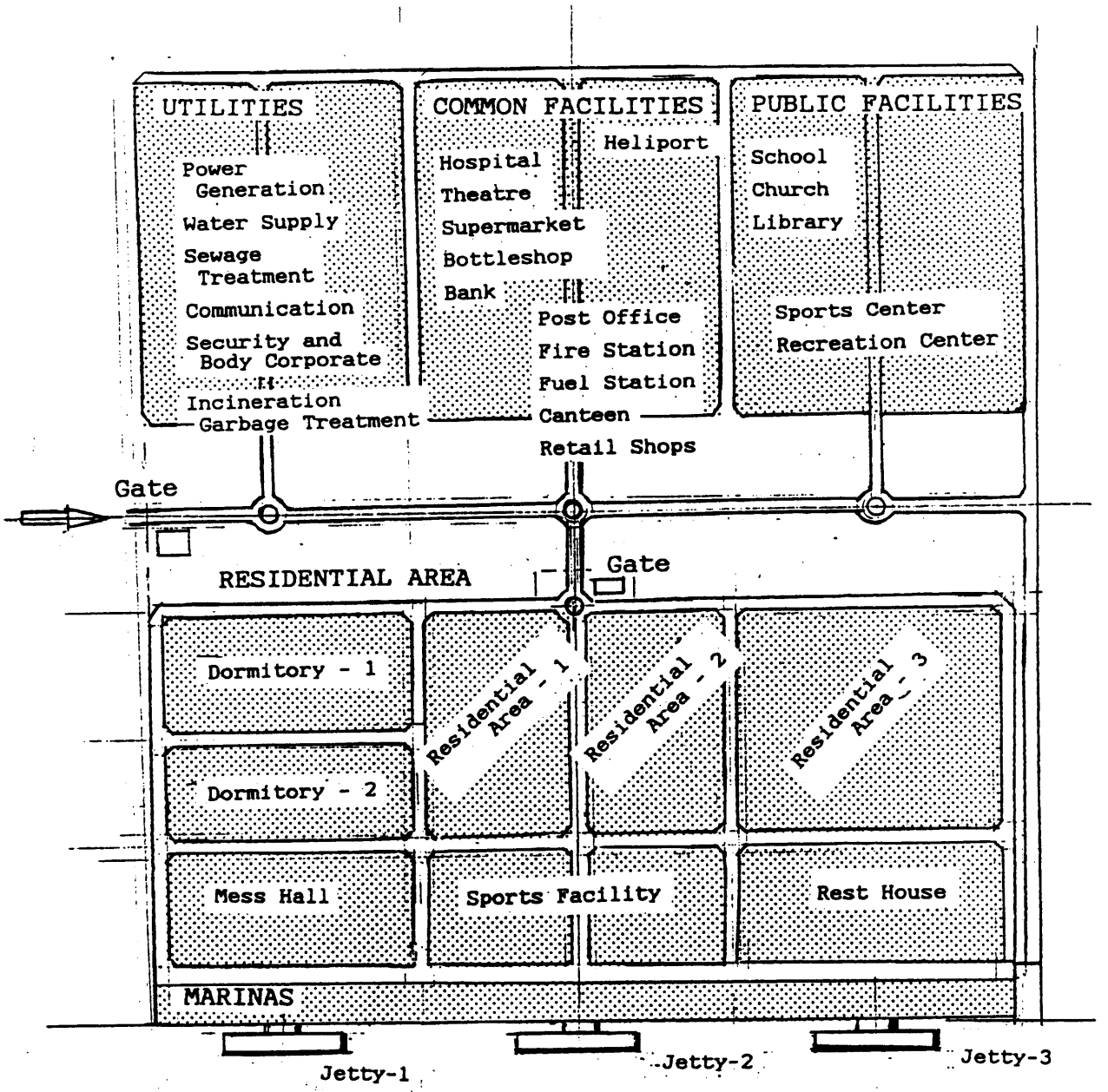


Fig. IV. 2.9.1 - 2 Layout of Village

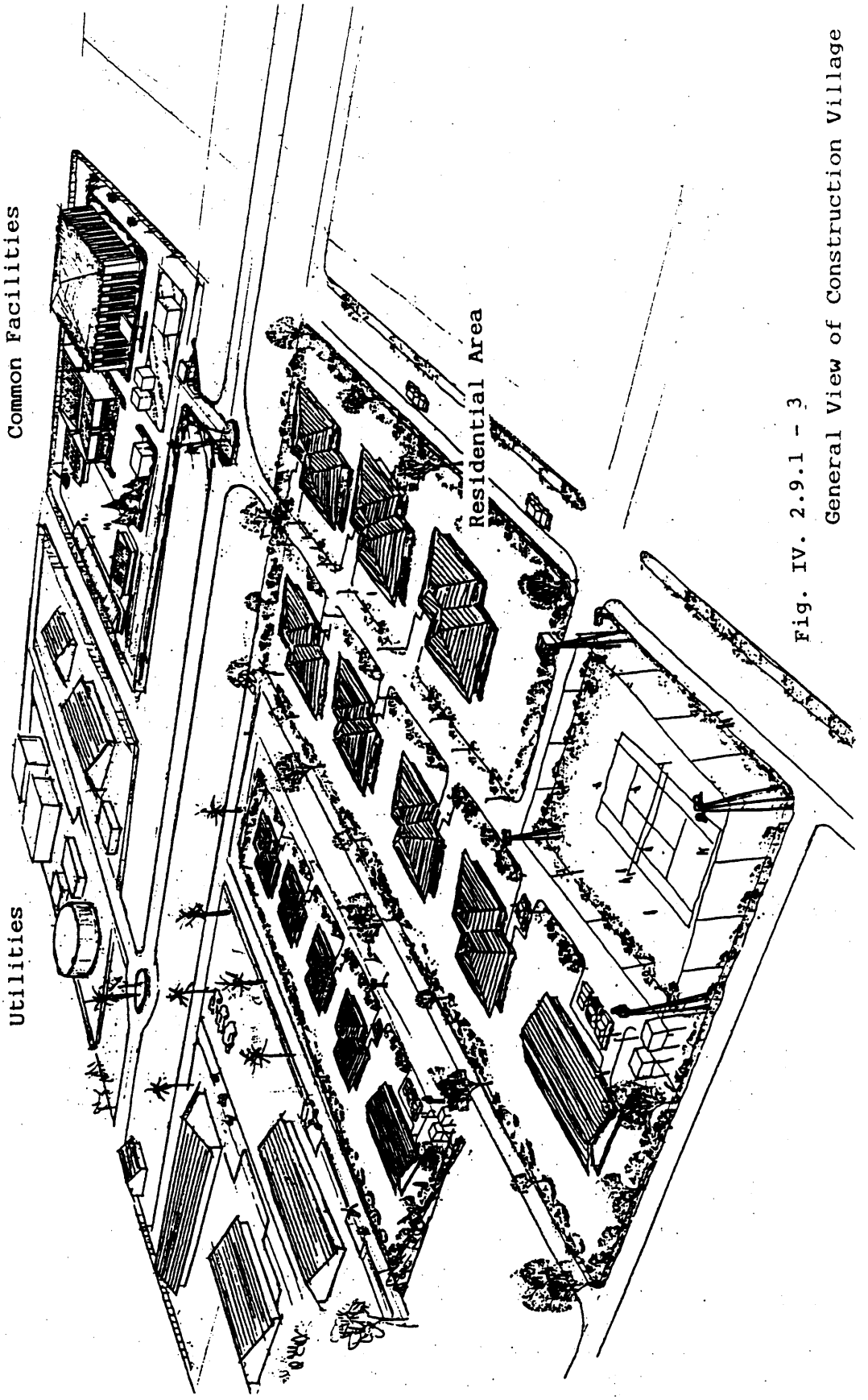


Fig. IV. 2.9.1 - 3
General View of Construction Village

9.2 Main Haul Road

(1) Prior to commencing construction work, a main haul road is to be provided along the canal.

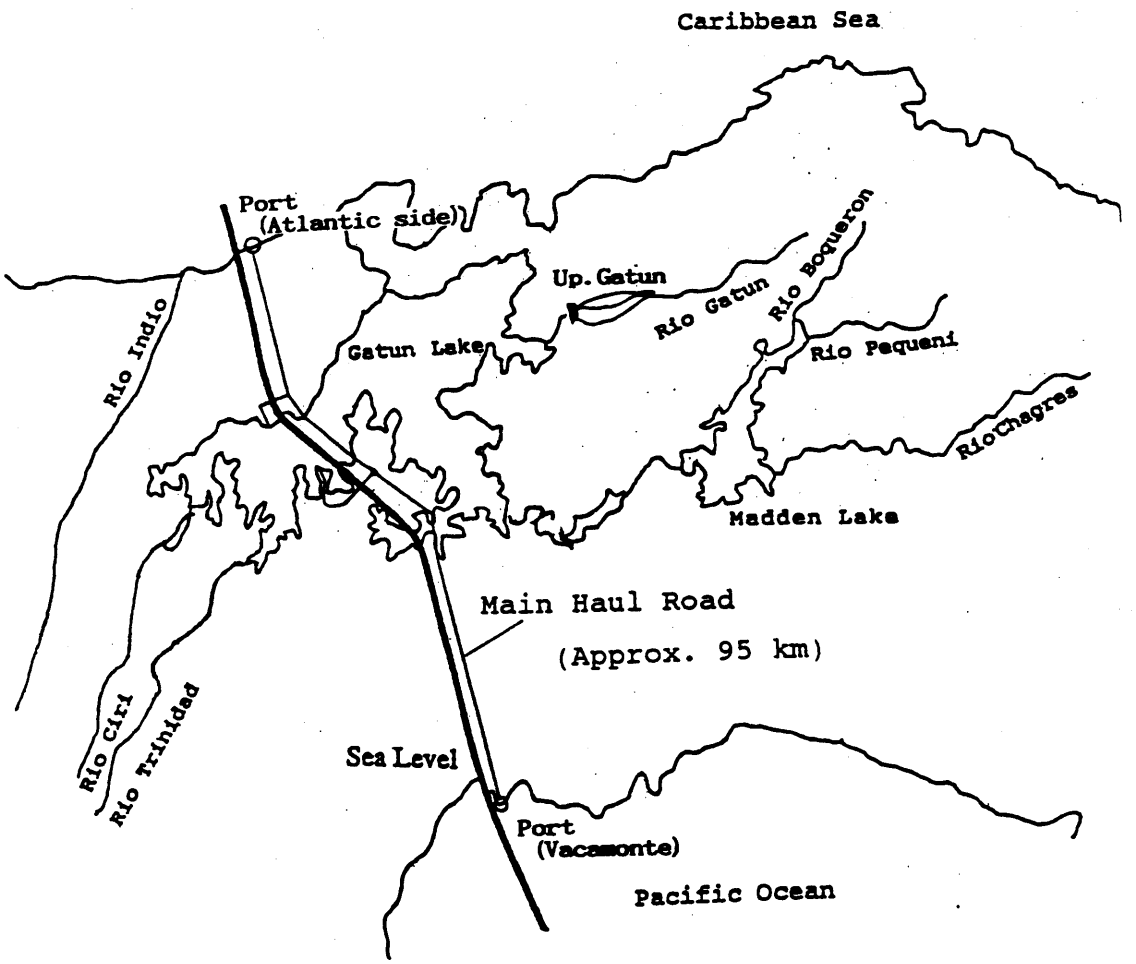


Fig. IV. 2.9.2 - 1 Location of Main Haul Road

(2) Width and Sub-base Course Material of Main Haul Road

Hard and soft rock obtained from canal excavation is used for sub-base course material.

Actual thickness of sub-base is to be determined at the time of construction stage depending on soil conditions.

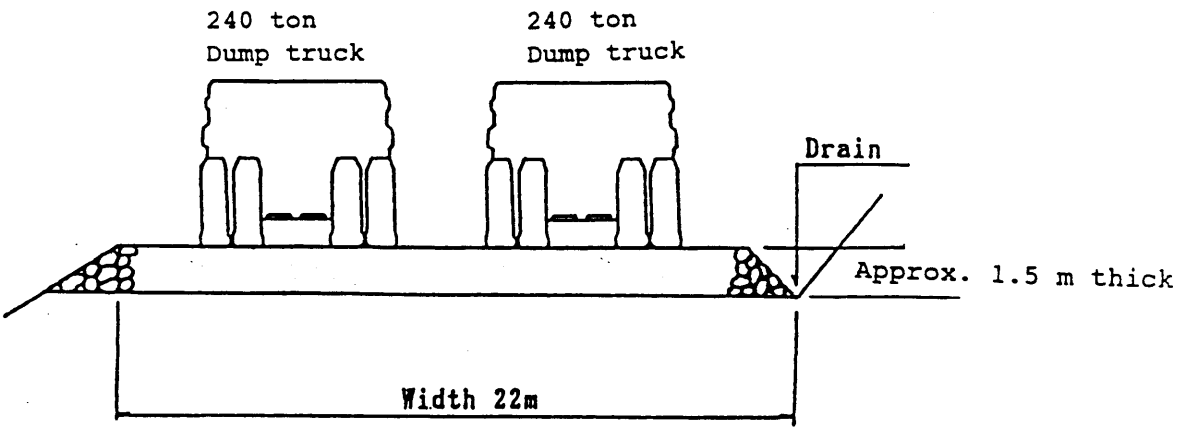
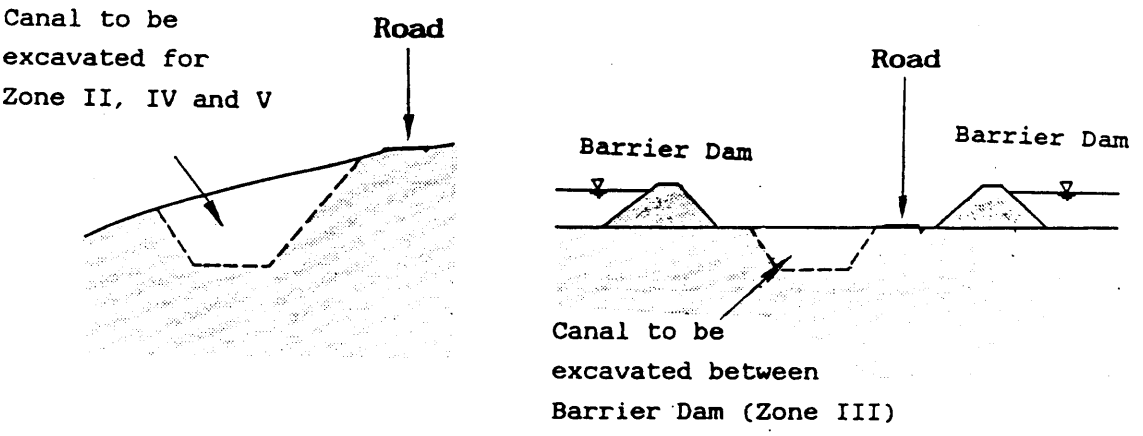


Fig.IV. 2.9.2 - 2 Typical Section of Main Haul Road

(3) Location of Main Haul Road to be constructed



Zone II, IV and V Between Barrier Dams (Zone III)

Fig. IV. 2.9.2 - 3 Relative Position of Main Haul Road

9.3 Access Road to and from Quarry/Wharf

(1) Location of Access Road

An access road with a width of 15m for transport of aggregate for lock/gate concrete and materials for breakwater and armor is provided.

Table IV. 2.9.3-1 Length and use of Access Road (29 km)

Section		Length	Use
Temporary Port	Quarry	9 km	Transport of Aggregate and Armour
Quarry	Pacific Side Lock/Gate	9 km	Transport of Aggregate (for Lock/Gate)
Quarry	Temporary Port Vacamonte	11 km	Transport of Armour Material (for breakwater)

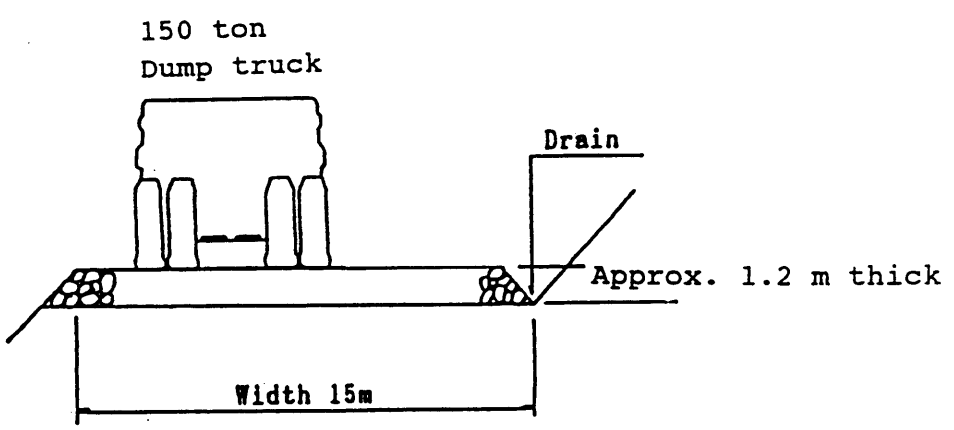


Fig. IV. 2.9.3-1 Typical Section of Access Road

Note: * Actual thickness is to be determined at the time of construction stage depending on soil conditions.

9.4 Logistic Base Facilities

(1) Purpose and Location of Logistic Base

Table IV. 2.9.4 - 1

Location of Wharf		Number	Use
Atlantic Side	Puerto Pilon	1 location	Storage and shipment of aggregate Shipment of armor rock for breakwater
	Atlantic Side	1 location	Unloading and storage of cement, unloading of aggregate Unloading and storage of fuel, lubricants, etc.
Pacific Side	Vacamonte	1 location	Shipment of armor rock Unloading and storage of cement Unloading and storage of fuel, lubricants, etc.

(2) Capacity of Facilities

1) Cement

a. Cement is to be imported from abroad in principle.

b. Approximately 20 day consumption quantity of cement.

c. Atlantic Ocean Side, Pacific

- Cement silos are to be installed at logistic base at Vacamonte.

2) Aggregate, Armor Rock (Breakwater)

a. Concrete aggregate for Lock/Gate on Atlantic Side is stored at logistic base at Puerto Pilon and shipment facilities are to be provided.

b. Shipment facilities of armor rock for breakwater are to be provided at Puerto Pilon.

3) Fuel, Oil and Lubricants

a. Fuel, oil and lubricants, etc., used for construction equipment are to be imported from abroad in principle.

b. At logistic base at Vacamonte on Atlantic Ocean Side, fuel and oil storage tanks are to be provided.

4) Others

a. At logistic base at Vacamonte on Atlantic Ocean Side, warehouses sheds, etc. for temporary storage of construction equipment, ports and construction materials, are to be provided.

Table IV. 2.9.4 - 2 Logistic Base Facilities

Case	a			b			c		
Atlantic/Pacific	Atlantic		L Pacific	G Atlantic		G Pacific	L Atlantic		L Pacific
Logistc Base	Puerto Pilon	Atlantic Ocean Side	Vacamonte	Puerto Pilon	Atlantic Ocean Side	Vacamonte	Puerto Pilon	Atlantic Ocean Side	Vacamonte
A. Cement storage facility Cement silo (1,500t/unit)	--	--	15	--	5	5	--	15	15
B. Facility for aggregate and armor rock * 1 storage, shipment	Armor	--	Armor	Armor, Aggregate	--	Armor	Armor, Aggregate	--	Armor
Storage, unloading	--	--	--	--	Aggregate	--	--	Aggregate	--
C.* 2 fuel, oil and lubricants storage facility Fuel storage tank (1,600kl/unit)	--	10	10	--	10	10	--	10	10
Oil tank (100kl/unit)		3	3		3	3		3	3
d. Warehouse, shed									

*1 Loading and unloading of aggregate and armor rock to and from barge are carried out using a crane.

*2 Storage facility is not provided for fuel, oil, lubricants, etc., as the quantity is small.

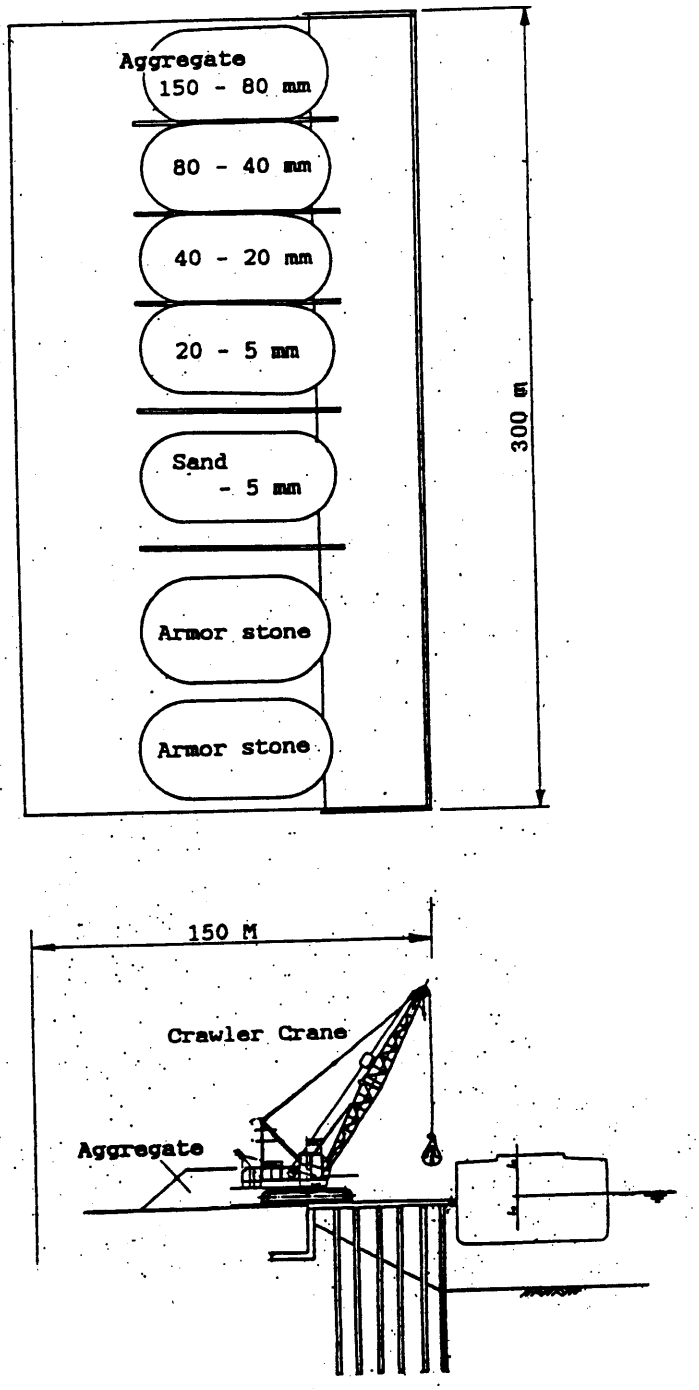


Fig. IV. 2.9.4 - 1 Logistic Base Facilities at Puerto Pilon

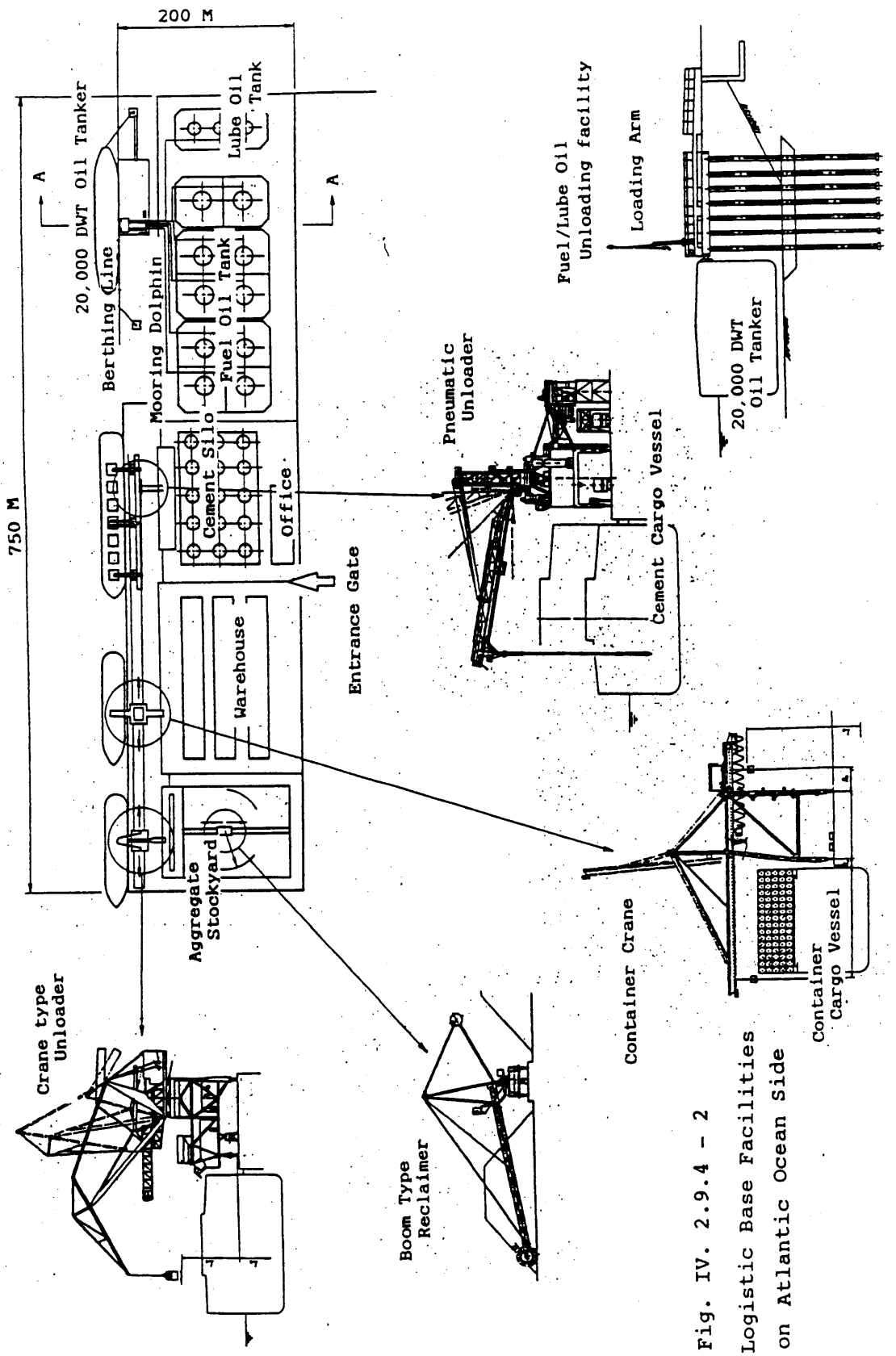


Fig. IV. 2.9.4 - 2
Logistic Base Facilities on Atlantic Ocean Side

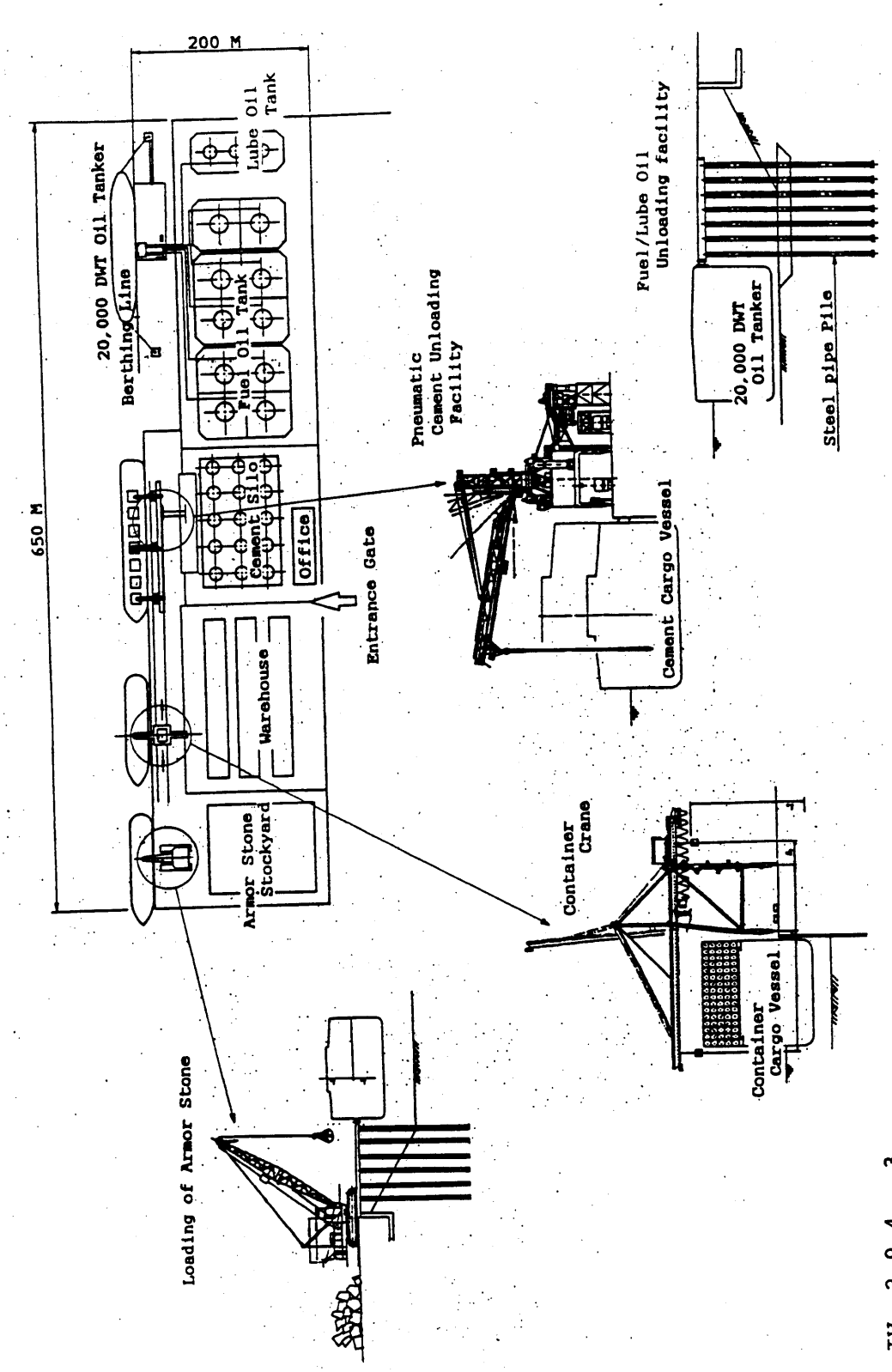


Fig. IV. 2.9.4 - 3
Logistic Base Facilities on Vacamonte

IV.2 Chapter 10. Constructabilities

Difficulties may be encountered at several points in the execution of the construction works. These will be overcome by the following measures:

10.1 Barrier Dam Construction

Although the construction procedure is the same as for the ordinary fill-type dam - including excavation, embankment construction, etc., - all the work has to be carried out underwater. This means that normal compaction methods cannot be used to compact the fill material. To solve this problem, the following are included in the design.

(1) Drainage layers are provided so as to achieve compaction of the fill-material through natural consolidation.

(2) Curtain grouting is performed on the core portion to form an impermeable zone.

No problems are anticipated from the point of view of execution, as this design has actually been used for the Plover Cove Dam Project in Hong Kong. But the problem remains as to whether or not it is possible to obtain fill material conforming to the design specification from excavated materials in the vicinity of the construction site. This has to be determined from the results of investigation carried out in the future.

10.2 Canal Excavation between Barrier Dams

As the canal excavation between barrier dams is assumed to involve areas of hard rock requiring blasting in part, the dry excavation method is adopted for excavation of the deep portion. In the case of using this method, it is necessary to pay more attention to drainage than for other canal excavation methods. Attention should also be

paid to reducing ground vibration using a carefully controlled blasting method (II.2.3.5 - 7). In addition to normal rainfall, the seepage water from Gatun Lake through Barrier Dams will have to be drained. Not only will the drainage system need to be more extensive than usual, but in some cases, a forced drainage system of groundwater, such as deep well, etc., may have to be considered. There will be no problems from the point of view of execution as long as sufficient drainage systems are provided. But as the excavation at this point constitutes the critical path in the entire construction programme, scrupulous investigation and planning is called for.

10.3 Dewatering of Entrapped Water between Barrier Dams

Dry excavation should be commenced after Barrier Dams have been completed and water between Barrier Dams drained. In this case, the method of drainage of this water will be such that the water is discharged to the drainage channel provided on the Atlantic side while excavation is in progress.
At that time, if high volume discharge occurs, erosion would occur in the channel or a slope failure would occur on the slope of the Barrier Dam. The drainage channel should be excavated while controlling discharge volume at a designated volume. Detailed planning will be necessary.

IV.2 Chapter 11. Construction Schedule

11.1 Overall Work Schedule

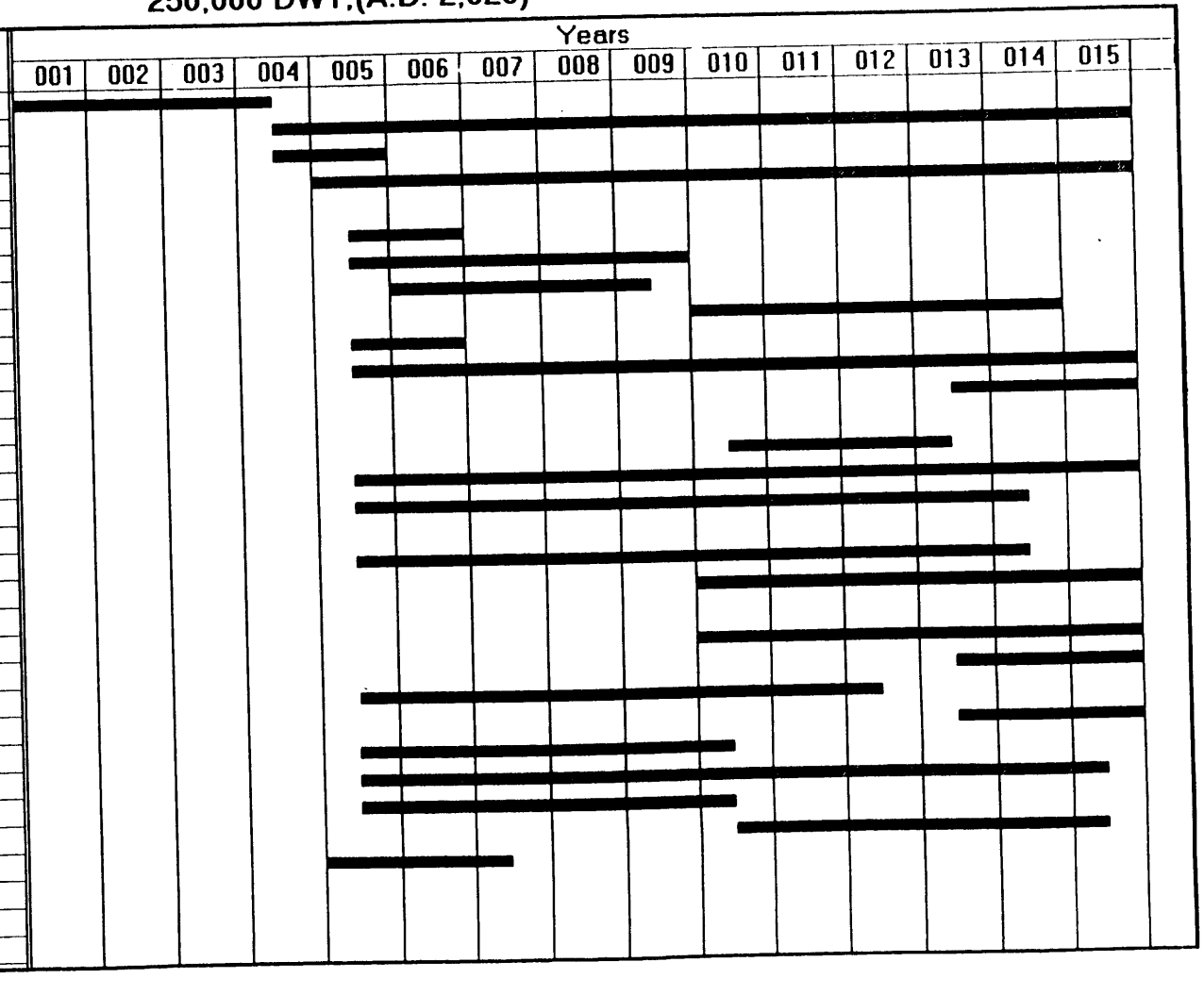
a. Sea Level Canal, 250,000 DWT - Case A
the year of 2,020

b. Sea Level Canal, 250,000 DWT - Case B
the year of 2,020

c. Sea Level Canal, 250,000 DWT - Case C
the year of 2,020

Overall Work Schedule
Sea Level Canel , Case A
250,000 DWT,(A.D. 2,020)

Task Name	Q'ty
Engineering,Design&Tender	1 ls
Construction	
Supporting construction	1 ls
Canal Excavation	
Zone I Dry Excavation	0m3
Zone I Dredging	16,262,000m3
Zone II Dry Excavation	149,516,000m3
Zone II Dredging	84,939,000m3
Zone III Dry Excavation	209,417,000m3
Zone III Dredging	24,753,000m3
Zone IV Dry Excavation	589,204,000m3
Zone IV Dredging	57,369,000m3
Zone V Dry Excavation	0m3
Zone V Dredging	21,020,000m3
Placing Area	51.0 km2
Lock Structure	
Atlantic Side	0m3
Pacific Side	6,000,000m3
Gate Leaves, etc.	
Atlantic Side	-
Pacific Side	1 ls
New Permanent Road	71 km
Canal Crossing(Bridges)	3 Bridges
Navigation System	1 ls
Barrier Dams E.F.G Dams	3 Dams
Breakwater	
Atlantic Side	1 ls
Pacific Side	1 ls
Diversion Scheme	1 ls



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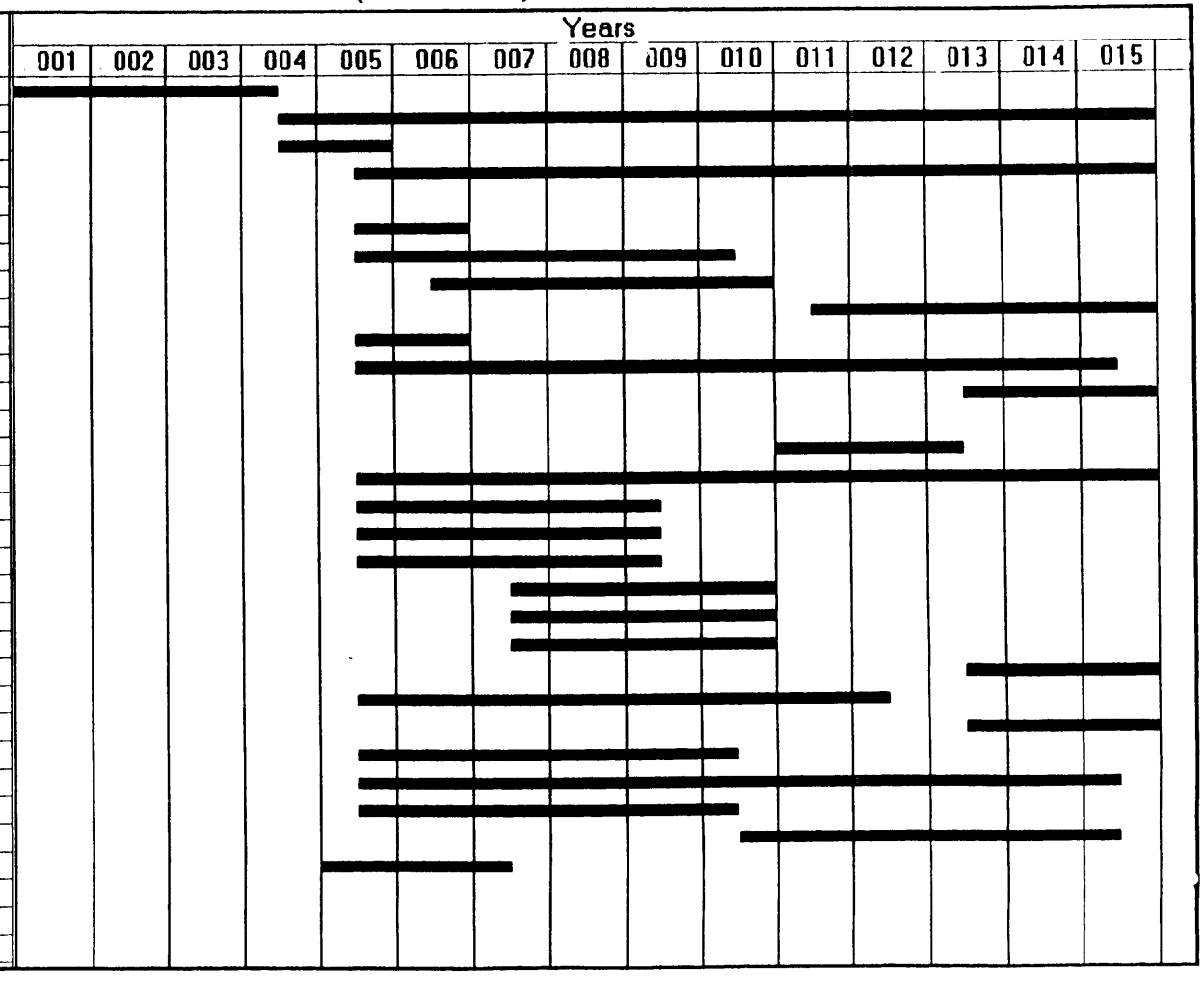
Overall Work Schedule
Sea Level Canel , Case B
250,000 DWT,(A.D. 2,020)

Task Name	Q'ty
Engineering,Design&Tender	
Construction	
Supporting construction	
Canal Excavation	
Zone I Dry Excavation	0m3
Zone I Dredging	17,495,000m3
Zone II Dry Excavation	239,581,000m3
Zone II Dredging	158,772,000m3
Zone III Dry Excavation	209,417,000m3
Zone III Dredging	24,753,000m3
Zone IV Dry Excavation	584,574,000m3
Zone IV Dredging	52,582,000m3
Zone V Dry Excavation	0m3
Zone V Dredging	97,776,000m3
Placing Area	51.0 km2
Lock Structure	
Atlantic Side	980,000m3
Pacific Side	980,000m3
Gate Leaves, etc.	
Atlantic Side	1 ls
Pacific Side	1 ls
New Permanent Road	71 km
Canal Crossing(Bridges)	3 Bridges
Navigation System	1 ls
Barrier Dams E.F.G Dams	3 Dams
Breakwater	
Atlantic Side	1 ls
Pacific Side	1 ls
Diversion Scheme	1 ls



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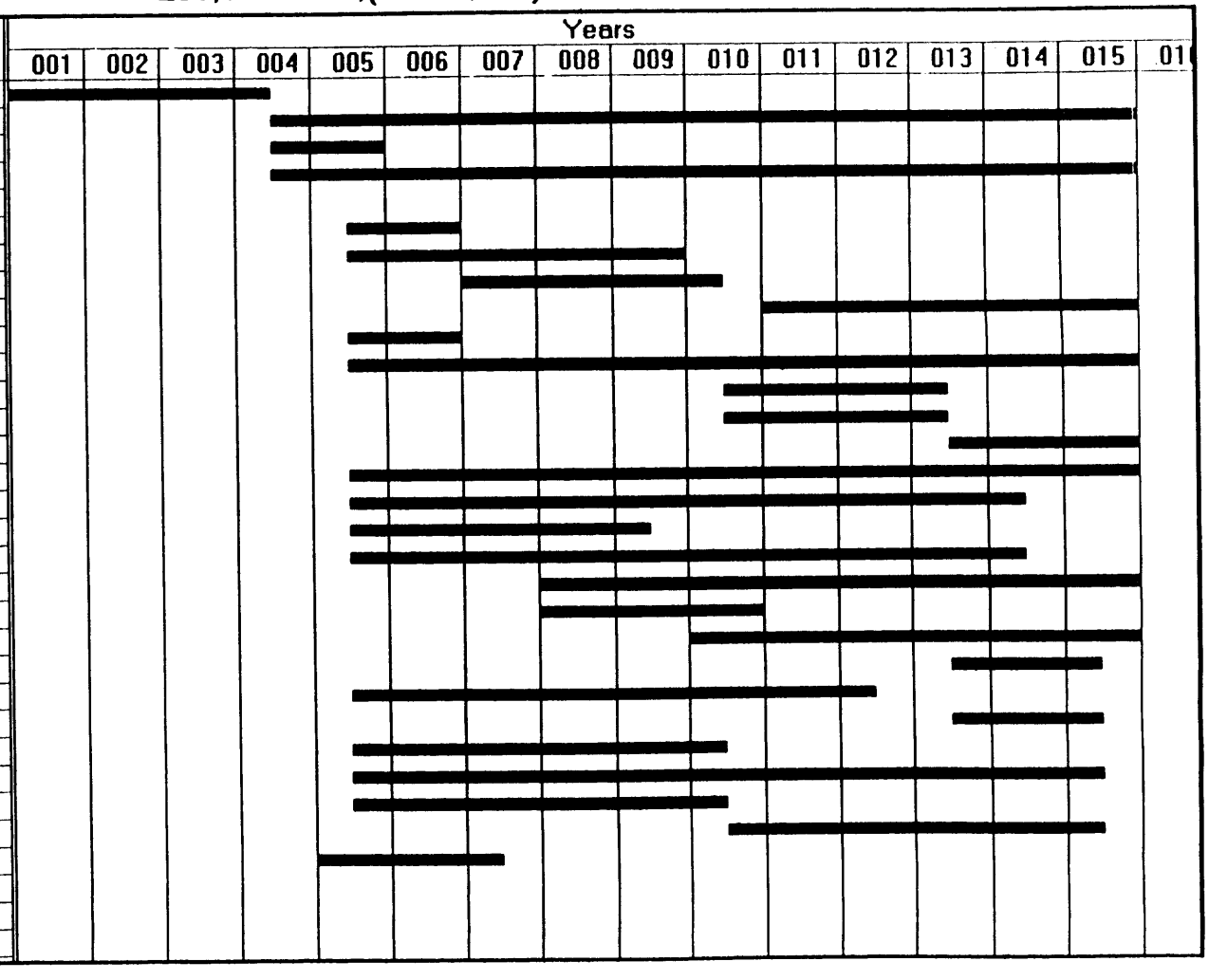
Overall Work Schedule
Sea Level Canel , Case C
250,000 DWT,(A.D. 2,020)

Task Name	Q'ty
Engineering,Design&Tender	1 ls
Construction	
Supporting construction	1 ls
Canal Excavation	
Zone I Dry Excavation	0m3
Zone I Dredging	16,262,000m3
Zone II Dry Excavation	149,516,000m3
Zone II Dredging	84,939,000m3
Zone III Dry Excavation	209,417,000m3
Zone III Dredging	24,753,000m3
Zone IV Dry Excavation	589,204,000m3
Zone V Dry Excavation	0m3
Zone V Dredging	121,020,000m3
Zone IV Dredging	57,369,000m3
Placing Area	51.0 km2
Lock Structure	
Atlantic Side	980,000m3
Pacific Side	6,000,000m3
Gate Leaves, etc.	
Atlantic Side	1 ls
Pacific Side	1 ls
New Permanent Road	71 km
Canal Crossing(Bridges)	3 Bridges
Navigation System	1 ls
Barrier Dams E.F.G Dams	3 Dams
Breakwater	
Atlantic Side	1 ls
Pacific Side	1 ls
Diversion Scheme	1 ls



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11.2 Schedule for Equipment and Vessel Requirements

	Description	D.W.T.	Case	Table No.
1.	Schedule for Equipment & Vessels	250,000	A	IV.2.11.2-1a
	Schedule for Equipment & Vessels	"	"	IV.2.11.2-1b
2.	Schedule for Equipment & Vessels	250,000	B	IV.2.11.2-2a
	Schedule for Equipment & Vessels	"	"	IV.2.11.2-2b
3.	Schedule for Equipment & Vessels	250,000	C	IV.2.11.2-3a
	Schedule for Equipment & Vessels	"	"	IV.2.11.2-3b

Table IV.2.11.2-1(a)
SCHEDULE FOR EQUIPMENT AND VESSELS
SEA LEVEL CANAL-250,000 D.W.T.-Case A

File:EQSSA02

DESCRIPTION	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PRICE CIF PANAMA ($/unit)
Canal Excavation(Dry)																		
Crawler Drill(32ton-225mm)						1	3	3	3	2	2	2	4	4	4			734,760
Bulldozer(98ton)					129	129	129	129	129	82	141	141	141	141	141			1,002,340
Shovel(30m3)					11	11	11	11	11	7	12	12	12	12	12			7,521,696
Dump Truck(240ton)					137	137	137	137	137	84	138	138	138	138	138			1,621,807
Canal Excavation(Dredging)																		
Grab(50m3)					2	1		2	2	2	2	2	2	2	2			13,314,286
Split Barge(5000m3)					6	8	8	8	6	6	10	10	12	8	8			3,850,000
Split Barge(1500m3)								4	4	4				4	4			2,652,857
Pusher Tug(3200HP)					3	4	4	4	3	3	5	5	6	4	4			3,646,429
Pusher Tug(1300HP)								2	2	2				2	2			2,088,571
Trailer(10000m3)						1					1	1	1					82,557,143
Cutter(18000HP)					1	2	1	1			1	1	2					27,485,714
Cutter(27500HP)					1	2	3	3	3	3	2	2	2	4	4			40,771,429
Blasting Barge w/t Assisting Vessels								2	2	2				2	2			26,196,343
Lock Construction																		
Crawler Drill(32ton-225mm)						3	3	3										734,760
Bulldozer(98ton)					118	118	118	118										1,002,340
Shovel(30m3)					10	10	10	10										7,521,696
Dump Truck(240ton)					120	120	120	120										1,621,807
Batching Plant(70m3/hr)								3	3	3	3	3	3	3				1,191,240
Genarator(450KVA)								3	3	3	3	3	3	3				175,160
Jib Crane(13.5ton-75m)								4	4	4	4	4	4	4				5,230,000
Generator(800KVA)								2	2	2	2	2	2	2				270,960
Agitating Car(4.5m3)								21	21	21	21	21	21	21				81,440
Aggregate Production																		
Crawler Drill(32ton-225mm)								1	1	1	1	1	1	1				734,760
Bulldozer(98ton)								1	1	1	1	1	1	1				1,002,340
Shovel(3.3m3)								2	2	2	2	2	2	2				946,194
Dump Truck(32ton)								5	5	5	5	5	5	5				430,505
Crushing Plant(500ton/hr)								1	1	1	1	1	1	1				14,909,332
Generator(800KVA)								4	4	4	4	4	4	4				270,960
Shovel(3.3m3)								1	1	1	1	1	1	1				946,194
Dump Truck(32ton)								15	15	15	15	15	15	15				430,505

Table IV.2.11.2-1(b)
SCHEDULE FOR EQUIPMENT AND VESSELS
SEA LEVEL CANAL-250,000 D.W.T.-Case A

File:EQSSA02

DESCRIPTION	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PRICE CIF PANAMA ($/unit)
Barrier Dam Construction																		
Grab Dredger(50m3)					2	2	2											13,314,286
Split Barge(5,000m3)					4	4	4											3,850,000
Pusher Tug(3,200HP)					2	2	2											3,646,429
Stone Barge(2,000ton)						18	24	12	2	2								5,085,390
Crawler Crane(70 ton)						38	54	40	18	16								559,857
Backhoe Barge(8 m3)						1	3	3	2	1								650,572
Flat Top Barge(2,000ton)						3	8	7	5	2								2,141,143
Pusher Tug(1,300HP)						3	8	11	9	6								2,088,571
Stone Barge(1,000ton)								1	1	1								4,018,214
Crane Barge(50tx2)								2	2	2								1,397,857
Flat Top Barge(1,000ton)								4	4	4								1,430,000
Breakwater Construction																		
Split Barge(5,000m3)					2	2				3								3,850,000
Pusher Tug(3,200HP)					1	1				2								3,646,429
Crawler Crane(70 ton)					16	18	12	8	8	12	6	12	10	8	8			559,857
Cutter Suction(18,000HP)										1								27,485,714
Backhoe Barge(8 m3)						1	2				1	2	1					650,572
Flat Top Barge(2,000ton)						3	5				3	5	3					2,141,143
Pusher Tug(1,300HP)						3	13	8	8	8	3	13	11	8	8			2,088,571
Stone Barge(2,000ton)					6	6				2	2							5,085,390
Stone Barge(1,000ton)																		4,018,214
Crane Barge(50tx2)							4	4	4	4		4	4	4	4			1,397,857
Flat Top Barge(1,000ton)							8	8	8	8		8	8	8	8			1,430,000

Table IV.2.11.2-2(a)
SCHEDULE FOR EQUIPMENT AND VESSELS
SEA LEVEL CANAL-250,000 D.W.T.-Case B

File:EQSSB02

DESCRIPTION	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PRICE CIF PANAMA ($/unit)
Canal Excavation(Dry)																		
Crawler Drill(32ton-225mm)							4	4	4	2	2	2	4	4	4			734,760
Bulldozer(98ton)					153	153	153	153	153	82	153	153	153	153	153			1,002,340
Shovel(30m3)					13	13	13	13	13	7	13	13	13	13	13			7,521,696
Dump Truck(240ton)					163	163	163	163	163	84	148	148	148	148	148			1,621,807
Canal Excavation(Dredging)																		
Grab(50m3)					2	1		3	3	3	2	2		2	2			13,314,286
Split Barge(5000m3)					6	8	14	14	14	14	6	10	8	6	6			3,850,000
Split Barge(1500m3)								6	6	6				4	4			2,652,857
Pusher Tug(3200HP)					3	4	7	7	7	7	3	5	4	3	3			3,646,429
Pusher Tug(1300HP)								3	3	3				2	2			2,088,571
Trailer(10000m3)						1					1	1						82,557,143
Cutter(18000HP)						2	1	1	1	1	1	1	2					27,485,714
Cutter(27500HP)					1	2	6	6	6	6		2	2	3	3			40,771,429
Blasting Barge w/t Assisting Vessels								3	3	3				2	2			26,196,343
Lock Construction																		
Crawler Drill(32ton-225mm)					4													734,760
Bulldozer(98ton)					48													1,002,340
Shovel(30m3)					4													7,521,696
Dump Truck(240ton)					57													1,621,807
Batching Plant(70m3/hr)						2	2	2	2									1,191,240
Genarator(450KVA)						2	2	2	2									175,160
Jib Crane(13.5ton-75m)						4	4	4	4									5,230,000
Generator(800KVA)						2	2	2	2									270,960
Agitating Car(4.5m3)						14	14	14	14									81,440
Aggregate Production																		
Crawler Drill(32ton-225mm)						2	2	2	2									734,760
Bulldozer(98ton)						2	2	2	2									1,002,340
Shovel(3.3m3)						4	4	4	4									946,194
Dump Truck(32ton)						10	10	10	10									430,505
Crushing Plant(500ton/hr)						2	2	2	2									14,909,332
Generator(800KVA)						8	8	8	8									270,960
Shovel(3.3m3)						2	2	2	2									946,194
Dump Truck(32ton)						59	59	59	59									430,505

Table IV.2.11.2-2(b)
SCHEDULE FOR EQUIPMENT AND VESSELS
SEA LEVEL CANAL-250,000 D.W.T.-Case B

File:EQSSB02

DESCRIPTION	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PRICE CIF PANAMA ($/unit)
Barrier Dam Construction																		
Grab Dredger(50m3)					2	2	2											13,314,286
Split Barge(5,000m3)					4	4	4											3,850,000
Pusher Tug(3,200 HP)					2	2	2											3,646,429
Stone Barge(2,000ton)						18	24	12	2	2								5,085,390
Crawler Crane(70 ton)						38	54	40	18	16								559,857
Backhoe Barge(8 m3)						1	3	3	2	1								650,572
Flat Top Barge(2,000ton)						3	8	7	5	2								2,141,143
Pusher Tug(1,300 HP)						3	8	11	9	6								2,088,571
Stone Barge(1,000ton)								1	1	1								4,018,214
Crane Barge(50tx2)								2	2	2								1,397,857
Flat Top Barge(1,000ton)								4	4	4								1,430,000
Breakwater Construction																		
Split Barge(5,000m3)					2	2				3								3,850,000
Pusher Tug(3,200 HP)					1	1				2								3,646,429
Crawler Crane(70 ton)					16	18	12	8	8	12	6	12	10	8	8			559,857
Cutter Suction(18,000HP)										1								27,485,714
Backhoe Barge(8 m3)						1	2				1	2	1					650,572
Flat Top Barge(2,000ton)						3	5				3	5	3					2,141,143
Pusher Tug(1,300 HP)						3	13	8	8	8	3	13	11	8	8			2,088,571
Stone Barge(2,000ton)					6	6				2	2							5,085,390
Stone Barge(1,000ton)																		4,018,214
Crane Barge(50tx2)							4	4	4	4		4	4	4	4			1,397,857
Flat Top Barge(1,000ton)							8	8	8	8		8	8	8	8			1,430,000

Table IV.2.11.2-3(a)
SCHEDULE FOR EQUIPMENT AND VESSELS
SEA LEVEL CANAL-250,000 D.W.T.-Case C

File:EQSSC02

DESCRIPTION	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PRICE CIF PANAMA ($/unit)
Canal Excavation(Dry)																		
Crawler Drill(32ton-225mm)						1	3	3	3	2	2	2	4	4	4			734,760
Bulldozer(98ton)					129	129	129	129	129	82	141	141	141	141	141			1,002,340
Shovel(30m3)					11	11	11	11	11	7	12	12	12	12	12			7,521,696
Dump Truck(240ton)					137	137	137	137	137	84	138	138	138	138	138			1,621,807
Canal Excavation(Dredging)																		
Grab(50m3)					2	1		2	2	2	2	2	2	2	2			13,314,286
Split Barge(5000m3)					6	8	8	8	6	6	10	10	12	8	8			3,850,000
Split Barge(1500m3)								4	4	4				4	4			2,652,857
Pusher Tug(3200HP)					3	4	4	4	3	3	5	5	6	4	4			3,646,429
Pusher Tug(1300HP)								2	2	2				2	2			2,088,571
Trailer(10000m3)						1					1	1	1					82,557,143
Cutter(18000HP)					1	2	1	1			1	1	2					27,485,714
Cutter(27500HP)					1	2	3	3	3	3	2	2	2	4	4			40,771,429
Blasting Barge w/t Assisting Vessels								2	2	2				2	2			26,196,343
Lock Construction																		
Crawler Drill(32ton-225mm)						3	3	3										734,760
Bulldozer(98ton)					142	118	118	118										1,002,340
Shovel(30m3)					12	10	10	10										7,521,696
Dump Truck(240ton)					146	120	120	120										1,621,807
Batching Plant(70m3/hr)						1	1	4	4	3	3	3	3	3				1,191,240
Generator(450KVA)						1	1	4	4	3	3	3	3	3				175,160
Jib Crane(13.5ton-75m)						2	2	6	6	4	4	4	4	4				5,230,000
Generator(800KVA)						1	1	3	3	2	2	2	2	2				270,960
Agitating Car(4.5m3)						7	7	28	28	21	21	21	21	21				81,440
Aggregate Production																		
Crawler Drill(32ton-225mm)						1	1	2	2	1	1	1	1	1				734,760
Bulldozer(98ton)						1	1	2	2	1	1	1	1	1				1,002,340
Shovel(3.3m3)						2	2	4	4	2	2	2	2	2				946,194
Dump Truck(32ton)						5	5	10	10	5	5	5	5	5				430,505
Crushing Plant(500ton/hr)						1	1	2	2	1	1	1	1	1				14,909,332
Generator(800KVA)						4	4	8	8	4	4	4	4	4				270,960
Shovel(3.3m3)						1	1	2	2	1	1	1	1	1				946,194
Dump Truck(32ton)						44	44	59	59	15	15	15	15	15				430,505

Table IV.2.11.2-3(b)
SCHEDULE FOR EQUIPMENT AND VESSELS
SEA LEVEL CANAL-250,000 D.W.T.-Case C

File:EQSSC02

DESCRIPTION	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PRICE CIF PANAMA ($/unit)
Barrier Dam Construction																		
Grab Dredger(50m3)					2	2	2											13,314,286
Split Barge(5,000m3)					4	4	4											3,850,000
Pusher Tug(3,200 HP)					2	2	2											3,646,429
Stone Barge(2,000ton)						18	24	12	2	2								5,085,390
Crawler Crane(70 ton)						38	54	40	18	16								559,857
Backhoe Barge(8 m3)						1	3	3	2	1								650,572
Flat Top Barge(2,000ton)						3	8	7	5	2								2,141,143
Pusher Tug(1,300 HP)						3	8	11	9	6								2,088,571
Stone Barge(1,000ton)								1	1	1								4,018,214
Crane Barge(50tx2)								2	2	2								1,397,857
Flat Top Barge(1,000ton)								4	4	4								1,430,000
Breakwater Construction																		
Split Barge(5,000m3)					2	2				3								3,850,000
Pusher Tug(3,200 HP)					1	1				2								3,646,429
Crawler Crane(70 ton)					16	18	12	8	8	12	6	12	10	8	8			559,857
Cutter Suction(18,000HP)										1								27,485,714
Backhoe Barge(8 m3)						1	2				1	2	1					650,572
Flat Top Barge(2,000ton)						3	5				3	5	3					2,141,143
Pusher Tug(1,300 HP)						3	13	8	8	8	3	13	11	8	8			2,088,571
Stone Barge(2,000ton)					6	6				2	2							5,085,390
Stone Barge(1,000ton)																		4,018,214
Crane Barge(50tx2)							4	4	4	4		4	4	4	4			1,397,857
Flat Top Barge(1,000ton)							8	8	8	8		8	8	8	8			1,430,000

11.3 Manpower Schedule

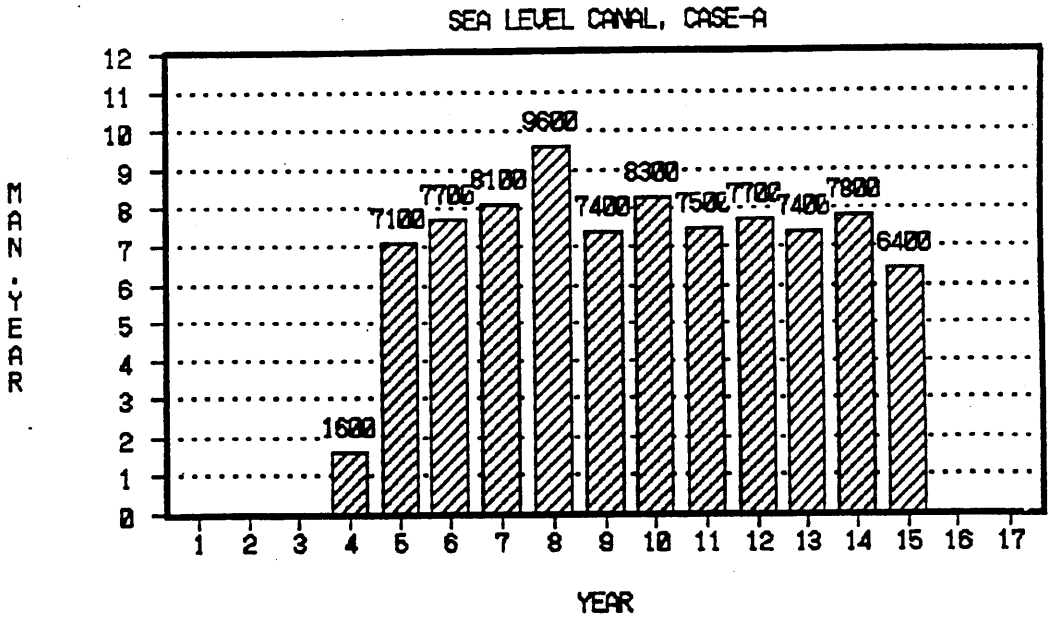

Fig. IV.2.11.3-1 Manpower Schedule

Table IV.2.11.3-2 MANPOWER SCHEDULE
SEA LEVEL CANAL, CASE-B

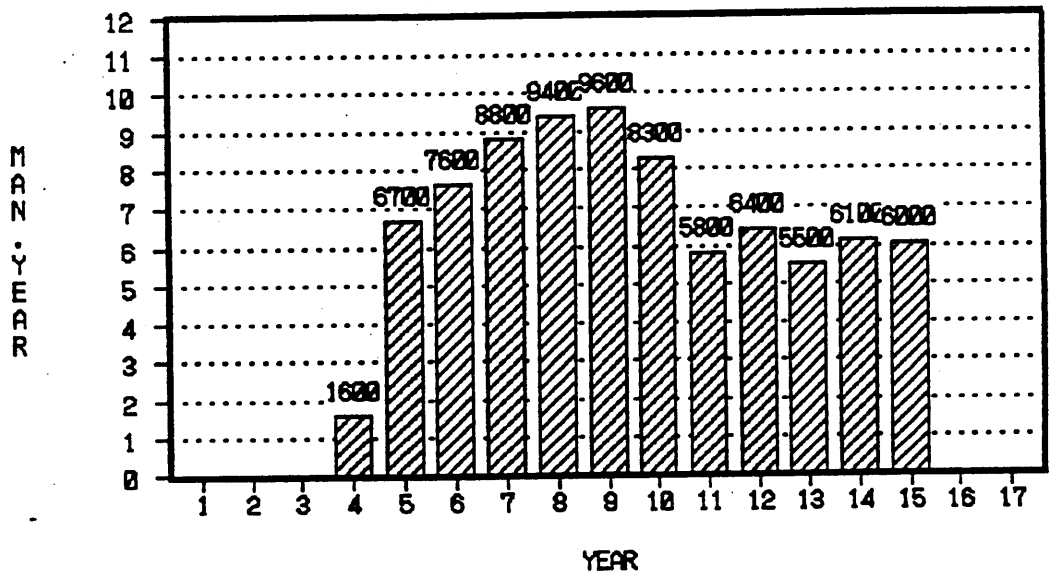

Fig. IV.2.11.3-2 Manpower Schedule

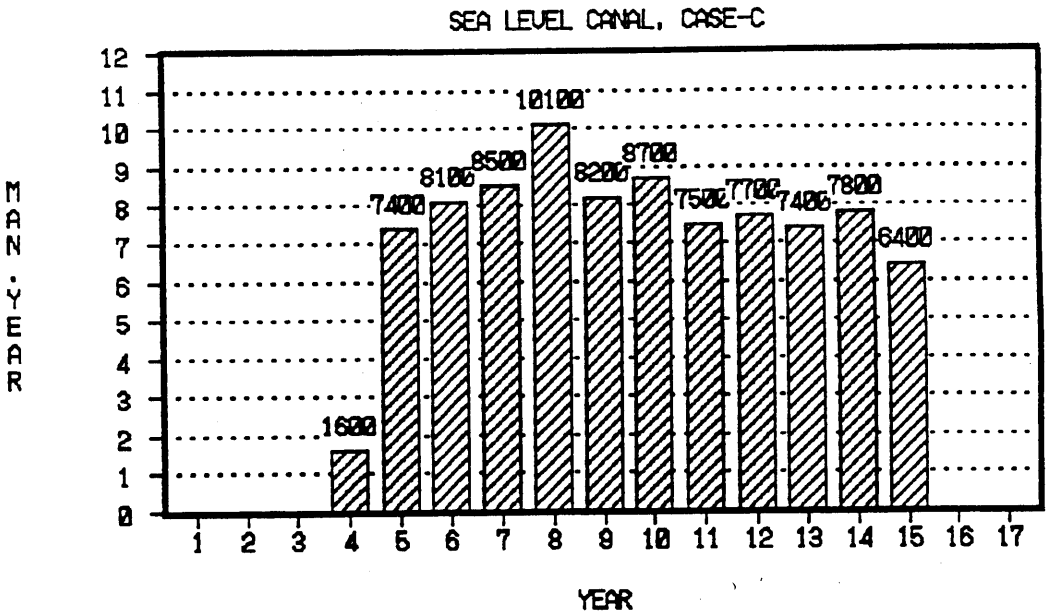

Fig. IV.2.11.3-3 Manpower Schedule

Note: These schedules are based on preliminary construction schedule and require levelizing.

PART-IV Section 3 Cost Estimates

IV.3 Chapter 1. Project Cost Summary

1.1 Project Cost Summary for Sea Level Canal

Table IV.3.1.1-1 indicates the project cost estimated for following cases listed below

1)-1	250,000	D.W.T.	Case - a	the year of 2,020
1)-2	"	"	"	the year of 2,060
2)-1	"	"	Case - b	the year of 2,020
2)-2	"	"	"	the year of 2,020
3)-1	"	"	Case - c	the year of 2,020
3)-2	"	"	"	the year of 2,060

The project costs comprise mainly Construction Costs and Indirect Costs.

Note: Cost estimates for water level 90′ case to be referred to III-1 Chapter II "90′ Study Alternatives"

Table IV.3.1.1-1 Project Cost Summary, Sea Level Canal

(Currency in US Dollars) (File: SUMSLC)

	Description	250,000 DWT								
		Case a			Case b			Case c		
		the year of 2,020 ($)	the year of 2,060 ($)	Total ($)	the year of 2,020 ($)	the year of 2,060 ($)	Total ($)	the year of 2,020 ($)	the year of 2,060 ($)	Total ($)
I	CONSTRUCTION COSTS									
(A)	CIVIL WORKS									
1	Canal Excavation	6,244,222,840	-	6,244,222,840	7,373,056,330	-	7,373,056,330	6,244,222,840	-	6,244,222,840
2	Placing Area	188,682,691	-	188,682,691	188,682,691	-	188,682,691	188,682,691	-	188,682,691
3	Lock Construction (Tidal Lock/Gate)	2,037,412,827	477,348,130	2,514,760,957	428,936,820	-	428,936,820	2,292,871,454	477,348,130	2,770,219,584
5	New Dams	-	89,963,144	89,963,144	-	89,963,144	89,963,144	-	89,963,144	89,963,144
6	Pump Station	-	-	-	-	-	-	-	-	-
7	New Permanent Roads	19,419,590	-	19,419,590	19,419,590	-	19,419,590	19,419,590	-	19,419,590
8	New Canal Crossings	221,936,760	547,713,010	769,649,770	309,088,760	547,713,010	856,801,770	221,936,760	547,713,010	769,649,770
10	Barrier Dams	493,502,306	-	493,502,306	493,502,306	-	493,502,306	493,502,306	-	493,502,306
11	Breakwater	402,015,840	-	402,015,840	402,015,840	-	402,015,840	402,015,840	-	402,015,840
12	Diversion Scheme	75,285,156	-	75,285,156	75,285,156	-	75,285,156	75,285,156	-	75,285,156
13	Supporting Construction	574,412,520	66,149,000	640,561,520	574,412,520	37,830,000	612,242,520	574,412,520	86,149,000	640,561,520
	Subtotal	10,256,890,530	1,181,173,284	11,438,063,814	9,864,400,013	675,506,154	10,539,906,167	10,612,349,167	1,181,173,284	11,693,522,441
(B)	PLANT FORMING A PART OF PERMANENT WORKS									
4	Gate Leaves and Related Facilities	949,550,400	316,008,430	1,265,558,830	737,960,800	-	737,960,800	1,252,234,600	316,008,430	1,568,243,030
9	Navigation Support System	546,295,047	-	546,295,047	477,046,333	-	477,046,333	546,295,047	-	546,295,047
	Subtotal	1,495,845,447	316,008,430	1,811,853,877	1,215,007,133	-	1,215,007,133	1,798,529,647	316,008,430	2,114,538,077
	CONSTRUCTION COSTS, TOTAL(I)	11,752,735,977	1,497,181,714	13,249,917,691	11,079,407,146	675,506,154	11,754,913,300	12,310,878,804	1,497,181,714	13,808,060,518
II	INDIRECT COSTS									
1	Administrative Costs	120,063,000	15,271,300	135,334,300	113,010,000	6,890,200	119,900,200	125,571,000	15,271,300	140,842,300
2	Headquarter's Costs	203,059,130	25,867,700	228,926,830	191,425,600	11,671,100	203,096,700	212,702,500	25,867,700	238,570,200
3	Construction Supervision	227,322,500	28,958,600	256,281,100	214,298,900	13,065,700	227,364,600	238,118,100	28,958,600	267,076,700
4	Land Aquisition & Rights	27,337,175	-	27,337,175	27,337,175	-	27,337,175	27,337,175	-	27,337,175
5	Compensation Costs	13,557,600	-	13,557,600	13,557,600	-	13,557,600	13,557,600	-	13,557,600
6	Contingency	1,175,274,000	149,718,000	1,324,992,000	1,107,941,000	67,551,000	1,175,492,000	1,231,088,000	149,718,000	1,380,806,000
	INDIRECT COSTS, TOTAL(II)	1,766,613,405	219,815,600	1,986,429,005	1,667,570,275	99,178,000	1,766,748,275	1,848,374,375	219,815,600	2,068,189,975
	PROJECT COSTS, GRAND TOTAL(I+II)	13,519,349,382	1,716,997,314	15,236,346,696	12,746,977,421	774,684,154	13,521,661,575	14,159,253,179	1,716,997,314	15,876,250,493

IV.3 Chapter 2. Construction Costs

2.1 Bill of Quantities for Case - a

(1) Sea Level Canal 250,000 DWT — the year of 2020

1) Summary
2) Direct Construction
3) Supporting Construction
4) General Conditions

(2) Additional Costs of phased Construction — the year of 2060

1) Summary
2) Direct Construction
3) Supporting Construction
4) General Conditions

2.2 Bill of Quantities for Case - b

(1) Sea Level Canal 250,000 DWT — the year of 2020

1) Summary
2) Direct Construction
3) Supporting Construction
4) General Conditions

(2) Additional Costs of phased Construction — the year of 2060

1) Summary
2) Direct Construction
3) Supporting Construction
4) General Conditions

2.3 Bill of Quantities for Case - c

(1) Sea Level Canal 250,000 DWT the year of 2020

1) Summary
2) Direct Construction
3) Supporting Construction
4) General Conditions

(2) Additional Costs of phased Construction the year of 2060

1) Summary
2) Direct Construction
3) Supporting Construction
4) General Conditions

2.1 Bill of Quantities for Case-a (250,000DWT)

(1) Sea Level Canal, the Year of 2,020

1) Summary

SEA LEVEL CANAL — CASE-a
(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	General Cond.	D. Const. Cost	Project Costs
			$	$	$
			(II)	(I)	(I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	Canal Excavation	ls	781,211,000	5,463,011,840	6,244,222,840.00
2	Placing Area	ls	23,606,000	165,076,691	188,682,691.00
3	Lock Construction	ls	277,989,000	1,759,423,827	2,037,412,827.00
5	New Dams(to be provided in 2,060)		-	-	-
6	Pump Station		nil	nil	nil
7	New Permanent Roads	ls	2,430,000	16,989,590	19,419,590.00
8	New Canal Crossing	ls	inclusive	221,936,760	221,936,760.00
10	Barrier Dams	ls	61,742,000	431,760,306	493,502,306.00
11	Breakwater	ls	50,296,000	351,719,840	402,015,840.00
12	Diversion Scheme	ls	9,419,000	65,866,156	75,285,156.00
13	Supporting Construction	ls	71,864,000	502,548,520	574,412,520.00
	Subtotal		1,278,557,000	8,978,333,530	10,256,890,530.00
(B)	PLANT FORMING A PART OF PERMANENT WORK				
4	Gate Leaves and Related Facilities	ls	inclusive	949,550,400	949,550,400.00
9	Navigation Support System	ls	74,538,000	471,757,047	546,295,047.00
	Subtotal		74,538,000	1,421,307,447	1,495,845,447
	CONSTRUCTION COSTS, TOTAL		1,353,095,000	10,399,640,977	11,752,735,977
III	INDIRECT COSTS				
1	Administrative Costs	ls	-	-	120,063,000.00
2	Headquarter's Costs	ls	-	-	203,059,130.00
3	Construction Supervision	ls	-	-	227,322,500.00
4	Land Aquisition & Rights	ls	-	-	27,337,175.00
5	Compensation Costs	ls	-	-	13,557,600.00
6	Contingency(10% of Const. Costs)	ls	-	-	1,175,274,000.00
	Subtotal				1,766,613,405.00
	GRAND TOTAL(PROJECT COSTS)				13,519,349,382.00

BILL NO. : 1 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
					0.00
I	DIRECT CONSTRUCTION COSTS				
1	CANAL EXCAVATION				
(1)	Grubbing & clearing in the Canal Area				
1)	ZONE 1	m2	0	0.21	0.00
2)	ZONE 2	m2	5,878,000	0.21	1,234,380.00
3)	ZONE 3	m2	2,073,000	0.21	435,330.00
4)	ZONE 4	m2	11,910,000	0.21	2,501,100.00
5)	ZONE 5	m2	0	0.21	0.00
	Grubbing & Clearing Total m2		19,861,000		
(2)	Dry Excavation				
1)	ZONE 1				
	Average hauling distance 0.0km				
1)-1	Common	m3	0	-	0.00
1)-2	Weathered rock (using ripper)	m3	0	-	0.00
1)-3	Medium Hard rock (using ripper)	m3	0	-	0.00
1)-4	Hard rock (using blasting)	m3	0	-	0.00
2)	ZONE 2				
	Average hauling distance 4.5km				
2)-1	Common	m3	14,851,000	2.42	35,939,420.00
2)-2	Weathered rock (using ripper)	m3	84,678,000	3.51	297,219,780.00
2)-3	Medium Hard rock (using ripper)	m3	39,990,000	3.51	140,364,900.00
2)-4	Hard rock (using blasting)	m3	9,997,000	5.43	54,283,710.00
	Subtotal this Sheet				531,978,620.00

BILL NO. : 2 (2,020) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	ZONE 3				
	Average hauling distance 3.5km				
3)-1	Common	m3	23,229,000	2.12	49,245,480.00
3)-2	Weathered rock (using ripper)	m3	117,992,000	3.14	370,494,880.00
3)-4	Medium Hard rock (using ripper)	m3	54,557,000	3.14	171,308,980.00
3)-5	Hard rock (using blasting)	m3	13,639,000	5.01	68,331,390.00
4)	ZONE 4				
	Average hauling distance 4.0km				
4)-1	Common	m3	41,967,000	2.27	95,265,090.00
4)-2	Weathered rock (using ripper)	m3	373,581,000	3.32	1,240,288,920.00
4)-3	Medium Hard rock (using ripper)	m3	121,559,000	3.32	403,575,880.00
4)-4	Hard rock (using blasting)	m3	52,097,000	5.22	271,946,340.00
5)	ZONE 5				
	Average hauling distance 0.0km				
5)-1	Common	m3	0		0.00
5)-2	Weathered rock (using ripper)	m3	0		0.00
5)-3	Medium Hard rock (using ripper)	m3	0		0.00
5)-4	Hard rock (using blasting)	m3	0		0.00
	Dry Excavation Total m3		948,137,000		
	Subtotal this Sheet				2,670,456,960.00

BILL NO. : 3 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(3)	Dredging				
1)	ZONE 1				
	Average hauling distance 2.5km				
1)-1	Clayey material(clay, silt)	m3	8,857,000	3.91	34,630,870.00
1)-2	Loose material(sand, gravel)	m3	5,163,000	3.61	18,638,430.00
1)-3	Weathered rock	m3	2,242,000	6.94	15,559,480.00
1)-4	Medium Hard rock	m3	0	-	0.00
1)-5	Hard rock (using blasting)	m3	0	-	0.00
2)	ZONE 2				
	Average hauling distance 10.5km				
2)-1	Clayey material(clay, silt)	m3	0	2.39	0.00
2)-2	Loose material(sand, gravel)	m3	18,104,000	2.25	40,734,000.00
2)-3	Weathered rock	m3	27,935,000	4.31	120,399,850.00
2)-4	Medium Hard rock	m3	31,120,000	8.98	279,457,600.00
2)-5	Hard rock (using blasting)	m3	7,780,000	70.53	548,723,400.00
3)	ZONE 3				
	Average hauling distance 2.0km				
3)-1	Clayey material(clay, silt)	m3	7,755,000	2.41	18,689,550.00
3)-2	Loose material(sand, gravel)	m3	6,612,000	2.22	14,678,640.00
3)-3	Weathered rock	m3	10,386,000	4.28	44,452,080.00
3)-4	Medium Hard rock	m3	0	-	0.00
3)-5	Hard rock (using blasting)	m3	0	-	0.00
4)	ZONE 4				
	Average hauling distance 2.5km				
4)-1	Clayey material(clay, silt)	m3	0	2.39	0.00
4)-2	Loose material(sand, gravel)	m3	8,579,000	2.22	19,045,380.00
4)-3	Weathered rock	m3	33,888,000	4.28	145,040,640.00
4)-4	Medium Hard rock	m3	10,431,000	8.95	93,357,450.00
4)-5	Hard rock (using blasting)	m3	4,471,000	70.46	315,026,660.00
5)	ZONE 5				
	Average hauling distance 2.5km				
5)-1	Clayey material(clay, silt)	m3	50,094,000	2.41	120,726,540.00
5)-2	Loose material(sand, gravel)	m3	39,840,000	2.22	88,444,800.00
5)-3	Weathered rock	m3	31,086,000	4.28	133,048,080.00
5)-4	Medium Hard rock	m3	0	-	0.00
5)-5	Hard rock (using blasting)	m3	0	-	0.00
	Wet Excavation Total m3		304,343,000		
	Subtotal this Sheet				2,050,653,450.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Vegetation(Seeding) of Canal Slope				
1)	ZONE 1	m2	12,000	0.75	9,000.00
2)	ZONE 2	m2	2,687,000	0.75	2,015,250.00
3)	ZONE 3	m2	2,199,000	0.75	1,649,250.00
4)	ZONE 4	m2	7,327,000	0.75	5,495,250.00
5)	ZONE 5	m2	-	0.75	0.00
	Total Area m2		12,225,000		
(5)	Temporary Works				
1)	Access Roads(W=22m, t=1.5m)	m	30,000	1002.98	30,089,400.00
	Starting from excavating spot in the Canal to main construction road which is lying along the Canal				
2)	Dewatering for Dry Excavation	m3	948,137,000	0.18	170,664,660.00
	Subtotal this Sheet				209,922,810.00
	Total-Item No.1 Canal Excavation				5,463,011,840.00

BILL NO. : 5 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	Placing Areas for Surplus Material				
(1)	Grubbing & Clearing for Placing Areas				
1)	D-01 Area	m2	2,100,000.0	0.21	441,000.00
2)	D-02 Area	m2	2,200,000.0	0.21	462,000.00
3)	D-03 Area	m2	3,700,000.0	0.21	777,000.00
4)	D-04 Area	m2	200,000.0	0.21	42,000.00
5)	D-05 Area	m2	400,000.0	0.21	84,000.00
6)	D-06 Area	m2	2,200,000.0	0.21	462,000.00
7)	D-07 Area	m2	4,600,000.0	0.21	966,000.00
8)	D-08 Area	m2	2,400,000.0	0.21	504,000.00
9)	D-09 Area	m2	1,600,000.0	0.21	336,000.00
10)	D-10 Area	m2	1,600,000.0	0.21	336,000.00
11)	D-11 Area	m2	2,300,000.0	0.21	483,000.00
12)	D-12 Area	m2	2,100,000.0	0.21	441,000.00
13)	D-13 Area	m2	2,300,000.0	0.21	483,000.00
14)	D-14 Area	m2	2,700,000.0	0.21	567,000.00
15)	D-15 Area	m2	5,300,000.0	0.21	1,113,000.00
16)	D-16 Area	m2	8,300,000.0	0.21	1,743,000.00
17)	D-17 Area	m2	4,700,000.0	0.21	987,000.00
18)	D-18 Area	m2	1,300,000.0	0.21	273,000.00
19)	D-19 Area	m2	1,000,000.0	0.21	210,000.00
	Total Area m2		51,000,000.0		
(2)	Placing Area Preparation Including Surface Drainage(Open Ditch) Vegetation Under Ground Drainage	km2	51.00	2,535,141.00	129,292,191.00
(3)	Access Roads (W = 22m, t=1.5m) Starting from placing area to the main construction road	m	25,000	1002.98	25,074,500.00
	Subtotal this Sheet				165,076,691.00
	Total-Item No.2 Placing Areas for Surplus Material				165,076,691.00

BILL NO. : 6 (2,020) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	LOCK CONSTRUCTION				
(1)	PACIFIC TIDAL LOCK				
1)	Excavation(Hauling Distance 5.0m)				
1)-1	Common	m3	47,500,000	2.57	122,075,000.00
1)-2	Weathered Rock	m3	28,500,000	3.69	105,165,000.00
1)-3	Hard Rock	m3	19,000,000	5.64	107,160,000.00
	Total m3		95,000,000		
1)-4	Dewatering	ls	1.00	86,920,900	86,920,900.00
2)	Backfill	m3	8,800,000	3.85	33,880,000.00
3)	Grouting				
3)-1	Consolidation Groutiong	m	377,420	20.05	7,567,271.00
3)-2	Curtain Groutiong	m	377,420	66.80	25,211,656.00
4)	Concrete including form works, etc	m3	6,000,000	76.49	458,940,000.00
5)	Reinforcing Bar (Deformed)	t	240,000	804.10	192,984,000.00
6)	Excavation for Approaching Channel to the Lock (Dry Excavation)				
6)-1	Common	m3	88,000,000	2.57	226,160,000.00
6)-2	Weathered Rock	m3	52,800,000	3.69	194,832,000.00
6)-3	Hard Rock	m3	35,200,000	5.64	198,528,000.00
	Total m3		176,000,000		
	Subtotal this Sheet				1,759,423,827.00

BILL NO. : 7 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	ATLANTIC TIDAL LOCK/GATE		nil	-	-
	Subtotal this Sheet				0.00
	Total-Item No. 3 Lock Construction				1,759,423,827.00

BILL NO. : 8 (2,020) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	GATE LEAVES AND RELATED FACILITIES				
(1)	GATE LEAVES AT PACIFIC TIDAL LOCK				
1)	Gate Leaves	ton	32,328	9,730	314,551,440.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	9,628	11,110	106,967,080.00
2)-2	Gate Hoists	ton	4,510	15,000	67,650,000.00
2)-3	Locomotives	unit	30	3,600,000	108,000,000.00
2)-4	Rails and Racks for Locomotives	ton	9,042	8,140	73,601,880.00
2)-5	Power Supply Line for Locomotives	set	1	12,000,000	12,000,000.00
2)-6	Other Mechanical Component (Compressed Air System, Drainage Pumps Piping and Misc. Mechanical Equip.)	set	1	94,400,000	94,400,000.00
3)	Electrical Power and Control				
3)-1	Electric Power and Control Equipments (84000KW)	set	1	78,400,000	78,400,000.00
3)-2	Emergency Power Plant(84000kw)	kw	84,000	770	64,680,000.00
3)-3	Miscellaneous El. Equipments	set	1	16,000,000	16,000,000.00
4)	Others				
4)-1	Local Control Builidings	set	1	1,100,000	1,100,000.00
4)-2	Electrical Equipments	set	1	300,000	300,000.00
4)-3	Cathodic Protection	set	1	4,100,000	4,100,000.00
4)-4	Monitoring & Surveillance Equip. Communication Syestem	set	1	4,800,000	4,800,000.00
4)-5	Grounding System	set	1	1,100,000	1,100,000.00
4)-6	Other Electric works and Consumable	set	1	1,900,000	1,900,000.00
	Subtotal this Sheet				949,550,400.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	GATE LEAVES AT ATLANTIC SIDE		nil	-	-
	Subtotal this Sheet				-
	Total-Item No. 4 Gate Leaves and Related Structure				949,550,400.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	NEW DAMS				
(1)	UPPER GATUN DAM (H=100M) to be provided in the year of 2,060		-	-	-
	Subtotal this Sheet				-
	Total-Item No. 5 New Dams				-

BILL NO. : 11 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6	PUMP STATIONS		nil	-	-
	Subtotal this Sheet				-
	Total-Item No. 6 Pump Stations				-

BILL NO. : 12 (2,020) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
7	NEW PERMANENT ROADS				
(1)	ROADS FOR INSPECTION (NEW ROADS) W = 6.8m				
1)	Subgrade, Base Course(t=0.4m)	km	71.0	110,490.00	7,844,790.00
2)	Asphalt Paving(t=70mm)	m2	710,000.0	12.88	9,144,800.00
	Subtotal this Sheet				16,989,590.00
	Total-Item No.7 New Permanent Roads				16,989,590.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
8	NEW CANAL CROSSINGS				
(1)	BRIDGES OVER THE NEW CANAL				
1)	Bridges Over The Canal on Pacific Side				
1)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=250+90+90=430m Width = 20.5m (Four Lane)	m2	8,815	6,064.00	53,454,160.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 20.5m (Four Lane)	m2	12,300	2,956.00	36,358,800.00
2)	Bridges Over the Canal at Middle				
2)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=350+140+140=630m Width = 10.0m (Two Lane)	m2	6,300	11,146.00	70,219,800.00
2)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Two Lane)	m2	6,000	2,980.00	17,880,000.00
3)	Bridges Over The Canal on Atlantic Side				
3)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=350+140+140=430m Width = 10.0m (Two Lane)	m2	4,300	6,080.00	26,144,000.00
3)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Two Lane)	m2	6,000	2,980.00	17,880,000.00
	Subtotal this Sheet				221,936,760.00
	Total-Item No.8 New Canal Crossings				221,936,760.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
9	NAVIGATION SUPPORT SYSTEMS				
	For Two-Way Canal Portion				
(1)	Navigation Lights (Buoys or Beacons) and Leading Channel Range Lights				
1)	Navigation Lights (Buoys or Beacons) 10 w, Lens Type Light Range : Three Nautical miles Power supply : Battery				
1)-1	Pacific Ocean Side Navigation For 30km (interval every 927m) 30,000/927=33 * 2 sides	sets	66	121,506.00	8,019,396.00
1)-2	At turning points, L and M 2 points * 2 sides	sets	4	121,506.00	486,024.00
1)-3	Atlantic Ocean Side Navigation For 3km (interval every 927m) 3,000/927 = 4 * 2 sides	sets	8	121,506.00	972,048.00
	For One-Way Canal Portion				
	Navigation Lights (Beacon, Pole Type) 5w, Lens Type Light Range : One Nautical miles Power supply : by supply				
2)-4	Navigation Lights (Beacon, Pole Type) 55,000m / 152m = 362 * 2 sides	sets	724	46,656.00	33,778,944.00
2)-5	Navigation Lights (Beacon, Pole Type) At turning points, B, C ... K 10 points x 2 sets	sets	20	46,656.00	933,120.00
	Subtotal this Sheet				44,189,532.00

BILL NO. : 15 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	Channel Range Marker(Light)				
3)-1	For One-Way Canal Portion 5 points x 1 lane x 2 sets	sets	10	473,496.00	4,734,960.00
3)-2	For Two-Way Canal Portion 4 points x 2 lanes x 4 sets	sets	32	473,496.00	15,151,872.00
	Subtotal this Sheet				19,886,832.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	TUG STATION				
1)	Provide Tug Boats, 6,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	16	6,649,286	106,388,576.00
2)	Provide/Supply Tug Boats, 3,000 HP-4,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	9	4,652,857	41,875,713.00
3)	Lunches(for 10 persons) Twin Screw (maintenance/running Cost not included)	unit	14	163,571	2,289,994.00
(3)	EMERGENCY TIE UP STATION (Mooring Dolphin Type)				
1)	Located Near Station B	nos	1	14,043,200	14,043,200.00
2)	Located Near Station C	nos	1	14,043,200	14,043,200.00
3)	Excavation				
	Dry Excavation(Hauling distance 4.0km)				
3)-1	Common	m3	2,000,000	2.27	4,540,000.00
3)-2	Weathered Rock	m3	1,200,000	3.32	3,984,000.00
3)-3	Hard Rock	m3	800,000	5.22	4,176,000.00
	Dredging(Hauling Distance 22km)				
3)-4	Clayey material(clay, silt)	m3	2,000,000	4.79	9,580,000.00
3)-5	Weathered Rock	m3	1,200,000	7.33	8,796,000.00
3)-6	Hard Rock	m3	800,000	100.95	80,760,000.00
	Total Excavation m3		8,000,000		
	Subtotal this Sheet				290,476,683.00

BILL NO. : 17 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Jetty(10m x 50m)				
	Three(3) Locations for Tug Jetty				
1)	Located Near Station A	nos	2	4,972,000	9,944,000.00
2)	Located Near Station B	nos	2	4,972,000	9,944,000.00
3)	Located Near Station C	nos	3	4,972,000	14,916,000.00
(5)	Mooring Buoy				
1)	Located at Atlantic Entrance (50,000 DWT * 2)	nos	2	20,600,000	41,200,000.00
2)	Located at Pacific Entrance (50,000 DWT * 2)	nos	2	20,600,000	41,200,000.00
	Subtotal this Sheet				117,204,000.00
	Total-Item No.9 Navigation Support Systems				471,757,047.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 0	BARRIER DAMS				
(1)	BARRIER DAM 'E'				
1)	Dredging(Hauling distance 10km)				
1)-1	Clayey Material(Clay, Silt)	m3	2,900,000	2.89	8,381,000.00
1)-2	Loose Material(Sand, Gravel)	m3	3,000,000	2.88	8,640,000.00
	Total Excavation m3		5,900,000		
2)	Filling Materials Onland Hauling(10km) Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	4,300,000	4.52	19,436,000.00
2)-2	Filter Material	m3	3,600,000	4.52	16,272,000.00
2)-3	Sand Material	m3	300,000	4.52	1,356,000.00
2)-4	Rock Material	m3	4,540,000	4.46	20,248,400.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	260,000	4.46	1,159,600.00
	Total Volume m3		13,000,000		
3)	Filling on Water Operation (Filling Below WL -4.0m)				
3)-1	Core Material	m3	3,700,000	5.67	20,979,000.00
3)-2	Filter Material	m3	3,380,000	6.54	22,105,200.00
3)-3	Sand Material	m3	240,000	5.67	1,360,800.00
3)-4	Rock Material	m3	4,295,000	6.54	28,089,300.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	120,000	21.58	2,589,600.00
4)	Filling on Water Operation (Filling, Above WL -4.0m)				
4)-1	Core Material	m3	600,000	8.70	5,220,000.00
4)-2	Filter Material	m3	220,000	14.38	3,163,600.00
4)-3	Sand Material	m3	60,000	8.70	522,000.00
4)-4	Rock Material	m3	245,000	14.38	3,523,100.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	140,000	84.04	11,765,600.00
	Total Filling m3		13,000,000		
	Subtotal this Sheet				174,811,200.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5)	Curtain Grouting				
5)-1	Drilling	m	36,000	73.09	2,631,240.00
5)-2	Pressure Grouting(cement 50kg/m)	m	20,000	71.50	1,430,000.00
6)	Excavation for Spillway				
	Dredging				
6)-1	Clayey Material	m3	500,000	2.89	1,445,000.00
6)-2	Weathered Rock	m3	300,000	2.88	864,000.00
6)-3	Hard Rock	m3	200,000	70.53	14,106,000.00
	Toatal m3		1,000,000		
	Dry Excavation(Hauling Distance 0.5km)				
	Shovel(3.0m3), Dump Truck(32t)				
6)-4	Excavation Common	m3	2,150,000	1.82	3,913,000.00
6)-5	Weathered Rock	m3	1,290,000	3.03	3,908,700.00
6)-6	Hard Rock	m3	860,000	4.72	4,059,200.00
	Toatal m3		4,300,000		
7)	Concrete works including forms, etc.				
7)-1	For Spillway	m3	6,000	100.00	600,000.00
7)-2	Reinforcing Bars(Deformed)	t	360	804.10	289,476.00
8)	Gates				
8)-1	Sliding gates	t	17.0	10,000.00	170,000.00
8)-2	Sliding gates hoists	t	4.0	12,100.00	48,400.00
8)-3	Spare gate	t	6.0	9,300.00	55,800.00
8)-4	Radial gate	t	9.0	12,100.00	108,900.00
8)-5	Radial gate hoist	t	5.0	12,100.00	60,500.00
8)-6	Spare gate	t	9.0	9,300.00	83,700.00
	Subtotal this Sheet				33,773,916.00

BILL NO. : 20 (2,020) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	BARRIER DAM 'F'				
1)	Dredging(Hauling Distance 15km)				
1)-1	Clayey Material(Clay, Silt)	m3	3,000,000	2.91	8,730,000.00
1)-2	Loose Material(Sand, Gravel)	m3	3,500,000	2.90	10,150,000.00
	Total Excavation m3		6,500,000		
2)	Filling Materials Onland Hauling(10km) Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	4,650,000	4.52	21,018,000.00
2)-2	Filter Material	m3	3,900,000	4.52	17,628,000.00
2)-3	Sand Material	m3	350,000	4.52	1,582,000.00
2)-4	Rock Material	m3	5,040,000	4.46	22,478,400.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	260,000	4.46	1,159,600.00
	Total Volume m3		14,200,000		
3)	Filling on Water Operation (Filling Below WL -4.0m)				
3)-1	Core Material	m3	4,000,000	5.67	22,680,000.00
3)-2	Filter Material	m3	3,660,000	6.54	23,936,400.00
3)-3	Sand Material	m3	290,000	5.67	1,644,300.00
3)-4	Rock Material	m3	4,760,000	6.54	31,130,400.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	120,000	21.58	2,589,600.00
4)	Filling on Water Operation (Filling, Above WL -4.0m)				
4)-1	Core Material	m3	650,000	8.74	5,681,000.00
4)-2	Filter Material	m3	240,000	14.38	3,451,200.00
4)-3	Sand Material	m3	60,000	8.74	524,400.00
4)-4	Rock Material	m3	280,000	14.42	4,037,600.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	140,000	84.04	11,765,600.00
	Total Filling m3		14,200,000		
5)	Curtain Grouting				
4)-1	Drilling	m	38,000	73.09	2,777,420.00
4)-2	Grouting(cement 50kg/m)	m	23,000	71.50	1,644,500.00
	Subtotal this Sheet				194,608,420.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(3)	BARRIER DAM 'G'				
1)	Dredging(Hauling Distance 10km)				
1)-1	Clayey Material(Clay, Silt)	m3	500,000	2.89	1,445,000.00
1)-2	Loose Material(Sand, Gravel)	m3	500,000	2.88	1,440,000.00
	Total Excavation m3		1,000,000		
2)	Filling Materials Onland Hauling(10km) Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	650,000	4.52	2,938,000.00
2)-2	Filter Material	m3	600,000	4.52	2,712,000.00
2)-3	Sand Material	m3	50,000	4.52	226,000.00
2)-4	Rock Material	m3	655,000	4.46	2,921,300.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	45,000	4.46	200,700.00
	Total Volume m3		2,000,000		
3)	Filling on Water Operation (Filling Below WL -4.0m)				
3)-1	Core Material	m3	540,000	5.67	3,061,800.00
3)-2	Filter Material	m3	560,000	6.54	3,662,400.00
3)-3	Sand Material	m3	40,000	5.67	226,800.00
3)-4	Rock Material	m3	610,000	6.54	3,989,400.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	20,000	21.58	431,600.00
4)	Filling on Water Operation (Filling, Above WL -4.0m)				
4)-1	Core Material	m3	110,000	8.70	957,000.00
4)-2	Filter Material	m3	40,000	14.38	575,200.00
4)-3	Sand Material	m3	10,000	8.70	87,000.00
4)-4	Rock Material	m3	45,000	14.38	647,100.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	25,000	84.13	2,103,250.00
	Total Filling m3		2,000,000		
5)	Curtain Grouting				
4)-1	Drilling	m	8,000	73.09	584,720.00
4)-2	Grouting(cement 50kg/m)	m	5,000	71.50	357,500.00
	Subtotal this Sheet				28,566,770.00
	Total-Item No.10 Barrier Dams				431,760,306.00

BILL NO. : 22 (2,020) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 1	BREAKWATER				
(1)	BREAKWATER AT ATLANTIC OCEAN SIDE				
	East Break Water 3,000m (M. Depth -17m) West Break Water 3,400m (M. Depth -17m)				
1)	Core				
1)-1	Core Materials(below -4.0m)	m3	6,705,000	12.34	82,739,700.00
1)-2	Core Materials(above -4.0m)	m3	795,000	13.54	10,764,300.00
2)	Armor Rock				
2)-1	Armor Rock (0.5ton/piece, below-4.0m)	m3	1,488,000	15.31	22,781,280.00
2)-2	Armor Rock (0.5ton/piece, above-4.0m)	m3	112,000	19.69	2,205,280.00
2)-3	Armor Rock (3.0ton/piece below-4.0m)	m3	-	30.86	0.00
2)-4	Armor Rock (3.0ton/piece above-4.0m)	m3	700,000	109.40	76,580,000.00
	Total Fill m3		9,800,000		
2)-5	Armor Rock supply, hauling(6km)	m3	2,300,000	5.88	13,524,000.00
(2)	BREAK WATER AT PACIFIC OCEAN SIDE				
	East Breakwater 8,000m (M. Depth -17m) West Breakwater (nil)				
1)	Core				
1)-1	Core Materials(below-4.0m)	m3	4,774,000	5.97	28,500,780.00
1)-2	Core Materials(above-4.0m)	m3	1,626,000	10.49	17,056,740.00
2)	Armor Rock				
2)-1	Armor Rock (0.5ton/piece, below-4.0m)	m3	928,000	8.31	7,711,680.00
2)-2	Armor Rock (0.5ton/piece, above-4.0m)	m3	272,000	16.64	4,526,080.00
2)-3	Armor Rock (3.0ton/piece below-4.0m)	m3	-	24.56	0.00
2)-4	Armor Rock (3.0ton/piece above-4.0m)	m3	700,000	105.94	74,158,000.00
	Total Fill m3		8,300,000		
2)-5	Armor Rock supply, hauling(6km)	m3	1,900,000	5.88	11,172,000.00
	Subtotal this Sheet				351,719,840.00
	Total-Item No. 11 Breakwater				351,719,840.00

BILL NO. : 23 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 2	DIVERSION SCHEME				
(1)	COFFER DAMS FOR DIVERSION				
1)	Coffer Dams				
	E-1-D				
	W-1-D				
	W-3-D				
	W-4-D				
	W-6-D				
	W-7-D				
	E-3-Di				
	Excavation(Hauling Diatance 5.0km)				
	Shovel(3.0m3), Dump Truck(32t)				
1)-1	Common	m3	147,500	4.77	703,575.00
1)-2	Weathered Rock	m3	147,500	6.68	985,300.00
	Total m3		295,000		
	Embankment(Hauling Distance 5.0km)				
	Shovel(3.0m3), Dump Truck(32t)				
1)-3	Core Material	m3	311,000	11.69	3,635,590.00
1)-4	Filter	m3	330,000	11.70	3,861,000.00
1)-5	Rock	m3	889,000	8.46	7,520,940.00
	Total Volume m3		1,530,000		
2)	Grouting				
	Blanket Grouting				
2)-1	Drilling Grouting Hole	m	11,500	19.99	229,885.00
2)-2	Pressure Grouting	m	11,500	34.07	391,805.00
3)	Concrete Works including forms and etc.				
3)-1	Concrete	m3	3,500	100.00	350,000.00
3)-1	Reinforcing Bars(Deformed)	t	210	804.10	168,861.00
	Subtotal this Sheet				17,846,956.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Diversion Channels E-1-C W-1-C W-3-C W-4-C W-6-C W-7-C E-3-C				
1)	Dry Excavation(Hauling Distance 0.5km)				
1)-1	Common	m3	5,700,000	1.82	10,374,000.00
1)-2	Weathered Rock	m3	3,420,000	3.03	10,362,600.00
1)-3	Hard Rock	m3	2,280,000	4.72	10,761,600.00
	Total m3		11,400,000		
2)	Dredging(Hauling Distance 2.5km)				
2)-1	Clayey Materials	m3	500,000	2.29	1,145,000.00
2)-2	Weathered Rock	m3	300,000	4.28	1,284,000.00
2)-3	Hard Rock	m3	200,000	70.46	14,092,000.00
	Total m3		1,000,000		
	Subtotal this Sheet				48,019,200.00
	Total-Item No.12 Diversion Scheme				65,866,156.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 3	SUPPORTING CONSTRUCTION				
(1)	CONSTRUCTION VILLAGE AND CAMPS				
1)	Site Preparation				
	5 site*140000m2 + 2 village*1000000m2	m2	2,700,000	1.72	4,644,000.00
2)	Housing and Building				
2)-1	Office and Warehouse		Estimated in General Conditions		0.00
2)-2	Detached House A 400m2/house	Nos	5	80,000	400,000.00
2)-3	Detached House B 300m2/house	Nos	50	60,000	3,000,000.00
2)-4	Detached House C 200m2/house	Nos	200	40,000	8,000,000.00
2)-5	Dormitory 2 village*120psn*100m2	m2	24,000	150	3,600,000.00
2)-6	Resthouse 2 village*2000m2	m2	4,000	200	800,000.00
2)-7	Canteen/Messhouse 1000m2*2 1000m2*5	m2	7,000	150	1,050,000.00
2)-8	Labor Camp 5 site*2000psn*50m2/psn	m2	500,000	120	60,000,000.00
2)-9	Supermarket 2village*1000m2 5site*200	m2	3,000	120	360,000.00
2)-10	School 2 village*2500m2	m2	5,000	150	750,000.00
2)-11	Theatre 2 village*5000m2	m2	10,000	150	1,500,000.00
2)-12	Sports/Recreation Center	m2	10,000	150	1,500,000.00
2)-13	Church 2 village*1000m2	m2	2,000	150	300,000.00
2)-14	Fire Station 7 places*500m2	m2	3,500	120	420,000.00
2)-15	Hospital 2 village*5000m2	m2	10,000	200	2,000,000.00
3)	Facilities and Services				
3)-1	Road W=6M 5site*600m 2village*2000m	m2	42,000	13	546,000.00
3)-2	Sewage 1 unit 2 village 5 site				
	Sewage Plant 5000t/day	unit	7	1,000,000	7,000,000.00
	Piping	m	20,000	50	1,000,000.00
	Operation Cost	yrs	8	60000	480,000.00
3)-3	Water Supply				
	Pump for Well (20m3/h)	Nos	7	10,000	70,000.00
	Water Treatment	Nos	7	500,000	3,500,000.00
	Piping 3000m*7	m	21000	8	168,000.00
3)-4	Power Supply Generator 800kVA*3Nos*7				
	Power Distribution 3000m*7	m	21000	20	420,000.00
	Operation 11unit*24h*365*12	Hrs	1,156,320	58	67,066,560.00
3)-5	Fuel Supply Station	site	7	100,000	700,000.00
3)-6	Communication(Telephone/Fax/Radio/TV)	site	7	200,000	1,400,000.00
3)-7	Landscaping	m2	2,700,000	4	10,800,000.00
	Subtotal this Sheet				181,474,560.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4)	Maintenance Cost Personnel Cost for Maintenance				
4)-1	Camp Manager 1psn*2site*144mo	M.Mo	288	3,000	864,000.00
4)-2	Guardman 20psn*7site*144mo	M.Mo	20,160	1,000	20,160,000.00
4)-3	Medical Doctor 2psn*2Hosp*144	M.Mo	576	10,000	5,760,000.00
4)-4	Nurse 8psn*2*180 4psn*5*144	M.Mo	2,880	1,500	4,320,000.00
4)-5	Catering Staff 10psn*7*144	M.Mo	10,080	1,200	12,096,000.00
4)-6	Housekeeper 20*7*144	M.Mo	20,160	700	14,112,000.00
4)-7	Chief Driver 2psn*144mo	M.Mo	288	1,200	345,600.00
4)-8	Bus Driver 30Nos*144	M.Mo	4,320	1,000	4,320,000.00
4)-9	School Teacher 2 village*4*144mo	M.Mo	1,152	7,000	8,064,000.00
4)-10	Gardener 4psn*7site*144	M.Mo	4,032	1,000	4,032,000.00
4)-11	Supermarket Staff 4psn*7site*144	M.Mo	4,032	1,200	4,838,400.00
5)	Vehicles				
5)-1	Buses 30Nos*144mo	M.Mo	4,320	3,800	16,416,000.00
5)-2	Ambulance 2Nos*7*144	M.Mo	2,016	1,000	2,016,000.00
5)-3	Patrol Vehicle 2Nos*7*144	M.Mo	2,016	1,500	3,024,000.00
5)-4	Fire Engine 1No*7*144	M.Mo	1,008	2,500	2,520,000.00
	Subtotal this Sheet				102,888,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Main Construction Roads				
1)	Cut., Fill., Subgrade, Base Course, etc. (W = 22m, t = 1.2m)	m	95,000.0	1,002.98	95,283,100.00
(3)	Access Roads to Quarries				
1)	Cut., Fill., Subgrade, Base Course, etc. (W = 22m, t = 1.2m)	m	29,000.0	1,002.98	29,086,420.00
	Subtotal this Sheet				124,369,520.00

BILL NO. : 28 (2,020) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Logistic Base				
1)	Puerto Pilon on Atlantic Side				
1)-1	Embankment, Grading	m3	30,000	12.00	360,000.00
1)-2	Jetty for Aggregates	m	240	2,800.00	672,000.00
1)-3	Control House	m2	100	400.00	40,000.00
1)-4	Guard House	m2	9	160.00	1,440.00
1)-5	Rest House	m2	100	240.00	24,000.00
1)-6	Roads	m2	7,000	20.00	140,000.00
1)-7	Fence	m	700	24.00	16,800.00
1)-8	Gate	set	1	8,000.00	8,000.00
1)-9	Drainage Way	m	700	104.00	72,800.00
1)-10	Operation of Generator	year	7	162,000.00	1,134,000.00
2)	Atlantic Side				
1)-1	Embankment, Grading	m3	127,500	12.00	1,530,000.00
1)-2	Sea wall(Conc.)	m	590	270.00	159,300.00
1)-3	Jetty for Aggregates	m	200	2,800.00	560,000.00
1)-4	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
1)-5	Strage Facilities				
1)-5	Cement Silo(1,500t/No.)	no.	15	240,000.00	3,600,000.00
1)-6	Tank for Fuel(1600kl/no.)	no.	10	520,000.00	5,200,000.00
1)-7	Tank for Oil (100kl/no.)	no.	3	80,000.00	240,000.00
1)-8	Warehouse	m2	8,000	240.00	1,920,000.00
1)-9	Control House	m2	1,000	400.00	400,000.00
1)-10	Guard House	m2	27	160.00	4,320.00
1)-11	Rest House	m2	500	240.00	120,000.00
1)-12	Roads W=12m	m2	44,160	20.00	883,200.00
1)-13	Fence	m	1,090	24.00	26,160.00
1)-14	Gate	set	3	8,000.00	24,000.00
1)-15	Drainage Way	m	3,680	104.00	382,720.00
1)-16	Operation of Generator	year	12	252,000.00	3,024,000.00
	Subtotal this Sheet				48,142,740.00

BILL NO. : 29 SEA LEVEL CANAL CASE-a

(2,020) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	Vacamonte on Pacific Side				
1)-1	Embankment, Grading	m3	127,500	12.00	1,530,000.00
1)-2	Sea wall(Conc.)	m	590	270.00	159,300.00
1)-3	Jetty for Armor Stone	m	200	2,800.00	560,000.00
1)-4	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
	Strage Facilities				
1)-5	Cement Silo(1,500t/No.)	no.	15	240,000.00	3,600,000.00
1)-6	Tank for Fuel(1600kl/no.)	no.	10	520,000.00	5,200,000.00
1)-7	Tank for Oil (100kl/no.)	no.	3	80,000.00	240,000.00
1)-8	Warehouse	m2	8,000	240.00	1,920,000.00
1)-9	Control House	m2	1,000	400.00	400,000.00
1)-10	Guard House	m2	27	160.00	4,320.00
1)-11	Rest House	m2	500	240.00	120,000.00
1)-12	Roads	m2	44,160	20.00	883,200.00
1)-13	Fence	m	1,090	24.00	26,160.00
1)-14	Gate	set	3	8,000.00	24,000.00
1)-15	Drainage Way	m	3,680	104.00	382,720.00
1)-16	Operation of Generator	year	12	252,000.00	3,024,000.00
	Subtotal this Sheet				45,673,700.00
	Total-Item No. 13 ~~Diversion Scheme~~ Supporting Construction				502,548,520.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
14	GENERAL CONDITIONS				
(1)	Canal Excavation, (14.3%, Item Total)	ls	1		781,211,000.00
(2)	Placing Area	ls	1		23,606,000.00
(3)	Lock Construction (15.8%, Item Total)	ls	1		277,989,000.00
(4)	Gate Leaves and Related Facilities		-		-inclusive-
(5)	New Dams(to be provided in 2,060)		-		-
(6)	Pump Station		nil		-
(7)	New Parmanent Roads	ls	1		2,430,000.00
(8)	New Canal Crossing		-		-inclusive-
(9)	Navigation Support System(15.8% I.Total	ls	1		74,538,000.00
(10)	Barrier Dams (14.3%, Item Total)	ls	1		61,742,000.00
(11)	Breakwater (14.3%, Item Total)	ls	1		50,296,000.00
(12)	Diversion Scheme (14.3%, Item Total)	ls	1		9,419,000.00
(13)	Supporting Construction(14.3% I. Total)	ls	1		71,864,000.00
	Subtotal this Sheet				1,353,095,000.00
	Total-Item No.14 General Conditions				1,353,095,000.00

2.1 Bill of Quantities for Case-a (250,000DWT)
(2) Additional Costs of Phased Construction Sea Level Canal, the year of 2,060
1) Summary

SEA LEVEL CANAL CASE-a
(2,060) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	General Cond. $	D. Const. Cost $	Project Costs $
			(II)	(I)	(I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	New dams	ls	11,255,000	78,708,144	89,963,144.00
2	Lock Construction	ls	65,130,000	412,218,130	477,348,130.00
3	New Canal Crossings	ls	-inclusive-	547,713,010	547,713,010.00
5	Supporting Construction	ls	8,276,000	57,873,000	66,149,000.00
	Subtotal		84,661,000	1,096,512,284	1,181,173,284.00
(B)	PLANT FORMING A PART OF PERMANENT WORK				
4	Gate Leaves and Related Facilities	ls	-inclusive-	316,008,430	316,008,430.00
	CONSTRUCTION COSTS, TOTAL		84,661,000	1,412,520,714	1,497,181,714.00
I I I	INDIRECT COSTS(*1)				
1	Administrative Costs	ls	-	-	15,271,300.00
2	Headquarter's Costs	ls	-	-	25,867,700.00
3	Construction Supervision	ls	-	-	28,958,600.00
4	Land Aquisition Costs	ls	-	-	-
5	Compensation Costs	ls	-	-	-
6	Contingency(10% OF Const. Costs)	ls	-	-	149,718,000.00
	Sub Total				219,815,600.00
	(*1): to be assigned as percentage of Construction Costs				
	GRAND TOTAL(PROJECT COSTS)				1,716,997,314.00

BILL NO. : 1 (2,060) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1	NEW DAMS				
(1)	UPPER GATUN DAM (H=95M)				
1)	Earthwork Excavation for Dam Foundation				
1)-1	Top Soil Removal	m2	244,800	1.59	389,232.00
	Excavation(Hauling Distance 5km) Shovel(3.0m3), Dump Truck(32t)				
1)-2	Common	m3	400,000	4.77	1,908,000.00
1)-3	Weathered Rock	m3	400,000	6.68	2,672,000.00
	Total m3		800,000		
1)-4	Foundation preparation (FInish Excavation, t=0.5m) Foundation Area, 244,800m2*20%	m2	49,000	34.28	1,679,720.00
1)-5	Foundation preparation by washing	m2	49,000	30.50	1,494,500.00
1)-6	Excavation for Diversion tunnel	m3	20,000	120.00	2,400,000.00
	Excavation for Spillway				
1)-7	Common	m3	39,000	4.77	186,030.00
1)-8	Weathered Rock	m3	23,400	6.68	156,312.00
1)-9	Hard Rock	m3	15,600	8.46	131,976.00
	Total m3		78,000		
	Embankment(Hauling Distance 10.0km)				
1)-10	Core	m3	900,000	11.69	10,521,000.00
1)-11	Filter	m3	800,000	11.70	9,360,000.00
1)-12	Rock	m3	4,500,000	8.46	38,070,000.00
	Total m3		6,200,000		
	Subtotal this Sheet				68,968,770.00

BILL NO. : 2 SEA LEVEL CANAL CASE-a

(2,060) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2)	Curtain Grouting				
2)-1	Drilling Grouting Hole	m	33,000	73.09	2,411,970.00
2)-2	Pressure Grouting	m	33,000	71.50	2,359,500.00
	Blanket Grouting				
2)-3	Drilling Grouting Hole	m	14,100	19.99	281,859.00
2)-4	Pressure Grouting	m	14,100	34.07	480,387.00
3)	Concrete Works including Formworks etc				
3)-1	Concrete for Spillway	m3	16,000	100.00	1,600,000.00
3)-2	Concrete for Diversion Tunnel	m3	6,000	120.00	720,000.00
3)-3	Concrete for Outlet	m3	1,000	100.00	100,000.00
	Total m3		23,000		
3)-4	Reinforcing Bars(Deformed)	t	1,380	804.10	1,109,658.00
4)	Steel Works & Equipment				
4)-1	Outlet Penstock	t	30	7,200.00	216,000.00
4)-2	Hollow-jet Valve φ=0.8m	set	1	290,000.00	290,000.00
4)-3	Spare Valve φ=0.8m	set	1	170,000.00	170,000.00
	Subtotal this Sheet				9,739,374.00
	Total-Item No.1 New Dams				78,708,144.00

BILL NO. : 3 (2,060) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	LOCK CONSTRUCTION				
(1)	PACIFIC TIDAL LOCK				
1)	Excavation(Hauling Distance 5.0m)				
1)-1	Common	m3	15,840,000	2.57	40,708,800.00
1)-2	Weathered Rock	m3	9,500,000	3.69	35,055,000.00
1)-3	Hard Rock	m3	6,340,000	5.64	35,757,600.00
	Total m3		31,680,000		
1)-4	Dewatering	ls	1	28,980,000	28,980,000.00
2)	Backfill	m3	2,940,000	3.85	11,319,000.00
3)	Grouting				
3)-1	Consolidation Grouting	m	125,800	20.05	2,522,290.00
3)-2	Curtain Groutiong	m	125,800	66.80	8,403,440.00
4)	Concrete including form works, etc	m3	2,000,000	76.49	152,980,000.00
5)	Reinforcing Bar (Deformed)	t	120,000	804.10	96,492,000.00
	Subtotal this Sheet				412,218,130.00
	Total-Item No.2 Lock Construction				412,218,130.00

BILL NO. : 4 SEA LEVEL CANAL CASE-a

(2,060) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	GATE LEAVES AND RELATED FACILITIES				
(1)	GATE LEAVES AT PACIFIC TIDAL LOCK				
1)	Gate Leaves	ton	10,776	9,730	104,850,480.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	3,209	11,110	35,651,990.00
2)-2	Gate Hoists	ton	1,503	15,000	22,545,000.00
2)-3	Locomotives	unit	10	3,600,000	36,000,000.00
2)-4	Rails and Racks for Locomotives	ton	3,014	8,140	24,533,960.00
2)-5	Power Supply Line For Locomotive	set	1	4,000,000	4,000,000.00
2)-6	Other Mechanical Component (Compressed Air System, Drainage Pumps Piping and Misc. Mechanical Equip.	set	1	31,467,000	31,467,000.00
3)	Electrical Power and Control				
3)-1	Electric Power and Control Equipment 28000kw	set	1	25,900,000	25,900,000.00
3)-2	Emergency Power Plant	kw	28,000	770	21,560,000.00
3)-3	Misc. Electical Equip.	set	1	5,000,000	5,000,000.00
4)	Others				
4)-1	Local Control Builidings and Their and Other Electric works and Consumables	set	1	400,000	400,000.00
4)-2	Their Electrical Equip.	set	1	100,000	100,000.00
4)-3	Cathodic Protection	set	1	1,400,000	1,400,000.00
4)-4	Monitoring & Surveyllance Equip. and Communication System	set	1	1,600,000	1,600,000.00
4)-5	Grounding System	set	1	400,000	400,000.00
4)-6	Other Electrical Works and Consumable	set	1	600,000	600,000.00
	Subtotal this Sheet				316,008,430.00
	Total-Item No. 3 Gate Leaves and Related Facilities				316,008,430.00

BILL NO. : 5 (2,060) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	NEW CANAL CROSSINGS				
(1)	BRIDGE OVER THE NEW CANAL				
1)	Bridges Over the Canal for Van Dam Bypass				
1)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=250+90+90=430m Width = 20.5m (Four Lane)	m2	8,815	6,064.00	53,454,160.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 20.5m (Four Lane)	m2	12,300	2,964.00	36,457,200.00
	Subtotal this Sheet				89,911,360.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	BRIDGE OVER THE EXISTING CANAL				
1)	Bridges Over the (Existing) Canal for Van Dam Bypass				
1)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=500+200+200=900m Width = 20.5m (Dual Two Ways)	m2	18,450	16,679.00	307,727,550.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 950m (One Span 60m) Width = 20.5m (Dual Two Ways)	m2	19,475	2,964.00	57,723,900.00
2)	Bridges Over the (Existing) Canal at Middle Gomba				
2)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=200+80+80=360m Width = 10.0m (Dual Two Ways)	m2	3,600	4,874.00	17,546,400.00
2)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Dual One Ways)	m2	6,000	2,980.00	17,880,000.00
3)	Bridges Over the (Existing) Canal on Atlantic Side				
3)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=230+90+90=410m Width = 10.0m (Dual One Way)	m2	4,100	5,598.00	22,951,800.00
3)-2	Approaching Bridges(Steel Box Girder) Total Length = 1,140m (One Span 60m) Width = 10.0m (Dual One Way)	m2	11,400	2,980.00	33,972,000.00
	Subtotal this Sheet				457,801,650.00
	Total-Item No.4 New Canal Crossings				547,713,010.00

BILL NO. : 7 (2,060) SEA LEVEL CANAL TIDAL LOCK(PACIFIC). CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	SUPPORTING CONSTRUCTION to be assigned as percentage of Construction Costs(Civil Works)	ls	1	-	57,873,000.00
	Subtotal this Sheet				57,873,000.00
	Total-Item No. 5 Supporting Construction				57,873,000.00

BILL NO. : 8 SEA LEVEL CANAL CASE-a

(2,060) TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6	GENERAL CONDITIONS				
(A)	CIVIL WORKS				
(1)	New Dams(14.3%, Item Total)	ls	1		11,255,000
(2)	Lock Construction(15.8%, Item Total)	ls	1		65,130,000
(3)	Gate Leaves and Related Facilities	ls	1		-inclusive-
(4)	New Canal Crosssings	ls	1		-inclusive-
(5)	Supporting Construction	ls	1		8,276,000
	Subtotal				84,661,000
	Subtotal this Sheet				84,661,000.00
	Total-Item No. 6 General Conditions				84,661,000.00

2.2 Bill of Quantities for Case-b (250,000DWT)

(1) Sea Level Canal, the Year of 2,020

1) Summary

SEA LEVEL CANAL — CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) — 250,000DWT

Item No.	Description	Unit	General Cond. $ (II)	D. Const. Cost $ (I)	Project Costs $ (I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	Canal Excavation	ls	922,438,000	6,450,618,330	7,373,056,330.00
2	Placing Area	ls	23,606,000	165,076,691	188,682,691.00
3	Gate Construction	ls	58,525,000	370,411,820	428,936,820.00
5	New Dams(to be provided in 2,060)		-	-	-
6	Pump Station		nil	nil	nil
7	New Permanent Roads	ls	2,430,000	16,989,590	19,419,590.00
8	New Canal Crossing	ls	inclusive	309,088,760	309,088,760.00
10	Barrier Dams	ls	61,742,000	431,760,306	493,502,306.00
11	Breakwater	ls	50,296,000	351,719,840	402,015,840.00
12	Diversion Scheme	ls	9,419,000	65,866,156	75,285,156.00
13	Supporting Construction	ls	71,864,000	502,548,520	574,412,520.00
	Subtotal		1,200,320,000	8,664,080,013	9,864,400,013
(B)	PLANT FORMING A PART OF PERMANENT WORK				
4	Gate Leaves and Related Facilities	ls	inclusive	737,960,800	737,960,800.00
9	Navigation Support System	ls	65,089,000	411,957,333	477,046,333.00
	Subtotal		65,089,000	1,149,918,133	1,215,007,133.00
	CONSTRUCTION COSTS, TOTAL		1,265,409,000	9,813,998,146	11,079,407,146.00
III	INDIRECT COSTS(*1)				
1	Administrative Costs	ls	-	-	113,010,000.00
2	Headquarter's Costs	ls	-	-	191,425,600.00
3	Construction Supervision	ls	-	-	214,298,900.00
4	Land Aquisition & Rights	ls	-	-	27,337,175.00
5	Compensation Costs	ls	-	-	13,557,600.00
6	Contingency(10% of Const. Costs)	ls	-	-	1,107,941,000.00
	Subtotal				1,667,570,275.00
	(*1): to be assigned as percentage of Construction Costs				
	GRAND TOTAL(PROJECT COSTS)				12,746,977,421.00

BILL NO. : 1 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
					0.00
I	DIRECT CONSTRUCTION COSTS				
1	CANAL EXCAVATION				
(1)	Grubbing & clearing in the Canal Area				
1)-1	ZONE 1	m2	0	0.21	0.00
1)-2	ZONE 2	m2	5,878,000	0.21	1,234,380.00
1)-3	ZONE 3	m2	2,073,000	0.21	435,330.00
1)-4	ZONE 4	m2	11,910,000	0.21	2,501,100.00
1)-5	ZONE 5	m2	0	0.21	0.00
	Grubbing & Clearing Total m2		19,861,000		
(2)	Dry Excavation				
1)	ZONE 1				
	Average hauling distance 0.0km				
1)-1	Common	m3	-		0.00
1)-2	Weathered rock (using ripper)	m3	-		0.00
1)-3	Medium Hard rock (using ripper)	m3	-		0.00
1)-4	Hard rock (using blasting)	m3	-		0.00
2)	ZONE 2				
	Average hauling distance 4.5km				
2)-1	Common	m3	24,392,000	2.42	59,028,640.00
2)-2	Weathered rock (using ripper)	m3	136,983,000	3.51	480,810,330.00
2)-3	Medium Hard rock (using ripper)	m3	62,565,000	3.51	219,603,150.00
2)-4	Hard rock (using blasting)	m3	15,641,000	5.43	84,930,630.00
	Subtotal this Sheet				848,543,560.00

BILL NO. : 2 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	ZONE 3				
	Average hauling distance 3.5km				
3)-1	Common	m3	23,229,000	2.12	49,245,480.00
3)-2	Weathered rock (using ripper)	m3	117,992,000	3.14	370,494,880.00
3)-4	Medium Hard rock (using ripper)	m3	54,557,000	3.14	171,308,980.00
3)-5	Hard rock (using blasting)	m3	13,639,000	5.01	68,331,390.00
4)	ZONE 4				
	Average hauling distance 4.0km				
4)-1	Common	m3	41,419,000	2.27	94,021,130.00
4)-2	Weathered rock (using ripper)	m3	370,149,000	3.32	1,228,894,680.00
4)-3	Medium Hard rock (using ripper)	m3	121,103,000	3.32	402,061,960.00
4)-4	Hard rock (using blasting)	m3	51,903,000	5.22	270,933,660.00
5)	ZONE 5				
	Average hauling distance 0.0km				
5)-1	Common	m3	-		0.00
5)-2	Weathered rock (using ripper)	m3	-		0.00
5)-3	Medium Hard rock (using ripper)	m3	-		0.00
5)-4	Hard rock (using blasting)	m3	-		0.00
	Dry Excavation Total m3		1,033,572,000		
	Subtotal this Sheet				2,655,292,160.00

BILL NO. : 3 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(3)	Dredging				
1)	ZONE 1				
	Average hauling distance 2.5km				
1)-1	Clayey material(clay, silt)	m3	8,857,000	3.91	34,630,870.00
1)-2	Loose material(sand, gravel)	m3	5,515,000	3.61	19,909,150.00
1)-3	Weathered rock	m3	3,123,000	6.94	21,673,620.00
1)-4	Medium Hard rock	m3	0	-	0.00
1)-5	Hard rock (using blasting)	m3	0	-	0.00
2)	ZONE 2				
	Average hauling distance 10.5km				
2)-1	Clayey material(clay, silt)	m3	0	2.39	0.00
2)-2	Loose material(sand, gravel)	m3	36,378,000	2.25	81,850,500.00
2)-3	Weathered rock	m3	54,902,000	4.31	236,627,620.00
2)-4	Medium Hard rock	m3	53,994,000	8.98	484,866,120.00
2)-5	Hard rock (using blasting)	m3	13,498,000	70.53	952,013,940.00
3)	ZONE 3				
	Average hauling distance 2.0km				
3)-1	Clayey material(clay, silt)	m3	7,755,000	2.41	18,689,550.00
3)-2	Loose material(sand, gravel)	m3	6,612,000	2.22	14,678,640.00
3)-3	Weathered rock	m3	10,386,000	4.28	44,452,080.00
3)-4	Medium Hard rock	m3	0	-	0.00
3)-5	Hard rock (using blasting)	m3	0	-	0.00
4)	ZONE 4				
	Average hauling distance 2.5km				
4)-1	Clayey material(clay, silt)	m3	0	2.39	0.00
4)-2	Loose material(sand, gravel)	m3	7,657,000	2.22	16,998,540.00
4)-3	Weathered rock	m3	30,946,000	4.28	132,448,880.00
4)-4	Medium Hard rock	m3	9,785,000	8.95	87,575,750.00
4)-5	Hard rock (using blasting)	m3	4,194,000	70.46	295,509,240.00
5)	ZONE 5				
	Average hauling distance 2.5km				
5)-1	Clayey material(clay, silt)	m3	38,132,000	2.41	91,898,120.00
5)-2	Loose material(sand, gravel)	m3	32,824,000	2.22	72,869,280.00
5)-3	Weathered rock	m3	26,820,000	4.28	114,789,600.00
5)-4	Medium Hard rock	m3	0	-	0.00
5)-5	Hard rock (using blasting)	m3	0	-	0.00
	Wet Excavation Total m3		351,378,000		
	Subtotal this Sheet				2,721,481,500.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Vegetation(Seeding) of Canal Slope				
1)	ZONE 1	m2	12,000	0.75	9,000.00
2)	ZONE 2	m2	2,687,000	0.75	2,015,250.00
3)	ZONE 3	m2	2,199,000	0.75	1,649,250.00
4)	ZONE 4	m2	7,327,000	0.75	5,495,250.00
5)	ZONE 5	m2	-	0.75	0.00
	Total Area m2		12,225,000		
(5)	Temporary Works				
1)	Access Roads(W=22m, t=1.5m) Starting from excavating spot in the Canal to main construction road which is lying along the Canal	m	30,000	1,002.98	30,089,400.00
2)	Dewatering for Dry Excavation	m3	1,033,572,000	0.18	186,042,960.00
	Subtotal this Sheet				225,301,110.00
	Total-Item No.1 Canal Excavation				6,450,618,330.00

BILL NO. : 5 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	Placing Areas for Surplus Material				
(1)	Grubbing & Clearing for Placing Areas				
1)	D-01 Area	m2	2,100,000.0	0.21	441,000.00
2)	D-02 Area	m2	2,200,000.0	0.21	462,000.00
3)	D-03 Area	m2	3,700,000.0	0.21	777,000.00
4)	D-04 Area	m2	200,000.0	0.21	42,000.00
5)	D-05 Area	m2	400,000.0	0.21	84,000.00
6)	D-06 Area	m2	2,200,000.0	0.21	462,000.00
7)	D-07 Area	m2	4,600,000.0	0.21	966,000.00
8)	D-08 Area	m2	2,400,000.0	0.21	504,000.00
9)	D-09 Area	m2	1,600,000.0	0.21	336,000.00
10)	D-10 Area	m2	1,600,000.0	0.21	336,000.00
11)	D-11 Area	m2	2,300,000.0	0.21	483,000.00
12)	D-12 Area	m2	2,100,000.0	0.21	441,000.00
13)	D-13 Area	m2	2,300,000.0	0.21	483,000.00
14)	D-14 Area	m2	2,700,000.0	0.21	567,000.00
15)	D-15 Area	m2	5,300,000.0	0.21	1,113,000.00
16)	D-16 Area	m2	8,300,000.0	0.21	1,743,000.00
17)	D-17 Area	m2	4,700,000.0	0.21	987,000.00
18)	D-18 Area	m2	1,300,000.0	0.21	273,000.00
19)	D-19 Area	m2	1,000,000.0	0.21	210,000.00
	Total Area m2		51,000,000.0		
(2)	Placing Area Preparation Including Surface Drainage(Open Ditch) Vegetation Under Ground Drainage	km2	51.00	2,535,141.00	129,292,191.00
(3)	Access Roads (W = 22m, t=1.5m) Starting from placing area to the main construction road	m	25,000	1002.98	25,074,500.00
	Subtotal this Sheet				165,076,691.00
	Total-Item No.2 Placing Areas for Surplus Material				165,076,691.00

BILL NO. : 6 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	GATE CONSTRUCTION				
(1)	PACIFIC TIDAL GATE				
1)	Excavation(Hauling Distance 5.0m)				
1)-1	Common	m3	9,000,000	2.57	23,130,000.00
1)-2	Weathered Rock	m3	5,400,000	3.69	19,926,000.00
1)-3	Hard Rock	m3	3,600,000	5.64	20,304,000.00
	Total m3		18,000,000		
1)-4	Dewatering	ls	1	14,470,000.00	14,470,000.00
2)	Backfill	m3	2,200,000	3.85	8,470,000.00
3)	Grouting				
3)-1	Consolidation Groutiong	m	62,600	20.05	1,255,130.00
3)-2	Curtain Groutiong	m	62,600	66.80	4,181,680.00
4)	Concrete including form works, etc	m3	980,000	76.49	74,960,200.00
5)	Reinforcing Bar (Deformed)	t	13,000	804.10	10,453,300.00
	Subtotal this Sheet				177,150,310.00

BILL NO. : 7 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	ATLANTIC TIDAL GATE				
1)	Excavation(Hauling Distance 5.0m)				
1)-1	Common	m3	9,000,000	2.57	23,130,000.00
1)-2	Weathered Rock	m3	5,400,000	3.69	19,926,000.00
1)-3	Hard Rock	m3	3,600,000	5.64	20,304,000.00
	Total m3		18,000,000		
1)-4	Dewatering	ls	1	14,470,000.00	14,470,000.00
2)	Backfill	m3	2,200,000	3.85	8,470,000.00
3)	Grouting				
3)-1	Consolidation Groutiong	m	62,600	20.05	1,255,130.00
3)-2	Curtain Groutiong	m	62,600	66.80	4,181,680.00
4)	Concrete including form works, etc	m3	980,000	92.93	91,071,400.00
5)	Reinforcing Bar (Deformed)	t	13,000	804.10	10,453,300.00
	Subtotal this Sheet				193,261,510.00
	Total-Item No.3 Gate Construction				370,411,820.00

BILL NO. : 8 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	GATE LEAVES AND RELATED FACILITIES				
(1)	ATLANTIC TIDAL GATE				
1)	Gate				
1)-1	Gate Leaves	ton	16,922	9,600	162,451,200.00
1)-2	Accessory	set	1	14,621,000	14,621,000.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	5,077	11,000	55,847,000.00
2)-2	Gate Hoists	ton	1,692	15,600	26,395,200.00
2)-3	Other Mechanical Component	set	1	53,122,000	53,122,000.00
3)	Electrical Power and Control				
3)-1	Electric Power and Control Equipment (6000KW)	set	1	7,000,000	7,000,000.00
3)-2	Emergency Power Plant	kw	6,000	1,000	6,000,000.00
3)-3	Miscellaneous El. Equipment	set	1	1,000,000	1,000,000.00
4)	Others	set	1	7,437,000	7,437,000.00
	Subtotal this Sheet				333,873,400.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	PACIFIC TIDAL GATE				
1)	Gate				
1)-1	Gate Leaves	ton	21,922	9,600	210,451,200.00
1)-2	Accessory	set	1	18,941,000	18,941,000.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	5,077	11,000	55,847,000.00
2)-2	Gate Hoists	ton	1,692	15,600	26,395,200.00
2)-3	Other Mechanical Component	set	1	68,818,000	68,818,000.00
2)-4					
3)	Electrical Power and Control				
3)-1	Electric Power and Control Equipment (6000KW)	set	1	7,000,000	7,000,000.00
3)-2	Emergency Power Plant	kw	6,000	1,000	6,000,000.00
3)-3	Miscellaneous El. Equipment	set	1	1,000,000	1,000,000.00
4)	Others	set	1	9,635,000	9,635,000.00
	Subtotal this Sheet				404,087,400.00
	Total-Item No.4 Gate Leaves and Related Facilities				737,960,800.00

BILL NO. : 10 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	NEW DAMS				
(1)	UPPER GATUN DAM (H=100M) to be provided in the year of 2,060		-	-	-
	Subtotal this Sheet Total-Item No. 5 New Dams				-

BILL NO. : 11 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6	PUMP STATIONS		nil	-	-
	Subtotal this Sheet				-
	Total-Item No.6 Pump Stations				-

BILL NO. : 12 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
7	NEW PERMANENT ROADS				
(1)	ROADS FOR INSPECTION (NEW ROADS) W = 6.8m				
1)	Subgrade, Base Course(t=0.4m)	km	71.0	110,490.00	7,844,790.00
2)	Asphalt Paving(t=70mm)	m2	710,000.0	12.88	9,144,800.00
	Subtotal this Sheet				16,989,590.00
	Total-Item No.7 New Permanent Roads				16,989,590.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
8	NEW CANAL CROSSINGS				
(1)	BRIDGES OVER THE NEW CANAL				
1)	Bridges Over The Canal on Pacific Side				
1)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=250+90+90=430m Width = 20.5m (Four Lane)	m2	8,815	6,064.00	53,454,160.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 20.5m (Four Lane)	m2	12,300	2,956.00	36,358,800.00
2)	Bridges Over the Canal at Middle				
2)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=350+140+140=630m Width = 10.0m (Two Lane)	m2	6,300	11,146.00	70,219,800.00
2)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Two Lane)	m2	6,000	2,980.00	17,880,000.00
3)	Bridges Over The Canal on Atlantic Side				
3)-1	Cable Stayed Bridge Canal Width 380m Span = L1(Main)+L2+L3=440+180+180=800m Width = 10.0m (Two Lane)	m2	8,000	14,162.00	113,296,000.00
3)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Two Lane)	m2	6,000	2,980.00	17,880,000.00
	Subtotal this Sheet				309,088,760.00
	Total-Item No.8 New Canal Crossings				309,088,760.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
9	NAVIGATION SUPPORT SYSTEMS				
	For Two-Way Canal Portion				
(1)	Navigation Lights (Buoys or Beacons) and Leading Channel Range Lights				
1)	Navigation Lights (Buoys or Beacons) 10 w, Lens Type Light Range : Three Nautical miles Power supply : Battery				
1)-1	Pacific Ocean Side Navigation For 30km (interval every 927m) 30,000/927=33 * 2 sides	sets	66	121,506.00	8,019,396.00
1)-2	At turning points, L and M 2 points * 2 sides	sets	4	121,506.00	486,024.00
1)-3	Atlantic Ocean Side Navigation For 3km (interval every 927m) 3,000/927 = 4 * 2 sides	sets	8	121,506.00	972,048.00
	For One-Way Canal Portion				
	Navigation Lights (Beacon, Pole Type) 5w, Lens Type Light Range : One Nautical miles Power supply : by supply				
2)-4	Navigation Lights (Beacon, Pole Type) 55,000m / 152m = 362 * 2 sides	sets	724	46,656.00	33,778,944.00
2)-5	Navigation Lights (Beacon, Pole Type) At turning points, B, C ... K 10 points x 2 sets	sets	20	46,656.00	933,120.00
	Subtotal this Sheet				44,189,532.00

BILL NO. : 15 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	Channel Range Marker(Light)				
3)-1	For One-Way Canal Portion 5 points x 1 lane x 2 sets	sets	10	473,496.00	4,734,960.00
3)-2	For Two-Way Canal Portion 4 points x 2 lanes x 4 sets	sets	32	473,496.00	15,151,872.00
	Subtotal this Sheet				19,886,832.00

BILL NO. : 16 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	TUG STATION				
1)	Provide Tug Boats, 6,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	10	6,649,286	66,492,860.00
2)	Provide/Supply Tug Boats, 3,000 HP-4,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	7	4,652,857	32,569,999.00
3)	Lunches(for 10 persons) Twin Screw (maintenance/running Cost not included)	unit	10	163,571	1,635,710.00
(3)	EMERGENCY TIE UP STATION (Mooring Dolphin Type)				
1)	Located Near Station B	nos	1	14,043,200	14,043,200.00
2)	Located Near Station C	nos	1	14,043,200	14,043,200.00
3)	Excavation				
	Dry Excavation(Hauling distance 4.0km)				
3)-1	Common	m3	2,000,000	2.27	4,540,000.00
3)-2	Weathered Rock	m3	1,200,000	3.32	3,984,000.00
3)-3	Hard Rock	m3	800,000	5.22	4,176,000.00
	Dredging(Hauling Distance 22km)				
3)-4	Clayey material(clay, silt)	m3	2,000,000	4.79	9,580,000.00
3)-5	Weathered Rock	m3	1,200,000	7.33	8,796,000.00
3)-6	Hard Rock	m3	800,000	100.95	80,760,000.00
	Total Excavation m3		8,000,000		
	Subtotal this Sheet				240,620,969.00

BILL NO. : 17 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Jetty(10m x 50m)				
	Three(3) Locations for Tug Jetty				
1)	Located Near Station A	nos	2	4,972,000	9,944,000.00
2)	Located Near Station B	nos	1	4,972,000	4,972,000.00
3)	Located Near Station C	nos	2	4,972,000	9,944,000.00
(5)	Mooring Buoy				
1)	Located at Atlantic Entrance (50,000 DWT * 2)	nos	2	20,600,000	41,200,000.00
2)	Located at Pacific Entrance (50,000 DWT * 2)	nos	2	20,600,000	41,200,000.00
	Subtotal this Sheet				107,260,000.00
	Total-Item No.9 Navigation Support System				411,957,333.00

BILL NO. : 18 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 0	BARRIER DAMS				
(1)	BARRIER DAM 'E'				
1)	Dredging(Hauling distance 10km)				
1)-1	Clayey Material(Clay, Silt)	m3	2,900,000	2.89	8,381,000.00
1)-2	Loose Material(Sand, Gravel)	m3	3,000,000	2.88	8,640,000.00
	Total Excavation m3		5,900,000		
2)	Filling Materials Onland Hauling(10km) Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	4,300,000	4.52	19,436,000.00
2)-2	Filter Material	m3	3,600,000	4.52	16,272,000.00
2)-3	Sand Material	m3	300,000	4.52	1,356,000.00
2)-4	Rock Material	m3	4,540,000	4.46	20,248,400.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	260,000	4.46	1,159,600.00
	Total Volume m3		13,000,000		
3)	Filling on Water Operation (Filling Below WL -4.0m)				
3)-1	Core Material	m3	3,700,000	5.67	20,979,000.00
3)-2	Filter Material	m3	3,380,000	6.54	22,105,200.00
3)-3	Sand Material	m3	240,000	5.67	1,360,800.00
3)-4	Rock Material	m3	4,295,000	6.54	28,089,300.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	120,000	21.58	2,589,600.00
4)	Filling on Water Operation (Filling, Above WL -4.0m)				
4)-1	Core Material	m3	600,000	8.70	5,220,000.00
4)-2	Filter Material	m3	220,000	14.38	3,163,600.00
4)-3	Sand Material	m3	60,000	8.70	522,000.00
4)-4	Rock Material	m3	245,000	14.38	3,523,100.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	140,000	84.04	11,765,600.00
	Total Filling m3		13,000,000		
	Subtotal this Sheet				174,811,200.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5)	Curtain Grouting				
5)-1	Drilling	m	36,000	73.09	2,631,240.00
5)-2	Pressure Grouting(cement 50kg/m)	m	20,000	71.50	1,430,000.00
6)	Excavation for Spillway				
	Dredging				
6)-1	Clayey Material	m3	500,000	2.89	1,445,000.00
6)-2	Weathered Rock	m3	300,000	2.88	864,000.00
6)-3	Hard Rock	m3	200,000	70.53	14,106,000.00
	Toatal m3		1,000,000		
	Dry Excavation(Hauling Distance 0.5km)				
	Shovel(3.0m3), Dump Truck(32t)				
6)-4	Excavation Common	m3	2,150,000	1.82	3,913,000.00
6)-5	Weathered Rock	m3	1,290,000	3.03	3,908,700.00
6)-6	Weathered Rock	m3	860,000	4.72	4,059,200.00
	Toatal m3		4,300,000		
7)	Concrete works including forms, etc.				
7)-1	For Spillway	m3	6,000	100.00	600,000.00
7)-2	Reinforcing Bars(Deformed)	t	360	804.10	289,476.00
8)	Gates				
8)-1	Sliding gates	t	17.0	10,000.00	170,000.00
8)-2	Sliding gates hoists	t	4.0	12,100.00	48,400.00
8)-3	Spare gate	t	6.0	9,300.00	55,800.00
8)-4	Radial gate	t	9.0	12,100.00	108,900.00
8)-5	Radial gate hoist	t	5.0	12,100.00	60,500.00
8)-6	Spare gate	t	9.0	9,300.00	83,700.00
	Subtotal this Sheet				33,773,916.00

BILL NO. : 20 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	BARRIER DAM 'F'				
	Dredging (Hauling Distance 15km)				
1)-1	Clayey Material(Clay, Silt)	m3	3,000,000	2.91	8,730,000.00
1)-2	Loose Material(Sand, Gravel)	m3	3,500,000	2.90	10,150,000.00
	Total Excavation m3		6,500,000		
2)	Filling Materials Onland Hauling(10km)				
	Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	4,650,000	4.52	21,018,000.00
2)-2	Filter Material	m3	3,900,000	4.52	17,628,000.00
2)-3	Sand Material	m3	350,000	4.52	1,582,000.00
2)-4	Rock Material	m3	5,040,000	4.46	22,478,400.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	260,000	4.46	1,159,600.00
	Total Volume m3		14,200,000		
3)	Filling on Water Operation				
	(Filling Below WL -4.0m)				
3)-1	Core Material	m3	4,000,000	5.67	22,680,000.00
3)-2	Filter Material	m3	3,660,000	6.54	23,936,400.00
3)-3	Sand Material	m3	290,000	5.67	1,644,300.00
3)-4	Rock Material	m3	4,760,000	6.54	31,130,400.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	120,000	21.58	2,589,600.00
4)	Filling on Water Operation				
	(Filling, Above WL -4.0m)				
4)-1	Core Material	m3	650,000	8.74	5,681,000.00
4)-2	Filter Material	m3	240,000	14.38	3,451,200.00
4)-3	Sand Material	m3	60,000	8.74	524,400.00
4)-4	Rock Material	m3	280,000	14.42	4,037,600.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	140,000	84.04	11,765,600.00
	Total Filling m3		14,200,000		
5)	Curtain Grouting				
4)-1	Drilling	m	38,000	73.09	2,777,420.00
4)-2	Grouting(cement 50kg/m)	m	23,000	71.50	1,644,500.00
	Subtotal this Sheet				194,608,420.00

BILL NO. : 21 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(3)	BARRIER DAM 'G'				
	Dredging(Hauling Distance 10km)				
1)-1	Clayey Material(Clay, Silt)	m3	500,000	2.89	1,445,000.00
1)-2	Loose Material(Sand, Gravel)	m3	500,000	2.88	1,440,000.00
	Total Excavation m3		1,000,000		
2)	Filling Materials Onland Hauling(10km)				
	Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	650,000	4.52	2,938,000.00
2)-2	Filter Material	m3	600,000	4.52	2,712,000.00
2)-3	Sand Material	m3	50,000	4.52	226,000.00
2)-4	Rock Material	m3	655,000	4.46	2,921,300.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	45,000	4.46	200,700.00
	Total Volume m3		2,000,000		
3)	Filling on Water Operation				
	(Filling Below WL -4.0m)				
3)-1	Core Material	m3	540,000	5.67	3,061,800.00
3)-2	Filter Material	m3	560,000	6.54	3,662,400.00
3)-3	Sand Material	m3	40,000	5.67	226,800.00
3)-4	Rock Material	m3	610,000	6.54	3,989,400.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	20,000	21.58	431,600.00
4)	Filling on Water Operation				
	(Filling, Above WL -4.0m)				
4)-1	Core Material	m3	110,000	8.70	957,000.00
4)-2	Filter Material	m3	40,000	14.38	575,200.00
4)-3	Sand Material	m3	10,000	8.70	87,000.00
4)-4	Rock Material	m3	45,000	14.38	647,100.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	25,000	84.13	2,103,250.00
	Total Filling m3		2,000,000		
5)	Curtain Grouting				
4)-1	Drilling	m	8,000	73.09	584,720.00
4)-2	Grouting(cement 50kg/m)	m	5,000	71.50	357,500.00
	Subtotal this Sheet				28,566,770.00
	Total-Item No.10 Barrier Dams				431,760,306.00

BILL NO. : 22 SEA LEVEL CANAL CASE-b

(2.020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 1	BREAKWATER				
(1)	BREAKWATER AT ATLANTIC OCEAN SIDE				
	East Break Water 3,000m (M. Depth -17m) West Break Water 3,400m (M. Depth -17m)				
1)	Core				
1)-1	Core Materials(below -4.0m)	m3	6,705,000	12.34	82,739,700.00
1)-2	Core Materials(above -4.0m)	m3	795,000	13.54	10,764,300.00
2)	Armor Rock				
2)-1	Armor Rock (0.5ton/piece, below-4.0m)	m3	1,488,000	15.31	22,781,280.00
2)-2	Armor Rock (0.5ton/piece, above-4.0m)	m3	112,000	19.69	2,205,280.00
2)-3	Armor Rock (3.0ton/piece below-4.0m)	m3	-	30.86	0.00
2)-4	Armor Rock (3.0ton/piece above-4.0m)	m3	700,000	109.40	76,580,000.00
	Total Fill m3		9,800,000		
2)-5	Armor Rock supply, hauling(6km)	m3	2,300,000	5.88	13,524,000.00
(2)	BREAK WATER AT PACIFIC OCEAN SIDE				
	East Breakwater 8,000m (M. Depth -17m) West Breakwater (nil)				
1)	Core				
1)-1	Core Materials(below-4.0m)	m3	4,774,000	5.97	28,500,780.00
1)-2	Core Materials(above-4.0m)	m3	1,626,000	10.49	17,056,740.00
2)	Armor Rock				
2)-1	Armor Rock (0.5ton/piece, below-4.0m)	m3	928,000	8.31	7,711,680.00
2)-2	Armor Rock (0.5ton/piece, above-4.0m)	m3	272,000	16.64	4,526,080.00
2)-3	Armor Rock (3.0ton/piece below-4.0m)	m3	-	24.56	0.00
2)-4	Armor Rock (3.0ton/piece above-4.0m)	m3	700,000	105.94	74,158,000.00
	Total Fill m3		8,300,000		
2)-5	Armor Rock supply, hauling(6km)	m3	1,900,000	5.88	11,172,000.00
	Subtotal this Sheet				351,719,840.00
	Total-Item No. 11 Breakwater				351,719,840.00

BILL NO. : 23 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 2	DIVERSION SCHEME				
(1)	COFFER DAMS FOR DIVERSION				
1)	Coffer Dams				
	E-1-D				
	W-1-D				
	W-3-D				
	W-4-D				
	W-6-D				
	W-7-D				
	E-3-Di				
	Excavation(Haulimg Diatance 5.0km)				
	Shovel(3.0m3), Dump Truck(32t)				
1)-1	Common	m3	147,500	4.77	703,575.00
1)-2	Weathered Rock	m3	147,500	6.68	985,300.00
	Total m3		295,000		
	Embankment(Hauling Distance 5.0km)				
	Shovel(3.0m3), Dump Truck(32t)				
1)-3	Core Material	m3	311,000	11.69	3,635,590.00
1)-4	Filter	m3	330,000	11.7	3,861,000.00
1)-5	Rock	m3	889,000	8.46	7,520,940.00
	Total Volume m3		1,530,000		
2)	Grouting				
	Blanket Grouting				
2)-1	Drilling Grouting Hole	m	11,500	19.99	229,885.00
2)-2	Pressure Grouting	m	11,500	34.07	391,805.00
3)	Concrete Works including forms and etc.				
3)-1	Concrete	m3	3,500	100.00	350,000.00
3)-1	Reinforcing Bars(Deformed)	t	210	804.10	168,861.00
	Subtotal this Sheet				17,846,956.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Diversion Channels E-1-C W-1-C W-3-C W-4-C W-6-C W-7-C E-3-C				
1)	Dry Excavation(Hauling Distance 0.5km)				
1)-1	Common	m3	5,700,000	1.82	10,374,000.00
1)-2	Weathered Rock	m3	3,420,000	3.03	10,362,600.00
1)-3	Hard Rock	m3	2,280,000	4.72	10,761,600.00
	Total m3		11,400,000		
2)	Dredging (Hauling Distance 2.5km)				
2)-1	Clayey Materials	m3	500,000	2.29	1,145,000.00
2)-2	Weathered Rock	m3	300,000	4.28	1,284,000.00
2)-3	Hard Rock	m3	200,000	70.46	14,092,000.00
	Total m3		1,000,000		
	Subtotal this Sheet				48,019,200.00
	Total-Item No.12 Diversion Channels				65,866,156.00

BILL NO. : 25 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 3	SUPPORTING CONSTRUCTION				
(1)	CONSTRUCTION VILLAGE AND CAMPS				
1)	Site Preparation				
	5 site*140000m2 + 2 village*1000000m2	m2	2,700,000	1.72	4,644,000.00
2)	Housing and Building				
2)-1	Office and Warehouse	Estimated in General Conditions			0.00
2)-2	Detached House A 400m2/house	Nos	5	80,000	400,000.00
2)-3	Detached House B 300m2/house	Nos	50	60,000	3,000,000.00
2)-4	Detached House C 200m2/house	Nos	200	40,000	8,000,000.00
2)-5	Dormitory 2 village*120psn*100m2	m2	24,000	150	3,600,000.00
2)-6	Resthouse 2 village*2000m2	m2	4,000	200	800,000.00
2)-7	Canteen/Messhouse 1000m2*2 1000m2*5	m2	7,000	150	1,050,000.00
2)-8	Labor Camp 5 site*2000psn*50m2/psn	m2	500,000	120	60,000,000.00
2)-9	Supermarket 2village*1000m2 5site*200	m2	3,000	120	360,000.00
2)-10	School 2 village*2500m2	m2	5,000	150	750,000.00
2)-11	Theatre 2 village*5000m2	m2	10,000	150	1,500,000.00
2)-12	Sports/Recreation Center	m2	10,000	150	1,500,000.00
2)-13	Church 2 village*1000m2	m2	2,000	150	300,000.00
2)-14	Fire Station 7 places*500m2	m2	3,500	120	420,000.00
2)-15	Hospital 2 village*5000m2	m2	10,000	200	2,000,000.00
3)	Facilities and Services				
3)-1	Road W=6M 5site*600m 2village*2000m	m2	42,000	13	546,000.00
3)-2	Sewage 1 unit 2 village 5 site				
	Sewage Plant 5000t/day	unit	7	1,000,000	7,000,000.00
	Piping	m	20,000	50	1,000,000.00
	Operation Cost	yrs	8	60000	480,000.00
3)-3	Water Supply				
	Pump for Well (20m3/h)	Nos	7	10,000	70,000.00
	Water Treatment	Nos	7	500,000	3,500,000.00
	Piping 3000m*7	m	21000	8	168,000.00
3)-4	Power Supply Generator 800kVA*3Nos*7				
	Power Distribution 3000m*7	m	21000	20	420,000.00
	Operation 1lunit*24h*365*12	Hrs	1,156,320	58	67,066,560.00
3)-5	Fuel Supply Station	site	7	100,000	700,000.00
3)-6	Communication(Telephone/Fax/Radio/TV)	site	7	200,000	1,400,000.00
3)-7	Landscaping	m2	2,700,000	4	10,800,000.00
	Subtotal this Sheet				181,474,560.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4)	Maintenance Cost				
	Personnel Cost for Maintenance				
4)-1	Camp Manager 1psn*2site*144mo	M.Mo	288	3,000	864,000.00
4)-2	Guardman 20psn*7site*144mo	M.Mo	20,160	1,000	20,160,000.00
4)-3	Medical Doctor 2psn*2Hosp*144	M.Mo	576	10,000	5,760,000.00
4)-4	Nurse 8psn*2*180 4psn*5*144	M.Mo	2,880	1,500	4,320,000.00
4)-5	Catering Staff 10psn*7*144	M.Mo	10,080	1,200	12,096,000.00
4)-6	Housekeeper 20*7*144	M.Mo	20,160	700	14,112,000.00
4)-7	Chief Driver 2psn*144mo	M.Mo	288	1,200	345,600.00
4)-8	Bus Driver 30Nos*144	M.Mo	4,320	1,000	4,320,000.00
4)-9	School Teacher 2 village*4*144mo	M.Mo	1,152	7,000	8,064,000.00
4)-10	Gardener 4psn*7site*144	M.Mo	4,032	1,000	4,032,000.00
4)-11	Supermarket Staff 4psn*7site*144	M.Mo	4,032	1,200	4,838,400.00
5)	Vehicles				
5)-1	Buses 30Nos*144mo	M.Mo	4,320	3,800	16,416,000.00
5)-2	Ambulance 2Nos*7*144	M.Mo	2,016	1,000	2,016,000.00
5)-3	Patrol Vehicle 2Nos*7*144	M.Mo	2,016	1,500	3,024,000.00
5)-4	Fire Engine 1No*7*144	M.Mo	1,008	2,500	2,520,000.00
	Subtotal this Sheet				102,888,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Main Construction Roads				
1)	Cut., Fill., Subgrade, Base Course, etc. (W = 22m, t = 1.2m)	m	95,000.0	1,002.98	95,283,100.00
(3)	Access Roads to Quarries				
1)	Cut., Fill., Subgrade, Base Course, etc. (W = 22m, t = 1.2m)	m	29,000.0	1,002.98	29,086,420.00
	Subtotal this Sheet				124,369,520.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Logistic Base				
1)	Puerto Pilon on Atlantic Side				
1)-1	Embankment, Grading	m3	30,000	12.00	360,000.00
1)-2	Jetty for Aggregates	m	240	2,800.00	672,000.00
1)-3	Control House	m2	100	400.00	40,000.00
1)-4	Guard House	m2	9	160.00	1,440.00
1)-5	Rest House	m2	100	240.00	24,000.00
1)-6	Roads	m2	7,000	20.00	140,000.00
1)-7	Fence	m	700	24.00	16,800.00
1)-8	Gate	set	1	8,000.00	8,000.00
1)-9	Drainage Way	m	700	104.00	72,800.00
1)-10	Operation of Generator	year	7	162,000.00	1,134,000.00
2)	Atlantic Side				
1)-1	Embankment, Grading	m3	127,500	12.00	1,530,000.00
1)-2	Sea wall(Conc.)	m	590	270.00	159,300.00
1)-3	Jetty for Aggregates	m	200	2,800.00	560,000.00
1)-4	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
	Storage Facilities				
1)-5	Cement Silo(1,500t/No.)	no.	15	240,000.00	3,600,000.00
1)-6	Tank for Fuel(1600kl/no.)	no.	10	520,000.00	5,200,000.00
1)-7	Tank for Oil (100kl/no.)	no.	3	80,000.00	240,000.00
1)-8	Warehouse	m2	8,000	240.00	1,920,000.00
1)-9	Control House	m2	1,000	400.00	400,000.00
1)-10	Guard House	m2	27	160.00	4,320.00
1)-11	Rest House	m2	500	240.00	120,000.00
1)-12	Roads W=12m	m2	44,160	20.00	883,200.00
1)-13	Fence	m	1,090	24.00	26,160.00
1)-14	Gate	set	3	8,000.00	24,000.00
1)-15	Drainage Way	m	3,680	104.00	382,720.00
1)-16	Operation of Generator	year	12	252,000.00	3,024,000.00
	Subtotal this Sheet				48,142,740.00

BILL NO. : 29 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	Vacamonte on Pacific Side				
1)-1	Embankment, Grading	m3	127,500	12.00	1,530,000.00
1)-2	Sea wall(Conc.)	m	590	270.00	159,300.00
1)-3	Jetty for Armor Stone	m	200	2,800.00	560,000.00
1)-4	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
	Strage Facilities				
1)-5	Cement Silo(1,500t/No.)	no.	15	240,000.00	3,600,000.00
1)-6	Tank for Fuel(1600kl/no.)	no.	10	520,000.00	5,200,000.00
1)-7	Tank for Oil (100kl/no.)	no.	3	80,000.00	240,000.00
1)-8	Warehouse	m2	8,000	240.00	1,920,000.00
1)-9	Control House	m2	1,000	400.00	400,000.00
1)-10	Guard House	m2	27	160.00	4,320.00
1)-11	Rest House	m2	500	240.00	120,000.00
1)-12	Roads	m2	44,160	20.00	883,200.00
1)-13	Fence	m	1,090	24.00	26,160.00
1)-14	Gate	set	3	8,000.00	24,000.00
1)-15	Drainage Way	m	3,680	104.00	382,720.00
1)-16	Operation of Generator	year	12	252,000.00	3,024,000.00
	Subtotal this Sheet				45,673,700.00
	Total-Item No. 13 Supporting Construction				502,548,520.00

BILL NO. : 30 SEA LEVEL CANAL CASE-b

(2,020) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
14	GENERAL CONDITIONS				
(1)	Canal Excavation, (14.3%, Item Total)	ls	1		922,438,000.00
(2)	Placing Area	ls	1		23,606,000.00
(3)	Lock Construction (15.8%, Item Total)	ls	1		58,525,000.00
(4)	Gate Leaves and Related Facilities				-inclusive-
(5)	New Dams(to be provided in 2,060)				-
(6)	Pump Station		-nil-		-
(7)	New Parmanent Roads (14.3%, Item Total)	ls	1		2,430,000.00
(8)	New Canal Crossing				-inclusive-
(9)	Navigation Support System(15.8%, I.Total	ls	1		65,089,000.00
(10)	Barrier Dams (14.3%, Item Total)	ls	1		61,742,000.00
(11)	Breakwater (14.3%, Item Total)	ls	1		50,296,000.00
(12)	Diversion Scheme (14.3%, Item Total)	ls	1		9,419,000.00
(13)	Supporting Construction (14.3%, I.Total)	ls	1		71,864,000.00
	Subtotal this Sheet				1,265,409,000.00
	Total-Item No.14 General Conditions				1,265,409,000.00

2.2 Bill of Quantities for Case-b (250,000DWT)

(2) Additional Costs of Phased Construction Sea Level Canal, the Year of 2,060

1) Summary

SEA LEVEL CANAL — CASE-b

(2,060) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) — 250,000DWT

Item No.	Description	Unit	General Cond. $	D. Const. Cost $	Project Costs $
			(II)	(I)	(I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	New dams	ls	11,255,000	78,708,144	89,963,144.00
2	Lock Construction		nil	nil	nil
4	New Canal Crossings	ls	-inclusive-	547,909,810	547,909,810.00
5	Supporting Construction	ls	4,734,000	33,108,000	37,842,000.00
	Subtotal		15,989,000	659,725,954	675,714,954.00
(B)	PLANT FORMING A PART OF PERMANENT WORK				
3	Gate Leaves and Related Facilities		nil	nil	nil
	CONSTRUCTION COSTS, TOTAL		15,989,000.00	659,725,954.00	675,714,954.00
I I I	INDIRECT COSTS(*1)				
1	Administrative Costs	ls	-	-	6,892,300.00
2	Headquarter's Costs	ls	-	-	11,674,700.00
3	Construction Supervision	ls	-	-	13,069,700.00
4	Land Aquisition & Rights	ls	-	-	-
5	Compensation Costs	ls	-	-	-
6	Contingency(10% of Const. Costs)	ls	-	-	67,571,000.00
	Subtotal				99,207,700.00
	(*1): to be assigned as percentage of Construction Costs.				
	GRAND TOTAL(PROJECT COSTS)				774,922,654.00

BILL NO. : 1 SEA LEVEL CANAL CASE-b

(2,060) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1	NEW DAMS				
(1)	UPPER GATUN DAM (H=95M)				
1)	Earthwork Excavation for Dam Foundation				
1)-1	Top Soil Removal	m2	244,800	1.59	389,232.00
	Excavation(Hauling Distance 5km) Shovel(3.0m3), Dump Truck(32t)				
1)-2	Common	m3	400,000	4.77	1,908,000.00
1)-3	Weathered Rock	m3	400,000	6.68	2,672,000.00
	Total m3		800,000		
1)-4	Foundation Preparation (FInish Excavation, t=0.5m) Foundation Area, 244,800m2*20%	m2	49,000	34.28	1,679,720.00
1)-5	Foundation Preparation by washing	m2	49,000	30.50	1,494,500.00
1)-6	Excavation for Diversion tunnel	m3	20,000	120.00	2,400,000.00
	Excavation for Spillway				
1)-7	Common	m3	39,000	4.77	186,030.00
1)-8	Weathered Rock	m3	23,400	6.68	156,312.00
1)-9	Hard Rock	m3	15,600	8.46	131,976.00
	Total m3		78,000		
	Embankment(Hauling Distance 10.0km)				
1)-10	Core	m3	900,000	11.69	10,521,000.00
1)-11	Filter	m3	800,000	11.70	9,360,000.00
1)-12	Rock	m3	4,500,000	8.46	38,070,000.00
	Total m3		6,200,000		
	Subtotal this Sheet				68,968,770.00

BILL NO. : 2 SEA LEVEL CANAL CASE-b

(2,060) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2)	Curtain Grouting				
2)-1	Drilling Grouting Hole	m	33,000	73.09	2,411,970.00
2)-2	Pressure Grouting	m	33,000	71.50	2,359,500.00
	Blanket Grouting				
2)-3	Drilling Grouting Hole	m	14,100	19.99	281,859.00
2)-4	Pressure Grouting	m	14,100	34.07	480,387.00
3)	Concrete Works including Formworks etc				
3)-1	Concrete for Spillway	m3	16,000	100.00	1,600,000.00
3)-2	Concrete for Diversion Tunnel	m3	6,000	120.00	720,000.00
3)-3	Concrete for Outlet	m3	1,000	100.00	100,000.00
	Total m3		23,000		
3)-4	Reinforcing Bars(Deformed)	t	1,380	804.10	1,109,658.00
4)	Steel Works & Equipment				
4)-1	Outlet Penstock	t	30	7,200.00	216,000.00
4)-2	Hollow-jet Valve φ=0.8m	set	1	290,000.00	290,000.00
4)-3	Spare Valve φ=0.8m	set	1	170,000.00	170,000.00
	Subtotal this Sheet				9,739,374.00
	Total-Item No.1 New Dams				78,708,144.00

BILL NO. : 3 SEA LEVEL CANAL CASE-b

(2,060) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	NEW CANAL CROSSINGS				
(1)	BRIDGES OVER THE NEW CANAL				
1)	Bridges Over the Canal for Van Dam Bypass				
1)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=250+90+90=430m Width = 20.5m (Four Lane)	m2	8,815	6,064.00	53,454,160.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 20.5m (Four Lane)	m2	12,300	2,980.00	36,654,000.00
	Subtotal this Sheet				90,108,160.00

BILL NO. : 4 SEA LEVEL CANAL CASE-b

(2,060) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	BRIDGE OVER THE EXISTING CANAL				
1)	Bridges Over the (Existing) Canal for Van Dam Bypass				
1)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=500+200+200=900m Width = 20.5m (Four Lane)	m2	18,450	16,679.00	307,727,550.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 950m (One Span 60m) Width = 20.5m (Four Lane)	m2	19,475	2,964.00	57,723,900.00
2)	Bridges Over the (Existing) Canal at Middle Gomba				
2)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=200+80+80=360m Width = 10.0m (Two Lane)	m2	3,600	4,874.00	17,546,400.00
2)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Two Lane)	m2	6,000	2,980.00	17,880,000.00
3)	Bridges Over the (Existing) Canal on Atlantic Side				
3)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=230+90+90=410m Width = 10.0m (Two Lane)	m2	4,100	5,598.00	22,951,800.00
3)-2	Approaching Bridges(Steel Box Girder) Total Length = 1,140m (One Span 60m) Width = 10.0m (Two Lane)	m2	11,400	2,980.00	33,972,000.00
	Subtotal this Sheet				457,801,650.00
	Total-Item No.2 New Canal Crossings				547,909,810.00

BILL NO. : 5 SEA LEVEL CANAL CASE-b

(2,060) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	SUPPORTING CONSTRUCTION to be assigned as percentage of Construction Costs(Civil Works)	ls	1		33,108,000.00
	Subtotal this Sheet				33,108,000.00
	Total-Item No. 3 Supporting Construction				33,108,000.00

BILL NO. : 6 SEA LEVEL CANAL CASE-b

(2,060) TIDAL GATE(PACIFIC), TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	GENERAL CONDITION				
(1)	New dams (14.3% , Item Total)	ls	1		11,255,000.00
(2)	Lock Construction(15.8% Item Total)	ls	1		-
(4)	Gate Leaves and Related Facilities		nil		-
(5)	New Canal Crossings	ls	1		-inclusive-
(6)	Supporting Construction(14.3%, I.Total)	ls	1		4,734,000.00
	Subtotal this Sheet				15,989,000.00
	Total-Item No.4 General Conditions				15,989,000.00

2.3 Bill of Quantities for Case-c (250,000DWT)

(1) Sea Level Canal, the Year of 2,020

1) Summary

SEA LEVEL CANAL — CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) — 250,000DWT

Item No.	Description	Unit	General Cond. $	D. Const. Cost $	Project Costs $
			(II)	(I)	(I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	Canal Excavation	ls	781,211,000	5,463,011,840	6,244,222,840.00
2	Placing Area	ls	23,606,000	165,076,691	188,682,691.00
3	Lock/Gate Construction	ls	312,844,000	1,980,027,454	2,292,871,454.00
5	New Dams(to be provided in 2,060)		-	-	-
6	Pump Station		nil	nil	nil
7	New Permanent Roads	ls	2,430,000	16,989,590	19,419,590.00
8	New Canal Crossing	ls	inclusive	221,936,760	221,936,760.00
10	Barrier Dams	ls	61,742,000	431,760,306	493,502,306.00
11	Breakwater	ls	50,296,000	351,719,840	402,015,840.00
12	Diversion Scheme	ls	9,419,000	65,866,156	75,285,156.00
13	Supporting Construction	ls	71,864,000	502,548,520	574,412,520.00
	Subtotal		1,313,412,000	9,198,937,157	10,512,349,157.00
(B)	PLANT FORMING A PART OF PERMANENT WORK				
4	Gate Leaves and Related Facilities	ls	inclusive	1,252,234,600	1,252,234,600.00
9	Navigation Support System	ls	74,538,000	471,757,047	546,295,047.00
	Subtotal		74,538,000	1,723,991,647	1,798,529,647.00
	CONSTRUCTION COSTS, TOTAL		1,387,950,000	10,922,928,804	12,310,878,804.00
III	INDIRECT COSTS(*1)				
1	Administrative Costs	ls	-	-	125,571,000.00
2	Headquarter's Costs	ls	-	-	212,702,500.00
3	Construction Supervision	ls	-	-	238,118,100.00
4	Land Aquisition & Rights	ls	-	-	27,337,175.00
5	Compensation Costs	ls	-	-	13,557,600.00
6	Contingency(10% of Const. Costs)	ls	-	-	1,231,088,000.00
	subtotal				1,848,374,375.00
	(*1): to be assigned as percentage of Construction Costs				
	GRAND TOTAL(PROJECT COSTS)				14,159,253,179.00

BILL NO. : 1 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
					0.00
I	DIRECT CONSTRUCTION COSTS				
1	CANAL EXCAVATION				
(1)	Grubbing & clearing in the Canal Area				
1)	ZONE 1	m2	0	0.21	0.00
2)	ZONE 2	m2	5,878,000	0.21	1,234,380.00
3)	ZONE 3	m2	2,073,000	0.21	435,330.00
4)	ZONE 4	m2	11,910,000	0.21	2,501,100.00
5)	ZONE 5	m2	0	0.21	0.00
	Grubbing & clearing Total m2		19,861,000		
(2)	Dry Excavation				
1)	ZONE 1				
	Average hauling distance 0.0km				
1)-1	Common	m3	0	-	0.00
1)-2	Weathered rock (using ripper)	m3	0	-	0.00
1)-3	Medium Hard rock (using ripper)	m3	0	-	0.00
1)-4	Hard rock (using blasting)	m3	0	-	0.00
2)	ZONE 2				
	Average hauling distance 4.5km				
2)-1	Common	m3	14,851,000	2.42	35,939,420.00
2)-2	Weathered rock (using ripper)	m3	84,678,000	3.51	297,219,780.00
2)-3	Medium Hard rock (using ripper)	m3	39,990,000	3.51	140,364,900.00
2)-4	Hard rock (using blasting)	m3	9,997,000	5.43	54,283,710.00
	Subtotal this Sheet				531,978,620.00

BILL NO. : 2 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	ZONE 3				
	Average hauling distance 3.5km				
3)-1	Common	m3	23,229,000	2.12	49,245,480.00
3)-2	Weathered rock (using ripper)	m3	117,992,000	3.14	370,494,880.00
3)-4	Medium Hard rock (using ripper)	m3	54,557,000	3.14	171,308,980.00
3)-5	Hard rock (using blasting)	m3	13,639,000	5.01	68,331,390.00
4)	ZONE 4				
	Average hauling distance 4.0km				
4)-1	Common	m3	41,967,000	2.27	95,265,090.00
4)-2	Weathered rock (using ripper)	m3	373,581,000	3.32	1,240,288,920.00
4)-3	Medium Hard rock (using ripper)	m3	121,559,000	3.32	403,575,880.00
4)-4	Hard rock (using blasting)	m3	52,097,000	5.22	271,946,340.00
5)	ZONE 5				
	Average hauling distance 0.0km				
5)-1	Common	m3	0		0.00
5)-2	Weathered rock (using ripper)	m3	0		0.00
5)-3	Medium Hard rock (using ripper)	m3	0		0.00
5)-4	Hard rock (using blasting)	m3	0		0.00
	Dry Excavation Total m3		948,137,000		
	Subtotal this Sheet				2,670,456,960.00

BILL NO. : 3 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(3)	Dredging				
1)	ZONE 1				
	Average hauling distance 2.5km				
1)-1	Clayey material(clay, silt)	m3	8,857,000	3.91	34,630,870.00
1)-2	Loose material(sand, gravel)	m3	5,163,000	3.61	18,638,430.00
1)-3	Weathered rock	m3	2,242,000	6.94	15,559,480.00
1)-4	Medium Hard rock	m3	0	-	0.00
1)-5	Hard rock (using blasting)	m3	0	-	0.00
2)	ZONE 2				
	Average hauling distance 10.5km				
2)-1	Clayey material(clay, silt)	m3	0	2.39	0.00
2)-2	Loose material(sand, gravel)	m3	18,104,000	2.25	40,734,000.00
2)-3	Weathered rock	m3	27,935,000	4.31	120,399,850.00
2)-4	Medium Hard rock	m3	31,120,000	8.98	279,457,600.00
2)-5	Hard rock (using blasting)	m3	7,780,000	70.53	548,723,400.00
3)	ZONE 3				
	Average hauling distance 2.0km				
3)-1	Clayey material(clay, silt)	m3	7,755,000	2.41	18,689,550.00
3)-2	Loose material(sand, gravel)	m3	6,612,000	2.22	14,678,640.00
3)-3	Weathered rock	m3	10,386,000	4.28	44,452,080.00
3)-4	Medium Hard rock	m3	0	-	0.00
3)-5	Hard rock (using blasting)	m3	0	-	0.00
4)	ZONE 4				
	Average hauling distance 2.5km				
4)-1	Clayey material(clay, silt)	m3	0	2.39	0.00
4)-2	Loose material(sand, gravel)	m3	8,579,000	2.22	19,045,380.00
4)-3	Weathered rock	m3	33,888,000	4.28	145,040,640.00
4)-4	Medium Hard rock	m3	10,431,000	8.95	93,357,450.00
4)-5	Hard rock (using blasting)	m3	4,471,000	70.46	315,026,660.00
5)	ZONE 5				
	Average hauling distance 2.5km				
5)-1	Clayey material(clay, silt)	m3	50,094,000	2.41	120,726,540.00
5)-2	Loose material(sand, gravel)	m3	39,840,000	2.22	88,444,800.00
5)-3	Weathered rock	m3	31,086,000	4.28	133,048,080.00
5)-4	Medium Hard rock	m3	0	-	0.00
5)-5	Hard rock (using blasting)	m3	0	-	0.00
	Wet Excavation Total m3		304,343,000		
	Subtotal this Sheet				2,050,653,450.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Vegetation(Seeding) of Canal Slope				
1)	ZONE 1	m2	12,000	0.75	9,000.00
2)	ZONE 2	m2	2,687,000	0.75	2,015,250.00
3)	ZONE 3	m2	2,199,000	0.75	1,649,250.00
4)	ZONE 4	m2	7,327,000	0.75	5,495,250.00
5)	ZONE 5	m2	-	0.75	0.00
	Total Area m2		12,225,000		
(5)	Temporary Works				
1)	Access Roads(W=22m, t=1.5m)	m	30,000	1002.98	30,089,400.00
	Starting from excavating spot in the Canal to main construction road which is lying along the Canal				
2)	Dewatering for Dry Excavation	m3	948,137,000	0.18	170,664,660.00
	Subtotal this Sheet				209,922,810.00
	Total-Item No.1 Canal Excavation				5,463,011,840.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	Placing Areas for Surplus Material				
(1)	Grubbing & Clearing for Placig Areas				
1)	D-01 Area	m2	2,100,000.0	0.21	441,000.00
2)	D-02 Area	m2	2,200,000.0	0.21	462,000.00
3)	D-03 Area	m2	3,700,000.0	0.21	777,000.00
4)	D-04 Area	m2	200,000.0	0.21	42,000.00
5)	D-05 Area	m2	400,000.0	0.21	84,000.00
6)	D-06 Area	m2	2,200,000.0	0.21	462,000.00
7)	D-07 Area	m2	4,600,000.0	0.21	966,000.00
8)	D-08 Area	m2	2,400,000.0	0.21	504,000.00
9)	D-09 Area	m2	1,600,000.0	0.21	336,000.00
10)	D-10 Area	m2	1,600,000.0	0.21	336,000.00
11)	D-11 Area	m2	2,300,000.0	0.21	483,000.00
12)	D-12 Area	m2	2,100,000.0	0.21	441,000.00
13)	D-13 Area	m2	2,300,000.0	0.21	483,000.00
14)	D-14 Area	m2	2,700,000.0	0.21	567,000.00
15)	D-15 Area	m2	5,300,000.0	0.21	1,113,000.00
16)	D-16 Area	m2	8,300,000.0	0.21	1,743,000.00
17)	D-17 Area	m2	4,700,000.0	0.21	987,000.00
18)	D-18 Area	m2	1,300,000.0	0.21	273,000.00
19)	D-19 Area	m2	1,000,000.0	0.21	210,000.00
	Total Area m2		51,000,000.0		
(2)	Placing Area Preparation Including Surface Drainage(Open Ditch) Vegetation Under Ground Drainage	km2	51.00	2,535,141.00	129,292,191.00
(3)	Access Roads (W = 22m, t=1.5m) Starting from placing area to the main construction road	m	25,000	1002.98	25,074,500.00
	Subtotal this Sheet				165,076,691.00
	Total-Item No.2 Placing Areas for Surplus Material				165,076,691.00

BILL NO. : 6 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	LOCK/GATE CONSTRUCTION				
(1)	PACIFIC TIDAL LOCK				
1)	Excavation(Hauling Distance 5.0m)				
1)-1	Common	m3	47,500,000	2.57	122,075,000.00
1)-2	Weathered Rock	m3	28,500,000	3.69	105,165,000.00
1)-3	Hard Rock	m3	19,000,000	5.64	107,160,000.00
	Total m3		95,000,000		
1)-4	Dewatering	ls	1.00	86,920,900	86,920,900.00
2)	Backfill	m3	8,800,000	3.85	33,880,000.00
3)	Grouting				
3)-1	Consolidation Grouting	m	377,420	20.05	7,567,271.00
3)-2	Curtain Grouting	m	377,420	66.80	25,211,656.00
4)	Concrete including form works, etc	m3	6,000,000	76.49	458,940,000.00
5)	Reinforcing Bar (Deformed)	t	240,000	804.10	192,984,000.00
6)	Excavation for Approaching Channel to the Lock (Dry Excavation)				
6)-1	Common	m3	88,000,000	2.57	226,160,000.00
6)-2	Weathered Rock	m3	52,800,000	3.69	194,832,000.00
6)-3	Hard Rock	m3	35,200,000	5.64	198,528,000.00
	Total m3		176,000,000		
	Subtotal this Sheet				1,759,423,827.00

BILL NO. : 7 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	ATLANTIC TIDAL GATE				
1)	Excavation(Hauling Distance 5.0m)				
1)-1	Common	m3	9,000,000	2.57	23,130,000.00
1)-2	Weathered Rock	m3	5,400,000	3.69	19,926,000.00
1)-3	Hard Rock	m3	3,600,000	5.64	20,304,000.00
	Total m3		18,000,000		
1)-4	Dewatering	ls	1	14,470,000	14,470,000.00
2)	Backfill	m3	2,200,000	3.85	8,470,000.00
3)	Grouting				
3)-1	Consolidation Groutiong	m	377,420	20.05	7,567,271.00
3)-2	Curtain Groutiong	m	377,420	66.80	25,211,656.00
4)	Concrete including form works, etc	m3	980,000	92.93	91,071,400.00
5)	Reinforcing Bar (Deformed)	t	13,000	804.10	10,453,300.00
	Subtotal this Sheet				220,603,627.00
	Total-Item No.3 Lock/Gate Construction				1,980,027,454.00

BILL NO. : 8 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	GATE LEAVES AND RELATED FACILITIES				
(1)	GATE LEAVES AT PACIFIC TIDAL LOCK				
1)	Gate Leaves	ton	32,328	9,730	314,551,440.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	9,628	11,110	106,967,080.00
2)-2	Gate Hoists	ton	4,510	15,000	67,650,000.00
2)-3	Locomotives	unit	30	3,600,000	108,000,000.00
2)-4	Rails and Racks for Locomotives	ton	9,042	8,140	73,601,880.00
2)-5	Power Supply Line for Locomotives	set	1	12,000,000	12,000,000.00
2)-6	Other Mechanical Component (Compressed Air System, Drainage Pumps Pumping and Misc. Mechanical Equip.)	set	1	94,400,000	94,400,000.00
3)	Electrical Power and Control				
3)-1	Electric Power and Control Equipment (84000KW)	set	1	78,400,000	78,400,000.00
3)-2	Emergency Power Plant	kw	84,000	770	64,680,000.00
3)-3	Miscellaneous El. Equipment	set	1	16,000,000	16,000,000.00
4)	Others				
4)-1	Local Control Builidings	set	1	1,100,000	1,100,000.00
4)-2	Electrical Equipment	set	1	300,000	300,000.00
4)-3	Cathodic Protection	set	1	4,100,000	4,100,000.00
4)-4	Monitoring & Surveillance Equipment Communication System	set	1	4,800,000	4,800,000.00
4)-5	Grounding System	set	1	1,100,000	1,100,000.00
4)-6	Other Electric works and Consumable	set	1	1,900,000	1,900,000.00
	Subtotal this Sheet				949,550,400.00

BILL NO. : 9 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	GATE LEAVES AT ATLANTIC TIDAL GATE				
1)	Gate				
1)-1	Gate Leaves	ton	16,556	9,600	158,937,600.00
1)-2	Accessory	set	1	14,304,000	14,304,000.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	3,467	11,000	38,137,000.00
2)-2	Gate Hoists	ton	1,156	15,600	18,033,600.00
2)-3	Other Mechanical Component	set	1	51,972,000	51,972,000.00
3)	Electrical Power and Control				
3)-1	Electric Power and Control Equipment (6000KW)	set	1	7,000,000	7,000,000.00
3)-2	Emergency Power Plant	kw	6,000	1,000	6,000,000.00
3)-3	Miscellaneous El. Equipment	set	1	1,000,000	1,000,000.00
4)	Others	set	1	7,300,000	7,300,000.00
	Subtotal this Sheet				302,684,200.00
	Total-Item No.4 Gate leaves and Related Facilities				1,252,234,600.00

BILL NO. : 10 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	NEW DAMS				
(1)	UPPER GATUN DAM (H=100M) to be provided in the year of 2,060		-	-	-
	Subtotal this Sheet				-
	Total-Item No. 5 New Dams				-

BILL NO. : 11 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6	PUMP STATIONS	-	nil	-	-
	Subtotal this Sheet				-
	Total-Item No. 6 Pump Stations				-

BILL NO. : 12 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
7	NEW PERMANENT ROADS				
(1)	ROADS FOR INSPECTION (NEW ROADS) W = 6.8m				
1)	Subgrade, Base Course(t=0.4m)	km	71.0	110,490.00	7,844,790.00
2)	Asphalt Paving(t=70mm)	m2	710,000.0	12.88	9,144,800.00
	Subtotal this Sheet				16,989,590.00
	Total-Item No.7 New Permanent Roads				16,989,590.00

BILL NO. : 13 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
8	NEW CANAL CROSSINGS				
(1)	BRIDGES OVER THE NEW CANAL				
1)	Bridges Over The Canal on Pacific Side				
1)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=250+90+90=430m Width = 20.5m (Four Lane)	m2	8,815	6,064.00	53,454,160.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 20.5m (Four Lane)	m2	12,300	2,956.00	36,358,800.00
2)	Bridges Over the Canal at Middle				
2)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=350+140+140=630m Width = 10.0m (Two Lane)	m2	6,300	11,146.00	70,219,800.00
2)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Two Lane)	m2	6,000	2,980.00	17,880,000.00
3)	Bridges Over The Canal on Atlantic Side				
3)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=350+140+140=430m Width = 10.0m (Two Lane)	m2	4,300	6,080.00	26,144,000.00
3)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Two Lane)	m2	6,000	2,980.00	17,880,000.00
	Subtotal this Sheet				221,936,760.00
	Total-Item No.8 New Canal Crossings				221,936,760.00

BILL NO. : 14 SEA LEVEL CANAL CASE-c
(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
9	NAVIGATION SUPPORT SYSTEMS				
	For Two-Way Canal Portion				
(1)	Navigation Lights (Buoys or Beacons) and Leading Channel Range Lights				
1)	Navigation Lights (Buoys or Beacons) 10 w, Lens Type Light Range : Three Nautical miles Power supply : Battery				
1)-1	Pacific Ocean Side Navigation For 30km (interval every 927m) 30,000/927=33 * 2 sides	sets	66	121,506.00	8,019,396.00
1)-2	At turning points, L and M 2 points * 2 sides	sets	4	121,506.00	486,024.00
1)-3	Atlantic Ocean Side Navigation For 3km (interval every 927m) 3,000/927 = 4 * 2 sides	sets	8	121,506.00	972,048.00
	For One-Way Canal Portion				
	Navigation Lights (Beacon, Pole Type) 5w, Lens Type Light Range : One Nautical miles Power supply : by supply				
2)-4	Navigation Lights (Beacon, Pole Type) 55,000m / 152m = 362 * 2 sides	sets	724	46,656.00	33,778,944.00
2)-5	Navigation Lights (Beacon, Pole Type) At turning points, B, C ... K 10 points x 2 sets	sets	20	46,656.00	933,120.00
	Subtotal this Sheet				44,189,532.00

BILL NO. : 15 SEA LEVEL CANAL CASE-c

(2.020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250.000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	Channel Range Marker(Light)				
3)-1	For One-Way Canal Portion 5 points x 1 lane x 2 sets	sets	10	473,496.00	4,734,960.00
3)-2	For Two-Way Canal Portion 4 points x 2 lanes x 4 sets	sets	32	473,496.00	15,151,872.00
	Subtotal this Sheet				19,886,832.00

BILL NO. : 16 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	TUG STATION				
1)	Provide Tug Boats, 6,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	16	6,649,286	106,388,576.00
2)	Provide/Supply Tug Boats, 3,000 HP-4,000 HP, (C&F Panama) (maintenance/running Cost not included)	unit	9	4,652,857	41,875,713.00
3)	Lunches(for 10 persons) Twin Screw (maintenance/running Cost not included)	unit	14	163,571	2,289,994.00
(3)	EMERGENCY TIE UP STATION (Mooring Dolphin Type)				
1)	Located Near Station B	nos	1	14,043,200	14,043,200.00
2)	Located Near Station C	nos	1	14,043,200	14,043,200.00
3)	Excavation				
	Dry Excavation(Hauling distance 4.0km)				
3)-1	Common	m3	2,000,000	2.27	4,540,000.00
3)-2	Weathered Rock	m3	1,200,000	3.32	3,984,000.00
3)-3	Hard Rock	m3	800,000	5.22	4,176,000.00
	Dredging(Hauling Distance 22km)				
3)-4	Clayey material(clay, silt)	m3	2,000,000	4.79	9,580,000.00
3)-5	Weathered Rock	m3	1,200,000	7.33	8,796,000.00
3)-6	Hard Rock	m3	800,000	100.95	80,760,000.00
	Total Excavation m3		8,000,000		
	Subtotal this Sheet				290,476,683.00

BILL NO. : 17 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Jetty(10m x 50m)				
	Three(3) Locations for Tug Jetty				
1)	Located Near Station A	nos	2	4,972,000	9,944,000.00
2)	Located Near Station B	nos	2	4,972,000	9,944,000.00
3)	Located Near Station C	nos	3	4,972,000	14,916,000.00
(5)	Mooring Buoy				
1)	Located at Atlantic Entrance (50,000 DWT * 2)	nos	2	20,600,000	41,200,000.00
2)	Located at Pacific Entrance (50,000 DWT * 2)	nos	2	20,600,000	41,200,000.00
	Subtotal this Sheet				117,204,000.00
	Total-Item No.9 Navigation Support Systems				471,757,047.00

BILL NO. : 18 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 0	BARRIER DAMS				
(1)	BARRIER DAM 'E'				
1)	Dredging(Hauling distance 10km)				
1)-1	Clayey Material(Clay, Silt)	m3	2,900,000	2.89	8,381,000.00
1)-2	Loose Material(Sand, Gravel)	m3	3,000,000	2.88	8,640,000.00
	Total Excavation m3		5,900,000		
2)	Filling Materials Onland Hauling(10km) Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	4,300,000	4.52	19,436,000.00
2)-2	Filter Material	m3	3,600,000	4.52	16,272,000.00
2)-3	Sand Material	m3	300,000	4.52	1,356,000.00
2)-4	Rock Material	m3	4,540,000	4.46	20,248,400.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	260,000	4.46	1,159,600.00
	Total Volume m3		13,000,000		
3)	Filling on Water Operation (Filling Below WL -4.0m)				
3)-1	Core Material	m3	3,700,000	5.67	20,979,000.00
3)-2	Filter Material	m3	3,380,000	6.54	22,105,200.00
3)-3	Sand Material	m3	240,000	5.67	1,360,800.00
3)-4	Rock Material	m3	4,295,000	6.54	28,089,300.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	120,000	21.58	2,589,600.00
4)	Filling on Water Operation (Filling, Above WL -4.0m)				
4)-1	Core Material	m3	600,000	8.70	5,220,000.00
4)-2	Filter Material	m3	220,000	14.38	3,163,600.00
4)-3	Sand Material	m3	60,000	8.70	522,000.00
4)-4	Rock Material	m3	245,000	14.38	3,523,100.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	140,000	84.04	11,765,600.00
	Total Filling m3		13,000,000		
	Subtotal this Sheet				174,811,200.00

BILL NO. : 19 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5)	Curtain Grouting				
5)-1	Drilling	m	36,000	73.09	2,631,240.00
5)-2	Pressure Grouting(cement 50kg/m)	m	20,000	71.50	1,430,000.00
6)	Excavation for Spillway				
	Dredging				
6)-1	Clayey Material	m3	500,000	2.89	1,445,000.00
6)-2	Weathered Rock	m3	300,000	2.88	864,000.00
6)-3	Hard Rock	m3	200,000	70.53	14,106,000.00
	Toatal m3		1,000,000		
	Dry Excavation(Hauling Distance 0.5km)				
	Shovel(3.0m3), Dump Truck(32t)				
6)-4	Excavation Common	m3	2,150,000	1.82	3,913,000.00
6)-5	Weathered Rock	m3	1,290,000	3.03	3,908,700.00
6)-6	Hard Rock	m3	860,000	4.72	4,059,200.00
	Toatal m3		4,300,000		
7)	Concrete works including forms, etc.				
7)-1	For Spillway	m3	6,000	100.00	600,000.00
7)-2	Reinforcing Bars(Deformed)	t	360	804.10	289,476.00
8)	Gates				
8)-1	Sliding gates	t	17.0	10,000.00	170,000.00
8)-2	Sliding gates hoists	t	4.0	12,100.00	48,400.00
8)-3	Spare gate	t	6.0	9,300.00	55,800.00
8)-4	Radial gate	t	9.0	12,100.00	108,900.00
8)-5	Radial gate hoist	t	5.0	12,100.00	60,500.00
8)-6	Spare gate	t	9.0	9,300.00	83,700.00
	Subtotal this Sheet				33,773,916.00

BILL NO. : 20 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	BARRIER DAM 'F'				
1)	Dredging(Hauling Distance 15km)				
1)-1	Clayey Material(Clay, Silt)	m3	3,000,000	2.91	8,730,000.00
1)-2	Loose Material(Sand, Gravel)	m3	3,500,000	2.90	10,150,000.00
	Total Excavation m3		6,500,000		
2)	Filling Materials Onland Hauling(10km) Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	4,650,000	4.52	21,018,000.00
2)-2	Filter Material	m3	3,900,000	4.52	17,628,000.00
2)-3	Sand Material	m3	350,000	4.52	1,582,000.00
2)-4	Rock Material	m3	5,040,000	4.46	22,478,400.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	260,000	4.46	1,159,600.00
	Total Volume m3		14,200,000		
3)	Filling on Water Operation (Filling Below WL -4.0m)				
3)-1	Core Material	m3	4,000,000	5.67	22,680,000.00
3)-2	Filter Material	m3	3,660,000	6.54	23,936,400.00
3)-3	Sand Material	m3	290,000	5.67	1,644,300.00
3)-4	Rock Material	m3	4,760,000	6.54	31,130,400.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	120,000	21.58	2,589,600.00
4)	Filling on Water Operation (Filling, Above WL -4.0m)				
4)-1	Core Material	m3	650,000	8.74	5,681,000.00
4)-2	Filter Material	m3	240,000	14.38	3,451,200.00
4)-3	Sand Material	m3	60,000	8.74	524,400.00
4)-4	Rock Material	m3	280,000	14.42	4,037,600.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	140,000	84.04	11,765,600.00
	Total Filling m3		14,200,000		
5)	Curtain Grouting				
4)-1	Drilling	m	38,000	73.09	2,777,420.00
4)-2	Grouting(cement 50kg/m)	m	23,000	71.50	1,644,500.00
	Subtotal this Sheet				194,608,420.00

BILL NO. : 21 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(3)	BARRIER DAM 'G'				
1)	Dredging(Hauling Distance 10km)				
1)-1	Clayey Material(Clay, Silt)	m3	500,000	2.89	1,445,000.00
1)-2	Loose Material(Sand, Gravel)	m3	500,000	2.88	1,440,000.00
	Total Excavation m3		1,000,000		
2)	Filling Materials Onland Hauling(10km) Dump Truck(240t), Shovel(30m3)				
2)-1	Core Material	m3	650,000	4.52	2,938,000.00
2)-2	Filter Material	m3	600,000	4.52	2,712,000.00
2)-3	Sand Material	m3	50,000	4.52	226,000.00
2)-4	Rock Material	m3	655,000	4.46	2,921,300.00
2)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	45,000	4.46	200,700.00
	Total Volume m3		2,000,000		
3)	Filling on Water Operation (Filling Below WL -4.0m)				
3)-1	Core Material	m3	540,000	5.67	3,061,800.00
3)-2	Filter Material	m3	560,000	6.54	3,662,400.00
3)-3	Sand Material	m3	40,000	5.67	226,800.00
3)-4	Rock Material	m3	610,000	6.54	3,989,400.00
3)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	20,000	21.58	431,600.00
4)	Filling on Water Operation (Filling, Above WL -4.0m)				
4)-1	Core Material	m3	110,000	8.70	957,000.00
4)-2	Filter Material	m3	40,000	14.38	575,200.00
4)-3	Sand Material	m3	10,000	8.70	87,000.00
4)-4	Rock Material	m3	45,000	14.38	647,100.00
4)-5	Rip Rap Material(2.0t/pc, d=1.0m)	m3	25,000	84.13	2,103,250.00
	Total Filling m3		2,000,000		
5)	Curtain Grouting				
4)-1	Drilling	m	8,000	73.09	584,720.00
4)-2	Grouting(cement 50kg/m)	m	5,000	71.50	357,500.00
	Subtotal this Sheet				28,566,770.00
	Total-Item No.10 Barrier Dams				431,760,306.00

BILL NO. : 22 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 1	BREAKWATER				
(1)	BREAKWATER AT ATLANTIC OCEAN SIDE				
	East Break Water 3,000m (M. Depth -17m)				
	West Break Water 3,400m (M. Depth -17m)				
1)	Core				
1)-1	Core Materials(below -4.0m)	m3	6,705,000	12.34	82,739,700.00
1)-2	Core Materials(above -4.0m)	m3	795,000	13.54	10,764,300.00
2)	Armor Rock				
2)-1	Armor Rock (0.5ton/piece, below-4.0m)	m3	1,488,000	15.31	22,781,280.00
2)-2	Armor Rock (0.5ton/piece, above-4.0m)	m3	112,000	19.69	2,205,280.00
2)-3	Armor Rock (3.0ton/piece below-4.0m)	m3	-	30.86	0.00
2)-4	Armor Rock (3.0ton/piece above-4.0m)	m3	700,000	109.40	76,580,000.00
	Total Fill m3		9,800,000		
2)-5	Armor Rock supply, hauling(6km)	m3	2,300,000	5.88	13,524,000.00
(2)	BREAKWATER AT PACIFIC OCEAN SIDE				
	East Breakwater 8,000m (M. Depth -17m)				
	West Breakwater (nil)				
1)	Core				
1)-1	Core Materials(below-4.0m)	m3	4,774,000	5.97	28,500,780.00
1)-2	Core Materials(above-4.0m)	m3	1,626,000	10.49	17,056,740.00
2)	Armor Rock				
2)-1	Armor Rock (0.5ton/piece, below-4.0m)	m3	928,000	8.31	7,711,680.00
2)-2	Armor Rock (0.5ton/piece, above-4.0m)	m3	272,000	16.64	4,526,080.00
2)-3	Armor Rock (3.0ton/piece below-4.0m)	m3	-	24.56	0.00
2)-4	Armor Rock (3.0ton/piece above-4.0m)	m3	700,000	105.94	74,158,000.00
	Total Fill m3		8,300,000		
2)-5	Armor Rock supply, hauling(6km)	m3	1,900,000	5.88	11,172,000.00
	Subtotal this Sheet				351,719,840.00
	Total-Item No. 11 Breakwater				351,719,840.00

BILL NO. : 23 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 2	DIVERSION SCHEME				
(1)	COFFER DAMS FOR DIVERSION				
1)	Coffer Dams				
	E-1-D				
	W-1-D				
	W-3-D				
	W-4-D				
	W-6-D				
	W-7-D				
	E-3-Di				
	Excavation(Hauling Diatance 5.0km)				
	Shovel(3.0m3), Dump Truck(32t)				
1)-1	Common	m3	147,500	4.77	703,575.00
1)-2	Weathered Rock	m3	147,500	6.68	985,300.00
	Total m3		295,000		
	Embankment(Hauling Distance 5.0km)				
	Shovel(3.0m3), Dump Truck(32t)				
1)-3	Core Material	m3	311,000	11.69	3,635,590.00
1)-4	Filter	m3	330,000	11.7	3,861,000.00
1)-5	Rock	m3	889,000	8.46	7,520,940.00
	Total Volume m3		1,530,000		
2)	Grouting				
	Blanket Grouting				
2)-1	Drilling Grouting Hole	m	11,500	19.99	229,885.00
2)-2	Pressure Grouting	m	11,500	34.07	391,805.00
3)	Concrete Works including forms and etc.				
3)-1	Concrete	m3	3,500	100.00	350,000.00
3)-1	Reinforcing Bars(Deformed)	t	210	804.10	168,861.00
	Subtotal this Sheet				17,846,956.00

BILL NO. : 24 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Diversion Channels				
	E-1-C				
	W-1-C				
	W-3-C				
	W-4-C				
	W-6-C				
	W-7-C				
	E-3-C				
1)	Dry Excavation(Hauling Distance 0.5km)				
1)-1	Common	m3	5,700,000	1.82	10,374,000.00
1)-2	Weathered Rock	m3	3,420,000	3.03	10,362,600.00
1)-3	Hard Rock	m3	2,280,000	4.72	10,761,600.00
	Total m3		11,400,000		
2)	Dredging(Hauling Distance 2.5km)				
2)-1	Clayey Materials	m3	500,000	2.29	1,145,000.00
2)-2	Weathered Rock	m3	300,000	4.28	1,284,000.00
2)-3	Hard Rock	m3	200,000	70.46	14,092,000.00
	Total m3		1,000,000		
	Subtotal this Sheet				48,019,200.00
	Total-Item No.12 Diversion Scheme				65,866,156.00

BILL NO. : 25 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1 3	SUPPORTING CONSTRUCTION				
(1)	CONSTRUCTION VILLAGE AND CAMPS	-			
1)	Site Preparation 5 site*140000m2 + 2 village*1000000m2	m2	2,700,000	1.72	4,644,000.00
2)	Housing and Building				
2)-1	Office and Warehouse	Estimated in General Conditions			0.00
2)-2	Detached House A 400m2/house	Nos	5	80,000	400,000.00
2)-3	Detached House B 300m2/house	Nos	50	60,000	3,000,000.00
2)-4	Detached House C 200m2/house	Nos	200	40,000	8,000,000.00
2)-5	Dormitory 2 village*120psn*100m2	m2	24,000	150	3,600,000.00
2)-6	Resthouse 2 village*2000m2	m2	4,000	200	800,000.00
2)-7	Canteen/Messhouse 1000m2*2 1000m2*5	m2	7,000	150	1,050,000.00
2)-8	Labor Camp 5 site*2000psn*50m2/psn	m2	500,000	120	60,000,000.00
2)-9	Supermarket 2village*1000m2 5site*200	m2	3,000	120	360,000.00
2)-10	School 2 village*2500m2	m2	5,000	150	750,000.00
2)-11	Theatre 2 village*5000m2	m2	10,000	150	1,500,000.00
2)-12	Sports/Recreation Center	m2	10,000	150	1,500,000.00
2)-13	Church 2 village*1000m2	m2	2,000	150	300,000.00
2)-14	Fire Station 7 places*500m2	m2	3,500	120	420,000.00
2)-15	Hospital 2 village*5000m2	m2	10,000	200	2,000,000.00
3)	Facilities and Services				
3)-1	Road W=6M 5site*600m 2village*2000m	m2	42,000	13	546,000.00
3)-2	Sewage 1 unit 2 village 5 site				
	Sewage Plant 5000t/day	unit	7	1,000,000	7,000,000.00
	Piping	m	20,000	50	1,000,000.00
	Operation Cost	yrs	8	60000	480,000.00
3)-3	Water Supply				
	Pump for Well (20m3/h)	Nos	7	10,000	70,000.00
	Water Treatment	Nos	7	500,000	3,500,000.00
	Piping 3000m*7	m	21000	8	168,000.00
3)-4	Power Supply Generator 800kVA*3Nos*7				
	Power Distribution 3000m*7	m	21000	20	420,000.00
	Operation 1lunit*24h*365*12	Hrs	1,156,320	58	67,066,560.00
3)-5	Fuel Supply Station	site	7	100,000	700,000.00
3)-6	Communication(Telephone/Fax/Radio/TV)	site	7	200,000	1,400,000.00
3)-7	Landscaping	m2	2,700,000	4	10,800,000.00
	Subtotal this Sheet				181,474,560.00

BILL NO. : 26 SEA LEVEL CANAL CASE-c

(2,020) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4)	Maintenance Cost				
	Personnel Cost for Maintenance				
4)-1	Camp Manager 1psn*2site*144mo	M.Mo	288	3,000	864,000.00
4)-2	Guardman 20psn*7site*144mo	M.Mo	20,160	1,000	20,160,000.00
4)-3	Medical Doctor 2psn*2Hosp*144	M.Mo	576	10,000	5,760,000.00
4)-4	Nurse 8psn*2*180 4psn*5*144	M.Mo	2,880	1,500	4,320,000.00
4)-5	Catering Staff 10psn*7*144	M.Mo	10,080	1,200	12,096,000.00
4)-6	Housekeeper 20*7*144	M.Mo	20,160	700	14,112,000.00
4)-7	Chief Driver 2psn*144mo	M.Mo	288	1,200	345,600.00
4)-8	Bus Driver 30Nos*144	M.Mo	4,320	1,000	4,320,000.00
4)-9	School Teacher 2 village*4*144mo	M.Mo	1,152	7,000	8,064,000.00
4)-10	Gardener 4psn*7site*144	M.Mo	4,032	1,000	4,032,000.00
4)-11	Supermarket Staff 4psn*7site*144	M.Mo	4,032	1,200	4,838,400.00
5)	Vehicles				
5)-1	Buses 30Nos*144mo	M.Mo	4,320	3,800	16,416,000.00
5)-2	Ambulance 2Nos*7*144	M.Mo	2,016	1,000	2,016,000.00
5)-3	Patrol Vehicle 2Nos*7*144	M.Mo	2,016	1,500	3,024,000.00
5)-4	Fire Engine 1No*7*144	M.Mo	1,008	2,500	2,520,000.00
	Subtotal this Sheet				102,888,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Main Construction Roads				
1)	Cut., Fill., Subgrade, Base Course, etc. (W = 22m, t = 1.2m)	m	95,000.0	1,002.98	95,283,100.00
(3)	Access Roads to Quarries				
1)	Cut., Fill., Subgrade, Base Course, etc. (W = 22m, t = 1.2m)	m	29,000.0	1,002.98	29,086,420.00
	Subtotal this Sheet				124,369,520.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(4)	Logistic Base				
1)	Puerto Pilon on Atlantic Side				
1)-1	Embankment, Grading	m3	30,000	12.00	360,000.00
1)-2	Jetty for Aggregates	m	240	2,800.00	672,000.00
1)-3	Control House	m2	100	400.00	40,000.00
1)-4	Guard House	m2	9	160.00	1,440.00
1)-5	Rest House	m2	100	240.00	24,000.00
1)-6	Roads	m2	7,000	20.00	140,000.00
1)-7	Fence	m	700	24.00	16,800.00
1)-8	Gate	set	1	8,000.00	8,000.00
1)-9	Drainage Way	m	700	104.00	72,800.00
1)-10	Operation of Generator	year	7	162,000.00	1,134,000.00
2)	Atlantic Side				
2)	Atlantic Side				
1)-1	Embankment, Grading	m3	127,500	12.00	
1)-1	Embankment, Grading	m3	127,500	12.00	1,530,000.00
1)-2	Sea wall(Conc.)	m	590	270.00	159,300.00
1)-3	Jetty for Aggregates	m	200	2,800.00	560,000.00
1)-4	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
1)-5	Strage Facilities	nos	15	240,000.00	
1)-5	Cement Silo(1,500t/No.)	no.	15	240,000.00	3,600,000.00
1)-6	Tank for Fuel(1600kl/no.)	no.	10	520,000.00	5,200,000.00
1)-7	Tank for Oil (100kl/no.)	no.	3	80,000.00	240,000.00
1)-8	Warehouse	m2	8,000	240.00	1,920,000.00
1)-9	Control House	m2	1,000	400.00	400,000.00
1)-10	Guard House	m2	27	160.00	4,320.00
1)-11	Rest House	m2	500	240.00	120,000.00
1)-12	Roads W=12m	m2	44,160	20.00	883,200.00
1)-13	Fence	m	1,090	24.00	26,160.00
1)-14	Gate	set	3	8,000.00	24,000.00
1)-15	Drainage Way	m	3,680	104.00	382,720.00
1)-16	Operation of Generator	year	12	252,000.00	3,024,000.00
	Subtotal this Sheet				48,142,740.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3)	Vacamonte on Pacific Side				
1)-1	Embankment, Grading	m3	127,500	12.00	1,530,000.00
1)-2	Sea wall(Conc.)	m	590	270.00	159,300.00
1)-3	Jetty for Armor Stone	m	200	2,800.00	560,000.00
1)-4	Jetty for Fuel, Cement, Materials, etc	m2	6,900	4,000.00	27,600,000.00
	Strage Facilities				
1)-5	Cement Silo(1,500t/No.)	no.	15	240,000.00	3,600,000.00
1)-6	Tank for Fuel(1600kl/no.)	no.	10	520,000.00	5,200,000.00
1)-7	Tank for Oil (100kl/no.)	no.	3	80,000.00	240,000.00
1)-8	Warehouse	m2	8,000	240.00	1,920,000.00
1)-9	Control House	m2	1,000	400.00	400,000.00
1)-10	Guard House	m2	27	160.00	4,320.00
1)-11	Rest House	m2	500	240.00	120,000.00
1)-12	Roads	m2	44,160	20.00	883,200.00
1)-13	Fence	m	1,090	24.00	26,160.00
1)-14	Gate	set	3	8,000.00	24,000.00
1)-15	Drainage Way	m	3,680	104.00	382,720.00
1)-16	Operation of Generator	year	12	252,000.00	3,024,000.00
	Subtotal this Sheet				45,673,700.00
	Total-Item No. 13 Supporting Construction				502,548,520.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
14	GENERAL CONDITIONS				
(1)	Canal Excavation, (14.3%, Item Total)	ls	1		781,211,000.00
(2)	Placing Area	ls	1		23,606,000.00
(3)	Lock/Gate Construction (15.8%, I.Total)	ls	1		312,844,000.00
(4)	Gate Leaves and Related Facilities		-		-inclusive-
(5)	New Dams(to be provided in 2,060)		-		-
(6)	Pump Station		nil		-
(7)	New Parmanent Roads(14.3%, Item Total)	ls	1		2,430,000.00
(8)	New Canal Crossing		-		-inclusive-
(9)	Navigation Support System(15.8%, I.Total	ls	1		74,538,000.00
(10)	Barrier Dams(14.8%, Item Total)	ls	1		61,742,000.00
(11)	Breakwater(14.3%, Item Total)	ls	1		50,296,000.00
(12)	Diversion Scheme(14.3%, Item Total)	ls	1		9,419,000.00
(13)	Supporting Construction(14.3%, I.Total)	ls	1		71,864,000.00
	Subtotal this Sheet				1,387,950,000.00
	Total-Item No.14 General Conditions				1,387,950,000.00

2.3 Bill of Quantities for Case-c (250,000DWT)

(2) Additional Costs of Phased Construction Sea Level Canal, the Year of 2,060

1) Summary

SEA LEVEL CANAL CASE-c

(2,060) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	General Cond. $	D. Const. Cost $	Project Costs $
			(II)	(I)	(I)+(II)
	SUMMARY				
I	DIRECT CONSTRUCTION COSTS				
(A)	CIVIL WORKS				
1	New dams	ls	11,255,000	78,708,144	89,963,144.00
2	Lock Construction	ls	65,130,000	412,218,130	477,348,130.00
4	New Canal Crossings	ls	-inclusive-	547,713,010	547,713,010.00
5	Supporting Construction	ls	8,276,000	57,873,000	66,149,000.00
	Subtotal		84,661,000	1,096,512,284	1,181,173,284.00
(B)	PLANT FORMING A PART OF PERMANENT WORK				
3	Gate Leaves and Related Facilities	ls	-inclusive-	316,008,430	316,008,430.00
	CONSTRUCTION COSTS, TOTAL		84,661,000.00	1,412,520,714	1,497,181,714.00
III	INDIRECT COSTS(*1)				
1	Administrative Costs	ls	-	-	15,271,300.00
2	Headquarter's Costs	ls	-	-	25,867,700.00
3	Construction Supervision	ls	-	-	28,958,600.00
4	Land Aquisition Costs	ls	-	-	-
5	Compensation Costs	ls	-	-	-
6	Contingency(10% of Const. Costs)	ls	-	-	149,718,000.00
	Sub Total				219,815,600.00
	(*1): to be assigned as percentage of Construction Costs				
	GRAND TOTAL(PROJECT COSTS)				1,716,997,314.00

BILL NO. : 1 SEA LEVEL CANAL CASE-c

(2,060) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1	NEW DAMS				
(1)	UPPER GATUN DAM (H=95M)				
1)	Earthwork Excavation for Dam Foundation				
1)-1	Top Soil Removal	m2	244,800	1.59	389,232.00
	Excavation(Hauling Distance 5km) Shovel(3.0m3), Dump Truck(32t)				
1)-2	Common	m3	400,000	4.77	1,908,000.00
1)-3	Weathered Rock	m3	400,000	6.68	2,672,000.00
	Total m3		800,000		
1)-4	Foundation Preparation (FInish Excavation, t=0.5m) Foundation Area, 244,800m2*20%	m2	49,000	34.28	1,679,720.00
1)-5	Foundation Preparation by washing	m2	49,000	30.50	1,494,500.00
1)-6	Excavation for Diversion tunnel	m3	20,000	120.00	2,400,000.00
	Excavation for Spillway				
1)-7	Common	m3	39,000	4.77	186,030.00
1)-8	Weathered Rock	m3	23,400	6.68	156,312.00
1)-9	Hard Rock	m3	15,600	8.46	131,976.00
	Total m3		78,000		
	Embankment(Hauling Distance 10.0km)				
1)-10	Core	m3	900,000	11.69	10,521,000.00
1)-11	Filter	m3	800,000	11.70	9,360,000.00
1)-12	Rock	m3	4,500,000	8.46	38,070,000.00
	Total m3		6,200,000		
	Subtotal this Sheet				68,968,770.00

BILL NO. : 2 SEA LEVEL CANAL CASE-c

(2,060) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2)	Curtain Grouting				
2)-1	Drilling Grouting Hole	m	33,000	73.09	2,411,970.00
2)-2	Pressure Grouting	m	33,000	71.50	2,359,500.00
	Blanket Grouting				
2)-3	Drilling Grouting Hole	m	14,100	19.99	281,859.00
2)-4	Pressure Grouting	m	14,100	34.07	480,387.00
3)	Concrete Works including Formworks etc				
3)-1	Concrete for Spillway	m3	16,000	100.00	1,600,000.00
3)-2	Concrete for Diversion Tunnel	m3	6,000	120.00	720,000.00
3)-3	Concrete for Outlet	m3	1,000	100.00	100,000.00
	Total m3		23,000		
3)-4	Reinforcing Bars(Deformed)	t	1,380	804.10	1,109,658.00
4)	Steel Works & Equipment				
4)-1	Outlet Penstock	t	30	7,200.00	216,000.00
4)-2	Hollow-jet Valve Φ=0.8m	set	1	290,000.00	290,000.00
4)-3	Spare Valve Φ=0.8m	set	1	170,000.00	170,000.00
	Subtotal this Sheet				9,739,374.00
	Total-Item No.1 New Dams				78,708,144.00

BILL NO. : 3 SEA LEVEL CANAL CASE-c

(2,060) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	LOCK CONSTRUCTION				
(1)	PACIFIC TIDAL LOCK				
1)	Excavation(Hauling Distance 5.0m)				
1)-1	Common	m3	15,840,000	2.57	40,708,800.00
1)-2	Weathered Rock	m3	9,500,000	3.69	35,055,000.00
1)-3	Hard Rock	m3	6,340,000	5.64	35,757,600.00
	Total m3		31,680,000		
1)-4	Dewatering	ls	1	28,980,000	28,980,000.00
2)	Backfill	m3	2,940,000	3.85	11,319,000.00
3)	Grouting				
3)-1	Consolidation Grouting	m	125,800	20.05	2,522,290.00
3)-2	Curtain Grouting	m	125,800	66.80	8,403,440.00
4)	Concrete including form works, etc	m3	2,000,000	76.49	152,980,000.00
5)	Reinforcing Bar (Deformed)	t	120,000	804.10	96,492,000.00
(1)	Atlantic Tidal Gate				
	Subtotal this Sheet				412,218,130.00
	Total-Item No.2 Lock Construction				412,218,130.00

BILL NO. : 4 SEA LEVEL CANAL CASE-c

(2,060) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	GATE LEAVES AND RELATED FACILITIES				
(1)	GATE LEAVES AT PACIFIC TIDAL LOCK				
1)	Gate Leaves	ton	10,776	9,730	104,850,480.00
2)	Mechanical Equipment				
2)-1	Gate Frames	ton	3,209	11,110	35,651,990.00
2)-2	Gate Hoists	ton	1,503	15,000	22,545,000.00
2)-3	Locomotives	unit	10	3,600,000	36,000,000.00
2)-4	Rails and Racks for Locomotives	ton	3,014	8,140	24,533,960.00
2)-5	Power Supply Line For Locomotive	set	1	4,000,000	4,000,000.00
2)-6	Other Mechanical Component (Compressed Air System, Drainage Pumps Piping and Misc. Mechanical Equip.	set	1	31,467,000	31,467,000.00
3)	Electrical Power and Control				
3)-1	Electric Power and Control Equipment 28000kw	set	1	25,900,000	25,900,000.00
3)-2	Emergency Power Plant	kw	28,000	770	21,560,000.00
3)-3	Misc. Electrical Equip.	set	1	5,000,000	5,000,000.00
4)	Others				
4)-1	Local Control Buildings and Their and Other Electric works and Consumables	set	1	400,000	400,000.00
4)-2	Their Electrical Equip.	set	1	100,000	100,000.00
4)-3	Cathodic Protection	set	1	1,400,000	1,400,000.00
4)-4	Monitoring & Surveillance Equip. and Communication System	set	1	1,600,000	1,600,000.00
4)-5	Grounding System	set	1	400,000	400,000.00
4)-6	Other Electrical Works and Consumable	set	1	600,000	600,000.00
	Subtotal this Sheet				316,008,430.00
	Total-Item No. 3 Gate Leaves and Related Facilities				316,008,430.00

BILL NO. : 5 SEA LEVEL CANAL CASE-c

(2,060) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	NEW CANAL CROSSINGS				
(1)	BRIDGE OVER THE NEW CANAL				
1)	Bridges Over the Canal for Van Dam Bypass				
1)-1	Cable Stayed Bridge Canal Width 190m Span = L1(Main)+L2+L3=250+90+90=430m Width = 20.5m (Four Lane)	m2	8,815	6,064.00	53,454,160.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 20.5m (Four Lane)	m2	12,300	2,964.00	36,457,200.00
	Subtotal this Sheet				89,911,360.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	BRIDGE OVER THE EXISTING CANAL				
1)	Bridges Over the (Existing) Canal for Van Dam Bypass				
1)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=500+200+200=900m Width = 20.5m (Dual Two Ways)	m2	18,450	16,679.00	307,727,550.00
1)-2	Approaching Bridges(Steel Box Girder) Total Length = 950m (One Span 60m) Width = 20.5m (Dual Two Ways)	m2	19,475	2,964.00	57,723,900.00
2)	Bridges Over the (Existing) Canal at Middle Gomba				
2)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=200+80+80=360m Width = 10.0m (Dual Two Ways)	m2	3,600	4,874.00	17,546,400.00
2)-2	Approaching Bridges(Steel Box Girder) Total Length = 600m (One Span 60m) Width = 10.0m (Dual One Ways)	m2	6,000	2,980.00	17,880,000.00
3)	Bridges Over the (Existing) Canal on Atlantic Side				
3)-1	Cable Stayed Bridge Existing Canal Width ---m Span = L1(Main)+L2+L3=230+90+90=410m Width = 10.0m (Dual One Way)	m2	4,100	5,598.00	22,951,800.00
3)-2	Approaching Bridges(Steel Box Girder) Total Length = 1,140m (One Span 60m) Width = 10.0m (Dual One Way)	m2	11,400	2,980.00	33,972,000.00
	Subtotal this Sheet				457,801,650.00
	Total-Item No.4 New Canal Crossings				547,713,010.00

BILL NO. : 7 SEA LEVEL CANAL CASE-c

(2,060) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	SUPPORTING CONSTRUCTION to be assigned as percentage of Construction Costs(Civil Works)	ls	1	-	57,873,000.00
	Subtotal this Sheet				57,873,000.00
	Total-Item No.5 Supporting Construction				57,873,000.00

BILL NO. : 8 SEA LEVEL CANAL CASE-c

(2,060) TIDAL LOCK(PACIFIC)/TIDAL GATE(ATLANTIC) 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
6	GENERAL CONDITIONS				
1	New dams (14.3% of Item Total)	ls	1		11,255,000.00
2	Lock Construction(15.8% of Item Total)	ls	1		65,130,000.00
3	Gate Leaves and Related Facilities		-		-inclusive-
4	New Canal Crossings		-		-inclusive-
5	Supporting Construction(14.3%, I.Total)	ls	1		8,276,000.00
	Subtotal this Sheet				84,661,000.00
	Total-Item No.6 General Conditions				84,661,000.00

IV.3 Chapter 3. Indirect Costs

3.1 Bill of Quantities for Case - a

A. Seal Level Canal 250,000 DWT the year of 2020

Indirect Costs for the cases mentioned below are to be assigned a percentage of construction costs.

- Bill of Quantities for Case - a

B. Additional Costs of phased Construction the year of 2060

- Bill of Quantities for Case - b

A. Seal Level Canal 250,000 DWT the year of 2020

B. Additional Costs of phased Construction the year of 2060

- Bill of Quantities for Case - c

A. Seal Level Canal 250,000 DWT the year of 2020

B. Additional Costs of phased Construction the year of 2060

3.1 Indirect Costs
Bill of Quantities for Case-a (250,000DWT)
Sea Level Canel, the Year of 2,020

BILL NO. : 31 (2,020) SEA LEVEL CANAL CASE-a
TIDAL LOCK(PACIFIC), 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
I I	INDIRECT COSTS				
1	ADMINISTRATIVE COSTS (For Five Sites Administration)				
(1)	Salaries/Wages for Personnel Staff Man-Month				
1)	Project Manager 1per *12mon. *15y	m-m	180	12,000.00	2,160,000.00
2)	Duputy Project Manager 1per *12mon. *12y	m-m	144	10,000.00	1,440,000.00
3)	Admi. Manager 1per *12mon. *15y	m-m	180	9,000.00	1,620,000.00
4)	Engineer Senior 2per *12mon. *12y	m-m	288	9,000.00	2,592,000.00
5)	Chief, Project Site 3.5per *12mon. *12y + 1*12	m-m	516	7,000.00	3,612,000.00
6)	Site Engineer 7per *12mon. *12y	m-m	1,008	6,000.00	6,048,000.00
7)	Assist. Labo. etc 9per *12mon. *12y	m-m	1,296	5,000.00	6,480,000.00
8)	Quantity Surveyor, 2per*12mon. *12y	m-m	288	8,000.00	2,304,000.00
9)	Accountant, 1per*12mon. *15y	m-m	180	5,000.00	900,000.00
10)	Land Surveyor, 9per*12mon. *12y	m-m	1,296	3,000.00	3,888,000.00
11)	Technician/Drafter, 14per*12mon. *12y	m-m	2,016	2,500.00	5,040,000.00
12)	Office Clark, 18per*12mon. *12y	m-m	2,592	2,000.00	5,184,000.00
13)	Inspector, 4.5per*12mon. *12y	m-m	648	3,000.00	1,944,000.00
14)	Store/Time keeper, 2per*12mon. *12y	m-m	288	1,500.00	432,000.00
15)	Survey Helper/Clerk, 36per*12mon. *12y	m-m	5,184	1,000.00	5,184,000.00
16)	Secretary/Typist, 18per*12mon. *12y	m-m	2,592	1,500.00	3,888,000.00
17)	Driver, 36per*12mon. *12y	m-m	5,184	1,000.00	5,184,000.00
18)	Office Boy, 13per*12mon. *12y	m-m	1,872	700.00	1,310,400.00
19)	Watchman, 46per*12mon. *12y	m-m	6,624	700.00	4,636,800.00
	Subtotal this Sheet				63,847,200.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Office Equipment and Engineering Supply 12mo.*15y	mon	180	23,000.00	4,140,000.00
(3)	Utilities Consumption (Water, Power, Etc.) 12mon.*15y	mon	180	16,600.00	2,988,000.00
(4)	Communications (Telephone, Fax, Telex, Etc.) 12mon.*15y	mon	180	18,400.00	3,312,000.00
(5)	Traveling expenses				
	EXPATRIATE (3p*2t*12y)	trip	72	5,000.00	360,000.00
	LOCAL (4p*4t*12t*12y)	trip	2,304	800.00	1,843,200.00
(6)	Welfare Expenses	mon.	180	9,200.00	1,656,000.00
(7)	Medical Expenses	mon.	144	11,000.00	1,584,000.00
(8)	Board of Consultanats (5p*12times)	time	12	200,000.00	2,400,000.00
(9)	Staff Transportation				
	Vehicles (18*12mon.*12year)	u-m	2,592	2,000.00	5,184,000.00
	Landcruiser (18*12mon.*12year)	u-m	2,592	2,500.00	6,480,000.00
	Pilot Boat (2*12*12)	u-m	288	25,000.00	7,200,000.00
	Helicopter (1*12mon.*15year)	u-m	180	50,000.00	9,000,000.00
(10)	Accomodation and Building				
	Offices (5sites * 920m2)	m2	4,600	200.00	920,000.00
	Warehouse (2sites * 1850m2)	m2	3,700	100.00	370,000.00
	Shops and Sheds (2 * 460m2)	m2	920	80.00	73,600.00
	Yards (2 * 4600m2)	m2	9,200	100.00	920,000.00
	Canteens and Messrooms (5sites*185m2)	m2	925	200.00	185,000.00
	Houses	no	190	40,000.00	7,600,000.00
	Subtotal this Sheet				56,215,800.00
	Total-Item No.1 Administrative Costs				120,063,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
2	HEADQUARTER'S COSTS				
(1)	SITE SURVEY/INVESTIGATIONS				
1)	Salaries/Wages 18per*12mon. *3.5y	m-m	765	7,000.00	5,355,000.00
2)	Travel Expenses 22per*4t. *3.5y	trip	308	5,000.00	1,540,000.00
3)	Communications (TEL, FAX)	mon	42	18,400.00	772,800.00
4)	Office Equipment & Supply	mon	42	9,200.00	386,400.00
5)	Site Transport	mon	42	27,500.00	1,155,000.00
6)	Geological Boring	ls	1	920,000.00	920,000.00
7)	Mapping/Documentations	ls	1	18,300,000.00	18,300,000.00
(2)	ENGINEERING AND DESIGN				
1)	SALARIES/wages				
1)-1	Project Director	m-m	144	10,000.00	1,440,000.00
1)-2	Senior Design Engineer (5per*12mon. *12y)	m-m	720	9,000.00	6,480,000.00
1)-3	Design Engineer (18per*12mon. *12y)	m-m	2,592	8,000.00	20,736,000.00
1)-4	Technician (18per*12mon. 12y)	m-m	2,592	2,500.00	6,480,000.00
1)-5	Drafter (46per*12mon. 12y)	m-m	6,624	2,500.00	16,560,000.00
1)-6	Computer Specialist 25*144 (23per*12mon. 12y)	m-m	3,312	2,500.00	8,280,000.00
1)-7	Chief Geologist (3per*12mon. *12y)	m-m	432	9,000.00	3,888,000.00
1)-8	Senior Geologist (9per*12mon. *12y)	m-m	1,296	8,000.00	10,368,000.00
	Subtotal this Sheet				102,661,200.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
1)-9	Administration Manager	m-m	144	9,000.00	1,296,000.00
1)-10	Accountant	m-m	144	5,000.00	720,000.00
1)-11	Office Clerk (9per*12mon.*12y)	m-m	1,296	2,000.00	2,592,000.00
1)-12	Secretary/Typist (14per*12mon.*12y)	m-m	2,016	1,500.00	3,024,000.00
1)-13	Driver (46per*12mon.*12y)	m-m	6,624	1,000.00	6,624,000.00
1)-14	Office Boy 5*5*12mon.*12y	m-m	3,600	700.00	2,520,000.00
1)-15	Watchman 46per*12mon.*12y	m-m	6,624	700.00	4,636,800.00
2)	Report/Documentations	ls	1	14,000,000.00	14,000,000.00
3)	Travel Expense 36*2*12	trip	864	5,000.00	4,320,000.00
4)	Communications (TEL, FAX)	mon	144	18,400.00	2,649,600.00
5)	Office Equipment & Supply	mon	144	27,500.00	3,960,000.00
6)	Staff Transpsortation				
6)-1	Vehicles 28*12mon.*12y	u-m	4,032	2,000.00	8,064,000.00
6)-2	Land Cruiser 36*12mon.*12y	u-m	5,184	2,500.00	12,960,000.00
	Subtotal this Sheet				67,366,400.00

BILL NO. : 35 (2,020) SEA LEVEL CANAL TIDAL LOCK(PACIFIC), CASE-a 250,000DWT

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
7)	Accomodation & Buildings				
7)-1	Office	m2	4,600	200.00	920,000.00
7)-2	Messroom	m2	280	200.00	56,000.00
7)-3	Houses	no.	45	40,000.00	1,800,000.00
(3)	TENDER PREPARATION/EVALUATION/CONTRACT				
1)	Salaries/Wages (3.5*12mon.*3.5y)	m-m	147	7,000.00	1,029,000.00
2)	Travel Expense (3.5*6trip.*3.5y)	trip	74	5,000.00	370,000.00
3)	Communications	mon	42	18,000.00	756,000.00
4)	Office Equipment & Supply	mon	42	9,200.00	386,400.00
5)	Documentations	ls	1	13,500,000.00	13,500,000.00
(4)	Home Office Overhead(7% of Item Total)	ls	1	14,214,130.00	14,214,130.00
	Subtotal this Sheet				33,031,530.00
	Total-Item No.2 Headquater's Costs				203,059,130.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
3	CONSTRUCTION SUPERVISION				
(1)	Salaries/Wages for Personnel Staff				
1)	Chief Superviser 1per *12mon. *15y	m-m	180	12,000	2,160,000.00
2)	Senior Superviser 5sites*2per *12mon. *15y	m-m	1,800	10,000	18,000,000.00
3)	Superviser 5sites*2per *12mon. *15y	m-m	1,800	8,000	14,400,000.00
4)	Inspector 5sites*5per *12mon. *15y	m-m	4,500	3,000	13,500,000.00
5)	Checker 5sites*22per *12mon. *15y	m-m	19,800	1,000	19,800,000.00
6)	Land Surveyor 5sites*3.5per *12mon. *15y	m-m	3,150	2,500	7,875,000.00
7)	Surveyor Helper 5sites*14per*12mon. *15y	m-m	12,600	1,000	12,600,000.00
8)	Driver 5sites*7per*12mon. *15y	m-m	6,300	1,000	6,300,000.00
9)	Secretary/Typist (5sites*3per+1per) *12mon. *15y	m-m	2,880	1,500	4,320,000.00
10)	Office Boy 5sites*3.5per*12mon. *15y	m-m	3,150	700	2,205,000.00
	Subtotal this Sheet				101,160,000.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
(2)	Office Equip. and Engineering Supply(Equipment) 5sites*12mon. *15year	mon	900	12,000	10,800,000.00
(3)	Utilities Consumption (Water, Power, Etc.) 5*12mon. *15y	mon	900	10,000	9,000,000.00
(4)	Communications (Telephone, Fax, Telex, Etc.) 5*12mon. *15y	mon	900	12,000	10,800,000.00
(5)	Traveling expenses				
1)	EXPATRIATE(5sites*4per+1)*2time*15y)	trip	630	10,000	6,300,000.00
2)	LOCAL Travel(5sites*10times*12m*15y)	trip	9,000	1,000	9,000,000.00
(6)	Welfare Expenses	mon	180	14,000	2,520,000.00
(7)	Staff Transportation				
1)	Vehicles (5sites* 10unit*12m * 15years)	u-m	9,000	2,000	18,000,000.00
2)	Pilot Boat (5sites* 1unit*12m * 15years)	u-m	900	30,000	27,000,000.00
3)	Helicopter(Suppervision/First Aids) (1unit*12m * 15years)	u-m	180	75,000	13,500,000.00
(8)	Accomodation and Buildings for superviser				
1)	Offices, 5sites*1 unit* 1000m2	m2	5,000	1,200	6,000,000.00
2)	Warehouse, 5sites*1unit* 500m2	m2	2,500	1,000	2,500,000.00
3)	Shops and Sheds, 5sites*1units*1000m2	m2	5,000	1,000	5,000,000.00
4)	Yards, 5sites*1unit*1000m2	m2	5,000	100	500,000.00
5)	Canteens and Messrooms 5sites*1units *200m2	m2	1,000	1,200	1,200,000.00
6)	Houses 5sites*21houses	nos	105	38,500.00	4,042,500.00
	Subtotal this Sheet				126,162,500.00
	Total-Item No.3 Construction Supervision				227,322,500.00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
4	LAND AQUISITION & RIGHTS				
(1)	Area along the Canal				
1	Town Residential Area	m2	2, 220, 700	3. 40	7, 550, 380. 00
2	Land aquisition for Agricultural Areas	m2	12, 440, 200	0. 11	1, 368, 422. 00
3	Land aquisition for Forest Areas	m2	8, 065, 400	0. 08	645, 232. 00
4	Land aquisition for Swamp Areas	m2	670, 300	0. 80	536, 240. 00
5	Land aquisition for Industrial Areas	m2	121, 900	12. 00	1, 462, 800. 00
	Sub-Total Area, m2		23, 518, 500		
(2)	Placing Area				
1	Town Residential Area	m2	3, 129, 500	0. 91	2, 847, 845. 00
2	Land aquisition for Agricultural Areas	m2	32, 437, 200	0. 37	12, 001, 764. 00
3	Land aquisition for Forest Areas	m2	15, 408, 200	0. 06	924, 492. 00
	Sub-Total (Placing Area), m2		50, 974, 900		
	Subtotal this Sheet				27, 337, 175. 00
	Total-Item No. 4 Land Aquisition & Rights				27, 337, 175. 00

Item No.	Description	Unit	Q'ty	Unit Cost $	Amount $
5	COMPENSATION COSTS				
(1)	Relocation of Housing	nos	269	38,400.00	10,329,600.00
(2)	Compensation	nos	269	12000	3,228,000.00
	Subtotal this Sheet				13,557,600.00
	Total-Item No. 5 Compensation Costs				13,557,600.00

IV.3 Chapter 4. Project Cost Distribution by year

4.1 Project Cost Distribution by year

Case - a the year of 2020

4.2 Project Cost Distribution by year

Case - b the year of 2020

4.3 Project Cost Distribution by year

Case - c the year of 2020

Table IV.3.4.1-1

4.1 Project Cost Distribution by Year
Sea Level Canal
Case : Case-a (the Year of 2020)

File:FLOESLC

	Major Cost Component	Amount	Year of Expenditure (unit:millions of dollars) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	CONSTRUCTION COSTS																	
(A)	CIVIL WORKS																	
1	Canal Excavation	6,244.22					1,561.06	437.10	437.10	468.32	468.32	468.32	468.32	468.32	468.32	468.32	530.76	
2	Placing Area	188.68					47.17	18.87	6.60	6.60	6.60	6.60	6.60	6.60	6.60	37.74	38.68	
3	Lock Construction	2,037.41					509.35	173.18	173.18	173.18	173.18	173.18	173.18	173.18	173.18	142.62		
5	New Dams	-																
6	Pump Station	-																
7	New Permanent Roads	19.42													4.85	8.74	5.83	
8	New Canal Crossing	221.94					55.48	25.52	25.52	25.52	25.52	25.52	25.52	13.32				
10	Barrier Dams	493.50					123.38	81.43	81.43	81.43	81.43	44.42						
11	Breakwater	402.02					100.50	31.36	31.36	31.36	31.36	31.36	31.36	31.36	31.36	31.36	19.30	
12	Diversion Scheme	75.29					32.76	28.23	14.30									
13	Supporting Construction	574.41				229.77	344.65											
	Subtotal	10,256.89				229.77	2,774.34	795.68	769.49	786.41	786.41	749.40	704.98	692.77	684.31	688.77	694.56	
(B)	PLANT FORMING A PART OF PERMANENT WORKS																	
4	Gate Leaves and and Related Facilities	949.55										237.39	137.68	137.68	137.68	137.68	161.42	
9	Navigation Support System	546.30													136.57	202.13	207.59	
	Subtotal	1,495.85										237.39	137.68	137.68	274.26	339.81	369.02	
	CONSTRUCTION COSTS TOTAL	11,752.74				229.77	2,774.34	795.68	769.49	786.41	786.41	986.78	842.67	830.46	958.57	1,028.58	963.58	
I I	INDIRECT COSTS																	
1	Administrative Costs	120.06	1.80	1.80	6.60	10.81	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
2	Headquarter's Costs	203.06	50.76	50.76	50.76	26.19	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23	
3	Construction Supervision	227.32	5.68	5.68	5.68	10.23	18.19	18.19	18.19	18.19	18.19	18.19	18.19	18.19	18.19	18.19	18.19	
4	Land Aquisition & Rights	21.34	10.93	10.93	5.47													
5	Compensation Costs	13.56	5.42	5.42	2.71													
6	Contingency	1,175.27				52.89	52.89	52.89	52.89	52.89	52.89	52.89	52.89	188.04	188.04	188.04	188.04	
	INDIRECT COSTS TOTAL	1,766.61	74.61	74.61	71.23	100.12	82.31	82.31	82.31	82.31	82.31	82.31	82.31	217.47	217.47	217.47	217.47	
	ANNUAL DISTRIBUTION	13,519.35	74.61	74.61	71.23	329.88	2,856.65	878.00	851.80	868.72	868.72	1,069.09	924.98	1,047.93	1,176.04	1,246.05	1,181.05	

Table IV.3.4.2-1

4.2 Project Cost Distribution by Year
Sea Level Canal
Case : Case-b (the Year of 2,020)

File:FLOESLC

	Major Cost Component	Amount	Year of Expenditure (unit:millions of dollars)															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	CONSTRUCTION COSTS																	
(A)	CIVIL WORKS																	
1	Canal Excavation	7,373.06					1,843.26	616.11	616.11	652.98	652.98	652.98	652.98	652.98	652.98	652.98	626.71	
2	Placing Area	188.68					47.17	18.87	6.60	6.60	6.60	6.60	6.60	6.60	6.60	37.74	38.68	
3	Lock Construction	420.94					107.23	90.08	90.08	90.08	61.47							
5	New Dams	-																
6	Pump Station	-																
7	New Permanent Roads	19.42													4.85	8.74	5.83	
8	New Canal Crossing	309.09					77.27	35.55	35.55	35.55	35.55	35.55	35.55	18.55				
10	Barrier Dams	493.50					123.38	81.43	81.43	81.43	81.43	44.42						
11	Breakwater	402.02					100.50	31.36	31.36	31.36	31.36	31.36	31.36	31.36	31.36	31.36	19.30	
12	Diversion Scheme	75.29					32.76	28.23	14.30									
13	Supporting Construction	674.41				229.77	344.66											
	Subtotal	9,864.40				229.77	2,676.22	801.62	776.43	797.99	759.39	670.90	626.49	609.49	695.80	630.81	690.51	
(B)	PLANT FORMING A PART OF PERMANENT WORKS																	
4	Gate Leaves and and Related Facilities	737.96							184.49	173.42	173.42	206.63						
9	Navigation Support System	477.05													119.26	176.51	181.28	
	Subtotal	1,215.01							184.49	173.42	173.42	206.63			119.26	176.51	181.28	
	CONSTRUCTION COSTS TOTAL	11,079.41				229.77	2,676.22	801.62	959.92	971.41	932.81	877.53	626.49	609.49	715.06	807.32	871.79	
I I	INDIRECT COSTS																	
1	Administrative Costs	113.01	1.70	1.70	6.22	10.17	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	
2	Headquarter's Costs	191.43	47.86	47.86	47.86	24.69	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	
3	Construction Supervision	214.30	5.36	5.36	5.36	9.64	17.14	17.14	17.14	17.14	17.14	17.14	17.14	17.14	17.14	17.14	17.14	
4	Land Acquisition & Rights	27.34	10.93	10.93	5.47													
5	Compensation Costs	13.56	5.42	5.42	2.71													
6	Contingency	1,107.94				49.86	49.86	49.86	49.86	49.86	49.86	49.86	49.86	171.27	177.27	177.27	177.27	
	INDIRECT COSTS TOTAL	1,667.57	71.27	71.27	67.61	94.37	77.58	77.58	77.58	77.58	77.58	77.58	77.58	205.00	205.00	205.00	205.00	
	ANNUAL DISTRIBUTION	12,746.98	71.27	71.27	67.61	324.13	2,753.80	879.20	1,037.50	1,048.99	1,010.39	955.11	704.07	814.48	920.05	1,012.31	1,076.79	

Table IV.3.4.3-1

4.3 Project Cost Distribution by Year
Sea Level Canal
Case : Case-c (the Year of 2,020)

File:FLOESLC

	Major Cost Component	Amount	Year of Expenditure (unit:millions of dollars) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	CONSTRUCTION COSTS																	
(A)	CIVIL WORKS																	
1	Canal Excavation	8,244.22					1,561.06	437.10	437.10	468.32	468.32	468.32	468.32	468.32	468.32	468.32	530.76	
2	Placing Area	188.68					47.17	16.87	8.60	8.60	8.60	8.60	8.60	8.60	8.60	37.74	38.68	
3	Lock Construction	2,292.87					573.22	194.89	194.89	194.89	194.89	194.89	194.89	194.89	194.89	160.50		
5	New Dams	-																
6	Pump Station	-																
7	New Permanent Roads	18.42													4.86	8.74	5.83	
8	New Canal Crossing	221.04					55.48	26.52	26.52	26.52	26.52	26.52	26.52	13.32				
10	Barrier Dams	493.50					123.38	81.43	81.43	81.43	81.43	44.42						
11	Breakwater	402.02					100.50	31.36	31.36	31.36	31.36	31.36	31.36	31.36	31.36	31.36	19.30	
12	Diversion Scheme	76.29					32.76	28.23	14.30									
13	Supporting Construction	674.41				228.77	344.65											
	Subtotal	10,512.35				229.77	2,838.20	817.40	791.21	808.12	808.12	771.11	726.69	714.49	706.03	706.65	594.56	
(B)	PLANT FORMING A PART OF PERMANENT WORKS																	
4	Gate Leaves and and Related Facilities	1,252.23								369.41	118.96	118.96	118.96	118.96	118.96	169.05	118.96	
9	Navigation Support System	546.30													136.57	202.13	207.59	
	Subtotal	1,798.53								369.41	118.96	118.96	118.96	118.96	255.54	371.18	326.55	
	CONSTRUCTION COSTS TOTAL	12,310.88				229.77	2,838.20	817.40	791.21	1,177.53	927.08	890.07	845.66	833.45	961.56	1,077.83	921.12	
I I	INDIRECT COSTS																	
1	Administrative Costs	126.67	1.88	1.88	6.91	11.30	9.42	9.42	9.42	9.42	9.42	9.42	9.42	9.42	9.42	9.42	9.42	
2	Headquarter's Costs	212.70	53.18	53.18	53.18	21.44	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34	
3	Construction Supervision	238.12	6.95	6.95	6.95	10.72	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	
4	Land Aquisition & Rights	27.34	10.93	10.93	5.47													
5	Compensation Costs	13.56	5.42	5.42	2.71													
6	Contingency	1,231.09				65.40	65.40	65.40	65.40	65.40	65.40	65.40	65.40	196.97	196.97	196.97	196.97	
	INDIRECT COSTS TOTAL	1,848.37	77.37	77.37	74.21	104.85	86.21	86.21	86.21	86.21	86.21	86.21	86.21	227.78	227.78	227.78	227.78	
	ANNUAL DISTRIBUTION	14,159.25	77.37	77.37	74.21	334.62	2,924.41	903.60	877.41	1,263.74	1,013.29	976.28	931.86	1,061.23	1,189.34	1,305.61	1,148.90	

IV.3 Chapter 5. Operation and Maintenance Costs

Refer to Part II.3 Chapter 3
"Operation and Maintenance Costs"