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PHASE 1 : PRELIMINARY ENGINEERING AND COST ESTIMATES

FINAL REPORT

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ABBREVIATION

Abbreviation		Term
AASHTO	:	American Association of State Highway and Transportation Officials
ASN	:	Alaskan North Slope
BPD	:	Barrel per Day
CALM	:	Catenary Anchor Leg Mooring
CAPAC	:	Camana Panamena De La Construccion
DDL	:	Deep Draft Lock
IOCS	:	Inter Ocean Canal Studies
JAX	:	Department of The Army Jacksonville District, Coup of Engineers
JSSC	:	Japanese Society of Steel Construction
PCC	:	Panama Canal Commission
PCU	:	Passenger Car Unit
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
ha	:	hector
ø	:	diameter
KW	:	Kilowatts
Kg	:	Kilograms
DWT	:	deadweight tonnage
HWL	:	high water level
MWL	:	mean water level
LWL	:	low water level
US$ or $	:	US dollars

SUMMARY REPORT

SUMMARY REPORT

1. General

This report is a summary of the Final Report for Phase 1 of the Panama Canal Alternative Study. Presented herein are the study results for the four basic study groups which have been considered in Phase 1 for the prescreening of alternatives.

The Final Report itself consists of Part I Engineering for Prescreening and Part II, Cost Estimation for Prescreening and Annex.

Each historic alternative is classified into one of the following four groups.

- Group A High rise lock canal (Water level 90' - 85')
- Group B Low rise lock canal (Water level 55' - 30')
- Group C Sea level canal (Route 10)
- Group D Sea level canal (Route 14S)

Each group is further classified into 9-study cases according to the size of ships, the highest water level in the lake (lock type only), number of lifts (lock type only), number of lanes, and route centerline location. The existing canal with announced Culebra Cut Widening is included as the status quo to serve as a basis for comparison.

The Final Report describes the results of the study of all 36 study cases. The interim findings for the Group A and Group C which were included in the Interim Report have been amended as necessary before inclusion in this Final Report.

The main features of the study cases are shown on the Comparative Summation Tables for Lock Type Canal and Sea Level Canal at the end of this Summary Report.

2. Group A - High Rise Lock (W.L.=90'- 85')

2.1 Routes

For the High Rise Lock system, there are two routes. On the first route 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 (Fig. S.1), 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. For this route, the characteristics of each of the 6 study cases are shown on Fig. S.1 as L-1, L-2, L-4, L-5, L-7 and L-8.

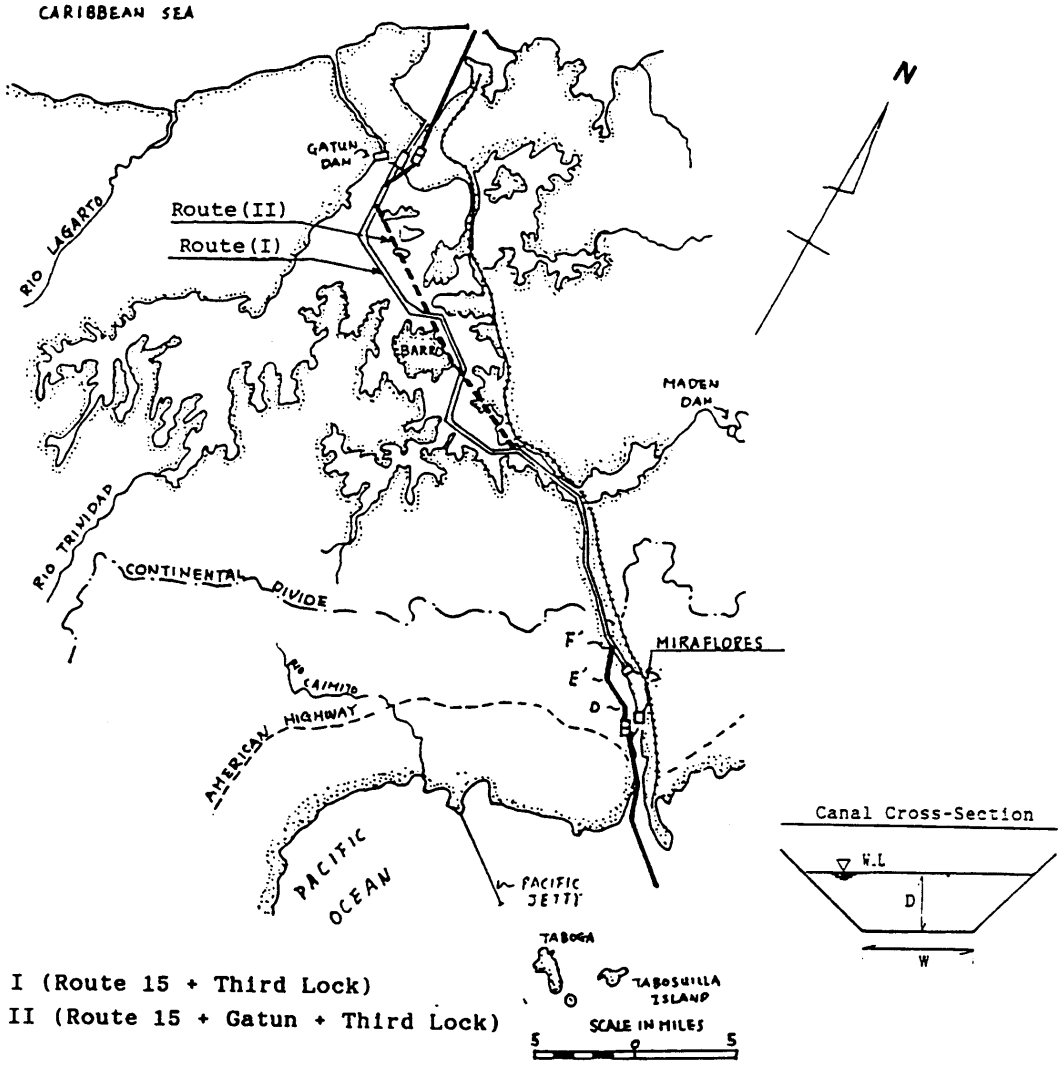
The 2nd route for the high rise lock system takes the same route from the Pacific coast side to reach Gatun Lake, then proceeds to take a modified route through Gatun Lake as shown by Route II (See dotted line) in Fig S.1. Three study cases, L-10, L-13 and L-16 adopt Route II.

2.2 Water Level

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 study cases L-1, L-4 and L-7, as shown in Fig. S.1

From the studies, it was found that the 90' water level cases require no major reconstructions of existing facilities at Miraflores Locks, Gatun Locks and Gatun Dam, or of the railways and roads around the lake.

Further studies and surveys shall be required to confirm the future safety of the Panamanian people.



Note:
Route I (Route 15 + Third Lock)
Route II (Route 15 + Gatun + Third Lock)

Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
L-1	I	90'	2	2	100	301 x 18.7
2	I	85'	2	2	100	301 x 18.7
4	I	90'	2	2	150	343 x 20.9
5	I	85'	2	2	150	343 x 20.9
7	I	90'	2	2	250	399 x 24.2
8	I	85'	2	2	250	399 x 24.2
2'	I	85'	1	2	100	301 x 18.7
10	II	85'	2	2	100	301 x 18.7
13	II	85'	2	2	150	343 x 20.9
16	II	85'	2	2	250	399 x 24.2

Fig. S.1 Layout of High Rise Lock System for Group A Study Cases

2.3 New Locks

The new locks at the Pacific coast side would be located in the area already excavated for the Third Lock plan to the West of Cerro Aguadulce and Cerro Cocoli.

The new locks at the Atlantic coast side would be located in the existing excavated area running parallel to the existing Gatun Locks. The new locks have been designed for ship sizes of 100,000, 150,000 and 250,000 DWT in accordance with each study case as shown in Fig. S.1. For the High Rise Lock system, all locks would have 2 lifts, but a single lift system was primarily studied for the L-2' study case.

Gravity type lock structures have been generally adopted. The wall heights are about 50 meters maximum. As one example, Fig. S.2 shows the length and width of 250,000 DWT lock chambers, and the overall length. The size of the water supply culvert allows the filling or draining of lock water within 10 minutes for each lock chamber.

A single miter gate has been adopted for the new lock gates. Separate from the main gate, emergency gates and maintenance gates have also been proposed. For dimensions and number of gate leaves refer to the Summation Table for Lock Type Study Cases at the end of this Summary.

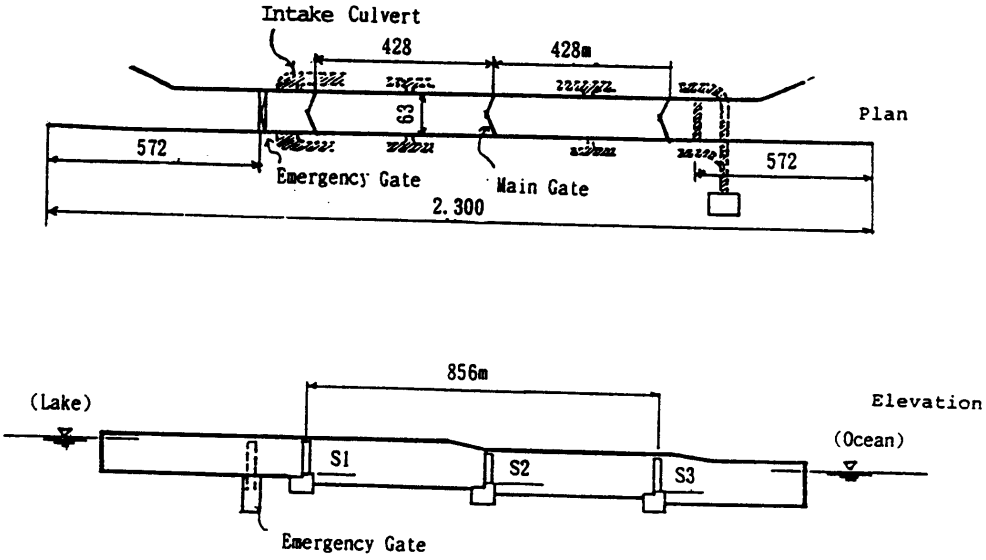


Fig. S.2 Lock Layout for 250,000 DWT Ships

2.4 Ancillary Facilities

(1) Anchorage Area

For the mooring of ships waiting for lock transit, anchorage and mooring areas are proposed above the new locks on the Pacific coast side. In Gatun Lake, no such anchorage area is required above the new locks on the Atlantic coast side because suitable areas are available in Gatun Lake.

(2) Surge Basin

The locks proposed at the Pacific coast side are directly connected by the open bypass channel to the existing canal, and surging may occur in the bypass channel as water pours from the bypass channel into the lock chambers.

To reduce the effects of surging, a surge basin is proposed in the area of the Rio Cocoli Valley. The surge basin utilizes natural terrain as much as possible. A closure dam is required at the south-east side of the basin.

(3) Recycling Pond

At the Pacific coast side, a recycling pond is proposed in the flat land on the northern part of San Juan Hill in order to hold discharged lockage water (mainly fresh water) as a source of supply for pumping operations during lock operation. The area of the pond is approximately 1.5 km^2. The effective water level would be +0.6 m - 1.6 m. A discharging channel for returning water from the recycling pond to the surge basin extends 800 meters. The width and depth of the channel have been chosen according to the number of pump stations required.

A similar recycling pond is proposed beside the approach channel on the Atlantic coast side.

(4) Pump Stations
(Recycling Pond to Surge Basin or Gatun Lake)

Approximate locations for pump stations have been proposed and the size of pump stations for each study case are shown in the Summation Table according to the number of transits.

2.5 Water Management

(1) Lockage Water

The sources of water for lock operation come from Madden Lake and Gatun Lake. The water volume of both lakes changes during the wet and dry seasons. Therefore, the available lockage water volume was calculated for each month according to the record of average discharge volume measured at several points over the last 50 years. Lockage water necessary for new lock systems are shown below in Fig. S.3. (The lockage water for existing canal is included.)

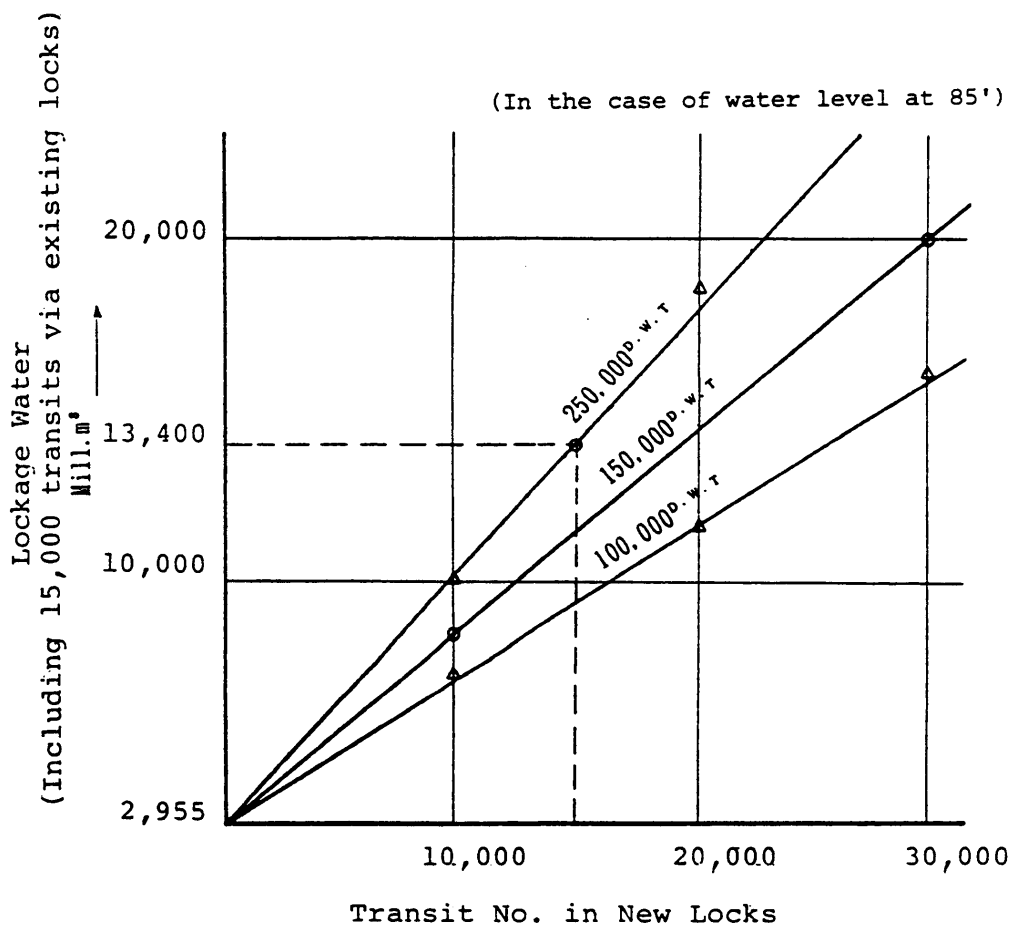


Fig. S.3 Lockage Water Volume by Transits
(Including allowance for 15,000 transits via existing locks)

For example:

a) When 15,000 ships with maximum ship size 250,000 DWT transit the new locks (85' water level) a year, the necessary lockage water volume is 13.4 billion m^3 (refer to Fig. S.3).

b) The total required lockage water for passing 10,000 ships of 100,000 DWT a year in the new locks (85') plus 15,000 transit per year in the existing locks is 6.83 billion m^3, comprising 3.88 billion m^3 for the new locks and 2.95 billion m^3 for the existing locks.

c) For 250,000 DWT, the water volume required is 9.92 billion m^3 for 10,000 transits in the new locks plus 15,000 transits in the existing canal locks (10,000 + 15,000 transits).

The water volume in Gatun Lake and Madden Lake is not sufficient for lockage water requirements. The necessary water volume for each study case, assuming transits of 10,000, 20,000 and 30,000 ships per year, are shown on the Comparative Summation Table for Lock Type Study Cases.

(2) New Dams to Increase Water Storage Capacity

To overcome the shortage of lockage water, Trinidad~~o~~ Dam and Ciri Dam have been proposed above Gatun Lake. Other dam sites were also considered but the two sites mentioned can most effectively provide the additional storage capacity given the limited catchment yield. These dams would reduce spillage losses at Gatun Dam but the overall catchment annual yield is not sufficient for the required volume of lockage water.

In the Summation Table, a solution to the shortage of water volume was studied by considering the increase in lockage water supply from the new dams.

(3) New Pump Stations for Solution of Water Shortage

Despite the added capacity of the possible new dams above Gatun Lake, the total annual supply of water is not sufficient in most cases to provide the required water volume for the lock systems proposed.

Therefore, the use of new pump stations to supply lockage water from a recycling pond was considered.

A pump station comprising two pumps, with an estimated capacity of 30 m^3/sec per pump, would have a total capacity of 60 m^3/sec. This total capacity becomes 1,829 million m^3 of additional available water supply per year. The Summation Table shows the necessary numbers of pump stations for each study case.

(4) Transit Capacity

For calculation of lockage water, 10,000, 20,000 and 30,000 transits per year are assumed in the new locks. Assuming also that the new locks have 2 lanes, the allowable relay time (time difference between successive ships passing the same point) between consecutive ships in the same lock would be as follows.

Transits/Year	Average Relay Time (min)
10,000	105
20,000	53
30,000	35

The actual relay time for 100,000-250,000 DWT ships would be at least 80 minutes considering the operation of locks and ship maneuvering. Hence, 13,000 transits would be the limit for 2 lane locks, and if more transits are required, then the number of lock lanes should be increased to 4 lanes or more.

Assuming that sufficient lanes of locks were available, the number of pump stations required for 10,000, 20,000 and 30,000 transits in the new locks, in addition to 15,000 transits in the existing locks, would be as shown in Table S.1.

Table S.1 No. of Pump Stations by Transits

Ship size (DWT)	Transits per year	No. of P.S's (with New Dams)	No. of P.S's (without New Dams)	Note
100,000	10,000	1-set	1-set	W.Level 85'
100,000	20,000	3-sets	4-sets	2-lift
100,000	30,000	5-sets	6-sets	locks
150,000	10,000	2-sets	2-sets	
150,000	20,000	4-sets	5-sets	
150,000	30,000	7-sets	7-sets	
250,000	10,000	2-sets	3-sets	
250,000	20,000	6-sets	7-sets	
250,000	30,000	10-sets	10-sets	

Note: P.S. = pumping station

3. Group B - Low Rise Lock Canal (W.L.=55'- 30')

In comparison to the High Rise Lock system, the feature of the Low Rise Lock System is the reduction of the water level in Gatun lake from 85' to 55' and 30'.

The location of the construction of new Low Rise Locks would be the same as for the High Rise Locks. The new locks are designed as a single lift. Ships from the Pacific side passing the new locks would follow the direction of the existing canal route after detouring from the Pedro Miguel Locks (demolished) and part of Miraflores Lake. An increase of water depth is required in the canal and in the lake waterway.

3.1 Layout for 55' Water Level

The layout for the 55' water level is shown in Fig. S.4. The following new facilities are required to reduce the water level to 55'.

(1) In order to keep the water level in other parts of Gatun Lake at the existing 85', barrier dams are required in Gatun Lake.

(2) Spillways/diversion channels are required to discharge major floods from the catchments retained by the barrier dams.

(3) At the existing Gatun Dam, spillway modification or reconstruction is required to meet the 55' water level.

(4) One of the lifts of the Gatun Locks would be demolished and it would also be necessary to demolish the Pedro Miguel Locks.

3.2 Layout for 30' Water Level

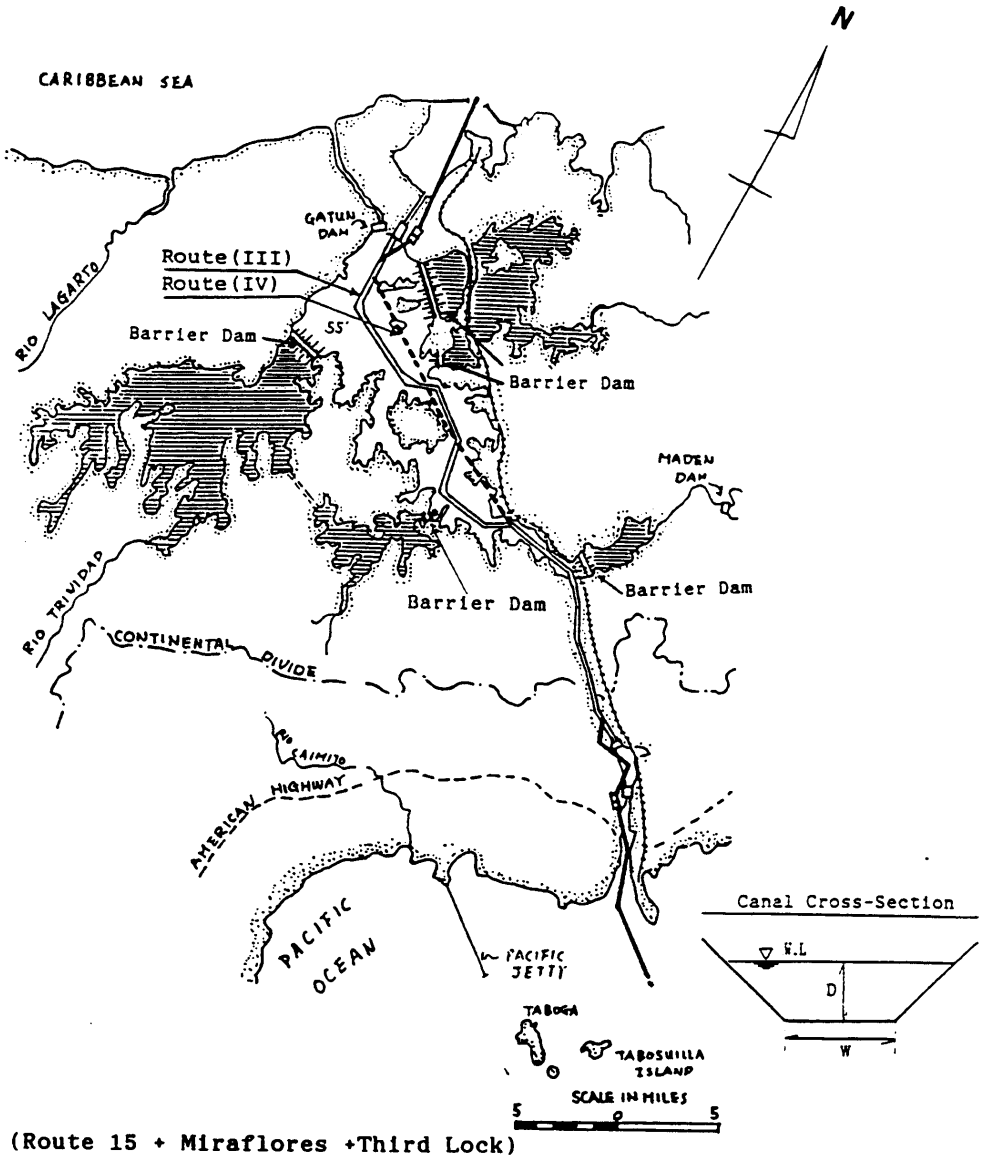
The layout for 30' water level is shown in Fig. S.5. In this case, the following points should be considered.

(1) Reconstruction, including some demolition, is required at the existing Miraflores Locks.

(2) Demolition of the Pedro Miguel Locks would be required.

(3) Ships passing the new Low Rise lock proceed along a new canal, partly along the Continental Divide after detouring away from Miraflores Lake and the Pedro Miguel Locks.

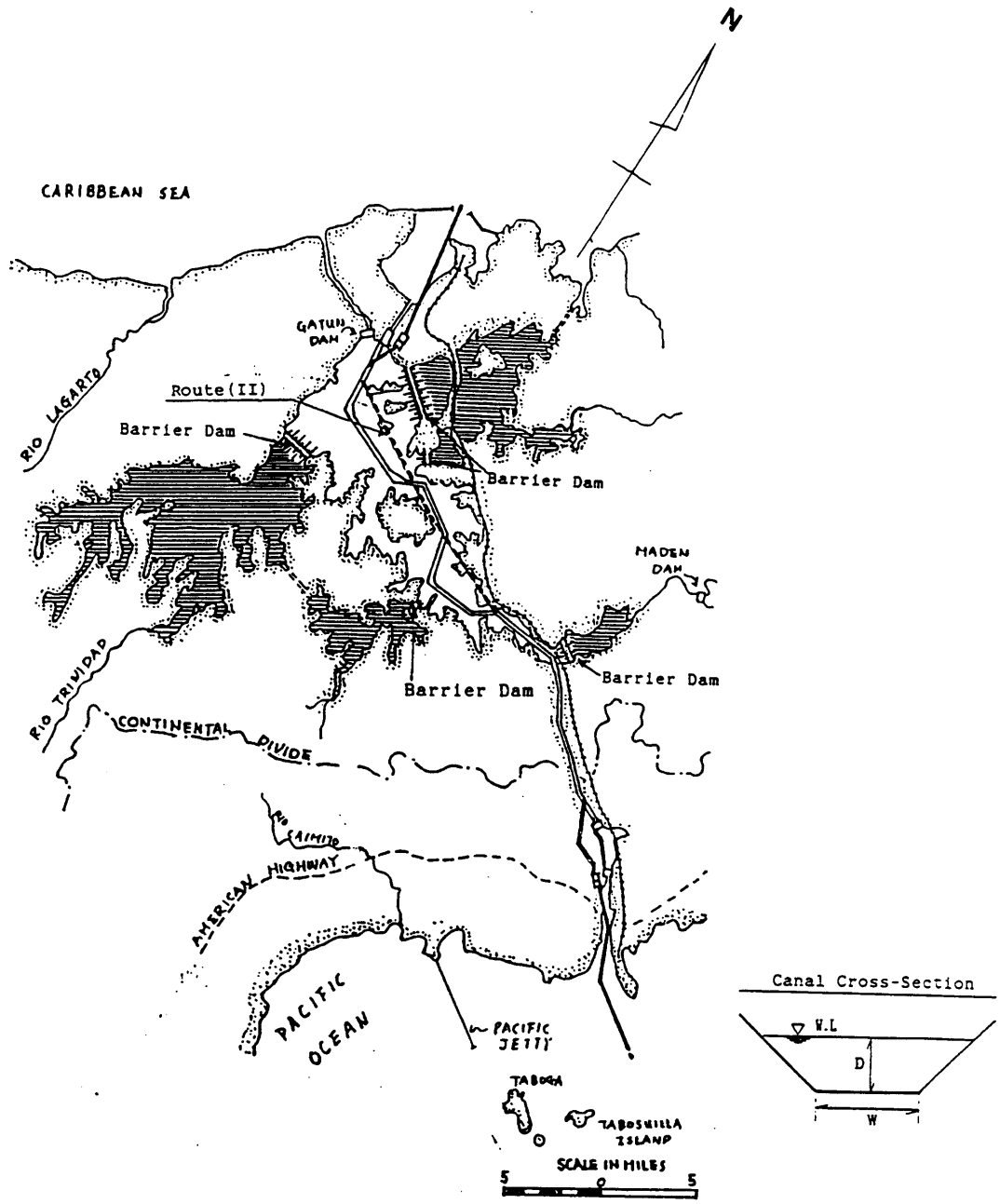
(4) Spillways/diversion channels are required to discharge major floods from the catchment retained by the barrier dams.



Note:
Route III (Route 15 + Miraflores +Third Lock)
Route IV (Route 15 + Gatun + Miraflores + Third Lock)

Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
L-3	III	55'	1	2	100	301 x 18.7
6	III	55'	1	2	150	301 x 20.9
9	III	55'	1	2	250	399 x 24.2
11	IV	55'	1	2	100	301 x 18.7
14	IV	55'	1	2	150	343 x 20.9
17	IV	55'	1	2	250	399 x 24.2

Fig. S.4 Layout of Low Rise Lock System for Group B Study Cases (55')



Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
L-12	II	30'	1	2	100	301 x 18.7
15	II	30'	1	2	150	343 x 20.9
18	II	30'	1	2	250	399 x 24.2

Fig. S.5 Layout of Low Rise Lock System for Group B Study Cases (30')

4. Group C - Sea-Level Canal (Route 10)

The Group C study cases follow Route 10 located 16 km west of and parallel to the existing canal as shown in Fig. S.6.

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 runs north-westerly through low ridges that become more open towards the coast. It enters the Atlantic at the town of Lagarto. 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.

A special feature of this group of study cases is the current stream in the new canal caused by tidal differences between the two ocean levels. For example, the tidal current in a sea level canal was estimated in "Isthmian Canal Studies-1947" (Annex 7, part IV) to be 4.5 knots. This velocity computation was supported by model tests at a scale of 1:100 conducted by the Panama Canal Company during the Isthmian Canal Studies. The results of the model test and the velocity computation were similar. The IOCS study also estimated tidal currents for various canal configurations and concluded that currents would exceed 3 knots for most tide cycles.

Therefore, some form of control of tidal currents should be provided and two methods have been considered. First, currents could be controlled by the construction of tidal gates (concrete structures with steel gates). In this report, various types of tidal gates are studied and a rolling gate of triangular section is recommended.

Another method of tide control was presented in the Vergara plan "El Canal Al Nivel" in 1982. The Vergara plan intended to provide tidal control and also safe anchorage and mooring of ships. The plan proposed the construction of large embankments of 20 km in length outside each canal entrance and completely enclosed with the exception of a small opening to allow for ship passage.

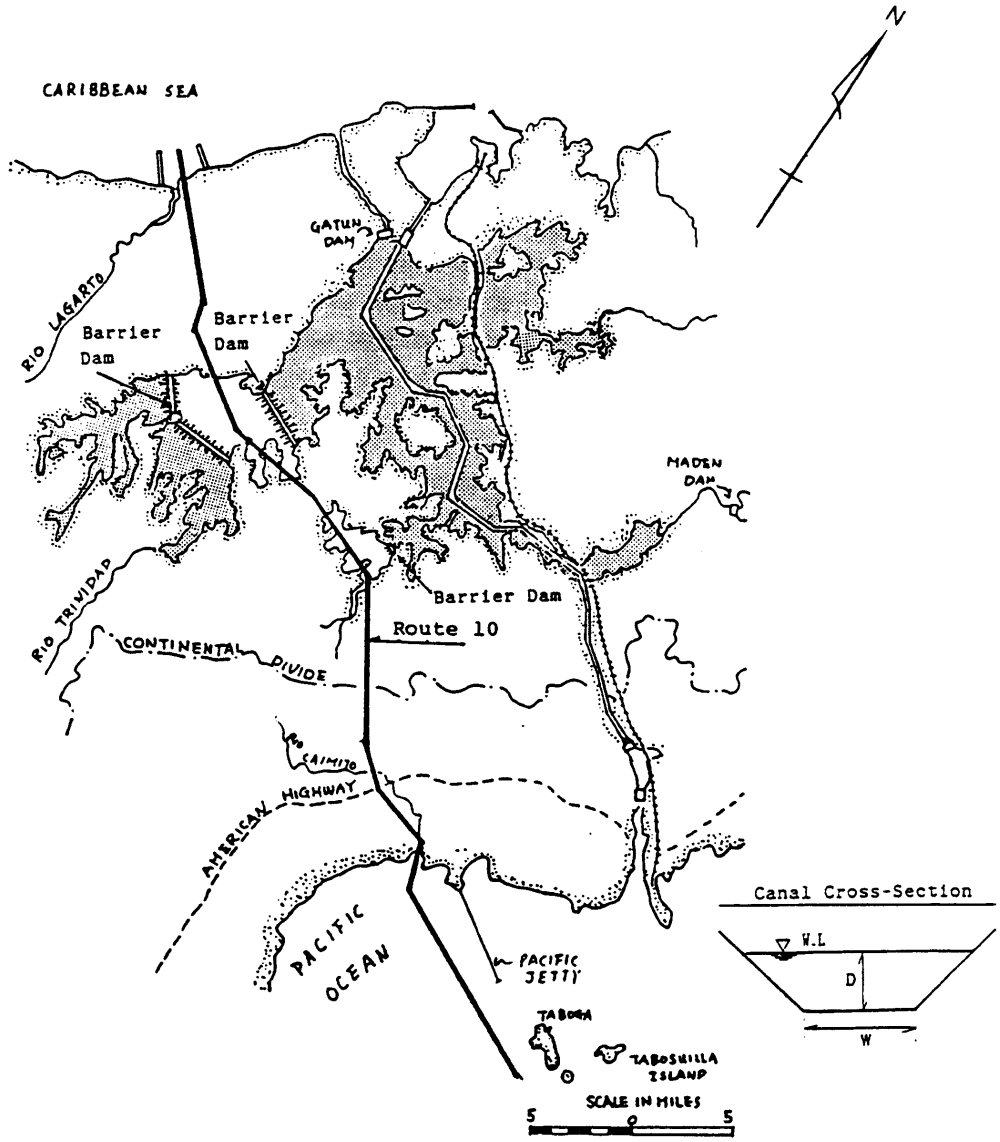
Facilities required for this sea level canal (Route 10) are as follows:

(1) Tidal gates and breakwaters are required at the Pacific Ocean side and Atlantic Ocean side except in the Vergara plan.

(2) Tidal basins are proposed according to the Vergara plan.

(3) Barrier dams and spillways are required to retain the water level of Gatun Lake from the canal route.

The layout of this study case is shown in Fig. S.6. This group of study cases is classified into 9 study cases: S-1 - 6, and S-13 - 15 in accordance with the conditions such as numbers of lanes and size of ships.

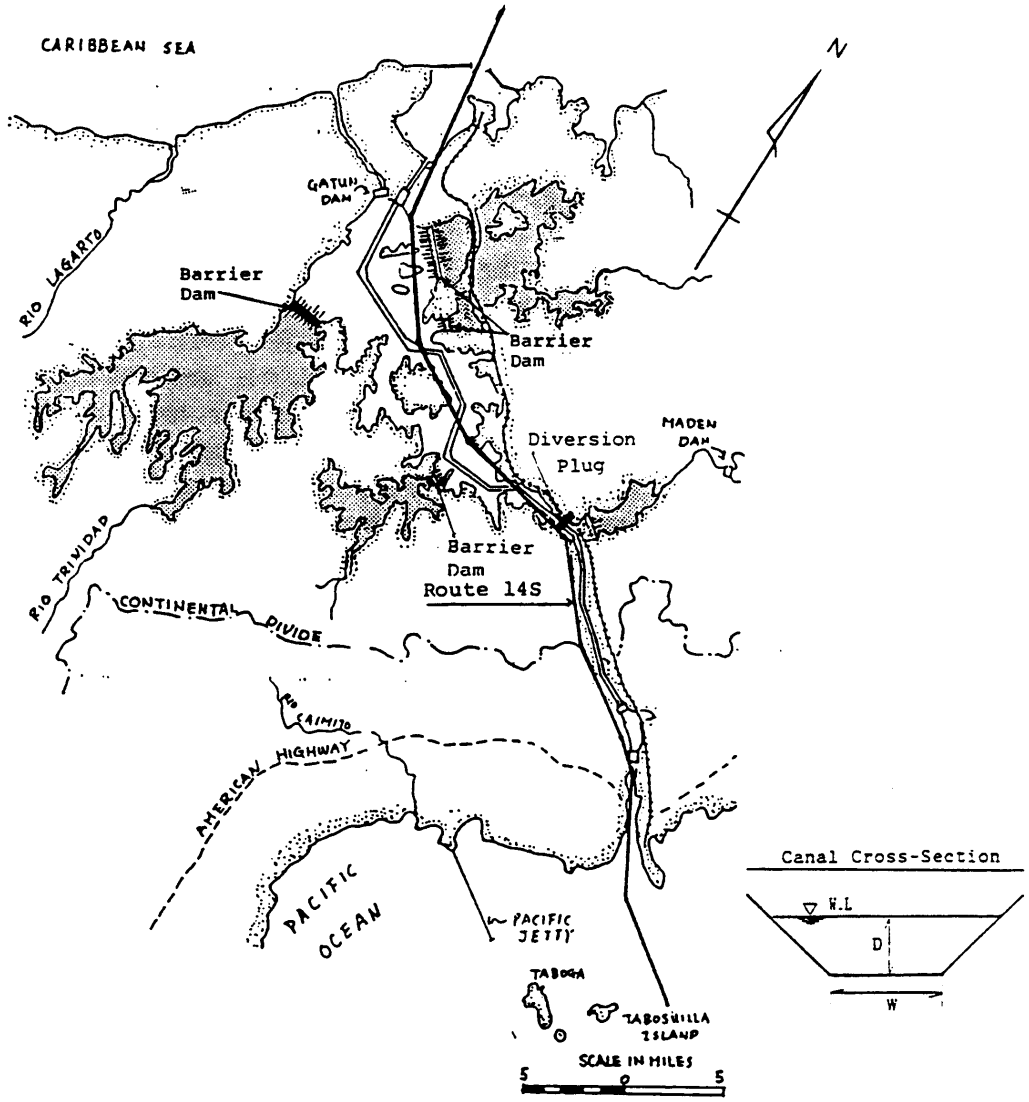


Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
S-1	10	0	-	1	150	147 x 20.9
2	10	0	-	2	150	343 x 20.9
3	10	0	-	1	250	171 x 24.2
4	10	0	-	2	250	399 x 24.2
5	10	0	-	1	300	183 x 25.3
6	10	0	-	2	300	424 x 25.3
13	10	0	-	50%-1	150	147 x 20.9
				50%-2		343 x 20.9
14	10	0	-	50%-1	250	171 x 24.2
				50%-2		399 x 24.2
15	10	0	-	50%-1	300	183 x 25.3
				50%-2		424 x 25.3

Fig. S.6 Layout of Sea Level Canal for Group C Study Cases (Route 10)

5. Group D - Sea-Level Canal (Route 14S)

5.1 The Route alignment of this group of study cases is shown in Fig. S.7. On the Pacific side, Route 14, coincides with approaches to the present lock canal until it reaches the Pacific Third Locks cut, where it follows a 12.9 km bypass through the divide. The route then generally follows the alignment of the existing canal northeast of Cerro Gordo and continues toward Gatun Lake, keeping southwest of the present canal until it reaches the Darien Peninsula. Turning slightly northward, it then passes Barro Colorado on the east, touching the end of Bohio Peninsula. The route then turns north across Gatun Lake and follows the present canal route to the Caribbean. The Pacific approach channel is about 20.9 km and the Atlantic approach is 12.9 km long.



Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
S-7	14S	0	-	1	150	147 x 20.9
8	14S	0	-	2	150	343 x 20.9
9	14S	0	-	1	250	171 x 24.2
10	14S	0	-	2	250	399 x 24.2
11	14S	0	-	1	300	183 x 25.3
12	14S	0	-	2	300	424 x 25.3
16	14S	0	-	50%-1	150	147 x 20.9
				50%-2		343 x 20.9
17	14S	0	-	50%-1	250	171 x 24.2
				50%-2		399 x 24.2
18	14S	0	-	50%-1	300	183 x 25.3
				50%-2		424 x 25.3

Fig. S.7 Layout of Sea Level Canal for Group D Study Cases (Route 14S)

6. Excavation Volume

Excavation volumes were calculated separately for the areas of sea, land and lake. Volumes include associated excavation volumes for locks, mooring areas, recycling ponds, etc.

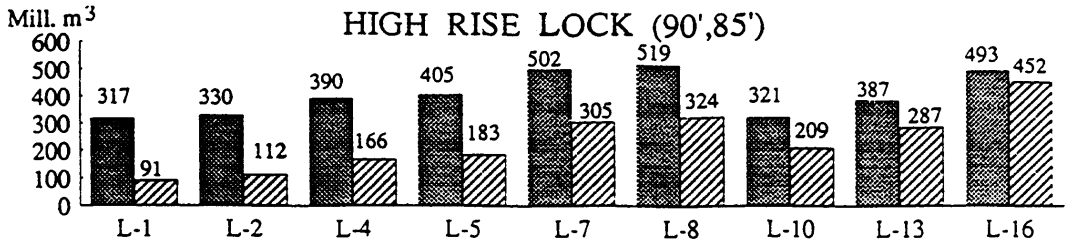
The volume of excavation in each area is classified into two categories, dry and dredging, and each category is further separated into seven sub-categories: Earth (common), Rock (weathered), Rock, Rock (underwater), Dredging (loose material), Dredging (clayey material) and Dredging (weathered softrock).

The total maximum and minimum dry and dredging excavation volumes for the Group A, B, C and D study cases are summarized in Table S.2.

Table S.2 Excavation Volume (Million m^3)

Group	Max. V Min. V	Case
A. High rise lock	945	L-16
	408	L-1
B. Low rise lock	1,510	L-18
	594	L-3
C. Sea level (R-10)	2,190	S-6
	937	S-1
D. Sea level (R-14S)	2,057	S-12
	899	S-7

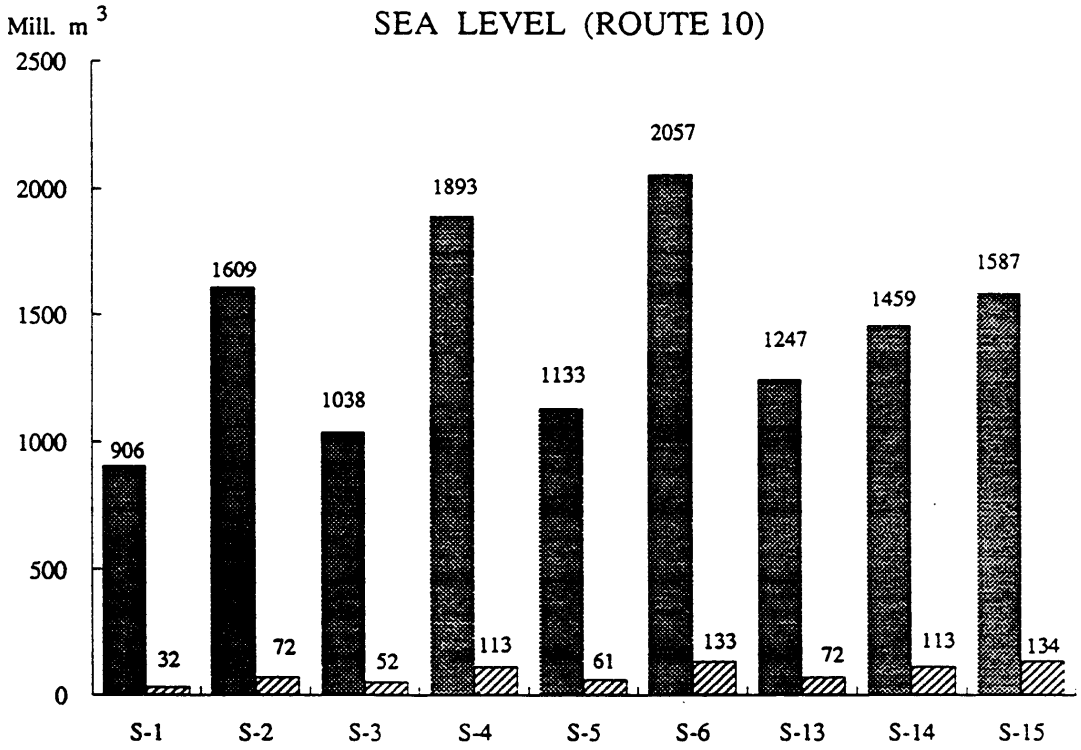
The excavation volumes for each study case are graphed in Figs. S.8 - S.11.



	L-1	L-2	L-4	L-5	L-7	L-8	L-10	L-13	L-16
W. Level	90'	85'	90'	85'	90'	85'	85'	85'	85'
Ship Size(1000DWT)	100	100	150	150	250	250	100	150	250
Lane No.	2	2	2	2	2	2	2	2	2
Lift No.	2	2	2	2	2	2	2	2	2

Dry Excavation Volume Dredging Excavation Volume

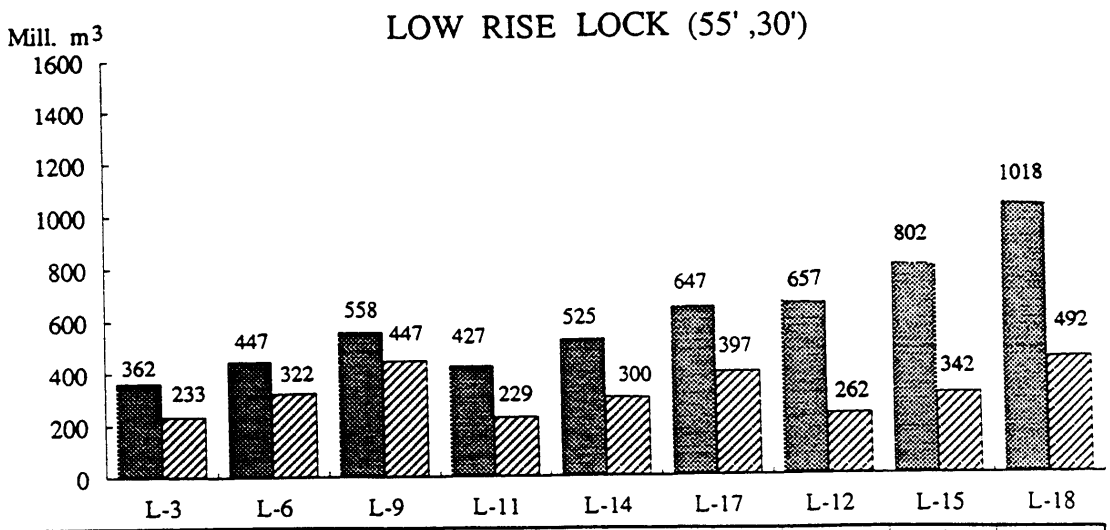
Fig. S.8 Excavation Volume (L1 - L16)



	S-1	S-2	S-3	S-4	S-5	S-6	S-13	S-14	S-15
W. Level	0'	0'	0'	0'	0'	0'	0'	0'	0'
Ship Size(1000DWT)	150	150	250	250	300	300	150	250	300
Lane No.	1	2	1	2	1	2	1, 2	1, 2	1, 2

Dry Excavation Volume Dredging Excavation Volume

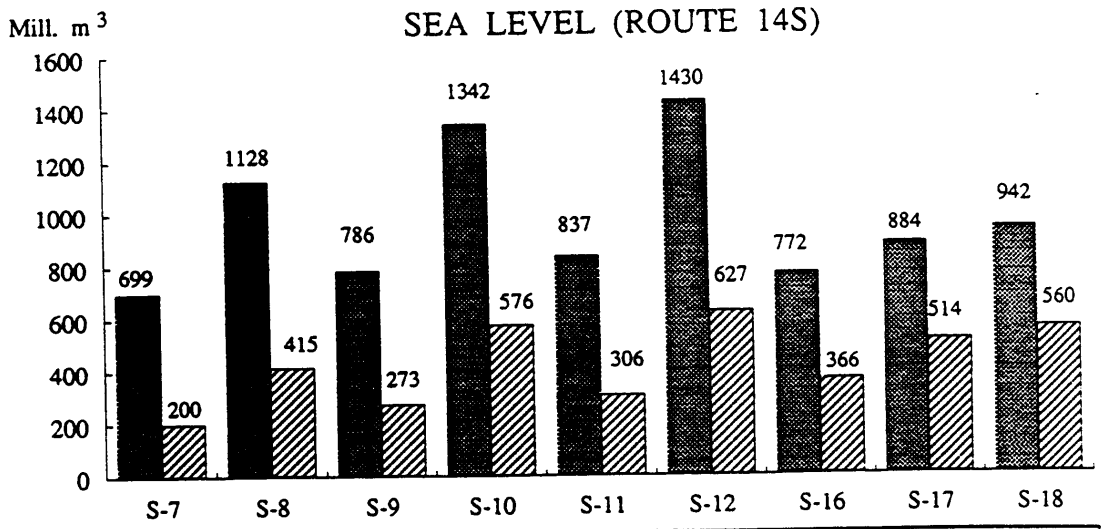
Fig. S.9 Excavation Volume (S1 - S15)



	L-3	L-6	L-9	L-11	L-14	L-17	L-12	L-15	L-18
W. Level	55'	55'	55'	55'	55'	55'	30'	30'	30'
Ship Size(1000DWT)	100	150	250	100	150	250	100	150	250
Lane No.	2	2	2	2	2	2	2	2	2
Lift No.	1	1	1	1	1	1	1	1	1

■ Dry Excavation Volume ▨ Dredging Excavation Volume

Fig. S.10 Excavation Volume (L3 - L18)



	S-7	S-8	S-9	S-10	S-11	S-12	S-16	S-17	S-18
W. Level	0'	0'	0'	0'	0'	0'	0'	0'	0'
Ship Size(1000DWT)	150	150	250	250	300	300	150	250	300
Lane No.	1	2	1	2	1	2	1, 2	1, 2	1, 2

■ Dry Excavation Volume ▨ Dredging Excavation Volume

Fig. S.11 Excavation Volume (S7 - S18)

7. Estimation of Operation and Maintenance Cost

Estimation of Operation and Maintenance costs are shown in APPENDIX 4.

8. Summation Tables

A. LOCK TYPE STUDY CASES COMPARATIVE SUMMATION TABLE(1)

I T E M S	Unit	L-1	L-2	L-2'	L-3	L-4	L-5	L-6	L-7	L-8	L-9	L-10	L-11	L-12	L-13	L-14	L-15	L-16	L-17	L-18
A - FEATURES OF CANAL ALTERNATIVES																				
(1) Design Ship	1000DWT	100	100	100	100	150	150	150	250	250	250	100	100	100	150	150	150	250	250	250
(2) Route	I~IV	I	I	I	III	I	I	III	I	I	III	II	IV	II	II	IV	II	II	IV	II
(3) Water level (El. ft.)	ft.	90	85	85	55	90	85	55	90	85	55	85	55	30	85	55	30	85	55	30
(4) Number of lifts	no.	2	2	1	1	2	2	1	2	2	1	2	1	1	2	1	1	2	1	1
(5) Number of lanes	no.	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
(6) Route length: a. Atlantic Approach	km	11.8	11.8	11.8	11.8	12.1	12.1	12.1	12.5	12.5	12.5	11.8	11.8	11.8	12.1	12.1	12.1	21.9	12.5	12.5
b. Channel	km	60.8	60.8	60.8	61.0	60.8	60.8	61.0	60.8	60.8	61.0	54.8	55.0	54.8	54.8	55.0	54.8	52.6	55.0	54.8
c. Pacific Approach	km	14.3	14.3	14.3	14.3	17.5	17.5	17.5	21.9	21.9	21.9	14.3	14.3	14.3	17.5	17.5	17.5	14.5	21.9	21.9
Total Route Length	km	86.9	86.9	86.9	87.1	90.4	90.4	90.6	95.2	95.2	95.4	80.9	81.1	80.9	84.4	84.6	84.4	89.0	89.4	89.2
(7) Channel cross-section (w x d)	m	301x18.7	301x18.7	301x18.7	301x18.7	343x20.9	343x20.9	343x20.9	399x24.2	399x24.2	399x24.2	301x18.7	301x18.7	301x18.7	343x20.9	343x20.9	343x20.9	399x24.2	399x24.2	399x24.2
B - WATER MANAGEMENT PLAN (3 CASES)																				
(1) Annual 15,000 transits in existing locks																				
a. Water volume required	bil.m3	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95
b. Available water capacity	bil.m3	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
(2) Case 1: 10,000 transits/year in new locks																				
a. Water volume required	bil.m3	4.09	3.87	7.74	5.01	5.35	5.06	6.55	7.36	6.96	9.01	3.87	5.01	2.70	5.06	6.55	3.53	6.96	9.01	4.85
b. Total water required ((1)a + (2)a)	bil.m3	7.04	6.82	10.69	7.96	8.30	8.01	9.50	10.31	9.91	11.96	6.82	7.96	5.65	8.01	9.50	6.48	9.91	11.96	7.80
c. Countermeasures to be taken																				
- Water pumping with new dam	bil.m3	1.30	1.05	4.90	2.47	2.57	2.29	4.01	4.54	4.04	6.47	1.05	2.47	1.55	2.29	4.01	0.99	4.04	6.47	2.31
- Water pumping without new dam	bil.m3	1.55	1.33	5.20	2.47	2.81	2.52	4.01	4.82	4.42	6.47	1.33	2.47	1.55	2.52	4.01	0.99	4.42	6.47	2.31
d. - Sets of pump stations (with new dam)	set	1	1	3	2	2	2	2	3	2	4	1	2	1	2	2	1	2	4	2
- Sets of pump stations (without new dam)	set	1	1	3	2	2	2	2	3	3	4	2	2	1	2	2	1	3	4	2
(3) Case 2: 20,000 transits/year in new locks																				
a. Water volume required	bil.m3	8.18	7.74	15.48	10.02	10.70	10.12	13.10	14.72	13.92	18.02	7.74	10.02	5.40	10.12	13.10	7.06	13.92	18.02	9.70
b. Total water required ((1)a + (3)a)	bil.m3	11.13	10.69	18.43	12.97	11.65	13.07	16.05	17.67	16.87	20.97	10.69	12.97	8.35	13.07	16.05	10.01	16.87	20.97	12.65
c. Countermeasures to be taken																				
- Water pumping with new dam	bil.m3	5.64	4.84	12.63	7.48	7.87	7.28	10.56	11.92	11.07	15.48	4.84	7.48	2.86	7.28	10.56	4.52	11.07	15.48	7.16
- Water pumping without new dam	bil.m3	5.35	5.20	12.94	7.48	8.16	7.58	10.56	12.18	11.38	15.48	5.20	7.48	2.86	7.58	10.56	4.52	11.38	15.48	7.16
d. - Sets of pump stations (with new dam)	set	3	3	7	4	5	4	6	7	6	9	3	4	2	4	6	3	6	9	4
- Sets of pump stations (without new dam)	set	4	3	8	4	5	5	6	7	7	9	3	4	2	5	6	3	7	9	5
(4) Case 3: 30,000 transits/year in new locks																				
a. Water volume required	bil.m3	12.27	11.61	23.22	15.03	16.05	15.18	19.65	22.08	20.88	27.03	11.61	15.03	8.10	15.18	19.65	10.59	20.88	27.03	14.55
b. Total water required ((1)a + (4)a)	bil.m3	15.22	14.56	26.17	17.98	19.00	18.13	22.60	25.03	23.83	29.98	14.56	17.98	11.05	18.13	22.60	13.54	23.83	29.98	17.50
c. Countermeasures to be taken																				
- Water pumping with new dam	bil.m3	9.47	8.69	20.34	12.49	13.26	12.37	17.11	19.28	18.07	24.49	8.69	12.49	5.55	12.37	17.11	8.05	18.07	24.49	12.01
- Water pumping without new dam	bil.m3	9.73	9.07	20.68	12.49	13.51	12.64	17.11	19.54	18.34	24.49	9.07	12.49	5.55	12.64	17.11	8.05	18.34	24.49	12.01
d. - Sets of pump stations (with new dam)	set	5	5	11	7	7	7	9	11	10	13	5	7	3	7	9	5	10	13	7
- Sets of pump stations (without new dam)	set	6	6	12	7	8	7	9	11	10	13	5	7	3	7	9	5	10	13	7
C - MAIN ELEMENTS OF THE STUDY CASES																				
(1) Lock																				
a. Lock chamber dimensions ((LxWxD)& No.)	note*1	(A)-2	(A)-2	(A)-1	(A)-1	(B)-2	(B)-2	(B)-1	(C)-2	(C)-2	(C)-1	(A)-2	(A)-1	(A)-1	(B)-2	(B)-1	(B)-1	(C)-2	(C)-1	(C)-1
b. Gates																				
- Max. lock gate dimensions (BxH)	m	47x36	47x35	47x48	47x39	54x37	54x37	54x41	63x41	63x40	63x44	47x35	47x39	47x32	54x37	54x41	54x34	63x40	63x44	63x37
- Lock gate total number (in pair)	no.	12	12	8	8	12	12	8	12	12	8	12	8	8	12	8	8	12	8	8
- Lock gates total weignt	1000 ton	32.7	31.8	27.9	21.4	43.2	41.9	27.9	61.9	59.9	39.2	31.8	21.4	16.9	41.9	27.9	21.6	59.9	39.2	29.4
- Main culvert number VALVES	no.	32	32	24	24	32	32	24	32	32	24	32	24	24	32	24	24	32	24	24
- Main culvert dimensions (BxH)	m	7x8	7x8	8x9	8x8	8x9	8x9	9x9	10x10	9x10	10x11	7x8	8x8	6x7	8x9	8x9	7x8	9x10	10x11	9x9
- Emergency gate number	no.	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
- Maintenance gate number	no.	1	1	1	2	1	1	2	2	2	2	1	2	2	1	2	2	2	2	2

Note*1: Lock dimensions: (A) 319x47x19, (B) 363x54x21, (C) 428x63x24

A. LOCK TYPE STUDY CASES COMPARATIVE SUMMATION TABLE(2)

ITEMS	Unit	L-1	L-2	L-2'	L-3	L-4	L-5	L-6	L-7	L-8	L-9	L-10	L-11	L-12	L-13	L-14	L-15	L-16	L-17	L-18
c. Mule towing system																				
- Size	L.M.S	M	M	M	M	L	L	L	L	L	L	M	M	M	L	L	L	L	L	L
- Number	no.	72	72	48	48	72	72	48	72	72	48	72	48	48	72	48	48	72	48	48
(2) Barrier Dams																				
a. Site A,B,C,D :Total Volume	mill.m3	0	0	20.3	20.3	0	0	20.3	0	0	20.3	0	20.3	20.3	0	20.3	20.3	0	20.3	20.3
(3) New Dams																				
a. Site Ciri and Trinidad:Total Volume	mill.m3	4	5.5	5.5	-	4	4	-	4	5.5	-	5.5	-	-	4	-	-	5.5	-	-
(4) Excavation																				
a. Dry excavation	mill.m3	317	330	330	362	390	405	447	502	519	558	321	427	657	387	525	802	493	647	1,018
b. Dredging	mill.m3	97	112	112	233	166	183	322	305	324	447	209	229	262	287	300	342	452	397	492
Total excavation volume	mill.m3	414	442	442	595	556	588	769	807	843	1,005	530	656	919	674	825	1,144	945	1,044	1,510
(5) Power Requirement																				
a. Lock operation total requirement	1000 kW	57.7	55.5	51.6	37.0	93.4	88.9	58.7	113	108.4	69.7	56.2	37.0	25.5	89.4	58.7	38.7	108.4	71.4	46.2
- Lock gate operation	1000 kW	32.3	31.5	27.6	21.4	42.6	40.9	27.7	62.2	60.4	38.7	32.2	21.4	17.1	41.4	27.7	21.7	60.4	40.4	29.2
- Mule operation	1000 kW	25.4	24.0	24.0	15.6	50.8	48.0	31.0	50.8	48.0	31.0	24.0	15.6	8.4	48.0	31.0	17.0	48.0	31.0	17.0
b. Pump stations total requirement																				
- Case 1: 10,000 transits (with dam)	1000 kW	18.4	18.4	55.2	36.8	36.8	18.4	36.8	55.2	36.8	73.6	18.4	36.8	18.4	36.8	36.8	18.4	36.8	73.6	36.8
- Case 2: 20,000 transits (with dam)	1000 kW	55.2	55.2	129.0	73.6	92.0	73.6	110.0	129.0	110.0	166.0	55.2	73.6	36.8	73.6	110.0	55.2	110.0	166.0	73.6
- Case 3: 30,000 transits (with dam)	1000 kW	92.0	92.0	202.0	129.0	129.0	129.0	166.0	202.4	184.0	239.0	92.0	129.0	55.2	129.0	166.0	92.0	184.0	239.0	129.0
c. Total power requirement																				
- Case 1 (Lock oper. + Case 1 pump sta.)	1000 kW	76	74	107	74	130	107	96	168	145	143	75	74	44	126	96	57	145	145	83
- Case 2 (Lock oper. + Case 2 pump sta.)	1000 kW	113	111	181	111	185	163	169	242	218	236	111	111	62	163	169	94	218	237	120
- Case 3 (Lock oper. + Case 3 pump sta.)	1000 kW	150	148	254	166	227	218	225	315	292	309	148	166	81	218	224	131	292	310	175
D - CONSTRUCTION COSTS																				
(1) Channel excavation																				
a. Dry excavation	mill.US$	1,055	1,683	1,683	2,053	1,955	2,042	2,528	2,494	2,589	3,154	1,645	2,402	3,622	1,955	2,944	4,495	2,465	3,632	5,580
b. Dredging	mill.US$	1,555	1,209	1,209	2,776	1,731	1,994	4,024	4,042	4,423	6,069	2,978	3,134	4,097	4,010	4,161	5,380	7,044	5,712	8,189
Total channel excavation	mill.US$	2,610	2,892	2,892	4,829	3,686	4,036	6,552	6,536	7,012	9,223	4,623	5,536	7,719	5,965	7,105	9,875	9,509	9,344	13,769
(2) Lock concrete structure	mill.US$	692	692	692	575	875	875	658	1,212	1,212	822	692	575	560	875	658	631	1,212	822	789
(3) Gate leaves and related items	mill.US$	1,265	1,239	1,159	1,065	1,668	1,632	1,393	2,556	2,496	1,951	1,239	1,065	936	1,632	1,393	1,208	2,496	1,951	1,657
(4) New dams	mill.US$	68	85	85	-	68	68	-	68	85	-	85	-	-	68	-	-	85	-	-
(5) Barrier dams	mill.US$	-	-	-	346	-	-	346	-	-	346	-	346	346	-	346	346	-	346	346
(6) Pumping stations (20,000 transits)	mill.US$	255	255	595	340	425	340	510	595	510	765	255	340	170	340	510	255	510	765	340
(7) Indirect Cost	mill.US$	896	940	982	1,259	1,189	1,226	1,627	1,868	1,924	2,211	1,217	1,372	1,370	1,535	1,716	2,084	2,324	2,230	2,817
(8) Culebra Cut Widening	mill.US$	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209
(9) Total Project Cost	mill.US$	5,577	6,103	6,405	8,414	7,911	8,177	11,086	12,835	13,239	15,318	8,111	9,234	11,401	10,415	11,728	14,399	16,136	15,458	19,718
(10) New bridges (for reference)	mill.US$	227	227	227	227	262	262	262	328	328	328	227	227	227	262	262	262	328	328	328
E - OPERATION AND MAINTENANCE COSTS																				
(1) Electrical power (energy)	mill.US$	40	40	64	40	64	58	58	86	77	85	40	40	22	58	58	33	77	85	42
(2) Manpower and other O&M costs	mill.US$	479	479	479	458	491	491	475	514	514	492	479	458	458	491	475	475	514	492	492
(3) Total O&M costs	mill.US$	519	519	543	498	555	549	533	600	591	577	519	498	480	549	533	508	591	577	534
F - CONSTRUCTION ASPECTS																				
(1) Comparative ease of construction	grade	B	B	B	B	B	B	B	B	B	B	A	A	C	A	A	C	A	A	C
(2) Technical soundness	grade	A	A	C	B	B	B	B	C	B	C	A	B	A	B	B	A	C	C	B
(3) Construction period	year	10	10	10	10	10	10	10	11	11	13	10	10	14	10	11	16	16	14	18
G - IMPACT AS REFLECTED IN COST ESTIMATES																				
(1) Impact on existing Panama Canal																				
a. Shutdown period during construction	month	0.5	0.5	0.5	2.0	0.5	0.5	2.0	0.5	0.5	2.0	0.5	2.0	2.0	0.5	2.0	2.0	0.5	2.0	2.0
b. Modification works to Panama Canal	grade	S	S	S	M	S	S	M	S	S	M	S	M	L	S	M	L	S	S	L
(2) Potential environmental impact																				
a. Gatun Lake salinity danger	grade	S	S	L	M	M	S	M	L	M	L	S	M	S	M	M	S	M	L	M
b. Placement of excavated materials	grade	S	S	S	S	S	S	M	M	M	M	S	M	M	M	M	L	M	L	L
(3) Socioeconomic impact																				
a. Relocation of residents	grade	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few	Few
b. Increase work opportunities	grade	M	M	M	M	M	M	L	L	L	L	M	L	L	L	L	L	L	L	L

Notes:

1) Comparative ease of construction.
A=Dredging works will be easy.
B=Dredging works will be difficult.
C=Dredging works will be very difficult.

2) Technical soundness (Especially water recycling).
A=Pumping volume will be small.
B=Pumping volume will be medium.
C=Pumping volume will be large.

3) IMPACT
S=To be small.
M=To be medium.
L=To be large.

4) The project costs for the lock canal are estimated based on a 35,000 transits/year case. (15,000 transits at existing lock and 20,000 transits at new locks.)

5) Refer to Appendix 4 for Operation and Maintenance costs.

6) Electrical power cost is calculated as follows.
Cost = Total Powerx365daysx24hrsx(a)x0.07US$
(where, (a):operating efficiency=60%, 1kw/hr=0.07US$)

B. SEA LEVEL CANALS COMPARATIVE SUMMATION TABLE(1)

ITEMS	unit	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16	S-17	S-18
A FEATURES OF ALTERNATIVES																			
(1) Design Ship	1000 DWT	150	150	250	250	300	300	150	150	250	250	300	300	150	250	300	150	250	300
(2) Route	10, 14S	10	10	10	10	10	10	14S	14S	14S	14S	14S	14S	10	10	10	14S	14S	14S
(3) Number of lane	No.	1	2	1	2	1	2	1	2	1	2	1	2	50%-1, 2	50%-1, 2	50%-1, 2	50%-1, 2	50%-1, 2	50%-1, 2
(4) Route Length; a. Atlantic Approach	km	3.5	3.5	3.85	3.85	3.9	3.9	12.1	12.1	12.5	12.5	12.6	12.6	3.5	3.85	3.9	12.1	12.5	12.6
b. Channel	km	57.0	57.0	57.0	57.0	57.0	57.0	53.0	53.0	53.0	53.0	53.0	53.0	57.0	57.0	57.0	53.0	53.0	53.0
c. Pacific Approach	km	25.7	25.7	27.7	27.7	28.7	28.7	17.5	17.5	21.9	21.9	23.2	23.2	25.7	27.7	28.7	17.5	21.9	23.2
Total Route Length	km	86.2	86.2	88.55	88.55	89.55	89.55	82.6	82.6	87.4	87.4	88.8	88.8	86.2	88.55	89.6	82.6	87.4	88.8
(5) Channel cross-section (Wxd)	m	147X21	343X21	171X24.5	399X24.5	183X25.5	427X25.5	147X27	147X27	171X30.3	171X30.3	183X25.5	427x25.5	147x21	171x24.5	183x25.5	147x21	171x24.5	183x25.5
B MAIN ELEMENTS OF THE STUDY CASES																			
(1) Tidal Gates Structure																			
a. Dimension	Note*1	A	A'	B	B'	C	C'	A	A'	B	B'	C	C'	A	B	C	A	B	C
b. Canal Partition Wall, length	km	-	26	-	26	-	27	-	27	-	27	-	27	-	-	-	-	-	-
(2) Tidal Gate																			
a. Tidal Gate dimension	m	147X27	147X27	171X30.3	171X30.3	183X31.4	183X31.4	147X27	147X27	171X30.3	171X30.3	183X31.4	183X31.4	147X27	171X30.3	183X31.4	147X27	171X30.3	183X31.4
b. Gate weight	ton	6,830	6,830	9,520	9,520	10,780	10,780	6,830	6,830	9,520	9,520	10,780	10,780	6,830	9,520	10,780	6,830	9,520	10,780
(3) Tidal Basin																			
a. Pacific: Basin area	Mill. m2	73	73	73	73	73	73	-	-	-	-	-	-	73	73	73	-	-	-
Embankment Volume	Mill. m3	18.5	18.5	18.5	18.5	18.5	18.5	-	-	-	-	-	-	18.5	18.5	18.5	-	-	-
b. Atlantic: Basin area	Mill. m2	62	62	62	62	62	62	-	-	-	-	-	-	62	62	62	-	-	-
Embankment Volume	Mill. m3	53.8	53.8	53.8	53.8	53.8	53.8	-	-	-	-	-	-	53.8	53.8	53.8	-	-	-
(4) Breakwater																			
a. Pacific : length	km	14.9	14.9	14.9	14.9	14.9	14.9	-	-	-	-	-	-	14.9	14.9	14.9	-	-	-
b. Atlantic: length	km	7.4	7.4	7.4	7.4	7.4	7.4	-	-	-	-	-	-	7.4	7.4	7.4	-	-	-
(5) Barrier Dams																			
a. Site A, B, C, D: Total Volume	Mill. m3	-	-	-	-	-	-	20.3	20.3	20.3	20.3	20.3	20.3	-	-	-	20.3	20.3	20.3
b. Site E, F, G : Total Volume	Mill. m3	10.7	10.7	10.7	10.7	10.7	10.7	-	-	-	-	-	-	10.7	10.7	10.7	-	-	-
(6) Flood Control																			
a. Diversion Culvert: Number	No.	2	2	2	2	2	2	-	-	-	-	-	-	2	2	2	-	-	-
b. Total length	km	18	18	18	18	18	18	-	-	-	-	-	-	18	18	18	-	-	-
(7) Excavation																			
a. Dry Excavation	Mill. m3	906	1,609	1,038	1,893	1,133	2,057	699	1,128	786	1,342	837	1,439	1,247	1,459	1,587	772	884	942
b. Dredging Excavation	Mill. m3	32	72	52	113	61	133	200	415	273	576	306	626	72	113	134	366	514	560
Total Excavation Volume	Mill. m3	938	1,681	1,090	2,006	1,194	2,190	899	1,543	1,059	1,918	1,143	2,065	1,319	1,572	1,721	1,138	1,398	1,502

Note*1: A = 147(B) X 27.0(H), 1LANE
A' = 147(B) X 27.0(H), 2LANES
B = 171(B) X 30.3(H), 1LANE
B' = 171(B) X 30.3(H), 2LANES
C = 183(B) X 31.4(H), 1LANE
C' = 183(B) X 31.4(H), 2LANES

B. SEA LEVEL CANALS COMPARATIVE SUMMATION TABLE (2)

ITEMS	unit	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16	S-17	S-18
A FEATURES OF ALTERNATIVES																			
(1) Design Ship	1000 DWT	150	150	250	250	300	300	150	150	250	250	300	30[illegible]	150	250	300	150	250	300
(2) Route	10, 14S	10	10	10	10	10	10	14S	14S	14S	14S	14S	14[illegible]	10	10	10	14S	14S	14S
(3) Number of lanes	No.	1	2	1	2	1	2	1	2	1	2	1	2	50%-1, 2	50%-1, 2	50%-1, 2	50%-1, 2	50%-1, 2	50%-1, 2
(4) Route Length; a. Atlantic Approach	km	3.5	3.5	3.85	3.85	3.9	3.9	12.1	12.1	12.5	12.5	12.6	12.[illegible]	3.5	3.85	3.9	12.1	12.5	12.6
b. Channel	km	57.0	57.0	57.0	57.0	57.0	57.0	53.0	53.0	53.0	53.0	53.0	53.[illegible]	57.0	57.0	57.0	53.0	53.0	53.0
c. Pacific Approach	km	25.7	25.7	27.7	27.7	28.7	28.7	17.5	17.5	21.9	21.9	23.2	23.[illegible]	25.7	27.7	28.7	17.5	21.9	23.2
Total Route Length	km	86.2	86.2	88.55	88.55	89.55	89.55	82.6	82.6	87.4	87.4	88.8	88.[illegible]	86.2	88.55	89.6	82.6	87.4	88.8
(5) Channel cross-section (Wxd)	m	147X21	343X21	171X24.5	399X24.5	183X25.5	427X25.5	147X27	147X27	171X30.3	171X30.3	183X25.5	427x25.[illegible]	147x21	171x24.5	183x25.5	147x21	171x24.5	183x25.5
C CONSTRUCTION COST																			
(1) Channel Excavation																			
a. Dry Excavation	Mill.US$	4,917	8,247	5,190	9,072	5,947	10,665	4,438	6,957	4,946	8,234	5,251	8,817	6,600	7,269	8,193	4,844	5,507	5,852
b. Dredging	Mill.US$	179	400	311	657	375	830	8,582	17,956	11,960	25,539	13,463	27,89[illegible]	400	657	830	15,544	22,447	24,546
Total Channel Excavation	Mill.US$	5,096	8,647	5,501	9,729	6,322	11,495	13,020	24,913	16,906	33,773	18,714	36,71[illegible]	7,000	7,926	9,023	20,388	27,954	30,398
(2) Tidal Gate Structure	Mill.US$	216	257	254	302	292	348	216	257	254	302	292	34[illegible]	216	254	292	216	254	292
(3) Canal Partition Wall	Mill.US$	-	556	-	650	-	743	-	578	-	675	-	77[illegible]	-	-	-	-	-	-
(4) Tidal Gate	Mill.US$	207	240	290	335	328	379	208	240	290	335	328	37[illegible]	208	290	328	208	290	328
(5) Breakwater	Mill.US$	45	45	45	45	45	45	-	-	-	-	-	-	45	45	45	-	-	-
(6) Barrier Dam	Mill.US$	182	182	182	182	182	182	346	346	346	346	346	34[illegible]	182	182	182	346	346	346
(7) Flood Control System	Mill.US$	13	13	13	13	13	13	-	-	-	-	-	-	13	13	13	-	-	-
(8) Indirect Costs	Mill.US$	1,044	1,713	1,128	1,923	1,271	2,235	2,320	4,327	2,863	5,783	3,263	6,28[illegible]	1,348	1,516	1,703	3,499	4,729	5,132
(9) Total Project Costs	Mill.US$	6,803	11,653	7,413	13,179	8,453	15,440	16,110	30,661	20,659	41,214	22,943	44,84[illegible]	9,012	10,226	11,586	24,657	33,573	36,496
(10) New bridges (for reference)	Mill.US$	145	262	153	328	167	354	145	262	153	328	167	354	262	328	354	262	328	354
D OPERATION AND MAINTENANCE COST																			
(1) Man Power and Others O&M Cost	Mill.US$	594	594	607	607	607	607	353	353	366	366	366	36[illegible]	594	594	607	366	366	366
E Construction Aspect																			
(1) Comparative Ease of Construction	Grade	A	A	A	A	A	A	B	B	B	B	B	B	A	A	A	B	B	B
(2) Technical Soundness	Grade	A	A	A	A	A	A	B	B	B	B	B	B	A	A	A	B	B	B
(3) Construction Period	Year	11	11	12	17	14	19	10	13	10	15	14	1[illegible]	15	16	17	13	12	14
F IMPACT AS REFLECTED IN COST ESTIMATES																			
(1) Impact on Existing Panama Canal																			
a. Shutdown Period During Construction	Month	-	-	-	-	-	-	6	6	6	6	6	6	-	-	-	6	6	6
b. Modification Works to Panama Canal	Grade	-	-	-	-	-	-	L	L	L	L	L	L	-	-	-	L	L	L
(2) Potential Enviromental Impact																			
a. Gatun Lake Salinity Danger	Grade	S	S	S	S	S	S	L	L	L	L	L	L	S	S	S	L	L	L
b. Placement of Excavated Materials	Grade	M	L	M	L	M	L	S	M	S	M	S	M	L	L	L	S	S	M
(3) Socioeconomic Impact																			
a. Relocation of Residents	Grade	L	L	L	L	L	L	S	S	S	S	S	S	L	L	L	S	S	S
b. Increase Works Opportunities	Grade	M	M	M	M	M	M	M	L	M	L	M	L	M	M	M	M	L	L

Notes:

1) Comparative ease of construction.
   A=Excavation works will be easy.
   B=Excavation works will be difficult.

2) IMPACT
   S=To be small.
   M=To be medium.
   L=To be large.

9. Members of the Study Team for Phase 1 Study

The members of Study Team are as follows:

Assignment	Name	Organisation
Project Manager	Dr. Akira Ishido	Yachiyo Engineering Co., Ltd.
Structural Engineer	Mr. Shuji Sekiguchi	Yachiyo Engineering Co., Ltd.
Geologist	Mr. Nobuhiko Uchiseto	Yachiyo Engineering Co., Ltd.
Geotechnical Engineer	Mr. Murao Toyama	Yachiyo Engineering Co., Ltd.
Civil/Hydraulics Engineer	Mr. Toshinobu Nakano	Sanyu Consultants Inc.
Mechanical Engineer	Mr. Hiroshi Terada	Mitsubishi Heavy Industries Co., Ltd.
Waterways Specialist	Mr. John Read	G. Maunsell & Partners
Port/Harbor Engineer	Mr. Takahisa Sogabe	Yachiyo Engineering Co., Ltd.
Railroad Engineer	Dr. Hideo Yokota	Yachiyo Engineering Co., Ltd.
Highway Specialist	Mr. Toshihiro Hotta	Yachiyo Engineering Co., Ltd.
Pipeline Engineer	Mr. Toyoichi Takeda	Japan Oil Engineering Co., Ltd.
Design/Quantities Engineer	Mr. Masaaki Naito	Seiwa Consultants Co., Ltd.
Cost Engineer (1)	Mr. Jun Iwasawa	Seiwa Consultants Co., Ltd.
Cost Engineer (2)	Mr. Koichi Nagayoshi	Yachiyo Engineering Co., Ltd.
System Engineer	Mr. Mahmoud-S. Riad	Yachiyo Engineering Co., Ltd.
Working members in Panama		
Port/Harbor Engineer	Mr. Satoru Nishino	Yachiyo Engineering Co., Ltd.
Structural Engineer	Mr. Masashi Bessho	Yachiyo Engineering Co., Ltd.

CHAPTER 1 - GENERAL

1.1 Description of Existing Canal

The existing situation of the Panama Canal route, facilities concerned, lockage water usage and traffic situation are understood as follows.

1.1.1 Route

The Panama Canal is an 81 km long water link connecting the Atlantic and Pacific Oceans. The lock canal consists of short sea-level sections at either end and a long elevated intermediate section including Gatun Lake. The elevated section is separated from the end sections by twin locks 33.5m wide, 304.8m long, and providing 12.5m of water over lock sill under normal conditions. Gatun Locks at the Atlantic end have three lifts from sea level to the Gatun Lake level which is regulated between 25 and 26.5m above Precise Level Datum (PLD). The Pacific end of the Canal has two sets of locks: the Miraflores Locks which raise ships in two lifts from sea level to Miraflores Lake at an elevation of about 16.5m, and the Pedro Miguel Locks which raise vessels in one lift from Miraflores Lake to the Gatun Lake level. All locks provide two parallel lanes which can accommodate traffic in either direction independently. The elevated intermediate section between Gatun and Pedro Miguel Locks is 51.5km long. The reach from Gatun to Gamboa through Gatun Lake is 38.6km long and has channel widths varying from 152.4 to 304.8m. The 12.9km Culebra Cut reach of the Canal through the Continental Divide (Gamboa to Pedro Miguel Locks) has a 152.4m width.

1.1.2 Dams and Lakes

Gatun Dam is an earth dam which forms Gatun Lake, with an area of about 430 km2 (165 sq. miles). The lake is an integral part of the waterway, as well as the principal source of water supply for canal operations. Pedro Miguel Locks and Dam, which also retain Gatun Lake, consist of the locks and short earth embankments on either end. The waterway between Pedro Miguel Locks and Miraflores Locks passes through Miraflores Lake. Miraflores Dam is an earth structure west of Miraflores Locks, and controls

the level of Miraflores Lake. Madden Dam, a concrete gravity dam across the Chagres River and upstream from Gatun Lake, forms Madden Lake which stores additional water for dry season lockages and controls floods in the upper Chagres River. A hydroelectric generating station (197 and 87 GIGA WATT-HOUR at Madden and Gatun respectively in 1990) at the dam is a source of power for the historic Canal Area.

1.1.3 Water Supply

The availability of water supply for the operation of the Panama Canal locks has become a subject of concern in recent years, and it is considered an important determining factor in the suitability of the various improvement alternatives. The existing water supply as described in the IOCS reports is summarized hereafter. In the last section recent data taken from the Panama Canal Commission 1989 Annual Report is introduced in order to form a comparison between the present water supply conditions and those prevailing in the late 1960's at the time of the IOCS study.

(1) Tributary Drainage

The water supply for the operation of the canal is provided by the 3,339 km2 (1,289 sq.miles) drainage area of Gatun Lake. This man-made lake was created in 1912 with the construction of Gatun Dam. The need for additional water supply and flood storage necessitated the construction of Madden Dam in the early 1930's, with a tributary drainage of 1,018 km2 (393 sq. miles). All water discharged from Madden Dam flows into Gatun Lake. Hydroelectric power is generated at both Madden and Gatun Dams. The main rivers contributing to the water supply of Gatun Lake are the Chagres, Pequeni, Boqueron, and Gatun on the east side of the canal, and the Ciri, Trinidad, and Cano Quebrado on the west side.

(2) Rainfall

On the basis of hydro-meteorological records, the climate of Panama can be categorized into two seasons. January through April is usually considered as the dry season, and May through December as the

wet season. About 90% of the total annual rainfall occurs during the wet season. The annual average rainfall in the Panama Canal Watershed amounts to approximately 2,500 mm. The rainfall isohyetals are presented in Fig. 2.1.1.

(3) Watershed Yield

The study identified the average annual yield for 51 years recorded by the Instituto De Recursos Hidraulicos Y Electrification, PANAMA (1933-1983) is about 6.6 billion m3. A frequency analysis of the records at that time indicated that a maximum yield of 10.7 billion m3, or a minimum yield of 3.7 billion m3, would be equaled or exceeded once per 100 years. Annual evaporation amounted to approximately 673 million m3. The net average annual yield from the watershed was 5.9 billion m3.

(4) Storage

The storage available in Gatun Lake to supplement the runoff during dry periods was about 659 million m3, between elevations 24.6m and 26.1m. Madden Lake provided an additional volume of 539 million m3 from elevation 61m and 76.2m, bringing the maximum usable storage to 1.2 billion m3.

(5) Water Use

The figures of total yield and percentage of water use vary according to the time and reports. The IOCS report (1970) calculated Gatun Lake water yield as 5.8 billion m3 and the percentage of water utilization was as follows: lockage water 31%, municipal 1%, power 35%, evaporation loss 10% and spillage 23%. According to the PCC annual report (1989) net yield of Gatun Lake was 4.8 billion m3, a decrease of 0.5 billion m3 from the previous year. In 1989 water use percentages were as follows: lockage water 51%, municipal 5%, power 25%, evaporation loss 13% and spillage 6%.

In this study, total yield was found to be (Gatun and Madden) 6.6 billion m3. Taking into account the increased municipal and power water requirement,

water use percentages examined are as follows: lock age 45%, municipal 4%, evaporation loss 10 % and power plus spillage 41%. Assuming 0.197 million m^3 per lockage, 15,000 transits can be supported with the present yield.

Note: 6.6 billion m^3 is calculated as a mean water yield from the data for 50 years which are procured from E.E.R.E.

1.1.4 Traffic

The Panama Canal Commission annual statistics show that during the past ten years the number of commercial transits declined by 20% from a peak of 14,000 in 1982, to a lower value in 1984. Some reports attribute this drop to the opening of the Panamanian pipeline. Although the number of transits annually increased from 1984, this trend was reversed in 1989. Details are shown in Table 1.1.1.

Table 1.1.1 Panama Canal Traffic

Year	Commercial Transits	Tonnage Long Tons (Mill)	Commercial Tolls (Mill. $)
1980	13,507	167.2	291.8
1981	13,884	171.2	301.8
1982	14,009	185.5	323.9
1983	11,707	145.6	286.0
1984	11,230	140.5	286.7
1985	11,515	138.6	298.5
1986	11,925	139.9	321.0
1987	12,230	148.7	328.4
1988	12,234	156.5	337.9
1989	11,989	151.6	327.9

Source : the P.C.C. Report

1.1.5 Operation and Maintenance

(1) Operations

The Panama Canal is operated by the Panama Canal Commission (PCC), an agency of the United States Government. The PCC, established under the Panama Canal Treaty of 1977, is charged with the management, operation, and maintenance of the Canal. Under the terms of the Treaty, PCC will perform these functions until the last calendar day of the year 1999 when the Canal shall be turned over to the Government of the Republic of Panama.

The operation of the Canal is conducted on a self-financing basis. The PCC is expected to recover through tolls and other revenues all costs of operating and maintaining the waterway. At the end of the fiscal year 1989, the PCC had a total staff of 8,577 employees, of which 7,584 employees were Panamanian nationals. The total payroll for that year was $200.5 million.

The daily transits by oceangoing ships averaged 33.1 per day during fiscal year 1989. Average time to complete the Canal crossing decreased from 21.9 hours in fiscal year 1988 to 17.4 hours in fiscal year 1989. In terms of ship dimensions; ships of 183m length and more were 33.8% of total oceangoing transits, those of 24.5m beam and more were 44.7%, and ships transiting at more than 11m draft were approximately 12%.

(2) Maintenance and Improvements

The Engineering and Construction Bureau of the PCC is responsible for the overall physical maintenance and improvement works. Dredging works are done annually with the dual purposes of maintenance and improvement. In the fiscal year 1989 a total of 2.56 million m3 of dredging work was accomplished, representing the largest work volume undertaken in any one year since the beginning of this decade. Volumes of dredging works during the past few years are shown below:

1980:	1.42 million m3
1981:	1.28 million m3
1982:	1.27 million m3
1983:	1.83 million m3
1984:	2.32 million m3
1985:	1.02 million m3
1986:	0.58 million m3

Canal facilities such as locks, dams and spillways, and floating equipment are regularly maintained and improved upon. In fiscal year 1989 the total operating expenses were US$443,119,486; and the amount spent on maintenance and engineering works was US$58,511,706. About 13.2% of total operating expenses.

1.1.6 Panama Canal Constraints

(1) General

Several factors limit the number and size of ships which can transit the waterway under the existing system. First, the dimensions of the locks and channel determine the maximum size ship that can use the Canal. With normal Gatun Lake regulation levels, vessels up to an average size of 65,000 DWT can transit. Second, the optimum rate at which vessels can navigate the locks restricts the number of ships that can transit in a given period of time. At present, approximately 34 ships can be accommodated daily (Transisthmian Alternatives for Increasing the Throughout Across Panama: David F. Bastian). Also, the natural supply of water available to operate the locks may restrict the number of transits possible during dry years as well as permissible draft. The decline in the water supply as a factor, was previously mentioned.

(2) Size Limitations

Criteria for size, width, length, and draft limitations are established by the Panama Canal Commission. The development of improved procedures through the years has enabled the criteria to be progressively modified to include larger ships with greater draft. However, the physical dimensions of

the locks and channel place an upper limit on the size of ships that can transit.

The width of the existing locks is 33.5m. the PCC regulations provide that 32.3m is the widest beam of commercial ships acceptable for regular transit. A report prepared in 1990 (Transisthmian Alternatives for Increasing the Throughput Across Panama : David F. Bastian) showed that an analysis of the annual reports of the PCC from 1983 to 1988 revealed that the percentage of ships whose beams equaled or exceeded 30.5m had increased from 20 to 23 percent.
The usable lock chamber length is 305m, thereby restricting transit to ships of lesser lengths.
The allowable draft of ships using the canal depends upon Gatun and Miraflores Lakes' elevations. The lower lock sill at the south end of Pedro Miguel Locks (elevation of 3.96m) provides a depth of water of 12.5m with Miraflores Lake at its minimum elevation of 16.4m. This is a more restrictive condition than that imposed by the upper sills at Gatun and Pedro Miguel Locks. These sills, at an elevation of 11.4m, provide a depth of 13.6m with Gatun Lake at the minimum regulation stage of 25m. The maximum draft allowable for transit is 12m in tropical fresh water.

(3) Transit Time

The PCC documents define the Canal water time as the sum of queuing and transit time, and show that it increased annually from 20.1 hours in fiscal 1983 to 24 hours in fiscal 1987.

1.2 FA/FR Study

By exchange of notes on September 1982, the Governments of the Republic of Panama and the United States of America agreed to establish the Preparatory Committee for the study of alternatives to the Panama Canal, including a sea-level canal. In September 1985, the Government of Japan was invited by the signatories to participate in the Commission for the Study of Alternatives to the Panama Canal. The Commission consists of commissioners from each of the member nations (Panama, the United States, and Japan) and a Secretariat composed of technical staff from the member nations.

After a selection process, the Commission chose a consortium of consultant firms representing the three countries (SINBOL) to carry out a Feasibility Analysis/Final Report (FA/FR) Study. The objectives of the FA/FR Study as set forth by the Study Commission were as follows:

- to identify potential alternatives to the Panama Canal in the Republic of Panama:

- to study these alternatives in accordance with the Final Report of the Preparatory Committee for the study, prepared in June 1985, in order to develop the information necessary to evaluate the feasibility of each alternative;

- to select the best alternative and study it in detail;

- and then to develop conceptual plans for said alternative for the consideration of the member governments of the Study Commission.

The FA/FR Study produced a Detailed Plan of the Study (DPS) which included an overall work flow plan (Fig. 1.2.1) identifying the various study components. The work flow plan also identified and described a number of Component Studies to be carried out by other consultants and prepared terms of reference for each. The component studies included the Engineering and Cost Estimates Study, identified in Fig. 1.2.1 as work items B.2.1, B.2.2, B.3.2 and B.3.3. Proposals to carry out this study were called for and following the selection

procedure, the Component Study Contractor for Engineering and Cost Estimates were appointed.

The Engineering and Cost Estimates Study was divided into two main phases. Phase 1 relates to prescreening and corresponds to work items B.2.1 and B.2.2 in Fig. 1.2.1. In this phase a broad range of study cases are being collated and developed to comparable detail so that the engineering feasibility and cost of each can be assessed. The thirty-seven study cases were developed by the Secretariat as described in Section 1.3 below.

The results of Phase 1 will be reviewed by the Commission and alternatives will be chosen for further study to be carried out in Phase 2, corresponding to work items B.3.2 and B.3.3 of Fig. 1.2.1. In Phase 2 the selected alternatives will be developed and costed in further data so that the Commission will have sufficient engineering data available for a cost-benefit comparison to be made.

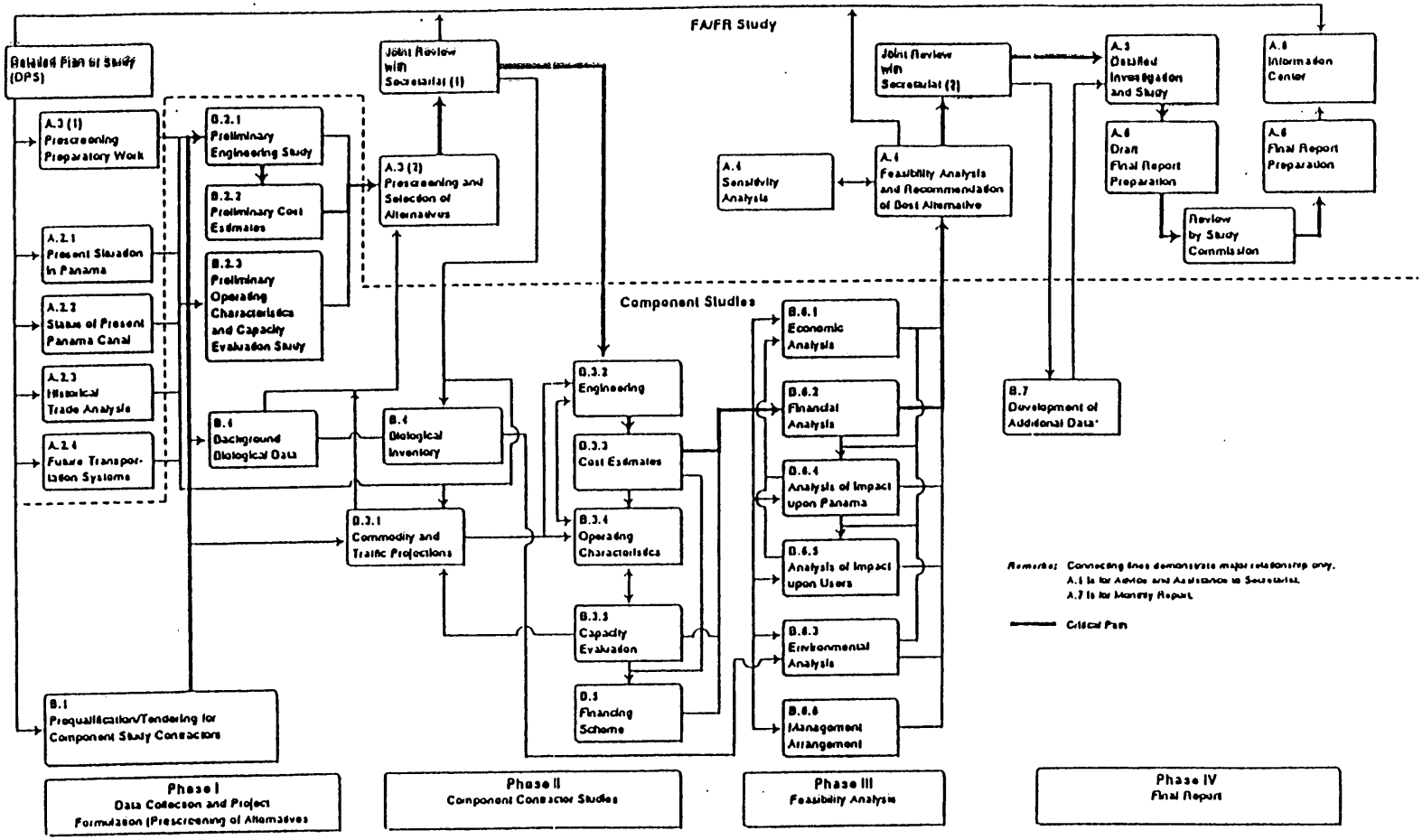


Fig. 1.2.1 Overall Work Plan Flow

1.3 Review of Historical Alternatives

1.3.1 Study Cases and Complementary Systems

Following the appointment by the Commission and subsequent commencement of the FA/FR, Study the following alternatives previously developed were reviewed by the Secretariat in order to categorize the various concepts for easier comparison:

A. Improvements to the Existing Canal
   (1) Culebra Cut Widening
   (2) Non-lock Improvements
   (3) Third Locks Plan
   (4) Terminal Lake plan
   (5) Deep Draft Lock Plan
   (6) Lopez-Moreno Plan (Panamanian Alternative)

B. Sea-Level Canal Alternatives

   (7) Route 10 of the IOCS Study
   (8) Route 14S of the IOCS Study
   (9) Vergara Plan
   (10) Nagano Plan

C. Non-Canal Complementary Transportation Systems

   (11) Oil Pipeline
   (12) Landbridge Systems
   (13) Centerport Plan

By reviewing the details of the existing alternatives listed above, the Commission prepared a list of cases for study in Phase 1 which encompassed the concepts inherent in the previous schemes, but in a way which would allow the broad range of concepts to be studied and compared on an equal basis. This was achieved by first identifying the concepts on which each existing alternative was based:

1) Substantial Concepts

The main concepts on which the schemes were based were described as substantial concepts and include:
a) Widening and deepening
b) Raising canal water level
c) Method of Water control (for lock canal)
d) Method of Tidal control (for sea level canal)

2) Partial Concepts

Concepts which are supplementary to the substantial concepts but involve relatively minor improvements compared to those described in 1) above include:
a) Improving ship navigation
b) Improving navigation aids
c) Improving locks

3) Complementary Systems

Concepts which relate to non-ship based means of transporting cargo across the Isthmus of Panama. These include supplementing road, rail or pipelines and the upgrading of harbors as necessary.

1.3.2 Conceptual Alternatives

From the substantial concepts described in 1) above, four different conceptual alternatives were formulated and four are the base from which all of the alternatives to be studied in Phase 1 were developed. The four conceptual alternatives are:

Group A. High Rise Lock Canal
(85'-90' water level, 1 and 2 lifts, 2 lanes)
Group B. Low Rise Lock Canal
(30'-55' water level, 1 lift, 2 lanes)
Group C. Route 10 Sea Level Canal
(sea-level, 0 lift, 1, 2, or 50% of 1&2 lane)
Group D. Route 14S Sea Level Canal
(sea-level, 0 lift, 1, 2, or 50% of 1&2 lane)
Group E. Status Quo
(The Panama Canal with the Culebra Cut Widening)

Alternatives A and B were broken down into 9 study cases each according to the route through Gatun Lake, the

maximum size of ship (100,000, 150,000 and 250,000 DWT) and the level of Gatun Lake (85' and 90' for the high rise and 55' and 30' for the low rise). Alternatives C and D have also been broken down into 9 study cases each according to the maximum size of ship (150,000, 250,000 and 300,000 DWT) and the number of lanes in the canal (1, 2 or 50% 1 lane and 50% 2 lane). The conceptual alternatives, and the 36 preliminary screening study cases derived from them, are shown in Table 1.3.1. Each study case is further detailed in Table 1.3.2 of the same appendix. The existing canal, which includes the Culebra Cut Widening, is shown in the tables as a baseline study case (status quo). The Culebra Cut Widening Project is described in the Panama Canal Commission 1985 Report as a 14.5km long section of the waterway carved mostly through rock and shale. Coming from the Atlantic Ocean, ships enter the Cut at Gamboa where the Chagres River flows into the Canal channel. A short distance before reaching Pedro Miguel Locks, the ships pass Gold Hill on the left, which rises 202m above sea level. The original excavated channel width at Culebra Cut was 92m. During the 1930's and 1940's, the straight section immediately north of Gold Hill was widened to 153m to provide a passing section for large ships, and during the period 1957-1971, the remaining portions of the Cut were also widened to 153m.

In July 1991, the Panama Canal Commission announced that a US$200 million project to widen the Culebra Cut will commence in 1992 using the PCC resources available for the dredging excavation work while employing outside contractors to implement the dry land work.
The project calls for the excavation of 26 million m3 of earth and rock to widen the Cut section from 153m to 192m along tangents and 223m with transitions from and to 192m, in curve sections. The widening objective is to permit two-way traffic through the divide, and thereby the entire Canal. It is reviewed for comparison with the other study cases but will not be studied for engineering feasibility.

The following schemes fall into the category of partial concepts as described in 2) above and will not be studied as part of Phase 1:

A. Non-Lock Improvements
B. Terminal Lake (except for the 100,000 DWT locks and the waterway route which will be considered in conceptual alternatives A)
C. Lock Consolidation

As appropriate, these schemes will be studied in Phase 2 as supplementary options to the alternatives chosen for further consideration during secondary screening.

Table 1.3.1 Conceptual Alternatives (For Prescreening)

June 12, 1991

Conceptual Alternative	Corresponding Alternative/Plan	Route	Size (10 DWT)	Rise (WL - ft)	No. of lift	No. of lane	Corresp. Case	Remarks
A. High Rise Lock Canal	I - d Third Locks I - e Terminal Lake plan except terminal lake I - f Deep Draft	15 + Third Locks Route and 15 (part) + Gatun Lake Modified Route + Third Locks Route	100 150 250	90 85	2	2	L - 1 L - 2* L - 4 L - 5 L - 7 L - 8 L - 10 L - 13 L - 16	
B. Low Rise Lock Canal	I - g Panamanian Alternative	15 + Third Locks Route and 15 (part) Gatun Lake Modified Route + Third Locks Route	100 150 250	55 30	1	2	L - 3 L - 6 L - 9 L - 11 L - 12 L - 14 L - 15 L - 17 L - 18	
C. Route 10 Sea Level Canal	II - a IOCS Route 10 II - c Vergara II - d New Panama Canal	10	150 250 300	0	0	1 2 50% - 1 50% - 2	S - 1 S - 2 S - 3 S - 4 S - 5 S - 6 S - 13 S - 14 S - 15	
D. Route 14S Sea Level Canal	II - b IOCS Route 14 S	14S	150 250 300	0	0	1 2 50% - 1 50% - 2	S - 7 S - 8 S - 9 S - 10 S - 11 S - 12 S - 16 S - 17 S - 18	
E. Status Quo (Baseline)	I - a Status Quo	15	65	85	3	1 and 2	SQ	

* Also perform a Major Feasibility Check for a single Lift Gate Design for Case L-2

June 12, 1991
Rev. 1 July 18, 1991

Table 1.3.2 Study Cases (For Prescreening)

CASE	ROUTE	SIZE (10^3 DWT)	RISE (El. ft.)	No. OF lift	No. OF lane	REMARKS
	(Lock Canal)					
L-1	15 + Third L.	100	90	2	2	
L-2	15 + Third L.	100	85	2	2	*
L-3	15 + Third L.	100	55	1	2	
L-4	15 + Third L.	150	90	2	2	
L-5	15 + Third L.	150	85	2	2	
L-6	15 + Third L.	150	55	1	2	
L-7	15 + Third L.	250	90	2	2	
L-8	15 + Third L.	250	85	2	2	
L-9	15 + Third L.	250	55	1	2	
L-10	15 + Gatun + Third L.	100	85	2	2	
L-11	15 + Gatun + Third L.	100	55	1	2	
L-12	15 + Gatun + Third L.	100	30	1	2	
L-13	15 + Gatun + Third L.	150	85	2	2	
L-14	15 + Gatun + Third L.	150	55	1	2	
L-15	15 + Gatun + Third L.	150	30	1	2	
L-16	15 + Gatun + Third L.	250	85	2	2	
L-17	15 + Gatun + Third L.	250	55	1	2	
L-18	15 + Gatun + Third L.	250	30	1	2	
	(Sea Level Canal)					
S-1	10	150	0	0	1	
S-2	10	150	0	0	2	
S-3	10	250	0	0	1	
S-4	10	250	0	0	2	
S-5	10	300	0	0	1	
S-6	10	300	0	0	2	
S-7	14S	150	0	0	1	
S-8	14S	150	0	0	2	
S-9	14S	250	0	0	1	
S-10	14S	250	0	0	2	
S-11	14S	300	0	0	1	
S-12	14S	300	0	0	2	
S-13	10	150	0	0	50% - 1 50% - 2	
S-14	10	250	0	0	50% - 1 50% - 2	
S-15	10	300	0	0	50% - 1 50% - 2	
S-16	14S	150	0	0	50% - 1 50% - 2	
S-17	14S	250	0	0	50% - 1 50% - 2	
S-18	14S	300	0	0	50% - 1 50% - 2	
SQ	15	65	85	3	1 or 2	

* Also perform a Major Feasibility Check for a single Lift Gate Design for Case L-2

The following schemes fall into the category of complementary systems as described in c) above:

A. Oil Pipeline and associated mooring facility.
B. Landbridge, Railway and associated port and terminal facilities.
C. Landbridge, Road and associated port and terminal facilities.

The complementary systems will be approximately costed as part of Phase 1 so that at the end of that phase, the systems can be combined with any of the 36 case studies, or the status quo, as necessary to increase their capacity and/or competitiveness. Details of the complementary systems and the corresponding capacities to be studied are shown in Table 1.3.3.

June 12, 1991
Rev.1 July 18, 1991

Table 1.3.3 Complementary Systems (For Detailed Analysis)

Complementary Systems	Route	Capacity
F. Oil Pipeline & Associated Mooring Facilities	Western Panama Near Existing Petro Terminales Location	(mil. b./day) 0.5 1.0 1.5 2.0
G. Landbridge, Railway & Associated Port and Terminal Facilities using Centerport Concepts	Central Panama; Panama City to Colon	(mil. ton/yr) 10 20 30 40
H. Landbridge, Road & Associated Port and Terminal Facilities using Centerport Concepts	Central Panama	(mil. ton/yr) 10 20 30 40

mil.b/day = million barrels/day

1.3.3 Prescribed Criteria for the Study Cases

The principal features of the 37 study cases are broadly described in Section 1.3.1. Specific details of the features and design criteria to be adopted were provided by the Secretariat and are described below.

(1) Design Ships

The dimensions of the design ships as provided by the Secretariat are shown in Table 1.3.4 below.

Table 1.3.4 Dimensions of Design Ships

Ship Size (DWT)	L (m)	B (m)	D (m)	Remarks
65,000	295	32	12	Max. Passable Size in existing canal
100,000	277	43	17	
150,000	316	49	19	
250,000	372	57	22	
300.000	394	61	23	

(2) Lock Chamber Dimensions

The Secretariat also provided the required dimensions of the lock chambers as shown in Table 1.3.5 below.

Table 1.3.5 Dimensions of the Lock Chambers

Ship Size (DWT)	L (m)	B (m)	D (m)	Remarks
65,000	304.8 (1,000ft)	33.5 (110ft)	12.8 (42ft)	Existing canal lock dimension
100,000	319	47	19	
150,000	363	54	21	
250,000	428	63	24	

Notes:

(1) The dimensions shown are the inside wetted surface of the lock chamber in the condition of lowest vessel position.

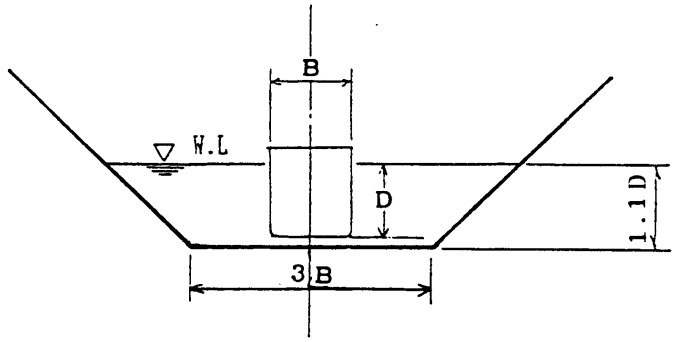
(2) Since lock chambers are considered for design ships having DWT up to 250,000 only, the dimensions for 300,000 DWT ships are not given in this table.

(3) Canal Sections

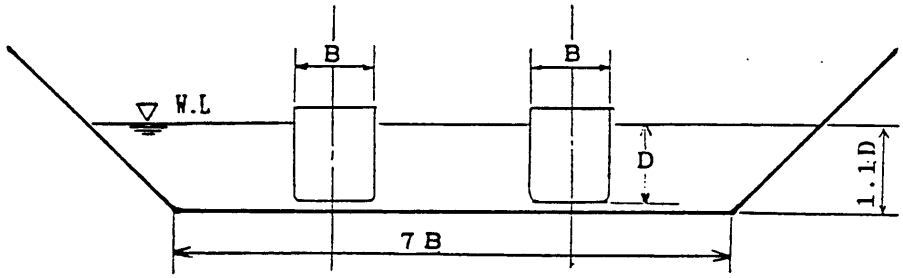
The required cross-section dimensions for the canal in one-way and two-way sections are shown in Fig. 1.3.1.

(4) Routes

The route co-ordinates to be adopted have been supplied by the Secretariat and are shown in the following tables 1.3.6, 1.3.7 and 1.3.8.



One Way



Two Way

Fig. 1.3.1 Typical Canal Sections

Table 1.3.6 Sea Level Canal Route 14S (IOCS Route 14S)

POINT	STATION	COORDINATES (Km) NORTH	EAST
A	Pacific Channel	982.60	662.60
B	West of Balboa	982.40	657.30
C	Northeast Aceite	990.55	656.90
D	Esclusas de Miraflores	994.55	654.30
E	North of Rio Grande Reserve	999.00	647.95
F	Earthen Dam	1,002.60	645.00
G	Gorgona Islands	1,007.50	639.70
H	East of Zaino Island	1,010.30	632.35
I	Southwest Juan Gallegos Island in Gatun Lake	1,017.30	624.20
J	West of Fort Davis	1,022.90	619.75
K	Causeway	1,028.25	618.90
L	Southwest of Ruins	1,029.10	618.65
M	Breakwater Entrance	1,038.00	618.65

Note: These coordinates apply for the Group D study cases.

Table 1.3.7 Sea Level Canal Route 10 (IOCS Route 10)

POINT	STATION	COORDINATES (Km) NORTH	EAST
A	Pacific Approach	977.65	643.65
B	Rio Caimito 1	982.20	641.65
C	Rio Caimito 2	985.30	636.95
D	Route 88	988.00	634.70
E	Rio Pescado	996.75	630.95
F	Gatun Lake	999.40	628.65
G	Gatun Lake	1,001.45	617.45
H	South Cerro Gigante	1,003.55	622.45
I	Cano Gignta Maria Islands	1,004.95	617.45
J	West Santa Maria Islands	1,007.85	611.62
K	Quebranda Brazito	1,011.35	607.75
L	Rio Cano Quebrando	1,014.30	606.55
M	Atlantic at La Paya de Anibal	1,022.10	600.70

Note: These coordinates apply for the Group C study cases.

Table 1.3.8 Third Lock, Terminal Lake and Variations
Deep Draft, The Panamanian Plan - Route II

POINT	STATION	COORDINATES (Km) NORTH	EAST
A	Pacific Channel	982.60	662.60
B	West of Balboa	989.40	657.30
C	Northeast Aceite	990.55	656.90
D	Esclusas de Miraflores	994.55	647.95
(D')	(Existing Canal just South of Pedro Miguel)	(996.00)	(653.35) (for lift 55')
E	West of Cerro Paraiso	997.10	650.70
F	Existing Canal West of Cerro Nitro	998.55	645.90
From F to X the route follows the existing canal (Route I)			
X	Just West of Jaguar and Vigilante Islands	1,020.20	618.20
J	West of Fort Davis (same as V)	1,022.90	619.75
From Point 'J' to end at Atlantic Breakwater, it follows Route V (Route 14S)			

Note: These coordinates apply for the Group A and B study cases although study cases L-10 to L-18 inclusive follow a modified route through Gatun Lake.

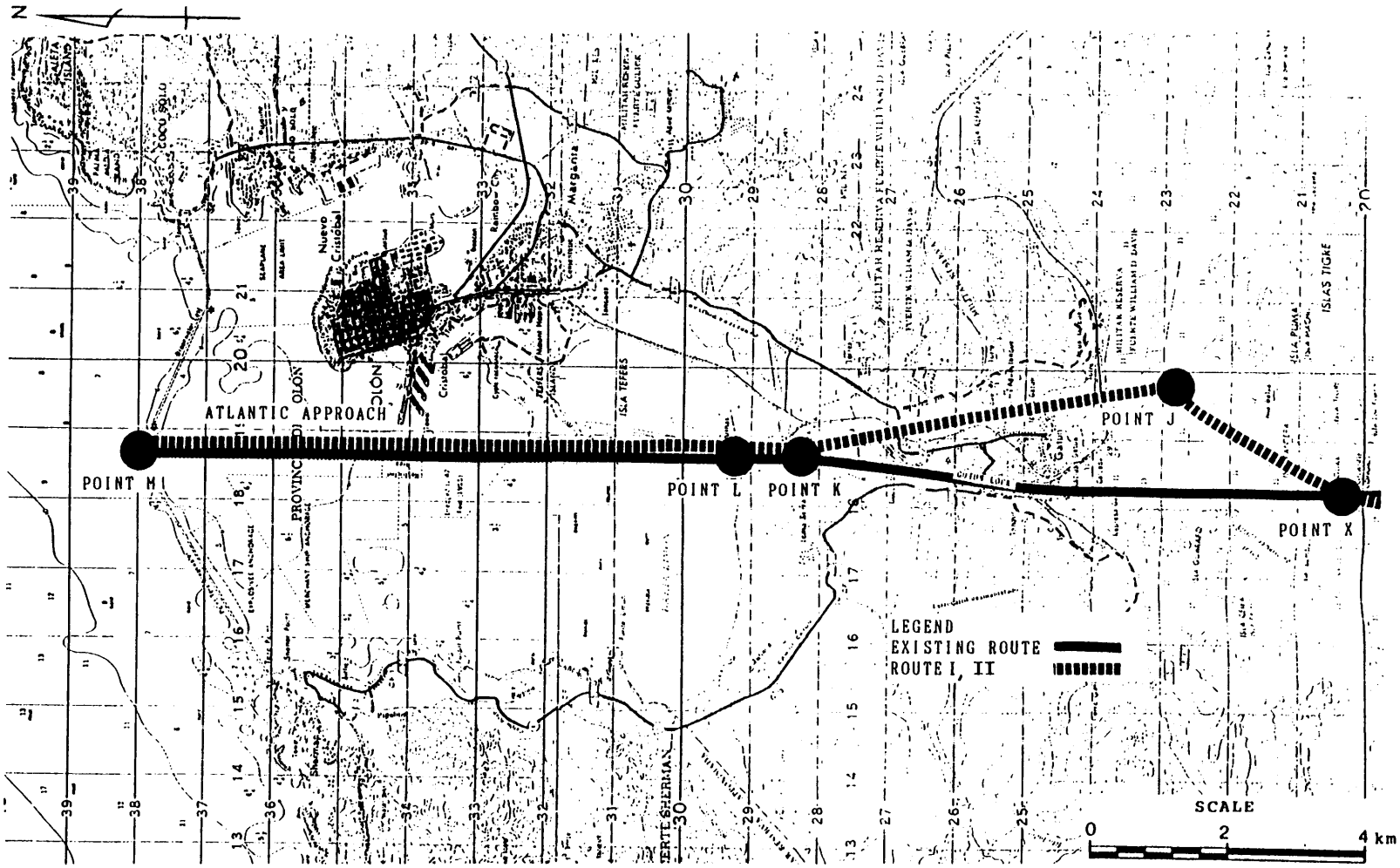


Fig. 1.3.2 Route Location (Atlantic Approach to Gatun Lake)

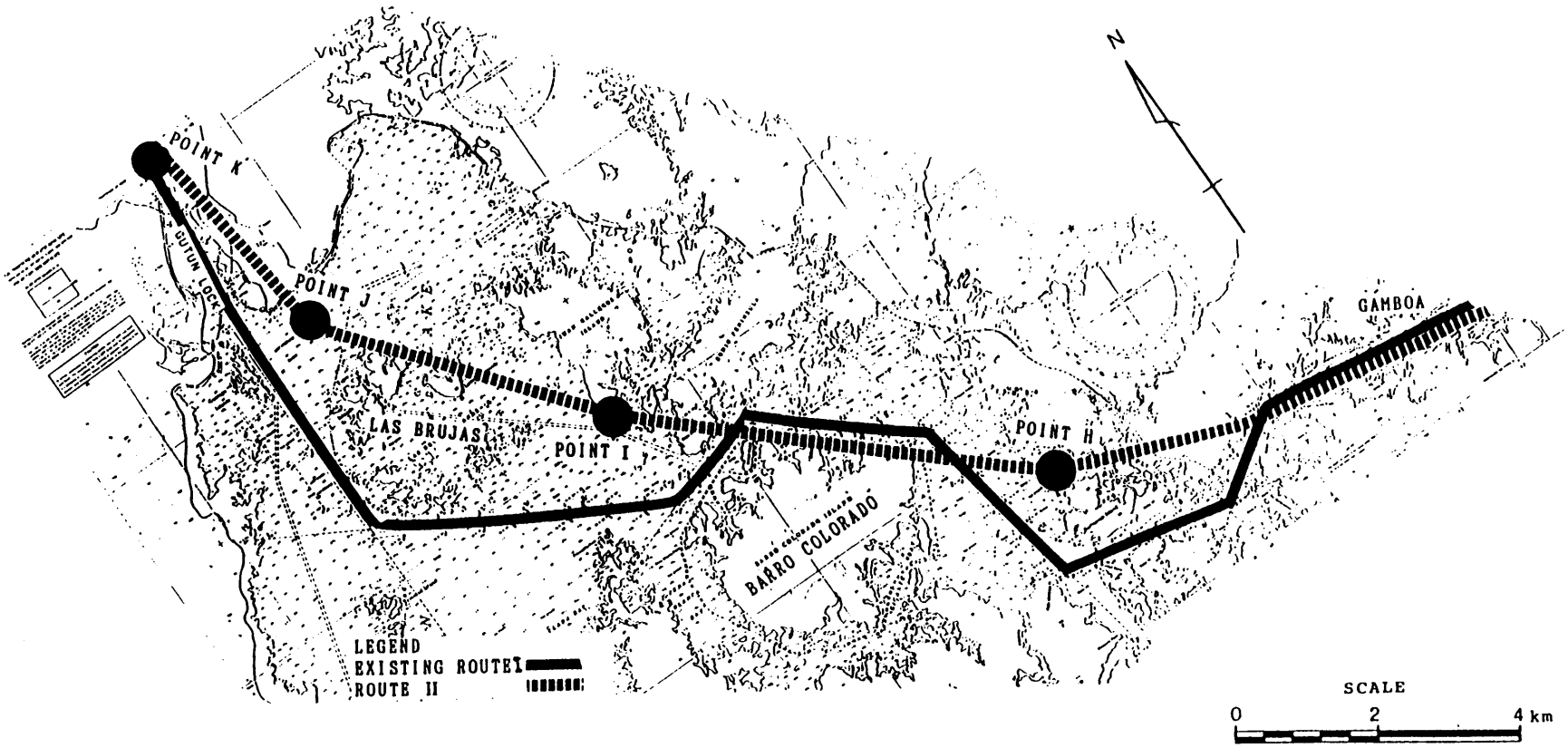


Fig. 1.3.3 Route Location (Gatun Lake)

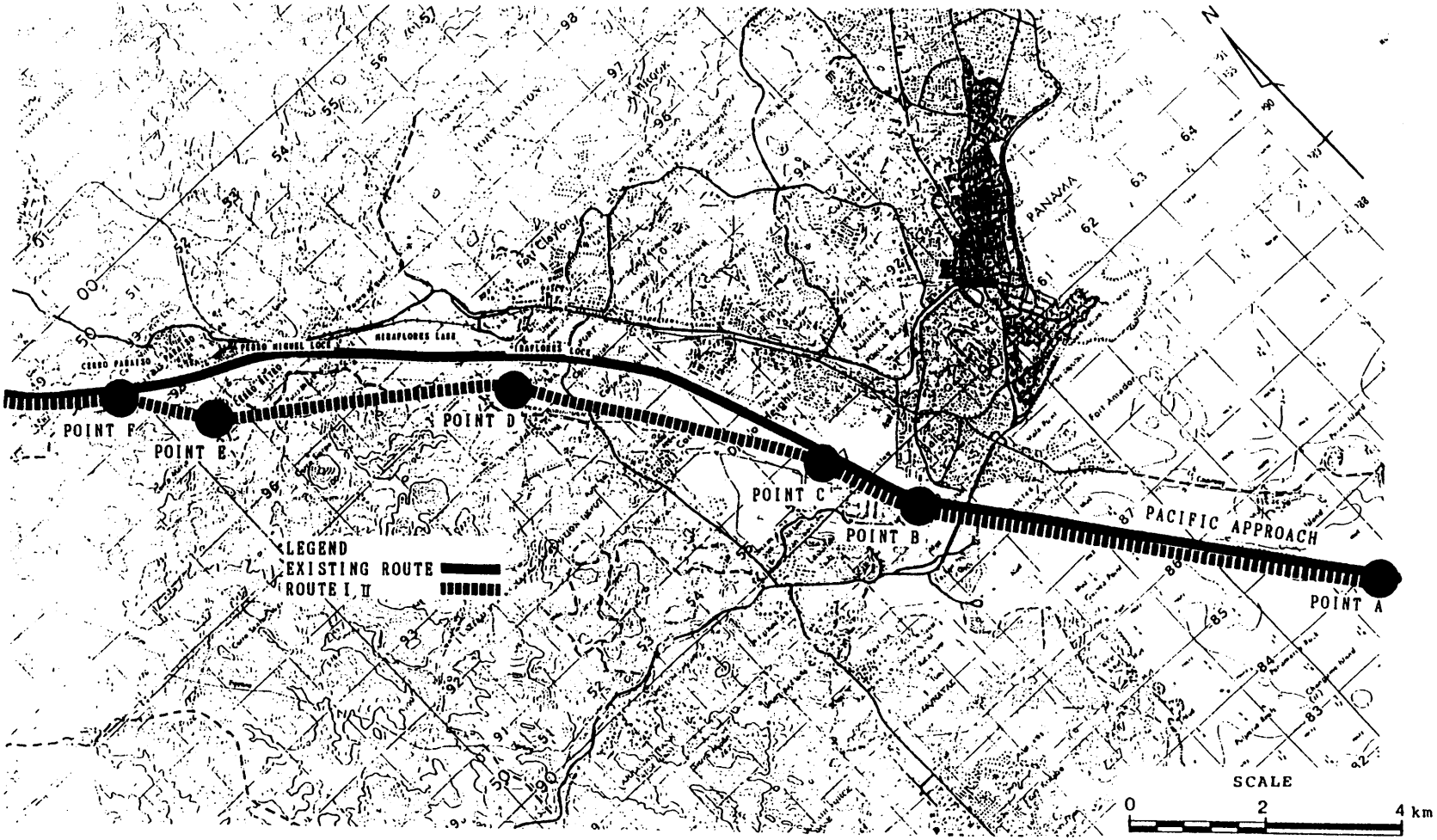


Fig. 1.3.4 Route Location (Paraiso to Pacific Approach)

(5) Planned Water Levels

Water levels are given by the Secretariat for each study case and are 90', 85', 55', 30' and 0'. These basic water levels for each study case were defined further into high water levels and low water levels, considering the variation in lake and sea levels, and are summarized below in metric units.

Table 1.3.9 Canal Water Levels (P.L.D. Datum)

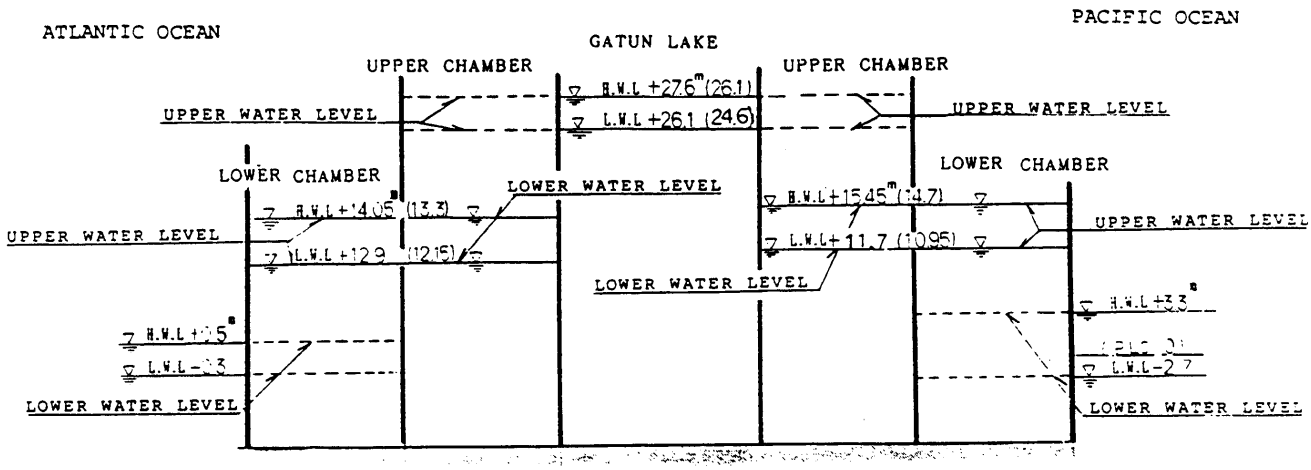
	Rise					
	90'	85'	55'	30'	Pacific	Atlantic
H.W.L	27.6	26.1	17.1	9.6	+3.3	+0.5
Design Level	90'	85'	55'	30'	+0.3	+0.5
	(27.4)	(25.9)	(16.8)	(9.1)		
L.W.L	26.1	24.6	15.6	8.1	-2.7	-0.3

These fundamental water levels have been defined further for the design of the lock gate leaves, and are shown in Table 1.3.10, Fig. 1.3.5 below.

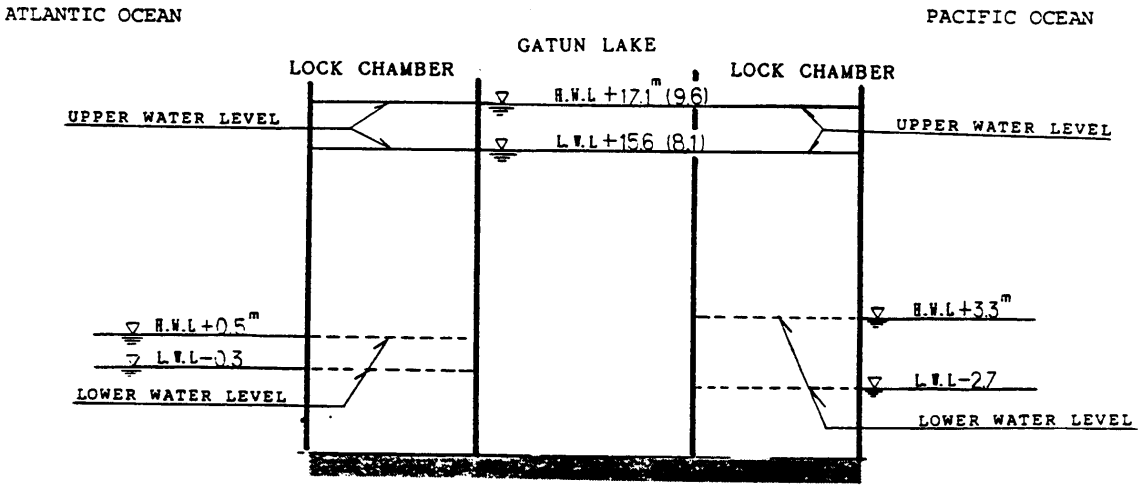
Table 1.3.10 Water Levels for Lock Gate Design

Case	Lower W.L of Lower Chamber - Atlantic	Lower W.L of Upper Chamber - Upper W.L of Lower Chamber	Gatun Lake - Upper W.L of Upper Chamber	Lower W.L of Upper Chamber - Upper W.L of Lower Chamber	Lower W.L of Lower Chamber - Pacific
	H.W.L - L.W.L	H.W.L - L.W.L	H.W.L - L.W.L	H.W.L - L.W.L	H.W.L - L.W.L
L-1, L-3, L-7 2Lift, 90' Rise	(m) 0.5 - -0.3	(m) 14.05 - 12.90	(m) 27.60 - 26.10	(m) 15.45 - 11.70	(m) 3.3 - -2.7
L-2, L-5, L-8 L-10, L-13, L-16 2Lift, 85' Rise	0.5 - -0.3	13.30 - 12.15	26.10 - 24.60	14.70 - 10.95	3.3 - -2.7
L-2' 1Lift, 85' Rise	0.5 - -0.3	26.1 - 24.6			3.3 - -2.7
L-3, L-6, L-9 L-11, L-14, L-17 1Lift, 55' Rise	0.5 - -0.3	17.1 - 15.6			3.3 - -2.7
L-12, L-15, L-18 1Lift, 30' Rise	0.5 - -0.3	9.6 - 8.1			3.3 - -2.7
S-1 - S-18	0.5 - -0.3				3.3 - -2.7

Note : The numbers in the above table are illustrated in Fig. 1.3.5.



Note: The values above show 90'water level case, and the values in the ( ) show 85'Case.

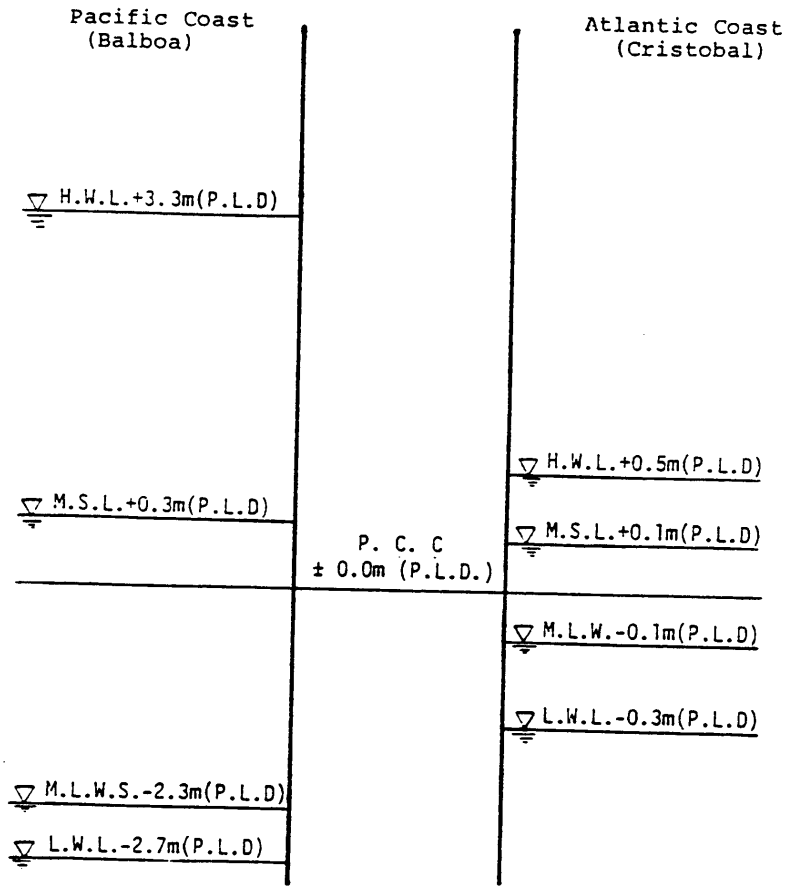


Note: The values above show 55'water level Case, and values in the ( ) show 30'Case.

Fig. 1.3.5 Water Levels for Lake Gate Design

(6) Tidal Levels

Tidal levels on the Pacific and the Atlantic coasts are summarized as follows.



(Datum line ±0.0(P.L.D)(P.C.C),unit: m)

Fig. 1.3.6 Tidal Levels on the Pacific and Atlantic Coasts

(7) Relation between Water Level Chart and P.L.D.

Various water levels at lakes and both Ocean coasts are indicated below showing the relation between P.L.D (Precise Level Datum) and each level.

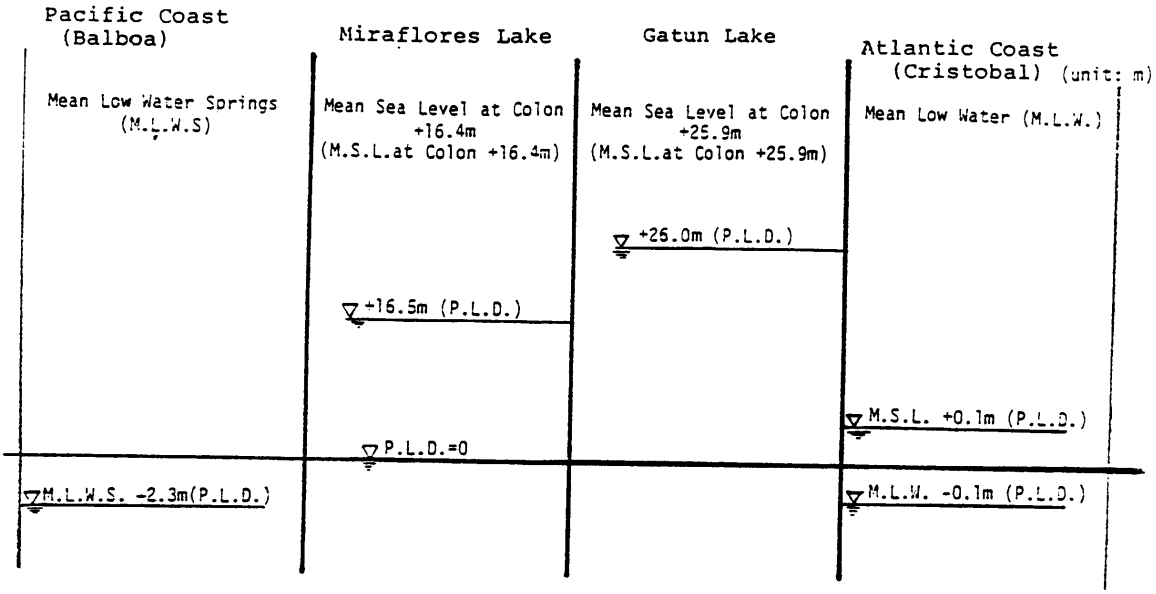


Fig. 1.3.7 P.L.D Datum Line

1.3.4 Review of Prescribed Criteria

The criteria suggested by the Secretariat were reviewed by the component contractor during the process of carrying out the study. In general, the criteria seem reasonable and have been adopted by the contractor. There are, however, some suggestions about the criteria and these are summarized below for consideration by the Commission. While these comments are presented, the criteria nominated by the Secretariat were adopted by the contractor for presentation, comparison and costing of the study cases.

(1) Design Ships

The ship dimensions given by the Secretariat (above) are envelope dimensions and should not be taken to represent actual ships. For example, the figures given for a 250,000 DWT ship imply a displacement of about 380,000 tones which is approximately 100,000 tones greater than the actual displacement of a typical tanker of that size.

The figures provided are appropriate for the sizing of the canal and locks, but the proposed designs should be checked for typical actual figures.

(2) Canal Sections

Assuming that the ship dimensions in Table 1.3.4 are applicable to the canal sections given in Fig. 1.3.1, then the single lane section would be satisfactory for a 250,000 DWT ship if the side slope is not less than 1:1.5. For a 300,000 DWT ship, the side slope would need to be reduced to 1:2. With steeper slopes the area ratios would be too small.

Lane widths would, in every case, be generous (for single lane canal).

In most cases the depths proposed would provide sufficient clearance between ship bottom and channel bottom. With the exception of the 150,000 DWT case, there would be a 2m deep siltation allowance which is probably excessive. In the case of the 150,000

DWT class (which contains a few very deep ships) the depth would be deficient and there would be no siltation allowance. In double lane sections of the canal, squat and trim would be less and the depths, with the one exception, would be even more generous.

There is much less information available about the size of two lane canals, but what there is suggests that the cross-section proposed by the Secretariat is too narrow. This report (International Commission for the Reception of Very Large Ships. Report of Working Group IV. Optimal layout and dimensions for the adjustment to large ships of maritime fairways in shallow seas, seastraits and maritime waterways, Supplement to Bulletin No. 35, PIANC), recommends a channel width of 12-13 times the beam of the largest ship. Work done for the Suez Canal development showed that a moored large ship experienced large forces when passed by another large ship with a separation clearance of 2B. If a maximum lane width of 2.8B is assumed, the minimum separation between passing ships could be as little as 0.7B in the cross-section proposed by the Secretariat. This would be equivalent to 0.76B of a typical 300,000 DWT ship. The Suez results suggested a minimum separation of 6.5B which, if applied to a canal, would lead to a minimum width of 9.3B plus an additional width necessary because the passing speed would be double the convoy speed. The PIANC proposal would seem reasonable in the light of the Suez data. Further studies for the width of the canal might be necessary in Phase 2.

PIANC: Permanent International Association of Navigation Congresses

1.4 Phase 1 Study

1.4.1 Description

The broad objective of Phase 1 of the component study of Engineering and Cost Estimates, is to investigate the engineering feasibility and costs of the cases, so: the Commission can identify potential alternatives for further study; and identify potential alternatives to be evaluated in more detail in Phase 2 of the component study.

The actual prescreening selection process will be carried out by the Commission using the results of Phase 1 of this component study as well as the results of the other component studies, operating characteristics and capacity evaluation, and commodity and traffic projections including preliminary environmental and socioeconomic data. The Commission will also consider preliminary environmental and socioeconomic data.

The results of all studies, when combined and collated by the Commission, will allow it to eliminate prior to further detailed study in Phase 2 those study cases which:

- are clearly unsound;
- do not meet demand projections even when complementary systems to increase capacity are added;
- are not competitive on the basis of capital costs;
- have adverse impacts the severity of which is obviously much greater than other alternatives.

In order to provide the Commission with the information necessary for them to carry out this prescreening process, the detailed objectives of Phase 1 are to investigate the study cases identified by the Secretariat in a consistent and equitable manner and supply the following:

- An assessment of the engineering feasibility of the four conceptual alternatives (High rise lock canal, Low rise lock canal, Route 10 sea level canal, Route 14S sea-level canal) for the range of variations listed in Table 1.3.2, giving particular emphasis to the major feasibility check items identified by the Secretariat

in the following Table 1.4.1 that are related to the engineering and cost estimates. The exclusion or modification of a study case may be proposed as a result of the check of the major feasibility items.

- Cost estimates for each study case including the status quo. The Status Quo is to include the announced plan by the PCC (July 1991) for the Culebra Cut widening. Existing cost data will be validated and adjusted as necessary to ensure that all estimates are prepared on an equitable basis. Costs of complementary systems will also be estimated.

- Project summary schedules and annual distribution of costs for each study case.

- An estimate of the impact the construction of each study case would have on continuity of operation of the existing canal.

- An estimate of areas affected by the construction and operation of each study case, including areas likely to be affected by environmental or socioeconomic impacts.

Table 1.4.1 (1) Major Feasibility Check Items
For Study Cases (For Prescreening)

Study Case	Engineering Feasibility Check Items	Route	Ship Size (10^3DWT)	Rise (El - ft)	No. of lift	No. of lane	Remarks
L - 1 to L - 18	1. Ship guidance in lock chamber including mule operation or other innovative systems *	- - -	All cases	- - -	- - -	- - -	
	2. Lock gate concept design: gate type, structural system, alloy, allowable stress, buoyancy provisions, size limitation, corresion protection, drive mechanism, bearings, seals and failures modes. *	- - - - - - - -	All cases	- - - - - - - -	All cases	- - - - - - - -	
	3. Water saving plan including new water sources, development, and reservoir operation. *	-	All cases	All cases	All cases	-	
	4. Sea water pumping *	-	All cases	All cases	All cases	-	
	5. Deep water dredging operation, *	-	All cases	All cases	All cases	-	
S - 1 to S - 18	6. Tidal current analysis with gate **	10 and 14S	All cases	-	-	All cases	
	7. Ship maneuvering in canal under tidal current with gate. **	10 and 14S	All cases	-	-	All cases	
	8. Tidal gate design (including items in 2 above) *	10 and 14S	All cases	-	-	1 and 2	

* To be done by Engineering and Cost Estimates Component Contractor
** To be done by Operating Characteristics and Capacity Evaluation Component Contractor

Table 1.4.1 (2) Major Feasibility Check Items
For Study Cases (For Prescreening)

Study Case	Engineering Feasibility Check Items	Route	Ship Size (10^3 DWT)	Rise (El - ft)	No. of lift	No. of lane	Remarks
S - 1 to S - 18	9. Tidal current analysis with tidal basin **	10	All cases	-	-	All cases	
	10. Ship maneuvering in canal under current with tidal basin **	10	All cases	-	-	All cases	
	11. Tidal basin design *	10	All cases	-	-	All cases	
	12. Tidal current analysis under no control condition **	10	All cases	-	- -	All cases	
	13. Ship maneuvering in canal under no tidal current control **	10	All cases	-	-	All cases	
Study Case	II. Major Socioeconomic Impacte	Route	Size	Rise	No. of lift	No. of lane	
L - 1 to S - 18	1. Possible major socioeconomic impact from various view points, both favourable and adverse	All cases	All cases	All cases	-	-	
Study Case	III. Ability to be financed	Route	Size	Rise	No. of lift	No. of lane	
L - 1 to S - 18	1. Ability to be financed under present and near future financial market including governments subsidy	By size of investment: 1) US$ 1 billion size 2) US$ 5 billion size 3) US$ 10 billion size 4) US$ 50 billion size 5) US$ 100 billion size					
Study Case	IV. Major Impacts on Existing Canal	Route	Size	Rise	No. of lift	No. of lane	
L - 1 to S - 18	1. Possible major impacts on the existing canal from various viewpoints, both favourable and adverse *	All cases	All cases	All cases	-	-	

* To be done by Engineering and Cost Estimates Component Contractor

** To be done by Operating Characteristics and Capacity Evaluation Component Contractor

The Study Process Flow Chart is shown in Fig. 1.4.1. A description of each study item was included in the Inception Report. The flow chart was based on several broad principles and Phase 1 has been implemented accordingly:

- The study work was executed in Japan, while periodic visits to Panama was provided opportunities for discussions with the Secretariat and various concerned parties to confirm the study course, submit reports, obtain data and hold hearings (receive information).

- Group A study cases and some study cases from Group C were studied in the first half of Phase 1, while the remaining study cases were reviewed in the second half of Phase 1.

1.4.2 Inception Report

The Inception Report for Phase 1 was the first report produced by this Component Contractor, and the purpose was to define the scope of works, implementation plan and schedule for Phase 1 of the Study. A separate Inception Report for Phase 2 will be produced prior to commencement of Phase 2.

The Phase 1 Inception Report was submitted in July 1991 and included the following:

- Study objectives and implementation policy
- Study framework
- Scope of study, including work content and procedures
- Study schedule
- Outline of report submissions

The Phase 1 study was carried out in accordance with the final contents of the Inception Report as revised following the Inception Visit to Panama in July 1991.

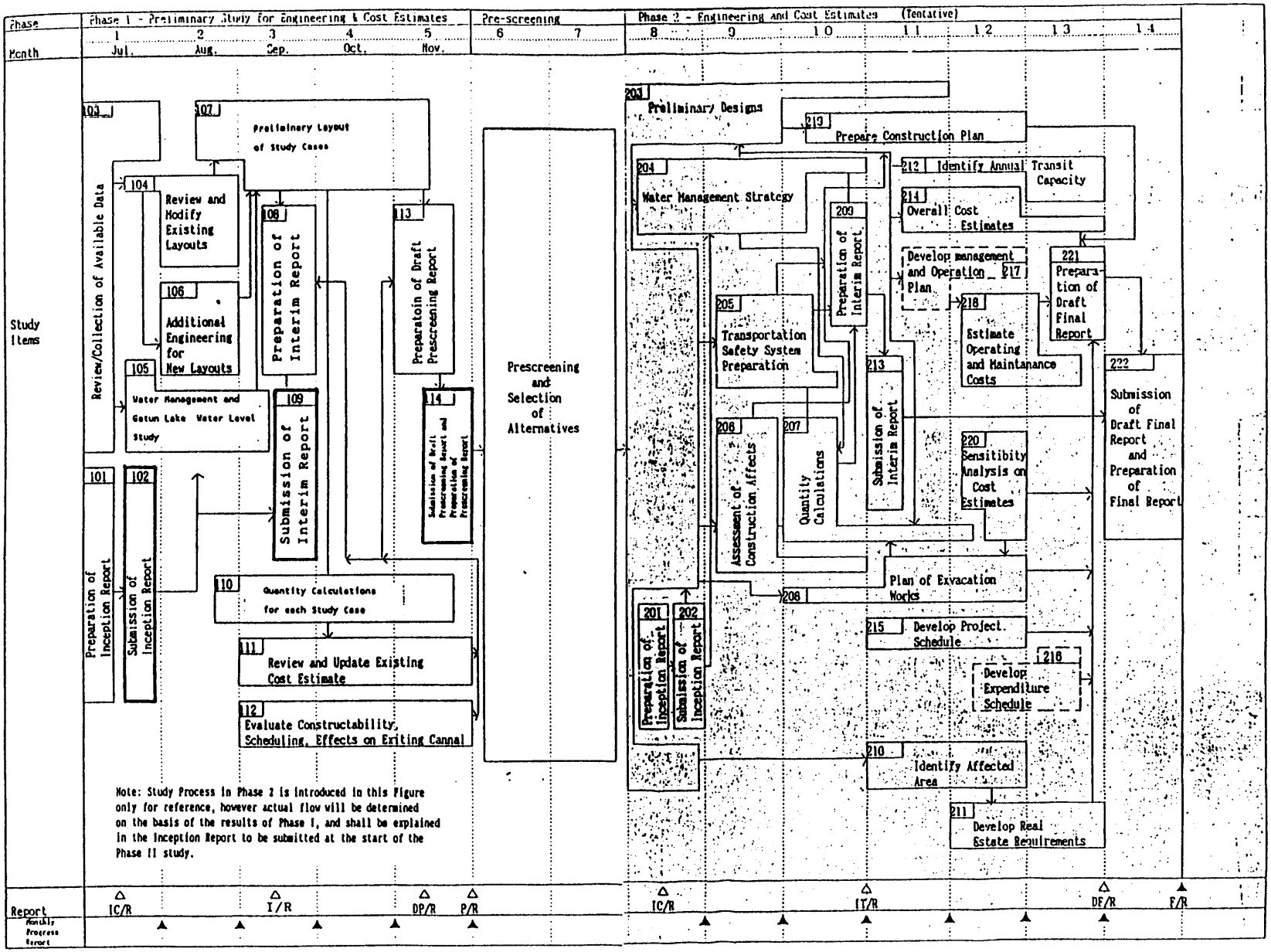


Fig. 1.4.1 Study Process Flowchart

1.4.3 Prescreening Reports

The final results of the Phase 1 study are presented in this Final Report for Phase 1 which is divided into two sections:

Part I - Engineering for Prescreening
Part II - Cost Estimates for Prescreening

A Summary Report summarizing the findings in the main reports above is provided at the front of the Final Report.

(1) Interim Report

In accordance with the Study Process Flowchart, an Interim Report was submitted to the Secretariat for review and discussion part way through Phase 1. The Interim Report had basically the same format and contents as this Final Report, but was not complete. It gave the Secretariat an opportunity to review the methods of presentation, costing and evaluation, and procedures were discussed and confirmed for the remaining study cases considered in the second half of Phase 1.

Of the 37 study cases, the 9 study cases included in Group A, High-Rise Lock Canal, as well as the Status Quo baseline alternative, were studied in the first part of Phase 1. The results were presented in the Interim Report. The review of the 9 study cases included in Group C, Route 10 Sea-level Canal, commenced during the first part of Phase 1, and partial results for these study cases were also included in the Interim Report.

Interim Report included a review of the following major feasibility check items:

- Ship guidance system within lock chambers using mules' operation
- Proposals for various sizes of lock chambers and lock gate models based on designs in existing alternatives
- Water saving plan including new water sources development and reservoir operation
- Sea water pumping

(2) Final Report

This final report of Phase 1 includes the Interim Report contents, modified as necessary to take into account any comments, as well as the results for the remaining study cases (Groups B and D, and remainder of C) which were reviewed during the latter half of the five-month period allocated for the Phase 1 Study. Cost estimates for the complementary systems were also derived during this period. Preliminary engineering studies of the complementary systems were carried out during Phase 1 of the Study, but further detailed studies will be required in Phase 2.

A draft of the Final Report was submitted to the Secretariat at the site visit in November 1991 for review and discussion. Following this the Final Report was submitted in February 1992.

CHAPTER 2 - WATER MANAGEMENT PLAN

2.1 Existing Water Supply

2.1.1 Rainfall

On the basis of hydro-meteorological records, the climate of Panama can be categorized into two seasons. January through April is usually considered as the dry season, and May through December, the wet season. About 90% of the total annual rainfall occurs during the wet season. The annual average rainfall in the Panama Canal Watershed amounts to approximately 2,500mm. The rainfall isohyetals are presented in Fig. 2.1.1 and Appendix AP 1-2.

2.1.2 Drainage Area

The water supply for operation of the Panama Canal is provided by the 3,339 sq.km drainage area of Gatun and Madden dams. Gatun dam was constructed across the lower Chagres river in 1912, and the Madden was constructed in the early 1930's across the upper Chagres river. The main rivers contributing to Gatun Lake are the Chagres, Pequeni, Boqueron and the Gatun from the east side of the canal, and the Ciri, Trinidad and Cano Quebrado from the west side. With the exception of the Cano Quebrado, these rivers have been gauged and discharge records are available. In addition, records from numerous rain gauge stations are also available to supplement the stream flow data. These hydrologic records provide an adequate basis for determining the yield that can be expected from the Gatun Lake drainage area. The active rain gauge and discharge measurement stations and the period of records are shown in Table 2.1.1 and Appendix AP 1-2.

2.1.3 Watershed Yield

Average annual yield for 51 years of record(1933-1983) by IRHE(Instituto de Recursos Hidraulicos y Electrification) is about 6,593 million m^3. Maximum and minimum yields of 10,653 and 3,557 million m^3 occurred in the years 1981 and 1965, respectively. Annual evaporation is about 673 million m^3. Therefore, net annual average yield of the watershed would be about 5,920 million m^3. The

amount of monthly evaporation in the watershed is given in the Table below (See also Appendix AP 1-3 to 1-6).

MONTHLY EVAPORATION

(UNIT: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Gatun	140	149	166	156	109	93	89	95	90	94	89	114	1,384
Madden	137	145	162	153	107	91	87	93	88	92	87	112	1,354

Data Source: IOCS MEMORANDUM JAX-50

2.1.4 Storage

The available storage in Gatun Lake is about 659 million m^3 between elevations 24.6m and 26.1m. On the other hand Madden Lake provides an additional volume of 539 million m^3 between elevations 61m and 76.2m, and increases the total usable storage to 1,198 million m^3. Details are presented in Section 2.3.3.

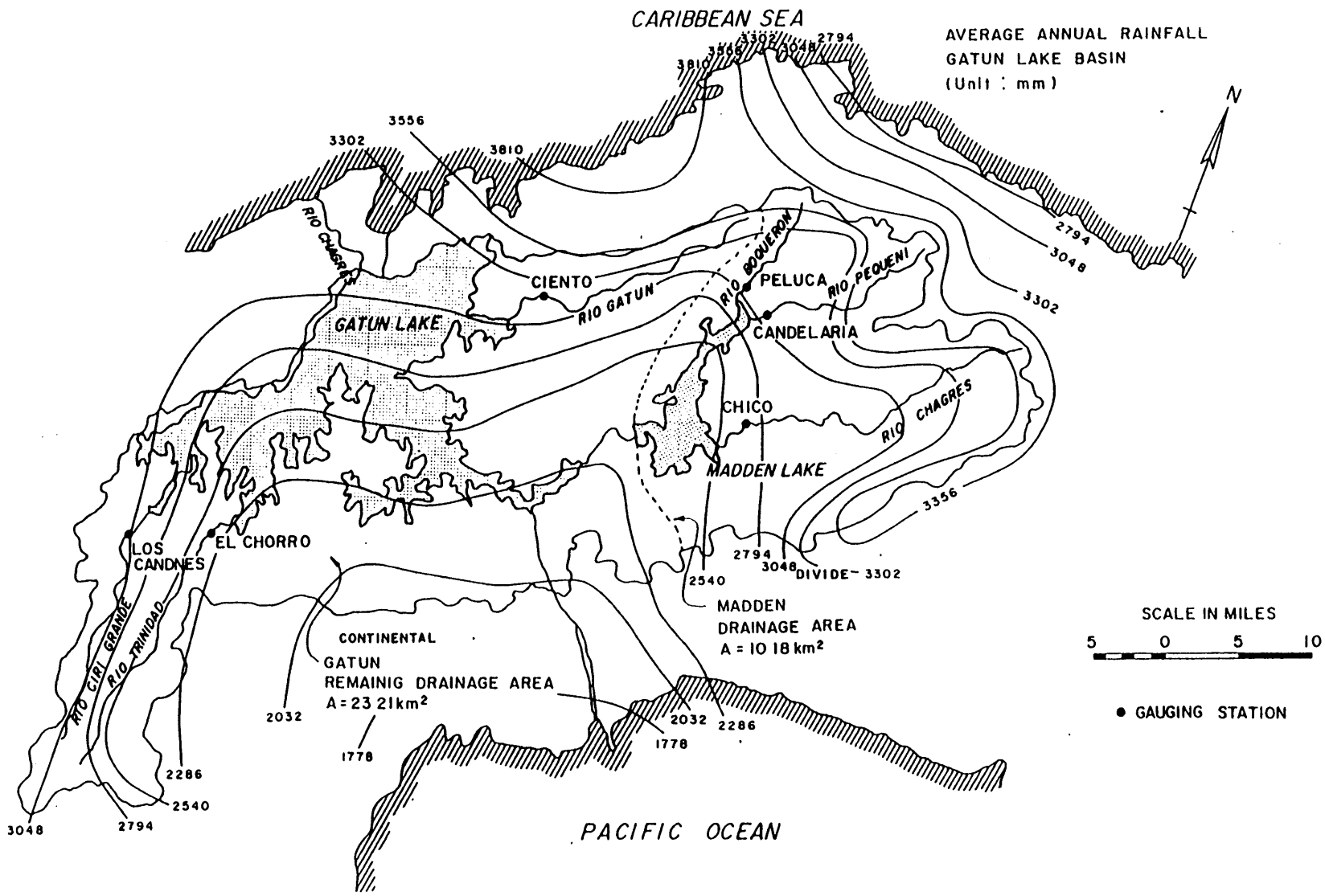
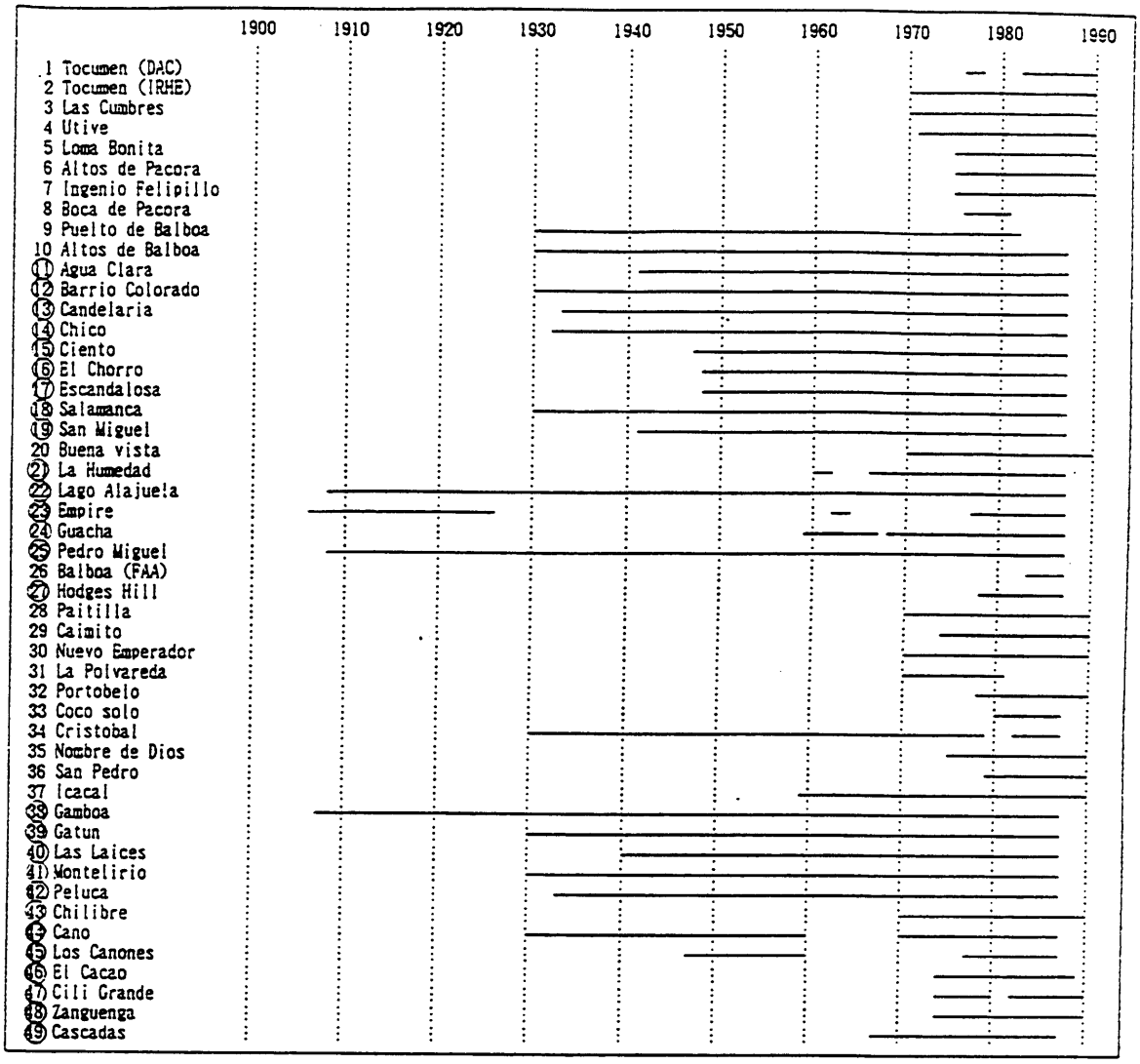


Fig. 2.1.1 Isohyetal Map of Canal Area

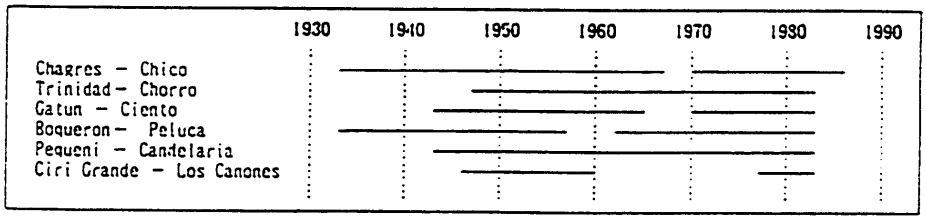
Table 2.1.1 Station and Period of Hydrological Data

(RAINFALL)



○ shows rainfall gages in the GATUN watershed

(DISCHARGE)



2.1.5 Water Use

Gatun and Madden lake waters are utilized as lockage water, as municipal water supplies for Panama City, the Canal Area, and Balboa, and for generating hydroelectric power. There are significant losses due to evaporation and spillage when run-off exceeds storage capacities. Percentage wise, water use from the Gatun Lake is as follows:

Item	Percent (%)
Lockages	45
Municipal	4
Evaporation	10
Power+Spillage	41
	100

It is assumed that one lockage would require 0.197 million m^3 of water. Deducting other losses, a total of 15,000 transits can be supported annually with the present storage volume. Municipal water use has increased significantly since 1968, and amounted to about 270 million m^3 in 1989.

2.2 Canal Facilities and Water Management Related Restrictions

The existing canal consists of two short sea-level sections at either end, and a long elevated intermediate section including Gatun Lake. Between the sections there are 110 ft wide and 1,000 ft long twin locks. These locks can provide 41 ft of water over lock sill under normal conditions. The Atlantic end locks, i.e., Gatun locks have three lifts from sea level to Gatun Lake level which is regulated at between 82 and 87 feet above P.L.D. The Pacific end has two sets of locks; the Miraflores locks which raise ships from sea level to Miraflores Lake in two lifts to an elevation of 54 feet, and the Pedro Miguel locks which raise vessels in one lift from Miraflores Lake to Gatun Lake level. The channel reaches have widths varying from 500 feet to 1,000 feet.

There are several factors which limit the transit capacity of the Panama Canal. The dimensions of the locks, Gatun Lake regulation levels, and natural water availability, effectively limit the transit capacity of the Panama Canal. The Panama Canal Commission allows ships with maximum widths of 106 feet for regular transit. The Culebra Cut, widened to 14.5 Km long and 153 m wide (status quo alternative) also imposes restrictions on ship size. At present ships with 950 feet length can transit routinely.

2.3 Water Management Plan

2.3.1 Basic concepts

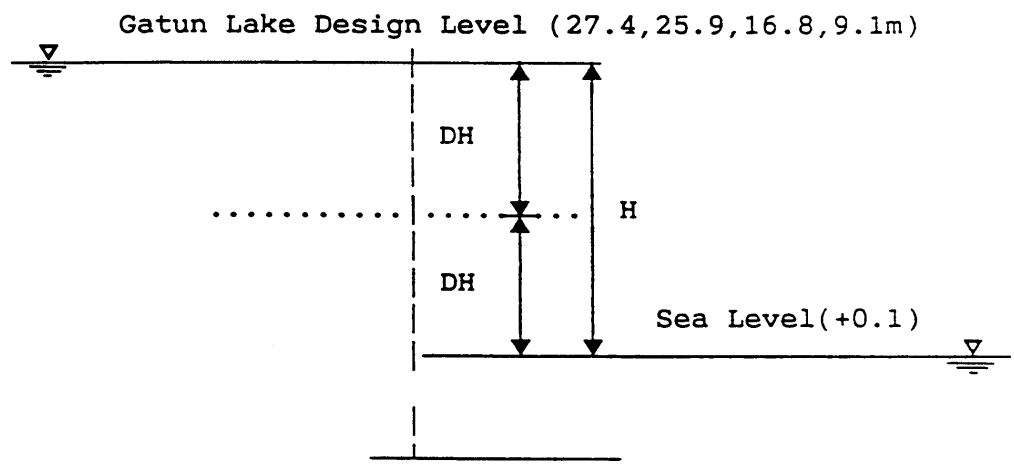
(1) Lockage Water

The volume of water that will be required for one transit through the canal is calculated using the formula given below:

V= BxLx(H/N)x2

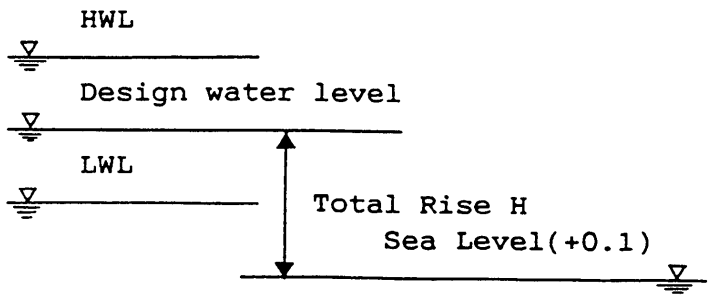
where, V= volume of water required
B= width of lock in meters
L= length of lock in meters
H= total rise of lock in meters
DH= height of one lift of lock in meters
N= number of lifts (N=H/DH)

A sketch of this concept is presented below for a clearer demonstration.



(2) Operational Water Level

The existing operational water level at Gatun Lake is between 87 feet(HWL) and 82 feet(LWL). In this study, three more cases were considered: When Gatun Lake operates between 90-87 ft; 57-52 ft; and 32-27 ft. Tabulations are given below.



HWL(m)	27.6	26.1	17.1	9.6
Design(m)	27.4 (90')	25.9 (85')	16.8 (55')	9.1 (30')
LWL(m)	26.1	24.6	15.6	8.1

(3) Simulation Model and Assumptions

In order to evaluate the lockage capability of present usable storage capacity, a model for computer simulation was developed and schematized in Fig. 2.3.1 and Appendix AP 1-7.

The assumptions made for the simulation are listed below:

1. Monthly discharge is calculated by using average discharge for 51 recorded years (1933-1983).
2. Gatun Lake operates at a design water level of 90, 85, 55 and 30 feet PLD.
3. Madden operates between 200 and 252 feet.
4. Miraflores Lake was not considered.
5. Evaporation loss and municipal water usages are examined.
6. Water for lane reversal, hydraulic assists, solo lockages and water required for floating deep draft ships over the middle sill at Gatun locks are not considered.
7. Water usage for Gatun hydropower generation is not considered.
8. Total usable storage includes the sum of Gatun and Madden lakes.

2.3.2 Study Cases

A mathematical simulation was performed for 19 different cases. In the simulation the total rise, ship size, width and length of the lock chamber and number of lifts were the variables examined. Applicable combinations of the above mentioned variables were formed and required water per lockage were calculated. The result of the simulation are presented in Table 2.3.1.

Based on the above table, 13 cases were selected and annual water requirements for additional transits with different ship size and water levels were calculated. The result of these calculations are shown in Table 2.3.2.

From the annual water requirement for existing plus additional transits, additional water requirements were calculated. The possible ways to supply this large volume of additional water are by construction of new dams and simultaneous use of pumps for recycling water back into the lake, or by using pumps only. Fig. 2.3.2(1) and (2) are presented for easier understanding of this aspect. Fig. (1) shows the case of simultaneous use of new dams and pumps for different increased numbers of annual transits. The dotted line designates the average discharge of Gatun watershed. The solid lines designate the water requirements for 10,000, 20,000 and 30,000 annual additional transits. The gaps between the dotted line and the solid lines are the amounts of water that have to be supplied by pumping for respective numbers of transits. Fig. (2) is the case of required pump capacities when no new dams are considered. The explanation is the same as for (1). The simulation results of required pump capacities for these cases are presented in Table 2.3.3 and Appendix AP 1-8 – 1-9. It is noteworthy to mention that in the simulation, pump capacity has been calculated without putting any limitation on the dam capacity and cumulative spill was counted as water shortage. A different simulation is required in order to know the exact pump capacity with fixed dam capacity and without spill. This case study may be done in the next phase.

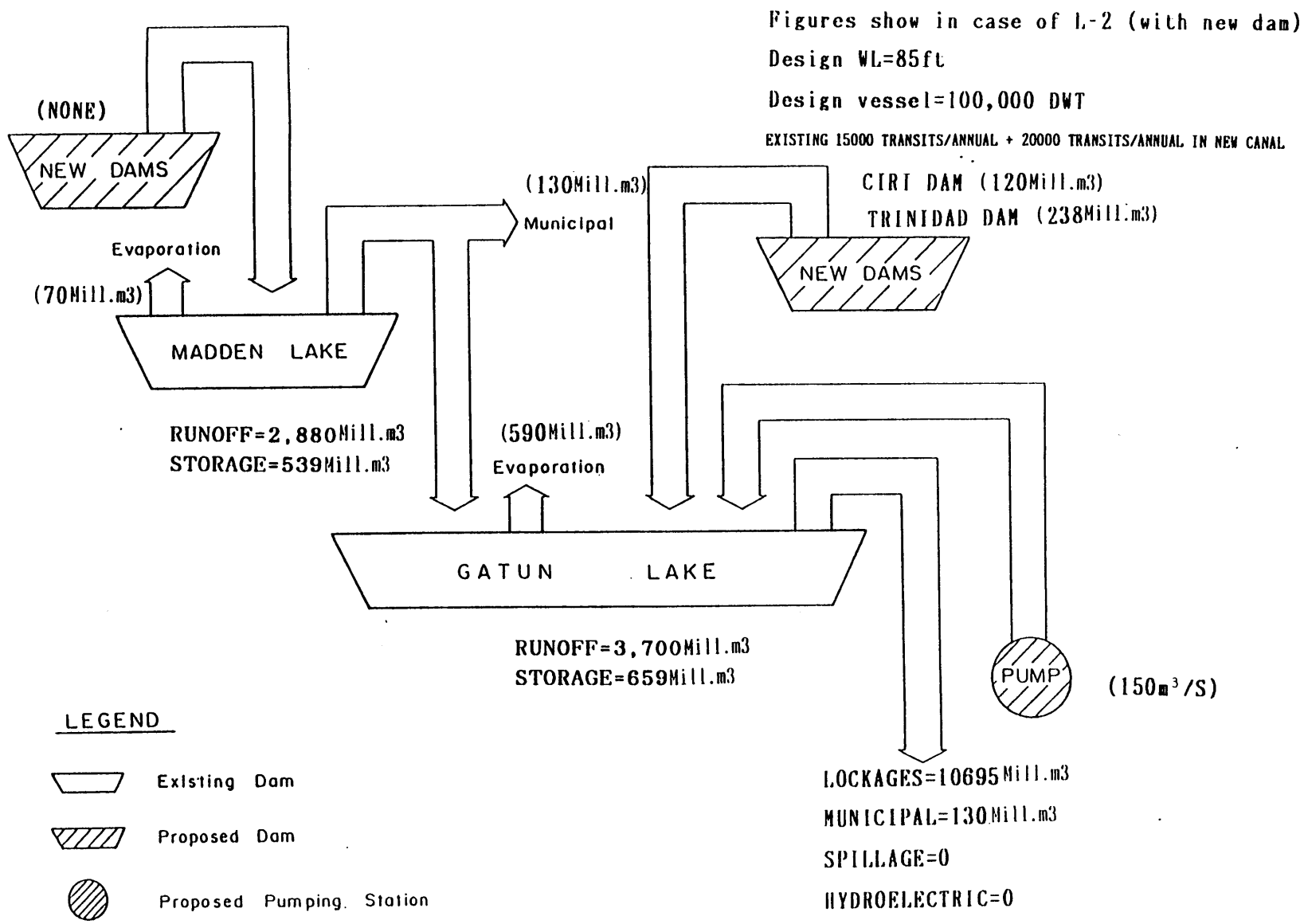
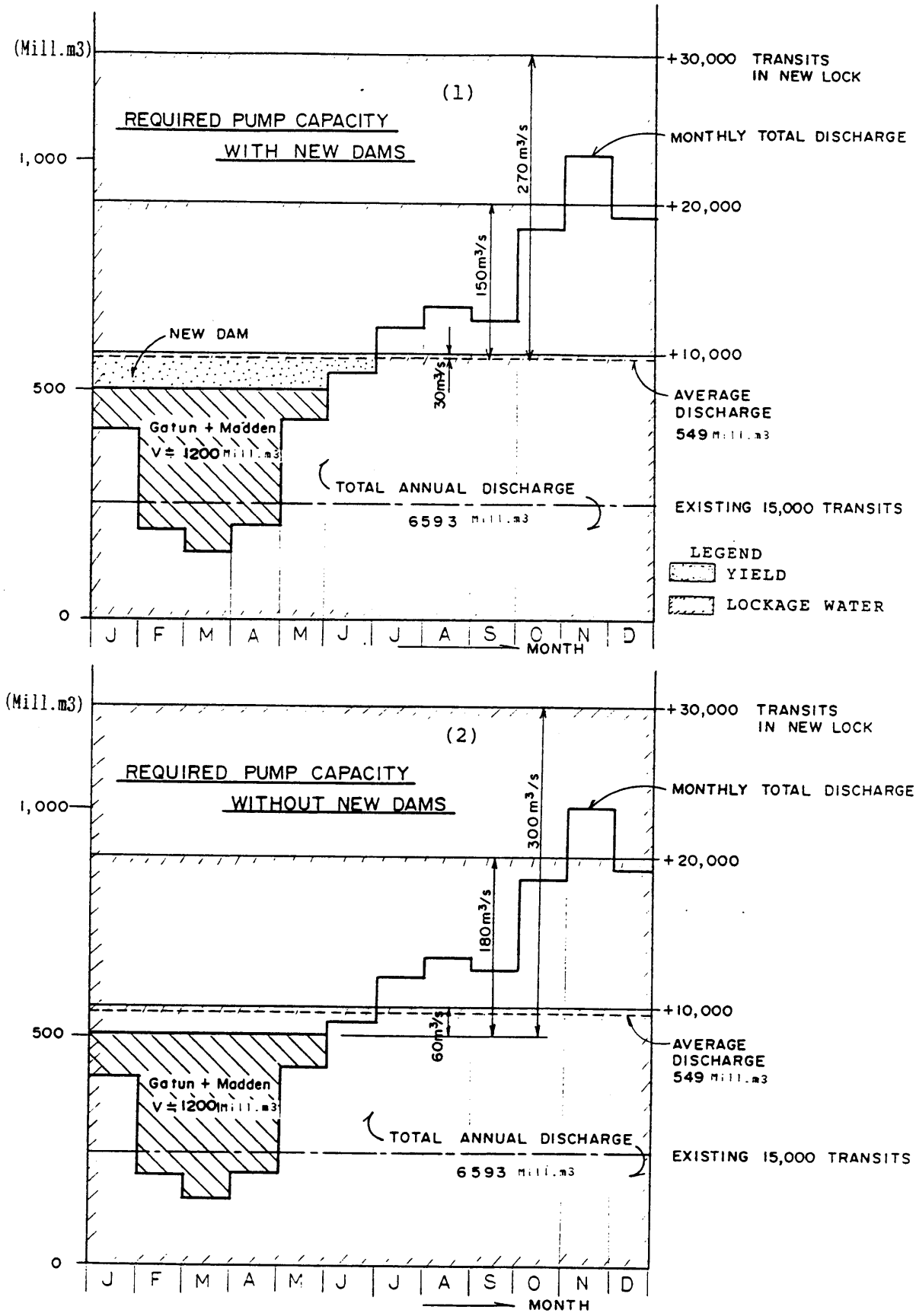


Fig. 2.3.1 Diagram for Water Supply and Usage



Note: NEW DAMS WITHIN GATUN WATERSHED

Fig. 2.3.2 Diagram for Required Pump Capacity (Case: 85FT 100,000DWT)

Table 2.3.1 Lockage Water for One Transit

CASE	RISE (ft)	SIZE $\times 10^3$ DWT	WIDTH (m)	LENGTH (m)	No. of Lift	Lockage Water ($\times 10^3$ m3)
L-1	90	100	47	319	2	409
L-2	85	100	47		2	387
L-2'	85	100	47		1	774
L-3	55	100	47		1	501
L-4	90	150	54	363	2	535
L-5	85	150	54		2	506
L-6	55	150	54		1	655
L-7	90	250	63	428	2	736
L-8	85	250	63		2	696
L-9	55	250	63		1	901
L-10	85	100	47	319	2	387
L-11	55	100	47		1	501
L-12	30	100	47		1	270
L-13	85	150	54	363	2	506
L-14	55	150	54		1	655
L-15	30	150	54		1	353
L-16	85	250	63	428	2	696
L-17	55	250	63		1	901
L-18	30	250	63		1	485

Note : Existing lockage water per one transit is 197×10^3 m^3
(Data Source : PCC Annual Report)

Table 2.3.2 Annual Lockage Water

(UNIT: MCM)

Case No.	L-12	L-15	L-18	L-3,11	L-6,14	L-9,17	L-2,10	L-2'	L-5,13	L-8,16	L-1	L-4	L-7
Water Level (Feet)	30	30	30	55	55	55	85	85*	85	85	90	90	90
Design Vessel ($\times 10^3$ DWT)	100	150	250	100	150	250	100	100	150	250	100	150	250
Existing Lock 15,000 Transits New Lock 0 Transits	2,955	2,955	2,955	2,955	2,955	2,955	2,955	2,955	2,955	2,955	2,955	2,955	2,955
Existing Lock 15,000 Transits New Lock 10,000 Transits	5,655	6,485	7,805	7,965	9,505	11,965	6,825	10,695	8,015	9,915	7,045	8,305	10,315
Existing Lock 15,000 Transits New Lock 20,000 Transits	8,355	10,015	12,655	12,975	16,055	20,975	10,695	18,435	13,075	16,875	11,135	13,655	17,675
Existing Lock 15,000 Transits New Lock 30,000 Transits	11,055	13,545	17,505	17,985	22,605	29,985	14,565	26,175	18,135	23,835	15,225	19,005	25,035

Note : *shows one lift case

Table 2.3.3 Water Balance Table

Case No.	L-12	L-15	L-18	L-3,11	L-6,14	L-9,17	L-2,10	L--2'	L-5,13	L-8,16	L-1	L-4	L-7
Design water level (FT)	30	30	30	55	55	55	85	85	85	85	90	90	90
Design vessel (1,000DWT)	100	150	250	100	150	250	100	100	150	250	100	150	250
Available water for lockage (MCM)	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
+ 10,000 Transits lockage water (MCM)	5,655	6,485	7,805	7,965	9,505	11,965	6,825	10,695	8,015	9,915	7,045	8,305	10,315
Water shortage (MCM)	155	985	2,305	2,465	4,005	6,465	1,325	5,195	2,515	4,415	1,545	2,805	4,815
Water release from new dam(MCM)	0	0	0	0	0	0	273	297	229	376	245	235	279
Water pumping (MCM)	155	985	2,305	2,465	4,005	6,465	1,052	4,898	2,286	4,039	1,300	2,570	4,536
Pump capacity(CU.M/SEC)Without new dam	10	30	70	70	120	200	30	150	70	120	40	80	140
sets of pump stations	1	1	2	2	2	4	1	3	2	2	1	2	3
Pump capacity (CU.M/SEC) with new dam	10	30	70	70	120	200	60	180	90	150	60	100	170
sets of pump stations	1	1	2	2	2	4	1	3	2	3	1	2	3
+ 20,000 Transits lockage water (MCM)	8,355	10,015	12,655	12,975	16,055	20,975	10,695	18,435	13,075	16,875	11,135	13,655	17,675
Water shortage (MCM)	2,855	4,515	7,155	7,475	10,555	15,475	5,195	12,935	7,575	11,375	5,635	8,155	12,175
Water release from new dam (MCM)	0	0	0	0	0	0	358	310	292	307	285	288	256
Water Pumping (MCM)	2,855	4,515	7,155	7,475	10,555	15,475	4,837	12,625	7,283	11,068	5,350	7,867	11,919
Pump capacity (CU.M/SEC) with new dam	90	140	230	240	340	490	150	400	230	350	170	250	380
sets of pump stations	2	3	4	4	6	9	3	7	4	6	3	5	7
Pump capacity (CU.M/SEC) with new dam	90	140	230	240	340	490	180	430	260	380	200	280	400
sets of pump stations	2	3	4	4	6	9	3	8	5	7	4	5	7
+ 30,000 Transits lockage water (MCM)	11,055	13,545	17,505	17,985	22,605	29,985	14,565	26,175	18,135	23,835	15,225	19,005	25,035
Water shortage (MCM)	5,555	8,045	12,005	12,485	17,105	24,485	9,065	20,675	12,635	18,335	9,725	13,505	19,535
Water release form new dam (MCM)	0	0	0	0	0	0	373	339	262	268	251	247	259
Water pumping (MCM)	5,555	8,045	12,005	12,485	17,105	24,485	8,692	20,336	12,373	18,067	9,474	13,258	19,276
Pump capacity (CU.M/SEC) without dam sets	180	250	380	390	540	770	270	640	390	570	300	420	610
of pump stations	3	5	7	7	9	13	5	11	7	10	5	7	11
Pump capacity (CU.M/SEC) with new dam	180	250	380	390	540	770	300	670	410	600	320	440	630
sets of pump stations	3	5	7	7	9	13	6	12	7	10	6	8	11
Actual pump head (meter)	(9.0)			(16.7)			(25.8)				(27.3)		

Note :

1) Lockage water includes the water for existing 15,000 transits.
2) Design water level 30'~55' cases have barrier dams.
3) New dam capacity is shown in AP1-9(Water balance simulation).
4) Pump capacity (1 set) = 60 cu.m/sec

2.3.3 Storage Capacity of Gatun and Madden Dam

(1) Gatun Lake

The usable storage depends upon the maximum elevation to which the lake can be filled and the minimum elevation to which the lake can be depleted. The former depends on flood control considerations and the latter on minimum draft restrictions and dam outlets. At present Gatun Lake is operated between 26.1 meter and 24.6 meter, the usable capacity is 659 million m^3 (see Fig. 2.3.3).

In the case of Gatun Lake elevation 85', planned water level changes from 82' to 87' and capacity of this 5' depth is 659 mill m^3.

If the water level of 87' becomes 90', the capacity will increase 400 mill m^3 then total capacity is 1059 mill m^3. But in this case reconsideration of lock structures and gates design and their cost are necessary.

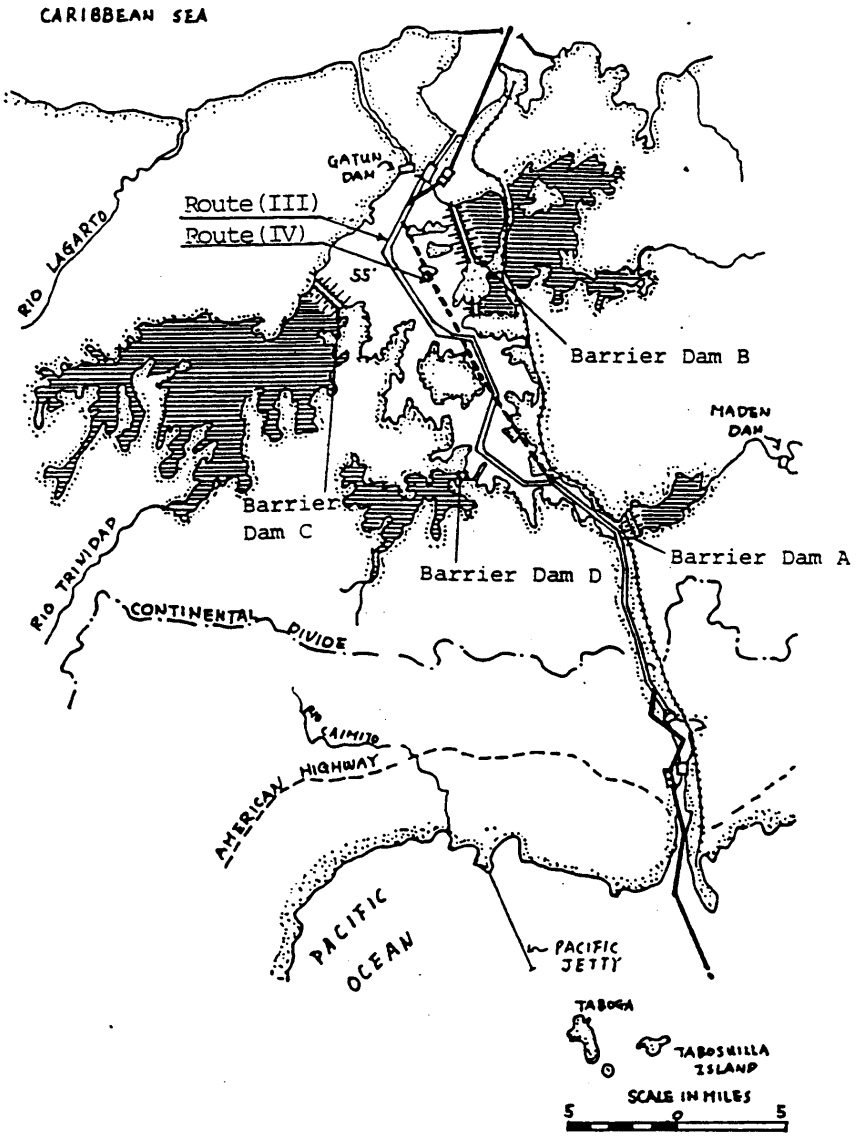
In this study, three more cases have been considered. In the case of 17.1 meter and 9.6 meter, Gatun Lake HWL levels, barrier dams will be needed to maintain the Gatun Lake water level behind the barrier dams at around 25.9 meters (see Fig. 2.3.4).

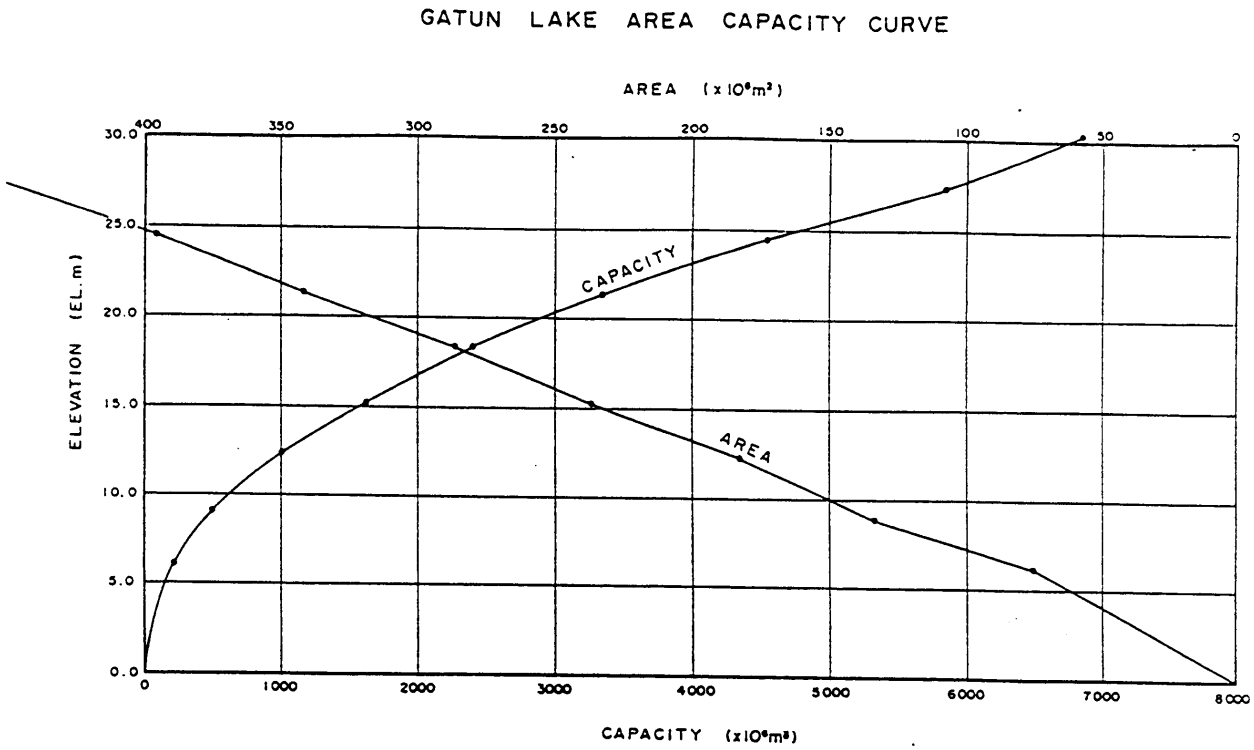
Table 2.3.4 Storage Capacity at Different Rises

Rise (ft)	L.W.L (m)	H.W.L (m)	Capacity (mil. m^3)	Note
90	26.1	27.6	664	
85	24.6	26.1	659	
55	15.6	17.1(26.1)	2,199	Barrier Dam
30	8.1	9.6(26.1)	2,314	ditto

( ) shows Gatun Lake water level behind Barrier Dams

Sketches are presented below for locations of barrier dams in Gatun Lake. Details are presented in Chapter 5.





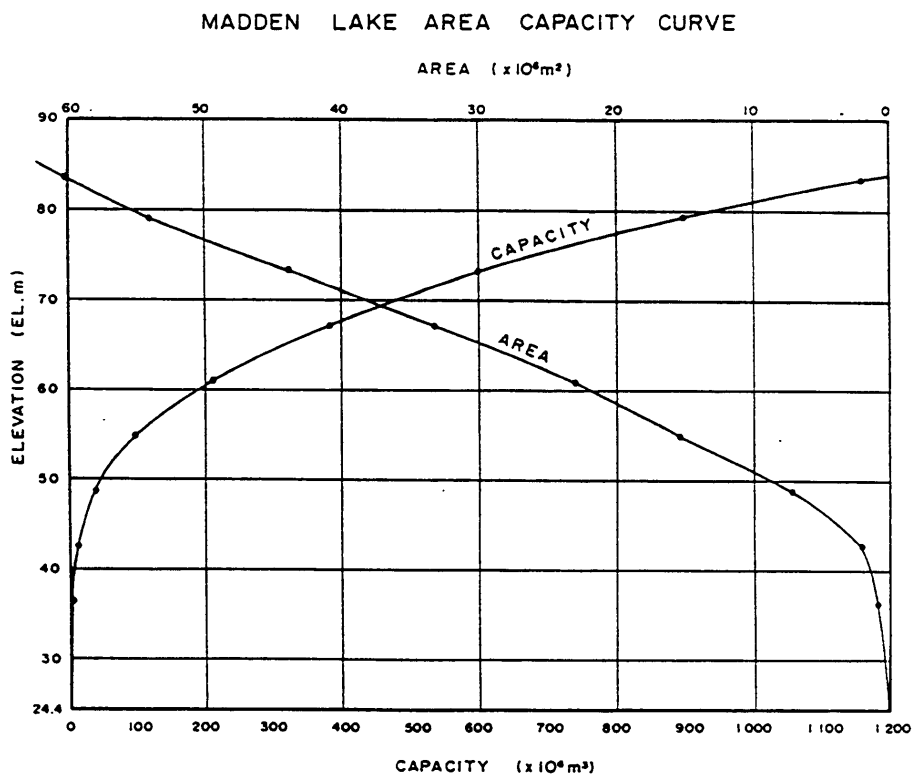
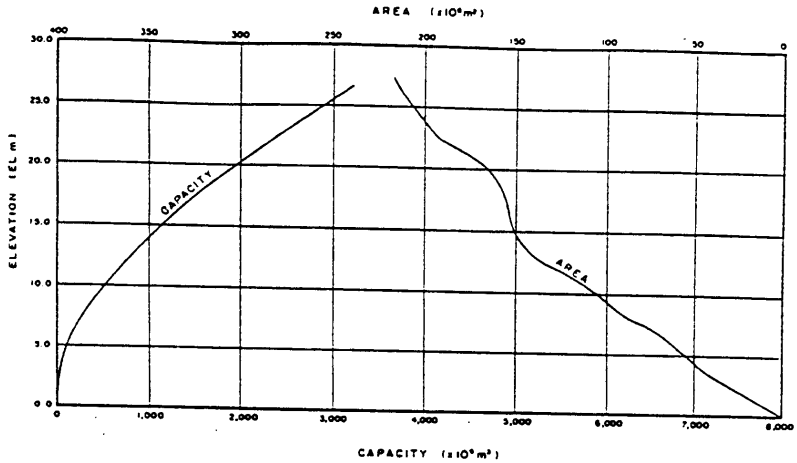
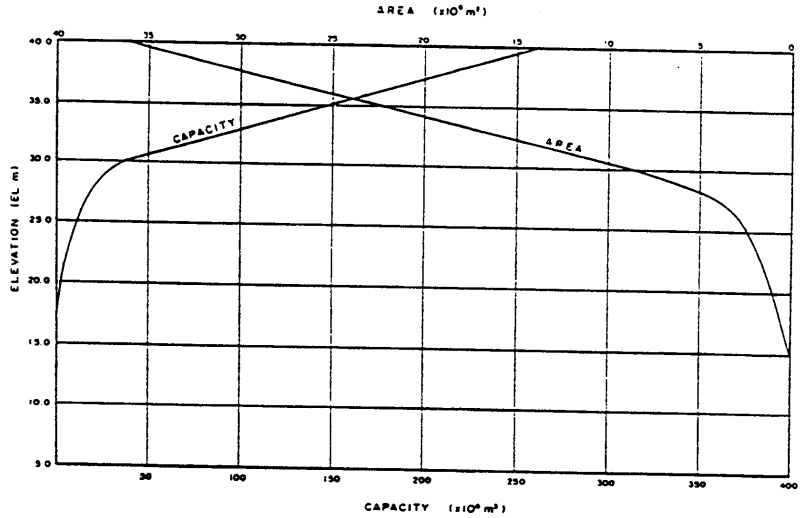


Fig. 2.3.3 Gatun Lake and Madden Lake Area Capacity Curve

GATUN LAKE WITH BARRIER DAM AREA CAPACITY CURVE



BARRIER DAM A (GAMBOA)



BARRIER DAM B (ISLAS JUAN GALLEGOS)

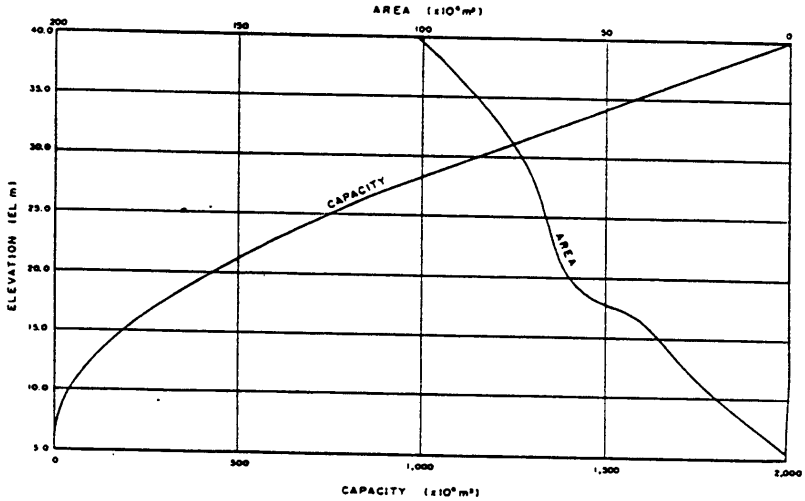
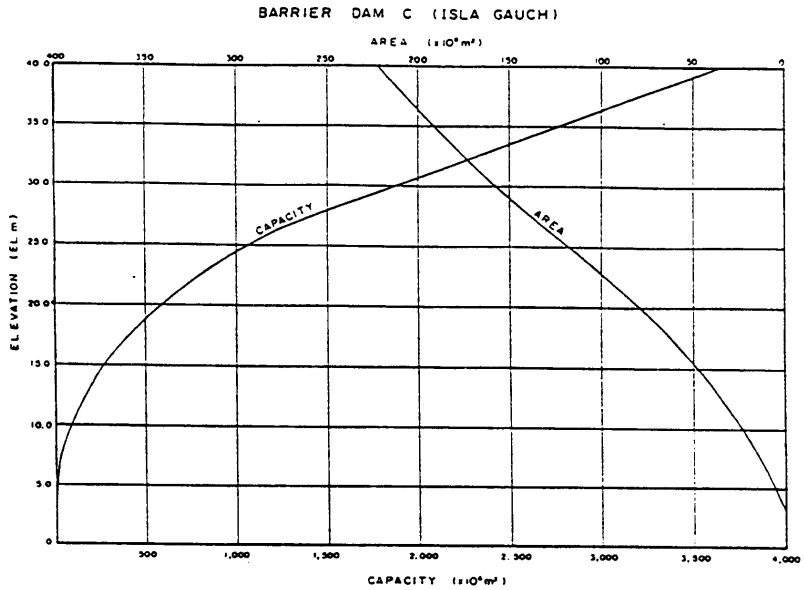


Fig. 2.3.4 (1) Barrier Dam Area Capacity Curve



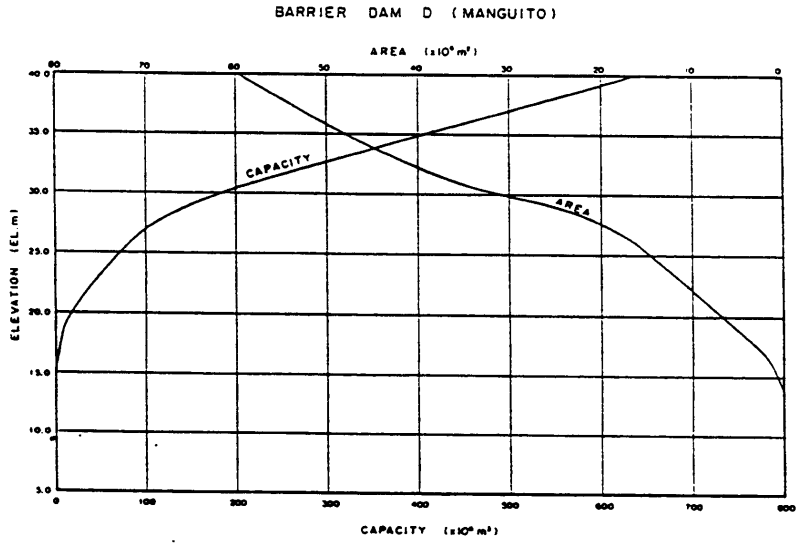


Fig. 2.3.4 (2) Barrier Dam Area Capacity Curve

(2) Madden Lake

The usable storage between elevations 76.2 meters and 61.0 meters is 539 million m^3 (see Fig. 2.3.3). Water below an elevation 61 meters is reserved for future municipal use in Panama.

2.3.4 Storage Capacity of New Dams

Present usable capacity of the two existing dams (Gatun and Madden) is about 1,200 million m^3. From the runoff-data analysis, it was found that about 2,700 million m^3 of water wasted as spill in an average year could be used more efficiently. A calculation was made of the possible number of additional transits that could be provided by utilization of the wasted water. The result of the calculation is presented below.

POSSIBLE TRANSITS BY REMAINING WATER

Design WL(ft)	30	30	30	55	55	55	85	85*	85	90	90	90	90
design Vessel($\times 10^3$)	100	150	250	100	150	250	100	100	150	250	100	150	250
Possible transits	9966	7623	5548	5371	4108	2986	6953	3476	5318	3866	6579	5029	3656

* shows one lift case

Using topographic maps and field survey data, it is apparent that there are possibilities for new dam construction within and outside the Gatun watershed. Promising sites within the Gatun watershed are at Pequeni, Trancado, Boqueron, Gatun, Trinidad and Ciri. Outside the Gatun watershed is at Indio.

However, considering the huge amount of lockage water requirement and watershed yield, total available capacity of these new dams would be limited. The relationship between discharge and dam capacity are shown in the Fig. 2.3.5(1). From the hydrograph, the average discharge line is drawn and storage capacity to average the hydrograph is calculated to be about 1,363 million m^3 (A1+A2). The capacities of Gatun and Madden reservoirs are 1,200 million m^3, which means that if new dams are constructed, maximum capacity should be 163 million m^3 (1,363-1,200) as shown. Therefore, new dams of capacity smaller or bigger than the volume of A1 would cause spill or inefficient use of the reservoirs (Fig. 2.3.5(2) and (3)). The simulation results of 13 cases for required

new dam capacity with pumps are presented in Table 2.3.3. In addition, Low rise cases show no necessity for new dams because the barrier dams capacity is about 2,000 million m^3.

A new dam could also be constructed at Indio Dam, outside the Gatun watershed. Due to the long distance, a 10 km diversion tunnel would be necessary to carry the water to the Gatun Lake.

Judging from economical conditions, new dam sites are limited. The proposed dam sites, tributaries and capacities are shown in Fig. 2.3.6, and details are presented in Chapter 5.

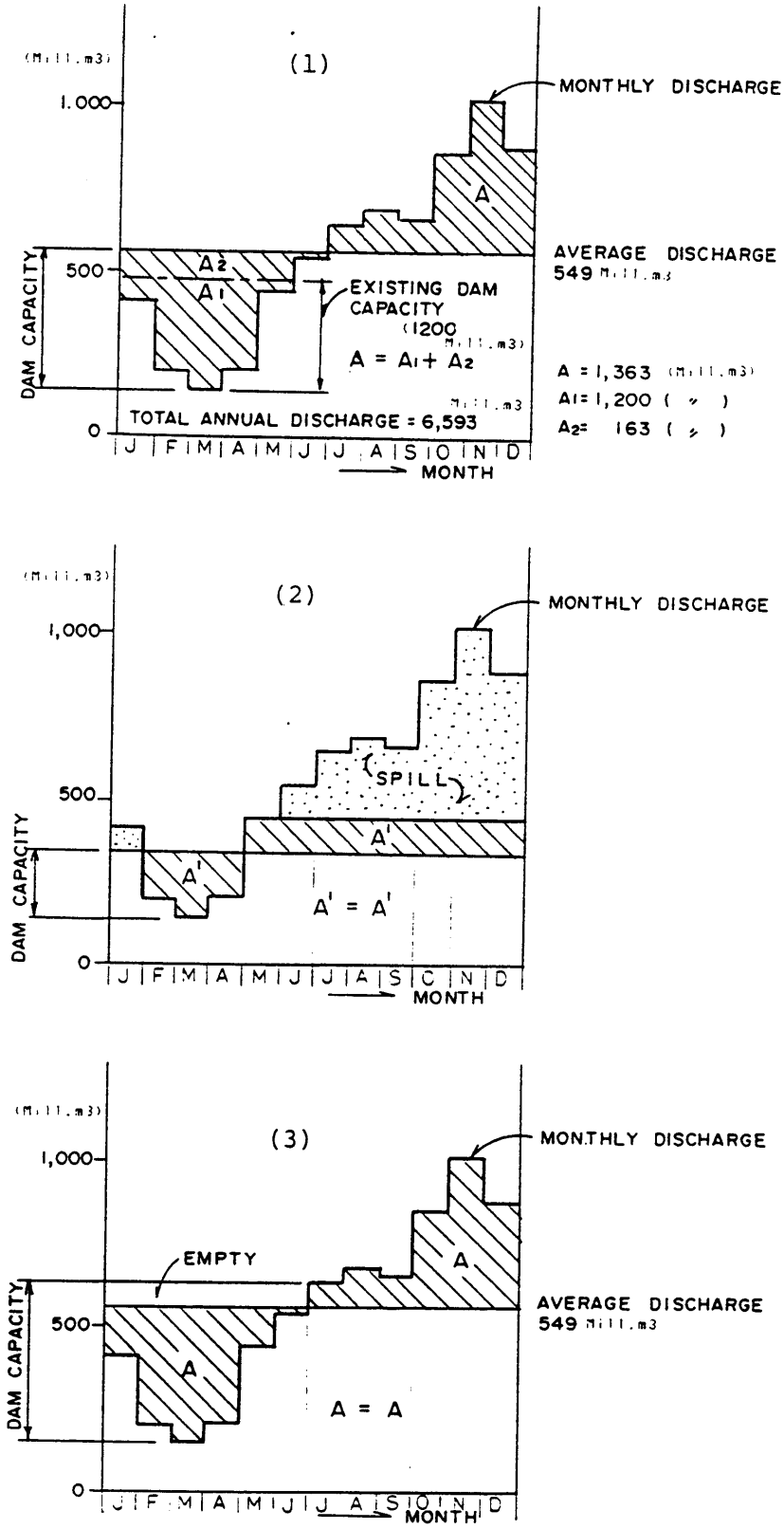
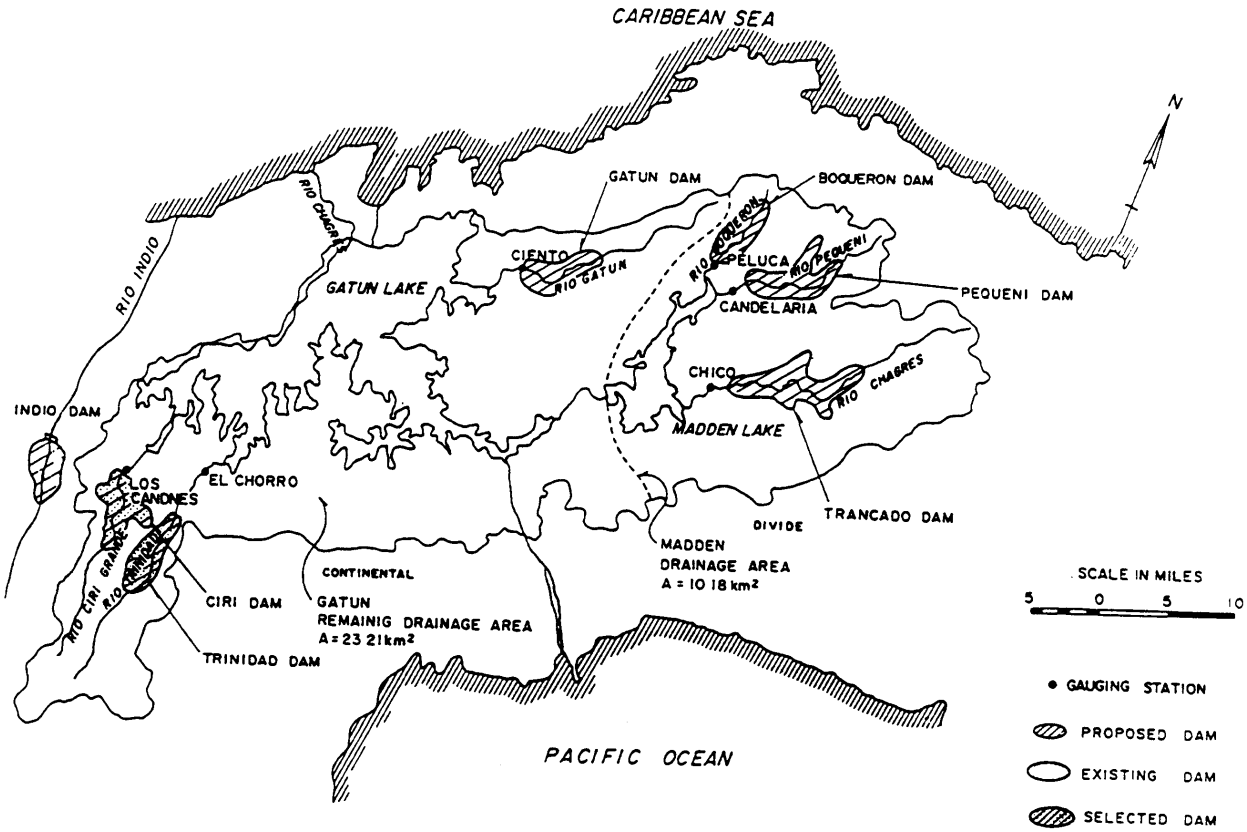


Fig. 2.3.5 Relationship between Discharge and Dam Capacity

LOCATION MAP OF EXISTING DAM AND PROPOSED DAM



Maximum Storage Capacities at Proposed Dam Sites

Dam Name	Tributary Name	Drainage Area(Km²)	Capacity (mill.m³)	Dam Height(m)	Note
Trancado	Chagres	425	---	---	
Pequeni	Pequeni	135	700	130	
Boqueron	Boqueron	95	600	110	
Gatun	Gatun	125	300	100	
Trinidad	Trinidad	165	700	90	Selected
Ciri	Ciri Grande	190	250	80	ditto
Indio	Indio	380	700	90	

Note : 1) Storage capacities (maximum) were estimated considering topographical condition only.
2) Storage capacity of Trancad dam were not estimated due to a lack of topographical maps.

Fig. 2.3.6 Proposed Dam Sites and Storage Capacity

2.4 Water Circulation Plan (Indirect System)

2.4.1 Basic Concept

Though the storage volume can be increased by adding new dams above Gatun and Madden lakes, total catchment yield is generally not sufficient to provide the required lockage water for the lock systems proposed at this time. Therefore the use of pump stations to recycle lockage water was proposed.

The number of pump stations needed depends on the study case, in particular the size of locks and number of ship transits. Considering the L-1 case, pump stations are not necessary when lockage water is available from existing lakes and from the two new dams, but if lockage water is available only from existing lakes, then two pump stations are required. For the L-2' case with a single lift, twelve pump stations are needed with the two new dams, and thirteen pump stations are needed without the two new dams.

2.4.2 Pump Stations

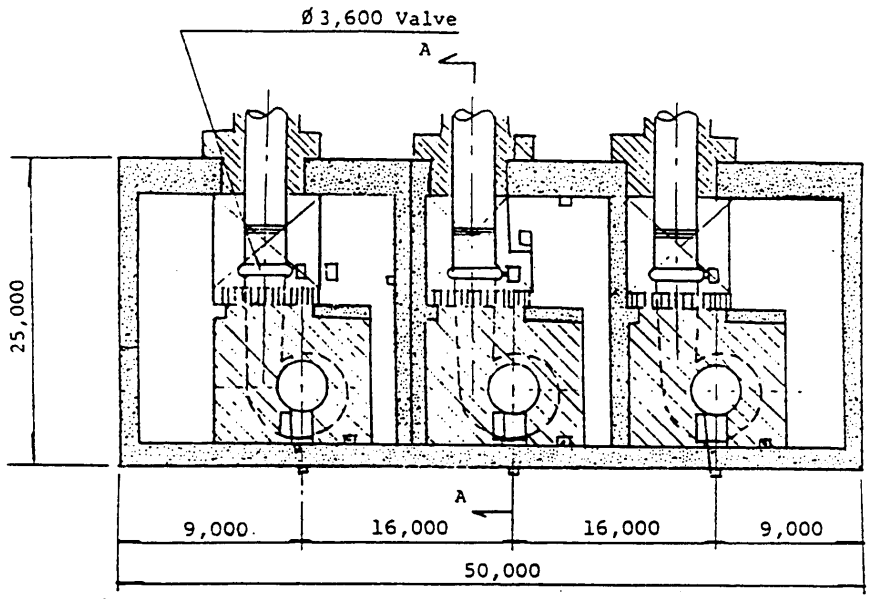
A pump station consists of three pumps (including one spare pump) and the characteristics of each pump are shown in Table 2.4.1.

A schematic drawing is shown in Fig. 2.4.1.

Table 2.4.1 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)

PLAN



A-A SECTION

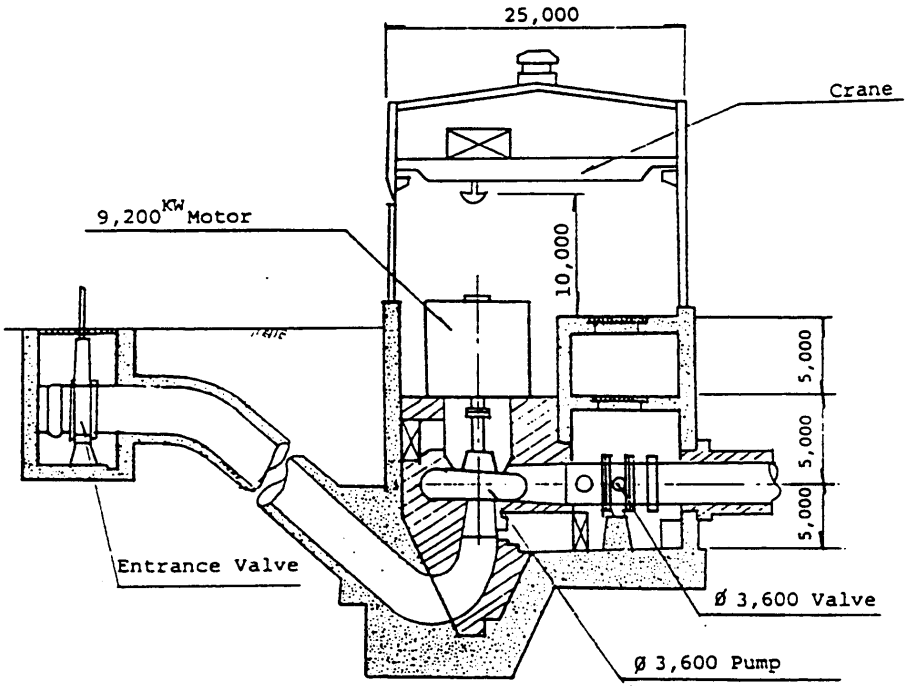


Fig. 2.4.1 Schematic Drawing of Pumps

2.5 Water Circulation Plan (Direct System)

2.5.1 General

In section 2.4, the indirect pumping method was discussed. Here the forced discharge method with pumps from one lock chamber to the neighboring lock chamber will be considered. However, according to the entering and outgoing ship schedule, a special chamber for water storage purposes between the lock chambers may be necessary.

This is the preferred method among the three methods for conserving lake water that were previously proposed. (Reference: "Consideration for Lockage System and Water of L. Canal" by T. Mochizuki.)

Pedro?

1) Counter balanced lock system (proposed by Mr. Lopez)
2) Air-lift lock system (proposed by Mr. Omachi)
3) Parallel lock system (proposed by Mr. J.A. Morales)

In one, there is a vertically movable steel floor on the bottom of the lock chamber. By moving this floor vertically using compressed air, the water level of a lock chamber is raised or lowered, and the lock may be operated in the same way as a conventional lock. In this case there is almost no consumption of lockage water.

In two, instead of mechanically moving a steel floor up and down, in simple terms, rubber balloons (or rubber chambers) are inflated with air and the water in the lock chamber is moved up and down, performing the lock operation.

In three, water drainage and infill is performed using a pump system from one lock chamber to the neighboring chamber.

Of these three proposals, one and two use air methods and with further study are considered feasible. However, a study of such an advanced system, including cost analysis, would be very difficult; and such a study of methods one and two is not proposed at this stage.

However, with regard to method three , there are no particular technical problems using existing technology, and this method is proposed for the purposes of this study.

The pump capacity requirements and electrical power requirements are given in more detail below.

2.5.2 System

The system proposed is shown in Fig. 2.5.1. As a ship enters the lock from the lake the gate is closed, and the valve is opened whereby the water in chamber A drains initially by gravity to chamber B, and then a pump system expels further water from chamber A to chamber B, raising chamber B to the required level.

Consideration as to the increase in Gatun Lake's salinity should be closely studied.

2.5.3 Pump Specifications

The following specifications are for pumps that can expel and flood water into and out of 250,000 ton lock chambers in 10 minutes. The movement of water from right to left or left to right is controlled by valve operation.

1)	Type	MESV.
2)	Head	15 m
3)	Discharge rate	33.3 m^3 / sec
4)	Number of pumps / lock chamber	20 units
5)	Motor output	6,000 kw

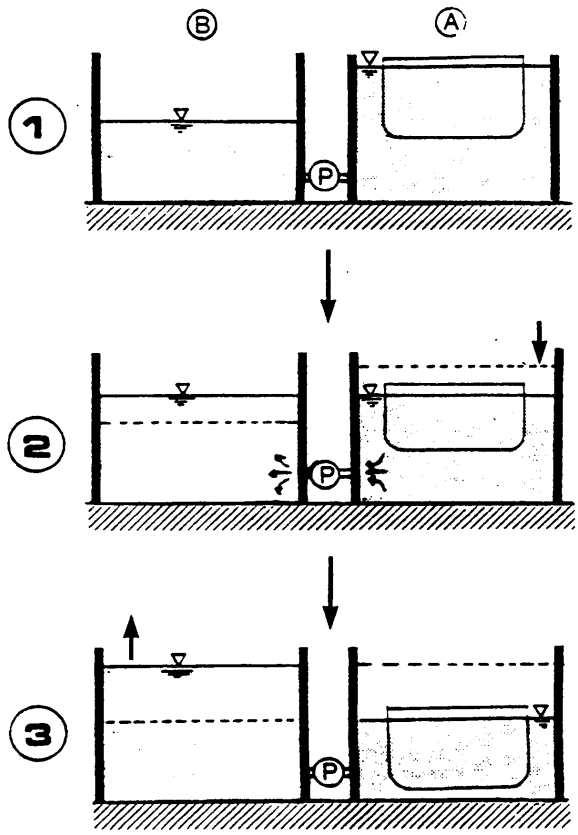


Fig. 2.5.1 Direct Pumping System

2.6 Flood Control and Potential Use of Excess Runoff

2.6.1 Flood Control and Inlet Facilities

(1) Flood Control Facilities

Flood control measures must be taken when considering the following alternatives:

a) Low rise lock (WL.55'-30')

When this alternative is considered construction of Barrier dams will separate the Gatun Lake watershed into five independent reservoirs (Fig. 2.6.1). Modification of Pedro Miguel Lake and Gatun Lake spillways will be required due to the reduction in water level from 85' to 55'/30'. Flood control measures incorporating new spillways at four dam sites are needed, and also a diversion culvert between dam C and D has to be provided in order to maintain the same water level. The flood control plan for the Low Rise Lock case is shown in Fig. 2.6.1. Details of Barrier dams are presented in Chapter 5.

b) Sea Level Canal (Route-10)

A sea level canal along the Route-10 alignment would intercept the drainage of several major streams from the west side, but would leave the drainage pattern of streams on its east side relatively intact. Uninterrupted operation of the existing lock canal could continue both during and after construction of sea level canal. The Gatun Dam will continue to control the runoff from the Chagres and Gatun Rivers. Dams will be required on the east side of the canal to retain Gatun Lake at its operating level, and on the west side a culvert is required to divert the Trinidad and Ciri Rivers in order to control any possible flooding. The proposals are shown in Fig. 2.6.2.

c) Sea Level Canal (Route-14S)

In this plan, the existing canal will be used as it is, but three new dams must be constructed. Flood

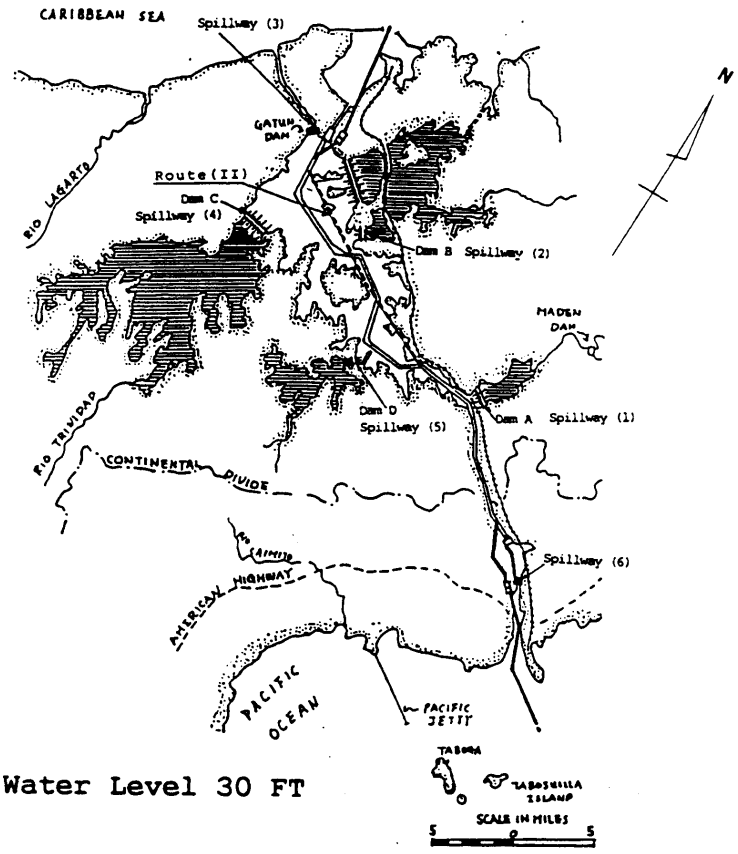
control measures would not be required during the construction stage because flood water could be released through the existing Gatun Spillways. As a flood control structure after construction, the Chagres diversion plug at Gamboa is required in order to divert the flood of Chagres River to the Pacific Ocean. The plan is shown in Fig. 2.6.2.

(2) Inlet Facilities

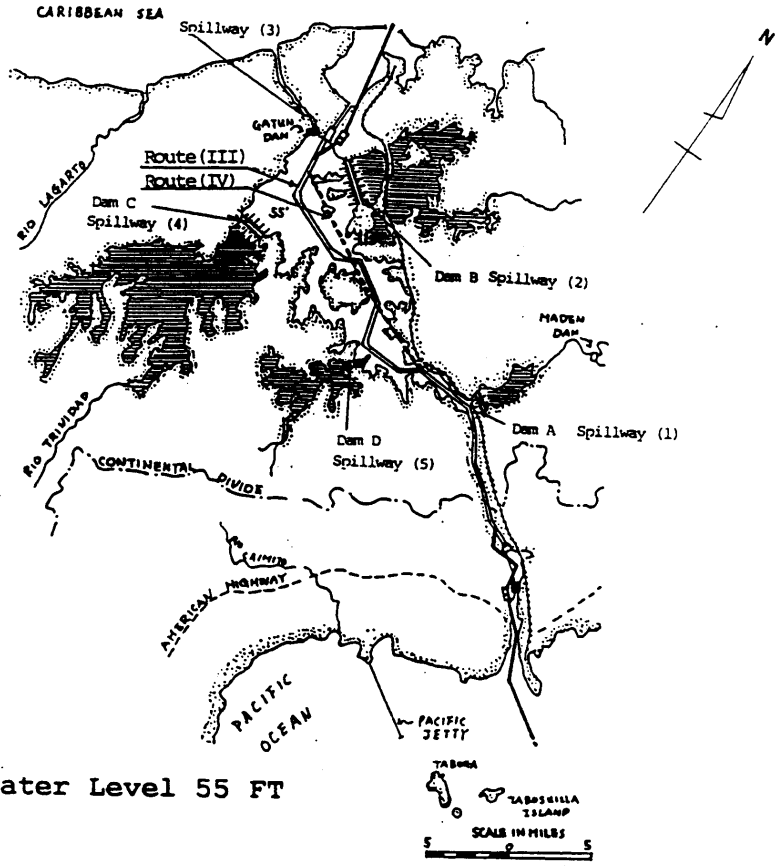
In Low Rise Lock Case, inlet facilities are required to intake water from barrier dams to facilitate lockages. Considering the fluctuations of water levels, orifice gate type inlet structures are suggested (See Fig. 2.6.3).

2.6.2 Potential Use of Excess Runoff

In the previous chapters, various flood control measures according to alternatives were described. Due to the geotechnical configuration of the project area, each alternative has dams as main components. Also, these dams can serve as hydroelectric power generation units using the excess runoff, reservoirs as fish culture/recreational purposes etc. Therefore, during the planning/design stage an indepth study should be carried out considering the above mentioned potentials and subsequent environmental impacts.

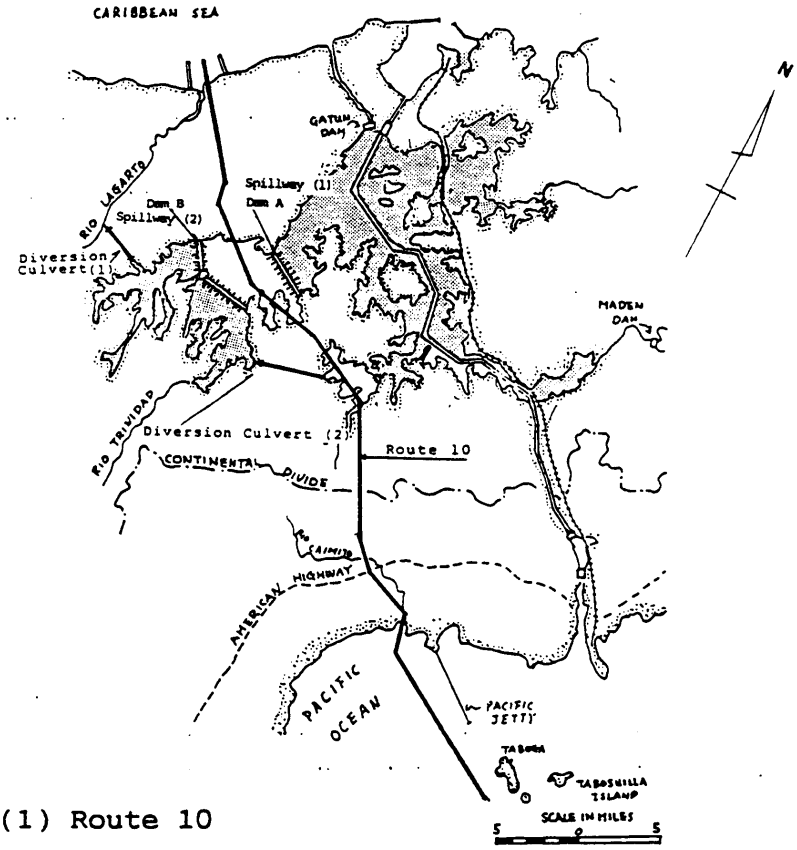


(1) Design Water Level 30 FT

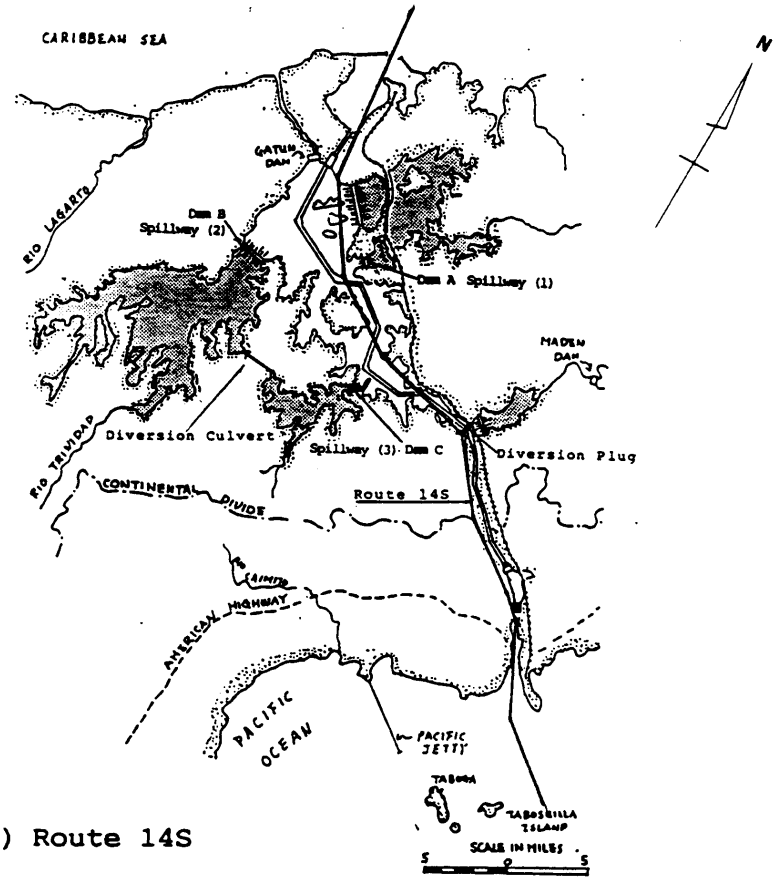


(2) Design Water Level 55 FT

Fig. 2.6.1 Flood Control Plan for Low Rise Case

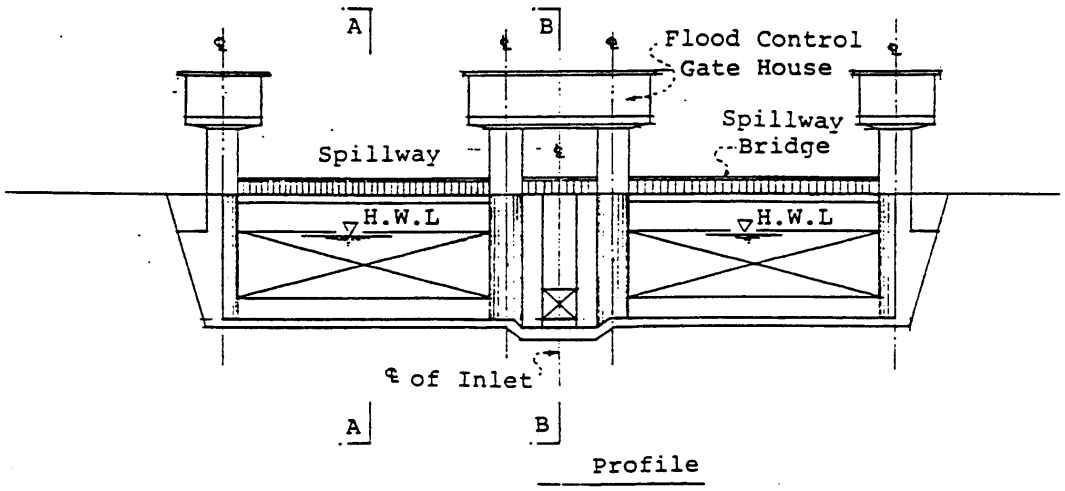


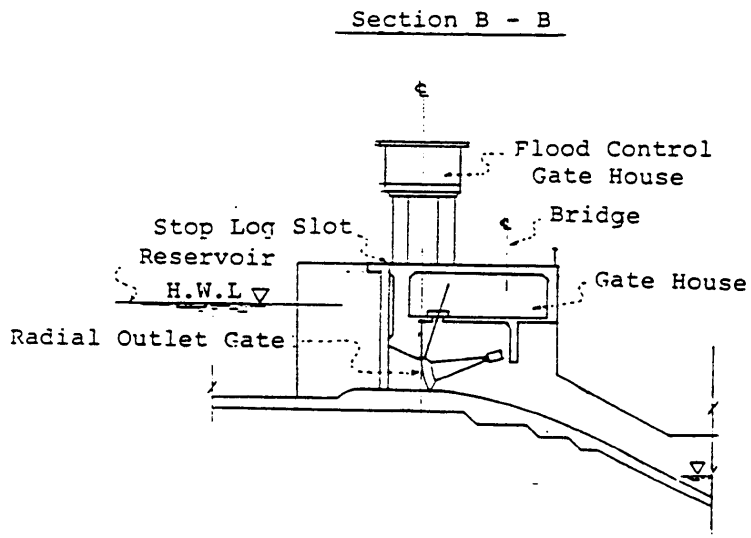
(1) Route 10



(2) Route 14S

Fig. 2.6.2 Flood Control Plan for Sea Level Canal Case





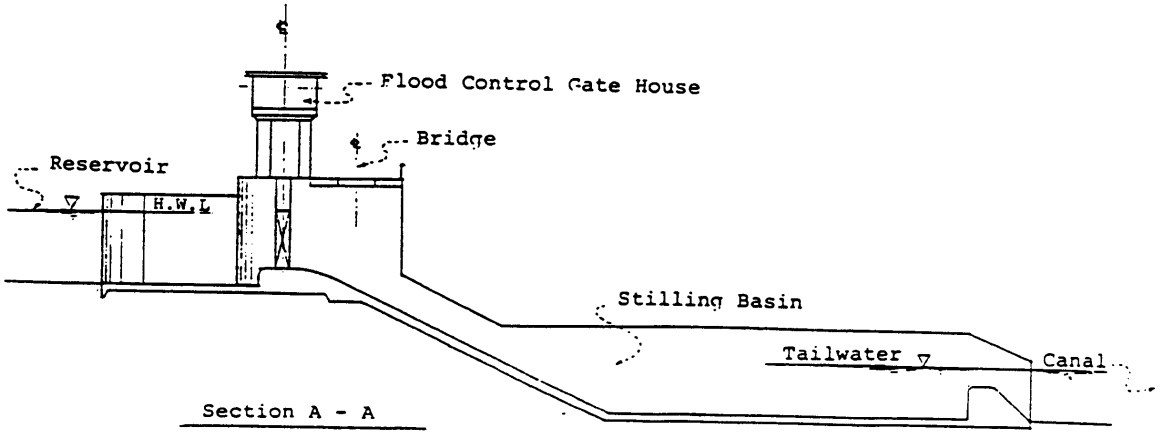


Fig. 2.6.3 Typical Spillway and Inlet Structure

2.7 Technical Feasibility

2.7.1 New Dams

Judging from the technical points of view considered in the preliminary analysis it seems there are no major engineering difficulties in the construction of new dams at the sites mentioned above. However, considering the hydrological points of view mentioned in the water management plan, total available capacity of new dams within the Gatun watershed would be limited. A detailed study should be performed which would include geological, hydrological and aerial surveys to confirm the technical feasibility, as well as visual reconnaissance should also be carried out in order to determine the number of inhabitants who would have to be resettled to a safer place outside the dam area. A study should also be done on the environmental aspects. Moreover, an economic comparison between the other alternatives should be considered.

2.7.2 Pump Station

Technically, construction of pump stations and the availability of pumps, with appropriate capacity and quality required for the purpose, would not be a problem. Nevertheless, a detailed study of the environmental impacts, including salinity effects on the Gatun watershed and other environmental impacts upon surrounding areas resulting from recycling water, particularly for the indirect system, should be carried out. An economic analysis should also be performed.

2.7.3 Barrier Dams

Technically, construction of barrier dams would not be a problem. However, flood control measures during and after construction should be taken into consideration. Likewise environmental impacts should also be assessed.

CHAPTER 3 - CANAL EXCAVATION PLAN

3.1 General

There are four routes under consideration for the Lock Systems. The four routes are made up of variations in the vicinity of Miraflores Lake and alternative alignments through a part of Gatun Lake. In addition, there are two proposals for sea level canals, a route (Route 10) well away from the existing canal, and a route (Route 14S) which mainly follows the existing canal.

Innovatory method of handling materials will be considered to be available in an actual construction time. But manufacturing, operational and maintenance costs of such innovative equipment are not available from any manufacturers without detailed specification in Phase 1 Study, therefore we recommend such innovatory equipment system is to be studied in Phase 2 Study.

3.1.1 Route I (Route 15 + Third Lock) (Ref. Fig. 3.1.1)

This lock system route makes as much use as possible of the existing canal. Then, existing Miraflores locks and Pedro Miguel lock are to be used in the same situation as present lock system. New Miraflores locks in the Pacific side would be constructed on the west side of the existing canal. The route detours around the existing Gatun Locks in the Atlantic side. New Gatun Locks, and the approach channel, would be constructed on the east side of the existing locks.

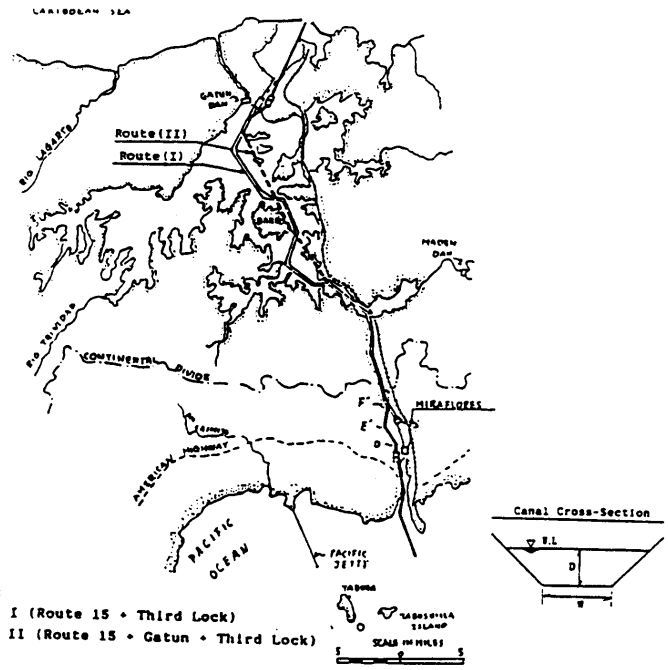
From the Caribbean approach, Route I drives to the east of the existing route 3 km north of the existing Gatun Locks. It passes through the new locks and joins Gatun Lake merging with the existing route. The route of the channel in Gatun Lake would be almost the same as the existing channel route, with the new canal being widened on the western side of the existing canal to accommodate new requirements. At Pedro Miguel Locks and Miraflores Lake, the route detours and takes a new direction on the western side of the existing canal. The new route is on the opposite side of Cerro Nitro and may impact its residential area. A new bypass canal connects to the new Miraflores Locks. The proposed new Miraflores Lock site

is approximately 1 km away to the western side of the existing locks. The Pacific approach on Route I joins the existing canal approximately 3 km to the Pacific side of the new Miraflores Locks via an area proposed and canceled in the 1940's for the Third Lock new route. It is proposed that from this point to the Pacific, the western side of the existing route be widened. The distance between the new Gatun Lock and the new Miraflores Lock will be about 55 km.

3.1.2 Route II (Route 15 + Gatun + Third Lock) (Ref. Fig. 3.1.1)

The approach sections are basically the same as Route I, but the route is shorter than Route I by about 6 km over the Gatun Lake section.
From Gatun Locks to the Gamboa entrance, Route II follows almost a straight line course and then follows the existing route for about 4 km on the east side of Barro Colorado.

The distance between the new Gatun Lock and the new Miraflores Lock is about 49 km.



Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
L-1	I	90'	2	2	100	301 x 18.7
2	I	85'	2	2	100	301 x 18.7
4	I	90'	2	2	150	343 x 20.9
5	I	85'	2	2	150	343 x 20.9
7	I	90'	2	2	250	399 x 24.2
8	I	85'	2	2	250	399 x 24.2
2'	I	85'	1	2	100	301 x 18.7
10	II	85'	2	2	100	301 x 18.7
13	II	85'	2	2	150	343 x 20.9
16	II	85'	2	2	250	399 x 24.2

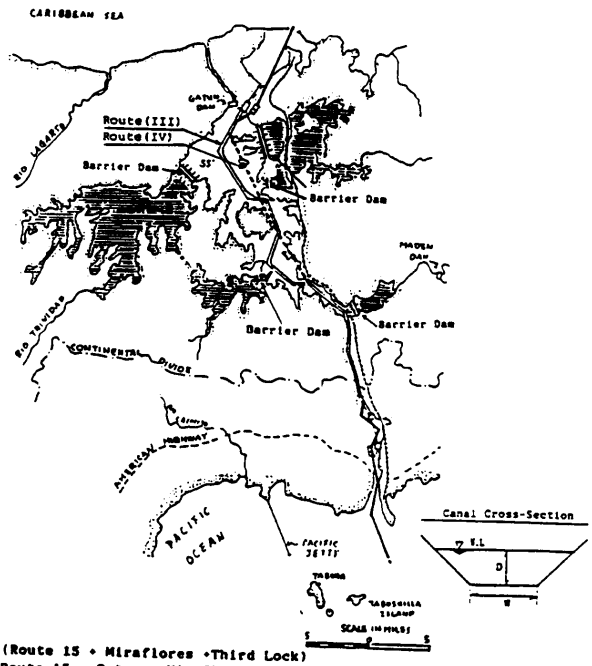
Fig. 3.1.1 Layout of High Rise Lock System for Route I and II

3.1.3 Route III (Route 15 + Miraflores + Third Lock) (Ref. Fig. 3.1.2)

Route III is basically the same as Route I. The lock rise is 55 feet so that Miraflores Lake can be used and the existing route can be followed. The new locks on this route are in different locations from those of the existing canal.

3.1.4 Route IV (Route 15 + Gatun + Miraflores + Third Lock) (Ref. Fig. 3.1.2)

Basically the same as Route II, however, there is a 55 foot lock rise and Route IV therefore passes along Miraflores Lake the same way as Route III. New locks will be constructed.



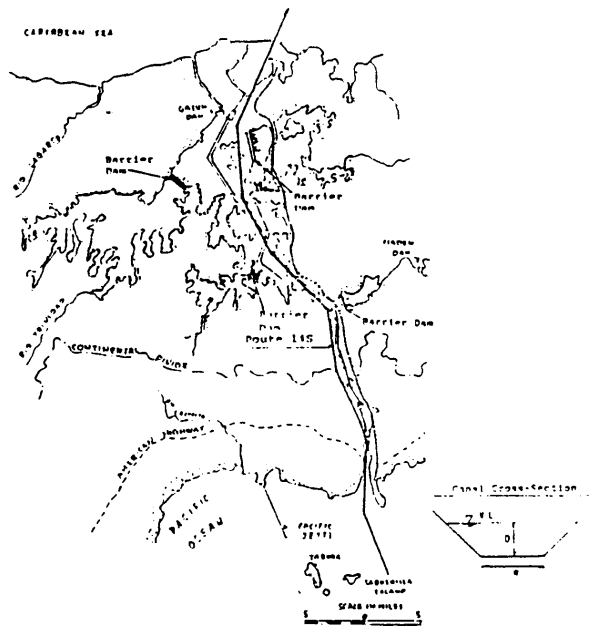
Note:
Route III (Route 15 + Miraflores +Third Lock)
Route IV (Route 15 + Gatun + Miraflores + Third Lock)

Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
L-3	III	55'	1	2	100	301 x 18.7
6	III	55'	1	2	150	301 x 20.9
9	III	55'	1	2	250	399 x 24.2
11	IV	55'	1	2	100	301 x 18.7
14	IV	55'	1	2	150	343 x 20.9
17	IV	55'	1	2	250	399 x 24.2
L-12	II	30'	1	2	100	301 x 18.7
15	II	30'	1	2	150	343 x 20.9
18	II	30'	1	2	250	399 x 24.2

Fig. 3.1.2 Layout of Low Rise Lock System for Route III and IV

3.1.5 Route 14S (Ref. Fig. 3.1.3)

This is a sea level route which basically follows the existing route. The approach section is the same route as the lock canal proposals but crosses the existing route at two places on Gatun Lake, the Gamboa section and the Barro Colorado section.



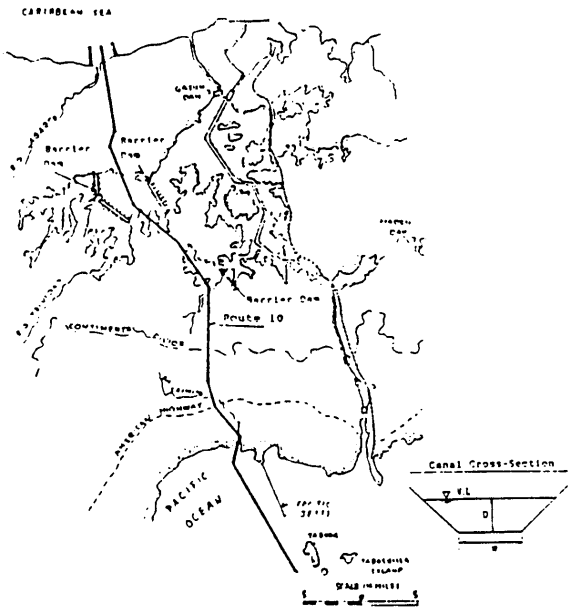
Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
S-7	14S	0	-	1	150	147 x 20.9
8	14S	0	-	2	150	343 x 20.9
9	14S	0	-	1	250	171 x 24.2
10	14S	0	-	2	250	399 x 24.2
11	14S	0	-	1	300	183 x 25.3
12	14S	0	-	2	300	424 x 25.3
16	14S	0	-	50%-1	150	147 x 20.9
				50%-2		343 x 20.9
17	14S	0	-	50%-1	250	171 x 24.2
				50%-2		399 x 24.2
18	14S	0	-	50%-1	300	183 x 25.3
				50%-2		424 x 25.3

Fig. 3.1.3 Layout of Sea Level Canal for Route 14S

3.1.6 Route 10 (Ref. Fig. 3.1.4)

Located approximately 16 km to the south-west of the existing route, using the plains section of Cano River, Gatun Lake and Caimito River.

This route is a sea level proposal passing along the Nuebo Chagres on the Caribbean Sea side and along the Puerto Caimito on the Pacific coast side.



Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size W (m) D
S-1	10	0	-	1	150	147 x 20.9
2	10	0	-	2	150	343 x 20.9
3	10	0	-	1	250	171 x 24.2
4	10	0	-	2	250	399 x 24.2
5	10	0	-	1	300	183 x 25.3
6	10	0	-	2	300	424 x 25.3
13	10	0	-	50%-1	150	147 x 20.9
				50%-2		343 x 20.9
14	10	0	-	50%-1	250	171 x 24.2
				50%-2		399 x 24.2
15	10	0	-	50%-1	300	183 x 25.3
				50%-2		424 x 25.3

Fig. 3.1.4 Layout of Sea Level Canal for Route 10

3.2 Geology

3.2.1 General Geology

As is shown in Fig. 3.2.1, using the plate tectonics principle, the Panama Canal Area is located at the southern tip of the Caribbean plate.

In the south western part of the Panama isthmus the Cocos Plate slides in under the Caribbean plate making up the border of the Middle American Arc. In addition, in the western part of the Canal Area a transformation feature, the Panama fracture zone, runs north to south. Looking at the Canal Area geologically over a wide area, it is in a complex geological area with the 3 plates (Cocos plate, Nazca plate and Caribbean plate) all converging.

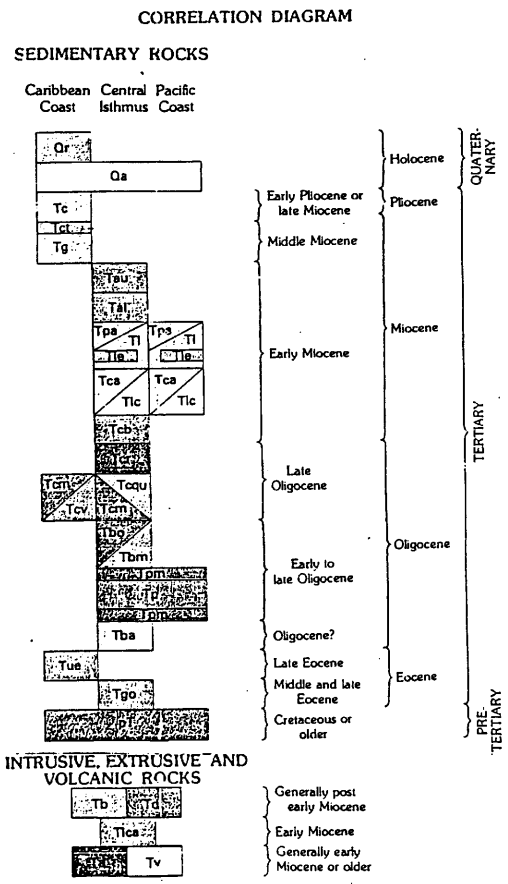
Fig. 3.2.1 Lithospheric Plates of the Middle America Region

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

3.2.2 Topography and Geology of The Canal Area

The Central Panama isthmus, located between the Panama bay in the Pacific and the Caribbean sea in the Atlantic ocean, generally runs in an east-west direction with the north-south width of the country being approximately 80 kms. The characteristics of the geology forming the topography of the Canal Area are well reflected in the central part where the Continental Divide runs east to west. The topography of this area is made up of tertiary formations presenting a gentle hill-like mountain range. Other characteristics include a plateau made up of basalt lava and cone-like topography made up of intrusive basalt. On the Caribbean sea side and Panamanian bay side, the areas with these characteristics are small and plains made up of alluvial sediment predominate.

As shown in Fig. 3.2.2, the Canal Area bed rock is made up of tertiary sedimentary rocks and extrusive or intrusive volcanic rocks. In addition, on the Caribbean side plains there is a distribution of quaternary sediments and along the Caribbean sea channel there are distributions of coral reefs. Moreover there are no active quaternary time volcanoes in the Canal Area.



LEGEND FOR GEOLOGIC MAP OF PANAMA AND CANAL ZONE

Undivided Holocene sediments, principally alluvium or fill	Qa	Sedimentos Holocenos, no diferenciados, principalmente aluvion o relleno
Holocene fringing coral reefs	Or	Arrecifes coralíferos Holocenos
Chagres Sandstone, late Miocene or early Pliocene. Massive, generally fine-grained sandstone	Tc	Arenisca Chagres, Mioceno superior o Plioceno inferior. Arenisca maciza, generalmente de grano-fino
Toro Limestone, basal member of Chagres Sandstone. Coquina	Tct	Caliza Toro, miembro basal de formación arenisca de Chagres, coquina
Gatun Formation, middle Miocene. Sandstone, siltstone, tuff and conglomerate	Tg	Formación Gatún, Mioceno medio. Arenisca, lutita, toba y conglomerado
Alhajuela Formation, upper member, late early Miocene. Tuffaceous sandstone, calcareous sandstone and limestone	Tsu	Formación Alhajuela, miembro superior, Mioceno inferior superior. Arenisca tobacea, arenisca calcarea y caliza
Alhajuela Formation, lower member, late early Miocene. Calcareous sandstone.	Tal	Formación Alhajuela, miembro inferior, Mioceno inferior superior. Arenisca calcarea
La Boca Formation, early Miocene. Mudstone, siltstone, sandstone, tuff and limestone	Tl	Formación La Boca, Mioceno inferior. Esquito arcilloso, lutita, arenisca, toba y caliza
Emperador Limestone, member in lower La Boca. Coralíferous limestone	Tle	Caliza Emperador, miembro en La Boca inferior. Caliza coralífera
Pedro Miguel Formation, early Miocene. Fine-to coarse-grained agglomerate	Tpa	Formación Pedro Miguel, Mioceno inferior. Aglomerado, grano-fino-a grueso
Cucaracha Formation, early Miocene. Bentonic clay shale, carbonaceous clay shale and in lower part, a thin ash flow tuff	Tcr	Formación Cucaracha, Mioceno inferior. Arcilla laminada bentonítica, arcilla laminada carbonífera y en la parte inferior, una capa delgada de ignimbrita
Las Cascadas Formation, early Miocene. Agglomerate and soft, fine-grained tuff	Tlc	Formación Las Cascadas, Mioceno inferior. Aglomerado y toba suave de grano-fino
Culebra Formation, early Miocene. Calcareous sandstone and siltstone	Tcu	Formacion Culebra, Mioceno inferior. Arenisca calcarea y lutita calcarea
Caraba Formation, late Oligocene. Principally a dacite porphyry agglomerate. In type area, conglomerate, fossiliferous calcareous sandstone and limestone	Tcb	Formación Caraba, Oligoceno superior. Principalmente aglomerado de dacitico porfido. En area typo, conglomerado, arenisca calcarea y caliza, ambas fosíileras
Calmito Formation, late Oligocene, marine. Tuffaceous sandstone, tuffaceous siltstone, tuff and foraminiferal limestone	Tcm	Formación Caimito, Oligoceno superior, marino. Arenisca tobacea, lutita tobácea, toba y caliza foraminifera
Caimito Formation, volcanic facies, late Oligocene. Agglomerate and tuffaceous graywacke	Tcv	Formación Caimito, facies volcanicas, Oligoceno superior. Aglomerado y gruuvaca tobacea
Quebrancha Limestone, member of Calmito Formation, late Oligocene. Foraminiferal limestone and calcareous siltstone	Tcqu	Caliza Quebrancha, miembro de la formacion Caimito, Oligoceno superior Caliza foraminifera y lutita calcárea
Bohio Formation, early to late Oligocene. Conglomerate, principally basaltic and graywacke sandstone	Tbo	Formación Bohío, Oligoceno inferior a superior. Conglomerado principalmente basaltico y arenisca (grauvaca)
Bohio Formation, marine facies, early to late Oligocene. Calcareous sandstone and small-pebble conglomerate	Tbm	Formación Bohío, facies marino, Oligoceno inferior a superior. Arenisca calcárea y conglomerado con guijarros pequenos
Panama Formation, early to late Oligocene. Principally agglomerate, generally andesitic in fine-grained tuff. Includes stream-deposited conglomerate	pm	Formación Panamá, Oligoceno inferior a superior. Principalmente aglomerado generalmente andesítico en tobas de grano-fino. Incluye conglomerado depositado por corrientes
Panama Formation, marine facies, early to late Oligocene. Tuffaceous sandstone, tuffaceous siltstone, algal and foraminiferal limestone. Sandy siltstone in basal part of formation in Quebrancha syncline	pm	Formación Panamá, facies marino, Oligoceno inferior a superior. Arenisca tobácea, lutita tobacea, caliza algacea y foraminifera. Lutita arenosa en la parte basal en el sinclinal Quebrancha
Bas Obispo Formation, Oligocene(?). Agglomerate and hard tuff	Tba	Formación Bas Obispo, Oligoceno(?). Aglomerado y toba dura
Marine rocks, late Eocene. Sandstone and siltstone	Tue	Rocas marinas. Eoceno superior. Arenisca y lutita
Gatuncillo Formation, middle and late Eocene. Mudstone, siltstone, quartz sandstone, algal and foraminiferal limestone	Tgo	Formación Gatuncillo, Eoceno medio a superior. Esquisto arcilloso, lutita, arenisca de cuarzo, caliza algácea y foraminifera
Pre-Tertiary. Altered basaltic and andesitic lavas and tuff. Includes dioritic and dacitic intrusive rocks	p	Anti-Terciario. Lavas y tobas basálticas y andesíticas alteradas. Incluye rocas intrusivas dioríticas y daciticas
INTRUSIVE, EXTRUSIVE AND VOLCANIC ROCKS		ROCAS INTRUSIVAS, EXTRUSIVAS Y VOLCANICAS
Intrusive and extrusive basalt, middle and late Miocene	Tb	Basalto, intrusivo y extrusivo, Mioceno medio y superior
Intrusive dacite and dacite porphyry, Miocene	Td	Dacita, intrusiva y dacita porfido, Mioceno
Andesite, equal in age to Las Cascadas Formation, early Miocene	Tlca	Andesita, la misma edad de formacion Las Cascadas, Mioceno inferior
Intrusive and extrusive andesite, Oligocene and early Miocene	Tv	Andesita, intrusiva y extrusiva, Oligoceno y Mioceno inferior
Volcanic rocks, undifferentiated, generally early Miocene or older	T	Rocas volcanicas no diferenciadas, generalmente Mioceno inferior o mas viejo
Contact		Contacto
Fault—Dashed where approximately located; dotted where concealed. Ball and bar on downthrown side; arrows show relative horizontal movement		Falla—Linea interrumpida donde su localid es approximada; punteada donde su localidad es cubierta. Bola y barra indica el desplazamiento descendente; flechas indican el movimiento horizontal relativo
Strike and dip of beds		Direccion y buzamiento de los estratos

Fig. 3.2.2 Schematic Stratigraphy in the Canal Area

Source: Geological Map of the Panama Canal and Vicinity, Republic of Panama (1980) R.H and J.L. Stewart et al

3.2.3 Seismology in Panama

For the seismic intensity scale, "The modified metrical scale of 1931" is now used by the Balboa Heights Seismological Observatory in Panama. It is believed that the earthquake of September 1882 is the most severe since 1502 and is rated VI to VII on the Modified Mercalli Scale of 1931. It will be noted that this scale is based on human observation and not instrumental recordings. The number of seismic disturbances felt by Canal Area residents from 1909-1965 are shown below. Scales representing more than V are not recorded for this period.

Scale	Times
I	77
II	107
III	79
IV	36
V	9
Total	308

Modified Mercalli Intensity Scale of 1931 is shown in the following page.

(Source: IOCS Memorandum PCC-3, Seismological History of the Canal Area and Panama.)

Table 3.2.1 Modified Mercalli Intensity Scale of 1931

I	Not felt except by a very few under especially favorable. (I Rossi-Forel scale)
II	Felt only by a few persons at rest, especially on upper floors of . Delicately suspended objects may swing. (I to II Rossi-Forel scale)
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations like a passing truck. Duration estimated. (III Rossi-Forel scale)
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked notice ably. (IV to V Rossi-Forel scale)
V	Felt by nearly everyone; many awakened. Some dishes, windows, etc. broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VII Rossi-Forel scale)
VI	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel scale)
VII	Everybody runs outdoors. Damage negligible to buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars. (VIII Rossi-Forel scale)

VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbed persons driving motor cars. (VIII+ to IX Rossi-Forel scale)
IX	Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel scale)
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel scale)
XI	Flew, if any, masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

3.2.4 Geology along The Routes

(1) Geology along Route I and III (R 15 + Third lock)

On the Pacific and Caribbean sides, with the exception of a part of the third lock alignment, Route-I is on the same alignment as the existing canal. Through the Continental Divide Route I is parallel to the existing canal but almost 1 km to the south.

The geology of the bed rock along Route-I is divided into four divisions consisting of the Pacific Coast, the Continental Divide, Gatun Lake and the Caribbean Coast. The characteristics of each zone are outlined below. Refer to Fig. 3.2.2 and Fig. 3.2.3 for a more detailed description of each formation type.

a) Pacific Coast Zone: Ranging from the Pacific Coast to the Pedro Miguel lock.

This zone is made up of the four main formations listed below.

Panama Formation	(Tpm)
La Boca Formation	(Tl)
Pedro Miguel Formation	(Tpa)
Intrusive and extrusive Basalt	(Tb)

Panama Formation and La Boca Formation are found along the coast and the third lock excavation is made up of Basalt. There are no large land slides and the geology is stable.

b) Continental Divide

This zone extends from the Pedro Miguel locks to the Rio Limon Fault, and is made up of the six main formations listed below.

Pedro Miguel Formation	(Tpa)
Cucaracha Formation	(Tca)
Culebra Formation	(Tcb)
La Boca Formation	(Tl)
Las Cascadas Formation	(Tlc)
Intrusive and extrusive Basalt	(Tb)

With the exception of the basalt, all are formations of the Miocene period and will result in land slides on the excavation slopes. In particular Route I passes through 3 km of the Cucaracha Formation which is interbedded with clay shale, likely to lead to major land slides.

c) Gatun Lake Zone: This zone extends from the Rio Limon Fault to the Gatun Lake coast and wholly contained within Gatun Lake. This zone is made up of the three main formations listed below.

Bas Obispo Formation	(Tba)
Bohio Formation	(Tbo)
Caimito Formation	(Tcm, Tcv)

These three formations are made up of an Oligocene formation and major land slides will not occur inside these formations.

d) Caribbean Coast: This zone extends from the Gatun Lake coast to the Caribbean ocean and includes the third lock excavation site. This zone is made up of the two main formations listed below.

Gatun Formation	(Tg)
Undivided Holocene Sediments	(Qa)

In this area the topography is gently sloping and there are no likely problems concerning land slides. It should also be noted that there are coral reefs.

(2) Geology along Route II and IV (R 15 + Third lock + Gatun Lake)

There are no great differences in alignment between Route I and Route II. On the Pacific and Caribbean coasts and through the Continental Divide, Route I and Route II are the same.

In the Gatun Lake zone most of the route runs to the north of the existing canal but is made up of the same kind of geology as Route I.

(3) Geology Along Route 10

The basic geology along Route 10 is divided into the following five main categories.

a) Atlantic coast plain

b) The Atlantic coast to the north shore of Gatun Lake

c) The north shore of Gatun Lake to the mouth of Rio Pescado

d) The mouth of Rio Pescado to the Rio Caimito plain

e) The Rio Caimito plain to the Pacific coast

The geological characteristics of each zone are outlined below.

a) Atlantic coast plain

Quaternary sediments are dispersed over Chagres sandstone which is the base rock in the coastal vicinity. The sediments (non-solid sand, silt and clay) are dispersed along the coast and in a narrow area around the river mouth with the thickness of sediments to be less than 10 m.

b) Atlantic coast to the north shore of Gatun Lake

The geography in this area is hilly with gentle mountain slopes and the basic geology is made up of tertiary miocene Chagres sandstone formations and Gatun formations (sandstone, silt, tuff and conglomerate).

The base is a semi-hard mass and there is no possibility of major landslides.

c) The north shore of Gatun Lake to the mouth of Rio Pescado

This sector applies to the Gatun Lake region. The geology is tertiary oligocene Caimito formation tuffaceous sandstone, tuffaceous siltstone, tuff and limestone). The rock base is stable with no possibility of major landslides.

d) The mouth of Rio Pescado to the Rio Caimito plain

This sector geographically applies to the Continental Divide. The geology is tertiary miocene volcanic rocks which is made up of volcanic pyroclastic rock (tuff, agglomerate etc.) and intrusive and extrusive basalt with the distribution being very complex. The condition of rocks is generally softened because of alteration. In particular altered tuff could become a cause for landslides.

e) The Rio Caimito plain to the Pacific coast

The sector geographically applies to the Rio Caimito mouth vicinity and the rock base is made up of quaternary unconsolidated sediments (sand, silt and clay).

3.2.5 Rock Base Categories for Excavation

Excavation is divided into land based open excavation (dry) and water based dredging (underwater).

Excavation on land is divided into rock and earth excavation. The former is divided into the following four categories with consideration of the rock base hardness and bedding.

a) High quality rock
b) Intermediate quality rock
c) Low quality rock
d) Soft rock

Earth excavation is generally unconsolidated sediments.

In summarizing existing information, all formations appearing on the respective routes and depths of the weathered zones are categorized as shown in Fig. 3.2.3.

	Rock Classification		Formation	Depth of Weathered Zone (Weathered ← → Sound)
Open Excavation	Rock	High Quality Rock	. Basalt (Tb) . Intrusive Dacite, Porphyry and Andesite (Td.Tlca, Ta.Tv) . Pedro Miguel F. (Tpa) . Bas Obispo F. (Tba) . Emperador L.S. (Tle)	2m Sound Rock Zone 2m
		Intermediate Quality Rock	. Toro L.S. (Tct) . Gatun F. (Tg) . Bahio F. (Tbo.Tbm) . Caimito F. (Tcm) . Marine rocks (Tue) . Gatuncillo F. (Tgo)	5m 10m
		Low Quality Rock	. Las Cascadas F. (TlC) . Culebra F. (Tcb) . La Boca F. (Tl) . Panama F. (Tp.Tpm)	Weathered Rock Zone all
		Soft Rock	. Cucaracha F. (Tca)	10m all
	Earth	Unconsolidated Sediments		
Dredging	Sedi-ments	Loose Material (Sand & Pebble)		
		Clayey Material (A. Muck) (P. Muck)		all
	Soft Rock	Weathered Rock (Altered Rock)		Weathered Rock Zone all

Fig. 3.2.3 Classification of Rocks and Sediments for Excavation

Note: Rock classification and soil strata characteristics are based on IOCS JAX. 96.

3.3 Excavation Volume

3.3.1 Excavation Zoning

With consideration to the canal structure, construction method and excavation volume, each route is divided into five zones. These zones consist of the Atlantic approach, Gatun Lake, Continental Divide, Miraflores and the Pacific approach.

(1) Zones of Route I, II, III, IV

a) Atlantic approach zone (Zone I)

The section between the Atlantic Ocean and Gatun Lock, depending on the size of the ships targeted 11.8 km - 12.5 km in length. Excavation in this zone will be carried out completely by dredging.

b) Gatun Lake zone (Zone II)

Extending from the Gatun Lock to the Rio Chagres, Routes I and III will use the existing route with the west side of the canal to be expanded and its length is 42 km. Excavation for these routes will be almost all by dredging in the Gatun Lake. Routes II and IV will be shortcuts of the existing route with a length of 36 km. There are a large number of islands on Gatun Lake that intersect this route but excavation for the most part is calculated as dredging work. However, in the area around Island Barbacoa there are a number of areas where dry excavation is feasible and will be carried out.

c) Culebra zone (Zone III)

A 10 km sector extending from Gamboa to Paraiso using the existing route with the west side of the canal to be expanded. Excavation will be carried out in 2 steps. Step 1: dry excavation works leaving the section where the canal and dry excavation areas meet is executed. Step 2: then the section remaining will be dredged.

d) Miraflores zone (Zone IV)

The sector between Paraiso and the Miraflores Lock with routes I and II is 9 km, and routes III and IV is 9.2 km. The dredging and dry excavation method in this sector will be the same as in the Culebra zone.

e) Pacific approach zone (Zone V)

The sector between the Miraflores Lock and the Pacific Ocean, depending on the size of the vessels targeted, will be 14.3 km - 21.9 km in length. Because this zone is almost all maritime, excavation will use the dredging method.

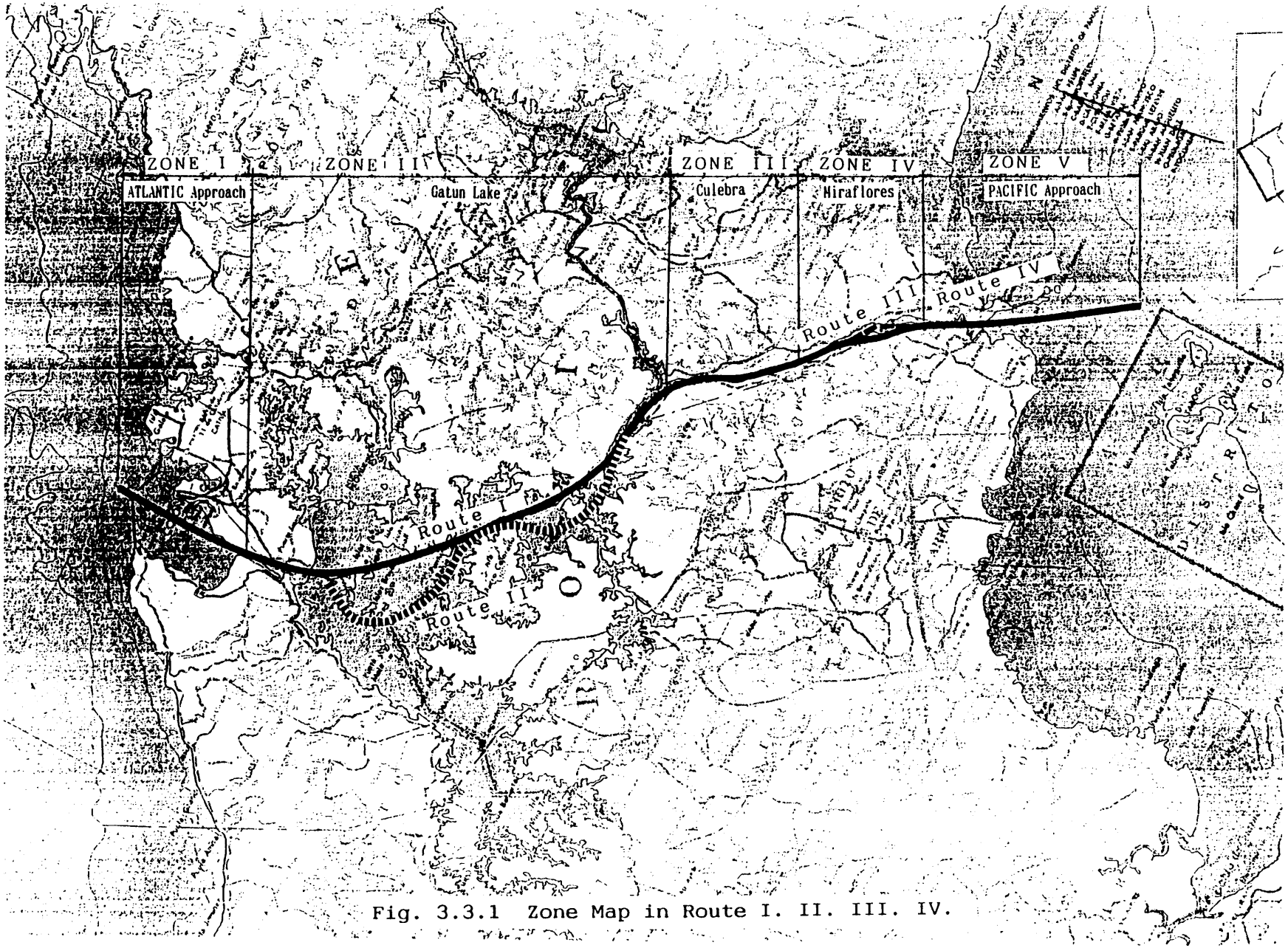


Fig. 3.3.1 Zone Map in Route I. II. III. IV.

(2) Route 14S

a) Atlantic approach zone (Zone I)

The section between the Atlantic Ocean and Gatun Lock, depending on the size of the vessels targeted 12.1 km - 12.6 km in length. Excavation in this zone will be carried out by dredging.

b) Gatun Lake zone (Zone II)

Extending from Gatun Lock to Juan Grande where the width of Gatun Lake narrows, the zone is 22 km in length. This route sector is the same as that in routes II and IV. This sector intersects the existing canal route in four places. To insure safe ship operation in the existing canal, all excavation works will be done by dredging method.

c) Culebra zone (Zone III)

This zone extends 27 km from Juan Grande to Paraiso with the route alignment running 1 - 2 km to the west side of, and parallel to the existing canal. It is calculated that the sectors in the existing Gatun Lake will be excavated by dredging while the remaining sectors will be done by dry excavation.

d) Miraflores zone (Zone IV)

The sector extending 4 km from Paraiso to Miraflores Lake is basically the same as routes I and III. Dry excavation and dredging in this zone will be carried out in the same method as routes I and III.

e) Pacific approach zone (Zone V)

The sector between the Miraflores Lock and the Pacific Ocean, depending on the size of the vessels targeted, will be 17.5 km - 23.2 km in length. Because this zone is almost all maritime, excavation will be carried out using the dredging method.

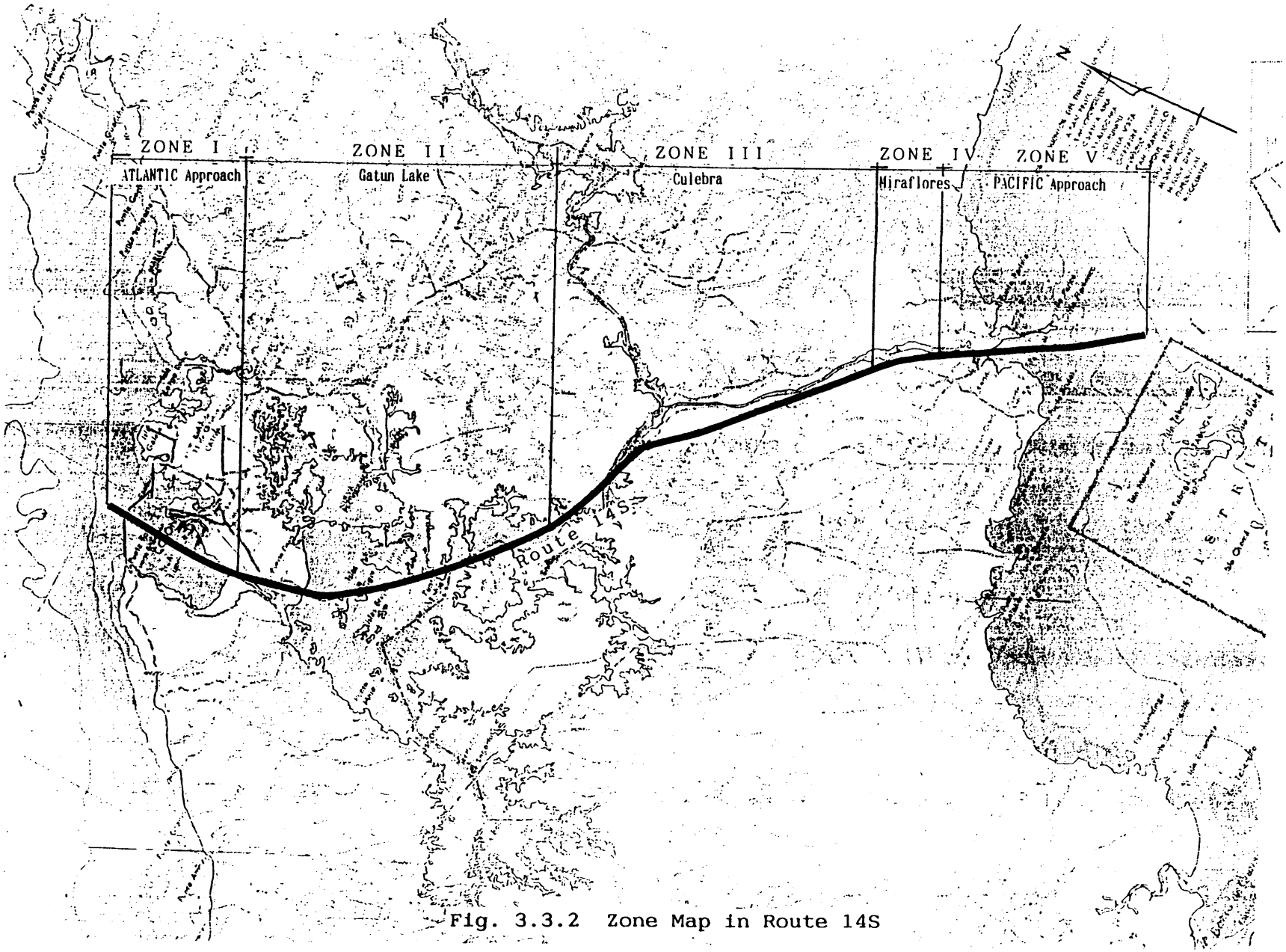


Fig. 3.3.2 Zone Map in Route 14S

(3) Route 10

a) Atlantic approach zone (Zone I)

This zone extends from the Atlantic Ocean to the coast line 3 km to the north east of Nuevo Chagres on the river mouth of the Rio Lagarto. Depending on the size of the vessels targeted, it will be 3.5 km - 3.9 km in length. All excavation in this zone will be by dredging.

b) Gatun Lake zone (Zone II)

This zone extends 26 km from the Caribbean coast to the Tidal Gate located in the northern port of Gatun Lake. A part of the Gatun Lake will be drained by a barrier dam and dry excavation will be carried out.

c) Continental Divide (Zone III)

This zone extends 26 km from the Gatun Lake Tidal Gate to the Pacific side Tidal Gate. This sector will be excavated by dry excavation.

d) Caimito zone (Zone IV)

This zone extends 5 km from the Pacific side Tidal Gate to Puerto Caimito. This zone includes a swamp area, but it is calculated that excavation will be dry.

e) Pacific approach zone (Zone V)

The sector between Puerto Caimito and the Pacific Ocean, depending on the size of the vessels targeted, will be 25.7 km - 28.7 km in length. All excavation will be carried out using the dredging method in this zone.

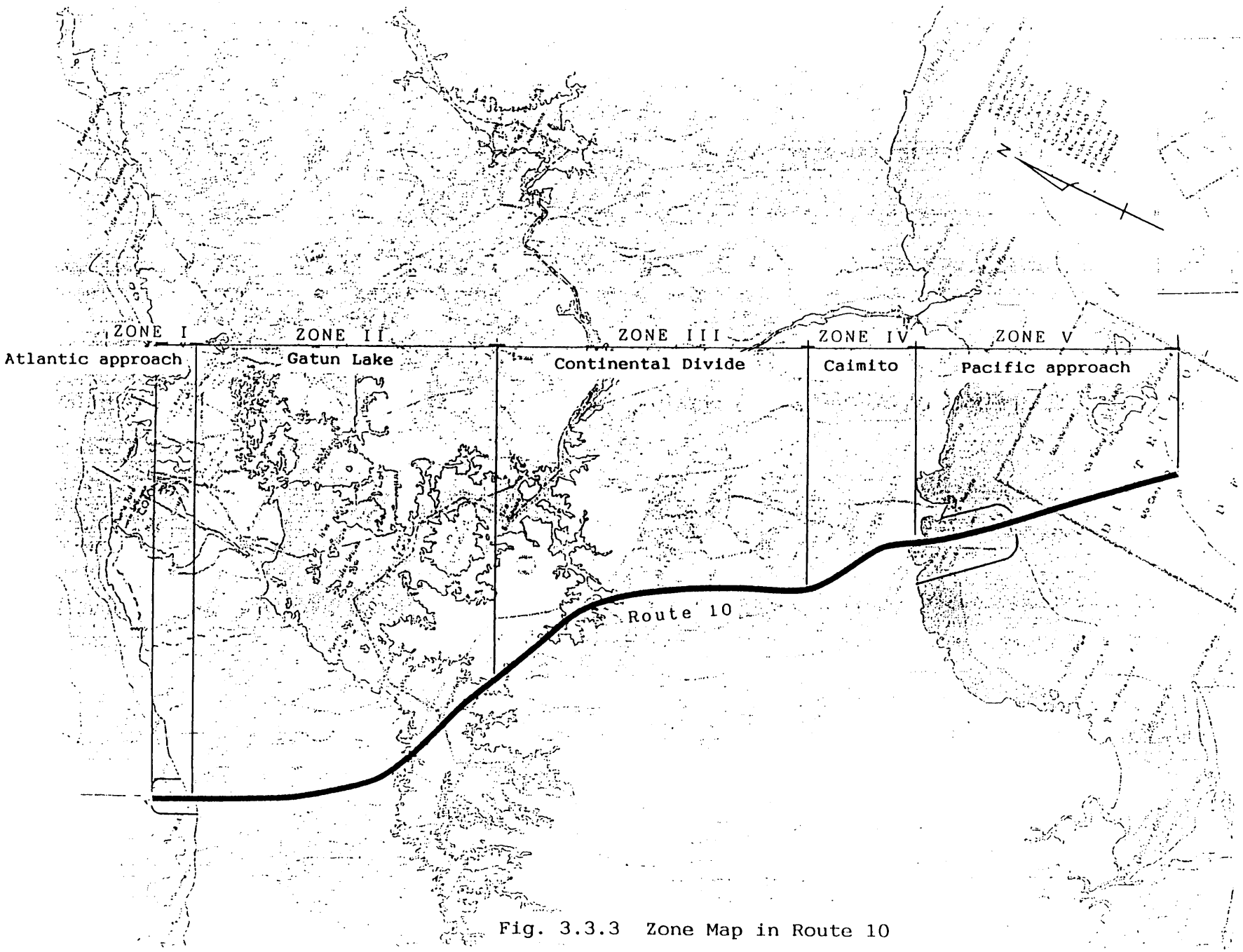


Fig. 3.3.3 Zone Map in Route 10

3.3.2 Excavation Slope

(1) Slope Criteria

Slope criteria for five types of geological conditions were developed based on the criteria provided by the Secretariat, and are described below.

Type 1. Strong unaltered or slightly altered volcanic rocks, e.g. basalt and hard agglomerate limestone. Slopes not exceeding 50 meters in height of moderately consolidated intact sedimentary rocks and tuffs. (Fig. 3.3.4)

Type 2. High slopes of moderately consolidated intact sedimentary rocks and tuffs, altered but still solid volcanic rocks. (Fig. 3.3.5)

Type 3. Soft volcano-sedimentary rocks, including soft agglomerate, with partial clay shales, but relatively stable as to form high massive hills. (Fig. 3.3.6)

Type 4. Soft volcano-sedimentary rocks, including soft agglomerate, with frequent development of clay shales and technically highly distorted and sheared, located in a landslide-inflicted zone. (Fig. 3.3.7)

Type 5. Unconsolidated deposits (Fig. 3.3.8)

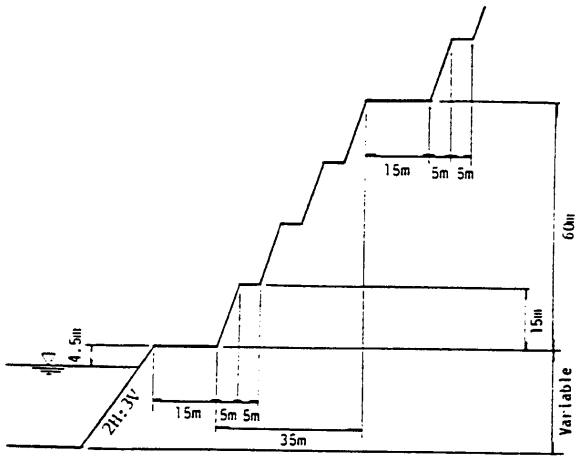


Fig. 3.3.4 Slope Criteria for Type 1

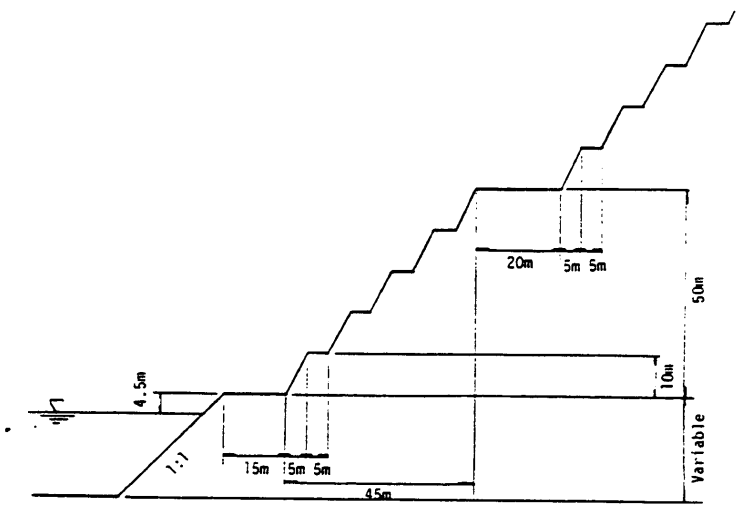


Fig. 3.3.5 Slope Criteria for Type 2

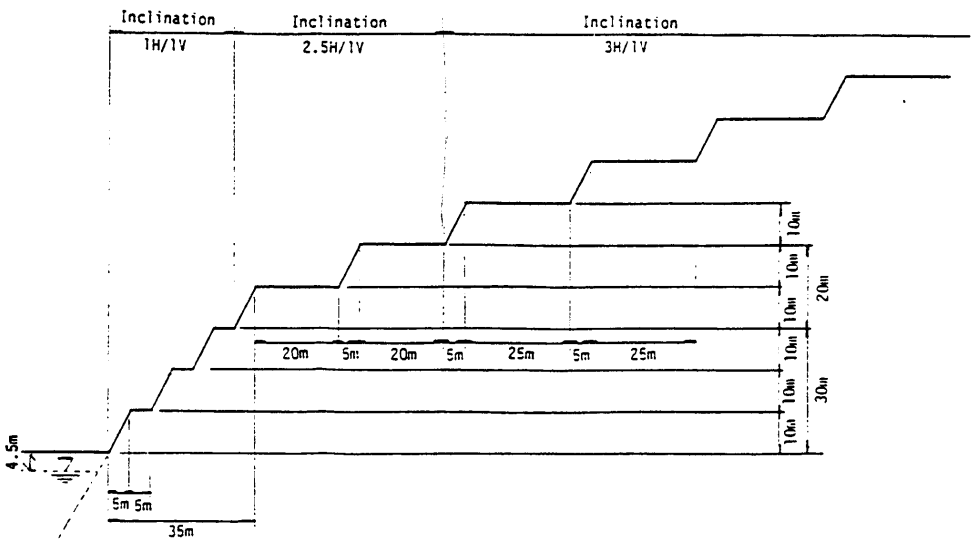


Fig. 3.3.6 Slope Criteria for Type 3

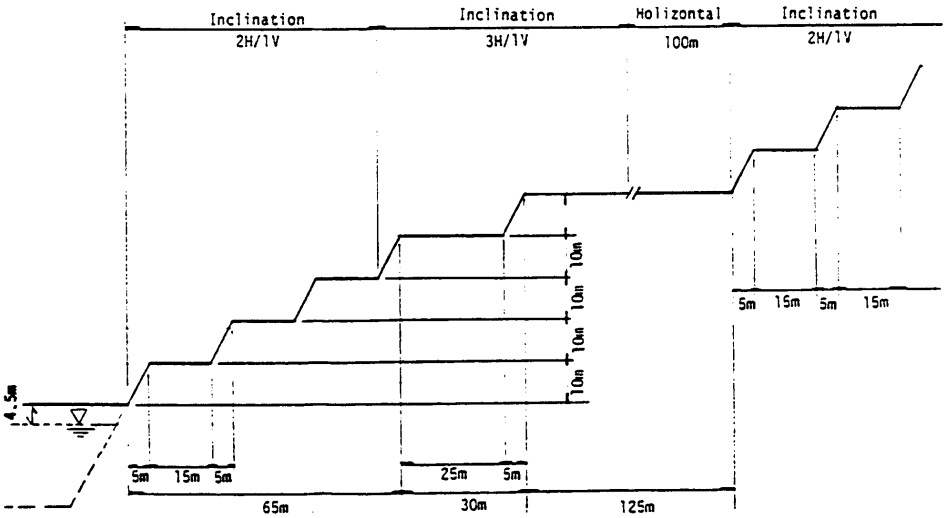


Fig. 3.3.7 Slope Criteria for Type 4

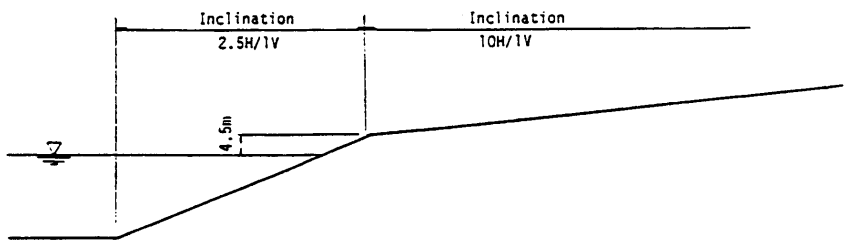


Fig. 3.3.8 Slope Criteria for Type 5

(2) Slope Type Suitability for each Route

a) Routes I, II, III, IV

1) Caribbean Ocean - Gatun Lock

This sector runs along the Rio Chagres plain hilly regions and the existing canal with the Gatun formation in Miocene. The depth of excavation is shallow and not overly affected by the excavation volume. The slope type of this sector is applied Type 5.

2) Gatun Lock - Darien Island - Rio Mandinga

The existing canal will be widened in this sector with excavation being almost all existing bed sedimentation. The geology is Caimito Formation and Bohio Formation in tertiary Oligocene and is extremely stable as can be seen at the Isla-Bruja Grande quarry on Gatun Lake. For this reason, Type 1 is appropriate for the slope resulting from widening.

3) Rio Mandinga - Paraiso

This sector is known as the Culebra Cut Zone and has a lot of faults giving a complex geology makeup. There are a lot of landslide formations such as the Cucaracha formation in intrusive basalt and with the exceptions of Gold Hill and Contractor Hill, a Type 4 slope is appropriate.

4) Paraiso - Miraflores Lock

This sector consists of the Panama Formation, La Boca Formation, Pedro Miguel Formation in sedimentary rock and basalt with relatively stable geological formations therefore it is suitable for slope Type 3.

5) Gold Hill, Contractor Hill Cerro Nitro

These hills are made up of hard basalt and are suitable for slope Type 1.

6) Miraflores Lock - Pacific Ocean

This sector consists of La Boca Formation in tertiary Miocene, Panama Formation and Basalt. The swamp area consists of Quarternary aluminum sediments along the Rio Chagres plain and the river mouth. The depth of excavation is shallow and not overly affected by the excavation volume making a Type 5 slope appropriate.

b) Route 14S

This route is almost the same as routes II and IV and the slopes will be basically the same. However, as it is a sea level canal with deep excavation, it will be slightly different than route II and IV cases.

1) Caribbean Sea - Gatun Lock

This sector runs along the Rio Chagres plain. The existing canal with the surface formation has an even covering of sedimentation. The depth of excavation is shallow and not overly affected by the excavation volume making a Type 5 slope appropriate.

2) Gatun Lock - Darien Island

The existing canal will be widened in this sector with excavation being almost all existing bed sedimentation. The geology is Caimito Formation and Bohio Formation, and is extremely stable as can be seen at the Isla-Bruja Grande quarry on Gatun Lake. For this reason, Type 1 is appropriate for the slope resulting from a widening.

3) Darien Island - Rio Mandinga

The geology along this sector is the relatively stable Caimito formation and Bohio formation. However, the slope resulting from excavation will be a maximum 220 m and as such, Type 2 which is extraordinarily stable, is appropriate.

4) Rio Mandinga - Larhen Dam

This sector is located in the north east part of the Continental Divide and the geology is complex, made up of La Boca F. and Las Cascada F. These formations are relatively stable, but there are faults and fault sections that have undergone metamorphic effects that are seen in places as being prone to landslides. Therefore Type 3 is appropriate for this slope.

5) Larthen Dam - Rio Grande North

This sector is in the Continental Divide and the geology consists mainly of Culebra F. and Cucaracha F. with many fault areas and many landslide areas. Slope Type 4 is therefore appropriate in this sector.

6) Rio Grande North - Cerro Escobal

This sector is relatively stable intrusive basalt and Type 1 is appropriate for this slope.

7) Cerro Escobal - Cerro Paraiso

The formations in this sector consist mainly of Cucaracha F., Pedro Miguel F., and intrusive basalt. The formations have faults and the geology is unstable, thus making a Type 4 slope appropriate.

8) Paraiso - Miraflores Lock

This sector consists of the Panama formation, La Boca Formation, Pedro Miguel Formation and extrusive Basalt which are relatively stable geological formations and therefore suitable for a slope type 3.

9) Miraflores Lock - Pacific Ocean

This sector passes lowlands, and consists of La Boca F. and Panama F. A part of swampland will be quarternary Alluvial Sediment, and the depth of excavation is shallow and not overly affected by the excavation volume making a Type 5 slope appropriate.

b) Route 10

This route is located about 10 km west of the existing canal and the slope's planning is basically the same as for route I-IV. This route is a sea level canal with deep excavation that will result in a slight difference compared with route I-IV.

1) Caribbean Sea - North Shore

This sector has a surface formation with an even covering of sedimentation from the Rio Lagarto. Furthermore, the depth of excavation is shallow and not overly affected by the excavation volume; making a Type 5 slope appropriate.

2) North Shore - Mouth of Rio Pescado

The geology of this sector is Chagres sand which is relatively stable; a Type 1 slope is appropriate.

3) Mouth of Rio Pescado - South of Loma De Jacob

This sector is in the swamp lands of the Rio Pescado plain, the geology is loose and weathered. Type 4 slope is appropriate.

4) South of Loma De Jacob - Continental Divide

This sector is located in the west region of the Continental Divide with a geology of intrusive basalt and is judged to be stable. A type 1 slope is appropriate for this sector.

5) Continental Divide - Chorrera, Nuevo Emperador Road

This sector is located along the Rio Congo and the geology consists of intrusive basalt. However, there are many faults and because of metamorphic effects due these faults, the geological formations are not considered stable. A type 4 slope here is appropriate.

6) Chorrera, Nuevo Emperador Road - South of Loma Alta

This sector intersects Quebrada Naranjal. The geology is relatively steep, the geological formation is assumed as being intrusive basalt or extrusive basalt. These basalt are relatively hard and stable, making a slope Type 1 appropriate.

7) South of Loma Alta - Hill of North Puerto Caimito Vicinity

This sector along the Rio Caimito with weathered extrusive basalt formations is unstable and a slope Type 4 is appropriate.

8) Hill of North Puerto Caimito Vicinity - Pacific Coast

This sector passes through the Rio Caimito plain and the river's mouth. The surface formation has a uniform covering of sedimen-

tation which has been deposited by the river. Furthermore the depth of excavation is shallow making a Type 5 slope appropriate.

3.3.3 Rock Classification for Excavation

(1) General

In order to translate geological characteristics into engineering concepts, each geological zone was divided into three sub zones according to the hardness of the excavated materials: earth, weathered rock and rock, referring to existing boring information, land surveys and existing canal reports. Furthermore, these are divided into seven categories according to the operating conditions (in order words dry or underwater excavation).

a) Earth (common)
Diluvial Formation, Alluvial Formation, weathered earth gravel and sand that can be excavated in dry conditions.

b) Rock (weathered)

Altered rock and weathered rock that can be excavated in dry conditions.

c) Rock

Rock that is excavated using a bulldozer with a dipper or explosives if carried out under dry conditions.

d) Rock (underwater)

Rock that is excavated underwater requiring the use of a large bucket, a large cutter suction pump or explosives and a bucket.

e) Dredging (loose material)

Loose material on the lake bed or marine bed that can be excavated using a suction pump.

f) Dredging (clayey material)

Clay on the lake bed or marine bed that can be excavated using a cutter suction pump.

g) Dredging (weathered softrock)

Altered or weathered rock on the lake bed or marine bed that can be excavated using a cutter suction pump.

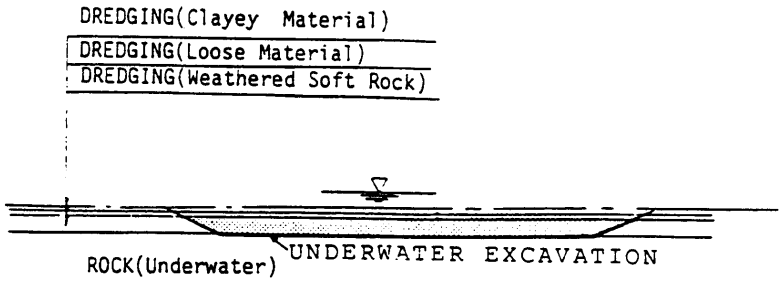


Fig. 3.3.9 Criteria for Marine Section

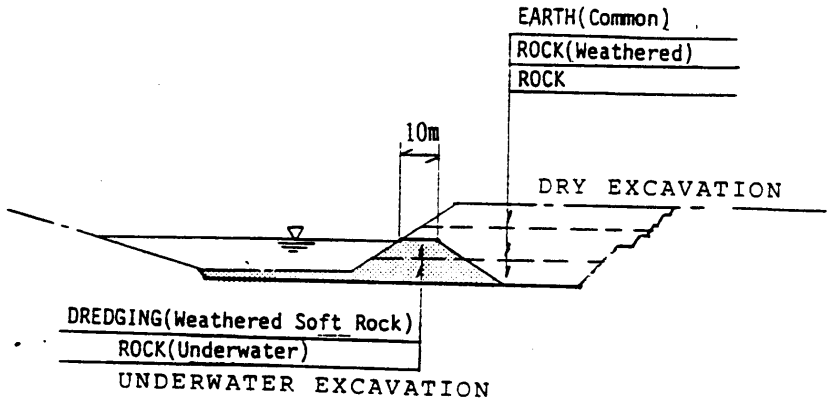


Fig. 3.3.10 Criteria for Existing Canal Section

(2) Route I-IV, VI Excavation Zones

These routes consist of widening the existing route or a location in the vicinity, and are composed of the following formations: Panama F.; La Boca F.; Pedro Miguel F.; Las Cascada F.; Bas Obispo F.; Bohio F.; and Caimito F. With the exception of the area around the Culebra Cut on the Continental Divide, the routes are relatively stable. In addition, the vicinity limits of earth construction with the exception of intrusive basalt, about 10 m from the surface formation is overburden or covered in weathered formation. For this reason, cut volume calculations for over 10 m from the surface layer use the weathered formation. However, the Continental Divide Culebra Cut area has many faults and is unstable. Due to this, a high rise lock is zoned according to the surveyed faults chart ("Technical Report S-70-9" by the P.C.C.) which records existing geological boring information. The depth for a low rise lock would be too great to allow the use of the surveyed faults chart as used for a high rise lock. Therefore, this zone will be aligned with the neighboring zones, and a weathered formation 10 m from the surface formation will be assumed.

There are large areas of plains and relatively few mountain areas with the overburden for all zones at 4 m. It is calculated that the surface formation of the Gatun Lake and Ocean approach beds consist of 2 m of Alluvial clay materials and under the surface formation at 2 - 4 m, there is 2 m of Alluvial loose materials.

(3) Route 10

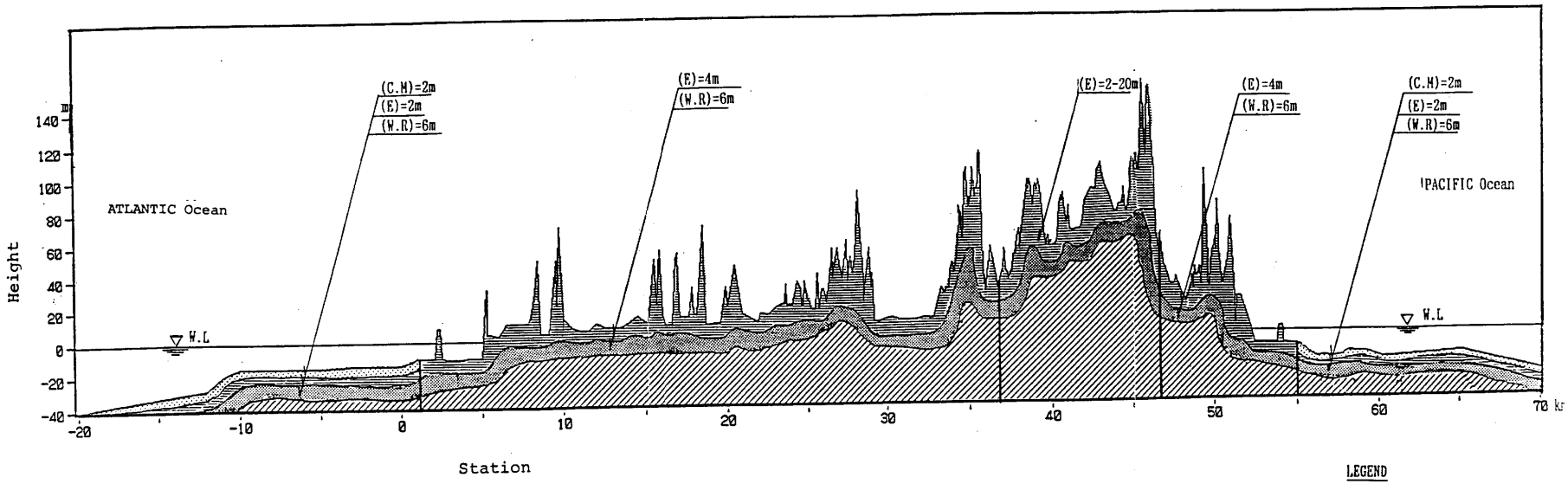
According to the Anderson Report the geology of the route is made up of Gatun sandstone (Gatun F.), Chagres sandstone (Chagres F.), extrusive basalt, intrusive basalt and Caimito F., etc. and soft altered volcanics. Of these, the Caimito formation is thought to be hard and dense as recorded at the Gatun Rock Quarry. In addition, sandstone, intrusive basalt, and sections of extrusive basalt are dense and hard while the remaining extrusive basalt and various formations are in relatively altered

states. Furthermore, the soft altered volcanic in the vicinity of the north west slope of the continental divide consist of many faults. The rocks are in an advanced altered state and are considered to be soft rock or soil. The basic formation from the Caribbean Ocean to Gatun Lake, for which there is almost no boring data, is assumed to be sandstone. In the Caimito F. from Gatun Lake to Rio Pescado, and the Continental Divide extrusive basalt region overburden is present in considerable quantity. This is about 4 m and the formation underneath is considered to be 6 m of weathered. The layer under this is calculated as hard rock. Other areas will be treated as earth, sand and soft rock zones with reference to IOCS Memorandum JAX Boring Log Report (IOCS JAX-93 Report).

3.3.4 Typical Cross Sections of Canals

Fig. 3.3.11 (1) and (2) show geologic profiles of Route 14S and Route 10. Considering rock and soil characteristics above, typical cross sections of the Canals are shown Fig. 3.3.12 - Fig. 3.3.14.

Geologic Profile (Route I, II, III, IV, 14-S)



LEGEND

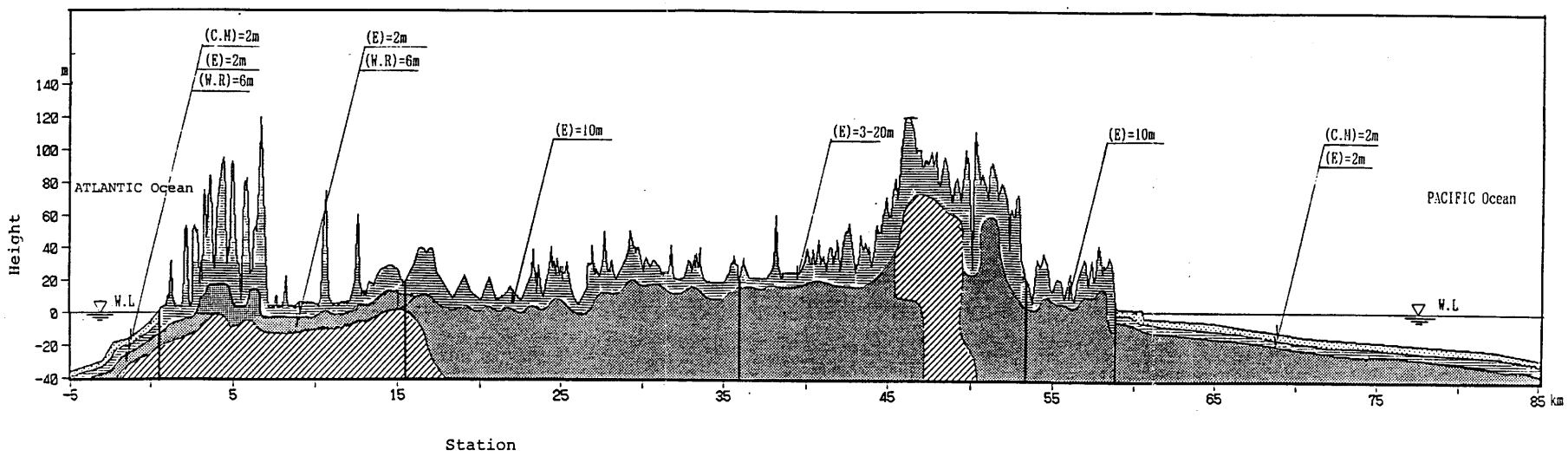
(C.M)	Clayey Material
(E)	Earth
(W.R)	Weathered Rock
(R)	Rock

Note : 1) The zone 37Km-47Km (Culebra cut zone), rocks and soil classification are based on "Technical Report S-70-9" by the PCC.

2) Station number correspond to route 14S

Fig. 3.3.11(1) Geologic Profile (Route I, II, III, IV, 14S)

Geologic Profile (Route 10)



LEGEND

(C.M)	Clayey Material
(E)	Earth
(W.R)	Weathered Rock
(R)	Rock

Note : 1) The zone from 37Km to 53Km is based on data obtained from The US Army Corps of Engineer.

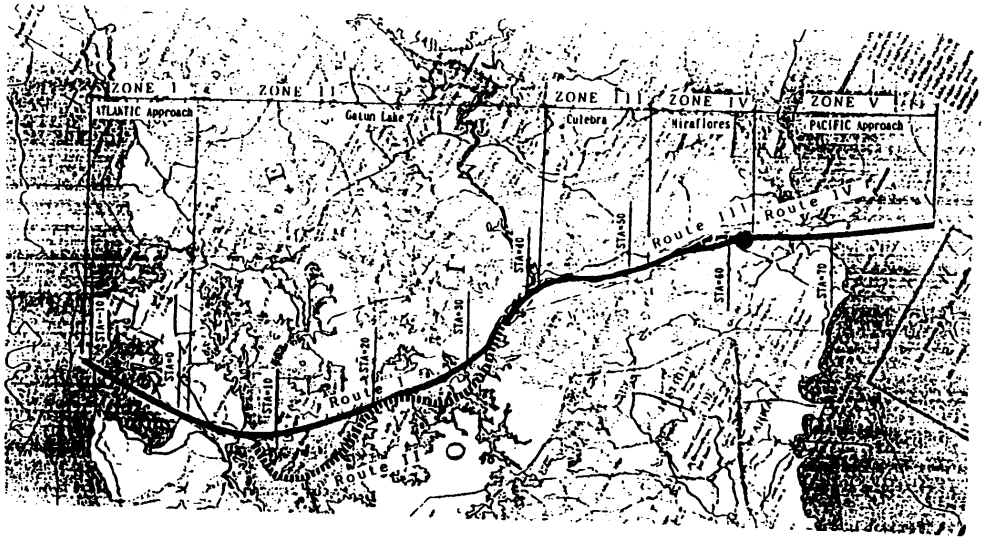
2) The balance is based on IOCS.

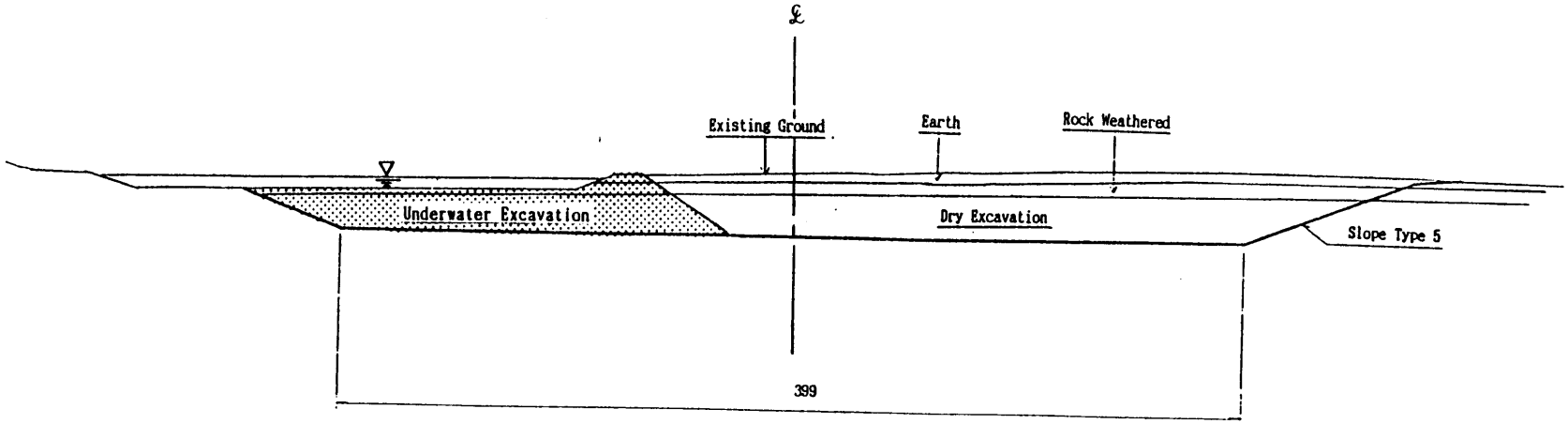
Fig. 3.3.11(2) Geologic Profile (Route 10)

L-7

STA. 62+00

GH=-7.0





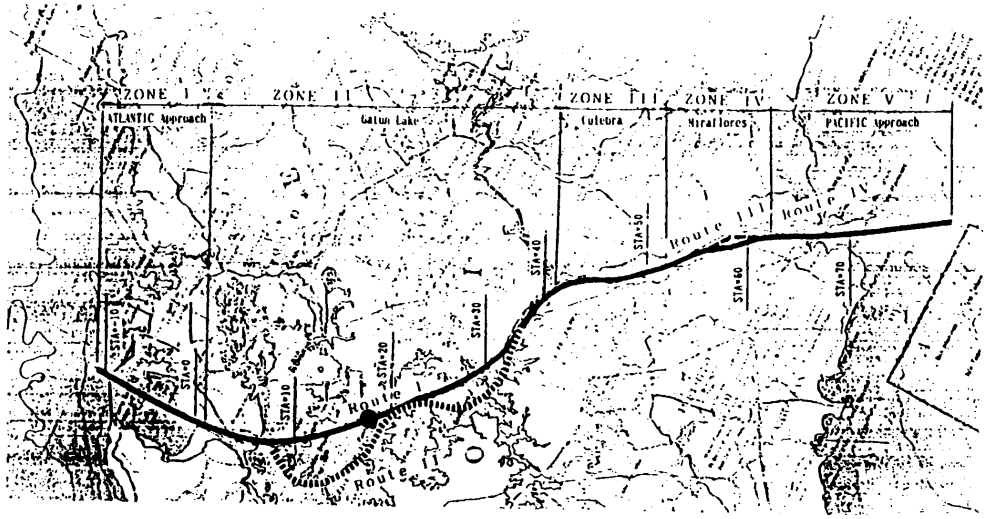
Note : GH = Ground Height at Center Line

Fig. 3.3.12 Cross Section for L-7 Case

L-18

STA.17+00

GH= 53.0



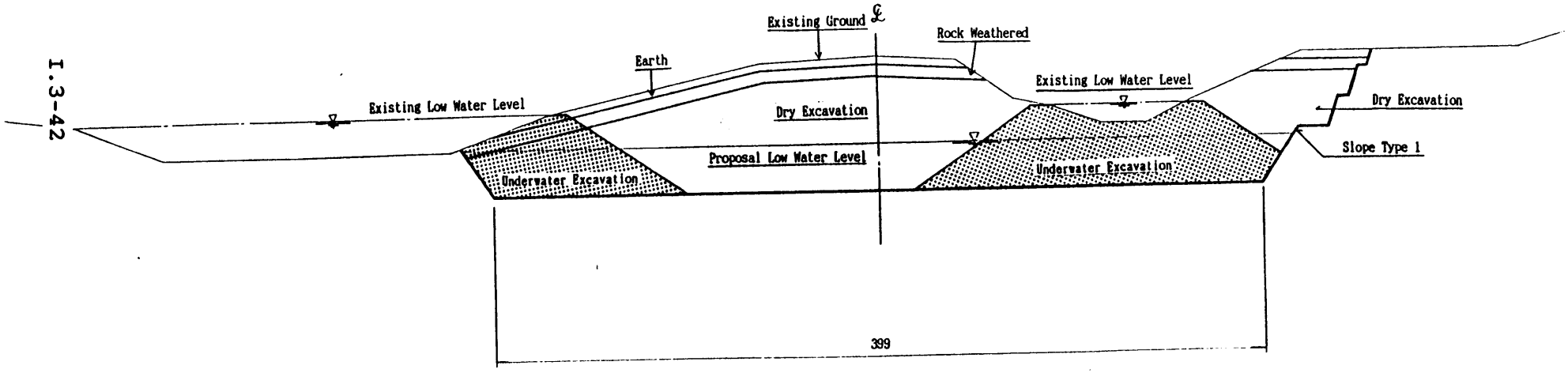
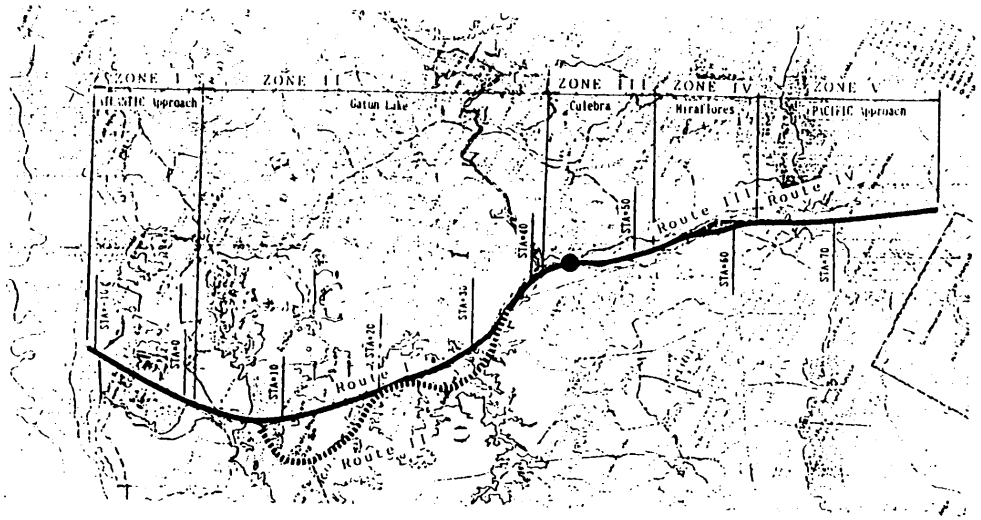


Fig. 3.3.13(1) Cross Section for L-18 Case

L-18

STA.44+00

GH = 75.0



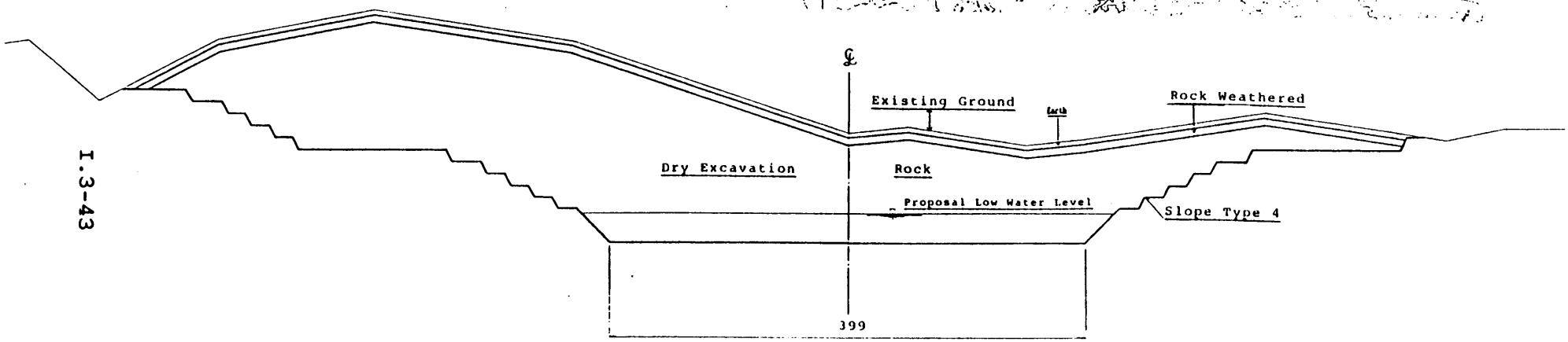
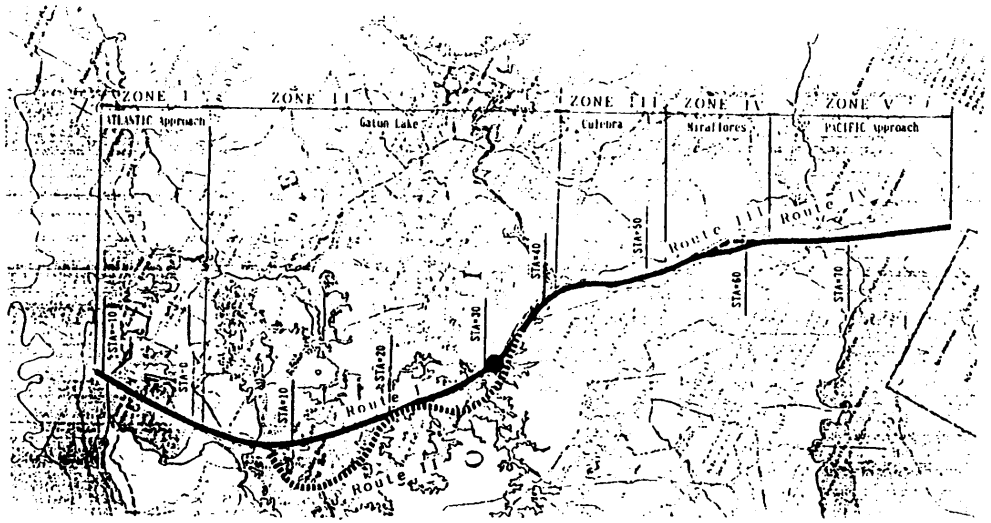


Fig. 3.3.13(2) Cross Section for L-18 Case

L-18

STA. 31+00

GH= 12.0



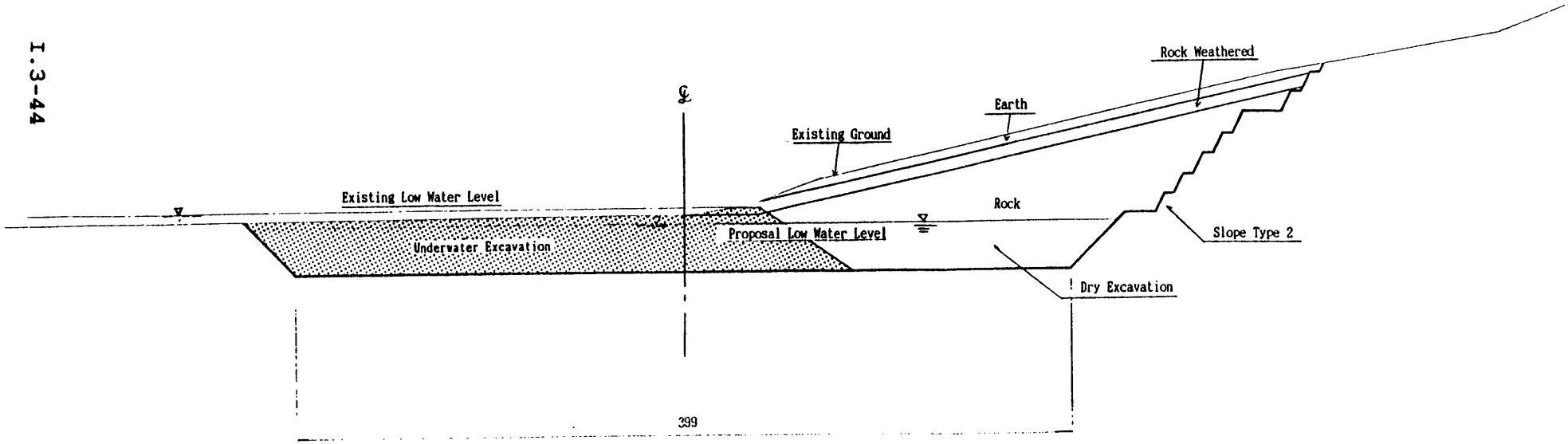
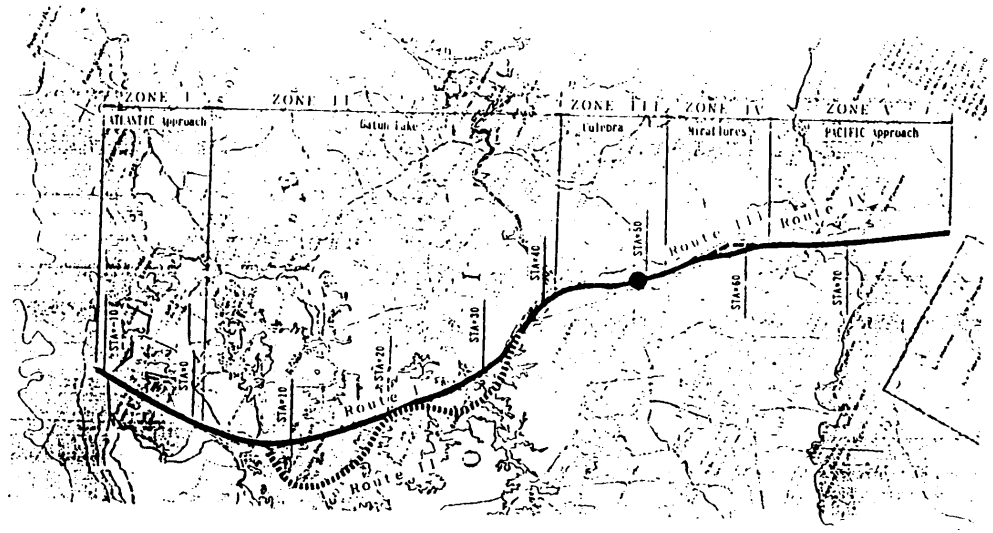


Fig. 3.3.13(3) Cross Section for L-18 Case

L-18

STA. 49+00

GH = 55.0



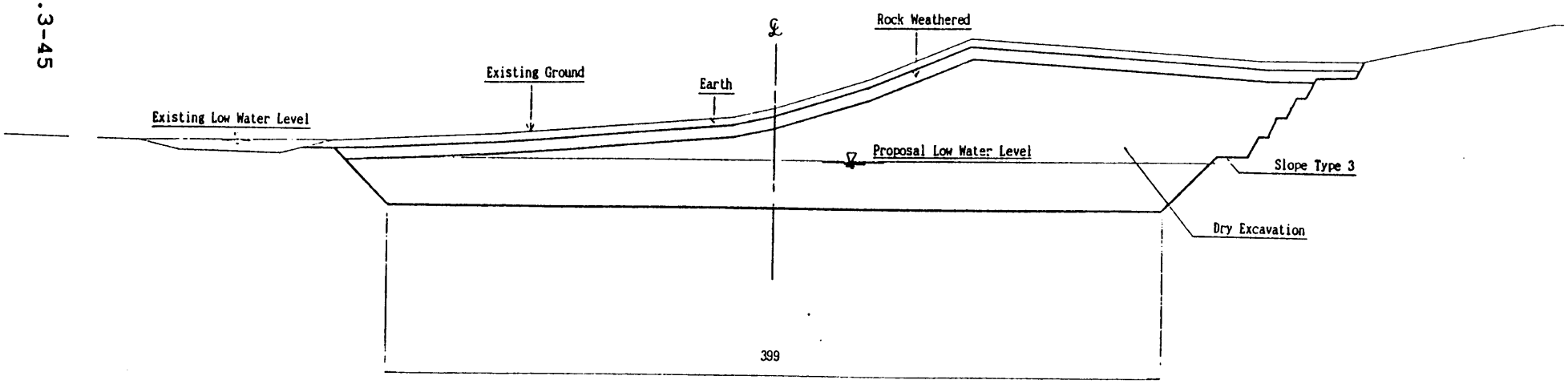
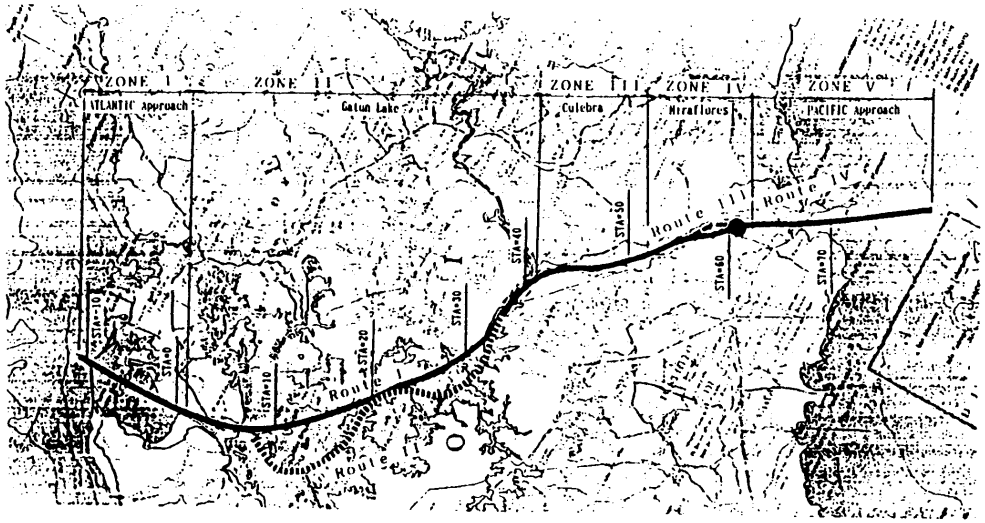


Fig. 3.3.13(4) Cross Section for L-18 Case

L-18

STA 61 00

GH = 35.0



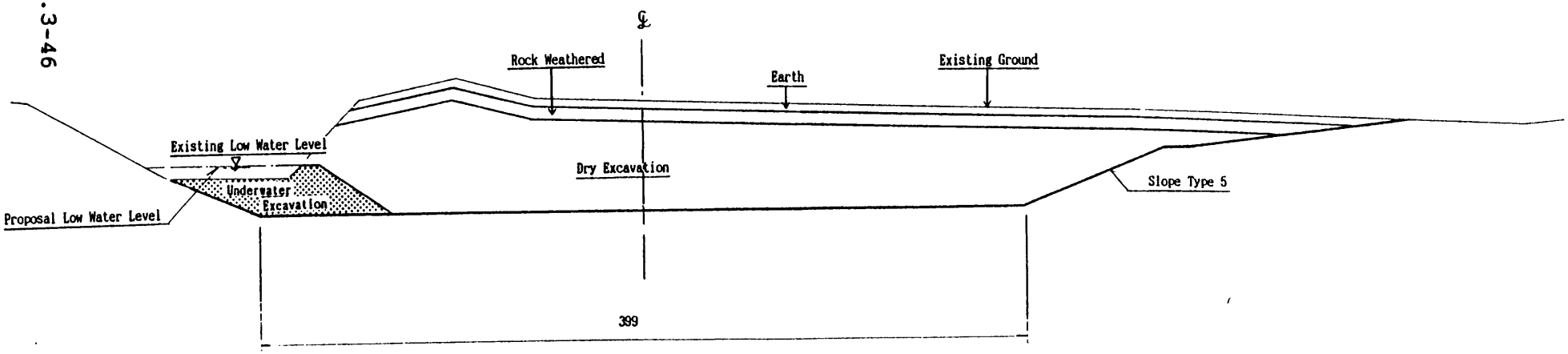
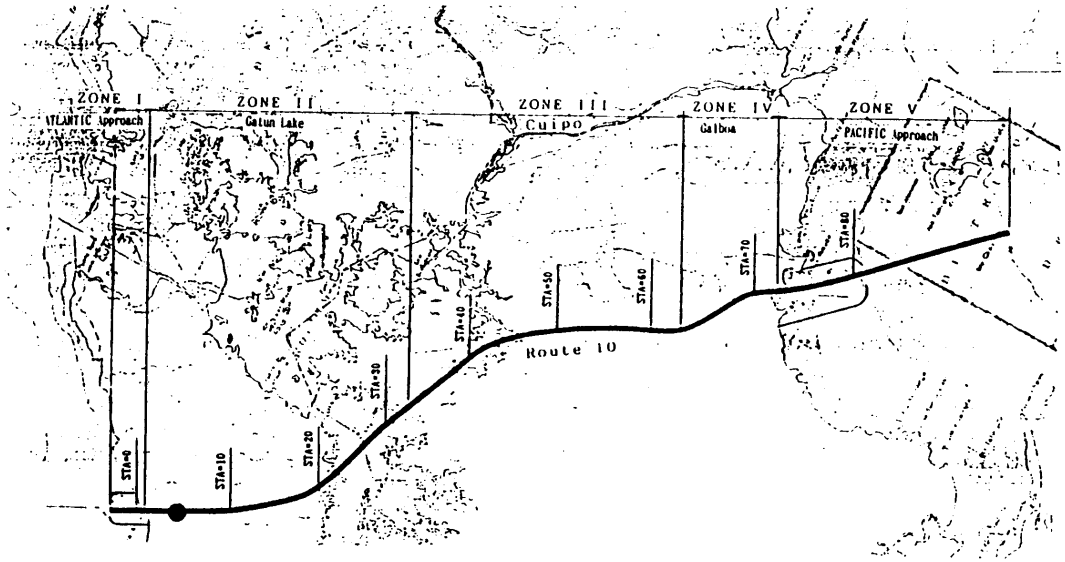


Fig. 3.3.13(5) Cross Section for L-18 Case

S-4

STA. 5+00

GH=90.0



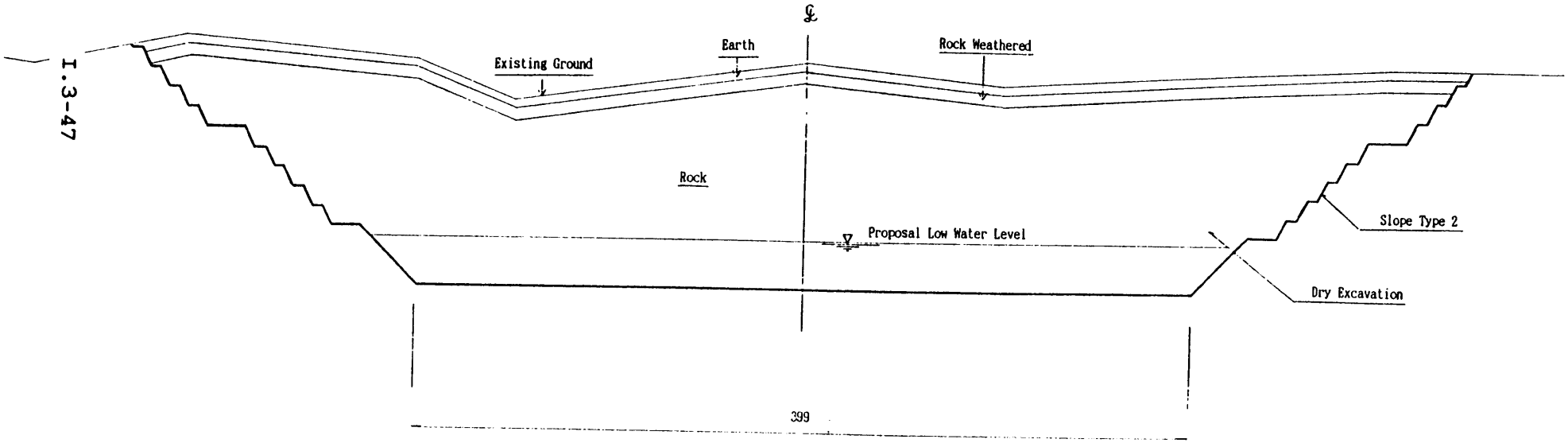
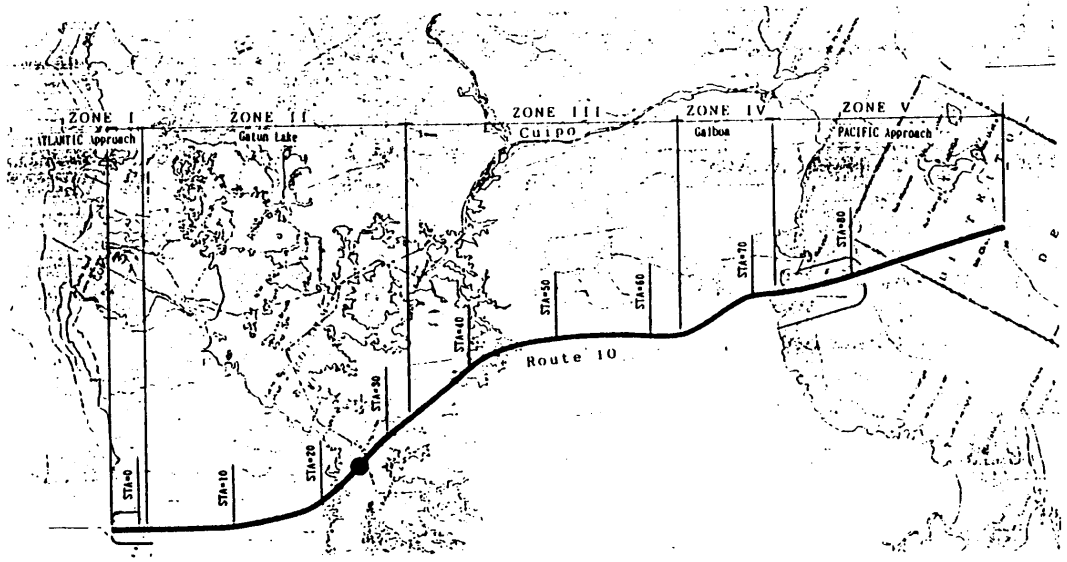


Fig. 3.3.14(1) Cross Section for S-4 Case

S-4

STA. 25+00

GH=23.0



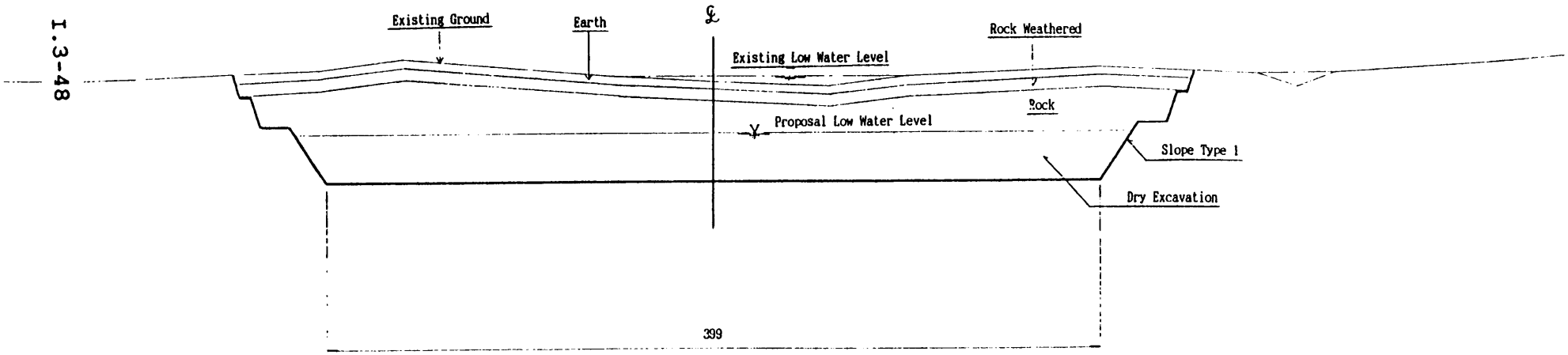
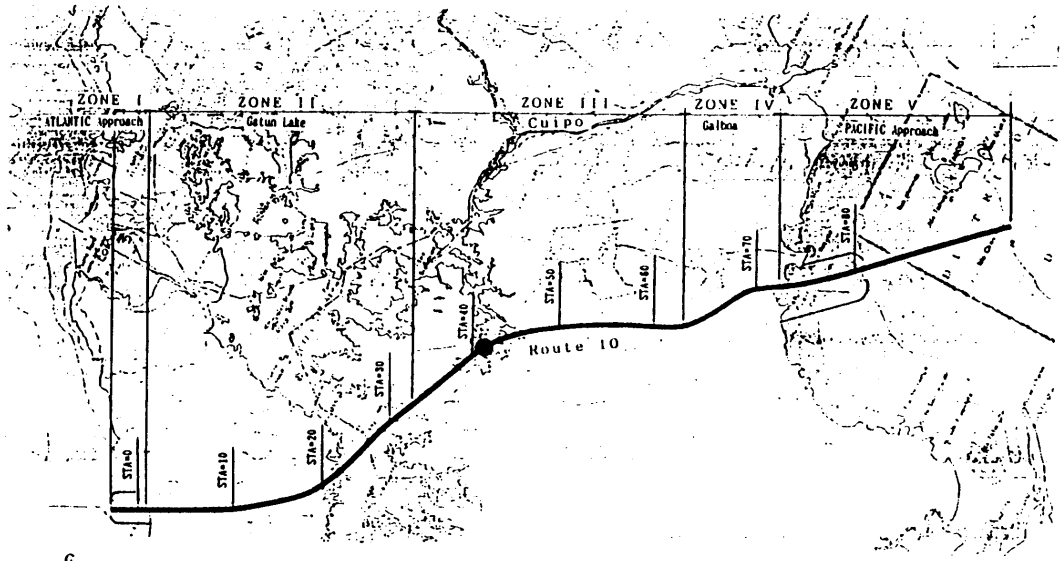


Fig. 3.3.14(2) Cross Section for S-4 Case

S-4

STA. 41+00

GH=35+00



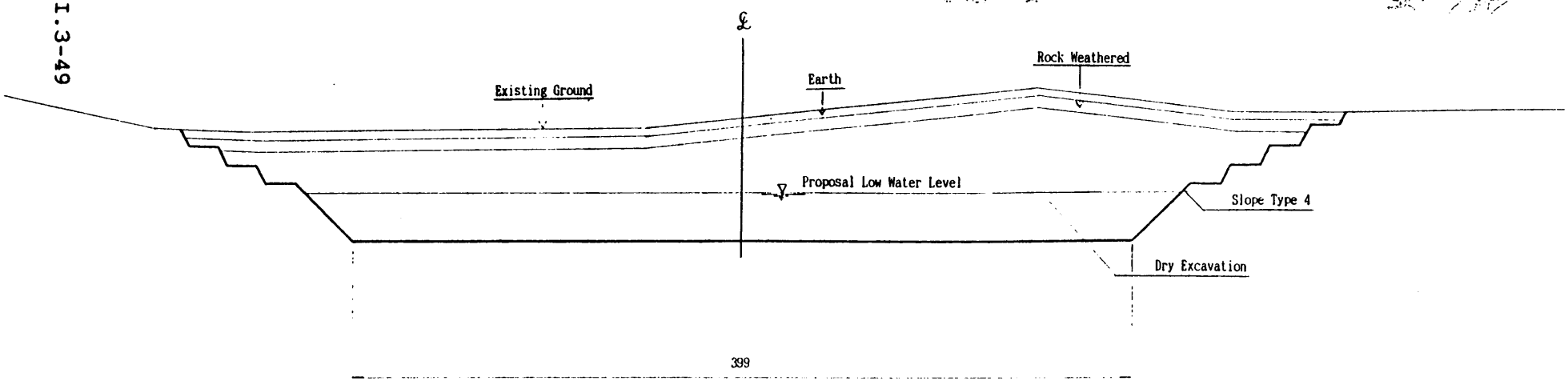


Fig. 3.3.14(3) Cross Section for S-4 Case

3.3.5 Cross-section Preparation

Cross-sections were prepared at a scale of 1:2000 using maps and hydrographic charts. The cross-section locations were chosen giving due consideration to topographical variations.

Maps used

(1) Topographical map (1:25,000 by the Defense Mapping Agency)

(2) Hydrographic map (1:25,000 by IGNTG)

(3) Hydrographic map (1:50,000 by IGNTG)

(4) Panama Canal Hydrographic Survey (1:3,000 and 1:1,000 by P.C.C.)

(5) Plates of Maps and Sections (Maps 1:3,000, Sections 1:1,000 Technical Report S-70-9, by P.C.C)

3.3.6 Excavation Volume

The excavation volume tables were composed according to 37 classifications. The results are presented in the following Table 3.3.1.

Calculation sheets by cross section method of each study case are shown in Appendix 3.

Excavation volume was also checked by means of the mean height method and confirmed as reasonable.

3.3.7 Dispose Area

The cost of transportation and disposal area for excavation works is to be estimated without deciding special disposal areas.

Then we assumed a hauling distance of approx. 3-6 Km and disposal areas in the Lake and depressed parts or valleys between the hills.

For the Lake, excavated materials are thought to be disposed beneath the planned water level in order not to affect the water storage capacity of the Lake, and for the land side to be included and ordinary soil compaction and drainage cost.

The pavement of the construction roads is thought to be water tightened Macadam pavement with 20 M wide.

Table 3.3.1(1) Excavation Volume Table

Case L-1 (100,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-10.8 - 1.00	0	2,240,000	0	2,240,000	940,000	10,377,000	5,492,000	2,880,000	19,689,000
II	1.00 - 43.12	16,670,150	59,268,750	6,059,500	81,998,400	14,299,400	14,251,300	3,848,000	0	32,398,700
III	43.12 - 53.00	42,992,814	57,829,897	24,513,991	125,336,702	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	63,445,000	33,245,000	10,275,000	106,965,000	705,000	0	0	0	705,000
V	62.00 - 76.30	0		0	0	6,792,800	9,577,400	7,665,000	10,259,800	34,295,000
Total		123,107,964	152,583,647	40,848,491	316,540,102	28,542,151	38,244,297	17,028,333	13,139,800	96,954,581

Case L-2 ,L-2' (100,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-10.8 - 1.00	0	2,240,000	0	2,240,000	940,000	10,377,000	5,492,000	5,532,000	22,341,000
II	1.00 - 43.12	18,255,150	59,830,950	5,809,500	83,895,600	22,426,400	18,531,300	4,068,000	0	45,025,700
III	43.12 - 53.00	47,323,051	60,123,558	24,513,991	131,960,600	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	67,490,000	33,500,000	10,075,000	111,065,000	705,000	0	0	0	705,000
V	62.00 - 76.30	472,350	30,150	0	502,500	6,792,800	9,577,400	7,665,000	10,259,800	34,295,000
Total		133,540,551	155,724,658	40,398,491	329,663,700	36,669,151	42,524,297	17,248,333	15,791,800	112,233,581

Case L-3 (100,000 DWT)

Table 3.3.1(2) Excavation Volume Table

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-10.80 - 1.00	0	2,240,000	0	2,240,000	940,000	10,377,000	5,492,000	5,532,000	22,341,000
II	1.00 - 43.00	42,229,250	15,947,750	9,460,500	67,637,500	48,545,500	56,254,000	20,042,500	20,245,000	145,087,000
III	43.00 - 53.00	132,990,000	20,500,000	14,310,000	167,800,000	22,420,000	740,000	200,000	0	23,360,000
IV	53.00 - 62.00	81,355,000	17,147,500	11,890,000	110,392,500	10,435,000	2,375,000	505,000	0	13,315,000
V	62.00 - 76.30	7,015,000	3,140,000	3,355,000	13,510,000	7,910,000	9,206,000	6,017,500	6,129,000	29,262,500
Total		263,589,250	58,975,250	39,015,500	361,580,000	90,250,500	78,952,000	32,257,000	31,906,000	233,365,500

Case L-4 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.1 - 1.00	0	0	0	0	2,060,000	19,501,500	6,419,500	6,419,500	34,400,500
II	1.00 - 43.12	24,254,738	65,054,398	7,353,000	96,662,136	31,237,800	23,823,800	4,746,000	0	59,807,600
III	43.12 - 53.00	56,658,619	76,376,479	32,724,915	165,760,013	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	75,555,000	38,885,000	13,095,000	127,535,000	705,000	0	0	0	705,000
V	62.00 - 79.50	0	0	0	0	9,702,350	27,975,000	10,250,000	13,044,400	60,971,750
Total		156,468,357	180,315,877	53,172,915	389,957,149	49,510,101	75,338,897	21,438,833	19,463,900	165,751,731

Table 3.3.1(3) Excavation Volume Table

Case L-5 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.1 - 1.00	0	0	0	0	2,060,000	19,501,500	6,419,500	6,419,500	34,400,500
II	1.00 - 43.12	26,047,338	65,541,198	7,353,000	98,941,536	40,593,400	32,165,800	4,746,000	0	77,505,200
III	43.12 - 53.00	61,566,221	78,652,420	32,724,915	172,943,556	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	80,745,000	39,140,000	13,095,000	132,980,000	705,000	0	0	0	705,000
V	62.00 - 79.50	532,650	30,150	0	562,800	9,702,350	27,975,000	10,250,000	13,044,400	60,971,750
Total		168,891,209	183,363,768	53,172,915	405,427,892	58,865,701	83,680,897	21,438,833	19,463,900	183,449,331

Case L-6 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.10 - 1.00	0	0	0	0	2,060,000	19,501,500	6,419,500	6,419,500	34,400,500
II	1.00 - 43.00	55,742,750	16,985,500	11,837,000	84,565,250	81,505,500	69,124,000	23,070,000	23,192,500	196,892,000
III	43.00 - 53.00	165,840,000	23,270,000	15,810,000	204,920,000	25,655,000	750,000	220,000	0	26,625,000
IV	53.00 - 62.00	103,942,500	19,672,500	13,557,500	137,172,500	12,240,000	2,375,000	345,000	0	14,960,000
V	62.00 - 79.50	11,715,000	4,750,000	3,745,000	20,210,000	13,727,500	18,775,000	8,195,000	8,322,500	49,020,000
Total		337,240,250	64,678,000	44,949,500	446,867,750	135,188,000	110,525,500	38,249,500	37,934,500	321,897,500

Table 3.3.1(4) Excavation Volume Table

Case L-7 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.5 - 1.00	0	0	0	0	20,842,500	21,750,000	8,000,000	8,000,000	58,592,500
II	1.00 - 43.12	37,558,610	76,257,072	9,000,000	122,815,682	77,734,450	38,259,500	8,556,200	688,500	125,238,650
III	43.12 - 53.00	75,097,338	102,671,963	44,148,627	221,917,928	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	97,520,000	45,125,000	14,835,000	157,480,000	705,000	0	0	0	705,000
V	62.00 - 83.90	0	0	0	0	37,486,650	41,295,300	14,103,100	17,670,950	110,556,000
Total		210,175,948	224,054,035	67,983,627	502,213,610	142,573,551	105,343,397	30,682,633	26,359,450	304,959,031

Case L-8 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.5 - 1.00	0	0	0	0	20,842,500	21,750,000	8,000,000	8,000,000	58,592,500
II	1.00 - 43.12	39,648,610	76,619,472	9,000,000	125,268,082	93,925,450	41,754,500	7,656,200	688,500	144,024,650
III	43.12 - 53.00	80,870,988	104,985,571	44,148,627	230,005,186	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	103,045,000	45,360,000	14,835,000	163,240,000	705,000	0	0	0	705,000
V	62.00 - 83.90	713,550	0	0	713,550	37,486,650	41,265,150	14,083,000	17,650,850	110,485,650
Total		224,278,148	226,965,043	67,983,627	519,226,818	158,764,551	108,808,247	29,762,533	26,339,350	323,674,681

Table 3.3.1(5) Excavation Volume Table

Case L-9 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.50 - 1.00	0	0	0	0	2,060,000	19,987,500	6,577,500	6,577,500	35,202,500
II	1.00 - 43.00	66,865,250	16,198,000	12,927,000	95,990,250	136,615,500	82,699,000	26,995,000	27,117,500	273,427,000
III	43.00 - 53.00	213,875,000	25,945,000	18,090,000	257,910,000	30,555,000	830,000	220,000	0	31,605,000
IV	53.00 - 62.00	136,687,500	22,585,000	15,630,000	174,902,500	16,725,000	2,375,000	345,000	0	19,445,000
V	62.00 - 83.90	18,180,000	6,250,000	4,900,000	29,330,000	29,716,000	33,918,000	11,809,500	11,959,000	87,402,500
Total		435,607,750	70,978,000	51,547,000	558,132,750	215,671,500	139,809,500	45,947,000	45,654,000	447,082,000

Case L-10 (100,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-10.8 - 1.00	0	2,240,000	0	2,240,000	940,000	10,377,000	5,492,000	5,532,000	22,341,000
II	1.00 - 43.12	16,009,750	53,650,950	5,809,500	75,470,200	95,997,400	36,403,300	9,056,000	0	141,456,700
III	43.12 - 53.00	47,323,051	60,123,558	24,513,991	131,960,600	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	67,490,000	33,500,000	10,075,000	111,065,000	705,000	0	0	0	705,000
V	62.00 - 76.30	472,350	30,150	0	502,500	6,792,800	9,577,400	7,665,000	10,259,800	34,295,000
Total		131,295,151	149,544,658	40,398,491	321,238,300	110,240,151	60,396,297	22,236,333	15,791,800	208,664,581

Table 3.3.1(6) Excavation Volume Table

Case L-11 (100,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-10.80 - 1.00	0	2,240,000	0	2,240,000	940,000	10,377,000	5,492,000	5,532,000	22,341,000
II	1.00 - 43.00	91,161,750	25,877,750	16,050,500	133,090,000	70,540,500	42,116,500	16,702,500	11,197,500	140,557,000
III	43.00 - 53.00	132,990,000	20,500,000	14,310,000	167,800,000	22,420,000	740,000	200,000	0	23,360,000
IV	53.00 - 62.00	81,355,000	17,147,500	11,890,000	110,392,500	10,435,000	2,375,000	505,000	0	13,315,000
V	62.00 - 76.30	7,015,000	3,140,000	3,355,000	13,510,000	7,910,000	9,206,000	6,017,500	6,129,000	29,262,500
Total		312,521,750	68,905,250	45,605,500	427,032,500	112,245,500	64,814,500	28,917,000	22,858,500	228,835,500

Case L-12 (100,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-10.80 - 1.00	0	0	0	0	940,000	12,617,000	5,492,000	5,532,000	24,581,000
II	1.00 - 37.00	185,349,250	63,602,750	22,020,500	270,972,500	110,810,500	39,141,500	13,312,500	13,347,500	176,612,000
III	37.00 - 47.00	155,405,000	19,455,000	14,750,000	189,610,000	22,930,000	2,610,000	200,000	0	25,740,000
IV	47.00 - 56.00	90,485,000	15,180,000	11,915,000	117,580,000	5,365,000	150,000	180,000	0	5,695,000
V	56.00 - 70.30	45,850,000	19,670,000	13,300,000	78,820,000	18,100,000	5,927,500	2,415,000	3,264,000	29,706,500
Total		477,089,250	117,907,750	61,985,500	656,982,500	158,145,500	60,446,000	21,599,500	22,143,500	262,334,500

Table 3.3.1(7) Excavation Volume Table

Case L-13 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.1 - 1.00	0	0	0	0	2,060,000	19,501,500	6,419,500	6,419,500	34,400,500
II	1.00 - 43.12	19,171,250	53,993,700	7,353,000	80,517,950	127,194,900	43,306,800	10,247,500	0	180,749,200
III	43.12 - 53.00	61,566,221	78,652,420	32,724,915	172,943,556	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	80,745,000	39,140,000	13,095,000	132,980,000	705,000	0	0	0	705,000
V	62.00 - 79.50	532,650	30,150	0	562,800	9,702,350	27,975,000	10,250,000	13,044,400	60,971,750
Total		162,015,121	171,816,270	53,172,915	387,004,306	145,467,201	94,821,897	26,940,333	19,463,900	286,693,331

Case L-14 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.10 - 1.00	0	0	0	0	2,060,000	19,501,500	6,419,500	6,419,500	34,400,500
II	1.00 - 43.00	114,815,250	28,300,500	19,327,000	162,442,750	95,678,000	48,691,500	17,727,500	13,827,500	175,924,500
III	43.00 - 53.00	165,840,000	23,270,000	15,810,000	204,920,000	25,655,000	750,000	220,000	0	26,625,000
IV	53.00 - 62.00	103,942,500	19,672,500	13,557,500	137,172,500	12,240,000	2,375,000	345,000	0	14,960,000
V	62.00 - 79.50	11,715,000	4,750,000	3,745,000	20,210,000	13,727,500	18,775,000	8,195,000	8,322,500	49,020,000
Total		396,312,750	75,993,000	52,439,500	524,745,250	149,360,500	90,093,000	32,907,000	28,569,500	300,930,000

Table 3.3.1(8) Excavation Volume Table

Case L-15 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.00 - 1.00	0	0	0	0	2,060,000	19,501,500	6,419,500	6,419,500	34,400,500
II	1.00 - 37.00	217,105,250	34,455,500	24,617,000	276,177,750	148,203,000	46,364,000	15,030,000	15,025,000	224,622,000
III	37.00 - 47.00	176,935,000	21,410,000	14,910,000	213,255,000	22,915,000	610,000	130,000	0	23,655,000
IV	47.00 - 56.00	184,065,000	24,040,000	17,160,000	225,265,000	8,995,000	150,000	195,000	0	9,340,000
V	56.00 - 73.50	56,280,000	20,405,000	10,840,000	87,525,000	26,335,000	14,757,500	4,900,000	4,680,000	50,672,500
Total		634,385,250	100,310,500	67,527,000	802,222,750	208,508,000	81,383,000	26,674,500	26,124,500	342,690,000

Case L-16 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.5 - 1.00	0	0	0	0	20,842,500	21,750,000	8,000,000	8,000,000	58,592,500
II	1.00 - 43.12	31,130,750	58,600,700	9,000,000	98,731,450	208,681,950	49,405,500	13,468,700	688,500	272,244,650
III	43.12 - 53.00	80,870,988	104,985,571	44,148,627	230,005,186	5,804,951	4,038,597	23,333	0	9,866,881
IV	53.00 - 62.00	103,045,000	45,360,000	14,835,000	163,240,000	705,000	0	0	0	705,000
V	62.00 - 83.90	713,550	0	0	713,550	37,486,650	41,295,300	14,083,000	17,650,850	110,515,800
Total		215,760,288	208,946,271	67,983,627	492,690,186	273,521,051	116,489,397	35,575,033	26,339,350	451,924,831

Table 3.3.1(9) Excavation Volume Table

Case L-17 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.50 - 1.00	0	0	0	0	2,060,000	19,987,500	6,577,500	6,577,500	35,202,500
II	1.00 - 43.00	135,855,250	30,290,500	20,697,000	186,842,750	130,770,500	56,346,500	20,542,500	15,982,500	223,642,000
III	43.00 - 53.00	213,875,000	25,875,000	18,090,000	257,840,000	30,555,000	830,000	220,000	0	31,605,000
IV	53.00 - 62.00	135,187,500	22,585,000	15,630,000	173,402,500	16,725,000	2,375,000	345,000	0	19,445,000
V	62.00 - 83.90	18,180,000	6,250,000	4,900,000	29,330,000	29,716,000	33,918,000	11,809,500	11,959,000	87,402,500
Total		503,097,750	85,000,500	59,317,000	647,415,250	209,826,500	113,457,000	39,494,500	34,519,000	397,297,000

Case L-18 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.50 - 1.00	0	0	0	0	20,842,500	21,750,000	8,000,000	8,000,000	58,592,500
II	1.00 - 37.00	278,510,250	74,697,350	29,400,000	382,607,600	198,629,750	51,569,000	17,290,000	17,235,000	284,723,750
III	37.00 - 47.00	241,315,000	26,440,000	18,135,000	285,890,000	31,265,000	830,000	260,000	0	32,355,000
IV	47.00 - 56.00	169,470,000	26,290,000	18,585,000	214,345,000	10,950,000	250,000	325,000	0	11,525,000
V	56.00 - 77.90	79,770,000	18,270,000	37,325,000	135,365,000	65,569,000	24,114,500	7,624,500	7,393,500	104,701,500
Total		769,065,250	145,697,350	103,445,000	1,018,207,600	327,256,250	98,513,500	33,499,500	32,628,500	491,897,750

Table 3.3.1(10) Excavation Volume Table

Case S-1 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.50 - 1.00	2,322,500	720,000	480,000	3,522,500	1,487,500	1,750,000	595,000	595,000	4,427,500
II	1.00 - 27.00	117,947,500	92,965,000	44,590,000	255,502,500	0	0	0	0	0
III	27.00 - 53.00	186,610,000	283,470,000	101,010,000	571,090,000	0	0	0	0	0
IV	53.00 - 58.00	0	40,645,000	16,250,000	56,895,000	0	0	0	0	0
V	58.00 - 83.70	0	13,275,000	5,700,000	18,975,000	0	16,558,000	5,678,500	5,678,500	27,915,000
Total		306,880,000	431,075,000	168,030,000	905,985,000	1,487,500	18,308,000	6,273,500	6,273,500	32,342,500

Case S-2 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.50 - 1.00	5,225,000	1,320,000	880,000	7,425,000	3,325,000	3,780,000	1,312,500	1,312,500	9,730,000
II	1.00 - 27.00	252,475,000	191,170,000	78,925,000	522,570,000	0	0	0	0	0
III	27.00 - 53.00	263,335,000	508,665,000	161,035,000	933,035,000	0	0	0	0	0
IV	53.00 - 58.00	0	80,675,000	27,125,000	107,800,000	0	0	0	0	0
V	58.00 - 83.70	0	29,265,000	9,075,000	38,340,000	0	36,904,000	12,618,500	12,618,500	62,141,000
Total		521,035,000	811,095,000	277,040,000	1,609,170,000	3,325,000	40,684,000	13,931,000	13,931,000	71,871,000

Table 3.3.1(11) Excavation Volume Table

Case S-3 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.85 - 1.00	3,060,000	810,000	540,000	4,410,000	3,003,000	2,252,250	808,500	808,500	6,872,250
II	1.00 - 27.00	146,125,000	122,390,000	50,540,000	319,055,000	0	0	0	0	0
III	27.00 - 53.00	11,845,000	493,588,000	117,750,000	623,183,000	0	0	0	0	0
IV	53.00 - 58.00	0	50,275,000	17,650,000	67,925,000	0	0	0	0	0
V	58.00 - 85.70	0	16,830,000	6,300,000	23,130,000	0	30,371,500	7,213,000	7,213,000	44,797,500
						0				
Total		161,030,000	683,893,000	192,780,000	1,037,703,000	3,003,000	32,623,750	8,021,500	8,021,500	51,669,750

Case S-4 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.85 - 1.00	6,970,000	1,560,000	1,040,000	9,570,000	4,966,500	4,889,500	1,674,750	1,674,750	13,205,500
II	1.00 - 27.00	308,725,000	247,915,000	88,950,000	645,590,000	0	0	0	0	0
III	27.00 - 53.00	0	883,785,000	173,580,000	1,057,365,000	0	0	0	0	0
IV	53.00 - 58.00	0	103,300,000	30,250,000	133,550,000	0	0	0	0	0
V	58.00 - 85.70	0	37,260,000	10,050,000	47,310,000	0	68,651,500	15,530,500	15,530,500	99,712,500
Total		315,695,000	1,273,820,000	303,870,000	1,893,385,000	4,966,500	73,541,000	17,205,250	17,205,250	112,918,000

Table 3.3.1(12) Excavation Volume Table

Case S-5 (300,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.90 - 1.00	4,825,000	840,000	560,000	6,225,000	3,724,500	2,437,500	858,000	858,000	7,878,000
II	1.00 - 27.00	161,045,000	127,185,000	51,870,000	340,100,000	0	0	0	0	0
III	27.00 - 53.00	191,840,000	362,495,000	134,230,000	688,565,000	0	0	0	0	0
IV	53.00 - 58.00	0	54,185,000	19,400,000	73,585,000	0	0	0	0	0
V	58.00 - 86.70	0	18,225,000	6,450,000	24,675,000	0	37,371,500	7,840,000	7,840,000	53,051,500
Total		357,710,000	562,930,000	212,510,000	1,133,150,000	3,724,500	39,809,000	8,698,000	8,698,000	60,929,500

Case S-6 (300,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.90 - 1.00	7,495,000	1,650,000	1,100,000	10,245,000	8,385,000	5,265,000	1,794,000	1,794,000	17,238,000
II	1.00 - 27.00	341,225,000	258,425,000	94,520,000	694,170,000	0	0	0	0	0
III	27.00 - 53.00	308,240,000	652,430,000	197,810,000	1,158,480,000	0	0	0	0	0
IV	53.00 - 58.00	0	111,250,000	31,550,000	142,800,000	0	0	0	0	0
V	58.00 - 86.40	0	40,620,000	10,500,000	51,120,000	0	82,890,000	16,883,000	16,883,000	116,656,000
Total		656,960,000	1,064,375,000	335,480,000	2,056,815,000	8,385,000	88,155,000	18,677,000	18,677,000	133,894,000

Table 3.3.1(13) Excavation Volume Table

Case S-7 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.00 - 1.00	0	0	0	0	1,040,000	9,720,500	3,240,000	3,240,000	17,240,500
II	1.00 - 23.00	28,972,500	8,625,250	6,898,500	44,496,250	68,879,250	20,368,250	7,005,000	6,315,000	102,567,500
III	23.00 - 50.00	513,098,000	62,950,000	43,485,000	619,533,000	38,137,000	8,635,000	4,770,000	1,215,000	52,757,000
IV	50.00 - 54.00	25,420,000	4,195,000	3,140,000	32,755,000	4,920,000	1,940,000	1,240,000	0	8,100,000
V	54.00 - 71.50	1,295,000	565,000	430,000	2,290,000	1,540,000	8,027,500	5,142,500	5,367,500	20,077,500
Total		568,785,500	76,335,250	53,953,500	699,074,250	114,516,250	48,691,250	21,397,500	16,137,500	200,742,500

Case S-8 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.00 - 1.00	0	0	0	0	2,060,000	19,501,500	6,419,500	6,419,500	34,400,500
II	1.00 - 23.00	57,150,250	14,700,500	11,937,000	83,787,750	147,303,000	39,861,500	13,405,000	12,030,000	212,599,500
III	23.00 - 50.00	826,195,000	88,630,000	61,140,000	975,965,000	75,705,000	15,580,000	8,215,000	2,210,000	101,710,000
IV	50.00 - 54.00	48,490,000	8,495,000	5,940,000	62,925,000	10,620,000	2,510,000	1,550,000	0	14,680,000
V	54.00 - 75.90	3,310,000	1,155,000	830,000	5,295,000	4,980,000	23,590,000	11,375,000	11,850,000	51,795,000
Total		935,145,250	112,980,500	79,847,000	1,127,972,750	240,668,000	101,043,000	40,964,500	32,509,500	415,185,000

Case S-9 (250,000 DWT)

Table 3.3.1(14) Excavation Volume Table

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.50 - 1.00	0	0	0	0	10,452,500	10,875,000	4,000,000	4,000,000	29,327,500
II	1.00 - 23.00	37,687,000	10,871,500	7,040,000	55,598,500	89,903,000	22,838,500	7,800,000	7,145,000	127,686,500
III	23.00 - 50.00	573,205,000	67,425,000	46,550,000	687,180,000	48,800,000	9,640,000	4,500,000	1,905,000	64,845,000
IV	50.00 - 54.00	30,565,000	4,920,000	3,720,000	39,205,000	7,490,000	2,100,000	1,240,000	0	10,830,000
V	54.00 - 75.90	3,185,000	660,000	570,000	4,415,000	6,499,000	18,631,500	7,343,500	7,732,500	40,206,500
Total		644,642,000	83,876,500	57,880,000	786,398,500	163,144,500	64,085,000	24,883,500	20,782,500	272,895,500

Case S-10 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.50 - 1.00	0	0	0	0	20,842,500	21,750,000	8,000,000	8,000,000	58,592,500
II	1.00 - 23.00	77,882,750	18,593,500	13,590,000	110,066,250	195,337,250	45,186,500	15,530,000	13,860,000	269,913,750
III	23.00 - 50.00	981,205,000	97,150,000	66,450,000	1,144,805,000	97,605,000	17,805,000	8,350,000	3,510,000	127,270,000
IV	50.00 - 54.00	63,010,000	9,820,000	6,925,000	79,755,000	13,600,000	2,670,000	1,660,000	0	17,930,000
V	54.00 - 75.90	4,690,000	1,350,000	965,000	7,005,000	25,558,500	44,544,500	15,849,500	16,304,000	102,256,500
Total		1,126,787,750	126,913,500	87,930,000	1,341,631,250	352,943,250	131,956,000	49,389,500	41,674,000	575,962,750

Table 3.3.1(15) Excavation Volume Table

Case S-11 (300,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.60 - 1.00	0	0	0	0	11,560,000	12,120,000	4,439,000	4,439,000	32,558,000
II	1.00 - 23.00	41,208,000	13,072,500	7,700,000	61,980,500	99,197,000	24,292,500	8,290,000	7,545,000	139,324,500
III	23.00 - 50.00	611,880,000	69,365,000	47,990,000	729,235,000	54,340,000	10,275,000	4,850,000	2,015,000	71,480,000
IV	50.00 - 54.00	32,520,000	5,295,000	3,910,000	41,725,000	8,720,000	2,130,000	1,310,000	0	12,160,000
V	54.00 - 75.20	2,400,000	710,000	550,000	3,660,000	10,400,000	22,716,000	8,296,000	8,648,000	50,060,000
		2								
Total		688,008,000	88,442,500	60,150,000	836,600,500	184,217,000	71,533,500	27,185,000	22,647,000	305,582,500

Case S-12 (300,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.60 - 1.00	0	0	0	0	23,120,000	24,240,000	8,878,000	8,878,000	65,116,000
II	1.00 - 23.00	84,392,000	20,779,000	14,760,000	119,931,000	206,467,000	47,976,000	16,030,000	14,680,000	285,153,000
III	23.00 - 50.00	1,057,945,000	99,485,000	68,045,000	1,225,475,000	107,270,000	19,105,000	9,070,000	3,700,000	139,145,000
IV	50.00 - 54.00	67,930,000	10,390,000	7,235,000	85,555,000	14,650,000	2,700,000	1,750,000	0	19,100,000
V	54.00 - 77.20	5,245,000	1,430,000	1,000,000	7,675,000	34,454,000	49,626,000	17,346,000	17,918,000	119,344,000
Total		1,215,512,000	132,084,000	91,040,000	1,438,636,000	385,961,000	143,647,000	53,074,000	45,176,000	627,858,000

Case S-13 (150,000 DWT)

Table 3.3.1(16) Excavation Volume Table

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.50 - 1.00	5,225,000	1,320,000	880,000	7,425,000	3,325,000	3,780,000	1,312,500	1,312,500	9,730,000
II	1.00 - 27.00	252,475,000	191,170,000	78,925,000	522,570,000	0	0	0	0	0
III	27.00 - 53.00	186,610,000	283,470,000	101,010,000	571,090,000	0	0	0	0	0
IV	53.00 - 58.00	0	80,675,000	27,125,000	107,800,000	0	0	0	0	0
V	58.00 - 83.70	0	29,265,000	9,075,000	38,340,000	0	36,904,000	12,618,500	12,618,500	62,141,000
Total		444,310,000	585,900,000	217,015,000	1,247,225,000	3,325,000	40,684,000	13,931,000	13,931,000	71,871,000

Case S-14 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.90 - 1.00	6,970,000	1,560,000	1,040,000	9,570,000	4,966,500	4,889,500	1,674,750	1,674,750	13,205,500
II	1.00 - 27.00	308,725,000	247,915,000	88,950,000	645,590,000	0	0	0	0	0
III	27.00 - 53.00	11,845,000	493,588,000	117,750,000	623,183,000	0	0	0	0	0
IV	53.00 - 58.00	0	103,300,000	30,250,000	133,550,000	0	0	0	0	0
V	58.00 - 83.70	0	37,260,000	10,050,000	47,310,000	0	68,651,500	15,530,500	15,530,500	99,712,500
Total		327,540,000	883,623,000	248,040,000	1,459,203,000	4,966,500	73,541,000	17,205,250	17,205,250	112,918,000

Case S-15 (300,000 DWT)

Table 3.3.1(17) Excavation Volume Table

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-2.90 - 1.00	7,495,000	1,650,000	1,100,000	10,245,000	8,385,000	5,265,000	1,794,000	1,794,000	17,238,000
II	1.00 - 27.00	341,225,000	258,425,000	94,520,000	694,170,000	0	0	0	0	0
III	27.00 - 53.00	191,840,000	362,495,000	134,230,000	688,565,000	0	0	0	0	0
IV	53.00 - 58.00	0	111,250,000	31,550,000	142,800,000	0	0	0	0	0
V	58.00 - 86.40	0	40,620,000	10,500,000	51,120,000	0	82,890,000	16,883,000	16,883,000	116,656,000
Total		540,560,000	774,440,000	271,900,000	1,586,900,000	8,385,000	88,155,000	18,677,000	18,677,000	133,894,000

Case S-16 (150,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.10 - 1.00	0	0	0	0	2,060,000	19,501,500	6,419,500	6,419,500	34,400,500
II	1.00 - 23.00	57,150,250	14,700,500	11,937,000	83,787,750	147,303,000	39,861,500	13,405,000	12,030,000	212,599,500
III	23.00 - 50.00	513,098,000	62,950,000	43,485,000	619,533,000	38,137,000	8,635,000	4,770,000	1,215,000	52,757,000
IV	50.00 - 54.00	48,490,000	8,495,000	5,940,000	62,925,000	10,620,000	2,510,000	1,550,000	0	14,680,000
V	54.00 - 71.50	3,310,000	1,155,000	830,000	5,295,000	4,980,000	23,590,000	11,375,000	11,850,000	51,795,000
Total		622,048,250	87,300,500	62,192,000	771,540,750	203,100,000	94,098,000	37,519,500	31,514,500	366,232,000

Table 3.3.1(18) Excavation Volume Table

Case S-17 (250,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.50 - 1.00	0	0	0	0	20,842,500	21,750,000	8,000,000	8,000,000	58,592,500
II	1.00 - 23.00	77,882,750	18,593,500	13,590,000	110,066,250	195,337,250	45,186,500	15,530,000	13,860,000	269,913,750
III	23.00 - 50.00	573,205,000	67,425,000	46,550,000	687,180,000	48,800,000	9,640,000	4,500,000	1,905,000	64,845,000
IV	50.00 - 54.00	63,010,000	9,820,000	6,925,000	79,755,000	13,600,000	2,670,000	1,660,000	0	17,930,000
V	54.00 - 75.90	4,690,000	1,350,000	965,000	7,005,000	25,558,500	44,544,500	15,849,500	16,304,000	102,256,500
									13,931,000	
Total		718,787,750	97,188,500	68,030,000	884,006,250	304,138,250	123,791,000	45,539,500	40,069,000	513,537,750

Case S-18 (300,000 DWT)

ZONES	STATION	Dry Excavation (m3)				Underwater Excavation (m3)				
		Rock	Weathered	Earth	Total	Rock	Weathered	Loose Material	Clayey Material	Total
I	-11.60 - 1.00	0	0	0	0	23,120,000	24,240,000	8,878,000	8,878,000	65,116,000
II	1.00 - 23.00	84,392,000	20,779,000	14,760,000	119,931,000	206,467,000	47,976,000	16,030,000	14,680,000	285,153,000
III	23.00 - 50.00	611,880,000	69,365,000	47,990,000	729,235,000	54,340,000	10,275,000	4,850,000	2,015,000	71,480,000
IV	50.00 - 54.00	67,930,000	10,390,000	7,235,000	85,555,000	14,650,000	2,700,000	1,750,000	0	19,100,000
V	54.00 - 77.20	5,245,000	1,430,000	1,000,000	7,675,000	34,454,000	49,626,000	17,346,000	17,918,000	119,344,000
Total		769,447,000	101,964,000	70,985,000	942,396,000	333,031,000	134,817,000	48,854,000	43,491,000	560,193,000

CHAPTER 4 - LOCK STRUCTURES AND MECHANICAL EQUIPMENT

4.1 Lock Structures (concrete)

4.1.1 General

The proposed lock site on the Atlantic side is located in the area previously identified for the Gatun Third locks, where excavation was conducted in the early 1940's in an area of simple monoclinal geologic structure. It lies approximately 1 km east of the present Gatun locks. (ref: Fig. 4.1.3). In this area the elevations are generally low (averaging about 30 meters), but the terrain is abrupt and irregular.

The 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 north 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 30 meters. The foundation rock at the site is correlated with the Gatun sandstone of the existing Gatun locks. The formation was classified as having an allowable bearing capacity of more than 200 ton/m^2.

At the Pacific coast side, the lock site takes full advantage of the existing third locks excavation and would be located approximately 900m south of the existing Miraflores locks. The area is characterized by steeply inclined, igneous hills separated by narrow valleys. The elevations of the hills in this area range from approximately 50 to 150 meters. (ref. Fig. 4.1.4)

The lock structures would be founded entirely in basalt that was classified as having an allowable bearing capacity of more than 500 ton/m^2 in the third locks study. The wing walls of the lock would rest in part on the La Boca formation. The La Boca formation consists of silty shales and sandstones of medium hardness and as a whole it is moderately strong. The La Boca formation was classified as having an allowable bearing capacity of 160 ton/m^2 at the proposed lock site during the third locks study.

These bearing capacities previously mentioned are considered enough for structure foundations.

4.1.2 Lock Dimensions

Lock chamber dimensions are considered for the design with sizes up to 250,000 DWT. Envelope dimensions for the various ship sizes are given in Table 4.1.2. The 300,000 DWT ship is used for the sea level canal study cases only. Lock dimensions such as length, width and depth are given in Table 4.1.1.

Table 4.1.1 Dimensions of Lock Chambers

Size (DWT)	L (m)	B (m)	D (m)	Remarks
65,000	304.8 (1,000 ft)	33.5 (110 ft)	12.8 (42 ft)	Existing canal lock dimension
100,000	319	47	19	
150,000	363	54	21	
250,000	428	63	24	

Table 4.1.2 Dimensions of Design Ships

Size (DWT)	L (m)	B (m)	D (m)	Remarks
65,000	295	32	12	Max. Passable Size
100,000	277	43	17	
150,000	316	49	19	
250,000	372	57	22	
300,000	394	61	23	

A typical layout for the lock chambers is shown in Fig. 4.1.1.

Considering the lake water level and the sea level, the Pacific locks sill design levels for each study case were adopted as shown in Table 4.1.3. Detailed sketches for the Group A high rise locks were prepared based on the

following sections and are shown in Fig. 4.1.6 and Fig. 4.1.7.

For Low Rise Lock study cases, each dimension is shown in Fig. 4.1.8, Fig. 4.1.9 and Fig 4.1.10.

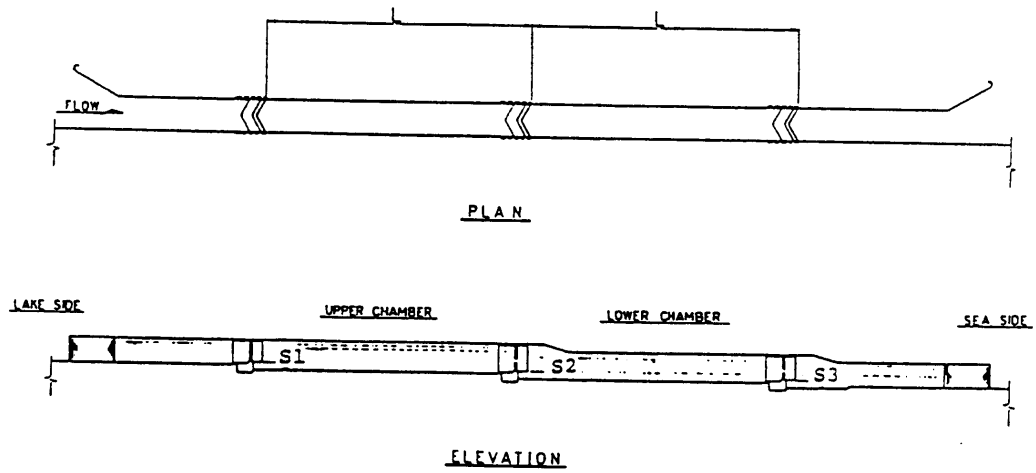


Fig. 4.1.1 Lock Dimension Plan

Table 4.1.3 Sill Elevations for Group A Study Cases

Study	Lake Side		Lower Lock	Pacific Coast		Sill Elevation		
Case	H.W.L.	L.W.L.	H.W.L.	H.W.L.	L.W.L.	Lake (S1)	Lock (S2)	Pacific (S3)
L-1	27.6	26.1	13.7	3.3	-2.7	7.1	-5.3	-21.70
L-2	26.1	24.6	12.9	3.3	-2.7	5.6	-6.1	-21.70
L-4	27.6	26.1	13.7	3.3	-2.7	5.1	-7.3	-23.70
L-5	26.1	24.6	12.9	3.3	-2.7	3.6	-8.1	-23.70
L-7	27.6	26.1	13.7	3.3	-2.7	2.1	-10.3	-26.70
L-8	26.1	24.6	12.9	3.3	-2.7	0.6	-11.1	-26.70
L-10	26.1	24.6	12.9	3.3	-2.7	5.6	-6.1	-21.70
L-13	26.1	24.6	12.9	3.3	-2.7	3.6	-8.1	-23.70
L-16	26.1	24.6	12.9	3.3	-2.7	0.6	-11.1	-26.70

4.1.3 Water Levels and Structure Levels

Wall top, sill top elevations, and water levels are schematically shown in Fig. 4.1.2, utilizing study cases L-8 and L-16 as a typical example.

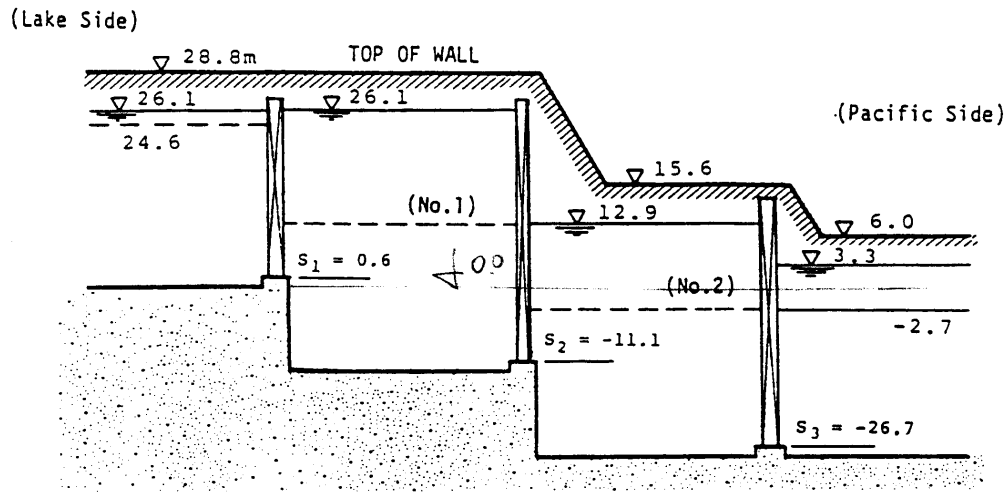


Fig. 4.1.2 Water Levels and Structure Levels

4.1.4 Design Assumptions

(1) Filling and Emptying System

The filling and emptying system adopted for the locks will be a bottom longitudinal tunnel system similar to that developed for the lower Granite Lock on the Snake River in Washington State.

The chosen dimension of filling and emptying tunnel, about 10m x 10m, was chosen based on the assumption that filling and emptying time is nine minutes.

(2) Structural Design Concept

All locks and approach walls will be of the gravity type, with cross sections varying to meet stability needs and for enclosure of the hydraulic tunnel system.

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 middle half of the base under maintenance and emergency conditions.

4.1.5 Ancillary Facilities

(1) Anchorage Area

For the purpose of mooring ships using the canal anchorage, mooring areas are provided on the upstream side of the new locks located on the Pacific Ocean side. In Gatun Lake, on the upstream side of the new locks located on the Atlantic Ocean side, a mooring area is not required because suitable areas are available.

(2) Surge Basin

A hydrodynamic impact caused by surging phenomena may occur when canal water pours into a lock chamber in a relatively short time.

The locks proposed on the Pacific Ocean side, and a bypass channel on the upstream side of the locks connect back to the main canal. The occurrence of surging in the bypass may cause harmful pitching and rolling in ships when lockage water filling commences.

To reduce the effects of surge on ships a surge basin is proposed in the area of the Rio Cocoli valley.

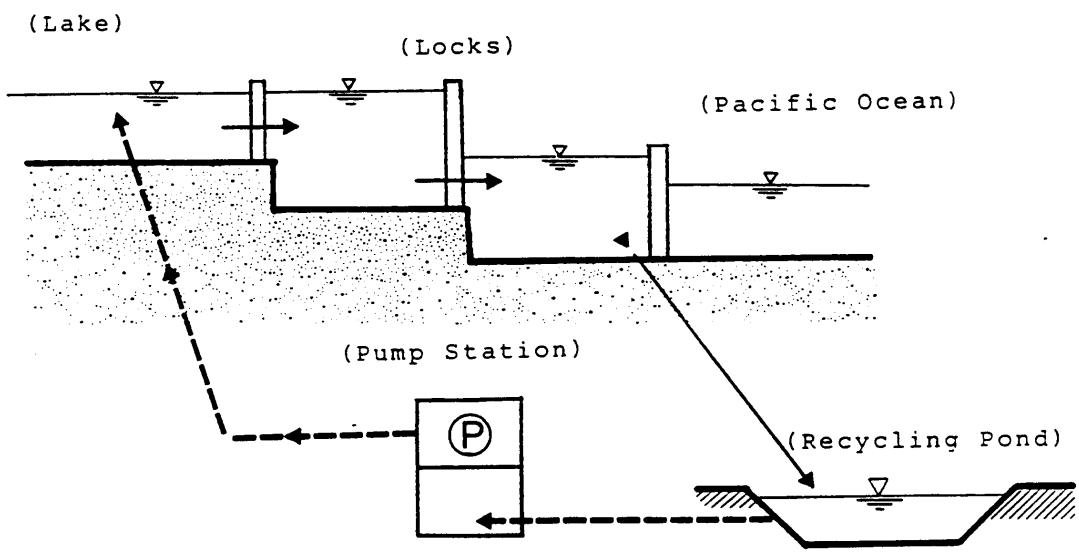
The surge basin utilizes the natural topography as much as possible. A closure dam is required at the south-east side of the basin.

(3) Recycling Pond

On the Pacific and Atlantic sides, recycling ponds are proposed for the purpose of storing spent lockage water (mainly fresh water) for subsequent recycling by pumping.

The pond has approximately 1.5 km^2 in area for a set of pump station. The effective water level range would be between -2.3 - -3.4m at the Pacific side and -0.1 - -1.2m at the Atlantic side respectively. A discharge channel to the surge basin extends about 800 meters (ref. Fig. 4.1.4). The width and depth of the channel is calculated based on the required number of pumping stations.

The following schematic drawing shows how the recycling pond is used.



(4) Pump Stations

A Pump station which has a capacity of 60 m3/sec. is provided between the recycling pond and the surge basin. The approximate location of the pump station is illustrated in Fig. 4.1.3 and Fig. 4.1.4.

The number of pump stations will be ascertained according to the transit capacity of the canal and whether new storage dams are provided. In the Summation Tables the number of pump stations (not the number of pumps) are shown.

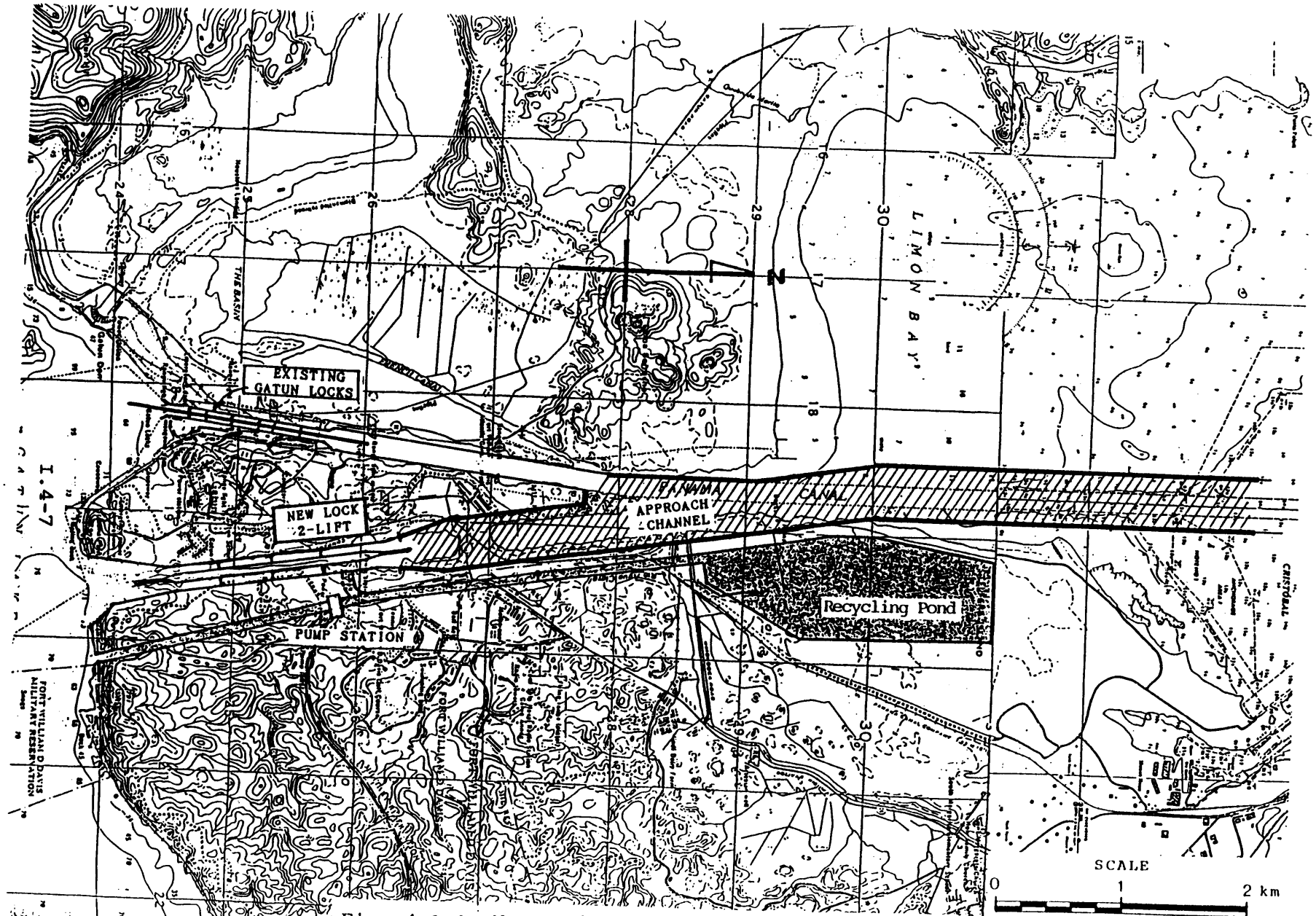


Fig. 4.1.3 New Lock Layout Plan (Atlantic Side)

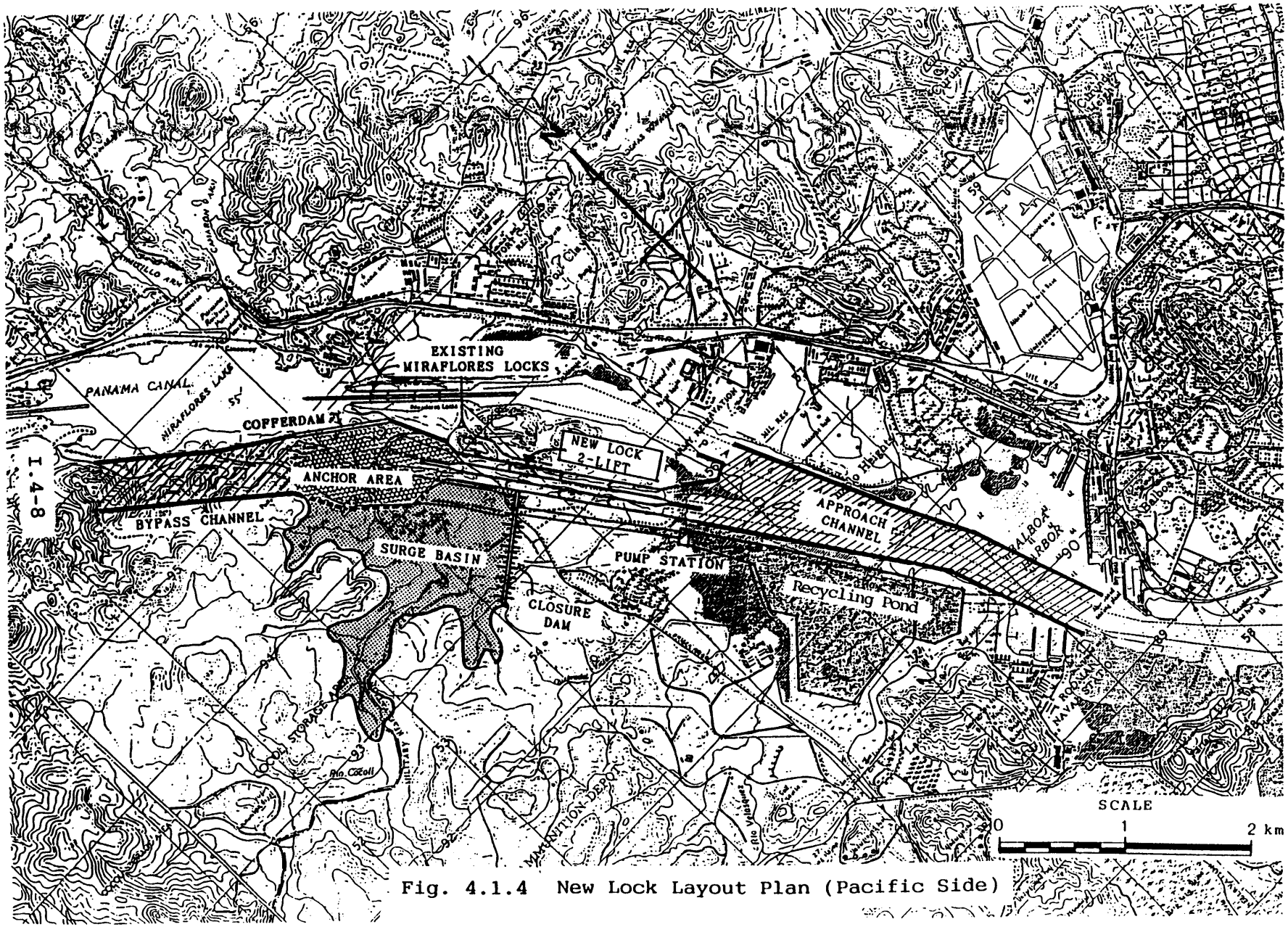
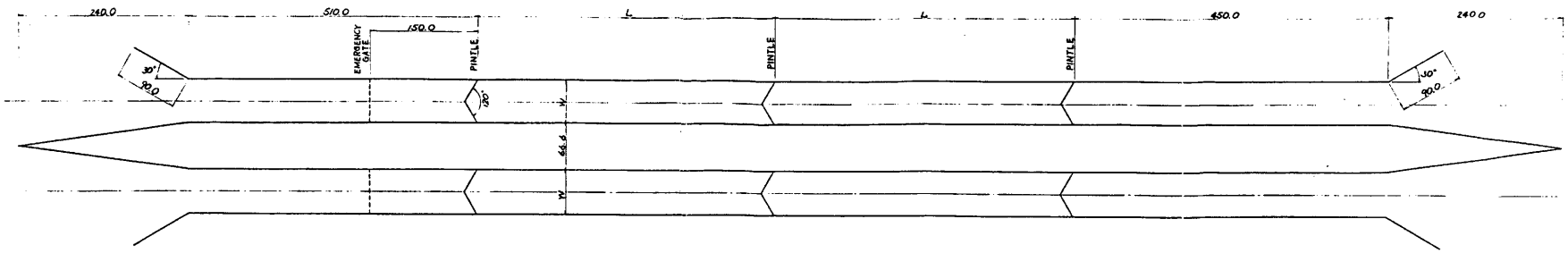
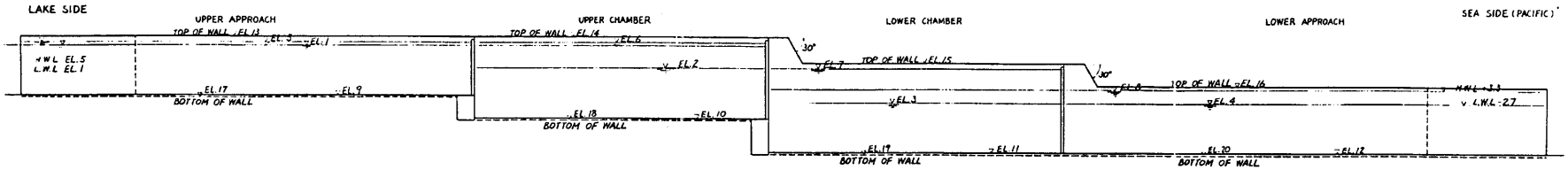


Fig. 4.1.4 New Lock Layout Plan (Pacific Side)



PLAN



PROFILE

250,000 DWT VESSEL LOCK

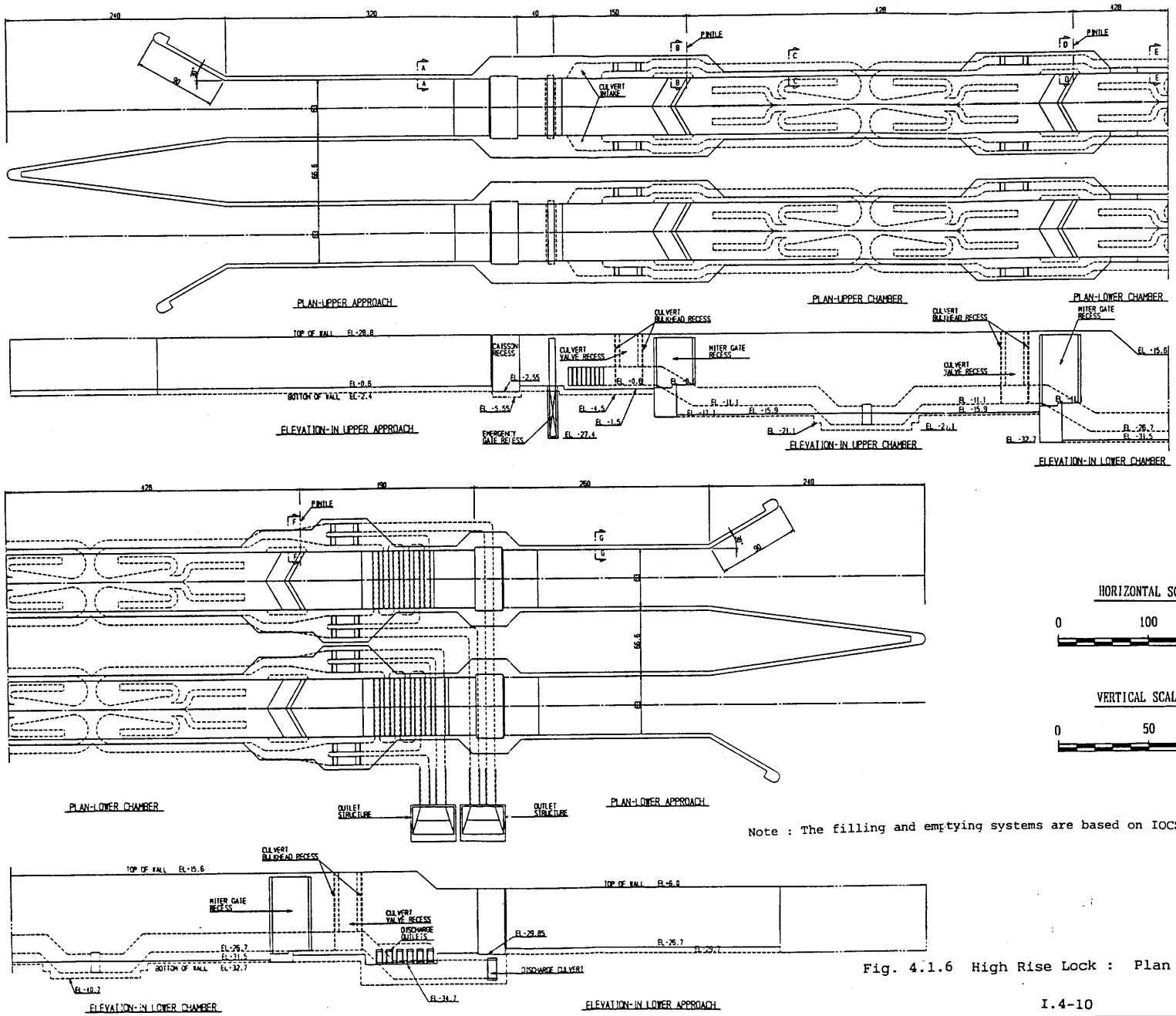
None Scale

Unit : Meter

STUDY CASE	LOCK SIZE DWT	L	W	D	HSE (%)	LOWEST WATER SURFACE ELEVATION GATUN EL.1	UPP LOCK EL.2	LOW LOCK EL.3	PACIFIC EL.4	HIGHEST WATER SURFACE ELEVATION GATUN EL.5	UPP LOCK EL.6	LOW LOCK EL.7	PACIFIC EL.8	BOTTOM ELEVATION GATUN EL.9	UPP LOCK EL.10	LOW LOCK EL.11	PACIFIC EL.12	TOP OF WALL GATUN EL.13	UPP LOCK EL.14	LOW LOCK EL.15	PACIFIC EL.16	BOTTOM OF WALL GATUN EL.17	UPP LOCK EL.18	LOW LOCK EL.19	PACIFIC EL.20
L-1	100,000	319	47	19	90	+26.1	+13.7	-2.7	-2.7	+27.6	+27.6	+13.7	+3.3	+7.1	-5.3	-21.7	-21.7	+30.3	+30.3	+16.4	+6.0	+2.0	-11.3	-27.7	-27.7
L-2	100,000	319	47	19	85	+24.6	+12.9	-2.7	-2.7	+26.1	+26.1	+12.9	+3.3	+5.6	-6.1	-21.7	-21.7	+28.8	+28.8	+15.6	+6.0	+0.5	-12.1	-27.7	-27.7
L-4	150,000	363	54	21	90	+26.1	+13.7	-2.7	-2.7	+27.6	+27.6	+13.7	+3.3	+5.1	-7.3	-23.7	-23.7	+30.3	+30.3	+16.4	+6.0	0.0	-13.3	-29.7	-29.7
L-5	150,000	363	54	21	85	+24.6	+12.9	-2.7	-2.7	+26.1	+26.1	+12.9	+3.3	+3.6	-8.1	-23.7	-23.7	+28.8	+28.8	+15.6	+6.0	-1.5	-14.1	-29.7	-29.7
L-7	250,000	428	63	24	90	+26.1	+13.7	-2.7	-2.7	+27.6	+27.6	+13.7	+3.3	+2.1	-10.3	-26.7	-26.7	+30.3	+30.3	+16.4	+6.0	-3.0	-16.3	-32.7	-32.7
L-8	250,000	428	63	24	85	+24.6	+12.9	-2.7	-2.7	+26.1	+26.1	+12.9	+3.3	+0.6	-11.1	-26.7	-26.7	+28.8	+28.8	+15.6	+6.0	-4.5	-17.1	-32.7	-32.7
L-10	100,000	319	47	19	85	+24.6	+12.9	-2.7	-2.7	+26.1	+26.1	+12.9	+3.3	+5.6	-6.1	-21.7	-21.7	+28.8	+28.8	+15.6	+6.0	+0.5	-12.1	-27.7	-27.7
L-13	150,000	363	54	71	85	+24.6	+12.9	-2.7	-2.7	+26.1	+26.1	+12.9	+3.3	+3.6	-8.1	-23.7	-23.7	+28.8	+28.8	+15.6	+6.0	-1.5	-14.1	-29.7	-29.7
L-16	250,000	428	63	24	85	+24.6	+12.9	-2.7	-2.7	+26.1	+26.1	+12.9	+3.3	+0.6	-11.1	-26.7	-26.7	+28.8	+28.8	+15.6	+6.0	-4.5	-17.1	-32.7	-32.7

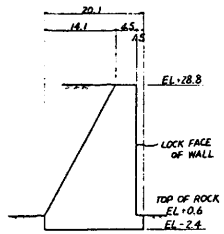
Note: Hatched mark is illustrated in Fig. 4.1.6 and Fig. 4.1.7

Fig. 4.1.5 High Rise Lock : General Dimensions

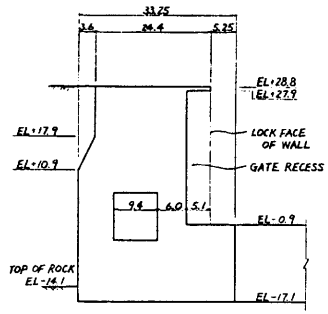


Note : The filling and emptying systems are based on IOCS (JAX 103 Report)

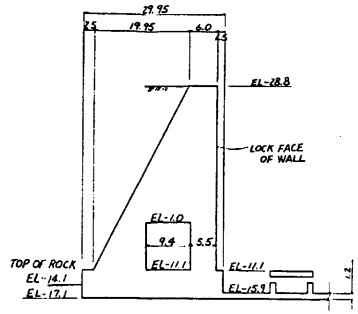
Fig. 4.1.6 High Rise Lock : Plan and Section



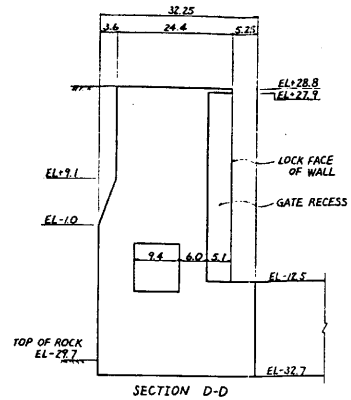
SECTION A-A
(UPPER APPROACH WALL)
SCALE 1:500



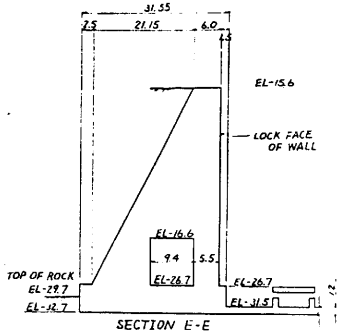
SECTION B-B
(UPPER GATE MONOLITH)
SCALE 1:500



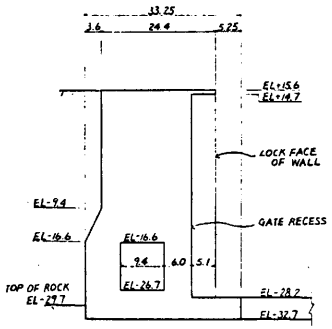
SECTION C-C
(UPPER CHAMBER WALL)
SCALE 1:500



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



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



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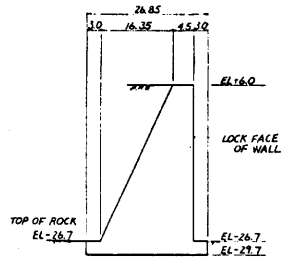
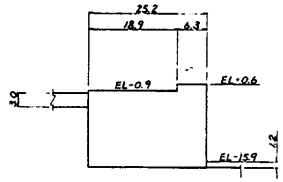


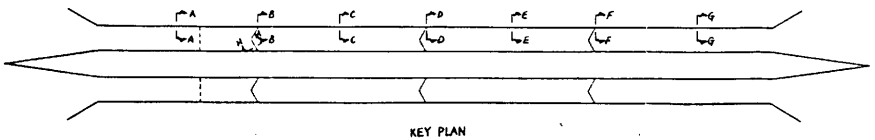
SECTION G-G
(LOWER APPROACH WALL)
SCALE 1:500



SECTION H-H
(TYPICAL MITER GATE SILL)
SCALE 1:500

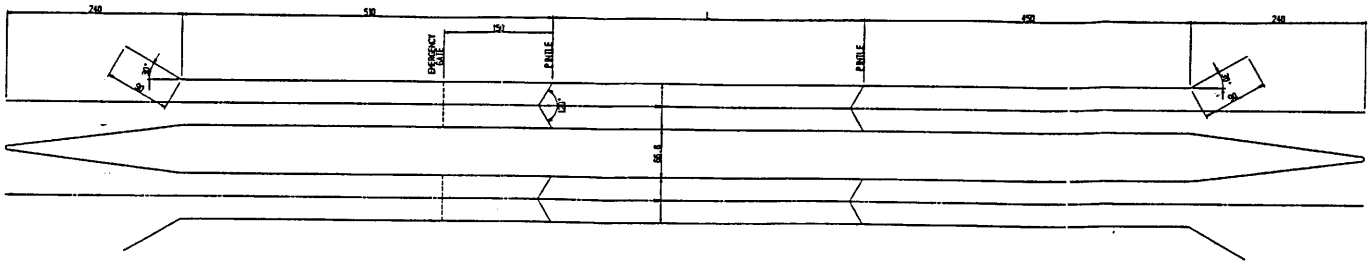
SCALE

0 50 m

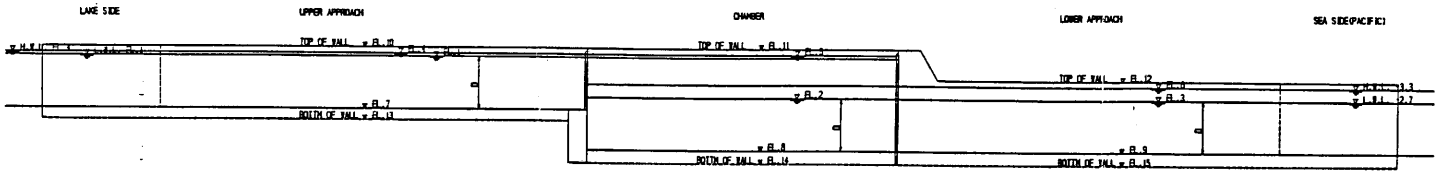


KEY PLAN

Fig. 4.1.7 High Rise Lock : Cross Section



PLAN



PROFILE

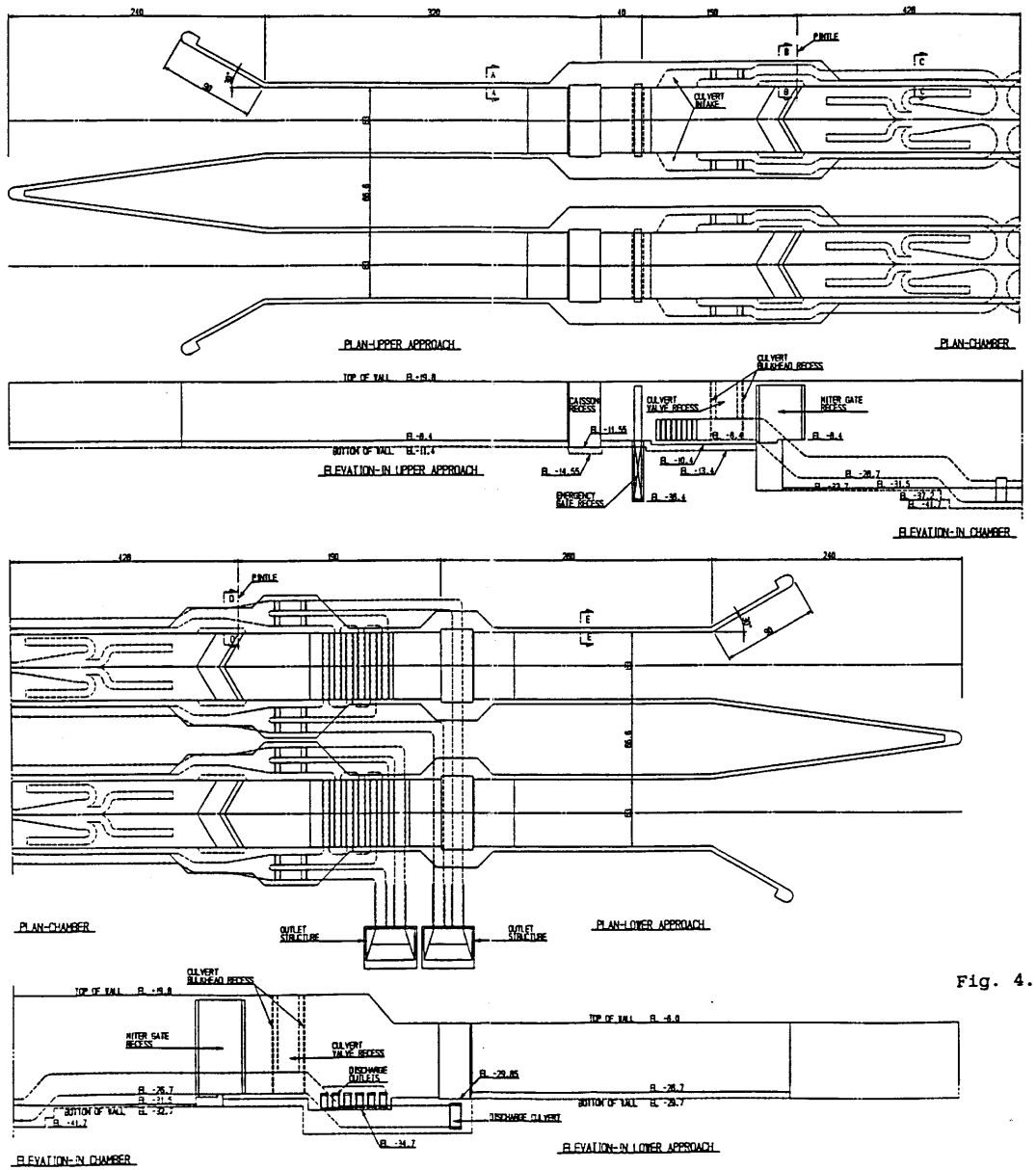
250,000 DWT VESSEL LOCK

Non Scale

Unit : Meter

STUDY CASE	LOCK SIZE				RISE	LOWEST WATER SURFACE ELEVATION			HIGHEST WATER SURFACE ELEVATION			BOTTOM ELEVATION			TOP OF WALL			BOTTOM OF WALL		
	DWT	L	W	D	(ft)	GATUN EL.1	LOCK EL.2	PACIFIC EL.3	GATUN EL.4	LOCK EL.5	PACIFIC EL.6	GATUN EL.7	LOCK EL.8	PACIFIC EL.9	GATUN EL.10	LOCK EL.11	PACIFIC EL.12	GATUN EL.13	LOCK EL.14	PACIFIC EL.15
L-3	100,000	319	47	19	55	+15.6	-2.7	-2.7	+17.1	+17.1	+3.3	-3.4	-21.7	-21.7	+19.8	+19.8	+6.0	-8.5	-27.7	-27.7
L-6	150,000	363	54	21	55	+15.6	-2.7	-2.7	+17.1	+17.1	+3.3	-5.4	-23.7	-23.7	+19.8	+19.8	+6.0	-10.5	-29.7	-29.7
L-9	250,000	428	63	24	55	+15.6	-2.7	-2.7	+17.1	+17.1	+3.3	-8.4	-26.7	-26.7	+19.8	+19.8	+6.0	-13.5	-32.7	-32.7
L-11	100,000	319	47	19	55	+15.6	-2.7	-2.7	+17.1	+17.1	+3.3	-3.4	-21.7	-21.7	+19.8	+19.8	+6.0	-8.5	-27.7	-27.7
L-12	100,000	319	47	19	30	+8.1	-2.7	-2.7	+9.6	+9.6	+3.3	-10.9	-21.7	-21.7	+12.3	+12.3	+6.0	-16.0	-27.7	-27.7
L-14	150,000	363	54	21	55	+15.6	-2.7	-2.7	+17.1	+17.1	+3.3	-5.4	-23.7	-23.7	+19.8	+19.8	+6.0	-10.5	-29.7	-29.7
L-15	150,000	363	54	21	30	+8.1	-2.7	-2.7	+9.6	+9.6	+3.3	-12.9	-23.7	-23.7	+12.3	+12.3	+6.0	-18.0	-29.7	-29.7
L-17	250,000	428	63	24	55	+15.6	-2.7	-2.7	+17.1	+17.1	+3.3	-8.4	-26.7	-26.7	+19.8	+19.8	+6.0	-13.5	-32.7	-32.7
L-18	250,000	428	63	24	30	+8.1	-2.7	-2.7	+9.6	+9.6	+3.3	-15.9	-26.7	-26.7	+12.3	+12.3	+6.0	-21.0	-32.7	-32.7

Fig. 4.1.8 Low Rise Lock : General Dimensions



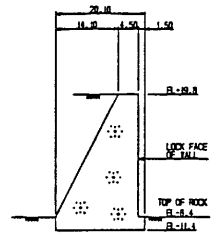
HORIZONTAL SCALE

0 100 200 m

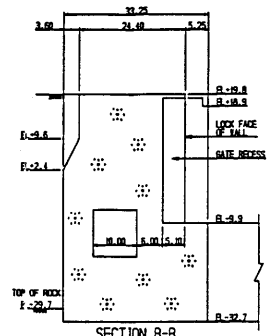
VERTICAL SCALE

0 50 100 m

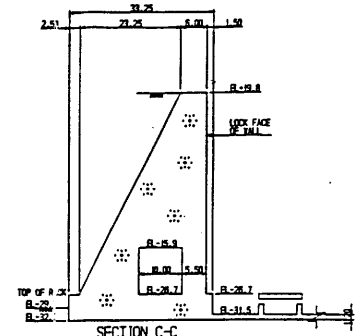
Fig. 4.1.9 Low Rise Lock : Plan and Section



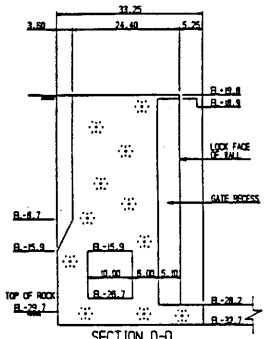
SECTION A-A
(UPPER APPROACH WALL)
SCALE 1:500



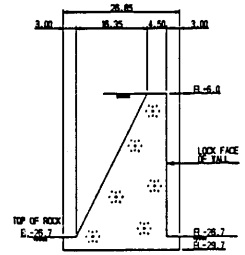
SECTION B-B
(UPPER GATE MONOLITH)
SCALE 1:500



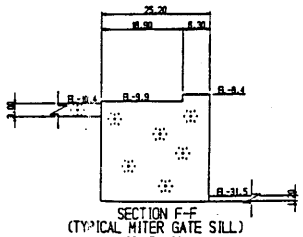
SECTION C-C
(CHAMBER WALL)
SCALE 1:500



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



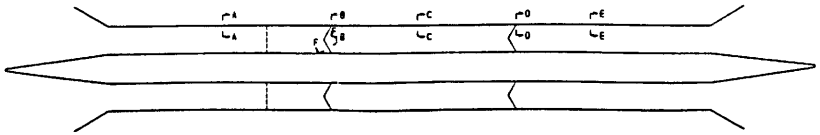
SECTION E-E
(LOWER APPROACH WALL)
SCALE 1:500



SECTION F-F
(TYPICAL MITER GATE SILL)
SCALE 1:500

SCALE

0 50 m



KEY PLAN

Fig. 4.1.10 Low Rise Lock : Cross Section

4.2 Gate Leaves

4.2.1 General Information

(1) Introduction

This section intends to give general technical information common to all kinds of gates to be utilized in the lock type canal. Further, the fundamental conditions, philosophy, and important procedures for conceptual designs whose results are going to be shown in the next section will be presented.

The kind of gates studied were: the Lock Gate, the Culvert Gate, the Emergency Gate and the Maintenance Gate. The Lock Gate plays a major role in canal lock functions and opens or closes the lock entrances according to ship transits. The Culvert Gate also plays a major role. It opens or closes culvert channels in the lock walls and controls water flow in the culvert channel running into or out of lock chambers and, eventually, lifts ships 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 Lock Gates due to ship collisions to prevent the areas surrounding the lock from disaster or reduce the level of damages. The Maintenance Gate is used to close the extreme ends of the lock whenever it becomes necessary for maintenance in the lock chamber during dry conditions.

<u>Comparison of Global Lock Gates</u>

The locks for ships can be divided into two groups: an entrance lock for docks, and a navigation lock for canals. Table 4.2.1 lists the entrance locks in The United Kingdom and in India. The example incorporation of India along with the UK is given since the engineering was performed by a British consultant firm. This table also list separately the entrance locks for the European continent. Both cases indicate positive correlations between the lock widths and the gate types, but at the same

lock widths and the gate types, but at the same time, there seems to be a minimal difference in development histories. There was not enough information found about entrance locks from other parts of the world, but time constraints hindered closer inspection of the southern hemisphere. Table 4.2.2 lists the navigation locks studied. Representative cases were selected for listing in the table from each waterway. The Saint Lawrence seaway and the Panama Canal are remarkable among the sample because each can accommodate bigger ships with deeper drafts. The Saint Lawrence is preferred over the Panama Canal when comparing lift per chamber. In spite of the smaller water depths found in other cases, many high lift locks are seen in the American continent and in Europe. The widths in the American continent much prevail over these in Europe.

Table 4.2.3 was converted from Table 4.2.2 to examine correlations between the principal technical data and gate types. A simplification rule for the conversions was employed. An extreme single case was chosen from each waterway and the names of the gate type listed in Table 4.2.2 were replaced by the gate movements when the gate opened. The cases enclosed by the bold lines on Table 4.2.3 are of a high lift compared with each's water depths. This relation led to correlations with a gate type; i.e. a combination of drop type and rise type as seen in the bolded area of the Table. There are also several exceptions, both in and out, of the enclosed area. Noted selections for hydraulic steel structures are not unusual, and there are possible justifications for selections that could be listed.

Table 4.2.1 Records of Lock Gates

ENTRANCE LOCK IN UK AND INDIA

COUNTRY	NAME OF LOCK OR DOCK	LOCK IN M		HEIGHT IN M		LIFT	GATE	REMARK
		LENGTH	WIDTH	GATE	WATER	IN M	TYPE	
UK	CHICHESTER HARBOUR	32	7.6		5.6		SECTOR	
UK	SHADWELL LOCK	107	18.3		8.5		MITER	
UK	BARRY DOCK (S.WALES)	197	19.8		14.8		MITER	
UK	GREENLAND	168	24.4		9.8		MITER	
UK	GALLION LOWER	168	24.4		10.5		MITER	
UK	SWANSEA DOCK	265	27.4		12.2		MITER	
UK	KING GEORGE	244	30.5		11.6		MITER	
UK	NEWPORT DOCK	305	30.5		16.8		MITER	WATER DEPTH IN DOCK
UK	GRANGEMOUTH DOCK	237	30.5		11.6		MITER	
UK	LEITH HARBOUR	259	33.5	14.2			SLIDE	
UK	PORT OF LIVERPOOL	251	39.6	17.1			SLIDE	
INDIA	HALDIA DOCK	380	40.0		13.7		SLIDE	WATER DEPTH IN DOCK
UK	WEST DOCK OF BRISTOL	366	42.7		17.1		SLIDE	NEEDS CONFIRMATION

ENTRANCE LOCK IN THE CONTINENT

COUNTRY	NAME OF LOCK OR DOCK	LOCK IN M		HEIGHT IN M		LIFT	GATE	REMARK
		LENGTH	WIDTH	GATE	WATER	IN M	TYPE	
FRANCE	DUQUESNE DOCK, DIEPPE		15.0		12.0		SECTOR	
GERMANY	HOLTENAU	125	25.0		10.1		MITER	
GERMANY	BRUNSBUTTEL	125	25.0		10.2		MITER	
FRANCE	THE PORT OF LE HAVRE	290	25.0		15.3		SLIDE	PLANNED IDEA
FRANCE	THE PORT OF LE HAVRE	300	42.0		20.3		SLIDE	PLANNED IDEA
GERMANY	HOLTENAU	310	45.0		13.8		SLIDE	
GERMANY	BRUNSBUTTEL	310	45.0		13.8		SLIDE	
BELGIUM	ANTWERP BAUDIN LOCK	360	45.0		14.3		SLIDE	
HOLLAND	IJMNIDEN	400	50.0				SLIDE	
BELGIUM	ANTWERP ZANTFLIET	500	57.0	22.9	21.0		SLIDE	
FRANCE	THE PORT OF LE HAVRE	360	60.0		21.3		SLIDE	PLANNED IDEA
BELGIUM	ANTWERP BERENDRECHT	500	68.0	22.6	21.0		SLIDE	

done

Table 4.2.2 Records of Lock Gates

NAVIGATION LOCK

COUNTRY	NAME OF LOCK	NAME OF RIVER / CANAL	LOCK IN M WIDTH	LENGTH	WATER DEPTH	LIFT IN M	NO.	UPPER LOCK GATE TYPE	HEIGHT	LOWER LOCK GATE TYPE	HEIGHT	REMARK
UK	TOWN LOCK	TRENT RIVER	9.1	59	2.6	1.9	1	MITER		MITER		
FRANCE	THE DON LOCK	DEULE CANAL	12.0	138	3.5	2.5	1	SECTOR		SECTOR		
GERMANY	KRIEGENBRUNN	TRANS-EUROPE	12.0	190	4.0		1	VERT. DROP		VERT. RISE		
GERMANY	NUREMBERG-SOUTH	TRANS-EUROPE	12.0	190	4.0	19.5	1	VERT. DROP		VERT. RISE		
GERMANY	LEERSTETTEN	TRANS-EUROPE	12.0	190	4.0	24.7	1	VERT. DROP		VERT. RISE		TYPES TO BE CONFIRMED
GERMANY	KLOZZENBURG	TRANS-EUROPE	12.0	300	4.0		1	MITER		MITER		
HOLLAND	THE TIEL LOCK	AMST.-RHINE	18.0	350	4.2	4.8	1	MITER		VERT. RISE		
USA	EISENHOWER	ST LAWRENCE	24.4	233	9.1	12.8	1	MITER		MITER		
USA	BERTRAND H. SNELL	ST LAWRENCE	24.4	233	9.1	14.9	1	MITER		MITER		
USA	NEW BONNEVILLE LOCK	COLUMBIA-SNAKE	26.2	206	4.6		1					UNDER CONSTRUCTION
USA	ICE HARBOUR	COLUMBIA-SNAKE	26.2	206	4.6	31.4	1	RADIAL DROP	6.1	VERT. RISE	27.7	
USA	LOWER GRANITE	COLUMBIA-SNAKE	26.2	206	4.6	32.0	1	RADIAL DROP	7.0	MITER	37.5	
USA	JOHN DAY	COLUMBIA-SNAKE	26.2	206	4.6	34.4	1	VERT. DROP	8.1	VERT. RISE	34.4	
USA	GAINESVILLE LOCK	TENN.-TOMBIGBEE	33.5	183	3.7	9.8	1	MITER		MITER		
USA	BAY SPRING LOCK	TENN.-TOMBIGBEE	33.5	183	3.7	25.6	1	MITER		MITER		
USA	LOCK NO 1	UPP. MISSISSIPPI	33.5	183	2.7		1	MITER		MITER		HIGH LIFT
USA	LOCK NO 27	UPP. MISSISSIPPI	33.5	366	2.7		1	MITER		MITER		
USA	KEOKUK LOCK	UPP. MISSISSIPPI	33.5	366	2.7		1	MITER		MITER		
USA	MEL PRICE LOCK	UPP. MISSISSIPPI	33.5	366	2.7		1					
USA	WILLOW ISLAND LOCK	OHIO	33.5	366	2.7		1					
USA	OLMSTED LOCK	OHIO	33.5	366	2.7		1					DESIGN STAGE
PANAMA	PEDRO MIGUEL LOCK	PANAMA	33.5	305	12.8	9.2	1	MITER	24.1	MITER	24.1	
PANAMA	MIRAFLORES LOCK	PANAMA	33.5	305	12.8	16.7	2	MITER	23.5	MITER	25.0	
PANAMA	GATUN LOCK	PANAMA	33.5	305	12.8	25.9	3	MITER	23.5	MITER	23.7	
ARGENTINA	YACIRETA DAM	RIO DE PARANA	27.0	270	3.7	24.0	1	VERT. DROP		MITER		

Table 4.2.3 Lock Gates for Canal Locks

NAME OF LOCK	NAME OF RIVER OR CANAL	LOCK IN M LENGTH	WIDTH	WATER DEPTH	LIFT IN M	LOCK GATE TYPE UPPER	LOWER
LEERSTETTEN	TRANS-EUROPE	190	12.0	4.0	24.7	DROP	RISE
JOHN DAY	COLUMBIA-SNAKE	206	26.2	4.6	34.4	DROP	RISE
YACIRETA DAM	RIO DE PARANA	270	27.0	3.7	24.0	DROP	SWING
BAY SPRING LOCK	TENN.-TOMBIGBEE	183	33.5	3.7	25.6	SWING	SWING
TOWN LOCK	TRENT RIVER	59	9.1	2.6	1.9	SWING	SWING
THE DON LOCK	DEULE CANAL	138	12.0	3.5	2.5	SWING	SWING
THE TIEL LOCK	AMST.-RHINE	350	18.0	4.2	4.8	SWING	RISE
BERTRAND H. SNELL	ST LAWRENCE	233	24.4	9.1	14.9	SWING	SWING
LOCK NO 27	UPP. MISSISSIPPI	366	33.5	2.7		SWING	SWING
GATUN LOCK	PANAMA	305	33.5	12.8	25.9	SWING	SWING

Comparison of Existing Locks

Five cases were chosen from the previously listed locks for comparison with existing Panama Canal locks. The results are given in Table 4.2.4.

Table 4.2.4 Comparison of Lock

Comparison Item		Panama	Bertrand H.Snell	Leers-tetten	Bay Spring	Leith	Beren-drecht
Navigation Lock		○	○	○	○		
Entrance Lock						○	○
Year of Completion		1913	1959	1974?	1985	1969	1987
Length in Meter		305	233	190	183	259	500
Width in Meter		33.5	24.4	12	33.5	33.5	68
Lift	in Meter	25.9	14.9	24.7	25.8		5.25
	Number	3	1	1*	1	1	1
Lock Gate Protection	Guard Gate	Yes	No	No	No	No	Yes
	Safety Gate	Yes	No	No	No	No	Yes
Lock Gate Type	Miter	○	○		○		
	Slide					○	○
	Vertical			○			
Culvert Gate	Stoney	○					
	Reverse Radial		○		○	○	
Emergency Gate		Yes	No	No	No	No	No

Note 1.* shows a water saving lock

(2) General Hydraulic Conditions for Gate Design

The general hydraulic conditions for various gate designs are shown in Table 4.2.5 whose content conforms to the water levels of design criteria as given in Chapter 1 except as noted.

Table 4.2.5 Required Water Levels

Location	Water Level	H.W.L.	L.W.L.
Gatun Lake	Rise	Rise+0.6m	Rise-0.9m
Atlantic Coast	+0.1 P.L.D.	+0.5m	-0.3m
Pacific Coast	+0.3 P.L.D	+3.3m	-2.7m

Note 1. For water elevations in the upper chambers of Two lift type locks, the mean value of the Gatun standard elevation and the respective ocean's standard elevation is taken for the Phase 1 study. Optimization of these elevations with respect to either construction cost or water consumption will be investigated during Phase 2.

2. The Emergency Gate will be designed for Gatun Lake H.W.L. plus 1.5m (approx.=5').

3. Hydraulic conditions for the design of Tidal Gates will conform to those given in IOCS Memorandum JAX 67.

4. Freeboard; as given in Table 4.2.6.

Table 4.2.6 Freeboard Allowances

Gate Name	Meter	Feet
Lock Gate	0.6	2*
Emergency Gate	0	0
Maintenance Gate	0.6	2*
Tidal Gates	0.6	2

Note 1: * Marked value corresponds to the one used in Deep Draft Lock Plan Study in IOCS memorandum JAX 103.

(3) Structural Materials and Allowable Stress Levels

a) Proposed Materials

For the purpose of this study, structural materials of the usual carbon, or low alloy carbon steels having good weldability, good notch ductility, and high resistance to brittle fracture are proposed. Steels that are classified in this category are presently widely available in mill markets. The proposed strength range is up to 100 kg/mm2 in fracture strength. Preference will be given to quenched and tempered steels in the case of high tensile strength steel (high-tension steel abbreviated as H.T. steel).

b) Allowable Stress Levels

<u>Failure Mode: Yielding</u>

The allowable stress levels used in this study are from the "Technical Standards for Gates and Penstocks", edited by the Hydraulic Gate and Penstock Association of Japan. Table 4.2.7 shows allowable values for tensile and compressive stresses for various strength grades. The values shown are only for examples and applicable for the plates thicker than 40 mm.

Table 4.2.7 Allowable Stresses

Strength level	Yield P. kg/mm2	Fracture P. kg/mm2	Allowable Stress kg/mm2
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

Failure Mode: Fatigue

The life duration of the gates is ascertained to be 50 years. Table 4.2.8 shows the number of lock operations over the design life calculated for various operation frequency levels:

Table 4.2.8 Number of Lock Operations

Frequency Class	Number of Operations	
	Per Year	Per 50 Years
A	15,000	750,000
B	20,000	1,000,000
C	25,000	1,250,000
D	35,000	1,750,000

Note 1. Number of operations is the number of gate operations and differs from the number of transits in general.

Allowable stresses for prevention of Fatigue failure for each frequency class established above are shown in Table 4.2.9. 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 in the shaded area in the table were adopted for this study. The frequency of lock operations per year in this area corresponds to approximately four times the capacity of new locks at Gatun as shown in Section Annex. 2.11.1 of this Final Report which states, 36 standard ships per day for two lanes in the relay operation.

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

Table 4.2.9 Allowable Stress for Fatigue Design

Load Frequency Class	Class A	Class B	Class C	Class D
Frequency of Operation Per Year	15,000	20,000	25,000	35,000
Tension				
Mother Metal	21.9	19.9	18.8	16.5
Finished Butt & Seam Joint	21.9	19.9	18.5	16.5
Fillet Weld Joint in Load Direction	17.7	16.1	14.9	13.3
Fillet Weld Joint in Normal Direction	14.2	12.9	11.9	10.7
Compression				
Mother Metal	28.5	25.9	24.0	21.5
Finished Butt & Seam Joint	28.5	25.9	24.0	21.5
Fillet Weld Joint in Load Direction	23.0	20.9	19.4	17.3
Fillet Weld Joint in Normal Direction	18.4	16.7	15.5	13.9

Note 1. The allowable stresses shown are in Kg/mm2

c) Failure Mode to be Considered for Each Gate

Failure modes to be considered for each gate are shown on Table 4.2.10.

Table 4.2.10 Failure Mode Application

Failure Mode	Gate Type				
	Lock G.	Culvert G.	Emergency G.	Maintenance G.	Tidal G.
Yielding	Yes	Yes	Yes	Yes	Yes
Fatigue	Yes	Yes	No	No	No

d) Corrosion protection

Both paint coatings and electric corrosion protection systems are proposed to reduce corrosion progression on metal works. Application of electric corrosion protection is also discussed for each gate in the next section. Further concrete discussion will accompany the Phase 2 study.

(4) Weight Estimation Procedure

a) Gate Leaves

All major factors controlling unit weights (ton/m2) of gate leaves were listed for each gate type, and the factor demonstrating the most effect on the leaf unit weight was selected. Table 4.2.11 shows the unit weight control factors selected for each type of gate.

Table 4.2.11 Weight Control Factor

Lock G.	Culvert G.	Emergency G.	Maintenance G.	Tidal G.
L x Pmean	Pc x H	L x H	L x P x P/H	$P^{2/3}$ x $H^{4/3}$ x $(1-2/5 \times \alpha)$

Note 1. L=Lock width (m), H=Gate height (m),
Pmean= Mean design pressure (ton/m2),
Pc= Pressure at leaf center (ton/m2),
P= Maximum Pressure (ton/m2),
α= P/H

Fig. 4.2.1 illustrates unit weights of various Lock Gates against the selected weight control factor. The unit weights of the existing Panama Lock Gates (Status Quo, SQ) lie on a line on the graph demonstrates the validity of the factor selection. Unit weights obtained from the Anderson Report for the Deep Draft Lock Plan are also shown (DDL).

The next step was selection of model cases for the preliminary designs. The three model cases shown on the figure were selected as representative of all

the study cases regarding the ranges of weight control factors. Preliminary designs were carried out on the selected model cases, and the unit weights for each were plotted on the figure. Unit weights for all study cases (S.C.) were then derived from the graph such that each study case would plot in the curve which was defined by the three points of the model cases. Fig. 4.2.2. shows total leaf weights plotted against a factor which relates to the magnitude of bending moments in the gate leaves. This graph demonstrates that the total Leaf weights adopted for the various study cases are also reasonable compared to existing Panama Lock (SQ), Deep Draft Lock (DDL), and the model cases (MODEL).

Table 4.2.12 is the numerical data on which Fig. 4.2.1 and Fig. 4.2.2 are based.

Fig. 4.2.3 shows unit weights of Culvert Gates, Fig. 4.2.4 Emergency Gates, Fig 4.2.5 Maintenance Gates and Fig. 4.2.6 Tidal Gates.

Fig. 4.2.7 shows total leaf weights of Tidal Gates plotted against a factor which relates to bending moments yielding in frames supporting the skin plates of the gate surfaces.

All gates were treated in the same manner the get unit weights, but preliminary designs based on the model cases were only developed for the Lock Gates. The unit weights for other gate types were determined based upon weight data given in the Anderson Report, or from other fabrication record sources.

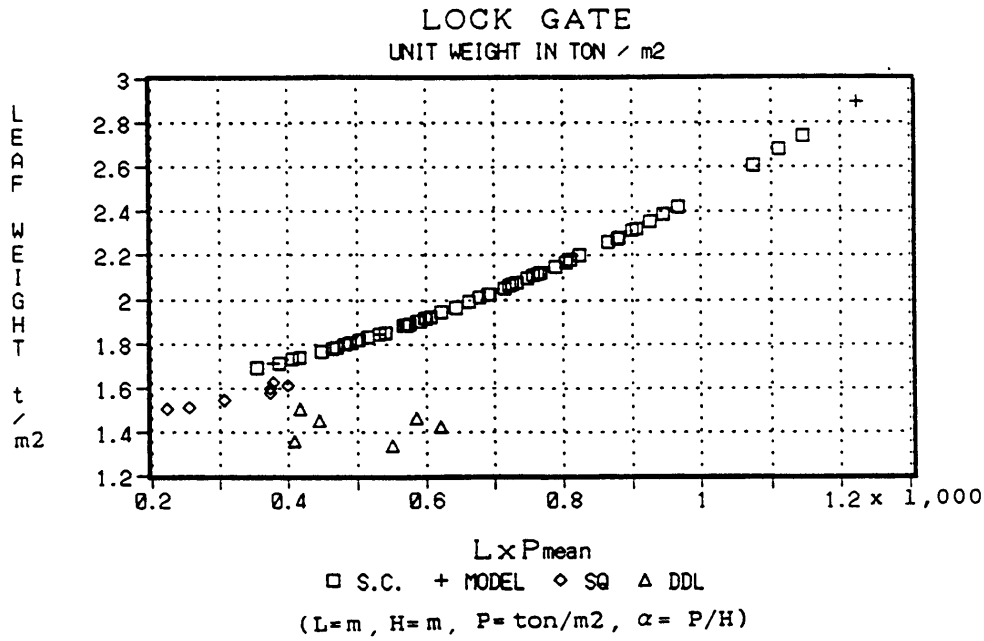


Fig. 4.2.1 Lock Gate Unit Weight

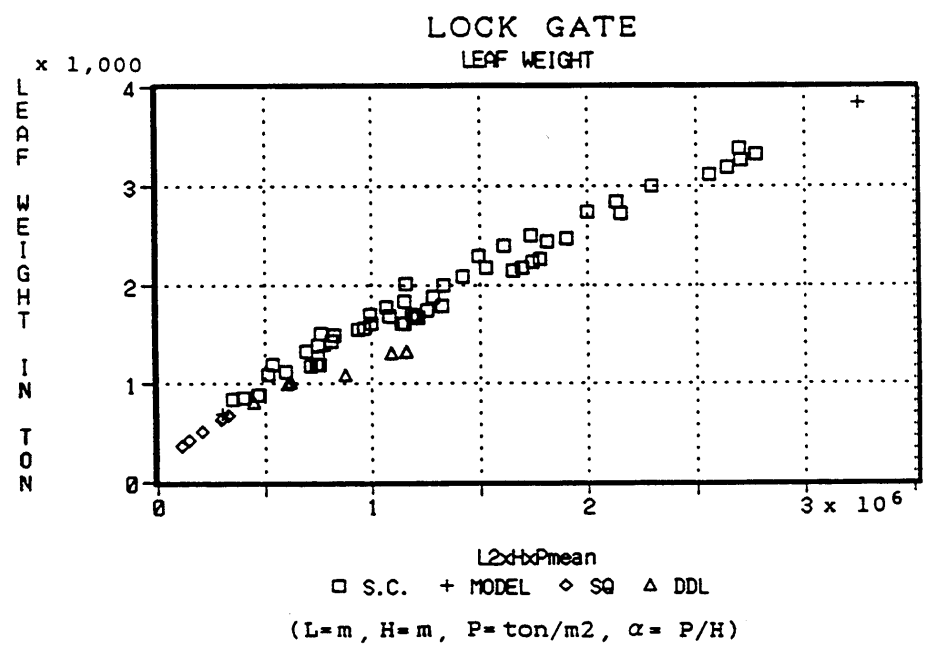


Fig. 4.2.2 Lock Gate Total Weight

Table 4.2.12 Lock Gate Weight Data

GATE IDENTIFICATION		Lx	GATE		UNIT WEIGHT (TON/m2)				TOTAL WEIGHT (TON)			
GROUP	NUMBER/NAME	Pmean	H	L	SQ	DDL	D.ML	S.C.	SQ	DDL	D.ML	S.C.
STATUS QUO	GATUN UPP. GUARD	254	16.7	33.5	1.510				422			
(S.Q.)	GATUN UPP. OPE.	372	23.7	33.5	1.581				629			
	PEDRO UPP. OPE.	378	24.1	33.5	1.623				655			
	MIRA. GUARD GATE	221	14.4	33.5	1.508				365			
	MIRA. UPP. OPE.	373	23.5	33.5	1.596				628			
	MIRA. LOWER OPE.	399	25.0	33.5	1.613				676			
	MIRA. LOWER GUARD	306	20.1	33.5	1.544				521			
DEEP DRAFT	150000-UPP. LOCK.	416	21.9	48.8		1.506				806		
LOCK PLAN	150000-MID. LOCK.	408	30.5	48.8		1.360				1011		
(DDL)	150000-LOW. LOCK.	446	28.7	48.8		1.449				1012		
	250000-UPP. LOCK.	585	26.5	56.4		1.468				1098		
	250000-MID. LOCK.	550	35.1	56.4		1.337				1321		
	250000-LOW. LOCK.	619	33.2	56.4		1.426				1335		
DESIGN	LARGEST CASE	1223	42.1	63.0			2.897				3841	
MODEL	MIDDLE CASE	533	29.9	48.8			1.845				1346	
(D.ML)	SMALLEST CASE	378	24.1	33.5			1.709				690	
STUDY CASE	GL1 M12	465	31.9	47.0				1.781				1335
(S.C.)	GL1 M11	405	21.1	47.0				1.730				858
	GL2 M23	568	35.2	47.0				1.881				1556
PACIFIC	GL2 M22	748	32.8	47.0				2.096				1615
SIDE	GL2 M21	482	21.1	47.0				1.796				891
	GL3 M23	592	36.0	47.0				1.907				1614
	GL3 M22	768	33.5	47.0				2.123				1671
	GL3 M21	482	21.1	47.0				1.796				891
	GL4 M12	693	39.4	47.0				2.025				1875
	GL4 M11	481	21.1	47.0				1.796				890
	GL5 M12	946	48.4	47.0				2.387				2715
	GL5 M11	482	21.1	47.0				1.796				891
	GL6 M12	542	33.9	54.0				1.854				1697
	GL6 M11	483	23.1	54.0				1.797				1121
	GL7 M23	663	37.2	54.0				1.988				1997
	GL7 M22	900	34.8	54.0				2.315				2175
	GL7 M21	608	23.1	54.0				1.924				1200
	GL8 M23	691	38.0	54.0				2.023				2075
	GL8 M22	926	35.5	54.0				2.355				2257
	GL8 M21	608	23.1	54.0				1.924				1200
	GL9 M12	810	41.4	54.0				2.180				2437
	GL9 M11	599	23.1	54.0				1.914				1194
	GL10 M12	644	36.9	63.0				1.965				2284
	GL10 M11	588	26.1	63.0				1.903				1564
	GL11 M23	789	40.2	63.0				2.151				2724
	GL11 M22	1112	37.8	63.0				2.678				3189
	GL11 M21	803	26.1	63.0				2.171				1785
	GL12 M23	823	41.0	63.0				2.200				2841
	GL12 M22	1146	38.5	63.0				2.743				3326
	GL12 M21	803	26.1	63.0				2.171				1785
	GL13 M12	965	44.4	63.0				2.419				3384
	GL13 M11	763	26.1	63.0				2.116				1739
STUDY CASE	GL1 M12	386	29.5	47.0				1.715				1189
(S.C.)	GL1 M11	353	21.1	47.0				1.690				838
	GL2 M23	490	32.7	47.0				1.804				1386
ATLANTIC	GL2 M22	734	32.9	47.0				2.077				1606
SIDE	GL2 M21	482	21.1	47.0				1.796				891
	GL3 M23	515	33.5	47.0				1.828				1439
	GL3 M22	757	33.6	47.0				2.107				1664
	GL3 M21	482	21.1	47.0				1.796				891
	GL4 M12	622	37.0	47.0				1.941				1687
	GL4 M11	471	21.1	47.0				1.786				886
	GL5 M12	880	46.0	47.0				2.284				2469
	GL5 M11	482	21.1	47.0				1.796				891
	GL6 M12	449	31.5	54.0				1.767				1503
	GL6 M11	417	23.1	54.0				1.740				1085
	GL7 M23	572	34.7	54.0				1.885				1766
	GL7 M22	877	34.9	54.0				2.279				2147
	GL7 M21	608	23.1	54.0				1.924				1200
	GL8 M23	601	35.5	54.0				1.917				1837
	GL8 M22	906	35.6	54.0				2.324				2234
	GL8 M21	608	23.1	54.0				1.924				1200
	GL9 M12	727	39.0	54.0				2.067				2177
	GL9 M11	576	23.1	54.0				1.890				1179
	GL10 M12	533	34.5	63.0				1.845				2005
	GL10 M11	503	26.1	63.0				1.816				1493
	GL11 M23	680	37.7	63.0				2.008				2385
	GL11 M22	1075	37.9	63.0				2.609				3115
	GL11 M21	803	26.1	63.0				2.171				1785
	GL12 M23	715	38.5	63.0				2.053				2489
	GL12 M22	1112	38.6	63.0				2.679				3257
	GL12 M21	803	26.1	63.0				2.171				1785
	GL13 M12	866	42.0	63.0				2.262				2993
	GL13 M11	722	26.1	63.0				2.062				1695

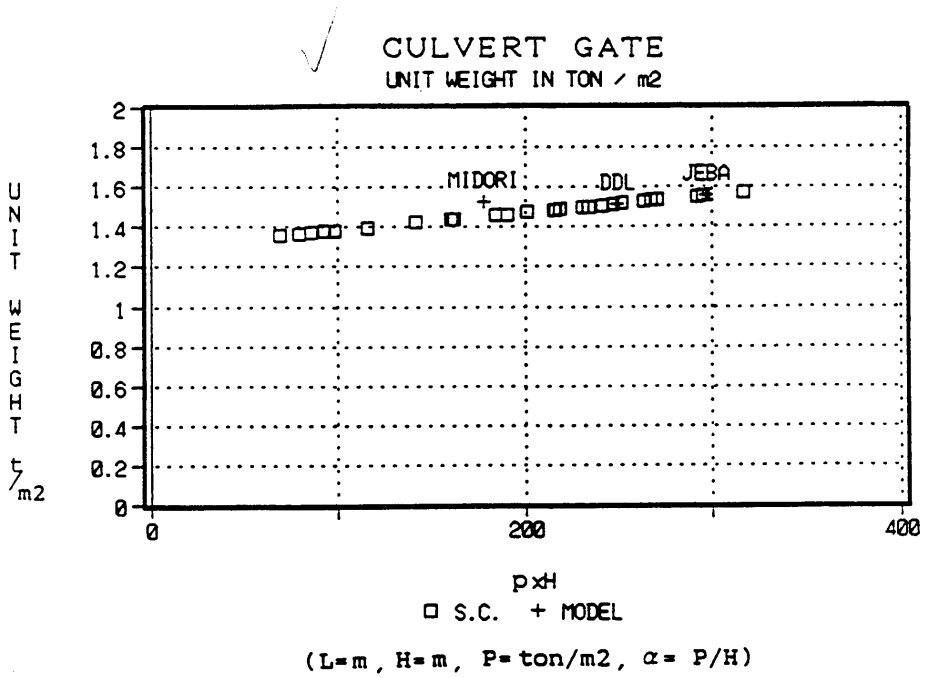


Fig. 4.2.3 Culvert Gate Unit Weight

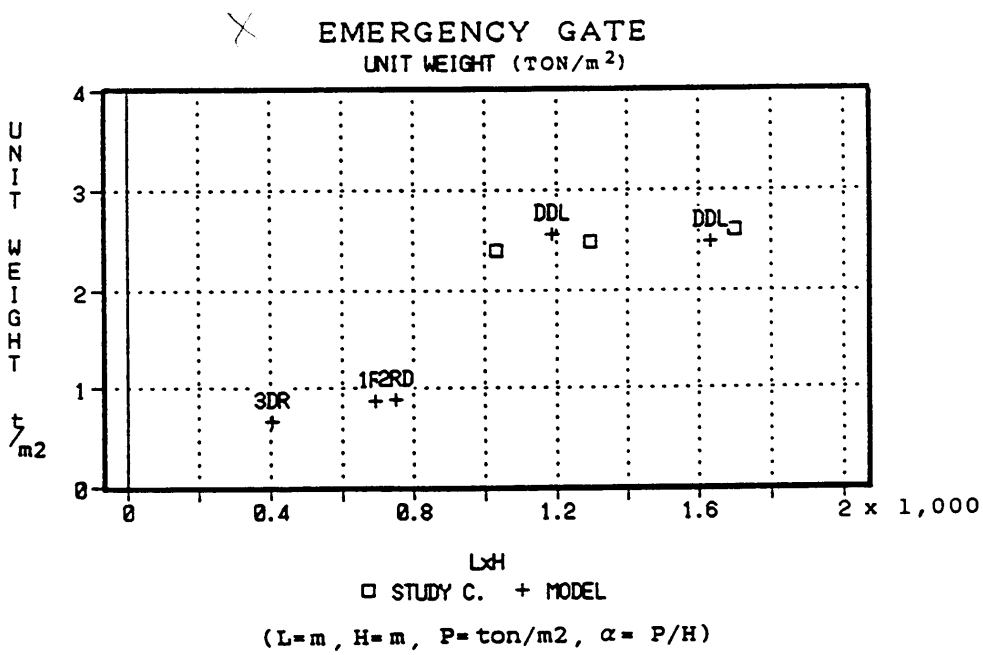
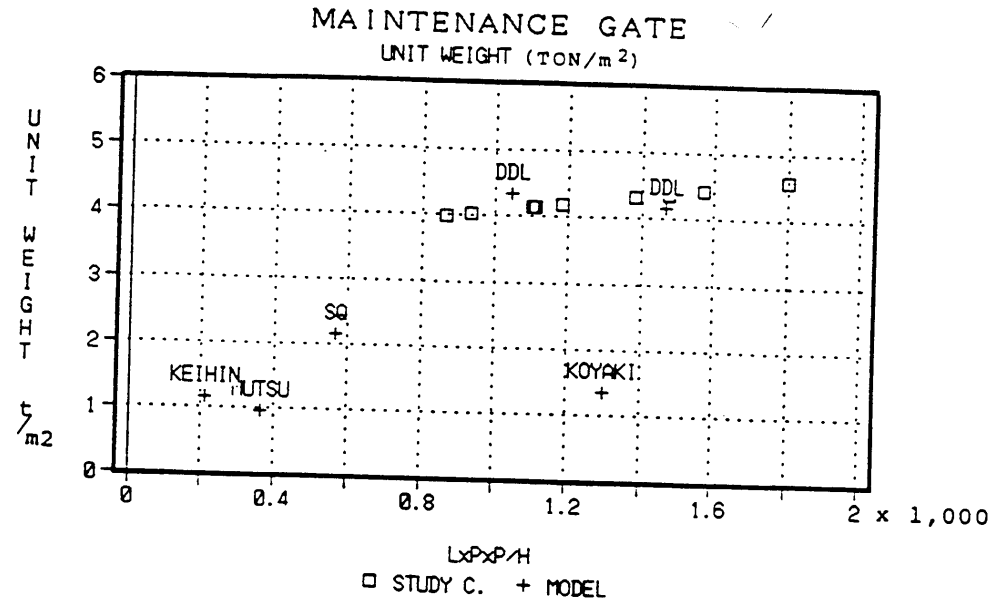
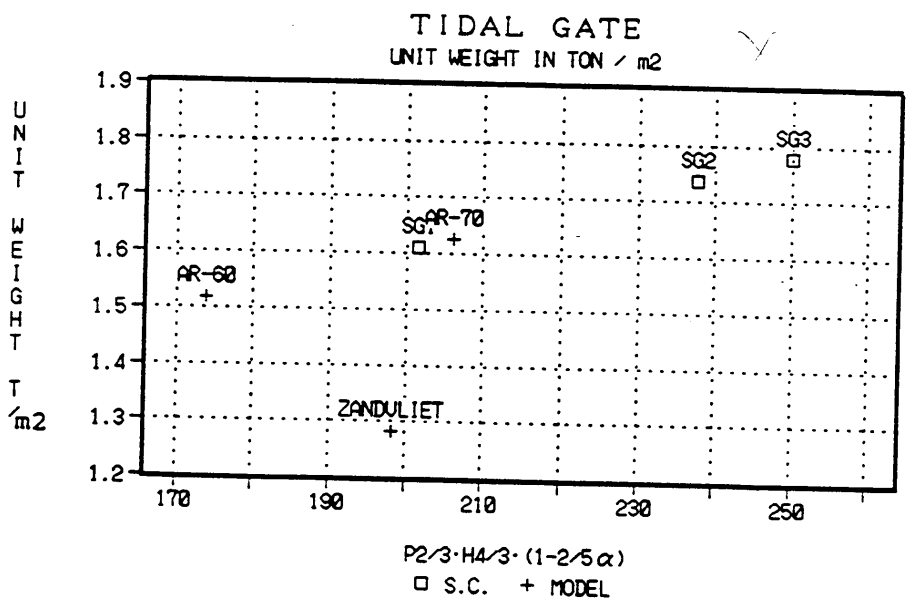


Fig.4.2.4 Emergency Gate Unit Weight



(L=m, H=m, P=ton/m2, α= P/H)

Fig. 4.2.5 Maintenance Gate Unit Weight



(L=m, H=m, P=ton/m2, α= P/H)

Note 1. Gate name
AR; Anderson Reports, 60; Gate Height in feet

Fig. 4.2.6 Tidal Gate Unit Weight

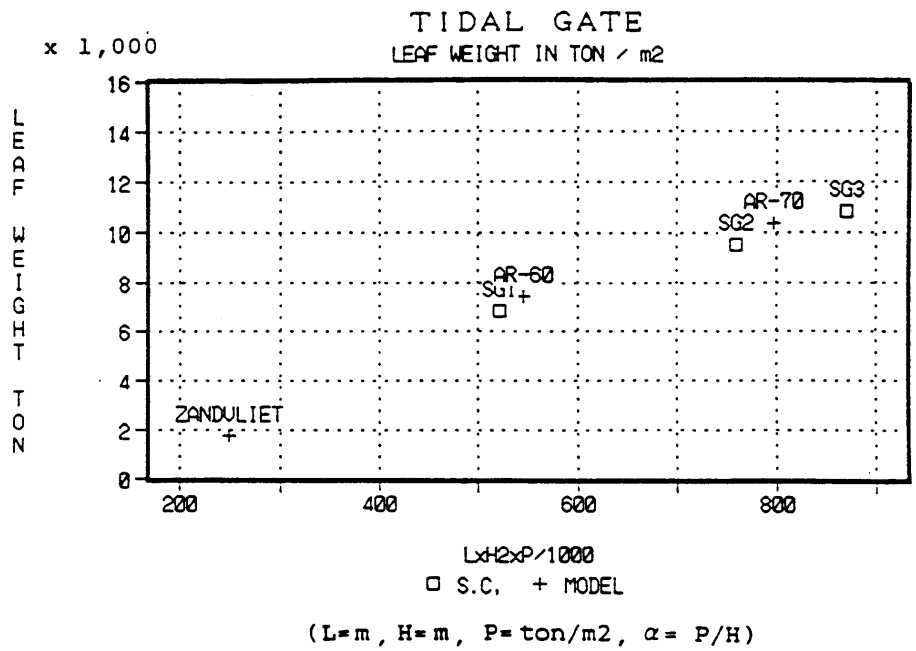


Fig. 4.2.7 Tidal Gate Total Weight

b) Gate Frames and Drive Mechanisms

Weights of the gate frames and drive mechanisms were derived from the corresponding leaf weights. Table 4.2.13 shows the weights of gate frames and drive mechanisms as a ratio of leaf weights. These values were established only for the purposes of cost estimations in this study.

Table 4.2.13 Factors for Weight Estimation

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

(5) Fabrication

All gates except Culvert Gates are fabricated at shops to a body either in open yards or docks, and Culvert Gates are fabricated according to conventional methods.

(6) Transportation

Culvert Gate sections are packed and shipped in a conventional way and all other gates are towed either on barges or floated according to a gate's shapes and dimensions.

(7) Installation

Culvert Gates are erected in place according to conventional methods, say by a truck crane, a tower crane or other available means. All other gates are set in place using a floating crane according to the steps shown in Fig. 4.2.8. Elimination of overhaul outage of locks after they start working was one of the main themes in the study of The Third Lock Plan, and the gate should be ready to work as soon as it is set in place (Just Set In Place Installation). To realize this, seal mechanisms, bearing systems, support systems etc., which are usually underwater must be able to adapt themselves to bigger dimensional deviations in gate leaves and embedded metals than ordinary gate designs. Just-Set-In-Place Installation is an important ideas of this conceptual design. However, all parts under water should also be adjustable in drained conditions.

4.2.2 Results of Conceptual Designs

(1) Lock Gates

a) Gate Type and Structural System

On Table 4.6.1, various gate types are compared with respect to important technical or economical elements relevant to Lock Gates. Although the best evaluation result was given to gate type No. 11 (torsion type rolling gate), the gate type proposed here is the Miter Gate that has worked without any major defects in the Panama Canal locks since its construction. The structure system is a box type supported along vertical ends.

Fig. 4.2.9 shows a general view of the proposed Lock Gates. The gate leaf is supported by

embedments in concrete at two points; i.e. at the top corner of the leaf by a gudgeon pin and at the 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 a pulling force on the gudgeon pin and a 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 no supports along the bottom sill except 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.

b) Hydraulic Conditions for Pre-Screening Design

The hydraulic conditions to be adopted for the design of the Lock Gates is the critical condition which can occur under natural conditions. This is a combination of the highest up-stream water elevation in front of each gate and the lowest sea level of the corresponding ocean.

c) Materials

All levels of structural steel to be considered are listed in Table 4.2.7.

Notwithstanding the above, it is predicted that all parts whose failure mode is classified as Fatigue will be composed of steels of up to SM570 level shown in the table.

d) Numerical Results of Conceptual Design

Table 4.2.14 lists the results of Lock Gates for the Pacific side and Table 4.2.15 lists the results for the Atlantic side.

Table 4.2.14 Design Results for the Pacific Side Lock Gates

CASE	LOCK GATE	WID-TH	LEAF HEIGHT	DESIGN HD		ESTIMATED WEIGHT IN TON			
				UP-S	DOWN	LEAF	GFRAME	MACH.	TOTAL
L - 1	UPPER	47	21.1	20.5	0.0	891	178	134	1.203
L - 1	MIDDLE	47	33.5	32.9	2.6	1.671	334	251	2.256
L - 1	LOWER	47	36.0	35.4	19.0	1.614	323	242	2.179
L - 2	UPPER	47	21.1	20.5	0.0	891	178	134	1.203
L - 2	MIDDLE	47	32.8	32.2	3.4	1.615	323	242	2.180
L - 2	LOWER	47	35.2	34.6	19.0	1.556	311	233	2.100
L - 2 '	UPPER	47	21.1	20.5	0.0	891	178	134	1.203
L - 2 '	LOWER	47	48.4	47.8	19.0	2.715	543	407	3.665
L - 3	UPPER	47	21.1	20.5	0.7	890	178	134	1.202
L - 3	LOWER	47	39.4	38.8	19.0	1.875	375	281	2.531
L - 4	UPPER	54	23.1	22.5	0.0	1.200	240	180	1.620
L - 4	MIDDLE	54	35.5	34.9	4.6	2.257	451	339	3.047
L - 4	LOWER	54	38.0	37.4	21.0	2.075	415	311	2.801
L - 5	UPPER	54	23.1	22.5	0.0	1.200	240	180	1.620
L - 5	MIDDLE	54	34.8	34.2	5.4	2.175	435	326	2.936
L - 5	LOWER	54	37.2	36.6	21.0	1.997	399	300	2.696
L - 6	UPPER	54	23.1	22.5	2.7	1.194	239	179	1.612
L - 6	LOWER	54	41.4	40.8	21.0	2.437	487	366	3.290
L - 7	UPPER	63	26.1	25.5	0.0	1.785	357	268	2.410
L - 7	MIDDLE	63	38.5	37.9	7.6	3.326	665	499	4.490
L - 7	LOWER	63	41.0	40.4	24.0	2.841	568	426	3.835
L - 8	UPPER	63	26.1	25.5	0.0	1.785	357	268	2.410
L - 8	MIDDLE	63	37.8	37.2	8.4	3.189	638	478	4.305
L - 8	LOWER	63	40.2	39.6	24.0	2.724	545	409	3.678
L - 9	UPPER	63	26.1	25.5	5.7	1.739	348	261	2.348
L - 9	LOWER	63	44.4	43.8	24.0	3.384	677	508	4.569
L - 10	UPPER	47	21.1	20.5	0.0	891	178	134	1.203
L - 10	MIDDLE	47	32.8	32.2	3.4	1.615	323	242	2.180
L - 10	LOWER	47	35.2	34.6	19.0	1.556	311	233	2.100
L - 11	UPPER	47	21.1	20.5	0.7	890	178	134	1.202
L - 11	LOWER	47	39.4	38.8	19.0	1.875	375	281	2.531
L - 12	UPPER	47	21.1	20.5	8.2	858	172	129	1.159
L - 12	LOWER	47	31.9	31.3	19.0	1.335	267	200	1.802
L - 13	UPPER	54	23.1	22.5	0.0	1.200	240	180	1.620
L - 13	MIDDLE	54	34.8	34.2	5.4	2.175	435	326	2.936
L - 13	LOWER	54	37.2	36.6	21.0	1.997	399	300	2.696
L - 14	UPPER	54	23.1	22.5	2.7	1.194	239	179	1.612
L - 14	LOWER	54	41.4	40.8	21.0	2.437	487	366	3.290
L - 15	UPPER	54	23.1	22.5	10.2	1.121	224	168	1.513
L - 15	LOWER	54	33.9	33.3	21.0	1.697	339	255	2.291
L - 16	UPPER	63	26.1	25.5	0.0	1.785	357	268	2.410
L - 16	MIDDLE	63	37.8	37.2	8.4	3.189	638	478	4.305
L - 16	LOWER	63	40.2	39.6	24.0	2.724	545	409	3.678
L - 17	UPPER	63	26.1	25.5	5.7	1.739	348	261	2.348
L - 17	LOWER	63	44.4	43.8	24.0	3.384	677	508	4.569
L - 18	UPPER	63	26.1	25.5	13.2	1.564	313	235	2.112
L - 18	LOWER	63	36.9	36.3	24.0	2.284	457	343	3.084

Note 1. Width, Height and Design Head are shown in meters.

Table 4.2.15 Design Results for the Atlantic Side Lock Gates

CASE	LOCK GATE	WID-TH	LEAF HEIGHT	DESIGN HD		ESTIMATED WEIGHT IN TON			
				UP-S	DOWN	LEAF	GFRAME	MACH.	TOTAL
L - 1	UPPER	47	21.1	20.5	0.0	891	178	134	1.203
L - 1	MIDDLE	47	33.6	33.0	5.1	1.664	333	250	2.247
L - 1	LOWER	47	33.5	32.9	19.0	1.439	288	216	1.943
L - 2	UPPER	47	21.1	20.5	0.0	891	178	134	1.203
L - 2	MIDDLE	47	32.9	32.3	5.9	1.606	321	241	2.168
L - 2	LOWER	47	32.7	32.1	19.0	1.386	277	208	1.871
L - 2 *	UPPER	47	21.1	20.5	0.0	891	178	134	1.203
L - 2 *	LOWER	47	46.0	45.4	19.0	2.469	494	370	3.333
L - 3	UPPER	47	21.1	20.5	3.1	867	177	133	1.177
L - 3	LOWER	47	37.0	36.4	19.0	1.687	337	253	2.277
L - 4	UPPER	54	23.1	22.5	0.0	1.200	240	180	1.620
L - 4	MIDDLE	54	35.6	35.0	7.1	2.234	447	335	3.016
L - 4	LOWER	54	35.5	34.9	21.0	1.837	367	276	2.480
L - 5	UPPER	54	23.1	22.5	0.0	1.200	240	180	1.620
L - 5	MIDDLE	54	34.9	34.3	7.9	2.147	429	322	2.898
L - 5	LOWER	54	34.7	34.1	21.0	1.766	353	265	2.384
L - 6	UPPER	54	23.1	22.5	5.1	1.179	236	177	1.592
L - 6	LOWER	54	39.0	38.4	21.0	2.177	435	327	2.939
L - 7	UPPER	63	26.1	25.5	0.0	1.785	357	268	2.410
L - 7	MIDDLE	63	38.6	38.0	10.1	3.257	651	489	4.397
L - 7	LOWER	63	38.5	37.9	24.0	2.489	498	373	3.360
L - 8	UPPER	63	26.1	25.5	0.0	1.785	357	268	2.410
L - 8	MIDDLE	63	37.9	37.3	10.9	3.115	623	467	4.205
L - 8	LOWER	63	37.7	37.1	24.0	2.385	477	358	3.220
L - 9	UPPER	63	26.1	25.5	8.1	1.695	339	254	2.288
L - 9	LOWER	63	42.0	41.4	24.0	2.993	599	449	4.041
L - 10	UPPER	47	21.1	20.5	0.0	891	178	134	1.203
L - 10	MIDDLE	47	32.9	32.3	5.9	1.606	321	241	2.168
L - 10	LOWER	47	32.7	32.1	19.0	1.386	277	208	1.871
L - 11	UPPER	47	21.1	20.5	3.1	886	177	133	1.196
L - 11	LOWER	47	37.0	36.4	19.0	1.687	337	253	2.277
L - 12	UPPER	47	21.1	20.5	10.6	838	168	126	1.132
L - 12	LOWER	47	29.5	28.9	19.0	1.189	238	178	1.605
L - 13	UPPER	54	23.1	22.5	0.0	1.200	240	180	1.620
L - 13	MIDDLE	54	34.9	34.3	7.9	2.147	429	322	2.898
L - 13	LOWER	54	34.7	34.1	21.0	1.766	353	265	2.384
L - 14	UPPER	54	23.1	22.5	5.1	1.179	236	177	1.592
L - 14	LOWER	54	39.0	38.4	21.0	2.177	435	327	2.939
L - 15	UPPER	54	23.1	22.5	12.6	1.085	217	163	1.465
L - 15	LOWER	54	31.5	30.9	21.0	1.503	301	225	2.029
L - 16	UPPER	63	26.1	25.5	0.0	1.785	357	268	2.410
L - 16	MIDDLE	63	37.9	37.3	10.9	3.115	623	467	4.205
L - 16	LOWER	63	37.7	37.1	24.0	2.385	477	358	3.220
L - 17	UPPER	63	26.1	25.5	8.1	1.695	339	254	2.288
L - 17	LOWER	63	42.0	41.4	24.0	2.993	599	449	4.041
L - 18	UPPER	63	26.1	25.5	15.6	1.493	299	224	2.016
L - 18	LOWER	63	34.5	33.9	24.0	2.005	401	301	2.707

Note 1. Width, Height and Design Head are shown in meters.

e) Sealing

Fig. 4.2.10 illustrates seal arrangements.

Each side, and the bottom of a 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 a box type leaf.

Dimensions of the rubber section are larger than normal to provide the necessary self-adjustability for the Just-Set-In-Place Installation method. The bulb portion of the rubber has the correct hardness to prevent excessive deformation in the bulb at high water pressure and, at the same time, maintain enough sealing ability at low water pressure.

f) Pintles, Gudgeon and Miter End and Quoin Bearings

Fig. 4.2.11 illustrates arrangement of a pintle and gudgeon, and Fig. 4.2.12 diagrams a miter end and quoin bearings.

The pintle sits rigidly on a base metal embedded in a 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 gudgeon so that the pin together with the gate leaf may move in the direction of the gate width.

As soon as the gate leaf starts supporting the hydraulic load, 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 on deviations from its

designed relative positions and enable the Just-Set-In-Place Method to be used. This will also contribute to decreased wear on the quoin bearing blocks.

The gudgeon and the pintle centers should be located in a common vertical axis. The gudgeon center is adjustable after the gate leaf is set in place. The pintle is removed with the gate leaf whenever the leaf is removed for maintenance.

g) Float Tanks

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 conditions.

h) Corrosion Protection

An electric corrosion protection system is proposed to reduce corrosion progression in embedded parts and in the gate leaf. It is also very helpful in extending the leaf's fatigue life. But too much voltage will accelerate consumption of the remaining fatigue life and very careful study is necessary for arrangement of the system.

i) Drive Mechanism

Fig. 4.2.13 shows the concept for the drive mechanism for Lock Gates. Hydraulic power cylinders provide the forces necessary to drive the mechanism.

(2) Culvert Gates

a) Gate Type and Structural System

The proposed gate type is the reversed Radial Gate which was proposed at the 3rd Lock Plan and also in the Deep Draft Lock Plan. Fig. 4.2.14 shows the general view of a Culvert Gate. The

existing canal locks have Stony sluice gates for the same purpose. Generally, development of the Fixed Wheel Type gates has made the Stony Type out-dated because of economical and technical reasons, and no consideration was given to this type of gate in the selection. The superiority of the Reversed Radial Gate to the Fixed Wheel Gate for this application is the reduced friction force during leaf operations.

b) Hydraulic Condition for the Pre-Screening Design

Hydraulic conditions for the design of Culvert Gates are a combination of the highest lake elevation and the lowest level of the corresponding ocean.

c) Materials

Structural steel to be adopted would be up to the SM490 level listed in Table 4.2.7.

d) Gate Dimensions for the Pre-Screening Purpose

Gate dimensions of the Culvert Gate were determined so that the same filling time as scheduled in the Deep Draft Lock Plan might be maintained. For the one lift study cases the filling time may be so short that the water in the chamber will boil up too rapidly for the locomotive to restrain the transiting ship in the chamber and the filling time should be reviewed during Phase II before finalizing the designs.

Data used in the calculations were for 250,000 DWT ships in the Anderson Report and filling time was nine minutes with a three minute valve time.

e) Sealing

A preference will be given to rubber seals for all leaf edges, including the leaf bottom.

f) Numerical Results of the Conceptual Design

Table 4.2.16 shows results for the Culvert Gate.

Table 4.2.16 Design Results for Culvert Gates

	CASE	CULVERT(m)		DESIGN	NO	ESTIMATED WEIGHT IN TON			
		L	H	PRESSURE	RQ	LEAF	GFRAME	MECHA.	TOTAL
P	L－1	7.1	7.6	30.7	16	81.0	64.8	48.6	194.4
A	L－2	7.0	7.5	29.2	16	78.2	62.6	46.9	187.7
C	L－2'	8.3	9.0	29.2	12	114.1	91.3	68.5	273.9
I	L－3	7.5	8.0	20.0	12	86.3	69.0	51.8	207.1
F	L－4	8.1	8.7	30.7	16	107.9	86.3	64.7	258.9
I	L－5	8.0	8.6	29.2	16	104.4	83.5	62.6	250.5
C	L－6	8.5	9.2	20.1	12	114.1	91.3	68.5	273.9
	L－7	9.5	10.3	30.7	16	154.1	123.3	92.5	369.9
	L－8	9.4	10.1	29.2	16	147.7	118.2	88.6	354.5
	L－9	10.0	10.8	20.1	12	160.6	128.5	96.4	385.5
	L－10	7.0	7.5	29.2	16	78.2	62.6	46.9	187.7
	L－11	7.5	8.0	20.0	12	86.3	69.0	51.8	207.1
	L－12	6.4	6.9	12.4	12	60.6	48.5	36.4	145.5
	L－13	8.0	8.6	29.2	16	104.4	83.5	62.6	250.5
	L－14	8.5	9.2	20.1	12	114.1	91.3	68.5	273.9
	L－15	7.3	7.9	12.4	12	79.8	63.8	47.9	191.5
	L－16	9.4	10.1	29.2	16	147.7	118.2	88.6	354.5
	L－17	10.0	10.8	20.1	12	160.6	128.5	96.4	385.5
	L－18	8.6	9.3	12.4	12	111.8	89.4	67.1	268.3
A	L－1	7.1	7.6	28.3	16	80.2	64.2	48.1	192.5
T	L－2	7.0	7.5	26.8	16	77.3	61.8	46.4	185.5
L	L－2'	8.3	9.0	26.8	12	112.7	90.2	67.6	270.5
A	L－3	7.5	8.0	17.7	12	85.3	68.2	51.2	204.7
N	L－4	8.1	8.7	28.3	16	106.6	85.3	64.0	255.9
T	L－5	8.0	8.6	26.8	16	103.1	82.5	61.9	247.5
I	L－6	8.5	9.2	17.7	12	112.6	90.1	67.6	270.3
C	L－7	9.5	10.3	28.3	16	151.9	121.5	91.1	364.5
	L－8	9.4	10.1	26.8	16	145.7	116.6	87.4	349.7
	L－9	10.0	10.8	17.7	12	158.1	126.5	94.9	379.5
	L－10	7.0	7.5	26.8	16	77.3	61.8	46.4	185.5
	L－11	7.5	8.0	17.7	12	85.3	68.2	51.2	204.7
	L－12	6.4	6.9	10.0	12	60.0	48.0	36.0	144.0
	L－13	8.0	8.6	26.8	16	103.1	82.5	61.9	247.5
	L－14	8.5	9.2	17.7	12	112.6	90.1	67.6	270.3
	L－15	7.3	7.9	10.0	12	78.8	63.0	47.3	189.1
	L－16	9.4	10.1	26.8	16	145.7	116.6	87.4	349.7
	L－17	10.0	10.8	17.7	12	158.1	126.5	94.9	379.5
	L－18	8.6	9.3	10.0	12	110.3	88.2	66.2	264.7

g) Drive Mechanisms

Hydraulic power cylinders are used to drive the mechanisms.

h) Corrosion Protection

An electric corrosion protection system is proposed to reduce corrosion progression in the embedded parts and in the gate leaf. The same precautions cited for the Lock Gate are necessary for studying the system arrangement.

i) Bulkhead Gates for Maintenance

Bulkhead gate slots are provided upstream and downstream of the Culvert Gate.

(3) Emergency Gates

a) Gate Types and Structural Systems

Emergency Gates are designed to close the locks in the case of an emergency such as fractures or collapses of the Lock Gates due to ship collisions. Also, the emergency gates prevent the areas surrounding the lock from natural disasters and keep the intensity of damages due to accidents to a minimum. Hence the role of Emergency Gates are substantial.

The proposed gate type for the Emergency Gates is the Drop Type Roller Gate.

Fig. 4.2.15 shows a general view of the Emergency Gate. A gate leaf consists of a box type main girder and vertical girders. Hydraulic loads acting on the skin plate are supported by wheels arranged at both ends of the main girder and along the gate bottom edge. Air supply systems provided in the concrete walls to supply air into a vacant zone under the flow passing over the gate top, avoid harmful vibrations during an emergency raising of the gate leaf.

The proposed gate type is similar to is dissimilar the one in the Deep Draft Lock plan (DDL), but is dissimilar from the gates (the Emergency Dam) in the existing Panama Canal.

The existing Emergency Dam consists of 30 roller gates, six gate guide girders and 30 hoists. All these components were stored in a very long truss arm similar to the arm of a tower crane. The truss arm with all gate components usually stays on the lock side wall with its direction parallel to the locomotive rails. In the event of an emergency situation, the truss arm rotates by 90 degrees, and its tip reaches the lock center wall where it is supported. Then, one end of the six gate guide girders are set on the lock bottom sill with the other ends supported at the truss arms. Finally all 30 roller gates are hoisted down along the gate guide girders.

The proposed emergency gate type is much simpler in mechanism and shorter in operation time than the existing emergency gate. It is more reliable than the above mentioned existing emergency gate type. Because of the increased reliability of the proposed gate type, the Guard Gates and the Safety Gates which were provided in the existing canal have disappeared in our proposal, so as did it in the Deep Draft Lock plan. The Guard Gates and the Safety Gates in the Panama Canal are the same Miter type as the Operating Gates, and are arranged in duplicate with the Operation Gate. These are operated together with the opponent Operating Gate and enable the locks to remain safe. The below figures are the numbers of the Miter gate leaves adopted in the Panama Canal, DDL, and the New Canal. Not withstanding omissions of the Intermediate Gates in the DDL and the New canal, and the differences in other conditions, total leaf numbers are explained for the benefit of the Emergency Gate proposed.

	Existing	DDL (Three Lifts)	Proposed (Two Lifts)
Operating Gate	36	32	24
Guard Gate	24	0	0
Safety Gate	12	0	0
Intermediate Gate	20	0	0
Total	92	32	24

Note 1. The Figures of the DDL were converted to two lanes for comparison purposes.

b) Hydraulic Conditions for the Pre-Screening Design

Hydraulic conditions for the design of Emergency Gates are water head equal to the gate height while downstream is dry.

c) Materials

The levels of structural steel would be adopted from those listed in Table 4.2.7.

d) Numerical Results of Conceptual Design

Table 4.2.17 lists results for the Emergency Gate. This table is applicable to the Pacific and Atlantic sides.

Table 4.2.17 Design Results for Emergency Gates

Case Number	Width (m)	Leaf Height (m)	Design Head UP-S (m)	Design Head Down (m)	Estimated Weight in Ton Leaf	G Frame	Mach	Total
L-1	47	22.0	22.0	0.0	2,476	990	371	3,837
L-2	47	22.0	22.0	0.0	2,476	990	371	3,837
L-2'	47	22.0	22.0	0.0	2,476	990	371	3,837
L-3	47	22.0	22.0	0.0	2,476	990	371	3,837
L-4	54	24.0	24.0	0.0	3,210	1,284	481	4,975
L-5	54	24.0	24.0	0.0	3,210	1,284	481	4,975
L-6	54	24.0	24.0	0.0	3,210	1,284	481	4,975
L-7	63	27.0	27.0	0.0	4,428	1,771	664	6,863
L-8	63	27.0	27.0	0.0	4,428	1,771	664	6,863
L-9	63	27.0	27.0	0.0	4,428	1,771	664	6,863
L-10	47	22.0	22.0	0.0	2,476	990	371	3,837
L-11	47	22.0	22.0	0.0	2,476	990	371	3,837
L-12	47	22.0	22.0	0.0	2,476	990	371	3,837
L-13	54	24.0	24.0	0.0	3,210	1,284	481	4,975
L-14	54	24.0	24.0	0.0	3,210	1,284	481	4,975
L-15	54	24.0	24.0	0.0	3,210	1,284	481	4,975
L-16	63	27.0	27.0	0.0	4,428	1,771	664	6,863
L-17	63	27.0	27.0	0.0	4,428	1,771	664	6,863
L-18	63	27.0	27.0	0.0	4,428	1,771	664	6,863

Note: UP-S=upstream, Down=downstream, G Frame=Gate Frame, Mach=Machine

e) Gate Top Configuration

The gate top configuration was determined so that the flow velocity passing over the gate top may be minimized.

f) Sealing

The side and the bottom of a leaf are sealed with J type seal rubbers. In addition to these, an intermediate seal mechanism installed along the canal bottom will decrease the amount of water flowing out from the gap between the gate leaf and the canal bottom during leaf raising.

g) Wheel Arrangement

The main wheels carrying hydraulic loads acting on the gate leaf are arranged on both ends of the main girder and along the gate bottom. In addition, smaller auxiliary guide wheels are also arranged on both ends of the gate leaf so that the large leaf may travel surely in the case of an emergency.

h) Float Tank

Two types of float tanks are provided in the leaf. All tanks, except one, are empty (permanent type) and the remaining tank will be drained by compressed air in the case of the emergency. The total amount of buoyancy will be much more than the gate leaf weight. Nevertheless, the rising movement of the gate leaf will be controlled mechanically by a driving mechanism. The tank arrangement described may be changed with further information on similar waterway projects in the United States.

i) Corrosion Protection

An electric corrosion protection system is proposed to reduce corrosion progression in embedded parts and in the gate leaf.

j) Drive Mechanism

A central jack type hoist machine, augmented by fire pump pressure and buoyancy tanks, as recommended in the Deep Draft Lock Plan, is proposed for operating Emergency Gate.

(4) Maintenance Gates

a) Gate Type and Structural System

Caisson type gates are proposed.

Fig. 4.2.16 shows a general view of the Maintenance Gate.

b) Hydraulic Condition for Design

Pressure side: Maximum sea or lake level
Lock side : Dry condition

c) Materials

The levels of Structural Steel would be adopted from those listed in Table 4.2.3.

d) Maintenance Gate Arrangements for Pre-Screening

Recesses for maintenance gates are proposed on the seaside and lakeside of locks for all study cases. A maintenance gate for the seasides of locks is proposed for all study cases. A maintenance gate for the lakeside is provided only for those cases where upper lock gates cannot withstand hydraulic pressures during maintenance conditions, or where upper lock gate sills are lower than the Maximum sea level.

e) Numerical Results of Conceptual Design

Table 4.2.18 and Table 4.2.19 list the results of the Maintenance Gate sizing for the Pacific coast and the Atlantic coast respectively.

Table 4.2.18 Design Results for the Pacific Side Maintenance Gates

CASE	MAINT. GATE	LEAF		DESIGN HD		ESTIMATED WEIGHT IN TON			
		L	HEIGHT	UP-S	DOWN	LEAF	GFRAME	MACH.	TOTAL
L-1	LOWER	47	26.5	25.0	0.0	4,693	516	464	5,673
L-2	LOWER	47	26.5	25.0	0.0	4,693	516	464	5,673
L-2'	LOWER	47	26.5	25.0	0.0	4,693	516	464	5,673
L-3	UPPER	47	21.1	20.5	0.0	3,637	400	360	4,397
L-3	LOWER	47	26.5	25.0	0.0	4,693	516	464	5,673
L-4	LOWER	54	28.5	27.0	0.0	6,041	664	597	7,302
L-5	LOWER	54	28.5	27.0	0.0	6,041	664	597	7,302
L-6	UPPER	54	23.1	22.5	0.0	4,754	522	470	5,746
L-6	LOWER	54	28.5	27.0	0.0	6,041	664	597	7,302
L-7	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L-7	LOWER	63	31.5	30.0	0.0	8,270	909	818	9,997
L-8	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L-8	LOWER	63	31.5	30.0	0.0	8,270	909	818	9,997
L-9	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L-9	LOWER	63	31.5	30.0	0.0	8,270	909	818	9,997
L-10	LOWER	47	26.5	25.0	0.0	4,693	516	464	5,673
L-11	UPPER	47	21.1	20.5	0.0	3,637	400	360	4,397
L-11	LOWER	47	26.5	25.0	0.0	4,693	516	464	5,673
L-12	UPPER	47	21.1	20.5	0.0	3,637	400	360	4,397
L-12	LOWER	47	26.5	25.0	0.0	4,693	516	464	5,673
L-13	LOWER	54	28.5	27.0	0.0	6,041	664	597	7,302
L-14	UPPER	54	23.1	22.5	0.0	4,754	522	470	5,746
L-14	LOWER	54	28.5	27.0	0.0	6,041	664	597	7,302
L-15	UPPER	54	23.1	22.5	0.0	4,754	522	470	5,746
L-15	LOWER	54	28.5	27.0	0.0	6,041	664	597	7,302
L-16	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L-16	LOWER	63	31.5	30.0	0.0	8,270	909	818	9,997
L-17	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L-17	LOWER	63	31.5	30.0	0.0	8,270	909	818	9,997
L-18	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L-18	LOWER	63	31.5	30.0	0.0	8,270	909	818	9,997

Table 4.2.19 Design Results for the Atlantic Side Maintenance Gates

CASE	MAINT.	LEAF		DESIGN HD		ESTIMATED WEIGHT IN TON			
	GATE	L	HEIGHT	UP-S	DOWN	LEAF	GFRAME	MACH.	TOTAL
L－1	LOWER	47	21.3	19.8	0.0	3,631	399	359	4,389
L－2	LOWER	47	21.3	19.8	0.0	3,631	399	359	4,389
L－2'	LOWER	47	21.3	19.8	0.0	3,631	399	359	4,389
L－3	UPPER	47	21.1	20.5	0.0	3,637	400	360	4,397
L－3	LOWER	47	21.3	19.8	0.0	3,631	399	359	4,389
L－4	LOWER	54	23.3	21.8	0.0	4,735	520	468	5,723
L－5	LOWER	54	23.3	21.8	0.0	4,735	520	468	5,723
L－6	UPPER	54	23.1	22.5	0.0	4,754	522	470	5,746
L－6	LOWER	54	23.3	21.8	0.0	4,735	520	468	5,723
L－7	LOWER	63	26.3	24.8	0.0	6,592	724	652	7,968
L－8	LOWER	63	26.3	24.8	0.0	6,592	724	652	7,968
L－9	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L－9	LOWER	63	26.3	24.8	0.0	6,592	724	652	7,968
L－10	LOWER	47	21.3	19.8	0.0	3,631	399	359	4,389
L－11	UPPER	47	21.1	20.5	0.0	3,637	400	360	4,397
L－11	LOWER	47	21.3	19.8	0.0	3,631	399	359	4,389
L－12	UPPER	47	21.1	20.5	0.0	3,637	400	360	4,397
L－12	LOWER	47	21.3	19.8	0.0	3,631	399	359	4,389
L－13	LOWER	54	23.3	21.8	0.0	4,735	520	468	5,723
L－14	UPPER	54	23.1	22.5	0.0	4,754	522	470	5,746
L－14	LOWER	54	23.3	21.8	0.0	4,735	520	468	5,723
L－15	UPPER	54	23.1	22.5	0.0	4,754	522	470	5,746
L－15	LOWER	54	23.3	21.8	0.0	4,735	520	468	5,723
L－16	LOWER	63	26.3	24.8	0.0	6,592	724	652	7,968
L－17	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L－17	LOWER	63	26.3	24.8	0.0	6,592	724	652	7,968
L－18	UPPER	63	26.1	25.5	0.0	6,634	729	656	8,019
L－18	LOWER	63	26.3	24.8	0.0	6,592	724	652	7,968

f) Sealing

The leaf sides and the leaf bottom are sealed by J type rubbers.

g) Float Tank

The leaf has many float tanks in it for adjusting draft for various conditions such as positioning on the oceanside, positioning on the lakesides or removing.

h) Corrosion Protection

An electric corrosion protection system is proposed to reduce corrosion progression in the embedded parts.

i) Water Filling Valves and Drainage Pumps

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

4.2.3 Sketches

(1) General

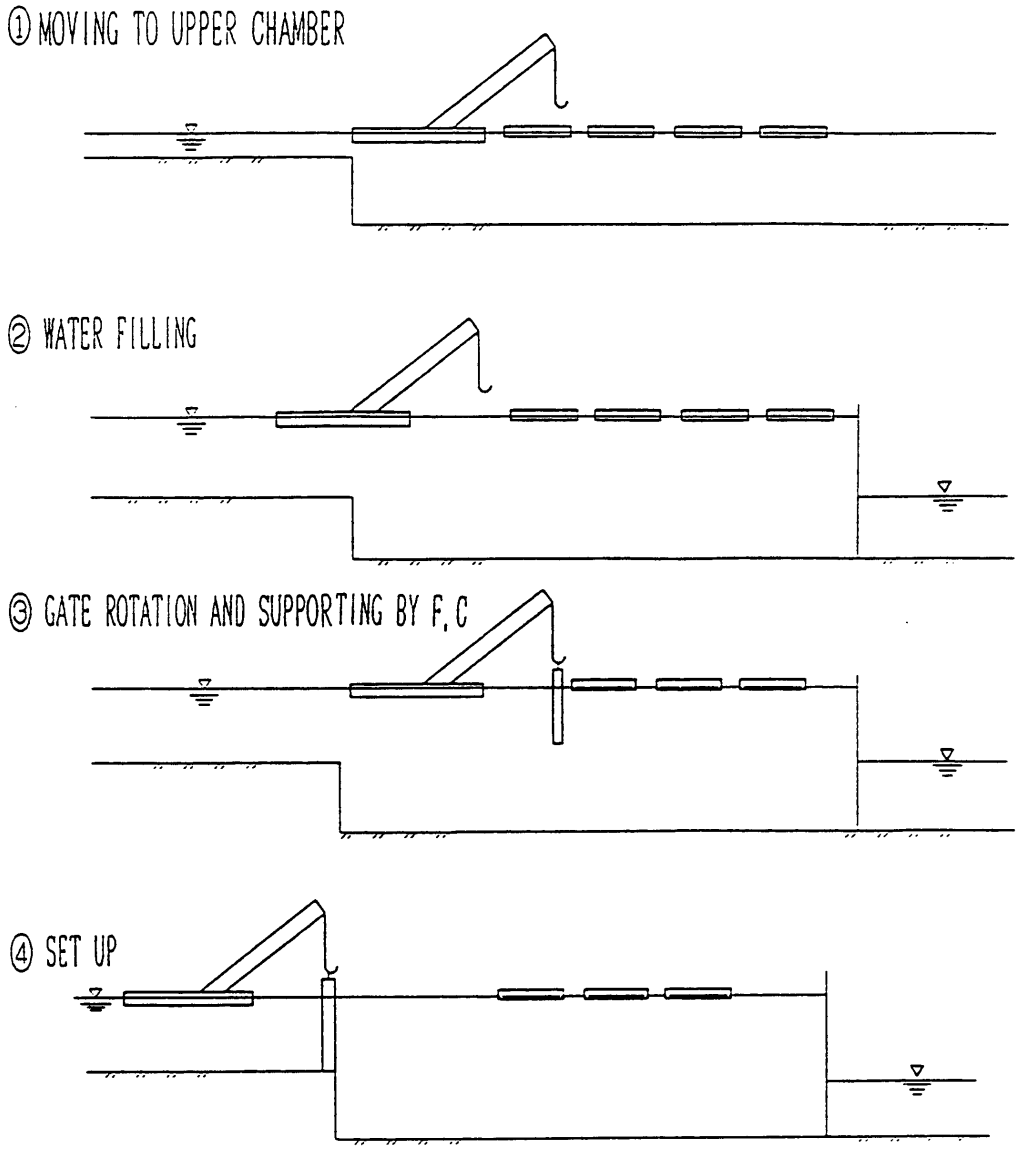


Fig. 4.2.8 Installation Procedure

(2) Lock Gates

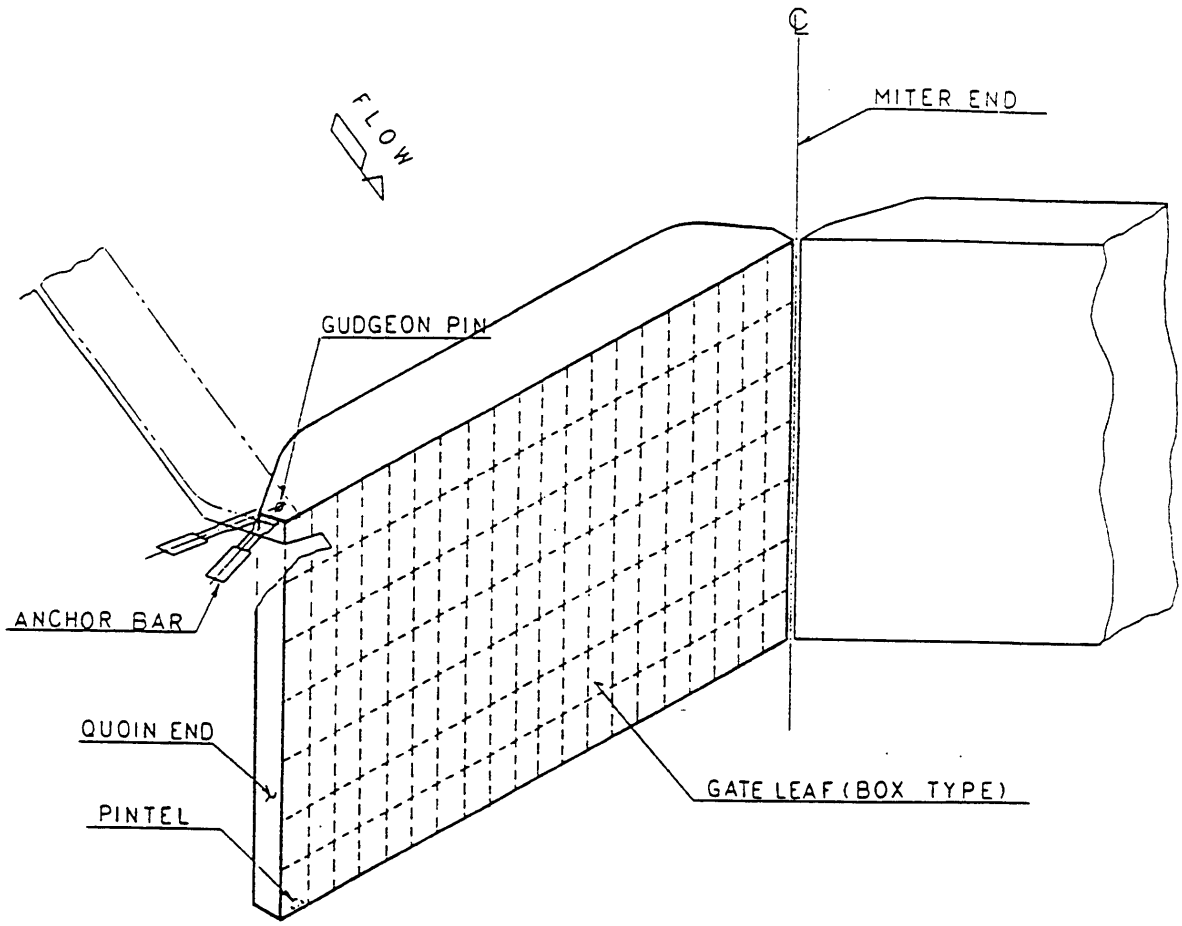


Fig. 4.2.9 General View of Lock Gate

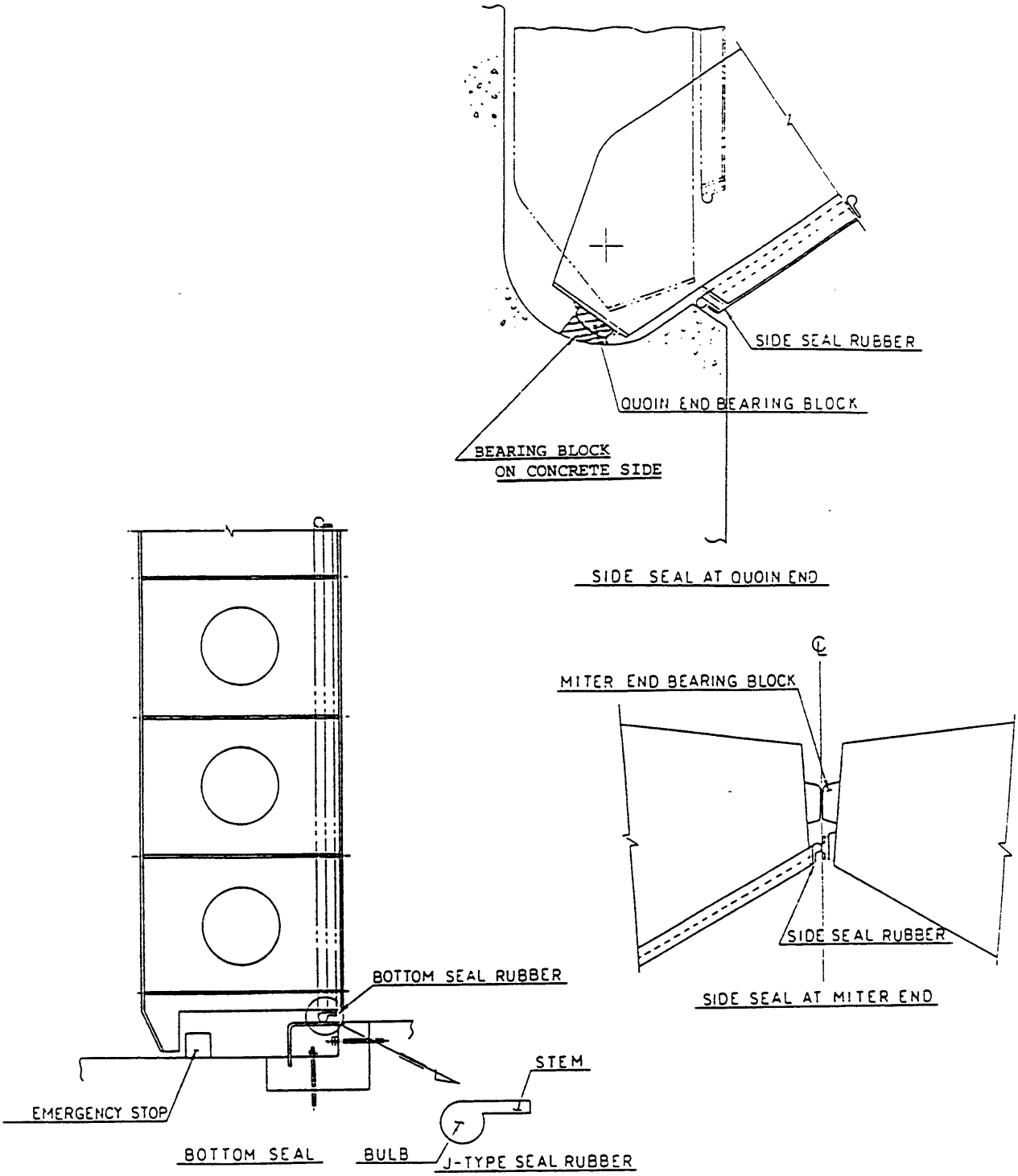


Fig. 4.2.10 Lock Gate Sealing and Bearing Blocks

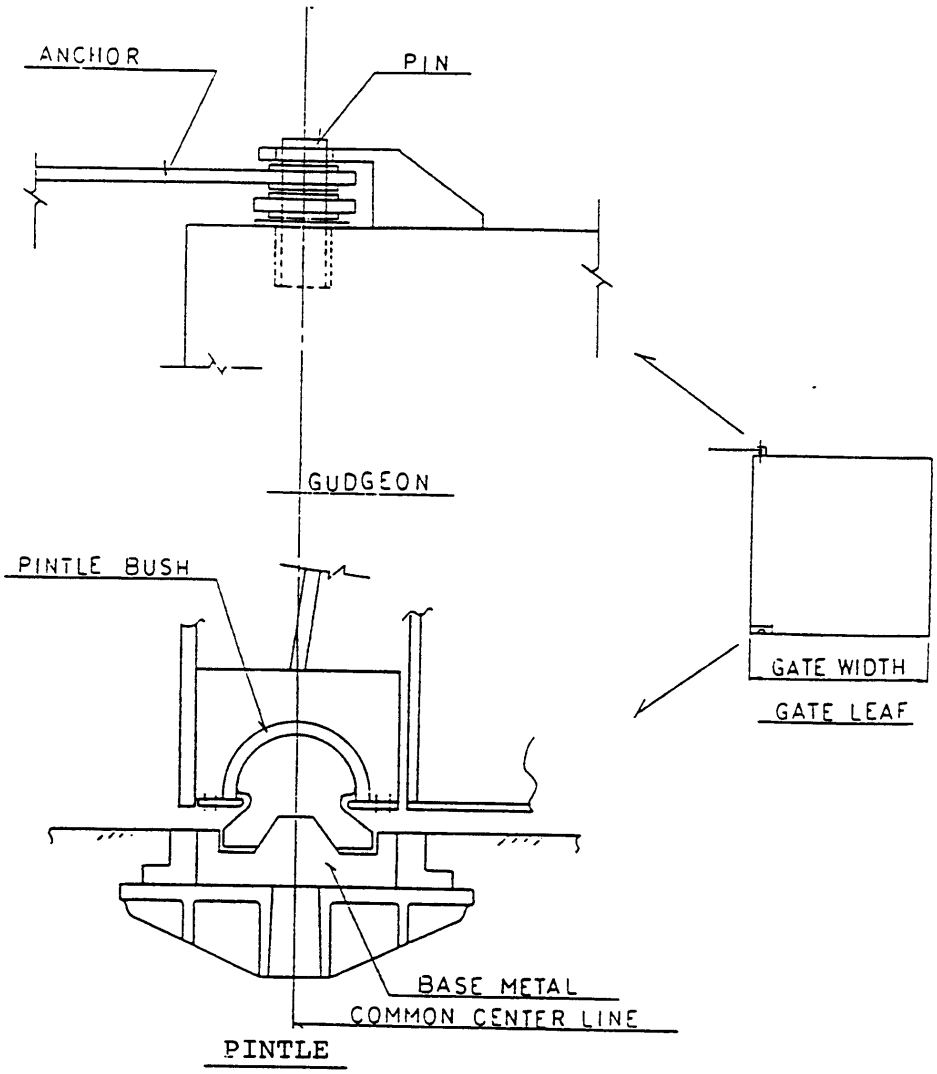


Fig. 4.2.11 Pintle and Gudgeon Pin

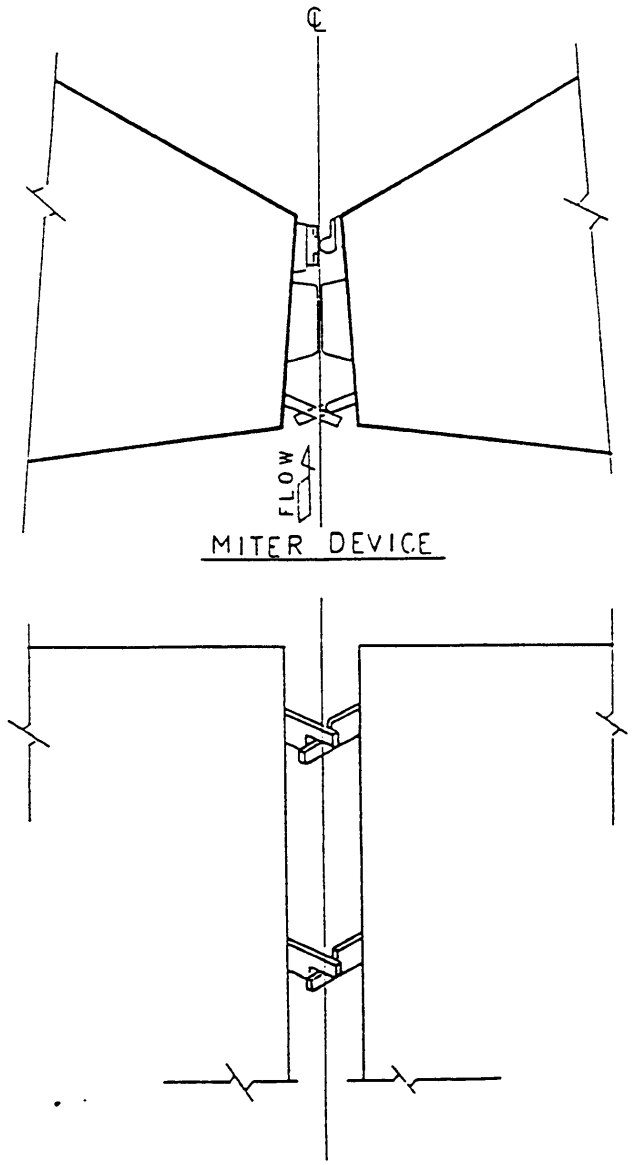


Fig. 4.2.12 Miter Device

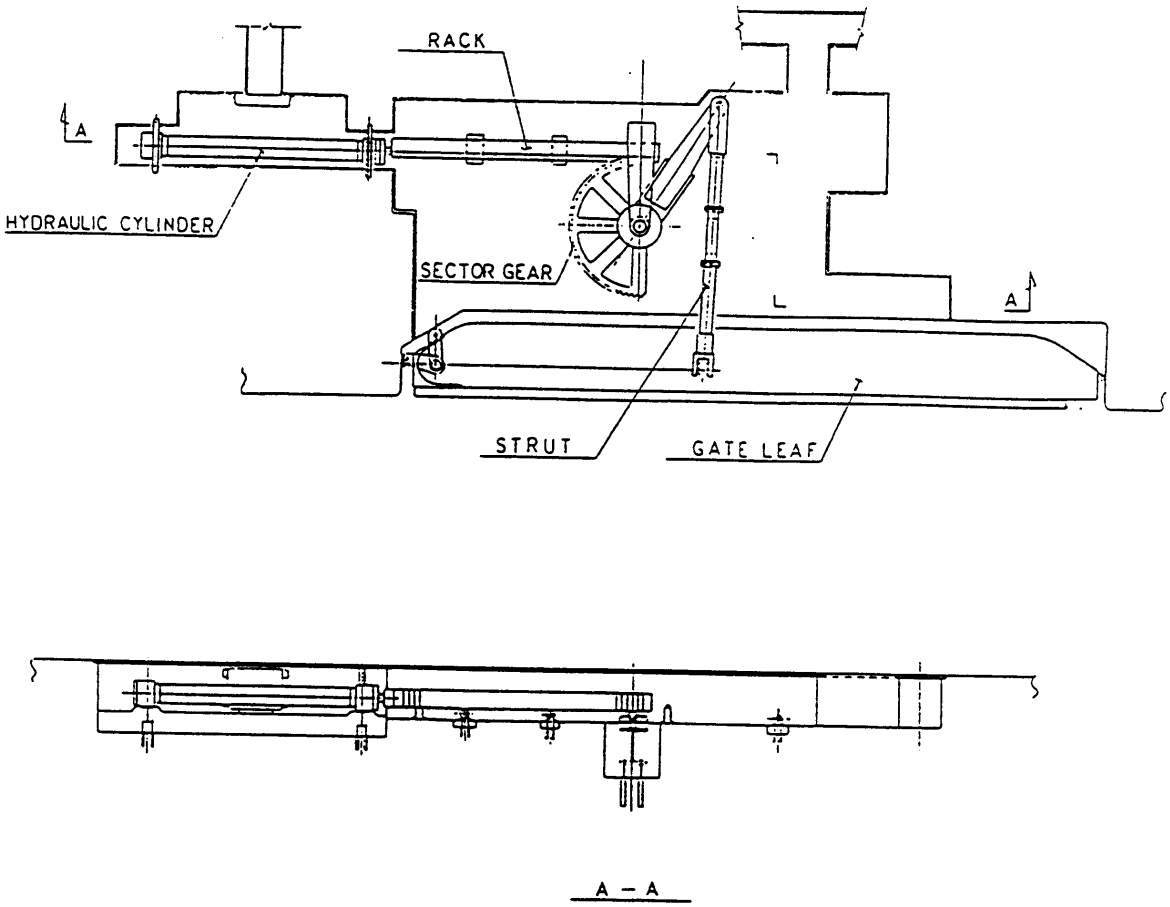


Fig. 4.2.13 General View of Drive Mechanism for Lock Gate

(2) Culvert Gates

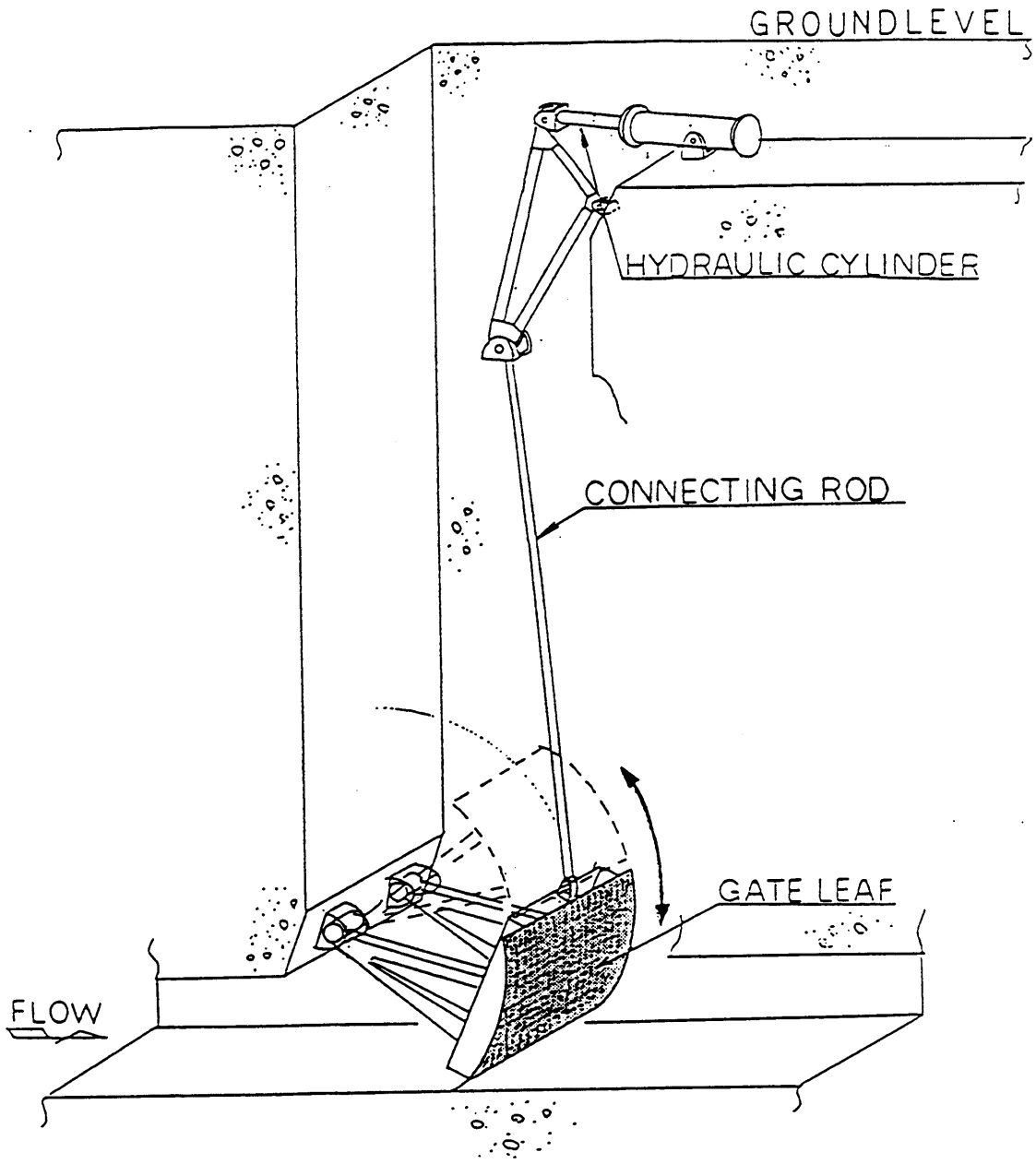


Fig. 4.2.14 General View of Culvert Gate

(3) Emergency Gates

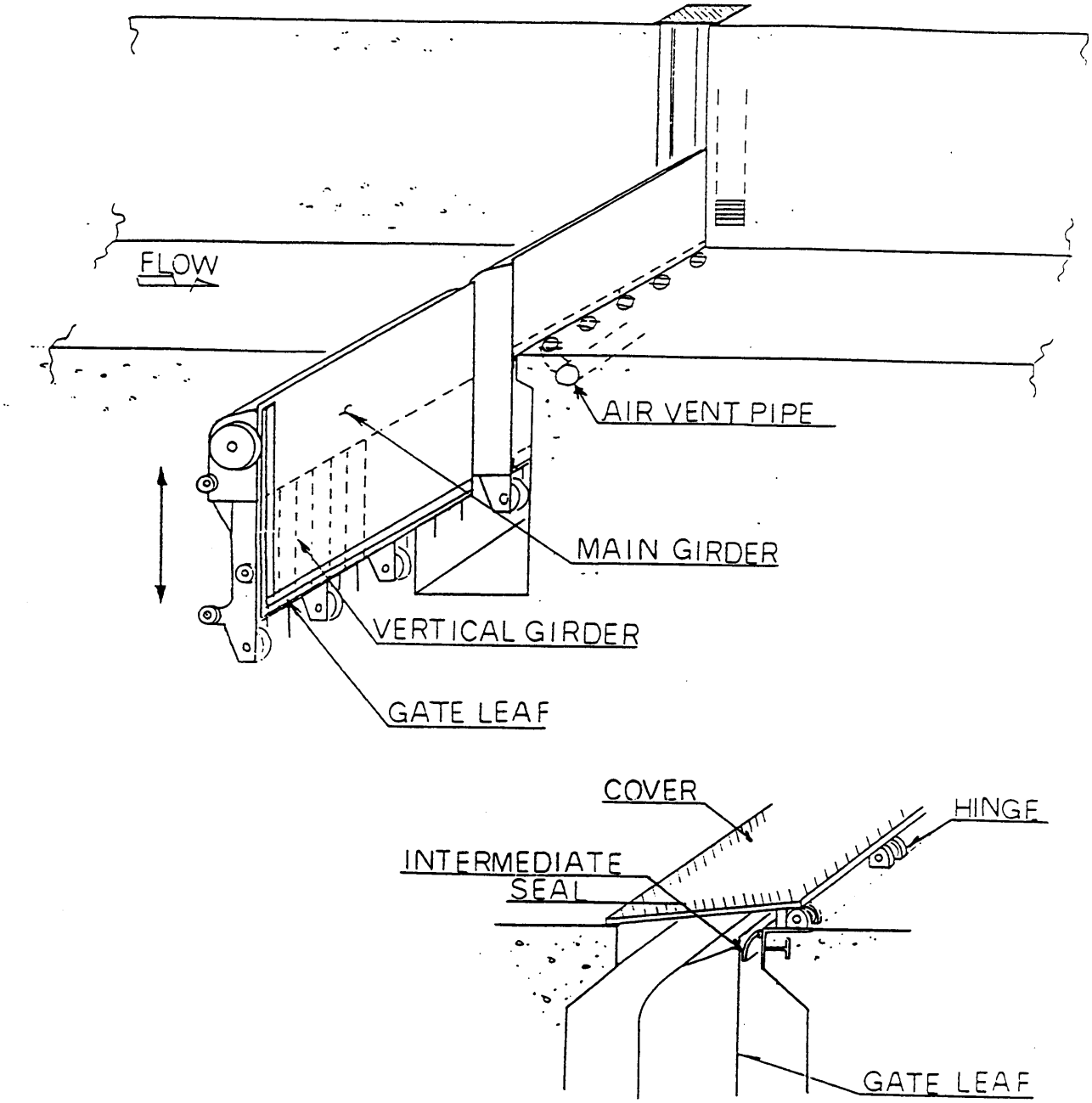


Fig. 4.2.15 General View of Emergency Gate

(4) Maintenance Gates

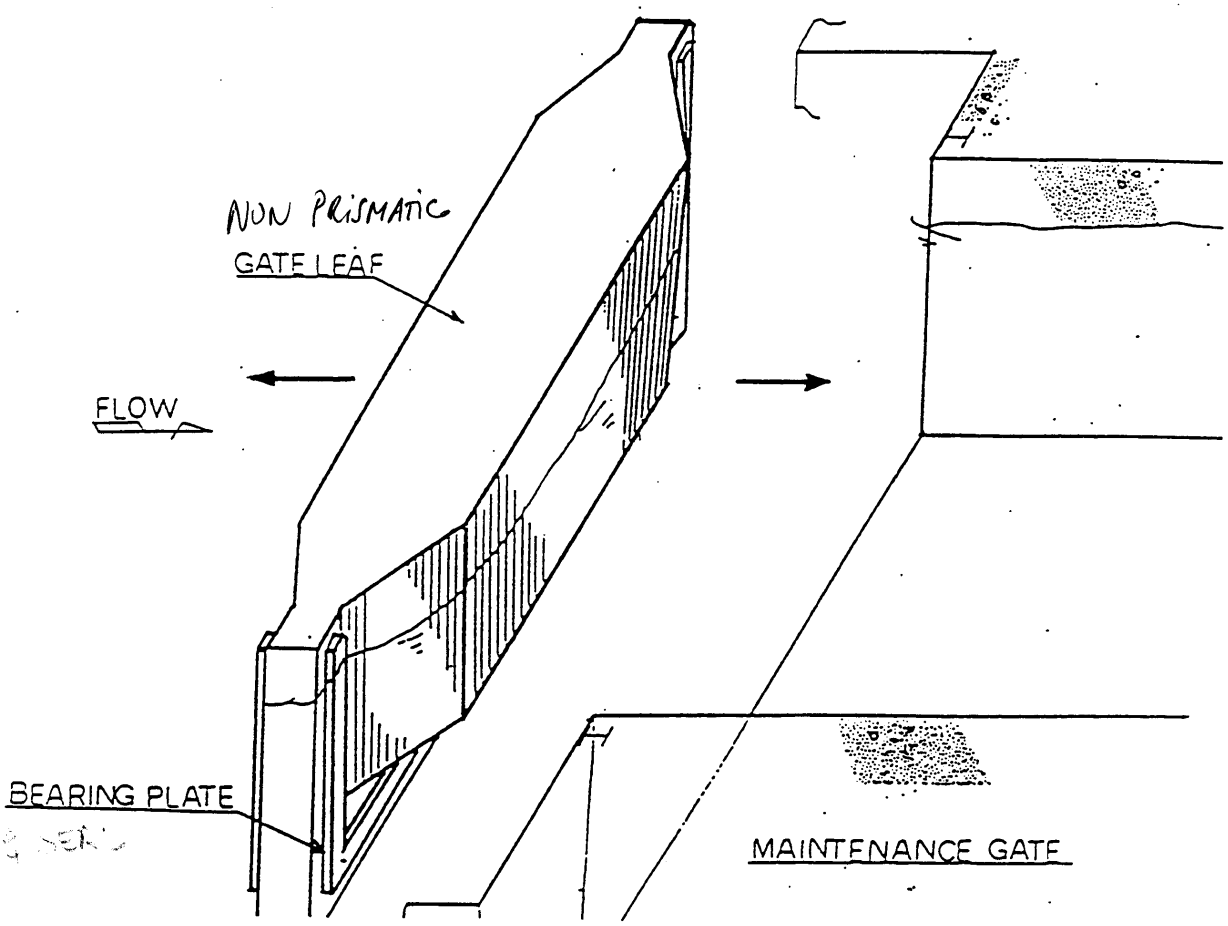


Fig. 4.2.16 General View of Maintenance Gate

4.3 Tidal Gate Structure

4.3.1 General

The sea level canal system will consist of a uniform canal section with single or dual lanes, or a combination of the two with two-way approaches to a central one-way section, according to the study cases (Refer Table 1.4.2).

Since the capacity of a canal allowing one-way operation only is severely constrained by the need for one convoy to completely clear the one-way section before the convoy from the opposite direction can enter, the provision of dual lanes throughout has been considered. Tidal gates could be used to control flow between the oceans, but the time interval between successive convoys would be significantly reduced. Convoys would pass each other in the central dual lane section while the closed tidal gates would prevent flow between the oceans. Then, at the proper time in the tide cycle when only minor differences in elevation exist between the oceans, the gates would shift laterally to the adjacent passing lanes to permit the convoys to complete the transit.

4.3.2 Tidal Gate Operation

Tidal gates would be provided at either end of a relatively long reach of one-way or two-way canal, and would be used during those times when currents would exceed acceptable values. The tidal gate would be opened or closed about every 6 or 12 hours when water levels are approximately equalized throughout the canal, always leaving one gate open and the other closed. Ships would leave and enter the reach between gates from one direction during the period that the gate at that end is open. Conceptual canal operation systems are illustrated in the following Figs. 4.3.1 and 4.3.2.

4.3.3 Tidal Gate Structures

Two tidal gate structures have been proposed, at distances of approximately 25% of the canal total length from the Pacific and Atlantic Oceans.

The gate structures include a hanger shelter, abutments, and a center pier with the main mechanical drive house in the case of the two lane canal.

For the one lane canal, the main mechanical drive house is located on an abutment. The hanger shelter and the abutments and center pier are connected by a concrete basement with rail tracks. 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 based on a pump dredging system would be necessary.

4.3.4 Canal partition wall

In the two lane Sea Level canal study cases – such as S-2, S-4, S-6, S-8, S-10 and S-12 – a partition wall about 26 km long between the lanes is planned for keeping different water levels that result from the tidal gates operation.

Using built-in steel pipe piles with a concrete cap as the wall's design feature, each pile will be connected with interlocking steel joints.

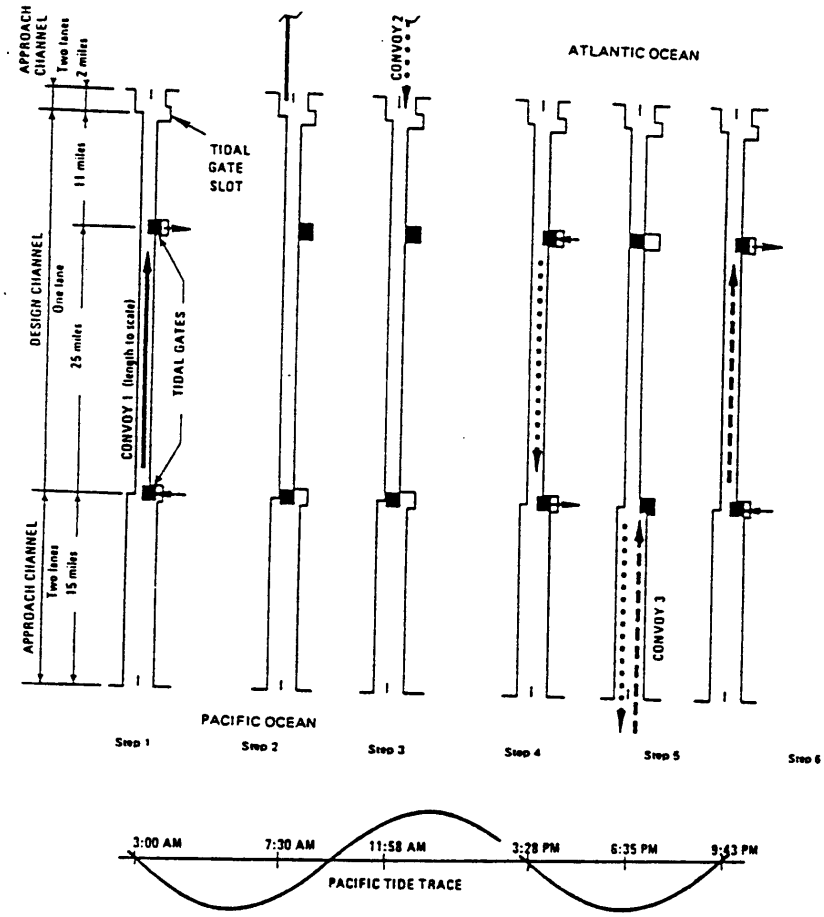


Fig. 4.3.1 Single Lane - Plan of Operation (Source: IOCS Study)

Step 1. (At 3:00 am)	Gates move at mean tide as convoy 1 reaches midway and moves toward the Atlantic.
Step 2. (At 7:30 am)	Convoy 1 clears one-way channel.
Step 3. (At 11:58 am)	Convoy 2 is about to enter one-way channel from the Atlantic.
Step 4. (At 3:28 pm)	Gates move at mean tide as convoy 2 reaches midway and moves toward the Pacific.
Step 5. (At 6:35 pm)	Convoy 2 clears one-way channel as convoy 3 starts to enter it.
Step 6. (At 9:43 pm)	Gates move at mean tide as convoy 3 reaches midway and moves toward the Atlantic.

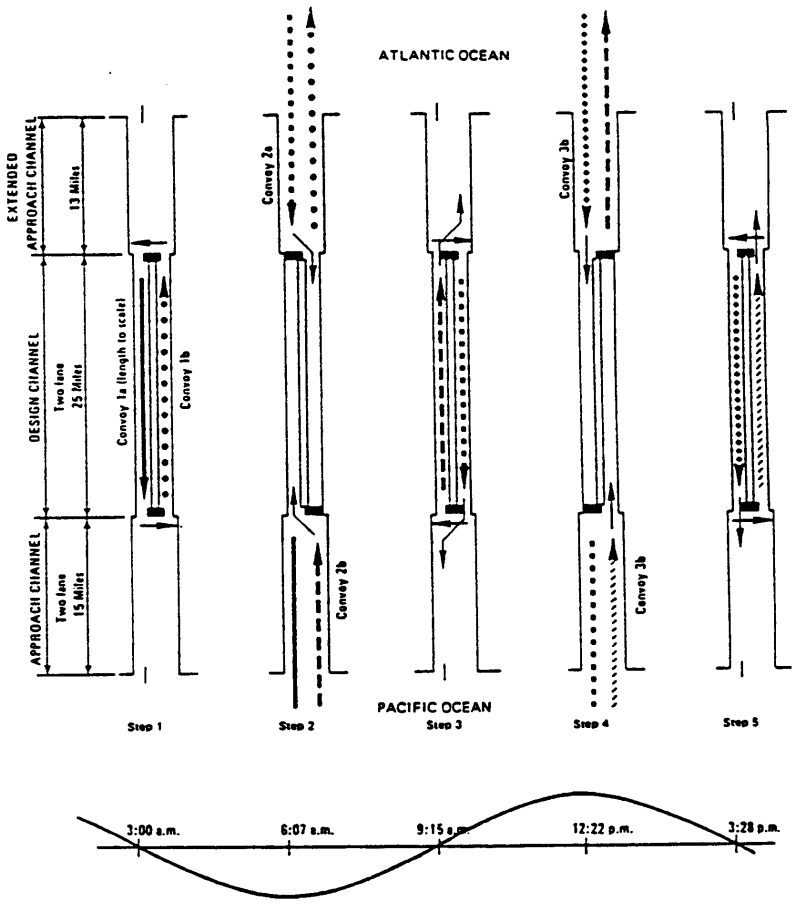


Fig. 4.3.2 Dual Lane - Plan of Operation
(Source: IOCS Study)

Step 1. (At 3:00 am) Gates move at mean tide as convoy 1a and 1b are midway and moving toward the approaches.

Step 2. (At 6:07 am) Convoys 1a and 1b have cleared gated reach, and convoys 2a and 2b are about to enter.

Step 3. (At 9:15 am) Gates move at mean tide as convoys 2a and 2b are midway and moving toward the approaches.

Step 4. (At 12:22 pm) Convoys 2a and 2b have cleared gated reach, and convoys 3a and 3b are about to enter.

Step 5. (At 3:28 pm) Gates move at mean tide as convoys 3a and 3b are midway and moving toward the approaches.

4.4 Tidal Gate

4.4.1 General Information

(1) Hydraulic Conditions for Gate Design

Table 4.4.1 shows hydraulic conditions adopted for the Tidal Gate design for Pre-screening. The water elevation on the seaside listed in the table conforms to the general hydraulic conditions given in 4.2.1 and the water elevation at the tidal gates with those given in Table 2 in the IOCS Memorandum JAX 67. These values correspond to a canal with a closed end of 24 miles in length.

In addition to the hydraulic conditions shown in the table, 0.9 m (=3') water head difference is considered for the gate leaf removing a lane to the opposite lane.

Table 4.4.1 Tidal Gate Hydraulic Condition

Water Elevation at Seaside				Water Elevation at Tidal Gate					
Pacific Coast		Atlantic Coast		Pacific Side		Atlantic Side		Difference	
Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	P->A	A->P
3.3	-2.7	0.5	-0.3	3.96	-3.81	0.61	-0.61	4.57	4.42

(2) Structural Materials and Allowable Stresses

Material: As proposed at (3)-a) of 4.2.1.
Allowable stress: Allowable stress level corresponding to the failure mode "Yielding" as shown in Table 4.2.3.

(3) Weight Estimation Procedure

As explained in (4) of 4.2.1.

(4) Fabrication

As explained in (5) of 4.2.1.

(5) Transportation

As explained in (6) of 4.2.1.

(6) Installation

As explained in (7) of 4.2.1.

4.4.2 Results of Conceptual Design

(1) Gate Type and Structural System

In Table 4.6.2, various gate types are compared with respect to important technical or economical elements established for the Tidal gate. Although the best evaluation result was given to gate type No. 11 (torsion type rolling gate), the gate type proposed here is a triangular leaf rolling gate because this type was adopted for Zandvliet lock before 1965 and has been in service since the lock was completed. A rubber type gate was also included in the table for the comparisons, but was eliminated because of the lower evaluation results. A fatal defect of the rubber type at this time is a lack of removal and reset ability in the wet condition. This was concluded after a study of the materials supplied by Bridgestone Corporation.

Fig. 4.4.1 shows a general view of the proposed Tidal Gate. The proposal is exactly the same as the IOCS proposal for Route 10 and Route 14S except for the following points.

a) Nominal leaf length conforms to the lane width instead of the canal top width as adopted in IOCS Memorandum JAX 67.

b) Wheel mounting: Preference is given to the combination of vertical and horizontal wheels or rimmed wheels instead of wheels mounted at right angles to the leaf frames as adopted in IOCS Memorandum JAX 67.

c) Water balancing apparatus is provided.

The wheel mounting in b) above is necessary for travel of the gate leaf with a three foot difference in water head between each side of the leaf. The rollers at the bottom of the leaf will slip off the rails without this consideration.

The water balancing apparatus in c) above is necessary for the leaf to withstand water loads from both directions. Without this apparatus it is possible that the leaf could topple under water loads from one of the directions.

(2) Numerical Results of Conceptual Design

Table 4.4.2 lists the results of the Tidal Gate sizing.

Table 4.4.2 Design Results for Tidal Gates

Case	Gate Width	Gate H.	D.Head 1		D.Head 2		Estimated Weight in Ton			
			PACI	ATLA	PACI	ATLA	LEAF	GFRM	MACH	TOTAL
S-1	147.0	27.0	26.4	23.0	18.6	21.8	6,832	1,025	683	8,540
S-2	147.0	27.0	26.4	23.0	18.6	21.8	6,832	1,025	683	8,540
S-3	171.0	30.0	29.7	26.3	21.9	25.1	9,523	1,428	952	11,903
S-4	171.0	30.0	29.7	26.3	21.9	25.1	9,523	1,428	952	11,903
S-5	183.0	31.4	30.8	27.4	23.0	26.2	10,781	1,617	1,078	13,476
S-6	183.0	31.4	30.8	27.4	23.0	26.2	10,781	1,617	1,078	13,476
S-7	147.0	27.0	26.4	23.0	18.6	21.8	6,832	1,025	683	8,540
S-8	147.0	27.0	26.4	23.0	18.6	21.8	6,832	1,025	683	8,540
S-9	171.0	30.3	29.7	26.3	21.9	25.1	9,523	1,428	952	11,903
S-10	171.0	30.3	29.7	26.3	21.9	25.1	9,523	1,428	952	11,903
S-11	183.0	31.4	30.8	27.4	23.0	26.2	10,781	1,617	1,078	13,476
S-12	183.0	31.4	30.8	27.4	23.0	26.2	10,781	1,617	1,078	13,476
S-13	147.0	27.0	26.4	23.0	18.6	21.8	6,832	1,025	683	8,540
S-14	171.0	30.3	29.7	26.3	21.9	25.1	9,523	1,428	952	11,903
S-15	183.0	31.4	30.8	27.4	23.0	26.2	10,781	1,617	1,078	13,476
S-16	147.0	27.0	26.4	23.0	18.6	21.8	6,832	1,025	683	8,540
S-17	171.0	30.3	29.7	26.3	21.9	25.1	9,523	1,428	952	11,903
S-18	183.0	31.4	30.8	27.4	23.0	26.2	10,781	1,617	1,078	13,476

(3) Sealing

The sides and bottoms of the gate leaf are sealed by J type rubber seals. The sealing has to be done for the Pacific and Atlantic sides. A perfect seal is not necessary but an allowable amount of water leakage relates to capacities of the water balancing apparatus proposed in (1) in the preceding page.

(4) Wheels

Wheels withstand horizontal thrusts while the gates are being removed.

(5) Water Level Balance Apparatus

The water level balance apparatus always keeps the water level in the gate body at the water level on the lowest side (Pacific side or Atlantic side).

(6) Float Tanks

Float tanks of sufficient volume are arranged in the leaf so that the leaf can be removed for maintenance after it is floated by the buoyancy forces of these float tanks. The water in the tanks is drained by pumps installed in the leaf.

(7) Corrosion Protection

An electric corrosion protection system is proposed to reduce corrosion progression in the embedded parts and in the gate leaf.

(8) Drive Mechanism

Fig. 4.4.1 illustrates the concept of a rack-pinion type drive mechanism which is the same concept proposed in the Anderson Report for Route 10 and Route 14S.

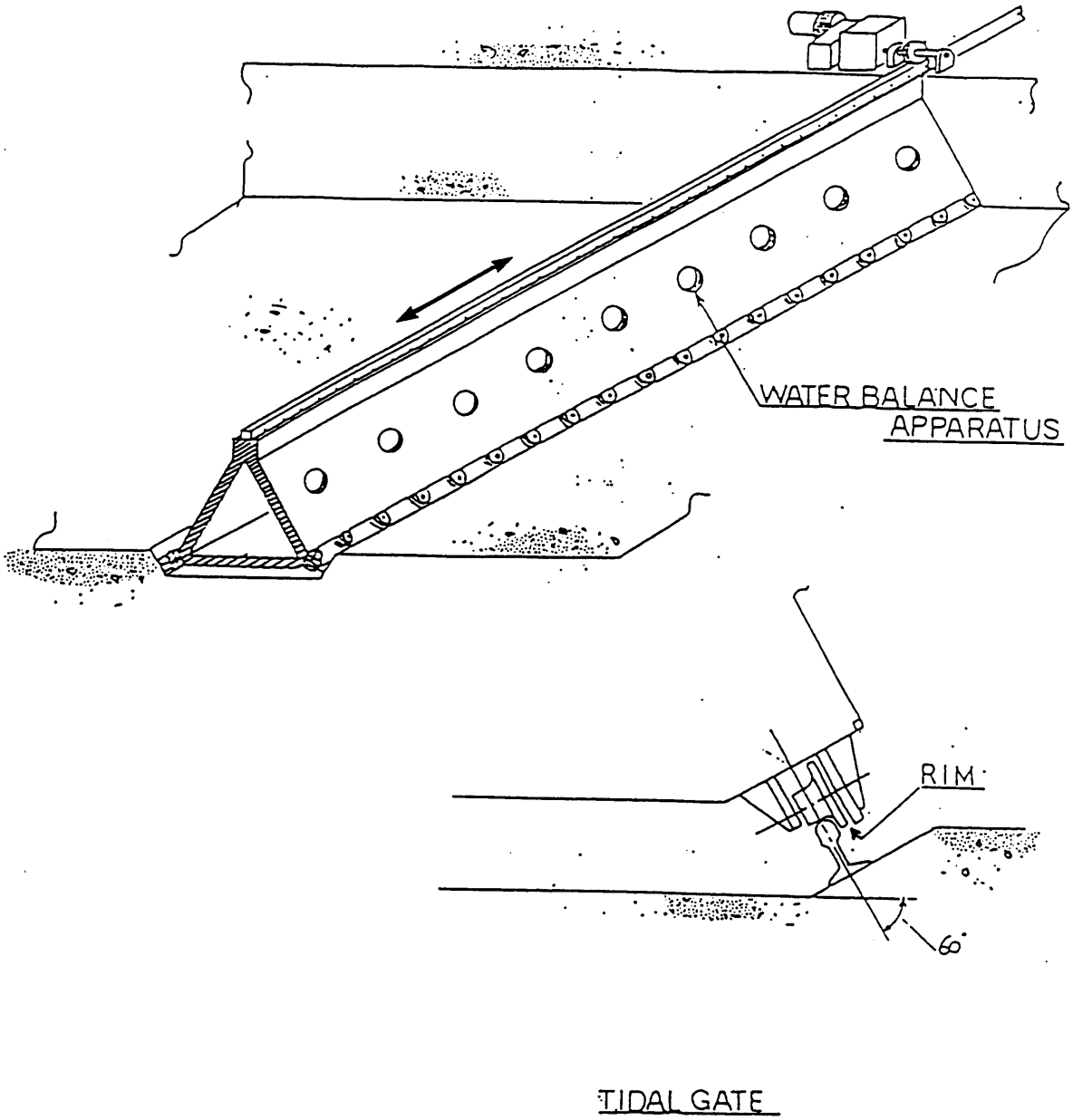
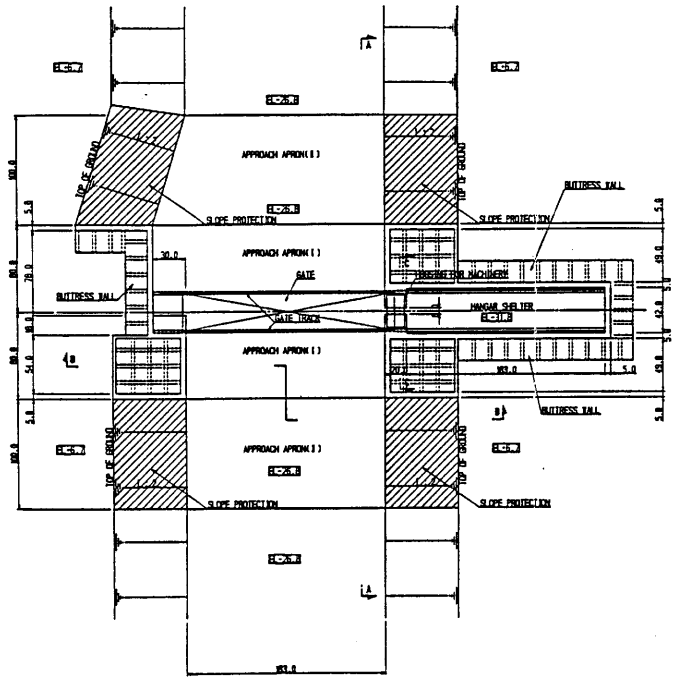


Fig. 4.4.1 General View and Drive Mechanism of the Tidal Gate



PLAN
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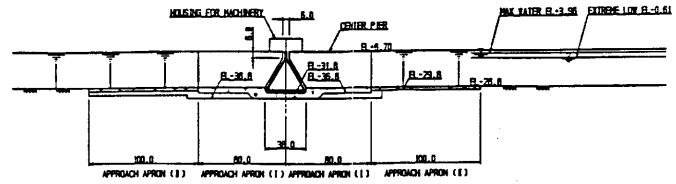

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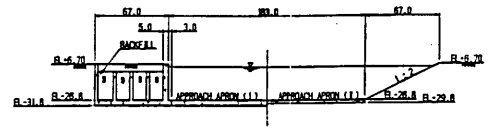
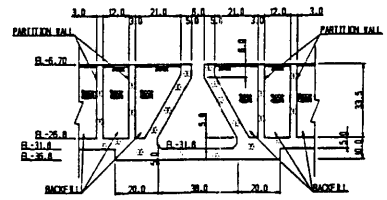


SECTION B-B
SCALE 1:4000



SECTION C-C
SCALE 1:2000

SCALE 1:4000

0 100 200 m

SCALE 1:2000

0 50 100 m

Fig. 4.4.2 300,000 DWT Vessel Tidal Gate (Case S-5, 1 Lane)

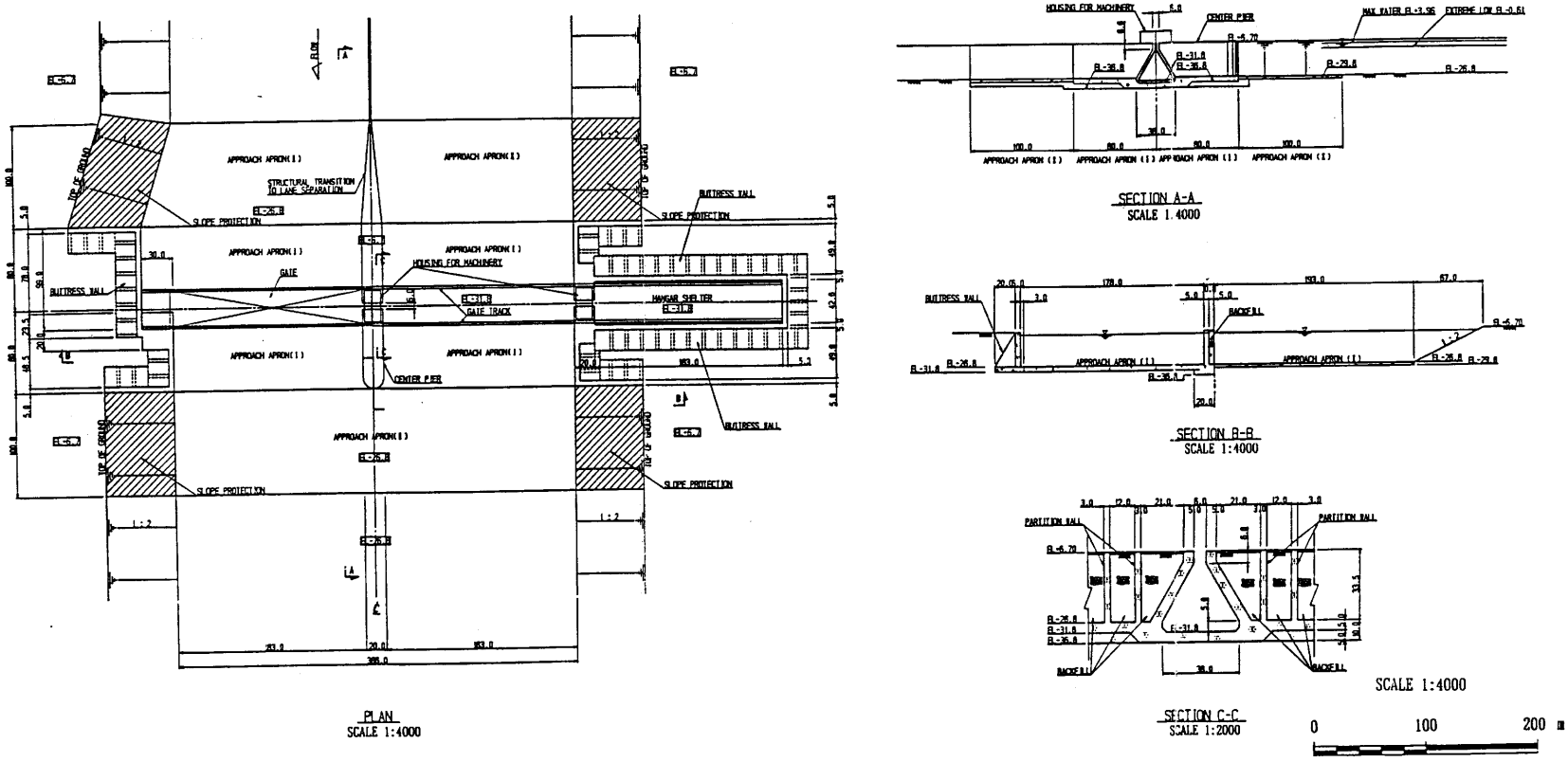


Fig. 4.4.3 300,000 DWT Vessel Tidal Gate (Case S-6, 2 Lanes)

4.5 Mules

4.5.1 Number of Mules and Functional Requirements

Ships are guided through the existing locks by locomotives, known as mules, which run on rails on both sides of the locks and use rack and pinion drive to augment wheel to rail friction. The system works well and is preferred for the new lock systems under consideration. The considerable increase in the size of ships for which the new locks are to cater requires the stowage system to be reviewed, not only to allow for the larger forces which will be needed to control the larger ships, but also to reduce as much as possible ship transit times through the new locks.

Table 4.5.1 shows the mule type and required numbers of mules for each study case. One team for a standard ship consists of six mules, and one lock provides two teams for one lift and three teams for two lifts including one team on the return trip.

Table 4.5.2 shows functional requirements for the mule types on Table 4.5.1.

The number of mules in a standard team, the team formation, and the functional requirements for the mules were determined based upon experiences in handling VLCCs and ULCCs for dockings and wharfing. The following conditions were considered.

(1) Ship propulsion is available at starting, accelerating, and stopping to relieve the strain on the locomotives while minimizing lockage time.

The usage of transit ship propulsion as an auxiliary means of ship accelerations during lockages has had a long history since the existing Panama Canal was constructed and it can be said that the usage is common practice in locking operations there today. For reference purposes, listed below are documents in which there are statements concerning the usage of ship propulsion during lockages.

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

b) The Panama Canal Pilot, Panama Canal Commission Maritime Training.

c) Pilot Hand Book, Panama Canal Commission, 1988.

(2) Maximum wind velocity is 13 m/sec.

(3) The maximum angle of tow lines with respect to the horizontal is 55 degrees which was derived in the Third Lock Plan study for a one lift lock of 200' width x 1500' length.

(4) Number of mules assigned is 4, 6 or 8 depending on ship size. These numbers are equal to those shown in c) of (1) above.

Table 4.5.1 Mule Arrangements

Case	DWT	Lock		Rise	Lift	Mule Type	Rq. Num.
		L	W				
L-1	100,000	360	47	90	2	M1	36
L-2	100,000	360	47	85	2	M1	36
L-2'	100,000	360	47	85	1	M1	24
L-3	100,000	360	47	55	1	M1	24
L-4	150,000	410	54	90	2	M2	36
L-5	150,000	410	54	85	2	M2	36
L-6	150,000	410	54	55	1	M2	24
L-7	250,000	485	63	90	2	M2	36
L-8	250,000	485	63	85	2	M2	36
L-9	250,000	485	63	55	1	M2	24
L-10	100,000	360	47	85	2	M1	36
L-11	100,000	360	47	55	1	M1	24
L-12	100,000	360	47	30	1	M1	24
L-13	150,000	410	54	85	2	M2	36
L-14	150,000	410	54	55	1	M2	24
L-15	150,000	410	54	30	1	M2	24
L-16	250,000	485	63	90	2	M2	36
L-17	250,000	485	63	85	1	M2	24
L-18	250,000	485	63	30	1	M2	24

Table 4.5.2 Functional Requirements for Mules

No.	Function	Examples of Detail Function
M1	Equal to the latest specification of the mules now in service.	Pulling force (Max): 35,000 lbs per on cable (16 ton) Number of cables: 2 Speed: 1, 2, 3, 6 and 9 M.P.H. Cable length: Max. 500' (150 m) Weight: 55 short ton
M2	Twice the pulling capacity of M1	Pulling force (Max): 32 ton per on cable Number of cables: 2 Speed: 0.5, 1, 2, 3, 6 and 9 M.P.H. Cable length: Max. 300 m

4.5.2 Specifications

		M1	M2
(1)	Dimension(m):	L10.4xW3.0xH3.8	L15xW3.3xH4.5
(2)	Weight(ton):	50	88 (approx.)
(3)	Drive Motor:	2 units	2 units
(4)	Drive Motor Size:	170HPx60Hzx440V	300HPx60Hzx440V
(5)	Cable Size(inch):	1	1-1/4
(6)	Rail Gauge(mm):	1,524	1,676

4.5.3 Electric Power Source

The electric power source is A.C. The advantages of A.C. compared to D.C. are the low cost of motors, low cost of transformers etc.

4.6 Technical Feasibility

4.6.1 Lock Gate

(1) General

Although the Lower Lock Gate L-2' is the largest with a height of 48.4m, it is still feasible. This is because the lock width is comparatively small (47m).

The heaviest unit weight is 2.74 ton/m2 for the Middle Gate in study case L-12 (LxH=63x38.5), whereas the heaviest leaf weight is 3,384 ton for the Lower Gate in study case L-13 (LxH=63x44.4).

(2) Optimization of Gate Design

Although possible leaf weights were derived for the study cases, optimization of the design of each gate is left for further study in Phase II. The following are examples of design factors which may be effective in decreasing costs, or in improving function.

a) Gate Depth

In the preliminary design of the three model cases, ratios of lock widths over gate depths (thicknesses) are 15.2 for the smaller two models, and 8.8 for the largest model. Although the ratio 15.2 is approximately equal to the ratio for the existing Panama locks (SQ), and was selected as a result of studies for weight optimization, the real optimum value may be another ratio. The ratio 8.8 was the highest necessary value to keep a plate thickness limitation for gate leaves. This value may require comparatively large gate depths which may result in increasing costs for concrete work since a large storage recess for the gate would be required. Optimization of gate and concrete work costs together may be necessary in this case.

b) Increasing the Fatigue Strength

The followings are examples of ideas by which joint strengths are improved and eventually considerable cost reductions may be realized.

a. To decrease stress levels of welded joints in critical areas.

b. To eliminate such welded joints which would be classified as having low grades of fatigue strength.

c. To apply high tension bolt joints wherever possible instead of welded joints.

c) A proper combination of structural steels of various strength levels.

A proper combination of various strength materials decreases leaf weights and eventually total costs may be reduced notwithstanding the increase in costs per unit weight.

In the studies of design optimization including the above mentioned factors, it is predicted that the two restrictions below may emerge as major obstacles to be overcome.

a. Allowable stress levels for fatigue designs.

b. Maximum thickness restrictions of welded joints.

Overcoming the above would require intensive design investigations, but such investigations should be worth while in this case because the capital expenditure to complete the whole project is large and there are significant benefits to be gained. Nevertheless, it is very important that the possibility of improvements has to be strictly evaluated before starting any experiments.

(3) Alternative Proposal for the Lock Gate

On Table 4.6.1, various gate types are compared with respect to important technical or economical elements established for the Lock Gate. Although the best evaluation result was given to No. 11 (torsion type rolling gate), it was not recommended in our proposal at (1) of 4.2.2 only because of a lack of actual installations records. Since torsion type flap gates (No. 4 on the same Table) do have a proven record in usage and its dimensions are indicative of torsion type rolling Lock Gates are feasible, this type can be considered as an alternative to the Miter gates.

Fig. 4.6.1 shows the Alternative for the Lock Gate.

This gate withstands rotational moment with its torsional rigidity and both gate ends are rigidly supported against the whole torsional moment whose magnitude is controlled by pair forces of hydraulic pressure acting on the gate leaf and reaction forces acting along the gate bottom. For this reason, this gate can be called a torsion type rolling gate.

Advantages of these gates are as follows:

a) Leaf weight is remarkably smaller than a bending type gate (the Miter type) because of the superiority of torsional rigidity to bending rigidity. Extent of the weight reductions may in some cases be more than 50%.

b) Very advantageous for fatigue designs due to lower tensile stresses. A magnitude of tensile stresses in this type of structure is equal to that of a shearing stress whose allowable stress is usually $1/\sqrt{3}$ of the allowable stress for tensile stress in bending type structures.

c) Very advantageous for fabrication because of the reduced thicknesses of shell plates comprising the gate leaves. Maximum plate thickness of the major portions of gate leaves in case of bending type Lock Gates will be up to 100mm whereas that of torsion types 20 - 40 mm.

d) Very stable for un-balanced water pressure such as the pressure of ship propulsion blows just in front of the Lock Gates.

Another possible alternative is the torsional type slide gate the leaf of which would be the lowest in cost and which has almost no mechanical parts. The reason why it was not recommended was mainly the leaf's gravity height change during operations that was likely to result in expensive hoist mechanisms and high operation costs. Nevertheless, this gate type is still difficult to omit completely because the leaf would have the most simple construction.

Table 4.6.1 Comparison of Gate Types for Lock Gates

MOVEMENT	DIRECTION OF MOVEMENT	NO	STRUCTURAL TYPE	FUNCTION		INITIAL COST	MAINTENANCE COST			HOIST LOAD		
				CHAMBER L[2] EFFICIENCY	STAB. AGAINST PROPULSION[3]		SAND & SILT	REMOVAL & RESET	MECHANI-CAL PART	FRIC TION	GRAV. EL. CHANGE[4]	HYDR. INERT[5]
ROTATION	VERTICAL	2	RADIAL(DOUBLE)	○	○	◎	○	×	△	○	○	○
		3	MITER	○	△	◎	△	○	○	○	○	△
	HORIZONTAL	4	FLAP(TORTIONAL)	×								
		5	FLAP(BENDING)	×								
		6	RADIAL(SINK TYP)	×								
LINEAR	VERTICAL	9 + 11	SLIDE(DROP)[6] (TORTIONAL)	○	○	◎	△	○	○	△	×	○
	HORIZONTAL	10	TRIANGLE	×								
		11	TORTIONAL	○	○	◎	◎	○	○	△	○	○

NOTE 1. NO: CORRESPONDS TO NO. OF SKETCHES ON FIG 4.6.3

2. CHAMBER L EFFICIENCY; EFFECTIVE CHAMBER LENGTH FOR LOCKAGES OVER ACTUAL CHAMBER LENGTHS. THE EFFECTIVE CHAMBER LENGTH = ACTUAL CHAMBER LENGTH - THE CHAMBER LENGTH WHICH CAN NOT BE USED FOR LOCKAGES BECAUSE OF EXISTANCE OR OPERATION OF A LOCK GATE.

3. STAB. AGAINST PROPULSION; STABILITY OF GATE LEAF SUPPORTS AGAINST SHIP PROPULSION BROWS.

4. GRAV. EL. CHANGE; GRAVITY CENTER ELEVATATION CHANGE OF A GATE LEAF. × MEANS THAT THERE IS THE CHANGE DURING LEAF OPERATIONS.

5. HYDRO. INERT; HYDRAULIC INERTIA FORCE. △ MEANS THAT HYDRAULIC INERTIA FORCE WILL ACT ON LEAF SKINS DURING LEAF OPERATIONS.

6. SLIDE(DROP) IS A GATE TYPE CORRESPONDING TO NO 9 IN FIG. 4.6.2 EXCEPT THAT SLIDE SHOES REPLACE ROLLERS AND THE GATE LEAF IS A TORSIONAL TYPE INSTEAD OF BENDING.

7. EVALUATION MARKS

×; NOT ACCEPTABLE, △; JUST AT ACCEPTABLE LEVEL, ○ACCEPTABLE WITHOUT ANY CONDITIONS,

◎; STRONGLY RECOMENDABLE

8. SHOWS RESULTS OF QUANTITATIVE STUDIES

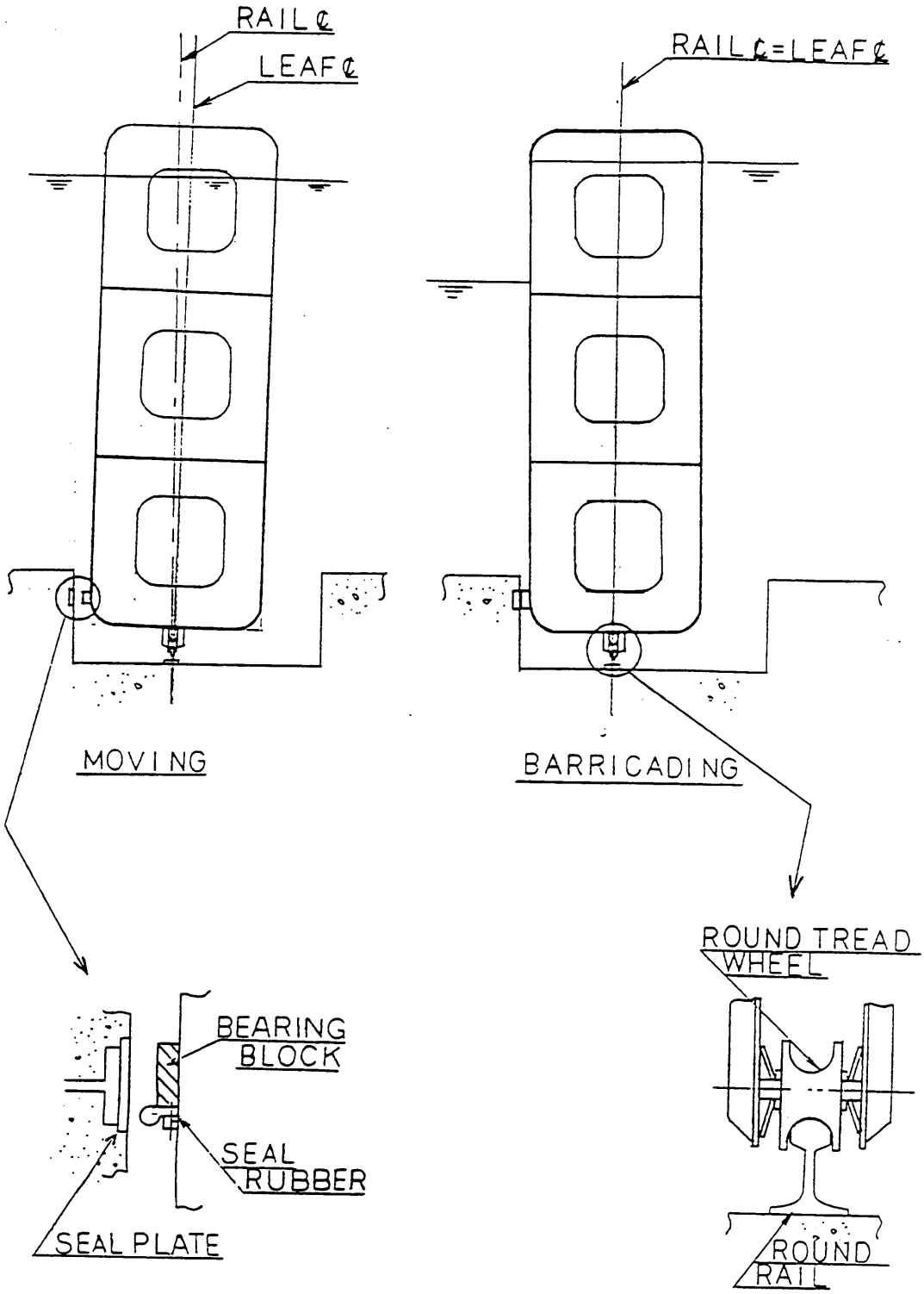


Fig. 4.6.1 Alternative for Lock Gate

4.6.2 Culvert Gate

(1) General

Culvert Gates in all study cases are fundamentally feasible.

(2) Technical items to be studied in Phase 2

a) Emergency closures of Culvert Gates

It is predicted that the water in the Culvert Gate chambers will surge due to emergency closures of the Culvert Gates. The amount of the surging will be examined at the next study phase and the chamber arrangements will be reviewed if necessary. However, the feasibility of the Culvert Gates are not affected.

b) Stability of the flow passing through the Culvert Gate chamber

Since the gate chamber length is comparatively large to accommodate a radial gate and flow velocity in the culvert will be very high in some study cases, hydraulic studies will be necessary, at a later stage of the design, on the stability of the flow passing through the chamber. And in the worst case, reviewing of the gate type selection, including the Fixed Wheel gates, may become necessary. Nevertheless, no big change is likely in the cost of the Culvert gate.

4.6.3 Emergency Gate

(1) General

Emergency Gates in all study cases are fundamentally feasible.

(2) Configuration of the Gate Top

Detail studies including hydraulic model experiments will be necessary to determine hydraulic characteristics of the gate top configurations. This has to

be done at a later stage before finalizing the emergency gate design.

(3) Structural Design of the Gate Leaves

The large torsional rigidity of the main box girder may cause difficulties in sealing at the gate bottom corners. Proper distribution of bending rigidities in vertical girders under the main girder will resolve this problem.

(4) Driving Mechanisms

Information is currently lacking with regard to the central jack type hoist machine energized by fire pump pressure. Ordinary hydraulic power cylinders combined with a pulley system would also be applicable for this gate.

4.6.4 Maintenance Gate

(1) General

Maintenance Gates in all study cases are fundamentally feasible.

(2) Structural Design of the Gate Leaves

The large torsional rigidity of the main box girder may cause difficulties in sealing at the gate bottom corners and in controlling bending stresses in the vertical girders located around mid-ship of the gate leaf. Proper distribution of rigidities within the main girders and vertical girders will resolve these problems. The leaf weights estimated may be a little high and reductions should be possible in the next stage of the study. In addition to this, further savings in weight are possible after considering the following conditions.

a) Adaptation of auxiliary maintenance gates for the upper operating gate.

b) Application of torsional type gates to the maintenance gate design. It is quite possible, and remarkable weight reduction could be achieved.

4.6.5 Tidal Gate

(1) General

Tidal Gates in all study cases are fundamentally feasible.

(2) Facilities for the Maintenance of Tidal Gate

Facilities for the maintenance of Tidal Gates were excluded from the pre-screening study. A maintenance facility could include docks for the gate leaves and some means for carrying out a maintenance of embedded parts in dry conditions.

(3) Alternative Proposal

On Table 4.6.2, various gate types are compared with respect to important technical or economical elements established for the Tidal gate. Although the best evaluation result was given to No. 11 (torsion type rolling gate), it was not recommended in our proposal in (1) of 4.3.2 because of the lack of existing installations. Since torsion type flap gates (No. 4 on the same Table) do have a proven usage record and its dimensions are inductive, this type can be considered as an alternative to the triangular rolling gates.

Fig. 4.6.2 shows the Alternative for the Tidal Gate.

This gate withstands rotational moment with its torsional rigidity. Both gate ends are rigidly supported against the whole torsional moment whose magnitude is controlled by the pair forces of hydraulic pressure acting on the gate leaf, and reaction forces acting along the gate bottom. For this reason, this gate can be called a torsion type rolling gate.

Advantages of this gate are as followings:

a) Leaf weight is much smaller than the Triangular Section Rolling Gate.

b) Ability to withstand pressure on both sides of the leaf without a pressure balance apparatus.

c) Reduced maintenance costs.

Table 4.6.2 Comparison of Gate Types for Tidal Gates

MOVEMENT	DIRECTION	NO	STRUCTURAL TYPE	FUNCTION	INITIAL COST	COST OF SAND & SILT REMOVAL	MAINTE. COST	REMOVAL & RESET	HOIST LOAD
ROTATION	VERTICAL	1	RADIAL(SINGLE)	○	△	×	×	×	○
		2	RADIAL(DOUBLE)	○	△	△	×	×	○
		3	MITER	×					
	HORIZONTAL	4	FLAP(TORTIONAL)	○	◎	○	△	○	△
		5	FLAP(BENDING)	○	△	△	○	○	△
		6	RADIAL(SINK TYP)	○	×	◎	◎	×	○
		7	VISOR	×					
LINEAR	VERTICAL	8	ROLLER(HOIST UP)	○	×	○	○	△	×
		9	ROLLER(DROP)	○	△	△	△	△	○
	HORIZONTAL	10	TRIANGLE	○	○	○	△	○	○
		11	TORTIONAL	○	◎	◎	○	○	○
CONFIGU-LATION	INFLATED/ DEFLATED	12	RUBBER DAM	○	△	◎	◎	×	△

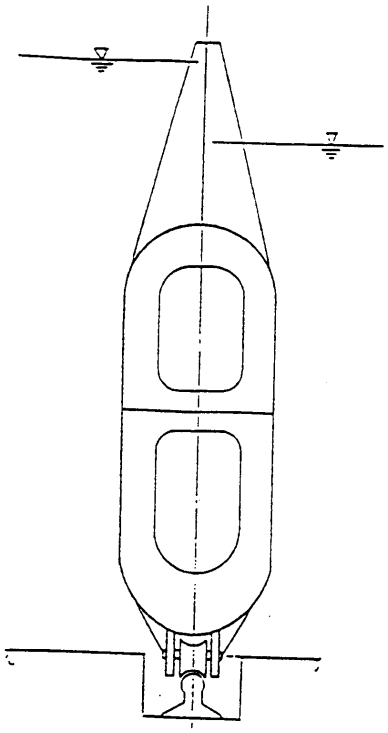
NOTE 1. NO; CORRESPONDS TO NO. OF SKETCHES ON FIG. 4.6.3.

2. EVALUATION MARKS

× ; NOT ACCEPTABLE, △ ; JUST AS ACCEPTABLE LEVEL, ○ ACCEPTABLE WITHOUT ANY CONDITIONS,

◎ ; STRONGLY RECOMENDABLE

3. SHOWS RESULTS OF QUANTITATIVE STUDIES



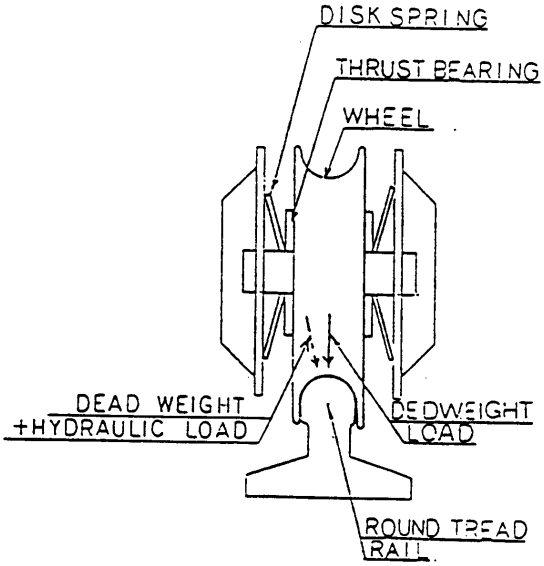


Fig. 4.6.2 Alternative for Tidal Gate

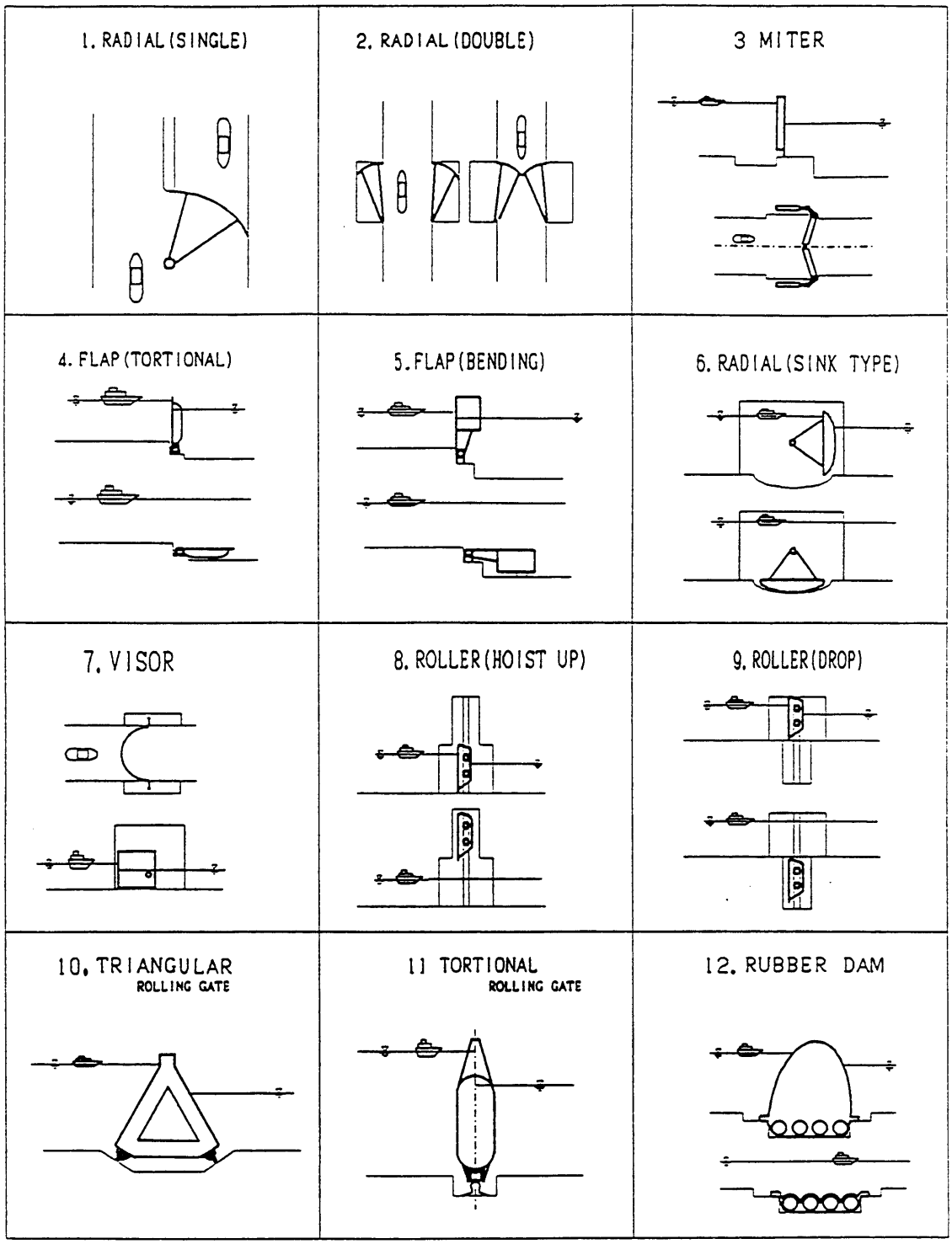


Fig. 4.6.3 Various Gate Types for Lock Gate and Tidal Gates

4.6.6 Mules

(1) General

Mules in all study cases are fundamentally feasible.

(2) Review of Mule Capacity in Phase 2

The capacity of the mule type M2 was tentatively decided to be twice that of the mule type M1 whose specification is exactly equal to the mules now in service at the Panama Canal. These capacities are for the Phase 1 study purpose and will be reviewed in the Phase 2 study. It is expected that the proper capacity ratio between M2 and M1 is between 1.0 and 2.0. The following are technical items for study and review in the next phase.

a) Necessary towing force for the transit ship running at the green light speed of mules (maximum towing speed established for various vessel sizes). In this calculation, the following elements are to be considered as well as wind force.

   a. Friction force on the hull surfaces from the flow due to ship speed plus water speed with respect to the lock. The later element relates to the movements of the transit ship.

   b. Friction force on the lock wall of the water flow.

   c. Resistance force corresponding to the absolute velocity head of the water flow along the ship.

b) The maximum stopping distance of the transit ships without ship propulsion aids. This calculation corresponds to an emergency condition and the effects of a) to c). Above can be included if minimum values are found. The number of mules at a braking load is the number of assigned mules for the ship minus 2.

c) Necessity of a hydraulic assistance for lockages. If the answer is yes, then modification of the culvert arrangements would follow.

(3) Alternative Mule Operation System

The following is an alternative idea for the mule operation system. Specific features of this alternative compared with the proposal are, minimum number of mules for a towing team and, no aid from a ship's propulsion.

a) Number of mules for a team: 4

b) Calculated cable pulling force per mule.

Ship Size (DWT)	Inertia Force (ton)	Wind Force (ton)	Cable Pulling Force (ton)
100,000	56	15	115
150,000	58	18	124
250,000	95	24	173

The following conditions were considered in the above calculation.

a) Towing speeds:
2mph for ships 150,000 and greater; 3mph for smaller vessels.

b) Acceleration:
The maximum towing speed is reached in 5 minutes.

c) Wake volume: 10% of a ship's displacement.

d) Maximum wind velocity is 13 m/sec.

e) Angle of the tow lines with respect to the direction of motion in a horizontal plane: 45 degrees.

f) The maximum angle of the tow lines with respect to the horizontal: 55 degrees.

No feasibility study was conducted for this alternative.

CHAPTER 5 - INCIDENTAL STRUCTURES

5.1 New Dams

New Dams are proposed for the high rise lock canal systems with water levels of 90' and 85' (L-1, L-2, L-2', L-4, L-5, L-7, L-8, L-10, L-13, L-16) in order to increase the supply of water for canal lock operations.

5.1.1 Rivers

Gatun Lake is the reservoir created by the Gatun Dam and spillway at the mouth of the Rio Chagres and covers a drainage area of approximately 3,339 km^2. Madden Lake is upstream from Gatun Lake and is the reservoir created by the dam across the upper Rio Chagres. It covers an area of approximately 1,018 km^2.

Fig. 5.1.1. shows the location of the river and the proposed new dams.

The main rivers flowing into Madden Lake flow from east to west and consist of the Rio Chagres, Rio Pequeni and Rio Boqueron, of which the Rio Chagres drainage area is the largest. The drainage areas of these three rivers account for about 70 percent of the Madden Lake basin. The main rivers flowing into Gatun Lake, aside from the Rio Chagres, are the Rio Gatun and the Rio Trinidad from the north-eastern side of the lake, Rio Ciri Grande and Rio Ciricito from the western side of the lake flowing from south to north.

Adjoining the Rio Ciricito basin and outside the Gatun Lake basin, is the Rio Indio. The Rio Indio has the largest drainage area of these rivers.

5.1.2 New Dams

In order to supply the water used in the canal operation, seven new dam sites were considered within or nearby the Gatun Lake basin. Some of the dam sites were nominated as potential sites in previous studies.

The dam sites and the existing gauging stations nearest each dam site are shown in Table 5.1.1, as well as in Fig. 5.1.1.

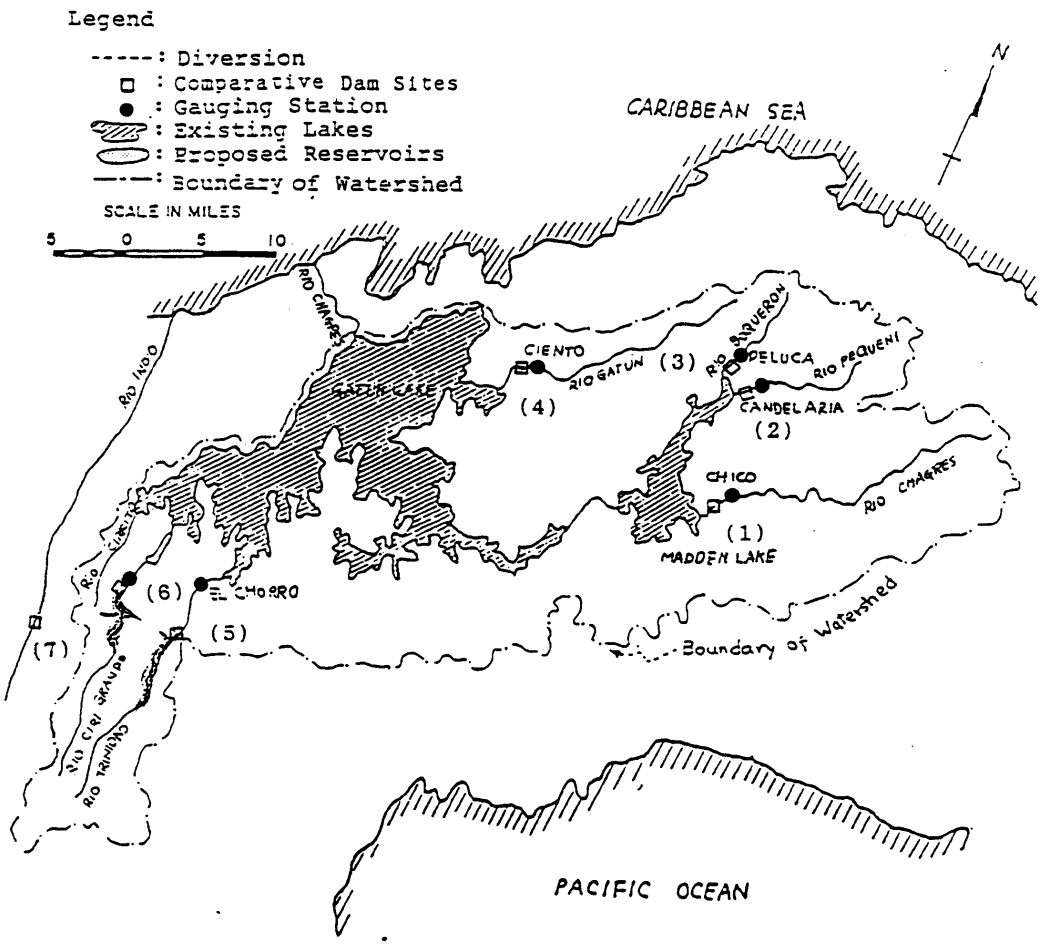


Fig. 5.1.1 Location of Rivers and Proposed New Dams

Table 5.1.1 Summary of Dam Sites and Gauging Stations

	Dam	River	Drainage Area (km^2)	Gauging Station	Drainage Area (km^2)
(1)	TRANCADO	Rio Chagres	425	CHICO	414
(2)	PEQUENI	Rio Pequeni	135	CANDELARIA	135
(3)	BOQUERON	Rio Boqueron	95	PELLICA	91
(4)	GATUN	Rio Gatun	125	CIENTO	122
(5)	TRINIDAD	Rio Trinidad	165	CHORRO	173
(6)	CIRI	Rio Ciri Grande	190	LOS CANONES	186
(7)	INDIO	Rio Indio	380	---	---

5.1.3 Location

(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 up stream from this site. This site was the furthest 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 selected after considering the effective use of water resources on the river. This site has the potential to supply an extremely large water yield, and the dam size should be as large as possible within engineering limits.

(2) Pequeni

A dam site was selected in a relatively narrow part of the valley approximately 2 km upstream from where the Rio Pequeni flows into Madden Lake, and is located near Candelaria gauging station. This site is located the furthest downstream of the candidate dam sites on the Pequeni River, but a further 2 km upstream there is another potential site.

(3) Boqueron

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

(4) 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 further downstream from this site there are other possible sites, however relative heights between the river bed and ridge are comparatively small and hence, the sites were not selected.

(5) Trinidad

A dam site was selected in a relatively narrow a part of the valley approximately 9 km upstream from where the Rio Trinidad flows into Gatun Lake, 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 Grande

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 Los Canones gauging station. The valley is quite narrow for approximately 2 km, including the gauging station site, and is suitable for a dam site. The topography upstream from the dam site area is relatively flat and in particular, the left bank ridge is low, then saddle dams might be prepared.

(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. Suitable sites for a dam meeting the proposed size on this river seem to be, according to the maps, 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 on the river. An alternative plan would be to move the dam site upstream so that the reservoir L.W.L could be raised. Water could then be conveyed to Rio Circito instead of Gatun Lake, making it possible to shorten the required length of the conduit pipe.

5.1.4 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 in the selection. On the other hand, economical considerations such as the distribution of construction materials are also very important factors. By considering the above factors it was decided that the fill type dam would be the most suitable. The materials from the canal excavation can be used as dam embankment materials.

A typical section of the proposed fill type dam is shown in Fig. 5.1.2.

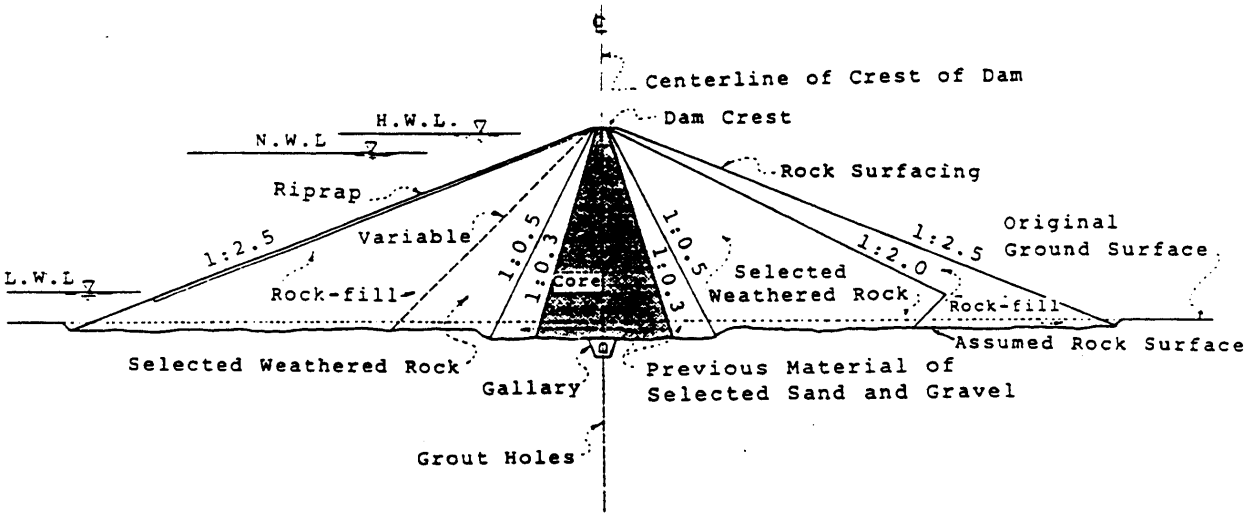


Fig. 5.1.2 Typical Section of New Dams

5.1.5 Design Criteria for Dams

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

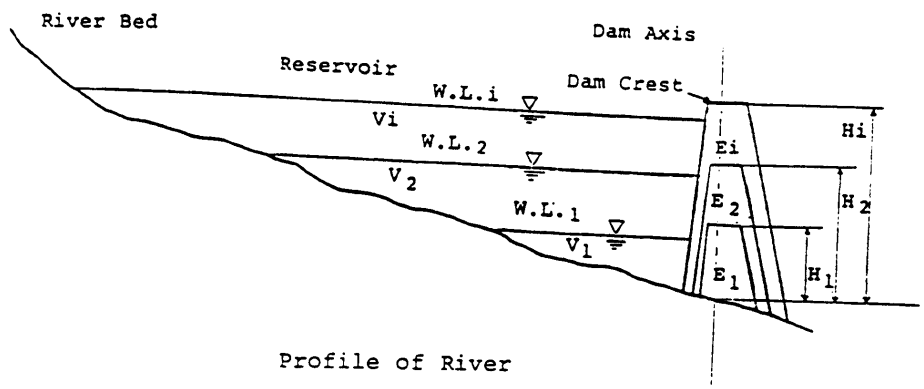
Water Demand (less than Annual Water Yield)
↓
Net Storage Capacity
← Sediment
Gross Storage Capacity
← H-V (Height-Volume) Curve
Normal Water Level (NWL)
← Spillway overflow depth (ungated spillway)
High Water Level (HWL)
← Freeboard
Dam Crest Elevation

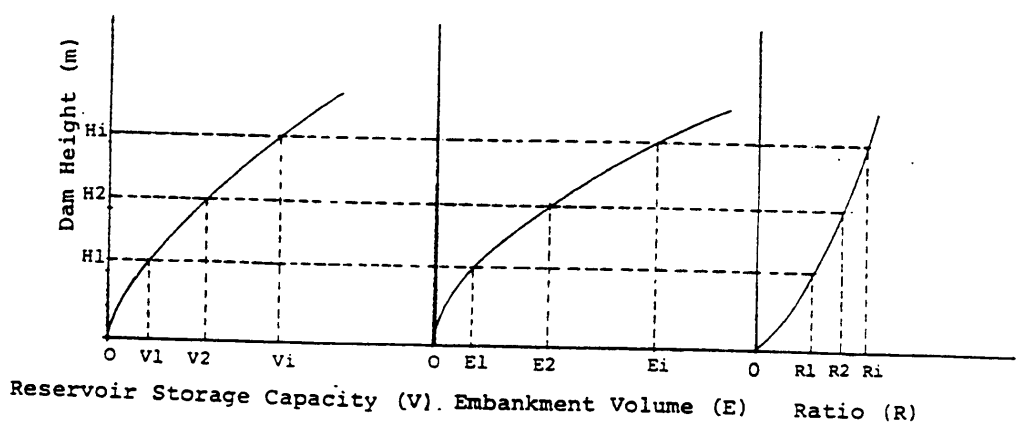
Note: H-V curves of the proposed dam sites were prepared by using topographical maps of 1:50,000 scale.

5.1.6 Selected Dam Sites

A prescreening study was carried out for the seven potential dam sites in the seven major river basins. Fig. 5.1.3 shows the relation between dam height and effective storage capacities per unit dam embankment volume for each site. The ratio curve is calculated as follows.

(1) Dam Height H-Gross Storage Capacity (V)
(2) Dam Height H-Dam Embankment Volume (E)
(3) Dam Height H-Effective Storage Ratio R=V/E





The Figure 5.1.3 illustrates that Ciri Grande and Trinidad dam are the most favorably located according to the H-R curves. Effective storage ratio of Trancado is estimated to a similar quantity of the Pequeni Dam site.

The ability of each site watershed to sustain the reservoir is adopted from the annual runoff discharge of each site. Unit runoff of Gatun Lake's annual drainage can be approximated at 1.77 mill.m3/km^2, as calculated below.

(Total annual mean discharge - Lake evaporation) ÷ Drainage Area (6593 mill.m3 - 673 mill.m3) ÷ 3339 km^2 = 1.77 mill.m3/km^2

Selection of the optimum dams would be confirmed after further studies in which water demand patterns, 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, were studied.

5.1.7 Development of New Dams

From the results of the water balance simulation for each study case, water resource development will be required. Development proposals are shown in the following Tables 5.1.2 and 5.1.3.

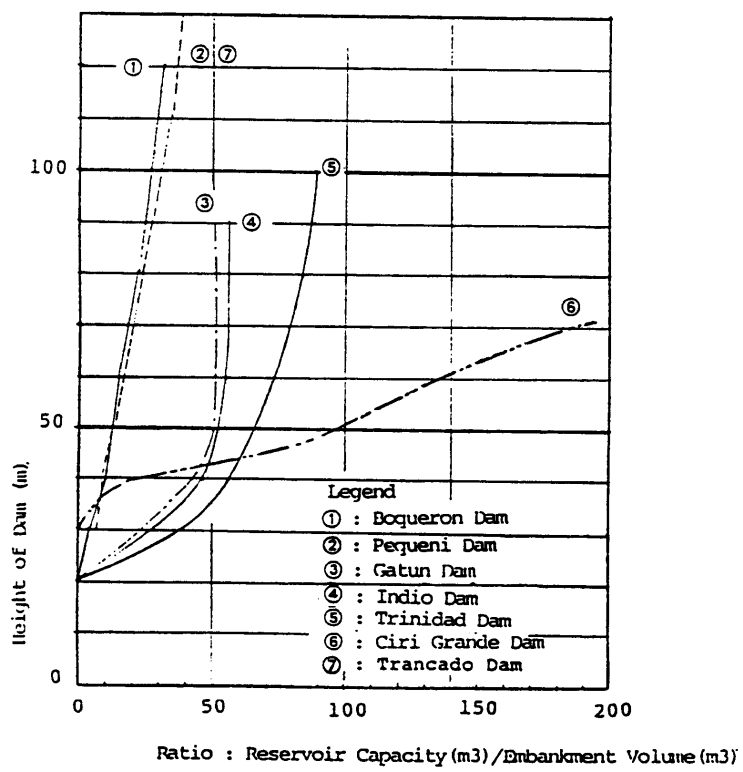


Fig. 5.1.3 Relation between Dam Height and Effective Storage Ratio per unit Dam Embankment Volume

Table 5.1.2 Water Resource Development Requirements

	L-1	L-2	L-2'	L-4	L-5	L-7	L-8	L-10	L-13	L-16
Water volume required (mill m^3)	285	373	339	288	292	279	376	373	292	376

Ciri and Trinidad dams were selected on the basis of Fig. 5.1.3 to meet the storage water volume requirements.

Table 5.1.3 Summary of New Dam Proposals

Study Case	New Dam	Drainage Area (km^2)	Reservoir: Stor. Cap. (mill m^3)	Reservoir: Sediment (m^3)	Reservoir: N.W.L (m)	Reservoir: L.W.L (m)	Reservoir: H.W.L. (m)	Dam: Crest El. (m)	Dam: H (m)	Dam: L (m)	Dam: Volume (mill m^3)
L-1, L-5 L-7, L-13 L-4	Trinidad	165	159-172	9	117	90	120	124	55	600	2.5
	Ciri	190	120	10	120	100	123	127	70	220	1.5
									Total		4.0
L-2, L-2' L-8, L-10 L-16	Trinidad	165	219-256	9	126	90	129	133	65	700	4.0
	Ciri	190	120	10	120	100	123	127	70	220	1.5
									Total		5.5

Note:

The storage capacities of dams are calculated in two ways. One is just potential capacity of dams as described in Chapter 2. and the other is planned capacity of dams actually used. Then these figures are not consistent naturally.

5.2 Barrier Dams

Barrier Dams are proposed for the low rise lock systems with water levels of 55' and 30' (L-3, L-6, L-9, L-11, L-12, L-14, L-15, L-17, L-18) in order to supply the water used in the canal lock operations, and for the Route 10 (S-1 - S-6, S-13 - S-15) and Route 14S (S-7 - S-12, S-16 - S-18) Sea Level Canals as a means of dewatering the Canal construction area.

5.2.1 Location of Barrier Dams

(1) for the low rise lock systems with water levels of 55' and 30', and the Route 14S Sea Level canal:

Fig. 5.2.1 shows the location of the barrier dams for the water level EL=55', 30' and Route 14S Sea Level Canal. The following four sites were considered based on the shape and topography of Gatun Lake and the distribution of the rivers flowing into the lake.

- A. Rio Chagres : Flowing in from the east side of the canal
- B. Rio Gatun, Rio Agua Sucia : As above
- C. Rio Trinidad, Rio Ciri Grande : Flowing in from the west side of the canal
- D. Rio Pescade, Rio Cano : As above

In order to provide the canal with an efficient supply of water, barrier dam sites were selected so as to provide large water surface areas and a high poundage in areas where the dam length would be shortest. All Barrier dams are equipped with a spillway and an outlet. An outline of the proposed barrier dams is shown in Table 5.2.1.

Table 5.2.1 Proposed Barrier Dams
(Low Rise Lock Canal & Route 14S)

Dam	River	Drainage Area (km^2)	Reservoir W.L. (m)	Reservoir Area (km^2)	Reservoir Capacity (mill.m^3)
A	Rio Chagres	1320	26.1	2.7	14
B	Rio Gatun	370	26.1	67	820
C	Rio Trinidad	780	26.1	127	1192
D	Rio Pescado	300	26.1	16	58

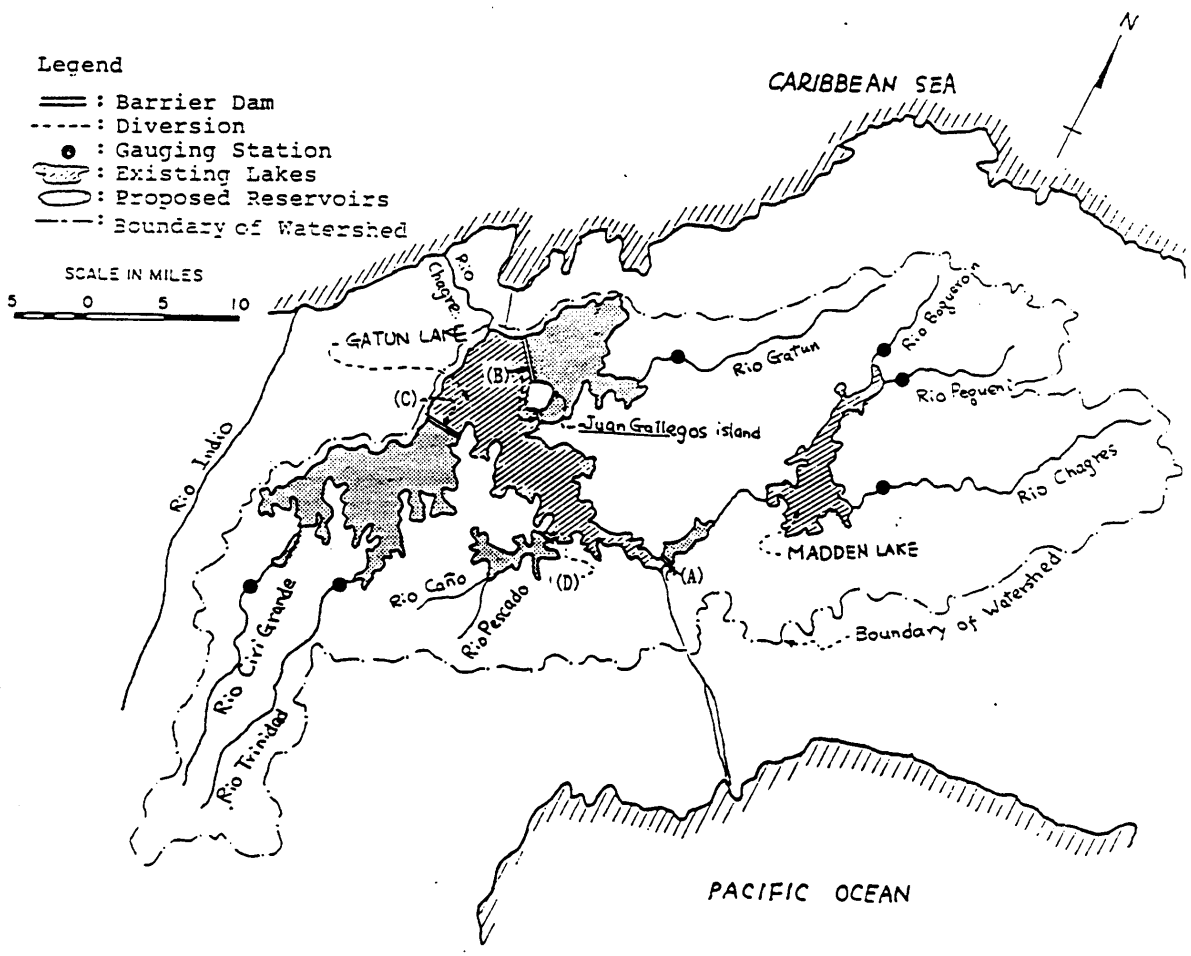


Fig. 5.2.1 Location of the Barrier Dams
(Low Rise Lock Canal Systems and Route 14S)

a) Dam site A - Rio Chagres

This dam site was selected approximately 1 km upstream from where the Rio Chagres enters the canal, at a location where the valley is relatively narrow. Gamboa is located at the point where the Rio Chagres flows into the canal. The barrier dam and its facilities (the spillway, intake and outlet) should be constructed away from the town. The reservoir surface and capacity are smallest among the proposed dams and increasing the capacity by raising the water level would present economic problems.

b) Dam site B - Rio Gatun/Rio Agua Sucia

The dam site is located downstream from the old Rio Gatun between the canal and the highway. Juan Gallegos Island in Gatun Lake would be closed off by four barrier dams. The reservoir surface is large and the capacity is also large but the impact on the highway must be considered in the event of increasing the existing water level.

The existing railway embankment is not coincident with new barrier dams. New barrier dams are planned at the west side of the railway embankment in order to keep the reservoir volume larger in the enclosed area. The stability of the existing embankment is also thought to be unsafe as barrier dams.

c) Dam site C - Rio Trinidad/Rio Ciri Grande

The dam site is located downstream of the old Rio Trinidad approximately 4 km south of the canal. Gaucha and Tern Islands in Gatun Lake would be closed off by three barrier dams. The reservoir surface area and capacity are largest for the proposed dams.

d) Dam site D - Rio Pescado

The dam site is located in the vicinity of Manguito, downstream of the old Rio Pesado, and approximately 2 km south of the Canal in an extremely narrow site. The reservoir surface and capacity are relatively small compared to the other proposed dams.

(2) for Route 10

Fig. 5.2.2 shows the location of the barrier dams for the Route 10 Sea Level Canal. The following three sites were proposed based on the shape and topography of Gatun Lake and to maintain a safe distance from the sea level canal alignment.

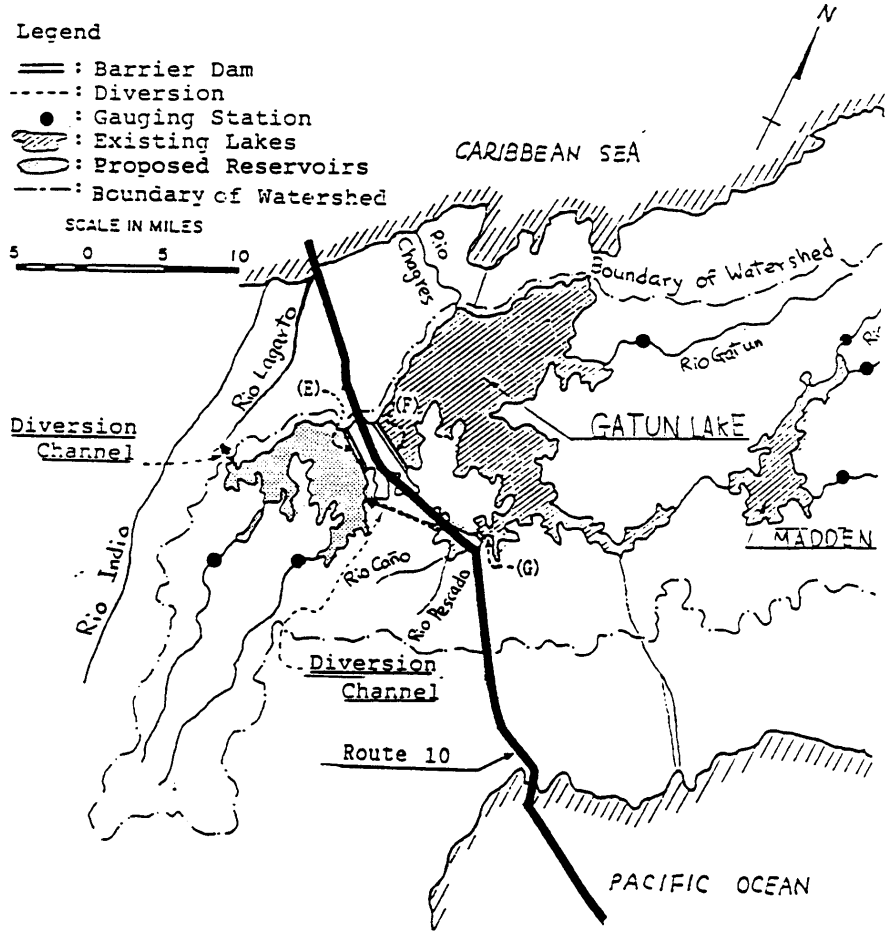


Fig. 5.2.2 Location of the Barrier Dams (Route 10)

a) Dam site E

The dam site is located downstream of the old Rio Trinidad, approximately 1 km south of the proposed Route 10. Los Negros and Esperanza Islands in the Lake would be closed off by three barrier dams. The barrier dam is equipped with a spillway to ensure the safety of the dams, and a diversion conduit from the reservoir to Rio Lagorto is also proposed in order to reduce the levels to which the water could rise. After the construction of the canal, concrete conduit is provided at the terrace of the diversion channel B, convey reservoir water into Route 10 canal between proposal tidal gates.

b) Dam site F

The dam site is located downstream of dam site E and north of Route 10. The axis of the dams are almost parallel and each dam is separated by approximately 3 km. Remon and Bajo Island in the Lake would be closed off by two barrier dams. The dam site is located downstream of the old Rio Pescado approximately 7 km south of the canal, and about 1 km away to the north of Route 10.

c) Dam site G

The dam site is located downstream of the old Rio Pescado approximately 7 km south of the canal, and about 1 km away to the north of Route 10.

5.2.2 Type of Barrier Dams

Considering the huge crest length, relatively small differences in water levels between the upstream and downstream side of the dams, and the dam foundation treatment that is almost under water, economics indicates the fill-type dam is most appropriate. The dam embankment materials would consist of core, filter and rockfill. The core material is decomposed rock which is made up of relatively fine grade (about 25% content passing 200# sieve). The filter material consists of well-graded sand and gravel which will not suffer segregation during placement in the water. The rockfill material is a

coarse material including hard rock to be used as riprap. Fig. 5.2.3 shows a typical section of the dam.

It is considered that there will be enough usable materials from appropriation of materials excavated from the canal, but some blending and separation will be necessary.

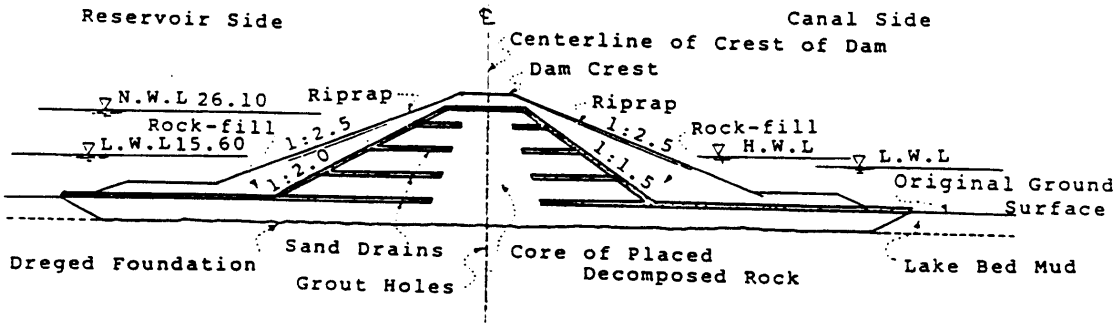


Fig. 5.2.3 Typical section of Barrier Dams

5.2.3 Design Criteria of Dam

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 (NWL)
↓ ← Spillway overflow depth (Gated spillway)
High Water Level (HWL)
↓ ← Freeboard
Dam Crest Elevation

5.2.4 Development of Barrier Dams

From the results of the water balance simulation for each study case, barrier dams will be required. An outline of the barrier dams are listed in the following Table 5.2.2.

Table 5.2.2 Summary of Barrier Dams

Study Case	Dam	Drainage Area (Km^2)	Reservoir NWL (m)	HWL (m)	LWL (m)	Dam Crest EL(m)	Height (m)	Length (m)	Volume (mill m^3)
L-3,L-11	A	1,320	26.1	26.1	15.6	30	17	900	0.8
L-6,L-14 L-9,L-17	B-1	370	26.1	26.1	15.6	30	29	4,100	11.3
	B-2						20	520	0.6
	B-3						20	100	0.2
	B-4						20	100	0.2
	C-1	780	26.1	26.1	15.6	30	30	1,800	4.3
	C-2						27	1,100	1.8
	C-3						27	500	0.7
	D	300	26.1	26.1	15.6	30	20	500	0.4
								Total	20.3
L-12,L-18	A	1,320	26.1	26.1	8.1	30	17	900	0.8
L-15	B	370	26.1	26.1	8.1	30	29-20	4,820	12.3
	C	780	26.1	26.1	8.1	30	30-27	3,400	6.8
	D	300	26.1	26.1	8.1	30	20	500	0.4
								Total	20.3
Route 14S (S-7 - S-12, S-16 - S-18)	A	1,320	26.1	26.1		30	17	900	0.8
	B	370	26.1	26.1		30	29-20	4,820	12.3
	C	780	26.1	26.1		30	30-27	3,400	6.8
	D	300	26.1	26.1		30	20	500	0.4
								Total	20.3
Route 10 (S-1 - S-6, S-13 - S-15)	E	685	26.1	26.1		30	25	4,350	4.5
	F	---	26.1	26.1		30	27	4,900	5.5
	G	---	26.1	26.1		30	20	880	0.7
								Total	10.7

5.3 Anchorages, Moorings and Breakwaters

5.3.1 Introduction

Anchorages are required at each end of a canal so that a ship waiting for its turn to transit the canal may anchor, if necessary. Within the canal and its immediate approaches, moorings are required for ships which have been delayed and cannot proceed. Buoyed moorings are appropriate in some locations, but the majority would be for along-side berths at the locks and throughout the length of the canal.

The benefits from the breakwaters at the entrances to the canal have been modified over the years by the increasing size of ships wanting to transit the canal. Originally, they provided sheltered anchorage for shipping as well as, shelter for the locks that otherwise were exposed to action from waves generated offshore. Those waves are potentially much larger than can be generated within the area sheltered by the breakwaters. The proportion of ships using the canal which require shelter while awaiting to enter is predicted to decrease (See Analytics predicted ship mix for 2010 in Sinbol's Status of the present canal), so that the prime function of the breakwaters has become to protect the immediate approaches to the canal to minimize wave effects on ship handling, and to protect the lock gates.

5.3.2 Anchorages

Until predictions of canal traffic become available which show the number of ships likely to use the canal and distribution in size, an approximate number of berths in the anchorages has been estimated as follows.

Recent the PCC Annual Reports e.g. 1989, show the number of transits to be almost equally split between the two directions. It was assumed that this situation will continue.

The mix of ships transiting the canal was assumed to be that predicted by Analytics (referenced above) for 2010. Maximum canal capacity with such a mix of ships has been estimated as 26,000 per year for a four-lane locked canal and 19,000 for a single lane sea level canal. (See Annex

to this report.) These capacities represent an average of 72 and 52 transits per day respectively. A figure of 72 transits per day was chosen to estimate the anchorage area required.

Of the 72 vessels arriving each day, most will plan their arrival to coincide with their time of passage and will not anchor. It is reasonable to assume that this may not be possible for half of the arrivals so that, on an average, 18 ships will require anchorage at each end of the canal. To this number a peaking factor of 1.3 has been applied to allow for grouping and random arrival. An anchorage sufficient in area for 24 ships will be required at each end of the canal. No allowance has been made for ships which may wish to delay departure from the canal as it is believed that this number is negligible.

The area required for anchorage will depend upon the size of ships and anchoring positions should be set out to accommodate a range of vessel sizes for a probable mix of ships.

The swinging radius comprises the sum of the scope of the anchor chain and the ship's overall length. For this purpose the scope of chain is assumed to be six times the depth of water (Technical standards for port and harbor facilities in Japan, 1980. Overseas Coastal Area Development Institute of Japan.), and the spacing of anchoring positions is taken as 2.5 times the swinging radius. This spacing will ensure clearance between ships allowing for variations in length of chain and the unlikely event of adjacent vessels lying in opposite directions from their anchors. The space required for 24 positions amounts to 25 km^2 and would be conservative should the ships be smaller. For the two lane sea level canal, the capacity could be 80% greater and the anchorage area would become 45 km^2.

Table 5.3.1 Anchorage Area Required for a Single Lane Canal

Ship size (DWT)	LOA (m)	Draught (m)	Water depth (m)	Radius (m)	No. of ships	Area occupied (km^2)
60,000	277	12	15	367	16	13.4
100,000	295	17	21	421	2	2.2
150,000	316	19	24	460	2	2.6
250,000	372	22	27.5	537	3	5.4
300,000	394	23	29	568	1	1.1
				Total		24.7

The existing designated anchorage area outside the breakwaters at Limon is about 26 sq km and appears to have depths of up to 100 feet (30.5m); and would be adequate for the largest vessels. In the Pacific, the area is larger (58 sq km) but shallower (17m). Then a new access channel would need to be dredged to depths ranging from 21 to 29 meters. A suitable location for the deeper area would be adjacent to the fairway into the canal.

5.3.3 Moorings

Moorings are needed for ships in the canal and immediate approaches if passage is interrupted. Sufficient mooring should also be provided to accommodate as many ships as may be unable to escape from the restricted channel.

As an example, consider ships approaching the canal from the Atlantic. Until a ship passes the breakwater heads, it will be able to turn from the channel if an emergency arises, but once inside the breakwaters, a large ship's freedom to maneuver will be restricted by the lack of depth and space. The maximum number of ships involved if an emergency occurs which prevents passage should be addressed. Provisions need to be made to moor all ships which may have entered the restricted channel within the breakwater heads.

Assuming there are two existing and two new lanes of locks with a combined frequency of 3.02 ships/hr, and that the steaming time from the breakwater heads to the locks is 1.08 hrs; there would be 3.02 x 1.08 + 1 = 4.26 (say 4) ships in the inner channel at any time. Thus if all the locks were to be closed, four moorings would be required. In practice, it is unlikely that both sets of locks would be out of action at the same time, and only two ships will need mooring.

Similar reasoning may be applied to each end of all the locks. Between Gatun and Pedro Miguel (Miraflores in the case of the new locks), the Culebra Cut will govern the number of ships needing to moor. For those sailing towards the Atlantic, all within the cut would need to stop, but as there is space for them to anchor in the lake, no moorings would be required. For southbound ships, those already in the Cut would be affected if either Pedro Miguel or the new locks at Miraflores, were to be shut unexpectedly. While moorings could be provided close to the locks, there will be, for safety reasons, emergency moorings along the banks of the Cut. These could be used provided ships using the operative locks can pass the moored vessels safely. This depends upon the dimensions of the canal cross-section and the size of the ships involved. The numbers given in the table below assume that all affected ships will moor close to the locks. Moorings for northbound ships at both sets of

locks will be determined by the factors described for Gatun.

Table 5.3.2 Mooring Requirements

Location	Direction	No. of moorings	Comment
Gatun	South	2	--
Gatun	North	8	Ships will anchor in the lake
Pedro Miguel	South	3	Ships could moor in the canal
Pedro Miguel	North	1	--
Miraflores	South	3	Ships could moor in the canal
Miraflores	North	3	--

Moorings within the canal would comprise bollards at regular intervals along the banks while at the locks mooring dolphins are preferred.

5.3.4 Breakwaters

Protective breakwaters at both ends of the canal need only be sited to shelter the immediate entrance from severe wave action and cross currents, both of which would hamper safe navigation into and out of the canal. Limited anchorage for small ships would be possible within such a configuration, but until detailed predictions of ship size and number are available, the area needed for anchorage cannot be determined. The existing arrangements at Limon and the Pacific entrance appear adequate for the foreseeable demands.

At the entrance to a sea level canal on Route 10, natural protection appears to be limited and breakwaters will be required. The distance offshore from the breakwater heads should be sufficient to give shelter to ships during the final stages of its stopping maneuver. For VLCC's this distance should be about 6 km. The location of the breakwaters will depend upon local bathymetry and topography, but its roots might be approximately 3 km either side of the channel so that an area of about 20 sq km would be enclosed. Particular attention will be required in assessing the changes to the local environment resulting from the introduction of the breakwaters and possible adverse effects on the neighboring coastline.

5.3.5 Conclusions

Anchorages should be provided at each end of the canal to accommodate ships awaiting turn to enter the canal. The estimated areas required amount to 17 sq km at each end of the locked and single lane sea level canals. A two lane sea level canal would need about 35 sq km of anchorage at each end. In view of the size of the majority of vessels expected to use the canal, the anchorages need not be protected. Water depths within the anchorage area may vary, but some deep-water areas will be required for the larger vessels.

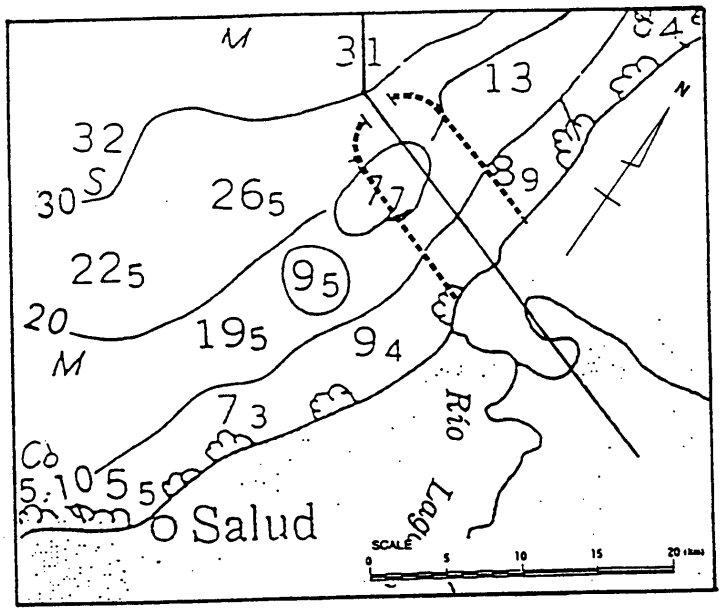
Moorings should be provided in the approaches to all the locks. Numbers vary depending upon the number of ships which might be in areas of restricted maneuverability when an emergency arises, but would not exceed three in any location. In general, mooring dolphins are to be preferred as they would minimize obstruction to the movements of other ships.

Existing breakwaters will be adequate for an enlarged existing canal or for a sea level canal on Route 14S. New breakwaters will be required for a canal on Route10. They should extend about 6 km offshore to provide shelter for the larger vessels in the more vulnerable stages of approach to the canal.

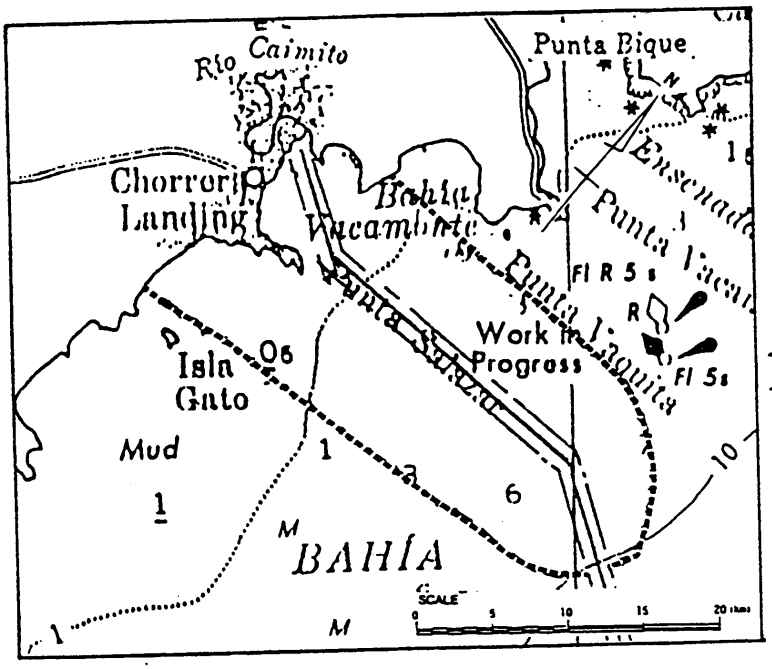
In case of route 10, one of the examples of an alignment of the breakwaters in both coasts sides is shown in Fig. 5.3.1.

In the Atlantic side, the slope of the seabed is much steeper than that of the Pacific side. So it is not realistic to extend breakwaters 6 km offshore where the depth is 35 meters or more. Therefore, it is suggested that to make the stopping distance into the existing land area. The width between west breakwaters and east breakwaters is decided to meet the space required for a turning basin of VLCC.

The typical cross section of breakwaters are shown in Fig. 5.3.2, 5.3.3. The type of breakwaters chosen are a sloping rubble mound with armor stones, given the experience of the Vacamonte Fishing Port's breakwaters.



Atlantic Coast



Pacific Coast

Fig. 5.3.1 Breakwaters on the Atlantic Coast and Pacific Coast

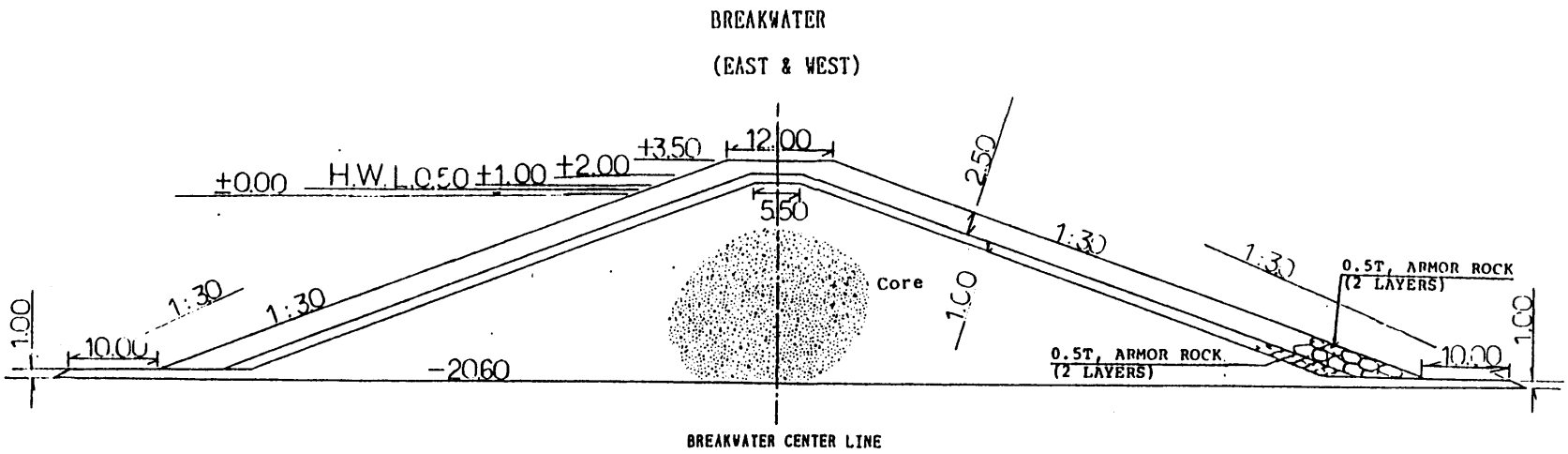


Fig. 5.3.2 Construction Method of Core and Armor Rock
(Atlantic Coast)

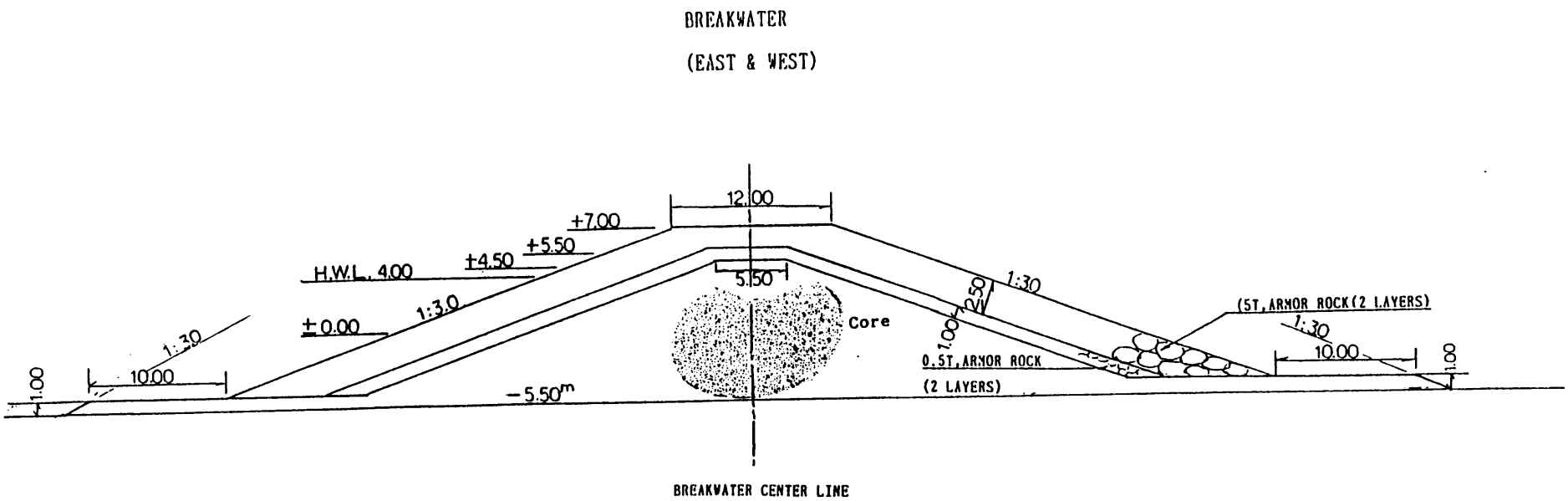


Fig. 5.3.3 Construction Method of Core and Armor Rock
(Pacific Coast)

Table 5.3.3 Breakwater Length and Depth

	Length		Mean Depth
Atlantic Coast	East 3,280 m	(Total 7.380 km)	- 20.60 m
	West 4,100 m		- 20.60 m
Pacific Coast	East 6,300 m	(Total 14.9 km)	- 5.50 m
	West 8,600 m		- 5.50 m

Table 5.3.4 Volume of Core and Armor Rocks for Breakwater

	Atlantic Coast	Pacific Coast
Core	11,070,000 m^3	5,580,000 m^3
Armor Rock (0.5 ton/rock)	1,107,000 m^3	894,000 m^3
Armor Rock (5.0 ton/rock)	2,583,000 m^3	2,533,000 m^3
Total	14,760,000 m^3	9,015,000 m^3

5.4 Tidal Basin

In this section, an attempt is made to clarify for further study several aspects of the tidal basin which were studied and recommended by Ing. Demostenes Vergara Stanziola. (hereafter called Vergara's Plan)

5.4.1 Outline of Vergara's Plan

An entrance channel (Route 10) in the Pacific provides access to a vast cove or tidal basin with port functions, ship anchorages, etc. The canal will follow Route 10 through the Panama isthmus, protected from tidal currents by the tidal basins instead of barriers or gates. Its termination in the Atlantic would include another port cove, even though the possible dimensions here are smaller than those on the Pacific side.

The entrance channel to the Pacific (more than one (1) kilometer long), will permit the simultaneous "crossing" of two "giant ships" of 250,000 tons or more and simultaneously "a fortiori", crossing of one of these "giant ships" and one or more conventional ships. Its initial width, at an average level of water, or zero level, would be about 600 meters (approx. 2,000 feet), and the outlet width to the cove would be about 650 meters (2,100 feet).

Within the cove, dissipation of the 'tide streams' would occur in the interior within a few miles of the entrance. Only the streams coming from unusual tidal waters, joined with strong winds from the sea to the land, might affect the inlet of the terrestrial channel stretch.

The 'tide gate' would be unnecessary, since the stream would be almost eliminated from the terrestrial stretches.

Fig. 5.4.1 shows the alignment of the Tidal basin recommended by Ing. Vergara in the Pacific coast.

5.4.2 The Subject of Vergara's Plan

- Tidal current - Tidal gates might be unnecessary because the tidal basin has the effect of reducing tidal currents in the canal.
He calculated very roughly an entering speed of tidal

currents using the Manning formula of 3 - 4.5 knots/hour. The speed depends on the opening dimensions at the tidal basin entrance and on the tidal range. The tidal basin size, its opening dimensions and the effect of the basin are not analyzed in this study.

- Area of anchorage basin - To meet requirements for anchoring capacity, 10,000 - 11,000 hectares is recommended for 2 giant ships and 200 conventional ships in Vergara's plan. However, this would depend on the distribution of ship sizes entering into the cove and it would be necessary to study ship sizes and distribution corresponding to traffic volumes through the canal.

- The plan for land use of areas reclaimed by construction of the breakwaters -
In Vergara's plan, it is described that vast "filter-breakwaters (embankments)" for many uses such as ports, management, tourism, residences, marine city, free zones etc. The above mentioned ideas are excellent, but the necessary land area, the volume of disposal of excavation and the cost of disposal must be studied.

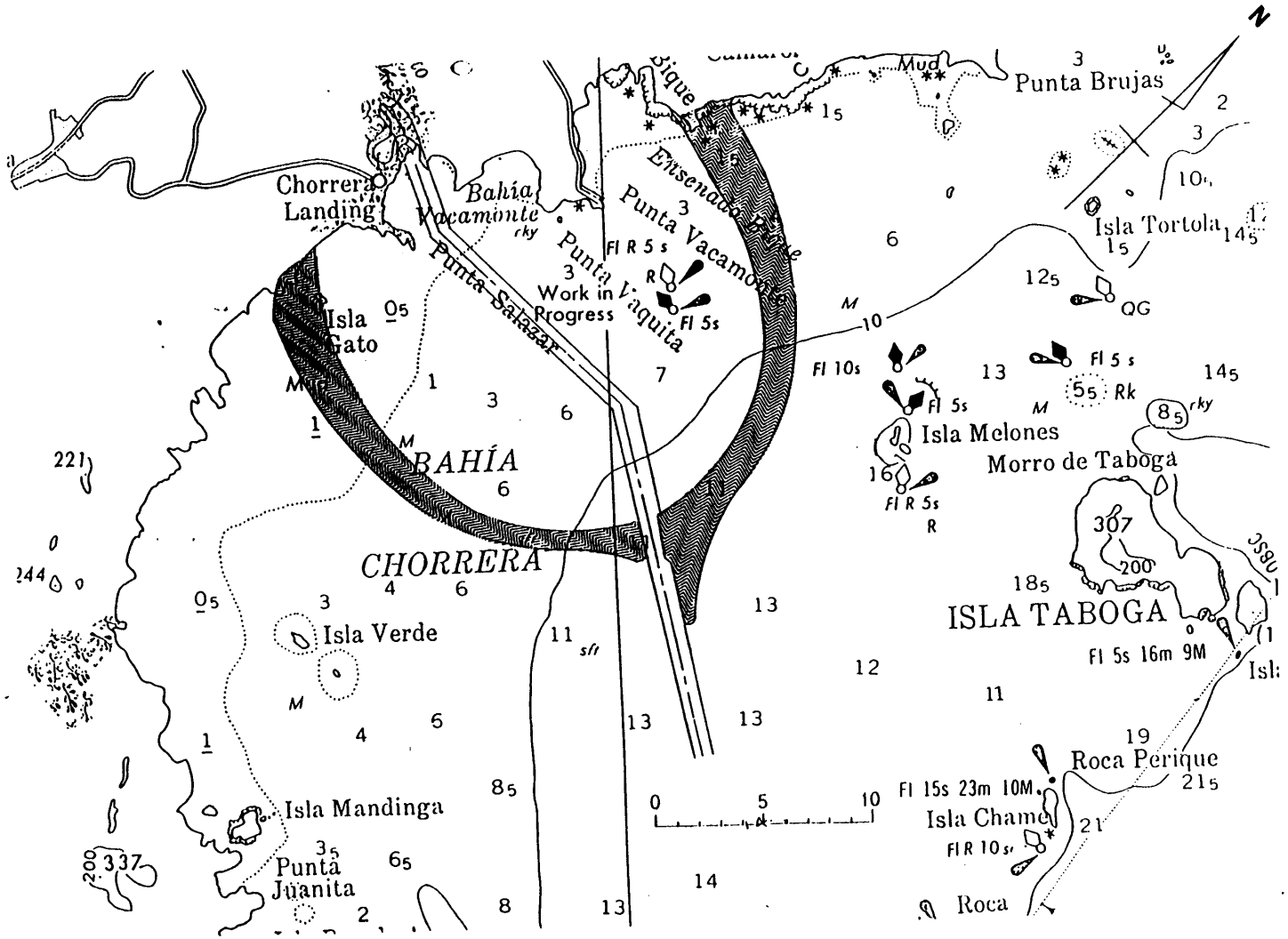


Fig. 5.4.1 Vergara's Breakwater on the Pacific Coast

5.4.3 The Design of Embankment

There is little data on natural conditions such as wave conditions and soil conditions at sites to enable the design of the embankment. Fig. 5.4.2 shows the wave conditions according to the data obtained from the Global Wave Statistics, compiled and edited by British Maritime Technology Ltd. Assuming this data is applicable, the design wave is likely to be 5.0m high (significant wave height), and would have a wave period of 12 seconds according to the data.

Latitude Range 0°N - 10°N
Longitude Range 80°W - 90°W

This means that the weight of armor stones for the embankment must be more than 10 tons. Soil conditions are also very important in design of the embankments. It is said that special improvements to the foundations were adopted in the case of construction of breakwaters for Vacamonte fishing port.

ALL DIRECTIONS

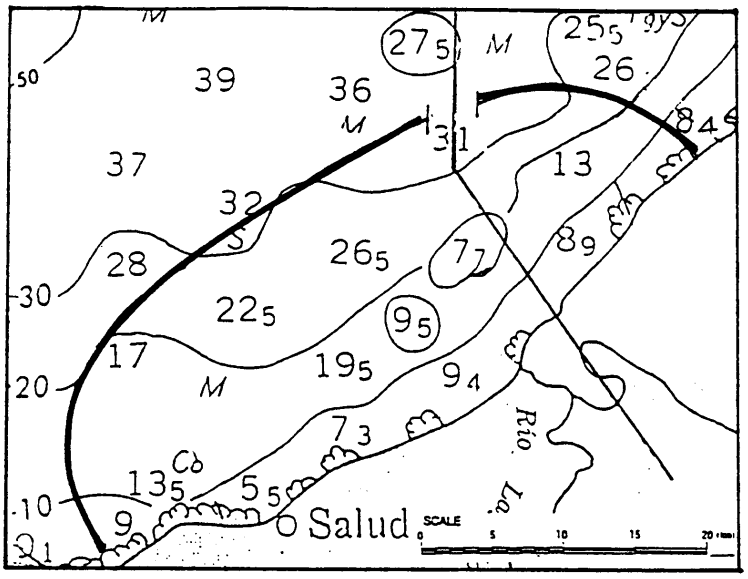
PERCENTAGE OF OBS = 100.00%
(INCLUDING 5.00% DIRECTION UNKNOWN)

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	-	-	-	-	-	-	-	-	-	-	-	-
4-5	-	-	1	1	2	1	1	-	-	-	-	1
3-4	-	1	6	12	11	7	3	1	-	-	-	6
2-3	1	10	42	63	48	23	8	2	1	-	-	41
1-2	6	64	159	153	79	28	7	2	-	-	-	196
0-1	20	79	92	48	15	3	1	-	-	-	-	498
												258

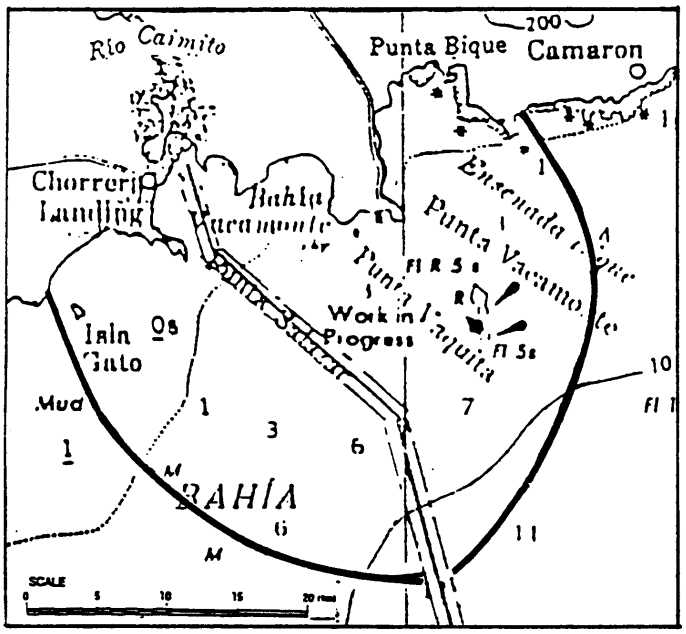
ZERO CROSSING PERIOD (s)

Source: Global Wave Statistics, edited by British Maritime Technology Ltd.

Fig. 5.4.2 Wave Statistics



Atlantic Coast



Pacific Coast

Fig. 5.4.3. Embankments on the Atlantic and Pacific Coasts.

5.4.4 Conclusion

For the construction of the embankments proposed by Vergara, a volume of more than 100 million cubic meters may be necessary. If the construction materials are the spoil from the canal excavation, the construction will be comparatively easy. However, before proceeding with a detailed consideration of this plan the following factors should be confirmed.

1) Soil Conditions in the Area:

To calculate the stability of the embankment (slip failures may occur), soil conditions are required. Special soil improvements may be required with tremendous costs and an extended construction period.

2) Retaining Structures at the Entrance:

Considering channel depths of-25m (in case of 300,000DWT ships) and embankment top level of about 5m, some special steel sheet pile type retaining structures in the deep sea area would be required with a long, and costly construction period.

3) Tidal Current Analysis:

Tidal current velocity without a tidal basin was calculated and tested in a 1/100 Model in 1940, and that the velocity in the canal, was determined to exceed 4 knots.

To avoid the consequences of the high current velocity, it is understood that tidal gates would normally be necessary.

Instead of this tidal current construction, if the current velocity could be significantly reduced by a tidal basin system, an analysis of this system should be conducted as well as a review of the calculation and/or model testing which was carried out in 1940.

4) Structure of the Embankment

In order to estimate the cost of the embankment, considerable study of the embankment's structure studied.

Given that the spoil from excavation will be used, and the experience of the construction work in Panama, a slope rubble mound type is chosen. If there isn't any wave data available at the construction site, armor stone's weight is substituted and assumed to be the same as Vacamonte breakwaters.

If an actual wave becomes more than four meters, the embankment would suffer some damage. The cross section of the embankment given is based on standards that should prevent damage from tidal head of seven meters between the inner side and outer side of the embankment. (cf. Fig. 5.4.4)

How to utilize the flat area formed by the embankment was not considered. The alignment of the embankment is the same as in the Vergara's plan.

Canal excavation materials

The materials for the embankment would be partially obtained from the canal excavation materials.

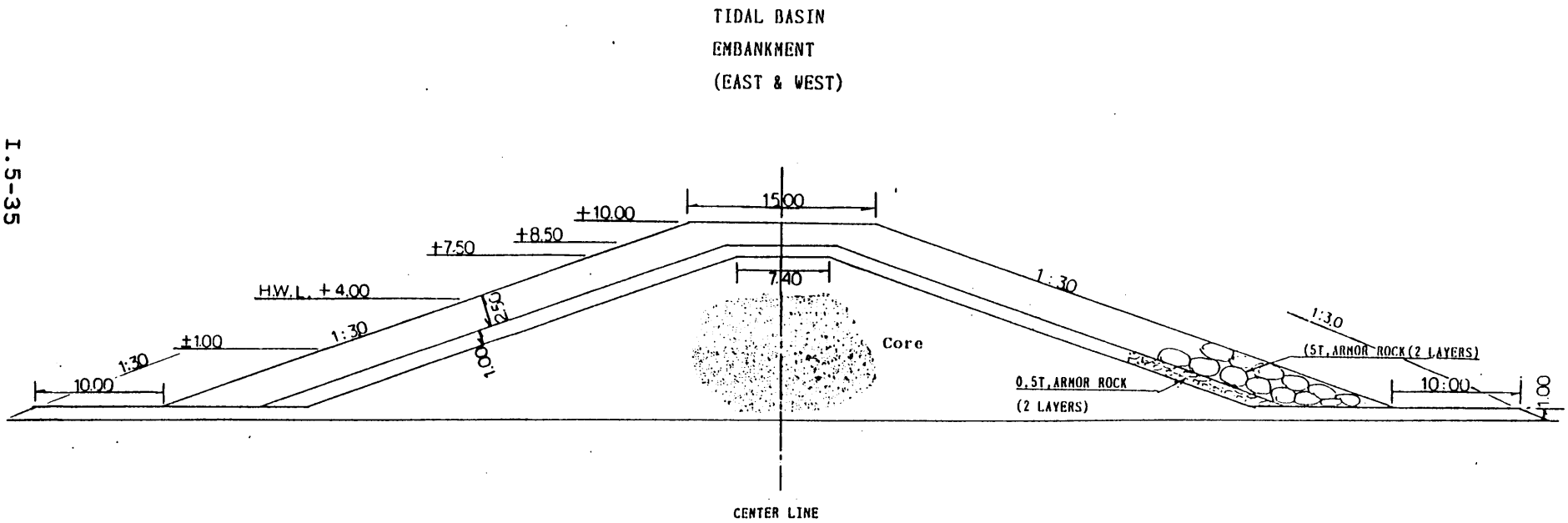


Fig. 5.4.4 Construction Method of Core and Armor Rock on the Pacific Coast

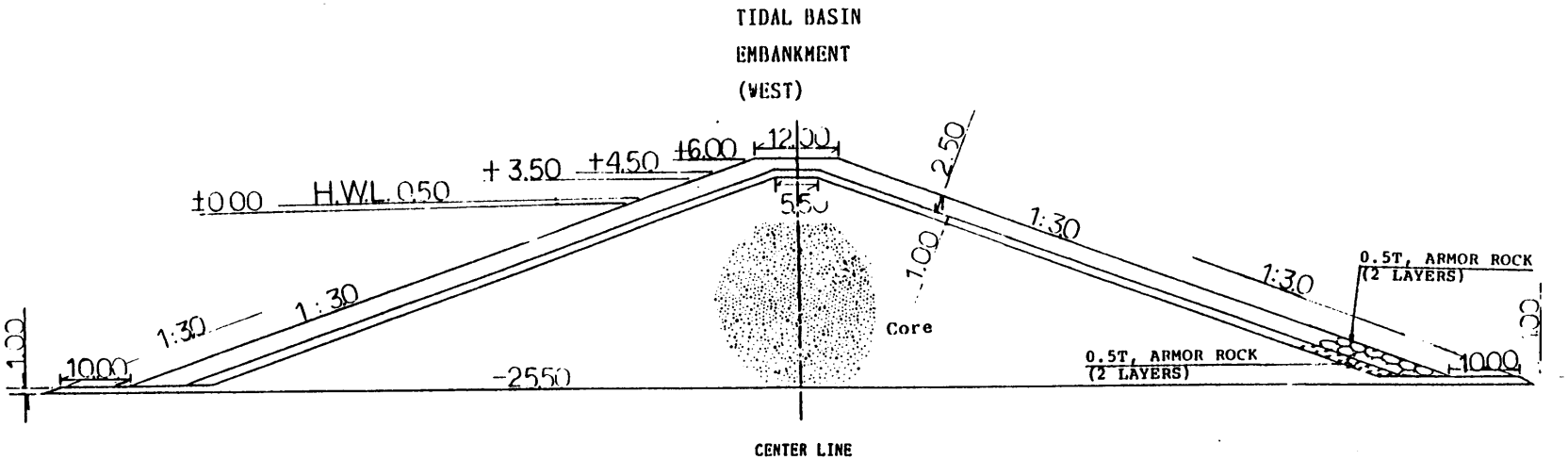


Fig. 5.4.5(1) Construction Method of Core and Armor Rock on the Pacific Coast

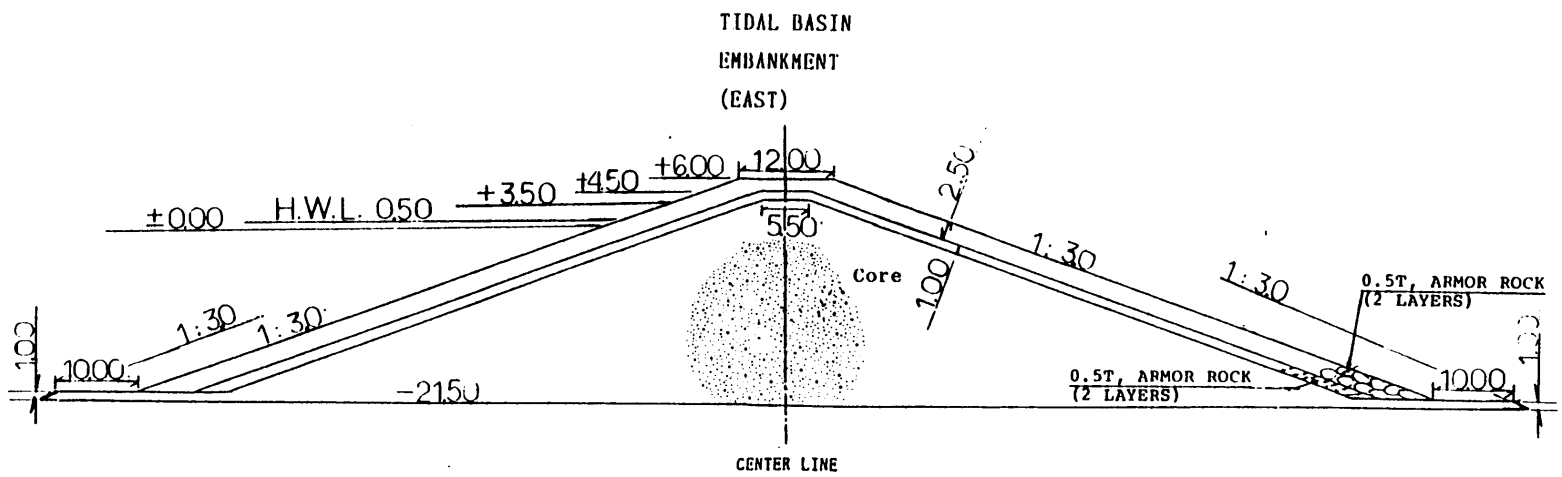


Fig. 5.4.5(2) Construction Method of Core and Armor Rock on the Pacific Coast

Table 5.4.1 Embankment Length and Mean Depth for Tidal Basin

	Length			Mean Depth
Atlantic Coast	East	5,000 m	(Total 17.6 km)	- 21.50 m
	West	12,600 m		- 25.50 m
Pacific Coast	East	10,200 m	(Total 20.1 km)	- 5.50 m
	West	9,900 m		- 5.50 m

Table 5.4.2 Volume of Core and Armor Rocks for Tidal Basin

	Atlantic Coast	Pacific Coast
Core	43,012,000 m^3	11,860,000 m^3
Armor Rock (0.5 ton/rock)	3,546,000 m^3	1,688,000 m^3
Armor Rock (5.0 ton/rock)	7,268,000 m^3	4,985,000 m^3
Total	53,826,000 m^3	18,533,000 m^3

CHAPTER 6 - COMPLEMENTARY FACILITIES

6.1 General

The complementary system is overland transportation by road, rail and pipeline systems when cargo volume exceeds the capacity of the existing canal. In order to make a comparison of canal alternatives, all fixed overland transportation costs (port, landing/loading facilities, overland transportation terminals and its attached facilities, and transportation machinery such as trucks and rolling stocks) must be known.

The handling of cargo designated for overland transportation is very complicated due to the cargo type, condition, handling, shipping companies and exporting and destination countries. However, for a comparison of canal alternatives, these will be simplified and it will be assumed that cargo handled by roads and railways will be containerized and the entrance and exit of the cargo will be managed suitably at the overland freight terminals.

6.1.1 Cargo Handling Capacity

Cargo handling capacities are given in the following table.

Table 6.1.1 Cargo Handling Capacity

Complementary Systems	Route	Capacity
		(mill.b./day)
F. Oil Pipeline & Associated Mooring Facilities	Western Panama Near Existing Petro Terminals Location	0.5 1.0 1.5 2.0
G. Landbridge, Railway Associated Port and Terminal Facilities using Centerport Concept	Central Panama; Panama City to Colon	(mill.ton/yr) 10 20 30 40
H. Landbridge, Road & Associated Port and Terminal Facilities using Centerport Concepts	Central Panama	(mill.ton/yr) 10 20 30 40

6.1.2 Layout Plan of the Facilities

The railway and road system composed of ports and terminal facilities are shown in Fig. 6.1.1.

The existing railway is 74 km long. With some improvement works and new port facilities near the Balboa Harbor on the east side of the canal, a railway system for 10 mill ton/year capacity was proposed.

A new railway system with port facilities, for capacities of 20, 30, 40, mill ton/year, was planned on the west side of the canal. The length of the railway is 69 km and the gauge is 1,524 mm.

A road system, instead of a railway system, with new port facilities that are the same as the railway system, was planned on the east side of the canal. The existing road, 82.5 km long with some improvement works, is

sufficient for 10 mill ton cargo volume/year case.

A new road with new port facilities was proposed on the west side of the canal. This new road system covers cargo capacities of 20, 30, 40, mill ton/year cases. The alignment of this road is almost the same as that of the new railway system.

Fig. 6.1.1 shows the arrangement of these systems. The length of this new road is 70 km and the number of lanes is 2-4.

Each project cost is summarized in Table 6.3.5, 6.4.3 and 6.5.3.

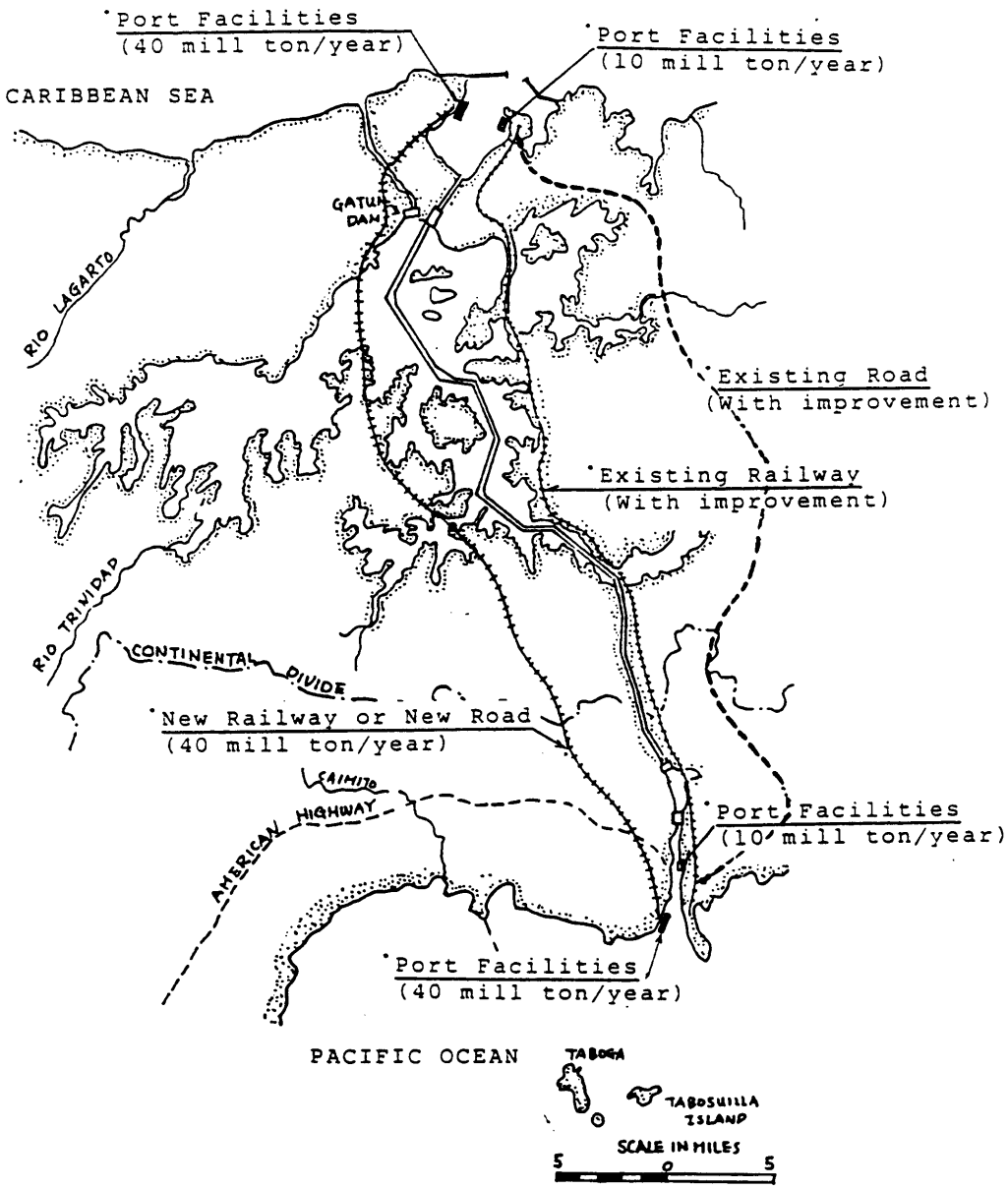


Fig. 6.1.1 Arrangement of Railway and Road System

6.2 Port Plan

Land Bridge Proposal

As a complementary facility to the existing Panama Canal, or to some of the 36 study cases considered elsewhere, the construction of the container bases on the Atlantic and Pacific Ocean sides and connection of the harbors by over land transportation, were considered. A study of the scale of harbor facilities required for handling annual freight volumes of 10,20,30 and 40 million tons per year was carried out and the findings are given below.

The following assumptions have been made:

1. Targeted freight is in 40' container units with a weight of *30 tons (2 TEU) each.

2. Containers landed on the Atlantic side are loaded as is onto freight trains or trucks and transported overland to the Pacific side and reloaded onto ships (and vice versa). Freight destined for Panama's would not be handled.

3. 250 work days per year is assumed excluding Saturday and Sunday and other holidays.

4. Variation in volume handled daily is 1.2 (maximum volume handled daily/average volume handled daily).

5. Freight handling is 24 hours/day, however, with worker shift changes and rest periods the work day is 18 hours and the actual work day coefficient is therefore 0.75 (18/24).

6. Freight handling time for one container ships should be less than 2 days.

7. Each container crane is a Gantry crane and has a handling capacity of 20 units/hour.

8. Targeted ships, with consideration to recent container ship designs, will be 40,000 DWT (approx. 2000 TEU) (max. 50,000 DWT, 2800 TEU).

Note: *

Statistical data obtained from a freight volume handled in the YOKOHAMA Port in Japan for 1990 was 13.3 mill ton (export), 10.3 mill ton (import) and a total of 23.6 mill ton.

From the results, the weight of a 40' container unit (2-TEU) becomes 33.6 ton/2-TEU for a packed container, and 28.6 ton/2-TEU for a empty container. The weight of a 30 Ton per 40' container as a mean weight for mixed containers was applied in the studies.

This table shows the freight volume actually handled and the number of containers in the YOKOHAMA Port.

	(1)	(2)	(3)	(4)	(5)
	mill ton	mill TEU	ton/TEU	mill ton	ton/TEU
Export	13.3	0.72	18.5	0.85	15.6
Import	10.3	0.69	15.0	0.80	12.9
Mean	23.6	1.41	16.8	1.65	14.3

Note: (1) Shows Freight volume in mill ton.
(2) Shows the number of containers excluding empty ones.
(3) Shows the weight of containers excluding empty ones.
(4) Shows the number of containers including empty ones.
(5) Shows the weight of containers including empty ones.

6.2.1 Required Number of Berths

The number of berths and cranes required for handling annual freight volumes of 10,20,30 and 40 million tons per year were estimated in this section, and the results are summarized below.

Handled freight volume	No. of berths required	No. of Gantry Cranes required
10 mill. tons	2	2 cranes x 2B = 4
20 mill. tons	4	2 cranes x 4B = 8
30 mill. tons	6	2 cranes x 6B = 12
40 mill. tons	8	2 cranes x 8B = 16

Details of the derivation of the number of berths required are given below.

(1) 10 million tons/year

Handled freight volume	10,000,000 t
Target ships	40,000 DWT
No. of 40' containers loaded per ship	1,000 units
Container unit weight	30 t/unit
Work days/year	250 days
Work hours coefficient	0.75
Crane capacity	20 units/hour
No. of cranes	2 units/berth
No. of containers to be handled per year (10 mill/30)	333,333
No. of ships arriving at the port per year (333,333/1000 containers/ship)	333
Crane capacity/berth/day (20 x 2 x 24 x 0.75)	720 containers
Maximum handling volume/day (720 x 1.2)	864 containers

Wharf time/ship (1000 units/[20x2])	25.00 hours
actual (25/0.75=33.3 hours/24)	1.39 days
Required no. of berths (333,333/[720x250])	1.9 berths

(2) 20 million tons/year

Handled freight volume	20,000,000 t
Target ships	40,000 D.W.T.
No. of 40' containers loaded per ship	1,000 units
Container unit weight	30 t/unit
Work days/year	250 days
Work hours coefficient	0.75
Crane capacity	20 units/hour
No. of cranes	2 units/berth
No. of containers to be handled per year	666,667
No. of ships arriving at the port per year	667
Crane capacity/berth/day	720 containers
Maximum handling volume/day	864 containers
Wharf time/ship	25.00 hours
actual	1.39 days
Required no. of berths	3.7 berths

(3) 30 million tons

Handled freight volume	30,000,000 t
Target ships	40,000 DWT
No. of 40' containers loaded per ship	1,000 units
Container unit weight	30 t/unit
Work days/year	250 days

Work hours coefficient	0.75
Crane capacity	20 units/hour
No. of cranes	2 units/berth
No. of containers to be handled per year	1,000,000
No. of ships arriving at the port per year	1,000
Crane capacity/berth/day	720 containers
Maximum handling volume/day	864 containers
Wharf time/ship	25.00 hours
actual	1.39 days
Required no. of berths	5.6 berths

(4) 40 million tons

Handled freight volume	40,000,000 t
Target ships	40,000 DWT
No. of 40' containers loaded per ship	1,000 units
Container unit weight	30 t/unit
Work days/year	250 days
Work hours coefficient	0.75
Crane capacity	20 units/hour
No. of cranes	2 units/berth
No. of containers to be handled per year	1,333,333
No. of ships arriving at the port per year	1,333
Crane capacity/berth/day	720 containers
Maximum handling volume/day	864 containers
Wharf time/ship	25.00 hours
actual	1.39 days
Required no. of berths	7.4 berths

6.2.2 Facility Scale

(1) Water facilities

For the assumed maximum container ship size of 50,000 DWT:

Water way: depth - 15 m,
width - 420 m (1.5 x ship length of 280 m)

Turning basin: depth - 15 m,
turning diameter to be 2 ship lengths
= 280 m x 2 = 560 m

(2) Mooring facilities

Container berth length: 350 m

(3) Marshaling Yard

350 m x 300 m = 100,000 m2

(4) Other Facilities (per berth)

. Gantry Crane	40 tons	2
. Yard Tractor	3 units (1 spare)	4
. Yard Chassis	6 units (2 spare)	8
. Straddle-Carrier System (40', 2 layer stack)	6 units (2 spare)	8
. Power facilities for refrigerate containers		1 unit
. Lighting System		1 unit

(5) Operations Center

1 operations center in the wharf area
(4 - 5 floors, total floor area 1,000 m2)

6.2.3 Site Plan

First, the expansion to Cristobal and Balboa harbors was considered with reference to the Center Port Plan. On Telfers Island in Cristobal harbor, it is possible to construct five new container berths (350 m x 5) and secure sufficient area for anchorage. At Balboa harbor, it is possible to construct three new berths (350 m x 3) in the Diablo area.

The existing facilities at Balboa harbor (Docks 14-15, approx. 580 m), because of berth water depth and structure, make it difficult to moor a 50,000 DWT container ship. Moreover, when considering that freight for domestic use in Panama is handled, it was decided that containers for transit across Panama would not be handled using the existing facilities.

For a handled volume of 10 million tons/year, the Diablo region could be used, but if volumes become greater than 20 million tons/year, it would become necessary to secure another area for cargo handling. This could be done by land filling the area around the current spoil dump on the west side of the canal at the mouth.

At Cristobal harbor, for freight volumes of 10 million tons/year, two new container berths would be constructed on Telfers Island. If freight volume were to reach 20 million tons/year, Cristobal would be connected to Balboa by a new road or rail and considering this, an area on the west side of the canal behind the scheduled anchorage expansion area, would be secured.

6.2.4 Facility Improvement and Construction Volumes

The crown height of the wharf would be 2.0 m above HWL.

Crown height of the wharf

Balboa harbor	8 m above M.L.W.S
Cristobal	2.6 m above MLW

(1) Balboa Harbor

Table 6.2.1 Construction Requirements

Freight volume	10 mill.tons	20 mill.tons	30 mill.tons	40 mill.tons
Wharf length	700 m	1,400 m	2,100 m	2,800 m
Bulkhead	150 m	800 m	800 m	800 m
Area	25 ha	42 ha	63 ha	84 ha
Land fill volume	0.8 mill.m^3	3.8 mill.m^3	5.7 mill.m^3	7.6 mill.m^3
Dredging volume	13.5 mill.m^3	71.5 mill.m^3	82.4 mill.m^3	93.3 mill.m^3

Table 6.2.2 Facility Improvements

Gantry cranes	4	8	12	16
Yard tractor	8	16	24	32
Yard chassis	16	32	48	56
Straddle-carrier system	16	32	48	56
Container power supply	1 system	1 system	1 system	1 system
Lighting	1 system	1 system	1 system	1 system
Operations center	1	1	1	1

(2) Cristobal Harbor

Table 6.2.3 Construction Requirements

Freight volume	10 mill.tons	20 mill.tons	30 mill.tons	40 mill.tons
Wharf length	700 m	1,400 m	2,100 m	2,800 m
Bulkhead	100 m	100 m	100 m	100 m
Area	24 ha	45 ha	66 ha	87 ha
Land fill volume	0.03 mill.m^3	3.4 mill.m^3	5.0 mill.m^3	6.4 mill.m^3
Dredging volume	9.2 mill.m^3	29.6 mill.m^3	36.4 mill.m^3	43.2 mill.m^3

Table 6.2.4 Facility Improvements

Gantry cranes	4	8	12	16
Yard tractor	8	16	24	32
Yard chassis	16	32	48	56
Straddle-carrier system	16	32	48	56
Container power supply	1 system	1 system	1 system	1 system
Lighting	1 system	1 system	1 system	1 system
Operations center	1	1	1	1

Table 6.2.5 Cost Estimation (10 Mil.Ton/Year)

Unit Mil. US$

	Cristobal	Balboa	Total
Port Construction	64.7	91.4	156.1
Gantry Crane	26.0	26.0	52.0
Tractor Head	0.6	0.6	1.2
Chassis	0.2	0.2	0.4
Straddle-Crrier	11.3	11.3	22.6
Electric	2.0	2.0	4.0
Housing	11.2	11.2	22.4
Total	116.0	142.7	258.7

Table 6.2.6 Cost Estimation (20 Mil.Ton/Year)

Unit Mil. US$

	Cristobal	Balboa	Total
Port Construction	197.2	455.3	652.5
Gantry Crane	52.0	52.0	104.0
Tractor Head	1.2	1.2	2.4
Chassis	0.4	0.4	0.8
Straddle-Crrier	22.6	22.6	45.2
Electric	2.3	2.3	4.6
Housing	12.8	12.8	25.6
Total	288.5	546.6	835.1

Table 6.2.7 Cost Estimation (30 Mil.Ton/Year)

Unit Mil. US$

	Cristobal	Balboa	Total
Port Construction	246.6	529.7	776.4
Gantry Crane	78.0	78.0	156.0
Tractor Head	1.8	1.8	3.6
Chassis	0.6	0.6	1.2
Straddle-Crrier	33.9	33.9	67.8
Electric	2.6	2.6	5.2
Housing	14.4	14.4	28.8
Total	377.9	661.0	1039.0

Table 6.2.8 Cost Estimation (40 Mil.Ton/Year)

Unit Mil. US$

	Cristobal	Balboa	Total
Port Construction	296.1	612.6	908.7
Gantry Crane	104.0	104.0	208.0
Tractor Head	2.4	2.4	4.8
Chassis	0.8	0.8	1.6
Straddle-Crrier	45.2	45.2	90.4
Electric	3.0	3.0	6.0
Housing	16.0	16.0	32.0
Total	467.5	784.0	1251.5

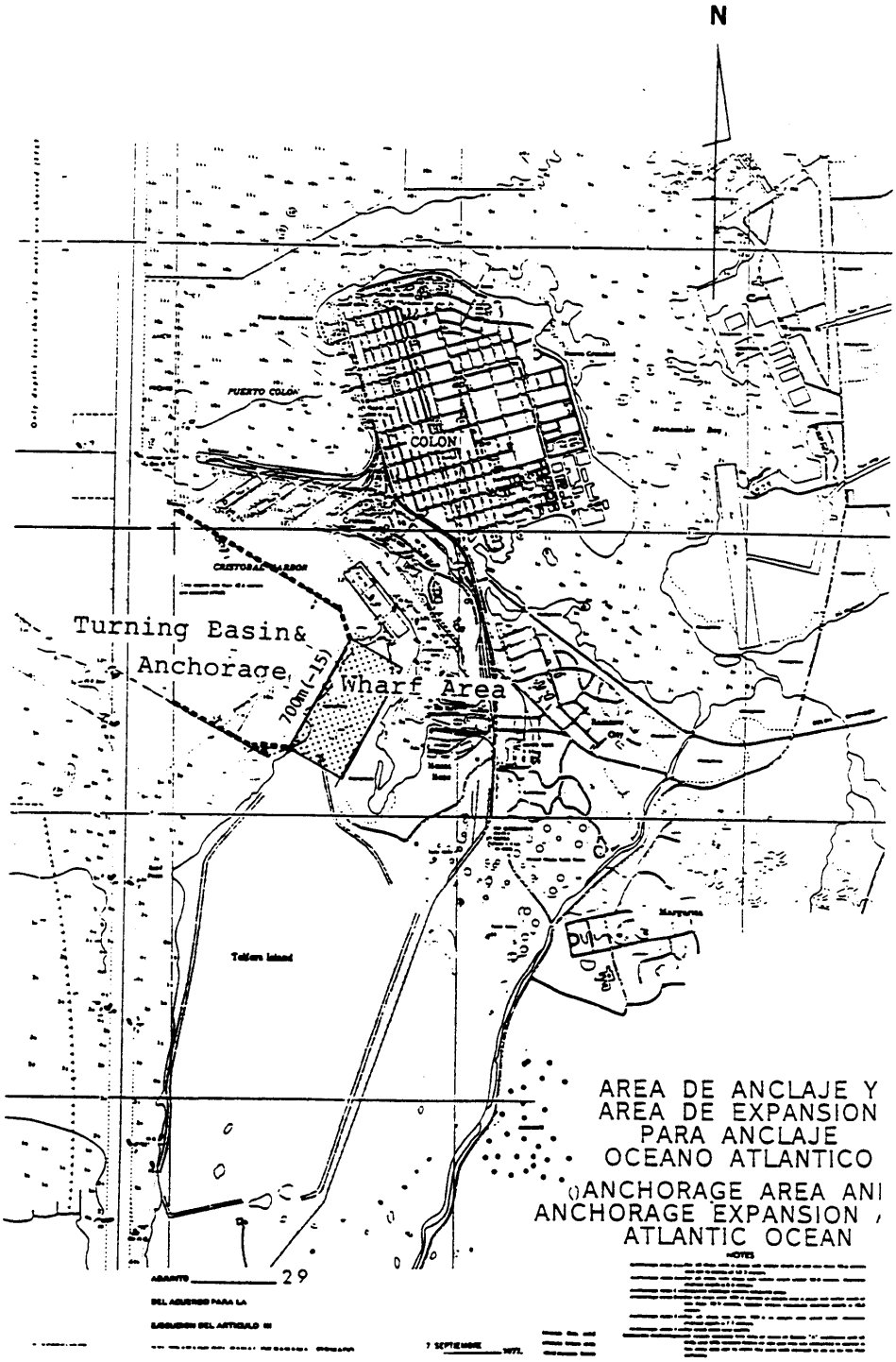


Fig. 6.2.1 Site Plan for 10 Mill.Tons/Year (Cristobal Harbor)

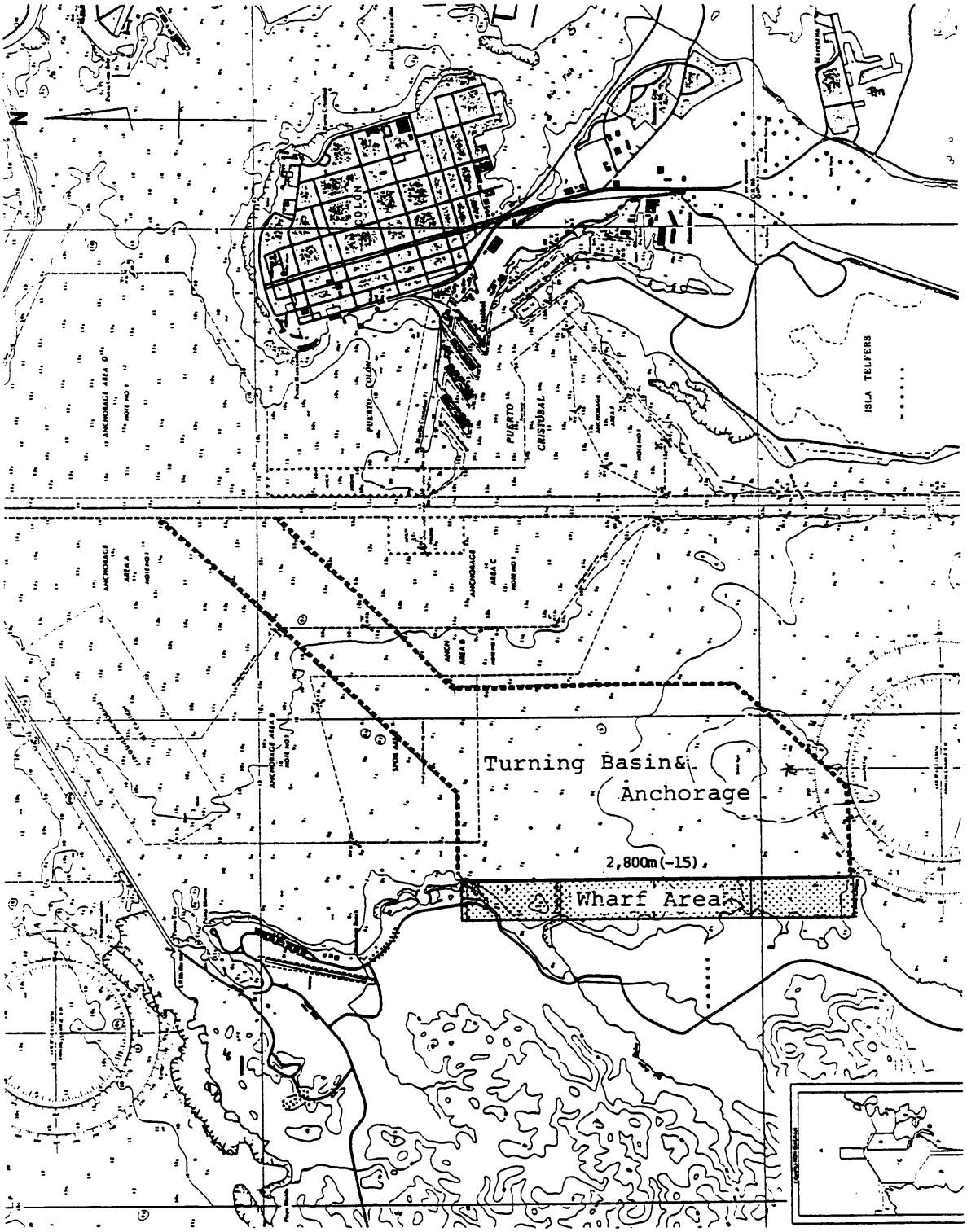


Fig. 6.2.2 Site Plan for 40 Mill.Tons/Year (Cristobal Harbor)

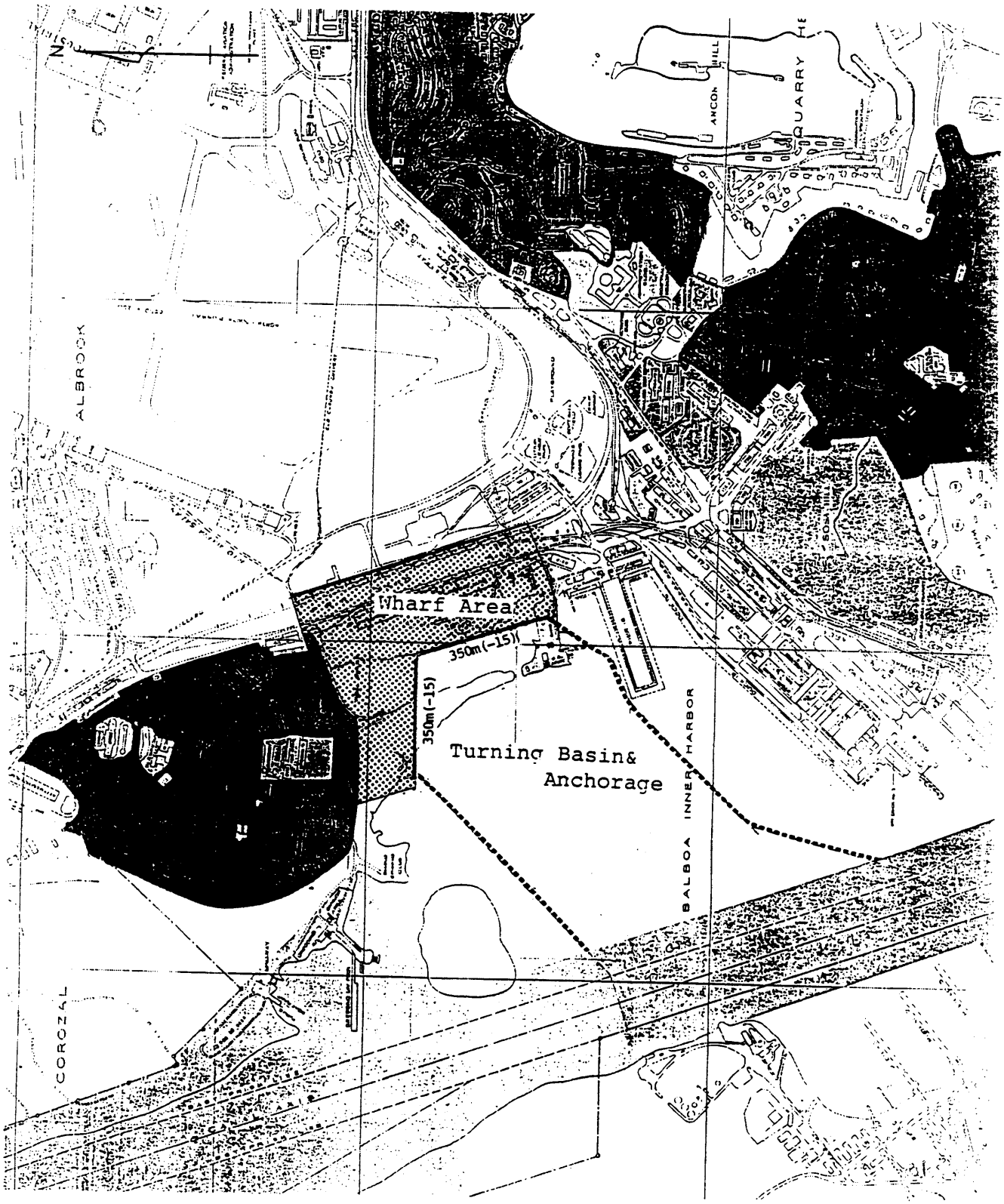


Fig. 6.2.3 Site Plan for 10 Mill.Tons/Year (Balboa Harbor)

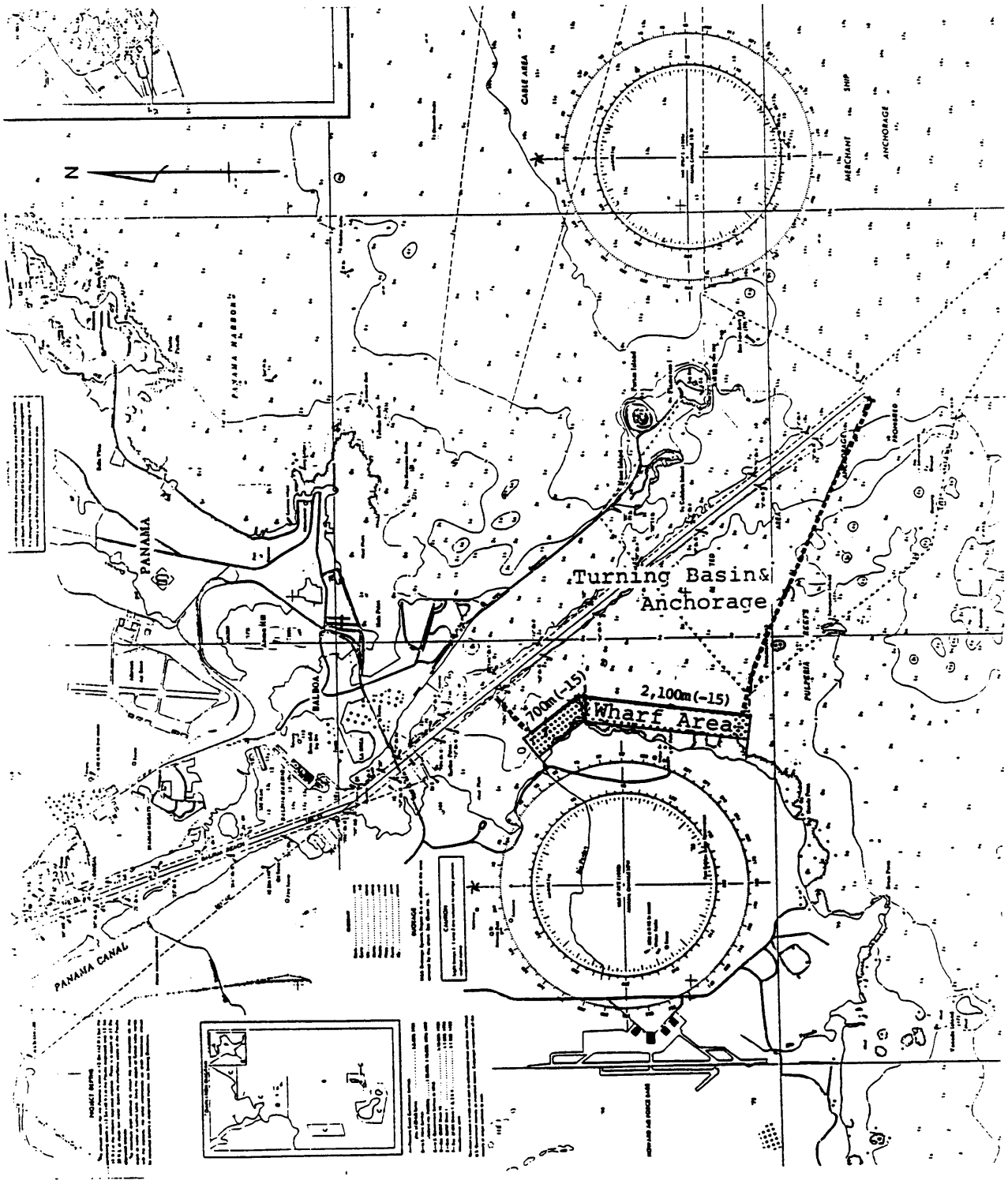


Fig. 6.2.4 Site Plan for 40 Mill.Tons/Year (Balboa Harbor)

6.3 Railway Plan

6.3.1 General Conditions

(1) Rail Freight Plan Objectives

In accordance with the request of the Secretariat, the objective is to establish the scale and basic layout of rail facilities required to handle annual transportation volumes of 10 million, 20 million, 30 million and 40 million tons/year.

(2) Daily Freight Volume Projections

The scale of the rail freight facilities required is set by the daily freight volume and freight configuration. The traffic projections for setting the facility scale assume the following.

a) All of the target freight is in 40 foot containers, each weighing an average of 30 tons. (Ref to Page I.6-5)

b) Saturday and Sunday are holidays and there are six festive holidays per year giving 250 operational days per year.

c) Daily handling fluctuation (maximum daily volume/average daily volume) is 1.2.

With the above assumptions, the maximum daily volumes are as follows:

10 million tons/year	1,600 containers/day
20 million tons/year	3,200 containers/day
30 million tons/year	4,800 containers/day
40 million tons/year	6,400 containers/day

(3) Rail Freight Plan Preconditions

If the existing Balboa and Cristobal harbors located on the east side on the existing canal and harbor facilities are improved and expanded to five berths (each berth being 350 m), an annual volume up to 10 million tons could be handled. When the annual volume is more than 10 to 15 million tons/year, the

surrounding conditions are such that securing sufficient berth numbers for the expansion of existing harbor facilities and securing sufficient space around the cargo handling area would be difficult. For this reason it is proposed that for more than 20 million tons annually, new harbor facilities for Balboa and Cristobal harbors be constructed on the west side of the existing canal.

For an annual freight volume of 10 million tons it is anticipated that the number of containers would amount to 1,600 units per day. The existing Balboa and Cristobal harbors on the east side of the canal would be improved and used for freight terminals. The present railway could be improved and strengthened and used for rail freight.

In the event that the annual freight volume handled is 20 million tons per year or more, a new railway line(s) on the west bank of the canal has been proposed for the following reasons.

a) Construction of a new freight terminal and a new rail line(s) on the west side of the canal would affect almost no residential areas and access would be convenient.

b) All annual freight volume of 20 million tons per year or more would mean 3,200 containers per day which would exceed the maximum capacity of the existing railway line.

c) If the existing railway line on the east side of the canal is used for freight, 2 major bridges crossing the canal would be necessary.

6.3.2 Outline of Transportation Plan

(1) Ocean Container Terminal and Railway Container Terminal Relationship

The ocean terminal and rail terminal must be managed in a closely interrelated way although the terminals would be partitioned and managed separately with transportation between the two accomplished by truck and trailer.

Accordingly, a gate at the truck and trailer entrance of the rail terminal would be erected and manned.

If possible, there should be just one Rail Container Terminal collecting freight from or distributing to the ocean container terminals.

Transportation distance by truck and trailer should be as short as possible and to this end the Rail Container Terminal would be constructed in the vicinity of the ocean container terminals. If it is unavoidable that the ocean terminals are some distance away making the transportation distance by truck and trailer large, multiple rail container terminals should then be situated at various appropriate locations.

In principle, rail transportation should arrive loaded with containers at the Rail Container Terminal and after unloading, containers destined for the other terminal should be loaded for departure. In the same way, truck and trailer transportation should arrive at the terminal loaded with containers for rail collection and after unloading them, depart for the various ocean terminals with containers for distribution.

Rail transportation management should be limited to the Rail Container Terminal with the trailers carrying the freight between the rail and ocean terminals coming under ocean container terminal management.

(2) Ocean container terminal locations and basic concepts of the rail freight transportation plan

a) 10 million tons/year

Ocean container terminals in the case of a 10 million ton/year volume, would be located on the east side of the canal on the Atlantic and Pacific coast sides. The proposals are shown in Fig. 6.3.2, 6.3.3 and 6.3.4. The existing railway lines (currently not in use) would be improved.

Atlantic coast side
(Cristobal side or Colon side)

The proposal divides the ocean container terminal into two sites with an ocean container terminal (A) adjoining the south east section of dock 9 and terminal (B), 1 km to the south on Telfers Island on the other side of the Canal Frances inlet.

Because each ocean container terminal would be some distance from a central Rail Container Terminal, it would not be efficient to consolidate the Rail Container Terminal in one location. Hence two separate Rail Container Terminals were proposed.

The Rail Container Terminal for Ocean Container Terminal (A) (Rail Container Terminal (A)) will be situated in the area between Ocean Container Terminal (A) and Mount Hope Yard with Mount Hope Yard being converted for use as sidings.

The Rail Container Terminal for Ocean Container Terminal (B) (Rail Container Terminal (B)) will be constructed behind Ocean Container Terminal (B) with a new line diverging from the existing line. The rail sidings would adjoin the Rail Container Terminal.

Pacific coast side (Balboa side)

The proposal divides the Ocean Container Terminal into two sites, the northern side of pier 18 (Ocean Container Terminal (A)) and the southern side (Ocean Container Terminal (B)) as shown in Fig. 6.3.3. It would be preferable to locate a Rail Container Terminal next to each Ocean Container Terminal however, because of severe space limitations, only one Rail Container Terminal has been proposed. It would be located on the western side of Ocean Container Terminal (A). This site is now occupied by the Diablo Yard, which is on the main line and would be converted for use as the Rail Container Terminal

with rail sidings located beside it and repair yards constructed on the southern side.

Rail line

Restoration and strengthening of the rail line (a single track currently not in use) would be carried out. Passing Lanes, new two stations where trains will pass, and signal automation for steep gradient sections etc., would be provided allowing efficient and safe freight transportation between ocean container terminals.

Freight transportation distance	:	Approximately 74 km
Gauge	:	1,524 mm
Permitted weight	:	15 tons
Maximum gradient	:	Approximately 1.3%
Minimum curve radius	:	300 m

Rolling stock

The trains will be made up of 30 freight cars (empty weight approx. 15 tons, freight weight of 30 tons, freight car length of approx. 15 m) each carrying one 40' container.

Diesel electric locomotives, widely used throughout the world, will be used; and coupled locomotives each with a power capacity of approx. 2,000hps and locomotive weight of approx. 80 tons are considered under the following conditions.

Scheduled speed: Approx. 23 m.p.h. (37 km/h)
Scheduled time : Approx. 2 hr.

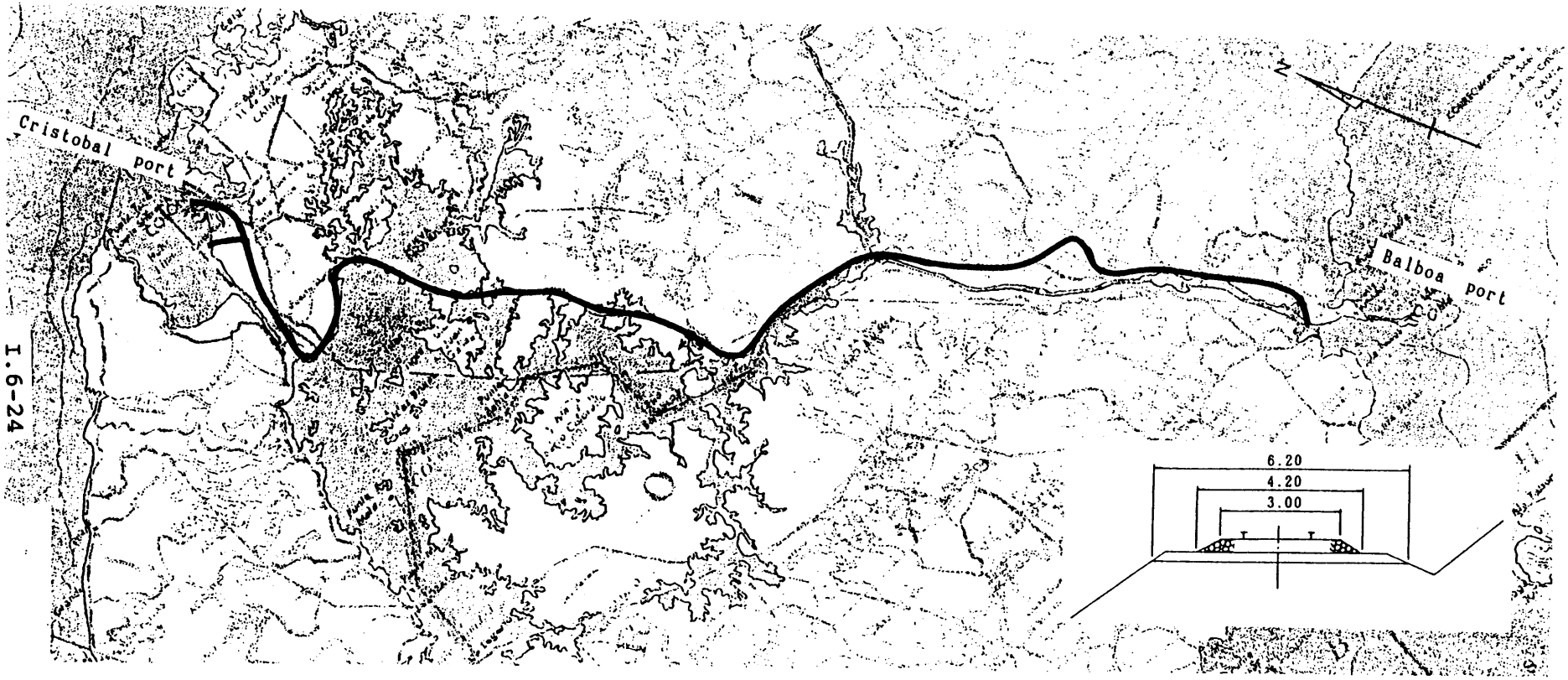


Fig. 6.3.1 Existing Railway Improvement Plan

b) 20 million tons/year and above

In the case of cargo of 20 million tons per year and above, the Ocean Container Terminal on the Atlantic and Pacific coast sides would be located on the west bank of the canal. However, there is as yet no definite proposal and preliminary locations shown in Figs. 6.3.2, 6.3.5 and 6.3.6 were adopted.

Rail freight transportation will be carried out using new lines (double track) constructed along the west bank of the canal.

Atlantic coast side

The proposed location of the Ocean Container Terminal is on the west side of Limon Bay, in contrast to the proposal for 10 million tons/year, locating ocean container terminals (A) and (B) on the eastern shore.

The Rail Container Terminal will be constructed in the area behind the Ocean Container Terminal with the rail sidings located beside it.

Pacific coast side

The Port Plan in Section 6.3 proposes that the Ocean Container Terminal should be located on the west bank of the canal near Guinea Point and on the coastline extending Point.

It is proposed that the Rail Container Terminal will be constructed in the area behind the Ocean Container Terminal.

However, due to space restrictions resulting from the hills to the rear, it would be difficult to locate the rail sidings and repair yards next to the Rail Container Terminal. Therefore, the proposed location of the parking tracks and repair yards is on the plain to the west of Fartan Hill, even though this is about 2 km away from the terminal.

Rail lines

A new line with a double track and automatic signal is proposed for 20 million tons/year and above.

To allow for the occurrence of breakdowns etc., passing stations with side tracks will be constructed every 20 or 30 kms (in other words, at two locations between Cristobal and Balboa) for use as shunting stations with power and signal facilities. The power will be supplied from the container terminals (or the repair yard) at each end to the respective shunting stations.

Freight transportation distance	:	69 km
Gauge	:	1,524 mm
Permitted weight	:	15 tons
Maximum gradient	:	1.0% or less, i.e. less than that of the existing line
Minimum curve radius	:	500 m

Rolling stock

The same train as is used for the existing line was considered, but its speed capability would be increased due to better rail conditions.

Scheduled speed: Approx. 31 m.p.h. (50 km/h)
Scheduled time : Approx. 1.5 hr

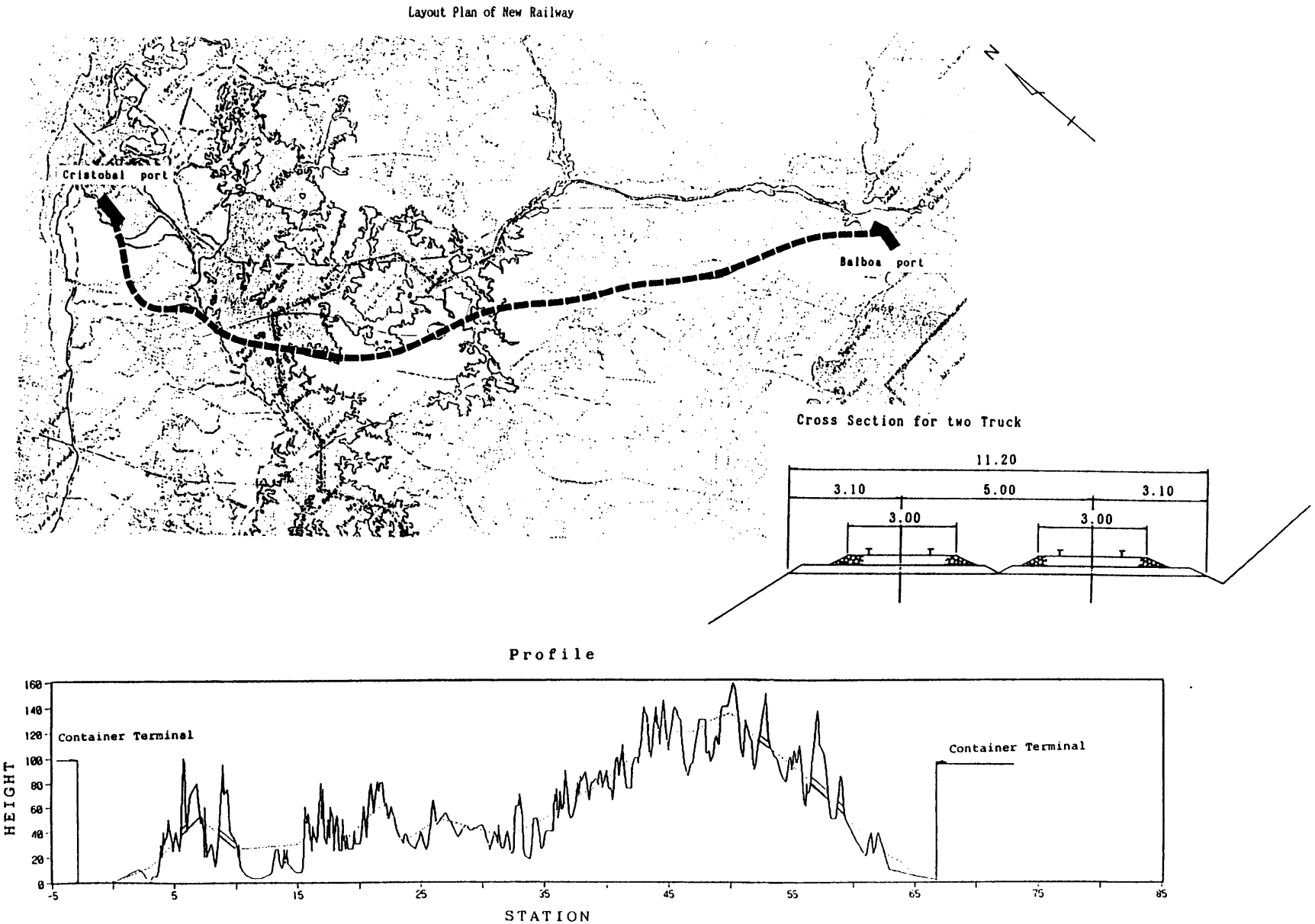


Fig. 6.3.2 Layout Plan for Location of New Railway

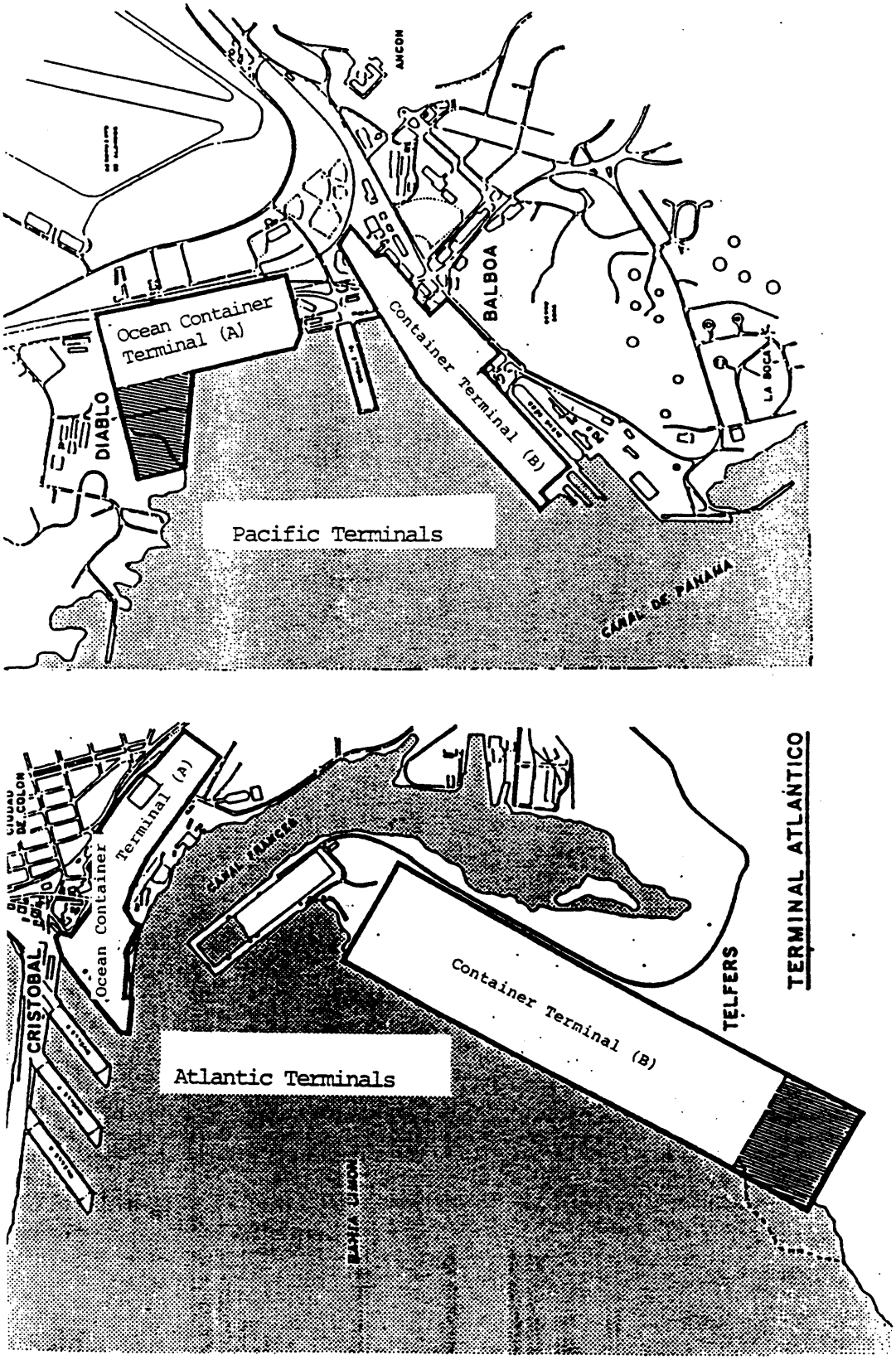


Fig. 6.3.3 Container Terminals (For 10 Million Tons/Year)

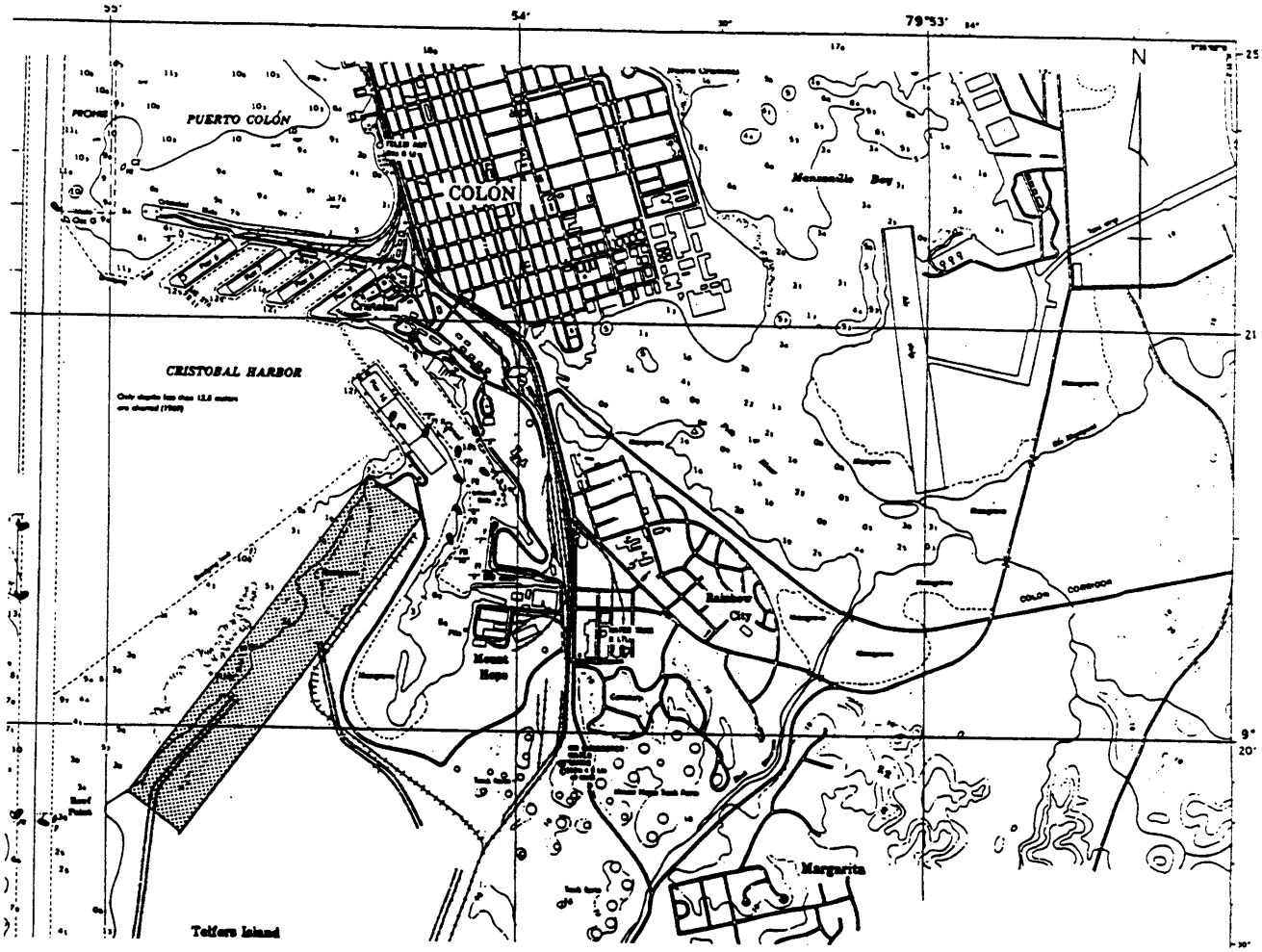


Fig. 6.3.4 Atlantic Side Rail Container Terminal B
(10 Million Tons/Year)

Fig. 6.3.5 Container Terminals (For 20 Million Tons/Year)
Atlantic Side

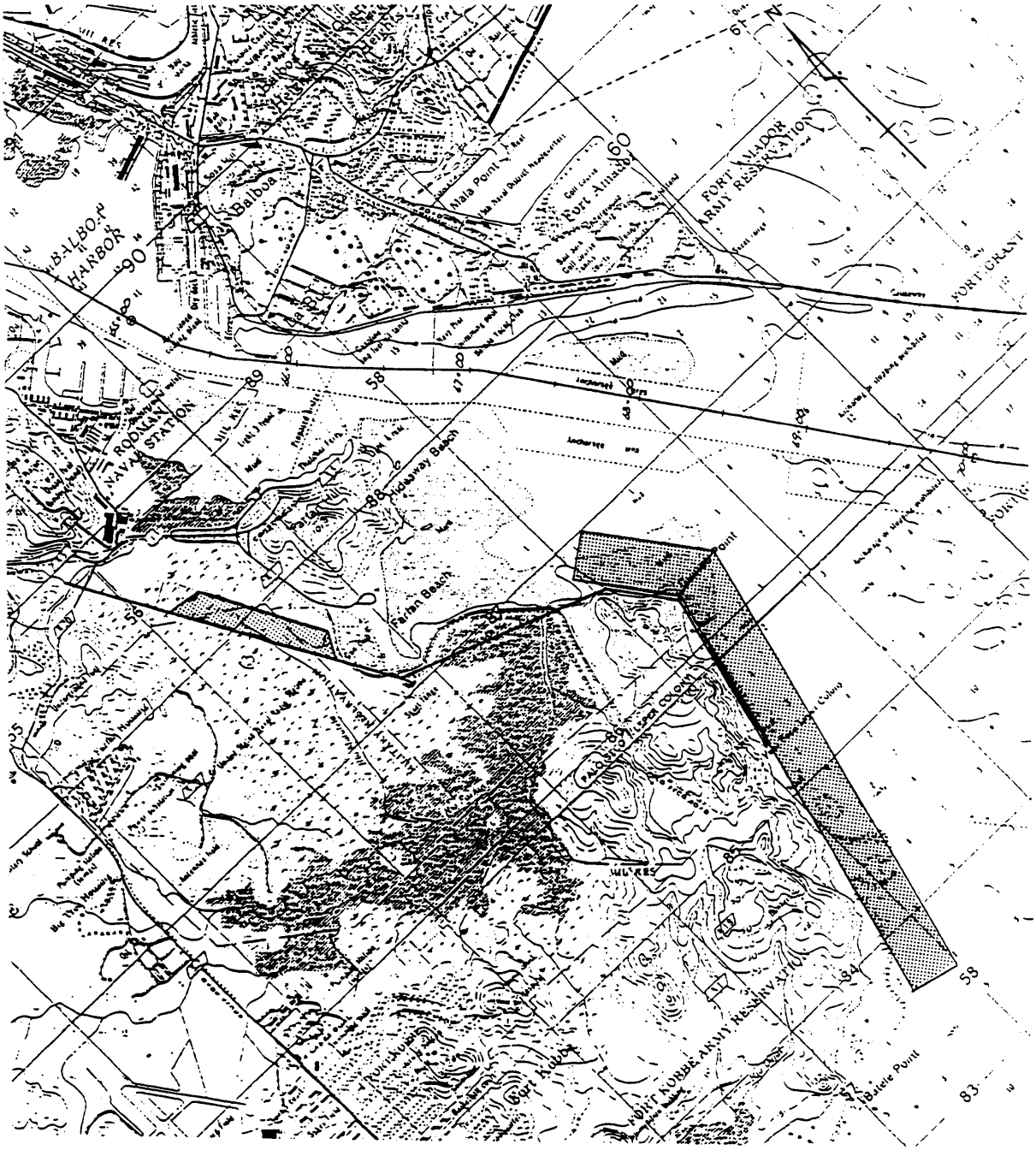


Fig. 6.3.6 Container Terminals (For 20 Million Tons/Year)
Pacific Side

6.3.3 Train Operation Plan and Cost Estimation

(1) Number of trains operating (daily)

Using a 30 car train with one 40' container per car, the required numbers of trains operations one way and train operating pitch are shown below.

Table 6.3.1 No. of Required Trains/Day and Train Operation Pitch

Annual Volume (t/year)	Daily Volume (containers/day)	Number of Required Trains Operation One Way (trains/day)	Train Operation Pitch (min.)	Comments
10 mill.tons	1,600	27	40	Round trip of 54 trains/day. Track capacity of a single track is usually 80 to 90 trains/day hence a single track (upgraded existing) would be adequate.
20 mill.tons	3,200	54	20	Round trip of 108 trains/day. New double track is proposed. Because the expected volume is quite high. Double tracks would be preferable considering future increases in volume handled.
30 mill.tons	4,800	80	14	The track capacity for double track is usually 130 to 150 trains/day on each track,therefore double track required and has adequate capacity.
40 mill.tons	6,400	107	10	Double tracks required, no capacity problem.

(2) Number of locomotives, freight cars and rail sidings to be provided. See Table 6.3.2.

Table 6.3.2 No. of Provided Locomotives, Freight Cars and Rail Sidings, Except Two Sidings for Loading and Unloading.

Volume handled daily (containers/day)	Usage	Coupled locomotives (couples)	Freight cars (cars)	Number of rail sidings Atlantic Coast	Number of rail sidings Pacific Coast
1,600	Cars in operation	7	9 x 30 = 270	3	2
	Held in reserve for maintenance	1	1.5 x 30 = 45	-	1
	Held in reserve for operation	1	1 x 30 = 30	-	1
	Total	9	345	3	4
3,200	Cars in operation	10	12 x 30 = 360	4	4
	Held in reserve for maintenance	2	2 x 30 = 60	-	2
	Held in reserve for operation	1	1 x 30 = 30	-	1
	Total	13	450	4	7
4,800	Cars in operation	14	16 x 30 = 480	6	6
	Held in reserve for maintenance	2	2.5 x 30 = 75	-	2
	Held in reserve for operation	1	1 x 30 = 30	-	1
	Total	17	585	6	9
6,400	Cars in operation	19	21 x 30 = 630	9	9
	Held in reserve for maintenance	3	3 x 30 = 90	-	3
	Held in reserve for operation	1	1 x 30 = 30	-	1
	Total	23	750	9	13

(3) Rail Container Terminal Facility. See Table 6.3.3.

Table 6.3.3 No. of Required Gates and Track Lanes

Volume Handled Day (containers)	Transfer Crane	No. of Gates Required	No. of Track Lanes
1,600 (30 containers unloaded and loaded in 40 mins)	2	1	1
3,200 (30 containers unloaded and loaded in 20 mins)	3	1	1
4,800 (30 containers unloaded and loaded in 14 mins)	5	2	2
6,400 (30 containers unloaded and loaded in 10 mins)	6	2	2

(4) Cost Estimation

Table 6.3.4 Cost Estimation

Unit: Mill. US$

(Mill. Tons/Year)	10	20	30	40
Railway construction	27	239	239	239
Rail and Track	10	28	29	31
Housing	17	23	23	23
Rolling stock	66	90	150	157
Repair shop	10	10	10	10
Container terminal	7	10	14	17
Electric facilities	2	3	4	5
Signal	10	36	36	36
Total	149	439	505	518

From the above, the land bridge railway and associated port and terminal facilities were used.

Furthermore it is thought that the maintenance costs for these facilities will be about 7% of the overall costs.

Table 6.3.5 Project Cost of Railway System

Unit: Mill. US$

(Mill. Tons/Year)	10	20	30	40
Port	259	835	1,039	1,251
Railway	149	439	505	518
Total	408	1,274	1,544	1,769

6.4 Road Plan

6.4.1 General Conditions

(1) Plan Objective

The objective of the road plan is to establish the scale of road facilities required to handle annual transportation volumes of 10, 20, 30 and 40 million tons/year.

(2) Traffic Volume Estimates

The scale of road facilities required will be estimated according to the volume of traffic use anticipated. (The units of traffic volume for the facility scale estimate will be in the thousands.)

a) The targeted freight will be 40' containers with an average weight of 30 tons.

b) Saturday and Sunday are considered holidays and there are six festive holidays per year, leaving 250 working days per year.

c) The daily handling variation rate (maximum handling rate/average daily rate) is 1.2.

d) It is also assumed that the effects of induced (flow on) traffic would increase traffic volumes by 25%.

e) The pcu (passenger car units) conversion rates for each 40' container trailer will be 4.0.

f) Resulting traffic volume increase

Freight Volume (tons/year)	Traffic Volume (pcu/year)	Traffic Volume/Day (average for 250 working days)	Traffic Volume/Day (Maximum) (pcu/day)	Including Flow-on (pcu/day)
10 million	1.3 million	5,300	6,400	7,800
20 million	2.7 million	10,700	12,800	15,600
30 million	4.0 million	16,000	19,200	23,400
40 million	5.3 million	21,300	25,600	31,200

* Total for both directions, pcu conversion rate = 4.0

(3) Road Plan Preconditions

The existing Balboa and Cristobal harbors are situated on the east side of the existing canal and if these harbor facilities are upgraded to a maximum of five berths (with one berth equaling 350m), a maximum of 10 million tons per year can be handled. However, space limitations are such that if volumes are in excess of about 10 or 15 million tons/year, it would be difficult to establish sufficient berths and storage space for expanding the harbor facilities on the east side of the existing canal. For this reason, it is proposed that new facilities in Balboa and Cristobal harbors would be constructed on the west side of the existing canal.

For freight transportation up to 10 million tons/year, a daily transportation volume of 7,800 - 10,000 pcu's would be expected. In this case, the terminal facilities at Balboa and Cristobal harbors on the east side of the existing canal would be upgraded and used. This would allow use of the existing Transistmica highway if upgraded.

In the case of freight transportation of 20 million tons/year or more, a new road is proposed on the west bank of the canal for the following reasons.

a) A new ocean container terminal would be constructed on the west, away from residential areas making access by a new west bank road convenient.

b) A yearly freight transportation volume of 20 million tons would mean a daily volume of 16,000 - 20,000 pcu's and a new road could handle this capacity.

c) Traffic conditions on the existing Transistmica highway are congested, and although there is a plan to expand it to 4 - 6 lanes in the near future, it would still be necessary to construct a new trans-isthmian road in order to handle the increase in traffic as a result of the land bridge.

6.4.2 Outline of Transportation Plan

(1) Ocean Container Terminal and Truck Terminal Relationship

Ocean Container Terminals consist of facilities for loading and unloading ships at the wharves and temporary storage facilities for the handled cargo. Truck terminals are used not only as bases for overland freight transportation between truck terminals, but also for distribution and delivery to the Ocean Container Terminals. There must be close liaison between the management of the Ocean Container Terminals and the Truck Terminals; but the two areas are under separate jurisdiction with transportation between the two being carried out by truck and trailer.

Two truck terminals would be required, one on the Pacific side and one on the Atlantic side. In order to make the freight transportation distance from the Ocean Container Terminal as short as possible and improve efficiency, it is proposed that the terminals should be constructed in the area behind the Ocean Container Terminal.

Trucks and trailers will come into the Truck Terminal loaded from the Ocean Container Terminal and the freight will be stored with the trailer for dispatch to the other Truck Terminal. The receiving Truck Terminal will then store the freight, with trailer, or dispatch it to the Ocean Container Terminal. Road transportation facility costs will apply between the truck terminals while transportation costs for the sector between the Truck Terminal and Ocean Container Terminal will be calculated as part of the Ocean Container Terminal management costs.

(2) Ocean Container Terminal Locations and Basic Concepts of Road Freight Transportation Plan

a) Condition of the Existing Road

The Transistmica Highway is the only significant road currently connecting Panama and Colon. It

serves as a trunk road, with roads branching off it connecting to the various regions. The Transistmica Highway passes through relatively hilly country with sections where the surface and vertical alignment standards are low. In addition, the road was constructed almost 30 years ago and with almost no alternative roads, other routes have been established using this road as the trunk route. The distance between Colon (Cristobal Port) and Panama (Balboa Port) is approximately 84.7km with 6.6km between Colon city and Cativa, and 15.2km between Panama City and Isidro are four lane roads, while the rest of the route, 62.5km, is two lanes. The sectors close to Colon and Panama Cities, including these cities, carry principally high volumes of urban traffic.

The section between Panama City and the surrounding area is already approaching its traffic capacity and will require the construction of a new road in the future. (ref. Fig. 6.4.1)

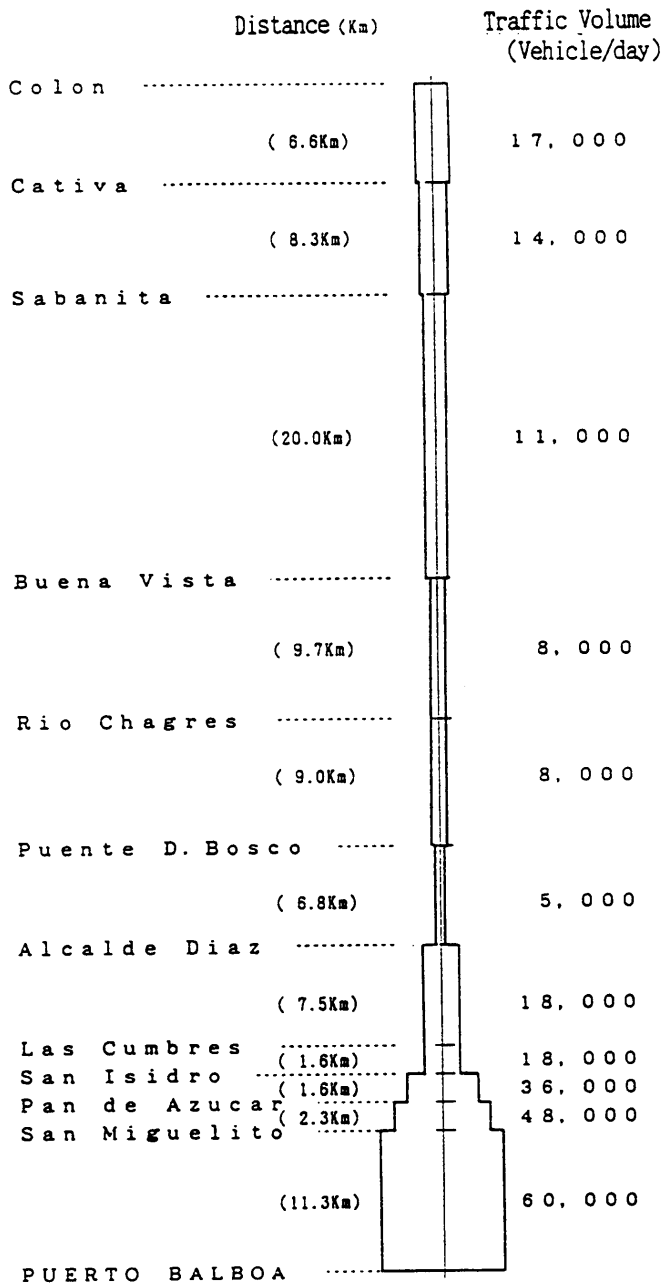


Fig. 6.4.1 Existing Traffic Volume at Colon Panama Road

b) 10 Million Tons/Year

The Ocean Container Terminals on the Atlantic and Pacific sides would be located on the east bank of the canal, and the freight transportation will be handled by the existing road after it is upgraded.

1) Atlantic Side

The Ocean Container Terminal will be located on two sites as in the Port Plan and it is proposed that the Truck Terminals should be located on the site identified in the Rail Freight Plan for the rail container terminal.

2) Pacific Side

The Truck Terminal on the Pacific side will also be located on the site set out in the Rail Freight Plan for the rail container terminal.

3) Road Plan

The existing facilities will be used as much as possible, however, in Panama City, the city of Colon and the surrounding areas, traffic capacity is a already at saturation point. Moreover, the Alcalde Diaz-Buena Vista section where traffic volume is relatively small, is hilly and the road alignment is below standard.

Because the scale of the existing road is small, raising the design speed as part of the road improvements would have a great effect on the route. The bridge between Rio Chagres and Sabanita can be widened to four lanes, but there would not be enough width for the center median. Considering an increase in heavy vehicle traffic and traffic safety, a new bridge is proposed in preference to widening the existing bridge. Because of a hindrance to traffic flow, the land bridge traffic volume and natural traf-

volume increases along with the significant increase in traffic due to the development of new branch routes, a road improvement plan was proposed as follows:

Design speed	80km/h
Maximum grade	5%
Minimum radius	300m
Road length	82.5km
Cross section	
Cristobal Port - Cativa	widened from 4 to 6 lanes (6.6km)
Cativa - Sabanita	widened from 2 to 6 lanes (8.3km)
Sabanita - Alcalde Diaz	widened from 2 to 4 lanes (45.5km)
Alcalde Diaz - San Isidro	widened from 2 to 6 lanes (7.5km)
San Isidro - Balboa Port	the construction of new San Miguelita Oeste, Corredor Norte 4 lane road (14.5km)

(ref. Fig. 6.4.2, 6.4.3 and 6.4.4)

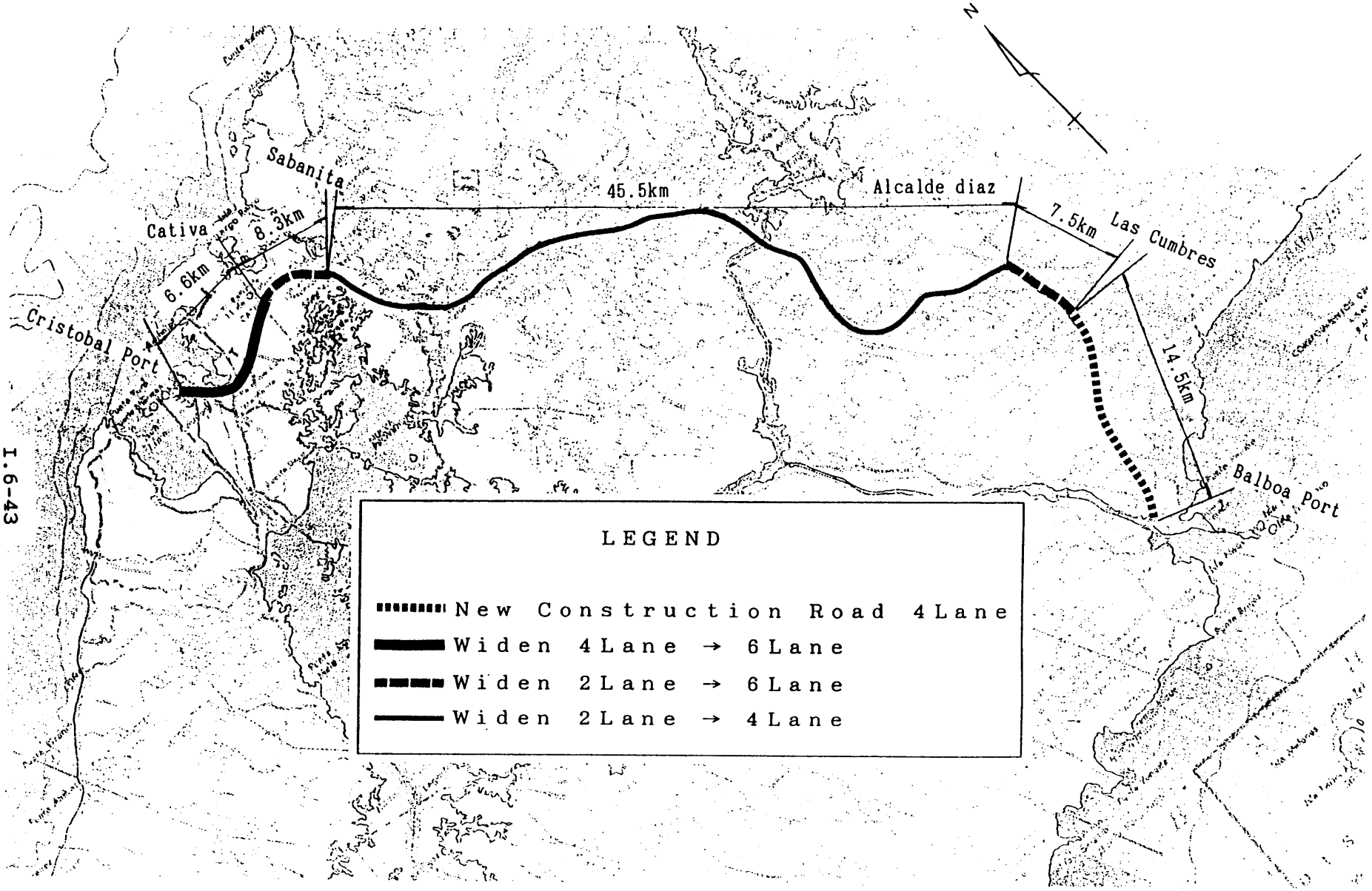


Fig. 6.4.2 Existing Road Improvement Plan

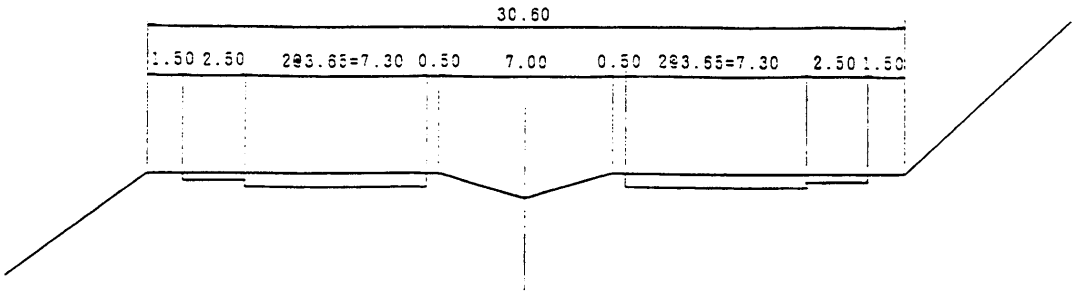


Fig. 6.4.3 Cross Section of Winding Road for 10 Mil. Ton/Year (4 Lanes)

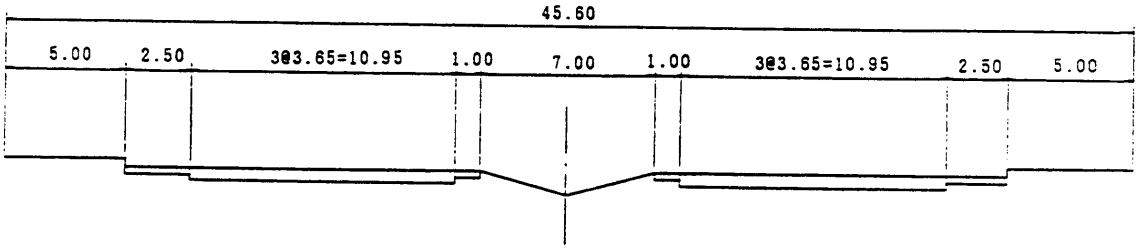


Fig. 6.4.4 Cross Section of Winding Road for 10 Mil. Ton/Year (6 Lanes)

c) More than 20 Million Tons/Year

With a container freight volume of 20 million tons/year or more, the Ocean Container Terminal would be constructed on the west bank of the canal on the Atlantic and Pacific sides.

1) Truck Terminal

It is proposed that one Truck Terminal would be located in the area behind the Ocean Container Terminals on the Atlantic and Pacific sides. A vehicle repair shop will be built next to each of these terminals.

2) Road Plan

If the existing road is upgraded to handle 20 million tons/year, approximately 16,000 containers/day will cross the land bridge and add to the increase in the traffic already expected. Because of conflict with urban traffic, traveling speeds would be reduced and an increase in traffic accidents with negative environmental conditions would be expected for the surrounding areas.

Moreover, if the existing road is used, major bridges will be required in two places to cross the canal at a cost of approximately US$100 million. In the case where the volume is 30 million tons/year, the volume of traffic will be 23,400 veh./day and for 40 million tons/year, 31,200 veh./day. This would require the construction of a four lane highway exclusively for freight transportation use to handle requirements for 30 million tons/year or more.

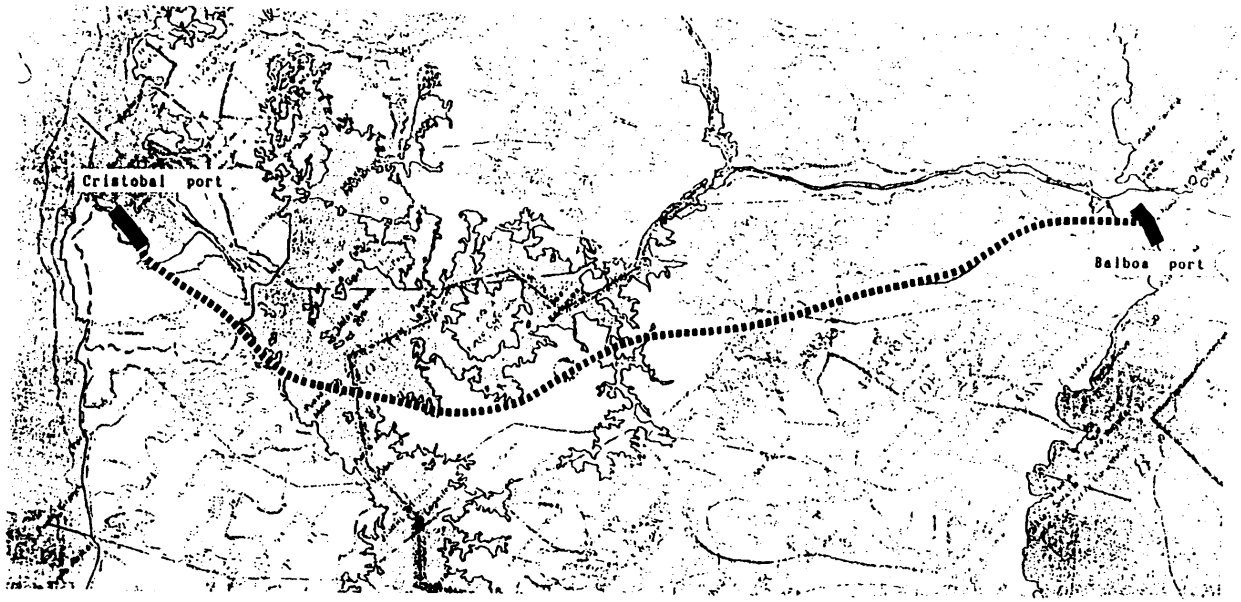
Therefore, a new road is proposed on the west bank of the canal to handle freight movement requirements for container freight volumes of 20 million tons/year or more. Land bridge freight would be carried by large truck and trailer units and would shorten the time it takes to cross the Atlantic - Pacific

crossing. Therefore the following standards were adopted as the provisions for a dedicated road.

Design speed	120km/h
Maximum grade	2.5%
Minimum radius	1,000m
Road length	70km
Cross section	
20 million tons/year	2 lane (ie. 1 lane in each direction)
30 million tons/year	4 lane (ie. 2 lanes in each direction)
40 million tons/year	4 lane (ie. 2 lanes in each direction)

(ref. Fig. 6.4.5, 6.4.6, 6.4.7 and 6.4.8)

Layout Plan of New Road



Location of New road

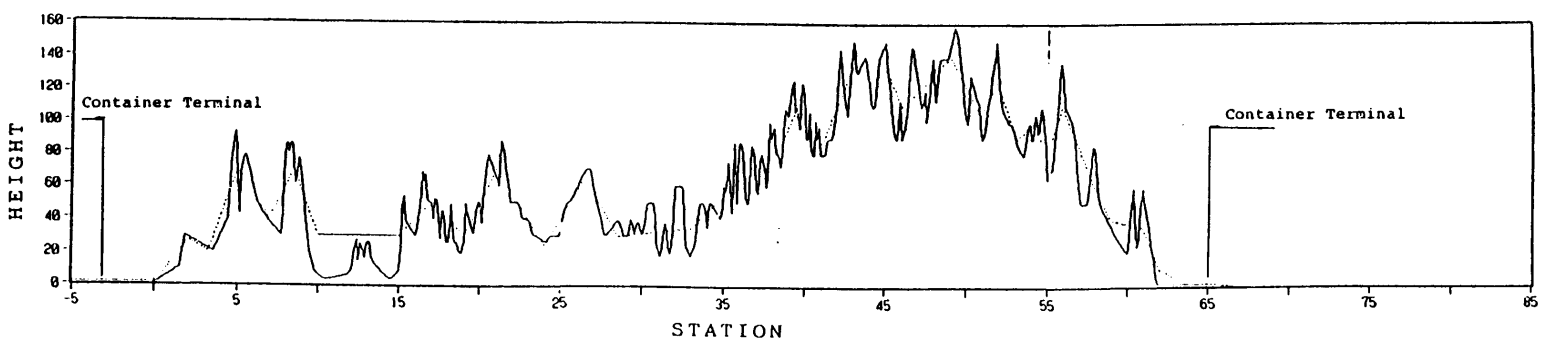


Fig. 6.4.5 Layout Plan for Location of New Road

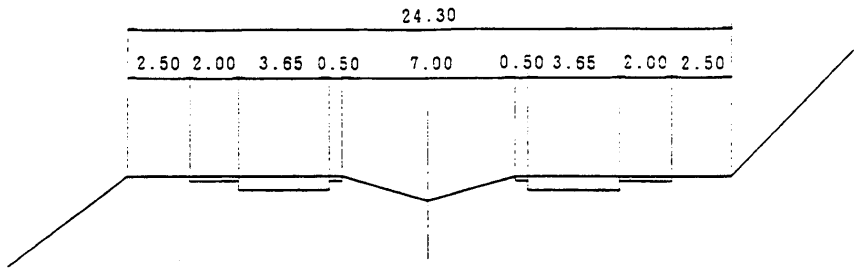


Fig. 6.4.6 Cross Section of New Road for 20 Mill. Ton/Year

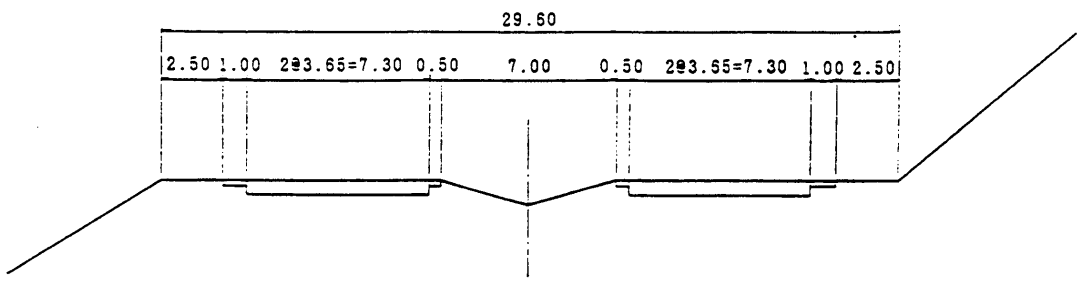


Fig. 6.4.7 Cross Section of New Road for 30 Mill. Ton/Year

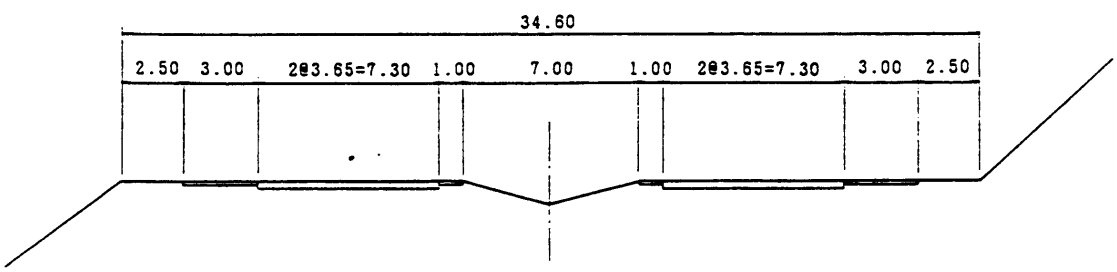


Fig. 6.4.8 Cross Section of New Road for 40 Mill. Ton/Year

6.4.3 Truck and Trailer Operation Plan

For each volume handled daily (40' containers assumed), the transported distance, the traveling speed, time taken and the required number of truck and trailer units are calculated below. The calculated traveling speed includes provisions for traveling at 40km/h on normal roads and 80km/h on dedicated freight transport roads, and also allows for 40 minutes operating time inside the terminal. Moreover, the number of trips is for one way trips and when using normal roads, the truck and trailer combination consists of only one trailer while on the dedicated roads, the combination consist of two trailers.

Table 6.4.1 Daily Handling Volume of 40' Containers and Number of Truck and Trailer Units Required

Volume handled annually (mill.tons/year)	Containers per day (max.)	Transport distance (km)	Traveling speed (km/h)	Time taken (hrs)	No. of one-way trips(*)	Containers per vehicle	Required No. of vehicles
10	1,600	82.5	30	3.5	2	1	800
20	3,200	70	60	1.8	4	2	400
30	4,800	70	60	1.8	4	2	600
40	6,400	70	60	1.8	4	2	800

(*) per vehicle per day

Table 6.4.2 Cost Estimation

Unit: Mill. US$

Freight volume handled (mill. tons/year)	10	20	30	40
Road construction	171	284	331	368
Housing	13	14	18	20
Truck units for truck & trailers	211	106	159	212
Repair shops	10	10	10	10
Truck terminal	7	10	14	17
Electric facilities	2	3	4	4
Total	414	427	536	631

From the above the land bridge road and associated port and terminal facilities were used.

Centerport costs are indicated below.

Furthermore, it is thought that the annual maintenance and management costs for these facilities will be about 7% of the overall costs.

Table 6.4.3 Project Cost of Road System

Unit: Mill. US$

(Mill. Tons/Year)	10	20	30	40
Port	259	835	1,039	1,251
Road	414	427	536	631
Total	673	1,262	1,575	1,882

6.5 Oil Pipeline Plan

6.5.1 Existing Facilities (Trans-Panama Pipeline System)

(1) Outline

At present the Trans-Panama Pipeline System, made up of the pipeline and two pumping stations between Charco Azul Terminal on the Pacific side and Chiriqui Grande Terminal on the Atlantic side and situated approximately 350 km to the west of Panama City, is able to pump up to 800,000 barrels per day (BPD). The crude oil runs out from the Chiriqui Grande Terminal Crude oil storage tank by gravity flow to the offshore loading buoy and to a waiting tanker. The pipeline system is controlled from the Operations Control Center at Puerto Armuelles Station by the Supervisory Control and Data Acquisition (SCADA) System that uses a microwave communications.

The pipeline was constructed to facilitate the transportation of Alaskan North Slope (ANS) crude oil, carried by supertankers from the Alaska Valdez Terminal, to the Eastern United States without having to use the Panama Canal, and has been operated by Petroterminal de Panama since 1983. The volume of ANS crude oil being transported through the Panama Canal has been markedly reduced due to the operation of this pipeline. The existing Trans-Panama Pipeline System route is shown in Fig. 6.5.1.

The main facilities on the existing Trans-Panama Pipeline System are listed below and are summarized on Table 6.5.1.

Route of the 82 mile, 36 and 40-in, line that connects Atlantic and Pacific Oceans across Western Panama.

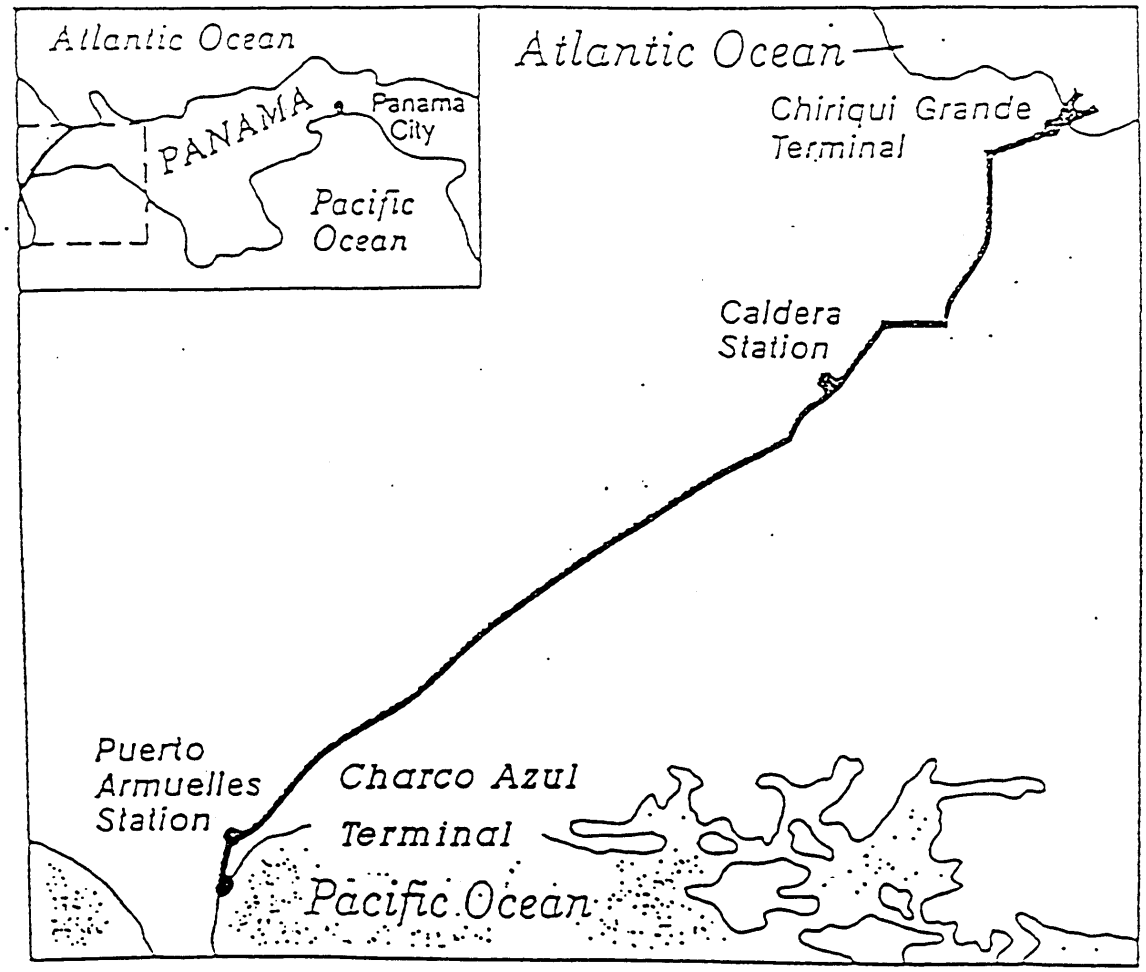


Fig. 6.5.1 Existing Trans-Panama Pipeline System Route

Table 6.5.1 Existing Pipeline Facilities

CASE	CHARCO AZUL TERMINAL	PUERTO ARMUELLES STATION	CALDERA STATION	OIL PIPELINE	CHIRIQUI GRANDE TERMINAL
EXISTING TRANS-PANAMA P/L CAPACITY 0.8 MILLION B/DAY	· JETTY NO.1/NO.2/NO.3 · CRUDE OIL/BALLAST LINES · CRUDE OIL STORAGE TANK (3 × 833,000 BBL/EA.) · BOOSTER PUMPS (2 × 500HP/EA.) · BALLAST WATER TREATMENT FACILITIES BALLAST WATER TANK (3 × 120,000 BBL/EA.) · FIRE AND ENVIRONMENTAL PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (4 × 5,000 HP/EA. CAPA. 200,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (4 × 5,000 HP/EA. CAPA. 200,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	(*1) A 40 in × 50 MILES (*2) A 36 in × 32 MILES CAPACITY 800,000 BPD	· CRUDE OIL STORAGE TANK (3 × 833,000 BBL/EA.) · BALLAST WATER TREATMENT FACILITIES BALLAST WATER TANK (3 × 120,000 BBL/EA.) · FIRE AND ENVIRONMENTAL PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM · CRUDE OIL/BALLAST LINES · CALM BUOYS (2 × 60,000 BPH/EA.)

NOTE : (*1) BETWEEN PUERTO ARMUELLES STATION AND CALDERA STATION
(*2) BETWEEN CALDERA STATION AND CHIRIQUI GRANDE TERMINAL

Charco Azul Terminal (Pacific Coast)

- Jetty No.1
  - Length : 1,000 ft
  - Maximum ship size : 270,000 DWT
  - Unloading rate : 110,000 barrels/hour
  - Crude oil line : (1 x 48 in.)
  - Ballast water line: (1 x 24 in.)
  - Diesel line : (1 x 12 in.)

- Jetty No.2
  - Length : 1,200 ft
  - Maximum ship size : 120,000 DWT
  - Loading/Unloading rate : 60,000 barrels/hour
  - Crude oil line : (1 x 36 in.)
  - Ballast water line : (1 x 24 in.)

- Jetty No.3
  - Maximum ship size : 60,000 DWT
  - Loading rate : 50,000 barrels/hour
  - Crude oil line : (1 x 36 in.)
  - Ballast water line: (1 x 36 in.)

- Crude Oil Storage Tank
  - Number : 3
  - Capacity : 833,000 barrels/ea.

- Booster Pumps : 2 x 500 HP/ea.

- Ballast Water Treatment Facilities
  - Ballast Water Tank (3 x 120,000 barrels/ea.)

- Fire and Environmental Protection System

- Electric Power Supply System

Puerto Armuelles Station

- Pipeline Pumps
  - Number : 4 (parallel operation)
  - Motor : 5,000 HP/ea.
  - Total capacity : 800,000 barrels/day

- Electric Power Supply System

Caldera Station

- Pipeline Pumps
  - Number : 4 (parallel operation)
  - Motor : 5,000 HP/ea.
  - Total capacity : 800,000 barrels/day

- Electric Power Supply System

Pipeline

- Total Pipeline Length : 82 miles

- Pipeline Size
  - 50 miles of 40" dia. pipe between Puerto Armuelles Station and Caldera Station
  - 32 miles of 36" dia. pipe between Caldera Station and Chiriqui Grande Terminal

- Maximum Design Rate : 800,000 barrels/day

Chiriqui Grande Terminal

Onshore Facilities

- Crude Oil Storage Tank
  - Number : 3
  - Capacity : 833,000 barrels/ea.

- Crude Oil Loading Line
  (2 x 36 in. x 3,600 m/ea.)

- Ballast Water Treatment Facilities
  - Ballast Water Tank (3 x 120,000 barrels/ea.)

- Fire and Environmental Protection System

- Electric Power Supply System

Offshore Loading Facilities

- Submarine Crude Oil Line
  (2 x 36 in. x 2,000 m/ea.)

- Submarine Ballast Water Line
  (2 x 30 in. x 2,000 m/ea.)

- Catenary Anchor Leg Mooring (CALM) Buoy
  - Number : 2
  - Loading rate : 60,000 barrels/hour each
  - Maximum ship size : 160,000 DWT

(2) Operating Conditions & Future Demand Projections

The average transported volume (pumping rate per day) from 1983 to 1988 of the Trans-Panama Pipeline System is shown below.

Year	Pumping Rate (1000.barrels/day)
1983	680
1984	568
1985	633
1986	590
1987	594
1988	474

In studying projections for demand on the pipeline system, the demand reduction factors listed below and those published in "The Transisthmian Alternatives For Increasing The Throughput Across Panama," May 1990, must be considered.

a) Consumption on the American west coast has been increasing.

b) Since 1988 a 16 inch four-corners pipeline (California) was joined to the 30 inch all American pipeline and 70,000 barrels/day of ANS crude oil can be shipped to the Texas market without using the Trans-Panama Pipeline System.

c) It is projected that there will be a reduction in the production volume of ANS crude oil unless there are new oil field discoveries.

d) There is a possibility of increased ANS crude oil sales to Pacific rim nations.

6.5.2 Proposed Facilities

The following four cases are the pipeline capacities to be investigated in this component study.

Case No.	Pipeline Capacity (Mill.barrels/day)
1	0.5
2	1.0
3	1.5
4	2.0

New facilities required for each of the above cases are estimated based on the following preconditions.

a) The existing Trans-Panama Pipeline System (maximum design rate of 800,000 barrels/day) will be used to maximum capacity and new facilities would be added to or expanded the existing facilities when the required capacity is more than 80,000 barrels/day.

b) Because the existing facilities have a capacity of 800,000 barrels/day, Case (1) which called for a 0.5 mill barrels/day capacity would not require the construction of new facilities.

c) The following is the design rate for the new facilities based on a) and b) above.

Case No.	Design Rate (barrels/day)
2	200,000
3	700,000
4	1,200,000

d) The new pipeline would be a single pipeline and constructed to adjoin the existing pipeline route.

e) Expansion requirements for the unloading facilities at Charco Azul Terminal and the loading facilities at Chiriqui Grande Terminal are estimated on the following.

Case 2

The existing unloading and loading facilities can be utilized without major modifications.

Case 3 and 4

The construction of a new jetty of the same scale as the existing jetty No.1 at the Charco Azul Terminal unloading facilities would be required, and the construction of new facilities of the same scale as the existing loading facilities at the Chiriqui Grande Terminal is also required.

The proposed pipeline facilities in each case, based on the above preconditions, are shown in Table 6.5.2.

Table 6.5.2 Proposed Pipeline Facilities

CASE	CAPACITY (MILLION BPD)	CHARCO AZUL TERMINAL	PUERTO ARMUELLES STATION	CALDERA STATION	OIL PIPELINE	CHIRIQUI GRANDE TERMINAL
1	0.5	NONE	NONE	NONE	NONE	NONE
2	1.0	· CRUDE OIL STORAGE TANK (3 × 200,000 BBL/EA.) · BOOSTER PUMPS (2 × 170 HP/EA. CAPA. 100,000 BPD/EA.) · FIRE PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (2 × 2,500 HP/EA. CAPA. 100,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (2 × 2,500 HP/EA. CAPA. 100,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	(*1) A 24 in. × 50 MILES (*2) A 22 in. × 32 MILES CAPACITY 200,000 BPD	· CRUDE OIL STORAGE TANK (3 × 200,000 BBL/EA.) · FIRE PROTECTION SYSTEM
3	1.5	· JETTY (1 × 260,000 DWT) · CRUDE OIL/BALLAST LINES · CRUDE OIL STORAGE TANK (3 × 700,000 BBL/EA.) · BALLAST WATER TANK (3 × 120,000 BBL/EA.) · BOOSTER PUMPS (4 × 300 HP/EA. CAPA. 175,000 BPD/EA.) · FIRE PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (4 × 4,400 HP/EA. CAPA. 175,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (4 × 4,400 HP/EA. CAPA. 175,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	(*1) A 38 in. × 50 MILES (*2) A 34 in. × 32 MILES CAPACITY 700,000 BPD	· CRUDE OIL STORAGE TANK (3 × 700,000 BBL/EA.) · BALLAST WATER TANK (3 × 120,000 BBL/EA.) · FIRE PROTECTION SYSTEM · CRUDE OIL/BALLAST LINES · CALM BUOYS (2 × 60,000 BPH/EA.)
4	2.0	· JETTY (1 × 260,000 DWT) · CRUDE OIL/BALLAST LINES · CRUDE OIL STORAGE TANK (6 × 600,000 BBL/EA.) · BALLAST WATER TANK (3 × 120,000 BBL/EA.) · BOOSTER PUMPS (6 × 340 HP/EA. CAPA. 200,000 BPD) · FIRE PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (6 × 5,000 HP/EA. CAPA. 200,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (6 × 5,000 HP/EA. CAPA. 200,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	(*1) A 48 in. × 50 MILES (*2) A 44 in. × 32 MILES CAPACITY 1,200,000 BPD	· CRUDE OIL STORAGE TANK (6 × 600,000 BBL/EA.) · BALLAST WATER TANK (3 × 120,000 BBL/EA.) · FIRE PROTECTION SYSTEM · CRUDE OIL/BALLAST LINES · CALM BUOYS (2 × 60,000 BPH/EA.)

NOTE : (*1) BETWEEN PUERTO ARMUELLES STATION AND CALDERA STATION
(*2) BETWEEN CALDERA STATION AND CHIRIQUI GRANDE TERMINAL

6.5.3 Cost Estimation

In 6.3.2 the cost estimation for each case of the proposed pipeline facilities is shown in Table 6.5.3. The cost estimation is calculated based on the preconditions stated.

(1) Direct Construction Costs

- Pipeline costs consist of facility construction costs and material costs. The unit cost is US$16.0/in-m.

- The crude oil and ballast water tank construction costs include material and civil work costs. The tank erection unit cost is US$6.0/BBL with a capacity of less than 200,000 BBL and US$8.0/BBL with more than 200,000 BBL. Furthermore, civil work cost is assumed at 20% of the above tank erection cost.

- Pump facility costs consist of machinery costs, civil work costs and installation costs. The machinery unit cost is US$260/HP for less than 500 HP and US$300/HP for more than 500 HP. Furthermore, civil work and installation costs are assumed at 40% of the above machinery cost.

- Supporting facilities necessary to operate the pipeline, unloading and loading facilities, and pump facilities include water disposal facilities, power facilities, instrumentation facilities, fire protection facilities, various utility facilities, communications facilities and buildings. The supporting facility costs include the costs such as piping work, electrical work, instrumentation work, installation work and civil work. The supporting facility costs are assumed at 10% of the total pipeline costs, unloading and loading facility costs and pump facility costs.

(2) Indirect Construction Costs

- Design costs and construction supervision costs will be 15% of the direct construction costs.

- General management costs will be 12.5% of the direct construction costs.

(3) Contingency

Contingency will be 25% of the total direct and indirect construction costs.

Table 6.5.3 Cost Estimation

Unit: Mill. US$

	Category	Case 2 1,000,000 BPD	Case 3 1,500,000 BPD	Case 4 2,000,000 BPD
1.	Direct construction costs	71	200	276
1.1	Pipeline costs	(49)	(77)	(98)
1.2	Unloading facility costs	(6)	(61)	(76)
	· Jetty	0	36	36
	· Crude oil tank	6	20	35
	· Ballast tank	0	3	3
	· Crude/ballst lines	0	2	2
1.3	Pump facility costs	(4)	(8)	(26)
1.4	Loading facility costs	(6)	(36)	(51)
	· Crude oil tank	6	20	35
	· Ballast tank	0	3	3
	· Crude/ballst lines/calm buoys	0	13	13
1.5	Supporting facility costs	(6)	(18)	(25)
2.	Indirect construction costs	20	55	(76)
2.1	Design and construction supervision costs	(11)	(30)	(41)
2.2	General management costs	(9)	(25)	(35)
3.	Contingency	23	(64)	88
	Total	114	319	440

Note: The value in ( ) are subtotals.

CHAPTER 7 - PRELIMINARY REVIEW OF IMPACTS

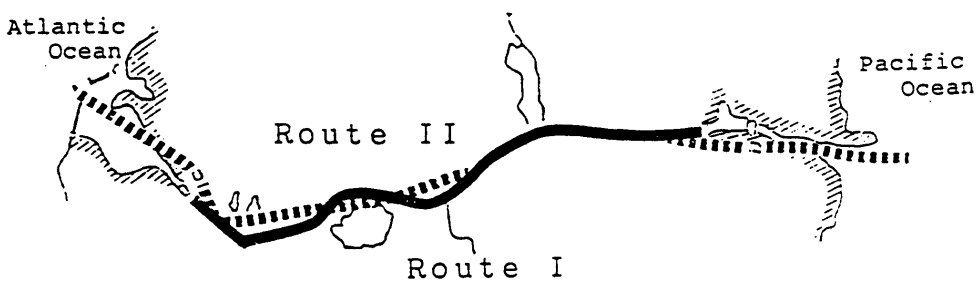
7.1 General

The inevitable result of construction of the nature discussed in this document will be an impact, sometimes significant, on the environment. These impacts are ecological, socioeconomic and cultural.

In this chapter such potential impacts created as a result of design and construction schemes are just identified and listed without resolution.

7.2 Lock System Canal Cases

7.2.1 Impact on Existing Canal



There are two routes considered for the Lock system canal as shown above. The following matters should be carefully considered during the planning and implementation of construction works.

(1) Dredging works in the Gatun lake should be executed while maintaining the highest levels of safety for ship transiting along the existing Gatun lake route. Therefore, construction methods and schedule should be carefully planned taking safety aspects into consideration.

(2) For a shift in operation to the new canal from the existing canal, a shut down period of about 10 days (for high rise lock cases) and two month (for low rise lock cases) would be required.

(3) Pedro Miguel locks become redundant (in the 55' and 30' water level cases) and the upper lock of Miraflores Locks must be demolished and the approach to the lower locks modified. (in the 30' water level cases)

(4) The existing canal and the rest of Miraflores locks would be available simultaneously with completion of the new canal.

7.2.2 Environmental Impact

(1) The lockage water supply is insufficient for the new locks operation 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 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 lockage water, new dams are also proposed at Rio Trinidad and Rio Ciri Grande approximately 3-9 km 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) The lock system canal cases, the lake levels are planned as 90', 85', 55', and 30'. These increased or decreased lake levels might cause some environmental impact in the surrounding area and aquatic creatures.

(4) Access channels 24.3-21.9 km long in the Pacific Ocean side; 11.8-12.5 km in the Atlantic Ocean side and 19-25 m deep are planned.

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

(5) Barrier dams planned in the lake in the cases of 55' and 30' lake water levels might causes environmental impacts.

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

(7) Dissolved and suspended sediment from the excavated and disposal areas is likely to contaminate the Gatun Lake water during the construction period and until regeneration occurs.

(8) The potential for interchange of ocean biota through the lock canal would be increased by larger ships and higher transits, especially for the low rise canal systems. The risks would be difficult to quantify but further study would be required.

7.2.3 Socioeconomic Impacts

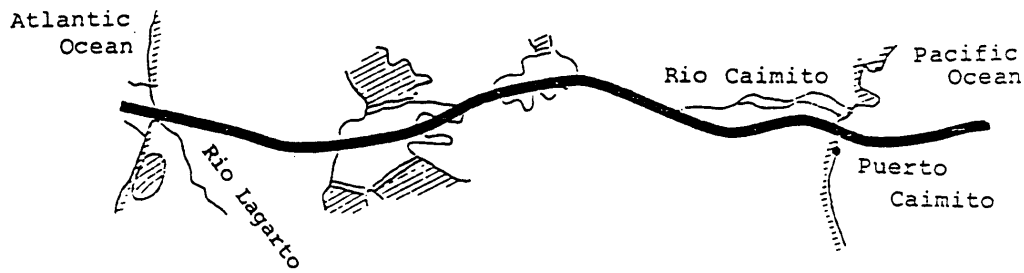
(1) If a larger ship alternative were selected, the Pan American Highway (k5) Bridge over the existing canal should be reconstructed because the span and clearance of the bridge is insufficient for passing the larger size ships.

(2) The railway terminal at the existing Gatun locks may need to be relocated to the new lock site.

(3) The road (no. 836, R-6) may be cut by the new locks hence a new bridge over the locks would be required.

7.3 Sea Level Canal (Route 10)

7.3.1 Impacts on the Existing Canal



Above Figure shows the Route 10 Sea Level Canal alignment. 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.

The Route 10 is about 16 km from the existing canal route, so Route 10 Sea Level Canal construction works would not directly affect the existing canal operations.

7.3.2 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. If the valleys in the upper reaches of the Rio Caimito, Rio Bernardino on the Pacific Coast side and Rio Los Hules, Rio Pescado, and Rio Tinajones in the central section of the Canal and Rio Lagarto and Rio Quebrado

in the Atlantic Coast side were to be used as disposal 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 connecting a western part of Gatun lake to the Rio Lagarto is planned and this will cause an impact in the surrounding area and to the aquatic creatures in the lake.

(4) Breakwaters planned 7.4-14.9 km long in both Ocean coast sides will create an impact.

7.3.3 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 Palmas Bellas village located near the mouth of Rio Lagaruto in the Atlantic Coast side would be impacted in part.

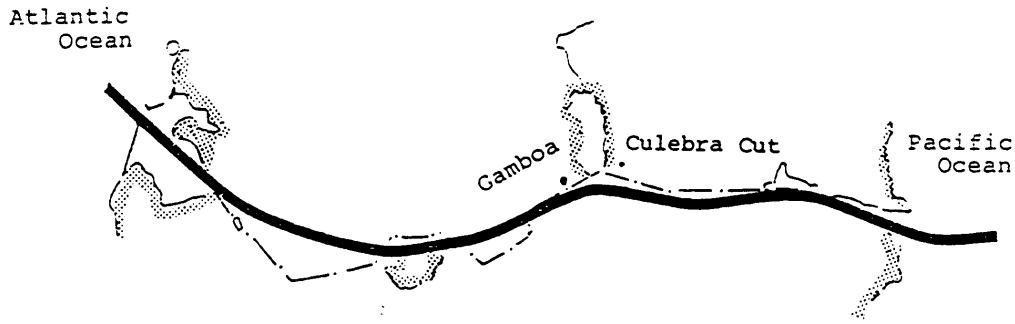
(3) A new bridge for the Pan American Highway should be constructed connecting Panama city and the separated western district.

(4) The road (no. 75, K-18) from La Chorrera to the northern district is cut by the new canal.

(5) For the road (no. 836, R-6), a new bridge may be required connecting Colon and the western district.

7.4. Sea Level Canal (Route 14S)

7.4.1 Impact on Existing Canal



The figure shows the Sea Level Canal alignment for Route-14S Entering from the Pacific Coast side, the Sea Level Canal route passes hilly areas through the continental divide, parallel to the existing canal zone through the Culebra Cut, then joins the existing canal near Gamboa.

In the Gatun Lake zone the route is the same as the High Rise Lock Canal route.

(1) The matters that require special attention concerning dredging and shut down periods are almost the same as in the High Rise Lock Canal cases.

(2) Pedro Migel Locks, Miraflores Locks and the existing canal through most of Culebra Cut become redundant.

(3) The Gatun Dam becomes redundant.

7.4.2 Environmental Impacts

(1) Sea water from both Oceans would flow in alternate directions with the tides, although the net flow direction would be from the Pacific to the Atlantic, and some ecological changes would be inevitable. The potential for interchange of ocean biota would be greatest in the absence of tidal gates or locks. In order to reduce these ecological effects, surveys and analysis would be required and special facilities to reduce sea water flow to the opposite side should be developed.

(2) The matters that require special attention regarding the environmental effects of solid disposal in the inland area would be similar to those described for the High Rise Lock cases.

(3) Socioeconomic Impact

The matters that demand special attention concerning socioeconomic effects would be similar to those described for the lock system cases.

APPENDIX

APPENDIX 1 : WATER MANAGEMENT SIMULATION

AP 1-1 RAINFALL AND DISCHARGE GAGE LOCATIONS IN CANAL ZONE

AP 1-2 AVERAGE RAINFALL IN CANAL ZONE

AP 1-3 WATERSHED YIELD

AP 1-4 DISCHARGE TABLE

AP 1-5 SPECIFIC DISCHARGE

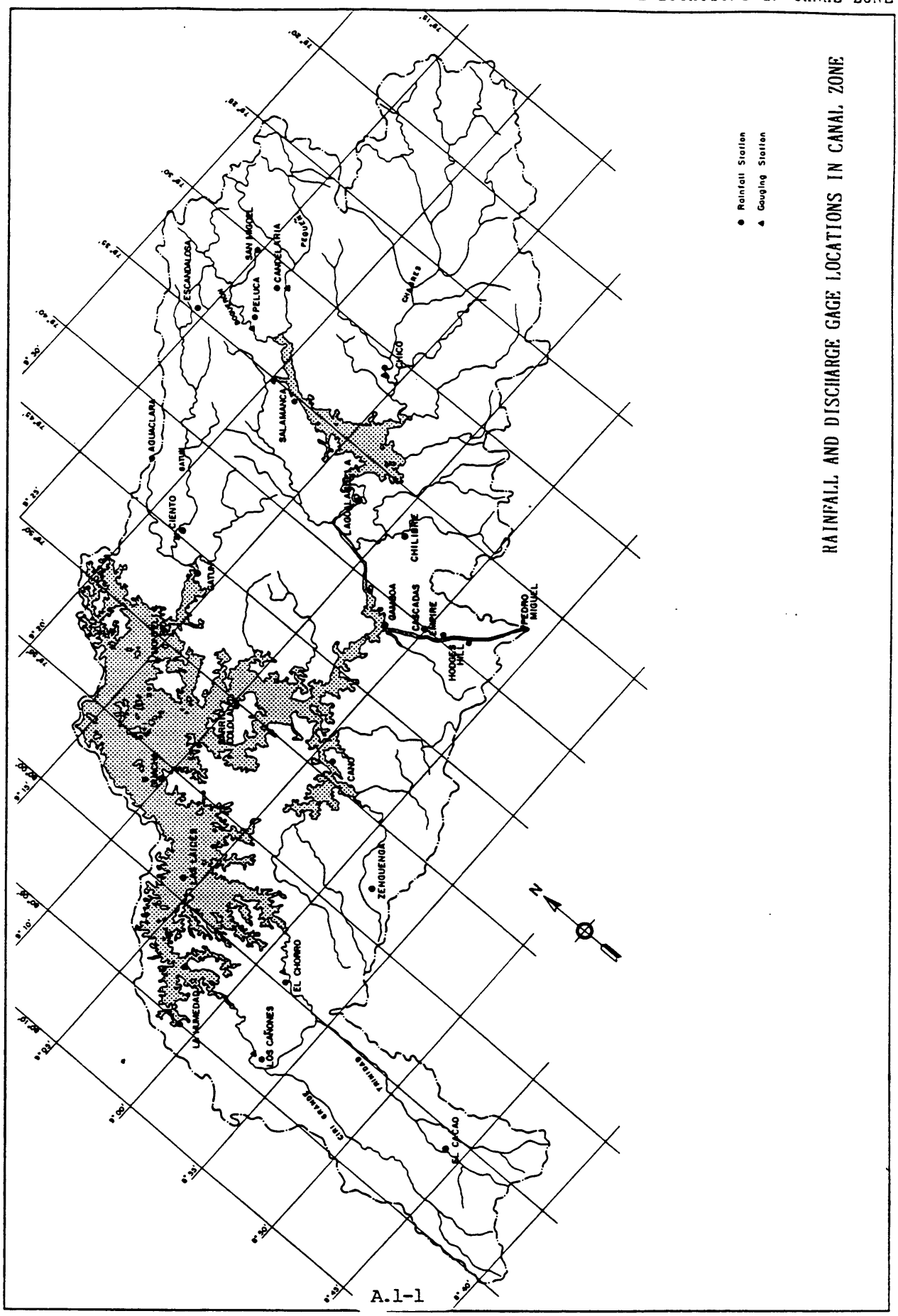
AP 1-6 MONTHLY EVAPORATION

AP 1-7 FLOWCHART FOR WATER BALANCE SIMULATION

AP 1-8 RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT

AP 1-9 WATER BALANCE SIMULATION

AP 1-1 RAINFALL AND DISCHARGE GAGE LOCATIONS IN CANAL ZONE



AVERAGE RAINFALL IN CANAL ZONE

(UNIT : m / m)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Agua Clara	108.3	54.6	55.4	157.1	371.0	335.8	319.8	374.2	325.6	512.9	539.4	348.2	3,502.3
Barrio Colorado	65.3	31.8	27.1	93.7	274.5	263.5	271.3	306.8	259.1	347.4	421.1	242.8	2,604.4
Candelaria	114.7	57.7	45.3	165.8	336.5	341.5	330.7	350.2	320.4	350.2	388.9	302.3	3,104.2
Chico	39.6	14.4	13.3	83.6	278.8	310.0	317.5	337.5	322.3	387.6	345.3	174.1	2,624.0
Ciento	100.8	11.1	38.0	129.6	314.3	307.7	311.7	336.4	13.7	501.7	501.7	304.1	2,870.8
El Chorro	68.7	30.0	29.0	93.0	266.5	245.1	197.3	260.6	276.8	326.0	313.6	167.3	2,273.9
Escandalosa	133.9	78.6	65.2	204.7	351.6	338.2	343.5	320.5	283.2	333.6	436.9	313.6	3,203.5
Salamanca	10.9	13.8	15.2	93.5	251.7	286.3	256.7	287.7	275.9	326.6	331.8	167.3	2,317.4
San Miguel	152.1	74.4	74.8	222.4	379.6	354.8	352.1	358.3	324.4	348.4	424.9	356.4	3,422.6
La Humedad	71.8	39.8	31.1	115.9	252.7	247.0	194.3	235.1	254.5	303.1	324.9	183.1	2,253.3
Lago Alajuela	29.5	13.7	16.0	83.9	271.9	290.6	276.2	287.9	290.3	359.9	332.0	131.3	2,383.2
Empire	22.9	15.9	11.2	94.4	212.6	251.9	233.2	231.4	258.0	326.4	278.6	106.9	2,043.4
Guacha	78.9	32.5	31.0	133.2	231.1	221.2	213.1	252.8	221.3	309.0	327.6	206.1	2,257.8
Pedro Miguel	30.1	10.2	10.9	87.2	245.8	240.3	203.3	228.7	234.3	311.4	272.6	132.7	2,007.5
Hodges Hill	24.6	17.5	8.2	106.2	216.7	164.1	166.9	183.6	217.2	279.9	188.5	105.9	1,679.3
Gamboa	33.7	17.2	13.8	75.1	253.4	249.8	246.9	247.3	246.3	306.1	297.3	137.7	2,124.6
Gatún	90.1	42.0	40.9	124.0	314.3	282.9	325.1	335.3	293.5	392.6	518.0	317.8	3,076.5
Las Raices	61.6	23.0	27.6	101.2	239.7	217.1	206.0	231.1	237.8	302.2	310.8	189.5	2,147.6
Montelirio	69.3	31.7	32.5	92.9	276.8	255.2	275.2	319.5	271.7	377.9	452.0	280.1	2,734.8
Peluca	100.2	50.9	40.3	164.5	328.2	322.9	309.3	318.3	290.8	331.1	386.8	284.8	2,928.1
Chilibre	19.5	7.4	18.6	74.6	217.9	258.6	247.6	269.1	274.8	347.9	275.6	81.5	2,093.1
Caño	51.5	20.0	20.4	73.2	243.5	225.1	224.3	252.9	236.0	325.1	349.2	187.2	2,208.4
Los Cañones	111.4	46.1	37.2	110.8	309.7	280.8	285.4	295.4	374.8	362.3	340.1	204.7	2,758.7
El cacao	47.5	23.1	45.8	105.2	274.8	217.6	197.0	262.9	308.1	417.0	264.4	120.2	2,283.6
Cirí Grande	54.4	35.9	21.9	121.1	304.2	251.9	201.5	306.2	329.9	399.7	285.6	153.8	2,466.1
Zanguenga	46.2	21.1	14.5	75.2	210.2	215.2	172.0	231.7	254.6	338.3	233.7	140.1	1,952.8
Cascadas	21.8	11.1	26.2	88.3	239.9	254.6	204.3	237.6	258.5	315.7	253.1	93.3	2,004.4
Ave.	65.3	30.6	30.0	113.8	276.9	268.1	255.2	284.0	269.0	353.6	345.7	201.4	2,493.6

WATERSHED YIELD

(GATUN WATERSHED)

(UNIT : m^3/s)

River	Station	Period of Record	Drainage Area	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Trinidad	Chorro	1947~1983	173km²	4.28	2.23	1.34	1.58	4.00	6.48	6.70	8.24	9.99	13.81	14.25	9.47
①			100km²	2.47	1.29	0.77	0.91	2.31	3.75	3.87	4.76	5.77	7.98	8.24	5.47
Gatun	Ciento	1943~1983	122km²	4.62	2.59	1.66	2.24	4.38	5.95	7.54	7.91	7.15	11.48	16.05	11.35
②			100km²	3.79	2.12	1.36	1.84	3.59	4.88	6.18	6.48	5.86	9.41	13.16	9.30
Ciri Grande	Los Cañones	1947~1983	186km²	7.94	3.69	2.42	2.43	6.47	10.68	11.26	13.16	15.23	17.85	18.42	13.24
③			100km²	4.27	1.98	1.30	1.31	3.48	5.74	6.05	7.08	8.19	9.60	9.90	7.12
①+②+③/3	Specific Yield		100km²	3.51	1.80	1.14	1.35	3.13	4.79	5.37	6.11	6.61	9.00	10.43	7.30

(MADDEN WATERSHED)

(UNIT : m^3/s)

River	Station	Period of Record	Drainage Area	Jan	Feb.	Mar	Apr.	May	Jun	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
Chagres	Chico	1933~1986	414km²	25.90	15.33	10.99	15.72	27.09	29.21	32.72	34.78	33.34	38.83	49.16	48.46
①			100km²	6.26	3.70	2.65	3.80	6.54	7.06	7.90	8.40	8.05	9.38	11.87	11.71
Boquerón	Peluca	1933~1983	91km²	5.84	2.92	1.95	3.81	8.09	8.07	10.03	9.79	7.64	8.04	12.87	13.24
②			100km²	6.42	3.21	2.14	4.19	8.89	8.87	11.02	10.76	8.40	8.84	14.14	14.55
Pequeñi	Candelaria	1943~1983	135km²	12.25	6.48	4.56	7.65	15.23	16.40	18.64	18.29	16.30	17.23	22.14	25.40
③			100km²	9.07	4.80	3.38	5.67	11.28	12.15	13.81	13.55	12.07	12.76	16.40	18.81
①+②+③/3	Specific Yield		100km²	7.25	3.90	2.72	4.55	8.90	9.36	10.91	10.90	9.51	10.33	14.14	15.02

DISCHARGE TABLE

Gatun Watershed
Trinidad Chorro 173km2

(UNIT : m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1947	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	16.20	6.67	11.44
1948	*******	1.87	1.03	.58	1.55	2.03	6.29	7.62	6.72	7.26	16.60	5.70	5.20
1949	2.26	1.05	.56	.55	1.84	10.30	9.65	10.50	15.90	13.00	22.90	17.00	8.79
1950	4.45	2.63	1.42	.69	6.24	9.83	10.10	13.50	8.62	13.30	19.20	15.80	8.81
1951	5.02	3.37	1.70	1.23	6.31	*******	7.13	9.21	*******	9.68	12.00	7.78	6.34
1952	3.17	1.95	1.01	.78	1.99	5.45	4.93	5.77	9.93	14.10	9.74	18.80	6.47
1953	7.49	6.43	1.67	1.17	6.72	6.22	5.69	4.16	5.85	11.50	11.90	6.36	6.26
1954	3.01	1.74	1.02	.90	8.20	7.11	17.80	*******	14.30	13.90	21.50	9.75	9.02
1955	10.10	3.22	1.58	1.12	2.13	8.25	6.96	11.00	13.00	15.20	22.00	10.80	8.78
1956	9.18	3.15	1.97	1.53	5.00	8.34	10.20	6.35	11.70	20.50	11.60	6.00	7.96
1957	2.65	1.46	.89	.50	2.25	2.83	*******	*******	5.17	13.70	9.95	5.37	4.48
1958	3.54	3.31	1.57	1.02	3.64	4.35	6.45	9.43	9.15	10.50	8.02	4.48	5.45
1959	2.36	1.32	.74	.61	1.09	2.70	2.78	3.59	4.26	13.40	9.16	11.70	4.48
1960	5.45	2.19	2.27	2.83	6.93	7.80	*******	*******	*******	*******	15.00	25.60	8.51
1961	4.03	2.03	1.14	1.17	2.07	5.39	4.72	5.26	8.57	13.60	11.80	9.50	5.77
1962	3.26	1.76	1.01	.92	1.41	2.19	3.04	7.83	6.70	9.12	9.50	7.14	4.49
1963	2.78	1.85	1.00	2.06	4.61	5.58	6.76	8.85	8.99	12.90	14.60	4.63	6.22
1964	2.27	1.18	.75	.89	3.38	11.40	11.30	11.50	13.70	15.00	17.70	5.25	7.86
1965	3.99	1.92	1.07	.61	.97	2.00	1.78	4.19	3.32	7.01	8.79	9.35	3.75
1966	3.18	1.52	1.00	1.08	6.65	9.09	7.25	*******	*******	14.20	19.20	14.60	7.78
1967	4.49	2.15	1.10	1.75	5.53	13.40	9.64	11.30	14.80	17.20	11.30	5.17	8.15
1968	2.38	1.71	1.07	.96	2.73	7.96	5.92	8.43	8.86	15.20	14.70	6.92	6.40
1969	2.86	1.65	.82	1.28	2.67	5.58	*******	*******	13.80	11.70	12.80	7.66	6.08
1970	6.22	2.70	2.28	2.39	7.46	4.94	5.55	12.40	10.40	15.80	12.60	26.30	9.09
1971	11.10	3.80	2.16	1.55	6.50	9.11	8.27	11.40	11.20	14.40	18.10	4.40	8.50
1972	2.87	1.85	1.43	3.84	2.72	5.21	2.09	3.39	8.56	8.28	7.83	3.11	4.26
1973	1.75	1.40	1.10	1.12	2.57	9.93	11.20	8.82	16.00	17.70	20.80	11.00	8.62
1974	4.36	2.01	1.60	1.24	2.22	4.77	5.96	7.54	8.60	24.10	14.60	7.61	7.05
1975	2.48	1.52	1.26	1.05	1.92	4.27	6.07	12.10	17.30	18.80	28.00	15.90	9.22
1976	5.97	2.34	1.50	1.48	3.33	2.96	1.49	1.93	6.41	15.70	11.20	3.77	4.84
1977	1.85	1.41	1.14	1.04	2.15	2.78	2.67	6.98	7.93	15.70	12.10	6.25	5.17
1978	2.31	1.58	1.28	6.30	6.18	9.53	8.94	14.40	13.00	17.10	18.70	9.51	9.07
1979	2.65	1.39	.87	1.66	3.54	6.52	7.02	10.20	11.50	14.00	8.33	7.06	6.23
1980	6.22	2.74	1.47	.99	3.62	7.27	5.23	8.91	6.78	13.90	13.80	8.94	6.66
1981	5.76	3.95	3.13	7.53	12.80	14.30	13.40	13.20	11.60	15.90	18.90	14.20	11.22
1982	6.69	3.15	2.04	2.11	2.63	4.03	2.69	2.75	6.40	11.70	8.51	2.34	4.59
1983	1.65	1.08	.67	.50	2.28	3.28	2.04	2.93	10.70	8.29	7.80	8.11	4.11
AVE.	4.28	2.23	1.34	1.58	4.00	6.48	6.70	8.24	9.99	13.81	14.25	9.47	6.95

Gatun Watershed

Gatun Ciento 122km2

DISCHARGE TABLE

(UNIT : m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1943	**********	**********	**********	**********	5.56	**********	**********	7.21	7.03	10.60	13.00	19.50	10.48
1944	4.65	2.32	1.19	2.79	9.05	5.04	7.46	12.10	5.97	20.40	15.40	20.20	8.88
1945	5.68	3.26	1.54	.91	2.68	3.19	**********	**********	**********	**********	**********	**********	2.88
1946	**********	**********	**********	1.24	2.57	3.34	9.06	6.31	8.95	6.89	7.83	16.00	6.91
1947	4.74	2.52	1.36	*******	2.11	5.73	*******	8.28	7.76	8.99	10.80	9.37	6.17
1948	4.17	2.42	1.50	.85	2.67	3.19	6.57	4.92	4.77	5.69	9.93	3.85	4.21
1949	1.28	1.28	.96	.91	2.57	6.28	6.80	6.99	7.13	**********	**********	9.81	4.40
1950	3.01	2.28	1.71	1.82	3.75	5.91	8.54	7.22	6.17	6.19	17.30	20.90	7.07
1951	3.60	4.70	2.40	2.06	4.16	3.95	**********	**********	7.42	9.98	10.30	6.98	5.55
1952	3.06	2.31	1.92	1.47	2.45	5.11	8.04	7.39	7.29	**********	**********	**********	4.34
1953	*******	5.32	2.64	2.38	4.93	*******	8.76	7.95	9.25	17.00	18.80	9.02	8.61
1954	3.89	2.82	1.45	1.55	5.96	5.87	11.40	9.49	9.11	8.84	15.40	10.10	7.16
1955	8.41	2.82	1.61	1.11	1.72	3.94	4.85	9.20	5.56	8.21	14.40	8.09	5.83
1956	6.48	2.43	1.76	1.13	**********	**********	9.12	*******	6.22	10.50	15.80	5.29	6.53
1957	.88	.49	.36	**********	**********	.51	.46	.57	1.28	5.17	11.50	4.18	2.54
1958	*******	3.07	2.43	1.49	3.20	4.48	4.82	3.68	6.50	6.10	*******	5.78	4.15
1959	2.65	1.62	1.13	1.01	1.88	3.45	3.31	4.14	7.98	9.85	16.80	26.00	6.65
1960	4.69	.94	.91	3.49	6.07	5.69	4.58	5.87	3.94	8.24	11.40	19.20	6.25
1961	2.77	1.57	1.14	1.10	2.47	8.90	7.16	6.85	8.20	12.70	15.70	8.05	6.38
1962	3.52	2.23	1.53	1.04	13.40	10.80	15.40	13.30	11.20	12.00	13.20	9.53	8.93
1963	9.70	2.86	1.65	1.32	7.49	13.30	12.20	19.60	15.30	18.80	34.10	6.17	11.87
1964	3.06	1.43	1.05	1.57	7.43	15.80	26.60	17.60	*******	26.40	30.80	10.70	12.95
1965	4.65	3.25	2.03	1.12	5.54	**********	**********	11.10	*******	35.50	56.30	25.50	16.11
1971	7.09	3.20	2.73	2.02	2.53	3.78	8.43	9.06	6.20	9.65	11.80	4.27	5.90
1972	10.10	3.18	1.99	3.29	4.09	8.47	4.96	3.71	7.76	9.12	8.57	10.10	6.28
1973	2.64	1.88	*******	.93	2.32	6.02	6.34	7.03	7.91	5.71	15.20	5.91	5.63
1974	4.85	2.70	.67	.42	.69	1.71	2.29	2.79	3.17	8.46	13.20	5.52	3.87
1975	3.03	1.97	**********	**********	.78	4.24	9.60	10.40	7.13	13.70	18.50	16.50	8.58
1976	4.32	2.18	1.47	1.64	2.10	2.60	1.29	2.13	6.81	9.82	14.10	4.98	4.45
1977	3.36	1.94	1.26	1.10	1.60	2.61	3.76	9.64	8.90	10.50	11.00	9.19	5.41
1978	4.33	3.66	2.66	6.03	6.60	8.03	11.10	12.90	10.10	8.95	18.00	9.68	8.50
1979	4.54	2.11	1.77	2.65	4.44	7.03	6.01	9.39	7.73	15.20	15.20	8.44	7.04
1980	7.39	3.69	2.19	1.69	4.97	8.15	3.70	5.06	4.58	8.05	9.32	8.47	5.60
1981	4.77	3.06	2.22	18.10	16.70	14.20	12.00	8.94	6.23	10.70	24.30	28.00	12.44
1982	8.86	5.57	3.25	2.61	2.36	6.12	6.43	3.98	5.37	11.20	6.80	2.57	5.43
1983	1.67	.90	.50	.74	2.00	2.84	2.80	6.35	6.91	9.58	9.00	17.90	5.10
AVE.	4.62	2.59	1.66	2.24	4.38	5.95	7.54	7.91	7.15	11.48	16.05	11.35	6.92

DISCHARGE TABLE

Gatun Watershed
Ciri Grande Los Cañones 186km2

(UNIT: m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1947	*******	*******	*******	*******	*******	21.90	25.60	21.10	*******	*******	19.80	9.21	19.52
1948	4.29	1.64	1.15	.85	1.88	2.69	10.50	12.30	11.70	10.80	22.10	5.98	7.16
1949	2.39	1.43	.92	.83	2.57	14.20	10.40	13.10	21.30	17.60	*******	24.50	9.93
1950	4.01	2.20	1.31	.92	7.00	*******	*******	20.20	13.30	18.20	23.90	24.00	11.50
1951	7.33	3.98	2.20	1.44	7.20	8.85	8.20	8.95	15.50	13.10	19.90	11.30	9.00
1952	4.80	2.24	1.17	1.03	4.03	10.60	8.13	8.63	14.80	21.40	13.30	19.00	9.09
1953	14.00	5.27	2.75	1.92	8.56	7.64	7.42	6.12	7.61	16.90	*******	13.30	8.32
1954	5.98	2.75	1.70	1.37	6.78	7.16	17.50	13.10	18.00	15.20	29.30	*******	10.80
1955	18.60	4.93	2.39	1.86	3.83	15.30	10.80	18.00	22.20	19.10	29.50	16.80	13.61
1956	17.20	4.53	2.87	2.67	10.60	15.40	14.40	10.70	17.40	*******	18.50	10.40	11.33
1957	1.05	2.04	1.29	.93	4.18	4.19	4.15	8.29	9.09	21.40	13.80	11.10	6.79
1958	6.81	5.21	2.73	1.92	6.22	7.51	10.50	*******	13.80	18.20	14.60	7.60	8.65
1959	*******	1.99	1.38	1.22	1.86	4.02	6.89	*******	*******	*******	*******	*******	2.89
1978	*******	*******	*******	*******	*******	*******	13.90	18.60	19.40	22.10	19.00	11.70	17.45
1979	8.24	6.59	6.08	6.67	9.93	15.40	15.70	21.30	25.60	25.10	9.86	8.77	13.27
1980	10.70	3.68	2.01	1.45	5.36	10.70	7.95	18.60	8.95	15.20	15.50	12.60	9.39
1981	11.40	9.23	8.02	13.00	21.00	22.80	20.20	14.70	14.50	21.70	20.70	19.60	16.40
1982	7.92	3.45	2.30	2.65	4.55	7.51	6.30	4.69	8.67	17.00	12.60	3.80	6.79
1983	2.39	1.49	.88	.54	4.41	5.67	4.13	5.28	17.10	12.60	12.30	15.50	6.86
AVE.	7.94	3.69	2.42	2.43	6.47	10.68	11.26	13.16	15.23	17.85	18.42	13.24	10.46

DISCHARGE TABLE

Madden Watershed

Chagres Chico 414km^2

(UNIT : m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1933	**********		11.40	9.05	19.50	21.30	20.40	24.30	30.90	19.20	42.10	67.60	26.58
1934	24.90	11.00	8.23	12.20	31.90	32.80	**********	**********	**********	51.50	62.90	41.80	30.80
1935	39.50	17.70	11.70	8.48	26.80	25.40	64.60	43.40	34.90	30.40	178.00	104.00	48.74
1936	15.90	9.53	7.76	9.40	38.20	24.40	30.50	33.50	40.20	38.80	42.60	24.80	26.30
1937	38.50	20.30	11.20	9.87	20.00	22.10	24.50	28.60	34.10	44.40	54.50	81.70	32.48
1938	20.40	14.50	11.00	*******	53.60	41.20	37.20	67.80	41.10	41.50	51.00	107.00	44.21
1939	25.80	12.10	9.30	8.88	10.00	19.70	15.00	23.10	23.90	23.40	49.30	41.10	21.80
1940	22.00	16.00	14.20	11.90	15.50	18.10	15.60	26.90	22.40	35.60	31.80	21.40	20.95
1941	15.00	22.10	17.50	11.90	22.20	37.30	28.10	37.50	40.40	75.60	67.00	43.40	34.83
1942	21.20	15.90	16.00	24.70	17.90	29.70	33.10	32.20	39.20	51.30	40.90	34.60	29.72
1943	28.80	20.50	15.80	17.00	33.60	35.40	27.30	31.90	31.60	45.40	41.20	76.60	33.76
1944	26.70	20.20	10.70	17.80	37.70	31.10	42.00	42.90	37.40	56.30	53.50	89.10	38.78
1945	29.40	17.80	11.20	11.30	25.30	28.90	30.70	40.20	36.10	34.80	31.40	65.70	30.23
1946	19.80	14.40	9.81	12.70	24.10	27.70	39.60	42.80	34.90	30.80	25.50	58.70	28.40
1947	19.90	13.60	8.59	9.55	13.90	22.90	32.20	33.70	28.50	32.10	35.60	39.30	24.15
1948	16.50	8.99	6.32	6.06	14.20	23.70	40.00	31.50	26.60	38.90	45.80	29.50	24.01
1949	15.00	9.36	6.86	7.15	23.50	39.10	51.00	48.30	38.30	45.00	61.20	53.60	33.20
1950	20.60	17.10	10.70	20.00	40.40	30.10	53.90	45.80	32.90	26.20	50.80	60.10	34.05
1951	19.70	43.20	23.30	19.40	25.80	30.50	33.20	24.80	28.70	24.80	28.90	28.20	27.54
1952	18.40	12.40	9.02	10.60	24.10	23.90	31.50	38.20	35.00	49.40	31.50	53.20	28.10
1953	41.40	27.00	14.00	12.50	37.60	27.60	32.70	31.40	28.10	33.60	39.60	34.30	29.98
1954	18.30	13.70	12.40	12.80	21.70	34.60	34.70	39.10	38.20	25.00	64.20	63.20	31.49
1955	64.80	18.40	12.70	10.20	15.30	17.50	28.30	48.70	31.40	28.40	77.00	44.00	33.06
1956	62.40	21.70	19.20	19.80	43.40	37.20	63.90	34.10	35.80	44.60	86.30	41.50	42.49
1957	17.50	11.50	8.19	6.90	13.10	12.70	11.90	13.90	17.90	30.60	49.00	33.00	18.85
1958	32.90	14.80	10.70	7.32	17.60	21.30	22.10	25.20	27.00	27.70	33.30	27.20	22.26
1959	12.70	8.58	6.69	9.73	17.90	17.50	16.40	18.40	32.10	33.20	55.00	89.50	26.48
1960	53.90	12.30	8.95	21.40	27.40	29.60	30.80	29.10	30.10	34.30	35.30	94.00	33.93
1961	18.40	10.10	8.17	11.90	18.50	43.10	26.80	33.40	31.50	37.80	45.00	28.40	26.09
1962	17.60	11.20	9.03	9.48	27.60	20.20	33.00	44.10	38.10	36.40	40.60	31.80	26.59
1963	37.80	19.30	12.90	27.30	39.00	41.30	47.70	45.70	49.40	37.70	43.90	25.40	35.62
1964	15.40	12.10	9.92	16.90	26.90	45.50	28.00	26.40	31.70	27.90	39.20	22.20	25.18
1965	18.20	14.10	11.90	10.70	23.70	33.10	23.30	30.70	40.30	50.80	50.10	51.40	29.86
1966	25.90	16.80	12.60	34.70	41.00	32.70	34.00	30.40	38.10	42.30	*******	77.10	35.05
1967	33.90	19.80	16.40	31.20	43.00	49.50	44.80	33.90	35.30	30.50	36.10	37.10	34.29
1971	31.10	16.30	*******	10.40	31.00	31.90	43.00	37.20	31.20	29.60	37.70	20.70	29.10
1972	51.10	19.20	11.10	22.50	40.70	21.80	14.90	11.40	19.20	30.80	32.90	20.50	24.68
1973	12.90	9.07	6.19	5.51	16.00	27.60	28.10	31.40	27.90	34.60	54.60	43.00	24.74
1974	27.30	14.20	10.40	8.15	13.50	17.30	21.70	30.30	30.40	40.30	38.00	15.80	22.28
1975	11.60	7.12	4.82	**********	29.80	48.20	53.60	34.30	46.40	58.60	59.00	35.34	
1976	25.30	13.50	10.80	12.50	**********	**********	**********	**********	**********	**********	**********	**********	15.52
1977	15.40	10.50	7.80	7.84	14.50	16.70	23.10	28.70	26.30	57.00	46.50	33.20	23.96
1978	13.40	11.30	8.10	28.80	27.70	42.00	47.60	49.20	32.00	34.50	42.90	23.10	30.05
1979	12.30	9.14	7.18	17.90	17.20	23.60	27.10	36.40	31.50	28.30	42.30	40.60	24.46
1980	30.70	18.50	10.30	11.00	22.20	29.10	18.00	21.20	23.50	30.50	43.10	39.20	24.77
1981	27.50	21.20	17.50	103.00	50.10	39.00	41.80	40.60	28.60	34.40	42.90	66.10	42.72
1982	33.50	14.10	8.90	12.20	22.30	19.20	33.60	31.90	30.30	48.50	33.30	20.20	25.67
1983	14.90	8.27	5.84	5.51	37.60	22.20	19.50	21.60	28.40	35.40	42.10	75.20	26.38
1984	32.50	18.30	9.39	6.72	21.50	37.30	49.20	81.00	60.90	68.20	70.30	44.40	41.64
1985	23.60	14.50	14.50	9.94	22.80	41.20	32.50	25.90	47.10	39.70	37.80	66.90	31.37
1986	22.60	13.00	12.50	27.30	58.40	33.30	26.20	21.70	40.00	66.90	65.50	33.70	35.09
AVE.	25.90	15.33	10.99	15.72	27.09	29.21	32.72	34.78	33.34	38.83	49.16	48.46	29.95

DISCHARGE TABLE

Madden Watershed
Boquerón Peluca 91km2

(UNIT: m^3/s)

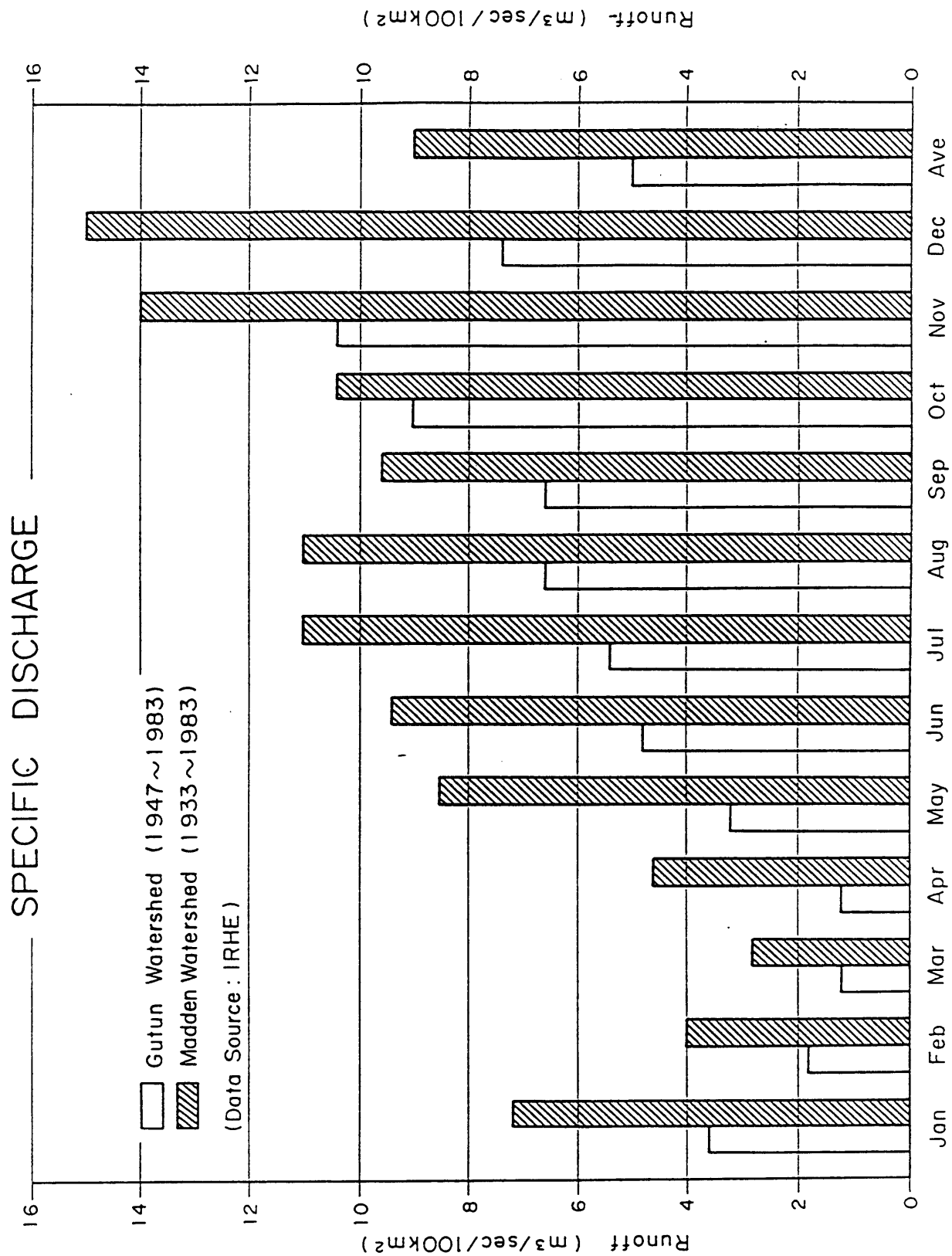
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1933	**********	**********	**********	**********	**********	**********	**********	**********	0.78	3.50	16.50	19.50	11.34
1934	4.94	1.68	.91	1.38	10.00	7.72	7.09	7.36	8.57	8.55	15.90	9.54	6.97
1935	7.51	3.25	2.29	2.19	9.50	5.60	15.00	9.60	5.74	5.60	39.60	20.70	10.55
1936	3.06	1.32	.75	1.80	8.77	4.80	10.40	8.68	9.91	9.53	12.60	4.85	6.37
1937	9.50	3.50	1.54	1.59	7.25	6.77	9.24	10.40	7.18	9.60	12.20	20.90	8.31
1938	4.07	2.66	1.31	5.30	15.20	18.30	6.91	12.10**********	**********	**********	10.70*******	**********	8.51
1939	4.88	1.77	2.02	2.32	2.32	7.37	7.98	15.20	8.53	6.58	19.60	14.10	7.72
1940	6.60	3.82	2.42	1.72	4.65	7.25	7.52	15.70	8.36	6.61	9.31	4.93	6.57
1941	2.95*******	**********	2.82	1.87	7.36*******	**********	10.70	12.00	6.94	19.20	15.80	8.19	8.78
1942	3.00	2.55	3.03	5.96	5.39	13.70	10.20	11.40	10.90	12.20	8.35	5.42	7.67
1943	4.17	3.67	2.63	2.92	9.01	11.10	8.39	12.40	11.20	8.75	9.22*******	**********	7.59
1944	4.07	3.61	2.05	4.41	16.00	8.81	11.30	15.40	10.20	19.20	22.60	38.40	13.00
1945	5.17	2.52	1.60	1.38	8.13	7.03	11.90	13.20**********	**********	**********	8.37	11.80	7.11
1946	3.81	1.80	1.16	1.54	4.84	6.62	12.60	6.39	6.84	3.57**********	**********	**********	4.92
1947	2.49	2.21	1.24	1.46*******	**********	8.42	15.80	11.70	5.51	4.94	5.03	8.27	6.10
1948	2.94	1.72*******	**********	1.32	3.58	5.17	12.90**********	**********	**********	**********	**********	**********	4.61
1949	2.38	1.60	1.32**********	**********	**********	11.60	15.00	11.70	8.81	10.40	13.20	13.80	8.98
1950	3.10	3.64	1.92	4.32	9.14	7.48	24.00	9.49	5.65	5.54	10.90	19.20	8.70
1951	3.89	9.70	4.68	5.80	7.47	7.38	5.02	8.11*******	**********	8.15	8.01	8.68	6.99
1952	3.68	2.17	1.39	2.67	4.43	6.38	11.70	13.90	8.98	11.20	5.91	16.30	7.39
1953	11.60	9.56	2.28	2.21	8.88	6.87	8.88	8.21	6.32	6.87	13.20	9.53	7.87
1954	3.38	2.63	1.82	3.89	7.48	10.50	13.30	15.10	7.45	6.14	19.20	22.00	9.41
1955	15.50	2.95	1.92	1.64	4.54	4.48	7.69	14.60	5.83	3.87	15.20*******	**********	7.11
1956	13.50	4.67	4.90	4.08	14.40	9.03	12.90	6.68	7.31	5.11	16.90	13.60	9.42
1957	2.91	1.60	1.17	1.01	4.69	3.20	2.24	4.17	4.85	6.57	16.90	11.40	5.06
1962	5.58*******	**********	1.22	1.38	5.70	5.39	10.10	11.20	6.90	7.78	9.89	6.92	6.55
1963	8.11	2.39	1.50	2.32	13.50	9.75	9.69	10.50	8.73	5.43	8.89	4.30	7.09
1964	2.13	1.19	1.13	1.39	6.72	13.00	10.40	7.92*******	**********	6.54	9.35	3.94	5.79
1965	3.77	1.78	1.60	1.50	5.08**********	**********	**********	4.96	7.06	10.60	14.70	13.20	6.43
1966	5.72	2.91	2.33	7.87	10.10	5.72	5.23	5.23	8.43	6.68	26.00	14.50	8.39
1967	5.12	3.01	2.40	6.48	9.94	8.98	14.90	6.60	6.18	4.21	10.60	9.48	7.32
1968	2.23	1.97	3.11	8.77	6.79	4.46	8.91	8.28	8.22	8.40	3.30	6.23	5.89
1969	2.66	2.29	2.00	2.24	6.06	3.33	5.39	8.53	6.38	6.84	7.31	22.50	6.29
1970	19.70	2.86	1.99	8.26	14.30	7.71	8.63	9.66	7.40	6.83	13.30	29.10	10.81
1971	4.66	1.96	2.75	1.08	3.98	8.28	14.20	8.72	6.37	6.46	8.35	3.78	5.88
1972	31.90	6.54	2.46	5.32	18.20	9.75	7.95	6.95	13.70	9.50	10.70	8.93	10.99
1973	3.37	2.11	1.03	.95	5.42	6.87	10.30	7.95	6.07	6.14	20.20	15.30	7.14
1974	6.00	2.48	1.87	1.67	3.50	7.61	10.40	8.79	6.04	7.72	19.00	6.71	6.82
1975	2.48	1.72	.96	.77	10.70	15.60	19.20	20.70	12.80	9.98	11.80	20.70	10.62
1976	5.81	3.31	2.57	5.29	5.10	6.85	4.76	4.52	7.65	7.37	15.30	3.66	6.02
1977	3.65	2.08	1.44	1.69	2.86	3.79	6.88	8.35	9.22	13.70	10.80	13.30	6.48
1978	2.24	3.20	2.27	10.10	18.20	12.80	4.66	10.40	8.22	5.89	8.91	4.98	7.66
1979	3.01	1.60	1.06	5.92	5.38	8.11	5.93	6.33	5.31	6.57	10.10	18.90	6.52
1980	5.71	2.42	1.21	1.40	6.11	11.40	4.84	4.10	4.28	8.14	8.51	12.10	5.85
1981	6.12	3.39	3.15	29.00	13.90	8.62	13.40	7.75	4.76	6.38	11.80	20.50	10.73
1982	6.54	2.92	1.52	2.71	2.55	3.63	8.39	11.60	7.38	11.70	6.00	3.70	5.72
1983	2.84	1.53	.87	2.67	9.03	7.78	8.55	8.20	7.89	9.32	9.93	32.40	8.42
AVE.	5.84	2.92	1.95	3.81	8.09	8.07	10.03	9.79	7.64	8.04	12.87	13.24	7.67

DISCHARGE TABLE

Madden Watershed
Pequeñi Candelaria 135km²

(UNIT: m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1943	-99.00	7.82	4.87	7.25	14.90	22.50	15.80	20.30	17.60	16.10	15.50	37.40	16.37
1944	9.29	9.20	3.83	5.72	20.90	15.00	20.90	24.40	16.40	24.60	26.40	54.10	19.23
1945	11.20	5.70	3.83	3.41	13.30	16.80	17.60	20.40	15.80	14.00	13.20	28.90	13.68
1946	5.35	3.79	2.62	3.75	12.90	17.20	27.50	16.10	16.00	15.40	11.70	34.50	13.90
1947	9.60	5.56	3.05	4.98	8.37	18.30	22.40	21.30	17.20	14.90	14.80	20.40	13.40
1948	6.61	3.50	2.26	2.29	7.26	11.80	20.40	15.10	17.10	15.90	17.90	10.10	10.85
1949	5.62	3.24	2.03	2.70	10.80	22.60	24.30	21.10	19.50	21.40	22.10	25.00	15.03
1950	7.54	7.42	4.18	8.79	22.30	16.20	38.10	25.90	16.60	13.00	21.90	31.40	17.78
1951	9.02	21.20	10.90	8.75	15.20	15.30	13.90	14.60	15.50	14.40	12.60	18.60	14.16
1952	7.95	4.75	2.69	3.54	12.10	11.60	19.20	24.30	18.00	23.00	14.80	23.70	13.80
1953	17.50	10.40	4.63	4.45	19.30	11.50	13.30	13.10	11.90	12.40	19.30	14.40	12.68
1954	6.70	4.80	4.45	6.39	13.60	16.50	17.80	19.20	15.00	10.80	30.70	29.20	14.60
1955	24.20	6.31	5.23	4.17	9.07	7.36	19.60	26.60	13.30	9.27	35.20	16.80	14.76
1956	23.50	9.41	9.23	9.34	25.10	17.80	23.50	15.10	14.90	13.00	28.00	22.00	17.57
1957	6.31	4.50	3.51	3.00	7.07	8.49	7.30	9.62	9.01	14.30	27.10	19.70	9.99
1958	19.70	7.52	5.98	4.14	8.94	9.50	16.30	12.80	18.30	14.30	19.30	13.50	12.52
1959	6.09	4.11	3.12	4.66	10.60	14.00	13.80	14.20	24.50	17.00	34.00	42.10	15.68
1960	19.00	5.62	4.63	15.90	17.40	16.80	15.80	12.90	11.80	12.70	19.40	38.70	15.89
1961	6.63	4.39	3.29	5.21	9.85	30.70	14.30	16.10	11.70	18.30	14.90	12.40	12.31
1962	5.67	4.28	3.25	3.98	12.90	11.80	22.70	21.60	16.30	15.80	18.00	13.50	12.48
1963	17.10	6.77	4.31	8.31	23.50	19.00	19.70	21.80	-99.00	-99.00	-99.00	-99.00	15.06
1964	4.73	3.39	3.04	5.81	14.30	22.20	17.10	15.90	13.50	12.30	17.10	8.80	11.51
1965	7.52	4.76	3.65	3.00	10.50	21.80	15.90	11.90	18.00	17.70	24.50	23.10	13.53
1966	11.10	5.78	4.28	15.70	19.00	15.10	13.60	13.90	17.60	15.60	44.60	35.30	17.63
1967	11.40	6.10	5.47	13.80	23.10	20.00	22.90	15.40	15.00	12.00	23.50	21.60	15.86
1968	5.90	4.80	5.39	6.56	17.70	15.30	17.80	17.20	17.40	16.00	14.60	11.30	12.50
1969	6.72	5.00	4.19	7.18	14.50	8.36	13.60	17.50	15.00	10.10	13.40	41.70	13.10
1970	36.80	11.60	8.33	20.80	24.70	12.90	14.80	18.00	17.10	19.40	20.20	41.80	20.54
1971	13.30	6.81	8.13	-99.00	10.40	18.30	25.10	14.40	11.00	13.00	12.70	8.70	12.89
1972	42.90	7.40	4.44	7.31	16.70	15.40	12.80	10.90	19.80	17.40	16.80	12.80	15.39
1973	6.27	3.78	1.79	1.36	10.80	11.80	18.20	18.10	12.40	12.40	27.20	18.80	11.91
1974	10.00	3.40	3.28	2.08	6.20	9.95	13.90	14.40	10.80	13.80	20.50	12.80	10.09
1975	4.87	3.20	2.61	1.93	14.80	18.40	21.60	30.60	19.20	18.10	22.60	29.10	15.58
1976	9.60	5.57	4.46	6.91	10.50	10.60	7.99	7.72	11.00	15.50	24.20	6.62	10.06
1977	6.19	4.18	3.04	3.32	5.45	7.14	11.50	18.00	14.20	25.40	19.60	21.20	11.60
1978	7.32	6.12	4.62	13.50	26.20	17.90	15.70	20.70	14.90	13.80	16.40	9.44	13.88
1979	4.04	3.50	2.43	10.90	10.10	15.10	11.70	13.40	10.10	13.70	18.10	26.50	11.63
1980	15.70	9.62	4.70	4.37	13.40	21.00	10.80	11.10	11.20	14.00	14.40	18.50	12.40
1981	12.70	8.07	6.48	43.10	20.90	39.00	41.80	40.60	28.60	34.40	43.00	66.10	32.06
1982	33.50	14.10	8.90	12.20	22.30	19.20	33.60	31.90	30.30	48.50	33.30	20.20	25.67
1983	14.90	8.27	5.84	5.54	37.60	22.20	19.50	21.60	28.40	35.40	42.10	75.20	26.38
AVE.	12.25	6.48	4.56	7.65	15.23	16.40	18.64	18.29	16.30	17.23	22.14	25.40	15.02


SPECIFIC DISCHARGE
Gutun Watershed (1947~1983)
Madden Watershed (1933~1983)
(Data Source : IRHE)
Runoff (m3/sec/100km2)
16
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ave

EVAPORATION RATIO

(UNIT : %)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Note
10.09	10.73	12.02	11.30	7.88	6.74	6.40	6.85	6.52	6.80	6.40	8.27	100.00	

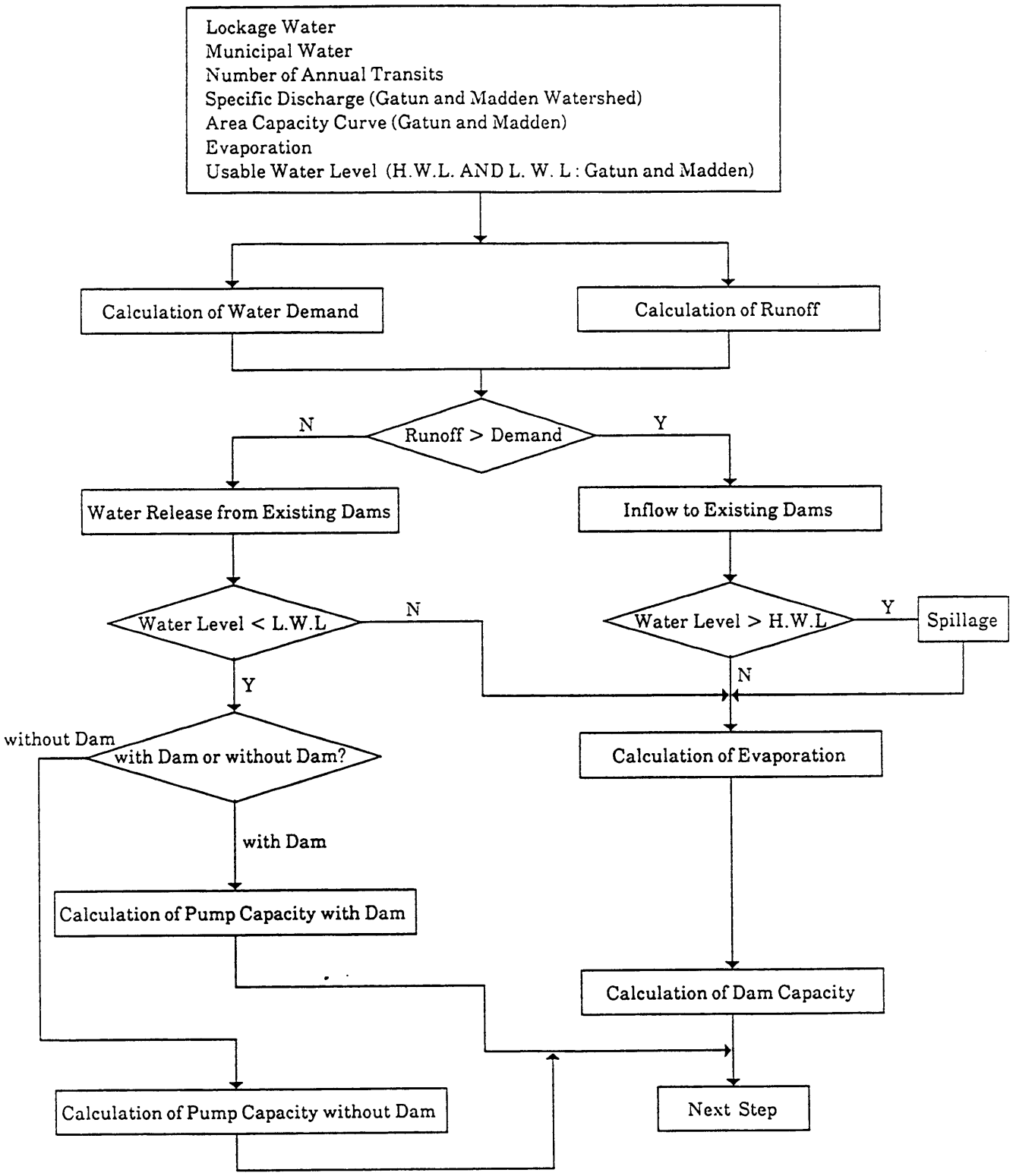
MONTHLY EVAPORATION

(UNIT : *mm*)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Gatun	140	149	166	156	109	93	89	95	90	94	89	114	1,384
Madden	137	145	162	153	107	91	87	93	88	92	87	112	1,354

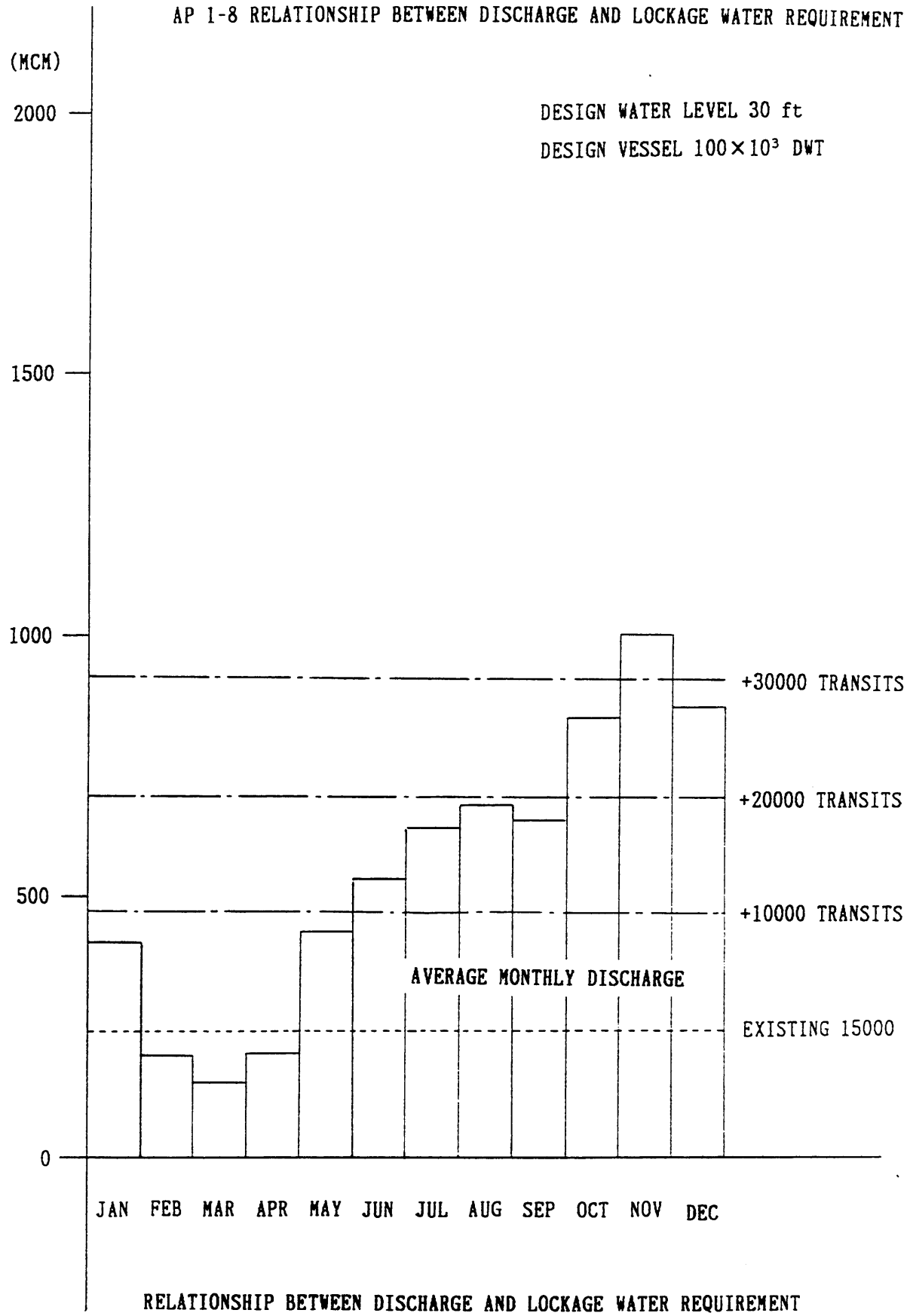
Data Source : IOCS MEMORANDUM JAX - 50

AP 1-7 FLOWCHART FOR WATER BALANCE SIMULATION

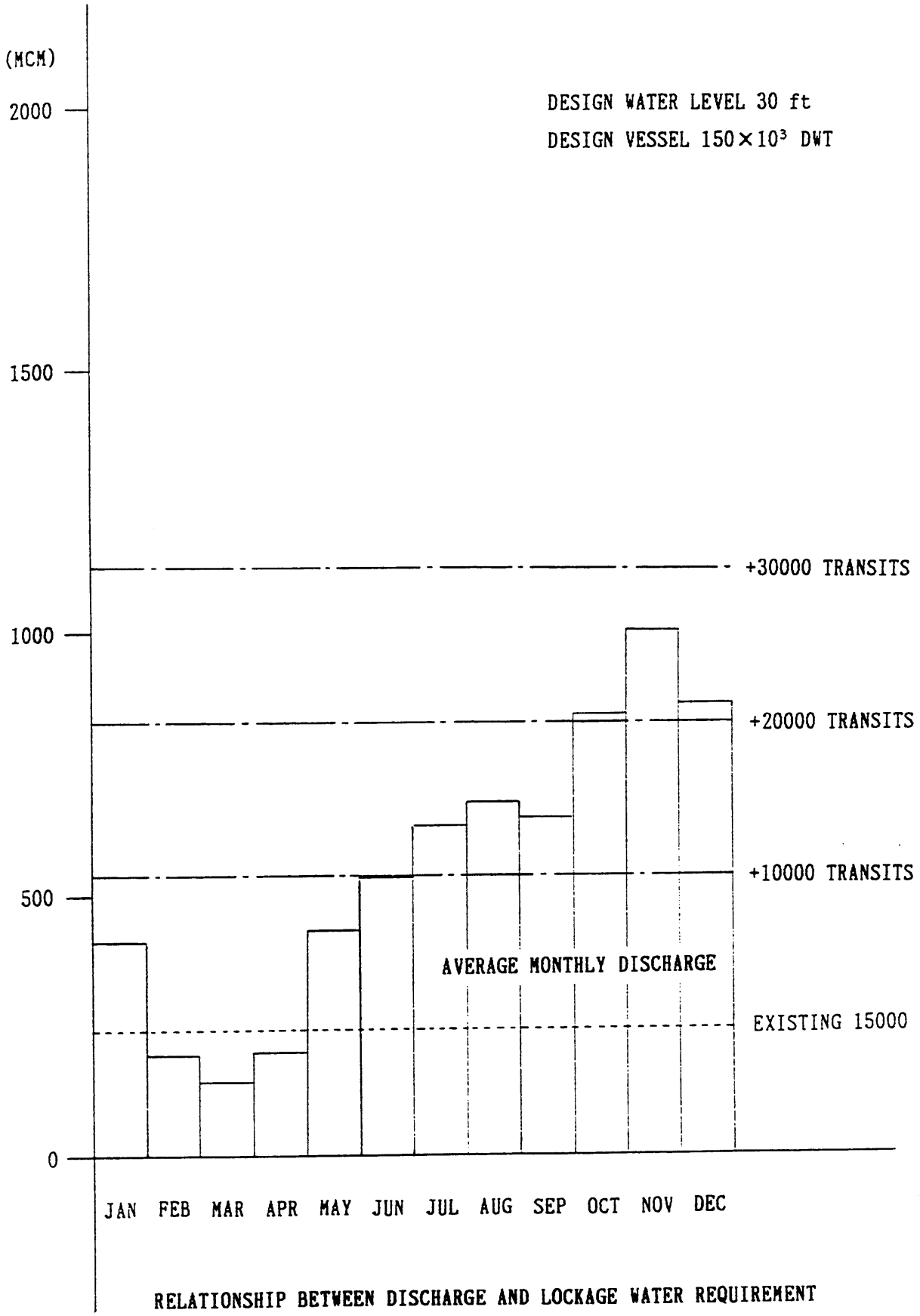


FLOWCHART FOR WATER BALANCE SIMULATION

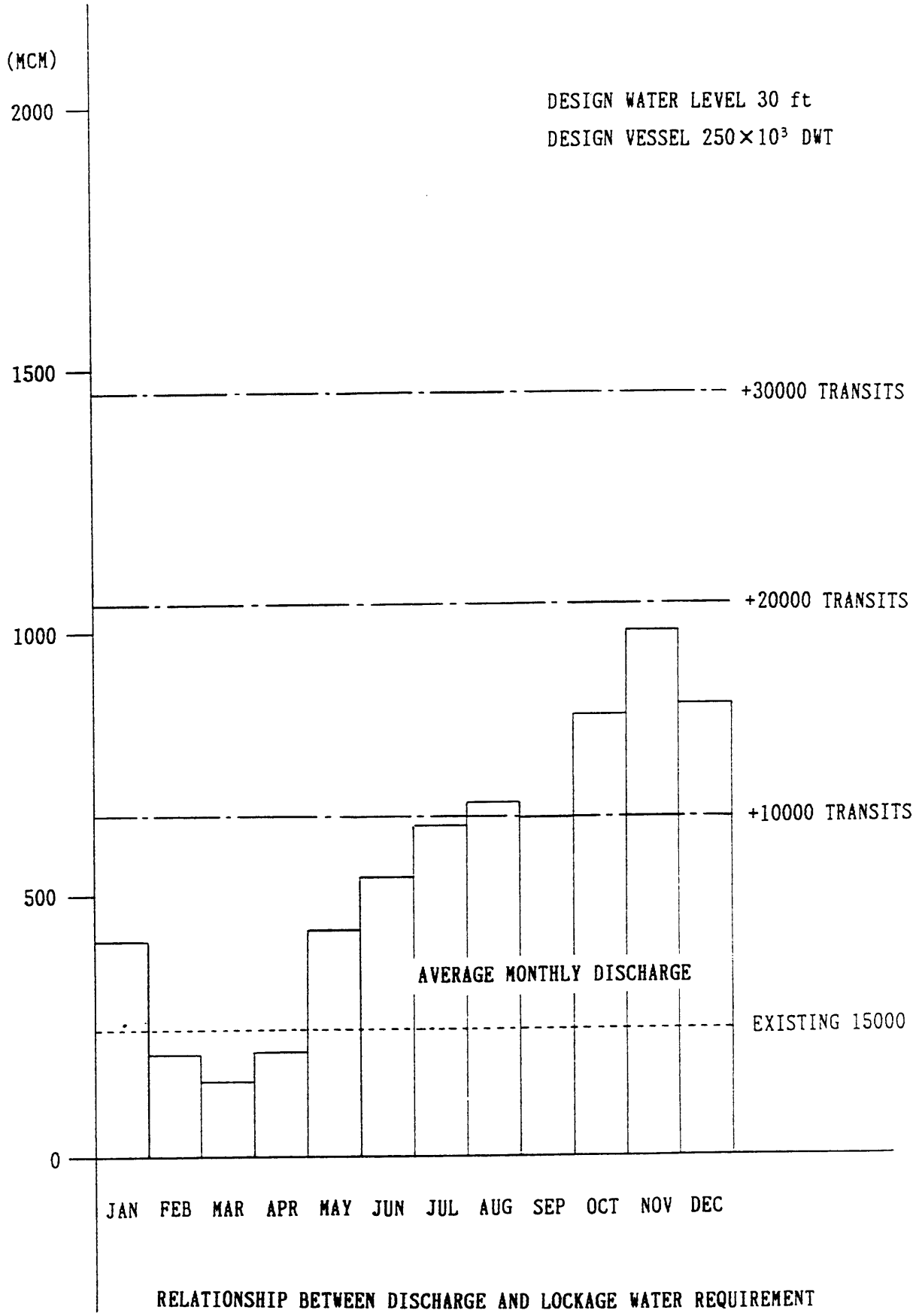
AP 1-8 RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



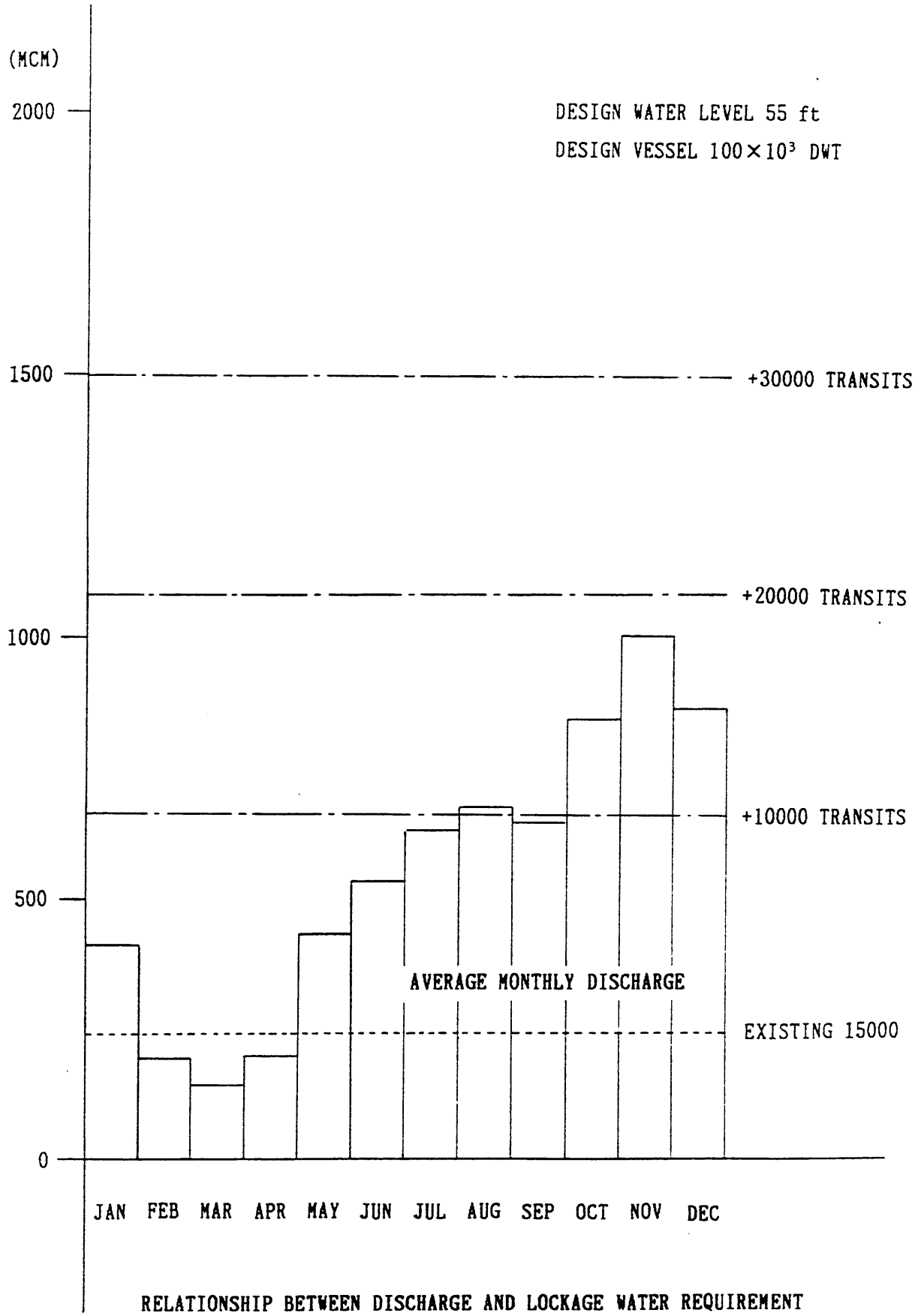
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



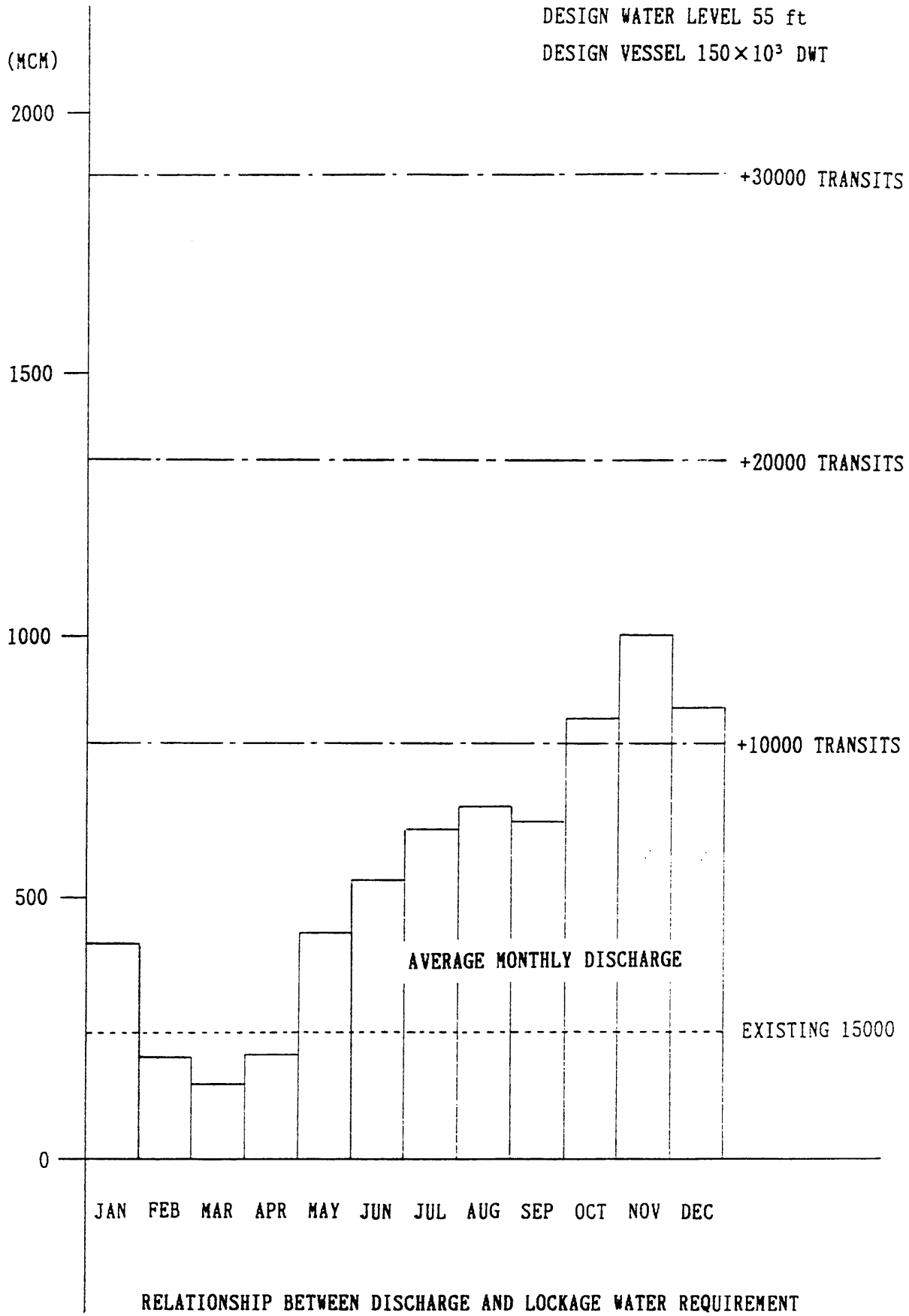
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



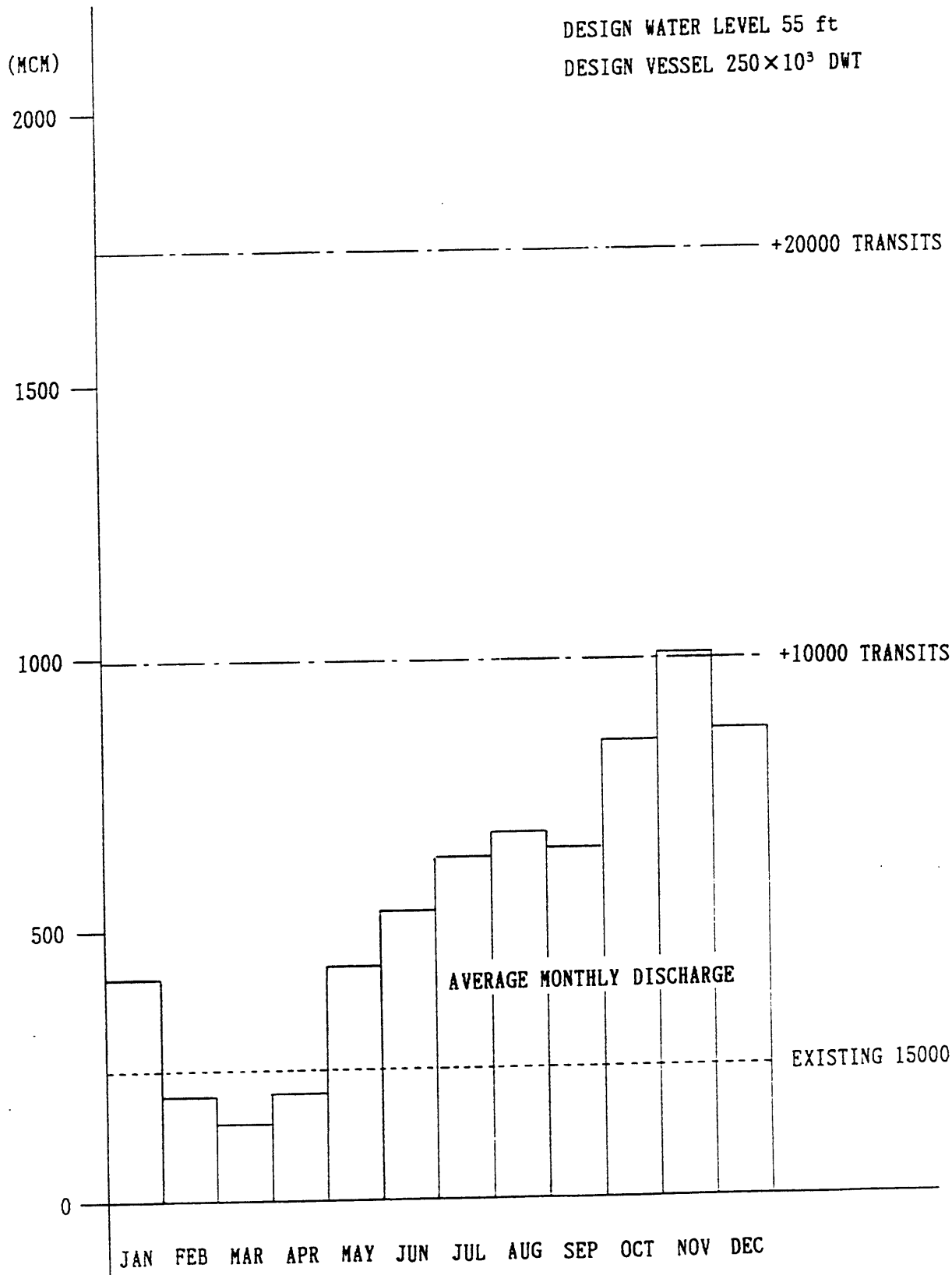
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



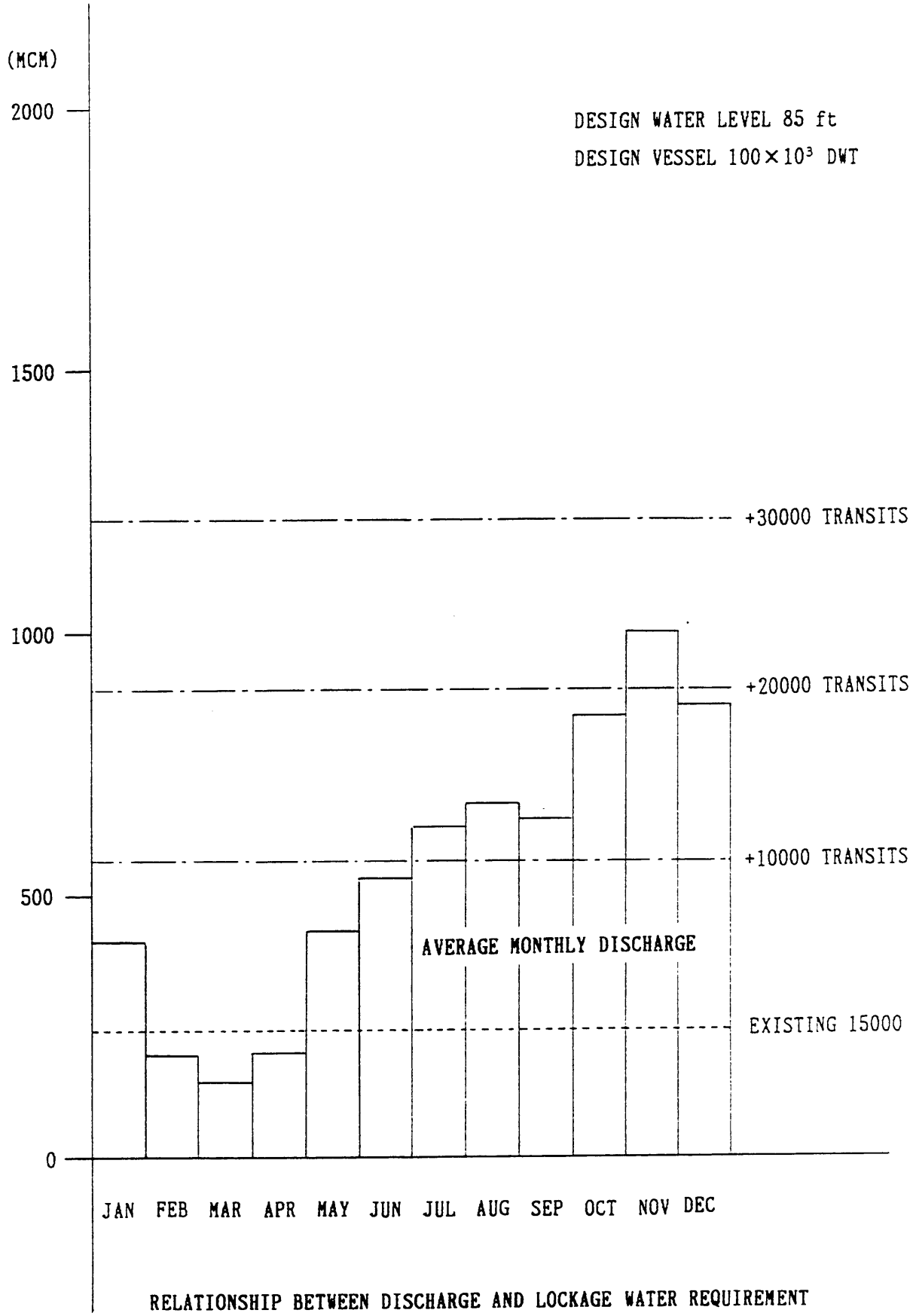
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



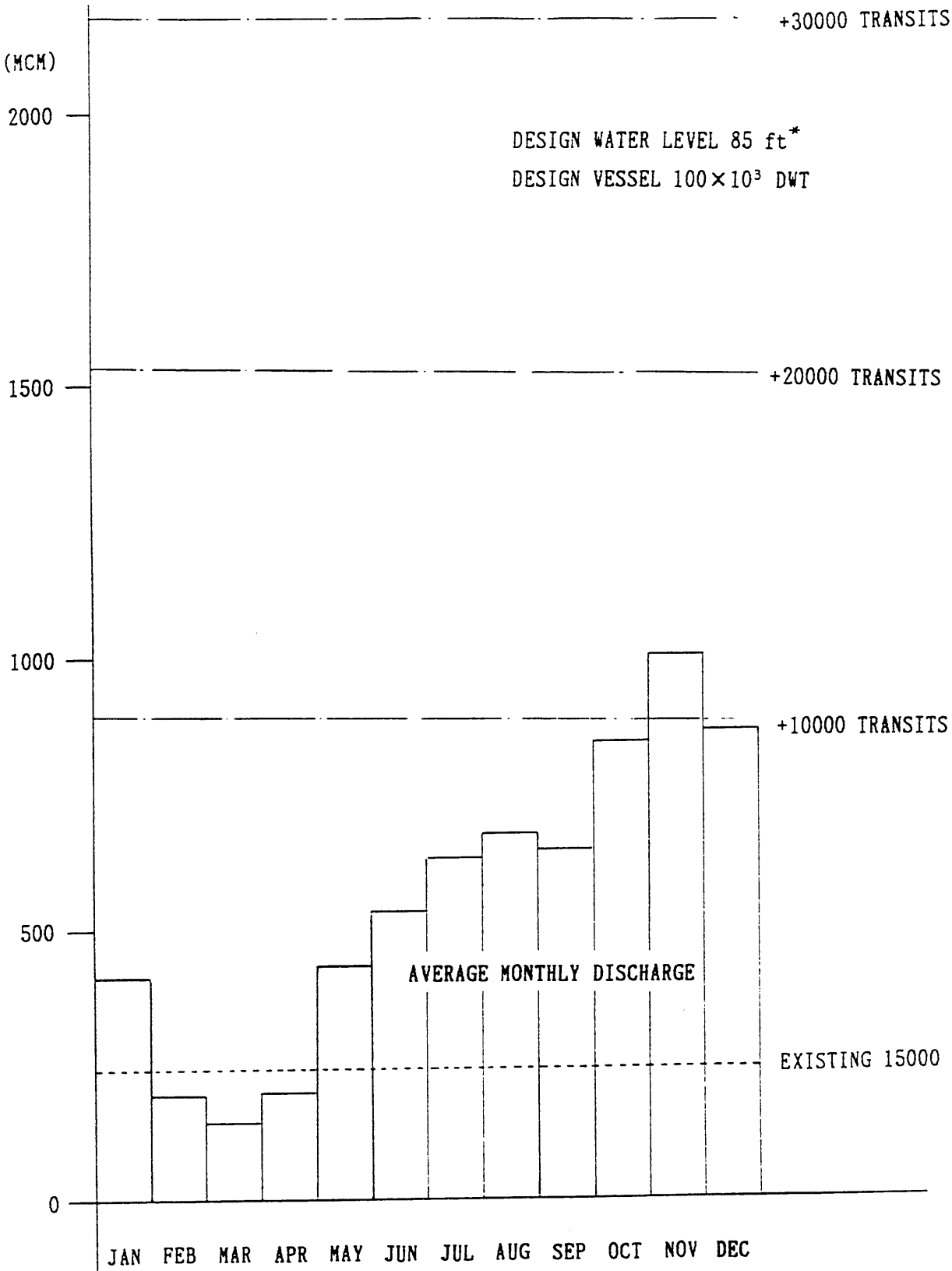
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



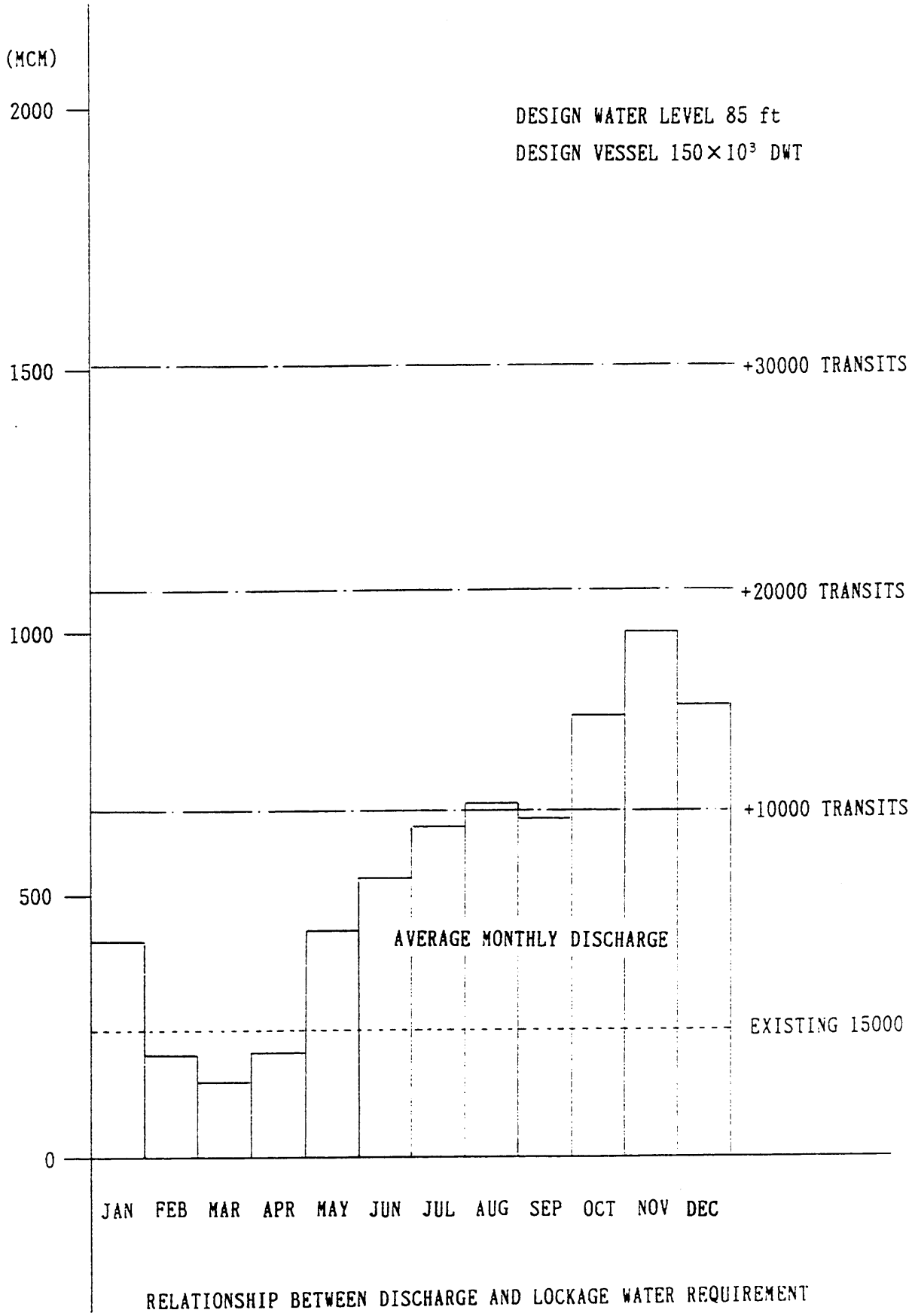
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



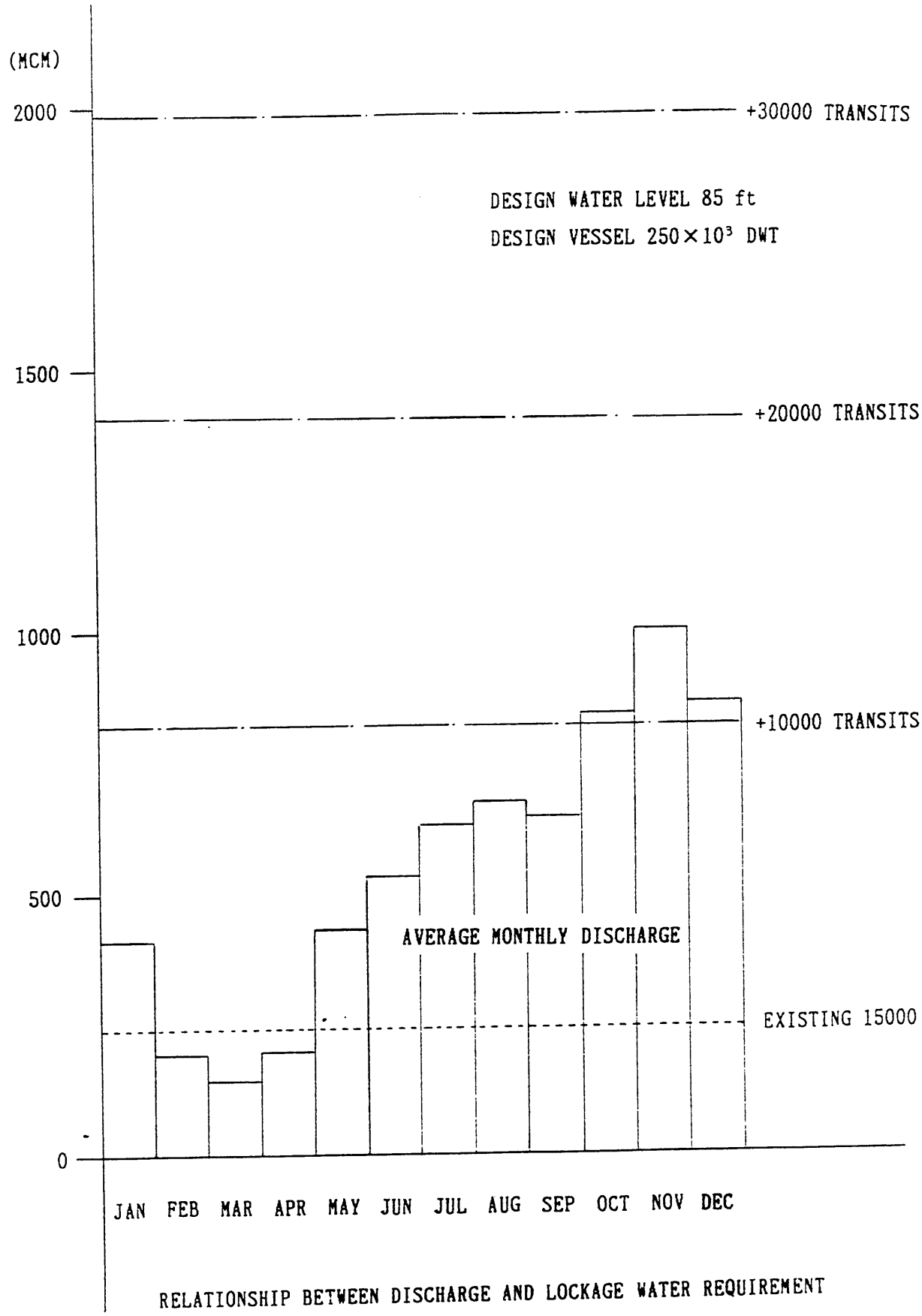
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



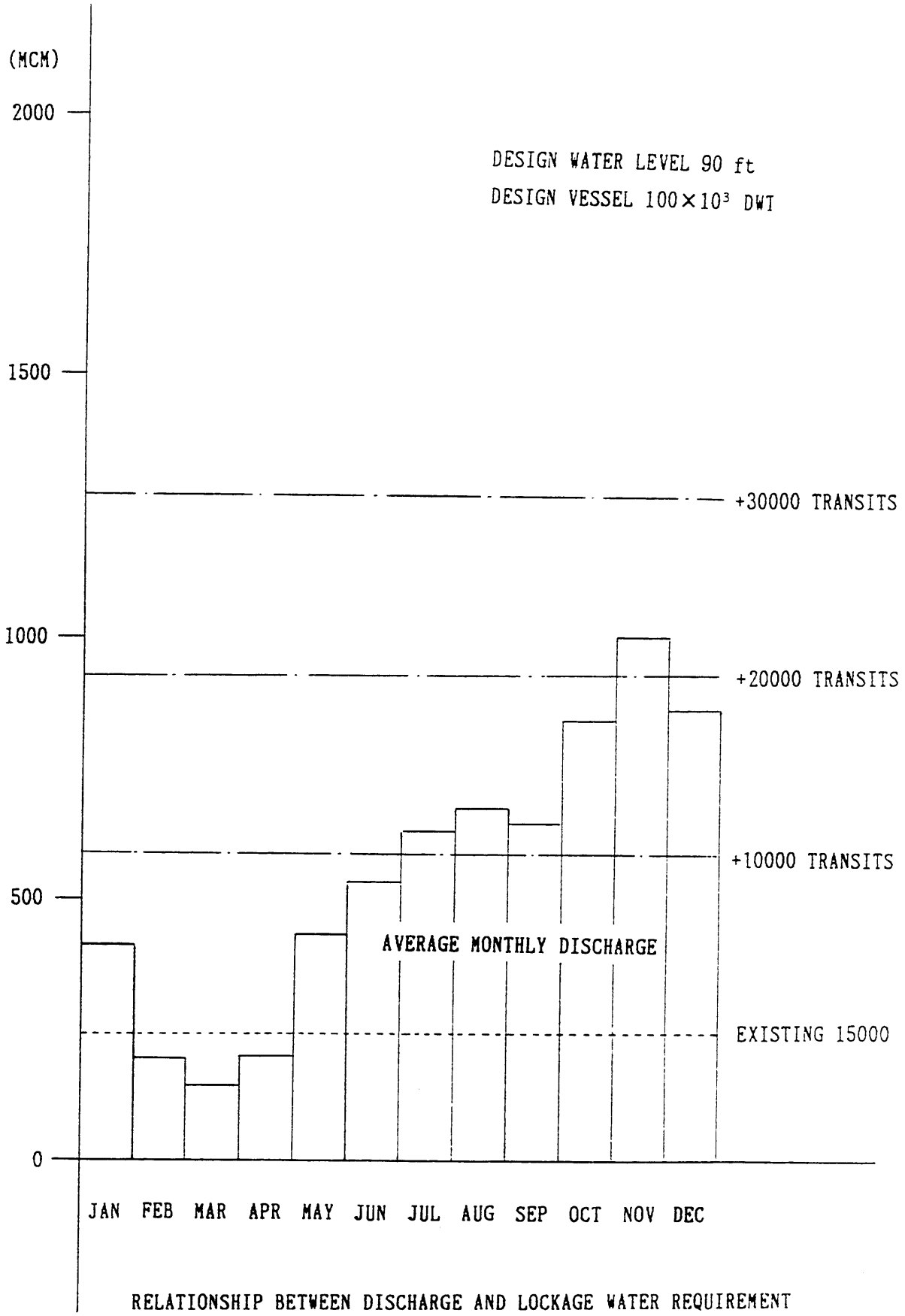
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



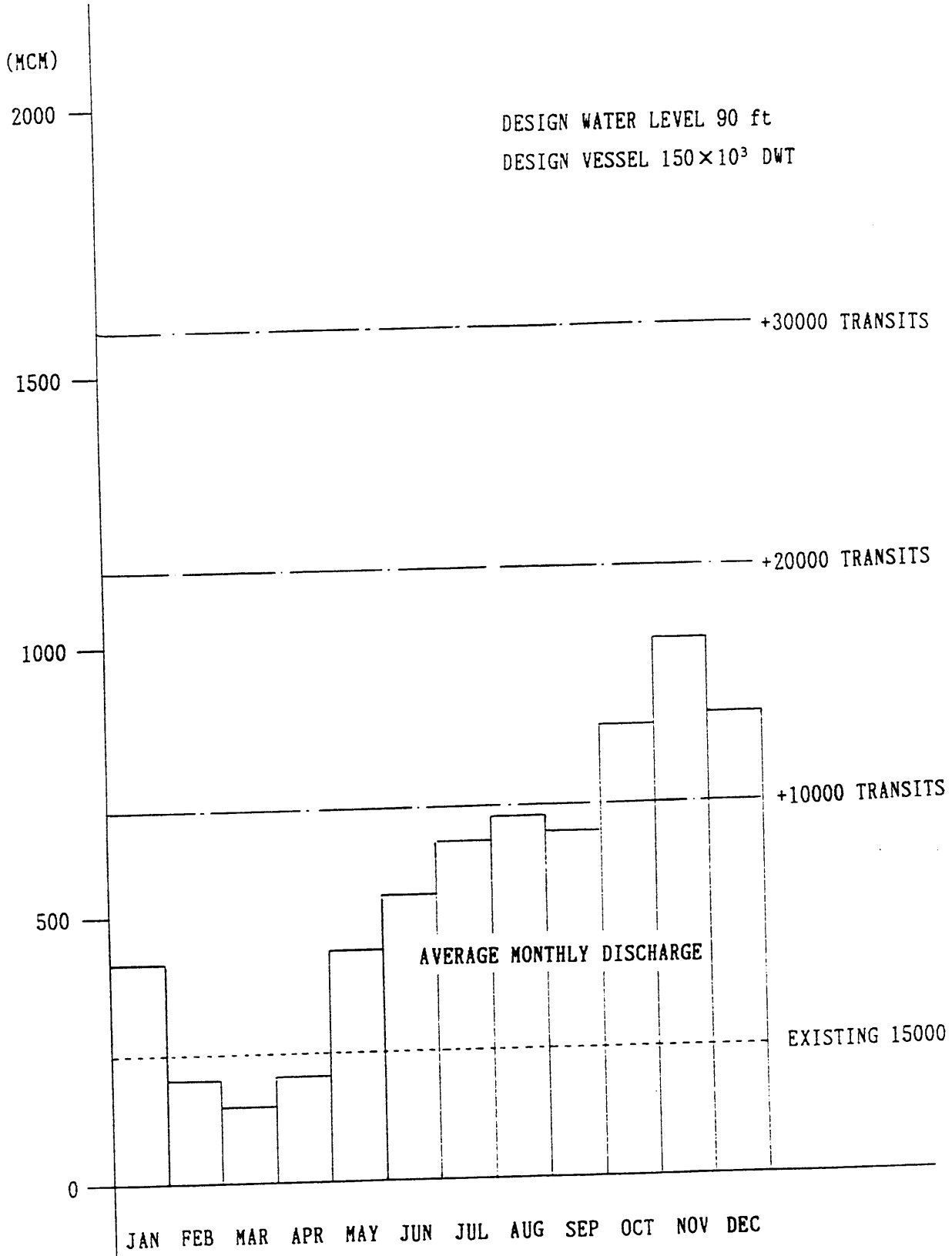
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



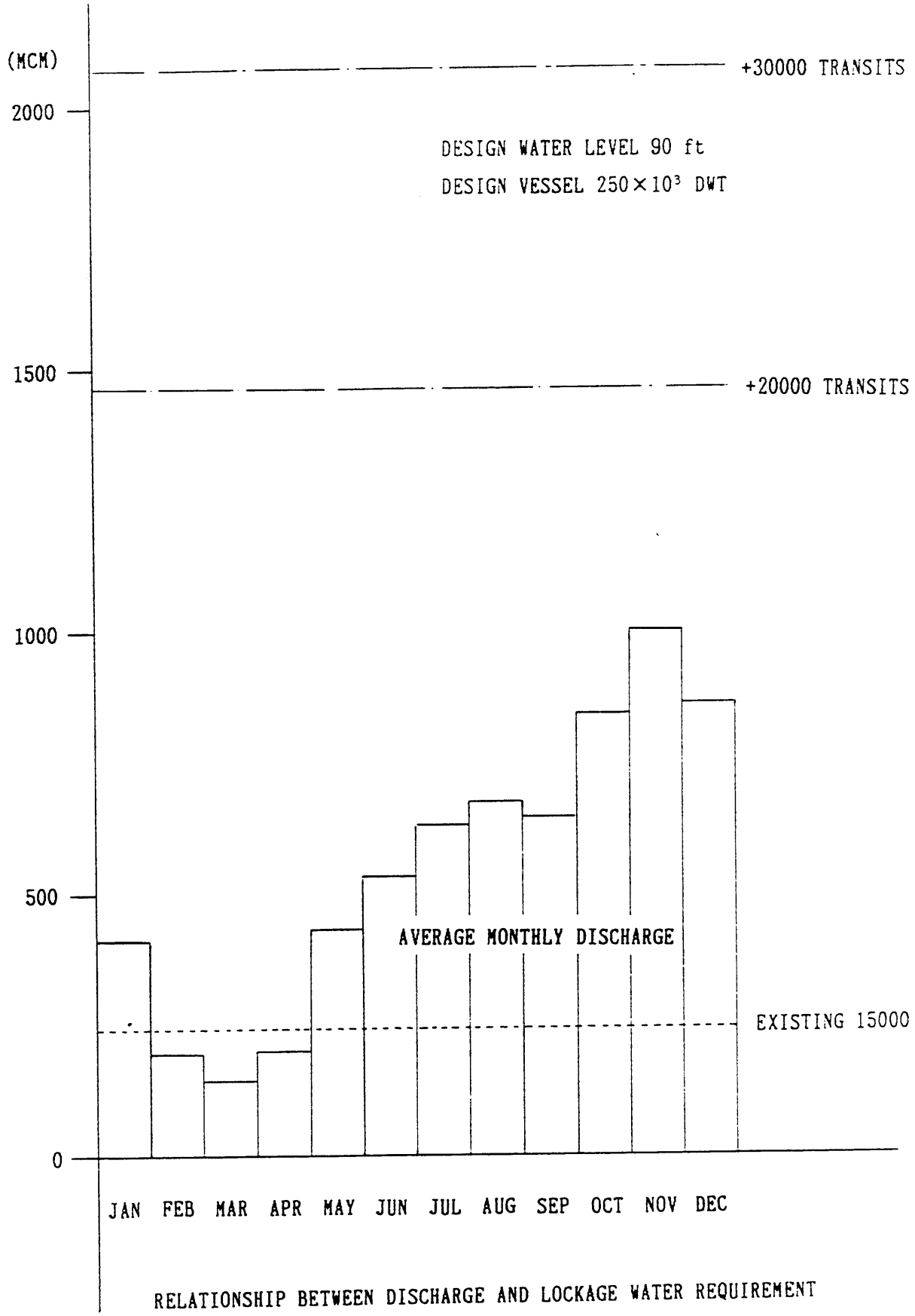
RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT



RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT

WATER BALANCE SIMULATION ON EXISTING CANAL

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 65×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5282.4	26.10	218.2	147.1	11.6	59.4	.1	753.1	76.20	197.7	103.3	11.6	7.2	75.6	0.	0.
FEB	5194.2	25.90	101.1	116.0	10.5	62.9	.0	721.2	75.56	96.0	110.2	10.5	7.2	.0	0.	0.
MAR	5060.5	25.60	70.9	122.3	11.6	70.6	.0	647.7	74.08	74.2	128.0	11.6	8.1	.0	0.	0.
APR	4966.4	25.38	81.2	97.8	11.3	66.3	.0	604.3	73.21	120.1	144.5	11.3	7.6	.0	0.	0.
MAY	4991.7	25.44	194.6	111.4	11.6	46.2	.0	691.1	74.95	242.7	139.0	11.6	5.3	.0	0.	0.
JUN	5098.8	25.68	288.2	130.5	11.3	39.4	.0	753.1	76.20	247.0	111.8	11.3	4.7	57.2	0.	0.
JUL	5250.9	26.03	333.8	132.4	11.6	37.7	.0	753.1	76.20	297.5	118.0	11.6	4.8	163.1	0.	0.
AUG	5282.4	26.10	379.8	250.4	11.6	40.6	45.8	753.1	76.20	297.2	.0	11.6	5.4	280.2	0.	0.
SEP	5282.4	26.10	397.7	242.3	11.3	38.6	105.5	753.1	76.20	250.9	.0	11.3	5.0	234.7	0.	0.
OCT	5282.4	26.10	559.5	250.4	11.6	41.0	256.5	753.1	76.20	281.7	.0	11.6	5.3	264.7	0.	0.
NOV	5282.4	26.10	627.5	242.3	11.3	39.0	334.9	753.1	76.20	373.1	.0	11.3	5.2	356.6	0.	0.
DEC	5282.4	26.10	453.8	250.4	11.6	49.3	142.5	753.1	76.20	409.5	.0	11.6	6.8	391.1	0.	0.
			308.8	174.4	11.4	49.2	73.8			240.6	71.2	11.4	6.0	151.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2314.2	25.65	218.2	263.6	11.6	59.0	.0	719.7	75.53	197.7	212.7	11.6	6.8	.0	0.	27.
FEB	2122.5	24.70	101.1	243.5	10.5	62.9	.0	611.3	73.35	96.0	186.7	10.5	7.2	.0	0.	24.
MAR	1867.2	23.24	70.9	270.8	11.6	70.6	.0	460.1	69.23	74.2	205.6	11.6	8.1	.0	0.	27.
APR	1679.4	22.13	81.2	217.4	11.3	66.3	.0	317.7	64.74	120.1	243.6	11.3	7.6	.0	0.	26.
MAY	1615.7	21.75	194.6	227.3	11.6	46.2	.0	294.3	63.90	242.7	249.1	11.6	5.3	.0	0.	27.
JUN	1621.1	21.78	288.2	258.1	11.3	39.4	.0	322.6	64.92	247.0	202.9	11.3	4.5	.0	0.	26.
JUL	1671.4	22.08	333.8	261.0	11.6	37.6	.0	388.8	67.26	297.5	215.3	11.6	1.3	.0	0.	27.
AUG	1751.0	22.55	379.8	275.2	11.6	40.2	.0	468.6	69.47	297.2	201.2	11.6	4.6	.0	0.	27.
SEP	1835.8	23.05	397.7	289.5	11.3	38.1	.0	532.4	71.23	250.9	171.5	11.3	4.4	.0	0.	26.
OCT	2048.9	24.31	559.5	321.8	11.6	39.8	.0	643.3	73.99	281.7	154.6	11.6	4.6	.0	0.	27.
NOV	2359.9	25.88	627.5	293.4	11.3	37.6	.0	753.1	76.20	373.1	167.6	11.3	4.6	80.0	0.	26.
DEC	2403.5	26.10	453.8	375.3	11.6	48.9	1.2	753.1	76.20	409.5	101.1	11.6	6.5	290.3	0.	27.
			308.8	274.7	11.4	48.9	.1			240.6	192.7	11.4	5.7	30.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2295.2	25.56	218.2	496.9	11.6	59.0	.0	718.5	75.51	197.7	213.9	11.6	6.8	.0	0.	241.
FEB	2047.3	24.30	101.1	493.3	10.5	62.9	.0	648.2	74.09	96.0	148.6	10.5	7.2	.0	0.	218.
MAR	1702.9	22.27	70.9	574.2	11.6	70.6	.0	566.2	72.16	74.2	136.5	11.6	8.1	.0	0.	241.
APR	1442.0	20.64	81.2	497.8	11.3	66.3	.0	477.4	69.71	120.1	190.0	11.3	7.6	.0	0.	233.
MAY	1363.4	20.10	194.6	456.5	11.6	46.2	.0	448.8	68.92	242.7	254.3	11.6	5.3	.0	0.	241.
JUN	1367.5	20.13	288.2	466.7	11.3	39.4	.0	459.0	69.20	247.0	221.1	11.3	4.5	.0	0.	233.
JUL	1424.7	20.52	333.8	468.4	11.6	37.6	.0	498.2	70.28	297.5	242.4	11.6	4.3	.0	0.	241.
AUG	1513.1	21.12	379.8	480.7	11.6	40.2	.0	549.1	71.69	297.2	230.1	11.6	4.6	.0	0.	241.
SEP	1602.6	21.67	397.7	492.1	11.3	38.1	.0	588.7	72.78	250.9	195.7	11.3	4.4	.0	0.	233.
OCT	1826.0	23.00	559.5	525.8	11.6	39.8	.0	669.2	74.51	281.7	185.0	11.6	4.6	.0	0.	241.
NOV	2158.1	24.87	627.5	479.8	11.3	37.6	.0	753.1	76.20	373.1	208.0	11.3	4.5	65.4	0.	233.
DEC	2345.8	25.81	453.8	447.2	11.6	48.3	.0	753.1	76.20	409.5	263.6	11.6	6.1	128.3	0.	241.
			308.8	489.9	11.4	48.8	.0			240.6	207.4	11.4	5.7	16.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2302.6	25.60	218.2	730.5	11.6	59.0	.0	726.2	75.66	197.7	206.2	11.6	6.8	.0	0.	182.
FEB	2048.2	24.31	101.1	717.6	10.5	62.9	.0	676.1	74.65	96.0	128.5	10.5	7.2	.0	0.	135.
MAR	1693.0	22.21	70.9	826.0	11.6	70.6	.0	619.8	73.52	74.2	110.8	11.6	8.1	.0	0.	182.
APR	1419.7	20.49	81.2	743.5	11.3	66.3	.0	558.0	71.93	120.1	163.0	11.3	7.6	.0	0.	167.
MAY	1349.1	20.01	194.6	689.5	11.6	46.2	.0	536.5	71.34	242.7	247.3	11.6	5.3	.0	0.	182.
JUN	1370.2	20.15	288.2	683.0	11.3	39.4	.0	544.2	71.55	247.0	223.5	11.3	4.5	.0	0.	167.
JUL	1450.4	20.70	333.8	686.5	11.6	37.6	.0	575.5	72.42	297.5	250.3	11.6	4.3	.0	0.	182.
AUG	1564.0	21.45	379.8	696.6	11.6	40.2	.0	616.3	73.45	297.2	240.2	11.6	4.6	.0	0.	182.
SEP	1676.4	22.11	397.7	702.5	11.3	38.1	.0	647.6	74.08	250.9	204.0	11.3	4.4	.0	0.	167.
OCT	1929.2	23.61	559.5	737.3	11.6	39.8	.0	713.7	75.41	281.7	199.4	11.6	4.6	.0	0.	182.
NOV	2298.4	25.57	627.5	676.0	11.3	37.6	.0	753.1	76.20	373.1	230.5	11.3	4.6	87.4	0.	167.
DEC	2403.5	26.10	453.8	769.1	11.6	48.9	1.2	753.1	76.20	409.5	167.7	11.6	6.3	223.9	0.	182.
			308.8	721.5	11.4	48.9	.1			240.6	197.6	11.4	5.7	25.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 150×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2303.0	25.60	218.2	328.4	11.6	59.0	.0	714.9	75.43	197.7	217.4	11.6	6.8	.0	0.	80.
FEB	2085.8	24.51	101.1	317.4	10.5	62.9	.0	617.7	73.48	96.0	175.6	10.5	7.2	.0	0.	73.
MAR	1788.6	22.77	70.9	366.2	11.6	70.6	.0	492.6	70.13	74.2	179.6	11.6	8.1	.0	0.	80.
APR	1569.1	21.48	81.2	301.0	11.3	66.3	.0	366.5	66.50	120.1	227.3	11.3	7.6	.0	0.	78.
MAY	1496.3	21.01	194.6	289.9	11.6	46.2	.0	336.3	65.41	242.7	255.9	11.6	5.3	.0	0.	80.
JUN	1496.2	21.01	288.2	315.4	11.3	39.4	.0	354.7	66.08	247.0	212.9	11.3	4.5	.0	0.	78.
JUL	1543.4	21.32	333.8	317.7	11.6	37.6	.0	408.1	67.79	297.5	228.2	11.6	4.3	.0	0.	80.
AUG	1620.1	21.78	379.8	331.7	11.6	40.2	.0	474.8	69.64	297.2	214.2	11.6	4.6	.0	0.	80.
SEP	1700.5	22.25	397.7	345.7	11.3	38.1	.0	527.7	71.10	250.9	182.5	11.3	4.4	.0	0.	78.
OCT	1909.9	23.49	559.5	379.0	11.6	39.8	.0	626.3	73.65	281.7	166.8	11.6	4.6	.0	0.	80.
NOV	2220.8	25.19	627.5	345.5	11.3	37.6	.0	753.1	76.20	373.1	182.8	11.3	4.5	47.8	0.	78.
DEC	2385.7	26.01	453.8	309.0	11.6	48.7	.0	753.1	76.20	409.5	236.9	11.6	6.1	154.9	0.	80.
			308.8	328.9	11.4	48.9	.0			240.6	206.7	11.4	5.7	16.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 150×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2286.8	25.52	218.2	639.2	11.6	59.0	.0	719.4	75.52	197.7	213.0	11.6	6.8	.0	0.	375.
FEB	2021.4	24.15	101.1	631.8	10.5	62.9	.0	659.7	74.32	96.0	138.0	10.5	7.2	.0	0.	339.
MAR	1654.3	21.98	70.9	730.7	11.6	70.6	.0	592.6	72.89	74.2	121.5	11.6	8.1	.0	0.	375.
APR	1371.6	20.16	81.2	649.2	11.3	66.3	.0	518.3	70.84	120.1	175.5	11.3	7.6	.0	0.	363.
MAY	1285.8	19.58	194.6	597.6	11.6	46.2	.0	489.5	70.04	242.7	254.6	11.6	5.3	.0	0.	375.
JUN	1288.3	19.59	288.2	597.9	11.3	39.4	.0	493.8	70.16	247.0	226.8	11.3	4.5	.0	0.	363.
JUL	1347.5	20.00	333.8	600.3	11.6	37.6	.0	523.4	70.98	297.5	251.9	11.6	4.3	.0	0.	375.
AUG	1439.0	20.62	379.8	611.5	11.6	40.2	.0	563.6	72.09	297.2	240.8	11.6	4.6	.0	0.	375.
SEP	1530.1	21.24	397.7	620.1	11.3	38.1	.0	594.4	72.94	250.9	204.6	11.3	4.4	.0	0.	363.
OCT	1758.3	22.60	559.5	654.9	11.6	39.8	.0	662.5	74.38	281.7	197.4	11.6	4.6	.0	0.	375.
NOV	2100.7	24.59	627.5	599.1	11.3	37.6	.0	753.1	76.20	373.1	225.7	11.3	4.4	41.1	0.	363.
DEC	2299.1	25.58	453.8	570.4	11.6	48.3	.0	753.1	76.20	409.5	281.9	11.6	6.0	110.1	0.	375.
			308.8	625.2	11.4	48.8	.0			240.6	211.0	11.4	5.6	12.6		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2282.0	25.49	218.2	938.7	11.6	59.0	.0	723.4	75.60	197.7	209.0	11.6	6.8	.0	0.	670.
FEB	2002.0	24.04	101.1	912.5	10.5	62.9	.0	677.6	74.68	96.0	124.2	10.5	7.2	.0	0.	605.
MAR	1617.0	21.76	70.9	1043.2	11.6	70.6	.0	627.5	73.68	74.2	104.5	11.6	8.1	.0	0.	670.
APR	1315.0	19.78	81.2	953.7	11.3	66.3	.0	571.7	72.31	120.1	157.0	11.3	7.6	.0	0.	648.
MAY	1225.3	19.17	194.6	896.1	11.6	46.2	.0	545.9	71.60	242.7	251.6	11.6	5.3	.0	0.	670.
JUN	1232.0	19.21	288.2	878.8	11.3	39.4	.0	545.2	71.58	247.0	231.9	11.3	4.5	.0	0.	648.
JUL	1300.9	19.68	333.8	885.3	11.6	37.6	.0	564.3	72.11	297.5	262.4	11.6	4.3	.0	0.	670.
AUG	1404.1	20.38	379.8	894.4	11.6	40.2	.0	592.0	72.87	297.2	253.3	11.6	4.6	.0	0.	670.
SEP	1504.7	21.07	397.7	895.7	11.3	38.1	.0	612.4	73.37	250.9	215.0	11.3	4.4	.0	0.	648.
OCT	1748.6	22.54	559.5	933.7	11.6	39.8	.0	663.9	74.41	281.7	214.0	11.6	4.6	.0	0.	670.
NOV	2115.9	24.66	627.5	859.3	11.3	37.6	.0	753.1	76.20	373.1	251.4	11.3	4.4	16.9	0.	648.
DEC	2338.3	25.77	453.8	841.1	11.6	48.3	.0	753.1	76.20	409.5	306.6	11.6	5.9	85.4	0.	670.
			308.8	911.0	11.4	48.8	.0			240.6	215.1	11.4	5.6	8.5		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2297.2	25.57	218.2	441.3	11.6	59.0	.0	717.4	75.48	197.7	215.0	11.6	6.8	.0	0.	187.
FEB	2056.8	24.36	101.1	437.4	10.5	62.9	.0	640.3	73.93	96.0	155.4	10.5	7.2	.0	0.	169.
MAR	1723.0	22.39	70.9	509.9	11.6	70.6	.0	548.4	71.67	74.2	146.4	11.6	8.1	.0	0.	187.
APR	1472.2	20.84	81.2	435.9	11.3	66.3	.0	450.4	68.96	120.1	199.3	11.3	7.6	.0	0.	181.
MAY	1395.1	20.32	194.6	401.4	11.6	46.2	.0	421.2	68.15	242.7	254.9	11.6	5.3	.0	0.	187.
JUN	1397.9	20.34	288.2	416.2	11.3	39.4	.0	433.5	68.49	247.0	218.9	11.3	4.5	.0	0.	181.
JUL	1452.0	20.71	333.8	417.9	11.6	37.6	.0	476.6	69.69	297.5	238.5	11.6	4.3	.0	0.	187.
AUG	1536.8	21.28	379.8	430.7	11.6	40.2	.0	531.9	71.21	297.2	225.6	11.6	4.6	.0	0.	187.
SEP	1623.5	21.80	397.7	443.1	11.3	38.1	.0	575.2	72.41	250.9	192.0	11.3	4.4	.0	0.	181.
OCT	1842.4	23.09	559.5	476.6	11.6	39.8	.0	661.0	74.35	281.7	179.7	11.6	4.6	.0	0.	187.
NOV	2167.8	24.92	627.5	434.7	11.3	37.6	.0	753.1	76.20	373.1	200.5	11.3	4.5	64.7	0.	181.
DEC	2348.6	25.83	453.8	400.5	11.6	48.3	.0	753.1	76.20	409.5	255.8	11.6	6.1	136.0	0.	187.
			308.8	437.1	11.4	48.8	.0			240.6	206.8	11.4	5.7	16.7		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2296.2	25.56	218.2	870.9	11.6	59.0	.0	726.0	75.66	197.7	206.1	11.6	6.8	.0	0.	616.
FEB	2031.2	24.21	101.1	849.0	10.5	62.9	.0	680.3	74.74	96.0	124.0	10.5	7.3	.0	0.	556.
MAR	1663.6	22.04	70.9	972.3	11.6	70.6	.0	629.8	73.72	74.2	105.0	11.6	8.1	.0	0.	616.
APR	1377.8	20.20	81.2	885.6	11.3	66.3	.0	574.1	72.38	120.1	157.0	11.3	7.6	.0	0.	596.
MAY	1301.5	19.68	194.6	829.1	11.6	46.2	.0	551.6	71.76	242.7	248.2	11.6	5.3	.0	0.	616.
JUN	1320.3	19.81	288.2	815.0	11.3	39.4	.0	555.2	71.86	247.0	227.6	11.3	4.5	.0	0.	596.
JUL	1400.5	20.36	333.8	820.4	11.6	37.6	.0	579.8	72.54	297.5	256.9	11.6	4.3	.0	0.	616.
AUG	1514.8	21.13	379.8	829.7	11.6	40.2	.0	613.2	73.39	297.2	247.6	11.6	4.6	.0	0.	616.
SEP	1626.9	21.82	397.7	832.4	11.3	38.1	.0	638.3	73.89	250.9	210.2	11.3	4.4	.0	0.	596.
OCT	1882.0	23.33	559.5	869.1	11.6	39.8	.0	695.6	75.04	281.7	208.2	11.6	4.6	.0	0.	616.
NOV	2257.8	25.37	627.5	798.9	11.3	37.6	.0	753.1	76.20	373.1	243.6	11.3	4.5	56.2	0.	596.
DEC	2403.5	26.10	453.8	862.7	11.6	48.9	.9	753.1	76.20	409.5	214.6	11.6	6.2	177.1	0.	616.
			308.8	852.9	11.4	48.9	.1			240.6	204.1	11.4	5.7	19.4		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 30ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2290.1	25.53	218.2	1278.7	11.6	59.0	.0	727.9	75.69	197.7	204.5	11.6	6.8	.0	0.	1018.
FEB	2012.6	24.10	101.1	1224.5	10.5	62.9	.0	691.0	74.95	96.0	115.3	10.5	7.2	.0	0.	919.
MAR	1630.4	21.84	70.9	1388.7	11.6	70.6	.0	650.8	74.14	74.2	94.6	11.6	8.1	.0	0.	1018.
APR	1328.9	19.87	81.2	1290.1	11.3	66.3	.0	606.8	73.26	120.1	145.3	11.3	7.6	.0	0.	985.
MAY	1247.6	19.32	194.6	1235.9	11.6	46.2	.0	585.1	72.68	242.7	247.4	11.6	5.3	.0	0.	1018.
JUN	1267.9	19.46	288.2	1202.2	11.3	39.4	.0	583.1	72.63	247.0	233.2	11.3	4.5	.0	0.	985.
JUL	1354.6	20.04	333.8	1215.7	11.6	37.6	.0	597.1	73.02	297.5	267.6	11.6	4.3	.0	0.	1018.
AUG	1477.2	20.88	379.8	1223.2	11.6	40.2	.0	618.0	73.49	297.2	260.1	11.6	4.6	.0	0.	1018.
SEP	1595.6	21.63	397.7	1214.9	11.3	38.1	.0	632.8	73.78	250.9	220.5	11.3	4.4	.0	0.	985.
OCT	1863.0	23.21	559.5	1258.5	11.6	39.8	.0	673.6	74.60	281.7	224.7	11.6	4.6	.0	0.	1018.
NOV	2260.8	25.39	627.5	1165.7	11.3	37.6	.0	753.1	76.20	373.1	269.7	11.3	4.3	8.2	0.	985.
DEC	2403.5	26.10	453.8	1267.3	11.6	48.9	1.1	753.1	76.20	409.5	215.9	11.6	6.2	175.8	0.	1018.
			308.8	1247.1	11.4	48.9	.1			240.6	208.2	11.4	5.7	15.3		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2663.3	25.60	218.2	450.3	11.6	59.0	.0	713.0	75.39	197.7	219.4	11.6	6.8	.0	0.	187.
FEB	2414.0	24.52	101.1	446.4	10.5	62.9	.0	632.8	73.78	96.0	158.5	10.5	7.2	.0	0.	169.
MAR	2069.8	22.79	70.9	520.4	11.6	70.6	.0	537.9	71.38	74.2	149.4	11.6	8.1	.0	0.	187.
APR	1810.1	21.46	81.2	444.8	11.3	66.3	.0	435.8	68.56	120.1	203.3	11.3	7.6	.0	0.	181.
MAY	1724.7	20.98	194.6	409.6	11.6	46.2	.0	401.4	67.61	242.7	260.1	11.6	5.3	.0	0.	187.
JUN	1719.0	20.94	288.2	424.7	11.3	39.4	.0	409.2	67.82	247.0	223.4	11.3	4.5	.0	0.	181.
JUL	1764.6	21.21	333.8	426.4	11.6	37.6	.0	447.4	68.88	297.5	243.3	11.6	4.3	.0	0.	187.
AUG	1840.6	21.61	379.8	439.5	11.6	40.2	.0	498.2	70.28	297.2	230.2	11.6	4.6	.0	0.	187.
SEP	1918.2	22.01	397.7	452.2	11.3	38.1	.0	537.6	71.37	250.9	195.9	11.3	4.4	.0	0.	181.
OCT	2127.5	23.08	559.5	486.3	11.6	39.8	.0	619.6	73.52	281.7	183.4	11.6	4.6	.0	0.	187.
NOV	2444.0	24.65	627.5	443.5	11.3	37.6	.0	753.1	76.20	373.1	204.6	11.3	4.4	19.4	0.	181.
DEC	2616.6	25.40	453.8	408.7	11.6	48.3	.0	753.1	76.20	409.5	261.0	11.6	6.1	130.8	0.	187.
			308.8	446.1	11.4	48.8	.0			240.6	211.1	11.4	5.6	12.5		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2670.6	25.63	218.2	898.3	11.6	59.0	.0	726.1	75.66	197.7	206.2	11.6	6.8	.0	0.	643.
FEB	2404.4	24.48	101.1	874.5	10.5	62.9	.0	681.3	74.76	96.0	123.2	10.5	7.2	.0	0.	581.
MAR	2035.3	22.61	70.9	1000.6	11.6	70.6	.0	631.8	73.76	74.2	104.0	11.6	8.1	.0	0.	643.
APR	1747.9	21.11	81.2	913.1	11.3	66.3	.0	577.1	72.46	120.1	155.9	11.3	7.6	.0	0.	622.
MAY	1671.1	20.66	194.6	856.4	11.6	46.2	.0	554.7	71.84	242.7	248.2	11.6	5.3	.0	0.	643.
JUN	1689.9	20.77	288.2	840.8	11.3	39.4	.0	557.8	71.93	247.0	228.1	11.3	4.5	.0	0.	622.
JUL	1770.6	21.25	333.8	846.7	11.6	37.6	.0	581.4	72.58	297.5	257.9	11.6	4.3	.0	0.	643.
AUG	1885.6	21.84	379.8	855.9	11.6	40.2	.0	613.6	73.40	297.2	248.7	11.6	4.6	.0	0.	643.
SEP	1998.1	22.42	397.7	857.9	11.3	38.1	.0	637.9	73.88	250.9	211.1	11.3	4.4	.0	0.	622.
OCT	2254.1	23.73	559.5	894.9	11.6	39.8	.0	693.7	75.01	281.7	209.7	11.6	4.6	.0	0.	643.
NOV	2631.6	25.46	627.5	823.2	11.3	37.6	.0	753.1	76.20	373.1	245.8	11.3	4.5	52.2	0.	622.
DEC	2778.6	26.10	453.8	888.5	11.6	48.8	.8	753.1	76.20	409.5	216.1	11.6	6.2	175.6	0.	643.
			308.8	879.2	11.4	48.9	.1			240.6	204.6	11.4	5.7	19.0		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2653.0	25.56	218.2	1317.7	11.6	59.0	.0	726.1	75.66	197.7	206.3	11.6	6.8	.0	0.	1045.
FEB	2363.7	24.29	101.1	1260.5	10.5	62.9	.0	688.6	74.90	96.0	115.9	10.5	7.2	.0	0.	943.
MAR	1968.0	22.26	70.9	1428.9	11.6	70.6	.0	648.0	74.09	74.2	95.0	11.6	8.1	.0	0.	1045.
APR	1653.8	20.56	81.2	1328.7	11.3	66.3	.0	603.2	73.18	120.1	146.1	11.3	7.6	.0	0.	1011.
MAY	1560.8	20.01	194.6	1274.4	11.6	46.2	.0	579.3	72.52	242.7	249.6	11.6	5.3	.0	0.	1045.
JUN	1570.1	20.07	288.2	1239.2	11.3	39.4	.0	575.0	72.40	247.0	235.6	11.3	4.5	.0	0.	1011.
JUL	1645.8	20.51	333.8	1253.4	11.6	37.6	.0	586.0	72.71	297.5	270.5	11.6	4.3	.0	0.	1045.
AUG	1757.5	21.17	379.8	1260.9	11.6	40.2	.0	603.9	73.20	297.2	263.1	11.6	4.6	.0	0.	1045.
SEP	1865.0	21.74	397.7	1251.8	11.3	38.1	.0	616.2	73.45	250.9	223.0	11.3	4.4	.0	0.	1011.
OCT	2121.3	23.05	559.5	1296.3	11.6	39.8	.0	654.1	74.21	281.7	227.6	11.6	4.6	.0	0.	1045.
NOV	2509.6	24.94	627.5	1201.2	11.3	37.6	.0	738.1	75.90	373.1	273.6	11.3	4.3	.0	0.	1011.
DEC	2751.0	25.98	453.8	1196.8	11.6	48.5	.0	753.1	76.20	409.5	327.1	11.6	5.8	50.0	0.	1045.
			308.8	1275.8	11.4	48.8	.0			240.6	219.4	11.4	5.6	4.2		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 150×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2663.0	25.60	218.2	584.5	11.6	59.0	.0	718.3	75.50	197.7	214.1	11.6	6.8	.0	0.	321.
FEB	2401.8	24.47	101.1	579.2	10.5	62.9	.0	654.5	74.22	96.0	142.1	10.5	7.2	.0	0.	290.
MAR	2040.3	22.63	70.9	671.6	11.6	70.6	.0	582.0	72.60	74.2	127.0	11.6	8.1	.0	0.	321.
APR	1763.2	21.20	81.2	591.7	11.3	66.3	.0	502.1	70.39	120.1	181.1	11.3	7.6	.0	0.	311.
MAY	1678.2	20.70	194.6	543.2	11.6	46.2	.0	472.4	69.57	242.7	255.5	11.6	5.3	.0	0.	321.
JUN	1679.5	20.71	288.2	547.3	11.3	39.4	.0	478.0	69.72	247.0	225.6	11.3	4.5	.0	0.	311.
JUL	1736.2	21.05	333.8	549.3	11.6	37.6	.0	510.2	70.61	297.5	249.4	11.6	4.3	.0	0.	321.
AUG	1824.8	21.53	379.8	560.9	11.6	40.2	.0	553.4	71.81	297.2	237.7	11.6	4.6	.0	0.	321.
SEP	1913.4	21.99	397.7	570.8	11.3	38.1	.0	586.7	72.73	250.9	202.1	11.3	4.4	.0	0.	311.
OCT	2137.7	23.13	559.5	605.1	11.6	39.8	.0	658.6	74.30	281.7	193.5	11.6	4.6	.0	0.	321.
NOV	2474.3	24.78	627.5	553.0	11.3	37.6	.0	753.1	76.20	373.1	219.8	11.3	4.5	43.1	0.	311.
DEC	2667.0	25.62	453.8	522.6	11.6	48.3	.0	753.1	76.20	409.5	276.1	11.6	6.0	115.8	0.	321.
			308.8	573.3	11.4	48.8	.0			240.6	210.3	11.4	5.6	13.2		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2673.3	25.65	218.2	1163.4	11.6	59.0	.0	728.7	75.71	197.7	203.7	11.6	6.8	.0	0.	911.
FEB	2405.0	24.48	101.1	1118.5	10.5	62.9	.0	690.7	74.95	96.0	116.3	10.5	7.2	.0	0.	823.
MAR	2033.2	22.60	70.9	1271.1	11.6	70.6	.0	649.1	74.11	74.2	96.0	11.6	8.1	.0	0.	911.
APR	1741.8	21.08	81.2	1176.3	11.3	66.3	.0	603.6	73.19	120.1	146.7	11.3	7.6	.0	0.	881.
MAY	1668.2	20.65	194.6	1121.0	11.6	46.2	.0	583.2	72.63	242.7	246.1	11.6	5.3	.0	0.	911.
JUN	1694.7	20.80	288.2	1092.4	11.3	39.4	.0	583.7	72.65	247.0	230.7	11.3	4.5	.0	0.	881.
JUL	1786.5	21.34	333.8	1103.4	11.6	37.6	.0	601.5	73.14	297.5	263.8	11.6	4.3	.0	0.	911.
AUG	1913.9	21.99	379.8	1111.2	11.6	40.2	.0	626.6	73.66	297.2	255.9	11.6	4.6	.0	0.	911.
SEP	2037.5	22.62	397.7	1106.0	11.3	38.1	.0	644.9	74.03	250.9	217.0	11.3	4.4	.0	0.	881.
OCT	2308.9	24.01	559.5	1147.3	11.6	39.8	.0	690.5	74.94	281.7	219.8	11.6	4.6	.0	0.	911.
NOV	2708.0	25.80	627.5	1060.7	11.3	37.6	.0	753.1	76.20	373.1	262.3	11.3	4.4	32.6	0.	881.
DEC	2778.6	26.10	453.8	1231.9	11.6	48.8	1.6	753.1	76.20	409.5	135.3	11.6	6.4	256.2	0.	911.
			308.8	1142.0	11.4	48.9	.1			240.6	199.5	11.4	5.7	24.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 150×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2660.4	25.59	218.2	1712.1	11.6	59.0	.0	729.1	75.72	197.7	203.3	11.6	6.8	.0	0.	1446.
FEB	2374.9	24.35	101.1	1619.5	10.5	62.9	.0	696.9	75.07	96.0	110.5	10.5	7.2	.0	0.	1306.
MAR	1983.8	22.35	70.9	1826.1	11.6	70.6	.0	662.1	74.37	74.2	89.3	11.6	8.1	.0	0.	1116.
APR	1672.5	20.67	81.2	1714.6	11.3	66.3	.0	624.3	73.61	120.1	139.0	11.3	7.6	.0	0.	1100.
MAY	1587.0	20.17	194.6	1668.6	11.6	46.2	.0	603.3	73.19	242.7	246.8	11.6	5.3	.0	0.	1446.
JUN	1607.2	20.29	288.2	1617.0	11.3	39.4	.0	597.9	73.04	247.0	236.6	11.3	4.5	.0	0.	1400.
JUL	1697.0	20.82	333.8	1641.2	11.6	37.6	.0	605.2	73.23	297.5	274.2	11.6	4.3	.0	0.	1446.
AUG	1824.0	21.53	379.8	1647.3	11.6	40.2	.0	618.1	73.49	297.2	268.1	11.6	4.6	.0	0.	1446.
SEP	1945.5	22.15	397.7	1626.5	11.3	38.1	.0	626.3	73.65	250.9	227.1	11.3	4.4	.0	0.	1100.
OCT	2220.4	23.56	559.5	1679.6	11.6	39.8	.0	655.9	74.25	281.7	235.8	11.6	4.6	.0	0.	1446.
NOV	2633.2	25.47	627.5	1565.5	11.3	37.6	.0	725.4	75.64	373.1	288.1	11.3	4.3	.0	0.	1400.
DEC	2778.6	26.10	453.8	1693.3	11.6	48.8	1.1	753.1	76.20	409.5	222.1	11.6	6.1	141.9	0.	1446.
			308.8	1667.6	11.4	48.9	.1			240.6	211.8	11.4	5.6	11.8		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2665.9	25.61	218.2	795.8	11.6	59.0	.0	723.7	75.61	197.7	208.7	11.6	6.8	.0	0.	536.
FEB	2398.1	24.46	101.1	779.3	10.5	62.9	.0	674.1	74.61	96.0	128.0	10.5	7.2	.0	0.	181.
MAR	2027.4	22.57	70.9	895.1	11.6	70.6	.0	619.1	73.51	74.2	109.4	11.6	8.1	.0	0.	536.
APR	1739.5	21.07	81.2	809.9	11.3	66.3	.0	558.1	71.94	120.1	162.2	11.3	7.6	.0	0.	518.
MAY	1658.0	20.59	194.6	754.0	11.6	46.2	.0	533.3	71.25	242.7	250.5	11.6	5.3	.0	0.	536.
JUN	1669.7	20.65	288.2	744.2	11.3	39.4	.0	536.7	71.35	247.0	227.9	11.3	4.5	.0	0.	518.
JUL	1741.5	21.08	333.8	748.5	11.6	37.6	.0	562.2	72.05	297.5	256.1	11.6	4.3	.0	0.	536.
AUG	1846.8	21.64	379.8	758.3	11.6	40.2	.0	596.9	73.01	297.2	246.2	11.6	4.6	.0	0.	536.
SEP	1950.5	22.18	397.7	763.1	11.3	38.1	.0	623.2	73.59	250.9	209.0	11.3	4.4	.0	0.	518.
OCT	2195.2	23.43	559.5	799.0	11.6	39.8	.0	683.2	74.80	281.7	205.5	11.6	4.6	.0	0.	536.
NOV	2558.9	25.15	627.5	733.3	11.3	37.6	.0	753.1	76.20	373.1	238.8	11.3	4.5	48.7	0.	518.
DEC	2777.5	26.10	453.8	710.5	11.6	48.8	.0	753.1	76.20	409.5	294.1	11.6	5.9	97.9	0.	536.
			308.8	774.3	11.4	48.9	.0			240.6	211.4	11.4	5.6	12.2		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2656.3	25.57	218.2	1582.2	11.6	59.0	.0	728.0	75.70	197.7	201.3	11.6	6.8	.0	0.	1312.
FEB	2367.8	24.31	101.1	1501.6	10.5	62.9	.0	694.3	75.02	96.0	112.1	10.5	7.2	.0	0.	1185.
MAR	1973.2	22.29	70.9	1695.7	11.6	70.6	.0	657.8	74.29	74.2	90.9	11.6	8.1	.0	0.	1312.
APR	1659.1	20.59	81.2	1587.9	11.3	66.3	.0	618.0	73.48	120.1	141.1	11.3	7.6	.0	0.	1270.
MAY	1569.4	20.07	194.6	1538.8	11.6	46.2	.0	595.9	72.98	242.7	247.8	11.6	5.3	.0	0.	1312.
JUN	1584.7	20.15	288.2	1492.4	11.3	39.4	.0	590.6	72.84	247.0	236.5	11.3	4.5	.0	0.	1270.
JUL	1668.5	20.65	333.8	1513.2	11.6	37.6	.0	598.7	73.06	297.5	273.4	11.6	4.3	.0	0.	1312.
AUG	1789.2	21.35	379.8	1519.7	11.6	40.2	.0	612.8	73.38	297.2	266.9	11.6	4.6	.0	0.	1312.
SEP	1904.8	21.94	397.7	1502.8	11.3	38.1	.0	622.0	73.57	250.9	226.1	11.3	4.1	.0	0.	1270.
OCT	2172.4	23.31	559.5	1552.9	11.6	39.8	.0	653.8	74.20	281.7	233.7	11.6	4.6	.0	0.	1312.
NOV	2576.2	25.22	627.5	1444.9	11.3	37.6	.0	727.3	75.68	373.1	284.1	11.3	4.3	.0	0.	1270.
DEC	2778.6	26.10	453.8	1502.9	11.6	48.8	.5	753.1	76.20	409.5	283.7	11.6	5.9	82.5	0.	1312.
			308.8	1536.3	11.4	48.9	.0			240.6	216.7	11.4	5.6	6.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 55ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	2650.4	25.55	218.2	2338.1	11.6	59.0	.0	729.7	75.73	197.7	202.7	11.6	6.8	.0	0.	2062.
FEB	2353.0	24.23	101.1	2187.8	10.5	62.9	.0	701.1	75.15	96.0	107.0	10.5	7.2	.0	0.	1863.
MAR	1948.7	22.17	70.9	2455.4	11.6	70.6	.0	670.2	74.53	74.2	85.4	11.6	8.1	.0	0.	2062.
APR	1623.8	20.38	81.2	2324.4	11.3	66.3	.0	637.0	73.87	120.1	134.4	11.3	7.6	.0	0.	1996.
MAY	1528.9	19.83	194.6	2294.1	11.6	46.2	.0	616.1	73.45	242.7	246.7	11.6	5.3	.0	0.	2062.
JUN	1543.4	19.91	288.2	2218.8	11.3	39.4	.0	607.4	73.27	247.0	239.9	11.3	4.5	.0	0.	1996.
JUL	1630.2	20.42	333.8	2260.1	11.6	37.6	.0	608.4	73.29	297.5	280.6	11.6	4.3	.0	0.	2062.
AUG	1755.5	21.16	379.8	2265.1	11.6	40.2	.0	613.7	73.40	297.2	275.6	11.6	4.6	.0	0.	2062.
SEP	1874.2	21.78	397.7	2225.5	11.3	38.1	.0	615.7	73.44	250.9	233.3	11.3	4.1	.0	0.	1996.
OCT	2150.4	23.20	559.5	2294.3	11.6	39.8	.0	634.7	73.82	281.7	246.5	11.6	4.6	.0	0.	2062.
NOV	2572.2	25.21	627.5	2152.6	11.3	37.6	.0	686.1	74.85	373.1	306.2	11.3	4.3	.0	0.	1996.
DEC	2778.6	26.10	453.8	2248.9	11.6	48.8	.6	753.1	76.20	409.5	291.9	11.6	5.7	33.3	0.	2062.
			308.8	2272.1	11.4	48.9	.0			240.6	220.8	11.4	5.6	2.8		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5213.3	25.94	218.2	377.4	11.6	59.0	.0	735.5	75.85	197.7	196.9	11.6	6.8	.0	0.	161.
FEB	5013.0	25.49	101.1	373.2	10.5	62.9	.0	668.3	74.50	96.0	145.6	10.5	7.2	.0	0.	145.
MAR	4727.3	24.84	70.9	435.0	11.6	70.6	.0	583.4	72.64	74.2	139.3	11.6	8.1	.0	0.	161.
APR	4622.9	24.60	81.2	368.8	11.3	66.3	.0	392.4	70.27	120.1	187.0	11.3	7.6	.0	0.	156.
MAY	4622.9	24.60	194.6	341.2	11.6	46.2	.0	341.4	67.16	242.7	233.1	11.6	5.3	.0	0.	161.
JUN	4659.0	24.68	288.2	357.0	11.3	39.4	.0	373.8	66.77	247.0	198.7	11.3	4.5	.0	0.	156.
JUL	4745.7	24.88	333.8	358.6	11.6	37.6	.0	439.7	68.67	297.5	215.7	11.6	4.3	.0	0.	161.
AUG	4863.8	25.15	379.8	370.6	11.6	40.2	.0	516.9	70.80	297.2	203.7	11.6	4.6	.0	0.	161.
SEP	4985.3	25.42	397.7	382.3	11.3	38.1	.0	578.8	72.51	250.9	173.4	11.3	4.4	.0	0.	156.
OCT	5241.3	26.01	559.5	412.8	11.6	39.8	.0	682.8	74.79	281.7	161.5	11.6	4.6	.0	0.	161.
NOV	5282.4	26.10	627.5	555.8	11.3	38.3	136.5	753.1	76.20	373.1	.0	11.3	5.1	286.5	0.	156.
DEC	5282.4	26.10	453.8	553.3	11.6	48.6	1.0	753.1	76.20	409.5	21.0	11.6	6.7	370.2	0.	161.
			308.8	407.2	11.4	48.9	11.5			240.6	156.3	11.4	5.8	54.7		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5202.2	25.92	218.2	709.9	11.6	59.0	.0	732.0	75.78	197.7	200.4	11.6	6.8	.0	0.	482.
FEB	4968.1	25.39	101.1	697.3	10.5	62.9	.0	685.5	74.84	96.0	124.8	10.5	7.2	.0	0.	435.
MAR	4636.3	24.63	70.9	802.6	11.6	70.6	.0	632.4	73.77	74.2	107.6	11.6	8.1	.0	0.	482.
APR	4622.9	24.60	81.2	722.5	11.3	66.3	.0	336.3	72.41	120.1	158.4	11.3	7.6	.0	0.	467.
MAY	4622.9	24.60	194.6	670.0	11.6	46.2	.0	270.7	64.89	242.7	240.3	11.6	5.3	.0	0.	482.
JUN	4663.4	24.69	288.2	663.7	11.3	39.4	.0	284.7	63.55	247.0	217.2	11.3	4.5	.0	0.	467.
JUL	4763.0	24.92	333.8	667.0	11.6	37.6	.0	323.1	64.93	297.5	243.2	11.6	4.3	.0	0.	482.
AUG	4896.3	25.22	379.8	676.8	11.6	40.2	.0	370.7	66.65	297.2	233.4	11.6	4.6	.0	0.	482.
SEP	5028.5	25.52	397.7	682.6	11.3	38.1	.0	407.8	67.78	250.9	198.2	11.3	4.4	.0	0.	467.
OCT	5282.4	26.10	559.5	736.1	11.6	39.9	.1	499.1	70.31	281.7	174.1	11.6	4.6	.0	0.	482.
NOV	5282.4	26.10	627.5	880.9	11.3	38.4	163.5	753.1	76.20	373.1	.0	11.3	4.6	103.2	0.	467.
DEC	5282.4	26.10	453.8	874.6	11.6	48.6	1.2	753.1	76.20	409.5	35.7	11.6	6.7	355.6	0.	482.
			308.8	732.0	11.4	48.9	13.7			240.6	161.1	11.4	5.7	38.2		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5199.4	25.91	218.2	1034.1	11.6	59.0	.0	732.3	75.78	197.7	200.1	11.6	6.8	.0	0.	804.
FEB	4954.2	25.35	101.1	998.7	10.5	62.9	.0	694.7	75.03	96.0	116.0	10.5	7.2	.0	0.	726.
MAR	4622.9	24.60	70.9	1137.6	11.6	70.6	.0	638.4	74.18	74.2	96.5	11.6	8.1	.0	0.	804.
APR	4622.9	24.60	81.2	1047.8	11.3	66.3	.0	326.6	72.91	120.1	146.5	11.3	7.6	.0	0.	778.
MAY	4622.9	24.60	194.6	992.8	11.6	46.2	.0	258.5	64.50	242.7	241.4	11.6	5.3	.0	0.	804.
JUN	4668.5	24.70	288.2	969.6	11.3	39.4	.0	265.0	62.84	247.0	224.7	11.3	4.5	.0	0.	778.
JUL	4778.3	24.95	333.8	978.3	11.6	37.6	.0	290.6	63.76	297.5	255.9	11.6	4.3	.0	0.	804.
AUG	4923.4	25.28	379.8	986.4	11.6	40.2	.0	323.9	64.96	297.2	247.7	11.6	4.6	.0	0.	804.
SEP	5065.1	25.61	397.7	984.2	11.3	38.1	.0	349.1	65.87	250.9	210.1	11.3	4.4	.0	0.	778.
OCT	5282.4	26.10	559.5	1093.9	11.6	39.9	.3	474.3	69.62	281.7	140.3	11.6	4.6	.0	0.	804.
NOV	5282.4	26.10	627.5	1194.3	11.3	38.4	161.1	753.1	76.20	373.1	.0	11.3	4.6	78.5	0.	778.
DEC	5282.4	26.10	453.8	1195.9	11.6	48.6	1.3	753.1	76.20	409.5	38.3	11.6	6.7	353.0	0.	804.
			308.8	1051.1	11.4	48.9	13.6			240.6	159.8	11.4	5.7	36.0		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5386.4	26.34	218.2	700.5	11.6	60.1	.0	734.7	75.83	197.7	197.7	11.6	6.8	.0	0.	482.
FEB	5160.4	25.82	101.1	688.1	10.5	64.0	.0	689.8	74.93	96.0	123.2	10.5	7.2	.0	0.	435.
MAR	4837.9	25.09	70.9	792.0	11.6	71.8	.0	638.1	73.89	74.2	106.2	11.6	8.1	.0	0.	182.
APR	4798.8	25.00	81.2	713.0	11.3	67.5	.0	378.2	72.63	120.1	156.3	11.3	7.6	.0	0.	467.
MAY	4798.8	25.00	194.6	661.1	11.6	47.0	.0	323.8	66.52	242.7	237.1	11.6	5.3	.0	0.	182.
JUN	4847.3	25.11	288.2	654.9	11.3	40.0	.0	340.7	65.57	247.0	214.3	11.3	4.5	.0	0.	467.
JUL	4955.1	25.36	333.8	658.2	11.6	38.3	.0	382.3	67.07	297.5	240.0	11.6	4.3	.0	0.	482.
AUG	5096.6	25.68	379.8	667.9	11.6	40.9	.0	432.9	68.48	297.2	230.3	11.6	4.6	.0	0.	482.
SEP	5237.2	26.00	397.7	673.6	11.3	38.7	.0	472.7	69.58	250.9	195.6	11.3	4.4	.0	0.	467.
OCT	5458.3	26.50	559.5	768.0	11.6	40.6	.2	607.9	73.28	281.7	130.3	11.6	4.6	.0	0.	482.
NOV	5458.3	26.50	627.5	869.3	11.3	39.1	174.4	753.1	76.20	373.1	.0	11.3	4.9	211.7	0.	467.
DEC	5458.3	26.50	453.8	873.7	11.6	49.4	1.2	753.1	76.20	409.5	24.5	11.6	6.7	366.7	0.	482.
			308.8	726.7	11.4	49.8	14.7			240.6	154.6	11.4	5.7	48.2		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85'ft

DESIGN VESSEL 100×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5384.5	26.33	218.2	1372.1	11.6	60.1	.0	734.4	75.82	197.7	198.0	11.6	6.8	.0	0.	1152.
FEB	5143.3	25.78	101.1	1308.0	10.5	64.0	.0	702.7	75.19	96.0	110.1	10.5	7.2	.0	0.	1010.
MAR	4802.2	25.01	70.9	1480.3	11.6	71.8	.0	667.3	74.48	74.2	89.8	11.6	8.1	.0	0.	1152.
APR	4798.8	25.00	81.2	1380.8	11.3	67.5	.0	369.6	73.72	120.1	138.6	11.3	7.6	.0	0.	1115.
MAY	4798.8	25.00	194.6	1330.3	11.6	47.0	.0	312.9	66.11	242.7	239.8	11.6	5.3	.0	0.	1152.
JUN	4858.3	25.14	288.2	1291.9	11.3	40.0	.0	316.7	64.70	247.0	227.5	11.3	4.5	.0	0.	1115.
JUL	4985.8	25.43	333.8	1308.1	11.6	38.3	.0	336.3	65.41	297.5	261.9	11.6	4.3	.0	0.	1152.
AUG	5149.9	25.80	379.8	1314.9	11.6	40.9	.0	362.1	66.34	297.2	255.2	11.6	4.6	.0	0.	1152.
SEP	5309.0	26.16	397.7	1303.2	11.3	38.7	.0	381.2	67.03	250.9	216.2	11.3	4.4	.0	0.	1115.
OCT	5458.3	26.50	559.5	1509.0	11.6	40.6	.6	585.6	72.70	281.7	61.1	11.6	4.6	.0	0.	1152.
NOV	5458.3	26.50	627.5	1519.4	11.3	39.1	172.3	753.1	76.20	373.1	.0	11.3	4.9	189.5	0.	1115.
DEC	5458.3	26.50	453.8	1543.1	11.6	49.4	1.4	753.1	76.20	409.5	27.0	11.6	6.7	364.2	0.	1152.
			308.8	1388.4	11.4	49.8	14.5			240.6	152.1	11.4	5.7	46.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5379.8	26.32	218.2	2019.5	11.6	60.1	.0	734.0	75.82	197.7	198.3	11.6	6.8	.0	0.	1795.
FEB	5129.8	25.75	101.1	1897.4	10.5	64.0	.0	706.6	75.26	96.0	105.8	10.5	7.2	.0	0.	1621.
MAR	4798.8	25.00	70.9	2133.1	11.6	71.8	.0	656.1	74.65	74.2	84.8	11.6	8.1	.0	0.	1795.
APR	4798.8	25.00	81.2	2013.4	11.3	67.5	.0	350.1	73.61	120.1	133.0	11.3	7.6	.0	0.	1737.
MAY	4798.8	25.00	194.6	1976.7	11.6	47.0	.0	288.5	65.36	242.7	241.2	11.6	5.3	.0	0.	1795.
JUN	4859.3	25.14	288.2	1913.0	11.3	40.0	.0	286.3	63.61	247.0	233.3	11.3	4.5	.0	0.	1737.
JUL	4991.8	25.44	333.8	1945.9	11.6	38.3	.0	295.9	63.95	297.5	272.0	11.6	4.3	.0	0.	1795.
AUG	5162.5	25.83	379.8	1951.2	11.6	40.9	.0	310.2	64.47	297.2	266.7	11.6	4.6	.0	0.	1795.
SEP	5326.2	26.20	397.7	1920.5	11.3	38.7	.0	319.7	64.81	250.9	225.8	11.3	4.4	.0	0.	1737.
OCT	5458.3	26.50	559.5	2168.9	11.6	40.6	.7	536.2	71.33	281.7	49.0	11.6	4.6	.0	0.	1795.
NOV	5458.3	26.50	627.5	2146.4	11.3	39.1	167.4	753.1	76.20	373.1	.0	11.3	4.7	140.2	0.	1737.
DEC	5458.3	26.50	453.8	2185.8	11.6	49.4	1.5	753.1	76.20	409.5	32.1	11.6	6.7	359.1	0.	1795.
			308.8	2022.7	11.4	49.8	14.1			240.6	153.5	11.4	5.7	41.6		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5199.9	25.91	218.2	471.1	11.6	59.0	.0	729.6	75.73	197.7	202.8	11.6	6.8	.0	0.	241.
FEB	4977.6	25.41	101.1	467.8	10.5	62.9	.0	667.0	74.47	96.0	140.9	10.5	7.2	.0	0.	218.
MAR	4662.8	24.69	70.9	544.5	11.6	70.6	.0	592.0	72.87	74.2	129.5	11.6	8.1	.0	0.	241.
APR	4622.9	24.60	81.2	472.0	11.3	66.3	.0	317.9	70.69	120.1	180.2	11.3	7.6	.0	0.	233.
MAY	4622.9	24.60	194.6	432.8	11.6	46.2	.0	247.6	64.19	242.7	241.1	11.6	5.3	.0	0.	241.
JUN	4651.2	24.66	288.2	442.6	11.3	39.4	.0	269.2	62.99	247.0	209.6	11.3	4.5	.0	0.	233.
JUL	4732.7	24.85	333.8	444.1	11.6	37.6	.0	320.9	64.86	297.5	229.8	11.6	4.3	.0	0.	241.
AUG	4846.0	25.11	379.8	455.8	11.6	40.2	.0	383.7	67.12	297.2	218.2	11.6	4.6	.0	0.	241.
SEP	4961.1	25.37	397.7	466.6	11.3	38.1	.0	433.5	68.50	250.9	185.6	11.3	4.4	.0	0.	233.
OCT	5211.7	25.94	559.5	498.5	11.6	39.8	.0	523.6	70.98	281.7	175.4	11.6	4.6	.0	0.	241.
NOV	5282.4	26.10	627.5	652.2	11.3	38.1	88.5	753.1	76.20	373.1	.0	11.3	4.7	127.6	0.	233.
DEC	5282.4	26.10	453.8	633.7	11.6	48.6	1.0	753.1	76.20	409.5	40.2	11.6	6.7	351.0	0.	241.
			308.8	498.5	11.4	48.9	7.5			240.6	162.8	11.4	5.7	39.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 150×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5211.1	25.94	218.2	915.3	11.6	59.0	.0	734.6	75.83	197.7	197.8	11.6	6.8	.0	0.	696.
FEB	4979.3	25.41	101.1	888.5	10.5	62.9	.0	696.0	75.05	96.0	116.9	10.5	7.2	.0	0.	629.
MAR	4649.3	24.66	70.9	1015.0	11.6	70.6	.0	652.4	74.18	74.2	98.1	11.6	8.1	.0	0.	696.
APR	4622.9	24.60	81.2	929.4	11.3	66.3	.0	380.3	73.24	120.1	147.8	11.3	7.6	.0	0.	674.
MAY	4622.9	24.60	194.6	874.8	11.6	46.2	.0	326.1	66.55	242.7	238.3	11.6	5.3	.0	0.	696.
JUN	4677.3	24.72	288.2	857.2	11.3	39.4	.0	337.3	65.45	247.0	220.0	11.3	4.5	.0	0.	674.
JUL	4794.5	24.99	333.8	863.7	11.6	37.6	.0	369.4	66.61	297.5	249.4	11.6	4.3	.0	0.	696.
AUG	4946.6	25.34	379.8	872.2	11.6	40.2	.0	409.5	67.83	297.2	240.9	11.6	4.6	.0	0.	696.
SEP	5096.1	25.68	397.7	872.8	11.3	38.1	.0	440.5	68.69	250.9	204.4	11.3	4.4	.0	0.	674.
OCT	5282.4	26.10	559.5	1017.5	11.6	39.9	.4	610.3	73.33	281.7	95.6	11.6	4.6	.0	0.	696.
NOV	5282.4	26.10	627.5	1077.2	11.3	38.4	174.5	753.1	76.20	373.1	.0	11.3	4.9	214.2	0.	674.
DEC	5282.4	26.10	453.8	1088.7	11.6	48.6	1.3	753.1	76.20	409.5	24.4	11.6	6.7	366.8	0.	696.
			308.8	939.4	11.4	48.9	14.7			240.6	152.8	11.4	5.7	48.4		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5192.1	25.89	218.2	1336.0	11.6	59.0	.0	731.8	75.77	197.7	200.6	11.6	6.8	.0	0.	1098.
FEB	4935.9	25.31	101.1	1275.8	10.5	62.9	.0	698.0	75.09	96.0	112.1	10.5	7.2	.0	0.	992.
MAR	4622.9	24.60	70.9	1445.0	11.6	70.6	.0	615.6	74.34	74.2	91.7	11.6	8.1	.0	0.	1098.
APR	4622.9	24.60	81.2	1345.8	11.3	66.3	.0	296.1	72.42	120.1	141.2	11.3	7.6	.0	0.	1063.
MAY	4622.9	24.60	194.6	1293.8	11.6	46.2	.0	220.1	63.34	242.7	242.9	11.6	5.3	.0	0.	1098.
JUN	4666.0	24.70	288.2	1257.2	11.3	39.4	.0	221.5	61.26	247.0	229.9	11.3	4.5	.0	0.	1063.
JUL	4776.4	24.95	333.8	1272.3	11.6	37.6	.0	238.7	61.89	297.5	264.3	11.6	4.3	.0	0.	1098.
AUG	4923.2	25.28	379.8	1279.4	11.6	40.2	.0	262.4	62.74	297.2	257.3	11.6	4.6	.0	0.	1098.
SEP	5065.2	25.61	397.7	1269.0	11.3	38.1	.0	279.7	63.37	250.9	218.1	11.3	4.4	.0	0.	1063.
OCT	5282.4	26.10	559.5	1388.5	11.6	39.9	.3	397.1	67.49	281.7	148.1	11.6	4.6	.0	0.	1098.
NOV	5282.4	26.10	627.5	1487.1	11.3	38.4	153.5	753.1	76.20	373.1	.0	11.3	4.3	1.5	0.	1063.
DEC	5282.4	26.10	453.8	1490.4	11.6	48.6	1.3	753.1	76.20	409.5	46.2	11.6	6.7	345.1	0.	1098.
			308.8	1345.0	11.4	48.9	12.9			240.6	162.7	11.4	5.7	28.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5200.2	25.91	218.2	631.6	11.6	59.0	.0	731.0	75.76	197.7	201.4	11.6	6.8	.0	0.	402.
FEB	4967.5	25.38	101.1	623.3	10.5	62.9	.0	680.3	74.74	96.0	129.0	10.5	7.2	.0	0.	363.
MAR	4637.9	24.63	70.9	720.0	11.6	70.6	.0	621.8	73.56	74.2	113.0	11.6	8.1	.0	0.	402.
APR	4622.9	24.60	81.2	642.1	11.3	66.3	.0	324.4	71.96	120.1	164.0	11.3	7.6	.0	0.	389.
MAY	4622.9	24.60	194.6	592.0	11.6	46.2	.0	255.7	64.43	242.7	240.9	11.6	5.3	.0	0.	402.
JUN	4658.7	24.68	288.2	590.6	11.3	39.4	.0	271.5	63.07	247.0	215.5	11.3	4.5	.0	0.	389.
JUL	4751.9	24.89	333.8	593.1	11.6	37.6	.0	313.2	64.58	297.5	239.8	11.6	4.3	.0	0.	402.
AUG	4878.2	25.18	379.8	603.5	11.6	40.2	.0	364.7	66.44	297.2	229.5	11.6	4.6	.0	0.	402.
SEP	5004.3	25.47	397.7	611.1	11.3	38.1	.0	405.0	67.71	250.9	195.0	11.3	4.4	.0	0.	389.
OCT	5269.8	26.07	559.5	644.2	11.6	39.9	.0	481.8	69.83	281.7	188.8	11.6	4.6	.0	0.	402.
NOV	5282.4	26.10	627.5	806.1	11.3	38.3	148.0	753.1	76.20	373.1	.0	11.3	4.6	85.9	0.	389.
DEC	5282.4	26.10	453.8	794.3	11.6	48.6	1.1	753.1	76.20	409.5	38.7	11.6	6.7	352.6	0.	402.
			308.8	654.3	11.4	48.9	12.4			240.6	163.0	11.4	5.7	36.5		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5208.9	25.93	218.2	1238.9	11.6	59.0	.0	734.2	75.82	197.7	198.1	11.6	6.8	.0	0.	1018.
FEB	4969.5	25.39	101.1	1186.3	10.5	62.9	.0	700.9	75.15	96.0	111.7	10.5	7.2	.0	0.	919.
MAR	4630.6	24.62	70.9	1345.4	11.6	70.6	.0	663.7	74.40	74.2	91.7	11.6	8.1	.0	0.	1018.
APR	4622.9	24.60	81.2	1250.0	11.3	66.3	.0	370.5	73.61	120.1	140.8	11.3	7.6	.0	0.	985.
MAY	4622.9	24.60	194.6	1197.4	11.6	46.2	.0	313.7	66.14	242.7	239.7	11.6	5.3	.0	0.	1018.
JUN	4680.7	24.73	288.2	1164.8	11.3	39.4	.0	319.0	64.79	247.0	226.0	11.3	4.5	.0	0.	985.
JUL	4805.2	25.01	333.8	1177.8	11.6	37.6	.0	341.3	65.59	297.5	259.2	11.6	4.3	.0	0.	1018.
AUG	4965.9	25.38	379.8	1185.1	11.6	40.2	.0	370.3	66.64	297.2	252.0	11.6	4.6	.0	0.	1018.
SEP	5122.2	25.74	397.7	1177.1	11.3	38.1	.0	392.0	67.35	250.9	213.6	11.3	4.4	.0	0.	985.
OCT	5282.4	26.10	559.5	1364.9	11.6	39.9	.6	585.3	72.69	281.7	72.2	11.6	4.6	.0	0.	1018.
NOV	5282.4	26.10	627.5	1390.7	11.3	38.4	172.0	753.1	76.20	373.1	.0	11.3	4.9	189.2	0.	985.
DEC	5282.4	26.10	453.8	1410.0	11.6	48.6	1.4	753.1	76.20	409.5	27.0	11.6	6.7	364.2	0.	1018.
			308.8	1257.4	11.4	48.9	14.5			240.6	152.7	11.4	5.7	46.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5214.8	25.95	218.2	1822.3	11.6	59.0	.0	735.0	75.84	197.7	197.4	11.6	6.8	.0	0.	1607.
FEB	4976.1	25.40	101.1	1717.9	10.5	62.9	.0	707.1	75.28	96.0	106.3	10.5	7.2	.0	0.	1452.
MAR	4637.7	24.63	70.9	1934.1	11.6	70.6	.0	676.1	74.65	74.2	85.5	11.6	8.1	.0	0.	1607.
APR	4622.9	24.60	81.2	1820.9	11.3	66.3	.0	396.4	74.00	120.1	133.6	11.3	7.6	.0	0.	1555.
MAY	4622.9	24.60	194.6	1779.9	11.6	46.2	.0	346.3	67.08	242.7	239.7	11.6	5.3	.0	0.	1607.
JUN	4692.2	24.76	288.2	1723.5	11.3	39.4	.0	346.6	65.79	247.0	230.9	11.3	4.5	.0	0.	1555.
JUL	4832.5	25.08	333.8	1751.2	11.6	37.6	.0	359.8	66.26	297.5	268.4	11.6	4.3	.0	0.	1607.
AUG	5010.8	25.48	379.8	1756.8	11.6	40.2	.0	377.9	66.92	297.2	262.8	11.6	4.6	.0	0.	1607.
SEP	5182.4	25.87	397.7	1731.9	11.3	38.1	.0	390.7	67.31	250.9	222.5	11.3	4.4	.0	0.	1555.
OCT	5282.4	26.10	559.5	2014.0	11.6	39.9	.9	650.6	74.14	281.7	5.6	11.6	4.6	.0	0.	1607.
NOV	5282.4	26.10	627.5	1954.5	11.3	38.5	178.5	753.1	76.20	373.1	.0	11.3	5.0	254.4	0.	1555.
DEC	5282.4	26.10	453.8	1999.1	11.6	48.6	1.5	753.1	76.20	409.5	20.5	11.6	6.7	370.7	0.	1607.
			308.8	1833.8	11.4	48.9	15.1			240.6	147.8	11.4	5.7	52.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							(NEW DAM)	(PUMP)
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5858.4	27.41	218.2	389.5	11.6	62.8	.0	729.2	75.72	197.7	203.2	11.6	6.8	.0	0.	161.
FEB	5642.0	26.92	101.1	385.1	10.5	66.9	.0	657.3	74.27	96.0	150.2	10.5	7.2	.0	0.	145.
MAR	5337.9	26.23	70.9	448.9	11.6	75.1	.0	568.0	72.21	74.2	143.8	11.6	8.1	.0	0.	161.
APR	5282.4	26.10	81.2	380.6	11.3	70.6	.0	306.0	69.67	120.1	193.0	11.3	7.6	.0	0.	156.
MAY	5282.4	26.10	194.6	352.2	11.6	49.2	.0	233.5	63.78	242.7	240.5	11.6	5.3	.0	0.	161.
JUN	5304.5	26.15	288.2	368.5	11.3	41.9	.0	259.7	62.64	247.0	205.1	11.3	4.5	.0	0.	156.
JUL	5377.3	26.32	333.8	370.1	11.6	40.1	.0	318.6	64.77	297.5	222.6	11.6	4.3	.0	0.	161.
AUG	5480.9	26.55	379.8	382.4	11.6	42.8	.0	389.3	67.27	297.2	210.3	11.6	4.6	.0	0.	161.
SEP	5587.8	26.79	397.7	394.6	11.3	40.5	.0	445.6	68.83	250.9	179.0	11.3	4.4	.0	0.	156.
OCT	5827.9	27.34	559.5	426.1	11.6	42.3	.0	544.4	71.56	281.7	166.6	11.6	4.6	.0	0.	161.
NOV	5943.4	27.60	627.5	573.6	11.3	40.3	42.3	753.1	76.20	373.1	.0	11.3	4.8	148.4	0.	156.
DEC	5943.4	27.60	453.8	550.4	11.6	51.7	.8	753.1	76.20	409.5	42.3	11.6	6.7	349.0	0.	161.
			308.8	418.5	11.4	52.0	3.6			240.6	163.1	11.4	5.7	41.4		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5872.0	27.44	218.2	750.8	11.6	62.8	.0	735.5	75.85	197.7	196.9	11.6	6.8	.0	0.	536.
FEB	5644.2	26.92	101.1	735.3	10.5	66.9	.0	693.1	74.99	96.0	120.7	10.5	7.2	.0	0.	181.
MAR	5319.6	26.18	70.9	844.5	11.6	75.1	.0	644.3	74.01	74.2	103.3	11.6	8.1	.0	0.	536.
APR	5282.4	26.10	81.2	764.2	11.3	70.6	.0	383.3	72.89	120.1	153.0	11.3	7.6	.0	0.	518.
MAY	5282.4	26.10	194.6	711.3	11.6	49.2	.0	330.8	66.73	242.7	236.4	11.6	5.3	.0	0.	536.
JUN	5333.7	26.22	288.2	702.2	11.3	41.9	.0	347.0	65.80	247.0	215.0	11.3	4.5	.0	0.	518.
JUL	5445.4	26.47	333.8	706.1	11.6	40.1	.0	387.0	67.21	297.5	241.6	11.6	4.3	.0	0.	536.
AUG	5591.0	26.80	379.8	715.5	11.6	42.8	.0	435.7	68.56	297.2	232.3	11.6	4.6	.0	0.	536.
SEP	5735.4	27.13	397.7	719.9	11.3	40.5	.0	473.8	69.61	250.9	197.2	11.3	4.4	.0	0.	518.
OCT	5943.4	27.60	559.5	832.8	11.6	42.5	.3	624.3	73.61	281.7	115.0	11.6	4.6	.0	0.	536.
NOV	5943.4	27.60	627.5	917.2	11.3	40.8	176.7	753.1	76.20	373.1	.0	11.3	4.9	228.1	0.	518.
DEC	5943.4	27.60	453.8	925.2	11.6	51.7	1.0	753.1	76.20	409.5	22.6	11.6	6.7	368.6	0.	536.
			308.8	777.1	11.4	52.1	14.8			240.6	152.8	11.4	5.7	49.7		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM& 4PUMP*	
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5854.5	27.40	218.2	1089.7	11.6	62.8	.0	732.1	75.78	197.7	200.3	11.6	6.8	.0	0.	857.
FEB	5602.3	26.83	101.1	1050.0	10.5	66.9	.0	695.2	75.04	96.0	115.2	10.5	7.2	.0	0.	771.
MAR	5282.4	26.10	70.9	1194.6	11.6	75.1	.0	620.7	74.21	74.2	95.5	11.6	8.1	.0	0.	857.
APR	5282.4	26.10	81.2	1103.0	11.3	70.6	.0	302.3	72.45	120.1	145.4	11.3	7.6	.0	0.	829.
MAY	5282.4	26.10	194.6	1048.2	11.6	49.2	.0	228.9	63.60	242.7	241.9	11.6	5.3	.0	0.	857.
JUN	5324.4	26.20	288.2	1022.5	11.3	41.9	.0	234.1	61.72	247.0	226.0	11.3	4.5	.0	0.	829.
JUL	5431.4	26.44	333.8	1032.2	11.6	40.1	.0	257.8	62.58	297.5	257.8	11.6	4.3	.0	0.	857.
AUG	5573.8	26.76	379.8	1040.1	11.6	42.8	.0	288.9	63.70	297.2	249.9	11.6	4.6	.0	0.	857.
SEP	5712.6	27.08	397.7	1036.5	11.3	40.5	.0	312.3	64.54	250.9	212.0	11.3	4.4	.0	0.	829.
OCT	5943.4	27.60	559.5	1131.5	11.6	42.5	.2	419.2	68.10	281.7	158.6	11.6	4.6	.0	0.	857.
NOV	5943.4	27.60	627.5	1248.4	11.3	40.7	156.5	753.1	76.20	373.1	.0	11.3	4.4	23.5	0.	829.
DEC	5943.4	27.60	453.8	1246.5	11.6	51.7	1.1	753.1	76.20	409.5	43.5	11.6	6.7	317.7	0.	857.
			308.8	1103.6	11.4	52.1	13.1			240.6	162.2	11.4	5.7	30.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5858.7	27.41	218.2	496.3	11.6	62.8	.0	730.5	75.75	197.7	201.9	11.6	6.8	.0	0.	268.
FEB	5631.6	26.89	101.1	492.7	10.5	66.9	.0	670.9	74.55	96.0	138.0	10.5	7.2	.0	0.	242.
MAR	5310.8	26.16	70.9	572.8	11.6	75.1	.0	600.0	73.09	74.2	125.4	11.6	8.1	.0	0.	268.
APR	5282.4	26.10	81.2	499.5	11.3	70.6	.0	312.5	71.02	120.1	176.2	11.3	7.6	.0	0.	259.
MAY	5282.4	26.10	194.6	457.9	11.6	49.2	.0	241.7	64.03	242.7	240.3	11.6	5.3	.0	0.	268.
JUN	5311.1	26.17	288.2	465.6	11.3	41.9	.0	262.8	62.76	247.0	210.1	11.3	4.5	.0	0.	259.
JUL	5393.9	26.35	333.8	467.2	11.6	40.1	.0	313.4	64.58	297.5	231.0	11.6	4.3	.0	0.	268.
AUG	5508.6	26.61	379.8	478.6	11.6	42.8	.0	374.8	66.80	297.2	219.6	11.6	4.6	.0	0.	268.
SEP	5624.8	26.88	397.7	488.9	11.3	40.5	.0	423.3	68.21	250.9	186.8	11.3	4.4	.0	0.	259.
OCT	5877.3	27.45	559.5	520.9	11.6	42.3	.0	511.5	70.65	281.7	177.3	11.6	4.6	.0	0.	268.
NOV	5943.4	27.60	627.5	675.7	11.3	40.5	93.1	753.1	76.20	373.1	.0	11.3	4.7	115.6	0.	259.
DEC	5943.4	27.60	453.8	657.5	11.6	51.7	.9	753.1	76.20	409.5	40.7	11.6	6.7	350.6	0.	268.
			308.8	522.8	11.4	52.0	7.8			240.6	162.3	11.4	5.7	38.8		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5871.7	27.44	218.2	965.4	11.6	62.8	.0	735.3	75.84	197.7	197.1	11.6	6.8	.0	0.	750.
FEB	5638.0	26.91	101.1	934.7	10.5	66.9	.0	698.3	75.10	96.0	115.3	10.5	7.2	.0	0.	677.
MAR	5305.8	26.15	70.9	1066.2	11.6	75.1	.0	656.4	74.26	74.2	96.3	11.6	8.1	.0	0.	750.
APR	5282.4	26.10	81.2	979.4	11.3	70.6	.0	381.1	73.36	120.1	145.7	11.3	7.6	.0	0.	726.
MAY	5282.4	26.10	194.6	924.9	11.6	49.2	.0	328.1	66.60	242.7	237.6	11.6	5.3	.0	0.	750.
JUN	5338.5	26.23	288.2	904.7	11.3	41.9	.0	338.9	65.51	247.0	220.4	11.3	4.5	.0	0.	726.
JUL	5458.4	26.50	333.8	912.2	11.6	40.1	.0	370.1	66.63	297.5	250.4	11.6	4.3	.0	0.	750.
AUG	5613.4	26.85	379.8	920.4	11.6	42.8	.0	408.9	67.82	297.2	242.1	11.6	4.6	.0	0.	750.
SEP	5765.4	27.20	397.7	919.6	11.3	40.5	.0	438.8	68.64	250.9	205.4	11.3	4.4	.0	0.	726.
OCT	5943.4	27.60	559.5	1076.9	11.6	42.5	.4	618.7	73.50	281.7	85.6	11.6	4.6	.0	0.	750.
NOV	5943.4	27.60	627.5	1125.1	11.3	40.7	176.2	753.1	76.20	373.1	.0	11.3	4.9	222.5	0.	726.
DEC	5943.4	27.60	453.8	1139.4	11.6	51.7	1.1	753.1	76.20	409.5	23.2	11.6	6.7	368.0	0.	750.
			308.8	989.1	11.4	52.1	14.8			240.6	151.6	11.4	5.7	49.2		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5855.0	27.40	218.2	1410.7	11.6	62.8	.0	732.7	75.79	197.7	199.7	11.6	6.8	.0	0.	1178.
FEB	5599.3	26.82	101.1	1343.8	10.5	66.9	.0	700.3	75.14	96.0	110.7	10.5	7.2	.0	0.	1064.
MAR	5282.4	26.10	70.9	1520.1	11.6	75.1	.0	623.9	74.42	74.2	90.2	11.6	8.1	.0	0.	1178.
APR	5282.4	26.10	81.2	1419.0	11.3	70.6	.0	306.6	72.70	120.1	139.4	11.3	7.6	.0	0.	1110.
MAY	5282.4	26.10	194.6	1368.5	11.6	49.2	.0	234.3	63.76	242.7	241.9	11.6	5.3	.0	0.	1178.
JUN	5329.2	26.21	288.2	1328.7	11.3	41.9	.0	235.8	61.78	247.0	229.7	11.3	4.5	.0	0.	1140.
JUL	5444.2	26.47	333.8	1345.7	11.6	40.1	.0	252.7	62.39	297.5	264.7	11.6	4.3	.0	0.	1178.
AUG	5595.7	26.81	379.8	1352.4	11.6	42.8	.0	275.7	63.22	297.2	257.9	11.6	4.6	.0	0.	1178.
SEP	5742.3	27.15	397.7	1339.8	11.3	40.5	.0	292.5	63.83	250.9	218.6	11.3	4.4	.0	0.	1140.
OCT	5943.4	27.60	559.5	1482.4	11.6	42.5	.3	430.0	68.40	281.7	128.0	11.6	4.6	.0	0.	1178.
NOV	5943.4	27.60	627.5	1558.4	11.3	40.7	157.6	753.1	76.20	373.1	.0	11.3	4.4	34.3	0.	1140.
DEC	5943.4	27.60	453.8	1567.9	11.6	51.7	1.1	753.1	76.20	409.5	42.5	11.6	6.7	348.8	0.	1178.
			308.8	1419.8	11.4	52.1	13.3			240.6	160.3	11.4	5.7	31.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5872.7	27.44	218.2	669.8	11.6	62.8	.0	735.8	75.85	197.7	196.6	11.6	6.8	.0	0.	155.
FEB	5648.6	26.93	101.1	659.0	10.5	66.9	.0	690.6	74.94	96.0	123.5	10.5	7.2	.0	0.	411.
MAR	5328.6	26.21	70.9	759.4	11.6	75.1	.0	638.0	73.89	74.2	107.0	11.6	8.1	.0	0.	155.
APR	5282.4	26.10	81.2	681.6	11.3	70.6	.0	387.0	72.61	120.1	156.8	11.3	7.6	.0	0.	441.
MAY	5282.4	26.10	194.6	630.9	11.6	49.2	.0	335.5	66.89	242.7	235.6	11.6	5.3	.0	0.	455.
JUN	5331.9	26.21	288.2	626.2	11.3	41.9	.0	354.5	66.07	247.0	212.2	11.3	4.5	.0	0.	441.
JUL	5440.1	26.46	333.8	629.2	11.6	40.1	.0	398.8	67.54	297.5	237.2	11.6	4.3	.0	0.	455.
AUG	5581.8	26.78	379.8	639.0	11.6	42.8	.0	452.4	69.02	297.2	227.4	11.6	4.6	.0	0.	455.
SEP	5723.1	27.10	397.7	645.3	11.3	40.5	.0	494.6	70.18	250.9	193.2	11.3	4.4	.0	0.	441.
OCT	5943.4	27.60	559.5	740.1	11.6	42.5	.2	633.8	73.80	281.7	126.3	11.6	4.6	.0	0.	455.
NOV	5943.4	27.60	627.5	838.5	11.3	40.8	177.6	753.1	76.20	373.1	.0	11.3	5.0	237.6	0.	441.
DEC	5943.4	27.60	453.8	844.8	11.6	51.7	1.0	753.1	76.20	409.5	21.6	11.6	6.7	369.6	0.	455.
			308.8	697.0	11.4	52.1	14.9			240.6	153.1	11.4	5.7	50.6		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							NEW DAM	PUMP
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5853.3	27.40	218.2	1305.2	11.6	62.8	.0	732.3	75.78	197.7	200.1	11.6	6.8	.0	0.	1071.
FEB	5597.2	26.82	101.1	1247.5	10.5	66.9	.0	698.6	75.10	96.0	112.1	10.5	7.2	.0	0.	968.
MAR	5282.4	26.10	70.9	1413.5	11.6	75.1	.0	618.0	74.35	74.2	91.8	11.6	8.1	.0	0.	1071.
APR	5282.4	26.10	81.2	1315.4	11.3	70.6	.0	298.7	72.49	120.1	141.3	11.3	7.6	.0	0.	1037.
MAY	5282.4	26.10	194.6	1263.1	11.6	49.2	.0	224.3	63.46	242.7	242.1	11.6	5.3	.0	0.	1071.
JUN	5326.4	26.20	288.2	1227.8	11.3	41.9	.0	226.7	61.45	247.0	228.9	11.3	4.5	.0	0.	1037.
JUL	5437.7	26.45	333.8	1242.3	11.6	40.1	.0	245.2	62.12	297.5	263.0	11.6	4.3	.0	0.	1071.
AUG	5585.0	26.79	379.8	1249.4	11.6	42.8	.0	270.3	63.03	297.2	255.9	11.6	4.6	.0	0.	1071.
SEP	5727.9	27.11	397.7	1239.8	11.3	40.5	.0	288.8	63.69	250.9	216.9	11.3	4.4	.0	0.	1037.
OCT	5943.4	27.60	559.5	1361.0	11.6	42.5	.3	410.0	67.84	281.7	144.3	11.6	4.6	.0	0.	1071.
NOV	5943.4	27.60	627.5	1456.7	11.3	40.7	155.6	753.1	76.20	373.1	.0	11.3	4.4	14.4	0.	1037.
DEC	5943.4	27.60	453.8	1460.8	11.6	51.7	1.1	753.1	76.20	409.5	44.5	11.6	6.7	346.8	0.	1071.
			308.8	1315.2	11.4	52.1	13.1			240.6	161.7	11.4	5.7	30.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITHOUT DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5852.6	27.40	218.2	1921.9	11.6	62.8	.0	733.0	75.80	197.7	199.4	11.6	6.8	.0	0.	1687.
FEB	5591.3	26.80	101.1	1809.1	10.5	66.9	.0	704.4	75.22	96.0	106.9	10.5	7.2	.0	0.	1524.
MAR	5282.4	26.10	70.9	2035.4	11.6	75.1	.0	618.0	74.59	74.2	85.9	11.6	8.1	.0	0.	1687.
APR	5282.4	26.10	81.2	1918.5	11.3	70.6	.0	298.7	72.68	120.1	134.4	11.3	7.6	.0	0.	1633.
MAY	5282.4	26.10	194.6	1879.0	11.6	49.2	.0	224.3	63.46	242.7	242.3	11.6	5.3	.0	0.	1687.
JUN	5331.4	26.21	288.2	1819.0	11.3	41.9	.0	221.7	61.27	247.0	233.9	11.3	4.5	.0	0.	1633.
JUL	5451.8	26.49	333.8	1849.2	11.6	40.1	.0	231.1	61.61	297.5	272.1	11.6	4.3	.0	0.	1687.
AUG	5609.9	26.84	379.8	1854.7	11.6	42.8	.0	245.4	62.13	297.2	266.6	11.6	4.6	.0	0.	1687.
SEP	5761.7	27.19	397.7	1827.1	11.3	40.5	.0	255.0	62.47	250.9	225.8	11.3	4.4	.0	0.	1633.
OCT	5943.4	27.60	559.5	2010.7	11.6	42.5	.4	409.8	67.84	281.7	110.6	11.6	4.6	.0	0.	1687.
NOV	5943.4	27.60	627.5	2052.9	11.3	40.7	155.6	753.1	76.20	373.1	.0	11.3	4.4	14.2	0.	1633.
DEC	5943.4	27.60	453.8	2076.7	11.6	51.7	1.2	753.1	76.20	409.5	44.6	11.6	6.7	346.7	0.	1687.
			308.8	1921.2	11.4	52.1	13.1			240.6	160.2	11.4	5.7	30.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5164.8	25.83	218.2	345.5	11.6	59.0	.0	703.6	75.21	197.7	228.8	11.6	6.8	.0	0.	80.
FEB	4931.1	25.30	101.1	334.0	10.5	62.9	.0	597.2	73.02	96.0	184.7	10.5	7.2	.0	0.	73.
MAR	4622.9	24.60	70.9	385.3	11.6	70.6	.0	454.5	69.30	74.2	189.0	11.6	8.1	.0	0.	80.
APR	4622.9	24.60	81.2	316.6	11.3	66.3	.0	214.2	61.00	120.1	239.1	11.3	7.6	.0	133.	78.
MAY	4622.9	24.60	194.6	305.1	11.6	46.2	.0	214.2	61.00	242.7	269.3	11.6	5.3	.0	261.	80.
JUN	4622.9	24.60	288.2	331.8	11.3	39.4	.0	214.2	61.00	247.0	224.0	11.3	4.5	.0	273.	78.
JUL	4653.6	24.67	333.8	334.2	11.6	37.6	.0	255.7	62.50	297.5	240.1	11.6	4.3	.0	273.	80.
AUG	4713.0	24.80	379.8	348.9	11.6	40.2	.0	311.3	64.51	297.2	225.4	11.6	4.6	.0	273.	80.
SEP	4775.3	24.95	397.7	363.8	11.3	38.1	.0	354.6	66.07	250.9	192.0	11.3	4.4	.0	273.	78.
OCT	4965.0	25.38	559.5	398.8	11.6	39.8	.0	444.5	68.80	281.7	175.5	11.6	4.6	.0	273.	80.
NOV	5257.8	26.04	627.5	363.5	11.3	37.7	.0	609.8	73.32	373.1	192.3	11.3	4.3	.0	273.	78.
DEC	5282.4	26.10	453.8	448.8	11.6	48.6	.6	753.1	76.20	409.5	125.5	11.6	6.0	123.0	273.	80.
			308.8	356.4	11.4	48.9	.0			240.6	207.1	11.4	5.6	10.3		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5141.6	25.78	218.2	690.2	11.6	59.0	.0	712.3	75.38	197.7	220.1	11.6	6.8	.0	0.	402.
FEB	4851.0	25.12	101.1	681.1	10.5	62.9	.0	649.7	74.12	96.0	141.0	10.5	7.2	.0	0.	363.
MAR	4622.9	24.60	70.9	786.8	11.6	70.6	.0	412.4	72.56	74.2	123.5	11.6	8.1	.0	0.	402.
APR	4622.9	24.60	81.2	701.6	11.3	66.3	.0	214.2	61.00	120.1	179.2	11.3	7.6	.0	189.	389.
MAY	4622.9	24.60	194.6	647.0	11.6	46.2	.0	214.2	61.00	242.7	263.3	11.6	5.3	.0	335.	402.
JUN	4622.9	24.60	288.2	645.4	11.3	39.4	.0	214.2	61.00	247.0	235.5	11.3	4.5	.0	358.	389.
JUL	4661.1	24.69	333.8	648.1	11.6	37.6	.0	233.6	61.70	297.5	262.1	11.6	4.3	.0	358.	402.
AUG	4731.4	24.85	379.8	659.5	11.6	40.2	.0	263.8	62.79	297.2	250.8	11.6	4.6	.0	358.	402.
SEP	4800.8	25.00	397.7	667.8	11.3	38.1	.0	286.1	63.60	250.9	213.1	11.3	4.4	.0	358.	389.
OCT	5006.7	25.47	559.5	704.0	11.6	39.8	.0	345.3	65.74	281.7	206.3	11.6	4.6	.0	358.	402.
NOV	5282.4	26.10	627.5	691.3	11.3	37.8	.2	513.3	70.70	373.1	189.5	11.3	4.3	.0	358.	389.
DEC	5282.4	26.10	453.8	794.5	11.6	48.6	.9	753.1	76.20	409.5	115.7	11.6	5.7	36.7	358.	402.
			308.8	693.1	11.4	48.9	.1			240.6	200.0	11.4	5.6	3.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5133.2	25.76	218.2	1020.0	11.6	59.0	.0	718.2	75.50	197.7	214.2	11.6	6.8	.0	0.	723.
FEB	4825.3	25.06	101.1	988.8	10.5	62.9	.0	670.6	74.54	96.0	125.9	10.5	7.2	.0	0.	653.
MAR	4622.9	24.60	70.9	1128.7	11.6	70.6	.0	405.1	73.52	74.2	105.4	11.6	8.1	.0	0.	723.
APR	4622.9	24.60	81.2	1035.2	11.3	66.3	.0	214.2	61.00	120.1	159.1	11.3	7.6	.0	199.	700.
MAY	4622.9	24.60	194.6	976.1	11.6	46.2	.0	214.2	61.00	242.7	258.1	11.6	5.3	.0	347.	723.
JUN	4622.9	24.60	288.2	955.5	11.3	39.4	.0	214.2	61.00	247.0	238.8	11.3	4.5	.0	373.	700.
JUL	4667.6	24.70	333.8	963.1	11.6	37.6	.0	224.7	61.38	297.5	271.0	11.6	4.3	.0	373.	723.
AUG	4746.6	24.88	379.8	972.2	11.6	40.2	.0	243.7	62.07	297.2	262.0	11.6	4.6	.0	373.	723.
SEP	4822.7	25.05	397.7	972.1	11.3	38.1	.0	256.8	62.54	250.9	222.3	11.3	4.4	.0	373.	700.
OCT	5042.0	25.55	559.5	1011.9	11.6	39.8	.0	300.0	64.10	281.7	222.2	11.6	4.6	.0	373.	723.
NOV	5282.4	26.10	627.5	1037.4	11.3	37.8	.4	500.7	70.35	373.1	156.9	11.3	4.3	.0	373.	700.
DEC	5282.4	26.10	453.8	1115.8	11.6	48.6	1.0	753.1	76.20	409.5	118.3	11.6	5.6	21.5	373.	723.
			308.8	1014.7	11.4	48.9	.1			240.6	196.2	11.4	5.6	1.8		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5325.5	26.20	218.2	681.1	11.6	60.1	.0	715.2	75.44	197.7	217.2	11.6	6.8	.0	0.	402.
FEB	5042.8	25.56	101.1	672.2	10.5	64.0	.0	654.4	74.22	96.0	139.1	10.5	7.2	.0	0.	363.
MAR	4798.8	25.00	70.9	776.4	11.6	71.8	.0	443.9	72.74	74.2	121.8	11.6	8.1	.0	0.	402.
APR	4798.8	25.00	81.2	692.4	11.3	67.5	.0	217.0	61.10	120.1	176.9	11.3	7.6	.0	150.	389.
MAY	4798.8	25.00	194.6	638.4	11.6	47.0	.0	217.0	61.10	242.7	259.8	11.6	5.3	.0	285.	402.
JUN	4798.8	25.00	288.2	636.9	11.3	40.0	.0	217.0	61.10	247.0	232.4	11.3	4.5	.0	297.	389.
JUL	4844.9	25.10	333.8	639.6	11.6	38.3	.0	239.9	61.93	297.5	258.6	11.6	4.3	.0	297.	402.
AUG	4923.2	25.28	379.8	650.8	11.6	40.9	.0	273.4	63.14	297.2	247.5	11.6	4.6	.0	297.	402.
SEP	5000.7	25.46	397.7	659.0	11.3	38.7	.0	298.4	64.04	250.9	210.3	11.3	4.4	.0	297.	389.
OCT	5215.1	25.95	559.5	694.7	11.6	40.5	.0	360.4	66.28	281.7	203.5	11.6	4.6	.0	297.	402.
NOV	5458.3	26.50	627.5	723.1	11.3	38.4	.3	571.8	72.31	373.1	146.2	11.3	4.3	.0	297.	389.
DEC	5458.3	26.50	453.8	793.6	11.6	49.4	.9	753.1	76.20	409.5	104.6	11.6	6.0	106.0	297.	402.
			308.8	688.2	11.4	49.7	.1			240.6	193.2	11.4	5.6	8.8		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5314.8	26.17	218.2	1361.4	11.6	60.1	.0	723.7	75.61	197.7	208.7	11.6	6.8	.0	0.	1071.
FEB	5007.9	25.48	101.1	1301.2	10.5	64.0	.0	685.1	74.83	96.0	116.9	10.5	7.2	.0	0.	968.
MAR	4798.8	25.00	70.9	1474.3	11.6	71.8	.0	437.4	74.00	74.2	95.7	11.6	8.1	.0	0.	1071.
APR	4798.8	25.00	81.2	1372.1	11.3	67.5	.0	217.0	61.10	120.1	147.3	11.3	7.6	.0	158.	1037.
MAY	4798.8	25.00	194.6	1317.5	11.6	47.0	.0	217.0	61.10	242.7	252.6	11.6	5.3	.0	295.	1071.
JUN	4798.8	25.00	288.2	1280.7	11.3	40.0	.0	217.0	61.10	247.0	238.7	11.3	4.5	.0	310.	1037.
JUL	4858.3	25.14	333.8	1295.8	11.6	38.3	.0	224.2	61.36	297.5	274.3	11.6	4.3	.0	310.	1071.
AUG	4953.8	25.35	379.8	1303.2	11.6	40.9	.0	238.3	61.87	297.2	266.9	11.6	4.6	.0	310.	1071.
SEP	5045.1	25.56	397.7	1293.2	11.3	38.7	.0	247.4	62.20	250.9	226.2	11.3	4.4	.0	310.	1037.
OCT	5285.0	26.11	559.5	1338.8	11.6	40.5	.0	281.6	63.44	281.7	231.2	11.6	4.6	.0	310.	1071.
NOV	5458.3	26.50	627.5	1440.5	11.3	38.4	.7	560.3	72.00	373.1	78.9	11.3	4.3	.0	310.	1037.
DEC	5458.3	26.50	453.8	1463.0	11.6	49.4	1.1	753.1	76.20	409.5	107.0	11.6	5.9	92.2	310.	1071.
			308.8	1353.5	11.4	49.7	.2			240.6	187.0	11.4	5.6	7.7		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5306.9	26.16	218.2	2012.1	11.6	60.1	.0	726.6	75.67	197.7	205.8	11.6	6.8	.0	0.	1711.
FEB	4988.8	25.43	101.1	1893.0	10.5	64.0	.0	694.7	75.03	96.0	110.2	10.5	7.2	.0	0.	1518.
MAR	4798.8	25.00	70.9	2129.4	11.6	71.8	.0	422.8	74.34	74.2	88.5	11.6	8.1	.0	0.	1711.
APR	4798.8	25.00	81.2	2007.8	11.3	67.5	.0	217.0	61.10	120.1	138.5	11.3	7.6	.0	178.	1659.
MAY	4798.8	25.00	194.6	1967.7	11.6	47.0	.0	217.0	61.10	242.7	250.2	11.6	5.3	.0	320.	1711.
JUN	4798.8	25.00	288.2	1904.7	11.3	40.0	.0	217.0	61.10	247.0	241.6	11.3	4.5	.0	339.	1659.
JUL	4860.3	25.14	333.8	1936.6	11.6	38.3	.0	217.2	61.11	297.5	281.3	11.6	4.3	.0	339.	1714.
AUG	4959.5	25.37	379.8	1942.2	11.6	40.9	.0	222.5	61.30	297.2	275.7	11.6	4.6	.0	339.	1714.
SEP	5053.1	25.58	397.7	1912.9	11.3	38.7	.0	224.4	61.37	250.9	233.4	11.3	4.1	.0	339.	1659.
OCT	5301.3	26.14	559.5	1973.4	11.6	40.5	.0	245.4	62.13	281.7	244.5	11.6	4.6	.0	339.	1714.
NOV	5458.3	26.50	627.5	2078.8	11.3	38.4	.9	535.4	71.31	373.1	67.6	11.3	4.3	.0	339.	1659.
DEC	5458.3	26.50	453.8	2105.8	11.6	49.4	1.2	753.1	76.20	409.5	112.1	11.6	5.8	62.3	339.	1714.
			308.8	1988.7	11.4	49.7	.2			240.6	187.4	11.4	5.6	5.2		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5164.4	25.83	218.2	453.1	11.6	59.0	.0	711.6	75.37	197.7	220.8	11.6	6.8	.0	0.	187.
FEB	4912.2	25.26	101.1	449.2	10.5	62.9	.0	630.4	73.73	96.0	159.5	10.5	7.2	.0	0.	169.
MAR	4622.9	24.60	70.9	523.6	11.6	70.6	.0	476.4	71.29	74.2	150.3	11.6	8.1	.0	0.	187.
APR	4622.9	24.60	81.2	447.6	11.3	66.3	.0	214.2	61.00	120.1	204.6	11.3	7.6	.0	104.	181.
MAY	4622.9	24.60	194.6	412.1	11.6	46.2	.0	214.2	61.00	242.7	261.8	11.6	5.3	.0	228.	187.
JUN	4622.9	24.60	288.2	427.4	11.3	39.4	.0	214.2	61.00	247.0	224.8	11.3	4.5	.0	229.	181.
JUL	4665.9	24.70	333.8	429.1	11.6	37.6	.0	250.9	62.33	297.5	244.8	11.6	4.3	.0	229.	187.
AUG	4739.2	24.86	379.8	442.2	11.6	40.2	.0	300.2	64.11	297.2	231.7	11.6	4.6	.0	229.	187.
SEP	4813.9	25.03	397.7	455.0	11.3	38.1	.0	338.4	65.49	250.9	197.2	11.3	4.4	.0	229.	181.
OCT	5020.1	25.50	559.5	489.4	11.6	39.8	.0	419.3	68.10	281.7	184.5	11.6	4.6	.0	229.	187.
NOV	5282.4	26.10	627.5	497.4	11.3	37.8	.2	622.1	73.57	373.1	154.8	11.3	4.3	.0	229.	181.
DEC	5282.4	26.10	453.8	580.3	11.6	48.6	.8	753.1	76.20	409.5	93.6	11.6	6.2	167.1	229.	187.
			308.8	467.2	11.4	48.9	.1			240.6	194.0	11.4	5.6	13.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85fc

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5146.1	25.79	218.2	899.9	11.6	59.0	.0	719.2	75.52	197.7	213.2	11.6	6.8	.0	0.	616.
FEB	4853.0	25.12	101.1	877.2	10.5	62.9	.0	669.4	74.52	96.0	128.2	10.5	7.2	.0	0.	556.
MAR	4622.9	24.60	70.9	1004.6	11.6	70.6	.0	445.5	73.43	74.2	108.5	11.6	8.1	.0	0.	616.
APR	4622.9	24.60	81.2	915.0	11.3	66.3	.0	214.2	61.00	120.1	162.2	11.3	7.6	.0	115.	596.
MAY	4622.9	24.60	194.6	856.7	11.6	46.2	.0	214.2	61.00	242.7	256.5	11.6	5.3	.0	279.	616.
JUN	4622.9	24.60	288.2	842.0	11.3	39.4	.0	214.2	61.00	247.0	235.2	11.3	4.5	.0	292.	596.
JUL	4675.9	24.72	333.8	847.7	11.6	37.6	.0	230.3	61.58	297.5	265.5	11.6	4.3	.0	292.	616.
AUG	4762.6	24.92	379.8	857.3	11.6	40.2	.0	255.4	62.49	297.2	255.8	11.6	4.6	.0	292.	616.
SEP	4847.1	25.11	397.7	860.1	11.3	38.1	.0	273.6	63.15	250.9	217.2	11.3	4.4	.0	292.	596.
OCT	5073.2	25.62	559.5	898.0	11.6	39.8	.0	323.9	64.96	281.7	215.2	11.6	4.6	.0	292.	616.
NOV	5282.4	26.10	627.5	964.9	11.3	37.8	.5	569.1	72.24	373.1	112.3	11.3	4.3	.0	292.	596.
DEC	5282.4	26.10	453.8	1008.7	11.6	48.6	1.0	753.1	76.20	409.5	104.4	11.6	6.0	103.5	292.	616.
			308.8	902.7	11.4	48.9	.1			240.6	189.5	11.4	5.6	8.6		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5145.9	25.79	218.2	1328.6	11.6	59.0	.0	724.4	75.62	197.7	208.0	11.6	6.8	.0	0.	1045.
FEB	4846.0	25.11	101.1	1271.1	10.5	62.9	.0	685.9	74.85	96.0	116.9	10.5	7.2	.0	0.	943.
MAR	4622.9	24.60	70.9	1440.8	11.6	70.6	.0	460.0	74.02	74.2	95.8	11.6	8.1	.0	0.	1045.
APR	4622.9	24.60	81.2	1339.8	11.3	66.3	.0	214.2	61.00	120.1	147.3	11.3	7.6	.0	125.	1011.
MAY	4622.9	24.60	194.6	1285.0	11.6	46.2	.0	214.2	61.00	242.7	251.6	11.6	5.3	.0	255.	1045.
JUN	4622.9	24.60	288.2	1249.5	11.3	39.4	.0	214.2	61.00	247.0	237.6	11.3	4.5	.0	262.	1011.
JUL	4688.2	24.75	333.8	1263.9	11.6	37.6	.0	223.0	61.32	297.5	272.8	11.6	4.3	.0	262.	1045.
AUG	4789.4	24.98	379.8	1271.4	11.6	40.2	.0	238.7	61.88	297.2	265.3	11.6	4.6	.0	262.	1045.
SEP	4886.4	25.20	397.7	1262.2	11.3	38.1	.0	249.1	62.26	250.9	224.9	11.3	4.4	.0	262.	1011.
OCT	5132.0	25.76	559.5	1307.1	11.6	39.8	.0	285.1	63.56	281.7	229.5	11.6	4.6	.0	262.	1045.
NOV	5282.4	26.10	627.5	1438.0	11.3	37.8	.8	593.6	72.92	373.1	49.1	11.3	4.3	.0	262.	1011.
DEC	5282.4	26.10	453.8	1437.1	11.6	48.6	1.1	753.1	76.20	409.5	99.6	11.6	6.1	132.8	262.	1045.
			308.8	1324.5	11.4	48.9	.2			240.6	183.2	11.4	5.6	11.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******						*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5141.8	25.78	218.2	609.6	11.6	59.0	.0	709.1	75.32	197.7	223.3	11.6	6.8	.0	0.	321.
FEB	4855.7	25.13	101.1	604.1	10.5	62.9	.0	639.2	73.91	96.0	148.2	10.5	7.2	.0	0.	290.
MAR	4622.9	24.60	70.9	700.5	11.6	70.6	.0	403.5	72.02	74.2	132.4	11.6	8.1	.0	0.	321.
APR	4622.9	24.60	81.2	617.2	11.3	66.3	.0	214.2	61.00	120.1	188.9	11.3	7.6	.0	201.	311.
MAY	4622.9	24.60	194.6	566.5	11.6	46.2	.0	214.2	61.00	242.7	266.4	11.6	5.3	.0	350.	321.
JUN	4622.9	24.60	288.2	570.8	11.3	39.4	.0	214.2	61.00	247.0	235.3	11.3	4.5	.0	376.	311.
JUL	4656.0	24.68	333.8	572.9	11.6	37.6	.0	235.7	61.78	297.5	260.1	11.6	4.3	.0	376.	321.
AUG	4720.4	24.82	379.8	585.0	11.6	40.2	.0	268.7	62.97	297.2	247.9	11.6	4.6	.0	376.	321.
SEP	4784.5	24.97	397.7	595.3	11.3	38.1	.0	293.2	63.86	250.9	210.8	11.3	4.4	.0	376.	311.
OCT	4982.9	25.42	559.5	631.1	11.6	39.8	.0	356.9	66.16	281.7	201.8	11.6	4.6	.0	376.	321.
NOV	5282.4	26.10	627.5	589.9	11.3	37.8	.0	498.3	70.29	373.1	216.2	11.3	4.3	.0	376.	311.
DEC	5282.4	26.10	453.8	714.2	11.6	48.6	.8	753.1	76.20	409.5	118.7	11.6	5.6	18.7	376.	321.
			308.8	613.1	11.4	48.9	.1			240.6	204.2	11.4	5.6	1.6		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5140.3	25.78	218.2	1227.2	11.6	59.0	.0	722.5	75.58	197.7	209.9	11.6	6.8	.0	0.	937.
FEB	4836.1	25.08	101.1	1178.6	10.5	62.9	.0	681.4	74.76	96.0	119.4	10.5	7.2	.0	0.	847.
MAR	4622.9	24.60	70.9	1338.6	11.6	70.6	.0	438.1	73.87	74.2	98.5	11.6	8.1	.0	0.	937.
APR	4622.9	24.60	81.2	1240.1	11.3	66.3	.0	214.2	61.00	120.1	150.6	11.3	7.6	.0	155.	907.
MAY	4622.9	24.60	194.6	1183.4	11.6	46.2	.0	214.2	61.00	242.7	253.7	11.6	5.3	.0	292.	937.
JUN	4622.9	24.60	288.2	1152.6	11.3	39.4	.0	214.2	61.00	247.0	238.1	11.3	4.5	.0	307.	907.
JUL	4680.4	24.73	333.8	1164.6	11.6	37.6	.0	223.2	61.33	297.5	272.5	11.6	4.3	.0	307.	937.
AUG	4773.3	24.94	379.8	1172.5	11.6	40.2	.0	239.7	61.92	297.2	264.5	11.6	4.6	.0	307.	937.
SEP	4862.4	25.14	397.7	1166.4	11.3	38.1	.0	250.7	62.32	250.9	224.3	11.3	4.4	.0	307.	907.
OCT	5098.5	25.68	559.5	1209.5	11.6	39.8	.0	288.6	63.69	281.7	227.6	11.6	4.6	.0	307.	937.
NOV	5282.4	26.10	627.5	1301.0	11.3	37.8	.7	556.4	71.89	373.1	89.7	11.3	4.3	.0	307.	907.
DEC	5282.4	26.10	453.8	1330.0	11.6	48.6	1.1	753.1	76.20	409.5	107.1	11.6	5.9	88.2	307.	937.
			308.8	1222.0	11.4	48.9	.1			240.6	188.0	11.4	5.6	7.4		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 85ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5142.6	25.78	218.2	1814.1	11.6	59.0	.0	726.9	75.67	197.7	205.5	11.6	6.8	.0	0.	1527.
FEB	4836.2	25.09	101.1	1713.0	10.5	62.9	.0	694.1	75.01	96.0	111.2	10.5	7.2	.0	0.	1379.
MAR	4622.9	24.60	70.9	1930.0	11.6	70.6	.0	457.5	74.31	74.2	89.6	11.6	8.1	.0	0.	1527.
APR	4622.9	24.60	81.2	1814.7	11.3	66.3	.0	214.2	61.00	120.1	139.8	11.3	7.6	.0	129.	1477.
MAY	4622.9	24.60	194.6	1770.1	11.6	46.2	.0	214.2	61.00	242.7	249.5	11.6	5.3	.0	259.	1527.
JUN	4623.3	24.60	288.2	1714.6	11.3	39.4	.0	214.2	61.00	247.0	239.8	11.3	4.5	.0	268.	1477.
JUL	4693.3	24.76	333.8	1741.2	11.6	37.6	.0	217.3	61.11	297.5	278.4	11.6	4.3	.0	268.	1527.
AUG	4800.8	25.00	379.8	1747.2	11.6	40.2	.0	225.9	61.42	297.2	272.4	11.6	4.6	.0	268.	1527.
SEP	4902.8	25.24	397.7	1723.8	11.3	38.1	.0	230.6	61.59	250.9	230.7	11.3	4.4	.0	268.	1477.
OCT	5158.2	25.82	559.5	1779.4	11.6	39.8	.0	255.8	62.50	281.7	240.2	11.6	4.6	.0	268.	1527.
NOV	5282.4	26.10	627.5	1930.6	11.3	37.8	1.0	589.5	72.81	373.1	23.9	11.3	4.3	.0	268.	1477.
DEC	5282.4	26.10	453.8	1919.1	11.6	48.6	1.2	753.1	76.20	409.5	100.5	11.6	6.1	127.8	268.	1527.
			308.8	1799.8	11.4	48.9	.2			240.6	181.8	11.4	5.6	10.6		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5825.6	27.34	218.2	368.7	11.6	62.8	.0	708.4	75.30	197.7	224.0	11.6	6.8	.0	0.	107.
FEB	5585.6	26.79	101.1	360.4	10.5	66.9	.0	611.7	73.36	96.0	175.0	10.5	7.2	.0	0.	97.
MAR	5282.4	26.10	70.9	418.4	11.6	75.1	.0	468.0	70.11	74.2	174.3	11.6	8.1	.0	0.	107.
APR	5282.4	26.10	81.2	347.8	11.3	70.6	.0	214.2	61.00	120.1	225.8	11.3	7.6	.0	116.	104.
MAY	5282.4	26.10	194.6	328.5	11.6	49.2	.0	214.2	61.00	242.7	264.2	11.6	5.3	.0	242.	107.
JUN	5282.4	26.10	288.2	351.8	11.3	41.9	.0	214.2	61.00	247.0	221.8	11.3	4.5	.0	245.	104.
JUL	5317.8	26.18	333.8	353.9	11.6	40.1	.0	257.0	62.55	297.5	238.8	11.6	4.3	.0	245.	107.
AUG	5382.2	26.33	379.8	368.1	11.6	42.8	.0	313.3	64.58	297.2	224.6	11.6	4.6	.0	245.	107.
SEP	5449.5	26.48	397.7	382.3	11.3	40.5	.0	357.3	66.17	250.9	191.3	11.3	4.4	.0	245.	104.
OCT	5645.5	26.93	559.5	416.7	11.6	42.3	.0	446.7	68.86	281.7	176.0	11.6	4.6	.0	245.	107.
NOV	5943.4	27.60	627.5	381.8	11.3	40.2	.0	612.5	73.37	373.1	191.8	11.3	4.3	.0	245.	104.
DEC	5943.4	27.60	453.8	497.0	11.6	51.7	.6	753.1	76.20	409.5	95.7	11.6	6.1	155.5	245.	107.
			308.8	381.3	11.4	52.0	.1			240.6	200.3	11.4	5.6	13.0		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 100×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5809.8	27.30	218.2	732.7	11.6	62.8	.0	717.4	75.48	197.7	215.0	11.6	6.8	.0	0.	455.
FEB	5523.9	26.65	101.1	720.9	10.5	66.9	.0	660.6	74.34	96.0	135.1	10.5	7.2	.0	0.	411.
MAR	5282.4	26.10	70.9	830.7	11.6	75.1	.0	448.2	73.04	74.2	117.1	11.6	8.1	.0	0.	455.
APR	5282.4	26.10	81.2	745.6	11.3	70.6	.0	214.2	61.00	120.1	171.5	11.3	7.6	.0	112.	441.
MAY	5282.4	26.10	194.6	690.1	11.6	49.2	.0	214.2	61.00	242.7	257.7	11.6	5.3	.0	275.	455.
JUN	5282.4	26.10	288.2	685.0	11.3	41.9	.0	214.2	61.00	247.0	232.1	11.3	4.5	.0	285.	441.
JUL	5331.6	26.21	333.8	688.3	11.6	40.1	.0	236.3	61.80	297.5	259.4	11.6	4.3	.0	285.	455.
AUG	5413.4	26.40	379.8	699.0	11.6	42.8	.0	268.5	62.96	297.2	248.7	11.6	4.6	.0	285.	455.
SEP	5494.0	26.58	397.7	705.9	11.3	40.5	.0	292.5	63.83	250.9	211.3	11.3	4.4	.0	285.	441.
OCT	5713.1	27.08	559.5	741.8	11.6	42.3	.0	352.1	65.98	281.7	205.9	11.6	4.6	.0	285.	455.
NOV	5943.4	27.60	627.5	786.0	11.3	40.2	.3	578.5	72.50	373.1	131.2	11.3	4.3	.0	285.	441.
DEC	5943.4	27.60	453.8	845.1	11.6	51.7	.8	753.1	76.20	409.5	102.7	11.6	6.0	114.7	285.	455.
			308.8	739.2	11.4	52.0	.1			240.6	190.7	11.4	5.6	9.6		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 100×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5809.8	27.30	218.2	1080.9	11.6	62.8	.0	723.3	75.60	197.7	209.1	11.6	6.8	.0	0.	801.
FEB	5515.2	26.63	101.1	1044.0	10.5	66.9	.0	680.3	74.74	96.0	121.3	10.5	7.2	.0	0.	726.
MAR	5282.4	26.10	70.9	1189.2	11.6	75.1	.0	465.2	73.81	74.2	100.9	11.6	8.1	.0	0.	801.
APR	5282.4	26.10	81.2	1095.3	11.3	70.6	.0	214.2	61.00	120.1	153.1	11.3	7.6	.0	119.	778.
MAY	5282.4	26.10	194.6	1037.8	11.6	49.2	.0	214.2	61.00	242.7	252.3	11.6	5.3	.0	216.	801.
JUN	5282.4	26.10	288.2	1013.6	11.3	41.9	.0	214.2	61.00	247.0	234.9	11.3	4.5	.0	251.	778.
JUL	5345.5	26.24	333.8	1022.6	11.6	40.1	.0	228.3	61.51	297.5	267.5	11.6	4.3	.0	251.	804.
AUG	5443.3	26.47	379.8	1031.1	11.6	42.8	.0	250.3	62.30	297.2	259.0	11.6	4.6	.0	251.	804.
SEP	5538.0	26.68	397.7	1028.8	11.3	40.5	.0	265.9	62.87	250.9	219.7	11.3	4.4	.0	251.	778.
OCT	5778.0	27.23	559.5	1069.1	11.6	42.3	.0	310.5	64.48	281.7	220.9	11.6	4.6	.0	251.	804.
NOV	5943.4	27.60	627.5	1187.5	11.3	40.2	.6	607.1	73.27	373.1	60.9	11.3	4.3	.0	251.	778.
DEC	5943.4	27.60	453.8	1193.2	11.6	51.7	.9	753.1	76.20	409.5	96.9	11.6	6.1	118.9	251.	804.
			308.8	1082.8	11.4	52.0	.1			240.6	183.0	11.4	5.6	12.4		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******						****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5822.3	27.33	218.2	479.2	11.6	62.8	.0	713.4	75.40	197.7	219.0	11.6	6.8	.0	0.	214.
FEB	5563.9	26.74	101.1	475.6	10.5	66.9	.0	636.7	73.86	96.0	155.0	10.5	7.2	.0	0.	194.
MAR	5282.4	26.10	70.9	554.1	11.6	75.1	.0	472.8	71.63	74.2	144.1	11.6	8.1	.0	0.	214.
APR	5282.4	26.10	81.2	477.1	11.3	70.6	.0	214.2	61.00	120.1	198.5	11.3	7.6	.0	109.	207.
MAY	5282.4	26.10	194.6	438.1	11.6	49.2	.0	214.2	61.00	242.7	260.0	11.6	5.3	.0	233.	214.
JUN	5282.4	26.10	288.2	450.9	11.3	41.9	.0	214.2	61.00	247.0	224.7	11.3	4.5	.0	235.	207.
JUL	5326.3	26.20	333.8	452.6	11.6	40.1	.0	250.1	62.30	297.5	245.6	11.6	4.3	.0	235.	214.
AUG	5400.6	26.37	379.8	465.4	11.6	42.8	.0	298.3	64.04	297.2	232.8	11.6	4.6	.0	235.	214.
SEP	5476.3	26.54	397.7	477.6	11.3	40.5	.0	335.5	65.38	250.9	198.1	11.3	4.4	.0	235.	207.
OCT	5684.2	27.01	559.5	511.9	11.6	42.3	.0	414.7	67.98	281.7	186.3	11.6	4.6	.0	235.	214.
NOV	5943.4	27.60	627.5	524.0	11.3	40.2	.2	620.6	73.54	373.1	151.6	11.3	4.3	.0	235.	207.
DEC	5943.4	27.60	453.8	604.1	11.6	51.7	.7	753.1	76.20	409.5	94.1	11.6	6.2	165.1	235.	214.
			308.8	492.5	11.4	52.0	.1			240.6	192.5	11.4	5.6	13.8		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5805.9	27.29	218.2	950.8	11.6	62.8	.0	720.7	75.55	197.7	211.7	11.6	6.8	.0	0.	670.
FEB	5510.1	26.62	101.1	924.3	10.5	66.9	.0	673.3	74.60	96.0	125.8	10.5	7.2	.0	0.	605.
MAR	5282.4	26.10	70.9	1056.7	11.6	75.1	.0	446.5	73.56	74.2	105.8	11.6	8.1	.0	0.	670.
APR	5282.4	26.10	81.2	966.0	11.3	70.6	.0	214.2	61.00	120.1	159.0	11.3	7.6	.0	144.	648.
MAY	5282.4	26.10	194.6	907.7	11.6	49.2	.0	214.2	61.00	242.7	254.9	11.6	5.3	.0	278.	670.
JUN	5282.4	26.10	288.2	890.2	11.3	41.9	.0	214.2	61.00	247.0	234.9	11.3	4.5	.0	288.	648.
JUL	5337.5	26.23	333.8	896.7	11.6	40.1	.0	229.9	61.57	297.5	265.8	11.6	4.3	.0	288.	670.
AUG	5426.5	26.43	379.8	906.0	11.6	42.8	.0	254.3	62.45	297.2	256.6	11.6	4.6	.0	288.	670.
SEP	5513.1	26.62	397.7	907.3	11.3	40.5	.0	271.9	63.08	250.9	217.7	11.3	4.4	.0	288.	648.
OCT	5742.4	27.15	559.5	945.8	11.6	42.3	.0	320.6	64.85	281.7	216.7	11.6	4.6	.0	288.	670.
NOV	5943.4	27.60	627.5	1022.5	11.3	40.2	.5	575.6	72.42	373.1	102.6	11.3	4.3	.0	288.	648.
DEC	5943.4	27.60	453.8	1059.3	11.6	51.7	.8	753.1	76.20	409.5	103.3	11.6	6.0	111.1	288.	670.
			308.8	952.8	11.4	52.0	.1			240.6	187.9	11.4	5.6	9.3		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 150×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5808.3	27.30	218.2	1403.8	11.6	62.8	.0	725.8	75.65	197.7	206.6	11.6	6.8	.0	0.	1125.
FEB	5508.7	26.61	101.1	1339.4	10.5	66.9	.0	689.0	74.91	96.0	115.2	10.5	7.2	.0	0.	1016.
MAR	5282.4	26.10	70.9	1516.3	11.6	75.1	.0	468.4	74.12	74.2	94.0	11.6	8.1	.0	0.	1125.
APR	5282.4	26.10	81.2	1413.4	11.3	70.6	.0	214.2	61.00	120.1	145.0	11.3	7.6	.0	115.	1089.
MAY	5282.4	26.10	194.6	1360.2	11.6	49.2	.0	214.2	61.00	242.7	250.2	11.6	5.3	.0	241.	1125.
JUN	5284.7	26.11	288.2	1321.4	11.3	41.9	.0	214.2	61.00	247.0	237.0	11.3	4.5	.0	247.	1089.
JUL	5354.2	26.26	333.8	1337.6	11.6	40.1	.0	223.0	61.32	297.5	272.8	11.6	4.3	.0	247.	1125.
AUG	5459.8	26.50	379.8	1344.8	11.6	42.8	.0	238.3	61.87	297.2	265.6	11.6	4.6	.0	247.	1125.
SEP	5561.0	26.73	397.7	1333.3	11.3	40.5	.0	248.6	62.24	250.9	225.1	11.3	4.4	.0	247.	1089.
OCT	5811.8	27.30	559.5	1379.7	11.6	42.3	.0	283.3	63.50	281.7	230.7	11.6	4.6	.0	247.	1125.
NOV	5943.4	27.60	627.5	1532.3	11.3	40.2	.8	614.8	73.42	373.1	26.1	11.3	4.3	.0	247.	1089.
DEC	5943.4	27.60	453.8	1514.5	11.6	51.7	1.0	753.1	76.20	409.5	95.9	11.6	6.2	157.6	247.	1125.
			308.8	1399.7	11.4	52.0	.1			240.6	180.3	11.4	5.6	13.1		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 250×10^3 DWT

EXISTING 15000 TRANSITS/ANNUAL + 10000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5812.3	27.31	218.2	649.9	11.6	62.8	.0	715.8	75.45	197.7	216.6	11.6	6.8	.0	0.	375.
FEB	5532.3	26.67	101.1	642.3	10.5	66.9	.0	653.9	74.21	96.0	140.3	10.5	7.2	.0	0.	339.
MAR	5282.4	26.10	70.9	742.9	11.6	75.1	.0	450.9	72.67	74.2	123.6	11.6	8.1	.0	0.	375.
APR	5282.4	26.10	81.2	660.0	11.3	70.6	.0	214.2	61.00	120.1	178.4	11.3	7.6	.0	138.	363.
MAY	5282.4	26.10	194.6	607.6	11.6	49.2	.0	214.2	61.00	242.7	258.9	11.6	5.3	.0	270.	375.
JUN	5282.4	26.10	288.2	607.9	11.3	41.9	.0	214.2	61.00	247.0	230.6	11.3	4.5	.0	279.	363.
JUL	5329.3	26.21	333.8	610.3	11.6	40.1	.0	239.6	61.92	297.5	256.1	11.6	4.3	.0	279.	375.
AUG	5408.0	26.39	379.8	621.6	11.6	42.8	.0	275.8	63.23	297.2	244.8	11.6	4.6	.0	279.	375.
SEP	5486.3	26.56	397.7	630.5	11.3	40.5	.0	303.1	64.21	250.9	208.0	11.3	4.4	.0	279.	363.
OCT	5701.1	27.05	559.5	665.8	11.6	42.3	.0	367.9	66.56	281.7	200.7	11.6	4.6	.0	279.	375.
NOV	5943.4	27.60	627.5	696.3	11.3	40.2	.3	583.3	72.63	373.1	142.2	11.3	4.3	.0	279.	363.
DEC	5943.4	27.60	453.8	764.8	11.6	51.7	.8	753.1	76.20	409.5	101.7	11.6	6.0	120.4	279.	375.
			308.8	658.3	11.4	52.0	.1			240.6	191.8	11.4	5.6	10.0		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 20000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5807.3	27.29	218.2	1297.7	11.6	62.8	.0	724.8	75.63	197.7	207.6	11.6	6.8	.0	0.	1018.
FEB	5507.6	26.61	101.1	1242.6	10.5	66.9	.0	686.2	74.86	96.0	117.0	10.5	7.2	.0	0.	919.
MAR	5282.4	26.10	70.9	1409.3	11.6	75.1	.0	462.5	74.02	74.2	96.0	11.6	8.1	.0	0.	1018.
APR	5282.4	26.10	81.2	1309.3	11.3	70.6	.0	214.2	61.00	120.1	147.4	11.3	7.6	.0	123.	985.
MAY	5282.4	26.10	194.6	1254.2	11.6	49.2	.0	214.2	61.00	242.7	251.0	11.6	5.3	.0	251.	1018.
JUN	5282.4	26.10	288.2	1220.0	11.3	41.9	.0	214.2	61.00	247.0	236.7	11.3	4.5	.0	256.	985.
JUL	5348.6	26.25	333.8	1233.7	11.6	40.1	.0	224.2	61.36	297.5	271.5	11.6	4.3	.0	256.	1018.
AUG	5450.5	26.48	379.8	1241.3	11.6	42.8	.0	241.2	61.98	297.2	264.0	11.6	4.6	.0	256.	1018.
SEP	5548.4	26.71	397.7	1232.9	11.3	40.5	.0	252.8	62.39	250.9	223.8	11.3	4.4	.0	256.	985.
OCT	5794.6	27.26	559.5	1277.2	11.6	42.3	.0	290.2	63.75	281.7	228.1	11.6	4.6	.0	256.	1018.
NOV	5943.4	27.60	627.5	1411.4	11.3	40.2	.7	602.4	73.16	373.1	45.3	11.3	4.3	.0	256.	985.
DEC	5943.4	27.60	453.8	1407.4	11.6	51.7	.9	753.1	76.20	409.5	97.9	11.6	6.1	143.3	256.	1018.
			308.8	1294.8	11.4	52.0	.1			240.6	182.2	11.4	5.6	11.9		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

WATER BALANCE SIMULATION ON STUDY CASE WITH DAM

DESIGN WATER LEVEL 90ft

DESIGN VESSEL 250×10³ DWT

EXISTING 15000 TRANSITS/ANNUAL + 30000 TRANSITS/ANNUAL IN NEW CANAL

	****** GATUN DAM ******							****** MADDEN DAM ******							*NEW DAM*	*PUMP*
MONTH	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL	VOL.	WL.	ROFF	DEM.L	DEM.E	EVP.	SPIL		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	5804.3	27.29	218.2	1916.7	11.6	62.8	.0	727.8	75.69	197.7	204.6	11.6	6.8	.0	0.	1634.
FEB	5497.6	26.59	101.1	1806.0	10.5	66.9	.0	696.1	75.06	96.0	110.0	10.5	7.2	.0	0.	1176.
MAR	5282.4	26.10	70.9	2032.9	11.6	75.1	.0	462.5	74.37	74.2	88.4	11.6	8.1	.0	0.	1634.
APR	5282.4	26.10	81.2	1914.6	11.3	70.6	.0	214.2	61.00	120.1	138.3	11.3	7.6	.0	123.	1581.
MAY	5282.4	26.10	194.6	1872.7	11.6	49.2	.0	214.2	61.00	242.7	248.6	11.6	5.3	.0	251.	1634.
JUN	5285.3	26.11	288.2	1813.3	11.3	41.9	.0	214.2	61.00	247.0	239.6	11.3	4.5	.0	259.	1581.
JUL	5358.6	26.27	333.8	1842.7	11.6	40.1	.0	217.2	61.11	297.5	278.6	11.6	4.3	.0	259.	1634.
AUG	5469.3	26.53	379.8	1848.5	11.6	42.8	.0	225.3	61.40	297.2	272.8	11.6	4.6	.0	259.	1634.
SEP	5574.5	26.76	397.7	1821.8	11.3	40.5	.0	229.6	61.56	250.9	231.0	11.3	4.4	.0	259.	1581.
OCT	5834.0	27.35	559.5	1879.9	11.6	42.3	.0	253.7	62.43	281.7	241.4	11.6	4.6	.0	259.	1634.
NOV	5943.4	27.60	627.5	2046.8	11.3	40.2	.9	605.1	73.23	373.1	6.1	11.3	4.3	.0	259.	1581.
DEC	5943.4	27.60	453.8	2023.3	11.6	51.7	1.0	753.1	76.20	409.5	98.0	11.6	6.1	145.8	259.	1634.
			308.8	1901.6	11.4	52.0	.2			240.6	179.8	11.4	5.6	12.2		

①GATUN DAM CAPACITY(MCM)

②GATUN DAM WATER LEVEL(EL.m)

③RUNOFF FROM GATUN DRAINAGE AREA(MCM)

④LOCKAGE WATER FROM GATUN DAM(MCM)

⑤MUNICIPAL WATER FROM GATUN DAM(MCM)

⑥EVAPORATION FROM GATUN DAM(MCM)

⑦SPILLAGE FROM GATUN DAM(MCM)

⑧MADDEN DAM CAPACITY(MCM)

⑨MADDEN DAM WATER LEVEL(EL.m)

⑩RUNOFF FROM MADDEN DAM(MCM)

⑪LOCKAGE WATER FROM MADDEN DAM(MCM)

⑫MUNICIPAL WATER FROM MADDEN DAM(MCM)

⑬EVAPORATION FROM MADDEN DAM(MCM)

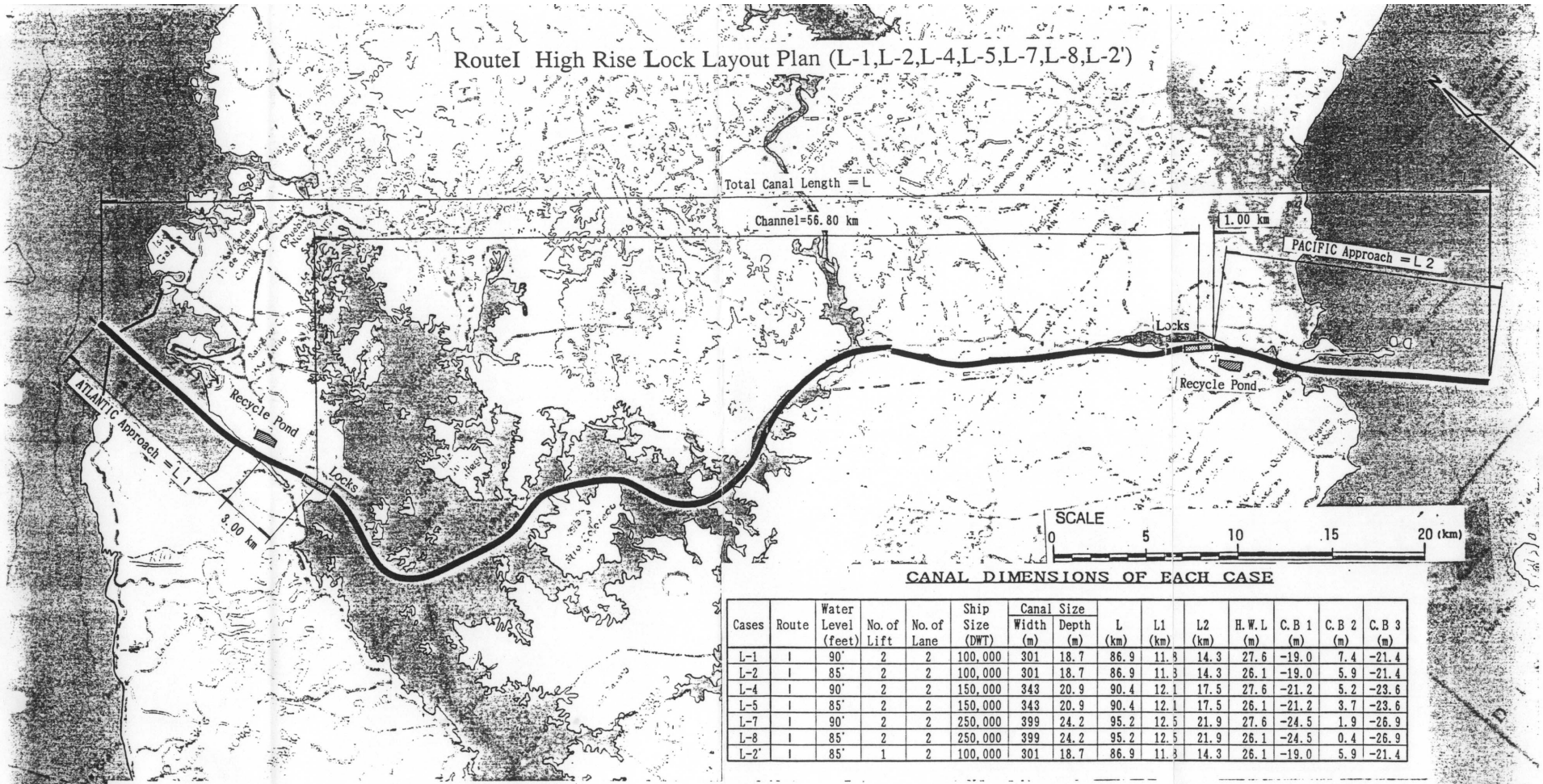
⑭SPILLAGE FROM MADDEN DAM(MCM)

⑮NEW DAM CAPACITY TO BE PLANNED(MCM)

⑯PUMP CAPACITY TO BE PLANNED(MCM)

APPENDIX 2 : LAYOUT PLANS AND PROFILES

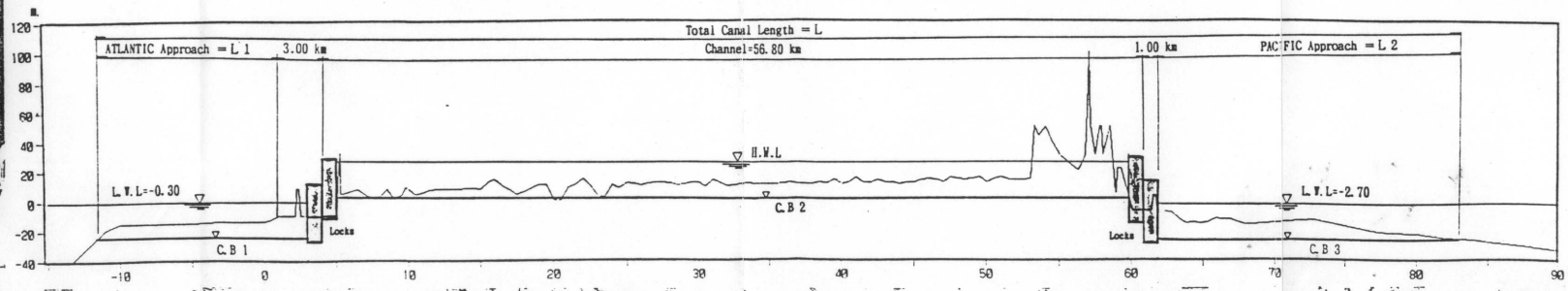
RouteI High Rise Lock Layout Plan (L-1,L-2,L-4,L-5,L-7,L-8,L-2')



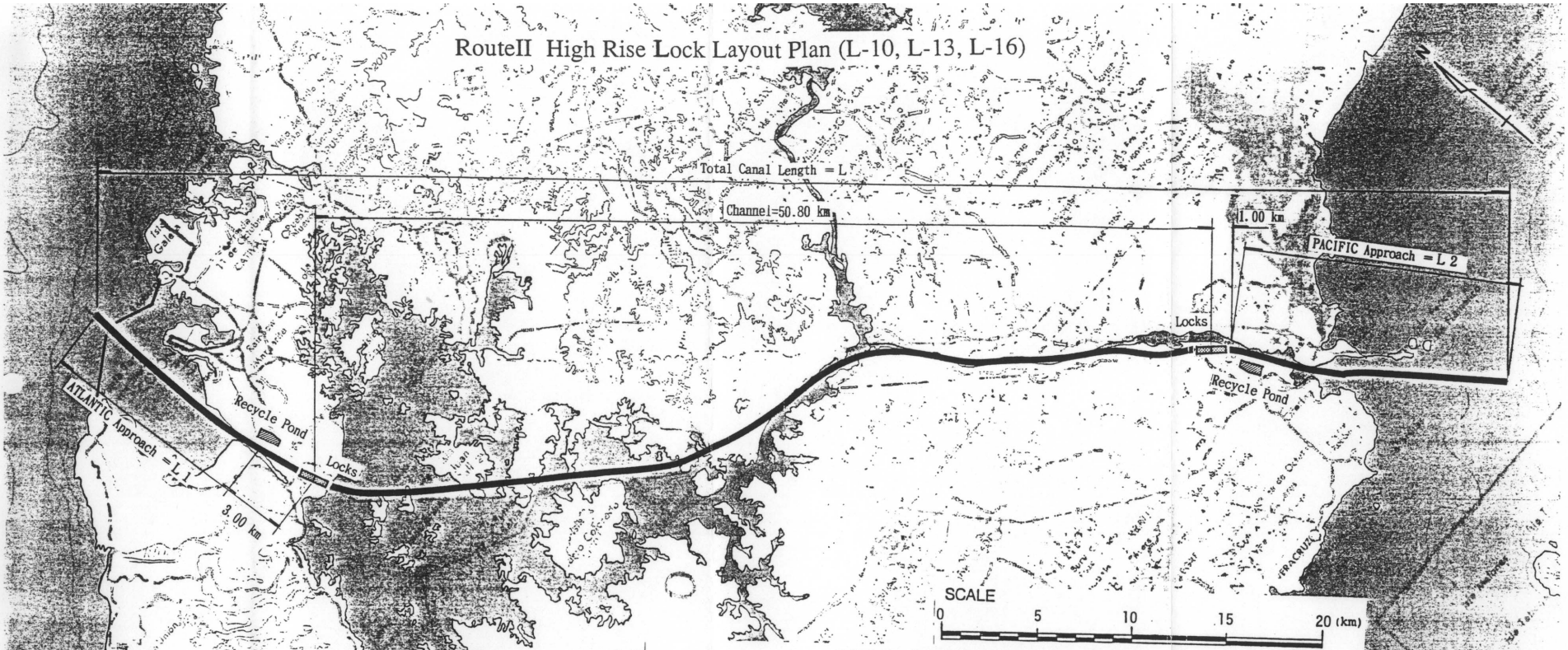
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (m)	L (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
L-1	I	90'	2	2	100,000	301	18.7	86.9	11.3	14.3	27.6	-19.0	7.4	-21.4
L-2	I	85'	2	2	100,000	301	18.7	86.9	11.3	14.3	26.1	-19.0	5.9	-21.4
L-4	I	90'	2	2	150,000	343	20.9	90.4	12.1	17.5	27.6	-21.2	5.2	-23.6
L-5	I	85'	2	2	150,000	343	20.9	90.4	12.1	17.5	26.1	-21.2	3.7	-23.6
L-7	I	90'	2	2	250,000	399	24.2	95.2	12.5	21.9	27.6	-24.5	1.9	-26.9
L-8	I	85'	2	2	250,000	399	24.2	95.2	12.5	21.9	26.1	-24.5	0.4	-26.9
L-2'	I	85'	1	2	100,000	301	18.7	86.9	11.3	14.3	26.1	-19.0	5.9	-21.4

Profile



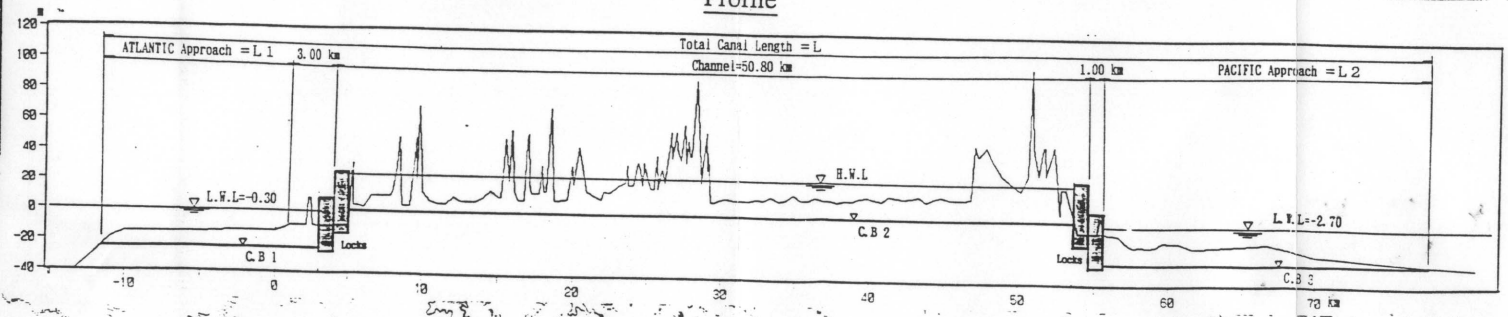
RouteII High Rise Lock Layout Plan (L-10, L-13, L-16)



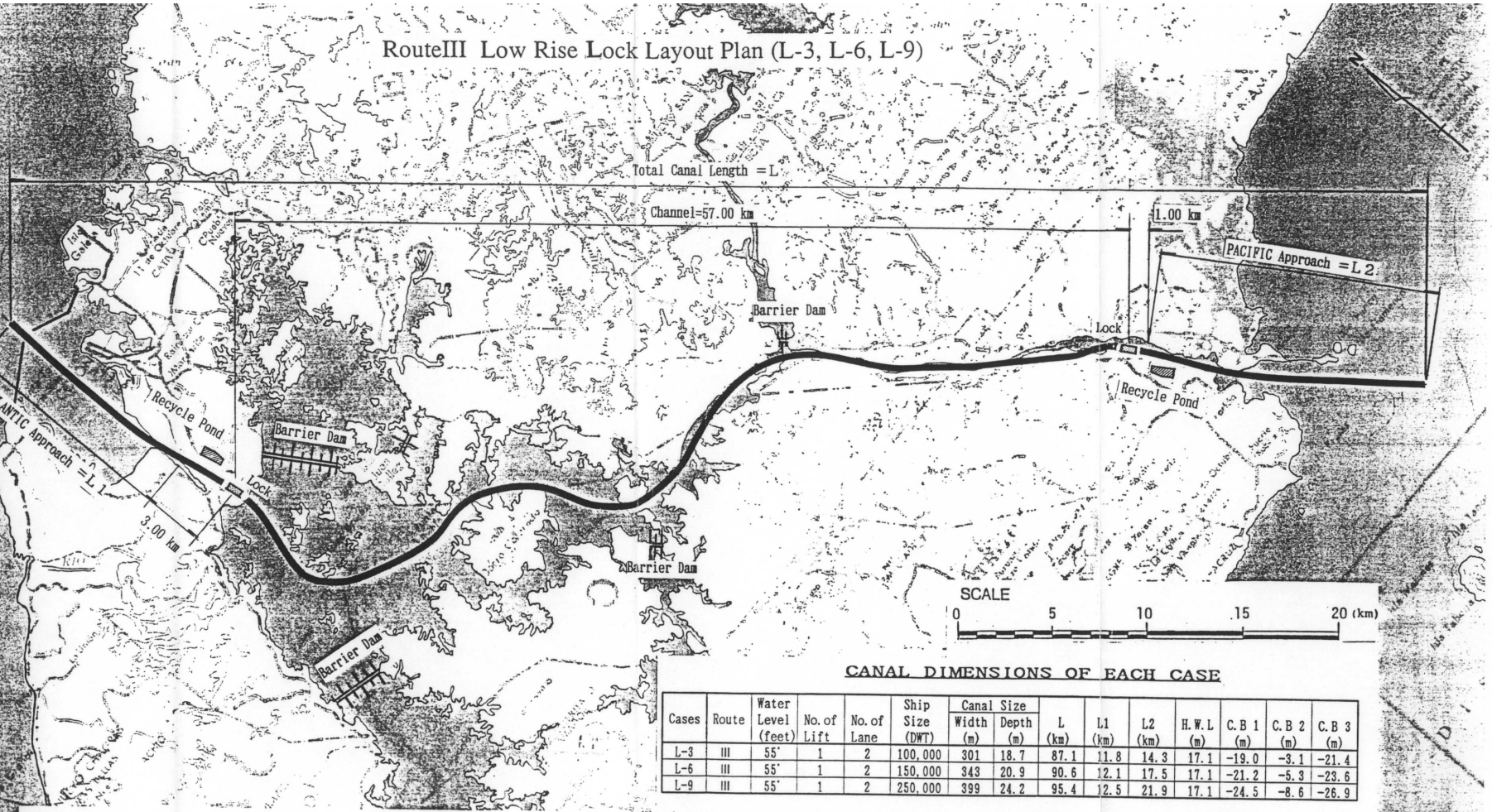
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (m)	L. (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
L-10	II	85'	2	2	100,000	301	18.7	80.9	11.8	14.3	26.1	-19.0	5.9	-21.4
L-13	II	85'	2	2	150,000	343	20.9	84.4	12.1	17.5	26.1	-21.2	3.7	-23.6
L-16	II	85'	2	2	250,000	399	24.2	89.2	12.5	21.9	26.1	-24.5	0.4	-26.9

Profile



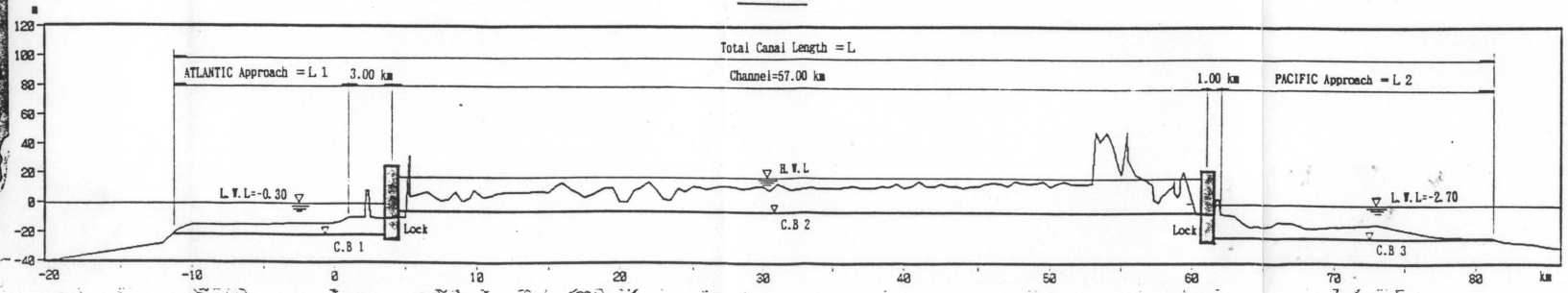
RouteIII Low Rise Lock Layout Plan (L-3, L-6, L-9)



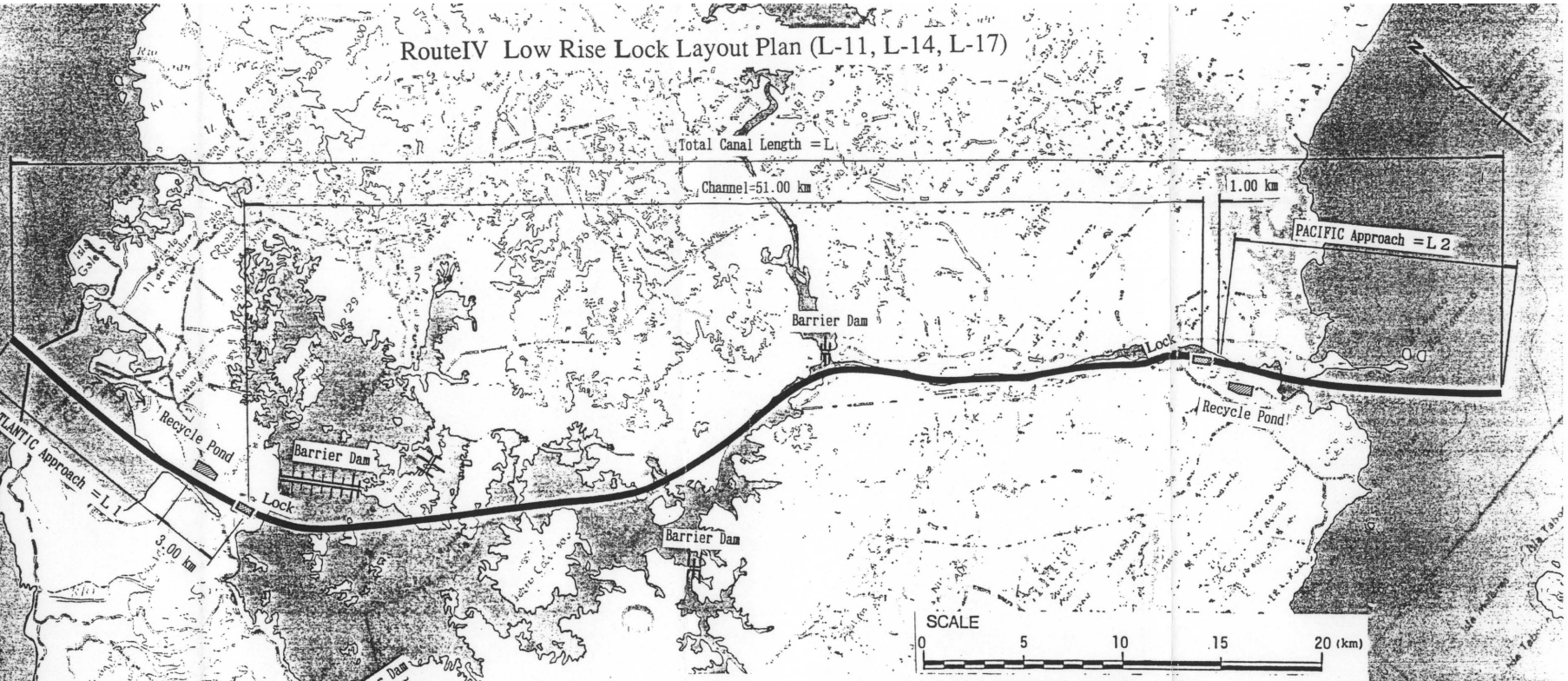
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (m)	L (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
L-3	III	55'	1	2	100,000	301	18.7	87.1	11.8	14.3	17.1	-19.0	-3.1	-21.4
L-6	III	55'	1	2	150,000	343	20.9	90.6	12.1	17.5	17.1	-21.2	-5.3	-23.6
L-9	III	55'	1	2	250,000	399	24.2	95.4	12.5	21.9	17.1	-24.5	-8.6	-26.9

Profile



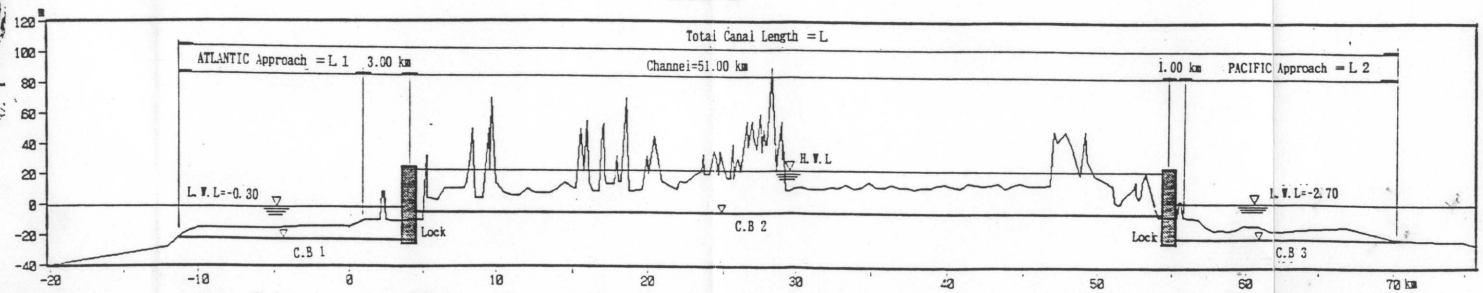
RouteIV Low Rise Lock Layout Plan (L-11, L-14, L-17)



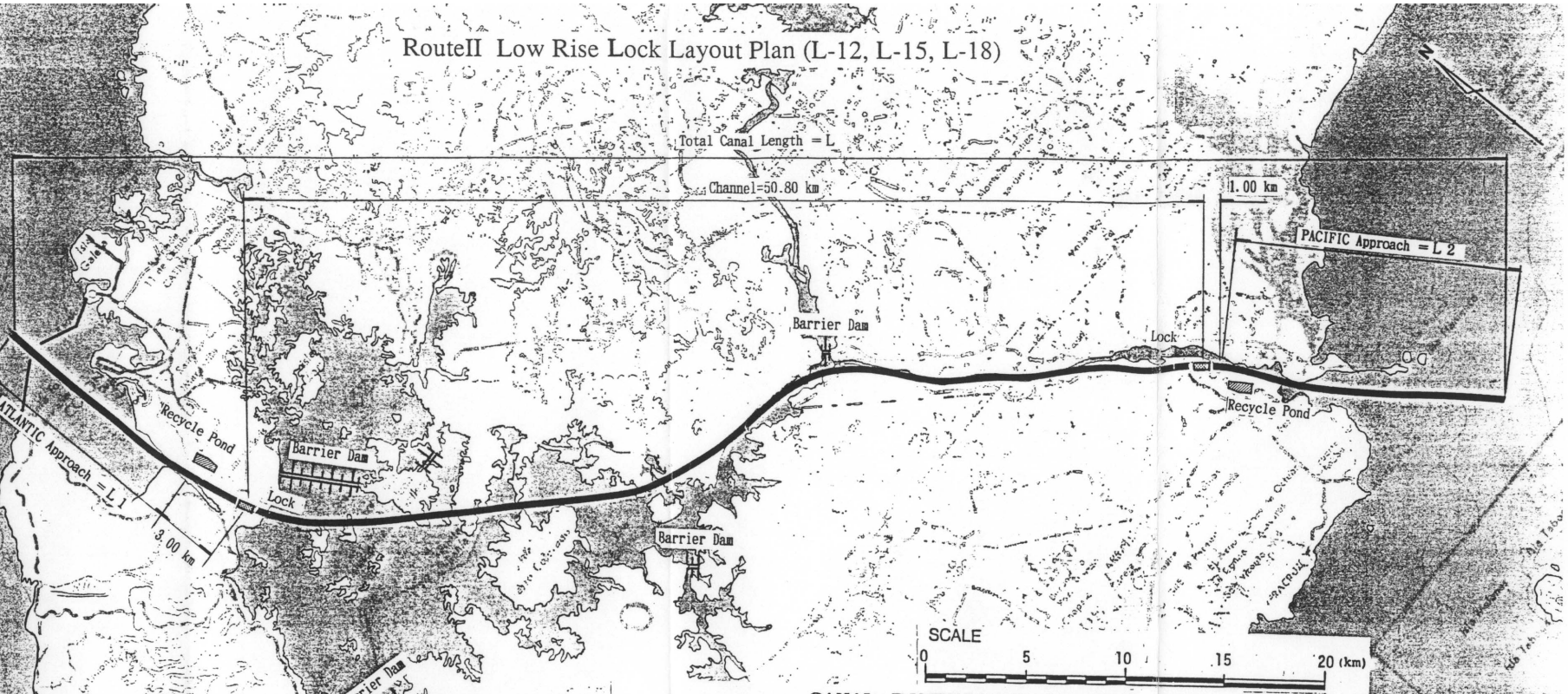
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (m)	L (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
L-11	IV	55'	1	2	100,000	301	18.7	81.1	11.8	14.3	17.1	-19.0	-3.1	-21.4
L-14	IV	55'	1	2	150,000	343	20.9	84.6	12.1	17.5	17.1	-21.2	-5.3	-23.6
L-17	IV	55'	1	2	250,000	399	24.2	89.4	12.5	21.9	17.1	-24.5	-8.6	-26.9

Profile



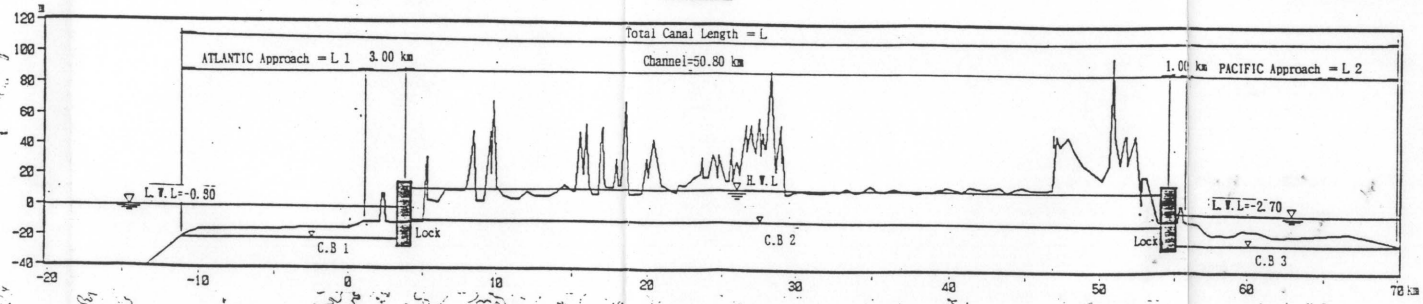
RouteII Low Rise Lock Layout Plan (L-12, L-15, L-18)



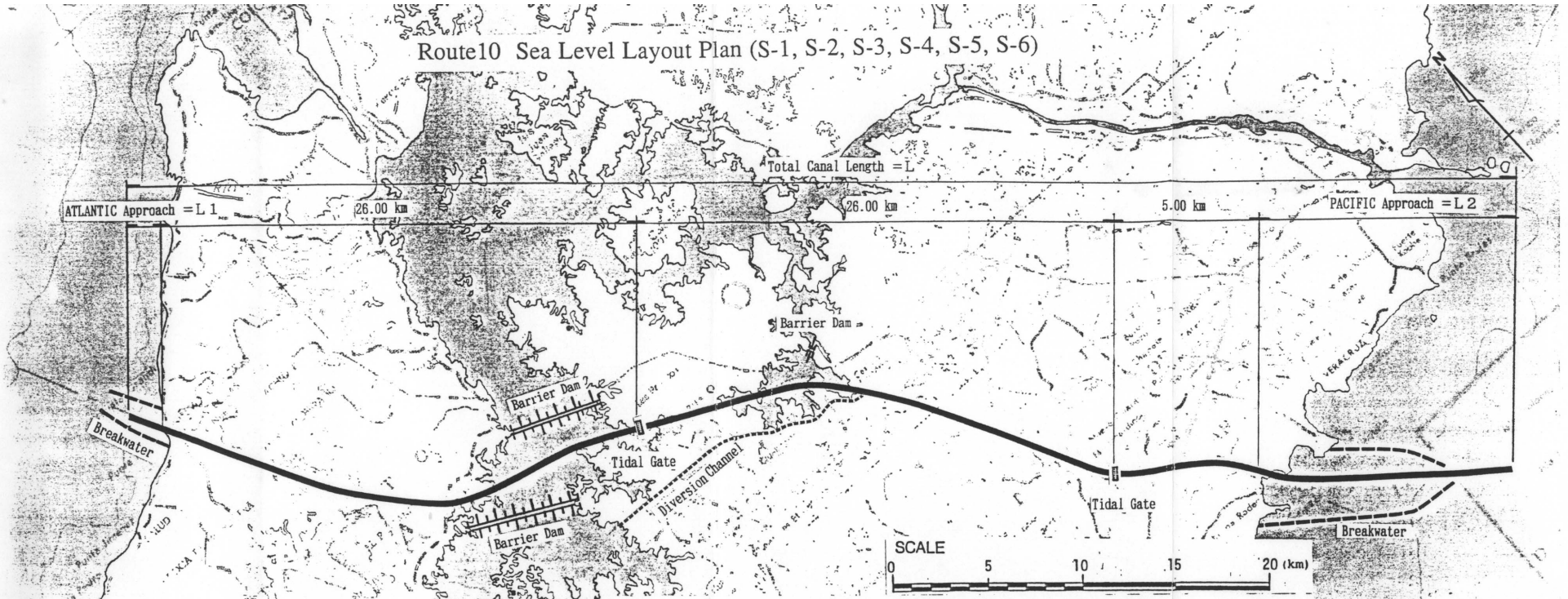
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (m)	L (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
L-12	II	30'	1	2	100,000	301	18.7	80.9	11.8	14.3	9.6	-19.0	-10.6	-21.4
L-15	II	30'	1	2	150,000	343	20.9	84.4	12.1	17.5	9.6	-21.2	-12.8	-23.6
L-18	II	30'	1	2	250,000	399	24.2	89.2	12.5	21.9	9.6	-24.5	-16.1	-26.9

Profile



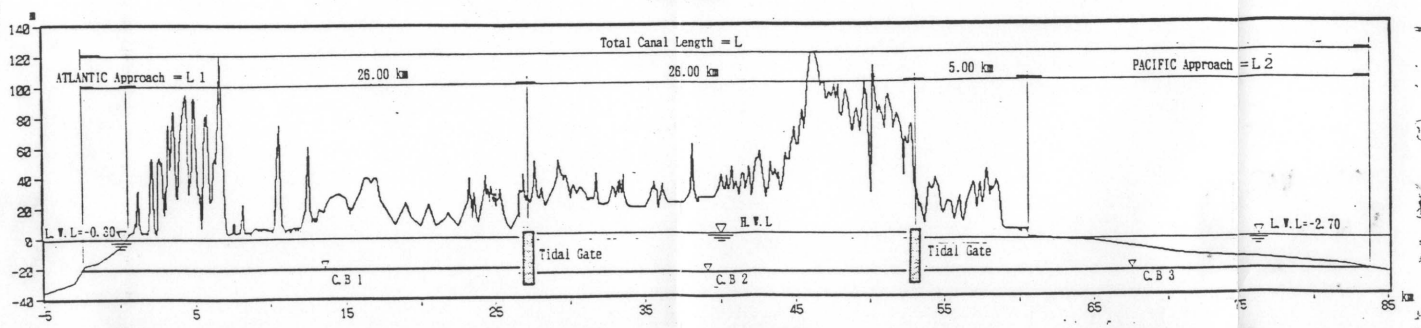
Route10 Sea Level Layout Plan (S-1, S-2, S-3, S-4, S-5, S-6)



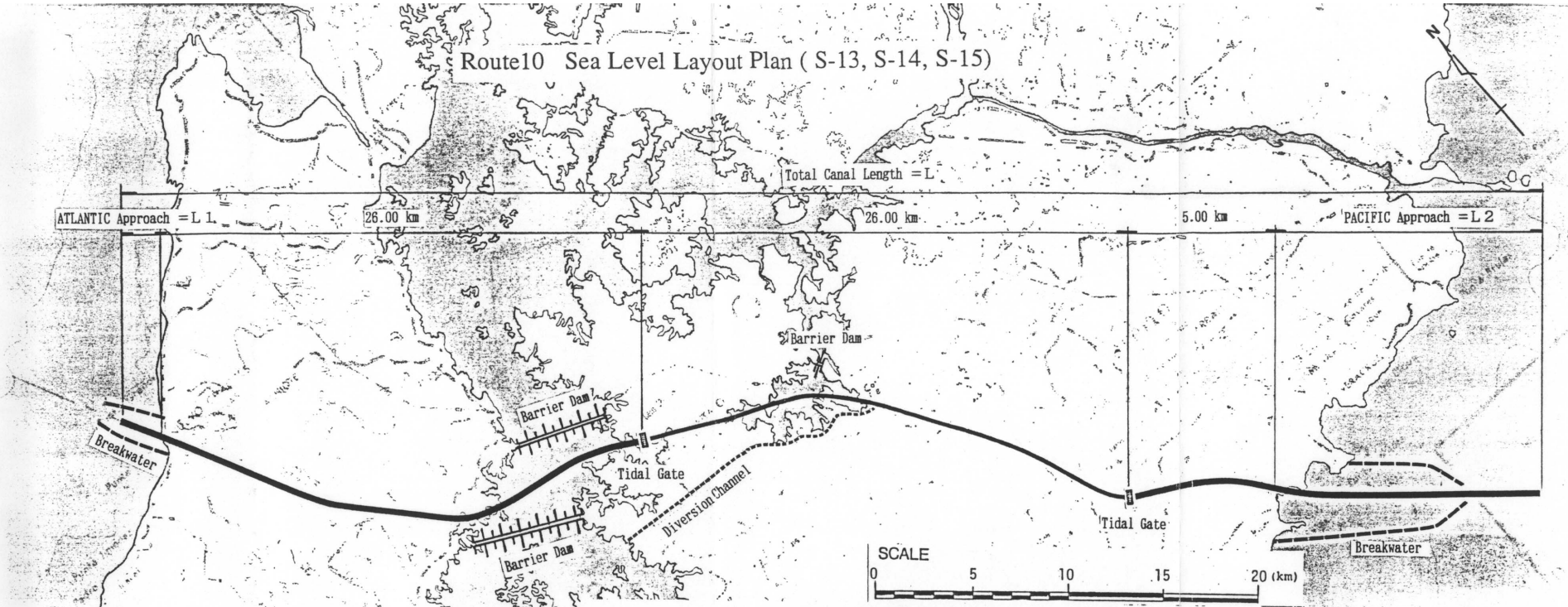
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (km)	L (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
S-1	10	0	0	1	150,000	147	20.9	86.2	3.5	25.7	3.3	-21.2	-23.3	-23.6
S-2	10	0	0	2	150,000	343	20.9	86.2	3.5	25.7	3.3	-21.2	-23.3	-23.6
S-3	10	0	0	1	250,000	171	24.2	88.55	3.85	27.7	3.3	-24.5	-26.6	-26.9
S-4	10	0	0	2	250,000	399	24.2	88.55	3.85	27.7	3.3	-24.5	-26.6	-26.9
S-5	10	0	0	1	300,000	183	25.3	89.6	3.9	28.7	3.3	-25.6	-27.7	-28.0
S-6	10	0	0	2	300,000	424	25.3	89.6	3.9	28.7	3.3	-25.6	-27.7	-28.0

Profile



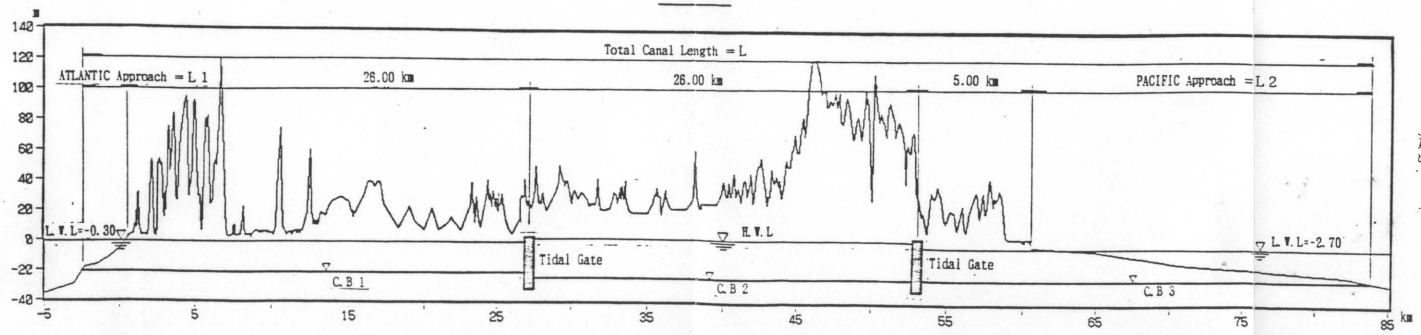
Route10 Sea Level Layout Plan (S-13, S-14, S-15)



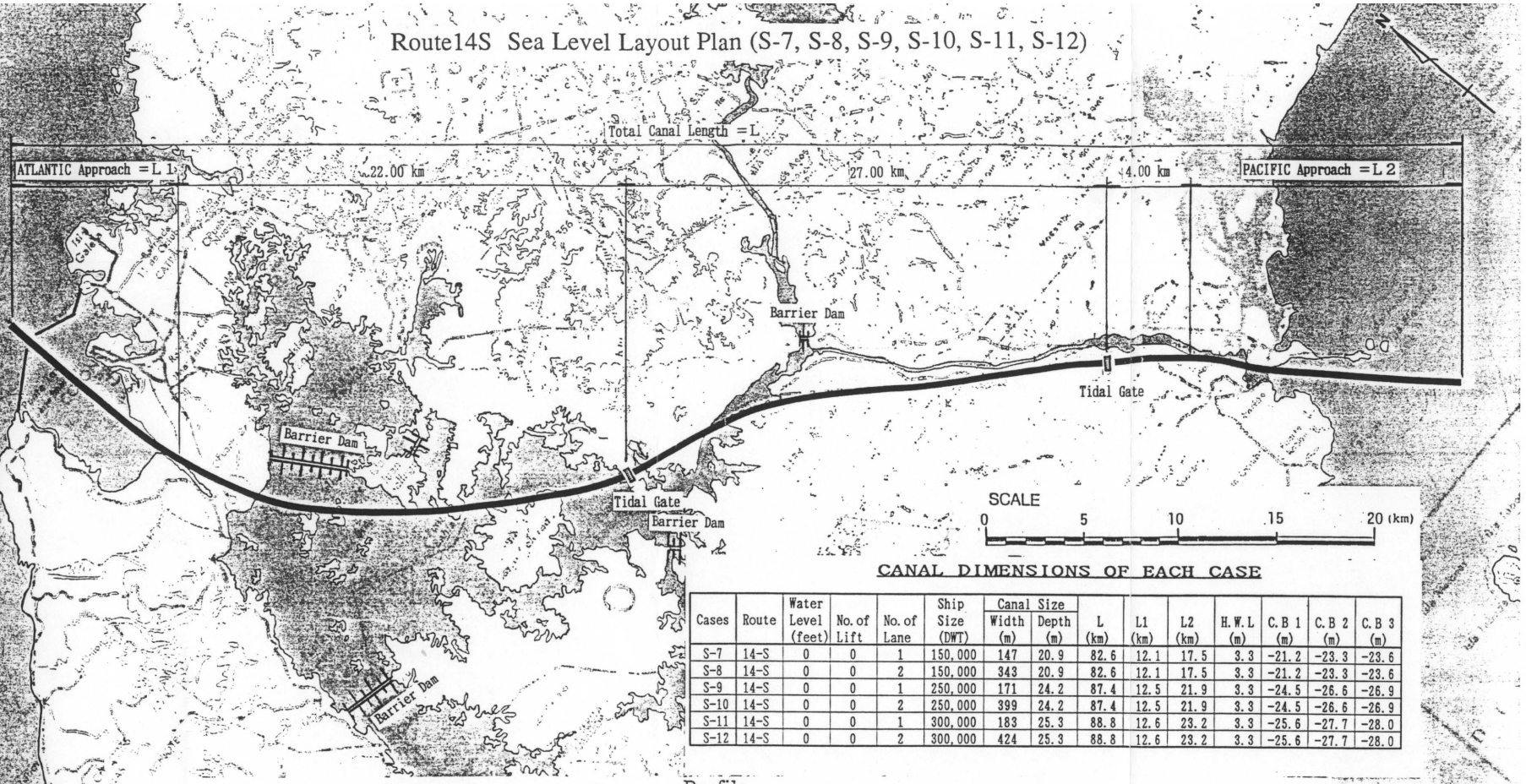
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (m)	L (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
S-13	10	0	0	50%-1	150,000	147	20.9	86.2	3.5	25.7	3.3	-21.2	-23.3	-23.6
				50%-2		343	20.9							
S-14	10	0	0	50%-1	250,000	171	24.2	88.55	3.85	27.7	3.3	-24.5	-26.6	-26.9
				50%-2		399	24.2							
S-15	10	0	0	50%-1	300,000	183	25.3	89.6	3.9	28.7	3.3	-25.6	-27.7	-28.0
				50%-2		424	25.3							

Profile



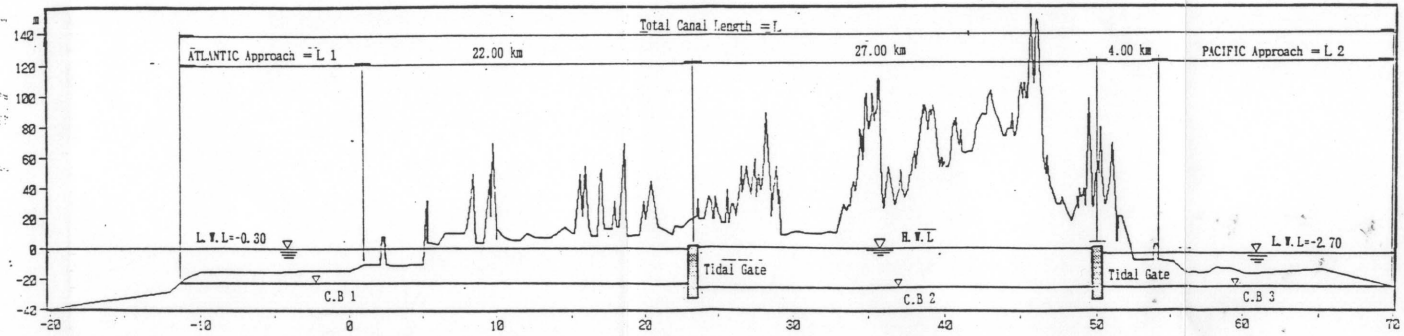
Route14S Sea Level Layout Plan (S-7, S-8, S-9, S-10, S-11, S-12)



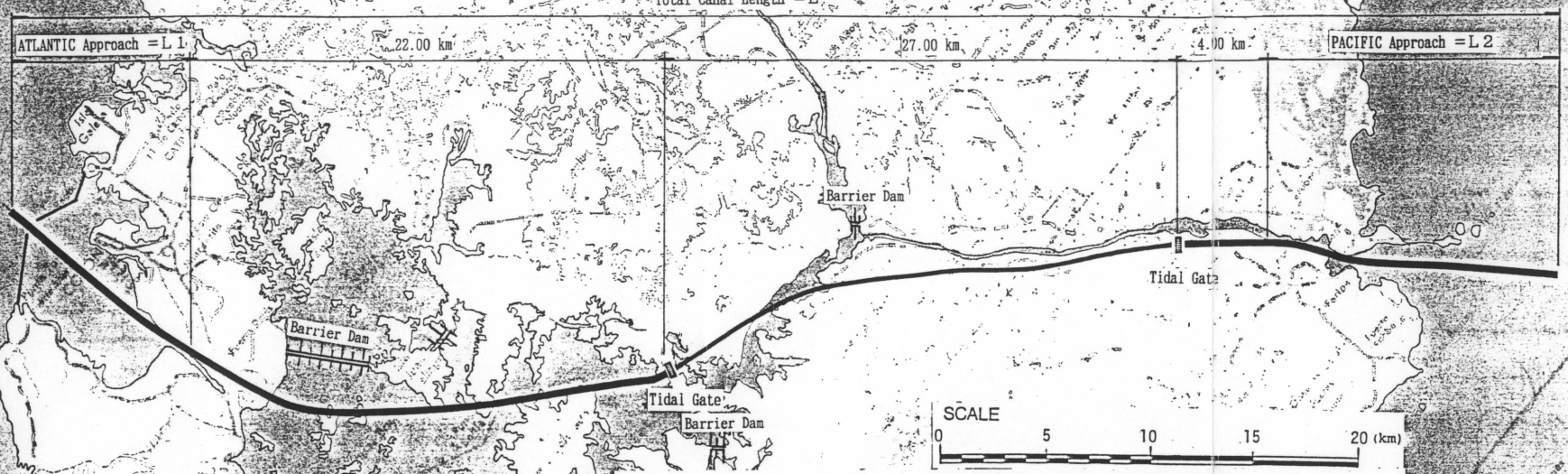
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (m)	L (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
S-7	14-S	0	0	1	150,000	147	20.9	82.6	12.1	17.5	3.3	-21.2	-23.3	-23.6
S-8	14-S	0	0	2	150,000	343	20.9	82.6	12.1	17.5	3.3	-21.2	-23.3	-23.6
S-9	14-S	0	0	1	250,000	171	24.2	87.4	12.5	21.9	3.3	-24.5	-26.6	-26.9
S-10	14-S	0	0	2	250,000	399	24.2	87.4	12.5	21.9	3.3	-24.5	-26.6	-26.9
S-11	14-S	0	0	1	300,000	183	25.3	88.8	12.6	23.2	3.3	-25.6	-27.7	-28.0
S-12	14-S	0	0	2	300,000	424	25.3	88.8	12.6	23.2	3.3	-25.6	-27.7	-28.0

Profile



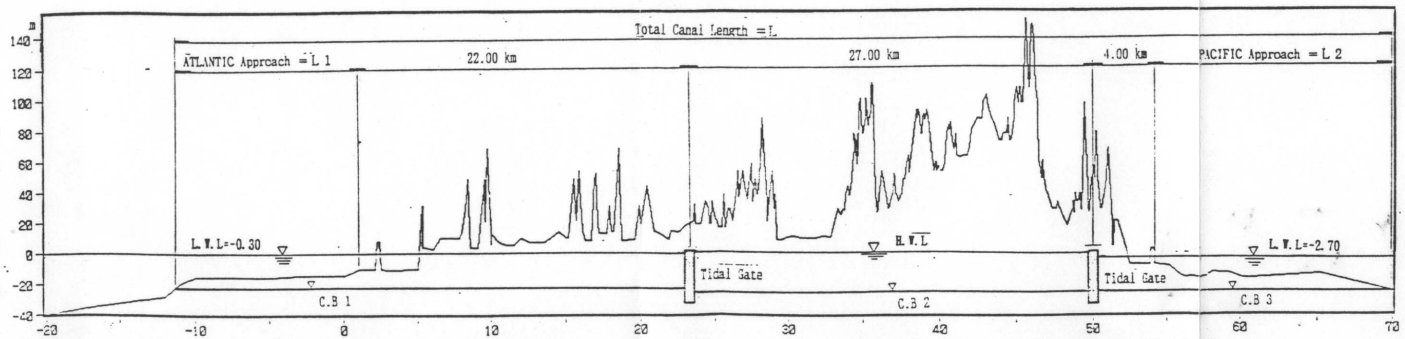
Route14S Sea Level Layout Plan (S-16, S-17, S-18)



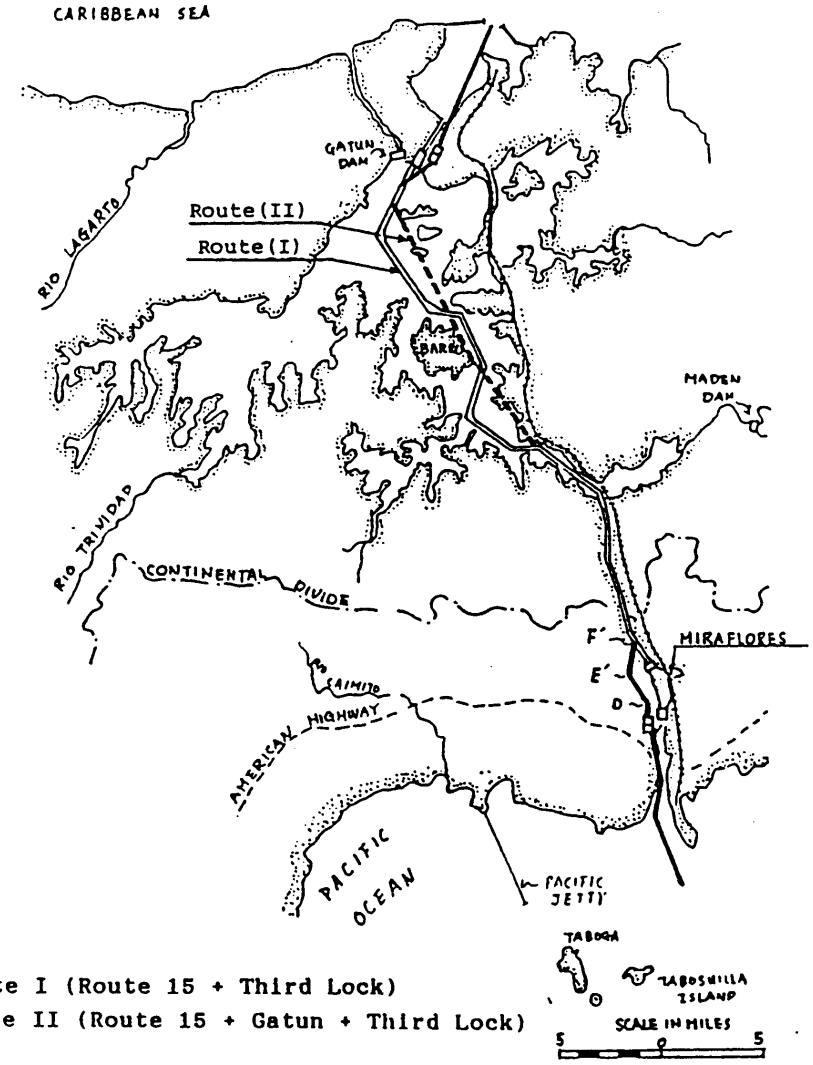
CANAL DIMENSIONS OF EACH CASE

Cases	Route	Water Level (feet)	No. of Lift	No. of Lane	Ship Size (DWT)	Canal Size Width (m)	Canal Size Depth (m)	L (km)	L1 (km)	L2 (km)	H.W.L (m)	C.B 1 (m)	C.B 2 (m)	C.B 3 (m)
S-16	14-S	0	0	50%-1	150,000	147	20.9	82.6	12.1	17.5	3.3	-21.2	-23.3	-23.6
				50%-2		343	20.9							
S-17	14-S	0	0	50%-1	250,000	171	24.7	87.4	12.5	21.9	3.3	-25.0	-26.7	-27.4
				50%-2		399	24.7							
S-18	14-S	0	0	50%-1	300,000	183	25.3	88.8	12.6	23.2	3.3	-25.6	-27.7	-28.0
				50%-2		424	25.3							

Profile



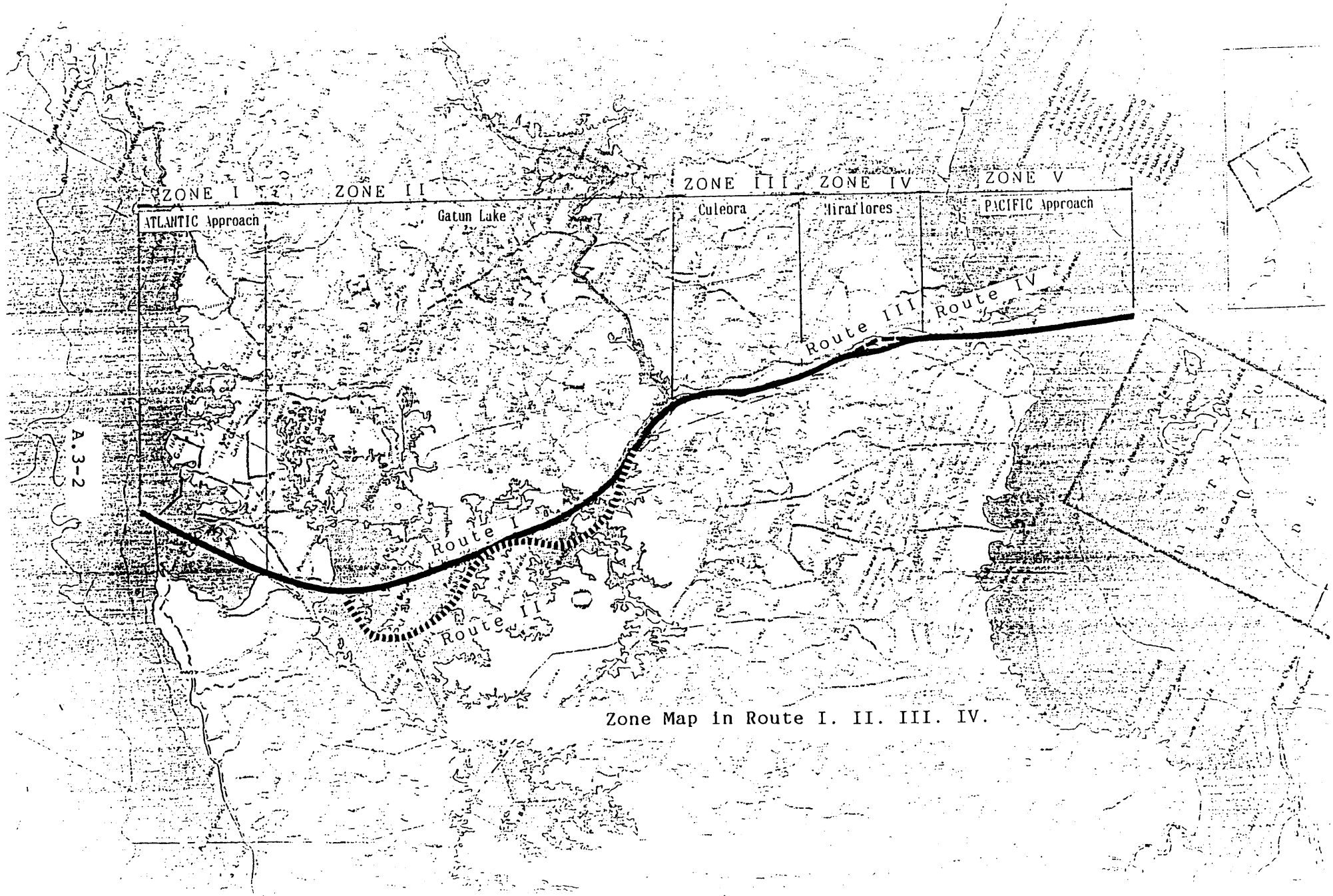
APPENDIX 3 : CALCULATION TABLES OF EXCAVATION VOLUME



Route I (Route 15 + Third Lock)
Route II (Route 15 + Gatun + Third Lock)

Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size (m)
L-1	I	90'	2	2	100	301 x 18.7
2	I	85'	2	2	100	301 x 18.7
4	I	90'	2	2	150	343 x 20.9
5	I	85'	2	2	150	343 x 20.9
7	I	90'	2	2	250	399 x 24.2
8	I	85'	2	2	250	399 x 24.2
2'	I	85'	1	2	100	301 x 18.7
10	II	85'	2	2	100	301 x 18.7
13	II	85'	2	2	150	343 x 20.9
16	II	85'	2	2	250	399 x 24.2

Layout of High Rise Lock System for Group A Study Cases



Zone Map in Route I. II. III. IV.

L-1 Calculation Table of Excavation Volume

Station No	Station (ft)	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Materials Total Ao
10.80		[illegible]	0	0	0	0		0	6,357,000		6,357,000		0	2,652,000	0	2,652,000	0	0
-3.00		4.000	0	940,000	0	940,000	0	1,630	6,260,000	1,630	4,020,000	2,240,000	680	2,840,000	680	2,840,000	0	680
1.00		0	470	0	470	0	0	1,500	0	380	0	0	740	0	740	0	0	740
Sum 1		31.800		940,000		940,000	0		12,617,000		10,377,000	2,240,000		5,492,000		5,492,000	0	
1.00		50	470	93,750	470	35,500	58,250	1,500	120,750	380	22,500	98,250	1,500	69,500	0	0	69,500	0
1.05		1.150	3,280	3,772,000	950	1,092,500	2,679,500	3,330	3,829,500	520	598,000	3,231,500	1,280	1,472,000	0	0	1,472,000	0
2.20		10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	1,280	17,800	0	0	17,800	0
2.21		190	3,280	623,200	950	180,500	442,700	3,330	632,700	520	98,800	533,900	2,280	433,200	0	0	433,200	0
2.40		10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	2,280	17,800	0	0	17,800	0
2.41		590	3,280	1,935,200	950	560,500	1,374,700	3,330	1,964,700	520	306,800	1,657,900	1,280	755,200	0	0	755,200	0
3.00		2.000	3,280	6,940,000	950	950,000	5,990,000	3,330	26,725,000	520	520,000	26,205,000	1,280	2,540,000	0	0	2,540,000	0
5.00		300	3,660	1,098,000	0	0	1,098,000	23,395	7,018,500	0	0	7,018,500	1,260	528,000	0	0	528,000	0
5.30		200	3,660	366,000	0	0	366,000	23,395	2,339,500	0	0	2,339,500	2,260	226,000	0	0	226,000	0
5.50		1.500		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.00		3.000		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.00		6.000		3,210,000	0	3,210,000	0	0	900,000	0	900,000	0	0	0	0	0	0	0
16.00		4.000	1,070	2,760,000	1,070	2,760,000	0	300	1,220,000	300	1,220,000	0	0	0	0	0	0	0
20.00		5.000	310	2,350,000	310	2,350,000	0	310	1,550,000	310	1,550,000	0	0	0	0	0	0	0
25.00		5.000	630	1,575,000	630	1,575,000	0	310	775,000	310	775,000	0	0	650,000	0	650,000	0	0
30.00		6.000		0	0	0	0	0	3,030,000	0	3,030,000	0	260	1,680,000	260	1,680,000	0	0
36.00		3.000		660,000	0	660,000	0	1,010	1,965,000	1,010	1,965,000	0	300	900,000	300	900,000	0	0
39.00		4.120	440	4,202,400	440	908,400	3,296,000	300	15,450,000	300	3,254,800	12,195,200	300	618,000	300	618,000	0	0
43.12	1.684	0	1,600	0	0	0	0	7,200	0	1,280	0	0	0	0	0	0	0	0
Sum 2		42.120		29,651,150		14,299,400	16,670,150		67,587,250		34,251,300	59,268,750		9,907,500		3,848,000	6,059,500	
43.12	1.684	180	2,240	896,871	0	0	896,871	10,080	1,061,885	1,280	115,168	946,717	0	182,649	0	0	182,649	0
	1.690	3	7,728	11,785	0	0	11,785	1,722	2,626	0	0	2,626	2,030	10,568	0	0	10,568	0
	1.690	61	0	0	0	0	0	0	0	0	0	0	4,900	298,900	0	0	298,900	0
	1.692	27	0	0	0	0	0	0	0	0	0	0	4,900	134,505	0	0	134,505	0
	1.693	3	0	11,785	0	0	11,785	0	2,626	0	0	2,626	4,900	10,568	0	0	10,568	0
	1.693	214	7,728	1,228,479	0	103,014	1,125,465	1,722	255,560	0	4,484	251,076	2,030	264,527	0	6,405	258,122	0
	1.700	275	3,780	1,037,610	965	264,893	772,718	672	184,464	42	11,529	172,935	448	122,976	60	16,470	106,506	0
	1.709	15	3,780	28,823	965	7,358	21,464	672	5,124	42	320	4,804	448	40,779	60	458	40,321	0
	1.710	15	0	0	0	0	0	0	0	0	0	0	4,900	74,725	0	0	74,725	0
	1.710	15	0	58,926	0	0	58,926	0	13,130	0	0	13,130	4,900	52,841	0	0	52,841	0
	1.711	46	7,728	353,556	0	0	353,556	1,722	78,782	0	0	78,782	2,030	92,873	0	0	92,873	0
	1.712	153	7,728	1,077,108	0	91,500	985,608	1,722	291,428	0	9,150	282,278	2,030	154,788	0	0	154,788	0
	1.717	305	6,398	1,951,390	1,200	366,000	1,585,390	2,100	640,500	120	36,600	603,900	0	0	0	0	0	0
	1.727	15	6,398	48,785	1,200	9,150	39,635	2,100	32,025	120	915	31,110	0	48,785	0	0	48,785	0
	1.728	76	0	0	0	0	0	2,100	160,125	0	0	160,125	6,398	487,848	0	0	487,848	0
	1.730	92	0	0	0	0	0	2,100	192,150	0	0	192,150	6,398	585,417	0	0	585,417	0
	1.733	15	0	24,873	0	0	24,873	2,100	40,138	0	0	40,138	6,398	61,702	0	0	61,702	0
	1.734	229	3,262	746,183	0	0	746,183	3,164	723,765	0	0	723,765	1,694	387,503	0	0	387,503	0
	1.741	6	3,262	9,949	0	0	9,949	3,164	19,300	0	0	19,300	1,694	20,283	0	0	20,283	0
	1.741	146	0	0	0	0	0	3,164	463,210	0	0	463,210	4,956	725,558	0	0	725,558	0
	1.746	15	0	24,873	0	9,150	15,723	3,164	48,251	0	0	48,251	4,956	50,706	0	0	50,706	0
	1.747	137	3,262	447,710	1,200	164,700	283,010	3,164	434,259	0	0	434,259	1,694	232,502	0	0	232,502	0
	1.751	397	3,262	1,293,383	1,200	475,800	817,583	3,164	1,254,526	0	0	1,254,526	1,694	671,671	0	0	671,671	0
	1.764	15	3,262	24,873	1,200	9,150	15,723	3,164	150,945	0	8,540	142,405	1,694	16,333	0	0	16,333	0
	1.765	168	0	0	0	0	0	16,632	2,790,018	1,120	187,880	2,602,138	448	75,152	0	0	75,152	0
	1.770	9	0	0	0	0	0	16,632	152,183	1,120	10,248	141,935	448	4,099	0	0	4,099	0
	1.770	143	0	514,770	0	0	514,770	16,632	1,969,772	1,120	146,217	1,823,555	448	64,221	0	0	64,221	0
	1.775	6	7,182	31,171	0	0	31,171	10,850	66,185	920	5,612	60,573	448	15,372	0	0	15,372	0
	1.775	238	3,038	722,740	0	0	722,740	10,850	2,581,215	920	218,868	2,362,347	4,592	1,092,437	0	0	1,092,437	0
	1.783	397	3,038	1,784,647	0	227,988	1,556,659	10,850	2,717,215	920	192,303	2,524,912	4,592	910,364	0	0	910,364	0
	1.796	61	5,964	363,804	1,150	70,150	293,654	2,856	174,216	50	3,050	171,166	0	0	0	0	0	0
	1.796	61	5,964	431,697	1,150	102,175	329,522	2,856	134,932	50	1,525	133,407	0	55,510	0	0	55,510	0
	1.800	183	8,190	1,498,770	2,200	402,600	1,096,170	1,568	286,944	0	0	286,944	1,820	333,060	0	0	333,060	0
	1.806	183	8,190	1,419,348	2,200	314,760	1,104,588	1,568	213,927	0	0	213,927	1,820	386,862	0	0	386,862	0
	1.812	122	7,322	893,284	1,240	151,280	742,004	770	93,940	0	0	93,940	2,408	293,776	0	0	293,776	0
	1.816	214	7,322	1,397,358	1,240	132,370	1,264,988	770	659,075	0	0	659,075	2,408	546,987	0	0	546,987	0
	1.823	214	5,768	1,231,468	0	0	1,231,468	5,404	1,153,754	0	0	1,153,754	2,716	579,866	0	0	579,866	0
	1.830	15	5,768	96,289	0	10,218	86,071	5,404	51,347	0	0	51,347	2,716	30,317	0	0	30,317	0
	1.831	137	6,860	941,535	1,340	183,915	757,620	1,330	182,543	0	0	182,543	1,260	172,935	0	0	172,935	0
	1.835	183	6,860	1,210,545	1,340	224,175	986,370	1,330	288,225	0	0	288,225	1,260	281,820	0	0	281,820	0
	1.841	427	6,370	2,663,199	1,110	446,215	2,216,984	1,820	687,470	0	0	687,470	1,820	1,392,874	0	0	1,392,874	0
	1.855	214	6,104	1,303,204	980	209,230	1,093,974	1,400	298,900	0	0	298,900	4,704	1,004,304	0	0	1,004,304	0
	1.862	15	6,104	56,151	980	7,473	48,678	1,400	150,838	0	7,091	143,747	4,704	39,071	0	0	39,071	0
	1.863	46	1,260	57,645	0	0	57,645	18,382	840,977	930	42,548	798,429	420	19,215	0	0	19,215	0
	1.864	153	1,260	192,150	0	0	192,150	18,382	2,803,255	930	141,825	2,661,430	420	64,050	0	0	64,050	0
	1.869	61	1,260	400,526	0	36,600	363,926	18,382	1,035,475	930	28,365	1,007,110	420	12,810	0	0	12,810	0
	1.871	275	11,872	3,258,864	1,200	329,400	2,929,464	15,568	4,273,416	0	0	4,273,416	0	0	0	0	0	0
	1.880	244	11,872	2,896,768	1,200	292,800	2,603,968	15,568	3,798,592	0	0	3,798,592	0	0	0	0	0	0
	1.888	15	11,872	90,524	1,200	9,150	81,374	15,568	118,706	0	0	118,706	0	71,202	0	0	71,202	0
	1.889	107	0	0	0	0	0	0	498,416	0	81,130	417,286	9,338	498,416	0	0	498,416	0
	1.892	336	0	0	0	0	0	9,338	3,802,222	1,520	459,635	3,342,587	0	32,879	0	0	32,879	0
	1.903	244	0	471,408	0	103,700	367,708	13,328	2,416,820	1,220	179,340	2,237,480	196	51,240	0	0	51,240	0
	1.911	305	3,864	589,260	850	129,625	459,635	6,482	3,458,700	250	388,875	3,069,825	224	81,130	0	0	81,130	0
	1.921	244	0	102,480	0	0	102,480	16,198	4,281,956	2,300	402,600	3,879,356	308	37,576	0	0	37,576	0
	1.929	305	840	256,200	0	0	256,200	18,900	5,764,500	1,000	305,000	5,459,500	0	0	0	0	0	0
	1.939	15	840	6,405	0	0	6,405	18,900	144,113	1,000	7,625	136,488	0	150,518	0	0	150,518	0
	1.940	558	0	0	0	0	0	0	0	0	0	0	19,740	11,017,881	0	0	11,017,881	0
	1.958	6	0	64,477	0	0	64,477	0	15,244	0	4,087	11,157	19,740	60,207	0	0	60,207	0
	1.958	122	21,140	2,579,080	0	0	2,579,080	4,998	609,756	1,340	163,480	446,276	0	0	0	0	0	0
	1.962	15	21,140	322,385	0	0	322,385	4,998	76,220	1,340	20,435	55,785	0	0	0	0	0	0
	1.963	168	21,140	2,788,844	0	109,038	2,679,806	4,998	833,718	1,340	112,393	721,325	0	19,962	0	0	19,962	0
	1.968	15	12,110	184,678	1,300	19,825	164,853	4,942	75,366	0	0	75,366	238	3,630	0	0	3,630	0
	1.969	46	12,110	554,033	1,300	59,475	494,558	4,942	226,097	0	0	226,097	238	10,889	0	0	10,889	0
	1.970	183	12,110	2,786,175	1,300	235,155	2,551,020	4,942	452,193	0	0	452,193	238	21,777	0	0	21,777	0
	1.976	183	18,340	2,757,993	1,270	140,910	2,617,083	0	269,010	0	115,290	153,720	0	0	0	0	0	0
	1.982	92	11,802	1,079,883	270	24,705	1,055,178	2,940	269,010	1,260	115,290	153,720	0	0	0	0	0	0
	1.985	15	11,802	89,990	270	2,059	87,932	2,940	80,063	1,260	17,995	62,068	0	0	0	0	0	0
	1.986	15	0	0	0	0	0	7,560	115,290	1,100	16,775	98,515	0	0	0	0	0	0
	1.986	153	0	0	0	0	0	7,560	1,487,028	1,100	173,088	1,313,940	0	0	0	0	0	0
	1.991	519	0	2,003,484	0	329,248	1,674,237	11,942	3,542,392	1,170	303,323	3,239,070	0	526,278	0	0	526,278	0
53.00	2.008	0	7,728	0	1,270	0	0	1,722	0	0	0	0	2,030	0	0	0	0	0
Sum 3		9.882		49,370,188		5,804,951	42,992,814		61,996,045		4,038,597	57,829,897		24,687,688		23,333	24,513,991	
53.00	2.008	1.000	5,520	3,825,000	1,270	635,000	3,190,000	1,230	2,215,000	0	0	2,215,000	1,450	1,250,000	0	0	1,250,000	0
54.00		1.000	2,130	4,780,000	0	0	4,780,000	3,200	3,350,000	0	0	3,350,000	1,050	1,170,000	0	0	1,170,000	0

55.00		[illegible]	7.430	8.560.000	0	35.000	8.625.000	3.500	[illegible]	0	[illegible]	3.500.000	1.290	[illegible]	0	0	1.200.000	0	[illegible]
56.00		[illegible]	9.890	9.600.000	70	35.000	9.565.000	3.500	[illegible]	0	[illegible]	3.500.000	1.110	[illegible]	0	0	1.080.000	0	[illegible]
57.00		[illegible]	9.310	22.605.000		0	22.605.000	3.500	14.325.000	0	0	14.325.000	1.050	[illegible]		0	2.895.000	0	[illegible]
60.00		1.000	5.760	8.195.000		0	8.195.000	6.050	4.135.000	0	0	4.135.000	880	1.180.000		0	1.180.000	0	[illegible]
61.00		1.000	10.630	6.485.000		0	6.485.000	2.220	2.220.000	0	0	2.220.000	1.480	1.500.000		0	1.500.000	0	0
62.00		0	2.340	0		0	0	2.220	0	0	0	0	1.520	0		0	0	0	0
Sum. 4		9.000		64.150.000		705.000	63.445.000		33.245.000		0	33.245.000		30.275.000		0	30.275.000	0	0
																		0	
62.00		10	2.340	23.400	2.340	23.400	0	2.220	22.200	2.220	22.200	0	760	7.600	760	7.600	0	760	7.600
62.01		1.990	2.340	4.099.400	2.340	4.099.400	0	2.220	3.442.700	2.220	3.442.700	0	760	1.512.400	760	1.512.400	0	760	2.547.200
64.00		3.000	1.780	2.670.000	1.780	2.670.000	0	1.240	3.435.000	1.240	3.435.000	0	760	2.190.000	760	2.190.000	0	1.800	3.750.000
67.00		2.000	0	0		0	0	1.050	1.400.000	1.050	1.400.000	0	700	1.400.000	700	1.400.000	0	700	1.400.000
69.00		7.300	0	0		0	0	350	1.277.500	350	1.277.500	0	700	2.555.000	700	2.555.000	0	700	2.555.000
76.00		0	0					0		0			0		0				
Sum. 5		14.300		6.792.800		6.792.800	0		9.577.400		9.577.400	0		7.665.000		7.665.000	0		10.259.800
L-1																			
Sum. 1		11.800		940.000		940.000	0		12.617.000		10.377.000	2.240.000		5.492.000		5.492.000	0		2.880.000
Sum. 2		42.120		29.651.150		14.299.400	16.670.150		67.587.250		14.251.300	53.268.750		9.907.500		3.848.000	6.059.500		0
Sum. 3		9.882		49.370.188		5.804.951	42.992.814		61.996.045		4.038.597	57.829.897		24.687.688		23.333	24.513.991		0
Sum. 4		9.000		64.150.000		705.000	63.445.000		33.245.000		0	33.245.000		30.275.000		0	30.275.000		0
Sum. 5		14.300		6.792.800		6.792.800	0		9.577.400		9.577.400	0		7.665.000		7.665.000	0		10.259.800
Total		87.102		150.904.138		28.542.151	123.107.964		185.022.695		38.244.297	152.583.647		68.027.188		17.028.333	40.848.491		13.139.800

Total Excavation Vol.	407.093.821
Dry	316.540.102
Wet	90.553.719

L-2

Calculation Table of Excavation Volume

Station		Dis.	Rock					Weathered Rock					Earth					Clayey Material	
			Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
No	(ft)	(m)	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo
-10.80		7.800	0	0	0	0		0	6,357,000		6,357,000		0	2,652,000	0	2,652,000	0	0	2,652,000
-3.00		4.000	0	940,000	0	940,000	0	1,630	6,260,000	1,630	4,020,000	2,240,000	680	2,840,000	680	2,840,000	0	950	2,260,000
1.00		0	470	0	470	0	0	1,500	0	380	0	0	740	0	740	0	0	750	0
Sum. 1		11,800		940,000		940,000	0		12,617,000		10,377,000	2,240,000		5,492,000		5,492,000	0		5,532,000
1.00		50	470	93,750	470	35,500	58,250	1,500	120,750	380	22,500	98,250	1,500	69,500	0	0	69,500	0	0
1.05		1,150	3,280	3,772,000	950	1,092,500	2,679,500	3,330	3,829,500	520	598,000	3,231,500	1,280	1,472,000	0	0	1,472,000	0	0
2.20		10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	1,280	17,800	0	0	17,800	0	0
2.21		190	3,280	623,200	950	180,500	442,700	3,330	632,700	520	98,800	533,900	2,280	433,200	0	0	433,200	0	0
2.40		10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	2,280	17,800	0	0	17,800	0	0
2.41		590	3,280	1,935,200	950	560,500	1,374,700	3,330	1,964,700	520	306,800	1,657,900	1,280	755,200	0	0	755,200	0	0
3.00		2,000	3,280	7,410,000	950	950,000	6,460,000	3,330	26,950,000	520	520,000	26,430,000	1,280	2,540,000	0	0	2,540,000		0
5.00		300	4,130	1,239,000	0	0	1,239,000	23,620	7,086,000	0	0	7,086,000	1,260	378,000	0	0	378,000		0
5.30		200	4,130	413,000	0	0	413,000	23,620	2,362,000	0	0	2,362,000	1,260	126,000	0	0	126,000		0
5.50		1,500		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
7.00		3,000		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
10.00		6,000		4,560,000	0	4,560,000	0	0	900,000	0	900,000	0	0	0	0	0	0		0
16.00		4,000	1,520	4,560,000	1,520	4,560,000	0	300	1,220,000	300	1,220,000	0	0	0	0	0	0		0
20.00		5,000	760	4,600,000	760	4,600,000	0	310	1,550,000	310	1,550,000	0	0	0	0	0	0		0
25.00		5,000	1,080	2,700,000	1,080	2,700,000	0	310	1,800,000	310	1,800,000	0	0	750,000	0	750,000	0		0
30.00		6,000	0	0	0	0	0	410	5,610,000	410	5,610,000	0	300	1,800,000	300	1,800,000	0		0
36.00		3,000	0	1,335,000	0	1,335,000	0	1,460	2,640,000	1,460	2,640,000	0	300	900,000	300	900,000	0		0
39.00		4,120	890	7,374,800	890	1,833,400	5,541,400	300	21,630,000	300	3,254,800	18,375,200	300	618,000	300	618,000	0		0
43.12	1,684	0	1,600	0	0	0	0	7,200	0	1,280	0	0	0	0	0	0	0		0
Sum. 2		42,120		40,681,550		22,426,400	18,255,150		78,362,250		18,531,300	59,830,950		9,877,500		4,068,000	5,809,500		0
43.12	1,684	180	2,690	977,848	0	0	977,848	10,200	1,083,479	1,280	115,168	968,311	0	182,649	0	0	182,649		0
	1,690	3	8,178	13,158	0	0	13,158	1,842	2,992	0	0	2,992	2,030	10,568	0	0	10,568		0
	1,690	61	450	27,450	0	0	27,450	120	7,320	0	0	7,320	4,900	298,900	0	0	298,900		0
	1,692	27	450	12,353	0	0	12,353	120	3,294	0	0	3,294	4,900	134,505	0	0	134,505		0
	1,693	3	450	13,158	0	0	13,158	120	2,992	0	0	2,992	4,900	10,568	0	0	10,568		0
	1,693	214	8,178	1,324,554	0	103,014	1,221,540	1,842	281,180	0	4,484	276,696	2,030	264,527	0	6,405	258,122		0
	1,700	275	4,230	1,161,135	965	264,893	896,243	792	217,404	42	11,529	205,875	448	122,976	60	16,470	106,506		0
	1,709	15	4,230	35,685	965	7,358	28,327	792	6,954	42	320	6,634	448	40,779	60	458	40,321		0
	1,710	15	450	6,863	0	0	6,863	120	1,830	0	0	1,830	4,900	74,725	0	0	74,725		0
	1,710	15	450	65,789	0	0	65,789	120	14,960	0	0	14,960	4,900	52,841	0	0	52,841		0
	1,711	46	8,178	374,144	0	0	374,144	1,842	84,272	0	0	84,272	2,030	92,873	0	0	92,873		0
	1,712	153	8,178	1,145,733	0	91,500	1,054,233	1,842	309,728	0	9,150	300,578	2,030	154,788	0	0	154,788		0
	1,717	305	6,848	2,088,640	1,200	366,000	1,722,640	2,220	677,100	120	36,600	640,500	0	0	0	0	0		0
	1,727	15	6,848	55,647	1,200	9,150	46,497	2,220	33,855	120	915	32,940	0	48,785	0	0	48,785		0
	1,728	76	450	34,313	0	0	34,313	2,220	169,275	0	0	169,275	6,398	487,848	0	0	487,848		0
	1,730	92	450	41,175	0	0	41,175	2,220	203,130	0	0	203,130	6,398	585,417	0	0	585,417		0
	1,733	15	450	31,735	0	0	31,735	2,220	41,968	0	0	41,968	6,398	61,702	0	0	61,702		0
	1,734	229	3,712	849,120	0	0	849,120	3,284	751,215	0	0	751,215	1,694	387,503	0	0	387,503		0
	1,741	6	3,712	12,694	0	0	12,694	3,284	20,032	0	0	20,032	1,694	20,283	0	0	20,283		0
	1,741	146	450	65,880	0	0	65,880	3,284	480,778	0	0	480,778	4,956	725,558	0	0	725,558		0
	1,746	15	450	31,735	0	9,150	22,585	3,284	50,081	0	0	50,081	4,956	50,706	0	0	50,706		0
	1,747	137	3,712	508,472	1,200	164,700	344,772	3,284	450,729	0	0	450,729	1,694	232,502	0	0	232,502		0
	1,751	397	3,712	1,471,808	1,200	475,800	996,008	3,284	1,302,106	0	0	1,302,106	1,694	671,671	0	0	671,671		0
	1,764	15	3,712	31,735	1,200	9,150	22,585	3,284	152,775	0	8,540	144,235	1,694	16,333	0	0	16,333		0
	1,765	168	450	75,488	0	0	75,488	16,752	2,810,148	1,120	187,880	2,622,268	448	75,152	0	0	75,152		0
	1,770	9	450	4,117	0	0	4,117	16,752	153,281	1,120	10,248	143,033	448	4,099	0	0	4,099		0
	1,770	143	450	579,277	0	0	579,277	16,752	1,986,974	1,120	146,217	1,840,757	448	64,221	0	0	64,221		0
	1,775	6	7,632	33,916	0	0	33,916	10,970	66,917	920	5,612	61,305	448	15,372	0	0	15,372		0
	1,775	238	3,488	829,795	0	0	829,795	10,970	2,615,710	920	218,868	2,396,842	4,592	1,092,437	0	0	1,092,437		0
	1,783	397	3,488	1,963,072	0	227,988	1,735,084	11,020	2,784,620	920	192,303	2,592,317	4,592	910,364	0	0	910,364		0
	1,796	61	6,414	391,254	1,150	70,150	321,104	3,026	184,586	50	3,050	181,536	0	0	0	0	0		0
	1,798	61	6,414	459,147	1,150	102,175	356,972	3,026	145,302	50	1,525	143,777	0	55,510	0	0	55,510		0
	1,800	183	8,640	1,581,120	2,200	402,600	1,178,520	1,738	318,054	0	0	318,054	1,820	333,060	0	0	333,060		0
	1,806	183	8,640	1,501,698	2,200	314,760	1,186,938	1,738	258,762	0	0	258,762	1,820	386,862	0	0	386,862		0
	1,812	122	7,772	948,184	1,240	151,280	796,904	1,090	132,980	0	0	132,980	2,408	293,776	0	0	293,776		0
	1,816	214	7,772	1,493,433	1,240	132,370	1,361,063	1,090	727,395	0	0	727,395	2,408	546,987	0	0	546,987		0
	1,823	214	6,218	1,327,543	0	0	1,327,543	5,724	1,222,074	0	0	1,222,074	2,716	579,866	0	0	579,866		0
	1,830	15	6,218	103,151	0	10,218	92,934	5,724	56,227	0	0	56,227	2,716	30,317	0	0	30,317		0
	1,831	137	7,310	1,003,298	1,340	183,915	819,383	1,650	226,463	0	0	226,463	1,260	172,935	0	0	172,935		0
	1,835	183	7,310	1,292,895	1,340	224,175	1,068,720	1,650	346,785	0	0	346,785	1,260	281,820	0	0	281,820		0
	1,841	427	6,820	2,855,349	1,110	446,215	2,409,134	2,140	798,490	0	0	798,490	1,820	1,392,874	0	0	1,392,874		0
	1,855	214	6,554	1,399,279	980	209,230	1,190,049	1,600	341,600	0	0	341,600	4,704	1,004,304	0	0	1,004,304		0
	1,862	15	6,554	63,013	980	7,473	55,541	1,600	153,888	0	7,091	146,797	4,704	39,071	0	0	39,071		0
	1,863	46	1,710	78,233	0	0	78,233	18,582	850,127	930	42,548	807,579	420	19,215	0	0	19,215		0
	1,864	153	1,710	260,775	0	0	260,775	18,582	2,833,755	930	141,825	2,691,930	420	64,050	0	0	64,050		0
	1,869	61	1,710	427,976	0	36,600	391,376	18,582	1,047,675	930	28,365	1,019,310	420	12,810	0	0	12,810		0
	1,871	275	12,322	3,382,389	1,200	329,400	3,052,989	15,768	4,332,434	0	0	4,332,434	0	0	0	0	0		0
	1,880	244	12,322	3,006,568	1,200	292,800	2,713,768	15,798	3,854,712	0	0	3,854,712	0	0	0	0	0		0
	1,888	15	12,322	97,387	1,200	9,150	88,237	15,798	122,214	0	0	122,214	0	71,202	0	0	71,202		0
	1,889	107	450	48,038	0	0	48,038	230	522,968	0	81,130	441,838	9,338	498,416	0	0	498,416		0
	1,892	336	450	150,975	0	0	150,975	9,568	3,879,387	1,520	459,635	3,419,752	0	32,879	0	0	32,879		0
	1,903	244	450	581,208	0	103,700	477,508	13,558	2,483,920	1,220	179,340	2,304,580	196	51,240	0	0	51,240		0
	1,911	305	4,314	726,510	850	129,625	596,885	6,802	3,556,300	250	388,875	3,167,425	224	81,130	0	0	81,130		0
	1,921	244	450	212,280	0	0	212,280	16,518	4,360,036	2,300	402,600	3,957,436	308	37,576	0	0	37,576		0
	1,929	305	1,290	393,450	0	0	393,450	19,220	5,862,100	1,000	305,000	5,557,100	0	0	0	0	0		0
	1,939	15	1,290	13,268	0	0	13,268	19,220	148,993	1,000	7,625	141,368	0	150,518	0	0	150,518		0
	1,940	558	450	251,167	0	0	251,167	320	156,282	0	0	156,282	19,740	11,017,881	0	0	11,017,881		0
	1,958	6	450	67,222	0	0	67,222	240	16,708	0	4,087	12,621	19,740	60,207	0	0	60,207		0
	1,958	122	21,590	2,633,980	0	0	2,633,980	5,238	639,036	1,340	163,480	475,556	0	0	0	0	0		0
	1,962	15	21,590	329,248	0	0	329,248	5,238	79,880	1,340	20,435	59,445	0	0	0	0	0		0
	1,963	168	21,590	2,864,331	0	109,038	2,755,294	5,238	873,978	1,340	112,393	761,585	0	19,962	0	0	19,962		0
	1,968	15	12,560	191,540	1,300	19,825	171,715	5,182	79,026	0	0	79,026	238	3,630	0	0	3,630		0
	1,969	46	12,560	574,620	1,300	59,475	515,145	5,182	237,077	0	0	237,077	238	10,889	0	0	10,889		0
	1,970	183	12,560	2,868,525	1,300	235,155	2,633,370	5,182	523,563	0	0	523,563	238	21,777	0	0	21,777		0
	1,976	183	18,790	2,840,343	1,270	140,910	2,699,433	540	367,830	0	115,290	252,540	0	0	0	0	0		0
	1,982	92	12,252	1,121,058	270	24,705	1,096,353	3,480	318,420	1,260	115,290	203,130	0	0	0	0	0		0
	1,985	15	12,252	96,853	270	2,059	94,794	3,480	88,298	1,260	17,995	70,303	0	0	0	0	0		0
	1,986	15	450	6,863	0	0	6,863	8,100	123,525	1,100	16,775	106,750	0	0	0	0	0		0
	1,986	153	450	68,625	0	0	68,625	8,100	1,569,378	1,100	173,088	1,396,290	0	0	0	0	0		0
	1,991	519	450	1,547,723	0	329,248	1,218,475	12,482	3,554,836	1,170	303,323	3,251,514	0	375,913	0	0	375,913		0
53.00	2,008	0	8,178	0	1,270	0	0	2,122	0	0	0	0	2,030	0	0	0	0		0
Sum. 3		9,882		53,128,002		5,804,951	47,323,051		64,162,155		4,038,597	60,123,558		24,537,323		23,333	24,513,991		0
53.00	2,008	1,000	5,520	4,050,000	1,270	635,000	3,415,000	1,230	2,230,000	0	0	2,230,000	1,450	1,250,000	0	0	1,250,000		0
54.00		1,000	2,580	5,275,000	0	0	5,275,000	3,230	3,380,000	0	0	3,380,000	1,050	1,170,000	0	0	1,170,000		0

55.00	1.000	7.970	9.200.000	0	35.000	9.165.000	3.530	3.530.000	0	0	3.530.000	1.290	1.200.000	0	0	1.200.000		0
56.00	1.000	10.430	10.095.000	70	35.000	10.060.000	3.530	3.530.000	0	0	3.530.000	1.110	1.080.000	0	0	1.080.000		0
57.00	3.000	9.760	24.315.000		0	24.315.000	3.530	14.415.000	0	0	14.415.000	1.050	2.745.000		0	2.745.000		0
60.00	1.000	6.450	8.540.000		0	8.540.000	6.080	4.165.000	0	0	4.165.000	780	1.130.000		0	1.130.000		0
61.00	1.000	10.630	6.720.000		0	6.720.000	2.250	2.250.000	0	0	2.250.000	1.480	1.500.000		0	1.500.000		0
62.00	0	2.810	0		0	0	2.250	0	0	0	0	1.520	0		0	0		0
Sum 4	9.000		68.195.000		705.000	67.490.000		33.500.000		0	33.500.000		10.075.000		0	10.075.000		0
62.00	10	2.810	28.100	2.340	23.400	4.700	2.250	22.500	2.220	22.200	300	760	7.600	760	7.600	0	760	7.600
62.01	1.990	2.810	4.567.050	2.340	4.099.400	467.650	2.250	3.472.550	2.220	3.442.700	29.850	760	1.512.400	760	1.512.400	0	760	2.547.200
64.00	3.000	1.780	2.670.000	1.780	2.670.000	0	1.240	3.435.000	1.240	3.435.000	0	760	2.190.000	760	2.190.000	0	1.800	3.750.000
67.00	2.000	0	0		0	0	1.050	1.400.000	1.050	1.400.000	0	700	1.400.000	700	1.400.000	0	700	1.400.000
69.00	7.300	0	0		0	0	350	1.277.500	350	1.277.500	0	700	2.555.000	700	2.555.000	0	700	2.555.000
76.30	0	0	0		0	0	0		0			0		0				0
Sum 5	14.300		7.265.150		6.792.800	472.350		9.607.550		9.577.400	30.150		7.665.000		7.665.000	0		10.259.800
C-2																		
Sum 1	11.800		940.000		940.000	0		12.617.000		10.377.000	2.240.000		5.492.000		5.492.000	0		5.532.000
Sum 2	42.120		40.681.550		22.426.400	18.255.150		78.362.250		18.531.300	59.830.950		9.877.500		4.068.000	5.809.500		0
Sum 3	9.882		53.128.002		5.804.951	47.323.051		64.162.155		4.038.597	60.123.558		24.537.323		23.333	24.513.991		0
Sum 4	9.000		68.195.000		705.000	67.490.000		33.500.000		0	33.500.000		10.075.000		0	10.075.000		0
Sum 5	14.300		7.265.150		6.792.800	472.350		9.607.550		9.577.400	30.150		7.665.000		7.665.000	0		10.259.800
Total	87.102		170.209.702		36.669.151	133.540.551		198.248.955		42.524.297	155.724.658		57.646.823		17.248.333	40.398.491		15.791.800

Total Excavation Vol	441.897.280
DRY	329.663.700
WET	112.233.580

L-4

Calculation Table of Excavation Volume

Station		Dis.	Rock					Weathered Rock					Earth					Canopy Material Total
			Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	
No	(ft)	(m)	Ao	Vo	Al	Vl	V2	Ao	Vo	Al	Vl	V2	Ao	Vo	Al	Vl	V2	No
-11.10		8.100	0	0	0	0		0	9,841,500		9,841,500		0	3,199,500	0	3,199,500	0	0
-3.00		4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790
1.00		0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820
Sum 1		12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0	
1.00		50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0
1.05		1,150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0
2.20		10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0
2.21		190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0
2.40		10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0
2.41		590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0
3.00		2,000	5,300	10,160,000	950	1,900,000	8,260,000	2,520	28,380,000	520	1,040,000	27,340,000	1,760	3,100,000	0	0	3,100,000	
5.00		300	4,860	1,458,000	950	285,000	1,173,000	25,860	7,758,000	520	156,000	7,602,000	1,340	402,000	0	0	402,000	
5.30		200	4,860	486,000	950	95,000	391,000	25,860	2,655,000	520	121,000	2,534,000	1,340	134,000	0	0	134,000	
5.50		1,500	0	0	0	0	0	690	637,500	690	637,500	0	0	0	0	0	0	
7.00		3,000		0	0	0	0	160	240,000	160	240,000	0	0	0	0	0	0	
10.00		6,000		5,970,000	0	5,970,000	0	0	1,050,000	0	1,050,000	0	0	0	0	0	0	
16.00		4,000	1,990	5,320,000	1,990	5,320,000	0	350	2,020,000	350	2,020,000	0	0	0	0	0	0	
20.00		5,000	670	5,025,000	670	5,025,000	0	660	2,525,000	660	2,525,000	0	0	0	0	0	0	
25.00		5,000	1,340	3,350,000	1,340	3,350,000	0	350	2,175,000	350	2,175,000	0	0	875,000	0	875,000	0	
30.00		6,000		0	0	0	0	520	6,480,000	520	6,480,000	0	350	2,100,000	350	2,100,000	0	
36.00		3,000		3,120,000	0	3,120,000	0	1,640	2,985,000	1,640	2,985,000	0	350	1,050,000	350	1,050,000	0	
39.00		4,120	2,080	10,110,288	2,080	4,284,800	5,825,488	350	26,935,698	350	3,357,800	23,577,898	350	721,000	350	721,000	0	
43.12	1.684	0	3,200	0	3,200	0	0	7,200	0	1,280	0	0	0	0	0	0	0	
Sum 2		42.120		55,492,538		31,237,800	24,254,738		88,878,198		23,823,800	65,054,398		12,099,000		4,746,000	7,353,000	
43.12	1.684	180	2,828	1,132,262	0	0	1,132,262	12,726	1,340,586	1,280	115,168	1,225,418	0	230,587	0	0	230,587	
	1.690	3	9,756	14,878	0	0	14,878	2,174	3,315	0	0	3,315	2,563	13,342	0	0	13,342	
	1.690	61	0	0	0	0	0	0	0	0	0	0	6,186	377,349	0	0	377,349	
	1.692	27	0	0	0	0	0	0	0	0	0	0	6,186	169,807	0	0	169,807	
	1.693	3	0	14,878	0	0	14,878	0	3,315	0	0	3,315	6,186	13,342	0	0	13,342	
	1.693	214	9,756	1,550,904	0	103,014	1,447,890	2,174	322,633	0	4,484	318,150	2,563	333,954	0	6,405	327,549	
	1.700	275	4,772	1,309,940	965	264,893	1,045,047	848	232,878	42	11,529	221,349	566	155,252	60	16,470	138,782	
	1.709	15	4,772	36,387	965	7,358	29,029	848	6,469	42	320	6,149	566	51,481	60	458	51,024	
	1.710	15	0	0	0	0	0	0	0	0	0	0	6,186	94,337	0	0	94,337	
	1.710	15	0	74,392	0	0	74,392	0	16,576	0	0	16,576	6,186	66,710	0	0	66,710	
	1.711	46	9,756	446,350	0	0	446,350	2,174	99,458	0	0	99,458	2,563	117,248	0	0	117,248	
	1.712	153	9,756	1,437,864	0	91,500	1,346,364	2,174	393,537	0	9,150	384,387	2,563	195,413	0	0	195,413	
	1.717	305	9,101	2,775,791	1,200	366,000	2,409,791	2,987	911,091	120	36,600	874,491	0	0	0	0	0	
	1.727	15	9,101	69,395	1,200	9,150	60,245	2,987	45,555	120	915	44,640	0	69,395	0	0	69,395	
	1.728	76	0	0	0	0	0	2,987	227,773	0	0	227,773	9,101	693,948	0	0	693,948	
	1.730	92	0	0	0	0	0	2,987	273,327	0	0	273,327	9,101	832,737	0	0	832,737	
	1.733	15	0	35,381	0	0	35,381	2,987	57,095	0	0	57,095	9,101	87,768	0	0	87,768	
	1.734	229	4,640	1,061,421	0	0	1,061,421	4,501	1,029,533	0	0	1,029,533	2,410	551,210	0	0	551,210	
	1.741	6	4,640	14,152	0	0	14,152	4,501	27,454	0	0	27,454	2,410	28,851	0	0	28,851	
	1.741	146	0	0	0	0	0	4,501	636,607	0	0	636,607	7,050	997,163	0	0	997,163	
	1.746	15	0	32,986	0	9,150	23,836	4,196	63,991	0	0	63,991	6,573	67,247	0	0	67,247	
	1.747	137	4,326	593,756	1,200	164,700	429,056	4,196	575,918	0	0	575,918	2,247	308,346	0	0	308,346	
	1.751	397	4,326	1,715,296	1,200	475,800	1,239,496	4,196	1,663,764	0	0	1,663,764	2,247	890,776	0	0	890,776	
	1.764	15	4,326	32,986	1,200	9,150	23,836	4,196	200,184	0	8,540	191,644	2,247	21,661	0	0	21,661	
	1.765	168	0	0	0	0	0	22,058	3,700,148	1,120	187,880	3,512,268	594	99,667	0	0	99,667	
	1.770	9	0	0	0	0	0	22,058	201,826	1,120	10,248	191,578	594	5,436	0	0	5,436	
	1.770	143	0	682,693	0	0	682,693	22,058	2,612,330	1,120	146,217	2,466,113	594	85,170	0	0	85,170	
	1.775	6	9,525	41,339	0	0	41,339	14,389	87,775	920	5,612	82,163	594	20,386	0	0	20,386	
	1.775	238	4,029	951,698	0	0	951,698	14,389	3,398,923	920	218,868	3,180,055	6,090	1,438,512	0	0	1,438,512	
	1.783	397	3,972	2,333,201	0	227,988	2,105,213	14,185	3,552,416	920	192,303	3,360,114	6,003	1,190,186	0	0	1,190,186	
	1.796	61	7,797	475,628	1,150	70,150	405,478	3,734	227,766	50	3,050	224,716	0	0	0	0	0	
	1.798	61	7,797	564,390	1,150	102,175	462,215	3,734	176,407	50	1,525	174,882	0	72,572	0	0	72,572	
	1.800	183	10,707	1,959,453	2,200	402,600	1,556,853	2,050	375,143	0	0	375,143	2,379	435,434	0	0	435,434	
	1.806	183	10,707	1,826,077	2,200	314,760	1,511,317	2,050	276,576	0	0	276,576	2,379	496,058	0	0	496,058	
	1.812	122	9,250	1,128,467	1,240	151,280	977,187	973	118,672	0	0	118,672	3,042	371,121	0	0	371,121	
	1.816	214	9,250	1,765,253	1,240	132,370	1,632,883	973	832,595	0	0	832,595	3,042	690,997	0	0	690,997	
	1.823	214	7,287	1,555,688	0	0	1,555,688	6,827	1,457,514	0	0	1,457,514	3,431	732,533	0	0	732,533	
	1.830	15	7,287	121,639	0	10,218	111,422	6,827	64,865	0	0	64,865	3,431	38,299	0	0	38,299	
	1.831	137	8,666	1,189,422	1,340	183,915	1,005,507	1,680	230,602	0	0	230,602	1,592	218,465	0	0	218,465	
	1.835	183	8,666	1,529,257	1,340	224,175	1,305,082	1,680	364,109	0	0	364,109	1,592	356,017	0	0	356,017	
	1.841	427	8,047	3,333,633	1,110	446,215	2,887,418	2,299	861,418	0	0	861,418	2,299	1,735,906	0	0	1,735,906	
	1.855	214	7,567	1,615,579	980	209,230	1,406,349	1,736	370,546	0	0	370,546	5,832	1,245,033	0	0	1,245,033	
	1.862	15	7,567	69,610	980	7,473	62,137	1,736	186,993	0	7,091	179,902	5,832	48,436	0	0	48,436	
	1.863	46	1,562	71,462	0	0	71,462	22,788	1,042,557	930	42,548	1,000,009	521	23,821	0	0	23,821	
	1.864	153	1,562	238,208	0	0	238,208	22,788	3,475,189	930	141,825	3,333,364	521	79,403	0	0	79,403	
	1.869	61	1,562	496,531	0	36,600	459,931	22,788	1,283,676	930	28,365	1,255,311	521	15,881	0	0	15,881	
	1.871	275	14,718	4,031,490	1,200	329,400	3,702,090	19,300	5,286,577	0	0	5,286,577	0	0	0	0	0	
	1.880	244	14,656	3,575,977	1,200	292,800	3,283,177	19,218	4,689,252	0	0	4,689,252	0	0	0	0	0	
	1.888	15	14,656	111,749	1,200	9,150	102,599	19,218	146,539	0	0	146,539	0	87,897	0	0	87,897	
	1.889	107	0	0	0	0	0	0	615,280	0	81,130	534,150	11,527	615,280	0	0	615,280	
	1.892	336	0	0	0	0	0	11,527	4,693,733	1,520	459,635	4,234,098	0	40,588	0	0	40,588	
	1.903	244	0	653,318	0	103,700	549,618	16,453	3,103,235	1,220	179,340	2,923,895	242	67,392	0	0	67,392	
	1.911	305	5,355	816,648	850	129,625	687,023	8,983	4,793,369	250	388,875	4,404,494	310	112,437	0	0	112,437	
	1.921	244	0	142,026	0	0	142,026	22,449	5,934,309	2,300	402,600	5,531,709	427	52,076	0	0	52,076	
	1.929	305	1,164	355,064	0	0	355,064	26,193	7,984,949	1,000	305,000	7,683,949	0	0	0	0	0	
	1.939	15	1,164	8,877	0	0	8,877	26,193	199,724	1,000	7,625	192,099	0	208,600	0	0	208,600	
	1.940	558	0	0	0	0	0	0	0	0	0	0	27,357	15,005,727	0	0	15,005,727	
	1.958	6	0	86,270	0	0	86,270	0	20,396	0	4,087	16,309	26,412	80,557	0	0	80,557	
	1.958	122	28,285	3,450,805	0	0	3,450,805	6,687	815,853	1,340	163,480	652,373	0	0	0	0	0	
	1.962	15	28,285	431,351	0	0	431,351	6,687	101,982	1,340	20,435	81,547	0	0	0	0	0	
	1.963	168	28,285	3,731,469	0	109,038	3,622,432	6,687	1,115,513	1,340	112,393	1,003,120	0	26,709	0	0	26,709	
	1.968	15	16,203	247,098	1,300	19,825	227,273	6,612	100,839	0	0	100,839	318	4,856	0	0	4,856	
	1.969	46	16,203	741,295	1,300	59,475	681,820	6,612	302,517	0	0	302,517	318	14,569	0	0	14,569	
	1.970	183	16,203	3,513,714	1,300	235,155	3,278,559	6,612	605,034	0	0	605,034	318	29,138	0	0	29,138	
	1.976	183	22,198	3,338,177	1,270	140,910	3,197,267	0	325,600	0	115,290	210,310	0	0	0	0	0	
	1.982	92	14,285	1,307,052	270	24,705	1,282,347	3,558	325,600	1,260	115,290	210,310	0	0	0	0	0	
	1.985	15	14,285	108,921	270	2,059	106,862	3,558	96,905	1,260	17,995	78,910	0	0	0	0	0	
	1.986	15	0	0	0	0	0	9,150	139,543	1,100	16,775	122,768	0	0	0	0	0	
	1.986	153	0	0	0	0	0	9,150	1,799,845	1,100	173,088	1,626,758	0	0	0	0	0	
	1.991	519	0	1,514,020	0	329,248	1,184,773	14,454	4,185,377	1,170	303,323	3,882,054	0	635,163	0	0	635,163	
53.00	2.008	0	9,470	0	1,270	0	0	2,110	0	0	0	0	2,488	0	0	0	0	
Sum 3		9,882		62,463,570		5,804,951	56,658,619		80,415,076		4,038,597	76,376,479		32,748,247		23,333	32,724,915	

53.00	2.008	1.000	5.840	4.145.000	1.270	635.000	3.510.000	1.890	2.375.000	0	[illegible]	2.675.000	2.450	2.225.000	0	0	2.295.000		[illegible]
54.00		1.000	2.450	5.730.000	0	0	5.730.000	3.660	3.780.000	0	0	3.780.000	2.140	1.930.000	0	0	1.930.000		[illegible]
55.00		1.000	9.010	10.420.000	0	35.000	10.385.000	3.900	3.950.000	0	0	3.950.000	1.720	1.505.000	0	0	1.505.000		[illegible]
56.00		1.000	11.830	11.150.000	70	35.000	11.115.000	4.000	3.900.000	0	0	3.900.000	1.290	1.245.000	0	0	1.245.000		[illegible]
57.00		3.000	10.470	26.505.000		0	26.505.000	3.800	16.980.000	0	0	16.980.000	1.200	3.120.000		0	3.120.000		[illegible]
60.00		1.000	7.200	10.000.000		0	10.000.000	7.520	5.005.000	0	0	5.005.000	880	1.270.000		0	1.270.000		[illegible]
61.00		1.000	12.800	8.310.000		0	8.310.000	2.490	2.595.000	0	0	2.595.000	1.660	1.730.000		0	1.730.000		[illegible]
62.00		0	3.820	0		0	0	2.700	0	0	0	0	1.800	0		0	0		[illegible]
Sum 4		9.000		76.260.000		705.000	75.555.000		38.885.000		0	38.885.000		13.095.000		0	13.095.000		[illegible]
62.00		10	3.820	38.200	3.820	38.200	0	2.700	27.000	2.700	27.000	0	900	9.000	900	9.000	0	900	9.000
62.01		1.990	3.820	6.139.150	3.820	6.139.150	0	2.700	5.373.000	2.700	5.373.000	0	900	1.791.000	900	1.791.000	0	900	2.905.490
64.00		3.000	2.350	3.525.000	2.350	3.525.000	0	2.700	7.665.000	2.700	7.665.000	0	900	2.610.000	900	2.610.000	0	2.020	4.290.000
67.00		2.000	0	0		0	0	2.410	4.410.000	2.410	4.410.000	0	840	1.640.000	840	1.640.000	0	840	1.610.000
69.00		10.500	0	0		0	0	2.000	10.500.000	2.000	10.500.000	0	800	4.200.000	800	4.200.000	0	800	4.200.000
79.50		0	0	0		0	0	0		0			0		0				0
Sum 5		17.500		9.702.350		9.702.350	0		27.975.000		27.975.000	0		10.250.000		10.250.000	0		13.014.400
L-4																			
Sum 1		12.100		2.060.000		2.060.000	0		19.501.500		19.501.500	0		6.419.500		6.419.500	0		6.419.500
Sum 2		42.120		55.492.538		31.237.800	24.254.738		88.878.198		23.823.800	65.054.398		12.099.000		4.746.000	7.353.000		0
Sum 3		9.882		62.463.570		5.804.951	56.658.619		80.415.076		4.038.597	76.376.479		32.748.247		23.333	32.724.915		0
Sum 4		9.000		76.260.000		705.000	75.555.000		38.885.000		0	38.885.000		13.095.000		0	13.095.000		0
Sum 5		17.500		9.702.350		9.702.350	0		27.975.000		27.975.000	0		10.250.000		10.250.000	0		13.014.400
Total		80.602		205.978.458		49.510.101	156.468.357		255.654.773		75.338.897	180.315.877		74.611.747		21.438.833	53.172.915		19.463.900

Total Excavation Vol.	555.708.879
DRY	389.957.149
WET	165.751.730

L-5

Calculation Table of Excavation Volume

Station No	Station (ft)	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Water Total Ao	Clayey Water Total Vo
11.10		8.100	0	0	0	0		0	9,841,500		9,841,500		0	3,199,500	0	3,199,500	0	0	[illegible]
-3.00		4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	[illegible]
1.00		0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820	[illegible]
Sum. 1		12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		5,419,500
1.00		50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	0
1.05		1,150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	0
2.20		10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	0
2.21		190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	0
2.40		10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	0
2.41		590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	0
3.00		2,000	5,300	10,690,000	950	1,900,000	8,790,000	2,520	28,610,000	520	1,040,000	27,570,000	1,760	3,100,000	0	0	3,100,000		0
5.00		300	5,390	1,617,000	950	285,000	1,332,000	26,090	7,827,000	520	156,000	7,671,000	1,340	402,000	0	0	402,000		0
5.30		200	5,390	539,000	950	95,000	444,000	26,090	2,730,000	520	173,000	2,557,000	1,340	134,000	0	0	134,000		0
5.50		1,500	0	0	0	0	0	1,210	907,500	1,210	907,500	0	0	0	0	0	0		0
7.00		3,000		0	0	0	0	0	1,020,000	0	1,020,000	0	0	0	0	0	0		0
10.00		6,000		7,530,000	0	7,530,000	0	680	3,090,000	680	3,090,000	0	0	0	0	0	0		0
16.00		4,000	2,510	7,400,000	2,510	7,400,000	0	350	2,020,000	350	2,020,000	0	0	0	0	0	0		0
20.00		5,000	1,190	7,625,000	1,190	7,625,000	0	660	2,525,000	660	2,525,000	0	0	0	0	0	0		0
25.00		5,000	1,860	4,650,000	1,860	4,650,000	0	350	3,475,000	350	3,475,000	0	0	875,000	0	875,000	0		0
30.00		6,000	0	0	0	0	0	1,040	9,600,000	1,040	9,600,000	0	350	2,100,000	350	2,100,000	0		0
36.00		3,000	0	3,885,000	0	3,885,000	0	2,160	3,765,000	2,160	3,765,000	0	350	1,050,000	350	1,050,000	0		0
39.00		4,120	2,590	12,211,488	2,590	5,335,400	6,876,088	350	27,100,498	350	3,357,800	23,742,698	350	721,000	350	721,000	0		0
43.12	1,684	0	3,200	0	3,200	0	0	7,200	0	1,280	0	0	0	0	0	0	0		0
Sum. 2		42.120		66,640,738		40,593,400	26,047,338		97,706,998		32,165,800	65,541,198		12,099,000		4,746,000	7,353,000		0
43.12	1,684	180	3,338	1,224,037	0	0	1,224,037	2,806	1,354,982	1,280	115,168	1,239,814	0	230,587	0	0	230,587		0
	1,690	3	10,266	16,434	0	0	16,434	2,254	3,559	0	0	3,559	2,563	13,342	0	0	13,342		0
	1,690	61	510	31,110	0	0	31,110	80	4,880	0	0	4,880	6,186	377,349	0	0	377,349		0
	1,692	27	510	14,000	0	0	14,000	80	2,196	0	0	2,196	6,186	169,807	0	0	169,807		0
	1,693	3	510	16,434	0	0	16,434	80	3,559	0	0	3,559	6,186	13,342	0	0	13,342		0
	1,693	214	10,266	1,659,789	0	103,014	1,556,775	2,254	339,713	0	4,484	335,230	2,563	333,954	0	6,405	327,549		0
	1,700	275	5,282	1,449,935	965	264,893	1,185,042	928	254,838	42	11,529	243,309	566	155,252	60	16,470	138,782		0
	1,709	15	5,282	44,165	965	7,358	36,807	928	7,689	42	320	7,369	566	51,481	60	458	51,024		0
	1,710	15	510	7,778	0	0	7,778	80	1,220	0	0	1,220	6,186	94,337	0	0	94,337		0
	1,710	15	510	82,169	0	0	82,169	80	17,796	0	0	17,796	6,186	66,710	0	0	66,710		0
	1,711	46	10,266	469,682	0	0	469,682	2,254	103,118	0	0	103,118	2,563	117,248	0	0	117,248		0
	1,712	153	10,266	1,515,639	0	91,500	1,424,139	2,254	405,737	0	9,150	396,587	2,563	195,413	0	0	195,413		0
	1,717	305	9,611	2,931,341	1,200	366,000	2,565,341	3,067	935,491	120	36,600	898,891	0	0	0	0	0		0
	1,727	15	9,611	77,172	1,200	9,150	68,022	3,067	46,775	120	915	45,860	0	69,395	0	0	69,395		0
	1,728	76	510	38,888	0	0	38,888	3,067	233,873	0	0	233,873	9,101	693,948	0	0	693,948		0
	1,730	92	510	46,665	0	0	46,665	3,067	280,647	0	0	280,647	9,101	832,737	0	0	832,737		0
	1,733	15	510	43,158	0	0	43,158	3,067	58,315	0	0	58,315	9,101	87,768	0	0	87,768		0
	1,734	229	5,150	1,178,083	0	0	1,178,083	4,581	1,047,833	0	0	1,047,833	2,410	551,210	0	0	551,210		0
	1,741	6	5,150	17,263	0	0	17,263	4,581	27,942	0	0	27,942	2,410	28,851	0	0	28,851		0
	1,741	146	510	74,664	0	0	74,664	4,581	651,979	0	0	651,979	7,050	997,163	0	0	997,163		0
	1,746	15	510	40,764	0	9,150	31,614	4,326	65,973	0	0	65,973	6,573	67,247	0	0	67,247		0
	1,747	137	4,836	663,754	1,200	164,700	499,054	4,326	593,761	0	0	593,761	2,247	308,346	0	0	308,346		0
	1,751	397	4,836	1,917,511	1,200	475,800	1,441,711	4,326	1,715,309	0	0	1,715,309	2,247	890,776	0	0	890,776		0
	1,764	15	4,836	40,764	1,200	9,150	31,614	4,326	202,166	0	8,540	193,626	2,247	21,661	0	0	21,661		0
	1,765	168	510	85,553	0	0	85,553	22,188	3,721,955	1,120	187,880	3,534,075	594	99,667	0	0	99,667		0
	1,770	9	510	4,666	0	0	4,666	22,188	203,016	1,120	10,248	192,768	594	5,436	0	0	5,436		0
	1,770	143	510	755,801	0	0	755,801	22,188	2,630,966	1,120	146,217	2,484,749	594	85,170	0	0	85,170		0
	1,775	8	10,035	44,450	0	0	44,450	14,519	88,568	920	5,612	82,956	594	20,386	0	0	20,386		0
	1,775	238	4,539	1,073,027	0	0	1,073,027	14,519	3,435,797	920	218,868	3,216,929	6,090	1,438,512	0	0	1,438,512		0
	1,783	397	4,482	2,535,416	0	227,988	2,307,428	14,365	3,623,786	920	192,303	3,431,484	6,003	1,190,186	0	0	1,190,186		0
	1,796	61	8,307	506,738	1,150	70,150	436,588	3,914	238,746	50	3,050	235,696	0	0	0	0	0		0
	1,798	61	8,307	595,500	1,150	102,175	493,325	3,914	187,387	50	1,525	185,862	0	72,572	0	0	72,572		0
	1,800	183	11,217	2,052,783	2,200	402,600	1,650,183	2,230	408,083	0	0	408,083	2,379	435,434	0	0	435,434		0
	1,806	183	11,217	1,919,407	2,200	314,760	1,604,647	2,230	322,326	0	0	322,326	2,379	496,058	0	0	496,058		0
	1,812	122	9,760	1,190,687	1,240	151,280	1,039,407	1,293	157,712	0	0	157,712	3,042	371,121	0	0	371,121		0
	1,816	214	9,760	1,874,138	1,240	132,370	1,741,768	1,293	900,915	0	0	900,915	3,042	690,997	0	0	690,997		0
	1,823	214	7,797	1,664,573	0	0	1,664,573	7,147	1,525,834	0	0	1,525,834	3,431	732,533	0	0	732,533		0
	1,830	15	7,797	129,417	0	10,218	119,199	7,147	69,745	0	0	69,745	3,431	38,299	0	0	38,299		0
	1,831	137	9,176	1,259,419	1,340	183,915	1,075,504	2,000	274,522	0	0	274,522	1,592	218,465	0	0	218,465		0
	1,835	183	9,176	1,622,587	1,340	224,175	1,398,412	2,000	422,669	0	0	422,669	1,592	356,017	0	0	356,017		0
	1,841	427	8,557	3,551,403	1,110	446,215	3,105,188	2,619	976,708	0	0	976,708	2,299	1,735,906	0	0	1,735,906		0
	1,855	214	8,077	1,724,464	980	209,230	1,515,234	1,956	417,516	0	0	417,516	5,832	1,245,033	0	0	1,245,033		0
	1,862	15	8,077	77,387	980	7,473	69,915	1,956	190,348	0	7,091	183,257	5,832	48,436	0	0	48,436		0
	1,863	46	2,072	94,795	0	0	94,795	23,008	1,052,822	930	42,548	1,010,074	521	23,821	0	0	23,821		0
	1,864	153	2,072	315,983	0	0	315,983	23,008	3,508,739	930	141,825	3,366,914	521	79,403	0	0	79,403		0
	1,869	61	2,072	527,641	0	36,600	491,041	23,008	1,297,096	930	28,365	1,268,731	521	15,881	0	0	15,881		0
	1,871	275	15,228	4,171,485	1,200	329,400	3,842,085	19,520	5,352,457	0	0	5,352,457	0	0	0	0	0		0
	1,880	244	15,166	3,700,417	1,200	292,800	3,407,617	19,478	4,752,682	0	0	4,752,682	0	0	0	0	0		0
	1,888	15	15,166	119,527	1,200	9,150	110,377	19,478	150,504	0	0	150,504	0	87,897	0	0	87,897		0
	1,889	107	510	54,443	0	0	54,443	260	643,035	0	81,130	561,905	11,527	615,280	0	0	615,280		0
	1,892	336	510	171,105	0	0	171,105	11,787	4,780,963	1,520	459,635	4,321,328	0	40,588	0	0	40,588		0
	1,903	244	510	777,758	0	103,700	674,058	16,713	3,171,555	1,220	179,340	2,992,215	242	67,392	0	0	67,392		0
	1,911	305	5,865	972,198	850	129,625	842,573	9,283	4,884,869	250	388,875	4,495,994	310	112,437	0	0	112,437		0
	1,921	244	510	266,466	0	0	266,466	22,749	6,007,509	2,300	402,600	5,604,909	427	52,076	0	0	52,076		0
	1,929	305	1,674	510,614	0	0	510,614	26,493	8,080,449	1,000	305,000	7,775,449	0	0	0	0	0		0
	1,939	15	1,674	16,654	0	0	16,654	26,493	204,299	1,000	7,625	196,674	0	208,600	0	0	208,600		0
	1,940	558	510	284,656	0	0	284,656	300	156,282	0	0	156,282	27,357	15,005,727	0	0	15,005,727		0
	1,958	6	510	89,381	0	0	89,381	260	21,982	0	4,087	17,895	26,412	80,557	0	0	80,557		0
	1,958	122	28,795	3,513,025	0	0	3,513,025	6,947	847,573	1,340	163,480	684,093	0	0	0	0	0		0
	1,962	15	28,795	439,128	0	0	439,128	6,947	105,947	1,340	20,435	85,512	0	0	0	0	0		0
	1,963	168	28,795	3,817,022	0	109,038	3,707,984	6,947	1,159,128	1,340	112,393	1,046,735	0	26,709	0	0	26,709		0
	1,968	15	16,713	254,876	1,300	19,825	235,051	6,872	104,804	0	0	104,804	318	4,856	0	0	4,856		0
	1,969	46	16,713	764,627	1,300	59,475	705,152	6,872	314,412	0	0	314,412	318	14,569	0	0	14,569		0
	1,970	183	16,713	3,607,044	1,300	235,155	3,371,889	6,872	678,234	0	0	678,234	318	29,138	0	0	29,138		0
	1,976	183	22,708	3,431,507	1,270	140,910	3,290,597	540	424,420	0	115,290	309,130	0	0	0	0	0		0
	1,982	92	14,795	1,353,717	270	24,705	1,329,012	4,098	375,010	1,260	115,290	259,720	0	0	0	0	0		0
	1,985	15	14,795	116,699	270	2,059	114,640	4,098	105,140	1,260	17,995	87,145	0	0	0	0	0		0
	1,986	15	510	7,778	0	0	7,778	9,690	147,778	1,100	16,775	131,003	0	0	0	0	0		0
	1,986	153	510	77,775	0	0	77,775	9,690	1,882,195	1,100	173,088	1,709,108	0	0	0	0	0		0
	1,991	519	510	1,646,238	0	329,248	1,316,990	14,994	4,325,372	1,170	303,323	4,022,049	0	635,163	0	0	635,163		0
53.00	2,008	0	9,980	0	1,270	0	0	2,470	0	0	0	0	2,488	0	0	0	0		0
Sum. 3		9,882		67,371,172		5,804,951	61,566,221		82,691,016		4,038,597	78,652,420		32,748,247		23,333	32,724,915		0
53.00	2,008	1,000	5,840	4,405,000	1,270	635,000	3,770,000	1,690	2,690,000	0	0	2,690,000	2,450	2,295,000	0	0	2,295,000		0
54.00		1,000	2,970	6,290,000	0	0	6,290,000	3,690	3,810,000	0	0	3,810,000	2,140	1,930,000	0	0	1,930,000		0

55.00	1.000	9.610	11.020.000	0	35.000	10.985.000	3.930	3.980.000	0	0	3.980.000	1.720	1.505.000	0	0	1.505.000		0
56.00	1.000	12.430	11.715.000	70	35.000	11.680.000	4.030	3.930.000	0	0	3.930.000	1.290	1.245.000	0	0	1.245.000		0
57.00	3.000	11.000	28.275.000		0	28.275.000	3.830	17.070.000	0	0	17.070.000	1.200	3.120.000		0	3.120.000		0
60.00	1.000	7.850	10.620.000		0	10.620.000	7.550	5.035.000	0	0	5.035.000	880	1.270.000		0	1.270.000		0
61.00	1.000	13.390	9.125.000		0	9.125.000	2.520	2.625.000	0	0	2.625.000	1.660	1.730.000		0	1.730.000		0
62.00	0	4.860	0		0	0	2.730	0	0	0	0	1.800	0		0	0		0
Sum 4	9.000		81.450.000		705.000	80.745.000		39.140.000		0	39.140.000		13.095.000		0	13.095.000		0
62.00	10	4.350	43.500	3.820	38.200	5.300	2.730	27.300	2.700	27.000	300	900	9.000	900	9.000	0	900	9.000
62.01	1.990	4.350	8.666.500	3.820	6.139.150	527.350	2.730	5.402.850	2.700	5.373.000	29.850	900	1.791.000	900	1.791.000	0	900	2.905.400
64.00	3.000	2.350	3.525.000	2.350	3.525.000	0	2.700	7.665.000	2.700	7.665.000	0	900	2.610.000	900	2.610.000	0	2.020	4.290.000
67.00	2.000	0	0		0	0	2.410	4.410.000	2.410	4.410.000	0	840	1.640.000	840	1.640.000	0	840	1.640.000
69.00	10.500	0	0		0	0	2.000	10.500.000	2.000	10.500.000	0	800	4.200.000	800	4.200.000	0	800	4.200.000
79.50	0	0	0		0	0	0		0			0		0				0
Sum 5	17.500		10.235.000		9.702.350	532.650		28.005.150		27.975.000	30.150		10.250.000		10.250.000	0		13.044.400
L-5																		
Sum 1	12.100		2.060.000		2.060.000	0		19.501.500		19.501.500	0		6.419.500		6.419.500	0		6.419.500
Sum 2	42.120		66.640.738		40.593.400	26.047.338		97.706.998		32.165.800	65.541.198		12.099.000		4.746.000	7.353.000		0
Sum 3	9.882		67.371.172		5.804.951	61.566.221		82.691.016		4.038.597	78.652.420		32.748.247		23.333	32.724.915		0
Sum 4	9.000		81.450.000		705.000	80.745.000		39.140.000		0	39.140.000		13.095.000		0	13.095.000		0
Sum 5	17.500		10.235.000		9.702.350	532.650		28.005.150		27.975.000	30.150		10.250.000		10.250.000	0		13.044.400
TOtal	90.602		227.756.910		58.865.701	168.891.210		267.044.664		83.680.897	183.363.767		74.611.747		21.438.833	53.172.915		119.463.900

Total Excavation Vol.	588.877.222
DRY	405.427.892
WET	183.449.330

L-7 Calculation Table of Excavation Volume

Station		Dis.	Rock					Weathered Rock					Earth					Clayey Material	
			Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
No	(ft)	(m)	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo
-11.50		8.500	0	9,222,500	0	9,222,500		0	9,222,500		9,222,500		0	4,080,000	0	4,080,000	0	0	4,080,000
-3.00		4.000	2,170	11,620,000	2,170	11,620,000	0	2,170	11,620,000	2,170	11,620,000	0	960	3,920,000	960	3,920,000	0	960	3,920,000
1.00		0	3,640	0	3,640	0	0	3,640	0	3,640	0	0	1,000	0	1,000	0	0	1,000	0
Sum 1		12.500		20,842,500		20,842,500	0		20,842,500		20,842,500	0		8,000,000		8,000,000	0		8,000,000
1.00		50	3,640	292,000	3,640	114,750	177,250	3,000	150,000	380	22,500	127,500	2,000	100,000	0	0	100,000	0	0
1.05		1.150	8,040	9,246,000	950	1,092,500	8,153,500	3,000	3,450,000	520	598,000	2,852,000	2,000	2,300,000	0	0	2,300,000	0	0
2.20		10	8,040	80,400	950	9,500	70,900	3,000	30,000	520	5,200	24,800	2,000	25,000	0	0	25,000	0	0
2.21		190	8,040	1,527,600	950	180,500	1,347,100	3,000	570,000	520	98,800	471,200	3,000	570,000	0	0	570,000	0	0
2.40		10	8,040	80,400	950	9,500	70,900	3,000	30,000	520	5,200	24,800	3,000	25,000	0	0	25,000	0	0
2.41		590	8,040	4,743,600	950	560,500	4,183,100	3,000	1,770,000	520	306,800	1,463,200	2,000	1,180,000	0	0	1,180,000	0	0
3.00		2.000	8,040	15,550,000	950	1,900,000	13,650,000	3,000	31,150,000	520	1,040,000	30,110,000	2,000	4,000,000	0	0	4,000,000	0	0
5.00		300	7,510	2,253,000	950	285,000	1,968,000	28,150	8,445,000	520	156,000	8,289,000	2,000	600,000	0	0	600,000	0	0
5.30		200	7,510	751,000	950	95,000	656,000	28,150	2,853,000	520	90,000	2,763,000	2,000	281,000	0	81,000	200,000	0	81,000
5.50		1.500	0	0	0	0	0	380	405,000	380	405,000	0	810	765,000	810	765,000	0	810	607,500
7.00		3.000	0	1,845,000	0	1,845,000	0	160	840,000	160	840,000	0	210	915,000	210	915,000	0	0	0
10.00		6.000	1,230	15,720,000	1,230	15,720,000	0	400	2,400,000	400	2,400,000	0	400	1,200,000	400	1,200,000	0	0	0
16.00		4.000	4,010	12,140,000	4,010	12,140,000	0	400	2,400,000	400	2,400,000	0	0	0	0	0	0	0	0
20.00		5.000	2,060	13,475,000	2,060	13,475,000	0	800	3,025,000	800	3,025,000	0	0	0	0	0	0	0	0
25.00		5.000	3,330	8,325,000	3,330	8,325,000	0	410	6,700,000	410	6,700,000	0	0	1,025,000	0	1,025,000	0	0	0
30.00		6.000	0	3,690,000	0	3,690,000	0	2,270	12,960,000	2,270	12,960,000	0	410	2,460,000	410	2,460,000	0	0	0
36.00		3.000	1,230	8,775,000	1,230	8,775,000	0	2,050	3,705,000	2,050	3,705,000	0	410	1,245,000	410	1,245,000	0	0	0
39.00		4.120	4,620	16,799,300	4,620	9,517,200	7,282,100	420	33,833,620	420	3,502,000	30,131,620	420	865,200	420	865,200	0	0	0
43.12	1.684	0	3,535	0	3,200	0	0	15,907	0	1,280	0	0	0	0	0	0	0	0	0
Sum 2		42.120		115,293,060		77,734,450	37,558,610		314,516,572		38,259,500	76,257,072		17,556,200		8,556,200	9,000,000		688,500
43.12	1.684	180	3,535	1,415,307	0	0	1,415,307	15,907	1,675,694	1,280	115,168	1,560,526	0	288,190	0	0	288,190		0
	1.690	3	12,195	18,597	0	0	18,597	2,717	4,143	0	0	4,143	3,203	16,677	0	0	16,677		0
	1.690	61	0	0	0	0	0	0	0	0	0	0	7,733	471,713	0	0	471,713		0
	1.692	27	0	0	0	0	0	0	0	0	0	0	7,733	212,271	0	0	212,271		0
	1.693	3	0	18,597	0	0	18,597	0	4,143	0	0	4,143	7,733	16,677	0	0	16,677		0
	1.693	214	12,195	1,938,580	0	103,014	1,835,566	2,717	403,195	0	4,484	398,711	3,203	417,393	0	6,405	410,988		0
	1.700	275	5,965	1,637,393	965	264,893	1,372,500	1,060	290,970	42	11,529	279,441	707	194,072	60	16,470	177,602		0
	1.709	15	5,965	45,483	965	7,358	38,125	1,060	8,083	42	320	7,762	707	64,355	60	458	63,898		0
	1.710	15	0	0	0	0	0	0	0	0	0	0	7,733	117,928	0	0	117,928		0
	1.710	15	0	92,987	0	0	92,987	0	20,717	0	0	20,717	7,733	83,387	0	0	83,387		0
	1.711	46	12,195	557,921	0	0	557,921	2,717	124,303	0	0	124,303	3,203	146,537	0	0	146,537		0
	1.712	153	12,195	1,895,499	0	91,500	1,803,999	2,717	524,143	0	9,150	514,993	3,203	244,229	0	0	244,229		0
	1.717	305	12,664	3,862,520	1,200	366,000	3,496,520	4,157	1,267,885	120	36,600	1,231,285	0	0	0	0	0		0
	1.727	15	12,664	96,563	1,200	9,150	87,413	4,157	63,394	120	915	62,478	0	96,563	0	0	96,563		0
	1.728	76	0	0	0	0	0	4,157	316,971	0	0	316,971	12,664	965,630	0	0	965,630		0
	1.730	92	0	0	0	0	0	4,157	380,366	0	0	380,366	12,664	1,158,756	0	0	1,158,756		0
	1.733	15	0	49,235	0	0	49,235	4,157	79,453	0	0	79,453	12,664	122,130	0	0	122,130		0
	1.734	229	6,457	1,477,039	0	0	1,477,039	6,263	1,432,661	0	0	1,432,661	3,353	766,999	0	0	766,999		0
	1.741	6	6,457	19,694	0	0	19,694	6,263	38,204	0	0	38,204	3,353	40,147	0	0	40,147		0
	1.741	146	0	0	0	0	0	6,263	870,568	0	0	870,568	9,810	1,363,643	0	0	1,363,643		0
	1.746	15	0	44,263	0	9,150	35,113	5,630	85,858	0	0	85,858	8,819	90,234	0	0	90,234		0
	1.747	137	5,805	796,736	1,200	164,700	632,036	5,630	772,718	0	0	772,718	3,015	413,809	0	0	413,809		0
	1.751	397	5,805	2,301,683	1,200	475,800	1,825,883	5,630	2,232,295	0	0	2,232,295	3,015	1,195,448	0	0	1,195,448		0
	1.764	15	5,805	44,263	1,200	9,150	35,113	5,630	268,606	0	8,540	260,066	3,015	29,067	0	0	29,067		0
	1.765	168	0	0	0	0	0	29,597	4,984,897	1,120	187,880	4,777,017	797	133,697	0	0	133,697		0
	1.770	9	0	0	0	0	0	29,597	270,813	1,120	10,248	260,565	797	7,293	0	0	7,293		0
	1.770	143	0	916,078	0	0	916,078	29,597	3,505,266	1,120	146,217	3,359,049	797	114,250	0	0	114,250		0
	1.775	6	12,781	55,470	0	0	55,470	19,308	117,779	920	5,612	112,167	797	27,355	0	0	27,355		0
	1.775	238	5,406	1,258,729	0	0	1,258,729	19,308	4,495,477	920	218,868	4,276,609	8,172	1,902,605	0	0	1,902,605		0
	1.783	397	5,176	3,040,560	0	227,988	2,812,573	18,485	4,629,336	920	192,303	4,437,033	7,823	1,550,910	0	0	1,550,910		0
	1.796	61	10,161	619,821	1,150	70,150	549,671	4,866	296,826	50	3,050	293,776	0	0	0	0	0		0
	1.798	61	10,161	735,477	1,150	102,175	633,302	4,866	229,879	50	1,525	228,354	0	94,581	0	0	94,581		0
	1.800	183	13,953	2,553,399	2,200	402,600	2,150,799	2,671	488,793	0	0	488,793	3,101	567,483	0	0	567,483		0
	1.806	183	13,953	2,382,477	2,200	314,760	2,067,717	2,671	360,693	0	0	360,693	3,101	647,363	0	0	647,363		0
	1.812	122	12,085	1,474,370	1,240	151,280	1,323,090	1,271	155,062	0	0	155,062	3,974	484,828	0	0	484,828		0
	1.816	214	12,085	2,306,334	1,240	132,370	2,173,964	1,271	1,087,783	0	0	1,087,783	3,974	902,785	0	0	902,785		0
	1.823	214	9,520	2,032,520	0	0	2,032,520	8,919	1,904,207	0	0	1,904,207	4,483	957,121	0	0	957,121		0
	1.830	15	9,520	158,920	0	10,218	148,703	8,919	84,744	0	0	84,744	4,483	49,890	0	0	49,890		0
	1.831	137	11,322	1,553,945	1,340	183,915	1,370,030	2,195	301,264	0	0	301,264	2,080	284,108	0	0	284,108		0
	1.835	183	11,322	1,987,994	1,340	224,175	1,773,819	2,195	475,709	0	0	475,709	2,080	465,186	0	0	465,186		0
	1.841	427	10,514	4,306,936	1,110	446,215	3,860,721	3,004	1,114,257	0	0	1,114,257	3,004	2,230,648	0	0	2,230,648		0
	1.855	214	9,659	2,062,197	980	209,230	1,852,967	2,215	472,903	0	0	472,903	7,444	1,589,294	0	0	1,589,294		0
	1.862	15	9,659	88,854	980	7,473	81,382	2,215	238,685	0	7,091	231,594	7,444	61,831	0	0	61,831		0
	1.863	46	1,994	91,226	0	0	91,226	29,088	1,330,776	930	42,548	1,288,229	665	30,424	0	0	30,424		0
	1.864	153	1,994	304,085	0	0	304,085	29,088	4,435,920	930	141,825	4,294,095	665	101,413	0	0	101,413		0
	1.869	61	1,994	633,790	0	36,600	597,190	29,088	1,638,552	930	28,365	1,610,187	665	20,283	0	0	20,283		0
	1.871	275	18,786	5,073,172	1,200	329,400	4,743,772	24,635	6,852,645	0	0	6,852,645	0	0	0	0	0		0
	1.880	244	18,177	4,435,188	1,200	292,800	4,142,388	23,836	5,815,984	0	0	5,815,984	0	0	0	0	0		0
	1.888	15	18,177	138,600	1,200	9,150	129,450	23,836	181,750	0	0	181,750	0	109,015	0	0	109,015		0
	1.889	107	0	0	0	0	0	0	763,102	0	81,130	681,972	14,297	763,102	0	0	763,102		0
	1.892	336	0	0	0	0	0	14,297	5,821,428	1,520	459,635	5,361,793	0	50,325	0	0	50,325		0
	1.903	244	0	950,136	0	103,700	846,436	20,406	4,082,120	1,220	179,340	3,902,780	300	91,622	0	0	91,622		0
	1.911	305	7,788	1,187,870	850	129,625	1,058,045	13,054	6,969,250	250	388,875	6,580,375	451	163,480	0	0	163,480		0
	1.921	244	0	206,546	0	0	206,546	32,646	8,630,036	2,300	402,600	8,227,436	621	75,762	0	0	75,762		0
	1.929	305	1,693	516,365	0	0	516,365	38,092	11,618,060	1,000	305,000	11,313,060	0	0	0	0	0		0
	1.939	15	1,693	12,909	0	0	12,909	38,092	290,452	1,000	7,625	282,827	0	303,361	0	0	303,361		0
	1.940	558	0	0	0	0	0	0	0	0	0	0	39,785	21,031,092	0	0	21,031,092		0
	1.958	6	0	116,184	0	0	116,184	0	27,468	0	4,087	23,381	5,575	108,504	0	0	108,504		0
	1.958	122	38,093	4,647,346	0	0	4,647,346	9,006	1,098,732	1,340	163,480	935,252	0	0	0	0	0		0
	1.962	15	38,093	580,918	0	0	580,918	9,006	137,342	1,340	20,435	116,907	0	0	0	0	0		0
	1.963	168	38,093	5,025,371	0	109,038	4,916,333	9,006	1,502,285	1,340	112,393	1,389,893	0	35,982	0	0	35,982		0
	1.968	15	21,822	332,786	1,300	19,825	312,961	8,905	135,801	0	0	135,801	429	6,542	0	0	6,542		0
	1.969	46	21,822	998,357	1,300	59,475	938,882	8,905	407,404	0	0	407,404	429	19,627	0	0	19,627		0
	1.970	183	21,822	4,476,638	1,300	235,155	4,241,483	8,905	814,808	0	0	814,808	429	39,254	0	0	39,254		0
	1.976	183	27,103	4,075,776	1,270	140,910	3,934,866	0	397,568	0	115,290	282,278	0	0	0	0	0		0
	1.982	92	17,441	1,595,852	270	24,705	1,571,147	4,345	397,568	1,280	115,290	282,278	0	0	0	0	0		0
	1.985	15	17,441	132,988	270	2,059	130,929	4,345	118,317	1,280	17,995	100,322	0	0	0	0	0		0
	1.986	15	0	0	0	0	0	11,172	170,373	1,100	16,775	153,598	0	0	0	0	0		0
	1.986	153	0	0	0	0	0	11,172	2,198,288	1,100	173,088	2,025,200	0	0	0	0	0		0
	1.991	519	0	1,514,020	0	329,248	1,184,772	17,658	5,015,969	1,170	303,323	4,712,647	0	635,163	0	0	635,163		0
53.00	2.008	0	12,058	0	1,270	0	0	2,687	0	0	0	0	3,167	0	0	0	0		0
Sum 3		9.882		80,902,288		5,804,951	75,097,338		106,710,560		4,038,597	102,671,963		44,171,959		23,333	44,148,627		0

53.00	2,008	1,000	5,840	4,970,000	1,270	635,000	4,335,000	1,690	2,995,000	0	0	2,995,000	2,450	2,510,000	0	0	2,510,000		0
54.00		1,000	4,100	7,790,000	0	0	7,790,000	4,300	4,500,000	0	0	4,500,000	2,570	2,225,000	0	0	2,225,000		0
55.00		1,000	11,480	13,020,000	0	35,000	12,985,000	4,700	4,700,000	0	0	4,700,000	1,880	1,690,000	0	0	1,690,000		0
56.00		1,000	14,560	13,405,000	70	35,000	13,370,000	4,700	4,600,000	0	0	4,600,000	1,500	1,425,000	0	0	1,425,000		0
57.00		3,000	12,250	33,675,000		0	33,675,000	4,500	19,605,000	0	0	19,605,000	1,350	3,525,000		0	3,525,000		0
60.00		1,000	10,200	13,625,000		0	13,625,000	8,570	5,710,000	0	0	5,710,000	1,000	1,450,000		0	1,450,000		0
61.00		1,000	17,050	11,740,000		0	11,740,000	2,850	3,015,000	0	0	3,015,000	1,900	2,010,000		0	2,010,000		0
62.00		0	6,430	0		0	0	3,180	0	0	0	0	2,120	0		0	0		0
Sum 4		9,000		98,225,000		705,000	97,520,000		45,125,000		0	45,125,000		14,835,000		0	14,835,000		0
62.00		10	6,430	64,300	6,430	64,300	0	3,180	31,800	3,180	31,800	0	1,060	10,600	1,060	10,600	0	1,060	10,600
62.01		1,990	6,430	11,372,850	6,430	11,372,850	0	3,180	6,268,500	3,180	6,268,500	0	1,060	2,089,500	1,060	2,089,500	0	1,060	3,512,350
64.00		3,000	5,000	9,960,000	5,000	9,960,000	0	3,120	9,180,000	3,120	9,180,000	0	1,040	3,060,000	1,040	3,060,000	0	2,470	5,205,000
67.00		2,000	1,640	3,350,000	1,640	3,350,000	0	3,000	5,700,000	3,000	5,700,000	0	1,000	1,940,000	1,000	1,940,000	0	1,000	1,940,000
69.00		14,900	1,710	12,739,500	1,710	12,739,500	0	2,700	20,115,000	2,700	20,115,000	0	940	7,003,000	940	7,003,000	0	940	7,003,000
83.90		0	0	0		0	0	0		0			0		0				0
Sum 5		21,900		37,486,650		37,486,650	0		41,295,300		41,295,300	0		14,103,100		14,103,100	0		17,670,950
Sum 1		12,500		20,842,500		20,842,500	0		21,750,000		21,750,000	0		8,000,000		8,000,000	0		8,000,000
Sum 2		42,120		115,293,060		77,734,450	37,558,610		114,516,572		38,259,500	76,257,072		17,558,200		8,556,200	9,000,000		688,500
Sum 3		9,882		80,902,288		5,804,951	75,097,338		106,710,568		4,038,597	102,671,963		44,171,959		23,333	44,148,627		0
Sum 4		9,000		98,225,000		705,000	97,520,000		45,125,000		0	45,125,000		14,835,000		0	14,835,000		0
Sum 5		21,900		37,486,650		37,486,650	0		41,295,300		41,295,300	0		14,103,100		14,103,100	0		17,670,950
Total		85,402		352,749,498		142,573,551	210,175,948		329,397,432		105,343,397	224,054,035		98,666,259		70,682,633	67,983,627		26,359,450

Total Excavation Vol.	807,172,639
DRY	502,213,609
WET	304,958,030

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L-8 Calculation Table of Excavation Volume

Station		Dis.	Rock					Weathered Rock					Earth					Clayey Material
			Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total
No	(ft)	(m)	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao
11.50		8.500	0	9.222.500	0	9.222.500		0	10.710.000		10.710.000		0	4.080.000	0	4.080.000	0	0
-3.00		4.000	2.170	11.620.000	2.170	11.620.000	0	2.520	11.040.000	2.520	11.040.000	0	960	3.920.000	960	3.920.000	0	960
1.00			3.640		3.640			3.000		3.000			1.000		1.000			1.000
Sum. 1		12.500		20.842.500		20.842.500	0		21.750.000		21.750.000	0		8.000.000		8.000.000	0	
1.00		50	3.640	292.000	3.640	114.750	177.250	3.000	150.000	380	22.500	127.500	2.000	100.000	0	0	100.000	0
1.05		1.150	8.040	9.246.000	950	1.092.500	8.153.500	3.000	3.450.000	520	598.000	2.852.000	2.000	2.300.000	0	0	2.300.000	0
2.20		10	8.040	80.400	950	9.500	70.900	3.000	30.000	520	5.200	24.800	2.000	25.000	0	0	25.000	0
2.21		190	8.040	1.527.600	950	180.500	1.347.100	3.000	570.000	520	98.800	471.200	3.000	570.000	0	0	570.000	0
2.40		10	8.040	80.400	950	9.500	70.900	3.000	30.000	520	5.200	24.800	3.000	25.000	0	0	25.000	0
2.41		590	8.040	4.743.600	950	560.500	4.183.100	3.000	1.770.000	520	306.800	1.463.200	2.000	1.180.000	0	0	1.180.000	0
3.00		2.000	8.040	16.160.000	950	1.900.000	14.260.000	3.000	31.350.000	520	1.040.000	30.310.000	2.000	4.000.000	0	0	4.000.000	
5.00		300	8.120	2.436.000	950	285.000	2.151.000	28.350	8.505.000	520	156.000	8.349.000	2.000	600.000	0	0	600.000	
5.30		200	8.120	812.000	950	95.000	717.000	28.350	2.933.000	520	150.000	2.783.000	2.000	281.000	0	81.000	200.000	
5.50		1.500	0	0	0	0	0	980	735.000	980	735.000	0	810	1.065.000	810	1.065.000	0	810
7.00		3.000	0	2.745.000	0	2.745.000	0	0	600.000	0	600.000	0	610	915.000	610	915.000	0	
10.00		6.000	1.830	19.320.000	1.830	19.320.000	0	400	2.400.000	400	2.400.000	0	0	0	0	0	0	
16.00		4.000	4.610	14.520.000	4.610	14.520.000	0	400	2.400.000	400	2.400.000	0	0	0	0	0	0	
20.00		5.000	2.650	16.450.000	2.650	16.450.000	0	800	3.025.000	800	3.025.000	0	0	0	0	0	0	
25.00		5.000	3.930	9.825.000	3.930	9.825.000	0	410	8.200.000	410	8.200.000	0	0	1.025.000	0	1.025.000	0	
30.00		6.000	0	5.490.000	0	5.490.000	0	2.870	14.790.000	2.870	14.790.000	0	410	2.460.000	410	2.460.000	0	
36.00		3.000	1.830	10.575.000	1.830	10.575.000	0	2.060	3.720.000	2.060	3.720.000	0	410	1.245.000	410	1.245.000	0	
39.00		4.120	5.220	19.271.060	5.220	10.753.200	8.517.860	420	33.715.972	420	3.502.000	30.213.972	420	865.200	420	865.200	0	
43.12	1.684		3.200		3.200			7.200		1.280			0		0			
Sum. 2		12.120		133.574.060		93.925.450	39.648.610		118.373.972		41.754.500	76.619.472		16.656.200		7.656.200	9.000.000	
43.12	1.684	180	4.135	1.523.298	0	0	1.523.298	5.947	1.682.930	1.280	115.168	1.567.762	0	288.234	0	0	288.234	
	1.690	3	2.795	20.428	0	0	20.428	2.757	4.266	0	0	4.266	3.203	16.677	0	0	16.677	
	1.690	61	600	36.600	0	0	36.600	40	2.440	0	0	2.440	7.733	471.686	0	0	471.686	
	1.692	27	600	16.470	0	0	16.470	40	1.098	0	0	1.098	7.733	212.259	0	0	212.259	
	1.693	3	600	20.428	0	0	20.428	40	4.266	0	0	4.266	7.733	16.677	0	0	16.677	
	1.693	214	2.795	2.066.730	0	103.014	1.963.716	2.757	411.832	0	4.484	407.348	3.203	417.442	0	6.405	411.037	
	1.700	275	6.565	1.802.124	965	264.893	1.537.232	1.100	302.078	42	11.529	290.549	707	194.065	60	16.470	177.595	
	1.709	15	6.565	54.634	965	7.358	47.276	1.100	8.696	42	320	8.376	707	64.351	60	458	63.894	
	1.710	15	600	9.150	0	0	9.150	40	610	0	0	610	7.733	117.922	0	0	117.922	
	1.710	15	600	102.140	0	0	102.140	40	21.330	0	0	21.330	7.733	83.387	0	0	83.387	
	1.711	46	2.795	585.387	0	0	585.387	2.757	126.153	0	0	126.153	3.203	146.560	0	0	146.560	
	1.712	153	2.795	1.987.056	0	91.500	1.895.556	2.757	530.261	0	9.150	521.111	3.203	244.266	0	0	244.266	
	1.717	305	3.264	4.045.641	1.200	366.000	3.679.641	4.197	1.280.025	120	36.600	1.243.425	0	0	0	0	0	
	1.727	15	3.264	105.716	1.200	9.150	96.566	4.197	64.001	120	915	63.086	0	96.566	0	0	96.566	
	1.728	76	600	45.750	0	0	45.750	4.197	320.006	0	0	320.006	2.664	965.660	0	0	965.660	
	1.730	92	600	54.900	0	0	54.900	4.197	384.008	0	0	384.008	2.664	1.158.792	0	0	1.158.792	
	1.733	15	600	58.384	0	0	58.384	4.197	80.060	0	0	80.060	2.664	122.134	0	0	122.134	
	1.734	229	7.057	1.614.266	0	0	1.614.266	6.303	1.441.792	0	0	1.441.792	3.353	767.034	0	0	767.034	
	1.741	6	7.057	23.354	0	0	23.354	6.303	38.448	0	0	38.448	3.353	40.148	0	0	40.148	
	1.741	146	600	87.840	0	0	87.840	6.303	885.965	0	0	885.965	9.810	1.363.672	0	0	1.363.672	
	1.746	15	600	53.412	0	9.150	44.262	5.800	88.456	0	0	88.456	8.819	90.233	0	0	90.233	
	1.747	137	6.405	879.061	1.200	164.700	714.361	5.800	796.108	0	0	796.108	3.015	413.743	0	0	413.743	
	1.751	397	6.405	2.539.511	1.200	475.800	2.063.711	5.800	2.299.869	0	0	2.299.869	3.015	1.195.257	0	0	1.195.257	
	1.764	15	6.405	53.412	1.200	9.150	44.262	5.800	271.202	0	8.540	262.662	3.015	29.065	0	0	29.065	
	1.765	168	600	100.650	0	0	100.650	29.767	4.993.431	1.120	187.880	4.805.551	797	133.735	0	0	133.735	
	1.770	9	600	5.490	0	0	5.490	29.767	272.369	1.120	10.248	262.121	797	7.295	0	0	7.295	
	1.770	143	600	1.002.057	0	0	1.002.057	29.767	3.529.634	1.120	146.217	3.383.417	797	114.283	0	0	114.283	
	1.775	6	3.381	59.130	0	0	59.130	19.478	118.815	920	5.612	113.203	797	27.355	0	0	27.355	
	1.775	238	6.006	1.401.457	0	0	1.401.457	19.478	4.539.430	920	218.868	4.320.562	8.172	1.902.577	0	0	1.902.577	
	1.783	397	5.776	3.278.318	0	227.988	3.050.330	18.685	4.708.490	920	192.303	4.516.187	7.823	1.550.944	0	0	1.550.944	
	1.796	61	10.761	656.396	1.150	70.150	586.246	5.066	309.004	50	3.050	305.954	0	0	0	0	0	
	1.798	61	10.761	772.062	1.150	102.175	669.887	5.066	242.077	50	1.525	240.552	0	94.570	0	0	94.570	
	1.800	183	14.553	2.663.183	2.200	402.600	2.260.583	2.871	525.453	0	0	525.453	3.101	567.419	0	0	567.419	
	1.806	183	14.553	2.492.266	2.200	314.760	2.177.506	2.871	409.207	0	0	409.207	3.101	647.367	0	0	647.367	
	1.812	122	12.685	1.547.566	1.240	151.280	1.396.286	1.601	195.308	0	0	195.308	3.974	484.877	0	0	484.877	
	1.816	214	12.685	2.434.439	1.240	132.370	2.302.069	1.601	1.158.258	0	0	1.158.258	3.974	902.802	0	0	902.802	
	1.823	214	10.120	2.160.638	0	0	2.160.638	9.249	1.974.726	0	0	1.974.726	4.483	957.069	0	0	957.069	
	1.830	15	10.120	168.074	0	10.218	157.857	9.249	89.780	0	0	89.780	4.483	50.038	0	0	50.038	
	1.831	137	11.922	1.636.354	1.340	183.915	1.452.439	2.525	346.579	0	0	346.579	2.080	285.429	0	0	285.429	
	1.835	183	11.922	2.107.805	1.340	224.175	1.883.630	2.525	536.105	0	0	536.105	2.080	465.144	0	0	465.144	
	1.841	427	11.114	4.563.085	1.110	446.215	4.116.870	3.334	1.240.285	0	0	1.240.285	3.004	2.230.563	0	0	2.230.563	
	1.855	214	10.259	2.190.313	980	209.230	1.981.083	2.475	528.495	0	0	528.495	7.444	1.589.228	0	0	1.589.228	
	1.862	15	10.259	98.004	980	7.473	90.531	2.475	242.653	0	7.091	235.562	7.444	61.826	0	0	61.826	
	1.863	46	2.594	118.668	0	0	118.668	29.348	1.342.671	930	42.548	1.300.124	665	30.406	0	0	30.406	
	1.864	153	2.594	395.562	0	0	395.562	29.348	4.475.570	930	141.825	4.333.745	665	101.354	0	0	101.354	
	1.869	61	2.594	670.399	0	36.600	633.799	29.348	1.654.414	930	28.365	1.626.049	665	20.271	0	0	20.271	
	1.871	275	19.386	5.237.896	1.200	329.400	4.908.496	24.895	6.726.702	0	0	6.726.702	0	0	0	0	0	
	1.880	244	18.777	4.581.519	1.200	292.800	4.288.719	24.116	5.884.183	0	0	5.884.183	0	0	0	0	0	
	1.888	15	18.777	147.747	1.200	9.150	138.597	24.116	186.016	0	0	186.016	0	109.015	0	0	109.015	
	1.889	107	600	64.050	0	0	64.050	280	792.993	0	81.130	711.863	14.297	763.103	0	0	763.103	
	1.892	336	600	201.300	0	0	201.300	14.577	5.915.360	1.520	459.635	5.455.725	0	50.340	0	0	50.340	
	1.903	244	600	1.096.492	0	103.700	992.792	20.686	4.150.439	1.220	179.340	3.971.099	300	91.688	0	0	91.688	
	1.911	305	8.388	1.370.616	850	129.625	1.240.991	13.334	7.053.137	250	388.875	6.664.262	451	163.512	0	0	163.512	
	1.921	244	600	352.942	0	0	352.942	12.916	8.695.886	2.300	402.600	8.293.286	621	75.732	0	0	75.732	
	1.929	305	2.293	699.355	0	0	699.355	18.362	11.700.328	1.000	305.000	11.395.328	0	0	0	0	0	
	1.939	15	2.293	22.059	0	0	22.059	18.362	294.567	1.000	7.625	286.942	0	303.358	0	0	303.358	
	1.940	558	600	334.890	0	0	334.890	270	156.282	0	0	156.282	19.785	21.029.801	0	0	21.029.801	
	1.958	6	600	119.845	0	0	119.845	290	29.238	0	4.087	25.151	15.571	108.491	0	0	108.491	
	1.958	122	18.693	4.720.597	0	0	4.720.597	9.296	1.134.136	1.340	163.480	970.656	0	0	0	0	0	
	1.962	15	18.693	590.075	0	0	590.075	9.296	141.767	1.340	20.435	121.332	0	0	0	0	0	
	1.963	168	18.693	5.126.033	0	109.038	5.016.996	9.296	1.550.973	1.340	112.393	1.438.580	0	35.971	0	0	35.971	
	1.968	15	22.422	341.931	1.300	19.825	322.106	9.195	140.228	0	0	140.228	429	6.540	0	0	6.540	
	1.969	46	22.422	1.025.794	1.300	59.475	966.319	9.195	420.684	0	0	420.684	429	19.621	0	0	19.621	
	1.970	183	22.422	4.586.436	1.300	235.155	4.351.281	9.195	890.778	0	0	890.778	429	39.241	0	0	39.241	
	1.976	183	27.703	4.185.622	1.270	140.910	4.044.712	540	496.369	0	115.290	381.079	0	0	0	0	0	
	1.982	92	18.041	1.650.775	270	24.705	1.626.070	4.885	446.959	1.260	115.290	331.669	0	0	0	0	0	
	1.985	15	18.041	142.140	270	2.059	140.081	4.885	126.553	1.260	17.995	108.558	0	0	0	0	0	
	1.986	15	600	9.150	0	0	9.150	11.712	178.613	1.100	16.775	161.838	0	0	0	0	0	
	1.986	153	600	91.500	0	0	91.500	11.712	2.279.912	1.100	173.088	2.106.824	0	0	0	0	0	
	1.991	519	600	1.669.570	0	329.248	1.340.323	18.188	5.153.410	1.170	303.323	4.850.087	0	635.163	0	0	635.163	
53.00	2.008		12.658		1.270			3.077		0			3.167		0			
Sum. 3		9.882		86.675.938		5.804.951	80.870.988		109.024.168		4.038.597	104.985.571		14.171.959		23.333	14.148.627	
53.00	2.008	1.000	5.840	5.270.000	1.270	635.000	4.635.000	1.690	3.010.000	0	0	3.010.000	2.450	2.510.000	0	0	2.510.000	
54.00		1.000	4.700	8.435.000	0	0	8.435.000	4.330	4.530.000	0	0	4.530.000	2.570	2.225.000	0	0	2.225.000	

55.00		1.000	12.170	13.710.000	0	35.000	13.675.000	4.730	4.730.000	0	-	4.730.000	1.880	1.697.[illegible]	0	0	1.690.000			0
56.00		1.000	15.250	14.055.000	70	35.000	14.020.000	4.730	4.630.000	0	0	4.630.000	1.500	1.425.000	0	0	1.425.000			0
57.00		3.000	12.860	35.580.000		0	35.580.000	4.530	19.695.000	0	0	19.695.000	1.350	3.525.000		0	3.525.000			0
60.00		1.000	10.860	14.300.000		0	14.300.000	8.600	5.725.000	0	0	5.725.000	1.000	1.450.000		0	1.450.000			0
61.00		1.000	17.740	12.400.000		0	12.400.000	2.850	3.040.000	0	0	3.040.000	1.900	2.010.000		0	2.010.000			0
62.00			7.060					3.230		0			2.120							
Subt. 4		9.000		103.750.000		705.000	103.045.000		45.360.000		0	45.360.000		14.835.000		0	14.835.000			0
62.00		10	7.140	71.400	6.430	64.300	7.100	3.150	31.500	3.150	31.500	0	1.040	10.400	1.040	10.400	0	1.040		10.400
62.01		1.990	7.140	12.079.300	6.430	11.372.850	706.450	3.150	6.238.650	3.150	6.238.650	0	1.040	2.069.600	1.040	2.069.600	0	1.040		3.492.450
64.00		3.000	5.000	9.960.000	5.000	9.960.000	0	3.120	9.180.000	3.120	9.180.000	0	1.040	3.060.000	1.040	3.060.000	0	2.470		5.205.000
67.00		2.000	1.640	3.350.000	1.640	3.350.000	0	3.000	5.700.000	3.000	5.700.000	0	1.000	1.940.000	1.000	1.940.000	0	1.000		1.940.000
69.00		14.900	1.710	12.739.500	1.710	12.739.500	0	2.700	20.115.000	2.700	20.115.000	0	940	7.003.000	940	7.003.000	0	940		7.003.000
83.90			0					0		0			0		0					
Subt. 5		21.900		38.200.200		37.486.650	713.550		41.265.150		41.265.150	0		14.083.000		14.083.000	0			17.650.850
1.-8																				
Subt. 1		12.500		20.842.500		20.842.500	0		21.750.000		21.750.000	0		8.000.000		8.000.000	0			8.000.000
Subt. 2		42.120		133.574.060		93.925.450	39.648.610		118.373.972		41.754.500	76.619.472		16.656.200		7.656.200	9.000.000			688.500
Subt. 3		9.882		86.675.938		5.804.951	80.870.988		109.024.168		4.038.597	104.985.571		44.171.959		23.333	44.148.627			0
Subt. 4		9.000		103.750.000		705.000	103.045.000		45.360.000		0	45.360.000		14.835.000		0	14.835.000			0
Subt. 5		21.900		38.200.200		37.486.650	713.550		41.265.150		41.265.150	0		14.083.000		14.083.000	0			17.650.850
Total		95.402		083.042.699		158.764.551	224.278.148		335.773.290		308.808.247	226.965.043		97.746.159		29.762.533	67.983.627			26.339.350

Total Excavation Vol.	842.901.498
DRY	519.226.818
WET	323.674.680

L-10 Calculation Table of Excavation Volume

Station		Dis.	Rock					Weathered Rock							Earth			Gravel Mixture	
			Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
No	(ft)	(m)	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo
-10.80		7,800	0	0	0	0		0	6,357,000		6,357,000		0	2,652,000	0	2,652,000	0	0	2,552,200
-3.00		4,000	0	940,000	0	940,000	0	1,630	6,260,000	1,630	4,020,000	2,240,000	680	2,840,000	680	2,840,000	0	680	2,880,300
1.00			470		470			1,500		380			740		740			760	
Sum. 1		11,800		940,000		940,000	0		12,617,000		10,377,000	2,240,000		5,492,000		5,492,000	0		5,532,300
1.00		50	470	93,750	470	35,500	58,250	1,500	120,750	380	22,500	98,250	1,500	69,500	0	0	69,500	0	0
1.05		1,150	3,280	3,772,000	950	1,092,500	2,679,500	3,330	3,829,500	520	598,000	3,231,500	1,280	1,472,000	0	0	1,472,000	0	0
2.20		10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	1,280	17,800	0	0	17,800	0	0
2.21		190	3,280	623,200	950	180,500	442,700	3,330	632,700	520	98,800	533,900	2,280	433,200	0	0	433,200	0	0
2.40		10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	2,280	17,800	0	0	17,800	0	0
2.41		590	3,280	1,935,200	950	560,500	1,374,700	3,330	1,964,700	520	306,800	1,657,900	1,280	755,200	0	0	755,200	0	0
3.00		2,000	3,280	7,410,000	950	950,000	6,460,000	3,330	26,950,000	520	520,000	26,430,000	1,280	2,540,000	0	0	2,540,000		0
5.00		300	4,130	1,239,000	0	0	1,239,000	23,620	7,086,000	0	0	7,086,000	1,260	378,000	0	0	378,000		0
5.30		200	4,130	413,000	0	0	413,000	23,620	2,362,000	0	0	2,362,000	1,260	126,000	0	0	126,000		0
5.50		1,500		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
7.00		1,000		295,000	0	295,000	0	0	600,000	0	600,000	0	0	150,000	0	150,000	0		0
8.00		2,000	590	970,000	590	970,000	0	1,200	2,440,000	1,200	2,440,000	0	300	610,000	300	610,000	0		0
10.00		3,500	380	1,085,000	380	1,085,000	0	1,240	4,340,000	1,240	4,340,000	0	310	1,085,000	310	1,085,000	0		0
13.50		2,500	240	9,450,000	240	9,450,000	0	1,240	3,500,000	1,240	3,500,000	0	310	875,000	310	875,000	0		0
16.00		3,000	7,320	10,980,000	7,320	10,980,000	0	1,560	3,525,000	1,560	3,525,000	0	390	1,050,000	390	1,050,000	0		0
19.00		1,000	0	2,525,000	0	2,525,000	0	790	1,095,000	790	1,095,000	0	310	330,000	310	330,000	0		0
20.00		4,000	5,050	16,600,000	5,050	16,600,000	0	1,400	5,360,000	1,400	5,360,000	0	350	1,340,000	350	1,340,000	0		0
24.00		1,000	3,250	3,495,000	3,250	3,495,000	0	1,280	1,320,000	1,280	1,320,000	0	320	330,000	320	330,000	0		0
25.00		1,000	3,740	4,550,000	3,740	4,550,000	0	1,360	1,380,000	1,360	1,380,000	0	340	345,000	340	345,000	0		0
26.00		1,000	5,360	7,280,000	5,360	7,280,000	0	1,400	1,400,000	1,400	1,400,000	0	350	350,000	350	350,000	0		0
27.00		1,000	9,200	11,285,000	9,200	11,285,000	0	1,400	1,480,000	1,400	1,480,000	0	350	370,000	350	370,000	0		0
28.00		1,000	13,370	12,605,000	13,370	12,605,000	0	1,560	1,540,000	1,560	1,540,000	0	390	385,000	390	385,000	0		0
29.00		1,000	11,840	6,720,000	11,840	6,720,000	0	1,520	1,400,000	1,520	1,400,000	0	380	350,000	380	350,000	0		0
30.00		0	1,600	0	1,600	0	0	1,280	0	1,280	0	0	320	0	320	0	0		0
36.20		2,800	1,600	3,486,000	1,600	3,486,000	0	1,280	2,212,000	1,280	2,212,000	0	320	868,000	320	868,000	0		0
39.00		4,120	890	5,129,400	890	1,833,400	3,296,000	300	15,450,000	300	3,254,800	12,195,200	300	618,000	300	618,000	0		0
43.12	1,684		1,600		0			7,200		1,280			0		0				
Sum. 2		35,920		112,007,150		95,997,400	16,009,750		90,054,250		36,403,300	53,650,950		14,865,500		9,056,000	5,809,500		0
43.12	1,684	180	2,690	977,848	0	0	977,848	10,200	1,083,479	1,280	115,168	968,311	0	182,649	0	0	182,649		0
	1,690	3	8,178	13,158	0	0	13,158	1,842	2,992	0	0	2,992	2,030	10,568	0	0	10,568		0
	1,690	61	450	27,450	0	0	27,450	120	7,320	0	0	7,320	4,900	298,900	0	0	298,900		0
	1,692	27	450	12,353	0	0	12,353	120	3,294	0	0	3,294	4,900	134,505	0	0	134,505		0
	1,693	3	450	13,158	0	0	13,158	120	2,992	0	0	2,992	4,900	10,568	0	0	10,568		0
	1,693	214	8,178	1,324,554	0	103,014	1,221,540	1,842	281,180	0	4,484	276,696	2,030	264,527	0	6,405	258,122		0
	1,700	275	4,230	1,161,135	965	264,893	896,243	792	217,404	42	11,529	205,875	448	122,976	60	16,470	106,506		0
	1,709	15	4,230	35,685	965	7,358	28,327	792	6,954	42	320	6,634	448	40,779	60	458	40,321		0
	1,710	15	450	6,863	0	0	6,863	120	1,830	0	0	1,830	4,900	74,725	0	0	74,725		0
	1,710	15	450	65,789	0	0	65,789	120	14,960	0	0	14,960	4,900	52,841	0	0	52,841		0
	1,711	46	8,178	374,144	0	0	374,144	1,842	84,272	0	0	84,272	2,030	92,873	0	0	92,873		0
	1,712	153	8,178	1,145,733	0	91,500	1,054,233	1,842	309,728	0	9,150	300,578	2,030	154,788	0	0	154,788		0
	1,717	305	6,848	2,088,640	1,200	366,000	1,722,640	2,220	677,100	120	36,600	640,500	0	0	0	0	0		0
	1,727	15	6,848	55,647	1,200	9,150	46,497	2,220	33,855	120	915	32,940	0	48,785	0	0	48,785		0
	1,728	76	450	34,313	0	0	34,313	2,220	169,275	0	0	169,275	6,398	487,848	0	0	487,848		0
	1,730	92	450	41,175	0	0	41,175	2,220	203,130	0	0	203,130	6,398	585,417	0	0	585,417		0
	1,733	15	450	31,735	0	0	31,735	2,220	41,968	0	0	41,968	6,398	61,702	0	0	61,702		0
	1,734	229	3,712	849,120	0	0	849,120	3,284	751,215	0	0	751,215	1,694	387,503	0	0	387,503		0
	1,741	6	3,712	12,694	0	0	12,694	3,284	20,032	0	0	20,032	1,694	20,283	0	0	20,283		0
	1,741	146	450	65,880	0	0	65,880	3,284	480,778	0	0	480,778	4,956	725,558	0	0	725,558		0
	1,746	15	450	31,735	0	9,150	22,585	3,284	50,081	0	0	50,081	4,956	50,706	0	0	50,706		0
	1,747	137	3,712	509,472	1,200	164,700	344,772	3,284	450,729	0	0	450,729	1,694	232,502	0	0	232,502		0
	1,751	397	3,712	1,471,808	1,200	475,800	996,008	3,284	1,302,106	0	0	1,302,106	1,694	671,671	0	0	671,671		0
	1,764	15	3,712	31,735	1,200	9,150	22,585	3,284	152,775	0	8,540	144,235	1,694	16,333	0	0	16,333		0
	1,765	168	450	75,488	0	0	75,488	16,752	2,810,148	1,120	187,880	2,622,268	448	75,152	0	0	75,152		0
	1,770	9	450	4,117	0	0	4,117	16,752	153,281	1,120	10,248	143,033	448	4,099	0	0	4,099		0
	1,770	143	450	579,277	0	0	579,277	16,752	1,986,974	1,120	146,217	1,840,757	448	64,221	0	0	64,221		0
	1,775	8	7,632	33,918	0	0	33,918	10,970	66,917	920	5,612	61,305	448	15,372	0	0	15,372		0
	1,775	238	3,488	829,795	0	0	829,795	10,970	2,615,710	920	218,868	2,396,842	4,592	1,092,437	0	0	1,092,437		0
	1,783	397	3,488	1,963,072	0	227,988	1,735,084	11,020	2,784,820	920	192,303	2,592,317	4,592	910,364	0	0	910,364		0
	1,796	61	6,414	391,254	1,150	70,150	321,104	3,026	184,586	50	3,050	181,536	0	0	0	0	0		0
	1,798	61	6,414	459,147	1,150	102,175	356,972	3,026	145,302	50	1,525	143,777	0	55,510	0	0	55,510		0
	1,800	183	8,640	1,581,120	2,200	402,600	1,178,520	1,738	318,054	0	0	318,054	1,820	333,060	0	0	333,060		0
	1,806	183	8,640	1,501,698	2,200	314,760	1,186,938	1,738	258,762	0	0	258,762	1,820	386,862	0	0	386,862		0
	1,812	122	7,772	948,184	1,240	151,280	796,904	1,090	132,980	0	0	132,980	2,408	293,776	0	0	293,776		0
	1,816	214	7,772	1,493,433	1,240	132,370	1,361,063	1,090	727,395	0	0	727,395	2,408	546,987	0	0	546,987		0
	1,823	214	6,218	1,327,543	0	0	1,327,543	5,724	1,222,074	0	0	1,222,074	2,716	579,866	0	0	579,866		0
	1,830	15	6,218	103,151	0	10,218	92,934	5,724	56,227	0	0	56,227	2,716	30,317	0	0	30,317		0
	1,831	137	7,310	1,003,298	1,340	183,915	819,383	1,650	226,463	0	0	226,463	1,260	172,935	0	0	172,935		0
	1,835	183	7,310	1,292,895	1,340	224,175	1,068,720	1,650	346,785	0	0	346,785	1,260	281,820	0	0	281,820		0
	1,841	427	6,820	2,855,349	1,110	446,215	2,409,134	2,140	798,490	0	0	798,490	1,820	1,392,874	0	0	1,392,874		0
	1,855	214	6,554	1,399,279	980	209,230	1,190,049	1,600	341,600	0	0	341,600	4,704	1,004,304	0	0	1,004,304		0
	1,862	15	6,554	63,013	980	7,473	55,541	1,600	153,888	0	7,091	146,797	4,704	39,071	0	0	39,071		0
	1,863	46	1,710	78,233	0	0	78,233	18,582	850,127	930	42,548	807,579	420	19,215	0	0	19,215		0
	1,864	153	1,710	260,775	0	0	260,775	18,582	2,833,755	930	141,825	2,691,930	420	64,050	0	0	64,050		0
	1,869	61	1,710	427,976	0	36,600	391,376	18,582	1,047,675	930	28,365	1,019,310	420	12,810	0	0	12,810		0
	1,871	275	12,322	3,382,389	1,200	329,400	3,052,989	15,768	4,332,434	0	0	4,332,434	0	0	0	0	0		0
	1,880	244	12,322	3,006,568	1,200	292,800	2,713,768	15,798	3,854,712	0	0	3,854,712	0	0	0	0	0		0
	1,888	15	12,322	97,387	1,200	9,150	88,237	15,798	122,214	0	0	122,214	0	71,202	0	0	71,202		0
	1,889	107	450	48,038	0	0	48,038	230	522,968	0	81,130	441,838	9,338	498,416	0	0	498,416		0
	1,892	336	450	150,975	0	0	150,975	9,568	3,879,387	1,520	459,635	3,419,752	0	32,879	0	0	32,879		0
	1,903	244	450	581,208	0	103,700	477,508	13,558	2,483,920	1,220	179,340	2,304,580	196	51,240	0	0	51,240		0
	1,911	305	4,314	726,510	850	129,625	596,885	8,802	3,556,300	250	388,875	3,167,425	224	81,130	0	0	81,130		0
	1,921	244	450	212,280	0	0	212,280	18,518	4,360,036	2,300	402,600	3,957,436	308	37,576	0	0	37,576		0
	1,929	305	1,290	393,450	0	0	393,450	19,220	5,862,100	1,000	305,000	5,557,100	0	0	0	0	0		0
	1,939	15	1,290	13,268	0	0	13,268	19,220	148,993	1,000	7,625	141,368	0	150,518	0	0	150,518		0
	1,940	558	450	251,167	0	0	251,167	320	156,282	0	0	156,282	19,740	11,017,881	0	0	11,017,881		0
	1,958	6	450	67,222	0	0	67,222	240	16,708	0	4,087	12,621	19,740	60,207	0	0	60,207		0
	1,958	122	21,590	2,633,980	0	0	2,633,980	5,238	639,036	1,340	163,480	475,556	0	0	0	0	0		0
	1,962	15	21,590	329,248	0	0	329,248	5,238	79,880	1,340	20,435	59,445	0	0	0	0	0		0
	1,963	168	21,590	2,864,331	0	109,038	2,755,294	5,238	873,978	1,340	112,393	761,585	0	19,962	0	0	19,962		0
	1,968	15	12,560	191,540	1,300	19,825	171,715	5,182	79,026	0	0	79,026	238	3,630	0	0	3,630		0
	1,969	46	12,560	574,620	1,300	59,475	515,145	5,182	237,077	0	0	237,077	238	10,889	0	0	10,889		0
	1,970	183	12,560	2,868,525	1,300	235,155	2,633,370	5,182	523,563	0	0	523,563	238	21,777	0	0	21,777		0
	1,976	183	18,790	2,840,343	1,270	140,910	2,699,433	540	367,830	0	115,290	252,540	0	0	0	0	0		0
	1,982	92	12,252	1,121,058	270	24,705	1,096,353	3,480	318,420	1,260	115,290	203,130	0	0	0	0	0		0
	1,985	15	12,252	96,853	270	2,059	94,794	3,480	88,298	1,260	17,995	70,303	0	0	0	0	0		0
	1,986	15	450	8,863	0	0	8,863	8,100	123,525	1,100	16,775	106,750	0	0	0	0	0		0
	1,986	153	450	68,625	0	0	68,625	8,100	1,569,378	1,100	173,088	1,396,290	0	0	0	0	0		0

	1.991	519	.50	1,547,723	0	329,248	1,218,475	2,482	[illegible]	1,170	303,32[illegible]	2,251,514	0	375,9[illegible]	0	0	375,312			0
53.00	2.008		3.78		1.270			2.122		0			2.030		0					
Subt. 3		9.882		53,128,002		5,804,951	47,323,051		64,162,155		4,038,597	60,123,558		24,537,323		23,333	24,513,991			0
53.00	2.008	1.000	5.520	4,050,000	1.270	635,000	3,415,000	1.230	2,230,000	0	0	2,230,000	1.450	1,250,000	0	0	1,250,000			0
54.00		1.000	2.580	5,275,000	0	0	5,275,000	3.230	3,380,000	0	0	3,380,000	1.050	1,170,000	0	0	1,170,000			0
55.00		1.000	7.970	9,200,000	0	35,000	9,165,000	3.530	3,530,000	0	0	3,530,000	1.290	1,200,000	0	0	1,200,000			0
56.00		1.000	10.430	10,095,000	70	35,000	10,060,000	3.530	3,530,000	0	0	3,530,000	1.110	1,080,000	0	0	1,080,000			0
57.00		3.000	9.760	24,315,000		0	24,315,000	3.530	14,415,000	0	0	14,415,000	1.050	2,745,000		0	2,745,000			0
60.00		1.000	6.450	8,540,000		0	8,540,000	6.080	4,165,000	0	0	4,165,000	780	1,130,000		0	1,130,000			0
61.00		1.000	10.630	6,720,000		0	6,720,000	2.250	2,250,000	0	0	2,250,000	1.480	1,500,000		0	1,500,000			0
62.00			2.810					2.250		0			1.520							
Subt. 4		9.000		68,195,000		705,000	67,490,000		33,500,000		0	33,500,000		10,075,000		0	10,075,000			0
62.00		10	2.810	28,100	2.340	23,400	4,700	2.250	22,500	2.220	22,200	300	760	7,600	760	7,600	0	760		7,500
62.01		1.990	2.810	4,567,050	2.340	4,099,400	467,650	2.250	3,472,550	2.220	3,442,700	29,850	760	1,512,400	760	1,512,400	0	760		2,547,250
64.00		3.000	1.780	2,670,000	1.780	2,670,000	0	1.240	3,435,000	1.240	3,435,000	0	760	2,190,000	760	2,190,000	0	1.800		3,750,000
67.00		2.000	0	0		0	0	1.050	1,400,000	1.050	1,400,000	0	700	1,400,000	700	1,400,000	0	700		1,100,000
69.00		7.300	0	0		0	0	350	1,277,500	350	1,277,500	0	700	2,555,000	700	2,555,000	0	700		2,555,000
76.30			0					0		0			0		0					
Subt. 5		14.300		7,265,150		6,792,800	472,350		9,607,550		9,577,400	30,150		7,665,000		7,665,000	0			10,259,800
L-10																				
Subt. 1		11.800		940,000		940,000	0		12,617,000		10,377,000	2,240,000		5,492,000		5,492,000	0			5,532,000
Subt. 2		35.920		112,007,150		95,997,400	16,009,750		90,054,250		36,403,300	53,650,950		14,865,500		9,056,000	5,809,500			0
Subt. 3		9.882		53,128,002		5,804,951	47,323,051		64,162,155		4,038,597	60,123,558		24,537,323		23,333	24,513,991			0
Subt. 4		9.000		68,195,000		705,000	67,490,000		33,500,000		0	33,500,000		10,075,000		0	10,075,000			0
Subt. 5		14.300		7,265,150		6,792,800	472,350		9,607,550		9,577,400	30,150		7,665,000		7,665,000	0			10,259,800
Total		80.902		241,535,302		110,240,151	131,295,151		209,940,955		60,396,297	149,544,658		62,634,823		22,236,333	40,398,491			15,791,900

Total Excavation Vol.	529,902,880
DRY	321,238,300
WET	208,664,580

L-13 Calculation Table of Excavation Volume

Station No	Station (ft)	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
11.10		8.100	0	0	0	0		0	9,841,500		9,841,500		0	3,199,500	0	3,199,500	0	0	3,199,500
-3.00		4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	3,220,000
1.00			1,030		1,030			2,400		2,400			820		820			820	
Sum. 1		12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
1.00		50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	0
1.05		1.150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	0
2.20		10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	0
2.21		190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	0
2.40		10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	0
2.41		590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	0
3.00		2,000	5,300	10,690,000	950	1,900,000	8,790,000	2,520	28,610,000	520	1,040,000	27,570,000	1,760	3,100,000	0	0	3,100,000		0
5.00		300	5,390	1,617,000	950	285,000	1,332,000	26,090	7,827,000	520	156,000	7,671,000	1,340	402,000	0	0	402,000		0
5.30		200	5,390	539,000	950	95,000	444,000	26,090	2,730,000	520	173,000	2,557,000	1,340	134,000	0	0	134,000		0
5.50		1,500	0	0	0	0	0	1,210	907,500	1,210	907,500	0	0	0	0	0	0		0
7.00		1,000		730,000	0	730,000	0	0	700,000	0	700,000	0	0	175,000	0	175,000	0		0
8.00		2,000	1,460	2,850,000	1,460	2,850,000	0	1,400	2,800,000	1,400	2,800,000	0	350	700,000	350	700,000	0		0
10.00		3,500	1,390	4,585,000	1,390	4,585,000	0	1,400	4,970,000	1,400	4,970,000	0	350	1,242,500	350	1,242,500	0		0
13.50		2,500	1,230	13,962,500	1,230	13,962,500	0	1,440	3,900,000	1,440	3,900,000	0	360	975,000	360	975,000	0		0
16.00		3,000	9,940	15,510,000	9,940	15,510,000	0	1,680	4,620,000	1,680	4,620,000	0	420	1,155,000	420	1,155,000	0		0
19.00		1,000	400	200,000	400	200,000	0	1,400	1,500,000	1,400	1,500,000	0	350	375,000	350	375,000	0		0
20.00		4,000	0	8,660,000	0	8,660,000	0	1,800	6,080,000	1,800	6,080,000	0	400	1,520,000	400	1,520,000	0		0
24.00		1,000	4,330	4,705,000	4,330	4,705,000	0	1,440	1,480,000	1,440	1,480,000	0	360	370,000	360	370,000	0		0
25.00		1,000	5,080	5,970,000	5,080	5,970,000	0	1,520	1,540,000	1,520	1,540,000	0	380	385,000	380	385,000	0		0
26.00		1,000	6,860	9,005,000	6,860	9,005,000	0	1,560	1,580,000	1,560	1,580,000	0	390	395,000	390	395,000	0		0
27.00		1,000	11,150	13,415,000	11,150	13,415,000	0	1,600	1,680,000	1,600	1,680,000	0	400	420,000	400	420,000	0		0
28.00		1,000	15,680	15,020,000	15,680	15,020,000	0	1,760	1,720,000	1,760	1,720,000	0	440	430,000	440	430,000	0		0
29.00		1,000	14,360	8,675,000	14,360	8,675,000	0	1,680	1,560,000	1,680	1,560,000	0	420	390,000	420	390,000	0		0
30.00		0	2,990	0	2,990	0	0	1,440	0	1,440	0	0	360	0	360	0	0		0
36.20		2,800	2,990	7,812,000	2,990	7,812,000	0	1,440	2,506,000	1,440	2,506,000	0	360	994,000	360	994,000	0		0
39.00		4,120	2,590	11,927,400	2,590	11,927,400	0	350	15,553,000	350	3,357,800	12,195,200	350	721,000	350	721,000	0		0
43.12	1,684		3,200		3,200			7,200		1,280			0		0				
Sum. 2		35,920		146,366,150		127,194,900	19,171,250		97,300,500		43,306,800	53,993,700		17,600,500		10,247,500	7,353,000		0
43.12	1,684	180	3,338	1,224,037	0	0	1,224,037	2,806	1,354,982	1,280	115,168	1,239,814	0	230,587	0	0	230,587		0
	1,690	3	10,266	16,434	0	0	16,434	2,254	3,559	0	0	3,559	2,563	13,342	0	0	13,342		0
	1,690	61	510	31,110	0	0	31,110	80	4,880	0	0	4,880	6,186	377,349	0	0	377,349		0
	1,692	27	510	14,000	0	0	14,000	80	2,196	0	0	2,196	6,186	169,807	0	0	169,807		0
	1,693	3	510	16,434	0	0	16,434	80	3,559	0	0	3,559	6,186	13,342	0	0	13,342		0
	1,693	214	10,266	1,659,789	0	103,014	1,556,775	2,254	339,713	0	4,484	335,230	2,563	333,954	0	6,405	327,549		0
	1,700	275	5,282	1,449,935	965	264,893	1,185,042	928	254,838	42	11,529	243,309	566	155,252	60	16,470	138,782		0
	1,709	15	5,282	44,165	965	7,358	36,807	928	7,689	42	320	7,369	566	51,481	60	458	51,024		0
	1,710	15	510	7,778	0	0	7,778	80	1,220	0	0	1,220	6,186	94,337	0	0	94,337		0
	1,710	15	510	82,169	0	0	82,169	80	17,796	0	0	17,796	6,186	66,710	0	0	66,710		0
	1,711	46	10,266	469,682	0	0	469,682	2,254	103,118	0	0	103,118	2,563	117,248	0	0	117,248		0
	1,712	153	10,266	1,515,639	0	91,500	1,424,139	2,254	405,737	0	9,150	396,587	2,563	195,413	0	0	195,413		0
	1,717	305	9,611	2,931,341	1,200	366,000	2,565,341	3,067	935,491	120	36,600	898,891	0	0	0	0	0		0
	1,727	15	9,611	77,172	1,200	9,150	68,022	3,067	46,775	120	915	45,860	0	69,395	0	0	69,395		0
	1,728	76	510	38,888	0	0	38,888	3,067	233,873	0	0	233,873	9,101	693,948	0	0	693,948		0
	1,730	92	510	46,665	0	0	46,665	3,067	280,647	0	0	280,647	9,101	832,737	0	0	832,737		0
	1,733	15	510	43,158	0	0	43,158	3,067	58,315	0	0	58,315	9,101	87,768	0	0	87,768		0
	1,734	229	5,150	1,178,083	0	0	1,178,083	4,581	1,047,833	0	0	1,047,833	2,410	551,210	0	0	551,210		0
	1,741	6	5,150	17,263	0	0	17,263	4,581	27,942	0	0	27,942	2,410	28,851	0	0	28,851		0
	1,741	146	510	74,664	0	0	74,664	4,581	651,979	0	0	651,979	7,050	997,163	0	0	997,163		0
	1,746	15	510	40,764	0	9,150	31,614	4,326	65,973	0	0	65,973	6,573	67,247	0	0	67,247		0
	1,747	137	4,836	663,754	1,200	164,700	499,054	4,326	593,761	0	0	593,761	2,247	308,346	0	0	308,346		0
	1,751	397	4,836	1,917,511	1,200	475,800	1,441,711	4,326	1,715,309	0	0	1,715,309	2,247	890,776	0	0	890,776		0
	1,764	15	4,836	40,764	1,200	9,150	31,614	4,326	202,166	0	8,540	193,626	2,247	21,661	0	0	21,661		0
	1,765	168	510	85,553	0	0	85,553	22,188	3,721,955	1,120	187,880	3,534,075	594	99,667	0	0	99,667		0
	1,770	9	510	4,666	0	0	4,666	22,188	203,016	1,120	10,248	192,768	594	5,436	0	0	5,436		0
	1,770	143	510	755,801	0	0	755,801	22,188	2,630,966	1,120	146,217	2,484,749	594	85,170	0	0	85,170		0
	1,775	6	10,035	44,450	0	0	44,450	14,519	88,568	920	5,612	82,956	594	20,386	0	0	20,386		0
	1,775	238	4,539	1,073,027	0	0	1,073,027	14,519	3,435,797	920	218,868	3,216,929	6,090	1,438,512	0	0	1,438,512		0
	1,783	397	4,482	2,535,416	0	227,988	2,307,428	14,365	3,623,786	920	192,303	3,431,484	6,003	1,190,186	0	0	1,190,186		0
	1,796	61	8,307	506,738	1,150	70,150	436,588	3,914	238,746	50	3,050	235,696	0	0	0	0	0		0
	1,798	61	8,307	595,500	1,150	102,175	493,325	3,914	187,387	50	1,525	185,862	0	72,572	0	0	72,572		0
	1,800	183	11,217	2,052,783	2,200	402,600	1,650,183	2,230	408,083	0	0	408,083	2,379	435,434	0	0	435,434		0
	1,806	183	11,217	1,919,407	2,200	314,760	1,604,647	2,230	322,326	0	0	322,326	2,379	496,058	0	0	496,058		0
	1,812	122	9,760	1,190,687	1,240	151,280	1,039,407	1,293	157,712	0	0	157,712	3,042	371,121	0	0	371,121		0
	1,816	214	9,760	1,874,138	1,240	132,370	1,741,768	1,293	900,915	0	0	900,915	3,042	690,997	0	0	690,997		0
	1,823	214	7,797	1,664,573	0	0	1,664,573	7,147	1,525,834	0	0	1,525,834	3,431	732,533	0	0	732,533		0
	1,830	15	7,797	129,417	0	10,218	119,199	7,147	69,745	0	0	69,745	3,431	38,299	0	0	38,299		0
	1,831	137	9,176	1,259,419	1,340	183,915	1,075,504	2,000	274,522	0	0	274,522	1,592	218,465	0	0	218,465		0
	1,835	183	9,176	1,622,587	1,340	224,175	1,398,412	2,000	422,669	0	0	422,669	1,592	356,017	0	0	356,017		0
	1,841	427	8,557	3,551,403	1,110	446,215	3,105,188	2,619	976,708	0	0	976,708	2,299	1,735,906	0	0	1,735,906		0
	1,855	214	8,077	1,724,464	980	209,230	1,515,234	1,956	417,516	0	0	417,516	5,832	1,245,033	0	0	1,245,033		0
	1,862	15	8,077	77,387	980	7,473	69,915	1,956	190,348	0	7,091	183,257	5,832	48,436	0	0	48,436		0
	1,863	46	2,072	94,795	0	0	94,795	23,008	1,052,622	930	42,548	1,010,074	521	23,821	0	0	23,821		0
	1,864	153	2,072	315,983	0	0	315,983	23,008	3,508,739	930	141,825	3,366,914	521	79,403	0	0	79,403		0
	1,869	61	2,072	527,641	0	36,600	491,041	23,008	1,297,096	930	28,365	1,268,731	521	15,881	0	0	15,881		0
	1,871	275	15,228	4,171,485	1,200	329,400	3,842,085	19,520	5,352,457	0	0	5,352,457	0	0	0	0	0		0
	1,880	244	15,166	3,700,417	1,200	292,800	3,407,617	19,478	4,752,692	0	0	4,752,692	0	0	0	0	0		0
	1,888	15	15,166	119,527	1,200	9,150	110,377	19,478	150,504	0	0	150,504	0	87,897	0	0	87,897		0
	1,889	107	510	54,443	0	0	54,443	260	643,035	0	81,130	561,905	11,527	615,280	0	0	615,280		0
	1,892	336	510	171,105	0	0	171,105	11,787	4,780,963	1,520	459,635	4,321,328	0	40,588	0	0	40,588		0
	1,903	244	510	777,758	0	103,700	674,058	16,713	3,171,555	1,220	179,340	2,992,215	242	67,392	0	0	67,392		0
	1,911	305	5,865	972,198	850	129,625	842,573	9,283	4,884,869	250	388,875	4,495,994	310	112,437	0	0	112,437		0
	1,921	244	510	266,466	0	0	266,466	22,749	6,007,509	2,300	402,600	5,604,909	427	52,076	0	0	52,076		0
	1,929	305	1,674	510,614	0	0	510,614	26,493	8,080,449	1,000	305,000	7,775,449	0	0	0	0	0		0
	1,939	15	1,674	16,654	0	0	16,654	26,493	204,299	1,000	7,625	196,674	0	208,600	0	0	208,600		0
	1,940	558	510	284,656	0	0	284,656	300	156,282	0	0	156,282	27,357	15,005,727	0	0	15,005,727		0
	1,958	6	510	89,381	0	0	89,381	260	21,982	0	4,087	17,895	26,412	80,557	0	0	80,557		0
	1,958	122	28,795	3,513,025	0	0	3,513,025	6,947	847,573	1,340	163,480	684,093	0	0	0	0	0		0
	1,962	15	28,795	439,128	0	0	439,128	6,947	105,947	1,340	20,435	85,512	0	0	0	0	0		0
	1,963	168	28,795	3,817,022	0	109,038	3,707,984	6,947	1,159,128	1,340	112,393	1,046,735	0	26,709	0	0	26,709		0
	1,968	15	16,713	254,876	1,300	19,825	235,051	6,872	104,804	0	0	104,804	318	4,856	0	0	4,856		0
	1,969	46	16,713	764,627	1,300	59,475	705,152	6,872	314,412	0	0	314,412	318	14,569	0	0	14,569		0
	1,970	183	16,713	3,607,044	1,300	235,155	3,371,889	6,872	678,234	0	0	678,234	318	29,138	0	0	29,138		0
	1,976	183	22,708	3,431,507	1,270	140,910	3,290,597	540	424,420	0	115,290	309,130	0	0	0	0	0		0
	1,982	92	14,795	1,353,717	270	24,705	1,329,012	4,098	375,010	1,260	115,290	259,720	0	0	0	0	0		0
	1,985	15	14,795	116,699	270	2,059	114,640	4,098	105,140	1,260	17,995	87,145	0	0	0	0	0		0
	1,986	15	510	7,778	0	0	7,778	9,690	147,778	1,100	16,775	131,003	0	0	0	0	0		0
	1,986	153	510	77,775	0	0	77,775	9,690	1,882,195	1,100	173,088	1,709,108	0	0	0	0	0		0

	1,991	519	510	1,646,238	0	329,248	1,316,990	14,994	4,225,372	1,170	303,323	4,022,049	0	635,163	0	0	525,163			0
53.00	2,008		9,980		1,270			2,470		0			2,488		0					
Sum. 3		9,882		67,371,172		5,804,951	61,566,221		82,691,016		4,038,597	78,652,420		32,748,247		23,333	32,724,915			0
53.00	2,008	1,000	5,840	4,405,000	1,270	635,000	3,770,000	1,690	2,690,000	0	0	2,690,000	2,450	2,295,000	0	0	2,295,000			0
54.00		1,000	2,970	6,290,000	0	0	6,290,000	3,690	3,810,000	0	0	3,810,000	2,140	1,930,000	0	0	1,930,000			0
55.00		1,000	9,610	11,020,000	0	35,000	10,985,000	3,930	3,980,000	0	0	3,980,000	1,720	1,505,000	0	0	1,505,000			0
56.00		1,000	12,430	11,715,000	70	35,000	11,680,000	4,030	3,930,000	0	0	3,930,000	1,290	1,245,000	0	0	1,245,000			0
57.00		3,000	11,000	28,275,000		0	28,275,000	3,830	17,070,000	0	0	17,070,000	1,200	3,120,000		0	3,120,000			0
60.00		1,000	7,850	10,620,000		0	10,620,000	7,550	5,035,000	0	0	5,035,000	880	1,270,000		0	1,270,000			0
61.00		1,000	13,390	9,125,000		0	9,125,000	2,520	2,625,000	0	0	2,625,000	1,660	1,730,000		0	1,730,000			0
62.00			4,860					2,730		0			1,800							
Sum. 4		9,000		81,450,000		705,000	80,745,000		39,140,000		0	39,140,000		13,095,000		0	13,095,000			0
62.00		10	4,350	43,500	3,820	38,200	5,300	2,730	27,300	2,700	27,000	300	900	9,000	900	9,000	0	900	9,000	
62.01		1,990	4,350	6,666,500	3,820	6,139,150	527,350	2,730	5,402,850	2,700	5,373,000	29,850	900	1,791,000	900	1,791,000	0	900	2,305,400	
64.00		3,000	2,350	3,525,000	2,350	3,525,000	0	2,700	7,665,000	2,700	7,665,000	0	900	2,610,000	900	2,610,000	0	2,020	4,290,000	
67.00		2,000	0	0		0	0	2,410	4,410,000	2,410	4,410,000	0	840	1,640,000	840	1,640,000	0	840	1,540,000	
69.00		10,500	0	0		0	0	2,000	10,500,000	2,000	10,500,000	0	800	4,200,000	800	4,200,000	0	800	4,200,000	
79.50			0					0		0			0		0					
Sum. 5		17,500		10,235,000		9,702,350	532,650		28,005,150		27,975,000	30,150		10,250,000		10,250,000	0		13,041,400	
L-13																				
Sum. 1		12,100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500	
Sum. 2		95,920		146,366,150		127,194,900	19,171,250		97,300,500		43,306,800	53,993,700		17,600,500		10,247,500	7,353,000		0	
Sum. 3		9,882		67,371,172		5,804,951	61,566,221		82,691,016		4,038,597	78,652,420		32,748,247		23,333	32,724,915		0	
Sum. 4		9,000		81,450,000		705,000	80,745,000		39,140,000		0	39,140,000		13,095,000		0	13,095,000		0	
Sum. 5		17,500		10,235,000		9,702,350	532,650		28,005,150		27,975,000	30,150		10,250,000		10,250,000	0		13,041,400	
Total		84,402		307,482,322		145,467,201	162,015,121		266,638,166		94,821,897	171,816,270		80,113,247		26,940,333	53,172,915		19,460,900	

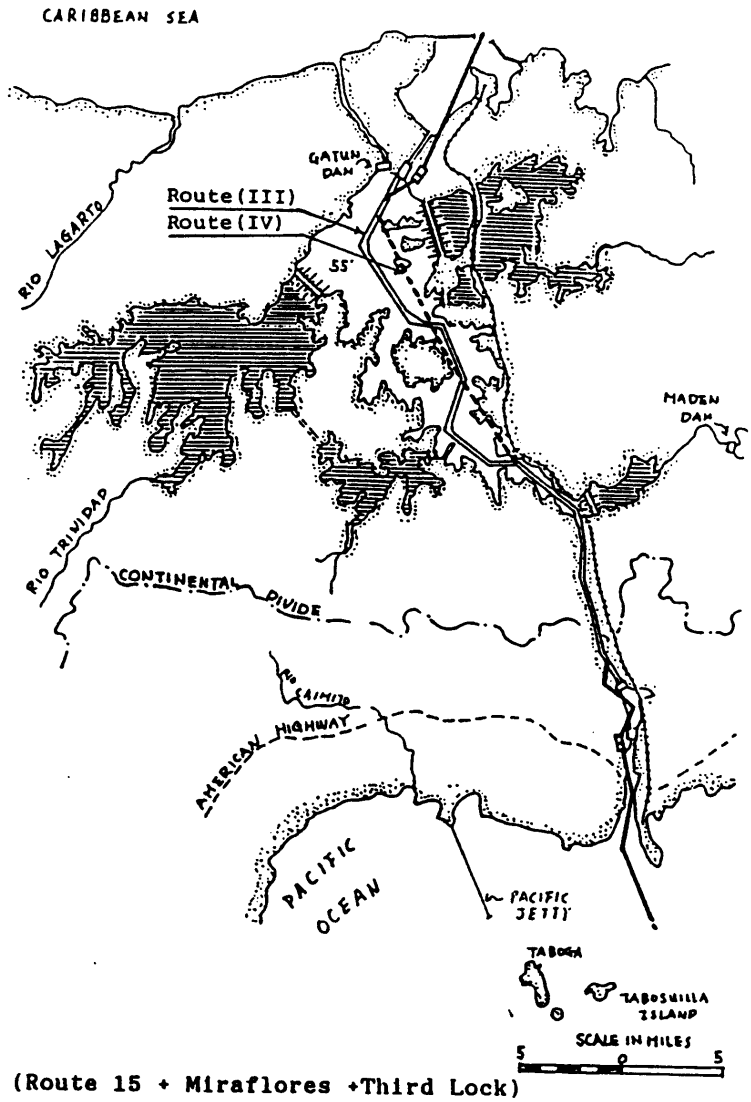
Total Excavation Vol.	673,697,636
DRY	387,004,306
WET	286,693,330

Calculation Table of Excavation Volume

Station No	Station (ft)	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Layer Volume Total Ao	Layer Volume Total V
11.50		8.500	0	9.222.500	0	9.222.500		0	10,710,000		10,710,000		0	4,080,000	0	4.080.000	0	0	[illegible]
-3.00		4.000	2.170	11.620.000	2.170	11.620.000	0	2.520	11,040,000	2.520	11,040,000	0	960	3,920,000	960	3.920.000	0	960	[illegible]
1.00		0	3.640		3.640			3.000		3.000			1,000		1,000			1.000	
Sum. 1		12.500		20.842.500		20.842.500	0		21,750,000		21,750,000	0		8,000,000		8,000,000	0		8,000 [illegible]
1.00		50	3.640	292.000	3.640	114.750	177.250	3,000	150,000	380	22.500	127,500	2,000	100,000	0	0	100.000	0	[illegible]
1.05		1,150	8.040	9.246.000	950	1,092.500	8.153.500	3.000	3,450,000	520	598.000	2,852,000	2,000	2,300,000	0	0	2.300.000	0	[illegible]
2.20		10	8.040	80.400	950	9.500	70.900	3.000	30,000	520	5.200	24,800	2.000	25,000	0	0	25.000	0	[illegible]
2.21		190	8.040	1.527.600	950	180.500	1,347.100	3.000	570,000	520	98,800	471,200	3,000	570.000	0	0	570.000	0	[illegible]
2.40		10	8.040	80.400	950	9.500	70.900	3.000	30.000	520	5,200	24,800	3,000	25,000	0	0	25,000	0	[illegible]
2.41		590	8.040	4.743.600	950	560.500	4,183.100	3.000	1,770,000	520	306.800	1,463,200	2,000	1,180.000	0	0	1.180.000	0	[illegible]
3.00		2.000	8.040	16.160.000	950	1,900.000	14,260.000	3.000	31,350.000	520	1,040,000	30,310,000	2,000	4.000.000	0	0	4.000.000		[illegible]
5.00		300	8.120	2.436.000	950	285.000	2,151.000	28.350	8.505.000	520	156.000	8,349,000	2,000	600.000	0	0	600.000		[illegible]
5.30		200	8.120	812.000	950	95.000	717.000	28,350	2,933.000	520	150.000	2,783,000	2,000	281,000	0	81.000	200.000		81,000
5.50		1.500	0	0	0	0	0	980	735,000	980	735,000	0	810	1,065.000	810	1,065.000	0	810	607,500
7.00		1.000	0	1.430.000	0	1.430.000	0	0	840.000	0	840.000	0	610	515,000	610	515.000	0		[illegible]
8.00		2.000	2.860	5.800.000	2.860	5.800.000	0	1,680	3,360,000	1,680	3,360,000	0	420	840,000	420	840.000	0		[illegible]
10.00		3.500	2.940	10.517.500	2.940	10.517.500	0	1,680	5,915.000	1,680	5,915.000	0	420	1,487,500	420	1.487.500	0		[illegible]
13.50		2.500	3.070	20.175.000	3.070	20.175.000	0	1,700	4,475.000	1,700	4,475,000	0	430	1,125.000	430	1,125.000	0		[illegible]
16.00		3.000	13.070	22.035.000	13,070	22.035,000	0	1,880	5,340.000	1,880	5,340,000	0	470	1,335.000	470	1.335.000	0		[illegible]
19.00		1.000	1.620	5.730.000	1.620	5,730.000	0	1,680	1,760.000	1.680	1,760,000	0	420	440.000	420	440.000	0		[illegible]
20.00		4.000	9.840	32.440.000	9.840	32.440.000	0	1,840	7,040.000	1,840	7,040,000	0	460	1,760.000	460	1.760.000	0		[illegible]
24.00		1.000	6.380	6.810.000	6.380	6.810.000	0	1.680	1,740,000	1,680	1,740,000	0	420	435.000	420	435.000	0		[illegible]
25.00		1.000	7.240	8.375.000	7.240	8.375.000	0	1.800	1,800,000	1,800	1,800,000	0	450	450,000	450	450.000	0		[illegible]
26.00		1.000	9.510	11,795.000	9.510	11.795.000	0	1.800	1,820.000	1,800	1,820,000	0	450	455.000	450	455.000	0		[illegible]
27.00		1.000	14.080	17.260.000	14.080	17.260.000	0	1.840	1,920.000	1,840	1,920,000	0	460	480,000	460	480.000	0		[illegible]
28.00		1.000	20.440	19,200.000	20.440	19,200.000	0	2.000	1,960.000	2.000	1,960,000	0	500	490.000	500	490.000	0		[illegible]
29.00		1.000	17.960	11.410.000	17.960	11.410.000	0	1,920	1,820,000	1,920	1,820,000	0	480	455.000	480	455.000	0		[illegible]
30.00		6.200	4.860	30,132.000	4.860	30,132,000	0	1.720	10,664.000	1,720	10,664,000	0	430	2,666,000	430	2,666.000	0		[illegible]
36.20		0	4.860	0	4.860	0	0	1,720	0	1,720	0	0	430	0	430	0	0		[illegible]
39.00		4.120	5.220	17,345.200	5,220	17,345.200	0	420	15,697.200	420	3,502,000	12,195,200	420	865,200	420	865.200	0		[illegible]
43.12	1,684	0	3.200		3,200			7,200		1,280			0		0				
Sum. 2		39.320		255,832,700		224.701,950	31,130,750		115,674,200		57,073,500	58,600,700		23,944,700		14,944.700	9.000.000		688,320
43.12	1,684	180	4.135	1,523,298	0	0	1,523,298	15,947	1,682,930	1,280	115,168	1,567,762	0	288,234	0	0	288.234		0
	1,690	3	12.795	20.428	0	0	20.428	2,757	4.266	0	0	4,266	3,203	16,677	0	0	16.677		0
	1,690	61	600	36,600	0	0	36,600	40	2,440	0	0	2,440	7,733	471,686	0	0	471,686		0
	1,692	27	600	16.470	0	0	16.470	40	1,098	0	0	1,098	7,733	212.259	0	0	212,259		0
	1,693	3	600	20.428	0	0	20.428	40	4,266	0	0	4,266	7,733	16,677	0	0	16,677		0
	1,693	214	12.795	2,066.730	0	103.014	1,963.716	2,757	411,832	0	4,484	407,348	3,203	417,442	0	6.405	411.037		0
	1,700	275	6,565	1,802.124	965	264.893	1,537,232	1,100	302,078	42	11,529	290,549	707	194.065	60	16,470	177,595		0
	1,709	15	6,565	54,634	965	7,358	47,276	1,100	8,696	42	320	8,376	707	64,351	60	458	63,894		0
	1,710	15	600	9,150	0	0	9,150	40	610	0	0	610	7,733	117,922	0	0	117,922		0
	1,710	15	600	102,140	0	0	102,140	40	21,330	0	0	21,330	7,733	83,387	0	0	83,387		0
	1,711	46	12.795	585,387	0	0	585,387	2,757	126,153	0	0	126,153	3,203	146,560	0	0	146,560		0
	1,712	153	12.795	1,987.056	0	91,500	1,895,556	2,757	530,261	0	9,150	521,111	3,203	244,266	0	0	244,266		0
	1,717	305	13.264	4,045,641	1,200	366,000	3,679,641	4,197	1,280,025	120	36,600	1,243,425	0	0	0	0	0		0
	1,727	15	13.264	105,716	1,200	9,150	96,566	4,197	64,001	120	915	63,086	0	96,566	0	0	96,566		0
	1,728	76	600	45,750	0	0	45,750	4,197	320,006	0	0	320,006	12,664	965,660	0	0	965,660		0
	1,730	92	600	54,900	0	0	54,900	4,197	384,008	0	0	384,008	12,664	1,158,792	0	0	1,158,792		0
	1,733	15	600	58,384	0	0	58,384	4,197	80,060	0	0	80,060	12,664	122,134	0	0	122,134		0
	1,734	229	7,057	1,614,266	0	0	1,614,266	6,303	1,441,792	0	0	1,441,792	3,353	767,034	0	0	767,034		0
	1,741	6	7,057	23,354	0	0	23,354	6,303	38,448	0	0	38,448	3,353	40,148	0	0	40,148		0
	1,741	146	600	87,840	0	0	87,840	6,303	885,965	0	0	885,965	9,810	1,363,672	0	0	1,363,672		0
	1,746	15	600	53,412	0	9,150	44,262	5,800	88,456	0	0	88,456	8,819	90,233	0	0	90,233		0
	1,747	137	6,405	879,061	1,200	164,700	714,361	5,800	796,108	0	0	796,108	3,015	413,743	0	0	413,743		0
	1,751	397	6,405	2,539,511	1,200	475,800	2,063,711	5,800	2,299,869	0	0	2,299,869	3,015	1,195,257	0	0	1,195,257		0
	1,764	15	6,405	53,412	1,200	9,150	44,262	5,800	271,202	0	8,540	262,662	3,015	29,065	0	0	29,065		0
	1,765	168	600	100,650	0	0	100,650	29,767	4,993,431	1,120	187,880	4,805,551	797	133,735	0	0	133,735		0
	1,770	9	600	5,490	0	0	5,490	29,767	272,369	1,120	10,248	262,121	797	7,295	0	0	7,295		0
	1,770	143	600	1,002,057	0	0	1,002,057	29,767	3,529,634	1,120	146,217	3,383,417	797	114,283	0	0	114,283		0
	1,775	6	13.381	59,130	0	0	59,130	19,478	118,815	920	5,612	113,203	797	27,355	0	0	27,355		0
	1,775	238	6,006	1,401,457	0	0	1,401,457	19,478	4,539,430	920	218,868	4,320,562	8,172	1,902,577	0	0	1,902,577		0
	1,783	397	5,776	3,278,318	0	227,988	3,050,330	18,685	4,708,490	920	192,303	4,516,187	7,823	1,550,944	0	0	1,550,944		0
	1,796	61	10,761	656,396	1,150	70,150	586,246	5,066	309,004	50	3,050	305,954	0	0	0	0	0		0
	1,798	61	10,761	772,062	1,150	102,175	669,887	5,066	242,077	50	1,525	240,552	0	94,570	0	0	94,570		0
	1,800	183	14,553	2,663,183	2,200	402,600	2,260,583	2,871	525,453	0	0	525,453	3,101	567,419	0	0	567,419		0
	1,806	183	14,553	2,492,266	2,200	314,760	2,177,506	2,871	409,207	0	0	409,207	3,101	647,367	0	0	647,367		0
	1,812	122	12,685	1,547,566	1,240	151,280	1,396,286	1,601	195,308	0	0	195,308	3,974	484,877	0	0	484,877		0
	1,816	214	12,685	2,434,439	1,240	132,370	2,302,069	1,601	1,158,258	0	0	1,158,258	3,974	902,802	0	0	902,802		0
	1,823	214	10,120	2,160,638	0	0	2,160,638	9,249	1,974,726	0	0	1,974,726	4,483	957,069	0	0	957,069		0
	1,830	15	10,120	168,074	0	10,218	157,857	9,249	89,780	0	0	89,780	4,483	50,038	0	0	50,038		0
	1,831	137	11,922	1,636,354	1,340	183,915	1,452,439	2,525	346,579	0	0	346,579	2,080	285,429	0	0	285,429		0
	1,835	183	11,922	2,107,805	1,340	224,175	1,883,630	2,525	536,105	0	0	536,105	2,080	465,144	0	0	465,144		0
	1,841	427	11,114	4,563,085	1,110	446,215	4,116,870	3,334	1,240,285	0	0	1,240,285	3,004	2,230,563	0	0	2,230,563		0
	1,855	214	10,259	2,190,313	980	209,230	1,981,083	2,475	528,495	0	0	528,495	7,444	1,589,228	0	0	1,589,228		0
	1,862	15	10,259	98,004	980	7,473	90,531	2,475	242,653	0	7,091	235,562	7,444	61,826	0	0	61,826		0
	1,863	46	2,594	118,668	0	0	118,668	29,348	1,342,671	930	42,548	1,300,124	665	30,406	0	0	30,406		0
	1,864	153	2,594	395,562	0	0	395,562	29,348	4,475,570	930	141,825	4,333,745	665	101,354	0	0	101,354		0
	1,869	61	2,594	670,399	0	36,600	633,799	29,348	1,654,414	930	28,365	1,626,049	665	20,271	0	0	20,271		0
	1,871	275	19,386	5,237,896	1,200	329,400	4,908,496	24,895	6,726,702	0	0	6,726,702	0	0	0	0	0		0
	1,880	244	18,777	4,581,519	1,200	292,800	4,288,719	24,116	5,884,183	0	0	5,884,183	0	0	0	0	0		0
	1,888	15	18,777	147,747	1,200	9,150	138,597	24,116	186,016	0	0	186,016	0	109,015	0	0	109,015		0
	1,889	107	600	64,050	0	0	64,050	280	792,993	0	81,130	711,863	14,297	763,103	0	0	763,103		0
	1,892	336	600	201,300	0	0	201,300	14,577	5,915,360	1,520	459,635	5,455,725	0	50,340	0	0	50,340		0
	1,903	244	600	1,096,492	0	103,700	992,792	20,686	4,150,439	1,220	179,340	3,971,099	300	91,688	0	0	91,688		0
	1,911	305	8,388	1,370,616	850	129,625	1,240,991	13,334	7,053,137	250	388,875	6,664,262	451	163,512	0	0	163,512		0
	1,921	244	600	352,942	0	0	352,942	12,916	8,695,886	2,300	402,600	8,293,286	621	75,732	0	0	75,732		0
	1,929	305	2,293	699,355	0	0	699,355	18,362	11,700,328	1,000	305,000	11,395,328	0	0	0	0	0		0
	1,939	15	2,293	22,059	0	0	22,059	18,362	294,567	1,000	7,625	286,942	0	303,358	0	0	303,358		0
	1,940	558	600	334,890	0	0	334,890	270	156,282	0	0	156,282	19,785	21,029,801	0	0	21,029,801		0
	1,958	6	600	119,845	0	0	119,845	290	29,238	0	4,087	25,151	15,571	108,491	0	0	108,491		0
	1,958	122	18,693	4,720,597	0	0	4,720,597	9,296	1,134,136	1,340	163,480	970,656	0	0	0	0	0		0

	1.962	15	08.693	590.075	0	0	590.075	9.296	141.767	1.340	20.435	121.332	0		0	0	0		0
	1.963	168	08.693	5.126.033	0	109.038	5.016.996	9.296	1.550.973	1.340	112.393	438.580	0	35.[illegible]	0	0	35.971		0
	1.968	15	22.422	341.931	1.300	19.825	322.106	9.195	140.228	0	0	140.228	429	6.3[illegible]	0	0	6.540		0
	1.969	46	22.422	1.025.794	1.300	59.475	966.319	9.195	420.684	0	0	420.684	429	19.62[illegible]	0	0	19.621		0
	1.970	183	22.422	4.586.436	1.300	235.155	4.351.281	9.195	890.778	0	0	890.778	429	39.241	0	0	39.241		0
	1.976	183	27.703	4.185.622	1.270	140.910	4.044.712	540	496.369	0	115.290	381.079	0	0	0	0	0		0
	1.982	92	18.041	1.650.775	270	24.705	1.626.070	4.885	448.959	1.260	115.290	331.669	0	0	0	0	0		0
	1.985	15	18.041	142.140	270	2.059	140.081	4.885	126.553	1.260	17.995	108.558	0	0	0	0	0		0
	1.986	15	600	9.150	0	0	9.150	11.712	178.613	1.100	16.775	161.838	0	0	0	0	0		0
	1.986	153	600	91.500	0	0	91.500	11.712	2.279.912	1.100	173.088	2.106.824	0	0	0	0	0		0
	1.991	519	600	1.669.570	0	329.248	1.340.323	18.188	5.153.410	1.170	303.323	4.850.087	0	635.163	0	0	635.163		0
53.00	2.008		12.658		1.270			3.077		0			3.167		0				
Subt. 3		9.882		86.675.938		5.804.951	80.870.988		109.024.168		4.038.597	104.985.571		44.171.959		23.333	44.148.627		0
53.00	2.008	1.000	5.840	5.270.000	1.270	635.000	4.635.000	1.690	3.010.000	0	0	3.010.000	2.450	2.510.000	0	0	2.510.000		0
54.00		1.000	4.700	8.435.000	0	0	8.435.000	4.330	4.530.000	0	0	4.530.000	2.570	2.225.000	0	0	2.225.000		0
55.00		1.000	12.170	13.710.000	0	35.000	13.675.000	4.730	4.730.000	0	0	4.730.000	1.880	1.690.000	0	0	1.690.000		0
56.00		1.000	15.250	14.055.000	70	35.000	14.020.000	4.730	4.630.000	0	0	4.630.000	1.500	1.425.000	0	0	1.425.000		0
57.00		3.000	12.860	35.580.000		0	35.580.000	4.530	19.695.000	0	0	19.695.000	1.350	3.525.000		0	3.525.000		0
60.00		1.000	10.860	14.300.000		0	14.300.000	8.600	5.725.000	0	0	5.725.000	1.000	1.450.000		0	1.450.000		0
61.00		1.000	17.740	12.400.000		0	12.400.000	2.850	3.040.000	0	0	3.040.000	1.900	2.010.000		0	2.010.000		0
62.00			7.060					3.230		0			2.120						
Subt. 4		9.000		103.750.000		705.000	103.045.000		45.360.000		0	45.360.000		14.835.000		0	14.835.000		0
62.00		10	7.140	71.400	6.430	64.300	7.100	3.180	31.800	3.180	31.800	0	1.040	10.400	1.040	10.400	0	1.040	10.400
62.01		1.990	7.140	12.079.300	6.430	11.372.850	706.450	3.180	6.268.500	3.180	6.268.500	0	1.040	2.069.600	1.040	2.069.600	0	1.040	3.492.450
64.00		3.000	5.000	9.960.000	5.000	9.960.000	0	3.120	9.180.000	3.120	9.180.000	0	1.040	3.060.000	1.040	3.060.000	0	2.470	5.205.000
67.00		2.000	1.640	3.350.000	1.640	3.350.000	0	3.000	5.700.000	3.000	5.700.000	0	1.000	1.940.000	1.000	1.940.000	0	1.000	1.940.000
69.00		14.900	1.710	12.739.500	1.710	12.739.500	0	2.700	20.115.000	2.700	20.115.000	0	940	7.003.000	940	7.003.000	0	940	7.003.000
83.90			0					0		0			0		0				
Subt. 5		21.900		38.200.200		37.486.650	713.550		41.295.300		41.295.300	0		14.083.000		14.083.000	0		17.650.850
L-16																			
Subt. 1		12.500		20.842.500		20.842.500	0		21.750.000		21.750.000	0		8.000.000		8.000.000	0		8.000.000
Subt. 2		99.320		255.832.700		224.701.950	31.130.750		315.674.200		57.073.500	58.600.700		23.944.700		14.944.700	9.000.000		688.500
Subt. 3		9.882		86.675.938		5.804.951	80.870.988		109.024.168		4.038.597	104.985.571		44.171.959		23.333	44.148.627		0
Subt. 4		9.000		103.750.000		705.000	103.045.000		45.360.000		0	45.360.000		14.835.000		0	14.835.000		0
Subt. 5		21.900		38.200.200		37.486.650	713.550		41.295.300		41.295.300	0		14.083.000		14.083.000	0		17.650.850
Total		82.602		505.301.338		289.541.051	215.760.288		533.103.668		324.157.397	208.946.271		105.034.659		37.051.033	67.983.627		26.339.350

Total Excavation Vol.	969.779.016
DRY	492.690.186
WET	477.088.830



Route III (Route 15 + Miraflores +Third Lock)
Route IV (Route 15 + Gatun + Miraflores + Third Lock)

Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size (m)
L-3	III	55'	1	2	100	301 x 18.7
6	III	55'	1	2	150	301 x 20.9
9	III	55'	1	2	250	399 x 24.2
11	IV	55'	1	2	100	301 x 18.7
14	IV	55'	1	2	150	343 x 20.9
17	IV	55'	1	2	250	399 x 24.2

Layout of Low Rise Lock System
for Group B Study Cases (55')

L-3

Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
-10.80	7.800	0	0	0	0		0	6,357,000		6,357,000		0	2,652,000	0	2,652,000	0	0	2,652,000
-3.00	4.000	0	940,000	0	940,000	0	1,630	6,260,000	1,630	4,020,000	2,240,000	680	2,840,000	680	2,840,000	0	680	2,880,000
1.00	0	470	0	470	0	0	1,500	0	380	0	0	740	0	740	0	0	760	0
Sum. 1	11.800		940,000		940,000	0		12,617,000		10,377,000	2,240,000		5,492,000		5,492,000	0		5,532,000
1.00	50	470	93,750	470	35,500	58,250	1,500	120,750	380	22,500	98,250	1,500	69,500	0	0	69,500	0	0
1.05	1,150	3,280	3,772,000	950	1,092,500	2,679,500	3,330	3,829,500	520	598,000	3,231,500	1,280	1,472,000	0	0	1,472,000	0	0
2.20	10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	1,280	17,800	0	0	17,800	0	0
2.21	190	3,280	623,200	950	180,500	442,700	3,330	632,700	520	98,800	533,900	2,280	433,200	0	0	433,200	0	0
2.40	10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	2,280	17,800	0	0	17,800	0	0
2.41	590	3,280	1,935,200	950	560,500	1,374,700	3,330	1,964,700	520	304,800	1,657,900	1,280	755,200	0	0	755,200	0	0
3.00	2,000	3,280	18,660,000	950	1,020,000	17,640,000	3,330	6,930,000	520	520,000	6,410,000	1,280	3,800,000	0	0	3,800,000	0	0
5.00	500	15,380	3,845,000	70	17,500	3,827,500	3,600	1,275,000	0	375,000	900,000	2,520	782,500	0	152,500	630,000	0	155,000
5.50	1,500	0	0	0	0	0	1,500	1,792,500	1,500	1,792,500	0	610	915,000	610	915,000	0	620	930,000
7.00	3,000	0	0	0	0	0	890	3,705,000	890	3,705,000	0	610	1,830,000	610	1,830,000	0	620	1,860,000
10.00	6,000	0	5,730,000	0	5,730,000	0	1,580	10,320,000	1,580	10,320,000	0	610	3,720,000	610	3,720,000	0	620	3,780,000
16.00	4,000	1,910	5,600,000	1,910	5,600,000	0	1,860	6,760,000	1,860	6,760,000	0	630	2,480,000	630	2,480,000	0	640	2,520,000
20.00	5,000	890	5,025,000	890	5,025,000	0	1,520	8,425,000	1,520	8,425,000	0	610	3,075,000	610	3,075,000	0	620	3,125,000
25.00	5,000	1,120	3,300,000	1,120	3,300,000	0	1,850	9,075,000	1,850	9,075,000	0	620	3,100,000	620	3,100,000	0	630	3,150,000
30.00	6,000	200	4,140,000	200	4,140,000	0	1,780	10,920,000	1,780	10,920,000	0	620	3,720,000	620	3,720,000	0	630	3,780,000
36.00	3,000	1,180	8,325,000	1,180	8,325,000	0	1,860	2,865,000	1,860	2,865,000	0	620	975,000	620	930,000	45,000	630	945,000
39.00	4,000	4,370	29,660,000	4,370	13,500,000	16,160,000	50	3,520,000	50	460,000	3,060,000	30	2,340,000	0	120,000	2,220,000	0	0
43.00	0	10,460	0	2,380	0	0	1,710	0	180	0	0	1,140	0	60	0	0	0	0
Sum. 2	42,000		90,774,750		48,545,500	42,229,250		72,201,750		56,254,000	15,947,750		29,503,000		20,042,500	9,460,500		20,245,000
43.00	1,000	10,460	9,065,000	2,380	2,125,000	6,940,000	1,710	1,750,000	180	145,000	1,605,000	1,140	1,140,000	60	30,000	1,110,000	0	0
44.00	1,000	7,670	8,930,000	-1,870	1,910,000	7,020,000	1,790	1,850,000	110	140,000	1,710,000	1,140	1,190,000	0	20,000	1,170,000	0	0
45.00	1,000	10,190	13,565,000	1,950	1,965,000	11,600,000	1,910	2,215,000	170	85,000	2,130,000	1,240	1,550,000	40	20,000	1,530,000	0	0
46.00	1,000	16,940	15,865,000	1,980	1,940,000	13,925,000	2,520	2,235,000	0	0	2,235,000	1,860	1,600,000	0	0	1,600,000	0	0
47.00	1,000	14,790	15,375,000	1,900	1,940,000	13,435,000	1,950	1,980,000	0	0	1,980,000	1,340	1,380,000	0	0	1,380,000	0	0
48.00	1,000	15,960	17,910,000	1,980	2,115,000	15,795,000	2,010	2,145,000	0	0	2,145,000	1,420	1,530,000	0	0	1,530,000	0	0
49.00	1,000	19,860	15,420,000	2,250	2,550,000	12,870,000	2,280	2,090,000	0	95,000	1,995,000	1,640	1,440,000	0	35,000	1,405,000	0	0
50.00	1,000	10,980	14,125,000	2,850	3,045,000	11,080,000	1,900	2,300,000	190	185,000	2,115,000	1,240	1,520,000	70	65,000	1,455,000	0	0
51.00	1,000	17,270	20,605,000	3,240	2,760,000	17,845,000	2,700	2,390,000	180	90,000	2,300,000	1,800	1,620,000	60	30,000	1,590,000	0	0
52.00	1,000	23,940	24,550,000	2,280	2,070,000	22,480,000	2,080	2,285,000	0	0	2,285,000	1,440	1,540,000	0	0	1,540,000	0	0
53.00	0	25,160	0	1,860	0	0	2,490	0	0	0	0	1,640	0	0	0	0	0	0
Sum. 3	10,000		155,410,000		22,420,000	132,990,000		21,240,000		740,000	20,500,000		14,510,000		200,000	14,310,000		0
53.00	1,000	25,160	23,500,000	1,860	930,000	22,570,000	2,490	2,760,000	0	0	2,760,000	1,640	1,860,000	0	0	1,860,000	0	0
54.00	1,000	21,840	15,005,000	0	0	15,005,000	3,030	2,685,000	0	0	2,685,000	2,080	1,830,000	0	0	1,830,000	0	0
55.00	500	8,170	3,995,000	0	0	3,995,000	2,340	1,157,500	0	0	1,157,500	1,580	790,000	0	0	790,000	0	0
55.50	500	7,810	3,090,000	0	0	3,090,000	2,290	1,110,000	0	0	1,110,000	1,580	760,000	0	0	760,000	0	0
56.00	1,000	4,550	7,030,000	0	365,000	6,665,000	2,150	2,390,000	0	245,000	2,145,000	1,460	1,660,000	0	160,000	1,500,000	0	0
57.00	1,000	9,510	6,450,000	730	1,015,000	5,435,000	2,630	2,180,000	490	630,000	1,550,000	1,860	1,340,000	320	200,000	1,140,000	0	0
58.00	1,000	3,390	5,270,000	1,300	1,190,000	4,080,000	1,730	1,750,000	770	470,000	1,280,000	820	970,000	80	50,000	920,000	0	0
59.00	1,000	7,150	8,690,000	1,080	2,690,000	6,000,000	1,770	1,810,000	170	290,000	1,520,000	1,120	1,085,000	20	35,000	1,050,000	0	0
60.00	1,000	10,230	11,095,000	4,300	2,815,000	8,280,000	1,850	1,750,000	410	205,000	1,545,000	1,050	1,075,000	50	25,000	1,050,000	0	0
61.00	1,000	11,960	7,665,000	1,330	1,430,000	6,235,000	1,650	1,930,000	0	535,000	1,395,000	1,100	1,025,000	0	35,000	990,000	0	0
62.00	0	3,370	0	1,530	0	0	2,210	0	1,070	0	0	950	0	70	0	0	0	0
Sum. 4	9,000		91,790,000		10,435,000	81,355,000		19,522,500		2,375,000	17,147,500		12,395,000		505,000	11,890,000	0	0
62.00	2,000	3,370	7,740,000	1,530	3,830,000	3,910,000	2,210	3,010,000	1,070	1,070,000	1,940,000	950	1,940,000	70	70,000	1,870,000	0	0
64.00	3,000	4,370	6,765,000	2,300	3,660,000	3,105,000	800	3,075,000	0	1,875,000	1,200,000	990	2,460,000	0	975,000	1,485,000	0	1,020,000
67.00	6,000	140	420,000	140	420,000	0	1,250	5,370,000	1,250	5,370,000	0	650	3,900,000	650	3,900,000	0	680	4,020,000
73.00	3,300	0	0	0	0	0	540	891,000	540	891,000	0	650	1,072,500	650	1,072,500	0	660	1,089,000
76.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	14,300		14,925,000		7,910,000	7,015,000		12,346,000		9,206,000	3,140,000		9,372,500		6,017,500	3,355,000		6,129,000
L-3																		
Sum. 1	11.800		940,000		940,000	0		12,617,000		10,377,000	2,240,000		5,492,000		5,492,000	0		5,532,000
Sum. 2	42,000		90,774,750		48,545,500	42,229,250		72,201,750		56,254,000	15,947,750		29,503,000		20,042,500	9,460,500		20,245,000
Sum. 3	10,000		155,410,000		22,420,000	132,990,000		21,240,000		740,000	20,500,000		14,510,000		200,000	14,310,000		0
Sum. 4	9,000		91,790,000		10,435,000	81,355,000		19,522,500		2,375,000	17,147,500		12,395,000		505,000	11,890,000		0
Sum. 5	14,300		14,925,000		7,910,000	7,015,000		12,346,000		9,206,000	3,140,000		9,372,500		6,017,500	3,355,000		6,129,000
Total	87,100		353,839,750		90,250,500	263,589,250		137,927,250		78,952,000	58,975,250		71,272,500		32,257,000	39,015,500		31,906,000

Total Excavation Vol.	594,945,500
DRY	361,580,000
WET	233,365,500

L-6 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Drayey Material Total Ao	Drayey Material Total Vo
-11.10	8.100	0	0	0	0		0	9,841,500		9,841,500		0	3,199,500	0	3,199,500	0	0	3,199,500
-3.00	4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	3,220,000
1.00	0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820	0
Sum. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
1.00	50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	0
1.05	1,150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	0
2.20	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	0
2.21	190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	0
2.40	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	0
2.41	590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	0
3.00	2,000	5,300	23,380,000	950	1,000,000	22,380,000	2,520	6,300,000	520	520,000	5,780,000	1,760	4,400,000	0	0	4,400,000	0	0
5.00	500	18,080	4,620,000	50	112,500	4,507,500	3,780	1,465,000	0	520,000	945,000	2,640	835,000	0	175,000	660,000	0	177,500
5.50	1,500	400	300,000	400	300,000	0	2,080	2,857,500	2,080	2,857,500	0	700	1,050,000	700	1,050,000	0	710	1,065,000
7.00	3,000	0	930,000	0	930,000	0	1,730	5,715,000	1,730	5,715,000	0	700	2,100,000	700	2,100,000	0	710	2,130,000
10.00	6,000	620	10,710,000	620	10,710,000	0	2,080	12,540,000	2,080	12,540,000	0	700	4,260,000	700	4,260,000	0	710	4,320,000
16.00	4,000	2,950	8,980,000	2,950	8,980,000	0	2,100	8,200,000	2,100	8,200,000	0	720	2,840,000	720	2,840,000	0	730	2,880,000
20.00	5,000	1,540	9,100,000	1,540	9,100,000	0	2,000	10,325,000	2,000	10,325,000	0	700	3,525,000	700	3,525,000	0	710	3,575,000
25.00	5,000	2,100	7,950,000	2,100	7,950,000	0	2,130	10,650,000	2,130	10,650,000	0	710	3,550,000	710	3,550,000	0	720	3,600,000
30.00	6,000	1,080	9,900,000	1,080	9,900,000	0	2,130	12,780,000	2,130	12,780,000	0	710	4,290,000	710	4,290,000	0	720	4,350,000
36.00	3,000	2,220	12,885,000	2,220	12,735,000	150,000	2,130	3,720,000	2,130	3,360,000	360,000	720	1,380,000	720	1,080,000	300,000	730	1,095,000
39.00	4,000	6,370	38,000,000	6,270	17,900,000	20,100,000	350	6,520,000	110	620,000	5,900,000	200	2,960,000	0	200,000	2,760,000	0	0
43.00	0	12,630	0	2,680	0	0	2,910	0	200	0	0	1,280	0	100	0	0	0	0
Sum. 2	42.000		137,248,250		81,505,500	55,742,750		86,109,500		69,124,000	16,985,500		34,907,000		23,070,000	11,837,000		23,192,500
43.00	1,000	12,630	11,260,000	2,680	2,405,000	8,855,000	2,910	2,495,000	200	155,000	2,340,000	1,280	1,300,000	100	50,000	1,250,000	0	0
44.00	1,000	9,890	11,490,000	2,130	2,205,000	9,285,000	2,080	2,135,000	110	140,000	1,995,000	1,320	1,380,000	0	20,000	1,360,000	0	0
45.00	1,000	13,090	16,950,000	2,280	2,280,000	14,670,000	2,190	2,355,000	170	85,080	2,270,000	1,440	1,740,000	40	20,000	1,720,000	0	0
46.00	1,000	20,810	19,525,000	2,280	2,230,000	17,295,000	2,520	2,375,000	0	0	2,375,000	2,040	1,780,000	0	0	1,780,000	0	0
47.00	1,000	18,240	18,790,000	2,180	2,205,000	16,585,000	2,230	2,255,000	0	0	2,255,000	1,520	1,560,000	0	0	1,560,000	0	0
48.00	1,000	19,340	21,755,000	2,230	2,400,000	19,355,000	2,280	2,340,000	0	0	2,340,000	1,600	1,620,000	0	0	1,620,000	0	0
49.00	1,000	24,170	19,425,000	2,570	2,895,000	16,530,000	2,400	2,285,000	0	95,000	2,190,000	1,640	1,535,000	0	35,000	1,500,000	0	0
50.00	1,000	14,680	18,470,000	3,220	3,510,000	14,960,000	2,170	2,570,000	190	185,000	2,385,000	1,430	1,690,000	70	65,000	1,625,000	0	0
51.00	1,000	22,260	25,380,000	3,800	3,195,000	22,185,000	2,970	2,665,000	180	90,000	2,575,000	1,950	1,745,000	60	30,000	1,715,000	0	0
52.00	1,000	28,500	28,450,000	2,590	2,330,000	26,120,000	2,360	2,545,000	0	0	2,545,000	1,540	1,680,000	0	0	1,680,000	0	0
53.00	0	28,400	0	2,070	0	0	2,730	0	0	0	0	1,820	0	0	0	0	0	0
Sum. 3	10,000		191,495,000		25,655,000	165,840,000		24,020,000		750,000	23,270,000		16,030,000		220,000	15,810,000		0
53.00	1,000	28,400	27,365,000	2,070	1,035,000	26,330,000	2,730	2,960,000	0	0	2,960,000	1,820	1,985,000	0	0	1,985,000	0	0
54.00	1,000	26,330	18,280,000	0	0	18,280,000	3,190	2,885,000	0	0	2,885,000	2,150	1,960,000	0	0	1,960,000	0	0
55.00	500	10,230	4,995,000	0	0	4,995,000	2,580	1,305,000	0	0	1,305,000	1,770	885,000	0	0	885,000	0	0
55.50	500	9,750	4,072,500	0	0	4,072,500	2,640	1,267,500	0	0	1,267,500	1,770	857,500	0	0	857,500	0	0
56.00	1,000	6,540	10,275,000	0	470,000	9,805,000	2,430	2,670,000	0	245,000	2,425,000	1,680	1,810,000	0	0	1,810,000	0	0
57.00	1,000	14,010	9,480,000	940	1,320,000	8,160,000	2,910	2,515,000	490	630,000	1,885,000	1,980	1,490,000	320	200,000	1,290,000	0	0
58.00	1,000	4,950	7,480,000	1,700	1,530,000	5,950,000	2,120	2,060,000	770	470,000	1,590,000	1,020	1,160,000	80	50,000	1,110,000	0	0
59.00	1,000	10,010	11,200,000	1,360	2,975,000	8,225,000	2,000	2,075,000	170	290,000	1,785,000	1,300	1,260,000	20	35,000	1,225,000	0	0
60.00	1,000	12,390	13,310,000	4,590	3,095,000	10,215,000	2,150	2,050,000	410	205,000	1,845,000	1,220	1,255,000	50	25,000	1,230,000	0	0
61.00	1,000	14,230	9,725,000	1,600	1,815,000	7,910,000	1,950	2,280,000	0	535,000	1,725,000	1,290	1,240,000	0	35,000	1,205,000	0	0
62.00	0	5,220	0	2,030	0	0	2,570	0	1,070	0	0	1,190	0	70	0	0	0	0
Sum. 4	9,000		116,182,500		12,240,000	103,942,500		22,047,500		2,375,000	19,672,500		13,902,500		345,000	13,557,500	0	0
62.00	2,000	5,220	11,430,000	2,030	4,830,000	6,600,000	2,570	3,870,000	1,070	1,070,000	2,800,000	1,190	2,240,000	70	70,000	2,170,000	0	0
64.00	3,000	6,210	10,485,000	2,800	5,370,000	5,115,000	1,300	4,560,000	0	2,610,000	1,950,000	1,050	2,700,000	0	1,125,000	1,575,000	0	1,170,000
67.00	6,000	780	2,910,000	780	2,910,000	0	1,740	9,960,000	1,740	9,960,000	0	750	4,530,000	750	4,530,000	0	780	4,650,000
73.00	6,500	190	617,500	190	617,500	0	1,580	5,135,000	1,580	5,135,000	0	760	2,470,000	760	2,470,000	0	770	2,502,500
79.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	17,500		25,442,500		13,727,500	11,715,000		23,525,000		18,775,000	4,750,000		11,940,000		8,195,000	3,745,000		8,322,500
L-6																		
Sum. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
Sum. 2	42.000		137,248,250		81,505,500	55,742,750		86,109,500		69,124,000	16,985,500		34,907,000		23,070,000	11,837,000		23,192,500
Sum. 3	10.000		191,495,000		25,655,000	165,840,000		24,020,000		750,000	23,270,000		16,030,000		220,000	15,810,000		0
Sum. 4	9.000		116,182,500		12,240,000	103,942,500		22,047,500		2,375,000	19,672,500		13,902,500		345,000	13,557,500		0
Sum. 5	17,500		25,442,500		13,727,500	11,715,000		23,525,000		18,775,000	4,750,000		11,940,000		8,195,000	3,745,000		8,322,500
Total	90,600		672,428,250		135,188,000	337,240,250		175,203,500		110,525,500	64,678,000		83,199,000		38,249,500	44,949,500		37,934,500

Total Excavation Vol.	768,765,250
Dry	446,867,750
Wet	321,897,500

L-9 Calculation Table of Excavation Volume

Station	Dis.	Rock					Weathered Rock					Earth					Clayey Material	
		Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
No.	(m)	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	V2	Ao	Vo
-11.50	8,500	0	0	0	0		0	10,327,500		10,327,500		0	3,357,500	0	3,357,500	0	0	3,357,500
-3.00	4,000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	3,220,000
1.00	0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820	0
Sum 1	12,500		2,060,000		2,060,000	0		19,987,500		19,987,500	0		6,577,500		6,577,500	0		6,577,500
1.00	50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	0
1.05	1,150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	0
2.20	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	0
2.21	190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	0
2.40	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	0
2.41	590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	0
3.00	2,000	5,300	27,910,000	950	1,060,000	26,850,000	2,520	6,570,000	520	520,000	6,050,000	1,760	4,600,000	0	0	4,600,000	0	0
5.00	500	22,610	6,027,500	110	402,500	5,625,000	4,050	1,822,500	0	610,000	1,012,500	2,840	915,000	0	205,000	710,000	0	207,500
5.50	1,500	1,500	1,680,000	1,500	1,680,000	0	2,440	3,652,500	2,440	3,652,500	0	820	1,230,000	820	1,230,000	0	830	1,245,000
7.00	3,000	740	3,930,000	740	3,930,000	0	2,430	7,290,000	2,430	7,290,000	0	820	2,460,000	820	2,460,000	0	830	2,490,000
10.00	6,000	1,880	19,980,000	1,880	19,980,000	0	2,430	14,790,000	2,430	14,790,000	0	820	4,980,000	820	4,980,000	0	830	5,040,000
16.00	4,000	4,780	14,960,000	4,780	14,960,000	0	2,500	10,040,000	2,500	10,040,000	0	840	3,320,000	840	3,320,000	0	850	3,360,000
20.00	5,000	2,700	16,175,000	2,700	16,175,000	0	2,520	12,500,000	2,520	12,500,000	0	820	4,125,000	820	4,125,000	0	830	4,175,000
25.00	5,000	3,770	16,325,000	3,770	16,325,000	0	2,480	12,450,000	2,480	12,450,000	0	830	4,175,000	830	4,175,000	0	840	4,225,000
30.00	6,000	2,760	19,170,000	2,760	19,170,000	0	2,500	14,970,000	2,500	14,970,000	0	840	5,040,000	840	5,040,000	0	850	5,100,000
36.00	3,000	3,630	18,930,000	3,630	18,905,000	2,025,000	2,490	4,635,000	2,490	3,900,000	735,000	840	1,920,000	840	1,260,000	660,000	850	1,275,000
39.00	4,000	8,990	47,900,000	7,840	24,140,000	23,760,000	800	5,340,000	110	940,000	4,400,000	440	3,440,000	0	200,000	3,240,000	0	0
43.00	0	14,960	0	4,430	0	0	2,070	0	360	0	0	1,280	0	100	0	0	0	0
Sum 2	42,000		203,480,750		136,615,500	66,865,250		98,897,000		82,699,000	16,198,000		39,922,000		26,995,000	12,927,000		27,117,500
43.00	1,000	14,960	14,305,000	4,430	3,465,000	10,840,000	2,070	2,305,000	360	235,000	2,070,000	1,280	1,470,000	100	50,000	1,420,000	0	0
44.00	1,000	13,650	15,335,000	2,500	2,600,000	12,735,000	2,540	2,555,000	110	140,000	2,415,000	1,680	1,665,000	0	20,000	1,645,000	0	0
45.00	1,000	17,020	21,940,000	2,700	2,600,000	19,340,000	2,570	2,635,000	170	85,000	2,550,000	1,670	1,915,000	40	20,000	1,895,000	0	0
46.00	1,000	26,860	25,105,000	2,500	2,500,000	22,605,000	2,700	2,660,000	0	0	2,660,000	2,160	2,000,000	0	0	2,000,000	0	0
47.00	1,000	23,350	23,910,000	2,500	2,550,000	21,360,000	2,620	2,640,000	0	0	2,640,000	1,840	1,850,000	0	0	1,850,000	0	0
48.00	1,000	24,470	26,940,000	2,600	2,750,000	24,190,000	2,660	2,665,000	0	0	2,665,000	1,860	1,840,000	0	0	1,840,000	0	0
49.00	1,000	29,410	24,770,000	2,900	3,370,000	21,400,000	2,670	2,605,000	0	95,000	2,510,000	1,820	1,745,000	0	35,000	1,710,000	0	0
50.00	1,000	28,130	24,505,000	3,840	4,220,000	20,285,000	2,540	2,890,000	190	185,000	2,705,000	1,670	1,925,000	70	65,000	1,860,000	0	0
51.00	1,000	28,880	31,645,000	4,800	3,800,000	27,845,000	3,240	2,970,000	180	90,000	2,880,000	2,180	1,980,000	60	30,000	1,950,000	0	0
52.00	1,000	34,410	35,975,000	3,000	2,700,000	33,275,000	2,700	2,850,000	0	0	2,850,000	1,780	1,920,000	0	0	1,920,000	0	0
53.00	0	37,540	0	2,400	0	0	3,000	0	0	0	0	2,060	0	0	0	0	0	0
Sum 3	10,000		244,430,000		30,555,000	213,875,000		26,775,000		830,000	25,945,000		18,310,000		220,000	18,090,000		0
53.00	1,000	37,540	34,855,000	2,400	1,200,000	33,655,000	3,000	3,230,000	0	0	3,230,000	2,060	2,195,000	0	0	2,195,000	0	0
54.00	1,000	32,170	22,750,000	0	0	22,750,000	3,460	3,200,000	0	0	3,200,000	2,330	2,155,000	0	0	2,155,000	0	0
55.00	500	13,330	6,535,000	0	0	6,535,000	2,940	1,487,500	0	0	1,487,500	1,980	1,002,500	0	0	1,002,500	0	0
55.50	500	12,810	5,587,500	0	0	5,587,500	3,010	1,457,500	0	0	1,457,500	2,030	987,500	0	0	987,500	0	0
56.00	1,000	9,540	14,950,000	0	650,000	14,300,000	2,820	3,065,000	0	245,000	2,820,000	1,920	2,120,000	0	0	2,120,000	0	0
57.00	1,000	20,360	13,920,000	1,300	1,800,000	12,120,000	3,310	2,910,000	490	630,000	2,280,000	2,320	1,810,000	320	200,000	1,610,000	0	0
58.00	1,000	7,480	10,505,000	2,300	2,020,000	8,485,000	2,510	2,435,000	770	470,000	1,965,000	1,300	1,410,000	80	50,000	1,360,000	0	0
59.00	1,000	13,530	14,715,000	1,740	4,420,000	10,295,000	2,380	2,285,000	170	290,000	1,995,000	1,520	1,400,000	20	35,000	1,365,000	0	0
60.00	1,000	15,900	19,785,000	7,100	4,450,000	12,335,000	2,210	2,255,000	410	205,000	2,050,000	1,280	1,400,000	50	25,000	1,375,000	0	0
61.00	1,000	17,870	12,810,000	1,800	2,185,000	10,625,000	2,300	2,635,000	0	535,000	2,100,000	1,520	1,495,000	0	35,000	1,460,000	0	0
62.00	0	7,950	0	2,570	0	0	2,970	0	1,070	0	0	1,470	0	70	0	0	0	0
Sum 4	9,000		153,412,500		16,725,000	136,687,500		24,960,000		2,375,000	22,585,000		15,975,000		345,000	15,630,000	0	0
62.00	2,000	7,950	16,520,000	2,570	6,020,000	10,500,000	2,970	4,710,000	1,070	1,070,000	3,640,000	1,470	2,870,000	70	70,000	2,800,000	0	0
64.00	3,000	8,570	15,705,000	3,450	8,025,000	7,680,000	1,740	6,405,000	0	3,795,000	2,610,000	1,400	3,450,000	0	1,350,000	2,100,000	0	1,395,000
67.00	6,000	1,900	9,240,000	1,900	9,240,000	0	2,530	15,210,000	2,530	15,210,000	0	900	5,430,000	900	5,430,000	0	930	5,550,000
73.00	10,900	1,180	6,431,000	1,180	6,431,000	0	2,540	13,843,000	2,540	13,843,000	0	910	4,959,500	910	4,959,500	0	920	5,014,000
83.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum 5	21,900		47,896,000		29,716,000	18,180,000		40,168,000		33,918,000	6,250,000		16,709,500		11,809,500	4,900,000		11,959,000
L-9																		
Sum 1	12,500		2,060,000		2,060,000	0		19,987,500		19,987,500	0		6,577,500		6,577,500	0		6,577,500
Sum 2	42,000		203,480,750		136,615,500	66,865,250		98,897,000		82,699,000	16,198,000		39,922,000		26,995,000	12,927,000		27,117,500
Sum 3	10,000		244,430,000		30,555,000	213,875,000		26,775,000		830,000	25,945,000		18,310,000		220,000	18,090,000		0
Sum 4	9,000		153,412,500		16,725,000	136,687,500		24,960,000		2,375,000	22,585,000		15,975,000		345,000	15,630,000		0
Sum 5	21,900		47,896,000		29,716,000	18,180,000		40,168,000		33,918,000	6,250,000		16,709,500		11,809,500	4,900,000		11,959,000
Total	95,400		651,279,250		215,671,500	435,607,750		210,787,500		139,808,500	70,978,000		97,494,000		45,947,000	51,547,000		45,654,000

Total Excavation Vol.	1,005,214,750
DRY	558,132,750
WET	447,082,000

L-11 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
-10.80	7.800	0	0	0	0		0	6,357,000		6,357,000		0	2,652,000	0	2,652,000	0	0	2,652,000
-3.00	4.000	0	940,000	0	940,000	0	1,630	6,260,000	1,630	4,020,000	2,240,000	680	2,840,000	680	2,840,000	0	680	2,880,000
1.00	0	470	0	470	0	0	1,500	0	380	0	0	740	0	740	0	0	760	0
Sum. 1	11.800		940,000		940,000	0		12,617,000		10,377,000	2,240,000		5,492,000		5,492,000	0		5,532,000
1.00	50	470	93,750	470	35,500	58,250	1,500	120,750	380	22,500	98,250	1,500	69,500	0	0	69,500	0	0
1.05	1,150	3,280	3,772,000	950	1,092,500	2,679,500	3,330	3,829,500	520	598,000	3,231,500	1,280	1,472,000	0	0	1,472,000	0	0
2.20	10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	1,280	17,800	0	0	17,500	0	0
2.21	190	3,280	623,200	950	180,500	442,700	3,330	632,700	520	98,800	533,900	2,280	433,200	0	0	433,200	0	0
2.40	10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	2,280	17,800	0	0	17,800	0	0
2.41	590	3,280	1,935,200	950	560,500	1,374,700	3,330	1,964,700	520	306,800	1,657,900	1,280	755,200	0	0	755,200	0	0
3.00	2,000	3,280	5,210,000	950	2,880,000	2,330,000	3,330	5,190,000	520	2,380,000	2,810,000	1,280	1,910,000	0	630,000	1,280,000	0	640,000
5.00	3,000	1,930	5,790,000	1,930	5,790,000	0	1,860	5,580,000	1,860	5,580,000	0	630	1,890,000	630	1,890,000	0	640	1,920,000
8.00	1,000	1,930	965,000	1,930	965,000	0	1,860	1,380,000	1,860	1,380,000	0	630	620,000	630	620,000	0	640	630,000
9.00	1,000	0	715,000	0	715,000	0	900	1,380,000	900	1,380,000	0	610	620,000	610	620,000	0	620	630,000
10.00	1,000	1,430	715,000	1,430	715,000	0	1,860	1,770,000	1,860	1,770,000	0	630	625,000	630	625,000	0	640	635,000
11.00	1,000	0	530,000	0	530,000	0	1,680	1,770,000	1,680	1,770,000	0	620	620,000	620	620,000	0	630	630,000
12.00	1,000	1,060	720,000	1,060	720,000	0	1,860	1,860,000	1,860	1,860,000	0	620	620,000	620	620,000	0	630	630,000
13.00	500	380	397,500	380	397,500	0	1,860	937,500	1,860	937,500	0	620	315,000	620	315,000	0	630	320,000
13.50	500	1,210	660,000	1,210	660,000	0	1,890	937,500	1,890	937,500	0	640	317,500	640	317,500	0	650	322,500
14.00	1,000	1,430	1,295,000	1,430	1,295,000	0	1,860	1,860,000	1,860	1,860,000	0	630	630,000	630	630,000	0	640	640,000
15.00	1,000	1,160	5,005,000	1,160	580,000	4,425,000	1,860	2,115,000	1,860	930,000	1,185,000	630	1,085,000	630	315,000	770,000	640	320,000
16.00	1,000	8,850	9,110,000	0	885,000	8,225,000	2,370	2,415,000	0	345,000	2,070,000	1,540	1,520,000	0	210,000	1,310,000	0	0
17.00	1,000	9,370	6,555,000	1,770	2,755,000	3,800,000	2,460	2,190,000	690	1,305,000	885,000	1,500	1,070,000	420	530,000	540,000	0	325,000
18.00	1,000	3,740	2,340,000	3,740	2,340,000	0	1,920	1,890,000	1,920	1,890,000	0	640	630,000	640	630,000	0	650	640,000
19.00	1,000	940	3,750,000	940	1,570,000	2,180,000	1,860	1,995,000	1,860	1,530,000	465,000	620	1,040,000	620	700,000	340,000	630	315,000
20.00	1,000	6,580	4,455,000	2,200	2,275,000	2,180,000	2,130	2,010,000	1,200	1,545,000	465,000	1,460	1,047,000	780	705,000	340,000	0	320,000
21.00	1,000	2,350	1,810,000	2,350	1,810,000	0	1,890	1,890,000	1,890	1,890,000	0	630	630,000	630	630,000	0	640	640,000
22.00	1,000	1,270	2,605,000	1,270	2,605,000	0	1,890	1,890,000	1,890	1,890,000	0	630	630,000	630	630,000	0	640	640,000
23.00	1,000	3,940	4,295,000	3,940	4,295,000	0	1,890	1,920,000	1,890	1,920,000	0	630	650,000	630	650,000	0	640	660,000
24.00	1,000	4,650	4,835,000	4,650	3,610,000	1,225,000	1,950	1,995,000	1,950	1,560,000	435,000	670	1,035,000	670	725,000	310,000	680	340,000
25.00	1,000	5,020	5,955,000	2,570	2,550,000	3,405,000	2,040	2,115,000	1,170	1,050,000	1,065,000	1,400	1,440,000	780	690,000	750,000	0	0
26.00	1,000	6,890	8,980,000	2,530	1,265,000	7,715,000	2,190	2,235,000	930	465,000	1,770,000	1,480	1,530,000	600	300,000	1,230,000	0	0
27.00	1,000	11,070	13,305,000	0	0	13,305,000	2,280	2,415,000	0	0	2,415,000	1,580	1,660,000	0	0	1,660,000	0	0
28.00	1,000	15,540	15,155,000	0	465,000	14,690,000	2,550	2,590,000	0	115,000	2,475,000	1,740	1,750,000	0	70,000	1,680,000	0	0
29.00	1,000	14,770	9,008,000	930	2,080,000	6,920,000	2,630	2,350,000	230	1,150,000	1,200,000	1,760	1,590,000	140	780,000	810,000	0	0
30.00	Brake 0	3,230	0	3,230	0	0	2,070	0	2,070	0	0	1,420	0	1,420	0	0	0	0
36.00	3,000	3,230	11,400,000	3,230	11,400,000	0	2,070	3,180,000	2,070	3,180,000	0	1,420	2,175,000	1,420	2,130,000	45,000	0	0
39.00	4,000	4,370	29,860,000	4,370	13,500,000	16,180,000	50	3,520,000	50	460,000	3,060,000	30	2,340,000	0	120,000	2,220,000	0	0
43.00	0	10,460	0	2,380	0	0	1,710	0	180	0	0	1,140	0	60	0	0	0	0
Sum. 2	36,000		861,702,250		70,540,500	91,161,750		67,994,250		42,116,500	25,877,750		32,753,000		16,702,500	16,050,500		11,197,500
43.00	1,000	10,460	9,065,000	2,380	2,125,000	6,940,000	1,710	1,750,000	180	145,000	1,605,000	1,140	1,140,000	60	30,000	1,110,000	0	0
44.00	1,000	7,670	8,930,000	1,870	1,910,000	7,020,000	1,790	1,850,000	110	140,000	1,710,000	1,140	1,190,000	0	20,000	1,170,000	0	0
45.00	1,000	10,190	13,565,000	1,950	1,965,000	11,600,000	1,910	2,215,000	170	85,000	2,130,000	1,240	1,550,000	40	20,000	1,530,000	0	0
46.00	1,000	16,940	15,865,000	1,980	1,940,000	13,925,000	2,520	2,235,000	0	0	2,235,000	1,860	1,600,000	0	0	1,600,000	0	0
47.00	1,000	14,790	15,375,000	1,900	1,940,000	13,435,000	1,950	1,980,000	0	0	1,980,000	1,340	1,380,000	0	0	1,380,000	0	0
48.00	1,000	15,980	17,910,000	1,980	2,115,000	15,795,000	2,010	2,145,000	0	0	2,145,000	1,420	1,530,000	0	0	1,530,000	0	0
49.00	1,000	19,860	15,420,000	2,250	2,550,000	12,870,000	2,280	2,090,000	0	95,000	1,995,000	1,640	1,440,000	0	35,000	1,405,000	0	0
50.00	1,000	10,980	14,125,000	2,850	3,045,000	11,080,000	1,900	2,300,000	190	185,000	2,115,000	1,240	1,520,000	70	65,000	1,455,000	0	0
51.00	1,000	17,270	20,605,000	3,240	2,760,000	17,845,000	2,700	2,390,000	180	90,000	2,300,000	1,800	1,620,000	60	30,000	1,590,000	0	0
52.00	1,000	23,940	24,550,000	2,280	2,070,000	22,480,000	2,080	2,285,000	0	0	2,285,000	1,440	1,540,000	0	0	1,540,000	0	0
53.00	0	25,160	0	1,860	0	0	2,490	0	0	0	0	1,640	0	0	0	0	0	0
Sum. 3	10,000		155,410,000		22,420,000	132,990,000		21,240,000		740,000	20,500,000		14,510,000		200,000	14,310,000		0
53.00	1,000	25,160	23,500,000	1,860	930,000	22,570,000	2,490	2,760,000	0	0	2,760,000	1,640	1,860,000	0	0	1,860,000	0	0
54.00	1,000	21,840	15,005,000	0	0	15,005,000	3,030	2,685,000	0	0	2,685,000	2,080	1,830,000	0	0	1,830,000	0	0
55.00	500	8,170	3,995,000	0	0	3,995,000	2,340	1,157,500	0	0	1,157,500	1,580	790,000	0	0	790,000	0	0
55.50	500	7,810	3,090,000	0	0	3,090,000	2,290	1,110,000	0	0	1,110,000	1,580	760,000	0	0	760,000	0	0
56.00	1,000	4,550	7,030,000	0	365,000	6,665,000	2,150	2,390,000	0	245,000	2,145,000	1,460	1,660,000	0	160,000	1,500,000	0	0
57.00	1,000	9,510	6,450,000	730	1,015,000	5,435,000	2,830	2,180,000	490	630,000	1,550,000	1,860	1,340,000	320	200,000	1,140,000	0	0
58.00	1,000	3,390	5,270,000	1,300	1,190,000	4,080,000	1,730	1,750,000	770	470,000	1,280,000	820	970,000	80	50,000	920,000	0	0
59.00	1,000	7,150	8,690,000	1,080	2,690,000	6,000,000	1,770	1,810,000	170	290,000	1,520,000	1,120	1,085,000	20	35,000	1,050,000	0	0
60.00	1,000	10,230	11,095,000	4,300	2,815,000	8,280,000	1,850	1,750,000	410	205,000	1,545,000	1,050	1,075,000	50	25,000	1,050,000	0	0
61.00	1,000	11,960	7,865,000	1,330	1,430,000	6,235,000	1,850	1,930,000	0	535,000	1,395,000	1,100	1,025,000	0	35,000	990,000	0	0
62.00	0	3,370	0	1,530	0	0	2,210	0	1,070	0	0	950	0	70	0	0	0	0
Sum. 4	9,000		91,790,000		18,435,000	81,355,000		18,522,500		2,375,000	17,147,500		12,395,000		505,000	11,890,000	0	0
62.00	2,000	3,370	7,740,000	1,530	3,830,000	3,910,000	2,210	3,010,000	1,070	1,070,000	1,940,000	950	1,940,000	70	70,000	1,870,000	0	0
64.00	3,000	4,370	6,765,000	2,300	3,660,000	3,105,000	800	3,075,000	0	1,875,000	1,200,000	990	2,460,000	0	975,000	1,485,000	0	1,020,000
67.00	6,000	140	420,000	140	420,000	0	1,250	5,370,000	1,250	5,370,000	0	650	3,900,000	650	3,900,000	0	680	4,020,000
73.00	3,300	0	0	0	0	0	540	891,000	540	891,000	0	850	1,072,500	850	1,072,500	0	660	1,089,000
76.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	14,300		14,925,000		7,910,000	7,015,000		12,346,000		9,206,000	3,140,000		9,372,500		6,017,500	3,355,000		6,129,000
L-11																		
Sum. 1	11.800		940,000		940,000	0		12,617,000		10,377,000	2,240,000		5,492,000		5,492,000	0		5,532,000
Sum. 2	36,000		861,702,250		70,540,500	91,161,750		67,994,250		42,116,500	25,877,750		32,753,000		16,702,500	16,050,500		11,197,500
Sum. 3	10,000		155,410,000		22,420,000	132,990,000		21,240,000		740,000	20,500,000		14,510,000		200,000	14,310,000		0
Sum. 4	9,000		91,790,000		10,435,000	81,355,000		18,522,500		2,375,000	17,147,500		12,395,000		505,000	11,890,000		0
Sum. 5	14,300		14,925,000		7,910,000	7,015,000		12,346,000		9,206,000	3,140,000		9,372,500		6,017,500	3,355,000		6,129,000
Total	81,100		824,767,250		112,245,500	312,521,750		133,719,750		64,814,500	68,905,250		74,522,500		28,917,000	45,605,500		22,858,500

Total Excavation Vol.	655,868,000
Dry	427,032,500
Wet	228,835,500

L-14 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry Vl	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry Vl	Earth Total Ao	Earth Total Vo	Earth Underwater Al	Earth Underwater Vl	Earth Dry Vl	Clayey Material Total Ao	Clayey Material Total Vo
-11.10	8.100	0	0	0	0		0	9,841,500		9,841,500		0	3,199,500	0	3,199,500	0	0	3,199,500
-3.00	4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	3,220,000
1.00	0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820	0
Sum. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
1.00	50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	0
1.05	1.150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	0
2.20	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	0
2.21	190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	0
2.40	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	0
2.41	590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	0
3.00	2.000	5,300	7,950,000	950	3,600,000	4,350,000	2,520	4,650,000	520	2,650,000	2,000,000	1,760	2,480,000	0	720,000	1,760,000	0	730,000
5.00	3.000	2,650	7,950,000	2,650	7,950,000	0	2,130	6,390,000	2,130	6,390,000	0	720	2,160,000	720	2,160,000	0	730	2,190,000
8.00	1.000	2,650	1,325,000	2,650	1,325,000	0	2,130	1,985,000	2,130	1,985,000	0	720	710,000	720	710,000	0	730	720,000
9.00	1.000	0	1,235,000	0	1,235,000	0	1,840	1,985,000	1,840	1,985,000	0	700	710,000	700	710,000	0	710	720,000
10.00	1.000	2,470	1,465,000	2,470	1,465,000	0	2,130	2,115,000	2,130	2,115,000	0	720	715,000	720	715,000	0	730	725,000
11.00	1.000	460	1,155,000	460	1,155,000	0	2,100	2,115,000	2,100	2,115,000	0	710	710,000	710	710,000	0	720	720,000
12.00	1.000	1,850	1,460,000	1,850	1,460,000	0	2,130	2,130,000	2,130	2,130,000	0	710	710,000	710	710,000	0	720	720,000
13.00	500	1,070	905,000	1,070	905,000	0	2,130	1,072,500	2,130	1,072,500	0	710	342,500	710	342,500	0	720	347,500
13.50	500	2,550	1,190,000	2,550	1,190,000	0	2,160	1,072,500	2,160	1,072,500	0	660	345,000	660	345,000	0	670	350,000
14.00	1.000	2,210	2,165,000	2,210	2,165,000	0	2,130	2,130,000	2,130	2,130,000	0	720	720,000	720	720,000	0	730	730,000
15.00	1.000	2,120	6,810,000	2,120	1,060,000	5,750,000	2,130	2,360,000	2,130	1,065,000	1,295,000	720	1,205,000	720	360,000	845,000	730	365,000
16.00	1.000	11,500	11,430,000	0	1,530,000	9,900,000	2,590	2,890,000	0	405,000	2,285,000	1,690	1,685,000	0	230,000	1,455,000	0	0
17.00	1.000	11,360	8,190,000	3,060	4,040,000	4,150,000	2,790	2,480,000	810	1,490,000	990,000	1,680	1,205,000	460	595,000	610,000	0	370,000
18.00	1.000	5,020	3,420,000	5,020	3,420,000	0	2,170	2,150,000	2,170	2,150,000	0	730	725,000	730	725,000	0	740	735,000
19.00	1.000	1,820	5,150,000	1,820	2,360,000	2,790,000	2,130	2,270,000	2,130	1,730,000	540,000	720	1,180,000	720	795,000	385,000	730	365,000
20.00	1.000	8,480	5,915,000	2,900	3,125,000	2,790,000	2,410	2,285,000	1,330	1,745,000	540,000	1,640	1,185,000	870	800,000	385,000	0	370,000
21.00	1.000	3,350	2,730,000	3,350	2,730,000	0	2,160	2,160,000	2,160	2,160,000	0	730	730,000	730	730,000	0	740	740,000
22.00	1.000	2,110	3,650,000	2,110	3,650,000	0	2,160	2,160,000	2,160	2,160,000	0	730	730,000	730	730,000	0	740	740,000
23.00	1.000	5,190	5,570,000	5,190	5,570,000	0	2,160	2,175,000	2,160	2,175,000	0	730	730,000	730	730,000	0	740	740,000
24.00	1.000	5,950	6,215,000	5,950	4,555,000	1,660,000	2,190	2,250,000	2,190	1,750,000	500,000	730	1,145,000	730	795,000	350,000	740	370,000
25.00	1.000	6,480	7,505,000	3,160	3,220,000	4,285,000	2,310	2,385,000	1,310	1,180,000	1,205,000	1,580	1,610,000	860	770,000	840,000	0	0
26.00	1.000	8,530	10,855,000	3,280	1,640,000	9,215,000	2,460	2,520,000	1,050	525,000	1,995,000	1,680	1,710,000	680	340,000	1,370,000	0	0
27.00	1.000	13,180	15,770,000	0	0	15,770,000	2,580	2,715,000	0	0	2,715,000	1,760	1,855,000	0	0	1,855,000	0	0
28.00	1.000	18,360	17,965,000	0	725,000	17,240,000	2,850	2,870,000	0	170,000	2,700,000	1,950	1,945,000	0	110,000	1,835,000	0	0
29.00	1.000	17,570	11,140,000	1,450	3,080,000	8,060,000	2,890	2,890,000	340	1,325,000	1,275,000	1,940	1,770,000	220	910,000	860,000	0	0
30.00	brake	4,710	0	4,710		0	2,310	0	2,310	0	0	1,600	0	1,600	0	0	0	0
36.00	3.000	2,220	12,885,000	2,220	12,735,000	150,000	2,130	3,720,000	2,130	3,360,000	360,000	710	1,365,000	710	1,065,000	300,000	720	1,080,000
39.00	4.000	6,370	38,000,000	6,270	17,900,000	20,100,000	350	6,520,000	110	620,000	5,900,000	200	2,960,000	0	200,000	2,760,000	0	0
43.00	0	12,630	0	2,680	0	0	2,910	0	200	0	0	1,280	0	100	0	0	0	0
Sum. 2	36.000		210,493,250		95,678,000	114,815,250		76,992,000		48,691,500	28,300,500		37,054,500		17,727,500	19,327,000		13,827,500
43.00	1.000	12,630	11,260,000	2,680	2,405,000	8,855,000	2,910	2,495,000	200	155,000	2,340,000	1,280	1,300,000	100	50,000	1,250,000	0	0
44.00	1.000	9,890	11,490,000	2,130	2,205,000	9,285,000	2,080	2,135,000	110	140,000	1,995,000	1,320	1,380,000	0	20,000	1,360,000	0	0
45.00	1.000	13,090	16,950,000	2,280	2,280,000	14,670,000	2,190	2,355,000	170	85,000	2,270,000	1,440	1,740,000	40	20,000	1,720,000	0	0
46.00	1.000	20,810	19,525,000	2,280	2,230,000	17,295,000	2,520	2,375,000	0	0	2,375,000	2,040	1,780,000	0	0	1,780,000	0	0
47.00	1.000	18,240	18,790,000	2,180	2,205,000	16,585,000	2,230	2,255,000	0	0	2,255,000	1,520	1,560,000	0	0	1,560,000	0	0
48.00	1.000	19,340	21,755,000	2,230	2,400,000	19,355,000	2,280	2,340,000	0	0	2,340,000	1,800	1,820,000	0	0	1,820,000	0	0
49.00	1.000	24,170	19,425,000	2,570	2,895,000	16,530,000	2,400	2,285,000	0	95,000	2,190,000	1,640	1,535,000	0	35,000	1,500,000	0	0
50.00	1.000	14,680	18,470,000	3,220	3,510,000	14,960,000	2,170	2,570,000	190	185,000	2,385,000	1,430	1,690,000	70	65,000	1,625,000	0	0
51.00	1.000	22,260	25,380,000	3,800	3,195,000	22,185,000	2,970	2,685,000	180	90,000	2,575,000	1,950	1,745,000	60	30,000	1,715,000	0	0
52.00	1.000	28,500	28,450,000	2,590	2,330,000	26,120,000	2,360	2,545,000	0	0	2,545,000	1,540	1,680,000	0	0	1,680,000	0	0
53.00	0	28,400	0	2,070	0	0	2,730	0	0	0	0	1,820	0	0	0	0	0	0
Sum. 3	10.000		191,495,000		25,655,000	165,840,000		24,020,000		750,000	23,270,000		16,030,000		220,000	15,810,000		0
53.00	1.000	28,400	27,365,000	2,070	1,035,000	26,330,000	2,730	2,960,000	0	0	2,960,000	1,820	1,985,000	0	0	1,985,000	0	0
54.00	1.000	26,330	18,280,000	0	0	18,280,000	3,190	2,885,000	0	0	2,885,000	2,150	1,960,000	0	0	1,960,000	0	0
55.00	500	18,230	4,995,000	0	0	4,995,000	2,580	1,305,000	0	0	1,305,000	1,770	885,000	0	0	885,000	0	0
55.50	500	9,750	4,872,500	0	0	4,872,500	2,640	1,287,500	0	0	1,287,500	1,770	857,500	0	0	857,500	0	0
56.00	1.000	9,540	10,275,000	0	470,000	9,805,000	2,430	2,970,000	0	245,000	2,425,000	1,680	1,810,000	0	0	1,810,000	0	0
57.00	1.000	14,910	9,480,000	940	1,320,000	8,160,000	2,910	2,515,000	490	630,000	1,885,000	1,960	1,490,000	320	200,000	1,290,000	0	0
58.00	1.000	4,950	7,480,000	1,700	1,530,000	5,950,000	2,120	2,060,000	770	470,000	1,590,000	1,020	1,180,000	80	50,000	1,110,000	0	0
59.00	1.000	10,010	11,200,000	1,360	2,975,000	8,225,000	2,000	2,075,000	170	290,000	1,785,000	1,300	1,260,000	20	35,000	1,225,000	0	0
60.00	1.000	12,390	13,310,000	4,590	3,095,000	10,215,000	2,150	2,050,000	410	205,000	1,845,000	1,220	1,255,000	50	25,000	1,230,000	0	0
61.00	1.000	14,230	9,725,000	1,600	1,815,000	7,910,000	1,950	2,260,000	0	535,000	1,725,000	1,290	1,240,000	0	35,000	1,205,000	0	0
62.00	0	5,220	0	2,030	0	0	2,570	0	1,070	0	0	1,190	0	70	0	0	0	0
Sum. 4	9.000		116,182,500		12,240,000	103,942,500		22,047,500		2,375,000	19,672,500		13,902,500		345,000	13,557,500		0
62.00	2.000	5,220	11,430,000	2,030	4,830,000	6,600,000	2,570	3,870,000	1,070	1,070,000	2,800,000	1,190	2,240,000	70	70,000	2,170,000	0	0
64.00	3.000	8,210	10,485,000	2,800	5,370,000	5,115,000	1,300	4,560,000	0	2,610,000	1,950,000	1,050	2,700,000	0	1,125,000	1,575,000	0	1,170,000
67.00	6.000	780	2,910,000	780	2,910,000	0	1,740	9,960,000	1,740	9,960,000	0	750	4,530,000	750	4,530,000	0	780	4,650,000
73.00	6.500	190	617,500	190	617,500	0	1,580	5,135,000	1,580	5,135,000	0	760	2,470,000	760	2,470,000	0	770	2,502,500
79.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	17.500		25,442,500		13,727,500	11,715,000		23,525,000		18,775,000	4,750,000		11,940,000		8,195,000	3,745,000		8,322,500
L-14																		
Sum. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
Sum. 2	36.000		210,493,250		95,678,000	114,815,250		76,992,000		48,691,500	28,300,500		37,054,500		17,727,500	19,327,000		13,827,500
Sum. 3	10.000		191,495,000		25,655,000	165,840,000		24,020,000		750,000	23,270,000		16,030,000		220,000	15,810,000		0
Sum. 4	9.000		116,182,500		12,240,000	103,942,500		22,047,500		2,375,000	19,672,500		13,902,500		345,000	13,557,500		0
Sum. 5	17.500		25,442,500		13,727,500	11,715,000		23,525,000		18,775,000	4,750,000		11,940,000		8,195,000	3,745,000		8,322,500
Total	84.600		545,673,250		149,360,500	396,312,750		166,086,000		90,093,000	75,993,000		85,346,500		32,907,000	52,439,500		28,569,500

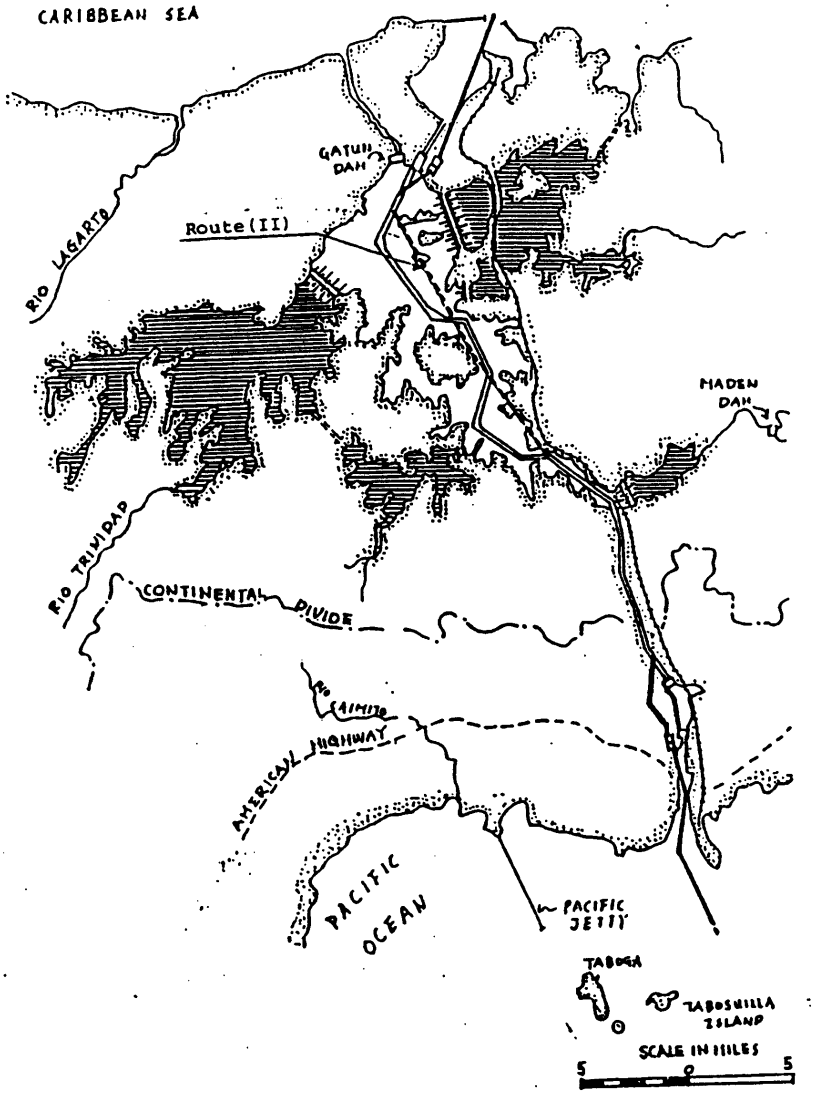
Total Excavation Vol.	825,675,250
DRY	524,745,250
WET	300,930,000

L-17

L-17 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Al	Earth Underwater Vl	Earth Dry V2	Survey Material Total Ao	Survey Material Total Vo
-11.50	8.500	0	0	0	0		0	10,327,500		10,327,500		0	3,357,500	0	3,357,500	0	0	3,357,500
-3.00	4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	3,220,000
1.00	0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820	0
Sum. 1	12.500		2,060,000		2,060,000	0		19,987,500		19,987,500	0		6,577,500		6,577,500	0		6,577,500
1.00	50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	0
1.05	1,150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	0
2.20	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	0
2.21	190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	0
2.40	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	0
2.41	590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	0
3.00	2,000	5,300	9,490,000	950	5,140,000	4,350,000	2,520	5,010,000	520	3,010,000	2,000,000	1,760	2,600,000	0	840,000	1,760,000	0	850,000
5.00	3,000	4,190	12,570,000	4,190	12,570,000	0	2,490	7,470,000	2,490	7,470,000	0	840	2,520,000	840	2,520,000	0	850	2,550,000
8.00	1,000	4,190	2,465,000	4,190	2,465,000	0	2,490	2,460,000	2,490	2,460,000	0	840	830,000	840	830,000	0	850	810,000
9.00	1,000	740	2,440,000	740	2,440,000	0	2,430	2,460,000	2,430	2,460,000	0	820	830,000	820	830,000	0	830	840,000
10.00	1,000	4,140	3,050,000	4,140	3,050,000	0	2,490	2,490,000	2,490	2,490,000	0	840	835,000	840	835,000	0	850	845,000
11.00	1,000	1,960	2,775,000	1,960	2,775,000	0	2,490	2,490,000	2,490	2,490,000	0	830	830,000	830	830,000	0	840	840,000
12.00	1,000	3,590	3,135,000	3,590	3,135,000	0	2,490	2,490,000	2,490	2,490,000	0	830	830,000	830	830,000	0	840	840,000
13.00	500	2,680	1,760,000	2,680	1,760,000	0	2,490	1,265,000	2,490	1,265,000	0	830	430,000	830	430,000	0	840	435,000
13.50	500	4,360	2,127,500	4,360	2,127,500	0	2,570	1,265,000	2,570	1,265,000	0	890	432,500	890	432,500	0	900	437,500
14.00	1,000	4,150	3,935,000	4,150	3,935,000	0	2,490	2,490,000	2,490	2,490,000	0	840	840,000	840	840,000	0	850	850,000
15.00	1,000	3,720	9,255,000	3,720	1,860,000	7,395,000	2,490	2,700,000	2,490	1,245,000	1,455,000	840	1,375,000	840	420,000	955,000	850	425,000
16.00	1,000	14,790	14,365,000	0	2,165,000	12,200,000	2,910	3,015,000	0	480,000	2,535,000	1,910	1,905,000	0	280,000	1,625,000	0	0
17.00	1,000	13,940	10,325,000	4,330	5,520,000	4,805,000	3,120	2,820,000	960	1,740,000	1,080,000	1,900	1,375,000	560	705,000	670,000	0	430,000
18.00	1,000	6,710	5,175,000	6,710	5,175,000	0	2,520	2,505,000	2,520	2,505,000	0	850	845,000	850	845,000	0	860	855,000
19.00	1,000	3,640	7,680,000	3,640	3,820,000	3,860,000	2,490	2,645,000	2,490	2,000,000	645,000	840	1,340,000	840	890,000	450,000	850	425,000
20.00	1,000	11,720	8,395,000	4,000	4,535,000	3,860,000	2,800	2,660,000	1,510	2,015,000	645,000	1,840	1,345,000	940	895,000	450,000	0	430,000
21.00	1,000	5,070	4,430,000	5,070	4,430,000	0	2,520	2,520,000	2,520	2,520,000	0	850	850,000	850	850,000	0	860	860,000
22.00	1,000	3,790	5,555,000	3,790	5,555,000	0	2,520	2,520,000	2,520	2,520,000	0	850	850,000	850	850,000	0	860	860,000
23.00	1,000	7,320	7,580,000	7,320	7,580,000	0	2,520	2,535,000	2,520	2,535,000	0	850	850,000	850	850,000	0	860	860,000
24.00	1,000	7,840	8,320,000	7,840	5,995,000	2,325,000	2,550	2,625,000	2,550	2,025,000	600,000	850	1,340,000	850	915,000	425,000	860	430,000
25.00	1,000	8,800	10,270,000	4,150	4,345,000	5,925,000	2,700	2,775,000	1,500	1,380,000	1,395,000	1,830	1,875,000	980	900,000	975,000	0	0
26.00	1,000	11,740	13,820,000	4,540	2,270,000	11,550,000	2,850	2,910,000	1,260	630,000	2,280,000	1,920	1,970,000	820	410,000	1,560,000	0	0
27.00	1,000	15,900	19,500,000	0	0	19,500,000	2,970	3,090,000	0	0	3,090,000	2,020	2,110,000	0	0	2,110,000	0	0
28.00	1,000	23,100	22,490,000	0	1,100,000	21,390,000	3,210	3,210,000	0	255,000	2,955,000	2,200	2,180,000	0	160,000	2,020,000	0	0
29.00	1,000	21,880	14,340,000	2,200	4,500,000	9,840,000	3,210	2,940,000	510	1,590,000	1,350,000	2,160	2,010,000	320	1,090,000	920,000	0	0
30.00	brake	6,800	0	6,800	0	0	2,670	0	2,670	0	0	1,860	0	1,860	0	0	0	0
36.00	3,000	2,220	12,885,000	2,220	12,735,000	150,000	2,130	3,720,000	2,130	3,360,000	360,000	710	1,365,000	710	1,065,000	300,000	720	1,080,000
39.00	4,000	6,370	38,000,000	6,270	17,900,000	20,100,000	350	6,520,000	110	620,000	5,900,000	200	2,960,000	0	200,000	2,760,000	0	0
43.00	0	12,630	0	2,680	0	0	2,910	0	200	0	0	1,280	0	100	0	0	0	0
Sum. 2	36.000		266,625,750		130,770,500	135,855,250		86,637,000		56,346,500	30,290,500		41,239,500		20,542,500	20,697,000		15,982,500
43.00	1,000	14,960	14,305,000	4,430	3,465,000	10,840,000	2,070	2,305,000	360	235,000	2,070,000	1,280	1,470,000	100	50,000	1,420,000	0	0
44.00	1,000	13,850	15,335,000	2,500	2,600,000	12,735,000	2,540	2,520,000	110	140,000	2,380,000	1,660	1,665,000	0	20,000	1,645,000	0	0
45.00	1,000	17,020	21,940,000	2,700	2,600,000	19,340,000	2,500	2,600,000	170	85,000	2,515,000	1,670	1,915,000	40	20,000	1,895,000	0	0
46.00	1,000	26,860	25,105,000	2,500	2,500,000	22,605,000	2,700	2,660,000	0	0	2,660,000	2,160	2,000,000	0	0	2,000,000	0	0
47.00	1,000	23,350	23,910,000	2,500	2,550,000	21,360,000	2,620	2,640,000	0	0	2,640,000	1,840	1,850,000	0	0	1,850,000	0	0
48.00	1,000	24,470	26,940,000	2,600	2,750,000	24,190,000	2,660	2,665,000	0	0	2,665,000	1,860	1,840,000	0	0	1,840,000	0	0
49.00	1,000	29,410	24,770,000	2,900	3,370,000	21,400,000	2,670	2,605,000	0	95,000	2,510,000	1,820	1,745,000	0	35,000	1,710,000	0	0
50.00	1,000	20,130	24,505,000	3,840	4,220,000	20,285,000	2,540	2,890,000	190	185,000	2,705,000	1,670	1,925,000	70	65,000	1,860,000	0	0
51.00	1,000	28,880	31,645,000	4,600	3,800,000	27,845,000	3,240	2,970,000	180	90,000	2,880,000	2,180	1,980,000	60	30,000	1,950,000	0	0
52.00	1,000	34,410	35,975,000	3,000	2,700,000	33,275,000	2,700	2,850,000	0	0	2,850,000	1,780	1,920,000	0	0	1,920,000	0	0
53.00	0	37,540	0	2,400	0	0	3,000	0	0	0	0	2,060	0	0	0	0	0	0
Sum. 3	10.000		244,430,000		30,555,000	213,875,000		26,705,000		830,000	25,875,000		18,310,000		220,000	18,090,000		0
53.00	1,000	37,540	34,855,000	2,400	1,200,000	33,655,000	3,000	3,230,000	0	0	3,230,000	2,060	2,195,000	0	0	2,195,000	0	0
54.00	1,000	32,170	21,750,000	0	0	21,750,000	3,460	3,200,000	0	0	3,200,000	2,330	2,155,000	0	0	2,155,000	0	0
55.00	500	31,330	6,035,000	0	0	6,035,000	2,940	1,487,500	0	0	1,487,500	1,980	1,002,500	0	0	1,002,500	0	0
55.50	500	32,810	5,587,500	0	0	5,587,500	3,010	1,457,500	0	0	1,457,500	2,030	987,500	0	0	987,500	0	0
56.00	1,000	9,540	14,950,000	0	650,000	14,300,000	2,820	3,065,000	0	245,000	2,820,000	1,920	2,120,000	0	0	2,120,000	0	0
57.00	1,000	20,360	13,920,000	1,300	1,800,000	12,120,000	3,310	2,910,000	490	630,000	2,280,000	2,320	1,810,000	320	200,000	1,610,000	0	0
58.00	1,000	7,480	10,505,000	2,300	2,020,000	8,485,000	2,510	2,435,000	770	470,000	1,965,000	1,300	1,410,000	80	50,000	1,360,000	0	0
59.00	1,000	13,530	14,715,000	1,740	4,420,000	10,295,000	2,360	2,285,000	170	290,000	1,995,000	1,520	1,400,000	20	35,000	1,365,000	0	0
60.00	1,000	15,900	16,785,000	7,100	4,450,000	12,335,000	2,210	2,255,000	410	205,000	2,050,000	1,280	1,400,000	50	25,000	1,375,000	0	0
61.00	1,000	17,670	12,810,000	1,800	2,185,000	10,625,000	2,300	2,635,000	0	535,000	2,100,000	1,520	1,495,000	0	35,000	1,460,000	0	0
62.00	0	7,950	0	2,570	0	0	2,970	0	1,070	0	0	1,470	0	70	0	0	0	0
Sum. 4	9.000		151,912,500		16,725,000	135,187,500		24,960,000		2,375,000	22,585,000		15,975,000		345,000	15,630,000	0	0
62.00	2,000	7,950	16,520,000	2,570	6,020,000	10,500,000	2,970	4,710,000	1,070	1,070,000	3,640,000	1,470	2,870,000	70	70,000	2,800,000	0	0
64.00	3,000	8,570	15,705,000	3,450	8,025,000	7,680,000	1,740	6,405,000	0	3,795,000	2,610,000	1,400	3,450,000	0	1,350,000	2,100,000	0	1,395,000
67.00	6,000	1,900	9,240,000	1,900	9,240,000	0	2,530	15,210,000	2,530	15,210,000	0	900	5,430,000	900	5,430,000	0	930	5,550,000
73.00	10,900	1,180	6,431,000	1,180	6,431,000	0	2,540	13,843,000	2,540	13,843,000	0	910	4,959,500	910	4,959,500	0	920	5,014,000
83.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	21.900		47,896,000		29,716,000	18,180,000		40,168,000		33,918,000	6,250,000		16,709,500		11,809,500	4,900,000		11,959,000
L-17																		
Sum. 1	12.500		2,060,000		2,060,000	0		19,987,500		19,987,500	0		6,577,500		6,577,500	0		6,577,500
Sum. 2	36.000		266,625,750		130,770,500	135,855,250		86,637,000		56,346,500	30,290,500		41,239,500		20,542,500	20,697,000		15,982,500
Sum. 3	10.000		244,430,000		30,555,000	213,875,000		26,705,000		830,000	25,875,000		18,310,000		220,000	18,090,000		0
Sum. 4	9.000		151,912,500		16,725,000	135,187,500		24,960,000		2,375,000	22,585,000		15,975,000		345,000	15,630,000		0
Sum. 5	21,900		47,896,000		29,716,000	18,180,000		40,168,000		33,918,000	6,250,000		16,709,500		11,809,500	4,900,000		11,959,000
Total	89.400		712,924,250		209,826,500	503,097,750		198,457,500		113,457,000	85,000,500		98,811,500		39,494,500	59,317,000		34,519,000

Total Excavation Vol.	1,044,712,250
Dry	647,415,250
Wet	397,297,000



Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size (m)
L-12	II	30'	1	2	100	301 x 18.7
15	II	30'	1	2	150	343 x 20.9
18	II	30'	1	2	250	399 x 24.2

Layout of Low Rise Lock System
for Group B Study Cases (30')

Calculation Table of Excavation Volume

L-12

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Colluvial Material Total Ao	Colluvial Material Total Vo
-10.80	7,800	0	0	0	0		0	6,357,000		6,357,000		0	2,652,000	0	2,652,000	0	0	2,652,000
-3.00	4,000	0	940,000	0	940,000	0	1,630	6,260,000	1,630	6,260,000	0	680	2,840,000	680	2,840,000	0	680	2,840,000
1.00	0	470	0	470	0	0	1,500	0	1,500	0	0	740	0	740	0	0	760	
Sum. 1	11,800		940,000		940,000	0		12,617,000		12,617,000	0		5,492,000		5,492,000	0		5,532,000
1.00	50	470	93,750	470	35,500	58,250	1,500	120,750	380	22,500	98,250	1,500	69,500	0	0	69,500	0	0
1.05	1,150	3,280	3,772,000	950	1,092,500	2,679,500	3,330	3,829,500	520	598,000	3,231,500	1,280	1,472,000	0	0	1,472,000	0	0
2.20	10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	1,280	17,800	0	0	17,800	0	0
2.21	190	3,280	623,200	950	180,500	442,700	3,330	632,700	520	98,800	533,900	2,280	433,200	0	0	433,200	0	0
2.40	10	3,280	32,800	950	9,500	23,300	3,330	33,300	520	5,200	28,100	2,280	17,800	0	0	17,800	0	0
2.41	590	3,280	1,935,200	950	560,500	1,374,700	3,330	1,964,700	520	306,800	1,657,900	1,280	755,200	0	0	755,200	0	0
3.00	2,000	3,280	7,410,000	950	950,000	6,460,000	3,330	26,950,000	520	520,000	26,430,000	1,280	2,540,000	0	720,000	1,820,000	0	730,000
5.00	500	4,130	1,567,500	0	535,000	1,032,500	23,620	6,372,500	0	467,500	5,905,000	1,260	472,500	720	337,500	135,000	730	342,500
5.50	500	2,140	1,170,000	2,140	1,170,000	0	1,870	945,000	1,870	945,000	0	630	317,500	630	317,500	0	640	322,500
6.00	1,000	2,540	1,920,000	2,540	1,920,000	0	1,910	1,890,000	1,910	1,890,000	0	640	635,000	640	635,000	0	650	645,000
7.00	1,000	1,300	2,745,000	1,300	2,745,000	0	1,870	1,905,000	1,870	1,905,000	0	630	655,000	630	655,000	0	640	565,000
8.00	1,000	4,190	2,905,000	4,190	2,905,000	0	1,940	1,910,000	1,940	1,910,000	0	680	655,000	680	655,000	0	690	565,000
9.00	1,000	1,620	2,925,000	1,620	2,925,000	0	1,880	1,910,000	1,880	1,910,000	0	630	645,000	630	645,000	0	640	565,000
10.00	1,000	4,230	3,125,000	4,230	3,125,000	0	1,940	1,925,000	1,940	1,925,000	0	660	650,000	660	650,000	0	690	670,000
11.00	1,000	2,020	2,685,000	2,020	2,685,000	0	1,910	1,915,000	1,910	1,915,000	0	640	645,000	640	645,000	0	650	655,000
12.00	1,000	3,350	2,975,000	3,350	2,975,000	0	1,920	1,920,000	1,920	1,920,000	0	650	650,000	650	650,000	0	660	660,000
13.00	500	2,600	1,627,500	2,600	1,627,500	0	1,920	997,500	1,920	997,500	0	650	335,000	650	335,000	0	660	340,000
13.50	500	3,910	1,960,000	3,910	1,960,000	0	2,070	1,005,000	2,070	1,005,000	0	690	337,500	690	337,500	0	700	342,500
14.00	1,000	3,930	3,785,000	3,930	3,785,000	0	1,950	1,945,000	1,950	1,945,000	0	660	655,000	660	655,000	0	670	665,000
15.00	1,000	3,640	7,895,000	3,640	1,820,000	6,075,000	1,940	2,160,000	1,940	970,000	1,190,000	650	1,145,000	650	325,000	820,000	660	330,000
16.00	1,000	12,150	13,075,000	0	2,315,000	10,760,000	2,380	1,910,000	0	90,000	1,820,000	1,640	1,280,000	0	45,000	1,235,000	0	0
17.00	1,000	14,000	10,200,000	4,630	5,515,000	4,685,000	1,440	1,705,000	180	1,075,000	630,000	920	795,000	90	380,000	415,000	0	365,000
18.00	1,000	6,400	4,760,000	6,400	4,760,000	0	1,970	1,945,000	1,970	1,945,000	0	670	655,000	670	655,000	0	730	690,000
19.00	1,000	3,120	6,880,000	3,120	4,415,000	2,465,000	1,920	1,660,000	1,920	1,170,000	490,000	640	665,000	640	320,000	345,000	650	325,000
20.00	1,000	10,640	7,725,000	5,710	5,260,000	2,465,000	1,400	1,675,000	420	1,185,000	490,000	690	690,000	0	345,000	345,000	0	350,000
21.00	1,000	4,810	4,130,000	4,810	4,130,000	0	1,950	1,950,000	1,950	1,950,000	0	690	670,000	690	670,000	0	700	680,000
22.00	1,000	3,450	4,895,000	3,450	4,895,000	0	1,950	2,065,000	1,950	2,065,000	0	650	690,000	650	690,000	0	660	700,000
23.00	1,000	6,340	6,650,000	6,340	6,650,000	0	2,180	2,155,000	2,180	2,155,000	0	730	725,000	730	725,000	0	740	735,000
24.00	1,000	6,960	8,050,000	6,960	6,380,000	1,670,000	2,130	1,755,000	2,130	1,290,000	465,000	720	735,000	720	415,000	320,000	730	365,000
25.00	1,000	9,140	10,075,000	5,800	5,600,000	4,475,000	1,380	1,435,000	450	340,000	1,095,000	750	785,000	110	55,000	730,000	0	0
26.00	0	11,010	0	5,400	0	0	1,490	0	230	0	0	820	0	0	0	0	0	0
26.00	1,000	11,350	12,810,000	5,630	2,815,000	9,995,000	1,580	1,995,000	230	115,000	1,880,000	900	1,280,000	0	0	1,280,000	0	0
27.00	1,000	14,270	16,630,000	0	0	16,630,000	2,410	2,535,000	0	0	2,535,000	1,660	1,750,000	0	0	1,750,000	0	0
28.00	1,000	18,990	18,460,000	0	950,000	17,510,000	2,680	2,625,000	0	65,000	2,560,000	1,840	1,700,000	0	0	1,700,000	0	0
29.00	1,000	17,930	11,815,000	1,900	3,800,000	8,015,000	2,590	2,375,000	130	1,145,000	1,230,000	1,560	1,150,000	0	370,000	780,000	0	375,000
30.00	1,000	5,700	8,215,000	5,700	5,430,000	2,785,000	2,180	1,725,000	2,180	1,125,000	600,000	740	785,000	740	370,000	415,000	750	375,000
31.00	1,000	10,730	7,600,000	5,160	4,815,000	2,785,000	1,290	1,645,000	90	1,045,000	600,000	830	755,000	0	340,000	415,000	0	345,000
32.00	1,000	4,470	6,250,000	4,470	5,300,000	950,000	2,000	1,335,000	2,000	1,015,000	320,000	680	490,000	680	340,000	150,000	690	345,000
33.00	1,000	8,030	12,165,000	6,130	3,065,000	9,100,000	670	1,600,000	30	15,000	1,585,000	300	1,005,000	0	0	1,005,000	0	0
34.00	1,000	16,300	28,785,000	0	0	28,785,000	2,530	2,870,000	0	0	2,870,000	1,710	1,935,000	0	0	1,935,000	0	0
35.00	1,000	41,270	29,970,000	0	0	29,970,000	3,210	3,075,000	0	0	3,075,000	2,160	2,090,000	0	0	2,090,000	0	0
36.00	1,000	18,670	15,835,000	0	1,700,000	14,135,000	2,940	2,345,000	0	90,000	2,255,000	2,020	1,600,000	0	30,000	1,570,000	0	0
37.00	0	13,000	0	3,400	0	0	1,750	0	180	0	0	1,180	0	60	0	0	0	0
Sum. 2	36,000		296,159,750		110,810,500	185,349,250		102,744,250		39,141,500	63,602,750		35,333,000		13,312,500	22,020,500	0	13,347,500
37.00	1,000	13,000	11,175,000	3,400	2,635,000	8,540,000	1,750	1,785,000	180	145,000	1,640,000	1,180	1,170,000	60	30,000	1,140,000	0	0
38.00	1,000	9,350	10,680,000	1,870	1,910,000	8,770,000	1,820	1,880,000	110	990,000	890,000	1,160	1,210,000	0	20,000	1,190,000	0	0
39.00	1,000	12,010	15,700,000	1,950	1,965,000	13,735,000	1,940	2,245,000	1,870	1,020,000	1,225,000	1,260	1,570,000	40	20,000	1,550,000	0	0
40.00	1,000	19,390	18,140,000	1,980	1,940,000	16,200,000	2,550	2,265,000	170	85,000	2,180,000	1,880	1,620,000	0	0	1,620,000	0	0
41.00	1,000	16,890	17,510,000	1,900	1,940,000	15,570,000	1,980	2,045,000	0	0	2,045,000	1,380	1,400,000	0	0	1,400,000	0	0
42.00	1,000	18,130	20,115,000	1,980	2,115,000	18,000,000	2,110	2,245,000	0	0	2,245,000	1,440	1,550,000	0	0	1,550,000	0	0
43.00	1,000	22,100	17,450,000	2,250	2,550,000	14,900,000	2,380	2,155,000	0	95,000	2,060,000	1,660	1,460,000	0	35,000	1,425,000	0	0
44.00	1,000	12,800	16,365,000	2,850	3,045,000	13,320,000	1,930	2,365,000	190	185,000	2,180,000	1,260	1,540,000	70	65,000	1,475,000	0	0
45.00	1,000	19,930	24,130,000	3,240	2,760,000	21,370,000	2,800	2,765,000	180	90,000	2,675,000	1,820	1,870,000	60	30,000	1,840,000	0	0
46.00	0	28,330	0	2,280	0	0	2,730	0	0	0	0	1,920	0	0	0	0	0	0
46.00	1,000	26,180	27,070,000	2,280	2,070,000	25,000,000	2,110	2,315,000	0	0	2,315,000	1,460	1,560,000	0	0	1,560,000	0	0
47.00	0	27,960	0	1,860	0	0	2,520	0	0	0	0	1,660	0	0	0	0	0	0
Sum. 3	10,000		178,335,000		22,930,000	155,405,000		22,065,000		2,610,000	19,455,000		14,950,000		200,000	14,750,000	0	0
47.00	1,000	27,960	18,805,000	1,860	930,000	17,875,000	2,520	2,520,000	0	0	2,520,000	1,660	1,685,000	0	0	1,685,000	0	0
48.00	0	9,650	0	0	0	0	2,520	0	0	0	0	1,710	0	0	0	0	0	0
48.00	1,000	9,640	12,580,000	0	0	12,580,000	2,400	2,475,000	0	0	2,475,000	1,620	1,700,000	0	0	1,700,000	0	0
49.00	1,000	15,520	16,635,000	0	0	16,635,000	2,550	2,595,000	0	0	2,595,000	1,780	1,810,000	0	0	1,810,000	0	0
50.00	1,000	17,750	17,260,000	0	420,000	16,840,000	2,640	2,435,000	0	50,000	2,385,000	1,840	1,705,000	0	60,000	1,645,000	0	0
51.00	2,000	16,770	22,290,000	840	2,110,000	20,180,000	2,230	3,460,000	100	100,000	3,360,000	1,570	3,020,000	120	120,000	2,900,000	0	0
53.00	3,000	5,520	8,280,000	1,270	1,905,000	6,375,000	1,230	1,845,000	0	0	1,845,000	1,450	2,175,000	0	0	2,175,000	0	0
56.00	0	4,860	0	0	0	0	2,730	0	0	0	0	1,660	0	0	0	0	0	0
Sum. 4	9,000		95,850,000		5,365,000	90,485,000		15,330,000		150,000	15,180,000		12,095,000		180,000	11,915,000		0
56.00	4,000	4,860	29,840,000	0	8,520,000	21,320,000	2,730	8,880,000	0	540,000	8,320,000	1,660	5,400,000	0	120,000	5,280,000	0	0
60.00	1,000	18,080	11,900,000	4,260	2,720,000	9,180,000	1,700	2,125,000	270	135,000	1,990,000	1,040	1,420,000	60	30,000	1,390,000	0	0
61.00	1,000	13,740	8,625,000	1,180	1,455,000	7,170,000	2,550	2,320,000	0	475,000	1,845,000	1,800	1,350,000	0	40,000	1,310,000	0	0
62.00	2,000	3,510	7,250,000	1,730	2,910,000	4,340,000	2,090	4,640,000	950	950,000	3,690,000	900	2,700,000	80	80,000	2,620,000	0	0
64.00	3,000	3,740	8,045,000	1,180	2,205,000	3,840,000	2,550	5,775,000	0	1,950,000	3,825,000	1,800	3,690,000	0	990,000	2,700,000	0	1,020,000
67.00	2,000	290	290,000	290	290,000	0	1,300	1,650,000	1,300	1,650,000	0	660	960,000	660	960,000	0	680	1,360,000
69.00	1,300	0	0	0	0	0	350	227,500	350	227,500	0	300	195,000	300	195,000	0	680	884,000
70.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	680	0
Sum. 5	14,300		63,950,000		18,100,000	45,850,000		25,597,500		5,927,500	19,670,000		15,715,000		2,415,000	13,300,000	0	3,264,000
L-12																		
Sum. 1	11,800		940,000		940,000	0		12,617,000		12,617,000	0		5,492,000		5,492,000	0		5,532,000
Sum. 2	36,000		296,159,750		110,810,500	185,349,250		102,744,250		39,141,500	63,602,750		35,333,000		13,312,500	22,020,500		13,347,500
Sum. 3	10,000		178,335,000		22,930,000	155,405,000		22,065,000		2,610,000	19,455,000		14,950,000		200,000	14,750,000		0
Sum. 4	9,000		95,850,000		5,365,000	90,485,000		15,330,000		150,000	15,180,000		12,095,000		180,000	11,915,000		0
Sum. 5	14,300		63,950,000		18,100,000	45,850,000		25,597,500		5,927,500	19,670,000		15,715,000		2,415,000	13,300,000		3,264,000
Total	81,100		635,234,750		158,145,500	477,089,250		178,353,750		60,446,000	117,907,750		83,585,000		21,579,500	61,985,500		22,143,500

Total Excavation Vol.	919,317,000
Dry	656,982,500
Wet	262,334,500

Calculation Table of Excavation Volume

L-15

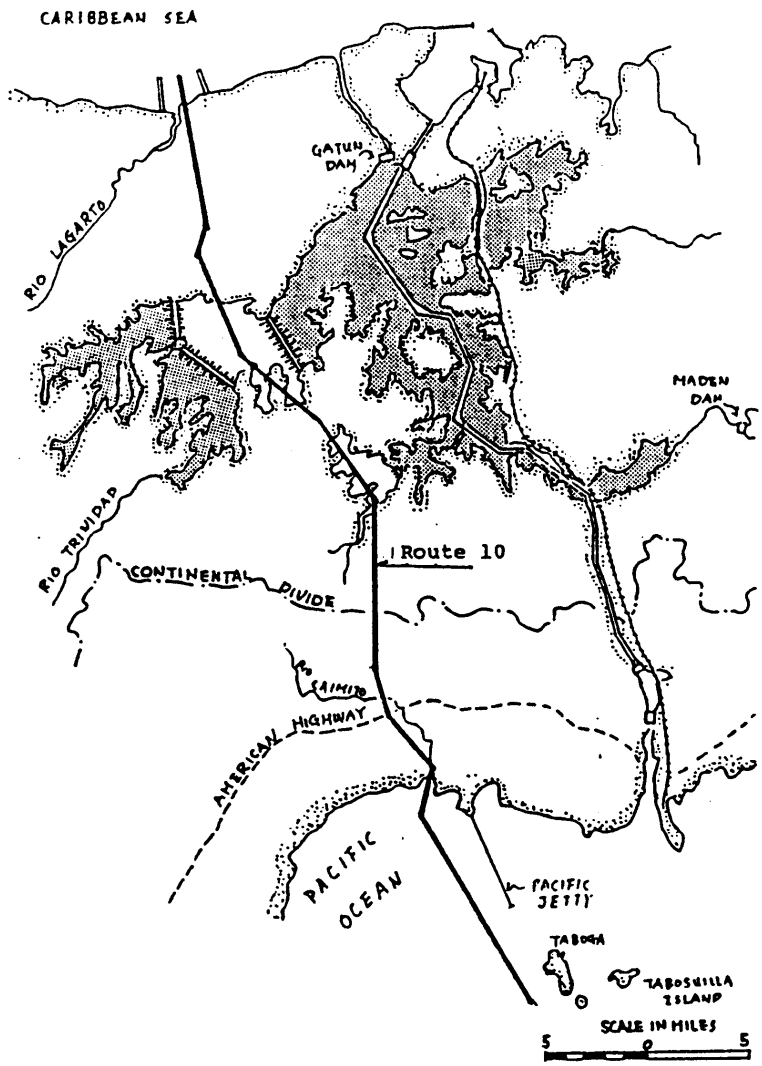
Station	Dis.	Rock					Weathered Rock					Earth					Clayey Material	
		Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
No.	(m)	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	Dry V2	Ao	Vo	Wet A1	Wet V1	Dry V2	Ao	Vo
-11.10	8.100	0	0	0	0		0	9,841,500		9,841,500		0	3,199,500	0	3,199,500	0	0	3,199,500
-3.00	4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	3,220,000
1.00	0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820	0
Sub. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
1.00	50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	0
1.05	1,150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	0
2.20	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	0
2.21	190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	0
2.40	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	0
2.41	590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	0
3.00	2,000	5,300	7,950,000	950	3,600,000	4,350,000	2,520	4,650,000	520	2,650,000	2,000,000	1,760	2,480,000	0	720,000	1,760,000	0	720,000
5.00	500	2,650	1,445,000	2,650	1,445,000	0	2,130	1,072,500	2,130	1,072,500	0	720	362,500	720	362,500	0	720	367,500
5.50	500	2,130	1,807,500	3,130	1,807,500	0	2,160	1,010,000	2,160	1,010,000	0	730	365,000	730	365,000	0	740	370,000
6.00	1,000	4,100	3,190,000	4,100	3,190,000	0	1,880	2,015,000	1,880	2,015,000	0	730	725,000	730	725,000	0	740	735,000
7.00	1,000	2,280	3,935,000	2,280	3,935,000	0	2,150	2,180,000	2,150	2,180,000	0	720	745,000	720	745,000	0	730	755,000
8.00	1,000	5,590	4,005,000	5,590	4,005,000	0	2,210	2,180,000	2,210	2,180,000	0	770	745,000	770	745,000	0	780	755,000
9.00	1,000	2,420	3,980,000	2,420	3,980,000	0	2,150	2,185,000	2,150	2,185,000	0	720	735,000	720	735,000	0	730	755,000
10.00	1,000	5,540	4,375,000	5,540	4,375,000	0	2,220	2,145,000	2,220	2,145,000	0	750	740,000	750	740,000	0	780	760,000
11.00	1,000	3,210	3,970,000	3,210	3,970,000	0	2,070	2,135,000	2,070	2,135,000	0	730	735,000	730	735,000	0	740	745,000
12.00	1,000	4,730	4,370,000	4,730	4,370,000	0	2,200	2,185,000	2,200	2,185,000	0	740	740,000	740	740,000	0	750	750,000
13.00	500	4,010	2,415,000	4,010	2,415,000	0	2,170	1,125,000	2,170	1,125,000	0	740	380,000	740	380,000	0	750	385,000
13.50	500	5,650	2,752,500	5,850	2,752,500	0	2,330	1,140,000	2,330	1,140,000	0	780	382,500	780	382,500	0	790	387,500
14.00	1,000	5,360	5,075,000	5,360	5,075,000	0	2,230	2,220,000	2,230	2,220,000	0	750	745,000	750	745,000	0	760	770,000
15.00	1,000	4,790	9,815,000	4,790	2,395,000	7,420,000	2,210	2,415,000	2,210	1,105,000	1,310,000	740	1,265,000	740	370,000	895,000	780	390,000
16.00	1,000	14,840	15,820,000	0	3,305,000	12,515,000	2,620	2,145,000	0	145,000	2,000,000	1,790	1,385,000	0	60,000	1,325,000	0	0
17.00	1,000	16,800	12,290,000	6,610	7,195,000	5,095,000	1,670	1,950,000	290	1,260,000	690,000	980	885,000	120	435,000	430,000	0	395,000
18.00	1,000	7,780	6,190,000	7,780	6,190,000	0	2,230	2,210,000	2,230	2,210,000	0	750	745,000	750	745,000	0	790	770,000
19.00	1,000	4,600	8,955,000	4,600	5,820,000	3,135,000	2,190	1,865,000	2,190	1,305,000	560,000	740	760,000	740	370,000	390,000	750	375,000
20.00	1,000	13,310	9,785,000	7,040	6,650,000	3,135,000	1,540	1,875,000	420	1,315,000	560,000	780	775,000	0	385,000	390,000	0	390,000
21.00	1,000	6,260	5,635,000	6,260	5,635,000	0	2,210	2,210,000	2,210	2,210,000	0	770	755,000	770	755,000	0	780	765,000
22.00	1,000	5,010	6,515,000	5,010	6,515,000	0	2,210	2,260,000	2,210	2,260,000	0	740	775,000	740	775,000	0	750	785,000
23.00	1,000	8,020	8,280,000	8,020	8,280,000	0	2,310	2,340,000	2,310	2,340,000	0	810	815,000	810	815,000	0	820	825,000
24.00	1,000	8,540	10,020,000	8,540	7,855,000	2,165,000	2,370	1,950,000	2,370	1,410,000	540,000	820	835,000	820	465,000	370,000	830	415,000
25.00	1,000	11,500	12,445,000	7,170	6,885,000	5,560,000	1,530	1,580,000	450	340,000	1,240,000	850	885,000	110	55,000	830,000	0	0
26.00	0	13,390	0	6,600	0	0	1,630	0	230	0	0	920	0	0	0	0	0	0
26.00	1,000	13,740	15,110,000	6,840	3,420,000	11,690,000	1,710	2,205,000	230	115,000	2,090,000	1,020	1,430,000	0	0	1,430,000	0	0
27.00	1,000	16,480	19,485,000	0	0	19,485,000	2,700	2,795,000	0	0	2,795,000	1,840	1,960,000	0	0	1,960,000	0	0
28.00	1,000	22,490	21,990,000	0	1,380,000	20,610,000	2,890	2,815,000	0	65,000	2,750,000	2,080	1,870,000	0	0	1,870,000	0	0
29.00	1,000	21,490	14,440,000	2,760	5,075,000	9,365,000	2,740	2,590,000	130	1,285,000	1,305,000	1,660	1,260,000	0	430,000	830,000	0	435,000
30.00	1,000	7,390	10,570,000	7,390	6,780,000	3,790,000	2,440	2,005,000	2,440	1,265,000	740,000	860	910,000	860	430,000	480,000	870	435,000
31.00	1,000	13,750	9,710,000	6,170	5,920,000	3,790,000	1,570	1,925,000	90	1,185,000	740,000	960	885,000	0	385,000	480,000	0	390,000
32.00	1,000	5,670	7,995,000	5,670	6,545,000	1,450,000	2,280	1,545,000	2,280	1,155,000	390,000	770	585,000	770	385,000	200,000	780	390,000
33.00	1,000	10,320	14,730,000	7,420	3,710,000	11,020,000	810	1,795,000	30	15,000	1,780,000	400	1,150,000	0	0	1,150,000	0	0
34.00	1,000	19,140	32,650,000	0	0	32,650,000	2,780	3,100,000	0	0	3,100,000	1,900	2,115,000	0	0	2,115,000	0	0
35.00	1,000	46,160	34,270,000	0	0	34,270,000	3,420	3,360,000	0	0	3,360,000	2,330	2,275,000	0	0	2,275,000	0	0
36.00	1,000	22,380	18,845,000	0	1,840,000	17,005,000	3,300	2,605,000	0	100,000	2,505,000	2,220	1,770,000	0	50,000	1,720,000	0	0
37.00	0	15,310	0	3,680	0	0	1,910	0	200	0	0	1,320	0	100	0	0	0	0
Sub. 2	36.000		365,308,250		148,203,000	217,105,250		80,819,500		46,364,000	34,455,500		39,647,000		15,030,000	24,617,000	0	15,025,000
37.00	1.000	15,310	13,580,000	3,680	2,905,000	10,675,000	1,910	2,010,000	200	155,000	1,855,000	1,320	1,330,000	100	50,000	1,280,000	0	0
38.00	0	11,850	0	2,130	0	0	2,110	0	110	0	0	1,340	0	0	0	0	0	0
39.00	1,000	15,260	19,400,000	2,220	2,385,000	17,015,000	2,220	2,385,000	170	85,000	2,300,000	1,460	1,780,000	40	20,000	1,740,000	0	0
40.00	1,000	23,540	20,215,000	2,550	2,405,000	17,810,000	2,550	2,405,000	0	0	2,405,000	2,060	1,800,000	0	0	1,800,000	0	0
41.00	1,000	16,890	19,305,000	2,260	2,320,000	16,985,000	2,260	2,320,000	0	0	2,320,000	1,540	1,580,000	0	0	1,580,000	0	0
42.00	1,000	21,720	24,240,000	2,380	2,440,000	21,800,000	2,380	2,440,000	0	0	2,440,000	1,620	1,640,000	0	0	1,640,000	0	0
43.00	1,000	26,760	21,770,000	2,500	2,350,000	19,420,000	2,500	2,350,000	0	95,000	2,255,000	1,660	1,555,000	0	0	1,555,000	0	0
44.00	1,000	16,780	20,990,000	2,200	2,635,000	18,355,000	2,200	2,635,000	190	185,000	2,450,000	1,450	1,710,000	0	30,000	1,680,000	0	0
45.00	1,000	25,200	29,135,000	3,070	2,900,000	26,235,000	3,070	2,900,000	180	90,000	2,810,000	1,970	1,965,000	60	30,000	1,935,000	0	0
46.00	0	33,070	0	2,730	0	0	2,730	0	0	0	0	1,960	0	0	0	0	0	0
46.00	1,000	31,090	31,215,000	2,390	2,575,000	28,640,000	2,390	2,575,000	0	0	2,575,000	1,560	1,700,000	0	0	1,700,000	0	0
47.00	0	31,340	0	2,760	0	0	2,760	0	0	0	0	1,840	0	0	0	0	0	0
Sub. 3	9.000		199,850,000		22,915,000	176,935,000		22,020,000		610,000	21,410,000		15,040,000		130,000	14,910,000		0
47.00	4.000	31,340	86,420,000	2,760	5,520,000	80,900,000	2,760	11,140,000	0	0	11,140,000	1,840	7,460,000	0	0	7,460,000	0	0
48.00	0	11,870	0	0	0	0	2,810	0	0	0	0	1,890	0	0	0	0	0	0
48.00	1,000	11,720	26,625,000	0	0	26,625,000	2,670	2,725,000	0	0	2,725,000	1,800	1,880,000	0	0	1,880,000	0	0
49.00	1,000	41,530	31,210,000	0	0	31,210,000	2,780	2,845,000	0	0	2,845,000	1,960	2,000,000	0	0	2,000,000	0	0
50.00	1,000	20,890	19,905,000	0	735,000	19,170,000	2,910	2,840,000	0	50,000	2,590,000	2,040	1,855,000	0	65,000	1,790,000	0	0
51.00	2,000	18,920	28,900,000	1,470	2,740,000	26,160,000	2,370	4,840,000	100	100,000	4,740,000	1,670	4,160,000	130	130,000	4,030,000	0	0
53.00	0	9,980	0	1,270	0	0	2,470	0	0	0	0	2,490	0	0	0	0	0	0
56.00	0	4,860	0	70	0	0	4,030	0	0	0	0	1,290	0	0	0	0	0	0
Sub. 4	9.000		193,060,000		8,995,000	184,065,000		24,190,000		150,000	24,040,000		17,355,000		195,000	17,160,000		0
56.00	4.000	4,860	34,820,000	70	9,860,000	24,960,000	4,030	12,020,000	0	540,000	11,480,000	1,290	5,060,000	0	120,000	4,940,000	0	0
60.00	1,000	12,550	14,380,000	4,860	3,120,000	11,260,000	1,980	2,385,000	270	135,000	2,250,000	1,240	1,570,000	60	30,000	1,540,000	0	0
61.00	1,000	16,210	10,600,000	1,380	1,720,000	8,880,000	2,790	2,605,000	0	475,000	2,130,000	1,900	1,510,000	0	40,000	1,470,000	0	0
62.00	2,000	4,990	11,330,000	2,060	5,100,000	6,230,000	2,420	3,670,000	950	970,000	2,700,000	1,120	1,860,000	80	80,000	1,780,000	0	0
64.00	3,000	6,340	10,695,000	3,040	5,745,000	4,950,000	1,250	4,740,000	20	2,895,000	1,845,000	740	2,250,000	0	1,140,000	1,110,000	0	1,170,000
67.00	2,000	790	790,000	790	790,000	0	1,910	4,320,000	1,910	4,320,000	0	760	1,600,000	760	1,600,000	0	780	1,620,000
69.00	4,500	0	0	0	0	0	2,410	5,422,500	2,410	5,422,500	0	840	1,890,000	840	1,890,000	0	840	1,890,000
73.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub. 5	17.500		82,615,000		26,335,000	56,280,000		35,162,500		14,757,500	20,405,000	0	15,740,000		4,900,000	10,840,000	0	4,680,000
L-15																		
Sub. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
Sub. 2	36.000		365,308,250		148,203,000	217,105,250		80,819,500		46,364,000	34,455,500		39,647,000		15,030,000	24,617,000		15,025,000
Sub. 3	9.000		199,850,000		22,915,000	176,935,000		22,020,000		610,000	21,410,000		15,040,000		130,000	14,910,000		0
Sub. 4	9.000		193,060,000		8,995,000	184,065,000		24,190,000		150,000	24,040,000		17,355,000		195,000	17,160,000		0
Sub. 5	17.500		82,615,000		26,335,000	56,280,000		35,162,500		14,757,500	20,405,000		15,740,000		4,900,000	10,840,000		4,680,000
Total	83.600		842,893,250		208,508,000	634,385,250		181,693,500		81,383,000	100,310,500		94,201,500		26,[illegible]500	67,527,000		26,[illegible]24,500

Total Excavation Vol.	1,144,912,750
Dry	802,222,750
Wet	342,690,000

L-18 Calculation Table of Excavation Volume

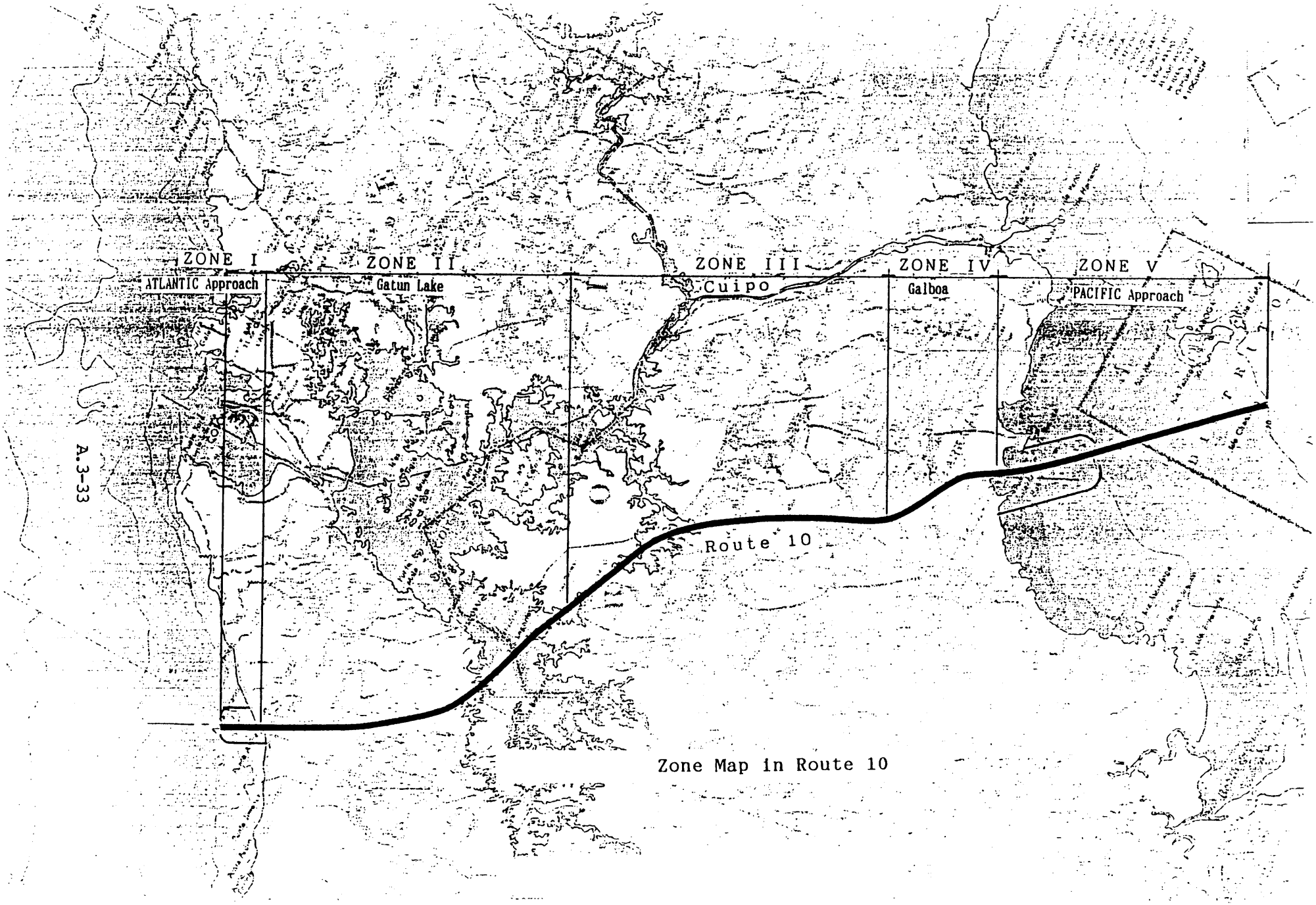
Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Wet Al	Earth Underwater Wet Vl	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
-11.50	8.500	0	9,222,500	0	9,222,500		0	10,710,000		10,710,000		0	4,080,000	0	4,080,000	0	0	4,080,000
-3.00	4.000	2,170	11,620,000	2,170	11,620,000	0	2,520	11,040,000	2,520	11,040,000	0	960	3,920,000	960	3,920,000	0	960	3,920,000
1.00	0	3,640	0	3,640	0	0	3,000	0	3,000	0	0	1,000	0	1,000	0	0	1,000	0
Sum. 1	12.500		20,842,500		20,842,500	0		21,750,000		21,750,000	0		8,000,000		8,000,000	0		8,000,000
1.00	50	3,640	292,000	3,640	114,750	177,250	3,000	150,000	380	22,500	127,500	2,000	100,000	0	0	100,000	0	0
1.05	1,150	8,040	9,246,000	950	1,092,500	8,153,500	3,000	3,450,000	520	598,000	2,852,000	2,000	2,300,000	0	0	2,300,000	0	0
2.20	10	8,040	80,400	950	9,500	70,900	3,000	30,000	520	5,200	24,800	2,000	25,000	0	0	25,000	0	0
2.21	190	8,040	1,527,600	950	180,500	1,347,100	3,000	570,000	520	98,800	471,200	3,000	570,000	0	0	570,000	0	0
2.40	10	8,040	80,400	950	9,500	70,900	3,000	31,650	520	5,200	26,450	3,000	25,000	0	0	25,000	0	0
2.41	590	8,040	4,743,600	950	560,500	4,183,100	3,330	1,964,700	520	306,800	1,657,900	2,000	1,180,000	0	0	1,180,000	0	0
3.00	2,000	8,040	16,160,000	950	1,900,000	14,260,000	3,330	31,680,000	520	1,040,000	30,640,000	2,000	4,000,000	0	720,000	3,280,000	0	730,000
5.00	500	8,120	3,255,000	950	1,462,500	1,792,500	28,350	7,717,500	520	760,000	6,957,500	2,000	712,500	720	392,500	320,000	730	397,500
5.50	500	4,900	2,630,000	4,900	2,630,000	0	2,520	1,262,500	2,520	1,262,500	0	850	425,000	850	425,000	0	860	430,000
6.00	1,000	5,620	4,745,000	5,620	4,745,000	0	2,530	2,520,000	2,530	2,520,000	0	850	845,000	850	845,000	0	860	855,000
7.00	1,000	3,870	5,780,000	3,870	5,780,000	0	2,510	2,545,000	2,510	2,545,000	0	840	865,000	840	865,000	0	850	875,000
8.00	1,000	7,690	6,110,000	7,690	6,110,000	0	2,580	2,490,000	2,580	2,490,000	0	890	870,000	890	870,000	0	900	880,000
9.00	1,000	4,530	6,115,000	4,530	6,115,000	0	2,400	2,490,000	2,400	2,490,000	0	850	875,000	850	875,000	0	860	885,000
10.00	1,000	7,700	6,440,000	7,700	6,440,000	0	2,580	2,565,000	2,580	2,565,000	0	900	880,000	900	880,000	0	910	890,000
11.00	1,000	5,180	6,025,000	5,180	6,025,000	0	2,550	2,560,000	2,550	2,560,000	0	860	860,000	860	860,000	0	870	870,000
12.00	1,000	6,870	6,390,000	6,870	6,390,000	0	2,570	2,575,000	2,570	2,575,000	0	860	860,000	860	860,000	0	870	870,000
13.00	500	5,910	3,495,000	5,910	3,495,000	0	2,580	1,325,000	2,580	1,325,000	0	860	445,000	860	445,000	0	870	450,000
13.50	500	8,070	3,900,000	8,070	3,900,000	0	2,720	1,330,000	2,720	1,330,000	0	920	447,500	920	447,500	0	930	452,500
14.00	1,000	7,530	7,225,000	7,530	7,225,000	0	2,600	2,590,000	2,600	2,590,000	0	870	870,000	870	870,000	0	880	880,000
15.00	1,000	6,920	12,750,000	6,920	3,460,000	9,290,000	2,580	2,760,000	2,580	1,290,000	1,470,000	870	1,435,000	870	435,000	1,000,000	880	440,000
16.00	1,000	18,580	19,535,000	0	4,360,000	15,175,000	2,940	2,460,000	0	210,000	2,250,000	2,000	1,555,000	0	60,000	1,495,000	0	0
17.00	1,000	20,490	15,220,000	8,720	9,335,000	5,885,000	1,980	2,280,000	420	1,500,000	780,000	1,110	990,000	120	495,000	495,000	0	450,000
18.00	1,000	9,950	8,310,000	9,950	8,310,000	0	2,580	2,570,000	2,580	2,570,000	0	870	865,000	870	865,000	0	900	885,000
19.00	1,000	6,670	12,075,000	6,670	7,685,000	4,390,000	2,560	2,140,000	2,560	1,490,000	650,000	860	895,000	860	430,000	465,000	870	435,000
20.00	1,000	17,480	13,040,000	8,700	8,650,000	4,390,000	1,720	2,150,000	420	1,500,000	650,000	930	910,000	0	445,000	465,000	0	450,000
21.00	1,000	8,600	7,865,000	8,600	7,865,000	0	2,580	2,575,000	2,580	2,575,000	0	890	875,000	890	875,000	0	900	885,000
22.00	1,000	7,130	8,825,000	7,130	8,825,000	0	2,570	2,620,000	2,570	2,620,000	0	860	895,000	860	895,000	0	870	905,000
23.00	1,000	10,520	10,855,000	10,520	10,855,000	0	2,670	2,700,000	2,670	2,700,000	0	930	930,000	930	930,000	0	940	940,000
24.00	1,000	11,190	12,825,000	11,190	9,945,000	2,880,000	2,730	2,220,000	2,730	1,590,000	630,000	930	950,000	930	520,000	430,000	940	470,000
25.00	1,000	14,460	15,870,000	8,700	8,530,000	7,340,000	1,710	1,755,000	450	340,000	1,415,000	970	1,005,000	110	55,000	950,000	0	0
26.00	0	17,280	0	8,360	0	0	1,800	0	230	0	0	1,040	0	0	0	0	0	0
26.00	1,000	17,480	18,770,000	8,540	4,270,000	14,500,000	1,870	2,465,000	230	115,000	2,350,000	1,140	1,610,000	0	0	1,610,000	0	0
27.00	1,000	20,060	23,635,000	0	0	23,635,000	3,060	3,195,000	0	0	3,195,000	2,080	2,210,000	0	0	2,210,000	0	0
28.00	1,000	27,210	26,830,000	0	2,005,000	24,825,000	3,330	3,130,000	0	65,000	3,065,000	2,340	2,070,000	0	0	2,070,000	0	0
29.00	1,000	26,450	18,350,000	4,010	7,130,000	11,220,000	2,930	2,920,000	130	1,520,000	1,400,000	1,800	1,390,000	0	490,000	900,000	0	500,000
30.00	1,000	10,250	14,285,000	10,250	9,095,000	5,190,000	2,910	2,370,000	2,910	1,500,000	870,000	980	1,050,000	980	490,000	560,000	1,000	500,000
31.00	1,000	18,320	13,130,000	7,940	7,940,000	5,190,000	1,830	2,235,000	90	1,365,000	870,000	1,120	1,010,000	0	450,000	560,000	0	455,000
32.00	1,000	7,940	10,855,000	7,940	8,615,000	2,240,000	2,640	1,845,000	2,640	1,335,000	510,000	900	720,000	900	450,000	270,000	910	455,000
33.00	1,000	13,770	18,475,000	9,290	4,645,000	13,830,000	1,050	2,100,000	30	15,000	2,085,000	540	1,340,000	0	0	1,340,000	0	0
34.00	1,000	23,180	38,000,000	0	0	38,000,000	3,150	3,405,000	0	0	3,405,000	2,140	2,335,000	0	0	2,335,000	0	0
35.00	1,000	52,820	40,460,000	0	0	40,460,000	3,660	3,660,000	0	0	3,660,000	2,530	2,550,000	0	0	2,550,000	0	0
36.00	1,000	28,100	22,940,000	0	2,925,000	20,015,000	3,860	2,865,000	0	180,000	2,685,000	2,570	1,945,000	0	50,000	1,895,000	0	0
37.00	0	17,780	0	5,850	0	0	2,070	0	360	0	0	1,320	0	100	0	0	0	0
Sum. 2	36.000		477,140,000		198,629,750	278,510,250		326,266,350		51,569,000	74,697,350		46,690,000		17,290,000	29,400,000	0	17,235,000
37.00	1,000	17,780	16,975,000	5,850	4,175,000	12,800,000	2,070	2,320,000	360	235,000	2,085,000	1,320	1,500,000	100	50,000	1,450,000	0	0
38.00	1,000	16,170	17,245,000	2,500	2,600,000	14,645,000	2,570	2,585,000	110	140,000	2,445,000	1,680	1,685,000	0	20,000	1,665,000	0	0
39.00	1,000	18,320	24,165,000	2,700	2,600,000	21,565,000	2,600	2,865,000	170	85,000	2,580,000	1,690	1,935,000	40	40,000	1,895,000	0	0
40.00	1,000	30,010	28,115,000	2,500	2,500,000	25,615,000	2,730	2,690,000	0	0	2,690,000	2,180	1,935,000	40	20,000	1,915,000	0	0
41.00	1,000	26,220	26,745,000	2,500	2,550,000	24,195,000	2,650	2,705,000	0	0	2,705,000	1,860	2,020,000	0	0	2,020,000	0	0
42.00	1,000	27,270	29,845,000	2,600	2,750,000	27,095,000	2,760	2,765,000	0	0	2,765,000	1,880	1,870,000	0	0	1,870,000	0	0
43.00	1,000	32,420	27,500,000	2,900	3,370,000	24,130,000	2,770	2,670,000	0	95,000	2,575,000	1,840	1,860,000	0	35,000	1,825,000	0	0
44.00	1,000	22,580	27,410,000	3,840	4,220,000	23,190,000	2,570	2,955,000	190	185,000	2,770,000	1,690	1,765,000	70	65,000	1,700,000	0	0
45.00	1,000	32,240	35,420,000	4,600	3,800,000	31,620,000	3,340	3,035,000	180	90,000	2,945,000	2,200	1,945,000	60	30,000	1,915,000	0	0
46.00	0	38,600	0	3,000	0	0	2,730	0	0	0	0	1,960	0	0	0	0	0	0
46.00	1,000	37,280	39,160,000	3,000	2,700,000	36,460,000	2,730	2,880,000	0	0	2,880,000	1,800	1,880,000	0	0	1,880,000	0	0
47.00	0	41,040	0	2,400	0	0	3,030	0	0	0	0	2,080	0	0	0	0	0	0
Sum. 3	10,000		272,580,000		31,265,000	241,315,000		27,270,000		830,000	26,440,000		18,395,000		260,000	18,135,000	0	0
47.00	4,000	18,770	70,040,000	2,400	4,800,000	65,240,000	3,030	12,240,000	0	0	12,240,000	2,360	9,000,000	0	0	9,000,000	0	0
48.00	0	15,250	0	0	0	0	3,090	0	0	0	0	2,140	0	0	0	0	0	0
48.00	1,000	15,130	18,775,000	0	0	18,775,000	3,060	3,120,000	0	0	3,120,000	2,060	2,120,000	0	0	2,120,000	0	0
49.00	1,000	22,420	23,695,000	0	0	23,695,000	3,180	3,185,000	0	0	3,185,000	2,180	2,190,000	0	0	2,190,000	0	0
50.00	1,000	24,970	23,570,000	0	1,230,000	22,340,000	3,190	2,875,000	0	50,000	2,825,000	2,200	2,000,000	0	65,000	1,935,000	0	0
51.00	2,000	22,170	44,340,000	2,460	4,920,000	39,420,000	2,560	5,120,000	100	200,000	4,920,000	1,800	3,600,000	130	260,000	3,340,000	0	0
53.00	0	22,170	0	2,460	0	0	2,560	0	100	0	0	1,800	0	130	0	0	0	0
56.00	0	16,170	0	7,210	0	0	2,220	0	420	0	0	1,310	0	60	0	0	0	0
Sum. 4	9.000		180,420,000		10,950,000	169,470,000		26,540,000		250,000	26,290,000		18,910,000		325,000	18,585,000		0
56.00	4,000	16,170	64,680,000	7,210	28,840,000	35,840,000	2,220	8,880,000	420	1,680,000	7,200,000	1,310	5,240,000	60	240,000	5,000,000	0	0
60.00	1,000	16,170	17,990,000	7,210	4,425,000	13,565,000	2,220	2,655,000	420	210,000	2,445,000	1,310	1,725,000	60	30,000	1,695,000	0	0
61.00	1,000	19,810	13,920,000	1,640	2,225,000	11,695,000	3,090	2,980,000	0	475,000	2,505,000	2,140	1,780,000	0	40,000	1,740,000	0	0
62.00	2,000	8,030	16,940,000	2,810	6,340,000	10,600,000	2,870	4,570,000	950	970,000	3,600,000	1,420	12,440,000	80	80,000	12,360,000	0	0
64.00	3,000	8,910	16,845,000	3,530	8,775,000	8,070,000	1,700	6,465,000	20	3,945,000	2,520,000	11,020	17,895,000	0	1,365,000	16,530,000	0	1,395,000
67.00	2,000	2,320	4,640,000	2,320	4,640,000	0	2,610	5,220,000	2,610	5,220,000	0	910	1,820,000	910	1,820,000	0	930	1,860,000
69.00	8,900	2,320	10,324,000	2,320	10,324,000	0	2,610	11,614,500	2,610	11,614,500	0	910	4,049,500	910	4,049,500	0	930	4,138,500
77.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	21,900		145,339,000		65,569,000	79,770,000		42,384,500		24,114,500	18,270,000		44,949,500		7,624,500	37,325,000	0	7,393,500
L-18																		
Sum. 1	12,500		20,842,500		20,842,500	0		21,750,000		21,750,000	0		8,000,000		8,000,000	0		8,000,000
Sum. 2	36.000		477,140,000		198,629,750	278,510,250		326,266,350		51,569,000	74,697,350		46,690,000		17,290,000	29,400,000		17,235,000
Sum. 3	10,000		272,580,000		31,265,000	241,315,000		27,270,000		830,000	26,440,000		18,395,000		260,000	18,135,000		0
Sum. 4	9,000		180,420,000		10,950,000	169,470,000		26,540,000		250,000	26,290,000		18,910,000		325,000	18,585,000		0
Sum. 5	21,900		145,339,000		65,569,000	79,770,000		42,384,500		24,114,500	18,270,000		44,949,500		7,624,500	37,325,000		7,393,500
Total	89.400		1,096,321,500		327,256,250	769,065,250		244,210,850		98,513,500	145,697,350		136,944,500		33,499,500	103,445,000		32,628,500

Total Excavation Vol.	1,510,105,350
Dry	1,018,207,600
Wet	491,897,750



Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size (m)
S-1	10	0	-	1	150	147 x 20.9
2	10	0	-	2	150	343 x 20.9
3	10	0	-	1	250	171 x 24.2
4	10	0	-	2	250	399 x 24.2
5	10	0	-	1	300	183 x 25.3
6	10	0	-	2	300	424 x 25.3
13	10	0	-	50%-1	150	147 x 20.9
				50%-2		343 x 20.9
14	10	0	-	50%-1	250	171 x 24.2
				50%-2		399 x 24.2
15	10	0	-	50%-1	300	183 x 25.3
				50%-2		424 x 25.3

Layout of Sea Level Canal
for Group C Study Cases (Route 10)



Zone Map in Route 10

S-1 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
-2.50	2.500	0	1,962,500	0	1,062,500	0	0	1,250,000	0	1,250,000	0	0	425,000	0	425,000	0	0	425,000
0.00	1.000	850	2,747,500	850	425,000	2,322,500	1,000	1,220,000	1,000	500,000	720,000	340	650,000	340	170,000	480,000	340	170,000
1.00	0	4,645	0	0	0	0	1,440	0	0	0	0	960	0	0	0	0	0	0
Subt. 1	3.500		3,810,000	0	1,487,500	2,322,500		2,470,000		1,750,000	720,000		1,075,000		595,000	480,000		595,000
1.00	1.000	4,645	5,852,500	0	0	5,852,500	1,440	1,470,000	0	0	1,470,000	960	980,000	0	0	980,000	0	0
2.00	1.000	7,060	6,125,000	0	0	6,125,000	1,500	1,530,000	0	0	1,530,000	1,000	1,020,000	0	0	1,020,000	0	0
3.00	1.000	5,190	8,155,000	0	0	8,155,000	1,560	1,800,000	0	0	1,800,000	1,040	1,200,000	0	0	1,200,000	0	0
4.00	1.000	11,120	17,850,000	0	0	17,850,000	2,040	2,280,000	0	0	2,280,000	1,360	1,520,000	0	0	1,520,000	0	0
5.00	1.000	21,580	20,490,000	0	0	20,490,000	2,520	2,340,000	0	0	2,340,000	1,680	1,560,000	0	0	1,560,000	0	0
6.00	1.000	16,400	14,795,000	0	0	14,795,000	2,160	2,160,000	0	0	2,160,000	1,440	1,440,000	0	0	1,440,000	0	0
7.00	1.000	13,190	8,000,000	0	0	8,000,000	2,160	1,770,000	0	0	1,770,000	1,440	1,180,000	0	0	1,180,000	0	0
8.00	1.000	2,810	3,370,000	0	0	3,370,000	1,380	1,470,000	0	0	1,470,000	920	980,000	0	0	980,000	0	0
9.00	1.000	3,930	3,685,000	0	0	3,685,000	1,560	1,500,000	0	0	1,500,000	1,040	1,000,000	0	0	1,000,000	0	0
10.00	1.000	3,440	4,620,000	0	0	4,620,000	1,440	1,590,000	0	0	1,590,000	960	1,060,000	0	0	1,060,000	0	0
11.00	1.000	5,800	4,655,000	0	0	4,655,000	1,740	1,560,000	0	0	1,560,000	1,160	1,040,000	0	0	1,040,000	0	0
12.00	1.000	3,510	1,755,000	0	0	1,755,000	1,380	5,035,000	0	0	5,035,000	920	960,000	0	0	960,000	0	0
13.00	1.000	4,990	6,720,000	0	0	6,720,000	1,500	1,590,000	0	0	1,590,000	1,000	1,060,000	0	0	1,060,000	0	0
14.00	1.000	8,450	8,050,000	0	0	8,050,000	1,680	1,650,000	0	0	1,650,000	1,120	1,100,000	0	0	1,100,000	0	0
15.00	1.000	7,650	3,825,000	0	0	3,825,000	1,620	4,300,000	0	0	4,300,000	1,080	1,940,000	0	0	1,940,000	0	0
16.00	1.000	0	0	0	0	0	8,690	8,355,000	0	0	8,355,000	2,800	2,850,000	0	0	2,850,000	0	0
17.00	1.000	0	0	0	0	0	8,020	6,730,000	0	0	6,730,000	2,900	2,750,000	0	0	2,750,000	0	0
18.00	1.000	0	0	0	0	0	5,440	6,210,000	0	0	6,210,000	2,600	2,500,000	0	0	2,500,000	0	0
19.00	1.000	0	0	0	0	0	6,980	5,330,000	0	0	5,330,000	2,400	2,300,000	0	0	2,300,000	0	0
20.00	1.000	0	0	0	0	0	3,680	3,525,000	0	0	3,525,000	2,200	2,200,000	0	0	2,200,000	0	0
21.00	1.000	0	0	0	0	0	3,370	3,015,000	0	0	3,015,000	2,200	2,200,000	0	0	2,200,000	0	0
22.00	1.000	0	0	0	0	0	4,710	5,510,000	0	0	5,510,000	2,200	2,325,000	0	0	2,325,000	0	0
23.00	1.000	0	0	0	0	0	6,310	6,265,000	0	0	6,265,000	2,450	2,450,000	0	0	2,450,000	0	0
24.00	1.000	0	0	0	0	0	6,220	6,560,000	0	0	6,560,000	2,450	2,450,000	0	0	2,450,000	0	0
25.00	1.000	0	0	0	0	0	6,900	4,780,000	0	0	4,780,000	2,450	2,300,000	0	0	2,300,000	0	0
26.00	1.000	0	0	0	0	0	2,660	4,640,000	0	0	4,640,000	2,150	2,225,000	0	0	2,225,000	0	0
27.00	0	0	0	0	0	0	6,620	0	0	0	0	2,300	0	0	0	0	0	0
Subt. 2	26.000		117,947,500		0	117,947,500		92,965,000		0	92,965,000		44,590,000		0	44,590,000		0
27.00	1.000	0	0	0	0	0	6,620	7,510,000	0	0	7,510,000	2,300	2,350,000	0	0	2,350,000	0	0
28.00	1.000	0	0	0	0	0	8,400	8,570,000	0	0	8,570,000	2,400	2,450,000	0	0	2,450,000	0	0
29.00	1.000	0	0	0	0	0	8,740	8,380,000	0	0	8,380,000	2,500	2,500,000	0	0	2,500,000	0	0
30.00	1.000	0	0	0	0	0	8,020	7,635,000	0	0	7,635,000	2,500	2,450,000	0	0	2,450,000	0	0
31.00	1.000	0	0	0	0	0	7,250	6,595,000	0	0	6,595,000	2,400	2,375,000	0	0	2,375,000	0	0
32.00	1.000	0	0	0	0	0	5,940	6,275,000	0	0	6,275,000	2,350	2,375,000	0	0	2,375,000	0	0
33.00	1.000	0	0	0	0	0	6,610	5,965,000	0	0	5,965,000	2,400	2,350,000	0	0	2,350,000	0	0
34.00	1.000	0	0	0	0	0	5,320	5,290,000	0	0	5,290,000	2,300	2,325,000	0	0	2,325,000	0	0
35.00	1.000	0	0	0	0	0	5,260	6,430,000	0	0	6,430,000	2,350	2,375,000	0	0	2,375,000	0	0
36.00	1.000	0	0	0	0	0	7,600	5,915,000	0	0	5,915,000	2,400	3,155,000	0	0	3,155,000	0	0
37.00	1.000	0	0	0	0	0	4,230	5,550,000	0	0	5,550,000	3,810	4,080,000	0	0	4,080,000	0	0
38.00	1.000	0	0	0	0	0	6,870	6,580,000	0	0	6,580,000	4,250	4,930,000	0	0	4,930,000	0	0
39.00	1.000	0	0	0	0	0	6,290	9,280,000	0	0	9,280,000	5,610	3,995,000	0	0	3,995,000	0	0
40.00	1.000	0	0	0	0	0	12,270	12,170,000	0	0	12,170,000	2,380	2,450,000	0	0	2,450,000	0	0
41.00	1.000	0	3,185,000	0	0	3,185,000	12,070	11,080,000	0	0	11,080,000	2,520	2,135,000	0	0	2,135,000	0	0
42.00	0	0	0	0	0	0	10,090	0	0	0	0	2,310	0	0	0	0	0	0
42.00	1.000	6,370	5,910,000	0	0	5,910,000	2,500	2,500,000	0	0	2,500,000	1,750	2,030,000	0	0	2,030,000	0	0
43.00	0	5,450	0	0	0	0	2,500	0	0	0	0	1,750	0	0	0	0	0	0
43.00	1.000	5,450	2,725,000	0	0	2,725,000	9,170	8,995,000	0	0	8,995,000	2,310	2,955,000	0	0	2,955,000	0	0
44.00	1.000	0	0	0	0	0	8,820	14,560,000	0	0	14,560,000	3,600	4,275,000	0	0	4,275,000	0	0
45.00	1.000	0	0	0	0	0	20,300	14,560,000	0	0	14,560,000	4,950	13,175,000	0	0	13,175,000	0	0
46.00	1.000	0	27,965,000	0	0	27,965,000	62,040	41,170,000	0	0	41,170,000	21,400	11,265,000	0	0	11,265,000	0	0
47.00	1.000	55,930	52,715,000	0	0	52,715,000	0	31,020,000	0	0	31,020,000	1,130	1,990,000	0	0	1,990,000	0	0
48.00	1.000	49,500	44,430,000	0	0	44,430,000	0	0	0	0	0	2,850	5,145,000	0	0	5,145,000	0	0
49.00	1.000	39,360	27,950,000	0	0	27,950,000	0	0	0	0	0	7,440	4,910,000	0	0	4,910,000	0	0
50.00	0	16,540	0	0	0	0	23,100	0	0	0	0	5,290	0	0	0	0	0	0
50.00	1.000	16,540	15,000,000	0	0	15,000,000	10,200	16,650,000	0	0	16,650,000	2,380	2,380,000	0	0	2,380,000	0	0
51.00	1.000	13,460	6,730,000	0	0	6,730,000	20,770	15,485,000	0	0	15,485,000	2,380	4,990,000	0	0	4,990,000	0	0
52.00	1.000	0	0	0	0	0	29,840	25,305,000	0	0	25,305,000	7,600	5,600,000	0	0	5,600,000	0	0
53.00	0	0	0	0	0	0	10,780	0	0	0	0	3,600	0	0	0	0	0	0
Subt. 3	26.000		186,610,000		0	186,610,000		283,470,000		0	283,470,000		101,010,000		0	101,010,000		0
53.00	1.000	0	0	0	0	0	10,780	10,385,000	0	0	10,385,000	3,600	3,550,000	0	0	3,550,000	0	0
54.00	1.000	0	0	0	0	0	9,990	7,365,000	0	0	7,365,000	3,500	3,025,000	0	0	3,025,000	0	0
55.00	1.000	0	0	0	0	0	4,740	6,315,000	0	0	6,315,000	2,550	2,975,000	0	0	2,975,000	0	0
56.00	1.000	0	0	0	0	0	7,890	8,050,000	0	0	8,050,000	3,400	3,250,000	0	0	3,250,000	0	0
57.00	1.000	0	0	0	0	0	8,210	8,530,000	0	0	8,530,000	3,100	3,450,000	0	0	3,450,000	0	0
58.00	0	0	0	0	0	0	8,850	0	0	0	0	3,800	0	0	0	0	0	0
Subt. 4	5.000		0		0	0		40,645,000		0	40,645,000		16,250,000		0	16,250,000		0
58.00	3.000	0	0	0	0	0	8,850	16,620,000	0	3,345,000	13,275,000	3,800	6,240,000	0	540,000	5,700,000	0	540,000
61.00	9.000	0	0	0	0	0	2,230	11,295,000	2,230	11,295,000	0	360	3,015,000	360	3,015,000	0	360	3,015,000
70.00	13.700	0	0	0	0	0	280	1,918,000	280	1,918,000	0	310	2,123,500	310	2,123,500	0	310	2,123,500
83.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subt. 4	25.700		0		0	0		29,833,000		16,558,000	13,275,000		11,378,500		5,678,500	5,700,000		5,678,500
S-1																		
Subt. 1	3.500		3,810,000		1,487,500	2,322,500		2,470,000		1,750,000	720,000		1,075,000		595,000	480,000		595,000
Subt. 2	26.000		117,947,500		0	117,947,500		92,965,000		0	92,965,000		44,590,000		0	44,590,000		0
Subt. 3	26.000		186,610,000		0	186,610,000		283,470,000		0	283,470,000		101,010,000		0	101,010,000		0
Subt. 4	5.000		0		0	0		40,645,000		0	40,645,000		16,250,000		0	16,250,000		0
Subt. 5	25.700		0		0	0		29,833,000		16,558,000	13,275,000		11,378,500		5,678,500	5,700,000		5,678,500
Total	86.200		308,367,500		1,487,500	306,880,000		449,383,000		18,308,000	431,075,000		174,303,500		6,273,500	168,030,000		6,273,500

Total Excavation Vol.	
	938,327,500
DRY	905,985,000
WET	32,342,500

Calculation Table of Excavation Volume

S-2

LIFT 21AWES 150,000t SHIP

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Al	Earth Underwater Vl	Earth Dry V2	Gravel Material Total Vo	Gravel Material Total
-2.50	2.500	0	2,375,000	0	2,375,000	0	0	2,700,000	0	2,700,000	0	0	937,500	0	937,500	0	0	937,500
0.00	1.000	1,900	6,175,000	1,900	950,000	5,225,000	2,160	2,400,000	2,160	1,080,000	1,320,000	750	1,255,000	750	375,000	880,000	750	375,000
1.00	0	10,450	0	0	0	0	2,640	0	0	0	0	1,760	0	0	0	0	0	
Sum. 1	3.500		8,550,000	0	3,325,000	5,225,000		5,100,000		3,780,000	1,320,000		2,192,500		1,312,500	880,000		1,312,500
1.00	1.000	10,450	12,275,000	0	0	12,275,000	2,640	2,670,000	0	0	2,670,000	1,760	1,780,000	0	0	1,780,000	0	
2.00	1.000	14,100	13,920,000	0	0	13,920,000	2,700	2,790,000	0	0	2,790,000	1,800	1,860,000	0	0	1,860,000	0	
3.00	1.000	13,740	18,075,000	0	0	18,075,000	2,880	2,910,000	0	0	2,910,000	1,920	1,940,000	0	0	1,940,000	0	
4.00	1.000	22,410	33,410,000	0	0	33,410,000	2,940	3,360,000	0	0	3,360,000	1,960	2,240,000	0	0	2,240,000	0	
5.00	1.000	44,410	37,700,000	0	0	37,700,000	3,780	3,510,000	0	0	3,510,000	2,520	2,340,000	0	0	2,340,000	0	
6.00	1.000	30,990	28,545,000	0	0	28,545,000	3,240	3,180,000	0	0	3,180,000	2,160	2,120,000	0	0	2,120,000	0	
7.00	1.000	26,100	16,230,000	0	0	16,230,000	3,120	2,850,000	0	0	2,850,000	2,080	1,900,000	0	0	1,900,000	0	
8.00	1.000	6,360	8,855,000	0	0	8,855,000	2,580	2,670,000	0	0	2,670,000	1,720	1,780,000	0	0	1,780,000	0	
9.00	1.000	11,350	10,750,000	0	0	10,750,000	2,760	2,910,000	0	0	2,910,000	1,840	1,940,000	0	0	1,940,000	0	
10.00	1.000	10,150	12,890,000	0	0	12,890,000	3,060	3,090,000	0	0	3,090,000	2,040	2,060,000	0	0	2,060,000	0	
11.00	1.000	15,630	11,715,000	0	0	11,715,000	3,120	2,850,000	0	0	2,850,000	2,080	1,900,000	0	0	1,900,000	0	
12.00	1.000	7,800	9,665,000	0	0	9,665,000	2,580	2,730,000	0	0	2,730,000	1,720	1,820,000	0	0	1,820,000	0	
13.00	1.000	11,530	14,415,000	0	0	14,415,000	2,880	2,880,000	0	0	2,880,000	1,920	1,920,000	0	0	1,920,000	0	
14.00	1.000	17,300	16,340,000	0	0	16,340,000	2,880	2,820,000	0	0	2,820,000	1,920	1,880,000	0	0	1,880,000	0	
15.00	1.000	15,380	7,690,000	0	0	7,690,000	2,760	9,935,000	0	0	9,935,000	1,840	3,270,000	0	0	3,270,000	0	
16.00	1.000	0	0	0	0	0	17,110	17,670,000	0	0	17,670,000	4,700	4,850,000	0	0	4,850,000	0	
17.00	1.000	0	0	0	0	0	18,230	15,405,000	0	0	15,405,000	5,000	4,800,000	0	0	4,800,000	0	
18.00	1.000	0	0	0	0	0	12,580	12,840,000	0	0	12,840,000	4,600	4,400,000	0	0	4,400,000	0	
19.00	1.000	0	0	0	0	0	13,100	10,660,000	0	0	10,660,000	4,200	4,150,000	0	0	4,150,000	0	
20.00	1.000	0	0	0	0	0	8,220	8,005,000	0	0	8,005,000	4,100	4,100,000	0	0	4,100,000	0	
21.00	1.000	0	0	0	0	0	7,790	8,975,000	0	0	8,975,000	4,100	4,125,000	0	0	4,125,000	0	
22.00	1.000	0	0	0	0	0	10,160	12,340,000	0	0	12,340,000	4,150	4,250,000	0	0	4,250,000	0	
23.00	1.000	0	0	0	0	0	14,520	15,245,000	0	0	15,245,000	4,350	4,425,000	0	0	4,425,000	0	
24.00	1.000	0	0	0	0	0	15,970	15,825,000	0	0	15,825,000	4,500	4,450,000	0	0	4,450,000	0	
25.00	1.000	0	0	0	0	0	15,680	12,110,000	0	0	12,110,000	4,400	4,350,000	0	0	4,350,000	0	
26.00	1.000	0	0	0	0	0	8,540	10,940,000	0	0	10,940,000	4,300	4,275,000	0	0	4,275,000	0	
27.00	0	0	0	0	0	0	13,340	0	0	0	0	4,250	0	0	0	0	0	
Sum. 2	26.000		252,475,000		0	252,475,000		191,170,000		0	191,170,000		78,925,000		0	78,925,000		
													0					
													0					
27.00	1.000	0	0	0	0	0	13,340	14,865,000	0	0	14,865,000	4,250	4,275,000	0	0	4,275,000	0	0
28.00	1.000	0	0	0	0	0	16,390	17,200,000	0	0	17,200,000	4,300	4,400,000	0	0	4,400,000	0	0
29.00	1.000	0	0	0	0	0	16,010	17,745,000	0	0	17,745,000	4,500	4,475,000	0	0	4,475,000	0	0
30.00	1.000	0	0	0	0	0	17,480	16,380,000	0	0	16,380,000	4,450	4,375,000	0	0	4,375,000	0	0
31.00	1.000	0	0	0	0	0	15,280	13,980,000	0	0	13,980,000	4,300	4,300,000	0	0	4,300,000	0	0
32.00	1.000	0	0	0	0	0	12,680	14,070,000	0	0	14,070,000	4,300	3,850,000	0	0	3,850,000	0	0
33.00	1.000	0	0	0	0	0	15,460	13,510,000	0	0	13,510,000	3,400	3,850,000	0	0	3,850,000	0	0
34.00	1.000	0	0	0	0	0	11,560	11,515,000	0	0	11,515,000	4,300	4,300,000	0	0	4,300,000	0	0
35.00	1.000	0	0	0	0	0	11,470	13,990,000	0	0	13,990,000	4,300	4,400,000	0	0	4,400,000	0	0
36.00	1.000	0	0	0	0	0	16,510	12,920,000	0	0	12,920,000	4,500	5,905,000	0	0	5,905,000	0	0
37.00	1.000	0	0	0	0	0	9,330	12,140,000	0	0	12,140,000	7,310	7,395,000	0	0	7,395,000	0	0
38.00	1.000	0	0	0	0	0	14,950	14,040,000	0	0	14,040,000	7,480	8,500,000	0	0	8,500,000	0	0
39.00	1.000	0	0	0	0	0	13,130	17,895,000	0	0	17,895,000	9,520	6,720,000	0	0	6,720,000	0	
40.00	1.000	0	0	0	0	0	22,660	22,330,000	0	0	22,330,000	3,920	3,815,000	0	0	3,815,000	0	
41.00	1.000	0	7,005,000	0	0	7,005,000	22,000	20,860,000	0	0	20,860,000	3,710	3,710,000	0	0	3,710,000	0	
42.00	0	0	0	0	0	0	19,720	0	0	0	0	3,710	0	0	0	0	0	
42.00	1.000	14,010	13,675,000	0	0	13,675,000	4,400	4,400,000	0	0	4,400,000	3,080	3,080,000	0	0	3,080,000	0	0
43.00	0	13,340	0	0	0	0	4,400	0	0	0	0	3,080	0	0	0	0	0	0
43.00	1.000	0	0	0	0	0	19,090	18,980,000	0	0	18,980,000	3,710	4,655,000	0	0	4,655,000	0	0
44.00	1.000	0	0	0	0	0	18,830	26,585,000	0	0	26,585,000	5,800	5,545,000	0	0	5,545,000	0	0
45.00	1.000	0	0	0	0	0	34,340	26,585,000	0	0	26,585,000	5,490	14,845,000	0	0	14,845,000	0	0
46.00	1.000	0	40,290,000	0	0	40,290,000	85,270	59,805,000	0	0	59,805,000	24,200	18,525,000	0	0	18,525,000	0	0
47.00	1.000	80,580	76,555,000	0	0	76,555,000	0	42,635,000	0	0	42,635,000	12,850	8,120,000	0	0	8,120,000	0	0
48.00	1.000	72,530	66,730,000	0	0	66,730,000	0	0	0	0	0	3,390	6,295,000	0	0	6,295,000	0	0
49.00	1.000	60,930	44,890,000	0	0	44,890,000	0	0	0	0	0	9,200	8,065,000	0	0	8,065,000	0	0
50.00	0	28,850	0	0	0	0	29,700	0	0	0	0	6,930	0	0	0	0	0	
50.00	1.000	28,380	14,190,000	0	0	14,190,000	35,900	22,800,000	0	0	22,800,000	3,710	3,745,000	0	0	3,745,000	0	
51.00	1.000	0	0	0	0	0	41,980	28,940,000	0	0	28,940,000	3,780	6,490,000	0	0	6,490,000	0	
52.00	1.000	0	0	0	0	0	47,050	44,515,000	0	0	44,515,000	9,200	7,400,000	0	0	7,400,000	0	0
53.00	0	0	0				20,340					5,600						
Sum. 3	26.000		263,335,000		0	263,335,000		508,665,000		0	508,665,000		161,035,000		0	161,035,000		0
53.00	1.000	0	0	0	0	0	28,340	19,825,000	0	0	19,825,000	5,600	6,050,000	0	0	6,050,000	0	0
54.00	1.000	0	0	0	0	0	19,310	14,510,000	0	0	14,510,000	6,500	5,600,000	0	0	5,600,000	0	0
55.00	1.000	0	0	0	0	0	9,710	12,785,000	0	0	12,785,000	4,700	4,950,000	0	0	4,950,000	0	0
56.00	1.000	0	0	0	0	0	15,880	15,865,000	0	0	15,865,000	5,200	5,050,000	0	0	5,050,000	0	0
57.00	1.000	0	0	0	0	0	15,870	17,690,000	0	0	17,690,000	4,900	5,475,000	0	0	5,475,000	0	0
58.00	0	0	0	0	0	0	19,510	0	0	0	0	6,050	0	0	0	0	0	0
Sum. 4	5.000		0		0	0		80,675,000		0	80,675,000		27,125,000		0	27,125,000		0
58.00	3.000	0	0	0	0	0	19,510	36,675,000	0	7,410,000	29,265,000	6,050	10,215,000	0	1,140,000	9,075,000	0	1,140,000
61.00	9.000	0	0	0	0	0	4,940	25,110,000	4,940	25,110,000	0	760	6,615,000	760	6,615,000	0	760	6,615,000
70.00	13.700	0	0	0	0	0	640	4,384,000	640	4,384,000	0	710	4,863,500	710	4,863,500	0	710	4,863,500
83.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	25.700		0		0	0		66,169,000		36,904,000	29,265,000		21,693,500		12,618,500	9,075,000		12,618,500
S-2																		
Sum. 1	3.500		8,550,000		3,325,000	5,225,000		5,100,000		3,780,000	1,320,000		2,192,500		1,312,500	880,000		1,312,500
Sum. 2	26.000		252,475,000		0	252,475,000		191,170,000		0	191,170,000		78,925,000		0	78,925,000		0
Sum. 3	26.000		263,335,000		0	263,335,000		508,665,000		0	508,665,000		161,035,000		0	161,035,000		0
Sum. 4	5.000		0		0	0		80,675,000		0	80,675,000		27,125,000		0	27,125,000		0
Sum. 5	25.700		0		0	0		66,169,000		36,904,000	29,265,000		21,693,500		12,618,500	9,075,000		12,618,500
Total	86.200		524,360,000		3,325,000	521,035,000		851,779,000		40,684,000	811,095,000		290,971,000		13,931,000	277,040,000		13,931,000

Total Excavation Vol.	1,681,041,000
DRY	1,609,170,000
WET	71,871,000

S-3 Calculation Table of Excavation Volume

Station	Dis.	Rock					Weathered Rock					Earth					Clayey Material	
		Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
No.	(m)	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	Dry V2	Ao	Vo	Wet A1	Wet V1	Dry V2	Ao	Vo
-2.85	2,850	0	2,223,000	0	2,223,000	0	0	1,667,250	0	1,667,250	0	0	598,500	0	598,500	0	0	598,500
0.00	1,000	1,560	3,840,000	1,560	780,000	3,060,000	1,170	1,395,000	1,170	585,000	810,000	420	750,000	420	210,000	540,000	420	210,000
1.00	0	6,120	0	0	0	0	1,620	0	0	0	0	1,080	0	0	0	0	0	0
Sum. 1	3,850		6,063,000	0	3,003,000	3,060,000		3,062,250		2,252,250	810,000		1,348,500		808,500	540,000		808,500
1.00	1,000	6,120	7,285,000	0	0	7,285,000	1,620	1,680,000	0	0	1,680,000	1,080	1,120,000	0	0	1,120,000	0	0
2.00	1,000	8,410	7,620,000	0	0	7,620,000	1,740	1,800,000	0	0	1,800,000	1,160	1,200,000	0	0	1,200,000	0	0
3.00	1,000	6,830	10,310,000	0	0	10,310,000	1,860	2,040,000	0	0	2,040,000	1,240	1,360,000	0	0	1,360,000	0	0
4.00	1,000	13,790	21,135,000	0	0	21,135,000	2,220	2,460,000	0	0	2,460,000	1,480	1,640,000	0	0	1,640,000	0	0
5.00	1,000	28,480	23,830,000	0	0	23,830,000	2,700	2,550,000	0	0	2,550,000	1,800	1,700,000	0	0	1,700,000	0	0
6.00	1,000	19,180	17,620,000	0	0	17,620,000	2,400	2,340,000	0	0	2,340,000	1,600	1,560,000	0	0	1,560,000	0	0
7.00	1,000	16,060	10,045,000	0	0	10,045,000	2,280	1,920,000	0	0	1,920,000	1,520	1,280,000	0	0	1,280,000	0	0
8.00	1,000	4,030	4,995,000	0	0	4,995,000	1,560	1,680,000	0	0	1,680,000	1,040	1,120,000	0	0	1,120,000	0	0
9.00	1,000	5,960	5,275,000	0	0	5,275,000	1,800	1,740,000	0	0	1,740,000	1,200	1,160,000	0	0	1,160,000	0	0
10.00	1,000	4,590	6,305,000	0	0	6,305,000	1,680	1,890,000	0	0	1,890,000	1,120	1,260,000	0	0	1,260,000	0	0
11.00	1,000	8,020	6,415,000	0	0	6,415,000	2,100	1,860,000	0	0	1,860,000	1,400	1,240,000	0	0	1,240,000	0	0
12.00	1,000	4,810	2,405,000	0	0	2,405,000	1,620	9,205,000	0	0	9,205,000	1,080	1,100,000	0	0	1,100,000	0	0
13.00	1,000	6,550	8,460,000	0	0	8,460,000	1,680	1,770,000	0	0	1,770,000	1,120	1,180,000	0	0	1,180,000	0	0
14.00	1,000	10,370	9,815,000	0	0	9,815,000	1,860	1,830,000	0	0	1,830,000	1,240	1,220,000	0	0	1,220,000	0	0
15.00	1,000	9,260	4,630,000	0	0	4,630,000	1,800	5,195,000	0	0	5,195,000	1,200	2,150,000	0	0	2,150,000	0	0
16.00	1,000	0	0	0	0	0	16,790	13,570,000	0	0	13,570,000	3,100	3,150,000	0	0	3,150,000	0	0
17.00	1,000	0	0	0	0	0	10,350	8,775,000	0	0	8,775,000	3,200	3,100,000	0	0	3,100,000	0	0
18.00	1,000	0	0	0	0	0	7,200	7,895,000	0	0	7,895,000	3,000	2,850,000	0	0	2,850,000	0	0
19.00	1,000	0	0	0	0	0	8,590	8,730,000	0	0	8,730,000	2,700	2,600,000	0	0	2,600,000	0	0
20.00	1,000	0	0	0	0	0	4,870	4,715,000	0	0	4,715,000	2,500	2,500,000	0	0	2,500,000	0	0
21.00	1,000	0	0	0	0	0	4,560	4,280,000	0	0	4,280,000	2,500	2,500,000	0	0	2,500,000	0	0
22.00	1,000	0	0	0	0	0	5,990	7,145,000	0	0	7,145,000	2,500	2,650,000	0	0	2,650,000	0	0
23.00	1,000	0	0	0	0	0	8,300	8,255,000	0	0	8,255,000	2,800	2,800,000	0	0	2,800,000	0	0
24.00	1,000	0	0	0	0	0	8,210	8,515,000	0	0	8,515,000	2,800	2,800,000	0	0	2,800,000	0	0
25.00	1,000	0	0	0	0	0	8,820	8,410,000	0	0	8,410,000	2,800	2,700,000	0	0	2,700,000	0	0
26.00	1,000	0	0	0	0	0	4,800	8,140,000	0	0	8,140,000	2,600	2,600,000	0	0	2,600,000	0	0
27.00	0	0	0	0	0	0	8,280	0	0	0	0	2,600	0	0	0	0	0	0
Sum. 2	26,000		146,125,000		0	146,125,000		122,390,000		0	122,390,000		50,540,000		0	50,540,000		0
													0					
													0					
27.00	1,000	0	0	0	0	0	8,280	9,275,000	0	0	9,275,000	2,600	2,650,000	0	0	2,650,000	0	0
28.00	1,000	0	0	0	0	0	10,270	10,550,000	0	0	10,550,000	2,700	2,750,000	0	0	2,750,000	0	0
29.00	1,000	0	0	0	0	0	10,830	10,450,000	0	0	10,450,000	2,800	2,800,000	0	0	2,800,000	0	0
30.00	1,000	0	0	0	0	0	10,070	9,610,000	0	0	9,610,000	2,800	2,750,000	0	0	2,750,000	0	0
31.00	1,000	0	0	0	0	0	9,150	8,290,000	0	0	8,290,000	2,700	2,650,000	0	0	2,650,000	0	0
32.00	1,000	0	0	0	0	0	7,430	8,015,000	0	0	8,015,000	2,600	2,650,000	0	0	2,650,000	0	0
33.00	1,000	0	0	0	0	0	8,080	7,785,000	0	0	7,785,000	2,700	2,650,000	0	0	2,650,000	0	0
34.00	1,000	0	0	0	0	0	6,970	6,900,000	0	0	6,900,000	2,600	2,600,000	0	0	2,600,000	0	0
35.00	1,000	0	0	0	0	0	6,830	6,100,000	0	0	6,100,000	2,600	2,650,000	0	0	2,650,000	0	0
36.00	1,000	0	0	0	0	0	9,370	7,460,000	0	0	7,460,000	2,700	3,560,000	0	0	3,560,000	0	0
37.00	1,000	0	0	0	0	0	5,550	7,110,000	0	0	7,110,000	4,420	4,590,000	0	0	4,590,000	0	0
38.00	1,000	0	0	0	0	0	8,670	8,245,000	0	0	8,245,000	4,760	5,530,000	0	0	5,530,000	0	0
39.00	1,000	0	0	0	0	0	7,820	11,345,000	0	0	11,345,000	6,300	4,535,000	0	0	4,535,000	0	0
40.00	1,000	0	0	0	0	0	14,870	14,545,000	0	0	14,545,000	2,770	2,785,000	0	0	2,785,000	0	0
41.00	1,000	0	4,115,000	0	0	4,115,000	14,220	13,200,000	0	0	13,200,000	2,800	2,380,000	0	0	2,380,000	0	0
42.00	0	0	0	0	0	0	12,180	0	0	0	0	2,550	0	0	0	0	0	0
42.00	1,000	8,230	4,115,000	0	0	4,115,000	2,880	6,375,000	0	0	6,375,000	1,980	2,345,000	0	0	2,345,000	0	0
43.00	0	0	0	0	0	0	3,950	0	0	0	0	1,930	0	0	0	0	0	0
43.00	1,000	7,230	3,615,000	0	0	3,615,000	3,980	7,380,000	0	0	7,380,000	2,730	3,340,000	0	0	3,340,000	0	0
44.00	1,000	0	0	0	0	0	18,820	17,125,000	0	0	17,125,000	3,950	4,405,000	0	0	4,405,000	0	0
45.00	1,000	0	0	0	0	0	23,430	17,125,000	0	0	17,125,000	4,880	12,960,000	0	0	12,960,000	0	0
46.00	1,000	0	0	0	0	0	66,610	45,020,000	0	0	45,020,000	21,060	15,880,000	0	0	15,880,000	0	0
47.00	1,000	0	0	0	0	0	81,160	63,885,000	0	0	63,885,000	10,700	6,850,000	0	0	6,850,000	0	0
48.00	1,000	0	0	0	0	0	63,680	57,410,000	0	0	57,410,000	3,000	5,420,000	0	0	5,420,000	0	0
49.00	1,000	0	0	0	0	0	63,280	48,470,000	0	0	48,470,000	7,840	5,215,000	0	0	5,215,000	0	0
50.00	0	0	0	0	0	0	32,830	0	0	0	0	5,670	0	0	0	0	0	0
50.00	1,000	0	0	0	0	0	27,520	35,175,000	0	0	35,175,000	2,590	2,625,000	0	0	2,625,000	0	0
51.00	1,000	0	0	0	0	0	24,513	26,016,500	0	0	26,016,500	2,668	5,280,000	0	0	5,280,000	0	0
52.00	1,000	0	0	0	0	0	32,980	28,746,500	0	0	28,746,500	7,900	5,900,000	0	0	5,900,000	0	0
53.00	0	0	0	0	0	0	12,870	0	0	0	0	3,900	0	0	0	0	0	0
Sum. 3	26,000		11,845,000		0	11,845,000		493,588,000		0	493,588,000		117,750,000		0	117,750,000		0
53.00	1,000	0	0	0	0	0	12,870	12,480,000	0	0	12,480,000	3,900	3,850,000	0	0	3,850,000	0	0
54.00	1,000	0	0	0	0	0	12,880	9,075,000	0	0	9,075,000	3,800	3,350,000	0	0	3,350,000	0	0
55.00	1,000	0	0	0	0	0	6,980	7,940,000	0	0	7,940,000	2,900	3,200,000	0	0	3,200,000	0	0
56.00	1,000	0	0	0	0	0	9,820	10,040,000	0	0	10,040,000	3,500	3,450,000	0	0	3,450,000	0	0
57.00	1,000	0	0	0	0	0	10,290	10,740,000	0	0	10,740,000	3,400	3,800,000	0	0	3,800,000	0	0
58.00	0	0	0	0	0	0	11,220	0	0	0	0	4,200	0	0	0	0	0	0
Sum. 4	5,000		0		0	0		50,275,000		0	50,275,000		17,850,000		0	17,850,000		0
58.00	3,000	0	0	0	0	0	11,220	21,675,000	0	4,845,000	16,830,000	4,200	6,930,000	0	630,000	6,300,000	0	630,000
61.00	9,000	0	0	0	0	0	3,230	18,540,000	3,230	18,540,000	0	420	3,600,000	420	3,600,000	0	420	3,600,000
70.00	15,700	0	0	0	0	0	890	6,986,500	890	6,986,500	0	380	2,983,000	380	2,983,000	0	380	2,983,000
85.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	27,700		0		0	0		47,201,500		30,371,500	16,830,000		13,513,000		7,213,000	6,300,000		7,213,000
S-3																		
Sum. 1	3,850		6,063,000		3,003,000	3,060,000		3,062,250		2,252,250	810,000		1,348,500		808,500	540,000		808,500
Sum. 2	26,000		146,125,000		0	146,125,000		122,390,000		0	122,390,000		50,540,000		0	50,540,000		0
Sum. 3	26,000		11,845,000		0	11,845,000		493,588,000		0	493,588,000		117,750,000		0	117,750,000		0
Sum. 4	5,000		0		0	0		50,275,000		0	50,275,000		17,850,000		0	17,850,000		0
Sum. 5	27,700		0		0	0		47,201,500		30,371,500	16,830,000		13,513,000		7,213,000	6,300,000		7,213,000
Total	88,550		164,033,000		3,003,000	161,030,000		716,516,750		32,623,750	683,893,000		200,801,500		8,021,500	192,780,000		8,021,500

Total Excavation Vol.	
	1,089,372,750
DRY	1,037,703,000
WET	51,669,750

S-4

Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Wet A1	Earth Underwater Wet V1	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
-2.85	2.850	0	3.676.500	0	3.676.500		0	3.619.500	0	3.619.500		0	1.239.750	0	1.239.750	0	0	1.239.750
0.00	1.000	2.580	8.260.000	2.580	1.290.000	6.970.000	2.540	2.830.000	2.540	1.270.000	1.560.000	870	1.475.000	870	435.000	1.040.000	870	435.000
1.00	0	13.940	0	0	0	0	3.120	0	0	0	0	2.080	0	0	0	0	0	0
Sum 1	3.850		11.936.500	0	4.966.500	6.970.000		6.449.500		4.889.500	1.560.000		2.714.750		1.674.750	1.040.000		1.674.750
1.00	1.000	13.940	15.650.000	0	0	15.650.000	3.120	3.120.000	0	0	3.120.000	2.080	2.080.000	0	0	2.080.000	0	0
2.00	1.000	17.360	17.575.000	0	0	17.575.000	3.120	3.150.000	0	0	3.150.000	2.080	2.100.000	0	0	2.100.000	0	0
3.00	1.000	17.790	22.080.000	0	0	22.080.000	3.180	3.180.000	0	0	3.180.000	2.120	2.120.000	0	0	2.120.000	0	0
4.00	1.000	26.370	39.525.000	0	0	39.525.000	3.180	3.660.000	0	0	3.660.000	2.120	2.440.000	0	0	2.440.000	0	0
5.00	1.000	32.680	44.660.000	0	0	44.660.000	4.140	3.870.000	0	0	3.870.000	2.760	2.580.000	0	0	2.580.000	0	0
6.00	1.000	36.640	34.020.000	0	0	34.020.000	3.600	3.510.000	0	0	3.510.000	2.400	2.360.000	0	0	2.360.000	0	0
7.00	1.000	31.400	20.205.000	0	0	20.205.000	3.420	3.180.000	0	0	3.180.000	2.320	2.140.000	0	0	2.140.000	0	0
8.00	1.000	9.010	12.130.000	0	0	12.130.000	2.940	3.030.000	0	0	3.030.000	1.960	2.020.000	0	0	2.020.000	0	0
9.00	1.000	15.250	15.070.000	0	0	15.070.000	3.120	3.390.000	0	0	3.390.000	2.080	2.260.000	0	0	2.260.000	0	0
10.00	1.000	14.890	17.980.000	0	0	17.980.000	3.660	3.540.000	0	0	3.540.000	2.440	2.360.000	0	0	2.360.000	0	0
11.00	1.000	21.070	15.865.000	0	0	15.865.000	3.420	3.210.000	0	0	3.210.000	2.280	2.140.000	0	0	2.140.000	0	0
12.00	1.000	10.660	5.330.000	0	0	5.330.000	3.000	11.920.000	0	0	11.920.000	2.000	2.140.000	0	0	2.140.000	0	0
13.00	1.000	15.750	18.625.000	0	0	18.625.000	3.420	3.360.000	0	0	3.360.000	2.280	2.240.000	0	0	2.240.000	0	0
14.00	1.000	21.500	20.380.000	0	0	20.380.000	3.300	3.240.000	0	0	3.240.000	2.200	2.160.000	0	0	2.160.000	0	0
15.00	1.000	19.260	9.630.000	0	0	9.630.000	3.180	9.770.000	0	0	9.770.000	2.120	3.760.000	0	0	3.760.000	0	0
16.00	1.000	0	0	0	0	0	20.840	21.905.000	0	0	21.905.000	5.400	5.550.000	0	0	5.550.000	0	0
17.00	1.000	0	0	0	0	0	22.970	19.875.000	0	0	19.875.000	5.700	5.500.000	0	0	5.500.000	0	0
18.00	1.000	0	0	0	0	0	16.780	16.570.000	0	0	16.570.000	5.300	5.050.000	0	0	5.050.000	0	0
19.00	1.000	0	0	0	0	0	16.360	13.695.000	0	0	13.695.000	4.800	4.750.000	0	0	4.750.000	0	0
20.00	1.000	0	0	0	0	0	11.030	10.975.000	0	0	10.975.000	4.700	4.700.000	0	0	4.700.000	0	0
21.00	1.000	0	0	0	0	0	10.920	11.565.000	0	0	11.565.000	4.700	4.750.000	0	0	4.750.000	0	0
22.00	1.000	0	0	0	0	0	13.640	16.215.000	0	0	16.215.000	4.800	4.900.000	0	0	4.900.000	0	0
23.00	1.000	0	0	0	0	0	18.790	19.760.000	0	0	19.760.000	5.000	5.050.000	0	0	5.050.000	0	0
24.00	1.000	0	0	0	0	0	20.730	20.885.000	0	0	20.885.000	5.100	4.450.000	0	0	4.450.000	0	0
25.00	1.000	0	0	0	0	0	21.040	16.625.000	0	0	16.625.000	3.800	4.400.000	0	0	4.400.000	0	0
26.00	1.000	0	0	0	0	0	12.210	14.715.000	0	0	14.715.000	5.000	4.950.000	0	0	4.950.000	0	0
27.00	0	0	0	0	0	0	17.220	0	0	0	0	4.900	0	0	0	0	0	0
Sum 2	26.000		308.725.000		0	308.725.000		247.915.000		0	247.915.000		88.950.000		0	88.950.000		0
													0					
													0					
27.00	1.000	0	0	0	0	0	17.220	18.620.000	0	0	18.620.000	4.900	4.950.000	0	0	4.950.000	0	0
28.00	1.000	0	0	0	0	0	20.020	21.430.000	0	0	21.430.000	5.000	5.050.000	0	0	5.050.000	0	0
29.00	1.000	0	0	0	0	0	22.840	22.415.000	0	0	22.415.000	5.100	5.100.000	0	0	5.100.000	0	0
30.00	1.000	0	0	0	0	0	21.990	20.560.000	0	0	20.560.000	5.100	5.000.000	0	0	5.000.000	0	0
31.00	1.000	0	0	0	0	0	19.130	17.705.000	0	0	17.705.000	4.900	4.900.000	0	0	4.900.000	0	0
32.00	1.000	0	0	0	0	0	16.280	17.660.000	0	0	17.660.000	4.900	4.950.000	0	0	4.950.000	0	0
33.00	1.000	0	0	0	0	0	19.040	17.040.000	0	0	17.040.000	5.000	4.950.000	0	0	4.950.000	0	0
34.00	1.000	0	0	0	0	0	15.040	14.945.000	0	0	14.945.000	4.900	4.900.000	0	0	4.900.000	0	0
35.00	1.000	0	0	0	0	0	14.850	17.955.000	0	0	17.955.000	4.900	5.000.000	0	0	5.000.000	0	0
36.00	1.000	0	0	0	0	0	21.060	16.765.000	0	0	16.765.000	5.100	6.965.000	0	0	6.965.000	0	0
37.00	1.000	0	0	0	0	0	12.470	15.585.000	0	0	15.585.000	8.830	8.750.000	0	0	8.750.000	0	0
38.00	1.000	0	0	0	0	0	18.700	18.295.000	0	0	18.295.000	8.670	9.685.000	0	0	9.685.000	0	0
39.00	1.000	0	0	0	0	0	17.890	22.900.000	0	0	22.900.000	10.700	7.540.000	0	0	7.540.000	0	0
40.00	1.000	0	0	0	0	0	27.910	27.485.000	0	0	27.485.000	4.380	4.290.000	0	0	4.290.000	0	0
41.00	1.000	0	0	0	0	0	27.060	25.800.000	0	0	25.800.000	4.200	3.870.000	0	0	3.870.000	0	0
42.00	0	0	0	0	0	0	24.540	0	0	0	0	4.200	0	0	0	0	0	0
42.00	1.000	0	0	0	0	0	22.930	22.670.000	0	0	22.670.000	3.540	3.925.000	0	0	3.925.000	0	0
43.00	0	0	0	0	0	0	22.410	0	0	0	0	3.540	0	0	0	0	0	0
43.00	1.000	0	0	0	0	0	13.810	18.850.000	0	0	18.850.000	4.310	5.305.000	0	0	5.305.000	0	0
44.00	1.000	0	0	0	0	0	23.890	31.775.000	0	0	31.775.000	6.300	4.710.000	0	0	4.710.000	0	0
45.00	1.000	0	0	0	0	0	39.860	31.775.000	0	0	31.775.000	3.120	14.060.000	0	0	14.060.000	0	0
46.00	1.000	0	0	0	0	0	94.290	66.975.000	0	0	66.975.000	25.000	19.000.000	0	0	19.000.000	0	0
47.00	1.000	0	0	0	0	0	90.450	92.370.000	0	0	92.370.000	13.000	8.300.000	0	0	8.300.000	0	0
48.00	1.000	0	0	0	0	0	81.160	85.805.000	0	0	85.805.000	3.600	6.640.000	0	0	6.640.000	0	0
49.00	1.000	0	0	0	0	0	69.860	75.510.000	0	0	75.510.000	9.680	6.940.000	0	0	6.940.000	0	0
50.00	0	0	0	0	0	0	66.510	0	0	0	0	7.490	0	0	0	0	0	0
50.00	1.000	0	0	0	0	0	52.010	59.260.000	0	0	59.260.000	4.200	4.200.000	0	0	4.200.000	0	0
51.00	1.000	0	0	0	0	0	50.580	51.295.000	0	0	51.295.000	4.200	6.800.000	0	0	6.800.000	0	0
52.00	1.000	0	0	0	0	0	54.100	52.340.000	0	0	52.340.000	9.400	7.800.000	0	0	7.800.000	0	0
53.00	0	0	0	0	0	0	27.880	0	0	0	0	6.200	0	0	0	0	0	0
Sum 3	26.000		0		0	0		883.785.000		0	883.785.000		173.580.000		0	173.580.000		0
53.00	1.000	0	0	0	0	0	27.780	25.930.000	0	0	25.930.000	6.200	6.650.000	0	0	6.650.000	0	0
54.00	1.000	0	0	0	0	0	24.080	18.680.000	0	0	18.680.000	7.100	6.250.000	0	0	6.250.000	0	0
55.00	1.000	0	0	0	0	0	13.280	16.630.000	0	0	16.630.000	5.400	5.600.000	0	0	5.600.000	0	0
56.00	1.000	0	0	0	0	0	19.980	19.815.000	0	0	19.815.000	5.800	5.650.000	0	0	5.650.000	0	0
57.00	1.000	0	0	0	0	0	19.650	22.245.000	0	0	22.245.000	5.500	6.100.000	0	0	6.100.000	0	0
58.00	0	0	0	0	0	0	24.840	0	0	0	0	6.700	0	0	0	0	0	0
Sum 4	5.000		0		0	0		103.300.000		0	103.300.000		30.250.000		0	30.250.000		0
58.00	3.000	0	0	0	0	0	24.840	47.970.000	0	10.710.000	37.260.000	6.700	11.370.000	0	1.320.000	10.050.000	0	1.320.000
61.00	9.000	0	0	0	0	0	7.140	41.535.000	7.140	41.535.000	0	880	7.695.000	880	7.695.000	0	880	7.695.000
70.00	15.700	0	0	0	0	0	2.090	16.406.500	2.090	16.406.500	0	830	6.515.500	830	6.515.500	0	830	6.515.500
85.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum 5	27.700		0		0	0		105.911.500		68.651.500	37.260.000		25.580.500		15.530.500	10.050.000		15.530.500
S-4																		
Sum 1	3.850		11.936.500		4.966.500	6.970.000		6.449.500		4.889.500	1.560.000		2.714.750		1.674.750	1.040.000		1.674.750
Sum 2	26.000		308.725.000		0	308.725.000		247.915.000		0	247.915.000		88.950.000		0	88.950.000		0
Sum 3	26.000		0		0	0		883.785.000		0	883.785.000		173.580.000		0	173.580.000		0
Sum 4	5.000		0		0	0		103.300.000		0	103.300.000		30.250.000		0	30.250.000		0
Sum 5	27.700		0		0	0		105.911.500		68.651.500	37.260.000		25.580.500		15.530.500	10.050.000		15.530.500
Total	88.550		320.661.500		4.966.500	315.695.000		1.347.361.000		73.541.000	1.273.820.000		321.075.250		17.205.250	303.870.000		17.205.250

Total Excavation Vol.	2.006.303.000
DRY	1.893.385.000
WET	112.918.000

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Calculation Table of Excavation Volume

Station	Dis.	Rock					Weathered Rock					Earth					Clayey Material	
		Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
V_0	(m)	Ao	V_0	A1	V1	V2	Ao	V_0	A1	V1	Dry V2	Ao	V_0	A1	V1	V2	Ao	V_0
-2.90	2.900	0	2,769,500	0	2,769,500		0	1,812,500	0	1,812,500		0	638,000	0	638,000	0	0	638,000
0.00	1.000	1,910	5,780,000	1,910	955,000	4,825,000	1,250	1,465,000	1,250	625,000	840,000	440	780,000	440	220,000	560,000	440	220,000
1.00	0	9,650	0	0	0	0	1,680	0	0	0	0	1,120	0	0	0	0	0	0
Sum. 1	3.900		8,549,500	0	3,724,500	4,825,000		3,277,500		2,437,500	840,000		1,418,000		858,000	560,000		858,000
1.00	1.000	6,950	8,100,000	0	0	8,100,000	1,680	1,740,000	0	0	1,740,000	1,120	1,160,000	0	0	1,160,000	0	0
2.00	1.000	9,250	8,285,000	0	0	8,285,000	1,800	1,860,000	0	0	1,860,000	1,200	1,240,000	0	0	1,240,000	0	0
3.00	1.000	7,320	10,960,000	0	0	10,960,000	1,920	2,100,000	0	0	2,100,000	1,280	1,400,000	0	0	1,400,000	0	0
4.00	1.000	14,600	22,150,000	0	0	22,150,000	2,280	2,550,000	0	0	2,550,000	1,520	1,700,000	0	0	1,700,000	0	0
5.00	1.000	29,700	25,180,000	0	0	25,180,000	2,820	2,640,000	0	0	2,640,000	1,880	1,760,000	0	0	1,760,000	0	0
6.00	1.000	20,660	18,940,000	0	0	18,940,000	2,460	2,430,000	0	0	2,430,000	1,640	1,620,000	0	0	1,620,000	0	0
7.00	1.000	17,220	10,775,000	0	0	10,775,000	2,400	2,040,000	0	0	2,040,000	1,600	1,360,000	0	0	1,360,000	0	0
8.00	1.000	4,330	5,400,000	0	0	5,400,000	1,680	1,770,000	0	0	1,770,000	1,120	1,180,000	0	0	1,180,000	0	0
9.00	1.000	6,470	5,810,000	0	0	5,810,000	1,860	1,830,000	0	0	1,830,000	1,240	1,220,000	0	0	1,220,000	0	0
10.00	1.000	5,150	7,035,000	0	0	7,035,000	1,800	1,950,000	0	0	1,950,000	1,200	1,300,000	0	0	1,300,000	0	0
11.00	1.000	8,920	7,125,000	0	0	7,125,000	2,100	1,890,000	0	0	1,890,000	1,400	1,260,000	0	0	1,260,000	0	0
12.00	1.000	5,330	6,225,000	0	0	6,225,000	1,680	6,520,000	0	0	6,520,000	1,120	1,160,000	0	0	1,160,000	0	0
13.00	1.000	7,120	9,195,000	0	0	9,195,000	1,800	1,860,000	0	0	1,860,000	1,200	1,240,000	0	0	1,240,000	0	0
14.00	1.000	11,270	10,750,000	0	0	10,750,000	1,920	1,920,000	0	0	1,920,000	1,280	1,280,000	0	0	1,280,000	0	0
15.00	1.000	10,230	5,115,000	0	0	5,115,000	1,920	6,640,000	0	0	6,640,000	1,280	2,240,000	0	0	2,240,000	0	0
16.00	1.000	0	0	0	0	0	11,360	11,185,000	0	0	11,185,000	3,200	3,300,000	0	0	3,300,000	0	0
17.00	1.000	0	0	0	0	0	11,010	9,405,000	0	0	9,405,000	3,400	3,250,000	0	0	3,250,000	0	0
18.00	1.000	0	0	0	0	0	7,800	8,600,000	0	0	8,600,000	3,100	2,900,000	0	0	2,900,000	0	0
19.00	1.000	0	0	0	0	0	9,400	7,330,000	0	0	7,330,000	2,700	2,650,000	0	0	2,650,000	0	0
20.00	1.000	0	0	0	0	0	5,260	5,245,000	0	0	5,245,000	2,600	2,550,000	0	0	2,550,000	0	0
21.00	1.000	0	0	0	0	0	5,230	5,940,000	0	0	5,940,000	2,500	2,550,000	0	0	2,550,000	0	0
22.00	1.000	0	0	0	0	0	6,650	7,800,000	0	0	7,800,000	2,600	2,500,000	0	0	2,500,000	0	0
23.00	1.000	0	0	0	0	0	8,950	8,950,000	0	0	8,950,000	2,400	2,650,000	0	0	2,650,000	0	0
24.00	1.000	0	0	0	0	0	8,950	9,210,000	0	0	9,210,000	2,900	2,900,000	0	0	2,900,000	0	0
25.00	1.000	0	0	0	0	0	9,470	8,995,000	0	0	8,995,000	2,900	2,800,000	0	0	2,800,000	0	0
26.00	1.000	0	0	0	0	0	4,520	6,785,000	0	0	6,785,000	2,700	2,700,000	0	0	2,700,000	0	0
27.00	0	0	0	0	0	0	9,050	0	0	0	0	2,700	0	0	0	0	0	0
Sum. 2	26.000		161,045,000		0	161,045,000		127,185,000		0	127,185,000		51,870,000		0	51,870,000		0
													0					
													0					
27.00	1.000	0	0	0	0	0	9,050	10,030,000	0	0	10,030,000	2,700	2,750,000	0	0	2,750,000	0	0
28.00	1.000	0	0	0	0	0	11,010	11,385,000	0	0	11,385,000	2,800	2,850,000	0	0	2,850,000	0	0
29.00	1.000	0	0	0	0	0	11,780	11,325,000	0	0	11,325,000	2,900	2,900,000	0	0	2,900,000	0	0
30.00	1.000	0	0	0	0	0	10,890	10,405,000	0	0	10,405,000	2,900	2,850,000	0	0	2,850,000	0	0
31.00	1.000	0	0	0	0	0	9,920	9,970,000	0	0	9,970,000	2,800	2,800,000	0	0	2,800,000	0	0
32.00	1.000	0	0	0	0	0	10,020	9,595,000	0	0	9,595,000	2,800	2,800,000	0	0	2,800,000	0	0
33.00	1.000	0	0	0	0	0	9,170	8,335,000	0	0	8,335,000	2,800	2,700,000	0	0	2,700,000	0	0
34.00	1.000	0	0	0	0	0	7,500	7,530,000	0	0	7,530,000	2,600	2,600,000	0	0	2,600,000	0	0
35.00	1.000	0	0	0	0	0	7,560	8,925,000	0	0	8,925,000	2,800	2,700,000	0	0	2,700,000	0	0
36.00	1.000	0	0	0	0	0	10,290	8,185,000	0	0	8,185,000	2,800	3,740,000	0	0	3,740,000	0	0
37.00	1.000	0	0	0	0	0	6,080	7,830,000	0	0	7,830,000	4,680	4,805,000	0	0	4,805,000	0	0
38.00	1.000	0	0	0	0	0	9,580	8,980,000	0	0	8,980,000	4,930	5,695,000	0	0	5,695,000	0	0
39.00	1.000	0	0	0	0	0	8,380	11,890,000	0	0	11,890,000	8,460	4,665,000	0	0	4,665,000	0	0
40.00	1.000	0	0	0	0	0	15,400	15,370,000	0	0	15,370,000	2,870	2,835,000	0	0	2,835,000	0	0
41.00	1.000	0	0	0	0	0	15,340	14,240,000	0	0	14,240,000	2,800	2,765,000	0	0	2,765,000	0	0
42.00	0	0	0	0	0	0	13,140	0	0	0	0	2,660	0	0	0	0	0	0
42.00	1.000	7,230	7,615,000	0	0	7,615,000	3,900	3,400,000	0	0	3,400,000	2,730	2,660,000	0	0	2,660,000	0	0
43.00	0	8,000	0	0	0	0	2,900	0	0	0	0	2,030	0	0	0	0	0	0
43.00	1.000	0	0	0	0	0	12,410	12,165,000	0	0	12,165,000	2,590	3,345,000	0	0	3,345,000	0	0
44.00	1.000	0	0	0	0	0	11,920	18,350,000	0	0	18,350,000	4,100	4,480,000	0	0	4,480,000	0	0
45.00	1.000	0	0	0	0	0	24,780	18,350,000	0	0	18,350,000	4,860	13,430,000	0	0	13,430,000	0	0
46.00	1.000	0	31,610,000	0	0	31,610,000	68,780	48,770,000	0	0	48,770,000	22,000	16,850,000	0	0	16,850,000	0	0
47.00	1.000	63,220	59,580,000	0	0	59,580,000	0	34,380,000	0	0	34,380,000	11,700	7,350,000	0	0	7,350,000	0	0
48.00	1.000	55,940	50,880,000	0	0	50,880,000	0	0	0	0	0	3,000	5,500,000	0	0	5,500,000	0	0
49.00	1.000	45,820	33,315,000	0	0	33,315,000	0	0	0	0	0	8,000	5,330,000	0	0	5,330,000	0	0
50.00	0	20,810	0	0	0	0	24,300	0	0	0	0	5,670	0	0	0	0	0	0
50.00	1.000	17,680	8,840,000	0	0	8,840,000	11,400	17,850,000	0	0	17,850,000	2,660	8,555,000	0	0	8,555,000	0	0
51.00	1.000	0	0	0	0	0	34,110	22,755,000	0	0	22,755,000	14,450	11,225,000	0	0	11,225,000	0	0
52.00	1.000	0	0	0	0	0	34,850	34,480,000	0	0	34,480,000	8,000	6,050,000	0	0	6,050,000	0	0
53.00	0	0	0	0	0	0	13,780	0	0	0	0	4,100	0	0	0	0	0	0
Sum. 3	28.000		191,840,000		0	191,840,000		362,495,000		0	362,495,000		134,230,000		0	134,230,000		0
53.00	1.000	0	0	0	0	0	13,760	13,235,000	0	0	13,235,000	4,100	4,650,000	0	0	4,650,000	0	0
54.00	1.000	0	0	0	0	0	12,710	9,735,000	0	0	9,735,000	5,200	4,100,000	0	0	4,100,000	0	0
55.00	1.000	0	0	0	0	0	8,760	8,700,000	0	0	8,700,000	3,000	3,300,000	0	0	3,300,000	0	0
56.00	1.000	0	0	0	0	0	10,840	10,880,000	0	0	10,880,000	3,800	3,500,000	0	0	3,500,000	0	0
57.00	1.000	0	0	0	0	0	11,120	11,835,000	0	0	11,835,000	3,400	3,850,000	0	0	3,850,000	0	0
58.00	0	0	0	0	0	0	12,150	0	0	0	0	4,300	0	0	0	0	0	0
Sum. 4	5.000		0		0	0		54,185,000		0	54,185,000		19,400,000		0	19,400,000		0
58.00	3.000	0	0	0	0	0	12,150	23,745,000	0	5,520,000	18,225,000	4,300	7,125,000	0	675,000	6,450,000	0	675,000
61.00	9.000	0	0	0	0	0	3,680	21,915,000	3,680	21,915,000	0	450	3,825,000	450	3,825,000	0	450	3,825,000
70.00	16.700	0	0	0	0	0	1,190	9,938,500	1,190	9,938,500	0	400	3,340,000	400	3,340,000	0	400	3,340,000
86.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	28.700		0		0	0		55,598,500		37,371,500	18,225,000		14,290,000		7,840,000	6,450,000		7,840,000
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Sum. 1	3.900		8,549,500		3,724,500	4,825,000		3,277,500		2,437,500	840,000		1,418,000		858,000	560,000		858,000
Sum. 2	26.000		161,045,000		0	161,045,000		127,185,000		0	127,185,000		51,870,000		0	51,870,000		0
Sum. 3	28.000		191,840,000		0	191,840,000		362,495,000		0	362,495,000		134,230,000		0	134,230,000		0
Sum. 4	5.000		0		0	0		54,185,000		0	54,185,000		19,400,000		0	19,400,000		0
Sum. 5	28.700		0		0	0		55,596,500		37,371,500	18,225,000		14,290,000		7,840,000	6,450,000		7,840,000
Total	89.600		361,434,500		3,724,500	357,710,000		602,739,000		39,809,000	562,930,000		221,208,000		8,698,000	212,510,000		8,698,000

Total Excavation Vol.	1,194,079,500
DRY	1,133,150,000
WET	60,929,500

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S-6 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Water Total Vo
-2.90	2.900	0	6.235.000	0	6.235.000		0	3.915.000	0	3.915.000		0	1.334.000	0	1.334.000	0	0
0.00	1.000	4.300	9.645.000	4.300	2.150.000	7.495.000	2.700	3.000.000	2.700	1.350.000	1.650.000	920	1.560.000	920	460.000	1.100.000	920
1.00	0	14.990	0	0	0	0	3.300	0	0	0	0	2.200	0	0	0	0	0
Sum. 1	3.900		15.880.000	0	8.385.000	7.495.000		6.915.000		5.265.000	1.650.000		2.894.000		1.794.000	1.100.000	
1.00	1.000	14.990	17.460.000	0	0	17.460.000	3.300	3.270.000	0	0	3.270.000	2.200	2.180.000	0	0	2.180.000	0
2.00	1.000	19.930	19.565.000	0	0	19.565.000	3.240	3.270.000	0	0	3.270.000	2.160	2.180.000	0	0	2.180.000	0
3.00	1.000	19.200	23.395.000	0	0	23.395.000	3.300	3.300.000	0	0	3.300.000	2.200	2.200.000	0	0	2.200.000	0
4.00	1.000	27.590	41.750.000	0	0	41.750.000	3.300	3.780.000	0	0	3.780.000	2.200	2.520.000	0	0	2.520.000	0
5.00	1.000	55.910	47.665.000	0	0	47.665.000	4.260	3.990.000	0	0	3.990.000	2.840	2.660.000	0	0	2.660.000	0
6.00	1.000	39.420	36.255.000	0	0	36.255.000	3.720	3.690.000	0	0	3.690.000	2.480	2.460.000	0	0	2.460.000	0
7.00	1.000	33.090	21.370.000	0	0	21.370.000	3.660	3.390.000	0	0	3.390.000	2.440	2.260.000	0	0	2.260.000	0
8.00	1.000	9.650	13.270.000	0	0	13.270.000	3.120	3.210.000	0	0	3.210.000	2.080	2.140.000	0	0	2.140.000	0
9.00	1.000	16.890	16.925.000	0	0	16.925.000	3.300	3.660.000	0	0	3.660.000	2.200	2.440.000	0	0	2.440.000	0
10.00	1.000	16.960	19.895.000	0	0	19.895.000	4.020	3.840.000	0	0	3.840.000	2.680	2.560.000	0	0	2.560.000	0
11.00	1.000	22.830	17.415.000	0	0	17.415.000	3.660	3.390.000	0	0	3.390.000	2.440	2.260.000	0	0	2.260.000	0
12.00	1.000	12.000	14.670.000	0	0	14.670.000	3.120	3.360.000	0	0	3.360.000	2.080	2.240.000	0	0	2.240.000	0
13.00	1.000	17.340	19.765.000	0	0	19.765.000	3.600	3.540.000	0	0	3.540.000	2.400	2.360.000	0	0	2.360.000	0
14.00	1.000	22.190	21.460.000	0	0	21.460.000	3.480	3.390.000	0	0	3.390.000	2.320	2.260.000	0	0	2.260.000	0
15.00	1.000	20.730	10.365.000	0	0	10.365.000	3.300	12.825.000	0	0	12.825.000	2.200	3.900.000	0	0	3.900.000	0
16.00	1.000	0	0	0	0	0	22.350	23.670.000	0	0	23.670.000	5.600	5.750.000	0	0	5.750.000	0
17.00	1.000	0	0	0	0	0	24.990	21.690.000	0	0	21.690.000	5.900	5.750.000	0	0	5.750.000	0
18.00	1.000	0	0	0	0	0	18.390	18.027.500	0	0	18.027.500	5.600	5.300.000	0	0	5.300.000	0
19.00	1.000	0	0	0	0	0	17.665	14.782.500	0	0	14.782.500	5.000	5.000.000	0	0	5.000.000	0
20.00	1.000	0	0	0	0	0	11.900	11.755.000	0	0	11.755.000	5.000	5.000.000	0	0	5.000.000	0
21.00	1.000	0	0	0	0	0	11.610	13.075.000	0	0	13.075.000	5.000	5.000.000	0	0	5.000.000	0
22.00	1.000	0	0	0	0	0	14.540	17.305.000	0	0	17.305.000	5.000	5.100.000	0	0	5.100.000	0
23.00	1.000	0	0	0	0	0	20.070	21.280.000	0	0	21.280.000	5.200	5.250.000	0	0	5.250.000	0
24.00	1.000	0	0	0	0	0	22.490	21.720.000	0	0	21.720.000	5.300	5.300.000	0	0	5.300.000	0
25.00	1.000	0	0	0	0	0	20.950	17.250.000	0	0	17.250.000	5.300	5.250.000	0	0	5.250.000	0
26.00	1.000	0	0	0	0	0	13.550	15.965.000	0	0	15.965.000	5.200	5.200.000	0	0	5.200.000	0
27.00	0	0	0	0	0	0	18.380	0	0	0	0	5.200	0	0	0	0	0
Sum. 2	26.000		341.225.000		0	341.225.000	0	258.425.000		0	258.425.000		94.520.000		0	94.520.000	
27.00	1.000	0	0	0	0	0	18.380	20.010.000	0	0	20.010.000	5.200	5.200.000	0	0	5.200.000	0
28.00	1.000	0	0	0	0	0	21.640	23.015.000	0	0	23.015.000	5.200	5.250.000	0	0	5.250.000	0
29.00	1.000	0	0	0	0	0	24.390	24.075.000	0	0	24.075.000	5.300	5.300.000	0	0	5.300.000	0
30.00	1.000	0	0	0	0	0	23.760	22.105.000	0	0	22.105.000	5.300	5.250.000	0	0	5.250.000	0
31.00	1.000	0	0	0	0	0	20.450	18.875.000	0	0	18.875.000	5.200	5.200.000	0	0	5.200.000	0
32.00	1.000	0	0	0	0	0	17.300	19.430.000	0	0	19.430.000	5.200	4.600.000	0	0	4.600.000	0
33.00	1.000	0	0	0	0	0	21.560	18.890.000	0	0	18.890.000	4.000	4.500.000	0	0	4.500.000	0
34.00	1.000	0	0	0	0	0	16.220	16.200.000	0	0	16.200.000	5.000	5.050.000	0	0	5.050.000	0
35.00	1.000	0	0	0	0	0	16.180	19.560.000	0	0	19.560.000	5.100	5.200.000	0	0	5.200.000	0
36.00	1.000	0	0	0	0	0	22.940	18.315.000	0	0	18.315.000	5.300	7.070.000	0	0	7.070.000	0
37.00	1.000	0	0	0	0	0	13.890	17.070.000	0	0	17.070.000	8.840	8.925.000	0	0	8.925.000	0
38.00	1.000	0	0	0	0	0	20.450	20.010.000	0	0	20.010.000	9.010	10.030.000	0	0	10.030.000	0
39.00	1.000	0	0	0	0	0	19.570	24.760.000	0	0	24.760.000	11.050	7.800.000	0	0	7.800.000	0
40.00	1.000	0	0	0	0	0	29.950	29.370.000	0	0	29.370.000	4.550	4.445.000	0	0	4.445.000	0
41.00	1.000	0	0	0	0	0	28.790	27.740.000	0	0	27.740.000	4.340	4.340.000	0	0	4.340.000	0
42.00	0	0	0	0	0	0	26.690	0	0	0	0	4.340	0	0	0	0	0
42.00	1.000	19.750	19.440.000	0	0	19.440.000	5.300	5.300.000	0	0	5.300.000	3.710	3.710.000	0	0	3.710.000	0
43.00	0	19.130	0	0	0	0	5.300	0	0	0	0	3.710	0	0	0	0	0
43.00	1.000	0	0	0	0	0	28.160	25.945.000	0	0	25.945.000	11.480	8.990.000	0	0	8.990.000	0
44.00	1.000	0	0	0	0	0	25.730	33.965.000	0	0	33.965.000	6.500	6.400.000	0	0	6.400.000	0
45.00	1.000	0	0	0	0	0	32.200	33.965.000	0	0	33.965.000	6.300	15.850.000	0	0	15.850.000	0
46.00	1.000	0	47.490.000	0	0	47.490.000	50.380	70.280.000	0	0	70.280.000	25.400	19.350.000	0	0	19.350.000	0
47.00	1.000	94.980	88.310.000	0	0	88.310.000	0	49.180.000	0	0	49.180.000	13.300	8.480.000	0	0	8.480.000	0
48.00	1.000	81.640	78.270.000	0	0	78.270.000	0	0	0	0	0	3.660	6.750.000	0	0	6.750.000	0
49.00	1.000	74.900	56.325.000	0	0	56.325.000	0	0	0	0	0	9.840	8.770.000	0	0	8.770.000	0
50.00	0	37.750	0	0	0	0	33.000	0	0	0	0	7.700	0	0	0	0	0
50.00	1.000	38.810	18.405.000	0	0	18.405.000	46.800	25.800.000	0	0	25.800.000	4.340	10.385.000	0	0	10.385.000	0
51.00	1.000	0	0	0	0	0	76.370	47.485.000	0	0	47.485.000	16.430	12.965.000	0	0	12.965.000	0
52.00	1.000	0	0	0	0	0	5.800	41.085.000	0	0	41.085.000	9.500	8.000.000	0	0	8.000.000	0
53.00	0	0	0	0	0	0	26.940	0	0	0	0	6.500	0	0	0	0	0
Sum. 3	26.000		308.240.000		0	308.240.000	0	652.430.000		0	652.430.000		197.810.000		0	197.810.000	
53.00	1.000	0	0	0	0	0	28.940	28.455.000	0	0	28.455.000	6.500	6.900.000	0	0	6.900.000	0
54.00	1.000	0	0	0	0	0	25.970	20.540.000	0	0	20.540.000	7.300	6.450.000	0	0	6.450.000	0
55.00	1.000	0	0	0	0	0	15.110	18.420.000	0	0	18.420.000	5.600	5.850.000	0	0	5.850.000	0
56.00	1.000	0	0	0	0	0	21.730	21.580.000	0	0	21.580.000	6.100	5.950.000	0	0	5.950.000	0
57.00	1.000	0	0	0	0	0	21.430	24.255.000	0	0	24.255.000	5.800	6.400.000	0	0	6.400.000	0
58.00	0	0		0			27.080		0			7.000		0		0	
Sum. 4	5.000		0		0	0		111.250.000		0	111.250.000		31.550.000		0	31.550.000	
58.00	3.000	0	0	0	0	0	27.080	52.770.000	0	12.150.000	40.620.000	7.000	11.895.000	0	1.395.000	10.500.000	0
61.00	9.000	0	0	0	0	0	8.100	48.600.000	8.100	48.600.000	0	930	8.190.000	930	8.190.000	0	930
70.00	16.400	0	0	0	0	0	2.700	22.140.000	2.700	22.140.000	0	890	7.298.000	890	7.298.000	0	890
86.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	28.400		0		0	0		123.510.000		82.890.000	40.620.000		27.383.000		16.883.000	10.500.000	
S-6																	
Sum. 1	3.900		15.880.000		8.385.000	7.495.000		6.915.000		5.265.000	1.650.000		2.894.000		1.794.000	1.100.000	
Sum. 2	26.000		341.225.000		0	341.225.000		258.425.000		0	258.425.000		94.520.000		0	94.520.000	
Sum. 3	26.000		308.240.000		0	308.240.000		652.430.000		0	652.430.000		197.810.000		0	197.810.000	
Sum. 4	5.000		0		0	0		111.250.000		0	111.250.000		31.550.000		0	31.550.000	
Sum. 5	28.400		0		0	0		123.510.000		82.890.000	40.620.000		27.383.000		16.883.000	10.500.000	
Total	89.300		665.345.000		8.385.000	656.960.000		1.152.530.000		88.155.000	1.064.375.000		354.157.000		18.677.000	335.480.000	

Total Excavation Vol.	2.190.709.000
DRY	2.056.815.000
WET	133.894.000

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S-13 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Water at Total Ao	Clayey Water at Total Vo
-2.50	2.500	0	2,375,000	0	2,375,000	0	0	2,700,000	0	2,700,000	0	0	937,500	0	937,500	0	0	937,500
0.00	1.000	1,900	6,175,000	1,900	950,000	5,225,000	2,160	2,400,000	2,160	1,080,000	1,320,000	750	1,255,000	750	375,000	880,000	750	375,000
1.00	0	10,450	0	0	0	0	2,640	0	0	0	0	1,760	0	0	0	0	0	0
Sum. 1	3.500		8,550,000	0	3,325,000	5,225,000		5,100,000		3,780,000	1,320,000		2,192,500		1,312,500	880,000		1,312,500
1.00	1.000	10,450	12,275,000	0	0	12,275,000	2,640	2,670,000	0	0	2,670,000	1,760	1,780,000	0	0	1,780,000	0	0
2.00	1.000	14,100	13,920,000	0	0	13,920,000	2,700	2,790,000	0	0	2,790,000	1,800	1,860,000	0	0	1,860,000	0	0
3.00	1.000	13,740	18,075,000	0	0	18,075,000	2,880	2,910,000	0	0	2,910,000	1,920	1,940,000	0	0	1,940,000	0	0
4.00	1.000	22,410	33,410,000	0	0	33,410,000	2,940	3,360,000	0	0	3,360,000	1,960	2,240,000	0	0	2,240,000	0	0
5.00	1.000	44,410	37,700,000	0	0	37,700,000	3,780	3,510,000	0	0	3,510,000	2,520	2,340,000	0	0	2,340,000	0	0
6.00	1.000	30,990	28,545,000	0	0	28,545,000	3,240	3,180,000	0	0	3,180,000	2,160	2,120,000	0	0	2,120,000	0	0
7.00	1.000	26,100	16,230,000	0	0	16,230,000	3,120	2,850,000	0	0	2,850,000	2,080	1,900,000	0	0	1,900,000	0	0
8.00	1.000	6,360	8,855,000	0	0	8,855,000	2,580	2,670,000	0	0	2,670,000	1,720	1,780,000	0	0	1,780,000	0	0
9.00	1.000	11,350	10,750,000	0	0	10,750,000	2,760	2,910,000	0	0	2,910,000	1,840	1,940,000	0	0	1,940,000	0	0
10.00	1.000	10,150	12,890,000	0	0	12,890,000	3,060	3,090,000	0	0	3,090,000	2,040	2,060,000	0	0	2,060,000	0	0
11.00	1.000	15,630	11,715,000	0	0	11,715,000	3,120	2,850,000	0	0	2,850,000	2,080	1,900,000	0	0	1,900,000	0	0
12.00	1.000	7,800	9,665,000	0	0	9,665,000	2,580	2,730,000	0	0	2,730,000	1,720	1,820,000	0	0	1,820,000	0	0
13.00	1.000	11,530	14,415,000	0	0	14,415,000	2,880	2,880,000	0	0	2,880,000	1,920	1,920,000	0	0	1,920,000	0	0
14.00	1.000	17,300	16,340,000	0	0	16,340,000	2,880	2,820,000	0	0	2,820,000	1,920	1,880,000	0	0	1,880,000	0	0
15.00	1.000	15,380	7,690,000	0	0	7,690,000	2,760	9,935,000	0	0	9,935,000	1,840	3,270,000	0	0	3,270,000	0	0
16.00	1.000	0	0	0	0	0	17,110	17,670,000	0	0	17,670,000	4,700	4,850,000	0	0	4,850,000	0	0
17.00	1.000	0	0	0	0	0	16,230	15,405,000	0	0	15,405,000	5,000	4,800,000	0	0	4,800,000	0	0
18.00	1.000	0	0	0	0	0	12,580	12,840,000	0	0	12,840,000	4,600	4,400,000	0	0	4,400,000	0	0
19.00	1.000	0	0	0	0	0	13,100	10,660,000	0	0	10,660,000	4,200	4,150,000	0	0	4,150,000	0	0
20.00	1.000	0	0	0	0	0	8,220	8,005,000	0	0	8,005,000	4,100	4,100,000	0	0	4,100,000	0	0
21.00	1.000	0	0	0	0	0	7,790	8,975,000	0	0	8,975,000	4,100	4,125,000	0	0	4,125,000	0	0
22.00	1.000	0	0	0	0	0	10,160	12,340,000	0	0	12,340,000	4,150	4,250,000	0	0	4,250,000	0	0
23.00	1.000	0	0	0	0	0	14,520	15,245,000	0	0	15,245,000	4,250	4,425,000	0	0	4,425,000	0	0
24.00	1.000	0	0	0	0	0	15,970	15,825,000	0	0	15,825,000	4,500	4,450,000	0	0	4,450,000	0	0
25.00	1.000	0	0	0	0	0	15,680	12,110,000	0	0	12,110,000	4,400	4,350,000	0	0	4,350,000	0	0
26.00	1.000	0	0	0	0	0	8,540	10,940,000	0	0	10,940,000	4,300	4,275,000	0	0	4,275,000	0	0
27.00	0	0	0	0	0	0	13,340	0	0	0	0	4,250	0	0	0	0	0	0
Sum. 2	26.000		252,475,000		0	252,475,000		191,170,000		0	191,170,000		78,925,000		0	78,925,000		
													0					
													0					
27.00	1.000	0	0	0	0	0	6,620	7,510,000	0	0	7,510,000	2,300	2,350,000	0	0	2,350,000	0	0
28.00	1.000	0	0	0	0	0	8,400	8,570,000	0	0	8,570,000	2,400	2,450,000	0	0	2,450,000	0	0
29.00	1.000	0	0	0	0	0	8,740	8,380,000	0	0	8,380,000	2,500	2,500,000	0	0	2,500,000	0	0
30.00	1.000	0	0	0	0	0	8,020	7,635,000	0	0	7,635,000	2,500	2,450,000	0	0	2,450,000	0	0
31.00	1.000	0	0	0	0	0	7,250	6,595,000	0	0	6,595,000	2,400	2,375,000	0	0	2,375,000	0	0
32.00	1.000	0	0	0	0	0	5,940	6,275,000	0	0	6,275,000	2,350	2,375,000	0	0	2,375,000	0	0
33.00	1.000	0	0	0	0	0	6,610	5,965,000	0	0	5,965,000	2,400	2,350,000	0	0	2,350,000	0	0
34.00	1.000	0	0	0	0	0	5,320	5,290,000	0	0	5,290,000	2,300	2,325,000	0	0	2,325,000	0	0
35.00	1.000	0	0	0	0	0	5,260	6,430,000	0	0	6,430,000	2,350	2,375,000	0	0	2,375,000	0	0
36.00	1.000	0	0	0	0	0	7,800	5,915,000	0	0	5,915,000	2,400	3,155,000	0	0	3,155,000	0	0
37.00	1.000	0	0	0	0	0	4,230	5,550,000	0	0	5,550,000	3,910	4,080,000	0	0	4,080,000	0	0
38.00	1.000	0	0	0	0	0	6,870	6,580,000	0	0	6,580,000	4,250	4,930,000	0	0	4,930,000	0	0
39.00	1.000	0	0	0	0	0	6,290	9,280,000	0	0	9,280,000	5,610	3,995,000	0	0	3,995,000	0	0
40.00	1.000	0	0	0	0	0	12,270	12,170,000	0	0	12,170,000	2,380	2,450,000	0	0	2,450,000	0	0
41.00	1.000	0	3,185,000	0	0	3,185,000	12,070	11,080,000	0	0	11,080,000	2,520	2,135,000	0	0	2,135,000	0	0
42.00	0	0	0	0	0	0	10,090	0	0	0	0	2,310	0	0	0	0	0	0
42.00	1.000	6,370	5,910,000	0	0	5,910,000	2,500	2,500,000	0	0	2,500,000	1,750	2,030,000	0	0	2,030,000	0	0
43.00	0	5,450	0	0	0	0	2,500	0	0	0	0	1,750	0	0	0	0	0	0
43.00	1.000	5,450	2,725,000	0	0	2,725,000	9,170	8,995,000	0	0	8,995,000	2,310	2,955,000	0	0	2,955,000	0	0
44.00	1.000	0	0	0	0	0	8,820	14,560,000	0	0	14,560,000	3,600	4,275,000	0	0	4,275,000	0	0
45.00	1.000	0	0	0	0	0	20,300	14,560,000	0	0	14,560,000	4,950	13,175,000	0	0	13,175,000	0	0
46.00	1.000	0	27,965,000	0	0	27,965,000	32,040	41,170,000	0	0	41,170,000	21,400	11,265,000	0	0	11,265,000	0	0
47.00	1.000	55,930	52,715,000	0	0	52,715,000	0	31,020,000	0	0	31,020,000	1,130	1,990,000	0	0	1,990,000	0	0
48.00	1.000	49,500	44,430,000	0	0	44,430,000	0	0	0	0	0	2,850	5,145,000	0	0	5,145,000	0	0
49.00	1.000	39,360	27,950,000	0	0	27,950,000	0	0	0	0	0	7,440	4,910,000	0	0	4,910,000	0	0
50.00	0	16,540	0	0	0	0	23,100	0	0	0	0	5,390	0	0	0	0	0	0
50.00	1.000	16,540	15,000,000	0	0	15,000,000	10,200	16,650,000	0	0	16,650,000	2,380	2,380,000	0	0	2,380,000	0	0
51.00	1.000	13,460	8,730,000	0	0	8,730,000	20,770	15,485,000	0	0	15,485,000	2,380	4,990,000	0	0	4,990,000	0	0
52.00	1.000	0	0	0	0	0	29,840	25,305,000	0	0	25,305,000	7,600	5,600,000	0	0	5,600,000	0	0
53.00	0	0	0	0	0	0	10,780	0	0	0	0	3,600	0	0	0	0	0	0
Sum. 3	26.000		188,610,000		0	188,610,000		283,470,000		0	283,470,000		101,010,000		0	101,010,000		
53.00	1.000	0	0	0	0	0	20,340	19,825,000	0	0	19,825,000	5,600	6,050,000	0	0	6,050,000	0	0
54.00	1.000	0	0	0	0	0	19,310	14,510,000	0	0	14,510,000	6,500	5,600,000	0	0	5,600,000	0	0
55.00	1.000	0	0	0	0	0	9,710	12,785,000	0	0	12,785,000	4,700	4,950,000	0	0	4,950,000	0	0
56.00	1.000	0	0	0	0	0	15,860	15,865,000	0	0	15,865,000	5,200	5,050,000	0	0	5,050,000	0	0
57.00	1.000	0	0	0	0	0	15,870	17,690,000	0	0	17,690,000	4,900	5,475,000	0	0	5,475,000	0	0
58.00	0	0	0	0	0	0	19,510	0	0	0	0	6,050	0	0	0	0	0	0
Sum. 4	5.000		0		0	0		80,675,000		0	80,675,000		27,125,000		0	27,125,000		0
58.00	3.000	0	0	0	0	0	19,510	36,675,000	0	7,410,000	29,265,000	6,050	10,215,000	0	1,140,000	9,075,000	0	1,140,000
61.00	9.000	0	0	0	0	0	4,940	25,110,000	4,940	25,110,000	0	760	6,615,000	760	6,615,000	0	760	6,615,000
70.00	13.700	0	0	0	0	0	640	4,384,000	640	4,384,000	0	710	4,863,500	710	4,863,500	0	710	4,863,500
83.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	25.700		0		0	0		66,169,000		36,904,000	29,265,000		21,693,500		12,618,500	9,075,000		12,618,500
S-13																		
Sum. 1	3.500		8,550,000		3,325,000	5,225,000		5,100,000		3,780,000	1,320,000		2,192,500		1,312,500	880,000		1,312,500
Sum. 2	26.000		252,475,000		0	252,475,000		191,170,000		0	191,170,000		78,925,000		0	78,925,000		0
Sum. 3	26.000		188,610,000		0	188,610,000		283,470,000		0	283,470,000		101,010,000		0	101,010,000		0
Sum. 4	5.000		0		0	0		80,675,000		0	80,675,000		27,125,000		0	27,125,000		0
Sum. 5	25.700		0		0	0		66,169,000		36,904,000	29,265,000		21,693,500		12,618,500	9,075,000		12,618,500
Total	86.200		447,635,000		3,325,000	444,310,000		626,584,000		40,684,000	585,900,000		230,946,000		13,931,000	217,015,000		13,931,000
Station No.	Dis (m)	Hard Rock Ao	Hard Rock Vo	Hard Rock Wet A1	Hard Rock Wet V1	Hard Rock Dry V2	Soft Rock Ao	Soft Rock Vo	Soft Rock Wet A1	Soft Rock Wet V1	Soft Rock Dry V2	Earth Ao	Earth Vo	Earth Wet A1	Earth Wet V1	Earth Dry V2	Mud Ao	Mud Vo

Total Excavation Vol.	1,319,096,000
DRY	1,247,225,000
WET	71,871,000

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S-14 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Al	Earth Underwater Vl	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
-2.85	2.850	0	3.676.500	0	3.676.500		0	3.619.500	0	3.619.500		0	1.239.750	0	1.239.750	0	0	1.239.750
0.00	1.000	2.580	8.260.000	2.580	1.290.000	6.970.000	2.540	2.830.000	2.540	1.270.000	1.560.000	870	1.475.000	870	435.000	1.040.000	870	435.000
1.00	0	13.940	0	0	0	0	3.120	0	0	0	0	2.080	0	0	0	0	0	0
Sum 1	3.850		11.936.500	0	4.966.500	6.970.000		6.449.500		4.889.500	1.560.000		2.714.750		1.674.750	1.040.000		1.674.750
1.00	1.000	13.940	15.650.000	0	0	15.650.000	3.120	3.120.000	0	0	3.120.000	2.080	2.080.000	0	0	2.080.000	0	0
2.00	1.000	17.360	17.575.000	0	0	17.575.000	3.120	3.150.000	0	0	3.150.000	2.080	2.100.000	0	0	2.100.000	0	0
3.00	1.000	17.790	22.080.000	0	0	22.080.000	3.180	3.180.000	0	0	3.180.000	2.120	2.120.000	0	0	2.120.000	0	0
4.00	1.000	26.370	39.525.000	0	0	39.525.000	3.180	3.660.000	0	0	3.660.000	2.120	2.440.000	0	0	2.440.000	0	0
5.00	1.000	52.680	44.660.000	0	0	44.660.000	4.140	3.870.000	0	0	3.870.000	2.760	2.580.000	0	0	2.580.000	0	0
6.00	1.000	36.640	34.020.000	0	0	34.020.000	3.600	3.510.000	0	0	3.510.000	2.400	2.360.000	0	0	2.360.000	0	0
7.00	1.000	31.400	20.205.000	0	0	20.205.000	3.420	3.180.000	0	0	3.180.000	2.320	2.140.000	0	0	2.140.000	0	0
8.00	1.000	9.010	12.130.000	0	0	12.130.000	2.940	3.030.000	0	0	3.030.000	1.960	2.020.000	0	0	2.020.000	0	0
9.00	1.000	15.250	15.070.000	0	0	15.070.000	3.120	3.390.000	0	0	3.390.000	2.080	2.260.000	0	0	2.260.000	0	0
10.00	1.000	14.890	17.980.000	0	0	17.980.000	3.660	3.540.000	0	0	3.540.000	2.440	2.360.000	0	0	2.360.000	0	0
11.00	1.000	21.070	15.865.000	0	0	15.865.000	3.420	3.210.000	0	0	3.210.000	2.280	2.140.000	0	0	2.140.000	0	0
12.00	1.000	10.660	5.330.000	0	0	5.330.000	3.000	11.920.000	0	0	11.920.000	2.000	2.140.000	0	0	2.140.000	0	0
13.00	1.000	15.750	18.625.000	0	0	18.625.000	3.420	3.360.000	0	0	3.360.000	2.280	2.240.000	0	0	2.240.000	0	0
14.00	1.000	21.500	20.380.000	0	0	20.380.000	3.300	3.240.000	0	0	3.240.000	2.200	2.160.000	0	0	2.160.000	0	0
15.00	1.000	19.260	9.630.000	0	0	9.630.000	3.180	9.770.000	0	0	9.770.000	2.120	3.760.000	0	0	3.760.000	0	0
16.00	1.000	0	0	0	0	0	20.840	21.905.000	0	0	21.905.000	5.400	5.550.000	0	0	5.550.000	0	0
17.00	1.000	0	0	0	0	0	22.370	19.875.000	0	0	19.875.000	5.700	5.500.000	0	0	5.500.000	0	0
18.00	1.000	0	0	0	0	0	16.780	16.570.000	0	0	16.570.000	5.300	5.050.000	0	0	5.050.000	0	0
19.00	1.000	0	0	0	0	0	16.360	13.695.000	0	0	13.695.000	4.800	4.750.000	0	0	4.750.000	0	0
20.00	1.000	0	0	0	0	0	11.030	10.975.000	0	0	10.975.000	4.700	4.700.000	0	0	4.700.000	0	0
21.00	1.000	0	0	0	0	0	10.920	11.565.000	0	0	11.565.000	4.700	4.750.000	0	0	4.750.000	0	0
22.00	1.000	0	0	0	0	0	13.640	16.215.000	0	0	16.215.000	4.800	4.900.000	0	0	4.900.000	0	0
23.00	1.000	0	0	0	0	0	18.790	19.780.000	0	0	19.780.000	5.000	5.050.000	0	0	5.050.000	0	0
24.00	1.000	0	0	0	0	0	20.730	20.885.000	0	0	20.885.000	5.100	4.450.000	0	0	4.450.000	0	0
25.00	1.000	0	0	0	0	0	21.040	16.625.000	0	0	16.625.000	5.800	4.400.000	0	0	4.400.000	0	0
26.00	1.000	0	0	0	0	0	12.210	14.715.000	0	0	14.715.000	5.000	4.950.000	0	0	4.950.000	0	0
27.00	0	0	0	0	0	0	17.220	0	0	0	0	4.900	0	0	0	0	0	0
Sum 2	26.000		308.725.000		0	308.725.000		247.915.000		0	247.915.000		88.950.000		0	88.950.000		0
													0					
													0					
27.00	1.000	0	0	0	0	0	8.280	9.275.000	0	0	9.275.000	2.600	2.650.000	0	0	2.650.000	0	0
28.00	1.000	0	0	0	0	0	10.270	10.550.000	0	0	10.550.000	2.700	2.750.000	0	0	2.750.000	0	0
29.00	1.000	0	0	0	0	0	10.830	10.450.000	0	0	10.450.000	2.800	2.800.000	0	0	2.800.000	0	0
30.00	1.000	0	0	0	0	0	10.070	9.610.000	0	0	9.610.000	2.800	2.750.000	0	0	2.750.000	0	0
31.00	1.000	0	0	0	0	0	9.150	8.290.000	0	0	8.290.000	2.700	2.650.000	0	0	2.650.000	0	0
32.00	1.000	0	0	0	0	0	7.430	8.015.000	0	0	8.015.000	2.600	2.650.000	0	0	2.650.000	0	0
33.00	1.000	0	0	0	0	0	8.600	7.785.000	0	0	7.785.000	2.700	2.650.000	0	0	2.650.000	0	0
34.00	1.000	0	0	0	0	0	8.970	8.900.000	0	0	8.900.000	2.600	2.600.000	0	0	2.600.000	0	0
35.00	1.000	0	0	0	0	0	6.830	8.100.000	0	0	8.100.000	2.600	2.650.000	0	0	2.650.000	0	0
36.00	1.000	0	0	0	0	0	9.370	7.460.000	0	0	7.460.000	2.700	3.560.000	0	0	3.560.000	0	0
37.00	1.000	0	0	0	0	0	5.550	7.110.000	0	0	7.110.000	4.420	4.590.000	0	0	4.590.000	0	0
38.00	1.000	0	0	0	0	0	8.670	8.245.000	0	0	8.245.000	5.760	5.530.000	0	0	5.530.000	0	0
39.00	1.000	0	0	0	0	0	7.820	11.345.000	0	0	11.345.000	5.300	4.535.000	0	0	4.535.000	0	0
40.00	1.000	0	0	0	0	0	14.870	14.545.000	0	0	14.545.000	2.770	2.785.000	0	0	2.785.000	0	0
41.00	1.000	0	4.115.000	0	0	4.115.000	14.220	13.200.000	0	0	13.200.000	2.800	2.380.000	0	0	2.380.000	0	0
42.00	0	0	0	0	0	0	12.180	0	0	0	0	2.550	0	0	0	0	0	0
42.00	1.000	8.230	4.115.000	0	0	4.115.000	2.800	6.375.000	0	0	6.375.000	1.960	2.345.000	0	0	2.345.000	0	0
43.00	0	0	0	0	0	0	9.950	0	0	0	0	1.930	0	0	0	0	0	0
43.00	1.000	7.230	3.615.000	0	0	3.615.000	3.900	7.360.000	0	0	7.360.000	2.730	3.340.000	0	0	3.340.000	0	0
44.00	1.000	0	0	0	0	0	10.820	17.125.000	0	0	17.125.000	0.950	4.405.000	0	0	4.405.000	0	0
45.00	1.000	0	0	0	0	0	23.430	17.125.000	0	0	17.125.000	9.860	12.960.000	0	0	12.960.000	0	0
46.00	1.000	0	0	0	0	0	66.610	45.020.000	0	0	45.020.000	>>>>>>	15.880.000	0	0	15.880.000	0	0
47.00	1.000	0	0	0	0	0	61.160	63.885.000	0	0	63.885.000	>>>>>>	6.850.000	0	0	6.850.000	0	0
48.00	1.000	0	0	0	0	0	53.860	57.410.000	0	0	57.410.000	0.000	5.420.000	0	0	5.420.000	0	0
49.00	1.000	0	0	0	0	0	43.280	48.470.000	0	0	48.470.000	7.840	5.215.000	0	0	5.215.000	0	0
50.00	0	0	0	0	0	0	42.830	0	0	0	0	6.870	0	0	0	0	0	0
50.00	1.000	0	0	0	0	0	27.520	35.175.000	0	0	35.175.000	2.590	2.625.000	0	0	2.625.000	0	0
51.00	1.000	0	0	0	0	0	24.513	28.016.500	0	0	28.016.500	2.660	5.280.000	0	0	5.280.000	0	0
52.00	1.000	0	0	0	0	0	32.980	28.746.500	0	0	28.746.500	7.900	5.900.000	0	0	5.900.000	0	0
53.00	0	0	0	0	0	0	12.870	0	0	0	0	0.900	0	0	0	0	0	0
Sum 3	26.000		11.845.000		0	11.845.000		493.588.000		0	493.588.000		117.750.000		0	117.750.000		0
53.00	1.000	0	0	0	0	0	27.780	25.930.000	0	0	25.930.000	6.200	6.650.000	0	0	6.650.000	0	0
54.00	1.000	0	0	0	0	0	24.080	18.680.000	0	0	18.680.000	7.100	6.250.000	0	0	6.250.000	0	0
55.00	1.000	0	0	0	0	0	13.280	16.630.000	0	0	16.630.000	6.400	5.600.000	0	0	5.600.000	0	0
56.00	1.000	0	0	0	0	0	19.980	19.815.000	0	0	19.815.000	6.800	5.650.000	0	0	5.650.000	0	0
57.00	1.000	0	0	0	0	0	19.650	22.245.000	0	0	22.245.000	6.500	6.100.000	0	0	6.100.000	0	0
58.00	0	0	0	0	0	0	24.840	0	0	0	0	6.700	0	0	0	0	0	0
Sum 4	5.000		0		0	0		103.300.000		0	103.300.000		30.250.000		0	30.250.000		0
58.00	3.000	0	0	0	0	0	24.840	47.970.000	0	10.710.000	37.260.000	6.700	11.370.000	0	1.320.000	10.050.000	0	1.320.000
61.00	9.000	0	0	0	0	0	7.140	41.535.000	7.140	41.535.000	0	880	7.695.000	880	7.695.000	0	880	7.695.000
70.00	15.700	0	0	0	0	0	2.090	16.406.500	2.090	16.406.500	0	830	6.515.500	830	6.515.500	0	830	6.515.500
85.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum 5	27.700		0		0	0		105.911.500		68.651.500	37.260.000		25.580.500		15.530.500	10.050.000		15.530.500
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Sum 1	3.850		11.936.500		4.966.500	6.970.000		6.449.500		4.889.500	1.560.000		2.714.750		1.674.750	1.040.000		1.674.750
Sum 2	26.000		308.725.000		0	308.725.000		247.915.000		0	247.915.000		88.950.000		0	88.950.000		0
Sum 3	26.000		11.845.000		0	11.845.000		493.588.000		0	493.588.000		117.750.000		0	117.750.000		0
Sum 4	5.000		0		0	0		103.300.000		0	103.300.000		30.250.000		0	30.250.000		0
Sum 5	27.700		0		0	0		105.911.500		68.651.500	37.260.000		25.580.500		15.530.500	10.050.000		15.530.500
Total	88.550		332.506.500		4.966.500	327.540.000		957.164.000		73.541.000	883.623.000		265.245.250		17.205.250	248.040.000		17.205.250
Station No.	Dis (m)	Hard Rock Ao	Hard Rock Vo	Hard Rock Wet Al	Hard Rock Wet Vl	Hard Rock Dry V2	Soft Rock Ao	Soft Rock Vo	Soft Rock Wet Al	Soft Rock Wet Vl	Soft Rock Dry V2	Earth Ao	Earth Vo	Earth Wet Al	Earth Wet Vl	Earth Dry V2	Mud Ao	Mud Vo

Total Excavation Vol.	1.572.121.000
DRY	1.459.203.000
WET	112.918.000

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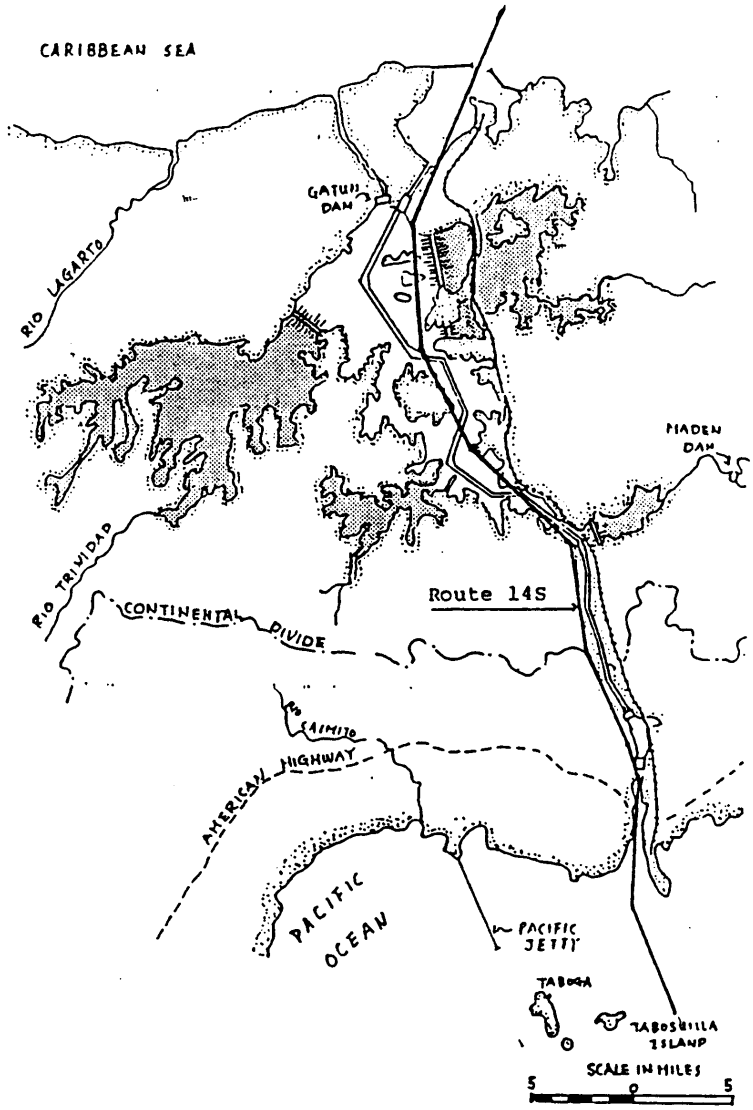
Calculation Table of Excavation Volume

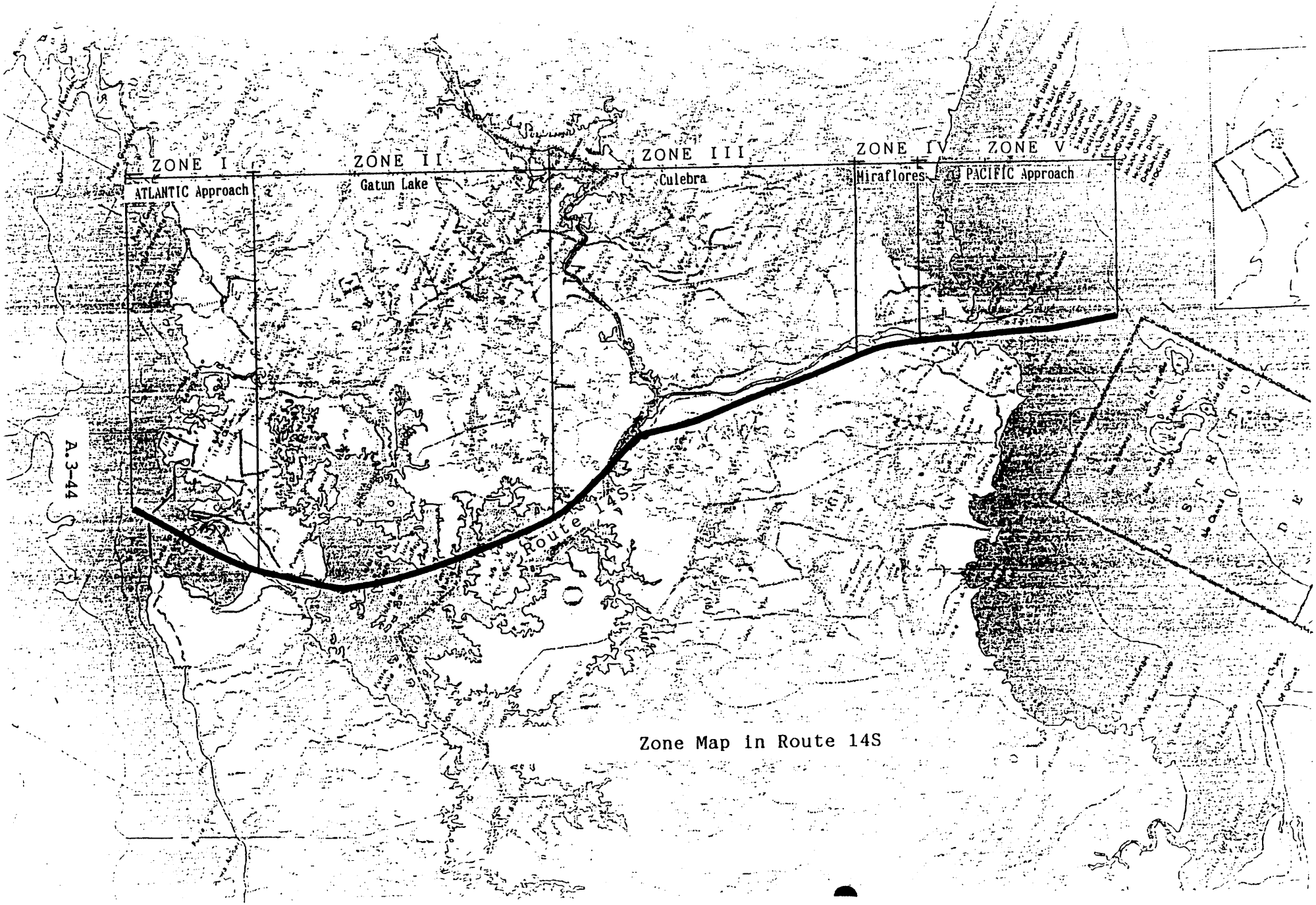
Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total An	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
-2.90	2.900	0	6,235,000	0	6,235,000		0	3,915,000	0	3,915,000		0	1,334,000	0	1,334,000	0	0	1,334,000
0.00	1.000	4.300	9,645,000	4.300	2,150,000	7,495,000	2.700	3,000,000	2.700	1,350,000	1,650,000	920	1,560,000	920	460,000	1,100,000	920	460,000
1.00	0	4.990	0	0	0	0	3.300	0	0	0	0	2.200	0	0	0	0	0	0
Sum. 1	3.900		15,880,000	0	8,385,000	7,495,000		6,915,000		5,265,000	1,650,000		2,894,000		1,794,000	1,100,000		1,794,000
1.00	1.000	14.990	17,460,000	0	0	17,460,000	3.300	3,270,000	0	0	3,270,000	2.200	2,180,000	0	0	2,180,000	0	0
2.00	1.000	19.930	19,565,000	0	0	19,565,000	3.240	3,270,000	0	0	3,270,000	2.160	2,180,000	0	0	2,180,000	0	0
3.00	1.000	19.200	23,395,000	0	0	23,395,000	3.300	3,300,000	0	0	3,300,000	2.200	2,200,000	0	0	2,200,000	0	0
4.00	1.000	27.590	41,750,000	0	0	41,750,000	3.300	3,780,000	0	0	3,780,000	2.200	2,520,000	0	0	2,520,000	0	0
5.00	1.000	55.910	47,665,000	0	0	47,665,000	4.260	3,990,000	0	0	3,990,000	2.840	2,660,000	0	0	2,660,000	0	0
6.00	1.000	39.420	36,255,000	0	0	36,255,000	3.720	3,690,000	0	0	3,690,000	2.480	2,460,000	0	0	2,460,000	0	0
7.00	1.000	33.090	21,370,000	0	0	21,370,000	3.660	3,390,000	0	0	3,390,000	2.440	2,260,000	0	0	2,260,000	0	0
8.00	1.000	9.650	13,270,000	0	0	13,270,000	3.120	3,210,000	0	0	3,210,000	2.080	2,140,000	0	0	2,140,000	0	0
9.00	1.000	16.890	16,925,000	0	0	16,925,000	3.300	3,660,000	0	0	3,660,000	2.200	2,440,000	0	0	2,440,000	0	0
10.00	1.000	16.960	19,895,000	0	0	19,895,000	4.020	3,840,000	0	0	3,840,000	2.680	2,560,000	0	0	2,560,000	0	0
11.00	1.000	22.830	17,415,000	0	0	17,415,000	3.660	3,390,000	0	0	3,390,000	2.440	2,260,000	0	0	2,260,000	0	0
12.00	1.000	12.000	14,670,000	0	0	14,670,000	3.120	3,360,000	0	0	3,360,000	2.080	2,240,000	0	0	2,240,000	0	0
13.00	1.000	17.340	19,765,000	0	0	19,765,000	3.600	3,540,000	0	0	3,540,000	2.400	2,360,000	0	0	2,360,000	0	0
14.00	1.000	22.190	21,460,000	0	0	21,460,000	3.480	3,390,000	0	0	3,390,000	2.320	2,260,000	0	0	2,260,000	0	0
15.00	1.000	20.730	10,365,000	0	0	10,365,000	3.300	12,825,000	0	0	12,825,000	2.200	3,900,000	0	0	3,900,000	0	0
16.00	1.000	0	0	0	0	0	22.350	23,670,000	0	0	23,670,000	5.600	5,750,000	0	0	5,750,000	0	0
17.00	1.000	0	0	0	0	0	24.990	21,690,000	0	0	21,690,000	5.900	5,750,000	0	0	5,750,000	0	0
18.00	1.000	0	0	0	0	0	18.390	18,027,500	0	0	18,027,500	5.600	5,300,000	0	0	5,300,000	0	0
19.00	1.000	0	0	0	0	0	17.665	14,782,500	0	0	14,782,500	5.000	5,000,000	0	0	5,000,000	0	0
20.00	1.000	0	0	0	0	0	11.900	11,755,000	0	0	11,755,000	5.000	5,000,000	0	0	5,000,000	0	0
21.00	1.000	0	0	0	0	0	11.610	13,075,000	0	0	13,075,000	5.000	5,000,000	0	0	5,000,000	0	0
22.00	1.000	0	0	0	0	0	14.540	17,305,000	0	0	17,305,000	5.000	5,100,000	0	0	5,100,000	0	0
23.00	1.000	0	0	0	0	0	20.070	21,280,000	0	0	21,280,000	5.200	5,250,000	0	0	5,250,000	0	0
24.00	1.000	0	0	0	0	0	22.490	21,720,000	0	0	21,720,000	5.300	5,300,000	0	0	5,300,000	0	0
25.00	1.000	0	0	0	0	0	20.950	17,250,000	0	0	17,250,000	5.300	5,250,000	0	0	5,250,000	0	0
26.00	1.000	0	0	0	0	0	13.550	15,965,000	0	0	15,965,000	5.200	5,200,000	0	0	5,200,000	0	0
27.00	0	0	0	0	0	0	18.380	0	0	0	0	5.200	0	0	0	0	0	0
Sum. 2	26.000		341,225,000		0	341,225,000	0	258,425,000		0	258,425,000		94,520,000		0	94,520,000		0
27.00	1.000	0	0	0	0	0	9.050	10,030,000	0	0	10,030,000	2.700	2,750,000	0	0	2,750,000	0	0
28.00	1.000	0	0	0	0	0	11.010	11,385,000	0	0	11,385,000	2.800	2,850,000	0	0	2,850,000	0	0
29.00	1.000	0	0	0	0	0	11.760	11,325,000	0	0	11,325,000	2.900	2,900,000	0	0	2,900,000	0	0
30.00	1.000	0	0	0	0	0	10.890	10,405,000	0	0	10,405,000	2.900	2,850,000	0	0	2,850,000	0	0
31.00	1.000	0	0	0	0	0	9.920	9,970,000	0	0	9,970,000	2.800	2,800,000	0	0	2,800,000	0	0
32.00	1.000	0	0	0	0	0	10.020	9,595,000	0	0	9,595,000	2.800	2,800,000	0	0	2,800,000	0	0
33.00	1.000	0	0	0	0	0	9.170	8,335,000	0	0	8,335,000	2.800	2,700,000	0	0	2,700,000	0	0
34.00	1.000	0	0	0	0	0	7.500	7,530,000	0	0	7,530,000	2.600	2,600,000	0	0	2,600,000	0	0
35.00	1.000	0	0	0	0	0	7.560	8,925,000	0	0	8,925,000	2.600	2,700,000	0	0	2,700,000	0	0
36.00	1.000	0	0	0	0	0	10.290	8,185,000	0	0	8,185,000	2.800	3,740,000	0	0	3,740,000	0	0
37.00	1.000	0	0	0	0	0	8.080	7,830,000	0	0	7,830,000	4.680	4,805,000	0	0	4,805,000	0	0
38.00	1.000	0	0	0	0	0	9.580	8,980,000	0	0	8,980,000	4.930	5,695,000	0	0	5,695,000	0	0
39.00	1.000	0	0	0	0	0	8.380	11,890,000	0	0	11,890,000	6.460	4,665,000	0	0	4,665,000	0	0
40.00	1.000	0	0	0	0	0	15.400	15,370,000	0	0	15,370,000	2.870	2,835,000	0	0	2,835,000	0	0
41.00	1.000	0	0	0	0	0	15.340	14,240,000	0	0	14,240,000	2.800	2,765,000	0	0	2,765,000	0	0
42.00	0	0	0	0	0	0	13.140	0	0	0	0	2.660	0	0	0	0	0	0
42.00	1.000	7.220	7,615,000	0	0	7,615,000	3.900	3,400,000	0	0	3,400,000	2.730	2,660,000	0	0	2,660,000	0	0
43.00	0	8.000	0	0	0	0	2.900	0	0	0	0	2.030	0	0	0	0	0	0
43.00	1.000	0	0	0	0	0	12.410	12,165,000	0	0	12,165,000	2.590	3,345,000	0	0	3,345,000	0	0
44.00	1.000	0	0	0	0	0	11.920	18,350,000	0	0	18,350,000	4.100	4,480,000	0	0	4,480,000	0	0
45.00	1.000	0	0	0	0	0	24.780	18,350,000	0	0	18,350,000	4.860	13,430,000	0	0	13,430,000	0	0
46.00	1.000	0	31,610,000	0	0	31,610,000	68.760	46,770,000	0	0	46,770,000	22.000	16,850,000	0	0	16,850,000	0	0
47.00	1.000	63.220	59,580,000	0	0	59,580,000	0	34,380,000	0	0	34,380,000	11.700	7,350,000	0	0	7,350,000	0	0
48.00	1.000	65.940	50,880,000	0	0	50,880,000	0	0	0	0	0	3.000	5,500,000	0	0	5,500,000	0	0
49.00	1.000	45.820	33,315,000	0	0	33,315,000	0	0	0	0	0	8.000	5,330,000	0	0	5,330,000	0	0
50.00	0	20.810	0	0	0	0	24.300	0	0	0	0	5.670	0	0	0	0	0	0
50.00	1.000	17.580	8,840,000	0	0	8,840,000	11.400	17,850,000	0	0	17,850,000	2.660	8,555,000	0	0	8,555,000	0	0
51.00	1.000	0	0	0	0	0	34.110	22,755,000	0	0	22,755,000	4.450	11,225,000	0	0	11,225,000	0	0
52.00	1.000	0	0	0	0	0	34.850	34,480,000	0	0	34,480,000	8.000	6,050,000	0	0	6,050,000	0	0
53.00	0	0	0	0	0	0	13.760	0	0	0	0	4.100	0	0	0	0	0	0
Sum. 3	26.000		191,840,000		0	191,840,000	0	362,495,000		0	362,495,000		134,230,000		0	134,230,000		0
53.00	1.000	0	0	0	0	0	26.940	26,455,000	0	0	26,455,000	6.500	6,900,000	0	0	6,900,000	0	0
54.00	1.000	0	0	0	0	0	25.970	28,540,000	0	0	28,540,000	7.300	6,450,000	0	0	6,450,000	0	0
55.00	1.000	0	0	0	0	0	15.110	18,420,000	0	0	18,420,000	5.600	5,850,000	0	0	5,850,000	0	0
56.00	1.000	0	0	0	0	0	21.730	21,580,000	0	0	21,580,000	6.100	5,950,000	0	0	5,950,000	0	0
57.00	1.000	0	0	0	0	0	21.430	24,255,000	0	0	24,255,000	5.800	6,400,000	0	0	6,400,000	0	0
58.00	0	0		0			27.080		0			7.000		0			0	
Sum. 4	5.000		0		0	0		111,250,000		0	111,250,000		31,550,000		0	31,550,000		0
58.00	3.000	0	0	0	0	0	27.080	52,770,000	0	12,150,000	40,620,000	7.000	11,895,000	0	1,395,000	10,500,000	0	1,395,000
61.00	9.000	0	0	0	0	0	8.100	48,600,000	8.100	48,600,000	0	930	8,190,000	930	8,190,000	0	930	8,190,000
70.00	16.400	0	0	0	0	0	2.700	22,140,000	2.700	22,140,000	0	890	7,298,000	890	7,298,000	0	890	7,298,000
86.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	28.400		0		0	0		123,510,000		82,890,000	40,620,000		27,383,000		16,883,000	10,500,000		16,883,000
S-15																		
Sum. 1	3.900		15,880,000		8,385,000	7,495,000		6,915,000		5,265,000	1,650,000		2,894,000		1,794,000	1,100,000		1,794,000
Sum. 2	26.000		341,225,000		0	341,225,000		258,425,000		0	258,425,000		94,520,000		0	94,520,000		0
Sum. 3	26.000		191,840,000		0	191,840,000		362,495,000		0	362,495,000		134,230,000		0	134,230,000		0
Sum. 4	5.000		0		0	0		111,250,000		0	111,250,000		31,550,000		0	31,550,000		0
Sum. 5	28.400		0		0	0		123,510,000		82,890,000	40,620,000		27,383,000		16,883,000	10,500,000		16,883,000
Total	89.300		548,945,000		8,385,000	540,560,000		862,595,000		88,155,000	774,440,000		290,577,000		18,677,000	271,900,000		18,677,000
Station No.	Dis (m)	Hard Rock Ao	Hard Rock Vo	Hard Rock Wet A1	Hard Rock Wet V1	Hard Rock Dry V2	Soft Rock Ao	Soft Rock Vo	Soft Rock Wet A1	Soft Rock Wet V1	Soft Rock Dry V2	Earth Ao	Earth Vo	Earth Wet A1	Earth Wet V1	Earth Dry V2	Mud Ao	Mud Vo

Total Excavation Vol. 1,720,794,000 m3
DRY 1,586,900,000 m3
WET 133,894,000 m3



Study Case	Route	W. Level	No. of Lifts	No. of Lanes	Ship Size (1000 DWT)	Canal Size (m)
S-7	14S	0	-	1	150	147 x 20.9
8	14S	0	-	2	150	343 x 20.9
9	14S	0	-	1	250	171 x 24.2
10	14S	0	-	2	250	399 x 24.2
11	14S	0	-	1	300	183 x 25.3
12	14S	0	-	2	300	424 x 25.3
16	14S	0	-	50%-1	150	147 x 20.9
				50%-2		343 x 20.9
17	14S	0	-	50%-1	250	171 x 24.2
				50%-2		399 x 24.2
18	14S	0	-	50%-1	300	183 x 25.3
				50%-2		424 x 25.3

Layout of Sea Level Canal
for Group D Study Cases (Route 14S)



Zone Map in Route 14S

S-7

Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Wet Al	Earth Underwater Wet Vl	Earth Dry Dry V2	Grassy Water s. Total Ao	Grassy Water s. Total Vo
-11.10	8.100	0	0	0	0		0	4.900.500		4.900.500		0	1.620.000	0	1.620.000	0	0	1.620.000
-3.00	4.000	0	1.040.000	0	1.040.000	0	1.210	4.820.000	1.210	4.820.000	0	400	1.620.000	400	1.620.000	0	400	1.620.000
1.00	0	520	0	520	0	0	1.200	0	1.200	0	0	410	0	410	0	0	410	0
Sum. 1	12.100		1.040.000		1.040.000	0		9.720.500		9.720.500	0		3.240.000		3.240.000	0		3.240.000
1.00	50	520	79.250	240	17.750	61.500	1.200	61.500	190	11.250	50.250	820	42.500	0	0	42.500	0	0
1.05	1.150	2.650	3.047.500	470	540.500	2.507.000	1.260	1.449.000	260	299.000	1.150.000	880	1.012.000	0	0	1.012.000	0	0
2.20	10	2.650	26.500	470	4.700	21.800	1.260	12.600	260	2.600	10.000	880	11.300	0	0	11.300	0	0
2.21	190	2.650	503.500	470	89.300	414.200	1.260	239.400	260	49.400	190.000	1.380	262.200	0	0	262.200	0	0
2.40	10	2.650	26.500	470	4.700	21.800	1.260	12.600	260	2.600	10.000	1.380	11.300	0	0	11.300	0	0
2.41	590	2.650	1.563.500	470	277.300	1.286.200	1.260	743.400	260	153.400	590.000	880	519.200	0	0	519.200	0	0
3.00	2.000	2.650	5.300.000	470	500.000	4.800.000	1.260	3.150.000	260	520.000	2.630.000	880	2.200.000	0	0	2.200.000	0	0
5.00	1.000	2.650	3.060.000	30	1.750.000	1.310.000	1.890	1.530.000	260	715.000	815.000	1.320	875.000	0	215.000	660.000	0	215.000
6.00	1.000	3.470	3.675.000	3.470	3.675.000	0	1.170	1.225.000	1.170	1.225.000	0	430	430.000	430	430.000	0	430	430.000
7.00	1.000	3.880	4.225.000	3.880	4.225.000	0	1.280	1.285.000	1.280	1.285.000	0	430	435.000	430	435.000	0	430	435.000
8.00	1.000	4.570	3.700.000	4.570	3.700.000	0	1.290	1.170.000	1.290	1.170.000	0	440	430.000	440	430.000	0	440	430.000
9.00	1.000	2.830	3.590.000	2.830	3.590.000	0	1.050	1.170.000	1.050	1.170.000	0	420	425.000	420	425.000	0	420	425.000
10.00	1.000	4.350	3.810.000	4.350	3.810.000	0	1.290	1.215.000	1.290	1.215.000	0	430	430.000	430	430.000	0	430	430.000
11.00	1.000	3.270	3.585.000	3.270	3.585.000	0	1.140	1.200.000	1.140	1.200.000	0	430	430.000	430	430.000	0	430	430.000
12.00	1.000	3.900	3.725.000	3.900	3.725.000	0	1.260	1.245.000	1.260	1.245.000	0	430	430.000	430	430.000	0	430	430.000
13.00	1.000	3.550	3.845.000	3.550	3.845.000	0	1.230	1.260.000	1.230	1.260.000	0	430	435.000	430	435.000	0	430	435.000
14.00	1.000	4.140	4.170.000	4.140	4.170.000	0	1.290	1.290.000	1.290	1.290.000	0	440	440.000	440	440.000	0	440	440.000
15.00	1.000	4.200	6.175.000	4.200	2.100.000	4.075.000	1.290	1.380.000	1.290	645.000	735.000	440	690.000	440	220.000	470.000	440	220.000
16.00	1.000	8.150	9.660.000	0	1.135.000	8.525.000	1.470	1.440.000	0	105.000	1.335.000	940	960.000	0	60.000	900.000	0	0
17.00	1.000	11.170	8.550.000	2.270	4.100.000	4.450.000	1.410	1.385.000	210	785.000	600.000	980	720.000	120	290.000	430.000	0	230.000
18.00	1.000	5.930	4.840.000	5.930	4.840.000	0	1.360	1.295.000	1.360	1.295.000	0	460	445.000	460	445.000	0	460	445.000
19.00	1.000	3.750	5.385.000	3.750	4.635.000	750.000	1.230	1.325.000	1.230	1.070.000	255.000	430	695.000	430	505.000	190.000	430	215.000
20.00	1.000	7.020	5.895.000	5.520	5.145.000	750.000	1.420	1.355.000	910	1.100.000	255.000	960	700.000	580	510.000	190.000	0	220.000
21.00	1.000	4.770	4.435.000	4.770	4.435.000	0	1.290	1.275.000	1.290	1.275.000	0	440	435.000	440	435.000	0	440	435.000
22.00	1.000	4.100	4.980.000	4.100	4.980.000	0	1.260	1.280.000	1.260	1.280.000	0	430	440.000	430	440.000	0	430	450.000
23.00	0	5.860	0	5.860	0	0	1.300	0	1.300	0	0	450	0	450	0	0	470	0
Sum. 2	22.000		97.851.750		68.879.250	28.972.500		28.993.500		20.368.250	8.625.250		13.903.500		7.005.000	6.898.500		6.315.000
23.00	1.000	5.860	5.975.000	5.860	5.975.000	0	1.300	1.340.000	1.300	1.340.000	0	450	455.000	450	455.000	0	470	470.000
24.00	1.000	6.090	6.330.000	6.090	5.780.000	550.000	1.380	1.375.000	1.380	1.135.000	240.000	460	685.000	460	510.000	175.000	470	235.000
25.00	1.000	6.570	7.210.000	5.470	4.950.000	2.260.000	1.370	1.370.000	890	730.000	640.000	910	945.000	560	475.000	470.000	0	0
26.00	0	7.850	0	4.430	0	0	1.370	0	570	0	0	980	0	390	0	0	0	0
26.00	1.000	8.320	10.495.000	4.484	2.242.000	8.253.000	1.560	1.620.000	660	330.000	1.290.000	1.480	1.310.000	820	410.000	900.000	0	0
27.00	1.000	12.670	13.850.000	0	0	13.850.000	1.680	1.770.000	0	0	1.770.000	1.140	1.240.000	0	0	1.240.000	0	0
28.00	1.000	15.030	14.210.000	0	40.000	14.170.000	1.860	1.935.000	0	0	1.935.000	1.340	1.365.000	0	0	1.365.000	0	0
29.00	1.000	13.390	9.365.000	80	2.710.000	6.655.000	2.010	1.755.000	0	750.000	1.005.000	1.390	945.000	0	250.000	695.000	0	255.000
30.00	1.000	5.340	5.755.000	5.340	4.850.000	905.000	1.500	1.560.000	1.500	1.230.000	330.000	500	810.000	500	560.000	250.000	510	255.000
31.00	1.000	6.170	5.490.000	4.360	4.585.000	905.000	1.620	1.500.000	960	1.170.000	330.000	1.120	1.040.000	620	790.000	250.000	0	0
32.00	1.000	4.810	4.760.000	4.810	4.705.000	55.000	1.380	1.410.000	1.380	1.320.000	90.000	960	990.000	960	900.000	90.000	0	0
33.00	1.000	4.710	8.830.000	4.600	2.300.000	6.530.000	1.440	1.635.000	1.260	630.000	1.005.000	1.020	1.145.000	840	420.000	725.000	0	0
34.00	1.000	12.950	22.710.000	0	0	22.710.000	1.830	2.190.000	0	0	2.190.000	1.270	1.515.000	0	0	1.515.000	0	0
35.00	1.000	12.470	22.400.000	0	0	22.400.000	2.550	2.325.000	0	0	2.325.000	1.760	1.595.000	0	0	1.595.000	0	0
36.00	1.000	12.330	12.260.000	0	0	12.260.000	2.100	1.935.000	0	0	1.935.000	1.430	1.320.000	0	0	1.320.000	0	0
37.00	1.000	12.190	15.760.000	0	0	15.760.000	1.770	1.935.000	0	0	1.935.000	1.210	1.325.000	0	0	1.325.000	0	0
38.00	0	19.330	0	0	0	0	2.100	0	0	0	0	1.440	0	0	0	0	0	0
38.00	1.000	22.620	31.440.000	0	0	31.440.000	3.300	4.020.000	0	0	4.020.000	2.260	2.500.000	0	0	2.500.000	0	0
39.00	1.000	20.260	29.725.000	0	0	29.725.000	4.740	3.990.000	0	0	3.990.000	3.200	2.970.000	0	0	2.970.000	0	0
40.00	1.000	19.190	21.780.000	0	0	21.780.000	3.240	3.660.000	0	0	3.660.000	2.740	2.755.000	0	0	2.755.000	0	0
41.00	1.000	24.370	30.110.000	0	0	30.110.000	4.080	4.350.000	0	0	4.350.000	2.770	2.975.000	0	0	2.975.000	0	0
42.00	1.000	35.850	61.540.000	0	0	61.540.000	4.620	6.435.000	0	0	6.435.000	3.180	4.350.000	0	0	4.350.000	0	0
43.00	1.000	37.230	75.075.000	0	0	75.075.000	8.250	7.110.000	0	0	7.110.000	5.520	4.770.000	0	0	4.770.000	0	0
44.00	1.000	32.920	47.125.000	0	0	47.125.000	5.970	4.035.000	0	0	4.035.000	4.020	2.720.000	0	0	2.720.000	0	0
45.00	1.000	31.330	32.590.000	0	0	32.590.000	2.100	3.225.000	0	0	3.225.000	1.420	2.220.000	0	0	2.220.000	0	0
46.00	1.000	33.850	23.035.000	0	0	23.035.000	4.350	3.270.000	0	0	3.270.000	3.020	2.280.000	0	0	2.280.000	0	0
47.00	1.000	12.220	9.990.000	0	0	9.990.000	2.190	1.995.000	0	0	1.995.000	1.540	1.390.000	0	0	1.390.000	0	0
48.00	1.000	7.760	10.055.000	0	0	10.055.000	1.800	1.875.000	0	0	1.875.000	1.240	1.280.000	0	0	1.280.000	0	0
49.00	1.000	12.350	13.370.000	0	0	13.370.000	1.950	1.965.000	0	0	1.965.000	1.320	1.360.000	0	0	1.360.000	0	0
50.00	0	14.390	0	0	0	0	1.980	0	0	0	0	1.400	0	0	0	0	0	0
Sum. 3	27.000		551.235.000		38.137.000	513.098.000		71.585.000		8.635.000	62.950.000		48.255.000		4.770.000	43.485.000		1.215.000
50.00	1.000	14.390	14.660.000	0	0	14.660.000	1.980	1.860.000	0	0	1.860.000	1.400	1.315.000	0	0	1.315.000	0	0
51.00	1.000	14.930	9.520.000	0	1.910.000	7.610.000	1.740	1.600.000	0	595.000	1.005.000	1.230	1.125.000	0	400.000	725.000	0	0
52.00	1.000	4.110	3.460.000	3.820	2.460.000	1.000.000	1.460	1.420.000	1.190	970.000	450.000	1.020	1.010.000	800	620.000	390.000	0	0
53.00	1.000	2.810	2.700.000	1.100	550.000	2.150.000	1.380	1.255.000	750	375.000	880.000	1.000	930.000	440	220.000	710.000	0	0
54.00	0	2.590	0	0	0	0	1.130	0	0	0	0	860	0	0	0	0	0	0
Sum. 4	4.000		30.340.000		4.920.000	25.420.000		6.135.000		1.940.000	4.195.000		4.380.000		1.240.000	3.140.000		0
54.00	1.000	2.590	1.915.000	0	620.000	1.295.000	1.130	1.165.000	0	600.000	565.000	860	850.000	0	220.000	430.000	0	225.000
55.00	1.000	1.240	620.000	1.240	620.000	0	1.200	995.000	1.200	995.000	0	640	410.000	440	410.000	0	450	420.000
56.00	1.000	0	0	0	0	0	790	685.000	790	685.000	0	380	370.000	380	370.000	0	390	385.000
57.00	1.000	0	70.000	0	70.000	0	580	700.000	580	700.000	0	360	360.000	360	360.000	0	380	380.000
58.00	1.000	140	85.000	140	85.000	0	820	685.000	820	685.000	0	360	360.000	360	360.000	0	380	380.000
59.00	1.000	30	15.000	30	15.000	0	550	525.000	550	525.000	0	360	360.000	360	360.000	0	380	380.000
60.00	1.000	0	0	0	0	0	500	475.000	500	475.000	0	360	350.000	360	350.000	0	380	370.000
61.00	1.000	0	25.000	0	25.000	0	450	545.000	450	545.000	0	340	360.000	340	360.000	0	360	375.000
62.00	1.000	50	65.000	50	65.000	0	640	645.000	640	645.000	0	380	380.000	380	380.000	0	390	390.000
63.00	1.000	80	40.000	80	40.000	0	650	550.000	650	550.000	0	380	370.000	380	370.000	0	390	380.000
64.00	1.000	0	0	0	0	0	450	420.000	450	420.000	0	360	355.000	360	355.000	0	370	365.000
65.00	1.000	0	0	0	0	0	390	350.000	390	350.000	0	350	340.000	350	340.000	0	360	355.000
66.00	5.500	0	0	0	0	0	310	852.500	310	852.500	0	330	907.500	330	907.500	0	350	962.500
71.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	17.500		2.835.000		1.540.000	1.295.000		8.592.500		8.027.500	565.000		5.572.500		5.142.500	430.000		5.367.500
S-7																		
Sum. 1	12.100		1.040.000		1.040.000	0		9.720.500		9.720.500	0		3.240.000		3.240.000	0		3.240.000
Sum. 2	22.000		97.851.750		68.879.250	28.972.500		28.993.500		20.368.250	8.625.250		13.903.500		7.005.000	6.898.500		6.315.000
Sum. 3	27.000		551.235.000		38.137.000	513.098.000		71.585.000		8.635.000	62.950.000		48.255.000		4.770.000	43.485.000		1.215.000
Sum. 4	4.000		30.340.000		4.920.000	25.420.000		6.135.000		1.940.000	4.195.000		4.380.000		1.240.000	3.140.000		0
Sum. 5	17.500		2.835.000		1.540.000	1.295.000		8.592.500		8.027.500	565.000		5.572.500		5.142.500	430.000		5.367.500
Total	82.600		683.301.750		114.516.250	568.785.500		125.026.500		48.691.250	76.335.250		75.351.000		21.397.500	53.953.500		16.137.500

Total Excavation Vol.	899.816.750
Dry	699.074.250
Wet	200.742.500

S-8 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Wet Al	Earth Underwater Wet Vl	Earth Dry Dry V2	Clayey material Total Ao	Clayey material Total Vo
-11.10	8.100	0	0	0	0		0	9,841,500		9,841,500		0	3,199,500	0	3,199,500	0	0	3,199,500
-3.00	4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	3,220,000
1.00	0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820	0
Sum. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
1.00	50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	0
1.05	1,150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	0
2.20	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	0
2.21	190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	0
2.40	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	0
2.41	590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	0
3.00	2,000	5,300	10,600,000	950	1,900,000	8,700,000	2,520	5,040,000	520	1,040,000	4,000,000	1,760	3,520,000	0	0	3,520,000	0	0
5.00	1,000	5,300	6,340,000	950	4,165,000	2,175,000	2,520	2,445,000	520	1,445,000	1,000,000	1,760	1,290,000	0	410,000	880,000	0	410,000
6.00	1,000	7,380	8,005,000	7,380	8,005,000	0	2,370	2,415,000	2,370	2,415,000	0	820	825,000	820	825,000	0	820	825,000
7.00	1,000	8,630	9,125,000	8,630	9,125,000	0	2,460	2,430,000	2,460	2,430,000	0	830	830,000	830	830,000	0	830	830,000
8.00	1,000	9,620	7,895,000	9,620	7,895,000	0	2,400	2,320,000	2,400	2,320,000	0	830	795,000	830	795,000	0	830	825,000
9.00	1,000	6,170	7,850,000	6,170	7,850,000	0	2,240	2,335,000	2,240	2,335,000	0	760	795,000	760	795,000	0	820	825,000
10.00	1,000	9,530	8,475,000	9,530	8,475,000	0	2,430	2,385,000	2,430	2,385,000	0	830	830,000	830	830,000	0	830	830,000
11.00	1,000	7,420	8,130,000	7,420	8,130,000	0	2,340	2,385,000	2,340	2,385,000	0	830	830,000	830	830,000	0	830	830,000
12.00	1,000	8,840	8,420,000	8,840	8,420,000	0	2,430	2,415,000	2,430	2,415,000	0	830	830,000	830	830,000	0	830	830,000
13.00	1,000	8,000	7,570,000	8,000	7,570,000	0	2,400	2,430,000	2,400	2,430,000	0	830	830,000	830	830,000	0	830	830,000
14.00	1,000	7,140	8,045,000	7,140	8,045,000	0	2,460	2,460,000	2,460	2,460,000	0	830	830,000	830	830,000	0	830	830,000
15.00	1,000	8,950	14,245,000	8,950	4,475,000	9,770,000	2,460	2,610,000	2,460	1,230,000	1,380,000	830	1,275,000	830	415,000	860,000	830	415,000
16.00	1,000	19,540	19,490,000	0	4,570,000	14,920,000	2,760	2,730,000	0	465,000	2,265,000	1,720	1,730,000	0	230,000	1,500,000	0	0
17.00	1,000	19,440	15,820,000	9,140	10,670,000	5,150,000	2,700	2,590,000	930	1,705,000	885,000	1,740	1,285,000	460	645,000	640,000	0	415,000
18.00	1,000	12,200	10,310,000	12,200	10,310,000	0	2,480	2,470,000	2,480	2,470,000	0	830	830,000	830	830,000	0	830	830,000
19.00	1,000	8,420	12,390,000	8,420	8,475,000	3,915,000	2,460	2,565,000	2,460	1,980,000	585,000	830	1,315,000	830	905,000	410,000	830	415,000
20.00	1,000	16,360	12,045,000	8,530	8,130,000	3,915,000	2,670	2,565,000	1,500	1,980,000	585,000	1,800	1,315,000	980	905,000	410,000	0	415,000
21.00	1,000	7,730	8,475,000	7,730	8,475,000	0	2,460	2,460,000	2,460	2,460,000	0	830	830,000	830	830,000	0	830	830,000
22.00	1,000	9,220	10,730,000	9,220	10,730,000	0	2,460	2,475,000	2,460	2,475,000	0	830	840,000	830	840,000	0	830	845,000
23.00	0	12,240	0	12,240	0	0	2,490	0	2,490	0	0	850	0	850	0	0	860	0
Sum. 2	22,000		204,453,250		147,303,000	57,150,250		54,562,000		39,861,500	14,700,500		25,342,000		13,405,000	11,937,000		12,030,000
23.00	1,000	12,240	12,625,000	12,240	12,625,000	0	2,490	2,495,000	2,490	2,495,000	0	850	845,000	850	845,000	0	860	860,000
24.00	1,000	13,010	13,560,000	13,010	10,760,000	2,800,000	2,500	2,525,000	2,500	1,985,000	540,000	840	1,285,000	840	900,000	385,000	860	430,000
25.00	1,000	14,110	15,095,000	8,510	8,080,000	7,015,000	2,550	2,560,000	1,470	1,320,000	1,240,000	1,730	1,745,000	960	870,000	875,000	0	0
26.00	0	16,080	0	7,650	0	0	2,570	0	1,170	0	0	1,760	0	780	0	0	0	0
26.00	1,000	16,580	18,785,000	7,840	3,920,000	14,865,000	2,790	2,795,000	1,260	630,000	2,165,000	1,880	1,900,000	820	410,000	1,490,000	0	0
27.00	1,000	20,990	24,875,000	0	0	24,875,000	2,800	2,990,000	0	0	2,990,000	1,920	2,040,000	0	0	2,040,000	0	0
28.00	1,000	28,760	27,400,000	0	1,700,000	25,700,000	3,180	3,150,000	0	240,000	2,910,000	2,160	2,145,000	0	165,000	1,980,000	0	0
29.00	1,000	26,040	18,985,000	3,400	7,665,000	11,320,000	3,120	2,895,000	480	1,575,000	1,320,000	2,130	1,515,000	330	615,000	900,000	0	460,000
30.00	1,000	11,930	13,830,000	11,930	9,390,000	4,440,000	2,870	2,880,000	2,670	2,115,000	765,000	900	1,500,000	900	960,000	540,000	920	460,000
31.00	1,000	15,730	12,735,000	6,850	8,295,000	4,440,000	3,090	2,835,000	1,560	2,070,000	765,000	2,100	1,910,000	1,020	1,370,000	540,000	0	0
32.00	1,000	9,740	10,925,000	9,740	9,070,000	1,855,000	2,580	2,565,000	2,580	2,220,000	345,000	1,720	1,790,000	1,720	1,470,000	320,000	0	0
33.00	1,000	12,110	18,015,000	8,400	4,200,000	13,815,000	2,550	2,730,000	1,860	930,000	1,800,000	1,860	1,950,000	1,220	610,000	1,340,000	0	0
34.00	1,000	23,920	38,080,000	0	0	38,080,000	2,910	3,240,000	0	0	3,240,000	2,040	2,230,000	0	0	2,230,000	0	0
35.00	1,000	52,240	39,960,000	0	0	39,960,000	3,570	3,540,000	0	0	3,540,000	2,420	2,400,000	0	0	2,400,000	0	0
36.00	1,000	27,680	25,420,000	0	0	25,420,000	3,510	3,230,000	0	0	3,230,000	2,380	2,220,000	0	0	2,220,000	0	0
37.00	1,000	23,180	24,830,000	0	0	24,830,000	2,950	3,065,000	0	0	3,065,000	2,060	2,100,000	0	0	2,100,000	0	0
38.00	0	28,500	0	0	0	0	3,180	0	0	0	0	2,140	0	0	0	0	0	0
38.00	1,000	35,640	47,580,000	0	0	47,580,000	4,310	5,005,000	0	0	5,005,000	2,920	3,420,000	0	0	3,420,000	0	0
39.00	1,000	59,520	46,775,000	0	0	46,775,000	5,700	5,205,000	0	0	5,205,000	3,920	3,745,000	0	0	3,745,000	0	0
40.00	1,000	34,030	38,835,000	0	0	38,835,000	4,710	4,905,000	0	0	4,905,000	3,570	3,555,000	0	0	3,555,000	0	0
41.00	1,000	39,640	49,545,000	0	0	49,545,000	5,100	6,210,000	0	0	6,210,000	3,540	4,220,000	0	0	4,220,000	0	0
42.00	1,000	59,450	88,635,000	0	0	88,635,000	7,320	8,130,000	0	0	8,130,000	4,900	5,490,000	0	0	5,490,000	0	0
43.00	1,000	117,820	94,505,000	0	0	94,505,000	8,940	7,750,000	0	0	7,750,000	6,080	5,290,000	0	0	5,290,000	0	0
44.00	1,000	71,190	66,120,000	0	0	66,120,000	6,580	5,230,000	0	0	5,230,000	4,500	3,550,000	0	0	3,550,000	0	0
45.00	1,000	61,050	55,845,000	0	0	55,845,000	3,900	4,650,000	0	0	4,650,000	2,800	3,150,000	0	0	3,150,000	0	0
46.00	1,000	50,640	37,090,000	0	0	37,090,000	5,400	4,335,000	0	0	4,335,000	3,700	3,000,000	0	0	3,000,000	0	0
47.00	1,000	23,540	19,930,000	0	0	19,930,000	3,270	3,150,000	0	0	3,150,000	2,300	2,170,000	0	0	2,170,000	0	0
48.00	1,000	16,320	19,585,000	0	0	19,585,000	3,030	3,030,000	0	0	3,030,000	2,040	2,060,000	0	0	2,060,000	0	0
49.00	1,000	22,850	24,335,000	0	0	24,335,000	3,030	3,115,000	0	0	3,115,000	2,080	2,130,000	0	0	2,130,000	0	0
50.00	0	25,820	0	0	0	0	3,200	0	0	0	0	2,180	0	0	0	0	0	0
Sum. 3	27,000		901,900,000		75,705,000	826,195,000		104,210,000		15,580,000	88,630,000		69,355,000		8,215,000	61,140,000		2,210,000
50.00	1,000	25,820	24,420,000	0	1,125,000	23,295,000	3,200	2,960,000	0	195,000	2,765,000	2,180	2,020,000	0	140,000	1,880,000	0	0
51.00	1,000	23,020	16,375,000	2,250	4,475,000	11,900,000	2,720	2,695,000	390	855,000	1,840,000	1,860	1,835,000	280	555,000	1,280,000	0	0
52.00	1,000	9,730	9,935,000	6,700	4,185,000	5,750,000	2,670	2,785,000	1,320	1,060,000	1,705,000	1,810	1,855,000	830	635,000	1,220,000	0	0
53.00	1,000	10,140	8,380,000	1,670	835,000	7,545,000	2,860	2,585,000	800	400,000	2,185,000	1,900	1,780,000	440	220,000	1,560,000	0	0
54.00	0	6,620	0	0	0	0	2,310	0	0	0	0	1,660	0	0	0	0	0	0
Sum. 4	4,000		59,110,000		10,620,000	48,490,000		11,005,000		2,510,000	8,495,000		7,490,000		1,550,000	5,940,000		0
54.00	1,000	6,620	4,170,000	0	860,000	3,310,000	2,310	2,375,000	0	1,220,000	1,155,000	1,660	1,250,000	0	420,000	830,000	0	410,000
55.00	1,000	1,720	1,205,000	1,720	1,205,000	0	2,440	2,285,000	2,440	2,285,000	0	840	855,000	840	855,000	0	880	900,000
56.00	1,000	690	345,000	690	345,000	0	2,130	1,975,000	2,130	1,975,000	0	870	815,000	870	815,000	0	920	850,000
57.00	1,000	0	240,000	0	240,000	0	1,820	2,070,000	1,820	2,070,000	0	760	840,000	760	840,000	0	780	905,000
58.00	1,000	480	430,000	480	430,000	0	2,320	2,000,000	2,320	2,000,000	0	920	855,000	920	855,000	0	1,030	920,000
59.00	1,000	380	360,000	380	360,000	0	1,680	1,745,000	1,680	1,745,000	0	790	815,000	790	815,000	0	810	860,000
60.00	1,000	340	170,000	340	170,000	0	1,810	1,455,000	1,810	1,455,000	0	840	810,000	840	810,000	0	910	855,000
61.00	1,000	0	240,000	0	240,000	0	1,100	1,440,000	1,100	1,440,000	0	780	795,000	780	795,000	0	800	815,000
62.00	1,000	480	570,000	480	570,000	0	1,780	1,810,000	1,780	1,810,000	0	810	810,000	810	810,000	0	830	830,000
63.00	1,000	660	385,000	660	385,000	0	1,840	1,690,000	1,840	1,690,000	0	810	790,000	810	790,000	0	830	810,000
64.00	1,000	110	115,000	110	115,000	0	1,540	1,580,000	1,540	1,580,000	0	770	775,000	770	775,000	0	790	795,000
65.00	1,000	120	60,000	120	60,000	0	1,620	1,350,000	1,620	1,350,000	0	780	760,000	780	760,000	0	800	780,000
66.00	5,500	0	0	0	0	0	1,080	2,970,000	1,080	2,970,000	0	740	2,035,000	740	2,035,000	0	760	2,090,000
71.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	17,500		8,290,000		4,980,000	3,310,000		24,745,000		23,590,000	1,155,000		12,205,000		11,375,000	830,000		11,850,000
S-8																		
Sum. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
Sum. 2	22,000		204,453,250		147,303,000	57,150,250		54,562,000		39,861,500	14,700,500		25,342,000		13,405,000	11,937,000		12,030,000
Sum. 3	27,000		901,900,000		75,705,000	826,195,000		104,210,000		15,580,000	88,630,000		69,355,000		8,215,000	61,140,000		2,210,000
Sum. 4	4,000		59,110,000		10,620,000	48,490,000		11,005,000		2,510,000	8,495,000		7,490,000		1,550,000	5,940,000		0
Sum. 5	17,500		8,290,000		4,980,000	3,310,000		24,745,000		23,590,000	1,155,000		12,205,000		11,375,000	830,000		11,850,000
Total	82,600		1,175,813,250		240,668,000	935,145,250		214,023,500		101,043,000	112,980,500		120,811,500		40,964,500	79,847,000		32,509,500

Total Excavation Vol.	1,543,157,750
Dry	1,127,972,750
Wet	415,185,000

S-9

Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry Vl	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry Vl	Earth Total Ao	Earth Total Vo	Earth Underwater Al	Earth Underwater Vl	Earth Dry Vl	Clayey Material Total Ao	Clayey Material Total Vo
-11.50	8.500	0	4.632.500	0	4.632.500		0	5.355.000		5.355.000		0	2.040.000	0	2.040.000	0	0	2.040.000
-3.00	4.000	1.090	5.820.000	1.090	5.820.000	0	1.260	5.520.000	1.260	5.520.000	0	480	1.960.000	480	1.960.000	0	480	1.960.000
1.00	0	1.820	0	1.820	0	0	1.500	0	1.500	0	0	500	0	500	0	0	500	0
Sum. 1	12.500		10.452.500		10.452.500	0		10.875.000		10.875.000	0		4.000.000		4.000.000	0		4.000.000
1.00	50	1.820	146.000	1.820	58.000	88.000	1.500	75.000	200	11.500	63.500	1.000	50.000	0	0	50.000	0	0
1.05	1.150	4.020	4.623.000	500	575.000	4.048.000	1.500	1.725.000	260	299.000	1.426.000	1.000	1.150.000	0	0	1.150.000	0	0
2.20	10	4.020	40.200	500	5.000	35.200	1.500	15.000	260	2.600	12.400	1.000	12.500	0	0	12.500	0	0
2.21	190	4.020	763.800	500	95.000	668.800	1.500	285.000	260	49.400	235.600	1.500	285.000	0	0	285.000	0	0
2.40	10	4.020	40.200	500	5.000	35.200	1.500	15.000	260	2.600	12.400	1.500	12.500	0	0	12.500	0	0
2.41	590	4.020	2.371.800	500	295.000	2.076.800	1.500	885.000	260	153.400	731.600	1.000	590.000	0	0	590.000	0	0
3.00	2.000	4.020	7.770.000	500	1.000.000	6.770.000	1.500	4.200.000	260	520.000	3.680.000	1.000	2.000.000	0	0	2.000.000	0	0
5.00	1.000	3.750	4.170.000	500	2.545.000	1.625.000	2.700	1.965.000	260	745.000	1.220.000	1.000	740.000	0	240.000	500.000	0	215.000
6.00	1.000	4.590	4.815.000	4.590	4.815.000	0	1.230	1.335.000	1.230	1.335.000	0	480	480.000	480	480.000	0	430	485.000
7.00	1.000	5.040	5.450.000	5.040	5.450.000	0	1.440	1.455.000	1.440	1.455.000	0	480	485.000	480	485.000	0	480	485.000
8.00	1.000	5.860	4.910.000	5.860	4.910.000	0	1.470	1.340.000	1.470	1.340.000	0	490	450.000	490	450.000	0	490	485.000
9.00	1.000	3.960	4.880.000	3.960	4.880.000	0	1.210	1.340.000	1.210	1.340.000	0	410	450.000	410	450.000	0	480	485.000
10.00	1.000	5.800	5.075.000	5.800	5.075.000	0	1.470	1.355.000	1.470	1.355.000	0	490	485.000	490	485.000	0	490	490.000
11.00	1.000	4.350	4.805.000	4.350	4.805.000	0	1.240	1.295.000	1.240	1.295.000	0	480	480.000	480	480.000	0	490	490.000
12.00	1.000	5.260	5.055.000	5.260	5.055.000	0	1.350	1.350.000	1.350	1.350.000	0	480	480.000	480	480.000	0	490	490.000
13.00	1.000	4.850	5.155.000	4.850	5.155.000	0	1.350	1.395.000	1.350	1.395.000	0	480	480.000	480	480.000	0	490	490.000
14.00	1.000	5.460	5.375.000	5.460	5.375.000	0	1.440	1.450.000	1.440	1.450.000	0	480	485.000	480	485.000	0	490	495.000
15.00	1.000	5.290	7.730.000	5.290	2.645.000	5.085.000	1.460	1.530.000	1.460	730.000	800.000	490	795.000	490	245.000	550.000	500	250.000
16.00	1.000	10.170	11.495.000	0	1.450.000	10.045.000	1.600	1.585.000	0	150.000	1.435.000	1.100	1.080.000	0	90.000	990.000	0	0
17.00	1.000	12.820	10.230.000	2.900	5.270.000	4.960.000	1.570	1.545.000	300	910.000	635.000	1.060	785.000	180	345.000	440.000	0	260.000
18.00	1.000	7.640	6.265.000	7.640	6.265.000	0	1.520	1.480.000	1.520	1.480.000	0	510	495.000	510	495.000	0	520	505.000
19.00	1.000	4.890	6.715.000	4.890	5.590.000	1.125.000	1.440	1.580.000	1.440	1.270.000	310.000	480	790.000	480	560.000	230.000	490	215.000
20.00	1.000	8.540	7.360.000	6.290	6.235.000	1.125.000	1.720	1.595.000	1.100	1.285.000	310.000	1.100	795.000	640	565.000	230.000	0	245.000
21.00	1.000	6.180	5.820.000	6.180	5.820.000	0	1.470	1.460.000	1.470	1.460.000	0	490	490.000	490	490.000	0	490	490.000
22.00	1.000	5.460	6.530.000	5.460	6.530.000	0	1.450	1.455.000	1.450	1.455.000	0	490	495.000	490	495.000	0	490	510.000
23.00	0	7.600	0	7.600	0	0	1.460	0	1.460	0	0	500	0	500	0	0	530	0
Sum. 2	22.000		127.590.000		89.903.000	37.687.000		33.710.000		22.838.500	10.871.500		14.840.000		7.800.000	7.040.000		7.145.000
23.00	1.000	7.600	7.725.000	7.600	7.725.000	0	1.460	1.510.000	1.460	1.510.000	0	500	510.000	500	510.000	0	530	530.000
24.00	1.000	7.850	8.005.000	7.850	7.225.000	780.000	1.560	1.545.000	1.560	1.260.000	285.000	520	780.000	520	570.000	210.000	530	265.000
25.00	1.000	8.160	8.880.000	6.600	5.990.000	2.890.000	1.530	1.545.000	960	810.000	735.000	1.040	1.050.000	620	520.000	530.000	0	0
26.00	0	9.600	0	5.380	0	0	1.560	0	660	0	0	1.060	0	420	0	0	0	0
26.00	1.000	10.420	12.245.000	5.600	2.800.000	9.445.000	1.770	1.800.000	760	380.000	1.420.000	1.200	1.230.000	480	240.000	990.000	0	0
27.00	1.000	14.070	15.570.000	0	0	15.570.000	1.830	1.965.000	0	0	1.965.000	1.260	1.360.000	0	0	1.360.000	0	0
28.00	1.000	17.070	16.460.000	0	385.000	16.075.000	2.100	2.130.000	0	30.000	2.100.000	1.460	1.480.000	0	20.000	1.460.000	0	0
29.00	1.000	15.850	11.325.000	770	3.785.000	7.540.000	2.160	1.905.000	60	855.000	1.050.000	1.500	1.030.000	40	300.000	730.000	0	285.000
30.00	1.000	6.800	7.540.000	6.800	6.100.000	1.440.000	1.650	1.740.000	1.650	1.350.000	390.000	560	890.000	560	610.000	280.000	570	285.000
31.00	1.000	8.280	7.180.000	5.400	5.740.000	1.440.000	1.830	1.695.000	1.050	1.305.000	390.000	1.220	870.000	660	590.000	280.000	0	270.000
32.00	1.000	8.080	6.220.000	6.080	6.045.000	175.000	1.560	1.610.000	1.560	1.460.000	150.000	520	820.000	520	700.000	120.000	540	270.000
33.00	1.000	8.360	10.790.000	6.010	3.005.000	7.785.000	1.660	1.815.000	1.360	680.000	1.135.000	1.120	1.250.000	880	440.000	810.000	0	0
34.00	1.000	15.220	25.735.000	0	0	25.735.000	1.970	2.325.000	0	0	2.325.000	1.380	1.600.000	0	0	1.600.000	0	0
35.00	1.000	36.250	25.675.000	0	0	25.675.000	2.680	2.490.000	0	0	2.490.000	1.820	1.690.000	0	0	1.690.000	0	0
36.00	1.000	15.100	14.685.000	0	0	14.685.000	2.300	2.140.000	0	0	2.140.000	1.560	1.450.000	0	0	1.450.000	0	0
37.00	1.000	14.270	18.110.000	0	0	18.110.000	1.980	2.130.000	0	0	2.130.000	1.340	1.440.000	0	0	1.440.000	0	0
38.00	0	21.950	0	0	0	0	2.280	0	0	0	0	1.540	0	0	0	0	0	0
38.00	1.000	24.620	34.155.000	0	0	34.155.000	3.360	4.080.000	0	0	4.080.000	2.180	2.740.000	0	0	2.740.000	0	0
39.00	1.000	43.690	32.765.000	0	0	32.765.000	4.800	4.125.000	0	0	4.125.000	3.300	3.090.000	0	0	3.090.000	0	0
40.00	1.000	21.840	24.730.000	0	0	24.730.000	3.450	3.845.000	0	0	3.845.000	2.880	2.860.000	0	0	2.860.000	0	0
41.00	1.000	27.620	33.435.000	0	0	33.435.000	4.240	4.520.000	0	0	4.520.000	2.840	3.090.000	0	0	3.090.000	0	0
42.00	1.000	39.250	66.340.000	0	0	66.340.000	4.800	6.620.000	0	0	6.620.000	3.340	4.490.000	0	0	4.490.000	0	0
43.00	1.000	93.430	79.745.000	0	0	79.745.000	8.440	7.250.000	0	0	7.250.000	5.640	4.870.000	0	0	4.870.000	0	0
44.00	1.000	66.060	50.810.000	0	0	50.810.000	6.060	4.490.000	0	0	4.490.000	4.100	3.060.000	0	0	3.060.000	0	0
45.00	1.000	35.560	36.590.000	0	0	36.590.000	2.920	3.740.000	0	0	3.740.000	2.020	2.560.000	0	0	2.560.000	0	0
46.00	1.000	37.620	26.155.000	0	0	26.155.000	4.560	3.515.000	0	0	3.515.000	3.100	2.385.000	0	0	2.385.000	0	0
47.00	1.000	14.690	12.475.000	0	0	12.475.000	2.470	2.255.000	0	0	2.255.000	1.670	1.525.000	0	0	1.525.000	0	0
48.00	1.000	10.260	12.620.000	0	0	12.620.000	2.040	2.100.000	0	0	2.100.000	1.380	1.420.000	0	0	1.420.000	0	0
49.00	1.000	14.980	16.040.000	0	0	16.040.000	2.160	2.180.000	0	0	2.180.000	1.460	1.510.000	0	0	1.510.000	0	0
50.00	0	17.100	0	0	0	0	2.200	0	0	0	0	1.560	0	0	0	0	0	0
Sum. 3	27.000		622.005.000		48.800.000	573.205.000		77.065.000		9.640.000	67.425.000		51.050.000		4.500.000	46.550.000		1.905.000
50.00	1.000	17.100	17.150.000	0	85.000	17.065.000	2.200	2.035.000	0	0	2.035.000	1.560	1.450.000	0	0	1.450.000	0	0
51.00	1.000	17.200	11.525.000	170	2.735.000	8.790.000	1.870	1.765.000	0	650.000	1.115.000	1.340	1.230.000	0	400.000	830.000	0	0
52.00	1.000	5.850	5.105.000	5.300	3.660.000	1.445.000	1.660	1.695.000	1.300	1.050.000	645.000	1.120	1.160.000	800	620.000	540.000	0	0
53.00	1.000	4.360	4.275.000	2.020	1.010.000	3.265.000	1.730	1.525.000	800	400.000	1.125.000	1.200	1.120.000	440	220.000	900.000	0	0
54.00	0	4.190	0	0	0	0	1.320	0	0	0	0	1.040	0	0	0	0	0	0
Sum. 4	4.000		38.055.000		7.490.000	30.565.000		7.020.000		2.100.000	4.920.000		4.960.000		1.240.000	3.720.000		0
54.00	1.000	4.190	3.265.000	0	1.170.000	2.095.000	1.320	1.395.000	0	735.000	660.000	1.040	780.000	0	260.000	520.000	0	270.000
55.00	1.000	2.340	1.445.000	2.340	1.445.000	0	1.470	1.385.000	1.470	1.385.000	0	520	490.000	520	490.000	0	540	515.000
56.00	1.000	550	380.000	550	380.000	0	1.260	1.260.000	1.260	1.260.000	0	460	455.000	460	455.000	0	490	480.000
57.00	1.000	210	470.000	210	470.000	0	1.260	1.260.000	1.260	1.260.000	0	450	450.000	450	450.000	0	470	470.000
58.00	1.000	730	560.000	730	560.000	0	1.260	1.260.000	1.260	1.260.000	0	450	450.000	450	450.000	0	470	470.000
59.00	1.000	390	385.000	390	385.000	0	1.260	1.245.000	1.260	1.245.000	0	450	455.000	450	455.000	0	470	475.000
60.00	1.000	380	265.000	380	265.000	0	1.230	1.185.000	1.230	1.185.000	0	460	435.000	460	435.000	0	480	455.000
61.00	1.000	150	415.000	150	415.000	0	1.140	1.215.000	1.140	1.215.000	0	410	440.000	410	415.000	25.000	430	460.000
62.00	1.000	680	615.000	680	615.000	0	1.290	1.290.000	1.290	1.290.000	0	470	470.000	420	445.000	25.000	490	490.000
63.00	1.000	550	445.000	550	445.000	0	1.290	1.290.000	1.290	1.290.000	0	470	460.000	470	460.000	0	490	480.000
64.00	1.000	340	205.000	340	205.000	0	1.230	1.215.000	1.230	1.215.000	0	450	455.000	450	455.000	0	470	475.000
65.00	1.000	70	145.000	70	45.000	100.000	1.200	1.035.000	1.200	1.035.000	0	460	445.000	460	445.000	0	480	465.000
66.00	9.900	220	1.089.000	29	99.000	990.000	870	4.306.500	870	4.306.500	0	430	2.128.500	430	2.128.500	0	450	2.227.500
75.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	21.900		9.684.000		6.499.000	3.185.000		19.291.500		18.631.500	660.000		7.913.500		7.343.500	570.000		7.732.500
S-9																		
Sum. 1	12.500		10.452.500		10.452.500	0		10.875.000		10.875.000	0		4.000.000		4.000.000	0		4.000.000
Sum. 2	22.000		127.590.000		89.903.000	37.687.000		33.710.000		22.838.500	10.871.500		14.840.000		7.800.000	7.040.000		7.145.000
Sum. 3	27.000		622.005.000		48.800.000	573.205.000		77.065.000		9.640.000	67.425.000		51.050.000		4.500.000	46.550.000		1.905.000
Sum. 4	4.000		38.055.000		7.490.000	30.565.000		7.020.000		2.100.000	4.920.000		4.960.000		1.240.000	3.720.000		0
Sum. 5	21.900		9.684.000		6.499.000	3.185.000		19.291.500		18.631.500	660.000		7.913.500		7.343.500	570.000		7.732.500
Total	87.400		807.786.500		163.144.500	644.642.000		147.961.500		64.085.000	83.876.500		82.763.500		24.883.500	57.880.000		20.782.500

Total Excavation Vol.	1.059.294.000
Dry	786.398.500
Wet	272.895.500

S-10 Calculation Table of Excavation Volume

Station	Dis.	Rock					Weathered Rock					Earth					Clayey Material	
		Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
No.	(m)	Ao	Vo	Al	V1	V2	Ao	Vo	Al	V1	V2	Ao	Vo	Al	V1	V2	Ao	Vo
-11.50	8.500	0	9.222.500	0	9.222.500		0	10.710.000		10.710.000		0	4.080.000	0	4.080.000	0	0	4.080.000
-3.00	4.000	2.170	11.620.000	2.170	11.620.000	0	2.520	11.040.000	2.520	11.040.000	0	960	3.920.000	960	3.920.000	0	960	3.920.000
1.00	0	3.640	0	3.640	0	0	3.000	0	3.000	0	0	1.000	0	1.000	0	0	1.000	0
Sum. 1	12.500		20.842.500		20.842.500	0		21.750.000		21.750.000	0		8.000.000		8.000.000	0		8.000.000
1.00	50	3.640	292.000	3.640	114.750	177.250	3.000	150.000	380	22.500	127.500	2.000	100.000	0	0	100.000	0	0
1.05	1.150	8.040	9.246.000	950	1.092.500	8.153.500	3.000	3.450.000	520	598.000	2.852.000	2.000	2.300.000	0	0	2.300.000	0	0
2.20	10	8.040	80.400	950	9.500	70.900	3.000	30.000	520	5.200	24.800	2.000	25.000	0	0	25.000	0	0
2.21	190	8.040	1.527.600	950	180.500	1.347.100	3.000	570.000	520	98.800	471.200	3.000	570.000	0	0	570.000	0	0
2.40	10	8.040	80.400	950	9.500	70.900	3.000	30.000	520	5.200	24.800	3.000	25.000	0	0	25.000	0	0
2.41	590	8.040	4.743.600	950	560.500	4.183.100	3.000	1.770.000	520	306.800	1.463.200	2.000	1.180.000	0	0	1.180.000	0	0
3.00	2.000	8.040	15.550.000	950	1.900.000	13.650.000	3.000	6.700.000	520	1.040.000	5.660.000	2.000	4.000.000	0	0	4.000.000	0	0
5.00	1.000	7.510	8.890.000	950	5.610.000	3.280.000	3.700	3.155.000	520	1.565.000	1.590.000	2.000	1.470.000	0	470.000	1.000.000	0	470.000
6.00	1.000	10.270	10.685.000	10.270	10.685.000	0	2.610	2.715.000	2.610	2.715.000	0	940	940.000	940	940.000	0	940	915.000
7.00	1.000	11.100	11.935.000	11.100	11.935.000	0	2.820	2.805.000	2.820	2.805.000	0	940	955.000	940	955.000	0	950	960.000
8.00	1.000	12.770	10.795.000	12.770	10.795.000	0	2.790	2.700.000	2.790	2.700.000	0	970	925.000	970	925.000	0	970	960.000
9.00	1.000	8.820	10.800.000	8.820	10.800.000	0	2.610	2.685.000	2.610	2.685.000	0	880	925.000	880	925.000	0	950	960.000
10.00	1.000	12.780	11.505.000	12.780	11.505.000	0	2.760	2.700.000	2.760	2.700.000	0	970	960.000	970	960.000	0	970	965.000
11.00	1.000	10.230	10.975.000	10.230	10.975.000	0	2.640	2.685.000	2.640	2.685.000	0	950	950.000	950	950.000	0	960	955.000
12.00	1.000	11.720	11.290.000	11.720	11.290.000	0	2.730	2.735.000	2.730	2.735.000	0	950	950.000	950	950.000	0	950	955.000
13.00	1.000	10.860	11.820.000	10.860	11.820.000	0	2.740	2.795.000	2.740	2.795.000	0	950	950.000	950	950.000	0	960	955.000
14.00	1.000	12.780	11.280.000	12.780	11.280.000	0	2.850	2.850.000	2.850	2.850.000	0	950	950.000	950	950.000	0	950	955.000
15.00	1.000	9.780	16.860.000	9.780	4.890.000	11.970.000	2.850	2.955.000	2.850	1.425.000	1.530.000	950	1.500.000	950	475.000	1.025.000	960	480.000
16.00	1.000	23.940	23.755.000	0	5.480.000	18.275.000	3.060	3.030.000	0	515.000	2.515.000	2.050	2.080.000	0	355.000	1.725.000	0	0
17.00	1.000	23.570	19.200.000	10.960	12.895.000	6.305.000	3.000	2.870.000	1.030	1.885.000	985.000	2.110	1.525.000	710	825.000	700.000	0	475.000
18.00	1.000	14.830	13.130.000	14.830	13.130.000	0	2.740	2.795.000	2.740	2.795.000	0	940	945.000	940	945.000	0	950	955.000
19.00	1.000	11.430	15.965.000	11.430	10.765.000	5.200.000	2.850	2.945.000	2.850	2.270.000	675.000	950	1.495.000	950	1.025.000	470.000	960	480.000
20.00	1.000	20.500	16.825.000	10.100	11.625.000	5.200.000	3.040	2.945.000	1.690	2.270.000	675.000	2.040	1.495.000	1.100	1.025.000	470.000	0	475.000
21.00	1.000	13.150	12.280.000	13.150	12.280.000	0	2.850	2.850.000	2.850	2.850.000	0	950	950.000	950	950.000	0	950	950.000
22.00	1.000	11.410	13.710.000	11.410	13.710.000	0	2.850	2.865.000	2.850	2.865.000	0	950	955.000	950	955.000	0	950	965.000
23.00	0	16.010	0	16.010	0	0	2.880	0	2.880	0	0	960	0	960	0	0	980	0
Sum. 2	22.000		273.220.000		195.337.250	77.882.750		63.780.000		45.186.500	18.593.500		29.120.000		15.530.000	13.590.000		13.860.000
23.00	1.000	16.010	16.465.000	16.010	16.465.000	0	2.880	2.875.000	2.880	2.875.000	0	960	960.000	960	960.000	0	980	980.000
24.00	1.000	16.920	17.300.000	16.920	13.610.000	3.690.000	2.870	2.905.000	2.870	2.260.000	645.000	960	1.470.000	960	1.020.000	450.000	980	490.000
25.00	1.000	17.680	19.065.000	10.300	9.970.000	9.095.000	2.940	2.945.000	1.850	1.500.000	1.445.000	1.980	1.970.000	1.080	970.000	1.000.000	0	0
26.00	0	20.450	0	9.640	0	0	2.950	0	1.350	0	0	1.960	0	860	0	0	0	0
26.00	1.000	20.920	23.110.000	9.900	4.950.000	18.160.000	3.120	3.165.000	1.440	720.000	2.445.000	2.120	2.150.000	940	470.000	1.680.000	0	0
27.00	1.000	25.300	29.535.000	0	0	29.535.000	3.210	3.405.000	0	0	3.405.000	2.180	2.310.000	0	0	2.310.000	0	0
28.00	1.000	33.770	32.495.000	0	2.515.000	29.980.000	3.600	3.580.000	0	360.000	3.220.000	2.440	2.420.000	0	220.000	2.200.000	0	0
29.00	1.000	31.220	23.280.000	5.030	10.185.000	13.095.000	3.520	3.275.000	680	1.855.000	1.420.000	2.400	1.715.000	440	735.000	980.000	0	525.000
30.00	1.000	15.340	18.420.000	15.340	12.070.000	6.350.000	3.030	3.270.000	3.030	2.385.000	885.000	1.030	1.710.000	1.030	1.085.000	625.000	1.050	525.000
31.00	1.000	21.500	17.310.000	8.800	10.960.000	6.350.000	3.510	3.225.000	1.740	2.340.000	885.000	2.390	1.685.000	1.140	1.060.000	625.000	0	495.000
32.00	1.000	13.120	14.470.000	13.120	11.720.000	2.750.000	2.940	3.045.000	2.940	2.500.000	545.000	980	1.545.000	980	1.160.000	385.000	990	495.000
33.00	1.000	15.820	22.420.000	10.320	5.160.000	17.260.000	3.150	3.210.000	2.080	1.030.000	2.180.000	2.110	2.165.000	1.340	670.000	1.495.000	0	0
34.00	1.000	29.020	44.215.000	0	0	44.215.000	3.270	3.585.000	0	0	3.585.000	2.220	2.425.000	0	0	2.425.000	0	0
35.00	1.000	59.410	46.965.000	0	0	46.965.000	3.900	3.900.000	0	0	3.900.000	2.630	2.635.000	0	0	2.635.000	0	0
36.00	1.000	34.520	31.520.000	0	0	31.520.000	3.900	3.570.000	0	0	3.570.000	2.640	2.400.000	0	0	2.400.000	0	0
37.00	1.000	28.520	33.635.000	0	0	33.635.000	3.240	3.390.000	0	0	3.390.000	2.160	2.280.000	0	0	2.280.000	0	0
38.00	0	38.750	0	0	0	0	3.540	0	0	0	0	2.400	0	0	0	0	0	0
38.00	1.000	41.430	53.970.000	0	0	53.970.000	4.020	5.355.000	0	0	5.355.000	3.180	3.850.000	0	0	3.850.000	0	0
39.00	1.000	66.510	53.135.000	0	0	53.135.000	6.090	5.700.000	0	0	5.700.000	4.120	4.020.000	0	0	4.020.000	0	0
40.00	1.000	39.760	42.595.000	0	0	42.595.000	5.310	5.460.000	0	0	5.460.000	3.920	3.890.000	0	0	3.890.000	0	0
41.00	1.000	45.430	50.915.000	0	0	50.915.000	5.610	6.630.000	0	0	6.630.000	3.860	4.500.000	0	0	4.500.000	0	0
42.00	1.000	56.400	93.105.000	0	0	93.105.000	7.650	8.415.000	0	0	8.415.000	5.140	5.680.000	0	0	5.680.000	0	0
43.00	1.000	129.810	118.390.000	0	0	118.390.000	9.180	7.980.000	0	0	7.980.000	6.220	5.390.000	0	0	5.390.000	0	0
44.00	1.000	106.970	89.225.000	0	0	89.225.000	6.780	5.590.000	0	0	5.590.000	4.560	3.750.000	0	0	3.750.000	0	0
45.00	1.000	71.480	64.580.000	0	0	64.580.000	4.400	5.125.000	0	0	5.125.000	2.940	3.490.000	0	0	3.490.000	0	0
46.00	1.000	57.680	43.150.000	0	0	43.150.000	5.850	4.755.000	0	0	4.755.000	4.040	3.290.000	0	0	3.290.000	0	0
47.00	1.000	28.620	25.045.000	0	0	25.045.000	3.660	3.585.000	0	0	3.585.000	2.540	2.470.000	0	0	2.470.000	0	0
48.00	1.000	21.470	24.800.000	0	0	24.800.000	3.510	3.510.000	0	0	3.510.000	2.400	2.400.000	0	0	2.400.000	0	0
49.00	1.000	28.130	29.695.000	0	0	29.695.000	3.510	3.525.000	0	0	3.525.000	2.400	2.430.000	0	0	2.430.000	0	0
50.00	0	31.280	0	0	0	0	3.540	0	0	0	0	2.400	0	0	0	0	0	0
Sum. 3	27.000		1.078.810.000		97.605.000	981.205.000		114.955.000		17.805.000	97.150.000		74.800.000		8.350.000	66.450.000		3.510.000
50.00	1.000	31.280	29.175.000	0	1.730.000	27.445.000	3.540	3.305.000	0	285.000	3.020.000	2.480	2.300.000	0	210.000	2.090.000	0	0
51.00	1.000	27.090	20.840.000	3.460	5.630.000	15.210.000	3.870	3.055.000	570	935.000	2.120.000	2.140	2.090.000	420	610.000	1.480.000	0	0
52.00	1.000	14.590	14.600.000	7.800	5.070.000	9.530.000	3.040	3.150.000	1.300	1.050.000	2.100.000	2.040	2.125.000	800	620.000	1.505.000	0	0
53.00	1.000	14.610	11.995.000	2.340	1.170.000	10.825.000	3.260	2.980.000	800	400.000	2.580.000	2.210	2.070.000	440	220.000	1.850.000	0	0
54.00	0	9.380	0	0	0	0	2.700	0	0	0	0	1.930	0	0	0	0	0	0
Sum. 4	4.000		76.610.000		13.600.000	63.010.000		12.490.000		2.670.000	9.820.000		8.585.000		1.660.000	6.925.000		0
54.00	1.000	9.380	7.000.000	0	2.310.000	4.690.000	2.700	2.790.000	0	1.440.000	1.350.000	1.930	1.480.000	0	495.000	965.000	0	530.000
55.00	1.000	4.620	3.775.000	4.620	3.775.000	0	2.880	2.745.000	2.880	2.745.000	0	990	1.015.000	990	1.015.000	0	1.060	1.090.000
56.00	1.000	2.930	1.995.000	2.930	1.995.000	0	2.610	2.625.000	2.610	2.625.000	0	1.040	970.000	1.040	970.000	0	1.120	1.025.000
57.00	1.000	1.060	2.110.000	1.060	2.110.000	0	2.640	2.820.000	2.640	2.820.000	0	900	1.035.000	900	1.035.000	0	930	1.090.000
58.00	1.000	3.160	2.440.000	3.160	2.440.000	0	3.000	2.865.000	3.000	2.865.000	0	1.170	1.060.000	1.170	1.060.000	0	1.250	1.110.000
59.00	1.000	1.720	1.975.000	1.720	1.975.000	0	2.730	2.835.000	2.730	2.835.000	0	950	1.025.000	950	1.025.000	0	970	1.050.000
60.00	1.000	2.230	1.620.000	2.230	1.620.000	0	2.940	2.775.000	2.940	2.775.000	0	1.100	1.000.000	1.100	1.000.000	0	1.130	1.025.000
61.00	1.000	1.010	1.540.000	1.010	1.540.000	0	2.610	2.700.000	2.610	2.700.000	0	900	935.000	900	935.000	0	920	955.000
62.00	1.000	2.070	2.170.000	2.070	2.170.000	0	2.790	2.805.000	2.790	2.805.000	0	970	975.000	970	975.000	0	990	995.000
63.00	1.000	2.270	1.790.000	2.270	1.790.000	0	2.820	2.760.000	2.820	2.760.000	0	980	980.000	980	960.000	0	1.000	980.000
64.00	1.000	1.310	1.345.000	1.310	1.345.000	0	2.700	2.650.000	2.700	2.650.000	0	940	945.000	940	945.000	0	960	960.000
65.00	1.000	1.380	855.000	1.380	855.000	0	2.600	2.605.000	2.600	2.605.000	0	950	930.000	950	930.000	0	960	940.000
66.00	9.900	330	1.633.500	330	1.633.500	0	2.610	12.919.500	2.610	12.919.500	0	910	4.504.500	910	4.504.500	0	920	4.554.000
75.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	21.900		30.248.500		25.558.500	4.690.000		45.894.500		44.544.500	1.350.000		16.814.500		15.849.500	965.000		16.304.000
S-10																		
Sum. 1	12.500		20.842.500		20.842.500	0		21.750.000		21.750.000	0		8.000.000		8.000.000	0		8.000.000
Sum. 2	22.000		273.220.000		195.337.250	77.882.750		63.780.000		45.186.500	18.593.500		29.120.000		15.530.000	13.590.000		13.860.000
Sum. 3	27.000		1.078.810.000		97.605.000	981.205.000		114.955.000		17.805.000	97.150.000		74.800.000		8.350.000	66.450.000		3.510.000
Sum. 4	4.000		76.610.000		13.600.000	63.010.000		12.490.000		2.670.000	9.820.000		8.585.000		1.660.000	6.925.000		0
Sum. 5	21.900		30.248.500		25.558.500	4.690.000		45.894.500		44.544.500	1.350.000		16.814.500		15.849.500	965.000		16.304.000
Total	87.400		1.479.731.000		352.943.250	1.126.787.750		258.869.500		131.956.000	126.913.500		137.319.500		49.389.500	87.930.000		41.674.000

Total Excavation Vol.	1.917.594.000
Dry	1.341.631.250
Wet	575.962.750

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Calculation Table of Excavation Volume

Station	Dis.	Rock					Weathered Rock					Earth					Clayey Material	
		Total		Underwater		Dry	Total		Underwater		Dry	Total		Underwater		Dry	Total	
No.	(m)	Ao	Vo	A1	V1	V2	Ao	Vo	A1	V1	Dry V2	Ao	Vo	Wet A1	Wet V1	Dry V2	Ao	Vo
-11.60	8.600	0	5.160.000	0	5.160.000		0	6.020.000		6.020.000		0	2.279.000	0	2.279.000	0	0	2.279.000
-3.00	4.000	1.200	6.400.000	1.200	6.400.000	0	1.400	6.100.000	1.400	6.100.000	0	530	2.160.000	530	2.160.000	0	530	2.160.000
1.00	0	2.000	0	2.000	0	0	1.650	0	1.650	0	0	550	0	550	0	0	550	0
Sum. 1	12.600		11.560.000		11.560.000	0		12.120.000		12.120.000	0		4.439.000		4.439.000	0		4.439.000
1.00	50	2.000	160.000	200	18.000	142.000	1.650	82.500	200	12.500	70.000	1.100	55.000	0	0	55.000	0	0
1.05	1.150	4.400	5.060.000	520	598.000	4.462.000	1.650	1.897.500	300	345.000	1.552.500	1.100	1.265.000	0	0	1.265.000	0	0
2.20	10	4.400	44.000	520	5.200	38.800	1.650	16.500	300	3.000	13.500	1.100	13.750	0	0	13.750	0	0
2.21	190	4.400	836.000	520	98.800	737.200	1.650	313.500	300	57.000	256.500	1.650	313.500	0	0	313.500	0	0
2.40	10	4.400	44.000	520	5.200	38.800	1.650	16.500	300	3.000	13.500	1.650	13.750	0	0	13.750	0	0
2.41	590	4.400	2.596.000	520	306.800	2.289.200	1.650	973.500	300	177.000	796.500	1.100	649.000	0	0	649.000	0	0
3.00	2.000	4.400	8.600.000	520	1.040.000	7.560.000	1.650	4.850.000	300	600.000	4.250.000	1.100	2.200.000	0	0	2.200.000	0	0
5.00	1.000	4.200	4.645.000	520	2.805.000	1.840.000	3.200	2.365.000	300	915.000	1.450.000	1.100	805.000	0	255.000	550.000	0	255.000
6.00	1.000	5.090	5.410.000	5.090	5.410.000	0	1.530	1.530.000	1.530	1.530.000	0	510	515.000	510	515.000	0	510	515.000
7.00	1.000	5.730	5.825.000	5.730	5.825.000	0	1.530	1.860.000	1.530	1.410.000	450.000	520	515.000	520	515.000	0	520	520.000
8.00	1.000	5.920	5.205.000	5.920	5.205.000	0	2.190	1.755.000	1.290	1.305.000	450.000	510	480.000	510	480.000	0	520	515.000
9.00	1.000	4.490	5.425.000	4.490	5.425.000	0	1.320	1.430.000	1.320	1.430.000	0	450	475.000	450	475.000	0	510	515.000
10.00	1.000	6.360	5.615.000	6.360	5.615.000	0	1.540	1.445.000	1.540	1.445.000	0	500	505.000	500	505.000	0	520	515.000
11.00	1.000	4.870	5.330.000	4.870	5.330.000	0	1.350	1.400.000	1.350	1.400.000	0	510	510.000	510	510.000	0	510	515.000
12.00	1.000	5.790	5.580.000	5.790	5.580.000	0	1.450	1.445.000	1.450	1.445.000	0	510	510.000	510	510.000	0	520	520.000
13.00	1.000	5.370	5.740.000	5.370	5.740.000	0	1.440	1.500.000	1.440	1.500.000	0	510	515.000	510	515.000	0	520	520.000
14.00	1.000	6.110	5.950.000	6.110	5.950.000	0	1.560	1.545.000	1.560	1.545.000	0	520	520.000	520	520.000	0	520	520.000
15.00	1.000	5.790	8.510.000	5.790	2.895.000	5.615.000	1.530	1.650.000	1.530	765.000	885.000	520	870.000	520	260.000	610.000	520	260.000
16.00	1.000	11.230	12.420.000	0	1.655.000	10.765.000	1.770	1.720.000	0	165.000	1.555.000	1.220	1.175.000	0	105.000	1.070.000	0	0
17.00	1.000	13.610	10.955.000	3.310	5.805.000	5.150.000	1.670	1.835.000	330	965.000	670.000	1.130	835.000	210	375.000	460.000	0	275.000
18.00	1.000	8.300	6.905.000	8.300	6.905.000	0	1.600	1.570.000	1.600	1.570.000	0	540	520.000	540	520.000	0	550	525.000
19.00	1.000	5.510	7.540.000	5.510	6.255.000	1.285.000	1.540	1.625.000	1.540	1.295.000	330.000	500	835.000	500	585.000	250.000	500	250.000
20.00	1.000	9.570	8.320.000	7.000	7.035.000	1.285.000	1.710	1.635.000	1.050	1.305.000	330.000	1.170	845.000	670	595.000	250.000	0	265.000
21.00	1.000	7.070	6.560.000	7.070	6.560.000	0	1.560	1.550.000	1.560	1.550.000	0	520	520.000	520	520.000	0	530	525.000
22.00	1.000	6.050	7.130.000	6.050	7.130.000	0	1.540	1.555.000	1.540	1.555.000	0	520	530.000	520	530.000	0	520	535.000
23.00	0	8.210	0	8.210	0	0	1.570	0	1.570	0	0	540	0	540	0	0	550	0
Sum. 2	22.000		140.405.000		99.197.000	41.208.000		37.365.000		24.292.500	13.072.500		15.990.000		8.290.000	7.700.000		7.545.000
23.00	1.000	8.210	8.395.000	8.210	8.395.000	0	1.570	1.600.000	1.570	1.600.000	0	540	545.000	540	545.000	0	550	555.000
24.00	1.000	8.580	8.810.000	8.580	7.920.000	890.000	1.630	1.635.000	1.630	1.325.000	310.000	550	825.000	550	605.000	220.000	560	280.000
25.00	1.000	9.040	9.715.000	7.260	6.545.000	3.170.000	1.640	1.640.000	1.020	865.000	775.000	1.100	1.125.000	660	570.000	555.000	0	0
26.00	0	10.390	0	5.830	0	0	1.840	0	710	0	0	1.150	0	480	0	0	0	0
26.00	1.000	11.150	13.080.000	6.100	3.050.000	10.030.000	1.870	1.905.000	810	405.000	1.500.000	1.280	1.300.000	520	260.000	1.040.000	0	0
27.00	1.000	15.010	16.695.000	0	0	16.695.000	1.940	2.050.000	0	0	2.050.000	1.320	1.430.000	0	0	1.430.000	0	0
28.00	1.000	18.380	17.725.000	0	590.000	17.135.000	2.180	2.220.000	0	55.000	2.165.000	1.540	1.550.000	0	40.000	1.510.000	0	0
29.00	1.000	17.070	12.350.000	1.180	4.405.000	7.945.000	2.280	2.025.000	110	940.000	1.085.000	1.560	1.080.000	80	340.000	740.000	0	305.000
30.00	1.000	7.630	8.710.000	7.630	6.875.000	1.835.000	1.770	1.860.000	1.770	1.440.000	420.000	600	995.000	600	650.000	345.000	610	305.000
31.00	1.000	9.790	8.295.000	6.120	6.460.000	1.835.000	1.950	1.815.000	1.110	1.395.000	420.000	1.390	975.000	700	630.000	345.000	0	285.000
32.00	1.000	6.800	7.010.000	6.800	6.750.000	260.000	1.680	1.730.000	1.680	1.545.000	185.000	560	885.000	560	745.000	140.000	570	285.000
33.00	1.000	7.220	11.955.000	6.700	3.350.000	8.605.000	1.780	1.910.000	1.410	705.000	1.205.000	1.210	1.320.000	930	465.000	855.000	0	0
34.00	1.000	16.690	27.475.000	0	0	27.475.000	2.040	2.410.000	0	0	2.410.000	1.430	1.660.000	0	0	1.660.000	0	0
35.00	1.000	38.260	27.395.000	0	0	27.395.000	2.780	2.605.000	0	0	2.605.000	1.890	1.770.000	0	0	1.770.000	0	0
36.00	1.000	16.530	16.005.000	0	0	16.005.000	2.430	2.250.000	0	0	2.250.000	1.650	1.525.000	0	0	1.525.000	0	0
37.00	1.000	15.480	19.500.000	0	0	19.500.000	2.070	2.215.000	0	0	2.215.000	1.400	1.495.000	0	0	1.495.000	0	0
38.00	0	23.520	0	0	0	0	2.360	0	0	0	0	1.590	0	0	0	0	0	0
38.00	1.000	26.610	35.990.000	0	0	35.990.000	3.450	4.170.000	0	0	4.170.000	2.420	2.900.000	0	0	2.900.000	0	0
39.00	1.000	45.370	34.295.000	0	0	34.295.000	4.890	4.215.000	0	0	4.215.000	3.380	3.160.000	0	0	3.160.000	0	0
40.00	1.000	23.220	26.195.000	0	0	26.195.000	3.540	3.960.000	0	0	3.960.000	2.940	2.950.000	0	0	2.950.000	0	0
41.00	1.000	29.170	35.240.000	0	0	35.240.000	4.380	4.650.000	0	0	4.650.000	2.960	3.170.000	0	0	3.170.000	0	0
42.00	1.000	41.310	68.255.000	0	0	68.255.000	4.920	6.690.000	0	0	6.690.000	3.380	4.540.000	0	0	4.540.000	0	0
43.00	1.000	95.200	86.235.000	0	0	86.235.000	8.460	7.290.000	0	0	7.290.000	5.700	4.900.000	0	0	4.900.000	0	0
44.00	1.000	77.270	57.495.000	0	0	57.495.000	6.120	4.580.000	0	0	4.580.000	4.100	3.090.000	0	0	3.090.000	0	0
45.00	1.000	37.720	38.420.000	0	0	38.420.000	3.040	3.835.000	0	0	3.835.000	2.080	2.595.000	0	0	2.595.000	0	0
46.00	1.000	39.120	27.165.000	0	0	27.165.000	4.830	3.600.000	0	0	3.600.000	3.110	2.420.000	0	0	2.420.000	0	0
47.00	1.000	15.210	13.060.000	0	0	13.060.000	2.570	2.350.000	0	0	2.350.000	1.730	1.585.000	0	0	1.585.000	0	0
48.00	1.000	10.910	13.475.000	0	0	13.475.000	2.130	2.185.000	0	0	2.185.000	1.440	1.480.000	0	0	1.480.000	0	0
49.00	1.000	16.040	17.280.000	0	0	17.280.000	2.240	2.245.000	0	0	2.245.000	1.520	1.570.000	0	0	1.570.000	0	0
50.00	0	18.520	0	0	0	0	2.250	0	0	0	0	1.820	0	0	0	0	0	0
Sum. 3	27.000		666.220.000		54.340.000	611.880.000		79.640.000		10.275.000	69.365.000		52.840.000		4.850.000	47.990.000		2.015.000
50.00	1.000	18.520	18.200.000	0	220.000	17.980.000	2.250	2.095.000	0	25.000	2.070.000	1.820	1.485.000	0	15.000	1.470.000	0	0
51.00	1.000	17.880	12.245.000	440	3.235.000	9.010.000	1.940	1.880.000	50	670.000	1.190.000	1.350	1.300.000	30	435.000	865.000	0	0
52.00	1.000	6.610	5.850.000	6.030	4.140.000	1.710.000	1.780	1.825.000	1.290	1.040.000	785.000	1.250	1.255.000	840	640.000	615.000	0	0
53.00	1.000	5.090	4.945.000	2.250	1.125.000	3.820.000	1.870	1.845.000	790	395.000	1.250.000	1.260	1.180.000	440	220.000	960.000	0	0
54.00	0	4.800	0	0	0	0	1.420	0	0	0	0	1.100	0	0	0	0	0	0
Sum. 4	4.000		41.240.000		8.720.000	32.520.000		7.425.000		2.130.000	5.295.000		5.220.000		1.310.000	3.910.000		0
54.00	1.000	4.800	3.785.000	0	1.385.000	2.400.000	1.420	1.490.000	0	780.000	710.000	1.100	825.000	0	275.000	550.000	0	285.000
55.00	1.000	2.770	1.850.000	2.770	1.850.000	0	1.560	1.470.000	1.560	1.470.000	0	550	530.000	550	530.000	0	570	550.000
56.00	1.000	930	715.000	930	715.000	0	1.380	1.365.000	1.380	1.365.000	0	510	500.000	510	500.000	0	530	520.000
57.00	1.000	500	680.000	500	680.000	0	1.350	1.350.000	1.350	1.350.000	0	490	490.000	490	490.000	0	510	510.000
58.00	1.000	860	695.000	860	695.000	0	1.350	1.335.000	1.350	1.335.000	0	490	490.000	490	490.000	0	510	510.000
59.00	1.000	530	505.000	530	505.000	0	1.320	1.335.000	1.320	1.335.000	0	490	495.000	490	495.000	0	510	515.000
60.00	1.000	480	440.000	480	440.000	0	1.350	1.320.000	1.350	1.320.000	0	500	490.000	500	490.000	0	520	515.000
61.00	1.000	400	505.000	400	505.000	0	1.290	1.335.000	1.290	1.335.000	0	480	490.000	480	490.000	0	510	515.000
62.00	1.000	610	735.000	610	735.000	0	1.380	1.380.000	1.380	1.380.000	0	500	500.000	500	500.000	0	520	520.000
63.00	1.000	860	885.000	860	885.000	0	1.380	1.350.000	1.380	1.350.000	0	500	490.000	500	490.000	0	520	510.000
64.00	1.000	910	620.000	910	620.000	0	1.320	1.335.000	1.320	1.335.000	0	480	490.000	480	490.000	0	500	510.000
65.00	1.000	330	265.000	330	265.000	0	1.350	1.305.000	1.350	1.305.000	0	500	480.000	500	480.000	0	520	500.000
66.00	11.200	200	1.120.000	200	1.120.000	0	1.260	7.056.000	1.260	7.056.000	0	460	2.576.000	460	2.576.000	0	480	2.688.000
77.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	23.200		12.800.000		10.400.000	2.400.000		23.426.000		22.716.000	710.000		8.846.000		8.296.000	550.000		8.648.000
S-11																		
Sum. 1	12.600		11.560.000		11.560.000	0		12.120.000		12.120.000	0		4.439.000		4.439.000	0		4.439.000
Sum. 2	22.000		140.405.000		99.197.000	41.208.000		37.365.000		24.292.500	13.072.500		15.990.000		8.290.000	7.700.000		7.545.000
Sum. 3	27.000		666.220.000		54.340.000	611.880.000		79.640.000		10.275.000	69.365.000		52.840.000		4.850.000	47.990.000		2.015.000
Sum. 4	4.000		41.240.000		8.720.000	32.520.000		7.425.000		2.130.000	5.295.000		5.220.000		1.310.000	3.910.000		0
Sum. 5	23.200		12.800.000		10.400.000	2.400.000		23.426.000		22.716.000	710.000		8.846.000		8.296.000	550.000		8.648.000
TOtal	88.800		872.225.000		184.217.000	688.008.000		159.976.000		71.533.500	88.442.500		87.335.000		27.185.000	60.150.000		22.517.000

TOtal Excavation Vol.	1.142.183.000
Dry	836.600.500
Wet	305.582.500

S-12 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Ai	Rock Underwater Vi	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Ai	Weathered Rock Underwater Vi	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Wet Ai	Earth Underwater Wet Vi	Earth Dry V2	Clayey Material Total Ao	Clayey Material Total Vo
-11.60	8.600	0	10.320.000	0	10.320.000		0	12.040.000		12.040.000		0	4.558.000	0	4.558.000	0	0	4.558.000
-3.00	4.000	2.400	12.800.000	2.400	12.800.000	0	2.800	12.200.000	2.800	12.200.000	0	1.060	4.320.000	1.060	4.320.000	0	1.060	4.320.000
1.00	0	4.000	0	4.000	0	0	3.300	0	3.300	0	0	1.100	0	1.100	0	0	1.100	0
Sum 1	12.600		23.120.000		23.120.000	0		24.240.000		24.240.000	0		8.878.000		8.878.000	0		8.878.000
1.00	50	4.000	321.000	520	39.000	282.000	3.300	165.000	410	24.500	140.500	2.200	110.000	0	0	110.000	0	0
1.05	1.150	8.840	10.166.000	1.040	1.196.000	8.970.000	3.300	3.795.000	570	655.500	3.139.500	2.200	2.530.000	0	0	2.530.000	0	0
2.20	10	8.840	88.400	1.040	10.400	78.000	3.300	33.000	570	5.700	27.300	2.200	27.500	0	0	27.500	0	0
2.21	190	8.840	1.679.600	1.040	197.600	1.482.000	3.300	627.000	570	108.300	518.700	3.300	627.000	0	0	627.000	0	0
2.40	10	8.840	88.400	1.040	10.400	78.000	3.300	33.000	570	5.700	27.300	3.300	27.500	0	0	27.500	0	0
2.41	590	8.840	5.215.600	1.040	613.600	4.602.000	3.300	1.947.000	570	336.300	1.610.700	2.200	1.298.000	0	0	1.298.000	0	0
3.00	2.000	8.840	17.140.000	1.040	2.080.000	15.060.000	3.300	7.800.000	570	1.140.000	6.660.000	2.200	4.400.000	0	0	4.400.000	0	0
5.00	1.000	8.300	9.850.000	1.040	6.220.000	3.630.000	4.500	3.735.000	570	1.770.000	1.965.000	2.200	1.595.000	0	495.000	1.100.000	0	500.000
6.00	1.000	11.400	12.120.000	11.400	12.120.000	0	2.970	2.975.000	2.970	2.975.000	0	990	995.000	990	995.000	0	1.000	1.000.000
7.00	1.000	12.840	13.380.000	12.840	13.380.000	0	2.980	2.945.000	2.980	2.945.000	0	1.000	1.005.000	1.000	1.005.000	0	1.000	1.010.000
8.00	1.000	13.920	11.950.000	13.920	11.950.000	0	2.910	2.850.000	2.910	2.850.000	0	1.010	970.000	1.010	970.000	0	1.020	1.010.000
9.00	1.000	9.980	11.940.000	9.980	11.940.000	0	2.790	2.850.000	2.790	2.850.000	0	930	970.000	930	970.000	0	1.000	1.010.000
10.00	1.000	13.900	12.445.000	13.900	12.445.000	0	2.910	2.850.000	2.910	2.850.000	0	1.010	1.005.000	1.010	1.005.000	0	1.020	1.010.000
11.00	1.000	10.990	11.840.000	10.990	11.840.000	0	2.790	2.810.000	2.790	2.810.000	0	1.000	990.000	1.000	990.000	0	1.000	990.000
12.00	1.000	12.690	12.100.000	12.690	12.100.000	0	2.830	2.870.000	2.830	2.870.000	0	980	990.000	980	990.000	0	980	1.000.000
13.00	1.000	11.510	12.550.000	11.510	12.550.000	0	2.910	2.955.000	2.910	2.955.000	0	1.000	1.000.000	1.000	1.000.000	0	1.020	1.015.000
14.00	1.000	13.590	8.425.000	13.590	8.425.000	0	3.000	3.000.000	3.000	3.000.000	0	1.000	1.000.000	1.000	1.000.000	0	1.010	1.055.000
15.00	1.000	3.260	14.430.000	3.260	1.630.000	12.800.000	3.000	3.105.000	3.000	1.500.000	1.605.000	1.000	1.575.000	1.000	500.000	1.075.000	1.100	550.000
16.00	1.000	25.600	25.560.000	0	6.160.000	19.400.000	3.210	3.195.000	0	570.000	2.625.000	2.150	2.050.000	0	240.000	1.810.000	0	0
17.00	1.000	25.520	20.625.000	12.320	14.025.000	6.600.000	3.180	3.035.000	1.140	2.015.000	1.020.000	1.950	1.465.000	480	730.000	735.000	0	505.000
18.00	1.000	15.730	13.820.000	15.730	13.820.000	0	2.890	2.945.000	2.890	2.945.000	0	980	990.000	980	990.000	0	1.010	1.005.000
19.00	1.000	11.910	17.170.000	11.910	11.465.000	5.705.000	3.000	3.105.000	3.000	2.385.000	720.000	1.000	1.580.000	1.000	1.070.000	510.000	1.000	500.000
20.00	1.000	22.430	18.665.000	11.020	12.960.000	5.705.000	3.210	3.110.000	1.770	2.390.000	720.000	2.160	1.580.000	1.140	1.070.000	510.000	0	505.000
21.00	1.000	14.900	14.085.000	14.900	14.085.000	0	3.010	3.005.000	3.010	3.005.000	0	1.000	1.000.000	1.000	1.000.000	0	1.010	1.005.000
22.00	1.000	13.270	15.205.000	13.270	15.205.000	0	3.000	3.015.000	3.000	3.015.000	0	1.000	1.010.000	1.000	1.010.000	0	1.000	1.010.000
23.00	0	17.140	0	17.140	0	0	3.030	0	3.030	0	0	1.020	0	1.020	0	0	1.020	0
Sum 2	22.000		290.859.000		206.467.000	84.392.000		68.755.000		47.976.000	20.779.000		30.790.000		16.030.000	14.760.000		14.680.000
23.00	1.000	17.140	17.515.000	17.140	17.515.000	0	3.030	3.030.000	3.030	3.030.000	0	1.020	1.015.000	1.020	1.015.000	0	1.020	1.030.000
24.00	1.000	17.890	18.535.000	17.890	14.495.000	4.040.000	3.030	3.075.000	3.030	2.385.000	690.000	1.010	1.555.000	1.010	1.075.000	480.000	1.040	520.000
25.00	1.000	19.180	20.405.000	11.100	10.750.000	9.655.000	3.120	3.105.000	1.740	1.590.000	1.515.000	2.100	2.105.000	1.140	1.050.000	1.055.000	0	0
26.00	0	21.630	0	10.400	0	0	3.090	0	1.440	0	0	2.110	0	960	0	0	0	0
26.00	1.000	22.700	25.085.000	10.720	5.360.000	19.725.000	3.290	3.340.000	1.540	770.000	2.570.000	2.250	2.285.000	1.020	510.000	1.775.000	0	0
27.00	1.000	27.470	31.950.000	0	0	31.950.000	3.390	3.570.000	0	0	3.570.000	2.320	2.430.000	0	0	2.430.000	0	0
28.00	1.000	36.430	35.095.000	0	2.770.000	32.325.000	3.750	3.725.000	0	385.000	3.340.000	2.540	2.525.000	0	250.000	2.275.000	0	0
29.00	1.000	33.760	25.380.000	5.540	11.270.000	14.110.000	3.700	3.450.000	770	1.985.000	1.465.000	2.510	1.805.000	500	800.000	1.005.000	0	550.000
30.00	1.000	17.000	20.545.000	17.000	13.340.000	7.205.000	3.200	3.445.000	3.200	2.515.000	930.000	1.100	1.805.000	1.100	1.150.000	655.000	1.100	550.000
31.00	1.000	24.090	19.010.000	9.680	11.805.000	7.205.000	3.690	3.405.000	1.830	2.475.000	930.000	2.510	1.775.000	1.200	1.120.000	655.000	0	525.000
32.00	1.000	13.930	15.670.000	13.930	12.615.000	3.055.000	3.120	3.215.000	3.120	2.630.000	585.000	1.040	1.845.000	1.040	1.225.000	420.000	1.050	525.000
33.00	1.000	17.410	24.245.000	11.300	5.650.000	18.595.000	3.310	3.380.000	2.140	1.070.000	2.310.000	2.250	2.290.000	1.410	705.000	1.585.000	0	0
34.00	1.000	31.080	46.630.000	0	0	46.630.000	3.450	3.735.000	0	0	3.735.000	2.330	2.530.000	0	0	2.530.000	0	0
35.00	1.000	62.180	49.990.000	0	0	49.990.000	4.020	4.050.000	0	0	4.050.000	2.730	2.735.000	0	0	2.735.000	0	0
36.00	1.000	37.800	34.255.000	0	0	34.255.000	4.080	3.750.000	0	0	3.750.000	2.740	2.530.000	0	0	2.5[illegible].000	0	0
37.00	1.000	30.710	36.175.000	0	0	36.175.000	3.420	3.585.000	0	0	3.585.000	2.320	2.410.000	0	0	2.410.000	0	0
38.00	0	41.640	0	0	0	0	3.750	0	0	0	0	2.500	0	0	0	0	0	0
38.00	1.000	44.230	58.100.000	0	0	58.100.000	4.860	5.220.000	0	0	5.220.000	3.280	3.590.000	0	0	3.590.000	0	0
39.00	1.000	71.970	57.885.000	0	0	57.885.000	5.580	5.580.000	0	0	5.580.000	3.900	3.900.000	0	0	3.900.000	0	0
40.00	1.000	43.800	47.150.000	0	0	47.150.000	5.580	5.680.000	0	0	5.680.000	3.900	3.900.000	0	0	3.900.000	0	0
41.00	1.000	50.500	61.140.000	0	0	61.140.000	5.780	6.760.000	0	0	6.760.000	3.900	4.560.000	0	0	4.560.000	0	0
42.00	1.000	71.780	103.115.000	0	0	103.115.000	7.740	8.490.000	0	0	8.490.000	5.220	5.750.000	0	0	5.750.000	0	0
43.00	1.000	124.450	123.085.000	0	0	123.085.000	9.240	8.040.000	0	0	8.040.000	6.280	5.440.000	0	0	5.440.000	0	0
44.00	1.000	111.720	93.655.000	0	0	93.655.000	6.840	5.660.000	0	0	5.660.000	4.600	3.830.000	0	0	3.830.000	0	0
45.00	1.000	75.590	68.080.000	0	0	68.080.000	4.480	5.225.000	0	0	5.225.000	3.060	3.595.000	0	0	3.595.000	0	0
46.00	1.000	60.570	46.905.000	0	0	46.905.000	5.970	4.865.000	0	0	4.865.000	4.130	3.365.000	0	0	3.365.000	0	0
47.00	1.000	33.240	27.885.000	0	0	27.885.000	3.760	3.755.000	0	0	3.755.000	2.800	2.610.000	0	0	2.610.000	0	0
48.00	1.000	22.530	26.205.000	0	850.000	25.355.000	3.750	3.735.000	0	135.000	3.600.000	2.620	2.585.000	0	85.000	2.500.000	0	0
49.00	1.000	29.880	31.525.000	1.700	850.000	30.675.000	3.720	3.720.000	270	135.000	3.585.000	2.550	2.550.000	170	85.000	2.465.000	0	0
50.00	0	33.170	0	0	0	0	3.720	0	0	0	0	2.550	0	0	0	0	0	0
Sum 3	27.000		1.165.215.000		107.270.000	1.057.945.000		118.590.000		19.105.000	99.485.000		77.115.000		9.070.000	68.045.000		3.700.000
50.00	1.000	33.170	30.995.000	0	1.925.000	29.070.000	3.720	3.475.000	0	310.000	3.165.000	2.550	2.400.000	0	235.000	2.165.000	0	0
51.00	1.000	28.820	22.370.000	3.850	6.090.000	16.280.000	3.230	3.200.000	620	955.000	2.245.000	2.250	2.215.000	470	655.000	1.560.000	0	0
52.00	1.000	15.920	15.965.000	8.330	5.400.000	10.565.000	3.170	3.285.000	1.290	1.040.000	2.245.000	2.180	2.230.000	840	640.000	1.590.000	0	0
53.00	1.000	16.010	13.250.000	2.470	1.235.000	12.015.000	3.400	3.130.000	790	395.000	2.735.000	2.280	2.140.000	440	220.000	1.920.000	0	0
54.00	0	10.490	0	0	0	0	2.860	0	0	0	0	2.000	0	0	0	0	0	0
Sum 4	4.000		82.580.000		14.650.000	67.930.000		13.090.000		2.700.000	10.390.000		8.985.000		1.750.000	7.235.000		0
54.00	1.000	10.490	8.155.000	0	2.910.000	5.245.000	2.860	2.945.000	0	1.515.000	1.430.000	2.000	1.525.000	0	525.000	1.000.000	0	565.000
55.00	1.000	5.820	4.630.000	5.820	4.630.000	0	3.030	3.060.000	3.030	3.060.000	0	1.050	1.080.000	1.050	1.080.000	0	1.130	1.150.000
56.00	1.000	3.440	2.505.000	3.440	2.505.000	0	3.090	2.940.000	3.090	2.940.000	0	1.110	1.005.000	1.110	1.005.000	0	1.170	1.040.000
57.00	1.000	1.570	2.435.000	1.570	2.435.000	0	2.790	3.075.000	2.790	3.075.000	0	900	1.075.000	900	1.075.000	0	910	1.110.000
58.00	1.000	3.300	2.815.000	3.300	2.815.000	0	3.360	3.135.000	3.360	3.135.000	0	1.250	1.130.000	1.250	1.130.000	0	1.310	1.170.000
59.00	1.000	2.330	2.675.000	2.330	2.675.000	0	2.910	3.000.000	2.910	3.000.000	0	1.010	1.065.000	1.010	1.065.000	0	1.030	1.085.000
60.00	1.000	3.020	2.455.000	3.020	2.455.000	0	3.090	2.970.000	3.090	2.970.000	0	1.120	1.060.000	1.120	1.060.000	0	1.140	1.080.000
61.00	1.000	1.890	1.060.000	1.890	1.060.000	0	2.850	2.910.000	2.850	2.910.000	0	1.000	1.015.000	1.000	1.015.000	0	1.020	1.035.000
62.00	1.000	230	1.650.000	230	1.650.000	0	2.970	2.985.000	2.970	2.985.000	0	1.030	1.035.000	1.030	1.035.000	0	1.050	1.055.000
63.00	1.000	3.070	2.430.000	3.070	2.430.000	0	3.000	2.925.000	3.000	2.925.000	0	1.040	1.015.000	1.040	1.015.000	0	1.060	1.040.000
64.00	1.000	1.790	1.720.000	1.790	1.720.000	0	2.850	2.850.000	2.850	2.850.000	0	990	990.000	990	990.000	0	1.020	1.060.000
65.00	1.000	1.650	1.345.000	1.650	1.345.000	0	2.850	2.805.000	2.850	2.805.000	0	990	975.000	990	975.000	0	1.100	1.040.000
66.00	11.200	1.040	5.824.000	1.040	5.824.000	0	2.760	15.456.000	2.760	15.456.000	0	960	5.376.000	960	5.376.000	0	980	5.488.000
77.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum 5	23.200		39.699.000		34.454.000	5.245.000		51.056.000		49.626.000	1.430.000		18.346.000		17.346.000	1.000.000		17.918.000
S-12																		
Sum 1	12.600		23.120.000		23.120.000	0		24.240.000		24.240.000	0		8.878.000		8.878.000	0		8.878.000
Sum 2	22.000		290.859.000		206.467.000	84.392.000		68.755.000		47.976.000	20.779.000		30.790.000		16.030.000	14.760.000		14.680.000
Sum 3	27.000		1.165.215.000		107.270.000	1.057.945.000		118.590.000		19.105.000	99.485.000		77.115.000		9.070.000	68.045.000		3.700.000
Sum 4	4.000		82.580.000		14.650.000	67.930.000		13.090.000		2.700.000	10.390.000		8.985.000		1.750.000	7.235.000		0
Sum 5	23.200		39.699.000		34.454.000	5.245.000		51.056.000		49.626.000	1.430.000		18.346.000		17.346.000	1.000.000		17.918.000
Total	88.800		1.601.473.000		385.961.000	1.215.512.000		275.731.000		143.647.000	132.084.000		144.114.000		53.074.000	91.040.000		45.175.000

Total Excavation Vol.	2.066.494.000
Dry	1.438.636.000
Wet	627.858.000

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Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total An	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Wet Al	Earth Underwater Wet Vl	Earth Dry Dry V2	Clayey Material Total An	Clayey Material Total Vo
-11.10	8.100	0	0	0	0		0	9,841,500		9,841,500		0	3,199,500	0	3,199,500	0	0	3,199,500
-3.00	4.000	0	2,060,000	0	2,060,000	0	2,430	9,660,000	2,430	9,660,000	0	790	3,220,000	790	3,220,000	0	790	3,220,000
1.00	0	1,030	0	1,030	0	0	2,400	0	2,400	0	0	820	0	820	0	0	820	0
Subt. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
1.00	50	1,030	158,250	470	35,500	122,750	2,400	123,000	380	22,500	100,500	1,640	85,000	0	0	85,000	0	
1.05	1.150	5,300	6,095,000	950	1,092,500	5,002,500	2,520	2,898,000	520	598,000	2,300,000	1,760	2,024,000	0	0	2,024,000	0	
2.20	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	1,760	22,600	0	0	22,600	0	
2.21	190	5,300	1,007,000	950	180,500	826,500	2,520	478,800	520	98,800	380,000	2,760	524,400	0	0	524,400	0	
2.40	10	5,300	53,000	950	9,500	43,500	2,520	25,200	520	5,200	20,000	2,760	22,600	0	0	22,600	0	
2.41	590	5,300	3,127,000	950	560,500	2,566,500	2,520	1,486,800	520	306,800	1,180,000	1,760	1,038,400	0	0	1,038,400	0	
3.00	2.000	5,300	10,600,000	950	1,900,000	8,700,000	2,520	5,040,000	520	1,040,000	4,000,000	1,760	3,520,000	0	0	3,520,000	0	0
5.00	1.000	5,300	6,340,000	950	4,165,000	2,175,000	2,520	2,445,000	520	1,445,000	1,000,000	1,760	1,290,000	0	410,000	880,000	0	410,000
6.00	1.000	7,380	8,005,000	7,380	8,005,000	0	2,370	2,415,000	2,370	2,415,000	0	820	825,000	820	825,000	0	820	825,000
7.00	1.000	8,630	9,125,000	8,630	9,125,000	0	2,460	2,430,000	2,460	2,430,000	0	830	830,000	830	830,000	0	830	830,000
8.00	1.000	9,620	7,895,000	9,620	7,895,000	0	2,400	2,320,000	2,400	2,320,000	0	830	795,000	830	795,000	0	830	825,000
9.00	1.000	6,170	7,850,000	6,170	7,850,000	0	2,240	2,335,000	2,240	2,335,000	0	760	795,000	760	795,000	0	820	825,000
10.00	1.000	9,530	8,475,000	9,530	8,475,000	0	2,430	2,385,000	2,430	2,385,000	0	830	830,000	830	830,000	0	830	830,000
11.00	1.000	7,420	8,130,000	7,420	8,130,000	0	2,340	2,385,000	2,340	2,385,000	0	830	830,000	830	830,000	0	830	830,000
12.00	1.000	8,840	8,420,000	8,840	8,420,000	0	2,430	2,415,000	2,430	2,415,000	0	830	830,000	830	830,000	0	830	830,000
13.00	1.000	8,000	7,570,000	8,000	7,570,000	0	2,400	2,430,000	2,400	2,430,000	0	830	830,000	830	830,000	0	830	830,000
14.00	1.000	7,140	8,045,000	7,140	8,045,000	0	2,460	2,460,000	2,460	2,460,000	0	830	830,000	830	830,000	0	830	830,000
15.00	1.000	8,950	14,245,000	8,950	4,475,000	9,770,000	2,460	2,610,000	2,460	1,230,000	1,380,000	830	1,275,000	830	415,000	860,000	830	415,000
16.00	1.000	19,540	19,490,000	0	4,570,000	14,920,000	2,760	2,730,000	0	465,000	2,265,000	1,720	1,730,000	0	230,000	1,500,000	0	0
17.00	1.000	19,440	15,820,000	9,140	10,670,000	5,150,000	2,700	2,590,000	930	1,705,000	885,000	1,740	1,285,000	460	645,000	640,000	0	415,000
18.00	1.000	12,200	10,310,000	12,200	10,310,000	0	2,480	2,470,000	2,480	2,470,000	0	830	830,000	830	830,000	0	830	830,000
19.00	1.000	8,420	12,390,000	8,420	8,475,000	3,915,000	2,460	2,565,000	2,460	1,980,000	585,000	830	1,315,000	830	905,000	410,000	830	415,000
20.00	1.000	18,360	12,045,000	8,530	8,130,000	3,915,000	2,670	2,565,000	1,500	1,980,000	585,000	1,800	1,315,000	980	905,000	410,000	0	415,000
21.00	1.000	7,730	8,475,000	7,730	8,475,000	0	2,460	2,460,000	2,460	2,460,000	0	830	830,000	830	830,000	0	830	830,000
22.00	1.000	9,220	10,730,000	9,220	10,730,000	0	2,460	2,475,000	2,460	2,475,000	0	830	840,000	830	840,000	0	830	845,000
23.00	0	12,240	0	12,240	0	0	2,490	0	2,490	0	0	850	0	850	0	0	860	0
Subt. 2	22.000		204,453,250		147,303,000	57,150,250		54,562,000		39,861,500	14,700,500		25,342,000		13,405,000	11,937,000		12,030,000
23.00	1.000	5,860	5,975,000	5,860	5,975,000	0	1,300	1,340,000	1,300	1,340,000	0	450	455,000	450	455,000	0	470	470,000
24.00	1.000	6,090	6,330,000	6,090	5,780,000	550,000	1,380	1,375,000	1,380	1,135,000	240,000	460	685,000	460	510,000	175,000	470	235,000
25.00	1.000	6,570	7,210,000	5,470	4,950,000	2,260,000	1,370	1,370,000	890	730,000	640,000	910	945,000	560	475,000	470,000	0	0
26.00	0	7,850	0	4,430	0	0	1,370	0	570	0	0	980	0	390	0	0	0	0
26.00	1.000	8,320	10,495,000	4,484	2,242,000	8,253,000	1,560	1,620,000	660	330,000	1,290,000	1,480	1,310,000	820	410,000	900,000	0	0
27.00	1.000	12,670	13,850,000	0	0	13,850,000	1,680	1,770,000	0	0	1,770,000	1,140	1,240,000	0	0	1,240,000	0	0
28.00	1.000	15,030	14,210,000	0	40,000	14,170,000	1,860	1,935,000	0	0	1,935,000	1,340	1,365,000	0	0	1,365,000	0	0
29.00	1.000	13,390	9,365,000	80	2,710,000	6,655,000	2,010	1,755,000	0	750,000	1,005,000	1,390	945,000	0	250,000	695,000	0	255,000
30.00	1.000	5,340	5,755,000	5,340	4,850,000	905,000	1,500	1,560,000	1,500	1,230,000	330,000	500	810,000	500	560,000	250,000	510	255,000
31.00	1.000	6,170	5,490,000	4,360	4,585,000	905,000	1,820	1,500,000	960	1,170,000	330,000	1,120	1,040,000	620	790,000	250,000	0	0
32.00	1.000	4,810	4,760,000	4,810	4,705,000	55,000	1,380	1,410,000	1,380	1,320,000	90,000	960	990,000	960	900,000	90,000	0	0
33.00	1.000	4,710	8,830,000	4,600	2,300,000	6,530,000	1,440	1,635,000	1,260	630,000	1,005,000	1,020	1,145,000	840	420,000	725,000	0	0
34.00	1.000	12,950	22,710,000	0	0	22,710,000	1,830	2,190,000	0	0	2,190,000	1,270	1,515,000	0	0	1,515,000	0	0
35.00	1.000	32,470	22,400,000	0	0	22,400,000	2,550	2,325,000	0	0	2,325,000	1,760	1,595,000	0	0	1,595,000	0	0
36.00	1.000	12,330	12,260,000	0	0	12,260,000	2,100	1,935,000	0	0	1,935,000	1,430	1,320,000	0	0	1,320,000	0	0
37.00	1.000	12,190	15,760,000	0	0	15,760,000	1,770	1,935,000	0	0	1,935,000	1,210	1,325,000	0	0	1,325,000	0	0
38.00	0	19,330	0	0	0	0	2,100	0	0	0	0	1,440	0	0	0	0	0	0
38.00	1.000	22,620	31,440,000	0	0	31,440,000	3,300	4,020,000	0	0	4,020,000	2,260	2,500,000	0	0	2,500,000	0	0
39.00	1.000	40,260	29,725,000	0	0	29,725,000	4,740	3,990,000	0	0	3,990,000	3,200	2,970,000	0	0	2,970,000	0	0
40.00	1.000	19,190	21,780,000	0	0	21,780,000	3,240	3,660,000	0	0	3,660,000	2,740	2,755,000	0	0	2,755,000	0	0
41.00	1.000	24,370	30,110,000	0	0	30,110,000	4,080	4,350,000	0	0	4,350,000	2,770	2,975,000	0	0	2,975,000	0	0
42.00	1.000	35,850	61,540,000	0	0	61,540,000	4,620	6,435,000	0	0	6,435,000	3,180	4,350,000	0	0	4,350,000	0	0
43.00	1.000	87,230	75,075,000	0	0	75,075,000	8,250	7,110,000	0	0	7,110,000	5,520	4,770,000	0	0	4,770,000	0	0
44.00	1.000	62,920	47,125,000	0	0	47,125,000	5,970	4,035,000	0	0	4,035,000	4,020	2,720,000	0	0	2,720,000	0	0
45.00	1.000	31,330	32,590,000	0	0	32,590,000	2,100	3,225,000	0	0	3,225,000	1,420	2,220,000	0	0	2,220,000	0	0
46.00	1.000	33,850	23,035,000	0	0	23,035,000	4,350	3,270,000	0	0	3,270,000	3,020	2,280,000	0	0	2,280,000	0	0
47.00	1.000	12,220	9,990,000	0	0	9,990,000	2,190	1,995,000	0	0	1,995,000	1,540	1,390,000	0	0	1,390,000	0	0
48.00	1.000	7,760	10,055,000	0	0	10,055,000	1,800	1,875,000	0	0	1,875,000	1,240	1,280,000	0	0	1,280,000	0	0
49.00	1.000	12,350	13,370,000	0	0	13,370,000	1,950	1,965,000	0	0	1,965,000	1,320	1,360,000	0	0	1,360,000	0	0
50.00	0	14,390	0	0	0	0	1,980	0	0	0	0	1,400	0	0	0	0	0	0
Subt. 3	27.000		551,235,000		38,137,000	513,098,000		71,585,000		8,635,000	62,950,000		48,255,000		4,770,000	43,485,000		1,215,000
50.00	1.000	25,820	24,420,000	0	1,125,000	23,295,000	3,200	2,960,000	0	195,000	2,765,000	2,180	2,020,000	0	140,000	1,880,000	0	0
51.00	1.000	23,020	16,375,000	2,250	4,475,000	11,900,000	2,720	2,695,000	390	855,000	1,840,000	1,860	1,835,000	280	555,000	1,280,000	0	0
52.00	1.000	9,730	9,935,000	6,700	4,185,000	5,750,000	2,670	2,765,000	1,320	1,060,000	1,705,000	1,810	1,855,000	830	635,000	1,220,000	0	0
53.00	1.000	10,140	8,380,000	1,670	835,000	7,545,000	2,860	2,585,000	800	400,000	2,185,000	1,900	1,780,000	440	220,000	1,560,000	0	0
54.00	0	6,620	0	0	0	0	2,310	0	0	0	0	1,660	0	0	0	0	0	0
Subt. 4	4.000		59,110,000		10,620,000	48,490,000		11,005,000		2,510,000	8,495,000		7,490,000		1,550,000	5,940,000		0
54.00	1.000	6,820	4,170,000	0	860,000	3,310,000	2,310	2,375,000	0	1,220,000	1,155,000	1,660	1,250,000	0	420,000	830,000	0	410,000
55.00	1.000	1,720	1,205,000	1,720	1,205,000	0	2,440	2,285,000	2,440	2,285,000	0	840	855,000	840	855,000	0	880	900,000
56.00	1.000	690	345,000	690	345,000	0	2,130	1,975,000	2,130	1,975,000	0	870	815,000	870	815,000	0	920	850,000
57.00	1.000	0	240,000	0	240,000	0	1,820	2,070,000	1,820	2,070,000	0	760	840,000	760	840,000	0	780	905,000
58.00	1.000	480	430,000	480	430,000	0	2,320	2,000,000	2,320	2,000,000	0	920	855,000	920	855,000	0	1,030	920,000
59.00	1.000	380	360,000	380	360,000	0	1,680	1,745,000	1,680	1,745,000	0	790	815,000	790	815,000	0	810	860,000
60.00	1.000	340	170,000	340	170,000	0	1,810	1,455,000	1,810	1,455,000	0	840	810,000	840	810,000	0	910	855,000
61.00	1.000	0	240,000	0	240,000	0	1,100	1,440,000	1,100	1,440,000	0	780	795,000	780	795,000	0	800	815,000
62.00	1.000	480	570,000	480	570,000	0	1,780	1,810,000	1,780	1,810,000	0	810	810,000	810	810,000	0	830	830,000
63.00	1.000	660	385,000	660	385,000	0	1,840	1,690,000	1,840	1,690,000	0	810	790,000	810	790,000	0	830	810,000
64.00	1.000	110	115,000	110	115,000	0	1,540	1,580,000	1,540	1,580,000	0	770	775,000	770	775,000	0	790	795,000
65.00	1.000	120	60,000	120	60,000	0	1,620	1,350,000	1,620	1,350,000	0	780	760,000	780	760,000	0	800	780,000
66.00	5.500	0	0	0	0	0	1,080	2,970,000	1,080	2,970,000	0	740	2,035,000	740	2,035,000	0	760	2,090,000
71.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subt. 5	17.500		8,290,000		4,980,000	3,310,000		24,745,000		23,590,000	1,155,000		12,205,000		11,375,000	830,000		11,850,000
S-16																		
Subt. 1	12.100		2,060,000		2,060,000	0		19,501,500		19,501,500	0		6,419,500		6,419,500	0		6,419,500
Subt. 2	22.000		204,453,250		147,303,000	57,150,250		54,562,000		39,861,500	14,700,500		25,342,000		13,405,000	11,937,000		12,030,000
Subt. 3	27.000		551,235,000		38,137,000	513,098,000		71,585,000		8,635,000	62,950,000		48,255,000		4,770,000	43,485,000		1,215,000
Subt. 4	4.000		59,110,000		10,620,000	48,490,000		11,005,000		2,510,000	8,495,000		7,490,000		1,550,000	5,940,000		0
Subt. 5	17.500		8,290,000		4,980,000	3,310,000		24,745,000		23,590,000	1,155,000		12,205,000		11,375,000	830,000		11,850,000
Total	82.600		825,148,250		203,100,000	622,048,250		181,398,500		94,098,000	87,300,500		99,711,500		37,519,500	62,192,000		31,514,500

Total Excavation Vol.	1,137,772,750
Dry	771,540,750
Wet	366,232,000

S-17 Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater Al	Rock Underwater Vl	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater Al	Weathered Rock Underwater Vl	Weathered Rock Dry Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater Al	Earth Underwater Vl	Earth Dry V2	Survey Material Total Ao	Survey Material Total Vo
-11.50	8.500	0	9.222.500	0	9.222.500		0	10.710.000		10.710.000		0	4.080.000	0	4.080.000	0	0	4.080.000
-3.00	4.000	2.170	11.620.000	2.170	11.620.000	0	2.520	11.040.000	2.520	11.040.000	0	960	3.920.000	960	3.920.000	0	960	3.920.000
1.00	0	3.640	0	3.640	0	0	3.000	0	3.000	0	0	1.000	0	1.000	0	0	1.000	0
Sub. 1	12.500		20.842.500		20.842.500	0		21.750.000		21.750.000	0		8.000.000		8.000.000	0		8.000.000
1.00	50	3.640	292.000	3.640	114.750	177.250	3.000	150.000	380	22.500	127.500	2.000	100.000	0	0	100.000	0	0
1.05	1.150	8.040	9.246.000	950	1.092.500	8.153.500	3.000	3.450.000	520	598.000	2.852.000	2.000	2.300.000	0	0	2.300.000	0	0
2.20	10	8.040	80.400	950	9.500	70.900	3.000	30.000	520	5.200	24.800	2.000	25.000	0	0	25.000	0	0
2.21	190	8.040	1.527.600	950	180.500	1.347.100	3.000	570.000	520	98.800	471.200	3.000	570.000	0	0	570.000	0	0
2.40	10	8.040	80.400	950	9.500	70.900	3.000	30.000	520	5.200	24.800	3.000	25.000	0	0	25.000	0	0
2.41	590	8.040	4.743.600	950	560.500	4.183.100	3.000	1.770.000	520	306.800	1.463.200	2.000	1.180.000	0	0	1.180.000	0	0
3.00	2.000	8.040	15.550.000	950	1.900.000	13.650.000	3.000	6.700.000	520	1.040.000	5.660.000	2.000	4.000.000	0	0	4.000.000	0	0
5.00	1.000	7.510	8.890.000	950	5.610.000	3.280.000	3.700	3.155.000	520	1.565.000	1.590.000	2.000	1.470.000	0	470.000	1.000.000	0	470.000
6.00	1.000	10.270	10.685.000	10.270	10.685.000	0	2.610	2.715.000	2.610	2.715.000	0	940	940.000	940	940.000	0	940	945.000
7.00	1.000	11.100	11.935.000	11.100	11.935.000	0	2.820	2.805.000	2.820	2.805.000	0	940	955.000	940	955.000	0	950	960.000
8.00	1.000	12.770	10.795.000	12.770	10.795.000	0	2.790	2.700.000	2.790	2.700.000	0	970	925.000	970	925.000	0	970	960.000
9.00	1.000	8.820	10.800.000	8.820	10.800.000	0	2.610	2.685.000	2.610	2.685.000	0	880	925.000	880	925.000	0	950	960.000
10.00	1.000	12.780	11.505.000	12.780	11.505.000	0	2.760	2.700.000	2.760	2.700.000	0	970	960.000	970	960.000	0	970	965.000
11.00	1.000	10.230	10.975.000	10.230	10.975.000	0	2.640	2.685.000	2.640	2.685.000	0	950	950.000	950	950.000	0	960	955.000
12.00	1.000	11.720	11.290.000	11.720	11.290.000	0	2.730	2.735.000	2.730	2.735.000	0	950	950.000	950	950.000	0	950	955.000
13.00	1.000	10.860	11.820.000	10.860	11.820.000	0	2.740	2.795.000	2.740	2.795.000	0	950	950.000	950	950.000	0	960	955.000
14.00	1.000	12.780	11.280.000	12.780	11.280.000	0	2.850	2.850.000	2.850	2.850.000	0	950	950.000	950	950.000	0	950	955.000
15.00	1.000	9.780	16.860.000	9.780	4.890.000	11.970.000	2.850	2.955.000	2.850	1.425.000	1.530.000	950	1.500.000	950	475.000	1.025.000	960	480.000
16.00	1.000	23.940	23.755.000	0	5.480.000	18.275.000	3.060	3.030.000	0	515.000	2.515.000	2.050	2.080.000	0	355.000	1.725.000	0	0
17.00	1.000	23.570	19.200.000	10.960	12.895.000	6.305.000	3.000	2.870.000	1.030	1.885.000	985.000	2.110	1.525.000	710	825.000	700.000	0	475.000
18.00	1.000	14.830	13.130.000	14.830	13.130.000	0	2.740	2.795.000	2.740	2.795.000	0	940	945.000	940	945.000	0	950	955.000
19.00	1.000	11.430	15.965.000	11.430	10.765.000	5.200.000	2.850	2.945.000	2.850	2.270.000	675.000	950	1.495.000	950	1.025.000	470.000	960	480.000
20.00	1.000	20.500	16.825.000	10.100	11.625.000	5.200.000	3.040	2.945.000	1.690	2.270.000	675.000	2.040	1.495.000	1.100	1.025.000	470.000	0	475.000
21.00	1.000	13.150	12.280.000	13.150	12.280.000	0	2.850	2.850.000	2.850	2.850.000	0	950	950.000	950	950.000	0	950	950.000
22.00	1.000	11.410	13.710.000	11.410	13.710.000	0	2.850	2.865.000	2.850	2.865.000	0	950	955.000	950	955.000	0	950	965.000
23.00	0	16.010	0	16.010	0	0	2.880	0	2.880	0	0	960	0	960	0	0	980	0
Sub. 2	22.000		273.220.000		195.337.250	77.882.750		63.780.000		45.186.500	18.593.500		29.120.000		15.530.000	13.590.000		13.860.000
23.00	1.000	7.600	7.725.000	7.600	7.725.000	0	1.460	1.510.000	1.460	1.510.000	0	500	510.000	500	510.000	0	530	530.000
24.00	1.000	7.850	8.005.000	7.850	7.225.000	780.000	1.560	1.545.000	1.560	1.260.000	285.000	520	780.000	520	570.000	210.000	530	265.000
25.00	1.000	8.160	8.880.000	6.600	5.990.000	2.890.000	1.530	1.545.000	960	810.000	735.000	1.040	1.050.000	620	520.000	530.000	0	0
26.00	0	9.600	0	5.380	0	0	1.560	0	660	0	0	1.060	0	420	0	0	0	0
26.00	1.000	10.420	12.245.000	5.600	2.800.000	9.445.000	1.770	1.800.000	760	380.000	1.420.000	1.200	1.230.000	480	240.000	990.000	0	0
27.00	1.000	14.070	15.570.000	0	0	15.570.000	1.830	1.965.000	0	0	1.965.000	1.260	1.360.000	0	0	1.360.000	0	0
28.00	1.000	17.070	16.460.000	0	385.000	16.075.000	2.100	2.130.000	0	30.000	2.100.000	1.460	1.480.000	0	20.000	1.460.000	0	0
29.00	1.000	15.850	11.325.000	770	3.785.000	7.540.000	2.160	1.905.000	80	855.000	1.050.000	1.500	1.030.000	40	300.000	730.000	0	285.000
30.00	1.000	6.800	7.540.000	6.800	6.100.000	1.440.000	1.650	1.740.000	1.650	1.350.000	390.000	560	890.000	560	610.000	280.000	570	285.000
31.00	1.000	6.280	7.180.000	5.400	5.740.000	1.440.000	1.830	1.885.000	1.050	1.305.000	390.000	1.220	870.000	660	590.000	280.000	0	270.000
32.00	1.000	6.080	6.220.000	6.080	6.045.000	175.000	1.560	1.610.000	1.560	1.460.000	150.000	520	820.000	520	700.000	120.000	540	270.000
33.00	1.000	6.360	10.790.000	6.010	3.005.000	7.785.000	1.660	1.815.000	1.360	680.000	1.135.000	1.120	1.250.000	880	440.000	810.000	0	0
34.00	1.000	15.220	25.735.000	0	0	25.735.000	1.970	2.325.000	0	0	2.325.000	1.380	1.600.000	0	0	1.600.000	0	0
35.00	1.000	16.250	25.675.000	0	0	25.675.000	2.680	2.490.000	0	0	2.490.000	1.820	1.690.000	0	0	1.690.000	0	0
36.00	1.000	15.100	14.685.000	0	0	14.685.000	2.300	2.140.000	0	0	2.140.000	1.560	1.450.000	0	0	1.450.000	0	0
37.00	1.000	14.270	18.110.000	0	0	18.110.000	1.990	2.130.000	0	0	2.130.000	1.340	1.440.000	0	0	1.440.000	0	0
38.00	0	21.950	0	0	0	0	2.280	0	0	0	0	1.540	0	0	0	0	0	0
38.00	1.000	24.620	34.155.000	0	0	34.155.000	3.360	4.080.000	0	0	4.080.000	2.180	2.740.000	0	0	2.740.000	0	0
39.00	1.000	43.690	32.765.000	0	0	32.765.000	4.800	4.125.000	0	0	4.125.000	3.300	3.090.000	0	0	3.090.000	0	0
40.00	1.000	21.840	24.730.000	0	0	24.730.000	3.450	3.845.000	0	0	3.845.000	2.880	2.860.000	0	0	2.860.000	0	0
41.00	1.000	27.620	33.435.000	0	0	33.435.000	4.240	4.520.000	0	0	4.520.000	2.840	3.090.000	0	0	3.090.000	0	0
42.00	1.000	39.250	66.340.000	0	0	66.340.000	4.800	6.820.000	0	0	6.820.000	3.340	4.490.000	0	0	4.490.000	0	0
43.00	1.000	93.430	79.745.000	0	0	79.745.000	8.440	7.250.000	0	0	7.250.000	5.640	4.870.000	0	0	4.870.000	0	0
44.00	1.000	66.060	50.810.000	0	0	50.810.000	6.080	4.490.000	0	0	4.490.000	4.100	3.060.000	0	0	3.060.000	0	0
45.00	1.000	35.560	36.590.000	0	0	36.590.000	2.920	3.740.000	0	0	3.740.000	2.020	2.560.000	0	0	2.560.000	0	0
46.00	1.000	37.620	26.155.000	0	0	26.155.000	4.560	3.515.000	0	0	3.515.000	3.100	2.385.000	0	0	2.385.000	0	0
47.00	1.000	14.690	12.475.000	0	0	12.475.000	2.470	2.255.000	0	0	2.255.000	1.670	1.525.000	0	0	1.525.000	0	0
48.00	1.000	10.260	12.620.000	0	0	12.620.000	2.040	2.100.000	0	0	2.100.000	1.380	1.420.000	0	0	1.420.000	0	0
49.00	1.000	14.980	16.040.000	0	0	16.040.000	2.160	2.180.000	0	0	2.180.000	1.460	1.510.000	0	0	1.510.000	0	0
50.00	0	17.100	0	0	0	0	2.200	0	0	0	0	1.560	0	0	0	0	0	0
Sub. 3	27.000		622.005.000		48.800.000	573.205.000		77.065.000		9.640.000	67.425.000		51.050.000		4.500.000	46.550.000		1.905.000
50.00	1.000	31.260	29.175.000	0	1.730.000	27.445.000	3.540	3.305.000	0	285.000	3.020.000	2.460	2.300.000	0	210.000	2.090.000	0	0
51.00	1.000	27.090	20.840.000	3.460	5.630.000	15.210.000	3.070	3.055.000	570	935.000	2.120.000	2.140	2.090.000	420	610.000	1.480.000	0	0
52.00	1.000	14.590	14.600.000	7.800	5.070.000	9.530.000	3.040	3.150.000	1.300	1.050.000	2.100.000	2.040	2.125.000	800	620.000	1.505.000	0	0
53.00	1.000	14.610	11.995.000	2.340	1.170.000	10.825.000	3.260	2.980.000	800	400.000	2.580.000	2.210	2.070.000	440	220.000	1.850.000	0	0
54.00	0	9.380	0	0	0	0	2.700	0	0	0	0	1.930	0	0	0	0	0	0
Sub. 4	4.000		76.610.000		13.600.000	63.010.000		12.490.000		2.670.000	9.820.000		8.585.000		1.660.000	6.925.000		0
54.00	1.000	9.380	7.000.000	0	2.310.000	4.690.000	2.700	2.790.000	0	1.440.000	1.350.000	1.930	1.460.000	0	495.000	965.000	0	530.000
55.00	1.000	4.620	3.775.000	4.620	3.775.000	0	2.880	2.745.000	2.880	2.745.000	0	990	1.015.000	990	1.015.000	0	1.060	1.090.000
56.00	1.000	2.930	1.995.000	2.930	1.995.000	0	2.610	2.625.000	2.610	2.625.000	0	1.040	970.000	1.040	970.000	0	1.120	1.025.000
57.00	1.000	1.060	2.110.000	1.060	2.110.000	0	2.640	2.820.000	2.640	2.820.000	0	900	1.035.000	900	1.035.000	0	930	1.090.000
58.00	1.000	3.160	2.440.000	3.160	2.440.000	0	3.000	2.865.000	3.000	2.865.000	0	1.170	1.060.000	1.170	1.060.000	0	1.250	1.110.000
59.00	1.000	1.720	1.975.000	1.720	1.975.000	0	2.730	2.835.000	2.730	2.835.000	0	950	1.025.000	950	1.025.000	0	970	1.050.000
60.00	1.000	2.230	1.620.000	2.230	1.620.000	0	2.940	2.775.000	2.940	2.775.000	0	1.100	1.000.000	1.100	1.000.000	0	1.130	1.025.000
61.00	1.000	1.010	1.540.000	1.010	1.540.000	0	2.610	2.700.000	2.610	2.700.000	0	900	935.000	900	935.000	0	920	955.000
62.00	1.000	2.070	2.170.000	2.070	2.170.000	0	2.790	2.805.000	2.790	2.805.000	0	970	975.000	970	975.000	0	990	995.000
63.00	1.000	2.270	1.790.000	2.270	1.790.000	0	2.820	2.780.000	2.820	2.780.000	0	980	960.000	980	960.000	0	1.000	980.000
64.00	1.000	1.310	1.345.000	1.310	1.345.000	0	2.780	2.650.000	2.780	2.650.000	0	940	945.000	940	945.000	0	960	960.000
65.00	1.000	1.380	855.000	1.380	855.000	0	2.880	2.805.000	2.880	2.805.000	0	950	930.000	950	930.000	0	960	940.000
66.00	9.900	330	1.633.500	330	1.633.500	0	2.610	12.919.500	2.610	12.919.500	0	910	4.504.500	910	4.504.500	0	920	4.554.000
75.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub. 5	21.900		30.248.500		25.558.500	4.690.000		45.894.500		44.544.500	1.350.000		16.814.500		15.849.500	965.000		16.304.000
S-17																		
Sub. 1	12.500		20.842.500		20.842.500	0		21.750.000		21.750.000	0		8.000.000		8.000.000	0		8.000.000
Sub. 2	22.000		273.220.000		195.337.250	77.882.750		63.780.000		45.186.500	18.593.500		29.120.000		15.530.000	13.590.000		13.860.000
Sub. 3	27.000		622.005.000		48.800.000	573.205.000		77.065.000		9.640.000	67.425.000		51.050.000		4.500.000	46.550.000		1.905.000
Sub. 4	4.000		76.610.000		13.600.000	63.010.000		12.490.000		2.670.000	9.820.000		8.585.000		1.660.000	6.925.000		0
Sub. 5	21.900		30.248.500		25.558.500	4.690.000		45.894.500		44.544.500	1.350.000		16.814.500		15.849.500	965.000		16.304.000
Total	87.400		1.022.926.000		304.138.250	718.787.750		220.979.500		123.791.000	97.188.500		113.569.500		45.539.500	68.030.000		40.069.000

Total Excavation Vol.	1.397.544.000
Dry	884.006.250
Wet	513.537.750

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Calculation Table of Excavation Volume

Station No.	Dis. (m)	Rock Total Ao	Rock Total Vo	Rock Underwater A1	Rock Underwater V1	Rock Dry V2	Weathered Rock Total Ao	Weathered Rock Total Vo	Weathered Rock Underwater A1	Weathered Rock Underwater V1	Weathered Rock Dry V2	Earth Total Ao	Earth Total Vo	Earth Underwater A1	Earth Underwater V1	Earth Dry V2	Every station Total Ao	Every station Total V2
-11.60	8.600	0	10.320.000	0	10.320.000		0	12.040.000		12.040.000		0	4.558.000	0	4.558.000	0	0	4.558.000
-3.00	4.000	2.400	12.800.000	2.400	12.800.000	0	2.800	12.200.000	2.800	12.200.000	0	1.060	4.320.000	1.060	4.320.000	0	1.060	4.320.000
1.00	0	4.000	0	4.000	0	0	3.300	0	3.300	0	0	1.100	0	1.100	0	0	1.100	0
Sum. 1	12.600		23.120.000		23.120.000	0		24.240.000		24.240.000	0		8.878.000		8.878.000	0		8.878.000
1.00	50	4.000	321.000	520	39.000	282.000	3.300	165.000	410	24.500	140.500	2.200	110.000	0	0	110.000	0	[illegible]
1.05	1.150	8.840	10.166.000	1.040	1.196.000	8.970.000	3.300	3.795.000	570	655.500	3.139.500	2.200	2.530.000	0	0	2.530.000	0	[illegible]
2.20	10	8.840	88.400	1.040	10.400	78.000	3.300	33.000	570	5.700	27.300	2.200	27.500	0	0	27.500	0	[illegible]
2.21	190	8.840	1.679.600	1.040	197.600	1.482.000	3.300	627.000	570	108.300	518.700	3.300	627.000	0	0	627.000	0	[illegible]
2.40	10	8.840	88.400	1.040	10.400	78.000	3.300	33.000	570	5.700	27.300	3.300	27.500	0	0	27.500	0	[illegible]
2.41	590	8.840	5.215.600	1.040	613.600	4.602.000	3.300	1.947.000	570	336.300	1.610.700	2.200	1.298.000	0	0	1.298.000	0	[illegible]
3.00	2.000	8.840	17.140.000	1.040	2.080.000	15.060.000	3.300	7.800.000	570	1.140.000	6.660.000	2.200	4.400.000	0	0	4.400.000	0	[illegible]
5.00	1.000	8.300	9.850.000	1.040	6.220.000	3.630.000	4.500	3.735.000	570	1.770.000	1.965.000	2.200	1.595.000	0	495.000	1.100.000	0	500.000
6.00	1.000	11.400	12.120.000	11.400	12.120.000	0	2.970	2.975.000	2.970	2.975.000	0	990	995.000	990	995.000	0	1.000	[illegible]
7.00	1.000	12.840	13.380.000	12.840	13.380.000	0	2.980	2.945.000	2.980	2.945.000	0	1.000	1.005.000	1.000	1.005.000	0	1.000	[illegible]
8.00	1.000	13.920	11.950.000	13.920	11.950.000	0	2.910	2.850.000	2.910	2.850.000	0	1.010	970.000	1.010	970.000	0	1.020	[illegible]
9.00	1.000	9.980	11.940.000	9.980	11.940.000	0	2.790	2.850.000	2.790	2.850.000	0	930	970.000	930	970.000	0	1.000	[illegible]
10.00	1.000	13.900	12.445.000	13.900	12.445.000	0	2.910	2.850.000	2.910	2.850.000	0	1.010	1.005.000	1.010	1.005.000	0	1.020	[illegible]
11.00	1.000	10.990	11.840.000	10.990	11.840.000	0	2.790	2.810.000	2.790	2.810.000	0	1.000	990.000	1.000	990.000	0	1.000	990.000
12.00	1.000	12.690	12.100.000	12.690	12.100.000	0	2.830	2.870.000	2.830	2.870.000	0	980	990.000	980	990.000	0	980	1.000.000
13.00	1.000	11.510	12.550.000	11.510	12.550.000	0	2.910	2.955.000	2.910	2.955.000	0	1.000	1.000.000	1.000	1.000.000	0	1.020	1.015.000
14.00	1.000	13.590	8.425.000	13.590	8.425.000	0	3.000	3.000.000	3.000	3.000.000	0	1.000	1.000.000	1.000	1.000.000	0	1.010	1.055.000
15.00	1.000	3.260	14.430.000	3.260	1.630.000	12.800.000	3.000	3.105.000	3.000	1.500.000	1.605.000	1.000	1.575.000	1.000	500.000	1.075.000	1.100	550.000
16.00	1.000	25.600	25.560.000	0	6.160.000	19.400.000	3.210	3.195.000	0	570.000	2.625.000	2.150	2.050.000	0	240.000	1.810.000	0	0
17.00	1.000	25.520	20.625.000	12.320	14.025.000	6.600.000	3.180	3.035.000	1.140	2.015.000	1.020.000	1.950	1.465.000	480	730.000	735.000	0	505.000
18.00	1.000	15.730	13.820.000	15.730	13.820.000	0	2.890	2.945.000	2.890	2.945.000	0	980	990.000	980	990.000	0	1.010	1.005.000
19.00	1.000	11.910	17.170.000	11.910	11.465.000	5.705.000	3.000	3.105.000	3.000	2.385.000	720.000	1.000	1.580.000	1.000	1.070.000	510.000	1.000	500.000
20.00	1.000	22.430	18.665.000	11.020	12.960.000	5.705.000	3.210	3.110.000	1.770	2.390.000	720.000	2.160	1.580.000	1.140	1.070.000	510.000	0	505.000
21.00	1.000	14.900	14.085.000	14.900	14.085.000	0	3.010	3.005.000	3.010	3.005.000	0	1.000	1.000.000	1.000	1.000.000	0	1.010	1.005.000
22.00	1.000	13.270	15.205.000	13.270	15.205.000	0	3.000	3.015.000	3.000	3.015.000	0	1.000	1.010.000	1.000	1.010.000	0	1.000	1.010.000
23.00	0	17.140	0	17.140	0	0	3.030	0	3.030	0	0	1.020	0	1.020	0	0	1.020	0
Sum. 2	22.000		290.859.000		206.467.000	84.392.000		68.755.000		47.976.000	20.779.000		30.790.000		16.030.000	14.760.000		14.680.000
23.00	1.000	8.210	8.395.000	8.210	8.395.000	0	1.570	1.600.000	1.570	1.600.000	0	540	545.000	540	545.000	0	550	555.000
24.00	1.000	8.580	8.810.000	8.580	7.920.000	890.000	1.630	1.635.000	1.630	1.325.000	310.000	550	825.000	550	605.000	220.000	560	280.000
25.00	1.000	9.040	9.715.000	7.260	6.545.000	3.170.000	1.640	1.840.000	1.020	865.000	775.000	1.100	1.125.000	660	570.000	555.000	0	0
26.00	0	10.390	0	5.830	0	0	1.640	0	710	0	0	1.150	0	480	0	0	0	0
26.00	1.000	11.150	13.080.000	6.100	3.050.000	10.030.000	1.870	1.905.000	810	405.000	1.500.000	1.280	1.300.000	520	260.000	1.040.000	0	0
27.00	1.000	15.010	16.695.000	0	0	16.695.000	1.940	2.050.000	0	0	2.050.000	1.320	1.430.000	0	0	1.430.000	0	0
28.00	1.000	18.380	17.725.000	0	590.000	17.135.000	2.160	2.220.000	0	55.000	2.165.000	1.540	1.550.000	0	40.000	1.510.000	0	0
29.00	1.000	17.070	12.350.000	1.180	4.405.000	7.945.000	2.280	2.025.000	110	940.000	1.085.000	1.560	1.080.000	80	340.000	740.000	0	305.000
30.00	1.000	7.630	8.710.000	7.630	6.875.000	1.835.000	1.770	1.860.000	1.770	1.440.000	420.000	600	995.000	600	650.000	345.000	610	305.000
31.00	1.000	9.790	8.295.000	6.120	6.460.000	1.835.000	1.950	1.815.000	1.110	1.395.000	420.000	1.390	975.000	700	630.000	345.000	0	285.000
32.00	1.000	6.800	7.010.000	6.800	6.750.000	260.000	1.680	1.730.000	1.680	1.545.000	185.000	560	885.000	560	745.000	140.000	570	285.000
33.00	1.000	7.220	11.955.000	6.700	3.350.000	8.605.000	1.780	1.910.000	1.410	705.000	1.205.000	1.210	1.320.000	930	465.000	855.000	0	0
34.00	1.000	16.690	27.475.000	0	0	27.475.000	2.040	2.410.000	0	0	2.410.000	1.430	1.660.000	0	0	1.660.000	0	0
35.00	1.000	38.260	27.395.000	0	0	27.395.000	2.780	2.605.000	0	0	2.605.000	1.890	1.770.000	0	0	1.770.000	0	0
36.00	1.000	16.530	16.005.000	0	0	16.005.000	2.430	2.250.000	0	0	2.250.000	1.650	1.525.000	0	0	1.525.000	0	0
37.00	1.000	15.480	19.500.000	0	0	19.500.000	2.070	2.215.000	0	0	2.215.000	1.400	1.495.000	0	0	1.495.000	0	0
38.00	0	23.520	0	0	0	0	2.360	0	0	0	0	1.590	0	0	0	0	0	0
38.00	1.000	26.610	35.990.000	0	0	35.990.000	3.450	4.170.000	0	0	4.170.000	2.420	2.900.000	0	0	2.900.000	0	0
39.00	1.000	45.370	34.295.000	0	0	34.295.000	4.890	4.215.000	0	0	4.215.000	3.380	3.160.000	0	0	3.160.000	0	0
40.00	1.000	23.220	26.195.000	0	0	26.195.000	3.540	3.960.000	0	0	3.960.000	2.940	2.950.000	0	0	2.950.000	0	0
41.00	1.000	29.170	35.240.000	0	0	35.240.000	4.380	4.650.000	0	0	4.650.000	2.960	3.170.000	0	0	3.170.000	0	0
42.00	1.000	41.310	68.255.000	0	0	68.255.000	4.920	6.690.000	0	0	6.690.000	3.380	4.540.000	0	0	4.540.000	0	0
43.00	1.000	95.200	86.235.000	0	0	86.235.000	8.460	7.290.000	0	0	7.290.000	5.700	4.900.000	0	0	4.900.000	0	0
44.00	1.000	77.270	57.495.000	0	0	57.495.000	6.120	4.580.000	0	0	4.580.000	4.100	3.090.000	0	0	3.090.000	0	0
45.00	1.000	37.720	38.420.000	0	0	38.420.000	3.040	3.835.000	0	0	3.835.000	2.080	2.595.000	0	0	2.595.000	0	0
46.00	1.000	39.120	27.165.000	0	0	27.165.000	4.630	3.600.000	0	0	3.600.000	3.110	2.420.000	0	0	2.420.000	0	0
47.00	1.000	15.210	13.060.000	0	0	13.060.000	2.570	2.350.000	0	0	2.350.000	1.730	1.585.000	0	0	1.585.000	0	0
48.00	1.000	10.910	13.475.000	0	0	13.475.000	2.130	2.185.000	0	0	2.185.000	1.440	1.480.000	0	0	1.480.000	0	0
49.00	1.000	16.040	17.280.000	0	0	17.280.000	2.240	2.245.000	0	0	2.245.000	1.520	1.570.000	0	0	1.570.000	0	0
50.00	0	18.520	0	0	0	0	2.250	0	0	0	0	1.620	0	0	0	0	0	0
Sum. 3	27.000		666.220.000		54.340.000	611.880.000		79.640.000		10.275.000	69.365.000		52.840.000		4.850.000	47.990.000		2.015.000
50.00	1.000	33.170	30.995.000	0	1.925.000	29.070.000	3.720	3.475.000	0	310.000	3.165.000	2.550	2.400.000	0	235.000	2.165.000	0	0
51.00	1.000	28.820	22.370.000	3.850	6.090.000	16.280.000	3.230	3.200.000	620	955.000	2.245.000	2.250	2.215.000	470	655.000	1.560.000	0	0
52.00	1.000	15.920	15.965.000	8.330	5.400.000	10.565.000	3.170	3.285.000	1.290	1.040.000	2.245.000	2.180	2.230.000	840	640.000	1.590.000	0	0
53.00	1.000	16.010	13.250.000	2.470	1.235.000	12.015.000	3.400	3.130.000	790	395.000	2.735.000	2.280	2.140.000	440	220.000	1.920.000	0	0
54.00	0	10.490	0	0	0	0	2.860	0	0	0	0	2.000	0	0	0	0	0	0
Sum. 4	4.000		82.580.000		14.650.000	67.930.000		13.090.000		2.700.000	10.390.000		8.985.000		1.750.000	7.235.000		0
54.00	1.000	10.490	8.155.000	0	2.910.000	5.245.000	2.860	2.945.000	0	1.515.000	1.430.000	2.000	1.525.000	0	525.000	1.000.000	0	565.000
55.00	1.000	5.820	4.630.000	5.820	4.630.000	0	3.030	3.060.000	3.030	3.060.000	0	1.050	1.080.000	1.050	1.080.000	0	1.130	1.150.000
56.00	1.000	3.440	2.505.000	3.440	2.505.000	0	3.090	2.940.000	3.090	2.940.000	0	1.110	1.005.000	1.110	1.005.000	0	1.170	1.070.000
57.00	1.000	1.570	2.435.000	1.570	2.435.000	0	2.790	3.075.000	2.790	3.075.000	0	900	1.075.000	900	1.075.000	0	910	1.110.000
58.00	1.000	3.300	2.815.000	3.300	2.815.000	0	3.360	3.135.000	3.360	3.135.000	0	1.250	1.130.000	1.250	1.130.000	0	1.310	1.170.000
59.00	1.000	2.330	2.675.000	2.330	2.675.000	0	2.910	3.000.000	2.910	3.000.000	0	1.010	1.065.000	1.010	1.065.000	0	1.030	1.085.000
60.00	1.000	3.020	2.455.000	3.020	2.455.000	0	3.090	2.970.000	3.090	2.970.000	0	1.120	1.060.000	1.120	1.060.000	0	1.140	1.080.000
61.00	1.000	1.890	1.060.000	1.890	1.060.000	0	2.850	2.910.000	2.850	2.910.000	0	1.000	1.015.000	1.000	1.015.000	0	1.020	1.035.000
62.00	1.000	230	1.650.000	230	1.650.000	0	2.970	2.985.000	2.970	2.985.000	0	1.030	1.035.000	1.030	1.035.000	0	1.050	1.055.000
63.00	1.000	3.070	2.430.000	3.070	2.430.000	0	3.000	2.925.000	3.000	2.925.000	0	1.040	1.015.000	1.040	1.015.000	0	1.060	1.040.000
64.00	1.000	1.790	1.720.000	1.790	1.720.000	0	2.850	2.850.000	2.850	2.850.000	0	990	990.000	990	990.000	0	1.020	1.060.000
65.00	1.000	1.650	1.345.000	1.650	1.345.000	0	2.850	2.805.000	2.850	2.805.000	0	990	975.000	990	975.000	0	1.100	1.040.000
66.00	11.200	1.040	5.824.000	1.040	5.824.000	0	2.760	15.456.000	2.760	15.456.000	0	960	5.376.000	960	5.376.000	0	980	5.488.000
77.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum. 5	23.200		39.699.000		34.454.000	5.245.000		51.056.000		49.626.000	1.430.000		18.346.000		17.346.000	1.000.000		17.918.000
S-18																		
Sum. 1	12.600		23.120.000		23.120.000	0		24.240.000		24.240.000	0		8.878.000		8.878.000	0		8.878.000
Sum. 2	22.000		290.859.000		206.467.000	84.392.000		68.755.000		47.976.000	20.779.000		30.790.000		16.030.000	14.760.000		14.680.000
Sum. 3	27.000		666.220.000		54.340.000	611.880.000		79.640.000		10.275.000	69.365.000		52.840.000		4.850.000	47.990.000		2.015.000
Sum. 4	4.000		82.580.000		14.650.000	67.930.000		13.090.000		2.700.000	10.390.000		8.985.000		1.750.000	7.235.000		0
Sum. 5	23.200		39.699.000		34.454.000	5.245.000		51.056.000		49.626.000	1.430.000		18.346.000		17.346.000	1.000.000		17.918.000
TOtal	88.800		1.102.478.000		833.031.000	769.447.000		236.781.000		134.817.000	101.964.000		119.839.000		48.854.000	70.985.000		43.191.000

TOtal Excavation Vol.	1.502.589.000
Dry	942.396.000
Wet	560.193.000

APPENDIX 4 : ESTIMATION OF OPERATION AND MAINTENANCE COST

APPENDIX 4 : Estimation of Operation and Maintenance Cost

Operation and maintenance cost of the Study Cases are roughly estimated as follows.

1. O&M cost for the canal consists of two costs, O&M cost of the existing canal system (if it is available) and O&M cost for the new canal system.

2. Usage of the existing canal with the new canal system are considered as follows.

New canal system	Existing canal
Group A (high rise lock system)	available
Group B (low rise lock system)	available with modifications
Group C (Route 10 sea level)	available
Group D (Route 14S sea level)	not available

3. O&M cost estimates will be based on the PCC's 1990 Annual Report. The items composed of O&M costs are classified in the annual report as given below.

   (Cost Items)

   1) Maintenance of channels and harbors
   2) Navigation service and control
   3) Locks operation
   4) General repair, engineering and maintenance services
   5) Supply and logistics
   6) Utilities
   7) Housing operations
   8) General and administrative
   9) Interest on interest-bearing investment
   10) Others

   Total cost for the existing canal operation and maintenance is about US$390 Million in 1990.

4. Cost estimations are based on the following method.

Existing canal	New canal including existing canal	
total cost ┬>cost of items	—>estimated cost of items ┬	—>total cost
├>cost of items	—>estimated cost of items ┤	
└>cost of items	—>estimated cost of items ┘	

5. Factors affecting the costs of each item

In order to estimate the O&M costs for the new canal from the costs associated with the existing canal, operation and maintenance costs of each item are classified into groups by the following factors.

1) Length of the canal
2) Size of the ship
3) Number of the lift of the locks

6. Relations between items and factors should be reliably estimated after a detailed survey. But for the Phase 1 Study, factors affecting items are shown in the table below and the ratio of the cost of each item between the new canal system (including existing one) and the cost of the existing one, are estimated as follows.

Cost of Item	Factor		
	1)Length of canal	2)Size of ship	3)Number of lift
1) Maintenance of channels and harbors 2) Navigation service and control	○	○	
3) Locks operation		○	
4) General repair, engineering and maintenance services 5) Supply and logistics 6) Utilities 7) Housing operations 8) General and administrative 9) Interest on interest-bearing investment 10) Others	○		

6.1 Items 1) Maintenance of channels and harbors, and 2) Navigation service and control, depend on these factors

1) Length of the canal, and
2) The size of the ship

6.1.1 For factor (1) Length of the canal, the cost for the maintenance of channels and navigation service will be estimated to change proportionally according to the length of the canal.

(1) Group A: For the most part, the canal routes are used for the new and existing canals. Costs will increase more than the existing one; but not significantly. The ratio of the existing canal will be 1.2 to the new and existing canal.

(2) Group B: The situation is the same as group A. The ratio is 1.2 for the new and existing canal.

(3) Group C: The new and existing canal will be operated separately; that is, there are two canals with different routes. The ratio will be 2.0 to the existing canal and for the new and existing canals.

(4) Group D: The existing canal is not available for use for this group. Costs will be based on the costs for the new canal only. The ratio will be 1.0.

(5) For factor (1) Length of the canal, final results are shown below.

Group	A	B	C	D
Ratio	1.2	1.2	2.0	1.0

6.1.2 For factor (2) Size of the ship, the costs for maintenance of channels and navigation service will increase according to the size of the ship passing through the canal. But the costs will not increase proportionally with the size of the ship. The increasing ratio of the costs by the ship size shall be further studied in a future survey. In this study, the cost estimated shows a small increase in ratio by the size of the ship. The following ratio will be adopted as an additional ratio calculated based on the size of a ship.

Size of ship (1000DWT)	65	100	150	250	300
Additional ratio	0	0	0.1	0.2	0.2

6.1.3 The increasing cost ratio for maintenance and navigation service will be summarized from 6.1.1 and 6.1.2 as shown below.

		Size of the ship (1,000DWT)				
		65	100	150	250	300
Group	basic rat.	0	0	0.1	0.2	0.2
SQ	1.0	1.0				
A	1.2		1.2	1.3	1.4	
B	1.2		1.2	1.3	1.4	
C	2.0			2.1	2.2	2.2
D	1.0			1.1	1.2	1.2

6.2 Item (3) Locks operation, depends on factors (2) Size of the ship, and (3) Number of the lift in the locks, but excludes the sea level canal.

6.2.1 For factor (2) Size of the ship for the lock canal, the costs for lock operations will be affected by the size of the ship. But an increasing ratio will be less than the increasing ratio of the size of the ship. The ratio shall be checked by a survey at a later date. In this study, cost increasing ratio will be estimated as follows.

Size of ship (1000DWT)	65	100	150	250	300
Cost increasing ratio	1.0	1.1	1.2	1.3	1.3

6.2.2 For the factor 3) Number of lift for the lock canal

There are three lifts for the existing lock canal. Costs for the lock operations will be affected directly by the number of lift. Considering that no lift means no costs for lock operation, a cost ratio for lock operations will be estimated as follows.

Number of lift	3	2	1	0
Cost ratio	1.0	0.7	0.4	0

6.2.3 For the sea level canal

There are no lock operations, but there is a tidal gate operation for the sea level canal system. Costs for a tidal gate operation will be estimated as 0.1 of the existing lock operation.

6.2.4 The increasing cost ratio for lock operations will be summarized from 6.2.1, 6.2.2 and 6.2.3 as shown below.

			Size of the ship (1,000DWT)				
For lock			65	100	150	250	300
canal	Basic rate		1.0	1.1	1.2	1.3	
Number of lift	3	1.0	(1.0)				
	2	0.7		1.8	1.8	2.0	
	1	0.4		1.4	1.5	1.6	
For sea level canal	Group C	1.1			1.1	1.1	1.1
	D	0.1			0.1	0.1	0.1

Increasing ratio = Ship x Lift + 1

6.3 Item 4) General repair, engineering and maintenance services, to Item 10) Others, depend on factor 1) Length of the canal. But an increasing ratio of costs for these items due to an increase in the length of the canal is not significantly larger than the other items.

(1) Group A: As explained in 6.1.1 and above, the ratio to the existing canal will be smaller than the others. It is estimated at 1.1 of the existing canal including it.

(2) Group B: The situation is the same with group A. The ratio will be estimated at 1.1 of the existing canal including it.

(3) Group C: The new and existing canal will be operated separately. The ratio will be 1.3 to the existing canal for the new and existing canals.

(4) Group D: The existing canal is not available for use in this case. Costs will be the costs for the new canal only. The ratio will be 1.0.

(5) The ratio of items 4) to 10) are summarized as shown below.

Group	A	B	C	D
Cost Ratio	1.2	1.2	2.0	1.0

7. O&M cost for each study case estimated under above mentioned conditions are shown as follows.

1) Lock canal

Case Number	Group	Size of ship	Number of Lift	Item		
				1) & 2)	3)	4) - 10)
(Ratio to SQ)						
				Ratio of Items		
L -1	A	100	2	1.2	1.8	1.1
2	A	100	2	1.2	1.8	1.1
3	B	100	1	1.2	1.4	1.1
4	A	150	2	1.3	1.8	1.1
5	A	150	2	1.3	1.8	1.1
6	B	150	1	1.3	1.5	1.1
7	A	250	2	1.4	2.0	1.1
8	A	250	2	1.4	2.0	1.1
9	B	250	1	1.4	1.6	1.1
10	A	100	2	1.2	1.8	1.1
11	B	100	1	1.2	1.4	1.1
12	B	100	1	1.2	1.4	1.1
13	A	150	2	1.3	1.8	1.1
14	B	150	1	1.3	1.5	1.1
15	B	150	1	1.3	1.5	1.1
16	A	250	2	1.4	2.0	1.1
17	B	250	1	1.4	1.6	1.1
18	B	250	1	1.4	1.6	1.1
(O&M Cost: million US$ 1990)						
				Cost of Items			Total
SQ	A	65	3	123	54	213	390
L -1,2	A	100	2	148	97	234	479
3	B	100	1	148	76	234	458
4,5	A	150	2	160	97	234	491
6	B	150	1	160	81	234	475
7,8	A	250	2	172	108	234	514
9	B	250	1	172	86	234	492
10	A	100	2	148	97	234	479
11,12	B	100	1	148	76	234	458
13	A	150	2	160	97	234	491
14,15	B	150	1	160	81	234	475
16	A	250	2	172	108	234	514
17,18	B	250	1	172	86	234	492

2) Sea level canal

Case Number	Group	Size of ship	Number of Lift	Item			
				1) & 2)	3)	4) - 10)	
(Ratio to SQ)							
				Ratio of Items			
S -1	C	150	0	2.1	1.1	1.3	
2	C	150	0	2.1	1.1	1.3	
3	C	250	0	2.2	1.1	1.3	
4	C	250	0	2.2	1.1	1.3	
5	C	300	0	2.2	1.1	1.3	
6	C	300	0	2.2	1.1	1.3	
7	D	150	0	1.1	0.1	1.0	
8	D	150	0	1.1	0.1	1.0	
9	D	250	0	1.2	0.1	1.0	
10	D	250	0	1.2	0.1	1.0	
11	D	300	0	1.2	0.1	1.0	
12	D	300	0	1.2	0.1	1.0	
13	C	150	0	2.1	1.1	1.3	
14	C	150	0	2.1	1.1	1.3	
15	C	250	0	2.2	1.1	1.3	
16	D	250	0	1.2	0.1	1.0	
17	D	300	0	1.2	0.1	1.0	
18	D	300	0	1.2	0.1	1.0	
(O&M Cost: million US$ 1990)							
				Cost of Items			Total
SQ	A	65	3	123	54	213	390
S -1,2	C	150	0	258	59	277	594
3-6	C	250-300	0	271	59	277	607
7,8	D	150	0	135	5	213	353
9-12	D	250-300	0	148	5	213	366
13,14	C	150	0	258	59	277	594
15	C	250	0	271	59	277	607
16-18	D	250-300	0	148	5	213	366

PART II : COST ESTIMATES FOR PRESCREENING

PART - II COST ESTIMATES FOR PRESCREENING CONTENTS

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CHAPTER 1 - CONSTRUCTION

1.1 Construction Method for Canal Excavation

1.1.1 Lock Canal (High-Rise and Low-Rise)

(1) Zoning

By examining the excavation procedure for the canal, the total length was divided into five zones of different topographical features and methods of construction, as follows:

ZONE I	ATLANTIC ENTRANCE
ZONE II	GATUN LAKE
ZONE III	CULEBRA CUT
ZONE IV	MIRAFLORES LAKE
ZONE V	PACIFIC ENTRANCE

Excavation of that portion above water level at Gatun Lake and along the canal, or above sea level at the canal entrance will in principle be carried out by the land based method. The below water level will be accomplished by the marine based method. The volume of the earthworks entailed is significantly large, so excavation machineries and working vessels will be of the largest class that can be procured.

(2) Dry Excavation

Prior to the excavation work, temporary roads will be constructed parallel to the canal. These will be on the east bank section from the Atlantic Entrance (near STA 0.00) to Gatun Lake, and on the west bank from the Culebra Cut westwards. These temporary roads are for the passage of off the road dump trucks to be employed, which are 20 m wide. In addition, further temporary roads will be provided to spoil-banks as branches from these temporary roads. The location of the spoil-banks is assumed

to be 3.5km from excavation areas.

Before excavation work commences, the land to be excavated will be cleared and grubbed. The top soil will in general be excavated using bulldozers (86 t class), loaded onto dump trucks (136 t class) using a shovel (18 m^3 class), transported to the spoil-banks, and spread. Excavation and loading will be also be done by backhoes (15 m^3 class) concurrently.

Weathered rock will mainly be ripped using a bulldozer with ripper, loaded with the shovel, and transported to the spoil-banks using dump trucks.

Hard rock will be excavated mainly by means of the high face bench method of 15 m high. First, blast hole drills (600 HP) will be used for blasting. Large rocks resulting from blasting will be broken into smaller pieces, collected into piles using the bulldozer, loaded onto the dump trucks using the shovel, transported, and dumped as spoil.
Excavated areas will be vegetated after landscaping.
Spoil-banks will be compacted and landscaped.
The number of days for dry excavation working have been estimated based on 250 working days a year with 20 actual working hours a day in two shifts.

The excavation of ZONE IV (Miraflores Lake) will consist mainly of dry excavation, in other words, the canal in this section will be excavated from the land. The ground adjoining the Culebra Cut and the Miraflores Lake will be left untouched. After completion of the cofferdam between the Miraflores Lake and the new canal with the new lock, the canal will be filled with water, equalizing the water level of the Culebra Cut and the new canal. Then, the remaining natural ground will be excavated.

(3) Underwater Excavation

Marine based excavation can be roughly categorized into works in the sea portion and in the canal portion.

The muck from excavation of the lake portion (ZONES II, III, and IV) will be discarded in Gatun Lake.

Ordinary soil and silt (mad) below the water level will be dredged using a trailer suction dredger (8,000 m^3 class). This dredger will draw the dredged material in through the hatch of the dredger, maneuver to the spoil-bank under its own power, and discharge the spoil using pumps. Muck from ZONE I (Atlantic Entrance), ZONE II (Gatun Lake), and ZONE V (Pacific Entrance) will be dumped into the lake or sea by transporting it at 2 km from the excavation point. Muck from ZONE III (Culebra Cut) will be transported to Gatun Lake, where it will be dumped in the bottom of the lake.

Soft rock below water level will be excavated using cutter suction dredgers (18,000 HP class). Dredged material from ZONE I (Atlantic Entrance), ZONE II (Gatun Lake), and ZONE V (Pacific Entrance) will be dumped directly into the lake or sea 2 km from the point of excavation through a sand-flushing pipe. Material from ZONE III (Culebra Cut) will be loaded onto a bottom-hopper barge (5,000 m^3 class) transported by a pusher boat (3,200 HP class) and dumped.

It is assumed that 70% of the rock below water level can be excavated using cutter suction dredger (18,000 HP class). The dredged material from dredger will be disposed of in the same manner as the soft rock. The remaining 30% should be excavated using a large grab dredger (50 m^3 class). Fifty percent of this hard rock is expected to require underwater blasting to be used as well. Drilling, explosive charging, and priming will be done from a drilling barge. Firing will be made by the supersonic method. The rock excavated by the large grab dredger will be loaded on a split barge (5,000 m^3 class), moved using the pusher boat, and dumped.

Dredged rock from ZONE I (Atlantic Entrance), ZONE II (Gatun Lake), and ZONE V (Pacific Entrance) will be dumped 2 km from the point of excavation. Dredged rock from ZONE III (Culebra Cut) will be transported to Gatun Lake for dumping.

The work of excavation by working vessel is assumed to take 240 days a year (10 months at 24 days a month), with an actual working time of 16 hours per day for the large grab dredger, and 22 hours per day for the cutter suction dredger and trailer suction dredger. Marine-based excavation of the sea portion and of ZONE II and ZONE III of the canal, will require close care as the work area is near an existing navigation channel, and the navigation of ships should not be hindered.

By excavating the islands and the head of the peninsula within Gatun Lake along ZONE II and ZONE IV, the muck will be dropped into the water nearby and dredged by working vessels instead of transporting it to the spoil-bank onshore.

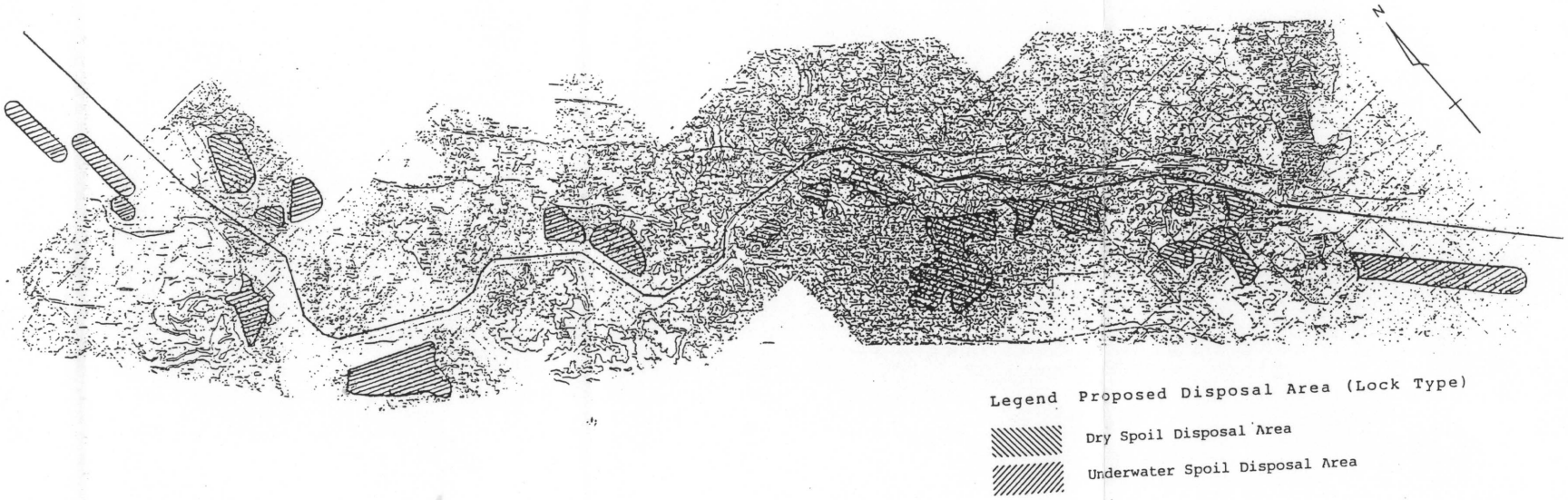
(4) Conversion Scheme

In the high-rise lock system, the cofferdam of the New Gatun Lock will be filled with water after completion, equalizing the water level outside and inside the cofferdam. The cofferdam will then be removed. At the New Miraflores Lock, the lock will be filled with water after completion of the new lock and the cofferdam separating Lock and Miraflores Lake on the north side. When the water level outside and inside the cofferdam has equalized, the cofferdam will be removed. The cofferdam on the Pacific Ocean side will also be dismantled similarly. The conversion in navigation channels will take place after completion of all structures and excavation of the canal. In this way, no hindrance to the navigation of ships through the existing canal will result from the conversion.

In the low-rise lock system, it is necessary to reduce the level of Gatun Lake to 55' or 30'. The procedure will entail dismantling the cofferdam on the inland side after the water level has fallen sufficiently. While the water level is lowered in Gatun Lake and the cofferdam is dismantled (a period estimated to be 60-120 days), the navigation of ships will be closed entirely.

As for the cofferdam for the construction of the New Gatun Lock, the original ground can be used as is. In this case, the section will be selected based on safety considerations during the construction of the Lock and the rate of progress of the dismantling work.

At the New Miraflores Lock, the cofferdam on the inland side will be constructed by reinforcing the original ground. On the Pacific Ocean side a new cofferdam will be constructed.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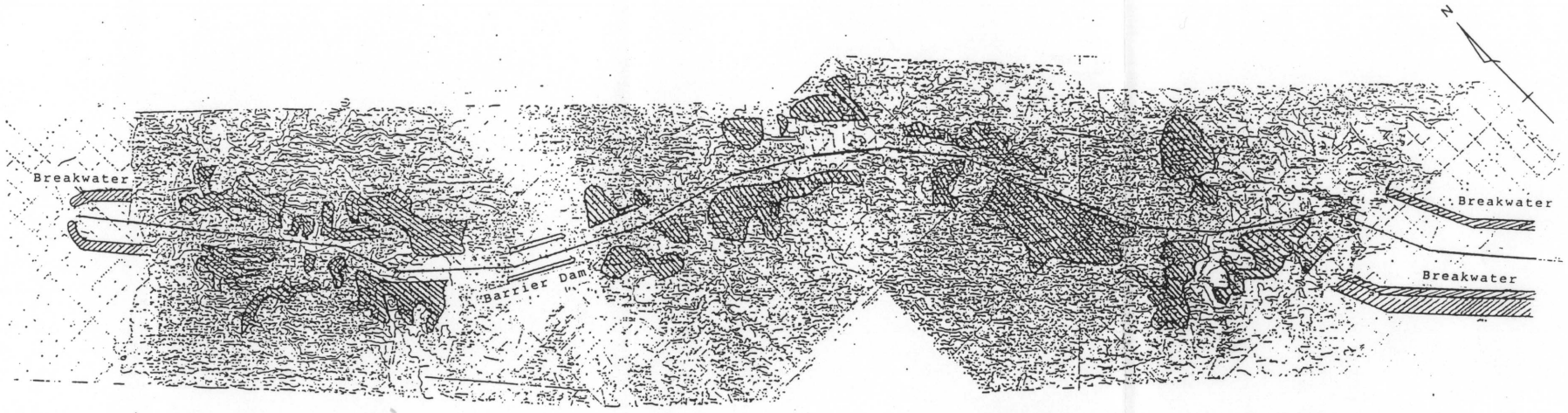
Legend Proposed Disposal Area (Lock Type)
Dry Spoil Disposal Area
Underwater Spoil Disposal Area



Legend Proposed Disposal Area (Route 10)

Dry Spoil Disposal Area

Underwater Spoil Disposal Area

1.1.2 Sea level Canal (ROUTE 10)

(1) Zoning

The methods of excavation employed will be subject to restrictions due to topographic and geologic features. This requires that the total length of the canal be divided into five zones. The location and features of each zone are listed below.

ZONE I STA. -2.5 to 1.0 L = 3.5 km

Features: Atlantic Ocean to entrance of the canal (Lagarto). Underwater excavation by dredging.

ZONE II STA. 1.0 to 27.0 L = 26.0 km

Features: Lagarto-Escobal to Gatun Lake to Lagarterita. Land-based excavation will be carried out. Bedrock between Lagarto and Escobal is sandstone. Bottom of Gatun Lake is covered with thick sedimentary stratum.

ZONE III STA. 27.0 to 53.0 L = 26.0 km

Features: Lagarterita to Continental Divide to San Jose. Geology in the divide area is complex. There are alternating layers of basalt and clay shale, and the stability of the high slopes is considered questionable.

ZONE IV STA.53.0 to 58.0 L = 5.0 km

Features: The swamp on the Pacific Ocean side is covered with thick sedimentary layer.

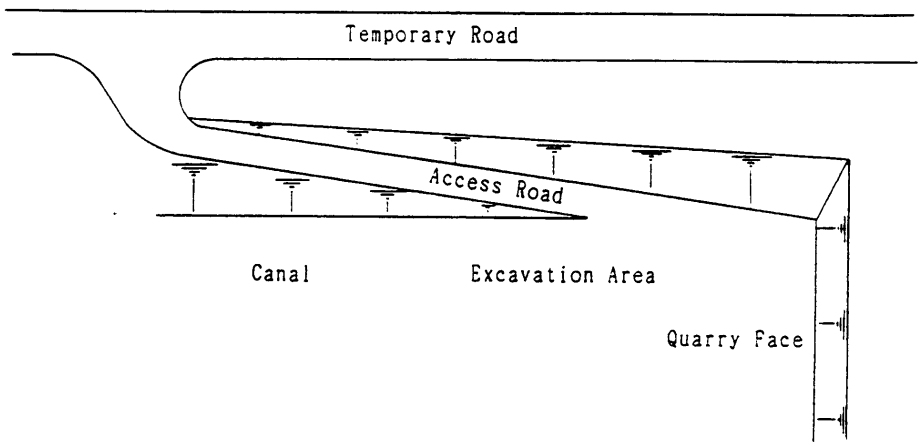
ZONE V, STA 58.0 to 83.7 L=25.7 km

Features: Estuary of Caimito River to Pacific Ocean. Underwater excavation by dredging will be carried out.

(2) Preparation Works

a) Temporary road

Temporary roads will be constructed parallel to the east bank of the section running from near the entrance of the canal (STA 1.00) to the eastern end of the No.2 barrier dam (STA 38.00) and with the west bank of the section from STA 38.00 to the vicinity of the canal entrance on the Pacific Ocean side (STA 60.00). The muck will be transported to nearby spoil-banks via these temporary roads. The roads will be 20 m in width and have a maximum gradient of 8% considering use by 136 t class dump trucks. Access roads to quarry faces will be provided every 2.5 km and the average hauling distance within the quarry faces will be 2.0 km. the average haulage outside the work field is assumed to be 2.0 km. A temporary road and access road plan is shown below.



Access Road Plan

b) Temporary drainage

The inflow of water into the canal during excavation is expected to include rainfall, seepage water and water from streams that are cut off due to excavation of the canal. As this water will collect in the dry-excavated canal, it will be necessary to provide a drainage system at each face. Small and medium-size rivers will be diverted into Gatun Lake. At the point in time when Gatun Lake is divided by the Barrier Dam, water from the southwest side of Gatun Lake will instead be diverted into a previously constructed temporary spillway and be discharged into the Atlantic Ocean.

(3) Dry Excavation

The excavation areas and temporary road areas will be cleared and grubbed in two stages. First, the felling will be executed using a large chain pulled by two bulldozers, and this will be followed by grubbing of the remaining roots using a bulldozer. The collected materials will be piled up and burned.

Since the overburden is considered thin, at an average of about 4 m, the method of excavation of earth common will be such that after all quantity of common are cut using bulldozers, collected and loaded on dump trucks with a shovel, hauled and dumped. At the spoil-banks, the muck will be spread and compacted.

The methods of excavation for soft rock include ripping it using bulldozers fitted with rippers, collecting the ripped material, and loading it on dump trucks using the shovel. Another method is to carry out excavation directly using the shovel, loading the material onto the dump trucks. Hauling and spreading will be the same as in the case of the earth common excavation.

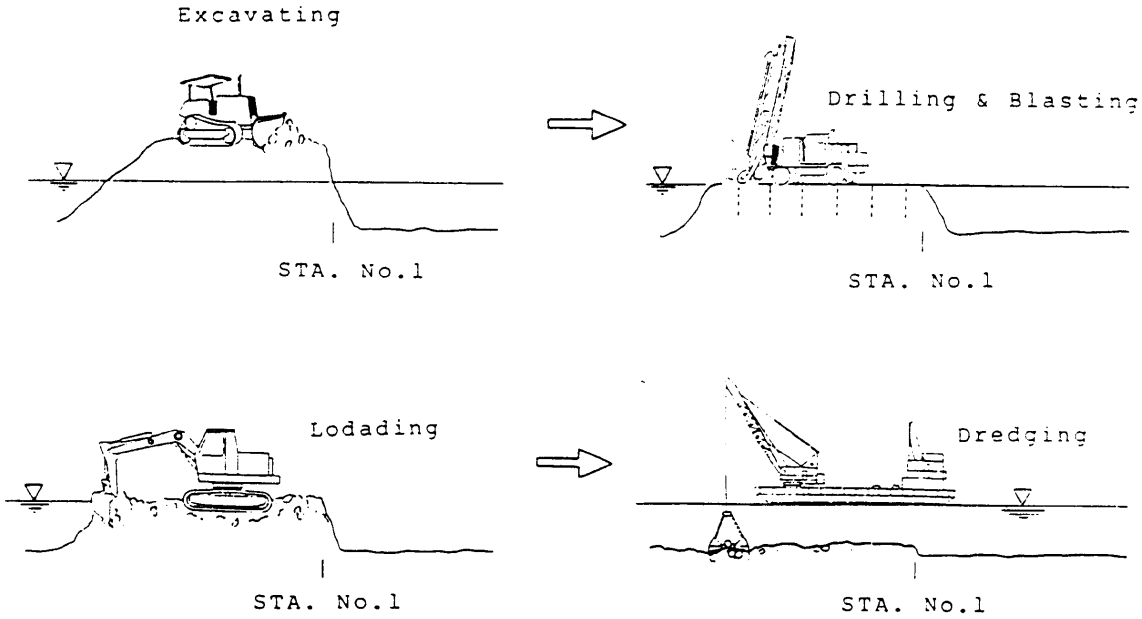
The average depth of hard rock excavation is about 30 m, so it will be carried out with blasting by means of the high-face bench cut method with a height of 15 m. Although the same combination of equipment will be used as will be for the earth common and weathered rock excavation, the bulldozers will be used as auxiliary machines for loading and finishing the bedrock.

(4) Conversion Scheme

After excavation of the land section of the canal is completed, leaving plugs on the Atlantic Ocean and the Pacific Ocean sides, these two oceans are finally to be connected through the new canal. Since the tidal range is small on the Atlantic Ocean side, seawater will first be led into the canal from that side. Then the plug on the Pacific side will be excavated, connecting the Atlantic with the Pacific Ocean.

a) Excavation of Canal entrance on the Atlantic side

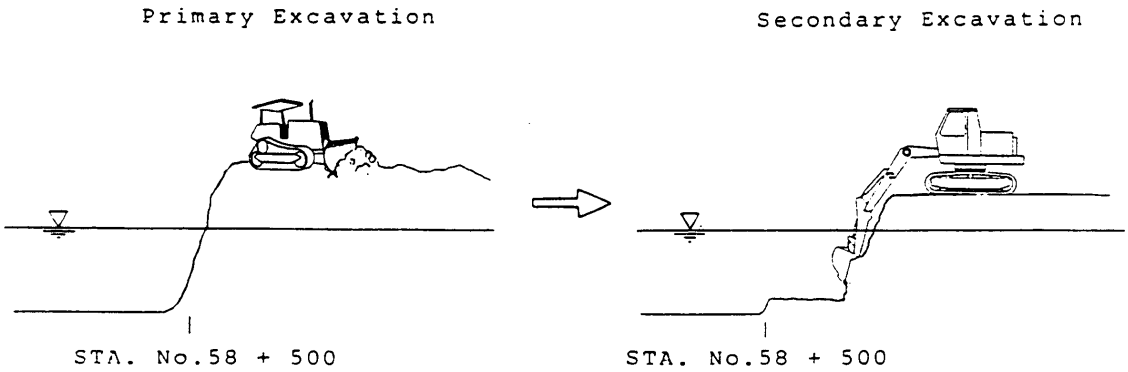
Initially, the canal will be completed to STA No.1 by dry excavation. After completing excavation of the common and weathered rock in the 500 m section from STA No.1 to the shore on the Atlantic Ocean side, the whole section will be blasted, loaded onto dump trucks, and hauled away using backhoes with dry excavation. The depth of the excavation will be about EL -10.00. After the canal is connected to the Atlantic Ocean, excavation below EL - 10.00 will be carried out using a large grab dredger. Dredged material will be loaded on a split barge, moved using a pusher boat, and disposed of in the designated disposal area. The final excavation of the canal will be carried out using a cutter suction dredger.

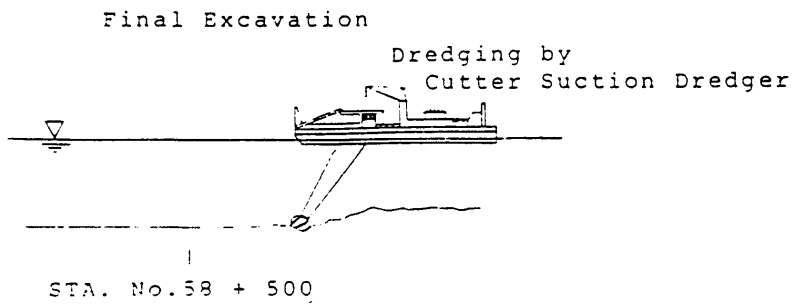


b) **Excavation of Canal Entrance on Pacific Ocean side**

First the canal is to be completed to STA No.58 + 500 by dry excavation. Primary excavation will be carried out to EL + 3.00 m above maximum sea level between STA No.58 + 500 and the Pacific shore. This will be followed by a secondary excavation below sea level to a depth of about 10 m, beginning from STA No.58 + 500, using backhoes, until the canal connects to the Pacific Ocean.

As the rock excavated around this area is assumed to be soft, the final excavation below sea level will be carried out using a cutter suction dredger. The muck will be disposed of in the designated disposal area.





(5) Equipment to be employed (excluding equipment for underwater excavation)

Equipment	Specification	Description
Bulldozer	86t-operating weight	Earth-excavating, ripping & dozing
Shovel	$18m^3$-heaped bucket capacity	Earth and weathered rock excavating & loading
Backhoe	$15m^3$-heaped bucket capacity	Underwater excavating and loading
Dump truck	136t-Max. Loading capacity	Hauling
Blast hole drill	165m/m dia. equ.	Rock drilling
Bulldozer	60t-operating weight	Spreading at disposal area and temporary works
Hydraulic drill	165m/m dia. equ.	Temporary works
Vibratory roller	15t-weight towed type	Compaction for fill dam & road maintenance
Motor grader	4.9m-blade	Road maintenance

1.1.3 Sea-level Canal (ROUTE 14S)

(1) Zoning

The length of the canal is divided into five zones as follows:

ZONE I	Atlantic Entrance
ZONE II	Gatun Lake
ZONE III	Gatun Lake Southeast Section and Inland Section
ZONE IV	Miraflores Lake
ZONE V	Pacific Entrance

The excavation of the canal will be by dry excavation for portions above sea level and lake level, as in the case of the lock canal plans, and working vessels will be used for work at lower levels. Excavation within Gatun Lake will be carried out without changing the existing lake water level. Prior to the excavation work, temporary roads will be constructed along the canal with the section from the Pacific entrance (near STA.54) to Gatun Lake and near Darien and the Culebra Cut on the west side of the planned canal. In addition, temporary roads to the spoil-banks will branch out from these main temporary roads. It is assumed that spoil-banks will be located at 4 km off the point of excavation.

(2) Dry Excavation

Prior to excavation work, clearing and grubbing will be carried out in these areas.

The machinery used to excavate ordinary soil, soft rock and hard rock, and the method of implementation, will be the same as for the Lock Canal in the preceding section.

The actual heavy equipment used for excavation is as follows:

Ordinary soil

Excavation & Piling: Bulldozer (86t class)
Loading: Shovel Loader ($18m^3$ class)
Haulage: Dump truck (136t class)
Excavation and Loading: Backhoe ($15m^3$ class)
will be used in combination.

Soft rock

Excavation & Piling: Bulldozer with ripper
Loading: Shovel loader
Haulage: Dump truck

Hard rock for blasting

Drilling: Blast hole drill
Piling: Bulldozer
Loading: Shovel loader
Haulage: Dump truck

Excavated areas will be replanted with vegetation after suitable landscaping. The spoil-banks will be compacted and landscaped using bulldozers. Dry excavation operations are based on 250 working days per year with 20 actual working hours in two shifts per day. In order to maintain the water level in Gatun Lake, the ground will be left as it is near STA.5 and excavation will be carried out in front of and behind this portion (plug). The plug will be taken out after the other excavation is completed, lowering the water level of the Gatun Lake to sea level.

Upper portions from water level at the islands and the peninsula within Gatun Lake between STA.6 and STA.26 will be bulldozed into Gatun Lake and later dredged using a cutter suction dredger or grab dredger. The portion parallel to the Culebra Cut from STA.34 to Miraflores Lake will be excavated by dry excavation, and the section between plugs near STA.34 and STA.50 will also be excavated using dry excavation machinery. Both plugs will be removed after all other excavations for the canal have been completed and the level of Gatun Lake is lowered to sea level.

In ZONE V (Pacific Entrance), excavation between Miraflores Lake near STA.51 + 500 and Third Locks will be plugged. The plug will be dismantled in the same way as other plugs.

(3) Underwater Excavation

Excavation below sea level and below lake water level will be carried out using working vessels.

The boat types to be used for excavating ordinary soil, weathered rock and rock, and the method of implementation, will be the same as for the lock canal excavation. In other words, ordinary soil and silt (mud) will be dredged using a drag suction dredger (8,000 m^3 class) and cutter suction dredger. The drag suction dredger stores up the dredged soil in its hatch, moves under its own power to the designated spot, and dumps it overboard. This method is for dredging at depths greater than 6 meters, and dumping will take place in water deeper than 11 meters. The excavation of ordinary soil in shallower water than this will be carried out using a cutter suction dredger.

Most of the weathered rock and rock (estimated at 70%) will be excavated using a cutter suction dredger. Where the dredged soil can be dumped near the dredging point, as in the case of work within Gatun Lake, piping will be laid 2 km from the dredging point and the material dumped directly through this. On the other hand, where the dumping location is distant, the excavated material will be loaded onto split barges (5,000 m^3 class) using a loading barge, moved using a pusher tug (3,200 HP class), and dumped.

About 30% of the rock will be dredged using a grab dredger, and 55% of this is expected to require the use of underwater blasting. A drilling barge will be used for drilling, and explosive charging. The muck, brought up using the grab dredger, will be loaded onto the split barges, moved using the pusher tug and dumped.

The muck from dredging in ZONE I (Atlantic Entrance) will be dumped outside the breakwater at the western end of Limon Bay when use of the trailing suction dredger and the split barge are called for.

Muck excavated using a cutter suction dredger will be pumped for dumping at the western end of Limon Bay. All muck from the excavation of STA.1 to STA.5 will be dumped outside Limon Bay.

Since dredging of the canal within Gatun Lake will be carried out with Gatun Lake at its present level, the dredging of rock shall take place at depths greater than 30m. Although this will be carried out using the grab dredger, efficiency will be extremely low because the rock is hard and ascent and descent of the grab will be time-consuming.

While it will be possible to dump muck from dredging ZONE II within Gatun Lake's immediate vicinity, muck from dredging that portion between STA.23 and STA.33 in ZONE III will have to be moved to the dumping point in Gatun Lake.

Muck from dredging in ZONE V (Pacific Entrance) will be dumped at the designated point to the west of the navigation channel. This is to prevent silting of the navigation channel by the spoil as a result of the prevailing tidal current.

Excavation work using vessels is assumed to take place 240 days per year (10 months a year, 24 days a month), with 16 actual working hours per day for the grab dredger and 22 hours for the cutter suction dredger and trailing suction dredger. Since excavation of the new canal in Gatun Lake will intersect with the existing canal at three points, it may be necessary to switch channels on a small scale several times as the crossing points are dredged. Careful consideration will be necessary to ensure that interference to the navigation channel is kept to a minimum.

Excavation at the site of the Barrier Dam will begin

with the removal of mud and ordinary soil from the bottom of the lake. Good quality muck from this excavation work will be reused for the construction of the dam itself. Although two possibilities might be considered for filling the dam --- working from vessels on the water or from dump trucks on land --- the vessel method will be used because access to the barrier dam site is not as easy from the land. From the lake bed to -6 m level, the filling material will be dumped using the split barge. Thereafter, rock will be dumped from a deck barge (shallower than -6 m) using the grab and final layer of riprap material will be spread over the surface.

(4) Conversion Scheme

When excavation of the new canal in ZONE III between STA.34 and STA.50, parallel to the Culebra Cut, is completed, this portion will be filled with water to the level of Gatun Lake and the plug near STA.34 will be removed. Switching to this channel will begin by lowering the water level of Gatun Lake, either by opening all the lock gates or using other methods. While this is accomplished, dismantling operations on the remaining three plugs (near STA.5, STA.50, and STA.51) will commence.

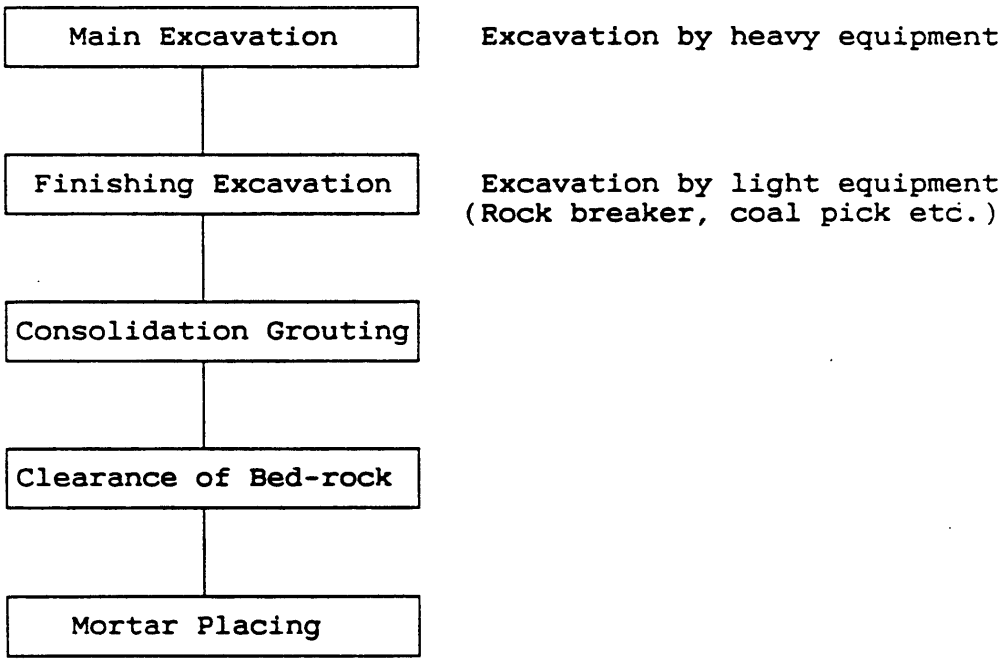
The shutdown period for navigation is considered prolonged for the study cases because of the massive quantity of plug material that shall be removed. More than a half of a year may be expected for the halting of the canal's traffic.

1.2 Construction Method for Lock Structure

1.2.1 Excavation

Prior to the commencement of excavation work, appropriate embankments and grouting works are to be carried out in order to prevent water inflow and seepage. The bench cut method will be applied the same as for the canal's excavation. Bed-rock shall be arranged so as to provide a good foundation free from any disturbance of bed-rock using light equipment, small scale blasting and hand tools. After excavation, bed-rock shall be cleaned and water tight mortar shall be placed, on which, the concrete will be placed.

Sequence of work is as follows:



1.2.2 Concrete

(1) Material

The proportion of the concrete is assumed to be the same as that of the dam concrete.

Cement content:	200 kg/m^3
Aggregates:	Crushed stone and sand of which a source is selected material from the Canal Excavation

(2) Mixing, Transportation and Placing

Batching and Mixing plant is to be installed at an adjacent location of rock. Mixed concrete will be transported to the placing site in concrete buckets on bogie carriages driven by diesel locomotive.

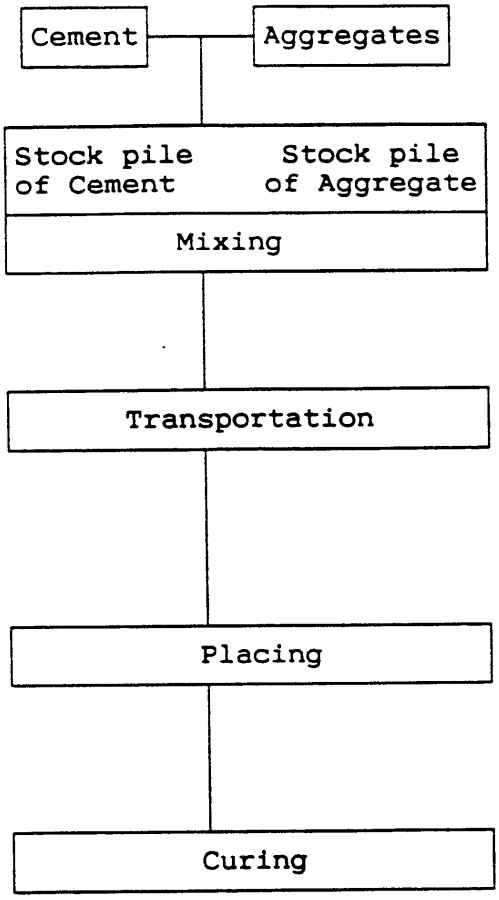
For concrete placing, a traveling tower crane will be used and a lift of concrete placing is estimated to be 1.5m - 2.0m. After placing, a concrete curing will be followed by means of a water spray or water pond.

After green-cutting, joint mortar will be placed and mixed concrete placement will precede. The tower crane will be concurrently utilized for installation of reinforcement and steel fabrics.

Sequence of works is as follows:

Study-Case 150,000 DWT
Lock Concrete 5,880,000m^3

(Atlantic Side)



Cement Silo 1,000 t x 3 sets
Conveyor for Aggregate 900mm x 150m
Batching/Mixing Plant 200m^3/h

200m^3/h Tracks 5 lane

Diesel Locomotive 5 sets
Bogie carriage 5 sets
Bucket 4.5m^3 10 sets

200m^3/h

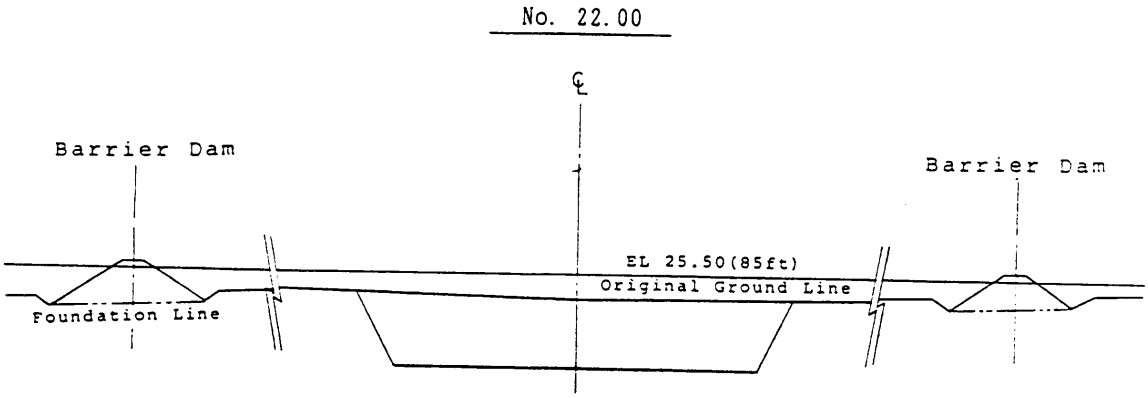
Traveling Tower Crane 4 sets
Vibro-dozer 4 sets
Concrete Vibrator 12 sets

$$\frac{588{,}000\ m^3}{250\ \text{days/yr} \times 20\ \text{h/day} \times 200\ m^3/h} = 6\ \text{yrs}$$

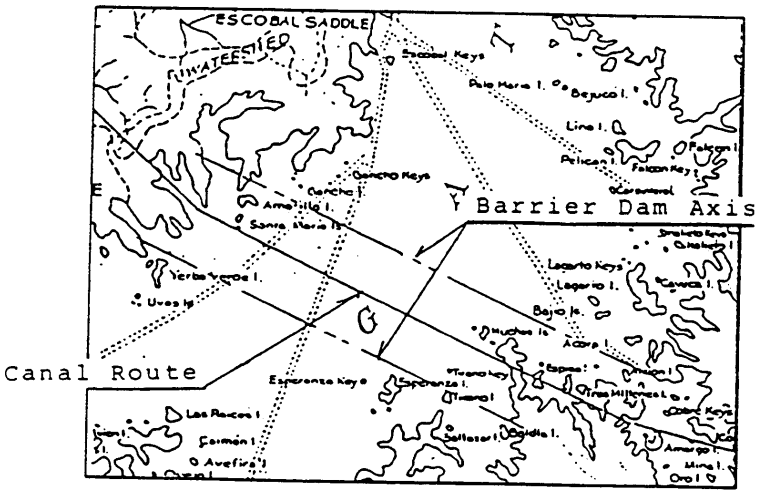
1.3 Construction Method for Barrier Dams (Case Route 10)

The barrier dam is a cofferdam constructed to allow canal excavation on the Gatun Lake under dry conditions. The barrier dam will be in two parts parallel to the left bank and right bank of the canal. In consideration of dam stability, it will be positioned sufficiently away from the canal; but, in an effort to reduce the volume of water needing dewatering as much as possible, it should not be placed too far away. A distance of about 500 m between the dam and the canal will be selected.

A plan and cross section of the dam and canal are shown below.



Cross Section



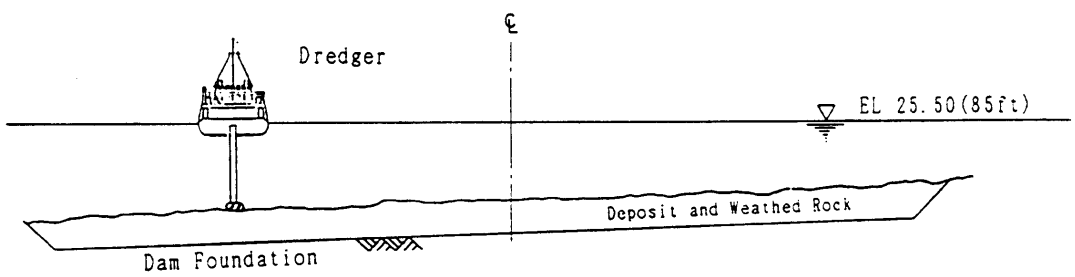
Plan

Construction Sequence is as follows:

Dredging of Dam Foundation
Embankment of Both Dams
Construction of Impervious Zone
Water Removal by Diversion channel between Gatun Lake and Atlantic Ocean
Access road for Dry Excavation
Canal Excavation

1.3.1 Dredging of Dam Foundations

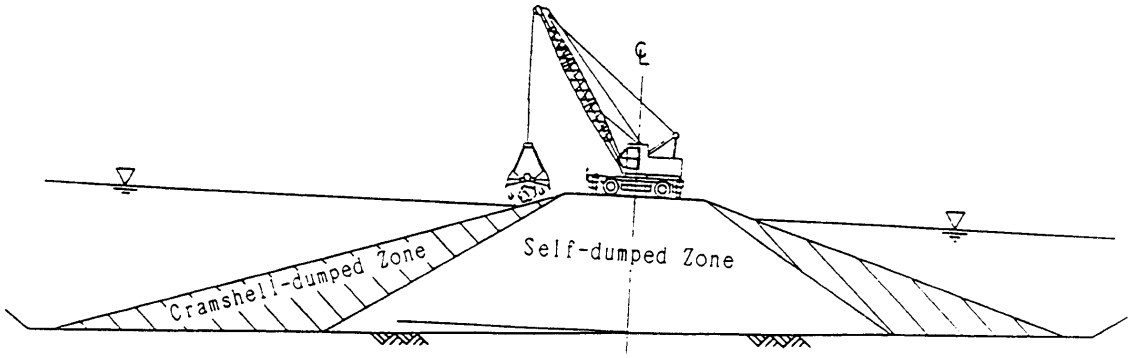
Prior to embankment, the sedimentary layer and soft rock in the area that is to form the foundation of the dams will be excavated using a cutter suction dredger. The muck will be brought ashore, stored, and selected material will be reused for the embankment.



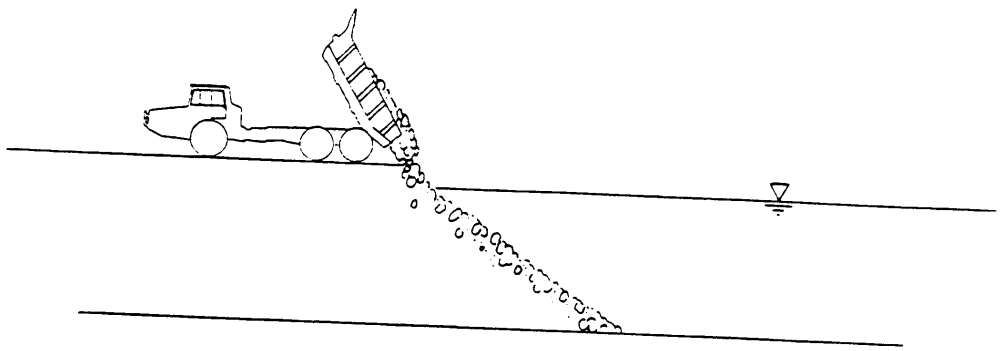
Plan

1.3.2 Embankment

The embankment will be formed by dumping material into the water from both left and right banks. Where the dumped material cannot be placed at the designed place, the work will be carried out using a clamshell bucket. A similar method will apply to riprap work. The material used for the banks will be obtained from canal excavation and dredging, which is to be temporarily stored as described previously. The embankment material above water will be compacted using a vibration roller.



Typical Cross Section



Longitudinal Section

1.3.3 Impervious Zone

The dam is of a homogeneous design that will be constructed by dumping random waste material. Accordingly, it will be difficult to construct an impervious zone during the banking work. The zone will be constructed after banking has been completed. The following methods are possible for the type of impervious zone:

a Sheet pile: length = max. 20m
b Substitution of a core material
c Impervious wall of concrete diaphragm
d Impervious wall by grouting

Examination of these types resulted in the following conclusions:

In the case of the sheet pile method, it is thought that lumps and tree roots, etc., may be mixed in with the banking material, making it impossible to drive piles to form a continuous wall. Also, there is a risk of sheet piles corroding in the future, causing water leakage, because the piles are a permanent structure.

In the case of the substitution of a core material, it is assumed that a large quantity of water would seep in during excavation for the core replacement, making it difficult to rewater and roller-compact the core material.

In the case of an impervious wall of concrete diaphragm, the excavation face would tend to collapse as the excavation is carried out, considerably extending the excavation time. Also, this method would cause the highest construction costs.

Finally, in the case of an impervious wall by grouting, a grouting material based on cement is the main material used in the work. Some contractors have abundant experience in the construction of this type of impervious wall, and it is the most economical. Maintenance after construction would also be the most straightforward.

For these reasons the grouting method will be adopted for construction of the impervious wall of the dam. Drilling will be carried out using a percussion drill with a double tube. This type of drill offers a faster drilling speed and provided with an outer tube to protect the collapse of the borehole wall.

1.4 Construction Schedule

1.4.1 General

(1) Preparation Works and Finishing Clearances

It is estimated that six months is required to prepare the commencement of the works, and four months to clean the project site after completion.

Preparation works are listed as follows:

- Mobilization of Equipment and Manpower
- Procurement of Equipment and Material
- Temporary Facilities
- Legal Procedures etc.

Finishing clearances are listed as follows:

- Demobilization of Equipment and Manpower
- Dismantlement of Temporary Facilities

(2) Canal Excavation

a) Dry Excavation

As for the dry excavation, the construction schedule is dominated by the hauling work. The hauling road will be arranged at interval of 2.5 km each then,

$$\text{Ave. interval of trucks} = \frac{3.5\text{km} \times 2}{27 \text{ trucks}} = 0.26 \text{ km/truck}$$

average interval of truck will be approximately 250m. The interval of approximately 250m is considered for the safety of traffic and the scheduled velocity/cycle can be secured.

b) Underwater Excavation

Underwater excavation shall be executed in a way as to not hinder the navigation of ships in transit. Approximately 3.0km is thought to be the minimum

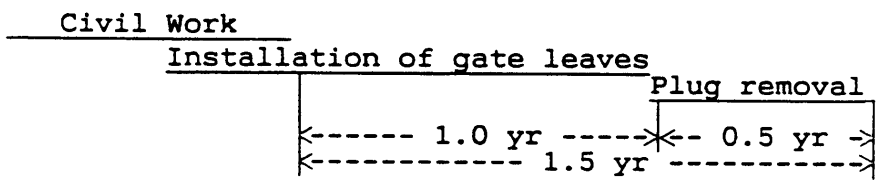
interval for working vessels in order to secure the safe navigation. In the case of the working site being far from the existing canal, no impact to the navigation of ships in transit is considered. In such an area, working vessels will be allocated at intervals of approximately 1.0km.

(3) Installation of Gate Leaves

The installation of the gate leaves is estimated to take about one year after completion of the civil works at the Lock Concrete Structure.

(4) Removal of Plugs at Route 14S

After the completion of the canal excavation and installation of gate leaves, it will take six months to remove the plugs.



(5) Engineering, Design and Tender Preparation

Along the Route-15 and Route-14S, numerous investigations and studies were accomplished and indicate, the schedule of Engineering, Design and Tender preparation can be minimized up to 2.5 years, while at Route-10, further investigations and engineering are required. Subsequently, about 3.5 years may be adequate for the period of Engineering, Design and Tender Preparation.

(6) Minimum Construction Schedule

A number of large, heavy equipment will be used for the dry excavation. It is not clear at present whether such kinds of equipment can be reused for similar projects in the near future. A minimum of 7.5 years for the actual construction is considered for each case from an economic's point in which more or less 90% of the depreciation for the book price of the equipment may be attained.

1.4.2. High-rise Lock Canal

CONSC-1.WJ2

TYPE	WORKS	YEARS																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
L-1	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-2 (L-2')	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-4	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-5	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-7	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══								
L-8	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══								
L-10	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-13	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-16	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══			

1.4.3. Low-rise Lock Canal

CONSC-2.WJ2

TYPE	WORKS	YEARS																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
L-3	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-6	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-9	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══						
L-11	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
L-12	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══					
L-14	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══								
L-15	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══			
L-17	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══					
L-18	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	

1.4.4. Sea-level Canal (Route 10)

CONSC-3.WJ2

TYPE	WORKS	YEARS																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
S-1	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══							
S-2	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══							
S-3	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══	═══						
S-4	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	
S-5	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══				
S-6	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══
S-13	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══			
S-14	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══		
S-15	ENGINEERING, DESIGN & TENDER	═══	═══	═══	═══|															
	CONSTRUCTION				|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	

1.4.5. Sea-level Canal (Route 14S)

CONSC-4.WJ2

TYPE	WORKS	YEARS																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
S-7	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
S-8	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══						
S-9	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══									
S-10	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══				
S-11	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══					
S-12	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	
S-16	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══						
S-17	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══							
S-18	ENGINEERING, DESIGN & TENDER	═══	═══	═══|																
	CONSTRUCTION			|	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══	═══					

1.5 Impacts for Existing Canal Operations

1.5.1 High Rise Lock Canal

Navigation through the existing canal will be affected during the construction of the high rise lock canal at the following points:

(1) While widening and deepening the existing canal, it will be necessary to prevent hindrance to the navigation of ships such as by the loosening of the anchor cables on work boats. Every time this occurs, construction work will have to be interrupted. This will result in a considerable reduction in operating efficiency even if the operations of navigation and construction are planned systematically. Ships passing by will be forced to wait until work comes to a pause, reducing their efficiency. Even if priority is given to navigation, efficiency is still expected to be lowered by about 10%, and impacts for the Canal Revenue should be considered. In particular, because navigation and construction work will be closely interlinked in the Culebra Cut, safety precautions are also called for.

(2) There isn't any need to consider a temporary shutdown of the navigation channel when the new channel is completed and operation is switched to the new channel.

(3) Comparing ROUTE I and ROUTE II, as work on ROUTE I is carried out away from the existing navigation channel in Gatun Lake, the impact on existing traffic will be reduced.

However, the impact on existing traffic in the Culebra Cut will remain the same.

1.5.2 Low Rise Lock Canal

(1) The impact of construction work for the low-rise lock canal on existing canal operations will be much greater than in the case of constructing the

high rise lock canal. This is because the amount of excavation is larger and the excavation is deeper. In other words, the number of work boats will be greater and the construction period longer.

It appears that navigation efficiency will be reduced about eighty percent.

(2) Switching from the existing channel to the new one as the new canal is completed, a shutdown of navigation of about 60-120 days will be necessary as mentioned in 1.1.2(4) Conversion Scheme.

1.5.3 Sea-level Canal (ROUTE 10)

Since ROUTE 10 will be constructed in parallel with the existing ROUTE 15, and about 16-20 km away from it, there is no fear of hindrance to operations on the existing canal. But in the dry year's 10% probability (once every ten years), the traffic at the existing canal may be restricted to 80 - 90% during/after the construction period of the new canal due to the shortage of lock water capacity which ought to be caused by dividing Gatun Lake with the barrier dams decreasing the catchment area.

1.5.4 Sea-level Canal (ROUTE 14S)

The significant impact on the operations of the existing canal will be caused by the construction of the sea-level canal (ROUTE 14S). The total amount of excavation is greatest, particularly the volume of deep-water dredging. As some part of the route is adjacent to the existing canal, the loss of construction efficiency due to the passage of ships will significantly increase. Ships will have to pass in the congested vicinity of many work boats, and therefore it is assumed that there will be many occasions when ships have to wait in order to guarantee safety.

With regard to convert channels, since the work involves the discharge of large volumes of water and considerable weir material must be removed, it will be necessary to have a navigational shutdown of about 180-270 days as mentioned in 1.1.3 (4).

1.6 Construction Feasibilities

1.6.1 Deep Water Dredging Operations

For dredging ordinary soil (silt or sand), a drag suction dredger which can excavate to a depth of 60 m is available. Work at such a depth has already been carried out, and there are sufficient records of successful use. Since deep-water dredging in this study is to a maximum depth of 52.3 m, there should be no problems involved in the dredging of ordinary soil. However, the cutter suction dredger can only be used for work to a maximum depth of 30 m, so excavation of weathered rock and rock at deeper sites will have to depend on the use of a grab dredger.

With regard to the excavation of weathered rock and soft rock, it will be possible to use a grab dredger with a large bucket, but efficiency will be reduced. To excavate hard rock where blasting is required, a blasting barge or SEP will be the base for drilling and blasting. It will be equipped with a rock drill which can drill blasting holes 250 mm in diameter, and the muck will be loaded onto a split barge using a grab dredger, hauled to the designated location, and dumped.

This work can be done down to the necessary depth of about 60 m, but raising and lowering of the casing and rod will take time and the cycle time for ascent and descent of the grab will be increased. Thus, the efficiency will be reduced and the unit rate for excavation will be higher. The explosives used for underwater blasting will necessarily be a gelatinized waterproof explosive.

To summarize, although there will be no problems of feasibility as long as the water depth does not exceed about 60 m, the effects of deep water dredging operations on the construction period and cost will be considerable.

The cost of the Sea Level Canal (ROUTE 14S) is higher and its construction period is longer. The primary reason for this is the deep water dredging operations.

1.6.2 Canal Excavation at near Existing Canal

Since the Culebra Cut section will be a two-lane channel as the widening project starts in 1991-92, the study will make full use of the wider channel. Work boats will occupy one lane out of two, and therefore when construction work is under way in the Culebra Cut, passing ships will have one lane available. Today, navigation is by one lane only, so operations with one lane will not cause problems. The only concern is that the anchor cables used to moor the temporary constructional facilities in position, particularly the cutter section dredger, would hinder passing ships. When ships pass close to the cutter suction dredger, it will be necessary to loosen the anchor cables on the channel side to prevent such hindrance. While the anchor wires are loose, construction operations will have to be temporarily suspended, significantly affecting the operational efficiency. When construction is underway using a trailer suction dredger, no anchor cables are used since the position of the dredger may be adjusted by means of the bow thruster and twin screws located at the bow of the dredger. In this case, therefore, construction need not be interrupted.

As the blast debris may disperse into the existing navigation channel after blasting, navigation must be stopped until the rock can be removed. The debris generated by blasting will be loaded onto a split barge, then an anchor cable will be necessary to secure the grab dredger in position. This will constitute a hindrance to passing ships. As already stated, where construction work is carried out at near the existing canal, it can be assumed to have a great effect on passing ships, considerably reducing the efficiency of navigation. Operations would have to be suspended, especially during dense fog.

Although it is difficult to quantify the reduction in operational efficiency, a judgment may be made to a certain degree based on experience with the Culebra Cut widening project.

1.6.3 Barrier Dam Construction

The barrier dams will be constructed using material from wet excavation for the low-rise lock canal and ROUTE 14S, while dry excavation for the sea-level canal (ROUTE 10). In either case, the muck will be dumped into the water, and effective compaction will be difficult. The technical difficulties are quite different depending on the character of material to be used for the embankment. In case that the fine material is used, it will be necessary to reduce the excess pore-water pressure within the embankment, when the water level between the dams is lowered, so as to prevent the slope from collapsing. Some kind of filter drain layers will be effective for reduction of pore-water pressure. If the coarse material is used for the embankment, some kind of impervious zone or wall shall be specified to stop the water seepage.

Although various methods may be considered for stopping the water, the best method is probably to use the grouting method. However, as this is a new technique, it will be necessary to verify the relationship between specifications and effectiveness through experiments and testing. If satisfactory water-stoppage cannot be obtained using the curtain grout, choosing the concrete water-stoppage wall method using an underground continuous diaphragm may be preferred.

CHAPTER 2 - COST ESTIMATES

2.1 Estimate Basis and Assumptions

2.1.1 Type of Contract

Selection of contractors and types of contracts shall be based on an international competitive tender in accordance with the FIDIC 4th Edition, 1987.

2.1.2 Estimate Date and Currency

All estimates are based on data as of 1990 in US dollars. Cost increases during the construction period and cost increases in the case of delays in commencement, are excluded.

2.1.3 Payment

It is assumed that progressive payment will be made during construction such that no payment/receipt of interest is gained by the contractors.

2.1.4 Taxes and Custom Duties

Taxes and duties are not considered in the cost estimate of case studies for phase 1.

2.1.5 Labor Costs

Overtime premiums and allowances for social benefits, amounting to 65%, are added to the man-day/hour cost in Panama as of 1990. Considering the Panamanian Labor Regulation.

2.1.6 Operating Hours and Days

For land-based excavation, 250 operating days per year and 20 actual hours of operation per day are assumed. Marine-based excavation will take place on 240 operating days per year (10 months per year and 24 days per month) and for 16 actual hours per day in the case of the cutter

suction dredgers or drag suction dredgers.

2.1.7 Loading and Unloading Facilities

Existing loading and unloading facilities are to be utilized as loading and unloading facilities used for the construction works.

2.1.8 Hauling Distance of Dry Excavation

As for the hauling distance of dry excavation, it is difficult in the limited period of the Phase 1 Study to define the disposal area without precise site surveys. Then, 3.5km for Lock Canal Excavation and 4.0km for Sea Level Canal Excavation were adopted as hauling distances by studying the map. If conditions are allowed in the Phase 2 study, reconnaissance of the site will be done to identify the location of the disposal area and to define the hauling distances.

2.1.9 Gate Leaves and Related Facilities

The study period for Phase 1 is too limited to obtain a firm quotation of Gate Leaves and Related Facilities from outside Japan. So, estimates for these are based on the assumption of manufacturing in Japan, transported from Japan to Panama and installed in Panama.

In the Phase 2 study, estimates will be based on quotations through the worldwide aspects.

2.1.10 General Conditions

The Panama Canal alternative project will be divided into 10 - 20 work blocks. The amount of one contract will be more or less US$ 500 million. Considering the scale of the projects, general conditions of the project are assumed to be 15% of the direct costs.

Items of the general conditions considered are as follows:

(1) Field Office Expenses

- Salaries/Wages of Managers, Engineers, Technicians, Clerks, Watchman, Safety Personnel and Others.
- Office Facilities and Engineering Supplies.
- Utilities* (Water, Power, etc.) * consumption
- Communications (Telephone, etc.)
- Traveling Expenses and Crew Transportations
- Welfare Expenses
- Reports and Photos
- Legal Expenses
- Insurance (Construction, Third Party and Equipment)
- Bonds (Performance and Advance Payment)
- Vehicles

(2) Home Office Expenses

- Overhead for Headquarters
- Risks and Profits
- Subcontracting

2.1.11 Supporting Construction

In order to carry out construction works, many supporting works and facilities are required during the construction period. The costs of the supporting works and facilities are estimated 5.6% of the direct cost by trial calculation. Items included in the supporting conditions are as follows:

(1) Mobilization and Demobilization

- Ocean freight
- Stevedoring
- Inland transportation
- Packing and lashing
- Air freight etc.

(2) Area Sanitation and Health

- Medical office and hospital
- Preventive medicine
- Medical support

(3) Support Facilities

- Office
- Housing (Family quarters, Bachelor quarters)
- Public service (Mess, School, Police, Fire, Postal etc.)
- Utilities (Water, Sewerage, Power, Telephone System, Garbage, etc.)
- Warehouse
- Repair shops
- Motor pools
- Temporary jetties
- Laboratories (Soil, Concrete etc.)

2.1.12 Indirect Costs

Indirect costs shall be managed by the clients which are categorized as follows:

(1) Administrative Costs

Client costs for salaries, travel, and expenses in support of engineering and construction activities.

(2) Headquarters Costs

Engineering, design, and headquarters support, including salaries, travel, and expenses of all home office assigned personnel.

(3) Construction Supervision

Salaries, travel and expenses in support of construction management activities.

(4) Land Acquisition and Land Rights

(5) Compensation Costs

To include costs for relocation of existing facilities and structures as well as resettlement of current inhabitants.

(6) Contingency

Physical contingency allowing for uncertainties in scooping, quantities, and pricing.

(7) Other Indirect Costs

2.1.13 Method of Cost Calculation for Status Quo Alternative

The cost of Status Quo Alternative is defined as follows:

The project cost, if Existing Canal were constructed in 1990, combined with the cost of Canal Improvement which are scheduled at present.

According to the PCC year book, the total excavated volume of Existing Panama Canal from 1904 until 1990 is 506.14 mill.cu.yd (386.97 mill.M^3).

In the Memorandum of U.S. Government dated May 3, 1991, total volume of 34.90 mill.cu.yd (26.68 mill.M^3) is scheduled to be excavated for Culebra Cut Widening Project.

In order to obtain the direct excavation cost of Status Quo Alternative, the excavation quantities and same unit costs used for this study are to be applied.

2.1.14 Calculation Procedure of Indirect Costs

(1) Administrative Costs, Headquarters Costs and Construction Supervision

Captioned costs are estimated from the Construction Costs using percentages to the construction cost considering project size and nature.

(2) Land Acquisition and Land Rights

As for Sea Level Canal (Route 10 and Route 14S), calculations for Costs of Land Acquisition and Land Rights are based on Anderson Report ANNEX- V, where those costs have been estimated US$ 24.1 mill. for Route 10 and US$ 2.1 mill. for Route 14S.

Escalation Index for Land Acquisition and Land Rights from 1970 to 1990 are assumed to be 420% considering Annual Price Adjustment Values supplied by SINBOL.

Consequently, estimated those costs are US$ 101.22 mill. for Route 10 and US$ 8.82 mill. for Route 14S.

As for Lock Type Canal, the same assumptions and considerations are applied for estimating the cost of Land Acquisition and Land Rights.

(3) Compensation Costs

The estimates of compensation costs are made based on data of Culebra Cut Widening Project which is calculated at approximately US$ 21 mill. in The Memorandum of U.S. Government.
The compensation costs for Lock Type Canal and Sea Level Canal Route 10 and 14S are estimated taking into account the project size and total length proposed canal as well as those estimated for Culebra Cut Widening Project, i.e. approximately US$ 21.0 million.

(4) Contingency

10% of Construction Costs is assumed as physical contingency. Financial contingency for price escalation is not considered.

2.2 Unit Cost Analysis for Main Works

2.2.1 Canal Excavation

(1) Dry Excavation

a) General Condition

Shift	2 Shifts
Working hours per day	12 hours x 2 shifts = 24 hours
Equipment operating hours per day	10 hours x 2 shifts = 20 hours
Output (m^3/h)	Based on loading equipment (Shovel)

b) Combination of Set

Combination of one set is as follows: (Ref. Table 2.2.1-(7))

Table 2.2.1-(1)

Description		Common	Weathered Rock	Hard Rock *1
Bulldozer 86t-eq.		1,480/540	1,190/240	(1,050/385)x0.33
	(Nos.)	2.74	4.96	0.91
Blast hole drill 165 m/m		-	-	1,050/280
	(Nos.)			3.75
Shovel 18m^3-eq.				
	(Nos.)	1.00	1.00	1.00
Dump Truck 136t-eq.				
	(Nos.)	9.00	9.00	9.00
Bulldozer 60t-eq. *2		(1,480/520)x0.33	(1.190/420)x0.33	(1,050/370)x0.33
	(Nos.)	0.95	0.94	0.93
Output	(m^3/h)	1,480	1,190	1,050

*1 One third of blasted rocks will be gathered by bulldozer 86t-eq. at rock face.

*2 One third of disposed material will be spreaded by bulldozer 60t-eq. at disposal area.

c) Break down of Unit cost

COMMON

Table 2.2.1-(2)

Description	(A) Equipment Cost/Unit ($/h)	(B) Number of Equipment (Each)	(C) Total Equipment cost (AxB) ($/h)	(D) Output (m^3/h)	(E) Unit cost (C/D) ($/$m^3$)
Blasting					
Excavating	189	2.74	517.86	1,480	0.35
Loading	441	1.00	441	1,480	0.30
Hauling	247	9.00	2,223	1,480	1.50
Disposing	100	0.95	95.0	1,480	0.06
			Composite Unit Rate ($/$m^3$)		2.21

WEATHERED ROCK

Table 2.2.1-(3)

Description	(A) Equipment Cost/Unit ($/h)	(B) Number of Equipment (Each)	(C) Total Equipment cost (AxB) ($/h)	(D) Output (m^3/h)	(E) Unit cost (C/D) ($/$m^3$)
Blasting					
Excavating	189	4.96	937.44	1,190	0.79
Loading	441	1.00	441	1,190	0.37
Hauling	247	9.00	2,223	1,190	1.87
Disposing	100	0.93	93.0	1,190	0.08
			Composite Unit Rate ($/$m^3$)		3.11

ROCK

Table 2.2.1-(4)

Description	(A) Equipment Cost/Unit ($/h)	(B) Number of Equipment (Each)	(C) Total Equipment cost (AxB) ($/h)	(D) Output (m^3/h)	(E) Unit cost (C/D) ($/$m^3$)
Blasting	507	3.75	1,901.25	1,050	1.81
Excavating	189	0.91	171.99	1,050	0.16
Loading	441	1.00	441	1,050	0.42
Hauling	247	9.00	2,223	1,050	2.12
Disposing	100	0.93	93	1,050	0.09
			Composite Unit Rate ($/$m^3$)		4.60

Note: 1) Hauling distance L = 3km

2) Unit Costs include Operating and Maintenance.

d) Hourly Cost of heavy Equipment

Table 2.2.1-(5)

Description	Unit	Bulldozer 86t Equiv.	Bulldozer 60t Equiv.	Shovel $15m^3$ Equiv.	Dump Truck 136t Equiv.	Blast Hole Drill 165 m/m Equiv.
Purchase Price	$	1,143,000	643,000	4,071,000	1,407,000	$943,000
Final Depreciation rate		0.9	0.9	0.9	0.9	0.9
Durable years	year	6	6	6	6	5
Annual Depr. rate	per year	0.15	0.15	0.15	0.15	0.18
Annual Charge rate	per year	0.07	0.07	0.07	0.07	0.07
Maintenance & Repair Rate		1.70	1.20	0.70	1.40	0.80
Annual Maintenance & Repair Rate	per year	0.283	0.200	0.117	0.233	0.160
Annual Operating Hour	h	4,000	4,000	4,000	4,000	4,000
Hourly Equipment Rate	per hour	0.000126	0.000105	0.000085	0.000113	0.000103
Total Equipment Cost	$/h	144.00	67.50	346.00	159.00	97.10
Fuel Oil	$/h	95 ltr 27.60	64 ltr 18.60	217 ltr 62.90	92 ltr 26.70	85 ltr 24.70
Lubricating Oil	$/h	0.92 ltr 1.70	0.56 ltr 1.00	3.56 ltr 6.60	1.55 ltr 2.90	0.83 ltr 1.50
Consumable Materials	$/h	7.30	4.90	17.20	7.40	Bit. Lot. etc. 85.70
Tire Consumption					0.0004 Sets	0.0004 Sets
	$/h				45.00	5.10
Anfo	$/h					12.6kg 78.10
Detonator	$/h					71.4kg 107.10
Detonating Cord	$/h					2 nos 6.50
						20 m 72.00
Total Material Cost	$/h	36.60	24.50	86.70	82.00	380.70
Foreman		0.20 nos	0.20 nos	0.20 nos	0.20 nos	0.20 nos
	$/h	1.30	1.30	1.30	1.30	1.30
Driver/Operator		1 nos	1 nos	1 nos	1 nos	2 nos
	$/h	5.70	5.70	5.70	3.10	6.20
Unskilled Labor		0.33 nos	0.33 nos	0.33 nos	0.33 nos	6 nos
	$/h	1.20	1.20	1.20	1.20	21.60
Total Labor Cost	$/h	8.20	8.20	8.20	5.60	29.10
Total Hourly Cost	$/hour	189.00	100.00	441.00	247.00	507.00

Equipment Hourly Cost of Heavy Equipment

Table 2.2.1-(6)

Description	Unit	Crawler Drill 75 m/m		Compactor (Tamping Type) 30.8t 314HP		Tire Roller 20t 2.3mw 100HP		Motor Grader 4.9m 280HP 29t		Vibratory Roller 2.4m wide 177HP	
Purchase price	$		243,000		418,000		59,000		325,000		115,000
Depreciation rate	year		0.9		0.9		0.9		0.9		0.9
Durable years	year		5		8		8		7		6
Annual Depr. Rate	Per year		0.18		0.11		0.11		0.13		0.15
Annual Charge Rate	Per year		0.07		0.07		0.07		0.07		0.07
Maintenance & Repair Rate			0.40		0.07		0.70		0.70		0.80
Annual Maintenance & Repair Rate	Per year		0.08		0.09		0.09		0.10		0.13
Annual Operating Hour	h		2,000		2,000		2,000		2,000		2,000
Hourly Equipment Rate	Per hour		0.000165		0.000135		0.000135		0.000249		0.000177
Total Equipment Cost	$/h		40.10		55.40		8.00		48.40		20.40
Fuel Oil	$/h	22 ltr	6.30	34 ltr	9.90	7 ltr	2.00	20 ltr	5.80	19 ltr	5.50
Lubricating oil	$/h	0.8 ltr	1.50	0.5 ltr	0.90	0.2 ltr	0.40	0.5 ltr	0.90	0.3 ltr	0.60
Consumable Materials	$/h		57.90*1						28.80*2		
Dynamite	$/h	6.9kg	42.80								
Anfo	$/h	3.9kg	58.50								
Detonating Cord	$/h	0.386m	1.40								
Detonator	$/h	2.861 pcs	9.20								
Total Material Cost	$/h		177.60		10.80		2.40		35.50		6.10
Foreman	s/h	1/3 nos	2.20	1/5 nos	1.30	1/5 nos	1.30	1/5 nos	1.30	1/5 nos	1.30
Operator	$/h	1 nos	4.80	1 nos	5.70	1 nos	5.70	1 nos	5.70	1 nos	5.70
Unskilled Labor	$/h	1 nos	3.60	1/3 nos	1.20	1/3 nos	1.20	1/3 nos	1.20	1/3 nos	1.20
Total Labor Cost	$/h		10.60		8.20		8.20		8.20		8.20
Total Hourly Cost	$/hour		228.00		74.00		19.00		92.00		35.00

*1

Bit	75 m/m dia	0.06	pcs	20.80
Rod	45 m/m dia	0.03	pcs	12.70
Shank Rod		0.02	pcs	4.70
Sleeve		0.049	pcs	4.40
Others				15.30
Total				$57.90

*2

Cutting Edge	0.03	pcs	19.20
End Bit	0.015	pcs	4.80
Tire	0.004	sets	4.80
Total			$28.80

e) Capacities of Heavy Equipment

Table 2.2.1-(7)

Description	Spec. & Working Substance	q [m^3]	L (m)	Cm (min)	E	A (m^2)	K	t1 (min)	t2 (min)	t3 (min)	v (km/h)	n (nos)	Formula	Q1 m^3/h	f	Qn m^3/h	
Bulldozer	86t-equiv. Dozing	20.8	30	1.34	0.7								$\frac{60xqxE}{cm}$	652	0.83 0.67 0.59	540 440 385	Earth Common Weathered Rock Hard Rock
Bulldozer	86t-equiv. Ripping		30	1.49	0.5	0.84							$\frac{60xAxLxE}{cm}$			510	
Bulldozer	86t-equiv. Ripping & Dozing		Ripping Capacity Q1=440 Dozing Capacity Q2=510										$\frac{Q1xQ2}{Q1 + Q2}$ *1			240	
Bulldozer	60t-equiv. Spreading	14.3	20	0.96	0.7								$\frac{60xqxE}{cm}$	626	0.83 0.67 0.59	520 420 370	Earth Common Weathered Rock Hard Rock
Shovel	$15m^3$-equiv. Loading	15		0.5	0.9		1.1						$\frac{60xqxKxE}{cm}$	1,782	0.83 0.69 0.59	1,480 1,190 1,050	Earth Common Weathered Rock Hard Rock
Dump Truck	136t-equiv. Hauling	82.5	3,000	22 *4	0.9			18 *2	2.5 *3	1.5	20	8.8 *5	$\frac{60xqtxnxE}{cm}$	1,782	0.83 0.67 0.59	1,480 1,190 1,050	Earth Common Weathered Rock Hard Rock
Blast Hole	165m/m-equiv. Drilling												$\frac{DxWxV}{1.1x1.05}$ *6			280	Hard Rock

Abbreviation

- q: Bowl capacity for blade, bucket, vessel and etc. [m^3] at struck loading
- L: Hauling distance [m]
- Cm: Cycle time [min]
- t_1: Hauling time [min]
- t_2: Loading time [min]
- t_3: Dumping time [min]
- n: Number of dump truck [nos]
- A: Ripping Area [m^2]
- K: Heaped factor for struck loading
- V: Ave. Hauling speed [km/h]
- E: Working efficiency
- Ql: Capacity of heavy equipment [m^3/h: loose]
- f: Loading factor
- Qn: Capacity of heavy equipment [m^3/h: compacted]

Note:

*1 Composite Capacity

*2 t1 : Hauling time

$$t1 = \frac{0.12 \times L}{V} = \frac{0.12 \times 3,000}{20} = 18 \text{ [min]}$$

*3 t2 : Loading time

$$t2 = \frac{qt \times Cms}{qs \times K} = \frac{82.5 \times 0.5}{15 \times 1.1} = 2.5 \text{ [min]}$$

qt: Bowl Capacity of Dump truck
qs: Bucket Capacity of Shovel
Cms: Cycle time of Shovel

*4 Cm : Cycle time of Dump truck

$$Cm = t1 + t2 + t3 = 18 + 2.5 + 1.5 = 22 \text{ [min]}$$

*5 N : Number of Dump truck

$$N = \frac{t1 + t3}{t2} + 1 = \frac{18 + 2.5}{2.5} + 1 = 8.8 \text{ [nos]}$$

*6 H: Height of Bench-Cut 15 [m]
D: Drilling Hole Spacing 6.5 [m]
W: Overburden 5 [m]
V: Drilling Speed 10 [m/h]
t: Drilling time [h]

$$t = \frac{1.1 \times H}{V}$$

Drilling lengths 1.1 x H

Q: Capacity of Drilling [m^3/h]

$$Q = \frac{D \times W \times H}{t} = \frac{DWH}{\left(\frac{1.1 \times H}{V}\right)} \times \frac{1}{1.05}$$

$$= \frac{D \times W \times V}{1.1 \times 1.05}$$

Working factor 1.05

f) Transportation Cost Table - Dry Excavation

Table 2.2.1-(8)

Distance (km)	Cycle Time (min) T1	T2	T3	cm	Kind of Material	Output (m^3/h)	Cost ($/$m^3$)
1.0	6	2.5	1.5	10	Common	378	0.67
					Weathered	305	0.83
					Rock	269	0.94
1.5	9	2.5	1.5	13	Common	284	0.89
					Weathered	230	1.11
					Rock	202	1.25
2.0	12	2.5	1.5	16	Common	231	1.09
					Weathered	187	1.36
					Rock	164	1.54
2.5	15	2.5	1.5	19	Common	195	1.29
					Weathered	157	1.61
					Rock	138	1.83
3.0	18	2.5	1.5	22	Common	160	1.50
					Weathered	136	1.87
					Rock	120	2.12
3.5	21	2.5	1.5	25	Common	147	1.70
					Weathered	119	2.13
					Rock	105	2.41
4.0	24	2.5	1.5	28	Common	132	1.90
					Weathered	107	2.37
					Rock	94	2.67
5.0	30	2.5	1.5	34	Common	109	2.31
					Weathered	88	2.88
					Rock	77	3.26
10.0	60	2.5	1.5	64	Common	58	4.41
					Weathered	47	5.50
					Rock	41	6.24

Note (1) Combination of dump trucks (136t) and shovel loader (15 cu.m) is considered. Ave. velocity of dump truck is assumed to be 20 km/h.

Note (2) t1 Hauling hour (min)
t2 Loading hour (min)
t3 Dumping hour (min)

UNIT COST OF CANAL DRY EXCAVATION

Table 2.2.1-(9)

Case	Route	Average Hauling Distance	Description	Excavation ($/m^3) Blasting	Excavating	Loading	Hauling	Disposal	Total Unit Cost
Lock Canal L-1 L-2 L-3 L-4 L-5 L-6 L-7 L-8 L-9	15 + Third L.	3.5 km	Earth Common	-	0.35	0.30	1.70	0.06	2.41
			Weathered Rock	-	0.79	0.37	2.13	0.08	3.37
			Hard Rock	1.81	0.16	0.42	2.41	0.09	4.89
Lock Canal L-10 L-11 L-12 L-13 L-14 L-15 L-16 L-17 L-18	15 + Gatun + Third L.	3.5 km	Earth Common	-	0.35	0.30	1.70	0.06	2.41
			Weathered Rock	-	0.79	0.37	2.13	0.08	3.37
			Hard Rock	1.81	0.16	0.42	2.41	0.09	4.89
Sea Level Canal S-1 S-13 S-2 S-14 S-3 S-15 S-4 S-5 S-6	10	4.0 km	Earth Common	-	0.35	0.30	1.90	0.06	2.61
			Weathered Rock	-	0.79	0.37	2.37	0.08	3.61
			Hard Rock	1.81	0.16	0.42	2.67	0.09	5.15
Sea Level Canal S-7 S-16 S-8 S-17 S-9 S-18 S-10 S-11 S-12	14 S	4.0 km	Earth Common	-	0.35	0.30	1.90	0.06	2.61
			Weathered Rock	-	0.79	0.37	2.37	0.08	3.61
			Hard Rock	1.81	0.16	0.42	2.67	0.09	5.15

(2) Underwater Excavation

a) General Condition

Shift	2 shifts
Working hours per day	12 h x 2 shifts = 24 hours
Equipment operating hours per day	10 h x 2 shifts = 20 hours

b) Organization, Output & Unit

Table 2.2.1-(10)

Description		Organizations	out-put m^3 per year	unit cost $\$/m^3$
Rock	Blasting	Blasting barge,	218,700	60.38
Rock	Grab dredging	Grab dredger,	1,360,000	7.05
Rock	Cutter suction dredging	Cutter suction & split barge	2,477,200	8.43
Weathered Rock	Cutter suction dredging	Cutter suction dredger & split barge	5,346,000	4.47
Common	Cutter suction dredging	Cutter suction dredger & split barge	9,900,000 (L=2km)	1.71
Common	Drag suction dredging	Drag suction Dredger	12,183,000	2.11
Deep water (below -30m)				
Hard rock Soft Rock	Grab dredging	Grab dredger	1,000,000	9.09

c) Breakdown of Unit Cost

Table 2.2.1-(11)

	Blasting barge drill 10 nos, 300HP	Anchor boat 240HP
Kind of work	Rock blasting	
Number of vessels	1	3
Book price (brand new)	$3,059,000	$821,429,000
Depreciation period	5 years	16 years
Monthly operation	350 hours	200 hours
Months in operation per year	10 months	10 months
Out-put per year	218,700m^3	

Equipment cost per year

		Amount $		Amount $	
Equipment		4,926,540		225,060	
Depreciation		3,233,350		64,170	
Maintenance and repair		1,693,190		160,890	
Lubricating and fuel oil		730,800		22,410	
Manpower		2,389,520		163,180	
Skilled sea-man	19	1,302,860	2	137,140	
Common sea-man	36	468,720	2	26,040	
Diver	12	617,940			
Material		3,604,090		107,140	
Explosives		3,175,520			
Miscellaneous		428,570		107,140	
Total		11,650,950		517,790	
Unit cost		53.27	2.37 x 3 = 7.11		$60.38/m^3

Table 2.2.1-(12)

Working vessel	Grab dredger $50m^3$, 3000HP	Anchor boat 600HP
Kind of work	Rock grab dredging	
Book price (brand new)	$11,214,286,000	$1,785,714,000
Depreciation Period	8 years	14 years
Monthly operation	400 hours	250 hours
Months in operation per year	10 months	10 months
Out-put per year	$1,360,000m^3$	

Equipment cost per year

		Amount $		Amount $	
Equipment		5,748,230		473,770	
Depreciation period		2,831,890		199,300	
Maintenance and repair		2,916,340		274,470	
Lubricating and fuel oil		560,280		70,040	
Manpower		678,770		163,180	
Skilled sea-man	8	548,570	2	137,140	
Common sea-man	10	130,200	2	26,040	
Material		1,757,520		142,000	
Total		8,744,860		848,990	
Unit cost		6.43		0.62	$7.05/m^3$

Table 2.2.1-(13)

Working vessel	Cutter suction dredger 18,000 HP		Anchor boat 600 HP		Loading barge 500 HP	
Kind of work	Cutter suction dredging (rock)					
Book price (brand new)	$25,286,000		$1,786,000		$714,000	
Depreciation period	8 years		14 years		12 years	
Monthly operation	400 hours		250 hours		400 hours	
Months in operation per year	11 months		11 months		11 months	
Out-put per year	2,477,200m^3					
Equipment cost per year						
		Amount $		Amount $		Amount $
Equipment		9,723,430		508,650		268,450
Depreciation		4,544,820		219,230		163,690
Maintenance and repair		5,178,610		289,420		104,760
Lubricating and fuel oil		3,697,850		77,040		102,718
Manpower		972,150		163,180		189,220
Skilled sea-man	10	685,710	2	137,140	2	137,140
Common sea-man	22	286,440	2	26,040	4	52,080
Material		4,897,760		142,860		142,860
Total		19,291,190		891,730		703,248
Unit cost		7.79		0.36		0.28

$8.43/m^3

Cutter Suction Dredging (Weathered Rock)

Table 2.2.1-(14)

Working vessel	Cutter suction dredger 18,000HP		Anchor boat 600HP		Loading barge 500HP	
Kind of work	Cutter suction dredging (weathered rock)					
Book price (brand new)	$25,286,000		$1,786,000		$714,000	
Depreciation Period	8 years		14 years		12 years	
Monthly operation	450 hours		250 hours		450 hours	
Months in operation per year	11 months		11 months		11 months	
Out-put per year	5,346,000m^3					
Equipment cost per year						
		Amount $		Amount $		Amount $
Equipment		10,737,280		508,650		288,910
Depreciation		5,112,920		219,230		184,150
Maintenance and repair		5,624,340		289,420		104,760
Lubricating and fuel oil		4,160,080		77,040		115,560
Manpower		972,150		163,180		189,220
Skilled sea-man	10	685,710	2	137,140	2	137,140
Common sea-man	22	286,440	2	26,040	4	52,080
Material		6,423,310		142,860		142,860
Total		22,292,820		891,730		736,550
Unit cost		4.17		0.16		0.14

$4.47/m^3

Table 2.2.1-(15)

Working vessel	Cutter suction dredger pump 10,000PS, cutter 2,500 HP		Anchor boat 600 HP		Loading barge 500 HP	
Kind of work	Cutter suction dredging (earth common)					
Book price (brand new)	$25,286,000		$1,786,000		$714,000	
Depreciation Period	12 years		14 years		12 years	
Monthly operation	500 hours		250 hours		500 hours	
Months in operation per year	11 months		11 months		11 months	
Out-put per year	9,900,000m^3					
Equipment cost per year						
		Amount $		Amount $		Amount $
Equipment		8,316,020		508,650		309,370
Depreciation		3,787,350		219,230		204,610
Maintenance and repair		4,528,670		289,420		104,760
Lubricating and fuel oil		4,622,310		77,040		128,400
Manpower		972,150		163,180		189,220
Skilled sea-man	10	685,710	2	137,140	2	137,140
Common sea-man	22	286,440	2	26,040	4	52,080
Material		1,335,520		142,860		142,860
Total		15,246,000		891,730		769,850
Unit cost		1.54		0.09		0.08 $1.71/m^3

Table 2.2.1-(16)

Working vessel	Drag suction dredger pump 7,800 HP	Survey boat 750 HP
Kind of work	Common dredging (less than 2 km of hauling distance)	
Book price (brand new)	$48,000,000	$461,000
Depreciation period	14 years	12 years
Monthly operation	616 hours	300 hours
Months in operation per year	11 months	11 months
Out-put per year	12,183,050m^3	

Equipment cost per year

		Amount $		Amount $	
Equipment		17,584,320		170,830	
Depreciation		7,592,160		79,190	
Maintenance and repair		9,992,160		91,640	
Lubricating and fuel oil		4,112,830		115,560	
Manpower		1,634,430		163,180	
Skilled sea-man	17	1,165,710	2	137,140	
Common sea-man	36	468,720	2	26,040	
Material		1,782,240		142,860	
Total		25,113,820		592,430	
Unit cost		2.06		0.05	$2.11/m^3

Table 2.2.1-(17)

Working vessel	Grab dredger 50 m^3 3,000 HP	Anchor boat 600 HP
Kind of work	Grab dredging (deep water, below -30m)	
Book price (brand new)	$11,214,000	$1,786,000
Depreciation period	7 years	14 years
Monthly operation	400 hours	250 hours
Months in operation per year	10 months	10 months
Out-put per year	1,000,000m^3	

Equipment cost per year

		Amount $		Amount $	
Equipment		5,748,630		473,770	
Depreciation		2,833,190		199,300	
Maintenance and repair		2,915,440		274,470	
Lubricating and fuel oil		560,280		70,040	
Manpower		678,770		163,180	
Skilled sea-man	8	548,570	2	137,140	
Common sea-man	10	130,200	2	26,040	
Material		1,252,320		142,860	
Total		8,240,000		849,850	
Unit cost		8.24		0.85	$9.09/$m^3$

d) Unit Cost of Transportation (Underwater excavation)

Unit costs of transportation are shown in Table 2.2.1-(19). Average hauling distances of each case are shown in Table 2.2.1-(18).

Table 2.2.1-(18)

	Z-I	Z-II	Z-III	Z-IV	Z-V
High-rise	3.6	9.0	34.9	41.9	9.9
Low-rise	3.6	9.0	34.9	21.5	9.9
Route 14S	3.6	2.2	18.4	18.4	9.9
Route 10	3.6	-	-	-	3.6

(km)

Unit Cost of Transportation

Table 2.2.1-(19)
unit cost $\$/m^3$

Distance (km)	Hard Rock Below -30m deep	Hard Rock Above -30m deep	Weathered Rock Below -30m deep	Weathered Rock Above -30m deep	Common
2.2	1.80	1.00	1.80	0.58	0.46
2.4	1.81	1.01	1.81	0.59	0.47
3.5	1.87		1.87		
3.6	1.87	1.07	1.87	0.66	0.53
4.0	1.0			0.68	
6.0					0.67
6.3				0.80	
7.7		1.30			
8.1	2.12	1.32	2.12	0.90	
9.0		1.37		0.95	6.85
9.9	2.20	1.40	2.20		0.90
10.0		1.42			
12.5		1.56			
13.9			1.22		
18.4	2.68	1.88	2.68	1.46	1.35
18.5					
18.9	2.71		2.71		
19.1					1.38
20.8				1.66	
21.3		20.30			
21.5	2.05	2.04	2.05	2.81	1.49
34.9		3.01		2.22	2.15
41.9		3.33		2.69	2.45

e) Combined Unit Cost of Underwater Excavation

Assumptions of case study are as follows:

In case of lock canal, 15% of rock will be excavated by blasting.

In case of sea-level canal;

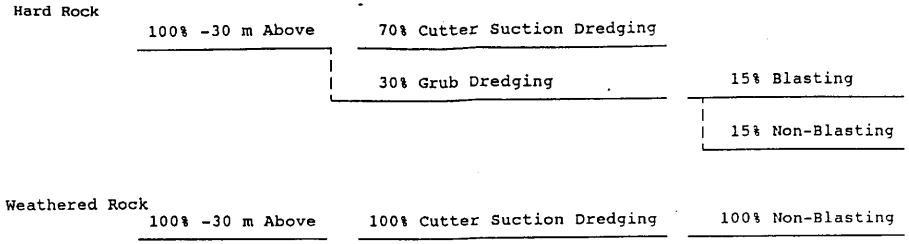
deep water dredging operation (-30m - -53m) will be carried out.

55% of rock will be excavated by blasting.

45% of weathered rock will be excavated by blasting.

Unit costs of each case are shown in Table 2.2.1-(20) to (23).

Assumed proportion for underwater excavation



DREDGING UNIT COST (Case of High-rise)
For Depths up to -30 meters

Unit cost in dollars Table 2.2.1-(20)

Material to be Excavated	Type of Equipment	Dredging Loading Cost: Soil ratio %	Unit Cost	Weighted Average ($/m^3)	Transportation Disposal Haul Distance (km): Z-I 3.6	Z-II 9.0	Z-III 34.9	Z-IV 41.9	Z-V 9.9	Total Dredging Unit Costs: Z-I	Z-II	Z-III	Z-IV	Z-V
Hard Rock	Cutter suction dredging	70	8.43	5.90										
	Grub dredging	30	7.05	2.12										
	Blasting (grub dredging)	15	60.38	9.06										
	Cost per m^3			17.08	1.07	1.37	3.01	3.33	1.43	18.15	18.45	20.09	20.41	18.51
Weathered Rock	Cutter suction dredging	100												
	Cost per m^3			4.47	0.66	0.95	2.22	2.69	1.00	5.13	5.42	6.69	7.16	5.47
Common	Cutter suction dredging	100												
	Cost per m^3			1.71	0.53	0.86	2.15	2.45	0.90	2.24	2.57	3.86	4.16	2.61

Note: 1) Transportation Costs, Refer to Table 2.2.1-(19).
2) Total Dredging Unit Costs equal 'Dredging Loading Cost and Transportation'.

DREDGING UNIT COST (Case of Low-rise)
For Depths up to -30 meters

Unit cost in dollars Table 2.2.1-(21)

Material to be Excavated	Type of Equipment	Dredging Loading Cost: Soil ratio %	Dredging Loading Cost: Unit Cost	Dredging Loading Cost: Weighted Average ($/m^3)	Transportation Disposal Haul Distance (km): Z-I 3.6	Z-II 9.0	Z-III 34.9	Z-IV 21.9	Z-V 9.9	Total Dredging Unit Costs: Z-I	Z-II	Z-III	Z-IV	Z-V
Hard Rock	Cutter suction dredging	70	8.43	5.90										
	Grub dredging	30	7.05	2.12										
	Blasting (grub dredging)	15	60.38	9.06										
	Cost per m^3			17.08	1.07	1.37	3.01	2.04	1.43	18.15	18.45	20.09	19.12	18.51
Weathered Rock	Cutter suction dredging	100												
	Cost per m^3			4.47	0.66	0.95	2.22	2.81	1.00	5.13	5.42	6.69	7.28	5.47
Common	Cutter suction dredging	100												
	Cost per m^3			1.71	0.53	0.85	2.15	1.49	0.90	2.24	2.56	3.86	3.20	2.61

Assumed proportion for underwater excavation

Hard Rock

- 100% -30 m Above
  - 70% Cutter Suction Dredging
  - 30% Grub Dredging
    - 15% Blasting
    - 15% Non-Blasting

Weathered Rock

- 100% -30 m Above
  - 100% Cutter Suction Dredging
    - 100% Non-Blasting

DREDGING UNIT COST (Route 14S Sea Level)
For Depths below -30 meters

Unit cost in dollars Table 2.2.1-(22)

Material to be Excavated	Type of Equipment	Dredging Loading Cost: Soil ratio %	Unit Cost	Weighted Average ($/m³)	Transportation Disposal Haul Distance (km): Z-I 3.6	Z-II 2.2	Z-III 18.4	Z-IV 18.4	Z-V 9.9	Total Dredging Unit Costs: Z-I	Z-II	Z-III	Z-IV	Z-V
Hard Rock	Cutter suction dredging	10	17.08	1.71										
	Grub dredging	90	9.09	8.18										
	Blasting (grub dredging)	55	60.38	33.21										
	Cost per m³			43.10	1.87	1.80	2.65	2.65	2.20	44.97	44.90	45.75	45.75	45.30
Weathered Rock	Cutter suction dredging	10	4.47	0.45										
	Grub dredging	90	9.09	8.18										
	Blasting (grub dredging)	45	60.38	27.17										
	Cost per m³			35.80	1.87	1.80	2.65	2.65	2.20	37.67	37.60	38.45	38.45	38.00
Common	Cutter suction dredging	100												
	Cost per m³			1.71	0.53	0.46	1.35	1.35	0.90	2.24	2.17	3.06	3.06	2.61

Assumed proportion for underwater excavation

Hard Rock

- 10% -30 m Above
  - 7% Cutter Suction Dredging
  - 3% Grub Dredging
    - 1.5% Blasting
    - 1.5% Non-Blasting
- 90% -30 m Below
  - 90% Grub Dredging
    - 55% Blasting
    - 35% Non-Blasting

Weathered Rock

- 10% -30 m Above
  - 10% Cutter Suction Dredging
- 90% -30 m Below
  - 90% Grub Dredging
    - 45% Blasting
    - 45% Non-Blasting

DREDGING UNIT COST (Route 10 Sea Level)
For Depths up to -30 meters

Unit cost in dollars Table 2.2.1-(23)

Material to be Excavated	Type of Equipment	Dredging Loading Cost: Soil ratio %	Dredging Loading Cost: Unit Cost	Dredging Loading Cost: Weighted Average ($/m^3)	Transportation Disposal Haul Distance (km): Z-I 3.6	Z-II -	Z-III -	Z-IV -	Z-V 3.6	Total Dredging Unit Costs: Z-I	Z-II	Z-III	Z-IV	Z-V
Hard Rock	Cutter suction dredging	70	8.43	5.90										
	Grub dredging	30	7.05	2.12										
	Blasting (grub dredging)	15	60.38	9.06										
	Cost per m^3			17.08	1.07	-	-	-	1.07	18.15	-	-	-	18.15
Weathered Rock	Cutter suction dredging	100												
	Cost per m^3			4.47	0.66	-	-	-	0.66	5.13	-	-	-	5.13
Common	Cutter suction dredging	100												
	Cost per m^3			1.71	0.53	-	-	-	0.53	2.24	-	-	-	2.24

Assumed proportion for underwater excavation

Hard Rock

100% -30 m Above — 70% Cutter Suction Dredging

30% Grub Dredging — 15% Blasting

15% Non-Blasting

Weathered Rock

100% -30 m Above — 100% Cutter Suction Dredging — 100% Non-Blasting

(3) Miscellaneous Works

a) Haul road construction (Route 10)

a. Route 10

- Plan of Haul Road

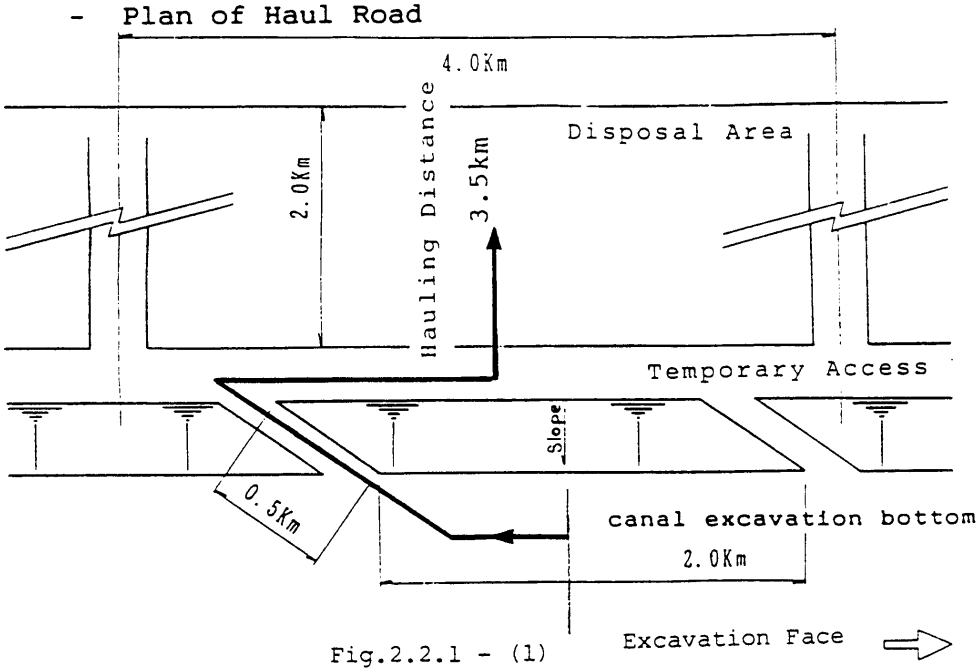


Fig.2.2.1 - (1)

Average hauling distance	km	Ave.
Excavation face - Inclined drive	0 - 2.0	1.0
Inclined drive	0 - 1.0	0.5
Inclined drive - disposal area	0 - 4.0	2.0
Total		3.5 km

Haul Road Length (km)

Lagarto - Escobal	16
Lagarterita - 2nd Barrier Dam	5
STA No.38 - Puerto Caimito	22
Sub-total	43 km

Inclined drive

Ave. 0.5 x 30 Spots =	15 km
Total	58 km

- Quantities (Assumed)

Common excavation	90,000 x 30 x 0.40	= 1,080,000 m^3
Weathered rock	36 x 43,000 x 1.00	= 1,548,000
	90,000 x 30 x 0.60	= 1,620,000
	Subtotal	= 3,168,000 m^3
Hard rock	150,000*1 x 30	= 4,500,000 m^3
Pavement (Water Tightened Macadam)	58,000 x 20	= 1,160,000 m^2
Temporary bridge*2		24 nos

- Estimate

	Q'ty	Unit cost ($)	Amount (million dollars)
Common	1,080,000	2.21	2.39
Weathered rock	3,168,000	3.11	9.85
Hard rock	4,500,000	4.92	22.14
Pavement	1,160,000	6.00	6.96
Temporary bridge	24	200,000.00	4.80
			$46.14

- Unit cost

$46,160,000 / 58,000m = 795.9 = $796.00/m

*1 150,000 cubic meters of excavation volume is assumed as per spot.

*2 Specification of assumed bridge is as follows:

Temporary Bridge
Specification

Proposed Vehicle	Dump truck	136t
Ave. Span		6m
Width		20m
Structure	Steel plate Girder	
	Steel weight	67t

Cost

Steel Fabrication			
Material	67t	725/t	$ 48,575.00
Processing	67t	1,000/t	$ 67,000.00
Sub-total			$115,575.00
Foundation	1 L.S.		$ 17,425.00
Installation/ Removal	67t	1,000/t	$ 67,000.00
Total Cost			$200,000.00

b. Route 14S

- Road Length

Temporary access road		31 km
Access road to excavation face 31 / 2 = 15.5 = 16		
	16 spots x 0.5	= 8 km
	Total	= 39 km

- Quantities

Common excavation	90,000 x 16 x 0.4	=	576,000 m^3
Weathered rock	90,000 x 16 x 0.6	=	864,000
	36 x 31,000	=	1,116,000
	Sub-total		1,980,000 m^3
Hard rock	150,000 x 16	=	2,400,000 m^3
Pavement	(31,000 + 16 x 500) x 20	=	780,000 m^2
Temporary bridge	31/43 x 24	=	18 nos

- Estimates

	Q'ty	Unit cost ($)	Amount (million dollars)
Common	576,000	2.21	1.27
Weathered rock	1,980,000	3.11	6.16
Hard rock	2,400,000	4.92	11.81
Pavement	780,000	6.00	4.68
Temporary bridge	18	200,000.00	3.60
Total			$27.52

- Unit Cost

$27,520,000 / 39,000 = 705.6 = $705.09/m

c. Lock Type Canal

- Road Length

Gamboa - Miraflores	18 km
Limon Bay - Gatun	5
Access road to quarry face 23 / 2 x 0.5	6
Total	29 km

- Quantities

Common excavation	90,000 x 12 x 0.4	=	432,000 m^3
Weathered rock	90,000 x 12 x 0.6	=	648,000
	36 x 18,000	=	648,000
	Sub-total	=	1,296,000 m^3
Hard rock	150,000 x 12	=	1,800,000 m^3
Pavement	29,000 x 20	=	580,000 m^2
Temporary bridge		=	8 nos

- Estimate

	Q'ty	Unit cost ($)	Amount (million dollars)
Common	432,000	2.21	0.95
Weathered rock	1,296,000	3.11	4.03
Hard rock	1,800,000	4.92	8.86
Pavement	580,000	6.00	3.48
Temporary bridge	8	200,000.00	1.66
Total			$18.92

- Unit Cost

$18,920,000 / 29,000 = 652.4 = $652.00/m

b) Clearing and grubbing

	Q'ty (h)	Unit cost ($)	Amount (per ha)
(Equipment cost)			
Bulldozer 86t-eq.	10	187.00	1,870.00
(Labor cost)	nos.		
Foreman	1	34.40	34.40
Unskilled	20	18.80	376.00
		Total	$2,280.40/ha

Unit price $2,280.40 / 10,000 = 0.228 = $0.23/$m^2$

c) Vegetation $0.70/$m^2$ (from actual data)

2.2.2 LOCK CONCRETE STRUCTURE

(1) Estimate Basis

a) Study case

Concrete of 150,000 DWT lock, volume of concrete 5,880,000m^3

b) Material and proportioning

Materials are to be procured and mixed at concrete plants.
proportioning: dam concrete specification

(2) Summary of Execution

a) Capacity of concrete placing

150,000 DWT lock (Pacific side) concrete volume 5,880,000m^3

construction period: 6 years
total working hours 6 yrs x 250 days / yr.
x (10h / day x 2 shifts) = 30,000 h

capacity per hour $\frac{5,880,000m^3}{30,000h}$ = 196 m^3/h

b) Flow of concrete placing

196m^3/h

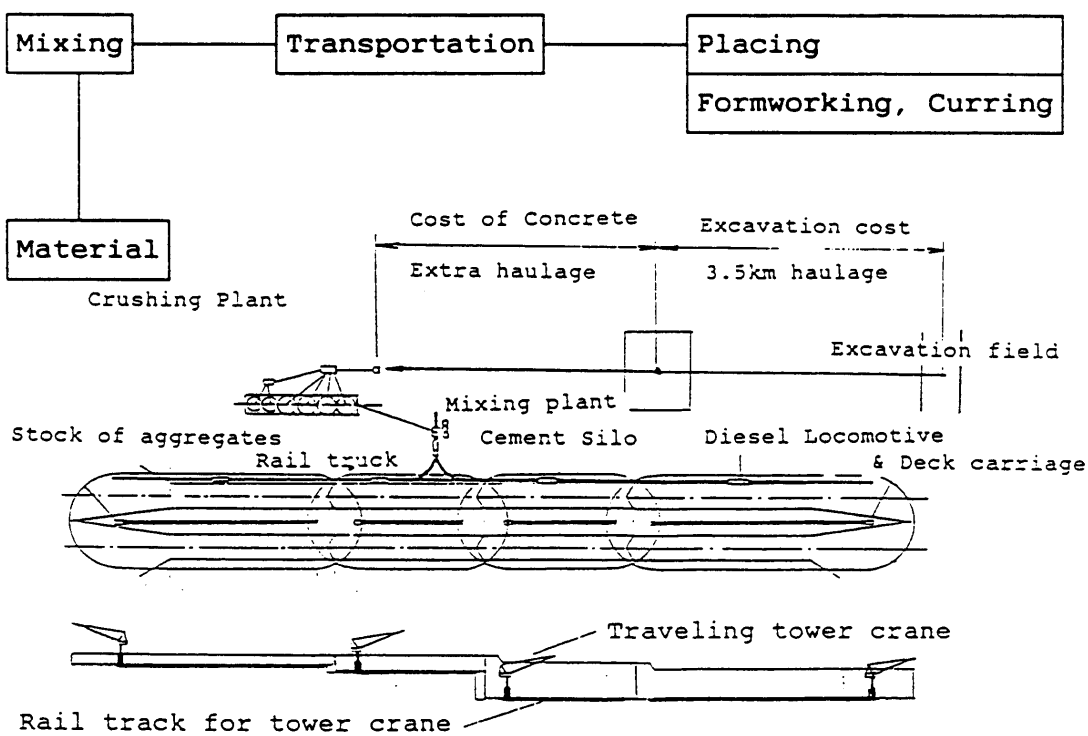


Fig. 2. 2. 2 – (1) Concept of concrete work

c) Cycle time and placing capacity

Table 2.2.2-(1)

	Mixing	Transportation	Placing
cycle time (min)	concrete mixer $3m^3$ x 3 nos 2.5 min	method $4.5m^3$ Distance av. 1.1km av. velocity 15km/h 1.1/15+t1+t2=12.4min t1: loading 1.0 min t2: unloading 3.5 min x 2	cycle of placing $4.5m^3$ bucket 3.5 min
capacity per hour	60min/2.5minx$3m^3$x 3 nos = 216 m^3/h	60min/12.4minx($4.5m^3$x 2 nos) = 43.5 m^3/h	60min/3.5minx$4.5m^3$ x0.8=61.7m^3/h efficiency: 0.8
equipment per $196m^3$/h placing	196/216=0.91set	196/43.5=4.5set	196/61.7=3.2set
arrangement of main equipment	mixing plant 1 ($3m^3$mixer x 3sets)	diesel locomotive (12t) 5 deck carriage 5 ($4.5m^3$ bucket 2 sets on board) concrete bucket $4.5m^3$ 10 track 2.3km x 5 lane	traveling tower crane 4 concrete vibro dozer 4

(3) Unit Cost of Concrete

a)	material	$33.91/$m^3$
b)	mixing	1.53/m^3
c)	transportation	0.85/m^3
d)	placing	6.57/m^3
e)	form work and curing	3.81/m^3
	unit cost of concrete	$46.67/$m^3$

(4) Calculation for Unit Cost of Concrete

	Contents	Unit Cost ($)	Cost ($/m^3)
a) Material			
cement	0.2t/m^3	106.00/t	21.20
coarse aggregate	0.85m^3	9.20/m^3*1	7.82
fine aggregate	0.46m^3	8.30/m^3*2	3.82
additives	0.0006t/m^3	1,786.00/t	1.07
unit cost of material			$33.91/m^3
b) Cost of Mixing			
- installation and demolition of concrete plant L.S.	$213,000.00		$0.04/m^3
- mixing			
plant operation	1 hour		157.00
operation for aggregate feeding conveyor	1 hour		26.00
operation for cement storage	3 hours	$12.00/h	36.00
operation for cement feeding conveyor	3 hours	$4.00/h	12.00
wheel loader operation for aggregate stock yard	1 hour		26.00
generation operation for mixing plant	1 hour		36.00
Total	196 m^3/h		$293.00/h
unit cost of mixing			$1.49/m^3
unit cost of concrete mixing 0.04 + 1.49 =			$1.53/m^3

*1 Coarse aggregate

(Disposal Area) — 5.0 km — (Crushing Plant) — (Stock pile)

Loading $0.42/m^3 — Hauling $3.20/m^3 — Crushing & Sieving $5.52/m^3 — Coarse aggregates $9.20/m^3

*2 Fine aggregate

(Disposal Area) — (Crushing Plant & Rod Mill) — (Stock pile)

Loading $0.42/m^3 — Hauling $3.20/m^3 — Crushing, Milling & Washing $4.62/m^3 — Fine aggregates $8.30/m^3

	Contents	Unit Cost	Cost
c) Transportation			
- installation and demolition of rail truck for concrete transportation L.S.	$752,000.00		$0.13/m^3
- cost of transportation			
operation of diesel locomotive	4.5 hours	$17.00/h	76.50
operation of deck carriage	4.5 hours	$5.00/h	22.50
operation of concrete bucket	2x4.5 hours	$1.00/h	9.00
labor cost			
foreman	0.2/hours	$6.70/h	1.30
un-skilled labor	9.0/hours	$3.60/h	32.40
Total	196 m^3/h		$141.70/h
Transportation Cost			$0.72/m^3
Concrete Transportation Cost 0.13 + 0.72 =			$0.85/m^3

	Contents	Unit Cost	Cost
d) Placing			
- installation and demolition of traveling tower crane L.S.	$756,000.00		$0.13/m^3
- concrete placing			
operation of tower crane	4 hours	$205.00/h	820.00
operation of generation	4 hours	$23.00/h	92.00
vibro-dozer	4 hours	$43.00/h	172.00
concrete vibrator	3x4 hours	$1.00/h	12.00
miscellaneous (pump etc.)	10x4 hours	$1.00/h	40.00
concrete gang			
foreman	4x1 man-hours	$6.70/h	26.80
skilled labor	4x3 man-hours	$3.90/h	46.80
unskilled labor	4x2 man-hours	$3.60/h	28.80
carpenter	4x1 man-hours	$3.90/h	15.60
electrician	4x0.5 man-hours	$3.90/h	7.80
mechanic	4x0.5 man-hours	$4.80/h	9.60
Total	196m^3/h		$1,261.40/h
unit cost of placing			$6.44/m^3
unit cost of concrete placing 0.13 + 6.44 =			$6.57/m^3

e) Form work and Curring

- form work (0.2m^2/m^3)

  $18.00/m^2 x 0.2m^2/m^3 = $3.6/m^3

- green cut and curring

  output

  per block 1.5m x 15m x 30m = 675m^3 (1 lift: 1.5m)

  2 block/day 675m^3 x 2 block/day = 1,350m^3/day

labor cost			
foreman	1 men-day	$53.30/day	53.30
skilled labor	2 men-day	$31.00/day	62.00
unskilled labor	6 men-day	$29.10/day	174.60
Total			$289.90/day
unit cost of green cut and curing			$0.21/m^3
unit cost of form work and curing 3.60 + 0.21 =			$3.81 /m^3

(5) Unit Cost (per hour) of Equipment for Concrete Works

HOURY COST OF EQUIPMENT

Table 2.2.2-(2)

Description	Unit	Mixing plant 200m³/H 3m³x3 nos.	Belt conveyor 900mm 150m	Cement Silo 1,000t	Screw Conveyor & Bucket Elevator 40t/H	Generator 440HP 300KVA
Purchase price	$	1,030,000	286,000	144,000	37,000	69,000
Depreciation rate		0.9	0.9	0.9	0.9	0.9
Duarable years	year	8	8	8	8	9
Annual depr. rate	per year	0.11	0.11	0.11	0.11	0.10
Annual charge rate	per year	0.07	0.05	0.05	0.05	0.05
Maintenance & repair rate		0.40	0.20	0.05	0.40	0.80
Annual maintenance & repair rate	per year	0.05	0.03	0	0.05	0.09
Annual operating hour	h	4,000	4,000	4,000	4,000	4,000
Hourly equipment rate	per hour	0.000058	0.000052	0.000042	0.000047	0.000060
Total Equipment Cost	$/h	59.70	14.90	6.00	1.70	4.10
Fuel oil						52 ltr 15.10
Lubricating oil		98 ltr 1.50				0.31 ltr 0.60
Consumable materials		70.00				
Total Material cost	$/h	71.50	*1	*1	*1	15.70
Forman	$/h	1nos. 6.70	0.33nos. 2.20	0.33nos. 2.20	0.33nos. 2.20	0.2nos. 1.30
Operator	$/h	2nos. 11.40	1nos. 5.70			
Unskilled Laborer	$/h	2nos. 7.20	1nos. 3.60	1nos. 3.60		0.5nos. 1.80
Total labour cost	$/h	25.30	11.50	5.80	2.20	3.10
Total Hourly Cost	$/hour	157.00	26.00	12.00	4.00	23.00

*1 Including in Total Equipment cost

HOURLY COST OF EQUIPMENT

Table 2.2.2-(3)

Description	Unit	Diesel Locomotive 10t	Diesel Locomotive 110HP	Concrete Bucket $4.5m^3$ (for Dam)	Deck Carriage (Bogie Type) $4.5m^3$x2 nos.	Travelling Tower Crane 1,000t-m 300kw	Travelling Tower Crane 1,000t-m 424t
Purchase price	$		105,000	29,000	49,000		3,540,000
Depreciation rate			0.9	0.9	0.9		0.9
Duarable years	year		7	5	7		8
Annual Depr. rate	per year		0.13	0.18	0.13		0.11
Annual charage rate	per year		0.05	0.05	0.05		0.07
Maintenance & repair rate			0.7	0.9	0.9		0.20
Annual maintenance & repair rate	per year		0.10	0.18	0.14		0.03
Annual operating hour	h		4,000	4,000	4,000		4,000
Hourly equipment rate	per year		0.000070	0.000103	0.000077		0.000052
Total equipment cost	$/h		7.40	3.00	3.80		184.10
Fuel oil	$/h	4 ltr	1.20				
Lubricating oil	$/h	0.1 ltr	0.20		0.1 ltr 0.20	0.5 ltr	0.90
Wire rope	$/h					Wire rope 500m/1,000h	5.30
Total Material cost	$/h		1.40		0.20		6.20
Forman	$/h	0.20nos.	1.30		0.20nos. 1.30	0.20nos.	1.30
Operator	$/h	1 nos.	5.70			1 nos.	5.70
Unskilled Laborer	$/h	0.33nos.	1.20			2 nos.	7.20
Total Labour cost	$/h		8.20		1.30		14.20
Total Hourly cost	$/h		17.00	3.00	5.00		205.00

HOURLY COST OF EQUIPMENT

Table 2.2.2-(4)

Description	Unit	Vibro Dozer 57ps 8t	Concrete Vabrator 1.5kW x 135 dia.	Generator 300kVA 440ps 6t
Purchase price	$	93,000	1,800	69,000
Depreciation rate		0.9	0.9	0.9
Duarable years	year	4.5	4.5	9
Annual depr. rate	per year	0.20	0.20	0.10
Annual charge rate	per year	0.07	0.07	0.05
Maintenance & repair rate		2.00	2.00	0.80
Annual maintenance & repair rate	per year	0.44	0.44	0.09
Annual operating hour	h	2,000	2,000	4,000
Hourly equipment rate	per hour	0.000357	0.000357	0.000060
Total equipment cost	$/h	33.20	0.60	4.10
Fuel oil	$/h	6 ltr 1.70		52 ltr 15.10
Lubricating oil		0.1 ltr 0.20		0.31 ltr 0.60
Consumable materials			0.40	
Total Material cost	$/h	1.90	0.40	15.70
Foreman	$/h	0.2nos. 1.30		0.2nos. 1.30
Operator	$/h	1 nos. 5.70		
Unskilled laborer	$/h	0.33nos.1.20		0.50nos.1.80
Total Labor cost	$/h	8.20		3.10
Total Hourly Cost	$/h	43.00	1.00	23.00

HOURLY COST OF EQUIPMENT

Table 2.2.2-(5)

Description	Unit	Wheel Loader 14t 2.3m^3 160HP	Truck Crane 28HP 31.5t 30t
Purchase price	$	109,000	244,000
Depreciation rate		0.9	0.9
Duarable years	year	6	8
Annual depr. rate	per year	0.15	0.11
Annual charge rate	per year	0.07	0.07
Maintenance & repair rate		0.80	0.30
Annual maintenance & repair rate	per year	0.13	0.05
Annual operating hour	h	2,000	2,000
Hourly equipment cost	per hour	0.000177	0.000110
Total equipment cost	$/h	19.30	26.80
Fuel oil	$/h	19 ltr 5.50	10 ltr 2.90
Lubricating oil	$/h	0.3 ltr 0.60	0.3 ltr 0.60
Tire	$/h	0.005 set 2.80	
Wire rope	$/h		150m/200h 1.50
Total material cost		8.90	5.00
Foreman	$/h	0.2nos. 1.30	0.2nos. 1.30
Operator	$/h	1nos. 5.70	1nos. 5.70
Unskilled laborer	$/h	0.33nos. 1.20	1nos. 3.60
Total labor cost	$/h	8.20	10.60
Total Hourly Cost	$/h	36.00	42.00

(6) Unit Cost of Other Works

a) Rock excavation

	Ratio (%)	Unit cost ($/m^3)	Composite Unit Cost ($/m^3)
Common	6.9	2.11	0.146
Weathered rock	71.3	3.11	2.217
Hard rock	21.8	4.92	1.073
Total			$3.44/m^3

b) Backfill (weathered rock)

	Out put (m^3/h)	Unit price ($/h)	Composite Unit Cost ($/m^3)
Spreading	440	100.00	0.227
Compaction	1,000	74.00	0.07
Hauling			1.87
Loading			0.37
Total			$2.54/m^3

c) Re-bar fabrication

	($/ton)
Material	675.00
fabrication	67.00
Total	$742.00/ton

2.2.3 Other Works

(1) Barrier Dam

Barrier Dam Estimation

a) Quantities — Dam length = 10,130 m

a. Dredging — V = 120x5x10,130=6,078,000m^3

b. Clamshell dumped Embankment

V = 2x1/2x20x20x10,130=4,052,000m^3

c. Compaction — Compaction area = 1/2x(20+35)x10,130x4=1,114,300m^2

d. Impervious grouting

S=20x10,130=202,600m^2

e. Drilling & Grouting

L = (dam height + 20) x dam length x 1.05/1.5 =
(20.0 + 20.0) x 10.13 x 1.05/1.5 = 283,640 = 284,000 m

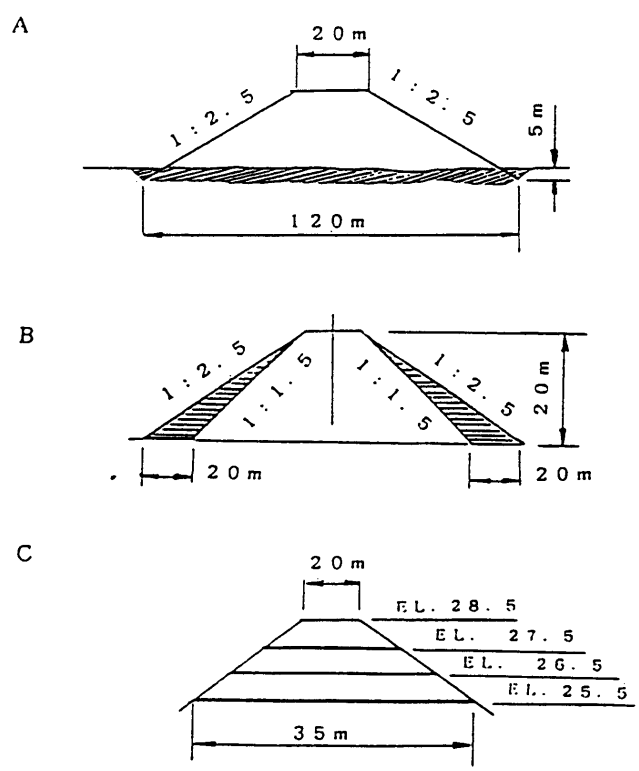


Fig. 2.2.3 (1)

b) Unit Cost

a. Dredging

Cutter suction type, direct discharge
$4.70 per m^3 (estimation from underwater Excavation)

b. Additional Cost of Hauling Distance Adjustment

Hauling distance of land excavation (L = 3.5km)

Hauling distance = 3.5 + 2.3 = 5.8 km = 5,800 m

Hauling hour t1 = $\frac{0.12 \times 5,800}{24}$ = 29'

(loading hour 2.5', dumping hour 1.5')

Nos of Dump Truck = $\frac{29 + 1.5}{2.5}$ + 1 = 13.2 = 14 nos

Additional unit cost per hour (for weathered rock)

(14 - 9) x $247.00 / 1,194 = $1.03/$m^3$

c. Clamshell Dumped Embankment

Output of clamshell (7,450)=20m^3x30 times/hx0.9=540m^3/h
Equipment cost 420/570 x 439 = $323.47

Unit cost $323.47 / 540 = $0.60/$m^3$

d. Impervious Grouting

Unit cost $214.00/$m^2$

e. Compaction

Output of compactor 2,400 m/h *1 x 2 m / 5 = 960 m^2/h
Unit cost = $74.00 / 960 = $0.08 / m^2

f. Drilling & Grouting

$75.00/m *2 for percussion drill.

*1 Velocity of Compactor

*2	Drilling	75 m/m	$36.12/m
	Cement Milk Mixing		6.55
	Grouting	7 kg/cm^2	24.62
	Material		
	Cement	0.07 t/m	7.42
	Miscellaneous	L.S.	0.29
	Total Cost		$75.00/m

c) Estimation (per V = 10,700,000)

Description	Unit	Q'ty ($x10^6$)	Unit cost ($)	Amount (million dollars)
Dredging	m^3	6.1	4.70	28.67
Hauling	m^3	10.7	1.03	11.02
Dumped Embankment	m^3	4.05	0.60	2.43
Compaction	m^2	1.11	0.08	0.09
Spreading	m^3	10.70	0.11	1.177
Impervious gone	m^2	0.202	214.00	43.23
Drilling & Grouting	m	0.284	75.00	21.30
		Sub-total		$107.915
Others *1 $107,915,000 x 0.40				43.166
		Total		$151.08

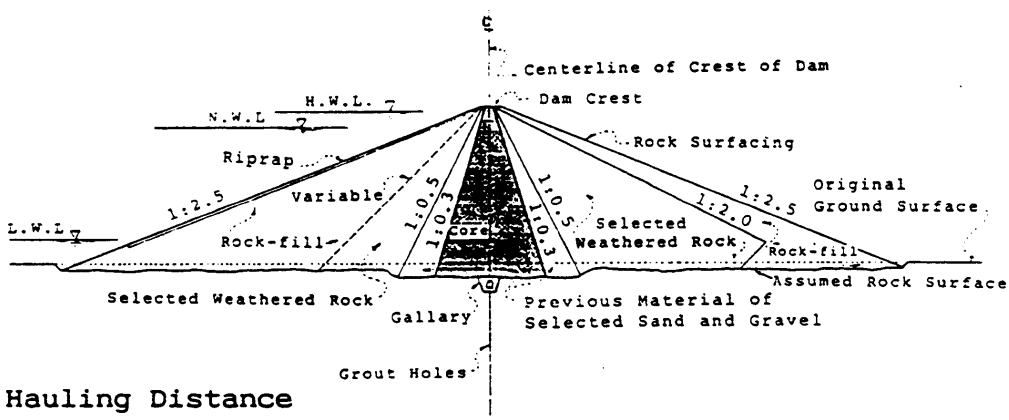
Unit cost (per m^3) = 151.08 / 10.7 = $14.12/$m^3$

*1 Diversion Tunnel, spillway and other works are included in others.

(2) New Dam

a) General Condition

a. Typical Section of Dam



b. Hauling Distance

Dam Site to disposal area = 3.5 km
Quarry site to disposal area = 3.5 km
Quarry site to dam site = 3.5 km

c. Item List

1.	Clearing and Grubbing	7.	Rock Embankment
2.	Spoiled Dump at Quarry	8.	Riprap Embankment
3.	Common Excavation	9.	Drilling & Grouting
4.	Rock Excavation	10.	Diversion Tunnel
5.	Core Embankment	11.	Spillway
6.	Filter Embankment	12.	Others

b) quantities

	Ciri	Trinidad (1)	Trinidad (2)
a. Clearing & Grubbing	$1.5 \times 10^6 m^3$	$2.5 \times 10^6 m^3$	$4.0 \times 10^6 m^3$
Quarry site	0.84	1.17	1.50
Dam site	0.08	0.17	0.24
Disposal area	0.28	0.39	0.50
Others	0.11	0.16	0.20
Total (million m^2)	1.31	1.89	2.44
b. Spoiled Dump at Quarry			
Assumed Area (million m^3)	0.35	0.59	0.75
c. Common Excavation			
Clearing & grubbing x 0.2 (million m^3)	0.26	0.38	0.49
d. Rock Excavation			
Common excavation x 0.25 (million m^3)	0.07	0.10	0.12

e. Respective Zone Embankment

Core zone	0.122
Filter zone	0.085
Rock zone	0.770
Riprap	0.023
Total zone	1,000

		Ciri	Trinidad (1)	Trinidad (2)
Zone		$1.5 \times 10^6 m^3$	$2.5 \times 10^6 m^3$	$4.0 \times 10^6 m^3$
(Ratio)				
Core	0.122	183,000	305,000	488,000
Filter	0.085	127,500	212,500	340,000
Rock	0.770	1,155,000	1,925,000	3,080,000
Rioprap	0.023	34,500	57,500	92,000
Total (m^3)		1,500,000	2,500,000	4,000,000

f. Drilling and Grouting

a. Ciri Dam ($1.5 \times 10^6 m^3$)
L = Dam volume x 1/100 = 15,000 m

b. Trinidad Dam (1) ($2.5 \times 10^6 m^3$)
L = (1/3xdam height+35)xDam lengthx1/1.5= 21,300 m

c. Trinidad Dam (2) ($4.0 \times 10^6 m^3$)
L = (1/3x dam height+35)xDam lengthx1/1.5= 26,400 m

c) Unit Cost

a. Clearing & Grubbing
Unit cost: $0.48/m^2$ (Assumed 2 times of Canal Excavation)

b. Spoiled Dump
Unit cost: $2.43/m^3$ (unit cost of common exc.x1.15)

c. Common Exc.: Aver. of common and weathered
(2.11 + 3.11) / 2 = $2.61
2.61 x 1.15 = $3.00/m^3$

d. Rock embankment

i. 5.39 *1 x 1.15 = $6.20/m^3$
6.20 x 0.792 *2 = $4.91/m^3$

ii. Compaction cost $0.08/m^3$

Unit cost of Rock Embankment $4.99/m^3$

e. Core Embankment
Rock embankment x 3 = 4.99 x 3 = $14.97/m^3$

f. Filter Embankment
Rock embankment x 1.5 = 4.99 x 1.5 = $7.485/m^3$

g. Riprap
Rock Embankment x 2.0 = 4.99 x 2 = $9.98/m^3$

h. Drilling & Grouting
Unit cost = $145.00/m *3

*1 Ref. Rock Excavation at Canal

*2 Load factor

*3 Unit Cost

Drilling	75 m/m	$72.24/m
Cement Milk Mixing		$6.55
Grouting	15 kg/cm^2	$49.24
Material		
Cement	0.15 t/m	$15.90
Miscellaneous	1 L.S.	$1.07
Total		$145.00/m

d) Cost Estimation

a. Ciri Dam ($1.5 \times 10^6 m^3$)

Depreciation	Unit	Q'ty ($x10^6$)	Unit cost ($)	Cost (million dollars)
Clearing & Grubbing	m^2	1.31	0.48	0.6288
Spoiled Dump	m^3	0.35	2.43	0.8505
Common Excavation	m^3	0.26	3.00	0.7800
Rock Exc.	m^3	0.07	5.85	0.4095
Core Embankment	m^3	0.183	14.99	2.7395
Filter Embankment	m^3	0.1275	7.485	0.9543
Rock Embankment	m^3	1.155	4.99	5.7635
Riprap	m^3	0.0345	9.98	0.3443
Drilling & Grouting	m	0.015	145.00	2.175
			Sub-Total	14.6454
Others *1 $14,645,400 x 0.50				7.3227
			Total	$21.9681

Unit cost (per m^3) = $21,968,100 / 1.5 = $14.65/m^3$

*1 Diversion tunnel, spillway & other works are included in others

b. Trinidad (1) ($V = 2.5 \times 10^6 m^3$)

Depreciation	Unit	Q'ty ($\times 10^6$)	Unit cost ($)	Cost (million dollars)
Clearing & Grubbing	m^2	1.89	0.48	0.9072
Spoiled Dump	m^3	0.59	2.43	1.4337
Common Excavation	m^3	0.38	3.00	1.1400
Rock Excavation	m^3	0.10	5.85	0.585
Core Embankment	m^3	0.305	14.97	4.5659
Filter Embankment	m^3	0.2125	7.485	1.5906
Rock Embankment	m^3	1.925	4.99	9.6058
Riprap	m^3	0.0575	9.98	0.5739
Drilling & Grouting	m	0.0213	145.00	3.0885
			Sub-total	23.4904
Others $23,490,400 x 0.45				10.5707
			Total	$34.0611
Unit Cost (per m^3) $34,061,100 / 2.5				$13.62/m^3$

c. Trinidad (2) ($V = 4.0 \times 10^6 m^3$)

Depreciation	Unit	Q'ty ($\times 10^6$)	Unit cost ($)	Cost (million dollars)
Clearing & Grubbing	m^2	1.50	0.48	0.72
Spoiled Dump	m^3	0.75	2.43	1.8225
Common Excavation	m^3	0.49	3.00	1.47
Rock Excavation	m^3	0.12	5.85	0.702
Core Embankment	m^3	0.488	14.97	7.3054
Filter Embankment	m^3	0.34	7.485	2.5449
Rock Embankment	m^3	3.08	4.99	15.3692
Riprap	m^3	0.092	9.98	0.9182
Drilling & Grouting	m^3	0.0264	145.00	3.828
			Sub-total	34.6801
Others $34,680,100 x 0.40				13.8720
			Total	$48.5521
Unit cost (per m^3) $48,551,100 / 4.0				$12.14/m^3$

(3) Flood Control System

Excavation volume per linear meter is small. Then, excavated material will be disposed at near area.

Assume the hauling distance is ave. 500 m, Unit costs of Excavation are as follows:

Earth Common	$0.96/m^3$
Rock Weathered	$1.55/m^3$
Rock	$2.83/m^3$

Depth of excavation is comparatively shallow. Assume the proportion of each material as follows:

Earth Common	50%
Rock Weathered	45%
Rock	5%

Combined Unit Cost is:

$0.96 \times 0.50 + 1.55 \times 0.45 + 2.83 \times 0.05 = \$1.32/m^3$

(4) Partition Wall

TABLE2.2.2-(6)

Case	Work Items	Steel Pipe Pile	Steel Joint	Excavation	Concrete Fill	Mortar Fill	Coping Concrete	Total Unit Cost of Partition Wall million dollar/ per 1.0km
	Unit Cost	819.60($/t)	761.30($/t)	16.40($/m3)	42.35($/m3)	48.15($/m3)	271.77($/m3)	
S-2	Quantity per meter	14.5(t)	0.5(t)	23.5(m3)	23.5(m3)	0.4(m3)	15.0(m3)	
	Cost per meter ($)	11,884.20	380.65	385.40	995.23	19.26	4,076.55	17.74
S-4	Quantity per meter	17.6(t)	0.72(t)	28.4(m3)	28.4(m3)	0.47(m3)	15.0(m3)	
	Cost per meter ($)	14,424.96	548.14	465.76	1,202.74	22.63	4,076.55	20.74
S-6	Quantity per meter	20.7(t)	0.85(t)	33.5(m3)	33.5(m3)	0.55(m3)	15.0(m3)	
	Cost per meter ($)	16,965.72	647.11	549.40	1,418.73	26.48	4,076.55	23.68
S-8	Quantity per meter	14.5(t)	0.51(t)	23.5(m3)	23.5(m3)	0.4(m3)	15.0(m3)	
	Cost per meter ($)	11,884.20	388.26	385.40	995.23	19.26	4,076.55	17.75
S-10	Quantity per meter	17.6(t)	0.72(t)	28.4(m3)	28.4(m3)	0.47(m3)	15.0(m3)	
	Cost per meter ($)	14,424.96	548.14	465.76	1,202.74	22.63	4,076.55	20.74
S-12	Quantity per meter	20.7(t)	0.85(t)	33.5(m3)	33.5(m3)	0.55(m3)	15.0(m3)	
	Cost per meter ($)	16,965.72	647.11	549.40	1,418.73	26.48	4,076.55	23.68

2.2.4 Unit Price Applied

Data Sources:

- CAPAC
- AOKI Corp. Panama
- Office of Canal Improvements Culebra Cut Feasibility Study
- ESSO Japan
- Instituto de Recursos Hidraulicos Y Electrificacion (IRHE)

(1) Unit Wage Rate (U.S. dollars)
Present day 1990

	Hourly Rate $/Hr	Daily Rate $/Day	Monthly Rate $/Month
Engineer	9.80	78.10	2,031.10
General foreman	8.20	65.70	1,708.70
Foreman	6.70	53.30	1,386.30
Earth worker	3.60	29.10	728.50
Carpenter	3.90	31.00	775.00
Bar bender	3.90	31.00	775.00
Rigger	4.80	38.40	961.00
Plasterer	3.90	31.00	775.00
Mechanic	4.80	38.40	961.00
Operator (winch, engine)	3.90	31.00	775.00
Operator (heavy eq.)	5.70	45.90	1,147.00
Welder	4.10	32.90	821.50
Electrician	3.90	31.00	775.00
Plumber	3.90	31.00	775.00
Ductworker	5.50	44.00	1,100.50
Driver (heavy dump)	4.80	38.40	961.00
Driver (light vehicle)	3.90	31.00	775.00
Unskilled labor	3.60	29.10	728.50

Note: 1) Social charges and overtime payment are included.
2) Based on Panamanian Labor Rates

(2) Unit Price of Main Material (U.S. dollars)
Present day 1990

	Items	Unit	Price ($)
a)	Fuel and lubricating oil		
	Gasoline	litter	0.47
	Diesel gas oil	litter	0.29
	Kerosene	litter	0.35
	Lubricating oil	litter	1.84
	Gear oil	litter	1.94
	Asphalt	ton	43.00
	Heavy oil	litter	0.29
b)	Concrete material		
	cement (94lbs sack)	ton	106.00
	Reinforcing bar	ton	675.00
	Steel fabrics	ton	725.00
	Gravel	m^3	9.20
	Sand	m^3	8.30
	Riprap	m^3	8.50
c)	Timber		
	Log (local)	m^3	185.00
	Square timber (imported)	m^3	185.00
d)	Dynamite	kg	6.20
	AN-FO	kg	1.50
	Detonator	nos	3.25
	Detonating cord	m	3.60

2.3 Construction Costs

SUMMARY.WJ2

2.3.1 Project Cost Summary

unit : million dollar

CASE	CONSTRUCTION COST	INDIRECT COST						TOTAL	REMARKS	
		ADMINIS. COST	HEADQUATERS COST	CONSTRUCTION SUPERVISION	LAND ACQ. & RIGHT COST	COMPENSATION	CONTINGENCY		ROUTE	RISE ft.
L-1 (100,000 DWT)	4,888.92	63.56	122.22	107.56	8.82	105.00	488.89	5,784.97	15	90
L-2 (100,000 DWT)	5,163.53	67.13	129.09	113.60	8.82	105.00	516.35	6,103.52	15	85
L-2' (100,000 DWT)	5,423.33	70.50	135.58	119.31	8.82	105.00	542.33	6,404.87	15	85
L-3 (100,000 DWT)	7,154.98	93.01	178.87	157.41	8.82	105.00	715.50	8,413.59	15	55
L-4 (150,000 DWT)	6,722.67	87.39	168.07	147.90	8.82	105.00	672.27	7,912.12	15	90
L-5 (150,000 DWT)	6,950.02	90.35	173.75	152.90	8.82	105.00	695.00	8,175.84	15	85
L-6 (150,000 DWT)	9,458.45	122.96	236.46	208.09	8.82	105.00	945.85	11,085.63	15	55
L-7 (250,000 DWT)	10,966.13	142.56	274.15	241.25	8.82	105.00	1,096.61	12,834.52	15	90
L-8 (250,000 DWT)	11,314.61	147.09	282.87	248.92	8.82	105.00	1,131.46	13,238.77	15	85
L-9 (250,000 DWT)	13,106.42	170.38	327.66	288.34	8.82	105.00	1,310.64	15,317.26	15	55
L-10 (100,000 DWT)	6,894.46	89.63	172.36	151.68	8.82	105.00	689.45	8,111.40	15+G	85
L-11 (100,000 DWT)	7,862.45	102.21	196.56	172.97	8.82	105.00	786.25	9,234.26	15+G	55
L-12 (100,000 DWT)	9,729.91	126.49	243.25	214.06	8.82	105.00	972.99	11,400.52	15+G	30
L-13 (150,000 DWT)	8,879.38	115.43	221.98	195.35	8.82	105.00	887.94	10,413.90	15+G	85
L-14 (150,000 DWT)	10,011.51	130.15	250.29	220.25	8.82	105.00	1,001.15	11,727.17	15+G	55
L-15 (150,000 DWT)	12,314.48	160.09	307.86	270.92	8.82	105.00	1,231.45	14,398.62	15+G	30
L-16 (250,000 DWT)	13,812.46	179.56	345.31	303.87	8.82	105.00	1,381.25	16,136.27	15+G	85
L-17 (250,000 DWT)	13,227.57	171.96	330.69	291.01	8.82	105.00	1,322.76	15,457.81	15+G	55
L-18 (250,000 DWT)	16,900.43	219.71	422.51	371.81	8.82	105.00	1,690.04	19,718.32	15+G	30
									ROUTE	LANE
S-1 (150,000 DWT)	5,760.12	74.88	144.00	126.72	101.22	21.00	576.01	6,803.95	10	1
S-2 (150,000 DWT)	9,940.70	129.23	248.52	218.70	101.22	21.00	994.07	11,653.44	10	2
S-3 (250,000 DWT)	6,284.59	81.70	157.11	138.26	101.22	21.00	628.46	7,412.34	10	1
S-4 (250,000 DWT)	11,256.09	146.33	281.40	247.63	101.22	21.00	1,125.61	13,179.28	10	2
S-5 (300,000 DWT)	7,182.14	93.37	179.55	158.01	101.22	21.00	718.21	8,453.50	10	1
S-6 (300,000 DWT)	13,204.95	171.66	330.12	290.51	101.22	21.00	1,320.49	15,439.95	10	2
S-7 (150,000 DWT)	13,789.07	179.26	344.73	303.36	8.82	105.00	1,378.91	16,109.15	14S	1
S-8 (150,000 DWT)	26,332.64	342.32	658.32	579.32	8.82	105.00	2,633.26	30,659.68	14S	2
S-9 (250,000 DWT)	17,804.58	231.46	445.11	391.70	8.82	105.00	1,780.46	20,767.13	14S	1
S-10 (250,000 DWT)	35,430.83	460.60	885.77	779.48	8.82	105.00	3,543.08	41,213.58	14S	2
S-11 (300,000 DWT)	19,680.44	255.85	492.01	432.97	8.82	105.00	1,968.04	22,943.13	14S	1
S-12 (300,000 DWT)	38,559.93	501.28	964.00	848.32	8.82	105.00	3,855.99	44,843.34	14S	2
S-13 (150,000 DWT)	7,663.42	99.62	191.59	168.60	101.22	21.00	766.34	9,011.79	10	1.5
S-14 (250,000 DWT)	8,709.78	113.23	217.74	191.62	101.22	21.00	870.98	10,225.57	10	1.5
S-15 (300,000 DWT)	9,882.44	128.47	247.06	217.41	101.22	21.00	988.24	11,585.84	10	1.5
S-16 (150,000 DWT)	21,156.88	275.04	528.92	465.45	8.82	105.00	2,115.69	24,655.80	14S	1.5
S-17 (250,000 DWT)	28,843.36	374.96	721.08	634.55	8.82	105.00	2,884.34	33,572.11	14S	1.5
S-18 (300,000 DWT)	31,363.71	407.73	784.09	690.00	8.82	105.00	3,136.37	36,495.72	14S	1.5
S.Q. (65,000 DWT)	4,459.48	57.97	111.49	98.11	0	105.00	445.95	5,278.00	15	1~2
	100.0%	1.3%	2.5%	2.2%			10.0%			

General Notes:

1) The project costs for the lock canal are estimated based on a 35,000 transits/year case. (15,000 transits at existing lock and 20,000 transits at new locks.)

2) All study cases are included Culebra Cut Widening Project. (208.58 mill.US$)

2.3.2 Construction Cost Summary

SUMMARY-1.WB2

unit : million dollar

CASE	DIRECT CONSTRUCTION COST	GENERAL CONDITIONS	SUPPORTING CONSTRUCTION	TOTAL CONSTRUCTION COST	REMARKS ROUTE	REMARKS RISE ft.
L-1 (100,000 DWT)	4,053.83	608.08	227.01	4,888.92	15	90
L-2 (100,000 DWT)	4,281.53	642.23	239.77	5,163.53	15	85
L-2' (100,000 DWT)	4,496.96	674.54	251.83	5,423.33	15	85
L-3 (100,000 DWT)	5,932.82	889.92	332.24	7,154.98	15	55
L-4 (150,000 DWT)	5,574.35	836.15	312.16	6,722.67	15	90
L-5 (150,000 DWT)	5,762.87	864.43	322.72	6,950.02	15	85
L-6 (150,000 DWT)	7,842.83	1,176.42	439.20	9,458.45	15	55
L-7 (250,000 DWT)	9,092.98	1,363.95	509.21	10,966.13	15	90
L-8 (250,000 DWT)	9,381.93	1,407.29	525.39	11,314.61	15	85
L-9 (250,000 DWT)	10,867.68	1,630.15	608.59	13,106.42	15	55
L-10 (100,000 DWT)	5,716.80	857.52	320.14	6,894.46	15+G	85
L-11 (100,000 DWT)	6,519.45	977.92	365.09	7,862.45	15+G	55
L-12 (100,000 DWT)	8,067.92	1,210.19	451.80	9,729.91	15+G	30
L-13 (150,000 DWT)	7,362.67	1,104.40	412.31	8,879.38	15+G	85
L-14 (150,000 DWT)	8,301.42	1,245.21	464.88	10,011.51	15+G	55
L-15 (150,000 DWT)	10,211.01	1,531.65	571.82	12,314.48	15+G	30
L-16 (250,000 DWT)	11,453.11	1,717.97	641.37	13,812.46	15+G	85
L-17 (250,000 DWT)	10,968.13	1,645.22	614.22	13,227.57	15+G	55
L-18 (250,000 DWT)	14,013.62	2,102.04	784.76	16,900.43	15+G	30
					ROUTE	LANE
S-1 (150,000 DWT)	4,776.22	716.43	267.47	5,760.12	10	1
S-2 (150,000 DWT)	8,242.70	1,236.41	461.59	9,940.70	10	2
S-3 (250,000 DWT)	5,211.10	781.66	291.82	6,284.59	10	1
S-4 (250,000 DWT)	9,333.41	1,400.01	522.67	11,256.09	10	2
S-5 (300,000 DWT)	5,955.34	893.30	333.50	7,182.14	10	1
S-6 (300,000 DWT)	10,949.38	1,642.41	613.17	13,204.95	10	2
S-7 (150,000 DWT)	11,433.72	1,715.06	640.29	13,789.07	14S	1
S-8 (150,000 DWT)	21,834.69	3,275.20	1,222.74	26,332.64	14S	2
S-9 (250,000 DWT)	14,763.33	2,214.50	826.75	17,804.58	14S	1
S-10 (250,000 DWT)	29,378.80	4,406.82	1,645.21	35,430.83	14S	2
S-11 (300,000 DWT)	16,318.77	2,447.82	913.85	19,680.44	14S	1
S-12 (300,000 DWT)	31,973.40	4,796.01	1,790.51	38,559.93	14S	2
S-13 (150,000 DWT)	6,354.41	953.16	355.85	7,663.42	10	1.5
S-14 (250,000 DWT)	7,222.04	1,083.31	404.43	8,709.78	10	1.5
S-15 (300,000 DWT)	8,194.39	1,229.16	458.89	9,882.44	10	1.5
S-16 (150,000 DWT)	17,543.02	2,631.45	982.41	21,156.88	14S	1.5
S-17 (250,000 DWT)	23,916.55	3,587.48	1,339.33	28,843.36	14S	1.5
S-18 (300,000 DWT)	26,006.40	3,900.96	1,456.36	31,363.71	14S	1.5
S.Q. (65,000 DWT)	3,697.75	554.66	207.07	4,459.48	15	1～2
	100%	15%	5.6%			

CASE L-1

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		2,609.92	SEE SUM-1.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		346.03	SEE SUM1-10.WJ2
ATLANTIC SIDE	LS	1		346.03	
SUBTOTAL				692.06	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,264.54	SEE SUM2-1.WJ2
F. NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	3	84.94	254.83	SEE SUM6.WJ2
TOTAL				4,888.92	

CASE L-2

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		2,892.38	SEE SUM-2.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		346.03	SEE SUM1-10.WJ2
ATLANTIC SIDE	LS	1		346.03	
SUBTOTAL				692.06	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,239.18	SEE SUM2-2.WJ2
F. NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	3	84.94	254.83	SEE SUM6.WJ2
TOTAL				5,163.53	

CASE L-2'

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		2,892.38	SEE SUM-2'.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		346.03	SEE SUM1-10'.WJ2
ATLANTIC SIDE	LS	1		346.03	
SUBTOTAL				692.06	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,159.21	SEE SUM2-2'.WJ2
F. NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	7	84.94	594.61	SEE SUM6.WJ2
TOTAL				5,423.33	

CASE L-3

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		4,828.78	SEE SUM-3.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		287.65	SEE SUM1-13.WJ2
ATLANTIC SIDE	LS	1		287.65	
SUBTOTAL				575.31	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,065.44	SEE SUM2-3.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				7,154.98	

CASE L-4

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		3,686.81	SEE SUM-4.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		437.69	SEE SUM1-11.WJ2
ATLANTIC SIDE	LS	1		437.69	
SUBTOTAL				875.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,668.20	SEE SUM2-4.WJ2
F. NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	5	84.94	424.72	SEE SUM6.WJ2
TOTAL				6,722.67	

CASE L-5

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		4,035.38	SEE SUM-5.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		437.69	SEE SUM1-11.WJ2
ATLANTIC SIDE	LS	1		437.69	
SUBTOTAL				875.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,631.92	SEE SUM2-5.WJ2
F. NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				6,950.02	

CASE L-6

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		6,552.22	SEE SUM-6.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		329.13	SEE SUM1-14.WJ2
ATLANTIC SIDE	LS	1		329.13	
SUBTOTAL				658.26	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,392.62	SEE SUM2-6.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	6	84.94	509.67	SEE SUM6.WJ2
TOTAL				9,458.45	

CASE L-7

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A.CANAL EXCAVATION	LS	1		6,536.00	SEE SUM-7.WJ2
B.LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		606.20	SEE SUM1-12.WJ2
ATLANTIC SIDE	LS	1		606.20	
SUBTOTAL				1,212.39	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		2,555.57	SEE SUM2-7.WJ2
F.NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G.PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	7	84.94	594.61	SEE SUM6.WJ2
TOTAL				10,966.13	

CASE L-8

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A.CANAL EXCAVATION	LS	1		7,011.27	SEE SUM-8.WJ2
B.LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		606.20	SEE SUM1-12.WJ2
ATLANTIC SIDE	LS	1		606.20	
SUBTOTAL				1,212.39	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		2,496.22	SEE SUM2-8.WJ2
F.NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G.PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	6	84.94	509.67	SEE SUM6.WJ2
TOTAL				11,314.61	

CASE L-9

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		9,223.32	SEE SUM-3.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		411.19	SEE SUM1-15.WJ2
ATLANTIC SIDE	LS	1		411.19	
SUBTOTAL				822.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,950.55	SEE SUM2-9
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	9	84.94	764.50	SEE SUM6.WJ2
TOTAL				13,106.42	

CASE L-10

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		4,623.32	SEE SUM-10.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		346.03	SEE SUM1-10.WJ2
ATLANTIC SIDE	LS	1		346.03	
SUBTOTAL				692.06	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,239.18	SEE SUM2-10.WJ2
F. NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	3	84.94	254.83	SEE SUM6.WJ2
TOTAL				6,894.46	

CASE L-11

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		5,536.25	SEE SUM-11.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		287.65	SEE SUM1-10.WJ2
ATLANTIC SIDE	LS	1		287.65	
SUBTOTAL				575.31	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,065.44	SEE SUM2-11.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				7,862.45	

CASE L-12

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		7,718.96	SEE SUM-12.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		279.77	SEE SUM1-23.WJ2
ATLANTIC SIDE	LS	1		279.77	
SUBTOTAL				559.55	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		935.84	SEE SUM2-12.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	2	84.94	169.89	SEE SUM6.WJ2
TOTAL				9,729.91	

CASE L-13

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		5,964.73	SEE SUM-13.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		437.69	SEE SUM1-11.WJ2
ATLANTIC SIDE	LS	1		437.69	
SUBTOTAL				875.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,631.92	SEE SUM2-13.WJ2
F. NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				8,879.38	

CASE L-14

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		7,105.28	SEE SUM-14.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		329.13	SEE SUM1-14.WJ2
ATLANTIC SIDE	LS	1		329.13	
SUBTOTAL				658.26	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,392.62	SEE SUM2-14.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	6	84.94	509.67	SEE SUM6.WJ2
TOTAL				10,011.51	

CASE L-15

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		9,875.01	SEE SUM-15.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		315.65	SEE SUM1-24.WJ2
ATLANTIC SIDE	LS	1		315.65	
SUBTOTAL				631.30	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,207.65	SEE SUM2-15.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	3	84.94	254.83	SEE SUM6.WJ2
TOTAL				12,314.48	

CASE L-16

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		9,509.12	SEE SUM-16.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		606.20	SEE SUM1-12.WJ2
ATLANTIC SIDE	LS	1		606.20	
SUBTOTAL				1,212.39	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		2,496.22	SEE SUM2-16.WJ2
F. NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	6	84.94	509.67	SEE SUM6.WJ2
TOTAL				13,812.46	

CASE L-17

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		9,344.46	SEE SUM-17.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		411.19	SEE SUM1-15.WJ2
ATLANTIC SIDE	LS	1		411.19	
SUBTOTAL				822.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,950.55	SEE SUM2-17.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	9	84.94	764.50	SEE SUM6.WJ2
TOTAL				13,227.57	

CASE L-18

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		13,768.36	SEE SUM-18.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		394.56	SEE SUM1-25.WJ2
ATLANTIC SIDE	LS	1		394.56	
SUBTOTAL				789.12	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,657.49	SEE SUM2-18.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				16,900.43	

CASE S-1

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		5,096.59	SEE SUM-19.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		107.89	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		107.89	
SUBTOTAL				215.77	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		207.69	SEE SUM2-19.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ22
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO.1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO.2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				5,760.12	

CASE S-2

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		8,647.27	SEE SUM-20.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		128.39	SEE SUM1-17.WJ2
ATLANTIC SIDE	LS	1		128.39	
SUBTOTAL				256.78	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		240.28	SEE SUM2-20.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO. 1 (PACIFIC SIDE)	LS	1		30.22	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
I. PARTITION WALL	LS	1		556.30	SEE SUM7.WJ2
TOTAL				9,940.70	

CASE S-3

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		5,500.87	SEE SUM-21.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		127.07	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		127.07	
SUBTOTAL				254.15	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		289.50	SEE SUM2-21.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				6,284.59	

CASE S-4

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		9,728.73	SEE SUM-22.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		151.01	SEE SUM1-19.WJ2
ATLANTIC SIDE	LS	1		151.01	
SUBTOTAL				302.03	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		334.92	SEE SUM2-22.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
I. PARTITION WALL	LS	1		650.35	SEE SUM7.WJ2
TOTAL				11,256.09	

CASE S-5

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		6,322.04	SEE SUM-23.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		146.14	SEE SUM1-20.WJ2
ATLANTIC SIDE	LS	1		146.14	
SUBTOTAL				292.28	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		327.74	SEE SUM2-23.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				7,182.14	

CASE S-6

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		11,494.77	SEE SUM-24.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		174.15	SEE SUM1-21.WJ2
ATLANTIC SIDE	LS	1		174.15	
SUBTOTAL				348.30	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		379.17	SEE SUM2-24.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
I. PARTITION WALL	LS	1		742.64	SEE SUM7.WJ2
TOTAL				13,204.95	

CASE S-7

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		13,019.93	SEE SUM-25.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		107.89	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		107.89	
SUBTOTAL				215.77	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		207.69	SEE SUM2-25.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				13,789.07	

CASE S-8

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		24,911.95	SEE SUM-26.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		128.39	SEE SUM1-17.WJ2
ATLANTIC SIDE	LS	1		128.39	
SUBTOTAL				256.78	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		240.28	SEE SUM2-26.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
I. PARTITION WALL	LS	1		577.94	SEE SUM7.WJ2
TOTAL				26,332.64	

CASE S-9

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		16,915.25	SEE SUM-27.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		127.07	SEE SUM1-18.WJ2
ATLANTIC SIDE	LS	1		127.07	
SUBTOTAL				254.15	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		289.50	SEE SUM2-27.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-8.WJ2
TOTAL				17,804.58	

CASE S-10

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		33,772.84	SEE SUM-28.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		151.01	SEE SUM1-19.WJ2
ATLANTIC SIDE	LS	1		151.01	
SUBTOTAL				302.03	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		334.92	SEE SUM2-28.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
I. PARTITION WALL	LS	1		675.36	SEE SUM7.WJ2
TOTAL				35,430.83	

CASE S-11

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		18,714.73	SEE SUM-29.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		146.14	SEE SUM1-29.WJ2
ATLANTIC SIDE	LS	1		146.14	
SUBTOTAL				292.28	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		327.74	SEE SUM2-29.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				19,680.44	

CASE S-12

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		36,715.58	SEE SUM-30.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		174.15	SEE SUM1-21.WJ2
ATLANTIC SIDE	LS	1		174.15	
SUBTOTAL				348.30	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		379.17	SEE SUM2-30.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
I. PARTITION WALL	LS	1		771.20	SEE SUM7.WJ2
TOTAL				38,559.93	

CASE S-13

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		6,999.89	SEE SUM-31.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		107.89	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		107.89	
SUBTOTAL				215.77	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		207.69	SEE SUM2-31.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				7,663.42	

CASE S-14

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		7,926.06	SEE SUM-32.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		127.07	SEE SUM1-18.WJ2
ATLANTIC SIDE	LS	1		127.07	
SUBTOTAL				254.15	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		289.50	SEE SUM2-32.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				8,709.78	

CASE S-15

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		9,022.34	SEE SUM-33.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		146.14	SEE SUM1-30.WJ2
ATLANTIC SIDE	LS	1		146.14	
SUBTOTAL				292.28	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		327.74	SEE SUM2-33.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAKWATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				9,882.44	

CASE S-16

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		20,387.74	SEE SUM-34.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		107.89	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		107.89	
SUBTOTAL				215.77	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		207.69	SEE SUM2-34.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				21,156.88	

CASE S-17

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		27,954.04	SEE SUM-35.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		127.07	SEE SUM1-18.WJ2
ATLANTIC SIDE	LS	1		127.07	
SUBTOTAL				254.15	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		289.50	SEE SUM2-35.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				28,843.36	

CASE S-18

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		30,398.00	SEE SUM-36.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		146.14	SEE SUM1-20.WJ2
ATLANTIC SIDE	LS	1		146.14	
SUBTOTAL				292.28	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		327.74	SEE SUM2-36.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				31,363.71	

CASE 'STATUS QUO'

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		2,570.87	SEE SUM-37.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		168.02	SEE SUM1-22.WJ2
ATLANTIC SIDE	LS	1		168.02	
SUBTOTAL				336.05	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,552.57	SEE SUM2-37.WJ2
TOTAL				4,459.48	

2.3.3 Breakdown of Canal Excavation

SUM-1.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(1) CASE L-1

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	6,060	24,514	10,275	0	40,849
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		14.61	59.08	24.76		98.45
ROCK, WEATHERED	QUANTITY	2,240	59,269	57,830	33,245	0	152,584
	UNIT PRICE	3.37	3.37	3.37	3.37		
	AMOUNT	7.55	199.74	194.89	112.04		514.21
ROCK	QUANTITY	0	16,670	42,993	63,445	0	123,108
	UNIT PRICE		4.89	4.89	4.89		
	AMOUNT		81.52	210.24	310.25		602.00
DREDGING, LOOSE MATERIAL	QUANTITY	5,492	3,848	23	0	7,665	17,028
	UNIT PRICE	2.24	2.57	3.86		2.61	
	AMOUNT	12.30	9.89	0.09		20.01	42.29
DREDGING, WEATHERED SOFT ROCK	QUANTITY	10,377	14,251	4,039	0	9,577	38,244
	UNIT PRICE	5.13	5.42	6.69		5.47	
	AMOUNT	53.23	77.24	27.02		52.39	209.88
ROCK UNDERWATER	QUANTITY	940	14,299	5,805	705	6,793	28,542
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	17.06	263.82	116.62	14.39	125.74	537.63
DREDGING, CLAYEY MATERIAL	QUANTITY	5,532	0	0	0	10,260	15,792
	UNIT PRICE	2.24				2.61	
	AMOUNT	12.39				26.78	39.17
TOTAL	QUANTITY	24,581	114,397	135,204	107,670	34,295	416,147
	AMOUNT	102.54	646.80	607.93	461.43	224.91	2,043.62

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00	$/m	18.91
c) CLEARING	12,900,000	m²	0.23	$/m²	2.97
d) VEGETATION	4,500,000	m²	0.70	$/m²	3.15
e) DEWATERING		ls			95.47
SUBTOTAL					2,164.11
SUPPORTING CONSTRUCTION					121.19
GENERAL CONDITIONS					324.62
TOTAL					2,609.92

SUM-2.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(2)CASE L-2

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	5,810	24,514	10,075	0	40,399
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		14.00	59.08	24.28		97.36
ROCK, WEATHERED	QUANTITY	2,240	59,830	60,124	33,500	30	155,724
	UNIT PRICE	3.37	3.37	3.37	3.37	3.37	
	AMOUNT	7.55	201.63	202.62	112.90	0.10	524.79
ROCK	QUANTITY	0	18,255	47,323	67,490	472	133,540
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		89.27	231.41	330.03	2.31	653.01
DREDGING, LOOSE MATERIAL	QUANTITY	5,492	4,068	23	0	7,665	17,248
	UNIT PRICE	2.24	2.57	3.86		2.61	
	AMOUNT	12.30	10.46	0.09		20.01	42.85
DREDGING, WEATHERED SOFT ROCK	QUANTITY	10,377	18,531	4,039	0	9,577	42,524
	UNIT PRICE	5.13	5.42	6.69		5.47	
	AMOUNT	53.23	100.44	27.02		52.39	233.08
ROCK UNDERWATER	QUANTITY	940	22,426	5,805	705	6,793	36,669
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	17.06	413.76	116.62	14.39	125.74	687.57
DREDGING, CLAYEY MATERIAL	QUANTITY	5,532	0	0	0	10,260	15,792
	UNIT PRICE	2.24				2.61	
	AMOUNT	12.39				26.78	39.17
TOTAL	QUANTITY	24,581	128,920	141,828	111,770	34,797	441,896
	AMOUNT	102.54	829.55	636.84	481.59	227.32	2,277.83

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00	$/m	18.91
c) CLEARING	12,900,000	m²	0.23	$/m²	2.97
d) VEGETATION	4,500,000	m²	0.70	$/m²	3.15
e) DEWATERING		ls			95.47
SUBTOTAL					2,398.33
SUPPORTING CONSTRUCTION					134.31
GENERAL CONDITIONS					359.75
TOTAL					2,892.38

SUM-2'.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(2')CASE L-2'

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	5,810	24,514	10,075	0	40,399
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		14.00	59.08	24.28		97.36
ROCK, WEATHERED	QUANTITY	2,240	59,830	60,124	33,500	30	155,724
	UNIT PRICE	3.37	3.37	3.37	3.37	3.37	
	AMOUNT	7.55	201.63	202.62	112.90	0.10	524.79
ROCK	QUANTITY	0	18,255	47,323	67,490	472	133,540
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		89.27	231.41	330.03	2.31	653.01
DREDGING, LOOSE MATERIAL	QUANTITY	5,492	4,068	23	0	7,665	17,248
	UNIT PRICE	2.24	2.57	3.86		2.61	
	AMOUNT	12.30	10.46	0.09		20.01	42.85
DREDGING,WEATHERED SOFT ROCK	QUANTITY	10,377	18,531	4,039	0	9,577	42,524
	UNIT PRICE	5.13	5.42	6.69		5.47	
	AMOUNT	53.23	100.44	27.02		52.39	233.08
ROCK UNDERWATER	QUANTITY	940	22,426	5,805	705	6,793	36,669
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	17.06	413.76	116.62	14.39	125.74	687.57
DREDGING, CLAYEY MATERIAL	QUANTITY	5,532	0	0	0	10,260	15,792
	UNIT PRICE	2.24				2.61	
	AMOUNT	12.39				26.78	39.17
TOTAL	QUANTITY	24,581	128,920	141,828	111,770	34,797	441,896
	AMOUNT	102.54	829.55	636.84	481.59	227.32	2,277.83

b) HAUL ROAD CONSTRUCTION	29,000 m	652.00	$/m	18.91
c) CLEARING	12,900,000 m²	0.23	$/m²	2.97
d) VEGETATION	4,500,000 m²	0.70	$/m²	3.15
e) DEWATERING	1 ls			95.47
SUBTOTAL				2,398.33
SUPPORTING CONSTRUCTION				134.31
GENERAL CONDITIONS				359.75
TOTAL				2,892.38

SUM-3.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(3) CASE L-3

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	9,461	14,310	11,890	3,355	39,016
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		22.80	34.49	28.66	8.09	94.03
ROCK, WEATHERED	QUANTITY	2,240	15,948	20,500	17,148	3,140	58,976
	UNIT PRICE	3.37	3.37	3.37	3.37	3.37	
	AMOUNT	7.55	53.75	69.09	57.79	10.58	198.75
ROCK	QUANTITY	0	42,229	132,990	81,355	7,015	263,589
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		206.50	650.32	397.83	34.30	1288.35
DREDGING,	QUANTITY	5,492	20,043	200	505	6,018	32,258
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
LOOSE MATERIAL	AMOUNT	12.30	51.31	0.77	1.62	15.71	81.71
DREDGING, WEATHERED	QUANTITY	10,377	56,254	740	2,375	9,206	78,952
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
SOFT ROCK	AMOUNT	53.23	304.90	4.95	17.29	50.36	430.73
ROCK UNDERWATER	QUANTITY	940	48,546	22,420	10,435	7,910	90,251
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	17.06	895.67	450.42	199.52	146.41	1709.08
DREDGING,	QUANTITY	5,532	20,245	0	0	6,129	31,906
	UNIT PRICE	2.24	2.56			2.61	
CLAYEY MATERIAL	AMOUNT	12.39	51.83			16.00	80.22
TOTAL	QUANTITY	24,581	212,726	191,160	123,708	42,773	594,948
	AMOUNT	102.54	1586.75	1210.03	702.69	281.45	3,883.47

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	12,900,000	m²	0.23 $/m²	2.97
d) VEGETATION	4,500,000	m²	0.70 $/m²	3.15
e) DEWATERING		ls		95.47
SUBTOTAL				4,003.96
SUPPORTING CONSTRUCTION				224.22
GENERAL CONDITIONS				600.59
TOTAL				4,828.78

SUM-4.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(4) CASE L-4

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	7,353	32,725	13,095	0	53,173
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		17.72	78.87	31.56		128.15
ROCK, WEATHERED	QUANTITY	0	65,054	76,376	38,885	0	180,315
	UNIT PRICE		3.37	3.37	3.37		
	AMOUNT		219.23	257.39	131.04		607.66
ROCK	QUANTITY	0	24,255	56,659	75,555	0	156,469
	UNIT PRICE		4.89	4.89	4.89		
	AMOUNT		118.61	277.06	369.46		765.13
DREDGING,	QUANTITY	6,420	4,746	23	0	10,250	21,439
	UNIT PRICE	2.24	2.57	3.86		2.61	
LOOSE MATERIAL	AMOUNT	14.38	12.20	0.09		26.75	53.42
DREDGING, WEATHERED	QUANTITY	19,502	23,824	4,039	0	27,975	75,340
	UNIT PRICE	5.13	5.42	6.69		5.47	
SOFT ROCK	AMOUNT	100.05	129.13	27.02		153.02	409.22
ROCK UNDERWATER	QUANTITY	2,060	31,238	5,805	705	9,702	49,510
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	37.39	576.34	116.62	14.39	179.58	924.33
DREDGING,	QUANTITY	6,420	0	0	0	13,044	19,464
	UNIT PRICE	2.24				2.61	
CLAYEY MATERIAL	AMOUNT	14.38				34.05	48.43
TOTAL	QUANTITY	34,402	156,470	175,627	128,240	60,971	555,710
	AMOUNT	166.20	1073.22	757.05	546.45	393.41	2,936.33

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	13,900,000	m²	0.23 $/m²	3.20
d) VEGETATION	4,500,000	m²	0.70 $/m²	3.15
e) DEWATERING		ls		95.47
SUBTOTAL				3,057.05
SUPPORTING CONSTRUCTION				171.19
GENERAL CONDITIONS				458.56
TOTAL				3,686.81

SUM-5.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(5) CASE L-5

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	7,353	32,725	13,095	0	53,173
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		17.72	78.87	31.56		128.15
ROCK, WEATHERED	QUANTITY	0	65,541	78,652	39,140	30	183,363
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		220.87	265.06	131.90	0.10	617.93
ROCK	QUANTITY	0	26,047	61,566	80,745	533	168,891
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		127.37	301.06	394.84	2.61	825.86
DREDGING,	QUANTITY	6,420	4,746	23	0	10,250	21,439
	UNIT PRICE	2.24	2.57	3.86		2.61	
LOOSE MATERIAL	AMOUNT	14.38	12.20	0.09		26.75	53.42
DREDGING, WEATHERED	QUANTITY	19,502	32,166	4,039	0	27,975	83,682
	UNIT PRICE	5.13	5.42	6.69		5.47	
SOFT ROCK	AMOUNT	100.05	174.34	27.02		153.02	454.43
ROCK UNDERWATER	QUANTITY	2,060	40,593	5,805	705	9,702	58,865
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	37.39	748.94	116.62	14.39	179.58	1096.93
DREDGING,	QUANTITY	6,420	0	0	0	13,044	19,464
	UNIT PRICE	2.24				2.61	
CLAYEY MATERIAL	AMOUNT	14.38				34.05	48.43
TOTAL	QUANTITY	34,402	176,446	182,810	133,685	61,534	588,877
	AMOUNT	166.20	1301.44	788.71	572.69	396.11	3,225.16

b) HAUL ROAD CONSTRUCTION	29,000 m	652.00 $/m		18.91
c) CLEARING	15,100,000 m²	0.23 $/m²		3.47
d) VEGETATION	4,400,000 m²	0.70 $/m²		3.08
e) DEWATERING	ls			95.47
SUBTOTAL				3,346.09
SUPPORTING CONSTRUCTION				187.38
GENERAL CONDITIONS				501.91
TOTAL				4,035.38

SUM-6.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(6) CASE L-6

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	11,837	15,810	13,558	3,745	44,950
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		28.53	38.10	32.68	9.03	108.33
ROCK, WEATHERED	QUANTITY	0	16,986	23,270	19,673	4,750	64,679
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		57.24	78.42	66.30	16.01	217.97
ROCK	QUANTITY	0	55,743	165,840	103,943	11,715	337,241
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		272.58	810.96	508.28	57.29	1649.11
DREDGING, LOOSE MATERIAL	QUANTITY	6,420	23,070	220	345	8,195	38,250
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
	AMOUNT	14.38	59.06	0.85	1.10	21.39	96.78
DREDGING, WEATHERED SOFT ROCK	QUANTITY	19,502	69,124	750	2,375	18,775	110,526
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
	AMOUNT	100.05	374.65	5.02	17.29	102.70	599.70
ROCK UNDERWATER	QUANTITY	2,060	81,506	25,655	12,240	13,728	135,189
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	37.39	1503.79	515.41	234.03	254.11	2544.72
DREDGING, CLAYEY MATERIAL	QUANTITY	6,420	23,193	0	0	8,323	37,936
	UNIT PRICE	2.24	2.56			2.61	
	AMOUNT	14.38	59.37			21.72	95.48
TOTAL	QUANTITY	34,402	281,459	231,545	152,134	69,231	768,771
	AMOUNT	166.20	2355.22	1448.76	859.68	482.24	5,312.09

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	15,100,000	m²	0.23 $/m²	3.47
d) VEGETATION	4,400,000	m²	0.70 $/m²	3.08
e) DEWATERING		ls		95.47
SUBTOTAL				5,433.02
SUPPORTING CONSTRUCTION				304.25
GENERAL CONDITIONS				814.95
TOTAL				6,552.22

SUM-7.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(7) CASE L-7

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	9,000	44,149	14,835	0	67,984
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		21.69	106.40	35.75		163.84
ROCK, WEATHERED	QUANTITY	0	76,257	102,672	45,125	0	224,054
	UNIT PRICE		3.37	3.37	3.37		
	AMOUNT		256.99	346.01	152.07		755.06
ROCK	QUANTITY	0	37,559	75,097	97,520	0	210,176
	UNIT PRICE		4.89	4.89	4.89		
	AMOUNT		183.66	367.22	476.87		1027.76
DREDGING,	QUANTITY	8,000	8,556	23	0	14,103	30,682
	UNIT PRICE	2.24	2.57	3.86		2.61	
LOOSE MATERIAL	AMOUNT	17.92	21.99	0.09		36.81	76.81
DREDGING, WEATHERED	QUANTITY	21,750	38,260	4,039	0	41,295	105,344
	UNIT PRICE	5.13	5.42	6.69		5.47	
SOFT ROCK	AMOUNT	111.58	207.37	27.02		225.88	571.85
ROCK UNDERWATER	QUANTITY	20,843	77,734	5,805	705	37,487	142,574
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	378.30	1434.19	116.62	14.39	693.88	2637.39
DREDGING,	QUANTITY	8,000	689	0	0	17,671	26,360
	UNIT PRICE	2.24	2.57			2.61	
CLAYEY MATERIAL	AMOUNT	17.92	1.77			46.12	65.81
TOTAL	QUANTITY	58,593	248,055	231,785	158,185	110,556	807,174
	AMOUNT	525.72	2127.66	963.36	679.09	1002.70	5,298.52

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	15,600,000	m²	0.23 $/m²	3.59
d) VEGETATION	4,400,000	m²	0.70 $/m²	3.08
e) DEWATERING		ls		95.47
SUBTOTAL				5,419.57
SUPPORTING CONSTRUCTION				303.50
GENERAL CONDITIONS				812.94
TOTAL				6,536.00

SUM-8.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(8) CASE L-8

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	9,000	44,149	14,835	0	67,984
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		21.69	106.40	35.75		163.84
ROCK, WEATHERED	QUANTITY	0	76,619	104,986	45,360	0	226,965
	UNIT PRICE		3.37	3.37	3.37		
	AMOUNT		258.21	353.80	152.86		764.87
ROCK	QUANTITY	0	39,649	80,871	103,045	714	224,279
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		193.88	395.46	503.89	3.49	1096.72
DREDGING, LOOSE MATERIAL	QUANTITY	8,000	7,656	23	0	14,083	29,762
	UNIT PRICE	2.24	2.57	3.86		2.61	
	AMOUNT	17.92	19.68	0.09		36.76	74.44
DREDGING, WEATHERED SOFT ROCK	QUANTITY	21,750	41,755	4,039	0	41,265	108,809
	UNIT PRICE	5.13	5.42	6.69		5.47	
	AMOUNT	111.58	226.31	27.02		225.72	590.63
ROCK UNDERWATER	QUANTITY	20,843	93,925	5,805	705	37,487	158,765
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	378.30	1732.92	116.62	14.39	693.88	2936.11
DREDGING, CLAYEY MATERIAL	QUANTITY	8,000	689	0	0	17,651	26,340
	UNIT PRICE	2.24	2.57			2.61	
	AMOUNT	17.92	1.77			46.07	65.76
TOTAL	QUANTITY	58,593	269,293	239,873	163,945	111,200	842,904
	AMOUNT	525.72	2454.46	999.39	706.89	1005.92	5,692.38

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	16,600,000	m²	0.23 $/m²	3.82
d) VEGETATION	4,400,000	m²	0.70 $/m²	3.08
e) DEWATERING		ls		95.47
SUBTOTAL				5,813.66
SUPPORTING CONSTRUCTION				325.56
GENERAL CONDITIONS				872.05
TOTAL				7,011.27

SUM-3.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(9) CASE L-9

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	12,927	18,090	15,630	4,900	51,547
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		31.15	43.60	37.67	11.81	124.23
ROCK, WEATHERED	QUANTITY	0	16,198	25,945	22,585	6,250	70,978
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		54.59	87.44	76.11	21.06	239.20
ROCK	QUANTITY	0	66,865	213,875	136,688	18,180	435,608
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		326.97	1045.85	668.40	88.90	2130.12
DREDGING, LOOSE MATERIAL	QUANTITY	6,578	26,995	220	345	11,810	45,948
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
	AMOUNT	14.74	69.11	0.85	1.10	30.82	116.62
DREDGING, WEATHERED SOFT ROCK	QUANTITY	19,988	82,699	830	2,375	33,918	139,810
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
	AMOUNT	102.54	448.23	5.55	17.29	185.53	759.14
ROCK UNDERWATER	QUANTITY	2,060	136,616	30,555	16,725	29,716	215,672
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	37.39	2520.57	613.85	319.78	550.04	4041.63
DREDGING, CLAYEY MATERIAL	QUANTITY	6,578	27,118	0	0	11,959	45,655
	UNIT PRICE	2.24	2.56			2.61	
	AMOUNT	14.74	69.42			31.21	115.37
TOTAL	QUANTITY	35,204	369,418	289,515	194,348	116,733	1,005,218
	AMOUNT	169.40	3520.03	1797.13	1120.36	919.38	7,526.31

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	17,800,000	m²	0.23 $/m²	4.09
d) VEGETATION	4,400,000	m²	0.70 $/m²	3.08
e) DEWATERING		ls		95.47
SUBTOTAL				7,647.86
SUPPORTING CONSTRUCTION				428.28
GENERAL CONDITIONS				1,147.18
TOTAL				9,223.32

SUM-10.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(10)CASE L-10

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	5,810	24,513	10,075	0	40,398
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		14.00	59.08	24.28		97.36
ROCK, WEATHERED	QUANTITY	2,240	53,651	60,124	33,500	30	149,545
	UNIT PRICE	3.37	3.37	3.37	3.37	3.37	
	AMOUNT	7.55	180.80	202.62	112.90	0.10	503.97
ROCK	QUANTITY	0	16,010	47,323	67,490	472	131,295
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		78.29	231.41	330.03	2.31	642.03
DREDGING,	QUANTITY	5,492	9,056	23	0	7,665	22,236
	UNIT PRICE	2.24	2.57	3.86		2.61	
LOOSE MATERIAL	AMOUNT	12.30	23.27	0.09		20.01	55.67
DREDGING,WEATHERED	QUANTITY	10,377	36,403	4,039	0	9,577	60,396
	UNIT PRICE	5.13	5.42	6.69		5.47	
SOFT ROCK	AMOUNT	53.23	197.30	27.02		52.39	329.95
ROCK UNDERWATER	QUANTITY	940	95,997	5,805	705	6,793	110,240
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	17.06	1771.15	116.62	14.39	125.74	2044.96
DREDGING,	QUANTITY	5,532	0	0	0	10,260	15,792
	UNIT PRICE	2.24				2.61	
CLAYEY MATERIAL	AMOUNT	12.39				26.78	39.17
	QUANTITY	24,581	216,927	141,827	111,770	34,797	529,902
TOTAL	AMOUNT	102.54	2264.82	636.84	481.59	227.32	3,713.10

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	12,900,000	m²	0.23 $/m²	2.97
d) VEGETATION	4,500,000	m²	0.70 $/m²	3.15
e) DEWATERING		ls		95.47
SUBTOTAL				3,833.60
SUPPORTING CONSTRUCTION				214.68
GENERAL CONDITIONS				575.04
TOTAL				4,623.32

SUM-11.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(11)CASE L-11

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	16,051	14,310	11,890	3,355	45,606
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		38.68	34.49	28.66	8.09	109.91
ROCK, WEATHERED	QUANTITY	2,240	25,878	20,500	17,148	3,140	68,906
	UNIT PRICE	3.37	3.37	3.37	3.37	3.37	
	AMOUNT	7.55	87.21	69.09	57.79	10.58	232.21
ROCK	QUANTITY	0	91,162	132,990	81,355	7,015	312,522
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		445.78	650.32	397.83	34.30	1528.23
DREDGING, LOOSE MATERIAL	QUANTITY	5,492	16,703	200	505	6,018	28,918
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
	AMOUNT	12.30	42.76	0.77	1.62	15.71	73.16
DREDGING, WEATHERED SOFT ROCK	QUANTITY	10,377	42,117	740	2,375	9,206	64,815
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
	AMOUNT	53.23	228.27	4.95	17.29	50.36	354.11
ROCK UNDERWATER	QUANTITY	940	70,541	22,420	10,435	7,910	112,246
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	17.06	1301.48	450.42	199.52	146.41	2114.89
DREDGING, CLAYEY MATERIAL	QUANTITY	5,532	11,198	0	0	6,129	22,859
	UNIT PRICE	2.24	2.56			2.61	
	AMOUNT	12.39	28.67			16.00	57.06
TOTAL	QUANTITY	24,581	273,650	191,160	123,708	42,773	655,872
	AMOUNT	102.54	2172.86	1210.03	702.69	281.45	4,469.57

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	15,200,000	m²	0.23 $/m²	3.50
d) VEGETATION	4,500,000	m²	0.70 $/m²	3.15
e) DEWATERING		ls		95.47
SUBTOTAL				4,590.59
SUPPORTING CONSTRUCTION				257.07
GENERAL CONDITIONS				688.59
TOTAL				5,536.25

SUM-12.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(12)CASE L-12

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	22,021	14,750	11,915	13,300	61,986
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		53.07	35.55	28.72	32.05	149.39
ROCK, WEATHERED	QUANTITY	0	63,603	19,455	15,180	19,670	117,908
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		214.34	65.56	51.16	66.29	397.35
ROCK	QUANTITY	0	185,349	155,405	90,485	45,850	477,089
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		906.36	759.93	442.47	224.21	2332.96
DREDGING, LOOSE MATERIAL	QUANTITY	5,492	13,313	200	180	2,415	21,600
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
	AMOUNT	12.30	34.08	0.77	0.58	6.30	54.03
DREDGING, WEATHERED SOFT ROCK	QUANTITY	12,617	39,142	2,610	150	5,928	60,447
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
	AMOUNT	64.73	212.15	17.46	1.09	32.43	327.85
ROCK UNDERWATER	QUANTITY	940	110,811	22,930	5,365	18,100	158,146
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	17.06	2044.46	460.66	102.58	335.03	2959.80
DREDGING, CLAYEY MATERIAL	QUANTITY	5,532	13,348	0	0	3,264	22,144
	UNIT PRICE	2.24	2.56			2.61	
	AMOUNT	12.39	34.17			8.52	55.08
TOTAL	QUANTITY	24,581	447,587	215,350	123,275	108,527	919,320
	AMOUNT	106.48	3498.63	1339.94	626.59	704.83	6,276.47

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	28,100,000	m²	0.23 $/m²	6.46
d) VEGETATION	4,500,000	m²	0.70 $/m²	3.15
e) DEWATERING		ls		95.47
SUBTOTAL				6,400.46
SUPPORTING CONSTRUCTION				358.43
GENERAL CONDITIONS				960.07
TOTAL				7,718.96

SUM-13.WK2

QUANTITY : 1,000 m3
UNIT COST : dollar
AMOUNT : million dol.

(13)CASE L-13

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	7,353	32,725	13,095	0	53,173
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		17.72	78.87	31.56		128.15
ROCK, WEATHERED	QUANTITY	0	53,994	78,652	39,140	30	171,815
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		181.96	265.06	131.90	0.10	579.02
ROCK	QUANTITY	0	19,171	61,566	80,745	533	162,015
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		93.75	301.06	394.84	2.61	792.25
DREDGING,	QUANTITY	6,420	10,248	23	0	10,250	26,941
	UNIT PRICE	2.24	2.57	3.86		2.61	
LOOSE MATERIAL	AMOUNT	14.38	26.34	0.09		26.75	67.56
DREDGING,WEATHERED	QUANTITY	19,502	43,307	4,039	0	27,975	94,823
	UNIT PRICE	5.13	5.42	6.69		5.47	
SOFT ROCK	AMOUNT	100.05	234.72	27.02		153.02	514.81
ROCK UNDERWATER	QUANTITY	2,060	127,195	5,805	705	9,702	145,467
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	37.39	2346.75	116.62	14.39	179.58	2694.73
DREDGING,	QUANTITY	6,420	0	0	0	13,044	19,464
	UNIT PRICE	2.24				2.61	
CLAYEY MATERIAL	AMOUNT	14.38				34.05	48.43
	QUANTITY	34,402	261,268	182,810	133,685	61,534	673,699
TOTAL	AMOUNT	166.20	2901.24	788.71	572.69	396.11	4,824.95

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00	18.91
c) CLEARING	15,100,000	m²	0.23	3.47
d) VEGETATION	4,400,000	m²	0.70	3.08
e) DEWATERING		ls		95.47
SUBTOTAL				4,945.88
SUPPORTING CONSTRUCTION				276.97
GENERAL CONDITIONS				741.88
TOTAL				5,964.73

SUM-14.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(14) CASE L-14

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	19,327	15,810	13,558	3,745	52,440
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		46.58	38.10	32.68	9.03	126.38
ROCK, WEATHERED	QUANTITY	0	28,301	23,270	19,673	4,750	75,994
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		95.37	78.42	66.30	16.01	256.10
ROCK	QUANTITY	0	114,815	165,840	103,943	11,715	396,313
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		561.45	810.96	508.28	57.29	1937.97
DREDGING,	QUANTITY	6,420	17,728	220	345	8,195	32,908
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
LOOSE MATERIAL	AMOUNT	14.38	45.38	0.85	1.10	21.39	83.11
DREDGING, WEATHERED	QUANTITY	19,502	48,692	750	2,375	18,775	90,094
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
SOFT ROCK	AMOUNT	100.05	263.91	5.02	17.29	102.70	488.96
ROCK UNDERWATER	QUANTITY	2,060	95,678	25,655	12,240	13,728	149,361
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	37.39	1765.26	515.41	234.03	254.11	2806.19
DREDGING,	QUANTITY	6,420	13,828	0	0	8,323	28,571
	UNIT PRICE	2.24	2.56			2.61	
CLAYEY MATERIAL	AMOUNT	14.38	35.40			21.72	71.50
TOTAL	QUANTITY	34,402	338,369	231,545	152,134	69,231	825,681
	AMOUNT	166.20	2813.35	1448.76	859.68	482.24	5,770.22

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	17,100,000	m²	0.23 $/m²	3.93
d) VEGETATION	4,400,000	m²	0.70 $/m²	3.08
e) DEWATERING		ls		95.47
SUBTOTAL				5,891.61
SUPPORTING CONSTRUCTION				329.93
GENERAL CONDITIONS				883.74
TOTAL				7,105.28

SUM-15.W12

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(15)CASE L-15

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	24,617	14,910	17,160	10,840	67,527
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		59.33	35.93	41.36	26.12	162.74
ROCK, WEATHERED	QUANTITY	0	34,456	21,410	24,040	20,405	100,311
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		116.12	72.15	81.02	68.77	338.05
ROCK	QUANTITY	0	217,105	176,935	184,065	56,280	634,385
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		1061.64	865.21	900.08	275.21	3102.14
DREDGING,	QUANTITY	6,420	15,036	130	195	4,900	26,681
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
LOOSE MATERIAL	AMOUNT	14.38	38.49	0.50	0.62	12.79	66.79
DREDGING,WEATHERED	QUANTITY	19,502	46,364	610	150	14,758	81,384
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
SOFT ROCK	AMOUNT	100.05	251.29	4.08	1.09	80.73	437.24
ROCK UNDERWATER	QUANTITY	2,060	148,203	22,915	8,995	26,335	208,508
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	37.39	2734.35	460.36	171.98	487.46	3891.54
DREDGING,	QUANTITY	6,420	15,025	0	0	4,680	26,125
	UNIT PRICE	2.24	2.56			2.61	
CLAYEY MATERIAL	AMOUNT	14.38	38.46			12.22	65.06
TOTAL	QUANTITY	34,402	500,806	236,910	234,605	138,198	1,144,921
	AMOUNT	166.20	4299.68	1438.24	1196.15	963.29	8,063.56

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00	$/m	18.91
c) CLEARING	31,400,000	m²	0.23	$/m²	7.22
d) VEGETATION	4,400,000	m²	0.70	$/m²	3.08
e) DEWATERING		ls			95.47
SUBTOTAL					8,188.24
SUPPORTING CONSTRUCTION					458.54
GENERAL CONDITIONS					1,228.24
TOTAL					9,875.01

SUM-16.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(16)CASE L-16

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	9,000	44,149	14,835	0	67,984
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		21.69	106.40	35.75		163.84
ROCK, WEATHERED	QUANTITY	0	58,601	104,986	45,360	0	208,947
	UNIT PRICE		3.37	3.37	3.37		
	AMOUNT		197.49	353.80	152.86		704.15
ROCK	QUANTITY	0	31,131	80,871	103,045	714	215,761
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		152.23	395.46	503.89	3.49	1055.07
DREDGING, LOOSE MATERIAL	QUANTITY	8,000	13,469	23	0	14,083	35,575
	UNIT PRICE	2.24	2.57	3.86		2.61	
	AMOUNT	17.92	34.62	0.09		36.76	89.38
DREDGING, WEATHERED SOFT ROCK	QUANTITY	21,750	49,406	4,039	0	41,295	116,490
	UNIT PRICE	5.13	5.42	6.69		5.47	
	AMOUNT	111.58	267.78	27.02		225.88	632.26
ROCK UNDERWATER	QUANTITY	20,843	208,682	5,805	705	37,487	273,522
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	378.30	3850.18	116.62	14.39	693.88	5053.38
DREDGING, CLAYEY MATERIAL	QUANTITY	8,000	689	0	0	17,651	26,340
	UNIT PRICE	2.24	2.57			2.61	
	AMOUNT	17.92	1.77			46.07	65.76
TOTAL	QUANTITY	58,593	370,978	239,873	163,945	111,230	944,619
	AMOUNT	525.72	4525.76	999.39	706.89	1006.09	7,763.85

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	16,600,000	m²	0.23 $/m²	3.82
d) VEGETATION	4,000,000	m²	0.70 $/m²	2.80
e) DEWATERING		ls		95.47
SUBTOTAL				7,884.84
SUPPORTING CONSTRUCTION				441.55
GENERAL CONDITIONS				1,182.73
TOTAL				9,509.12

SUM-17.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(17)CASE L-17

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	20,697	18,090	15,630	4,900	59,317
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		49.88	43.60	37.67	11.81	142.95
ROCK, WEATHERED	QUANTITY	0	30,291	25,875	22,585	6,250	85,001
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		102.08	87.20	76.11	21.06	286.45
ROCK	QUANTITY	0	135,855	213,875	135,188	18,180	503,098
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		664.33	1045.85	661.07	88.90	2460.15
DREDGING,	QUANTITY	6,578	20,543	220	345	11,810	39,496
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
LOOSE MATERIAL	AMOUNT	14.74	52.59	0.85	1.10	30.82	100.10
DREDGING,WEATHERED	QUANTITY	19,988	56,347	830	2,375	33,918	113,458
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
SOFT ROCK	AMOUNT	102.54	305.40	5.55	17.29	185.53	616.31
ROCK UNDERWATER	QUANTITY	2,060	130,771	30,555	16,725	29,716	209,827
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	37.39	2412.73	613.85	319.78	550.04	3933.79
DREDGING,	QUANTITY	6,578	15,983	0	0	11,959	34,520
	UNIT PRICE	2.24	2.56			2.61	
CLAYEY MATERIAL	AMOUNT	14.74	40.92			31.21	86.86
TOTAL	QUANTITY	35,204	410,487	289,445	192,848	116,733	1,044,717
	AMOUNT	169.40	3627.92	1796.90	1113.02	919.38	7,626.63

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00 $/m	18.91
c) CLEARING	19,600,000	m²	0.23 $/m²	4.51
d) VEGETATION	4,000,000	m²	0.70 $/m²	2.80
e) DEWATERING		ls		95.47
SUBTOTAL				7,748.31
SUPPORTING CONSTRUCTION				433.91
GENERAL CONDITIONS				1,162.25
TOTAL				9,344.46

SUM-18.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(18) CASE L-18

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	29,400	18,135	18,585	37,325	103,445
	UNIT PRICE		2.41	2.41	2.41	2.41	
	AMOUNT		70.85	43.71	44.79	89.95	249.30
ROCK, WEATHERED	QUANTITY	0	74,697	26,440	26,290	18,270	145,697
	UNIT PRICE		3.37	3.37	3.37	3.37	
	AMOUNT		251.73	89.10	88.60	61.57	491.00
ROCK	QUANTITY	0	278,510	241,315	169,470	79,770	769,065
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		1361.91	1180.03	828.71	390.08	3760.73
DREDGING, LOOSE MATERIAL	QUANTITY	8,000	17,290	260	325	7,625	33,500
	UNIT PRICE	2.24	2.56	3.86	3.20	2.61	
	AMOUNT	17.92	44.26	1.00	1.04	19.90	84.13
DREDGING, WEATHERED SOFT ROCK	QUANTITY	21,750	51,569	830	250	24,115	98,514
	UNIT PRICE	5.13	5.42	6.69	7.28	5.47	
	AMOUNT	111.58	279.50	5.55	1.82	131.91	530.36
ROCK UNDERWATER	QUANTITY	20,843	198,630	31,265	10,950	65,569	327,257
	UNIT PRICE	18.15	18.45	20.09	19.12	18.51	
	AMOUNT	378.30	3664.72	628.11	209.36	1213.68	6094.18
DREDGING, CLAYEY MATERIAL	QUANTITY	8,000	17,235	0	0	7,394	32,629
	UNIT PRICE	2.24	2.56			2.61	
	AMOUNT	17.92	44.12			19.30	81.34
TOTAL	QUANTITY	58,593	667,331	318,245	225,870	240,068	1,510,107
	AMOUNT	525.72	5717.11	1947.51	1174.32	1926.39	11,291.04

b) HAUL ROAD CONSTRUCTION	29,000	m	652.00	$/m	18.91
c) CLEARING	36,200,000	m²	0.23	$/m²	8.33
d) VEGETATION	4,000,000	m²	0.70	$/m²	2.80
e) DEWATERING		ls			95.47
SUBTOTAL					11,416.55
SUPPORTING CONSTRUCTION					639.33
GENERAL CONDITIONS					1,712.48
TOTAL					13,768.36

QUANTITY : 1,000 m3
UNIT COST : dollar
AMOUNT : million dol.

(19)CASE S-1

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	480	44,590	101,010	16,250	5,700	168,030
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	1.25	116.38	263.64	42.41	14.88	438.56
ROCK, WEATHERED	QUANTITY	720	92,965	283,470	40,645	13,275	431,075
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	2.60	335.60	1023.33	146.73	47.92	1556.18
ROCK	QUANTITY	2,323	117,948	186,610	0	0	306,881
	UNIT PRICE	5.15	5.15	5.15			
	AMOUNT	11.96	607.43	961.04			1580.44
DREDGING, LOOSE MATERIAL	QUANTITY	595	0	0	0	5,679	6,274
	UNIT PRICE	2.24				2.24	
	AMOUNT	1.33				12.72	14.05
DREDGING,WEATHERED SOFT ROCK	QUANTITY	1,750	0	0	0	16,558	18,308
	UNIT PRICE	5.13				5.13	
	AMOUNT	8.98				84.94	93.92
ROCK UNDERWATER	QUANTITY	1,488	0	0	0	0	1,488
	UNIT PRICE	18.15					
	AMOUNT	27.01					27.01
DREDGING, CLAYEY MATERIAL	QUANTITY	595	0	0	0	5,679	6,274
	UNIT PRICE	2.24				2.24	
	AMOUNT	1.33				12.72	14.05
TOTAL	QUANTITY	7,951	255,503	571,090	56,895	46,891	938,330
	AMOUNT	54.47	1059.42	2248.01	189.14	173.19	3,724.21

b) HAUL ROAD CONSTRUCTION	58,000 m	796.00 $/m		46.17
c) CLEARING	11,400,000 m²	0.23 $/m²		2.62
d) VEGETATION	4,890,000 m²	0.70 $/m²		3.42
e) DEWATERING	ls			449.60
SUBTOTAL				4,226.03
SUPPORTING CONSTRUCTION				236.66
GENERAL CONDITIONS				633.90
TOTAL				5,096.59

SUM-20.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(20) CASE S-2

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	880	78,925	161,035	27,125	9,075	277,040
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	2.30	205.99	420.30	70.80	23.69	723.07
ROCK, WEATHERED	QUANTITY	1,320	191,170	508,665	80,675	29,265	811,095
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	4.77	690.12	1836.28	291.24	105.65	2928.05
ROCK	QUANTITY	5,225	252,475	263,335	0	0	521,035
	UNIT PRICE	5.15	5.15	5.15			
	AMOUNT	26.91	1300.25	1356.18			2683.33
DREDGING,	QUANTITY	1,313	0	0	0	12,619	13,932
	UNIT PRICE	2.24				2.24	
LOOSE MATERIAL	AMOUNT	2.94				28.27	31.21
DREDGING, WEATHERED	QUANTITY	3,780	0	0	0	36,904	40,684
	UNIT PRICE	5.13				5.13	
SOFT ROCK	AMOUNT	19.39				189.32	208.71
ROCK UNDERWATER	QUANTITY	3,325	0	0	0	0	3,325
	UNIT PRICE	18.15					
	AMOUNT	60.35					60.35
DREDGING,	QUANTITY	1,313	0	0	0	12,619	13,932
	UNIT PRICE	2.24				2.24	
CLAYEY MATERIAL	AMOUNT	2.94				28.27	31.21
TOTAL	QUANTITY	17,156	522,570	933,035	107,800	100,482	1,681,043
	AMOUNT	119.59	2196.36	3612.76	362.03	375.19	6,665.93

b) HAUL ROAD CONSTRUCTION	58,000	m	796.00 $/m	46.17
c) CLEARING	22,100,000	m²	0.23 $/m²	5.08
d) VEGETATION	4,890,000	m²	0.70 $/m²	3.42
e) DEWATERING		ls		449.60
SUBTOTAL				7,170.21
SUPPORTING CONSTRUCTION				401.53
GENERAL CONDITIONS				1,075.53
TOTAL				8,647.27

SEM-21.XLS

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(21) CASE S-3

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	540	50,540	117,750	17,650	6,300	192,780
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	1.41	131.91	307.33	46.07	16.44	503.16
ROCK, WEATHERED	QUANTITY	810	122,390	493,588	50,275	16,830	683,893
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	2.92	441.83	1781.85	181.49	60.76	2468.85
ROCK	QUANTITY	3,060	146,125	11,845	0	0	161,030
	UNIT PRICE	5.15	5.15	5.15			
	AMOUNT	15.76	752.54	61.00			829.31
DREDGING, LOOSE MATERIAL	QUANTITY	809	0	0	0	7,213	8,022
	UNIT PRICE	2.24				2.24	
	AMOUNT	1.81				16.16	17.97
DREDGING, WEATHERED SOFT ROCK	QUANTITY	2,252	0	0	0	30,372	32,624
	UNIT PRICE	5.13				5.13	
	AMOUNT	11.55				155.81	167.36
ROCK UNDERWATER	QUANTITY	3,003	0	0	0	0	3,003
	UNIT PRICE	18.15					
	AMOUNT	54.50					54.50
DREDGING, CLAYEY MATERIAL	QUANTITY	809	0	0	0	7,213	8,022
	UNIT PRICE	2.24				2.24	
	AMOUNT	1.81				16.16	17.97
TOTAL	QUANTITY	11,283	319,055	623,183	67,925	67,928	1,089,374
	AMOUNT	89.77	1326.28	2150.18	227.56	265.32	4,059.12

b) HAUL ROAD CONSTRUCTION	58,000 m	796.00 $/m		46.17
c) CLEARING	12,800,000 m²	0.23 $/m²		2.94
d) VEGETATION	4,890,000 m²	0.70 $/m²		3.42
e) DEWATERING	ls			449.60
SUBTOTAL				4,561.25
SUPPORTING CONSTRUCTION				255.43
GENERAL CONDITIONS				684.19
TOTAL				5,500.87

SUM-22.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(22)CASE S-4

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	1,040	88,950	173,580	30,250	10,050	303,870
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	2.71	232.16	453.04	78.95	26.23	793.10
ROCK, WEATHERED	QUANTITY	1,560	247,915	883,785	103,300	37,260	1,273,820
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	5.63	894.97	3190.46	372.91	134.51	4598.49
ROCK	QUANTITY	6,970	308,725	0	0	0	315,695
	UNIT PRICE	5.15	5.15				
	AMOUNT	35.90	1589.93				1625.83
DREDGING,	QUANTITY	1,675	0	0	0	15,531	17,206
	UNIT PRICE	2.24				2.24	
LOOSE MATERIAL	AMOUNT	3.75				34.79	38.54
DREDGING,WEATHERED	QUANTITY	4,890	0	0	0	68,652	73,542
	UNIT PRICE	5.13				5.13	
SOFT ROCK	AMOUNT	25.09				352.19	377.27
ROCK UNDERWATER	QUANTITY	4,967	0	0	0	0	4,967
	UNIT PRICE	18.15					
	AMOUNT	90.15					90.15
DREDGING,	QUANTITY	1,675	0	0	0	15,531	17,206
	UNIT PRICE	2.24				2.24	
CLAYEY MATERIAL	AMOUNT	3.75				34.79	38.54
TOTAL	QUANTITY	22,777	645,590	1,057,365	133,550	147,024	2,006,306
	AMOUNT	166.98	2717.07	3643.51	451.87	582.50	7,561.93

b) HAUL ROAD CONSTRUCTION	58,000	m	796.00	$/m	46.17
c) CLEARING	25,300,000	m²	0.23	$/m²	5.82
d) VEGETATION	4,890,000	m²	0.70	$/m²	3.42
e) DEWATERING		ls			449.60
SUBTOTAL					8,066.94
SUPPORTING CONSTRUCTION					451.75
GENERAL CONDITIONS					1,210.04
TOTAL					9,728.73

SUM-23.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(23) CASE S-5

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	560	51,870	134,230	19,400	6,450	212,510
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	1.46	135.38	350.34	50.63	16.84	554.65
ROCK, WEATHERED	QUANTITY	840	127,185	362,495	54,185	18,225	562,930
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	3.03	459.14	1308.61	195.61	65.79	2032.18
ROCK	QUANTITY	4,825	161,045	191,840	0	0	357,710
	UNIT PRICE	5.15	5.15	5.15			
	AMOUNT	24.85	829.38	987.98			1842.21
DREDGING, LOOSE MATERIAL	QUANTITY	858	0	0	0	7,840	8,698
	UNIT PRICE	2.24				2.24	
	AMOUNT	1.92				17.56	19.48
DREDGING, WEATHERED SOFT ROCK	QUANTITY	2,438	0	0	0	37,372	39,810
	UNIT PRICE	5.13				5.13	
	AMOUNT	12.51				191.72	204.23
ROCK UNDERWATER	QUANTITY	3,725	0	0	0	0	3,725
	UNIT PRICE	18.15					
	AMOUNT	67.61					67.61
DREDGING, CLAYEY MATERIAL	QUANTITY	858	0	0	0	7,840	8,698
	UNIT PRICE	2.24				2.24	
	AMOUNT	1.92				17.56	19.48
TOTAL	QUANTITY	14,104	340,100	688,565	73,585	77,727	1,194,081
	AMOUNT	113.30	1423.90	2646.92	246.24	309.47	4,739.84

b) HAUL ROAD CONSTRUCTION	58,000 m	796.00	$/m	46.17
c) CLEARING	13,600,000 m²	0.23	$/m²	3.13
d) VEGETATION	4,890,000 m²	0.70	$/m²	3.42
e) DEWATERING	ls			449.60
SUBTOTAL				5,242.16
SUPPORTING CONSTRUCTION				293.56
GENERAL CONDITIONS				786.32
TOTAL				6,322.04

SUM-24.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(24)CASE S-6

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	1,100	94,520	197,810	31,550	10,500	335,480
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	2.87	246.70	516.28	82.35	27.41	875.60
ROCK, WEATHERED	QUANTITY	1,650	258,425	652,430	111,250	40,620	1,064,375
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	5.96	932.91	2355.27	401.61	146.64	3842.39
ROCK	QUANTITY	7,495	341,225	308,240	0	0	656,960
	UNIT PRICE	5.51	5.51	5.51			
	AMOUNT	41.30	1880.15	1698.40			3619.85
DREDGING,	QUANTITY	1,794	0	0	0	16,883	18,677
	UNIT PRICE	2.24				2.24	
LOOSE MATERIAL	AMOUNT	4.02				37.82	41.84
DREDGING,WEATHERED	QUANTITY	5,265	0	0	0	82,890	88,155
	UNIT PRICE	5.13				5.13	
SOFT ROCK	AMOUNT	27.01				425.23	452.24
ROCK UNDERWATER	QUANTITY	8,385	0	0	0	0	8,385
	UNIT PRICE	18.15					
	AMOUNT	152.19					152.19
DREDGING,	QUANTITY	1,794	0	0	0	16,883	18,677
	UNIT PRICE	2.24				2.24	
CLAYEY MATERIAL	AMOUNT	4.02				37.82	41.84
TOTAL	QUANTITY	27,483	694,170	1,158,480	142,800	167,776	2,190,709
	AMOUNT	237.36	3059.76	4569.96	483.96	674.91	9,025.94

b) HAUL ROAD CONSTRUCTION	58,000	m	796.00	$/m	46.17
c) CLEARING	26,900,000	m²	0.23	$/m²	6.19
d) VEGETATION	4,890,000	m²	0.70	$/m²	3.42
e) DEWATERING		ls			449.60
SUBTOTAL					9,531.32
SUPPORTING CONSTRUCTION					533.75
GENERAL CONDITIONS					1,429.70
TOTAL					11,494.77

QUANTITY : 1,000 m3
UNIT COST : dollar
AMOUNT : million dol.

(25) CASE S-7

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	6,899	43,485	3,140	430	53,954
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		18.01	113.50	8.20	1.12	140.82
ROCK, WEATHERED	QUANTITY	0	8,625	62,950	4,195	585	76,355
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		31.14	227.25	15.14	2.04	275.57
ROCK	QUANTITY	0	28,973	513,098	25,420	1,295	568,786
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		149.21	2642.46	130.91	6.67	2929.25
DREDGING, LOOSE MATERIAL	QUANTITY	3,240	7,005	4,770	1,240	5,143	21,398
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
	AMOUNT	7.26	15.20	14.60	3.79	13.42	54.27
DREDGING, WEATHERED SOFT ROCK	QUANTITY	9,721	20,368	8,635	1,940	8,028	48,692
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
	AMOUNT	366.19	765.84	332.02	74.59	305.06	1843.70
ROCK UNDERWATER	QUANTITY	1,040	68,879	38,137	4,920	1,540	114,516
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	46.77	3092.67	1744.77	225.09	69.76	5179.06
DREDGING, CLAYEY MATERIAL	QUANTITY	3,240	6,315	1,215	0	5,368	16,138
	UNIT PRICE	2.24	2.17	3.06		2.61	
	AMOUNT	7.26	13.70	3.72		14.01	38.69
TOTAL	QUANTITY	17,241	147,064	672,290	40,855	22,369	899,819
	AMOUNT	427.48	4085.76	5078.30	457.73	412.09	10,461.36

b) HAUL ROAD CONSTRUCTION	39,000	m	705.00 $/m	27.50
c) CLEARING	7,600,000	m²	0.23 $/m²	1.75
d) VEGETATION	3,300,000	m²	0.70 $/m²	2.31
e) DEWATERING		ls		303.05
SUBTOTAL				10,795.96
SUPPORTING CONSTRUCTION				604.57
GENERAL CONDITIONS				1,619.39
TOTAL				13,019.93

SUM-26.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(26) CASE S-8

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	11,937	61,140	5,940	830	79,847
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		31.16	159.58	15.50	2.17	208.40
ROCK, WEATHERED	QUANTITY	0	14,701	88,630	8,495	1,155	112,981
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		53.07	319.95	30.67	4.17	407.86
ROCK	QUANTITY	0	57,150	826,195	48,490	3,310	935,145
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		294.32	4254.90	249.72	17.05	4816.00
DREDGING,	QUANTITY	6,420	13,405	8,215	1,550	11,375	40,965
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
LOOSE MATERIAL	AMOUNT	14.38	29.09	25.14	4.74	29.69	103.04
DREDGING, WEATHERED	QUANTITY	19,502	39,862	15,580	2,510	23,590	101,044
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
SOFT ROCK	AMOUNT	734.64	1498.81	599.05	96.51	896.42	3825.43
ROCK UNDERWATER	QUANTITY	2,060	147,303	75,705	10,620	4,980	240,668
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	92.64	6613.91	3463.50	485.87	225.59	10881.51
DREDGING,	QUANTITY	6,420	12,030	2,210	0	11,850	32,510
	UNIT PRICE	2.24	2.17	3.06		2.61	
CLAYEY MATERIAL	AMOUNT	14.38	26.11	6.76		30.93	78.18
	QUANTITY	34,402	296,388	1,077,675	77,605	57,090	1,543,160
TOTAL	AMOUNT	856.04	8546.46	8828.89	883.01	1206.01	20,320.42

b) HAUL ROAD CONSTRUCTION	39,000	m	705.00 $/m	27.50
c) CLEARING	14,800,000	m²	0.23 $/m²	3.40
d) VEGETATION	3,300,000	m²	0.70 $/m²	2.31
e) DEWATERING		ls		303.05
SUBTOTAL				20,656.68
SUPPORTING CONSTRUCTION				1,156.77
GENERAL CONDITIONS				3,098.50
TOTAL				24,911.95

QUANTITY : 1,000 m3
UNIT COST : dollar
AMOUNT : million dol.

(27) CASE S-9

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	7,040	46,550	3,720	570	57,880
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		18.37	121.50	9.71	1.49	151.07
ROCK, WEATHERED	QUANTITY	0	10,872	67,425	4,920	660	83,877
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		39.25	243.40	17.76	2.38	302.80
ROCK	QUANTITY	0	37,687	573,205	30,565	3,185	644,642
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		194.09	2952.01	157.41	16.40	3319.91
DREDGING,	QUANTITY	4,000	7,800	4,500	1,240	7,344	24,884
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
LOOSE MATERIAL	AMOUNT	8.96	16.93	13.77	3.79	19.17	62.62
DREDGING, WEATHERED	QUANTITY	10,875	22,839	9,640	2,100	18,632	64,086
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
SOFT ROCK	AMOUNT	409.66	858.75	370.66	80.75	708.02	2427.83
ROCK UNDERWATER	QUANTITY	10,453	89,903	48,800	7,490	6,499	163,145
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	470.07	4036.65	2232.60	342.67	294.41	7376.39
DREDGING,	QUANTITY	4,000	7,145	1,905	0	7,733	20,783
	UNIT PRICE	2.24	2.17	3.06		2.61	
CLAYEY MATERIAL	AMOUNT	8.96	15.51	5.83		20.18	50.48
TOTAL	QUANTITY	29,328	183,286	752,025	50,035	44,623	1,059,297
	AMOUNT	897.65	5179.53	5939.76	612.09	1062.05	13,691.08

b) HAUL ROAD CONSTRUCTION	39,000 m	705.00 $/m		27.50
c) CLEARING	8,600,000 m²	0.23 $/m²		1.98
d) VEGETATION	3,300,000 m²	0.70 $/m²		2.31
e) DEWATERING	ls			303.05
SUBTOTAL				14,025.91
SUPPORTING CONSTRUCTION				785.45
GENERAL CONDITIONS				2,103.89
TOTAL				16,915.25

SUM-28.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(28)CASE S-10

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	13,590	66,450	6,925	965	87,330
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		35.47	173.44	18.07	2.52	229.50
ROCK, WEATHERED	QUANTITY	0	18,594	97,150	9,820	1,350	126,914
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		67.12	350.71	35.45	4.87	458.16
ROCK	QUANTITY	0	77,883	981,205	63,010	4,690	1,126,788
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		401.10	5053.21	324.50	24.15	5802.96
DREDGING, LOOSE MATERIAL	QUANTITY	8,000	15,530	8,350	1,660	15,850	49,390
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
	AMOUNT	17.92	33.70	25.55	5.08	41.37	123.62
DREDGING,WEATHERED SOFT ROCK	QUANTITY	21,750	45,187	17,805	2,670	44,545	131,957
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
	AMOUNT	819.32	1699.03	684.60	102.66	1692.71	4998.33
ROCK UNDERWATER	QUANTITY	20,843	195,337	97,605	13,600	25,559	352,944
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	937.31	8770.63	4465.43	622.20	1157.82	15953.39
DREDGING, CLAYEY MATERIAL	QUANTITY	8,000	13,860	3,510	0	16,304	41,674
	UNIT PRICE	2.24	2.17	3.06		2.61	
	AMOUNT	17.92	30.08	10.74		42.55	101.29
TOTAL	QUANTITY	58,593	379,981	1,272,075	97,685	109,263	1,917,597
	AMOUNT	1792.47	11037.13	10763.68	1107.97	2966.00	27,667.25

b) HAUL ROAD CONSTRUCTION	39,000	m	705.00	$/m	27.50
c) CLEARING	17,000,000	m²	0.23	$/m²	3.91
d) VEGETATION	3,300,000	m²	0.70	$/m²	2.31
e) DEWATERING		ls			303.05
SUBTOTAL					28,004.01
SUPPORTING CONSTRUCTION					1,568.22
GENERAL CONDITIONS					4,200.60
TOTAL					33,772.84

QUANTITY : 1,000 m3
UNIT COST : dollar
AMOUNT : million dol.

(29)CASE S-11

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	7,700	47,990	3,910	550	60,150
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		20.10	125.25	10.21	1.44	156.99
ROCK, WEATHERED	QUANTITY	0	13,073	69,365	5,295	710	88,443
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		47.19	250.41	19.12	2.56	319.28
ROCK	QUANTITY	0	41,208	611,880	32,520	2,400	688,008
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		212.22	3151.18	167.48	12.36	3543.24
DREDGING,	QUANTITY	4,439	8,290	4,850	1,310	8,296	27,185
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
LOOSE MATERIAL	AMOUNT	9.94	17.99	14.84	4.01	21.65	68.44
DREDGING,WEATHERED	QUANTITY	12,120	24,293	10,275	2,130	22,716	71,534
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
SOFT ROCK	AMOUNT	456.56	913.42	395.07	81.90	863.21	2710.19
ROCK UNDERWATER	QUANTITY	11,560	99,197	54,340	8,720	10,400	184,217
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	519.85	4453.95	2486.06	398.94	471.12	8329.31
DREDGING,	QUANTITY	4,439	7,545	2,015	0	8,648	22,647
	UNIT PRICE	2.24	2.17	3.06		2.61	
CLAYEY MATERIAL	AMOUNT	9.94	16.37	6.17		22.57	55.05
TOTAL	QUANTITY	32,558	201,306	800,715	53,885	53,720	1,142,184
	AMOUNT	996.30	5681.24	6428.98	681.65	1394.91	15,183.07

b) HAUL ROAD CONSTRUCTION	39,000 m	705.00 $/m		27.50
c) CLEARING	9,100,000 m²	0.23 $/m²		2.09
d) VEGETATION	3,300,000 m²	0.70 $/m²		2.31
e) DEWATERING	ls			303.05
SUBTOTAL				15,518.02
SUPPORTING CONSTRUCTION				869.01
GENERAL CONDITIONS				2,327.70
TOTAL				18,714.73

SUM-30.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(30)CASE S-12

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	14,760	68,045	7,235	1,000	91,040
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		38.52	177.60	18.88	2.61	237.61
ROCK, WEATHERED	QUANTITY	0	20,779	99,485	10,390	1,430	132,084
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		75.01	359.14	37.51	5.16	476.82
ROCK	QUANTITY	0	84,392	1,057,945	67,930	5,245	1,215,512
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		434.62	5448.42	349.84	27.01	6259.89
DREDGING, LOOSE MATERIAL	QUANTITY	8,878	16,030	9,070	1,750	17,346	53,074
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
	AMOUNT	19.89	34.79	27.75	5.36	45.27	133.05
DREDGING, WEATHERED SOFT ROCK	QUANTITY	24,240	47,976	19,105	2,700	49,626	143,647
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
	AMOUNT	913.12	1803.90	734.59	103.82	1885.79	5441.21
ROCK UNDERWATER	QUANTITY	23,120	206,467	107,270	14,650	34,454	385,961
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	1039.71	9270.37	4907.60	670.24	1560.77	17448.68
DREDGING, CLAYEY MATERIAL	QUANTITY	8,878	14,680	3,700	0	17,918	45,176
	UNIT PRICE	2.24	2.17	3.06		2.61	
	AMOUNT	19.89	31.86	11.32		46.77	109.83
TOTAL	QUANTITY	65,116	405,084	1,364,620	104,655	127,019	2,066,494
	AMOUNT	1992.60	11689.06	11666.42	1185.64	3573.38	30,107.10

b) HAUL ROAD CONSTRUCTION	39,000	m	705.00 $/m	27.50
c) CLEARING	18,000,000	m²	0.23 $/m²	4.14
d) VEGETATION	3,300,000	m²	0.70 $/m²	2.31
e) DEWATERING		ls		303.05
SUBTOTAL				30,444.10
SUPPORTING CONSTRUCTION				1,704.87
GENERAL CONDITIONS				4,566.61
TOTAL				36,715.58

SUM-31.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(31)CASE S-13

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	880	78,925	101,010	27,125	9,075	217,015
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	2.30	205.99	263.64	70.80	23.69	566.41
ROCK, WEATHERED	QUANTITY	1,320	191,170	283,470	80,675	29,265	585,900
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	4.77	690.12	1023.33	291.24	105.65	2115.10
ROCK	QUANTITY	5,225	252,475	186,610	0	0	444,310
	UNIT PRICE	5.15	5.15	5.15			
	AMOUNT	26.91	1300.25	961.04			2288.20
DREDGING,	QUANTITY	1,313	0	0	0	12,619	13,932
	UNIT PRICE	2.24				2.24	
LOOSE MATERIAL	AMOUNT	2.94				28.27	31.21
DREDGING,WEATHERED	QUANTITY	3,780	0	0	0	36,904	40,684
	UNIT PRICE	5.13				5.13	
SOFT ROCK	AMOUNT	19.39				189.32	208.71
ROCK UNDERWATER	QUANTITY	3,325	0	0	0	0	3,325
	UNIT PRICE	18.15					
	AMOUNT	60.35					60.35
DREDGING,	QUANTITY	1,313	0	0	0	12,619	13,932
	UNIT PRICE	2.24				2.24	
CLAYEY MATERIAL	AMOUNT	2.94				28.27	31.21
	QUANTITY	17,156	522,570	571,090	107,800	100,482	1,319,098
TOTAL	AMOUNT	119.59	2196.36	2248.01	362.03	375.19	5,301.18

b) HAUL ROAD CONSTRUCTION	58,000	m	796.00 $/m	46.17
c) CLEARING	16,700,000	m²	0.23 $/m²	3.84
d) VEGETATION	4,900,000	m²	0.70 $/m²	3.43
e) DEWATERING		ls		449.60
SUBTOTAL				5,804.22
SUPPORTING CONSTRUCTION				325.04
GENERAL CONDITIONS				870.63
TOTAL				6,999.89

SUM-32.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(32)CASE S-14

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	1,040	88,950	117,750	30,250	10,050	248,040
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	2.71	232.16	307.33	78.95	26.23	647.39
ROCK, WEATHERED	QUANTITY	1,560	247,915	493,588	103,300	37,260	883,623
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	5.63	894.97	1781.85	372.91	134.51	3189.88
ROCK	QUANTITY	6,970	308,725	11,845	0	0	327,540
	UNIT PRICE	5.15	5.15	5.15			
	AMOUNT	35.90	1589.93	61.00			1686.83
DREDGING,	QUANTITY	1,675	0	0	0	15,531	17,206
	UNIT PRICE	2.24				2.24	
LOOSE MATERIAL	AMOUNT	3.75				34.79	38.54
DREDGING,WEATHERED	QUANTITY	4,890	0	0	0	68,652	73,542
	UNIT PRICE	5.13				5.13	
SOFT ROCK	AMOUNT	25.09				352.19	377.27
ROCK UNDERWATER	QUANTITY	4,967	0	0	0	0	4,967
	UNIT PRICE	18.15					
	AMOUNT	90.15					90.15
DREDGING,	QUANTITY	1,675	0	0	0	15,531	17,206
	UNIT PRICE	2.24				2.24	
CLAYEY MATERIAL	AMOUNT	3.75				34.79	38.54
	QUANTITY	22,777	645,590	623,183	133,550	147,024	1,572,124
TOTAL	AMOUNT	166.98	2717.07	2150.18	451.87	582.50	6,068.60

b) HAUL ROAD CONSTRUCTION	58,000	m	796.00 $/m	46.17
c) CLEARING	19,100,000	m²	0.23 $/m²	4.39
d) VEGETATION	4,900,000	m²	0.70 $/m²	3.43
e) DEWATERING		ls		449.60
SUBTOTAL				6,572.19
SUPPORTING CONSTRUCTION				368.04
GENERAL CONDITIONS				985.83
TOTAL				7,926.06

SUM-33.WK2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(33)CASE S-15

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	1,100	94,520	134,230	31,550	10,500	271,900
	UNIT PRICE	2.61	2.61	2.61	2.61	2.61	
	AMOUNT	2.87	246.70	350.34	82.35	27.41	709.66
ROCK, WEATHERED	QUANTITY	1,650	258,425	362,495	111,250	40,620	774,440
	UNIT PRICE	3.61	3.61	3.61	3.61	3.61	
	AMOUNT	5.96	932.91	1308.61	401.61	146.64	2795.73
ROCK	QUANTITY	7,495	341,225	191,840	0	0	540,560
	UNIT PRICE	5.15	5.15	5.15			
	AMOUNT	38.60	1757.31	987.98			2783.88
DREDGING,	QUANTITY	1,794	0	0	0	16,883	18,677
	UNIT PRICE	2.24				2.24	
LOOSE MATERIAL	AMOUNT	4.02				37.82	41.84
DREDGING,WEATHERED	QUANTITY	5,265	0	0	0	82,890	88,155
	UNIT PRICE	5.13				5.13	
SOFT ROCK	AMOUNT	27.01				425.23	452.24
ROCK UNDERWATER	QUANTITY	8,385	0	0	0	0	8,385
	UNIT PRICE	18.15					
	AMOUNT	152.19					152.19
DREDGING,	QUANTITY	1,794	0	0	0	16,883	18,677
	UNIT PRICE	2.24				2.24	
CLAYEY MATERIAL	AMOUNT	4.02				37.82	41.84
	QUANTITY	27,483	694,170	688,565	142,800	167,776	1,720,794
TOTAL	AMOUNT	234.66	2936.92	2646.92	483.96	674.91	6,977.37

b) HAUL ROAD CONSTRUCTION	58,000	m	796.00	$/m	46.17
c) CLEARING	20,200,000	m²	0.23	$/m²	4.65
d) VEGETATION	4,900,000	m²	0.70	$/m²	3.43
e) DEWATERING		ls			449.60
SUBTOTAL					7,481.21
SUPPORTING CONSTRUCTION					418.95
GENERAL CONDITIONS					1,122.18
TOTAL					9,022.34

SUM-34.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(34) CASE S-16

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	11,937	43,485	5,940	830	62,192
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		31.16	113.50	15.50	2.17	162.32
ROCK, WEATHERED	QUANTITY	0	14,701	62,950	8,495	1,155	87,301
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		53.07	227.25	30.67	4.17	315.16
ROCK	QUANTITY	0	57,150	513,098	48,490	3,310	622,048
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		294.32	2642.46	249.72	17.05	3203.55
DREDGING,	QUANTITY	6,420	13,405	4,770	1,550	11,375	37,520
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
LOOSE MATERIAL	AMOUNT	14.38	29.09	14.60	4.74	29.69	92.50
DREDGING, WEATHERED	QUANTITY	19,502	39,862	8,635	2,510	23,590	94,099
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
SOFT ROCK	AMOUNT	734.64	1498.81	332.02	96.51	896.42	3558.40
ROCK UNDERWATER	QUANTITY	2,060	147,303	38,137	10,620	4,980	203,100
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	92.64	6613.91	1744.77	485.87	225.59	9162.77
DREDGING,	QUANTITY	6,420	12,030	1,215	0	11,850	31,515
	UNIT PRICE	2.24	2.17	3.06		2.61	
CLAYEY MATERIAL	AMOUNT	14.38	26.11	3.72		30.93	75.13
TOTAL	QUANTITY	34,402	296,388	672,290	77,605	57,090	1,137,775
	AMOUNT	856.04	8546.46	5078.30	883.01	1206.01	16,569.83

b) HAUL ROAD CONSTRUCTION	39,000	m	705.00	$/m	27.50
c) CLEARING	11,200,000	m²	0.23	$/m²	2.58
d) VEGETATION	3,300,000	m²	0.70	$/m²	2.31
e) DEWATERING		ls			303.05
SUBTOTAL					16,905.26
SUPPORTING CONSTRUCTION					946.69
GENERAL CONDITIONS					2,535.79
TOTAL					20,387.74

SUM-35.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(35) CASE S-17

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	13,590	46,550	6,925	965	68,030
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		35.47	121.50	18.07	2.52	177.56
ROCK, WEATHERED	QUANTITY	0	18,594	67,425	9,820	1,350	97,189
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		67.12	243.40	35.45	4.87	350.85
ROCK	QUANTITY	0	77,883	573,205	63,010	4,690	718,788
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		401.10	2952.01	324.50	24.15	3701.76
DREDGING,	QUANTITY	8,000	15,530	4,500	1,660	15,850	45,540
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
LOOSE MATERIAL	AMOUNT	17.92	33.70	13.77	5.08	41.37	111.84
DREDGING, WEATHERED	QUANTITY	21,750	45,187	9,640	2,670	44,545	123,792
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
SOFT ROCK	AMOUNT	819.32	1699.03	370.66	102.66	1692.71	4684.38
ROCK UNDERWATER	QUANTITY	20,843	195,337	48,800	13,600	25,559	304,139
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	937.31	8770.63	2232.60	622.20	1157.82	13720.56
DREDGING,	QUANTITY	8,000	13,860	1,905	0	16,304	40,069
	UNIT PRICE	2.24	2.17	3.06		2.61	
CLAYEY MATERIAL	AMOUNT	17.92	30.08	5.83		42.55	96.38
	QUANTITY	58,593	379,981	752,025	97,685	109,263	1,397,547
TOTAL	AMOUNT	1792.47	11037.13	5939.76	1107.97	2966.00	22,843.34

b) HAUL ROAD CONSTRUCTION	39,000	m	705.00 $/m	27.50
c) CLEARING	12,800,000	m²	0.23 $/m²	2.94
d) VEGETATION	3,300,000	m²	0.70 $/m²	2.31
e) DEWATERING		ls		303.05
SUBTOTAL				23,179.13
SUPPORTING CONSTRUCTION				1,298.03
GENERAL CONDITIONS				3,476.87
TOTAL				27,954.04

SUM-36.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(36) CASE S-18

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	14,760	47,990	7,235	1,000	70,985
	UNIT PRICE		2.61	2.61	2.61	2.61	
	AMOUNT		38.52	125.25	18.88	2.61	185.27
ROCK, WEATHERED	QUANTITY	0	20,779	69,365	10,390	1,430	101,964
	UNIT PRICE		3.61	3.61	3.61	3.61	
	AMOUNT		75.01	250.41	37.51	5.16	368.09
ROCK	QUANTITY	0	84,392	611,880	67,930	5,245	769,447
	UNIT PRICE		5.15	5.15	5.15	5.15	
	AMOUNT		434.62	3151.18	349.84	27.01	3962.65
DREDGING, LOOSE MATERIAL	QUANTITY	8,878	16,030	4,850	1,750	17,346	48,854
	UNIT PRICE	2.24	2.17	3.06	3.06	2.61	
	AMOUNT	19.89	34.79	14.84	5.36	45.27	120.14
DREDGING, WEATHERED SOFT ROCK	QUANTITY	24,240	47,976	10,275	2,700	49,626	134,817
	UNIT PRICE	37.67	37.60	38.45	38.45	38.00	
	AMOUNT	913.12	1803.90	395.07	103.82	1885.79	5101.70
ROCK UNDERWATER	QUANTITY	23,120	206,467	54,340	14,650	34,454	333,031
	UNIT PRICE	44.97	44.90	45.75	45.75	45.30	
	AMOUNT	1039.71	9270.37	2486.06	670.24	1560.77	15027.13
DREDGING, CLAYEY MATERIAL	QUANTITY	8,878	14,680	2,015	0	17,918	43,491
	UNIT PRICE	2.24	2.17	3.06		2.61	
	AMOUNT	19.89	31.86	6.17		46.77	104.68
TOTAL	QUANTITY	65,116	405,084	800,715	104,655	127,019	1,502,589
	AMOUNT	1992.60	11689.06	6428.98	1185.64	3573.38	24,869.66

b) HAUL ROAD CONSTRUCTION	39,000	m	705.00 $/m	27.50
c) CLEARING	13,600,000	m²	0.23 $/m²	3.13
d) VEGETATION	3,300,000	m²	0.70 $/m²	2.31
e) DEWATERING		ls		303.05
SUBTOTAL				25,205.64
SUPPORTING CONSTRUCTION				1,411.52
GENERAL CONDITIONS				3,780.85
TOTAL				30,398.00

SUM-37.WJ2

QUANTITY	: 1,000 m3
UNIT COST	: dollar
AMOUNT	: million dol.

(37)CASE 'STATUS QUO'

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH. COMMON	QUANTITY	0	5,419	22,958	9,431	0	37,808
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		13.06	55.33	22.73		91.12
ROCK. WEATHERED	QUANTITY	2,110	56,008	56,298	31,355	81	145,852
	UNIT PRICE	3.37	3.37	3.37	3.37	3.37	
	AMOUNT	7.11	188.75	189.72	105.67	0.27	491.52
ROCK	QUANTITY	0	17,084	44,302	63,164	455	125,005
	UNIT PRICE		4.89	4.89	4.89	4.89	
	AMOUNT		83.54	216.64	308.87	2.23	611.23
DREDGING.	QUANTITY	5,129	3,806	41	0	7,156	16,132
	UNIT PRICE	2.24	2.57	3.86		2.61	
LOOSE MATERIAL	AMOUNT	11.49	9.78	0.16		18.68	40.11
DREDGING. WEATHERED	QUANTITY	9,721	17,332	3,764	0	8,976	39,793
	UNIT PRICE	5.13	5.42	6.69		5.47	
SOFT ROCK	AMOUNT	49.87	93.94	25.18		49.10	218.03
ROCK UNDERWATER	QUANTITY	869	20,972	5,419	662	6,370	34,292
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	15.77	386.93	108.87	13.51	117.91	642.99
DREDGING.	QUANTITY	5,171	0	0	0	9,597	14,768
	UNIT PRICE	2.24				2.61	
CLAYEY MATERIAL	AMOUNT	11.58				25.05	36.63
	QUANTITY	23,000	120,621	132,782	104,612	32,535	413,650
TOTAL	AMOUNT	95.82	776.00	595.90	450.78	213.23	2,131.73

SUBTOTAL	2,131.73
SUPPORTING CONSTRUCTION	119.38
GENERAL CONDITIONS	319.76
TOTAL	2,570.87

2.3.4 Breakdown of Lock Concrete Structure

SUM1-10.WJ2

(1) High-rise Lock

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

a) 100,000 DWT

CASE L-1,L-2,L-10

DESCRIPTION		PACIFIC SIDE 4 CHAMBERS	ATLANTIC SIDE 4 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	3.30	3.30	6.60
	UNIT PRICE	3.44	3.44	
	AMOUNT	11.35	11.35	22.70
BUCKFILL	QUANTITY	9.80	9.80	19.60
	UNIT PRICE	2.54	2.54	
	AMOUNT	24.89	24.89	49.78
CONCRETE	QUANTITY	4.64	4.64	9.28
	UNIT PRICE	46.67	46.67	
	AMOUNT	216.55	216.55	433.10
REINFORCED BAR	QUANTITY	0.05	0.05	0.09
	UNIT PRICE	742.00	742.00	
	AMOUNT	34.13	34.13	68.26
TOTAL	AMOUNT	286.92	286.92	573.85

SUBTOTAL COST	286.92	286.92	
SUPPORTING CONSTRUCTION	16.07	16.07	
GENERAL CONDITIONS	43.04	43.04	
TOTAL	346.03	346.03	692.06

High-rise Lock

a') 100,000 DWT

CASE L-2'

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	3.30	3.30	6.60
	UNIT PRICE	3.44	3.44	
	AMOUNT	11.35	11.35	22.70
BUCKFILL	QUANTITY	9.80	9.80	19.60
	UNIT PRICE	2.54	2.54	
	AMOUNT	24.89	24.89	49.78
CONCRETE	QUANTITY	4.64	4.64	9.28
	UNIT PRICE	46.67	46.67	
	AMOUNT	216.55	216.55	433.10
REINFORCED BAR	QUANTITY	0.05	0.05	0.09
	UNIT PRICE	742.00	742.00	
	AMOUNT	34.13	34.13	68.26
TOTAL	AMOUNT	286.92	286.92	573.85

SUBTOTAL COST	286.92	286.92	
SUPPORTING CONSTRUCTION	16.07	16.07	
GENERAL CONDITIONS	43.04	43.04	
TOTAL	346.03	346.03	692.06

High-rise Lock

b) 150,000 DWT

CASE L-4,L-5,L-13

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

DESCRIPTION		PACIFIC SIDE 4 CHAMBERS	ATLANTIC SIDE 4 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	4.00	4.00	8.00
	UNIT PRICE	3.44	3.44	
	AMOUNT	13.76	13.76	27.52
BUCKFILL	QUANTITY	11.90	11.90	23.80
	UNIT PRICE	2.54	2.54	
	AMOUNT	30.23	30.23	60.45
CONCRETE	QUANTITY	5.88	5.88	11.76
	UNIT PRICE	46.67	46.67	
	AMOUNT	274.42	274.42	548.84
REINFORCED BAR	QUANTITY	0.06	0.06	0.12
	UNIT PRICE	742.00	742.00	
	AMOUNT	44.52	44.52	89.04
TOTAL	AMOUNT	362.93	362.93	725.85

SUBTOTAL COST	362.93	362.93	
SUPPORTING CONSTRUCTION	20.32	20.32	
GENERAL CONDITIONS	54.44	54.44	
TOTAL	437.69	437.69	875.38

High-rise Lock

c) 250,000 DWT

CASE L-7,L-8,L-16

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

DESCRIPTION		PACIFIC SIDE 4 CHAMBERS	ATLANTIC SIDE 4 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	4.70	4.70	9.40
	UNIT PRICE	3.44	3.44	
	AMOUNT	16.17	16.17	32.34
BUCKFILL	QUANTITY	14.00	14.00	28.00
	UNIT PRICE	2.54	2.54	
	AMOUNT	35.56	35.56	71.12
CONCRETE	QUANTITY	8.39	8.39	16.78
	UNIT PRICE	46.67	46.67	
	AMOUNT	391.56	391.56	783.12
REINFORCED BAR	QUANTITY	0.08	0.08	0.16
	UNIT PRICE	742.00	742.00	
	AMOUNT	59.36	59.36	118.72
TOTAL	AMOUNT	502.65	502.65	1,005.30

SUBTOTAL COST	502.65	502.65	
SUPPORTING CONSTRUCTION	28.15	28.15	
GENERAL CONDITIONS	75.40	75.40	
TOTAL	606.20	606.20	1,212.39

(2) Low-rise Lock 55'

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

a) 100,000 DWT

CASE L-3,L-11

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	1.54	1.54	3.08
	UNIT PRICE	3.44	3.44	
	AMOUNT	5.30	5.30	10.60
BUCKFILL	QUANTITY	8.40	8.40	16.80
	UNIT PRICE	2.54	2.54	
	AMOUNT	21.34	21.34	42.67
CONCRETE	QUANTITY	3.92	3.92	7.84
	UNIT PRICE	46.67	46.67	
	AMOUNT	182.95	182.95	365.89
REINFORCED BAR	QUANTITY	0.04	0.04	0.08
	UNIT PRICE	742.00	742.00	
	AMOUNT	28.94	28.94	57.88
TOTAL	AMOUNT	238.52	238.52	477.04

SUBTOTAL COST	238.52	238.52	
SUPPORTING CONSTRUCTION	13.36	13.36	
GENERAL CONDITIONS	35.78	35.78	
TOTAL	287.65	287.65	575.31

Low-rise Lock 55'

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

b) 150,000 DWT

CASE L-6,L-14

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	1.76	1.76	3.52
	UNIT PRICE	3.44	3.44	
	AMOUNT	6.05	6.05	12.11
BUCKFILL	QUANTITY	9.60	9.60	19.20
	UNIT PRICE	2.54	2.54	
	AMOUNT	24.38	24.38	48.77
CONCRETE	QUANTITY	4.48	4.48	8.96
	UNIT PRICE	46.67	46.67	
	AMOUNT	209.08	209.08	418.16
REINFORCED BAR	QUANTITY	0.05	0.05	0.09
	UNIT PRICE	742.00	742.00	
	AMOUNT	33.39	33.39	66.78
TOTAL	AMOUNT	272.91	272.91	545.82

SUBTOTAL COST	272.91	272.91	
SUPPORTING CONSTRUCTION	15.28	15.28	
GENERAL CONDITIONS	40.94	40.94	
TOTAL	329.13	329.13	658.26

Low-rise Lock 55'

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

c) 250,000 DWT

CASE L-9,L-17

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	2.20	2.20	4.40
	UNIT PRICE	3.44	3.44	
	AMOUNT	7.57	7.57	15.14
BUCKFILL	QUANTITY	12.00	12.00	24.00
	UNIT PRICE	2.54	2.54	
	AMOUNT	30.48	30.48	60.96
CONCRETE	QUANTITY	5.60	5.60	11.20
	UNIT PRICE	46.67	46.67	
	AMOUNT	261.35	261.35	522.70
REINFORCED BAR	QUANTITY	0.06	0.06	0.11
	UNIT PRICE	742.00	742.00	
	AMOUNT	41.55	41.55	83.10
TOTAL	AMOUNT	340.95	340.95	681.90

SUBTOTAL COST	340.95	340.95	
SUPPORTING CONSTRUCTION	19.09	19.09	
GENERAL CONDITIONS	51.14	51.14	
TOTAL	411.19	411.19	822.38

Low-rise Lock 30'

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

a) 100,000 DWT

CASE L-12

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	1.54	1.54	3.08
	UNIT PRICE	3.44	3.44	
	AMOUNT	5.30	5.30	10.60
BUCKFILL	QUANTITY	8.40	8.40	16.80
	UNIT PRICE	2.54	2.54	
	AMOUNT	21.34	21.34	42.67
CONCRETE	QUANTITY	3.78	3.78	7.56
	UNIT PRICE	46.67	46.67	
	AMOUNT	176.41	176.41	352.83
REINFORCED BAR	QUANTITY	0.04	0.04	0.08
	UNIT PRICE	742.00	742.00	
	AMOUNT	28.94	28.94	57.88
TOTAL	AMOUNT	231.98	231.98	463.97

SUBTOTAL COST	231.98	231.98	
SUPPORTING CONSTRUCTION	12.99	12.99	
GENERAL CONDITIONS	34.80	34.80	
TOTAL	279.77	279.77	559.55

Low-rise Lock 30'

b) 150,000 DWT

CASE L-15

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	1.76	1.76	3.52
	UNIT PRICE	3.44	3.44	
	AMOUNT	6.05	6.05	12.11
BUCKFILL	QUANTITY	9.60	9.60	19.20
	UNIT PRICE	2.54	2.54	
	AMOUNT	24.38	24.38	48.77
CONCRETE	QUANTITY	4.32	4.32	8.64
	UNIT PRICE	46.67	46.67	
	AMOUNT	201.61	201.61	403.23
REINFORCED BAR	QUANTITY	0.04	0.04	0.08
	UNIT PRICE	742.00	742.00	
	AMOUNT	29.68	29.68	59.36
TOTAL	AMOUNT	261.73	261.73	523.47

SUBTOTAL COST	261.73	261.73	
SUPPORTING CONSTRUCTION	14.66	14.66	
GENERAL CONDITIONS	39.26	39.26	
TOTAL	315.65	315.65	631.30

Low-rise Lock 30'

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

c) 250,000 DWT

CASE L-18

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	2.20	2.20	4.40
	UNIT PRICE	3.44	3.44	
	AMOUNT	7.57	7.57	15.14
BUCKFILL	QUANTITY	12.00	12.00	24.00
	UNIT PRICE	2.54	2.54	
	AMOUNT	30.48	30.48	60.96
CONCRETE	QUANTITY	5.40	5.40	10.80
	UNIT PRICE	46.67	46.67	
	AMOUNT	252.02	252.02	504.04
REINFORCED BAR	QUANTITY	0.05	0.05	0.10
	UNIT PRICE	742.00	742.00	
	AMOUNT	37.10	37.10	74.20
TOTAL	AMOUNT	327.17	327.17	654.33

SUBTOTAL COST	327.17	327.17	
SUPPORTING CONSTRUCTION	18.32	18.32	
GENERAL CONDITIONS	49.07	49.07	
TOTAL	394.56	394.56	789.12

(3) Tidal Gate Concrete Structure

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

a) 150,000 DWT (1 LANE)

CASE S-1,S-7,S-13,S-16

DESCRIPTION		PACIFIC SIDE	ATLANTIC SIDE	TOTAL
EXCAVATION	QUANTITY	5.85	5.85	11.70
	UNIT PRICE	3.44	3.44	
	AMOUNT	20.12	20.12	40.25
BUCKFILL	QUANTITY	5.55	5.55	11.10
	UNIT PRICE	2.54	2.54	
	AMOUNT	14.10	14.10	28.19
CONCRETE	QUANTITY	1.05	1.05	2.10
	UNIT PRICE	46.67	46.67	
	AMOUNT	49.00	49.00	98.01
REINFORCED BAR	QUANTITY	0.01	0.01	0.02
	UNIT PRICE	742.00	742.00	
	AMOUNT	6.23	6.23	12.47
TOTAL	AMOUNT	89.46	89.46	178.91

SUBTOTAL COST	89.46	89.46	
SUPPORTING CONSTRUCTION	5.01	5.01	
GENERAL CONDITIONS	13.42	13.42	
TOTAL	107.89	107.89	215.77

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

b) 150,000 DWT (2 LANE)

CASE S-2,S-8

DESCRIPTION		PACIFIC SIDE	ATLANTIC SIDE	TOTAL
EXCAVATION	QUANTITY	6.88	6.88	13.76
	UNIT PRICE	3.44	3.44	
	AMOUNT	23.67	23.67	47.33
BUCKFILL	QUANTITY	6.50	6.50	13.00
	UNIT PRICE	2.54	2.54	
	AMOUNT	16.51	16.51	33.02
CONCRETE	QUANTITY	1.26	1.26	2.52
	UNIT PRICE	46.67	46.67	
	AMOUNT	58.80	58.80	117.61
REINFORCED BAR	QUANTITY	0.01	0.01	0.02
	UNIT PRICE	742.00	742.00	
	AMOUNT	7.48	7.48	14.96
TOTAL	AMOUNT	106.46	106.46	212.92

SUBTOTAL COST	106.46	106.46	
SUPPORTING CONSTRUCTION	5.96	5.96	
GENERAL CONDITIONS	15.97	15.97	
TOTAL	128.39	128.39	256.78

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

c) 250,000 DWT (1 LANE)

CASE S-3,S-9,S-14,S-17

DESCRIPTION		PACIFIC SIDE	ATLANTIC SIDE	TOTAL
EXCAVATION	QUANTITY	6.50	6.50	13.00
	UNIT PRICE	3.44	3.44	
	AMOUNT	22.36	22.36	44.72
BUCKFILL	QUANTITY	6.17	6.17	12.34
	UNIT PRICE	2.54	2.54	
	AMOUNT	15.67	15.67	31.34
CONCRETE	QUANTITY	1.28	1.28	2.56
	UNIT PRICE	46.67	46.67	
	AMOUNT	59.74	59.74	119.48
REINFORCED BAR	QUANTITY	0.01	0.01	0.02
	UNIT PRICE	742.00	742.00	
	AMOUNT	7.60	7.60	15.20
TOTAL	AMOUNT	105.37	105.37	210.73

SUBTOTAL COST	105.37	105.37	
SUPPORTING CONSTRUCTION	5.90	5.90	
GENERAL CONDITIONS	15.81	15.81	
TOTAL	127.07	127.07	254.15

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

d) 250,000 DWT (2 LANE)

CASE S-4,S-10

DESCRIPTION		PACIFIC SIDE	ATLANTIC SIDE	TOTAL
EXCAVATION	QUANTITY	7.65	7.65	15.30
	UNIT PRICE	3.44	3.44	
	AMOUNT	26.32	26.32	52.63
BUCKFILL	QUANTITY	7.25	7.25	14.50
	UNIT PRICE	2.54	2.54	
	AMOUNT	18.42	18.42	36.83
CONCRETE	QUANTITY	1.53	1.53	3.06
	UNIT PRICE	46.67	46.67	
	AMOUNT	71.41	71.41	142.81
REINFORCED BAR	QUANTITY	0.01	0.01	0.02
	UNIT PRICE	742.00	742.00	
	AMOUNT	9.08	9.08	18.16
TOTAL	AMOUNT	125.22	125.22	250.44

SUBTOTAL COST	125.22	125.22	
SUPPORTING CONSTRUCTION	7.01	7.01	
GENERAL CONDITIONS	18.78	18.78	
TOTAL	151.01	151.01	302.03

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

c) 300,000 DWT (1LANE)

CASE S-5,S-11,S-15,S-18

DESCRIPTION		PACIFIC SIDE	ATLANTIC SIDE	TOTAL
EXCAVATION	QUANTITY	7.23	7.23	14.46
	UNIT PRICE	3.44	3.44	
	AMOUNT	24.87	24.87	49.74
BUCKFILL	QUANTITY	6.85	6.85	13.70
	UNIT PRICE	2.54	2.54	
	AMOUNT	17.40	17.40	34.80
CONCRETE	QUANTITY	1.50	1.50	3.00
	UNIT PRICE	46.67	46.67	
	AMOUNT	70.01	70.01	140.01
REINFORCED BAR	QUANTITY	0.01	0.01	0.02
	UNIT PRICE	742.00	742.00	
	AMOUNT	8.90	8.90	17.81
TOTAL	AMOUNT	121.18	121.18	242.36

SUBTOTAL COST	121.18	121.18	
SUPPORTING CONSTRUCTION	6.79	6.79	
GENERAL CONDITIONS	18.18	18.18	
TOTAL	146.14	146.14	292.28

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

f) 300,000 DWT (2LANE)

CASE S-6,S-12

DESCRIPTION		PACIFIC SIDE	ATLANTIC SIDE	TOTAL
EXCAVATION	QUANTITY	8.50	8.50	17.00
	UNIT PRICE	3.44	3.44	
	AMOUNT	29.24	29.24	58.48
BUCKFILL	QUANTITY	8.06	8.06	16.12
	UNIT PRICE	2.54	2.54	
	AMOUNT	20.47	20.47	40.94
CONCRETE	QUANTITY	1.80	1.80	3.60
	UNIT PRICE	46.67	46.67	
	AMOUNT	84.01	84.01	168.01
REINFORCED BAR	QUANTITY	0.01	0.01	0.03
	UNIT PRICE	742.00	742.00	
	AMOUNT	10.68	10.68	21.37
TOTAL	AMOUNT	144.40	144.40	288.81

SUBTOTAL COST	144.40	144.40	
SUPPORTING CONSTRUCTION	8.09	8.09	
GENERAL CONDITIONS	21.66	21.66	
TOTAL	174.15	174.15	348.30

(4) Status Quo

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

65,000 DWT

CASE SQ

DESCRIPTION		PACIFIC SIDE 6 CHAMBERS	ATLANTIC SIDE 6 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	2.80	2.80	5.60
	UNIT PRICE	3.44	3.44	
	AMOUNT	9.63	9.63	19.26
BUCKFILL	QUANTITY	8.30	8.30	16.60
	UNIT PRICE	2.54	2.54	
	AMOUNT	21.08	21.08	42.16
CONCRETE	QUANTITY	2.20	2.20	4.40
	UNIT PRICE	46.67	46.67	
	AMOUNT	102.67	102.67	205.35
REINFORCED BAR	QUANTITY	0.01	0.01	0.02
	UNIT PRICE	742.00	742.00	
	AMOUNT	5.94	5.94	11.87
TOTAL	AMOUNT	139.32	139.32	278.65

SUBTOTAL COST	139.32	139.32	
SUPPORTING CONSTRUCTION	7.80	7.80	
GENERAL CONDITIONS	20.90	20.90	
TOTAL	168.02	168.02	336.05

2.3.5 Breakdown of Gate Leaves and Related Facilities

SUM2-1.WJ2

CASE L-1
High-rise Lock
100,000 DWT

GATE LEAF WEIGHT ton	49,851

DESCRIPTION	COST million dol.
LEAVES	466.89
MACHINERY	622.99
ELECTRIC	143.99
OTHERS	30.68
TOTAL	1,264.54

(Including General Condition /Supporting Construction)

SUM2-2.WJ2

CASE L-2
High-rise Lock
100,000 DWT

GATE LEAF WEIGHT ton	48,862

DESCRIPTION	COST million dol.
LEAVES	457.52
MACHINERY	610.49
ELECTRIC	141.10
OTHERS	30.06
TOTAL	1,239.18

(Including General Condition
/Supporting Construction)

CASE L-2'
High-rise Lock
100,000 DWT

GATE LEAF WEIGHT ton	45,178

DESCRIPTION	COST million dol.
LEAVES	427.93
MACHINERY	571.09
ELECTRIC	132.00
OTHERS	28.12
TOTAL	1,159.21

(Including General Condition
/Supporting Construction)

SUM2-3.WJ2

CASE L-3
Low-rise Lock
100,000 DWT

GATE LEAF WEIGHT ton	41,647

DESCRIPTION	COST million dol.
LEAVES	393.37
MACHINERY	524.90
ELECTRIC	121.32
OTHERS	25.85
TOTAL	1,065.44

(Including General Condition
/Supporting Construction)

CASE L-4
High-rise Lock
150,000 DWT

GATE LEAF WEIGHT ton	65,527

DESCRIPTION	COST million dol.
LEAVES	615.92
MACHINERY	821.85
ELECTRIC	189.96
OTHERS	40.47
TOTAL	1,668.20

(Including General Condition
/Supporting Construction)

SUM2-5.WJ2

CASE L-5

High-rise Lock

150,000 DWT

GATE LEAF WEIGHT ton	64,141

DESCRIPTION	COST million dol.
LEAVES	602.53
MACHINERY	803.98
ELECTRIC	185.83
OTHERS	39.59
TOTAL	1,631.92

(Including General Condition /Supporting Construction)

CASE L-6

· Low-rise Lock

150,000 DWT

GATE LEAF WEIGHT ton	54.301

DESCRIPTION	COST million dol.
LEAVES	514.18
MACHINERY	686.09
ELECTRIC	158.58
OTHERS	33.79
TOTAL	1,392.62

(Including General Condition /Supporting Construction)

CASE L-7
High-rise Lock
250,000 DWT

GATE LEAF WEIGHT ton	99,445

DESCRIPTION	COST million dol.
LEAVES	943.55
MACHINERY	1,259.02
ELECTRIC	291.00
OTHERS	62.00
TOTAL	2,555.57

(Including General Condition
/Supporting Construction)

SUM2-8.WJ2

CASE L-8
High-rise Lock
250,000 DWT

GATE LEAF WEIGHT ton	97,241

DESCRIPTION	COST million dol.
LEAVES	921.64
MACHINERY	1,229.78
ELECTRIC	284.24
OTHERS	60.56
TOTAL	2,496.22

(Including General Condition /Supporting Construction)

SUM2-9.WJ2

CASE L-9
Low-rise Lock
250,000 DWT

GATE LEAF WEIGHT ton	75,684

DESCRIPTION	COST million dol.
LEAVES	720.17
MACHINERY	960.95
ELECTRIC	222.11
OTHERS	47.32
TOTAL	1,950.55

(Including General Condition
/Supporting Construction)

SUM2-10.WJ2

CASE L-10
High-rise Lock
100,000 DWT

GATE LEAF WEIGHT ton	48,862

DESCRIPTION	COST million dol.
LEAVES	457.52
MACHINERY	610.49
ELECTRIC	141.10
OTHERS	30.06
TOTAL	1,239.18

(Including General Condition
/Supporting Construction)

SUM2-11.WJ2

CASE L-11
Low-rise Lock
100,000 DWT

GATE LEAF WEIGHT ton	41,647

DESCRIPTION	COST million dol.
LEAVES	393.37
MACHINERY	524.90
ELECTRIC	121.32
OTHERS	25.85
TOTAL	1,065.44

(Including General Condition
/Supporting Construction)

CASE L-12
Low-rise Lock
100,000 DWT

GATE LEAF WEIGHT ton	36,557

DESCRIPTION	COST million dol.
LEAVES	345.53
MACHINERY	461.05
ELECTRIC	106.56
OTHERS	22.70
TOTAL	935.84

(Including General Condition /Supporting Construction)

SUM2-13.WJ2

CASE L-13
High-rise Lock
150,000 DWT

GATE LEAF WEIGHT ton	64,141

DESCRIPTION	COST million dol.
LEAVES	602.53
MACHINERY	803.98
ELECTRIC	185.83
OTHERS	39.59
TOTAL	1,631.92

(Including General Condition
/Supporting Construction)

SUM2-14.WJ2

CASE L-14
Low-rise Lock
150,000 DWT

GATE LEAF WEIGHT ton	54,301

DESCRIPTION	COST million dol.
LEAVES	514.18
MACHINERY	686.09
ELECTRIC	158.58
OTHERS	33.79
TOTAL	1,392.62

(Including General Condition
/Supporting Construction)

SUM2-15.WJ2

CASE L-15
Low-rise Lock
150,000 DWT

GATE LEAF WEIGHT ton	47.158

9,455 $/ton

DESCRIPTION	COST million dol.
LEAVES	445.88
MACHINERY	594.96
ELECTRIC	137.51
OTHERS	29.30
TOTAL	1,207.65

(Including General Condition
/Supporting Construction)

CASE L-16

High-rise Lock

250,000 DWT

GATE LEAF WEIGHT ton	97,241

DESCRIPTION	COST million dol.
LEAVES	921.64
MACHINERY	1,229.78
ELECTRIC	284.24
OTHERS	60.56
TOTAL	2,496.22

(Including General Condition /Supporting Construction)

CASE L-17
Low-rise Lock
250,000 DWT

GATE LEAF WEIGHT ton	75,684

DESCRIPTION	COST million dol.
LEAVES	720.17
MACHINERY	960.95
ELECTRIC	222.11
OTHERS	47.32
TOTAL	1,950.55

(Including General Condition
/Supporting Construction)

CASE L-18
Low-rise Lock
250,000 DWT

GATE LEAF WEIGHT ton	64,668

DESCRIPTION	COST million dol.
LEAVES	611.97
MACHINERY	816.58
ELECTRIC	188.74
OTHERS	40.21
TOTAL	1,657.49

(Including General Condition /Supporting Construction)

SUM2-19.WJ2

CASE S-1
Tidal Gate
150,000 DWT

WEIGHT	ton
LEAVES	13,664
EMBEDDED	2,050
MACHINERY	1,366

DESCRIPTION	COST million dol.
LEAVES	150.30
ACCESSORY	13.53
EMBEDDED	22.55
MACHINERY	21.32
TOTAL	207.69

(Including General Condition
/Supporting Construction)

SUM2-20.WJ2

CASE S-2
Tidal Gate
150,000 DWT

WEIGHT	ton
LEAVES	13,664
EMBEDDED	3,074
MACHINERY	2,733

DESCRIPTION	COST million dol.
LEAVES	150.30
ACCESSORY	13.53
EMBEDDED	33.82
MACHINERY	42.63
TOTAL	240.28

(Including General Condition
/Supporting Construction)

SUM2-21.WJ2

CASE S-3
Tidal Gate
250,000 DWT

WEIGHT	ton
LEAVES	19,046
EMBEDDED	2,857
MACHINERY	1,905

DESCRIPTION	COST million dol.
LEAVES	209.51
ACCESSORY	18.86
EMBEDDED	31.43
MACHINERY	29.71
TOTAL	289.50

(Including General Condition
/Supporting Construction)

CASE S-4
Tidal Gate
250,000 DWT

WEIGHT	ton
LEAVES	19,046
EMBEDDED	4,285
MACHINERY	3,809

DESCRIPTION	COST million dol.
LEAVES	209.51
ACCESSORY	18.86
EMBEDDED	47.14
MACHINERY	59.42
TOTAL	334.92

(Including General Condition
/Supporting Construction)

SUM2-23.WJ2

CASE S-5
Tidal Gate
300,000 DWT

WEIGHT	ton
LEAVES	21,562
EMBEDDED	3,234
MACHINERY	2,156

DESCRIPTION	COST million dol.
LEAVES	237.18
ACCESSORY	21.35
EMBEDDED	35.58
MACHINERY	33.64
TOTAL	327.74

(Including General Condition
/Supporting Construction)

CASE S-6
Tidal Gate
300,000 DWT

WEIGHT	ton
LEAVES	21,562
EMBEDDED	4,851
MACHINERY	4,312

DESCRIPTION	COST million dol.
LEAVES	237.18
ACCESSORY	21.35
EMBEDDED	53.37
MACHINERY	67.27
TOTAL	379.17

(Including General Condition
/Supporting Construction)

CASE S-7
Tidal Gate
150,000 DWT

WEIGHT	ton
LEAVES	13,664
EMBEDDED	2,050
MACHINERY	1,366

DESCRIPTION	COST million dol.
LEAVES	150.30
ACCESSORY	13.53
EMBEDDED	22.55
MACHINERY	21.32
TOTAL	207.69

(Including General Condition
/Supporting Construction)

CASE S-8
Tidal Gate
150,000 DWT

WEIGHT	ton
LEAVES	13,664
EMBEDDED	3,074
MACHINERY	2,733

DESCRIPTION	COST million dol.
LEAVES	150.30
ACCESSORY	13.53
EMBEDDED	33.82
MACHINERY	42.63
TOTAL	240.28

(Including General Condition
/Supporting Construction)

CASE S-9
Tidal Gate
250,000 DWT

WEIGHT	ton
LEAVES	19,046
EMBEDDED	2,857
MACHINERY	1,905

DESCRIPTION	COST million dol.
LEAVES	209.51
ACCESSORY	18.86
EMBEDDED	31.43
MACHINERY	29.71
TOTAL	289.50

(Including General Condition
/Supporting Construction)

CASE S-10
Tidal Gate
250,000 DWT

WEIGHT	ton
LEAVES	19,046
EMBEDDED	4,285
MACHINERY	3,809

DESCRIPTION	COST million dol.
LEAVES	209.51
ACCESSORY	18.86
EMBEDDED	47.14
MACHINERY	59.42
TOTAL	334.92

(Including General Condition
/Supporting Construction)

CASE S-11
Tidal Gate
300,000 DWT

WEIGHT	ton
LEAVES	21,562
EMBEDDED	3,234
MACHINERY	2,156

DESCRIPTION	COST million dol.
LEAVES	237.18
ACCESSORY	21.35
EMBEDDED	35.58
MACHINERY	33.64
TOTAL	327.74

(Including General Condition
/Supporting Construction)

CASE S-12
Tidal Gate
300,000 DWT

WEIGHT	ton
LEAVES	21,562
EMBEDDED	4,851
MACHINERY	4,312

DESCRIPTION	COST million dol.
LEAVES	237.18
ACCESSORY	21.35
EMBEDDED	53.37
MACHINERY	67.27
TOTAL	379.17

(Including General Condition
/Supporting Construction)

CASE S-13
Tidal Gate
150,000 DWT

WEIGHT	ton
LEAVES	13,664
EMBEDDED	2,050
MACHINERY	1,366

DESCRIPTION	COST million dol.
LEAVES	150.30
ACCESSORY	13.53
EMBEDDED	22.55
MACHINERY	21.32
TOTAL	207.69

(Including General Condition
/Supporting Construction)

CASE S-14
Tidal Gate
250,000 DWT

WEIGHT	ton
LEAVES	19,046
EMBEDDED	2,857
MACHINERY	1,905

DESCRIPTION	COST million dol.
LEAVES	209.51
ACCESSORY	18.86
EMBEDDED	31.43
MACHINERY	29.71
TOTAL	289.50

(Including General Condition
/Supporting Construction)

CASE S-15
Tidal Gate
300,000 DWT

WEIGHT	ton
LEAVES	21,562
EMBEDDED	3,234
MACHINERY	2,156

DESCRIPTION	COST million dol.
LEAVES	237.18
ACCESSORY	21.35
EMBEDDED	35.58
MACHINERY	33.64
TOTAL	327.74

(Including General Condition
/Supporting Construction)

CASE S-16
Tidal Gate
150,000 DWT

WEIGHT	ton
LEAVES	13,664
EMBEDDED	2,050
MACHINERY	1,366

DESCRIPTION	COST million dol.
LEAVES	150.30
ACCESSORY	13.53
EMBEDDED	22.55
MACHINERY	21.32
TOTAL	207.69

(Including General Condition
/Supporting Construction)

SUM2-35.WJ2

CASE S-17
Tidal Gate
250,000 DWT

WEIGHT	ton
LEAVES	19,046
EMBEDDED	2,857
MACHINERY	1,905

DESCRIPTION	COST million dol.
LEAVES	209.51
ACCESSORY	18.86
EMBEDDED	31.43
MACHINERY	29.71
TOTAL	289.50

(Including General Condition
/Supporting Construction)

CASE S-18
Tidal Gate
300,000 DWT

SUM2-36.WJ2

WEIGHT	ton
LEAVES	21,562
EMBEDDED	3,234
MACHINERY	2,156

DESCRIPTION	COST million dol.
LEAVES	237.18
ACCESSORY	21.35
EMBEDDED	35.58
MACHINERY	33.64
TOTAL	327.74

(Including General Condition
/Supporting Construction)

SUM2-37.WJ2

CASE SQ
Status Quo
65,000 DWT

GATE LEAF WEIGHT ton	71,212

DESCRIPTION	COST million dol.
LEAVES	675.60
MACHINERY	741.67
ELECTRIC	110.30
OTHERS	25.00
TOTAL	1,552.57

(Including General Condition
/Supporting Construction)

2.3.6 Breakdown of Barrier Dams

SUM3-2.WJ2

(1) Low-rise Lock Canal

a) 30 feet

CASE L-12,L-15,L-18

DESCRIPTION	UNIT	QUANTITY million	UNIT PRICE dollar	AMOUNT million dol.
BARRIER DAMS				
A	m3			
B	m3			
C	m3			
D	m3			
TOTAL		20.30	14.12	286.64

SUBTOTAL	286.64
SUPPORTING CONSTRUCION	16.05
GENERAL CONDITIONS	43.00
TOTAL	345.68

b) 55 feet

CASE L-3,L-6,L-9,L-11,L-14,L-17

DESCRIPTION	UNIT	QUANTITY million	UNIT PRICE dollar	AMOUNT million dol.
BARRIER DAMS				
A	m3	0.80		
B-1	m3	11.30		
B-2	m3	0.60		
B-3	m3	0.20		
B-4	m3	0.20		
C-1	m3	4.30		
C-2	m3	1.80		
C-3	m3	0.70		
D	m3	0.40		
TOTAL		20.30	14.12	286.64

SUBTOTAL	286.64
SUPPORTING CONSTRUCION	16.05
GENERAL CONDITIONS	43.00
TOTAL	345.68

(2) Sea-level Canal

a) Route 14S

CASE S-7,S-8,S-9,S-10,S-11,S-12,S-16,S-17,S-18

DESCRIPTION	UNIT	QUANTITY million	UNIT PRICE dollar	AMOUNT million dol.
BARRIER DAMS				
A	m3			
B	m3			
C	m3			
D	m3			
TOTAL		20.30	14.12	286.64

SUBTOTAL	286.64
SUPPORTING CONSTRUCTION	16.05
GENERAL CONDITIONS	43.00
TOTAL	345.68

b) Route 10

CASE S-1,S-2,S-3,S-4,S-5,S-6,S-13,S-14,S-15

DESCRIPTION	UNIT	QUANTITY million	UNIT PRICE dollar	AMOUNT million dol.
BARRIER DAMS				
E	m3	4.50		
F	m3	5.50		
G	m3	0.70		
TOTAL		10.70	14.12	151.08

SUBTOTAL	151.08
SUPPORTING CONSTRUCTION	8.46
GENERAL CONDITIONS	22.66
TOTAL	182.21

2.3.7 Breakdown of Flood Control System

SUM4.WJ2

CASE S-1,S-2,S-3,S-4,S-5,S-6,S-13,S-14,S-15

DESCRIPTION	QUANTITY million m3	UNIT PRICE dol./m3	TOTAL million dol.
OPEN CHANNEL	8.00	1.32	10.56
TOTAL			10.56

SUBTOTAL	10.56
SUPPORTING CONSTRUCTION	0.59
GENERAL CONDITIONS	1.58
TOTAL	12.74

General Note : The cost of access road is included in the total amount.

2.3.8 Breakdown of New Dams

SUM5-1.WJ2

(1)CASE L-1,L-4,L-5,L-7,L-13

DESCRIPTION	UNIT	QUANTITY million	UNIT PRICE dollar	AMOUNT million dol.
CIRI DAM	m3	1.50	14.65	21.98
TRINIDAD DAM	m3	2.50	13.62	34.05
TOTAL		4.00		56.03

SUBTOTAL	56.03
SUPPORTING CONSTRUCTION	3.14
GENERAL CONDITIONS	8.40
TOTAL	67.57

(2)CASE L-2,L-2',L-8,L-10,L-16

DESCRIPTION	UNIT	QUANTITY million	UNIT PRICE dollar	AMOUNT million dol.
CIRI DAM	m3	1.50	14.65	21.98
TRINIDAD DAM	m3	4.00	12.14	48.56
TOTAL		5.50		70.54

SUBTOTAL	70.54
SUPPORTING CONSTRUCTION	3.95
GENERAL CONDITIONS	10.58
TOTAL	85.07

2.3.9 Breakdown of Pump Station

SUM6.WJ2

CASE L-1,2,2',3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18

Per 1 Lot

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE dollar	AMOUNT million dol.
PUMP STATION				
CONCRETE	m3	14,680	170.00	2.50
EXCAVATION	m3	60,000	4.23	0.25
BUILDING	m2	1,750	1,000.00	1.75
SUBTOTAL				4.50
PUMP,MACHINERY & ELECTRICAL FACILITIES				
PUMP & VALVE	unit	3	7,350,000.00	22.05
MACHINERY	unit	3	4,410,000.00	13.23
ELECTRICAL FAC.	unit	3	2,940,000.00	8.82
SUBTOTAL				44.10
WATERWAY				
EMBANKMENT	m3	33,000	3.00	0.10
EXCAVATION	m3	45,000	4.23	0.19
SUBTOTAL				0.29
RECYCLING POND				
EMBANKMENT	m3	132,000	3.00	0.40
EXCAVATION	m3	5,000,000	4.23	21.15
SUBTOTAL				21.55
TOTAL				70.43

SUBTOTAL	70.43
SUPPORTING CONSTRUCTION	3.94
GENERAL CONDITIONS	10.57
TOTAL	84.94

2.3.10 Breakdown of Partition Wall

SUMT.A02

CASE		S- 2	S- 4	S- 6	S- 8	S-10	S-12
LENGTH OF PARTITION WALL	km	26.0	26.0	26.0	27.0	27.0	27.0
UNIT PRICE	million dollar /km	17.74	20.74	23.68	17.75	20.74	23.68
AMOUNT	million dol.	461.27	539.26	615.78	479.22	560.00	639.47

SUBTOTAL	461.27	539.26	615.78	479.22	560.00	639.47
SUPPORTING CONSTRUCTION	25.83	30.20	34.48	26.84	31.36	35.81
GENERAL CONDITIONS	69.19	80.89	92.37	71.88	84.00	95.92
TOTAL	556.30	650.35	742.64	577.94	675.36	771.20

2.3.11 Breakdown of Break Water

SUM8.WJ2

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE S-1,2,3,4,5,6,13,14,15

DESCRIPTION		PACIFIC SIDE	ATLANTIC SIDE	TOTAL
CORE	QUANTITY	5.59	11.07	16.66
	UNIT COST	0.14	0.24	
	AMOUNT	0.78	2.66	3.44
ARMOR ROCK (0.5 ton)	QUANTITY	0.89	1.11	2.00
	UNIT COST	3.38	6.07	
	AMOUNT	3.02	6.72	9.74
ARMOR ROCK (5.0 ton)	QUANTITY	2.53	2.58	5.12
	UNIT COST	3.38	6.07	
	AMOUNT	8.56	15.68	24.24
TOTAL	AMOUNT	12.37	25.06	37.42

SUBTOTAL COST	12.37	25.06	37.42
SUPPORTING CONSTRUCTION	0.69	1.40	2.10
GENERAL CONDITIONS	1.85	3.76	5.61
CONSTRUCTION COST TOTAL	14.91	30.22	45.13

APPENDIX 1. Breakdown of Lock Concrete Structure(one lane)

APPENDIX1-1.WJ2

(1) High-rise Lock(85',90')100,000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-1,L-2,L-10)

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	1.82	1.82	3.63
	UNIT PRICE	3.44	3.44	
	AMOUNT	6.24	6.24	12.48
BUCKFILL	QUANTITY	7.35	7.35	14.70
	UNIT PRICE	2.54	2.54	
	AMOUNT	18.67	18.67	37.34
CONCRETE	QUANTITY	2.32	2.32	4.64
	UNIT PRICE	46.17	46.17	
	AMOUNT	107.11	107.11	214.23
REINFORCEMENT BAR	QUANTITY	0.02	0.02	0.05
	UNIT PRICE	742.00	742.00	
	AMOUNT	17.07	17.07	34.13
TOTAL	AMOUNT	149.09	149.09	298.19

SUPPORTING CONSTRUCTION	16.70
GENERAL CONDITIONS	44.73
TOTAL	359.61

(2) High-rise Lock(85')100,000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-2')

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	1.82	1.82	3.63
	UNIT PRICE	3.44	3.44	
	AMOUNT	6.24	6.24	12.49
BUCKFILL	QUANTITY	7.35	7.35	14.70
	UNIT PRICE	2.54	2.54	
	AMOUNT	18.67	18.67	37.34
CONCRETE	QUANTITY	2.32	2.32	4.64
	UNIT PRICE	46.17	46.17	
	AMOUNT	107.11	107.11	214.23
REINFORCEMENT BAR	QUANTITY	0.02	0.02	0.05
	UNIT PRICE	742.00	742.00	
	AMOUNT	17.07	17.07	34.13
TOTAL	AMOUNT	149.09	149.09	298.19

SUPPORTING CONSTRUCTION	16.70
GENERAL CONDITIONS	44.73
TOTAL	359.61

(3) High-rise Lock(85',90')150,000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-4,L-5,L-13)

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	2.20	2.20	4.40
	UNIT PRICE	3.44	3.44	
	AMOUNT	7.57	7.57	15.14
BUCKFILL	QUANTITY	8.93	8.93	17.85
	UNIT PRICE	2.54	2.54	
	AMOUNT	22.67	22.67	45.34
CONCRETE	QUANTITY	2.94	2.94	5.88
	UNIT PRICE	46.17	46.17	
	AMOUNT	135.74	135.74	271.48
REINFORCEMENT BAR	QUANTITY	0.03	0.03	0.06
	UNIT PRICE	742.00	742.00	
	AMOUNT	22.26	22.26	44.52
TOTAL	AMOUNT	188.24	188.24	376.47

SUPPORTING CONSTRUCTION	21.08
GENERAL CONDITIONS	56.47
TOTAL	454.03

(4) High-rise Lock(85',90')250,000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-7,L-8,L-16)

DESCRIPTION		PACIFIC SIDE 2 CHAMBERS	ATLANTIC SIDE 2 CHAMBERS	TOTAL
EXCAVATION	QUANTITY	2.59	2.59	5.17
	UNIT PRICE	3.44	3.44	
	AMOUNT	8.89	8.89	17.78
BUCKFILL	QUANTITY	10.50	10.50	21.00
	UNIT PRICE	2.54	2.54	
	AMOUNT	26.67	26.67	53.34
CONCRETE	QUANTITY	4.20	4.20	8.39
	UNIT PRICE	46.17	46.17	
	AMOUNT	193.68	193.68	387.37
REINFORCEMENT BAR	QUANTITY	0.04	0.04	0.08
	UNIT PRICE	742.00	742.00	
	AMOUNT	29.68	29.68	59.36
TOTAL	AMOUNT	258.93	258.93	517.85

SUPPORTING CONSTRUCTION	29.00
GENERAL CONDITIONS	77.68
TOTAL	624.53

(5) Low-rise Lock(55')100,0000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-3,L-11)

DESCRIPTION		PACIFIC SIDE 1 CHAMBER	ATLANTIC SIDE 1 CHAMBER	TOTAL
EXCAVATION	QUANTITY	0.85	0.85	1.69
	UNIT PRICE	3.44	3.44	
	AMOUNT	2.91	2.91	5.83
BUCKFILL	QUANTITY	6.30	6.30	12.60
	UNIT PRICE	2.54	2.54	
	AMOUNT	16.00	16.00	32.00
CONCRETE	QUANTITY	1.96	1.96	3.92
	UNIT PRICE	46.17	46.17	
	AMOUNT	90.49	90.49	180.99
REINFORCEMENT BAR	QUANTITY	0.02	0.02	0.04
	UNIT PRICE	742.00	742.00	
	AMOUNT	14.47	14.47	28.94
TOTAL	AMOUNT	123.88	123.88	247.76

SUPPORTING CONSTRUCTION	13.87
GENERAL CONDITIONS	37.16
TOTAL	298.79

(6) Low-rise Lock(55')150,0000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-6,L-14)

DESCRIPTION		PACIFIC SIDE 1 CHAMBER	ATLANTIC SIDE 1 CHAMBER	TOTAL
EXCAVATION	QUANTITY	0.97	0.97	1.94
	UNIT PRICE	3.44	3.44	
	AMOUNT	3.33	3.33	6.66
BUCKFILL	QUANTITY	7.20	7.20	14.40
	UNIT PRICE	2.54	2.54	
	AMOUNT	18.29	18.29	36.58
CONCRETE	QUANTITY	2.24	2.24	4.48
	UNIT PRICE	46.17	46.17	
	AMOUNT	103.42	103.42	206.84
REINFORCEMENT BAR	QUANTITY	0.02	0.02	0.05
	UNIT PRICE	742.00	742.00	
	AMOUNT	16.70	16.70	33.39
TOTAL	AMOUNT	141.73	141.73	283.47

SUPPORTING CONSTRUCTION	15.87
GENERAL CONDITIONS	42.52
TOTAL	341.86

(7) Low-rise Lock(55')250,0000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-9,L-17)

DESCRIPTION		PACIFIC SIDE 1 CHAMBER	ATLANTIC SIDE 1 CHAMBER	TOTAL
EXCAVATION	QUANTITY	1.21	1.21	2.42
	UNIT PRICE	3.44	3.44	
	AMOUNT	4.16	4.16	8.32
BUCKFILL	QUANTITY	9.00	9.00	18.00
	UNIT PRICE	2.54	2.54	
	AMOUNT	22.86	22.86	45.72
CONCRETE	QUANTITY	2.80	2.80	5.60
	UNIT PRICE	46.17	46.17	
	AMOUNT	129.28	129.28	258.55
REINFORCEMENT BAR	QUANTITY	0.03	0.03	0.06
	UNIT PRICE	742.00	742.00	
	AMOUNT	20.78	20.78	41.55
TOTAL	AMOUNT	177.07	177.07	354.15

SUPPORTING CONSTRUCTION	19.83
GENERAL CONDITIONS	53.12
TOTAL	427.10

(8) Low-rise Lock(30')100,0000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-12)

DESCRIPTION		PACIFIC SIDE 1 CHAMBER	ATLANTIC SIDE 1 CHAMBER	TOTAL
EXCAVATION	QUANTITY	0.85	0.85	1.69
	UNIT PRICE	3.44	3.44	
	AMOUNT	2.91	2.91	5.83
BUCKFILL	QUANTITY	6.30	6.30	12.60
	UNIT PRICE	2.54	2.54	
	AMOUNT	16.00	16.00	32.00
CONCRETE	QUANTITY	1.89	1.89	3.78
	UNIT PRICE	46.17	46.17	
	AMOUNT	87.26	87.26	174.52
REINFORCEMENT BAR	QUANTITY	0.02	0.02	0.04
	UNIT PRICE	742.00	742.00	
	AMOUNT	14.10	14.10	28.20
TOTAL	AMOUNT	120.27	120.27	240.55

SUPPORTING CONSTRUCTION	13.47
GENERAL CONDITIONS	36.08
TOTAL	290.10

(9) Low-rise Lock(30')150,0000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-15)

DESCRIPTION		PACIFIC SIDE 1 CHAMBER	ATLANTIC SIDE 1 CHAMBER	TOTAL
EXCAVATION	QUANTITY	0.97	0.97	1.94
	UNIT PRICE	3.44	3.44	
	AMOUNT	3.33	3.33	6.66
BUCKFILL	QUANTITY	7.20	7.20	14.40
	UNIT PRICE	2.54	2.54	
	AMOUNT	18.29	18.29	36.58
CONCRETE	QUANTITY	2.16	2.16	4.32
	UNIT PRICE	46.17	46.17	
	AMOUNT	99.73	99.73	199.45
REINFORCEMENT BAR	QUANTITY	0.02	0.02	0.04
	UNIT PRICE	742.00	742.00	
	AMOUNT	15.95	15.95	31.91
TOTAL	AMOUNT	137.30	137.30	274.60

SUPPORTING CONSTRUCTION	15.38
GENERAL CONDITIONS	41.19
TOTAL	331.16

(10) Low-rise Lock(30')250,0000DWT

QUANTITY	: million m3
UNIT COST	: dollar
AMOUNT	: million dollar

CASE (L-18)

DESCRIPTION		PACIFIC SIDE 1 CHAMBER	ATLANTIC SIDE 1 CHAMBER	TOTAL
EXCAVATION	QUANTITY	1.21	1.21	2.42
	UNIT PRICE	3.44	3.44	
	AMOUNT	4.16	4.16	8.32
BUCKFILL	QUANTITY	9.00	9.00	18.00
	UNIT PRICE	2.54	2.54	
	AMOUNT	22.86	22.86	45.72
CONCRETE	QUANTITY	2.70	2.70	5.40
	UNIT PRICE	46.17	46.17	
	AMOUNT	124.66	124.66	249.32
REINFORCEMENT BAR	QUANTITY	0.03	0.03	0.05
	UNIT PRICE	742.00	742.00	
	AMOUNT	20.03	20.03	40.07
TOTAL	AMOUNT	171.72	171.72	343.43

SUPPORTING CONSTRUCTION	19.23
GENERAL CONDITIONS	51.51
TOTAL	414.18

APPENDIX 2.

Quantities of Main Equipment and Manpower

(At Midway of Construction Period)

MAINEM.WJ2

150,000 DWT-2 line

	Spec.	Case L-4 Lock Canal (High-rise) Construction Period 7.5 yrs	Case L-6 Lock Canal (Low-rise) Construction Period 7.5 yrs	Case S-2 Route-10 (Sea-level) Construction Period 12.5 yrs	Case S-6 Route 14-S (Sea-level) Construction Period 10.5 yrs
(1) Heavy Equipments					
Bulldozer	86 t - eq.	60	42	100	47
Shovel	15 m3 - eq.	17	16	26	24
Dumptruck	136 t - eq.	154	150	293	249
Bulldozer	60 t - eq.	16	19	32	26
Blast hole drill	165 dia.	36	44	39	77
(2) Dredgers, Barges					
Cutter Suction Dredger	18,000 HP	5	10	1	10
Anchor Boat	600 HP	22	55	2	258
Grab Dredger	50 m3 - 3,000 HP	1	3	1	22
Drag Suction Dredger	7,800 HP	1	1	1	1
Survey Boat	750 HP	1	1	1	1
Pusher Boat	3,200 HP	7	15	1	26
Split Barge	500 HP	13	28	3	51
Blasting Barge	Drill 10 nos 3,000 HP	5	14	1	84
(3) Plants					
Concrete Plant	100-200 m3/H	2	2	2	2
Crushing Plant	250-500 t/H	2	2	2	2
(4) Manpower					
Direct Manpower		8,020	9,820	8,210	17,190
Indirect Manpower		800	980	820	1,720
Total		8,820	10,800	9,030	18,910

APPENDIX 3. Project Cost Distribution by Year
(Assumptions : No advance payment and no retention money)

APPENDIX4-1.WJ2

High-rise Lock Canal

CASE L-4 (150,000 DWT)
Rise 90'

Route I, II, III, IV + Third Lock

unit : million dollar

MAJOR COST COMPONENT	YEAR of EXPENDITURE															Total Cost
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Construction Cost																
Canal Excavation			442.41	663.62	405.55	405.55	405.55	405.55	405.55	553.03						3,686.81
Lock Concrete Structure				245.10	148.81	148.81	148.81	183.85								875.38
Gate Leaves & Related Facillities								667.28	500.46	500.46						1,668.20
Barrier Dams			13.51	10.13	10.13	10.13	10.13	13.54								67.57
Pumping Station			84.94	42.47	42.47	42.47	106.18	106.19								424.72
Indirect Cost																
Administrative Cost	4.36	4.36	8.39	10.04	10.04	10.04	10.04	10.04	10.04	10.04						87.39
Headquaters Cost	40.35	40.34	40.34	6.72	6.72	6.72	6.72	6.72	6.72	6.72						168.07
Construction Supervision	4.43	4.43	14.86	17.74	17.74	17.74	17.74	17.74	17.74	17.74						147.90
Land Acquisition & Land Rights	3.52	3.54	1.76													8.82
Compensation Cost	42.00	42.00	21.00													105.00
Contingency				67.22	67.22	67.22	67.22	134.45	134.45	134.49						672.27
Annual Distribution	94.66	94.67	627.21	1,063.04	708.68	708.68	772.39	1,545.36	1,074.96	1,222.48						7,912.13

High-rise Lock Canal

CASE L-6 (150,000 DWT)
Rise 55'

Route I, II, III, IV + Third Lock

unit : million dollar

MAJOR COST COMPONENT	YEAR of EXPENDITURE															Total Cost
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Construction Cost																
Canal Excavation			786.26	1,179.39	720.74	720.74	720.74	720.74	720.74	982.87						6,552.22
Lock Concrete Structure				184.31	111.90	111.90	111.90	138.25								658.26
Gate Leaves & Related Facillities								557.04	417.80	417.78						1,392.62
Barrier Dams			69.13	51.85	51.85	51.85	51.85	69.15								345.68
Pumping Station			50.96	50.96	50.96	50.96	127.41	178.42								509.67
Indirect Cost																
Administrative Cost	6.14	6.14	11.70	14.14	14.14	14.14	14.14	14.14	14.14	14.14						122.96
Headquaters Cost	56.75	56.75	56.81	9.45	9.45	9.45	9.45	9.45	9.45	9.45						236.46
Construction Supervision	6.24	6.24	20.82	24.97	24.97	24.97	24.97	24.97	24.97	24.97						208.09
Land Acquisition & Land Rights	3.53	3.53	1.76													8.82
Compensation Cost	42.00	42.00	21.00													105.00
Contingency				94.58	94.58	94.58	94.58	189.17	189.17	189.19						945.85
Annual Distribution	114.66	114.66	1,018.44	1,609.65	1,078.59	1,078.59	1,155.04	1,901.33	1,376.27	1,638.40						11,085.63

Sea Level Canal

CASE S-2 (150,000 DWT)
Rise 0'

Route 10

unit : million dollar

MAJOR COST COMPONENT	YEAR of EXPENDITURE															Total Cost
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Construction Cost																
Canal Excavation				1,297.09	1,729.45	864.72	864.72	864.72	864.72	864.72	1,297.13					8,647.27
Tidal Gate Concrete Structure					71.89	43.65	43.65	43.65	53.94							256.78
Gate Leaves & Related Facillities									96.11	72.08	72.09					240.28
Barrier Dams				54.66	41.00	41.00	45.55									182.21
Flood Control System				3.82	2.87	2.87	3.18									
Breakwater				6.77	9.03	4.51	4.51	4.51	4.51	4.51	6.78					
Partition Wall				111.26	66.75	66.75	66.75	66.75	66.75	111.29						556.30
Indirect Cost																
Administrative Cost	3.87	3.87	7.75	14.27	14.21	14.21	14.21	14.21	14.21	14.21	14.21					129.23
Headquaters Cost	59.64	59.64	59.64	34.81	4.97	4.97	4.97	4.97	4.97	4.97	4.97					248.52
Construction Supervision	4.37	4.37	4.37	21.91	26.24	26.24	26.24	26.24	26.24	26.24	26.24					218.70
Land Acquisition & Land Rights	25.30	30.37	30.37	15.18												101.22
Compensation Cost	5.25	6.30	6.30	3.15												21.00
Contingency					99.40	99.40	99.40	99.40	198.81	198.81	198.85					994.07
Annual Distribution	98.43	104.55	108.43	1,562.92	2,065.81	1,168.32	1,173.18	1,124.45	1,330.26	1,296.83	1,620.27					11,653.45

Sea Level Canal

CASE S-8 (150,000 DWT)
Rise 0'

Route 14S

unit : million dollar

MAJOR COST COMPONENT	YEAR of EXPENDITURE															Total Cost
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Construction Cost																
Canal Excavation			2,989.43	4,235.03	1,743.83	1,743.83	1,743.83	1,743.83	1,743.83	1,743.83	1,743.83	1,743.83	3,736.85			24,911.95
Tidal Gate Concrete Structure						71.89	43.65	43.65	43.65	53.94						256.78
Gate Leaves & Related Facillities											96.11	72.09	72.08			240.28
Barrier Dams			103.70	77.78	77.78	86.42										345.68
Partition Wall							115.58	69.35	69.35	69.35	69.35	69.35	115.61			577.94
Indirect Cost																
Administrative Cost	6.84	6.84	20.64	30.80	30.80	30.80	30.80	30.80	30.80	30.80	30.80	30.80	30.80			342.32
Headquaters Cost	197.50	197.50	164.62	9.87	9.87	9.87	9.87	9.87	9.87	9.87	9.87	9.87	9.87			658.32
Construction Supervision	17.37	17.37	52.13	49.24	49.24	49.24	49.24	49.24	49.24	49.24	49.24	49.24	49.29			579.32
Land Acquisition & Land Rights	3.53	3.53	1.76													8.82
Compensation Cost	42.00	42.00	21.00													105.00
Contingency				184.32	184.32	184.32	184.32	184.32	184.32	184.32	447.65	447.65	447.72			2,633.26
Annual Distribution	267.24	267.24	3,353.28	4,587.04	2,095.84	2,176.37	2,177.29	2,131.06	2,131.06	2,141.35	2,446.85	2,422.83	4,462.22			30,659.67