4.4.3 Lighting

A total of 4 lighting units will be provided at both sides of the abutment. These lighting poles will not only illuminate the road surface, but will work as marks of channel for fishing boat.
Besides the 4 lighting poles mentioned above, a total of 8 lighting poles will be provided at intervals of 30 m along the approach road.

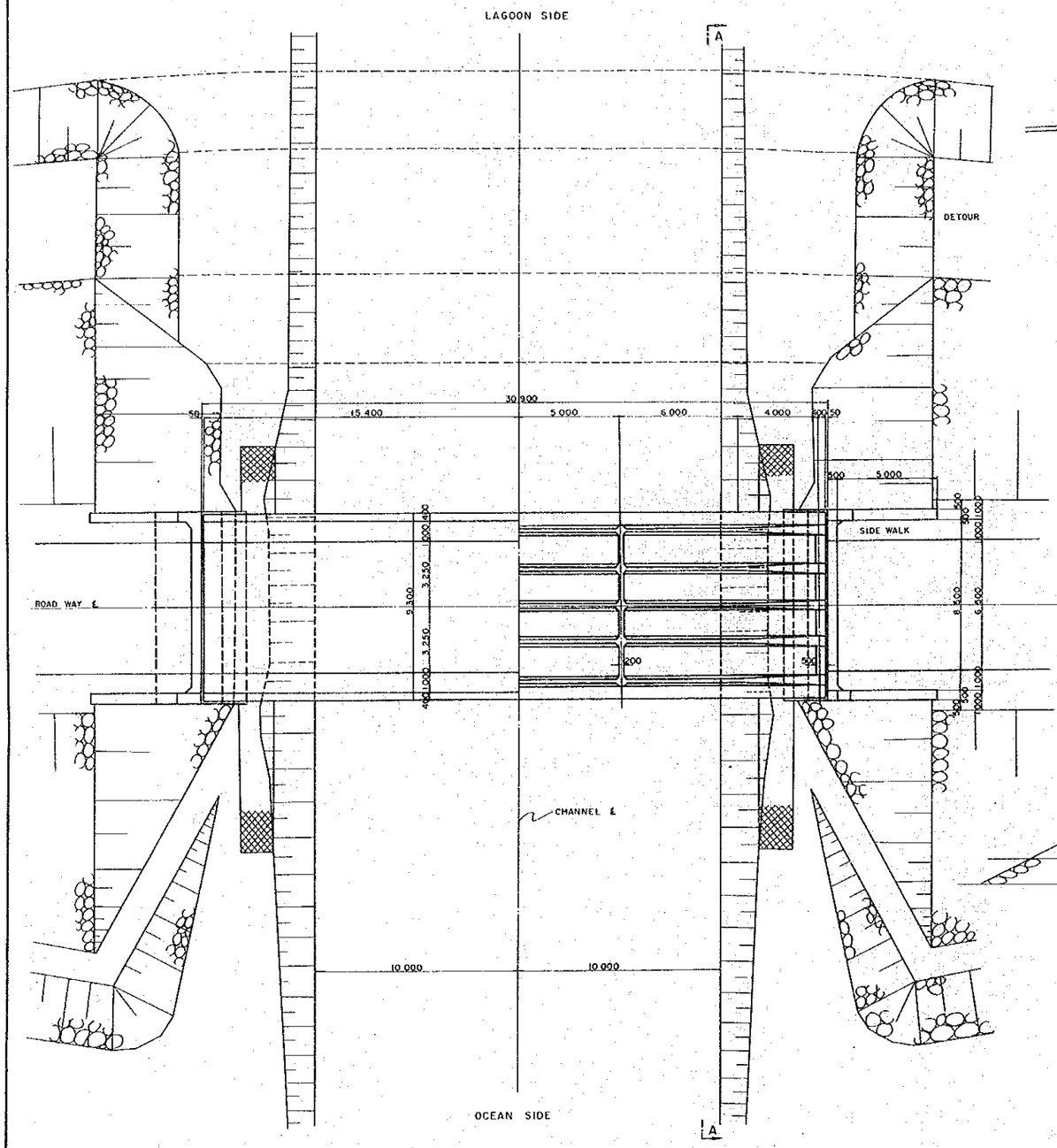
4.4.4 Guardrails

Guardrail made of reinforced concrete will be provided at the section of 30 m at the vicinity of the bridge, while wall type railings consisting of mortal masonry of coral stone will be provided at the remaining sections.

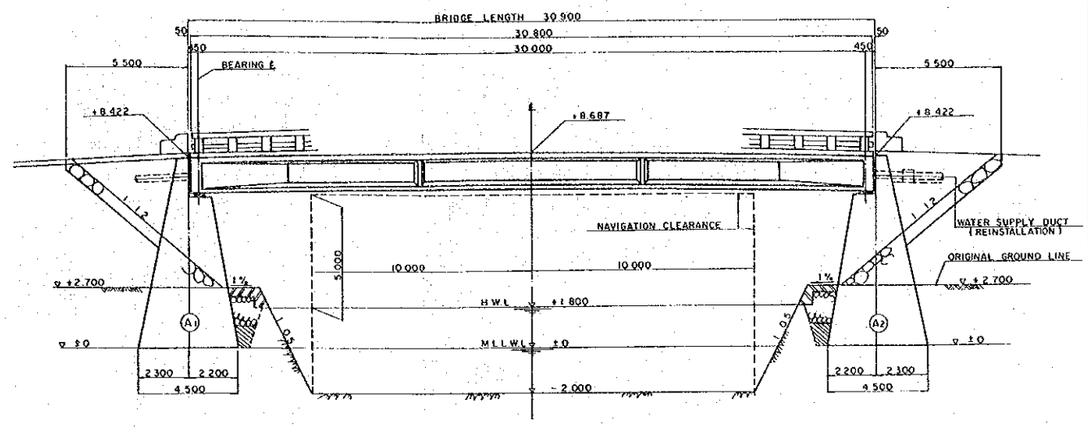
4.5 Navigation Aids

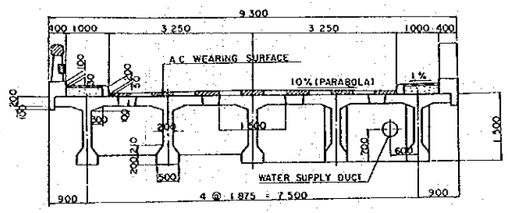
A navigation guidance plate (made of concrete) indicating the channel width and the height limit under the girder will be installed at the center of the bridge, at both sides of the handrails.

PLAN S = 1/100



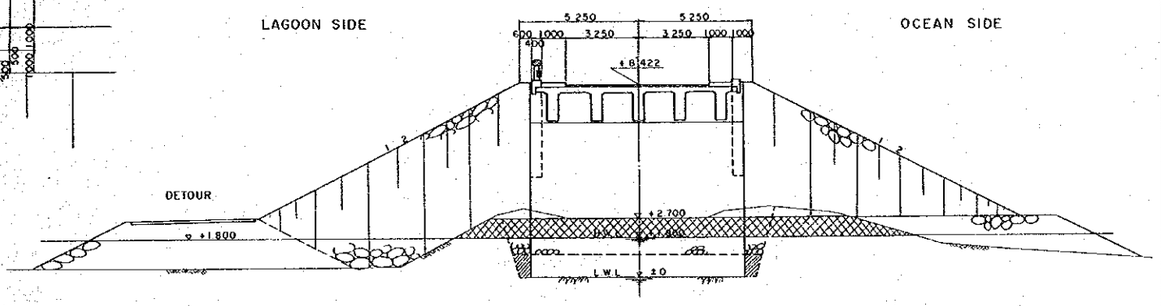
ELEVATION S = 1/100





CROSS SECTION S=1/50

SECTION "A" S = 1/100



DESIGN CRITERIA

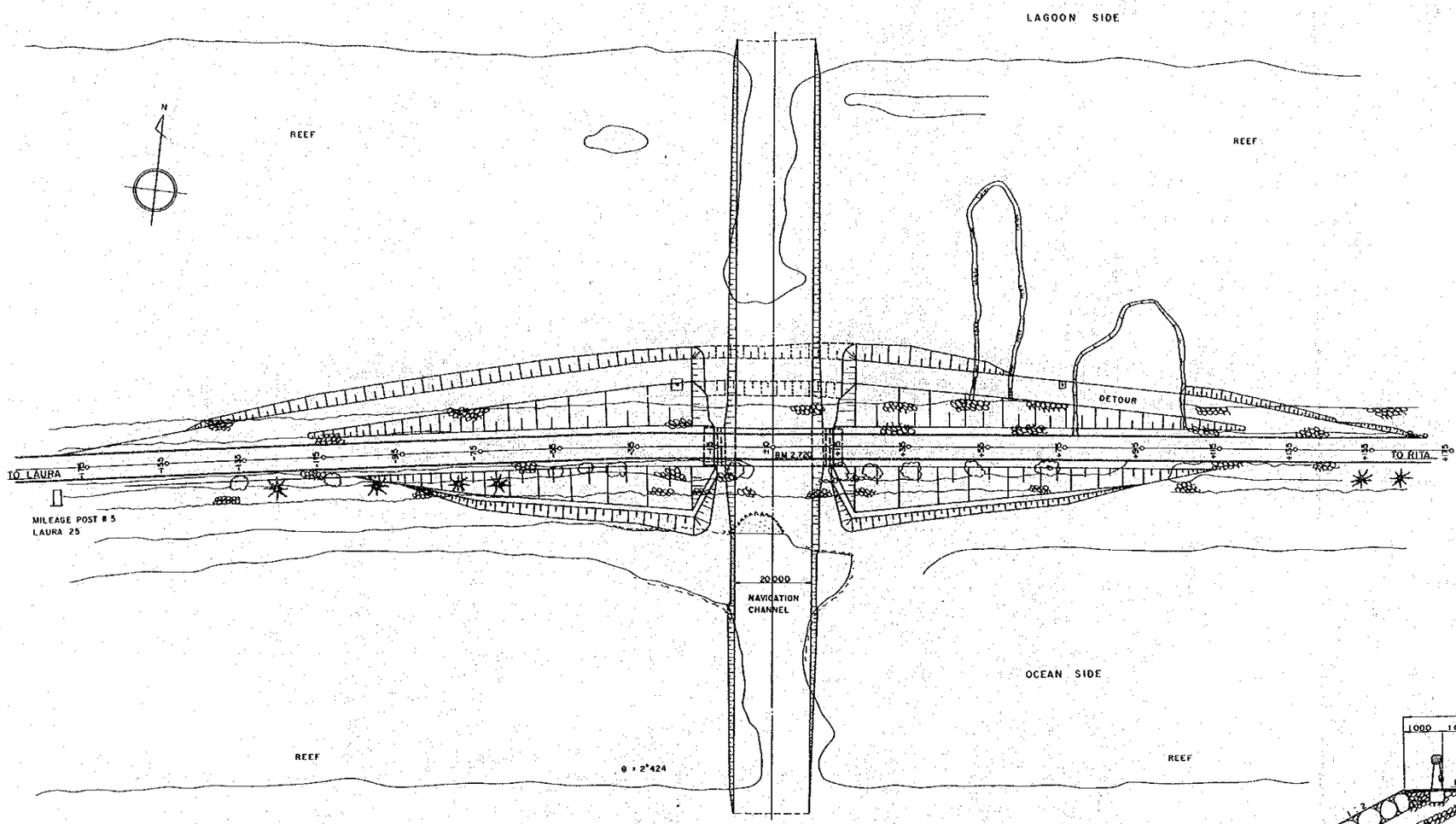
SUPER STRUCTURE ; POST TENSIONING PC T-BEAM

1. LIVE LOAD ; AASHTO HS 20-44 OR EQUAL
2. CONCRETE SHALL HAVA A MINIMUM COMPRESSIVE STRENGTH OF $400^{kg}/cm^2$ FOR MAIN BEAM AND OF $300^{kg}/cm^2$ FOR OTHER AT THE AGE OF 28 DAYS.
3. PC-CABLE SHALL HAVE A MINIMUM YIELD STRENGTH OF $15000^{kg}/cm^2$ FOR MAIN CABLE AND OF $12500^{kg}/cm^2$ FOR OTHER.
4. REINFORCING STEEL SHALL HAVE A MINIMUM YIELD STRENGTH OF $3000^{kg}/cm^2$.

SUB STRUCTURES ; GRAVITY - TYPE

5. CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF $210^{kg}/cm^2$ FOR BRIDGE SEAT AND OF $180^{kg}/cm^2$ FOR OTHER AT THE AGE OF 28 DAYS.
6. REINFORCING STEEL SHALL HAVE A MINIMUM YIELD STRENGTH OF $3000^{kg}/cm^2$.

PLAN S = 1/500

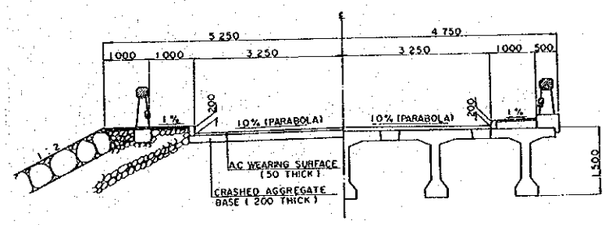


GEOMETRIC DESIGN STANDARDS

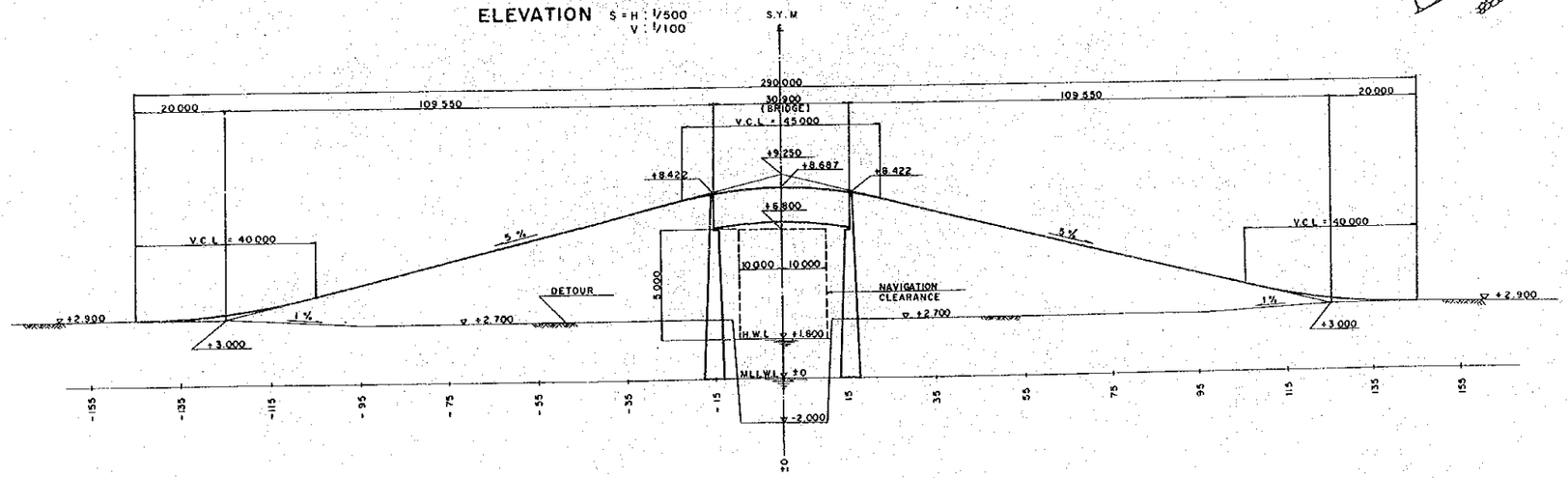
DESIGN SPEED		40 km/h
WIDTH OF CARRIAGE WAY		6.50 m
WIDTH OF SIDE WALK		1.00 m
WIDTH OF SHOULDER		1.00 m
MAXIMUM GRADIENT		5.0 %
MINIMUM VERTICAL RADIUS		450 m
NAVIGATION CLEARANCE	WIDTH	20 m
	HIGHT ABOVE H.W.L	5.00 m

CROSS SECTION S = 1/50

EMBANKMENT BRIDGE

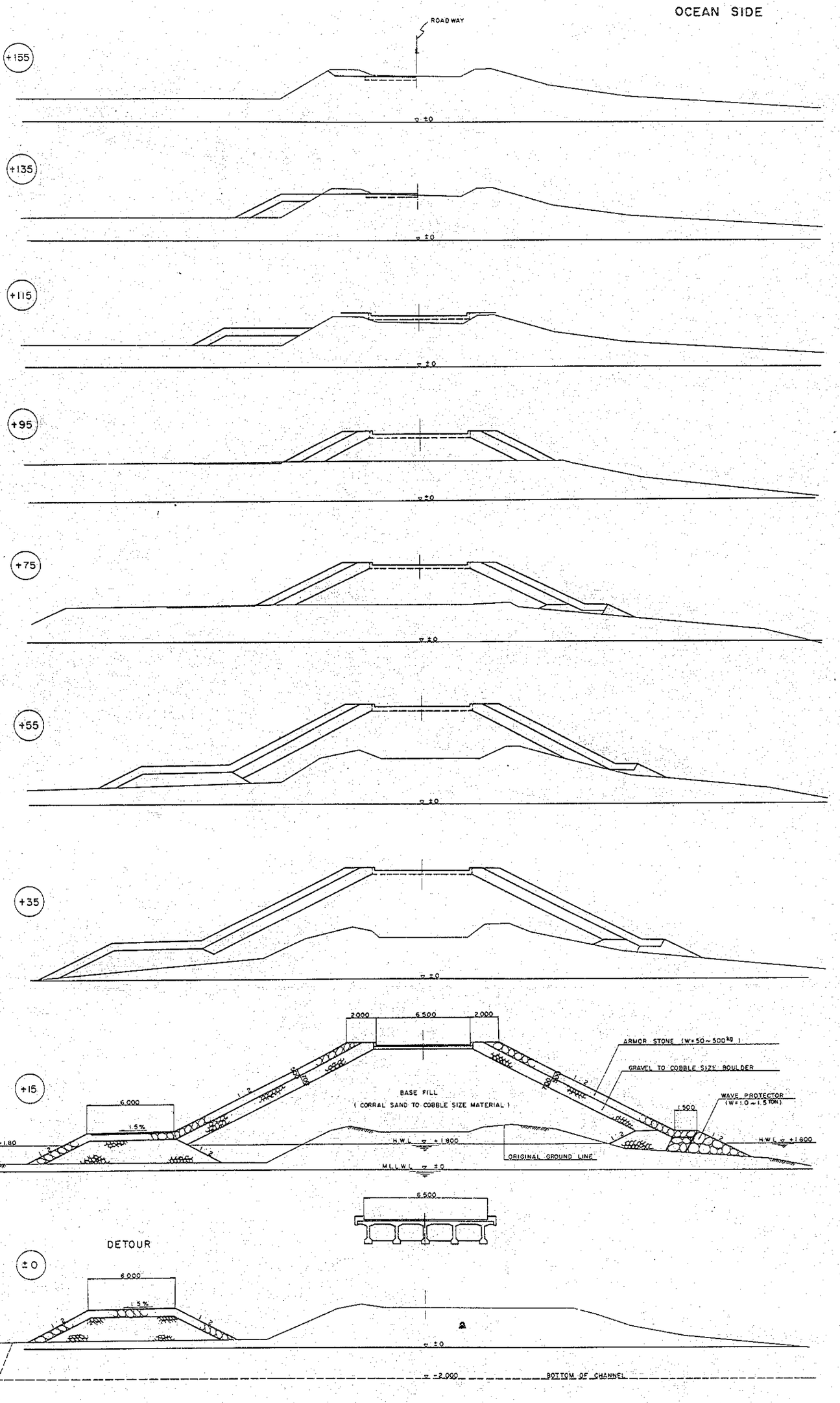


ELEVATION S = H : 1/500 V : 1/100



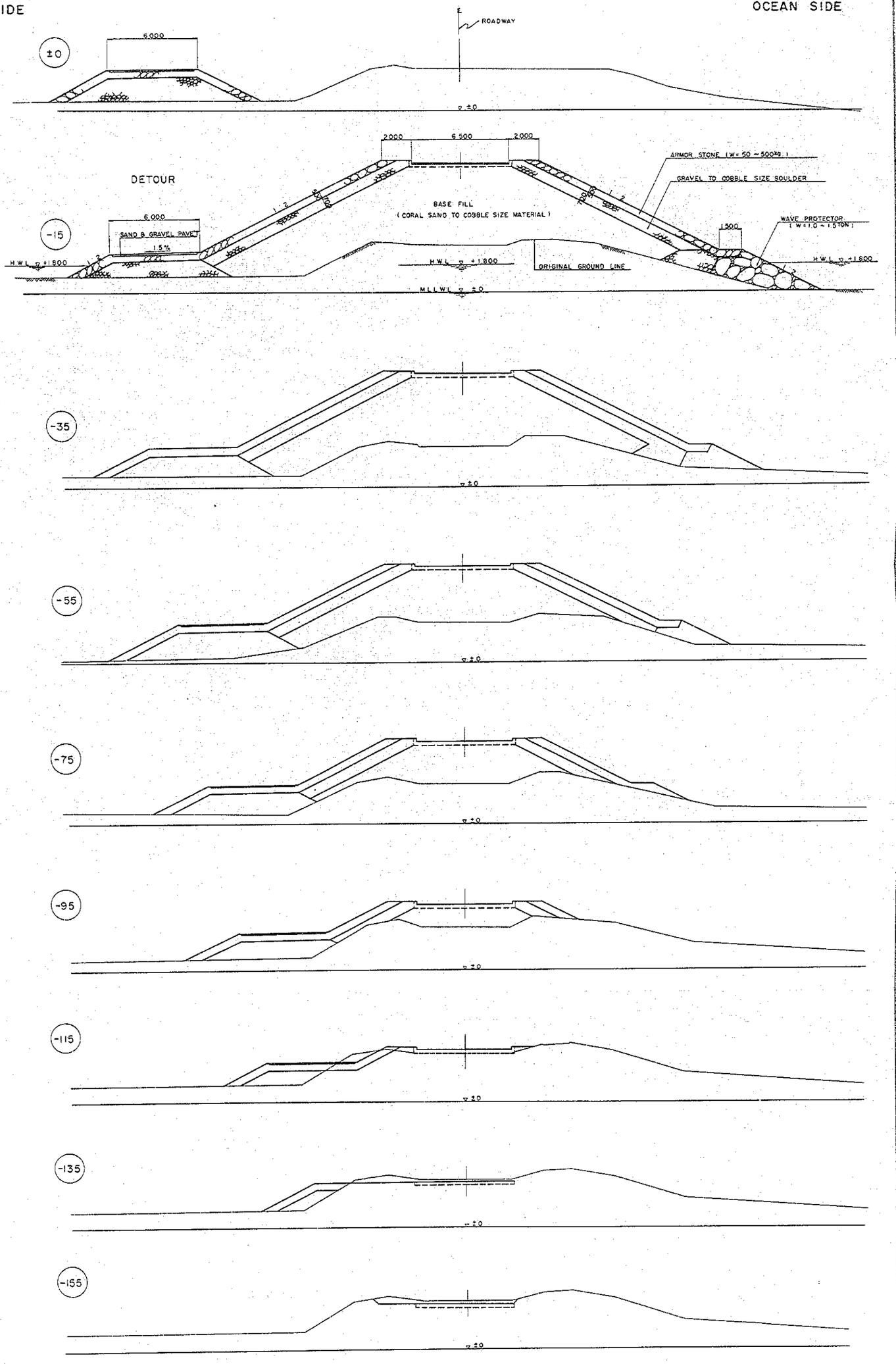
LAGOON SIDE

OCEAN SIDE



LAGOON SIDE

OCEAN SIDE



V System for Implementation of the Project

V. SYSTEM FOR IMPLEMENTATION OF THE PROJECT

1. Organ Responsible for Implementation of the Project

The ministry of Public Works will be responsible for implementation of this project. The Government of the Marshall Islands assigns an engineer responsible for the project (Project Coordinator) in order to set forth in a smooth manner every work related to the project, including the construction of the channel, bridges, approach roads and other utility appurtenances.

The detailed design and the supervision of the construction work shall be under the responsibility of the Japanese Consultant Engineer.

The construction work shall be carried out with a Japanese construction firm working as contractor. However, with regard to part of the works, local construction companies might work as subcontractors.

2. Plan for Execution of the Construction Works

2.1 Civil Works

The construction of the detour should be executed in advance of any thing else. Therefore, the excavation of the channel should be started in the first stage, in order to obtain the material required land fill for detour. The construction of the substructure and filling of approach road should be started after changing the traffic to the detour.

Sand, crushed stone and other filling materials required in the construction work should be obtained from the debris resulting from the excavation of the channel and sand dredged from Majuro lagoon.

2.2 Substructure

One of the abutment should be constructed in advance, while the other one should be constructed a little later. The excavation should be carried out medhanically, by using explosives at the bedrock and the finishing work at the vicinity of the botom should be carried out manually.

Concrete should be transported by mixer tracks from the plant located in Majuro and should be casted either manually or with bucket.

2.3 Superstructure

The main girders should be constructed in parallel with the substructure work, at a place where it does not interfere with the substructure work, and should be installed on the piers by means of a crane as soon as the substructure work is completed. It is possible to construct the superstructure with cast-in-place concrete using bent, but this method is disadvantageous from the point of view of required construction time, because the constuction of the superstructure can be started only after completion of the substructure.

2.4 Construction of Road

The approaches at both sides of the bridge should be constructed simultaneously. The rubble mound at the ocean side should be constructed in the first place and then the filling and the reventment works should be execute in parallel. The pavement should be constructed after laying the water pipes and constructing the curbstones and handrails. Bulldozer and vibrating roller should be used for rolling compaction of the subgrade, while crane should be used for construction of rubble mound and masonry work of slope gradient.

2.5 Excavation of the Channel

The excavation of channel should be carried out by using rock drill and explosives. Dredging of broken stones should be carriyd out by using backhoe, the collection of lumps should be carried out by using dozer shovels and other similar machinery and the said debris should be transported to the prescribed place by using dump trucks.

3. Scope of Work

The works to be carried out within the scope of the Japan's grand aid are as follows.

(1) A small fishing boat channel;

(2) A bridge over the channel, including approach roads with railings;

(3) Temporary road during construction period;

(4) Utility appurtenances

1) Lighting

2) Traffic control devices

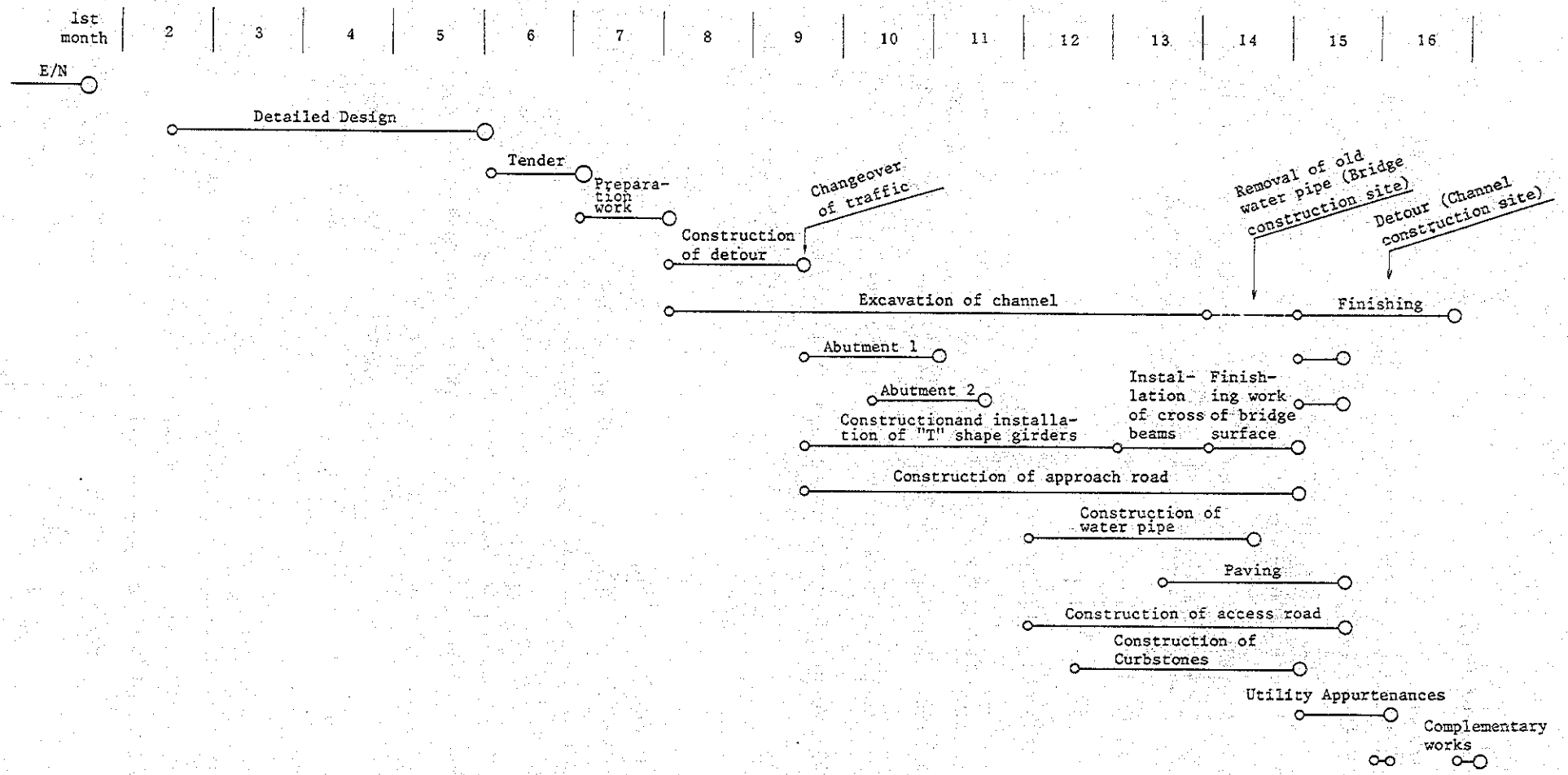
3) Navigation aids

4) Water supply mains of the Project Site;

(5) Temporary work to remove water pipes;

(6) Detailed designing and supervising services.

4. Construction Schedule



5. Maintenance and Operation

In principle, this is a maintenance-free work. However, the repair of damages occurring on the pavement, damages caused by accidents and maintenance of the lighting facilities shall be undertaken by the Ministry of Public Work, together with teh routine administration work of ordinary roads.

Water pipes under bridge require periodic inspection, and this job should be handled in the same way as the maintenance and operation of steel pipes of the filtration plant and pumping station.

With regard to the improvement of water quality resulting from the excavation of the channel and tidal current in the channel caused by difference of tidal range between lagoon and ocean, the Ministry of Public Work shall carry out the relevant observations, in order to provide data and information for future projects of this kind.

6. Procurement

6.1 Materials

Materials required for implementation of the project should be brought from Japan, because they are not available locally. The major items of materials which should be brought from Japan are as follows.

Cement
Fine aggregate and coarse aggregate
Prestressing tendon
Bearing shoes and expansion joints
Reinforcing bars
Asphalt (bitumen)

Other materials like cat's-eye for centerline of road, etc.

6.2 Machinery

The execution of the construction works involved in this project is possibly by using locally available machinery. However, it is required to take in at least one backhoe or more for execution of excavation works, because only one machine of this kind is available locally at present. In addition, it is also required to take in one set of machinery for construction of the main girders.

6.3 Manpower

The bridge of this project is a PC girder, requiring therefore specialized labor for its construction. Accordingly technician for erection of the main girder, installation of the fixing apparatuses, cable tensioning, grouting inside sheath, etc., will be required at the occasion of construction of the superstructure.

As for the construction of the substructure, the relevant works can be carried out by using the locally available manpower, by providing one expert supervisor.

VI Project Evaluation

VI. PROJECT EVALUATION

1. Economic Evaluation

1.1 Objectives of Evaluation

This project is evaluated in relation to the trolling of fishing boats of the DUD area of the Majuro Atoll for the following reasons:

(1) Almost all benefits brought by the new channel are received by the fishing boats in the DUD area.

(2) Especially, almost all the benefits are received by the trolling fishery operated in the open sea, 99% of the landing from the trolling fishery are occupied by the DUD area.

1.2 Evaluation Method

A presumption is made that 100% of the consumed fish are supplied domestically from the standpoint of improvement of protein nourishment supply and import substitution.

The catch effort is to be increased to satisfy this condition and the benefit that comes out of the pertinent project is evaluated by the total benefit consisting of beneficial factors on cost and time saving. The price used in this calculation is the price as of 1981.

(1) Demand forecast

The estimated fish demand in the Majuro Atoll based on the population growth and consumption per capita is about 650 tons in 1990 and about 1,100 tons in 2000. In addition, they consume chicken and if the chicken consumption is converted to fish, the total estimated protein demand is about 900 tons in 1990 and about 1,400 tons in 2000 (Tables 15 and 16).

(2) Target of catch and operation frequency of small fishing boat

The fish demand of the Majuro inhabitants can be satisfied by trawling operation of 16 to 19 DUD fishing boats in 1990 and 27 to 33 boats in 2000. Increase of catch is not planned on reef fishes in the reef areas and bottom fishes in the lagoon since these fishing grounds are limited and the population must be protected. The

target is to be hit by increase of pelagic fishes caught by DUD small fishing boats (Table 17).

(3) Annual benefit

The annual benefit is calculated using the following formula:

$$Y = A(B_1 + B_2)$$

where, Y : Annual benefit (¥/yr)
A : Number of operations (count/yr)
B_1: Cost saving benefit per operation (¥)
B_2: Time saving benefit per operation (¥)

(4) Cost saving benefit per operation

The cost saving benefit per operation is calculated using the following formula:

$$B_1 = 2(D_1 - D_2) \times \frac{1}{E} \times F$$

where, B_1: Cost saving benefit per operation (¥)
D_1: Average sailing distance from DUD area to the fishing ground (without project) (¥)
D_2: Average sailing distance from DUD area to the fishing ground (with project) (¥)
E : Fuel consumption efficiency (km/ℓ)
F : Fuel price (¥/ℓ)

(5) Time saving benefit per operation

The time saving benefit per operation is calculated using the following formulae:

$$B_2 = aT$$

$$a = \frac{W}{P} \times (1 + b)^n \times \frac{1}{K \times L} \times R \times N$$

$$T = 2(D_1 - D_2) \times \frac{1}{S}$$

where, B_2: Time saving benefit per operation((¥)
a : Value of time (¥/hr)
T : Time saving (hours)
W : Total wave ($)
P : Total number of laborers (persons)

b : Rate of annual wage raise

n : Number of years

K : Number of working days (days/yr)

L : Working hours per day (hours/day)

R : Foreign exchange rate (dollars to yen)

N : Number of crews (persons)

D_1 : Average sailing distance from DUD area to the fishing ground (without project) (km)

D_2 : Average sailing distance from DUD area to the fishing ground (with project) (km)

S : Sailing speed (km/hr)

1.3 Benefit Calculation

(1) Cost saving benefit per operation

The cost saving benefit per operation is calculated as follows:

$$B_1 = 2(54.2 - 32.3) \times \frac{1}{1.5} \times 93$$

$$= ¥2,716/\text{operation}$$

Data source:

F : Retail price in Majuro (price in December, 1981, based on ¥220:$1.00)

(2) Time saving benefit per operation

The time saving benefit per operation is calculated as follows:

$$a = \frac{8,065,000}{3,343} \times (1 + 0.035)^2 \times \frac{1}{260 \times 8} \times 220 \times 3$$

$$= ¥820/\text{hr}$$

$$T = 2(54.2 - 32.3) \times \frac{1}{40}$$

$$= 1.1 \text{ hours}$$

$$B_2 = 820 \times 1.1$$

$$= ¥902/\text{operation}$$

Data source:

W : Majuro Development Plan (1981), price of 1979

P : Majuro Development Plan (1981), price of 1979

b : Majuro Development Plan (1981)

n : 2 years (from 1979 to 1981)

K : Interview with Majuro inhabitants (December, 1981)

L : Interview with Majuro inhabitants (December, 1981)

R : Foreign exchange rate of December, 1981

N : Interview with Majuro inhabitants (December, 1981)

D_1 & D_2: Table 13 and Figs. 1 and 2

S : Table 10

(3) Annual benefit

The annual benefit on cost and time saving is calculated as follows:

$$Y = A(2,716 + 902)$$
$$= ¥3,618 \times A$$

Assuming that the channel is usable from 1983, the catch target, number of fishing operations and annual benefit (based on the prices of 1981) of trolling by fishing boats in the DUD area are calculated and the results are shown below: (Table 14)

Table 3 Annual Benefit

Year	Catch target (ton)	No. of operation	Annual benefit (¥ million)		
			Cost saving	Time saving	Total saving
1983	409.8	3,518	9.6	3.2	12.7
1992	653.8	5,612	15.2	5.1	20.3
2002	1,116.8	9,586	26.0	8.6	34.7

Note: The second place figure from the decimal point (¥10,000) was rounded by counting fractions of .05 and over as .1 and disregarding the rest. Therefore, the total values in the "Total saving" column do not necessarily match with the total of the expense saving and time saving values.

1.4 Cost-Benefit Analysis

Cost benefit analysis is carried out to understand the effect of the investment in case of the Government of the Marshall Islands invests directly to the project.

(1) Project Life

Project life: 20 years (1982 - 2002)
Construction duration: 1982 - March 1983

Cost benefit is calculated based on 20 years project life from 1982 to 2002.

(2) Cost

Construction cost (rough estimatation): ¥240,000,000.-
Maintenance cost: 1% per year

(3) Benefit

The project brings two kinds of benefit, direct benefit and indirect benefit.
Direct benefit: Time and cost saving of fishing operation
Indirect benefit: Benefit by production increase
Cost benefit is calculated by direct benefit only. To calculate indirect benefit is quite hard due to the difficulty of forecasting methodology of fish price and fish resources in the future.

(4) Evaluation

Economic Internal Rate of Return (EIRR) of this project was given 4.2% on the basis of above mentioned condition. Economical Effect of this project is not so high from the figure (Table 25, 26, 27). However, value of time on which calculated time saving benefit is not included increase of net national income in the future. Therefore calculated value is evaluated at lower side.
Moreover, after the completion of the project, about 30% of fishing operation will be increased, and this increase will bring indirect benefit.

In accordance with the mentioned above consideration the project expects direct benefit (time and cost saving benefit of the fishing operation) and indirect benefit of fisheries.

Consequently, this project will contribute economic growth of Marshall Islands.

2. Social Effect

2.1 Effect of Environmental Improvement

While the new channel contributes a little to improvement of the whole water in the lagoon, partial improvement of water in and around the channel area can be expected since the polluted water in the lagoon will flow out to the ocean and clean water will flow from the open sea into the lagoon.

2.2 Fish Migration Effect

Since the water is mixed between the lagoon and the open sea through the new channel, various reef fishes are expected to migrate into the lagoon through the channel. Reef fishes on the outer reef are expected to settle on the inner reef after the water improvement around the channel.

2.3 Welfare and Safety Effect

The distance between the DUD area and fishing areas in the south of Majuro Atoll is about 80 km and it takes about 2 hour to reach to fishing area by small boat, if passing through the Calalin Channel of the atoll north. In order to save time, often these boats dare the risk of crossing the reef at the edge of Darrit at high tide, and accidents causing mortality do occur. The new channel will eliminate the need of crossing the reef, and safety in the voyage becomes high. Also, emergency refuse is much easier when the weather changes suddenly.

2.4 Relationship with Arno Atoll

The Majuro and Arno atolls are very close and the linear distance is only about 20 km. However, since boats must go through the Calalin Channel of Majuro Atoll and the Dodo Channel of Arno Atoll, the actual sailing distance between the two atolls is about 110 km. Opening of the new channel in the Majuro Atoll shortens the distance only by 10 km.

The sailing distance by crossing the reef at the Arno Island north at high tide daring a certain degree of danger, is 70 km through the Calalin Channel and 35 km through the new fishing boat channel, and this is a substantial saving in the distance.

While additional investments are needed in many ways, the Arno Atoll will be receiving great benefit socially and economically from this new channel.

3. Indirect Effect

Expansion of industries by effect utilization of marine resources and increase of employment opportunities are expected as indirect effect of teh pertinent project.

VII Conclusions

VII. CONCLUSIONS

The major economic development on the Marshall Islands would be the establishment of fishery. However, the fisheries in Majuro Atoll, the capital of Marshall Islands, are in primitive stage yet and small fishing boats are currently inaccessable and practically unreachable to the fishing ground in the south of the atoll.

The effect of this project related to opening of a new channel for small fishing boats is great for development of the fisheries in Majuro and Arno Atoll.

Further, the following direct and indirect effects are expectable from realization of this project:

(a) Enthusiasm of the people to fisheries will become greater since the fuel consumption is economized, the operation hours can be extended and the sailing is safer.

(b) The relationship with the Arno Atoll is made closer and safety of the sailing is improved.

(c) The lagoon water around the channel will be able to flush itself cleaner through tidal circulation. Also, entry of pelagic fishes into the lagoon can be expected.

(d) Inhabitants have a lot of interest in realizing the new channel, and the project can be positioned as a monumentary project of independence.

(e) The bridge will be a symbol of Jajuro Atoll and it helps promote friendship between Marshall Islands and Japan.

Thus, it is recommendable that this project is an appropriate project to which the Japanese government provides the grant.

VIII Reference Materials

VIII. REFERENCE MATERIALS

Table 1 Organization of Study Team

Name	Speciality	Present Title
Mr. Sunao Sakai	Team leader	Disaster Prevention and Coastal Protection Div., Fishing Port Dept., The Fisheries Agency
Mr. Koichi Kobayashi	Cooperation Planner	Construction Div., Fishing Port Dept., The Fisheries Agency
Mr. Masanobu Nishizu	Economic Cooperator	Development Cooperation Div., Economic Cooperation Bureau, The Ministry of Foreign Affairs
Mr. Katsuyuki Hioki	Bridge Engineer	Chodai Co., Ltd
Mr. Hiroyuki Namiki	Civil Engineer	Chodai Co., Ltd
Mr. Shigeru Shimura	Fisheries General	Chodai Co., Ltd

Table 2 Related Parties of Marshall Islands

	Name	Present Title
1.	Honorable AMATA KABUA	President of the Marshall Islands
2.	Honorable KUNAR ABNER	Minister of Public Works
3.	Honorable KESAI NOTE	Minister of Resources and Development
4.	Honorable OSCAR deBRUM	Chief Secretary
5.	Honorable CHARLES DOMINIC	Chairman of Maritime Authority (Secretary of Public Works)
6.	Mr. TONY deBRUM	Secretary of Foreign Affairs
7.	Mr. STEVE MULLER	Deputy Secretary of Foreign Affairs; Far East Affairs and Fisheries
8.	Mr. EDINAL JORKAN	Assistant Secretary of Foreign Affairs
9.	Mr. JOHN PAUL JONES	Office Manager of Foreign Affairs
10.	Mr. JAMES A. ABERNATHY	Special Projects Coordinator
11.	Mr. JOHNNY LASAO	Civil Engineer, Planning Div., MOPW
12.	Miss MARIE MADDISON	Chairwoman, Public Service Communication
13.	Mr. LARRY BARING	Security Office, Foreign Affairs
14.	Mr. RUDY MULLER	Port Director
15.	Mr. DANNY WASE	Manager of Majuro Fisherman Cooperative Association
16.	Mr. OSCAR MILNE	Weather Station Majuro, Official Incharge
17.	Mr. DEAN ROBB	Legal Adviser, Fisheries
18.	Mr. BUJEN JACOB	District Sanitarian, Ministry of Health Services
19.	Mr. TONY FERRER	Marshall Islands High School
20.	Mr. KUNIO LIBOKMETO	Marshall Islands High School
21.	Mr. ABE HICKING	Marshall Islands High School
22.	Mr. JERRY KRAMER	Pacific International Inc.

Consulate in Agana

Mr. Hiroshi Ohi	Consulate-general
Mr. Fumio Shionoiri	Consul
Mr. Noboru Sudo	Vice-consul

Table 3 Survey Team Schedule

December 11, Friday	Left Narita at 10:15 and arrived Guam at 15:45 via CO 620. Visited the Consulate in Agana Stayed in Guam.
December 12, Saturday	Left Guam at 15:10 and arrived Majuro at 23:45 via CO 618. Met by Mr. Steve.
December 13, Sunday	Preparation for survey Preliminary survey and meeting of members
December 14, Monday	Visit to the Marshall Islands Governemnt. Made a curtesy call to the President. Explained the inception report and determined the survey schedule.
December 15, Tuesday	Visit to the site and meeting with Ministry of Public Works (PW). Surveyed the whole area of the southern side of the atoll and selected the site for bridge.
December 16, Wednesday	Meeting with PW and measurement of the project site Conferred on the matter of setting the project site and measured the site. Gave explanation on grant of the Japanese government.
December 17, Thursday	Meeting with PW and measurement at the field Conducted vertical and lateral measurements. Collected information from PW on matters of bridge construction and civil engineering.
December 18, Friday	Visit to PW, Pacific International Inc. (PII), and Majuro Fishermen's Cooperative Association (MFCA). Collected information.
December 19, Saturday	Home work Construction cost calculation, preparation of general charts, and arrangement of data
December 20, Sunday	Field survey Made a boat trip for survey of the northern side of the atoll. prepared the minutes of meeting (draft) and worked on various reference data.
December 21, Monday	Meeting with PW Concluded the Minutes of Meeting.

December 22, Tuesday	Field survey and visit to MFCA. Collected further data and discussed the construction schedule within the team members.
December 23, Wednesday	Field survey and courtesy visit to the Marshall Islands government. Measured the traffic volume, interviewed fishermen and investigated the construction machinery situation.
December 24, Thursday	Field survey Conducted airoplane survey over Majuro and Arno atolls. Sakai, Kobayashi and Nisuzu left Majuro at 10:35 and arrived from at 15:57. Visited the Consulate in Agana. Set a tentative bench for the project and collected information on Japanese fishing vessels.
December 25, Friday	Home work and field survey Set the measurement results in order. Surveyed the environmental and contamination situation within the atoll. Sakai, Kobayashi and Nisuzu left Guam at 6:30 and arrived Narita at 9:50.
December 26, Saturday	Field survey Surveyed the southwestern part of the atoll.
December 27, Sunday	Field survey Conducted plane surveying of the site and sea bottom investigation.
December 28, Monday	Visit to PW and Meteorological observatory. Collected and rearranged the information.
December 29, Tuesday	Meeting with PW and departure Left Majuro at 12:35 and arrived Guam at 16:57 via CO 617. Had a meeting with the consulate. Stayed in Guam.
December 30, Wednesday	Left Guam at 6:35 and arrived Narita at 9:50 via CO 615.

Table 4 List of Typical Fish Species by Major Fish Group (English and Scientific Name)

Pelagic fishes	
Albacore	Thunnus alalunga
Bigeye tuna	Thunnus obesus
Yellowfin tuna	Thunnus albacares
Skipjack tuna	Katsuwonus pelamis
Sail fish	Istiophorus platypterus
Blue marlin	Makaira nigricans
Wahoo (Spanish mackerel)	Acanthocybium solandri
Mackerels	Rastrelliger spp.
Dolfin	Coryphaena hippurus
Needle fishes	Belonidae
Flying fishes	Exocoetidae
Reef fishes	
Rabbit fishes	Signidae
Mullet	Mugilidae
Parrot fishes	Scaridae
Rudder fishes	Kyphosidae
Trigger fishes	Balistidae
Bat fish	Platax orbicularis
Bottom fishes	
Groupers	Epinephelus spp.
Snappers	Lutjanidae
Blacktipped soldierfishes	Holocentridae
Big eyes	Priacanthidae
Emperors	Lethrinidae
Needle fishes	Belonidae
Trevally	Alectis spp.

Table 5 Fish Landings by Major Fish Group by Area at MFCA in 1978

Unit: tons

Major fish group	Area		
	D.U.D.	Others	Total
Pelagic fish	92.5 (72.5)* [99.0]	0.9 (0.7)* [1.0]	93.4 (73.2)* [100.0]
Others	13.6 (10.7)*	20.6 (16.1)*	34.2 (26.8)*
Total	106.1 (83.2)*	21.5 (16.8)*	127.6 (100.0)*

Source: Rearranged from Table 2 1
Fish landings from unknown area are excluded.

Remarks: * : Figures in parentheses indicate shares of fish landings by major fish group by area to the ground total.

Table 6 Monthly Average Fish Landings per Operation at MFCA

Month	Pelagic fishes		Reef fishes		Bottom fishes	
	lbs	kg	lbs	kg	lbs	kg
1977						
Sept.	200.4	90.9	56.0	25.4	57.7	26.2
Oct.	258.7	117.3	63.8	28.9	30.8	14.0
Nov.	234.0	106.0	70.0	31.8	36.4	16.5
Dec.	238.9	108.4	63.4	28.8	51.5	23.4
1978						
Jan.	183.8	83.4	57.4	26.0	57.0	25.9
Feb.	294.0	133.3	56.0	25.4	58.0	26.3
Mar.	-	-	-	-	-	-
Apr.	247.1	112.1	72.4	32.8	56.6	25.7
May	253.5	115.0	81.4	36.9	49.8	22.6
Jun.	232.5	105.5	76.5	34.7	42.0	19.1
Jul.	-	-	-	-	-	-
Aug.	272.5	123.6	89.7	40.7	47.8	21.7

Remarks; - : No data

Source: Compiled by unpublished data on daily catches by major fish group from September 1977 to August 1978 (data lacking in March and July 1978) obtained from the Majuro Fishermen's Cooperative Association in December 1981.

Table 7 Number of Landing Times by Major Fish Group at MFCA

	Pelagic fishes	Reef fishes	Bottom fishes	Total
1977				
Sept.	78	378	198	654
Oct.	97	163	68	328
Nov.	62	156	60	278
Dec.	66	125	49	240
1978				
Jan.	34	101	32	167
Feb.	68	67	30	165
Mar.	-	-	-	-
Apr.	57	69	41	167
May	69	78	24	171
Jun.	53	96	35	184
Jul.	-	-	-	-
Aug.	82	62	32	176

Source: Compiled by unpublished data on daily catches by major fish group from September 1977 to August 1978 (data lacking in March and July 1978) obtained from the Majuro Fishermen's Cooperative Association in December 1981.

Remarks: Average number of landings for pelagic fishes are 80.0 times per month and 960 times per annum.

Table 8 Number of Fishing Boats in Majuro and Arno Atolls

Atoll	Area	Number of fishing boats
Majuro	Darrit	25
	Uliga	10
	Dalap	15
	Laura	15
	Others	5
	Subtotal	70
Arno		5
Total		75

Remarks: Number of fishing boats, four to nine meter long and powered with outboard engines or diesel engines, were estimated from the interview with the manager of the Majuro Fishermen's Cooperative Association in December 1981.

Table 9 Fuel Consumption per Fishing Operation

Outboard engine (H/P × No.)	Fuel consumption			
	Open sea		Lagoon	
	(gallon)	(liter)	(gallon)	(liter)
25 × Twin	30	114	12	45
50 × Twin	40	151	-	-
50 × Twin	40	151	10	38
50 × Twin	50	189	15	57
50 × Twin	60	227	25	95
85 × Twin	50	189	-	-
85 × Twin	60	227	-	-
85 × Twin	70	265	30	114

Remarks: 1 gallon = 3.785 liter

Source: Results of interview with local fishermen of D.U.D. area in December 1981

Table 10 Some Typical Fishing Boat Performance

Boat size (m)	Engines	Tank volume (A)	No. of crews	Speed (km/h)		Maximum cruising speed (C)	Maximum fuel consumption (D)	Cruising range per unit fuel (km/ℓ)	
Length × Width	H/P × No.	(ℓ)	(person)	Maximum (B)	Economical	(km/h)	(ℓ/h)	Maximum (B/D)	Minimum (C/A)
5.0 × 2.0	55 × 2	48	2	68	40	134	45	2.8	1.5
5.0 × 2.0	55 × 2	48	5	64	43	96	47	2.0	1.4
5.9 × 2.4	55 × 2	120	3	65	41	252	46	2.1	1.4
5.9 × 2.4	55 × 2	120	7	59	37	228	47	1.8	1.3
5.9 × 2.4	115 × 1	120	2	67	38	240	44	2.0	1.5
5.9 × 2.4	115 × 1	120	7	62	44	210	43	1.8	1.4
7.3 × 2.4	55 × 2	48	2	53	28	106	48	2.2	1.1
7.3 × 2.4	55 × 2	48	8	53	30	86	50	1.8	1.1
7.3 × 2.4	115 × 1	24	2	56	36	42	47	1.8	1.2
7.3 × 2.4	115 × 1	24	8	55	41	39	47	1.6	1.2

Source: Unpublished data obtained from Yamaha Motor Co., Ltd. in January 1982.
Data indicate the most efficient performance under calm weather conditions.

Table 11 Number of Fishermen and Their Fish Landings by Fishing Method at MFCA in 1978

Fishing method	No. of fishermen (persons)	Fish landing (lbs)		
		Max.	Min.	Average
Trolling	45	70,078	4	4,588
Spear	133	3,815	6	322
Hook	103	2,714	9	207
Net	133	2,521	5	198

Remarks: (1) Number of fishermen is 282, in total.

(2) Compiled by unpublished data on fish ladning by individual fishermen by fishing method obtained from the Majuro Fishermen's Cooperative Association in December 1981.

Table 12 Retail Price of Local Fish, Imported Frozen Fish, Canned Fish and Imported Meat

Item	Price ($)
Local fish	
Skipjack	0.95/1b.
Reef fish	1.00/1b.
Imported frozenfish	
Skipjack	0.90/1b.
Mackerel	0.60/1b.
Canned fish	
Mackerel	0.85/425 g.
Sardine	1.10/300 g.
Tune	1.35/200 g.
Meat	
Frying chicken	0.79/1b.

Source: Price at the Robert Reimers Super Market in December 1981.

Table 13 Distance from D.U.D. Area and Zone of Fishing Ground in the Open Sea, with or without the Project

Distance from D.U.D. area (km)	Zone of fishing ground (km^2)	
	Without	With
0 - 5	0	0
5 - 10	0	43
10 - 15	0	115
15 - 20	0	256
20 - 25	7	403
25 - 30	72	377
30 - 35	148	305
35 - 40	213	266
40 - 45	216	223
45 - 50	256	246
50 - 55	312	173
55 - 60	338	72
60 - 65	354	0
65 - 70	266	0
70 - 75	190	0
75 - 80	95	0
80 - 85	13	0
Total	2,480	2,480

Remarks: (1) See also Figs. 1 and 2.

(2) Average distance from D.U.D. area

without the project: 54.2 km
with the project : 32.3 km

Table 14 Target Catches of Pelagic Fishes by D.U.D. Fishing Boats and the Projected Annual Benefit

Year	Target catches (tons)	No. of times of operation	Benefit (1,000,000 yen) *		
			by Fuel cost saving	by Time saving	Total
1983	409.8	3,518	9.6	3.2	12.7
1984	431.8	3,706	10.1	3.3	13.4
1985	454.8	3,904	10.6	3.5	14.1
1986	477.8	4,101	11.1	3.7	14.8
1987	502.8	4,316	11.7	3.9	15.6
1988	529.8	4,548	12.4	4.1	16.5
1989	556.8	4,779	13.0	4.3	17.3
1990	586.8	5,037	13.7	4.5	18.2
1991	618.8	5,311	14.4	4.8	19.2
1992	653.8	5,612	15.2	5.1	20.3
1993	690.8	5,930	16.1	5.3	21.5
1994	728.8	6,256	17.0	5.6	22.6
1995	769.8	6,608	17.9	6.0	23.9
1996	812.8	6,977	18.9	6.3	25.2
1997	857.8	7,363	20.0	6.6	26.6
1998	902.8	7,749	21.0	7.0	28.0
1999	954.8	8,196	22.2	7.4	29.7
2000	1,006.8	8,642	23.5	7.8	31.3
2001	1,060.8	9,106	24.7	8.2	32.9
2002	1,116.8	9,586	26.0	8.6	34.7

Remarks: * : Current price in 1981

Table 15 Projected Population and Fish Demand in Majuro Atoll in 1990 and 2000

Item	Year		
	1980	1990	2000
Population *1	11,893	16,020	22,610
Per capita GDP *2 (US $)	955	1,187	1,475
Fish consumption index *3 (100 in 1980)	100	117	136
Fish demand in gross weight			
a) Without substitution for poultry			
Total (tons/year)	415	652	1,072
Per capita (kg/year)	34.9	40.7	47.4
b) With substitution for poulty			
Total (tons/year)	547	858	1,411
Per capita (kg/year)	46.0	53.6	62.4

Source : *1: Majuro Development Plan (1981)

*2: Wastewater Facilities Plan Marshall District (1979); current price in 1977. The projected growth rate of per capita GDP is estimated to 2.2% (a=0.022) based on "Low case growth of GNP per person in 1980-1990 of middle-income oil importing developing countries" in "World Development Report, 1981".

*3: Income elastisity of fish: e=0.7.

Index: $100(1 + a \times e)^n$, a=0.022, e=0.7, n=10,20.

Table 16 Projected Population and Fish Demand in Majuro Atoll from 1980 to 2000

Year	Population	Projected fish consumption in gross weight			
		Without substitution for poultry		With substitution for poultry	
		Total (tons)	Per capita (kg)	Total (tons)	Per capita (kg)
1980	11,893	415	34.9	547	46.0
1981	12,252	434	35.4	572	46.7
1982	12,622	454	36.0	598	47.4
1983	13,004	475	36.5	627	48.2
1984	13,396	497	37.1	655	48.9
1985	13,801	520	37.7	686	49.7
1986	14,217	543	38.2	717	50.4
1987	14,646	568	38.8	750	51.2
1988	15,089	595	39.4	785	52.0
1989	15,544	622	40.0	821	52.8
1990	16,010	652	40.7	858	53.6
1991	16,572	684	41.3	902	54.4
1992	17,153	719	41.9	949	55.3
1993	17,755	756	42.6	996	56.1
1994	18,378	794	43.2	1,048	57.0
1995	19,023	835	43.9	1,100	57.8
1996	19,691	878	44.6	1,156	58.7
1997	20,382	923	45.3	1,215	59.6
1998	21,098	968	45.9	1,279	60.6
1999	21,839	1,020	46.7	1,343	61.5
2000	22,610	1,072	47.4	1,411	62.4

Table 17 Target Catches of Pelagic Fishes by D.U.D. Fishing Boats in 1983, 1990 and 2000

Year	without substitution for poultry			with substitution for poultry		
	1983	1990	2000	1983	1990	2000
Estimated fish demands (tons)	475	652	1,072	627	858	1,411
Target catches of pelagic fish by D.U.D. fishing boats (tons)*	409.8	586.8	1,006.8	561.8	792.8	1,345.8
Catch per fishing operation (kg)	116.5	116.5	116.5	116.5	116.5	116.5
Number of times of fishing operation						
per annum	3,518	5,037	8,642	4,822	6,805	11,551
per month	293	420	720	402	567	963
per day **	13.5	19.4	33.2	18.5	26.2	44.4
Catch per fishing operation (kg)	142.8	142.8	142.8	142.8	142.8	142.8
Number of times of fishing operation						
per annum	2,870	4,109	7,050	3,934	5,552	9,424
per month	239	342	588	328	463	785
per day **	11.0	15.8	27.1	15.1	21.3	36.2

Remarks: * : The projected catches of other fishes or by other area are estimated to be constrant to the present condition (65.2 tons).

** : Equivalent to number of fishing boats in operation per day, on the basis that one fishing boat goes fishing once per day.
Calculated on the assumption of no fishing operation on Saturday and Sunday.

Table 18 . Monthly fish landings by major fish group at MFCA in 1978

Month	Pelagic fishes		Reef fishes		Bottom fishes		Lobsters		Total	
	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)
Jan.	5,533	3,209	5,640	3,328	1,841	1,086	0	0	13,014	7,623
Feb.	19,844	11,655	3,745	2,215	1,727	1,026	122	98	25,438	14,994
Mar.	26,611	15,745	6,410	3,802	1,620	985	9	8	34,650	20,540
Apr.	14,964	8,360	4,975	2,955	2,329	1,417	12	10	22,280	12,742
May	16,400	9,860	6,365	3,539	1,126	635	5	4	23,896	14,038
June	12,132	5,913	7,107	3,685	1,383	678	0	0	20,622	10,276
July	23,215	11,762	8,653	4,555	728	338	70	63	32,666	16,718
Aug.	19,298	9,857	4,830	2,344	1,379	679	73	73	25,580	12,953
Sept.	20,255	10,284	6,707	3,196	2,644	1,221	25	21	29,631	14,722
Oct.	17,315	8,987	7,140	3,489	4,508	2,094	45	41	29,008	14,611
Nov.	19,515	10,463	4,101	2,047	1,969	965	15	14	25,600	13,489
Dec.	13,122	7,952	1,992	1,247	2,148	1,184	29	29	17,291	10,412
Total	208,204	114,047	67,665	36,402	23,402	12,308	405	361	299,676	163,118
Total (kg)	94,316		30,652		10,601		183		135,753	

Source: Unpublished data, obtained from the Majuro Fishermen's Cooperative Association in December 1981.

Table 19 . Monthly fish landings by major fish group at MFCA in 1979

Month	Pelagic fishes		Reef fishes		Bottom fishes		Lobsters		Total	
	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)
Jan.	15,010	9,694	4,516	2,992	4,100	2,736	4	4	23,630	15,426
Feb.	20,601	13,948	4,245	2,843	3,217	2,092	0	0	28,063	18,883
Mar.	45,699	28,719	3,303	2,059	2,042	1,185	0	0	51,044	31,963
Apr.	18,043	11,053	4,090	2,635	1,457	865	0	0	23,590	14,553
May	31,588	19,165	6,502	4,083	2,351	1,375	0	0	40,441	24,623
June	44,076	24,318	3,322	1,840	2,323	1,321	3	3	49,724	27,482
July	36,860	19,858	8,202	4,672	5,581	2,591	11	10	50,654	27,131
Aug.	34,034	17,925	10,157	5,651	4,294	2,354	48	44	48,533	25,974
Sept.	17,882	9,413	3,869	2,410	824	444	56	50	22,631	12,317
Oct.	19,030	10,156	1,888	1,055	519	206	0	0	21,437	11,417
Nov.	14,895	7,840	3,036	1,819	557	310	0	0	18,488	9,969
Dec.	1,912	1,054	781	519	191	104	0	0	2,884	1,677
Total	299,630	173,143	53,911	32,578	27,450	15,583	122	111	381,119	221,415
Total (kg)	135,732		24,421		12,435		55		172,647	

Source: Unpublished data, obtained from the Majuro Fishermen's Cooperative Association in December 1981.

Table 20. Monthly fish landings by major fish group at MFCA in 1980

Month	Pelagic fishes		Reef fishes		Bottom fishes		Lobsters		Total	
	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)	Quantity (lbs)	Value ($)
Jan.	2,291	1,590	1,294	869	364	234	0	0	3,949	2,693
Feb.	4,571	3,344	1,313	971	487	332	0	0	6,371	4,647
Mar.	1,120	892	1,544	1,207	245	181	4	4	2,913	2,284
Apr.	1,262	1,044	2,140	1,717	288	224	0	0	3,690	2,985
May	10,811	9,242	2,641	1,989	703	528	0	0	14,155	11,759
June	1,039	425	4,168	3,210	839	526	4	4	6,050	4,165
July	17,091	13,996	9,688	7,075	1,940	1,325	27	27	28,746	22,423
Aug.	13,078	7,696	5,890	4,033	1,239	754	61	61	20,268	12,544
Sept.	9,053	5,095	3,304	2,302	1,714	1,090	77	67	14,148	8,554
Oct.	22,473	12,002	1,374	1,012	486	309	6	6	24,339	13,329
Nov.	5,424	2,859	1,779	1,419	228	132	0	0	7,431	4,410
Dec.	3,942	2,073	352	240	74	60	0	0	4,368	2,373
Total	92,155	60,258	35,487	26,044	8,607	5,695	179	169	136,428	92,166
Total (kg)	41,746		16,076		3,899		81		61,802	

Source: Unpublished data, obtained from the Majuro Fishermen's Cooperative Association in December 1981.

Table 21 . Fish landings by area by fishing method in 1978

Area	Fishing Method: Trolling (lbs)	Trolling (kg)	Spear (lbs)	Spear (kg)	Hook (lbs)	Hook (kg)	Net (lbs)	Net (kg)	Total (lbs)	Total (kg)
Darrit	193,903	87,838	2,974	1,347	3,333	1,510	7,218	3,270	207,428	93,965
Uliga	4,415	2,000	4,546	2,059	1,899	860	1,862	843	12,722	14,003
Dalap	5,796	2,626	4,562	2,067	944	428	2,101	1,224	14,003	6,343
D.U.D. subtotal	204,114	92,464	12,082	5,473	6,176	2,798	11,781	5,337	234,153	106,071
Laura	140	63	22,703	10,284	14,373	6,510	5,750	2,605	42,966	19,464
Arno	1,859	842	74	34	310	140	2,202	998	4,445	2,014
Subtotal	206,113	93,369	34,859	15,791	20,859	9,449	19,733	8,939	281,564	127,548
Unknown	309	140	7,960	3,606	430	195	705	319	9,404	4,260
Total	206,422	93,518	42,819	19,397	21,289	9,643	20,438	9,258	290,968	131,809

Remarks: Compiled by unpublished data on fish landing by individual fishermen by fishing method obtained from the Majuro Fishermen's Cooperative Association in December 1981.

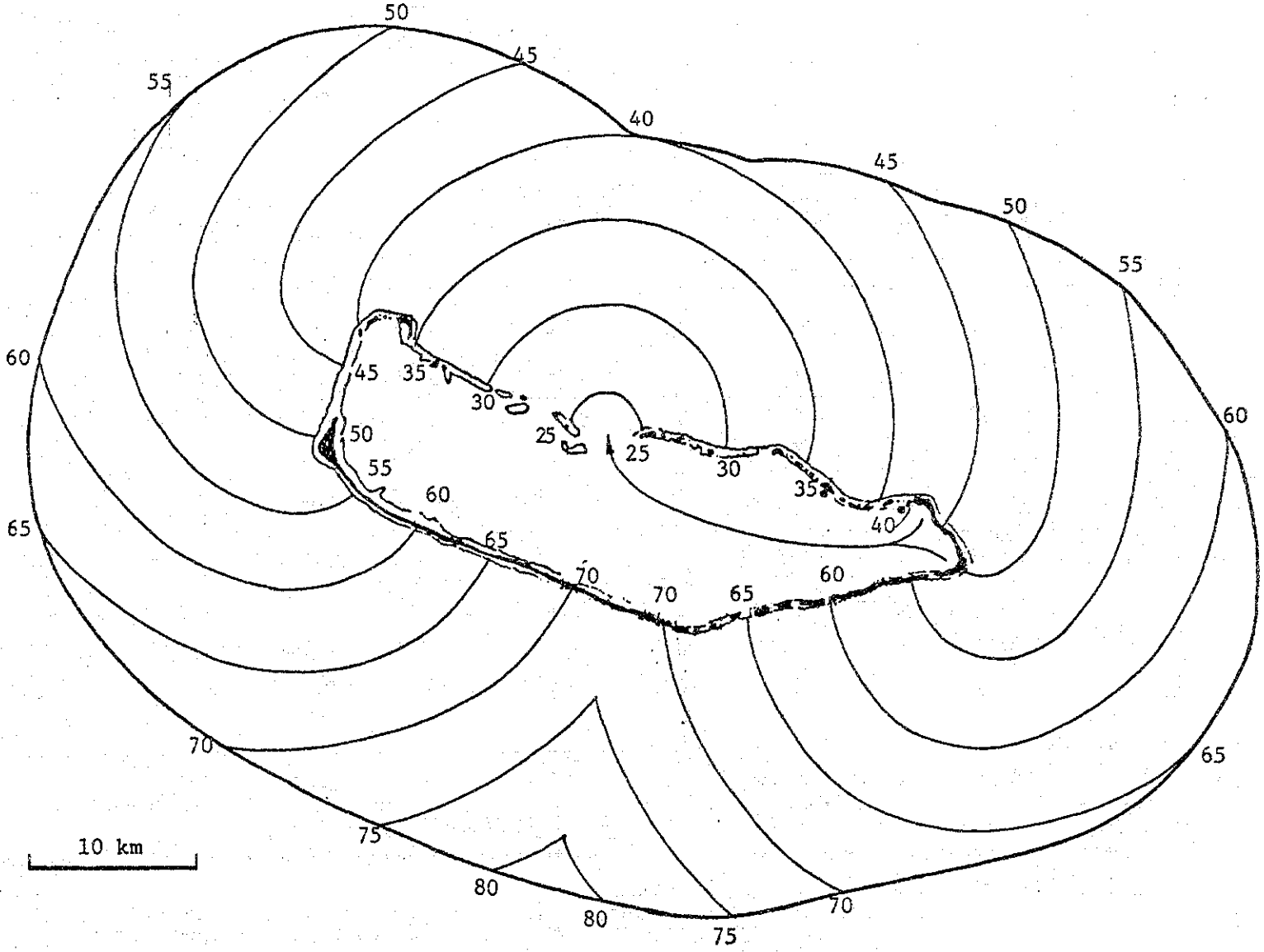


Fig. 1 Distance from D.U.D. Area through Calalin Channel to the Fishing Ground in the Open Sea (without the Project) (See also Fig. 2 and Table 13.)

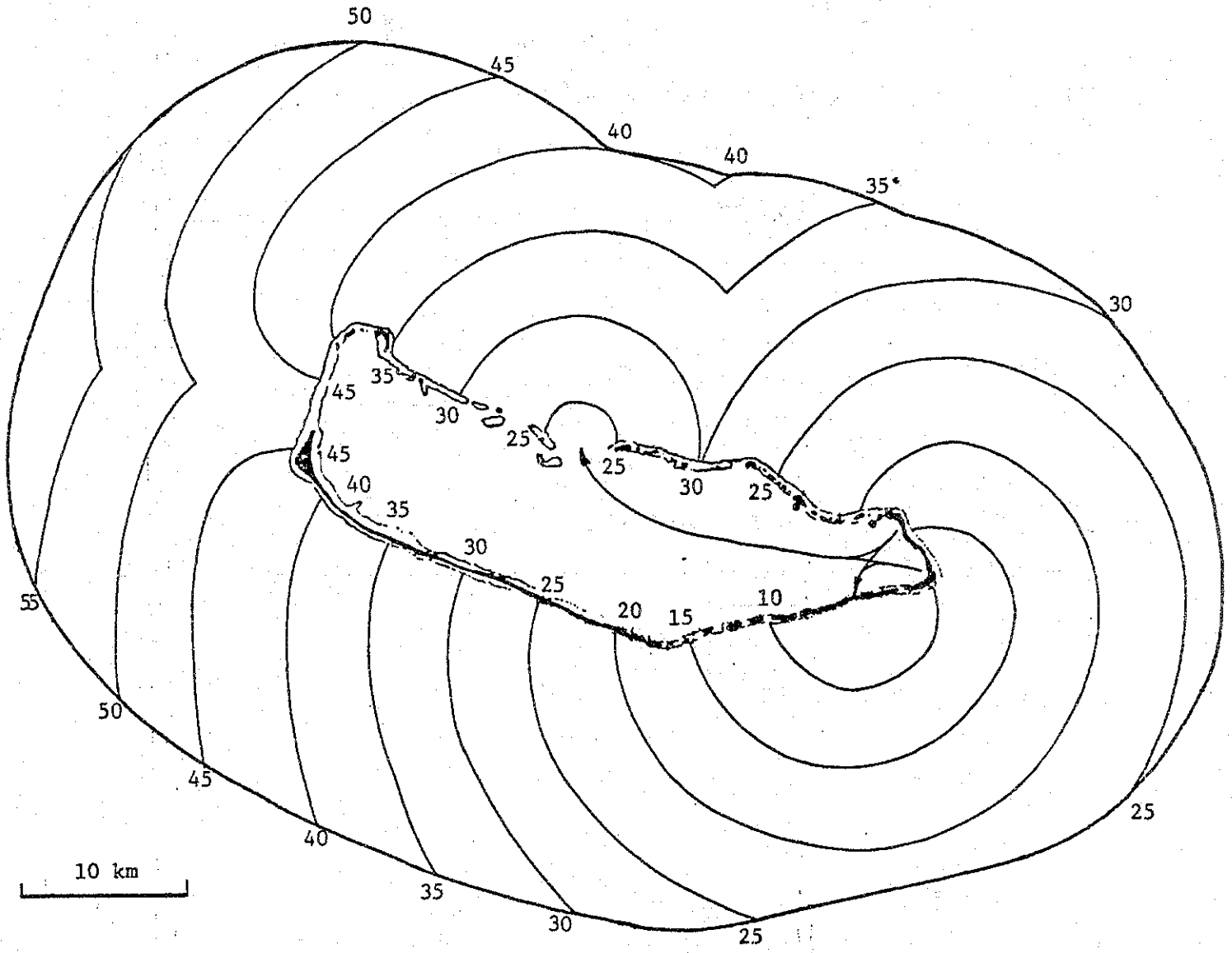


Fig. 2 Distance from D.U.D. Area through Calalin Channel or the Projected Small Boat Channel to the Fishing Ground in the Open Sea (with the Project) (See also Fig. 1 and Table 13.)

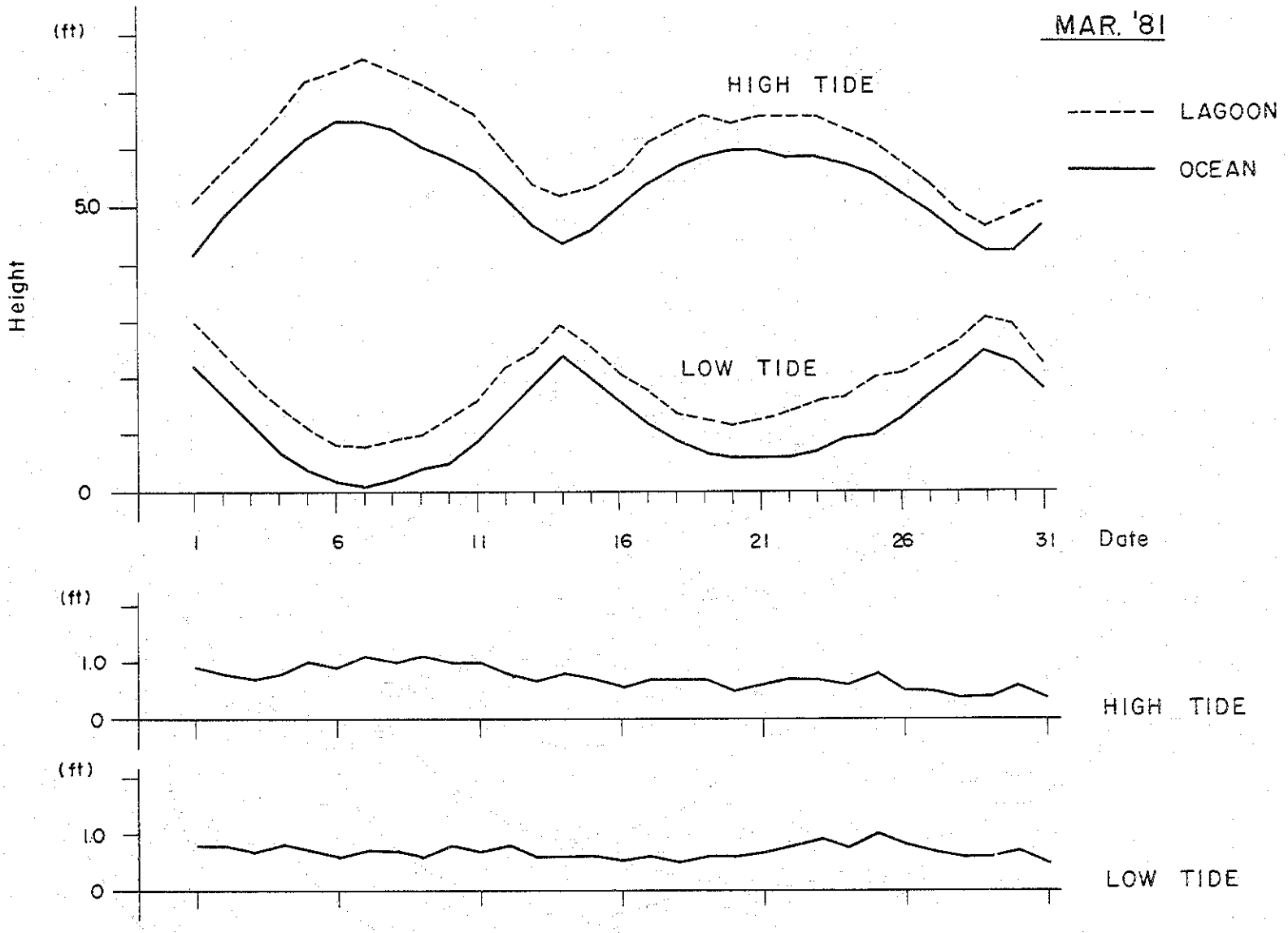


Fig. 3 Tidal Difference between LAGOON and OCEAN side (1)

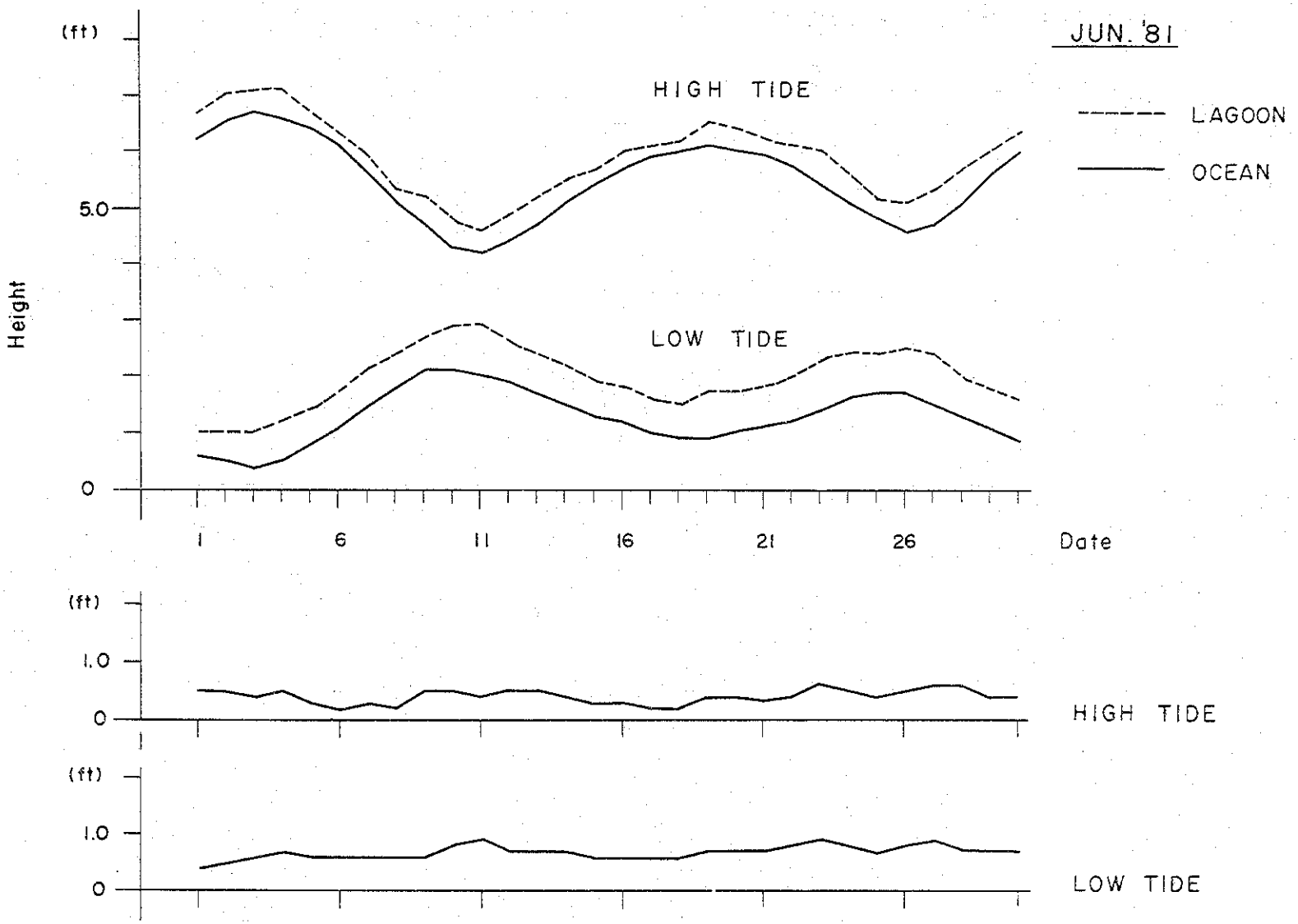


Fig. 4 Tidal Difference between LAGOON and OCEAN side (2)

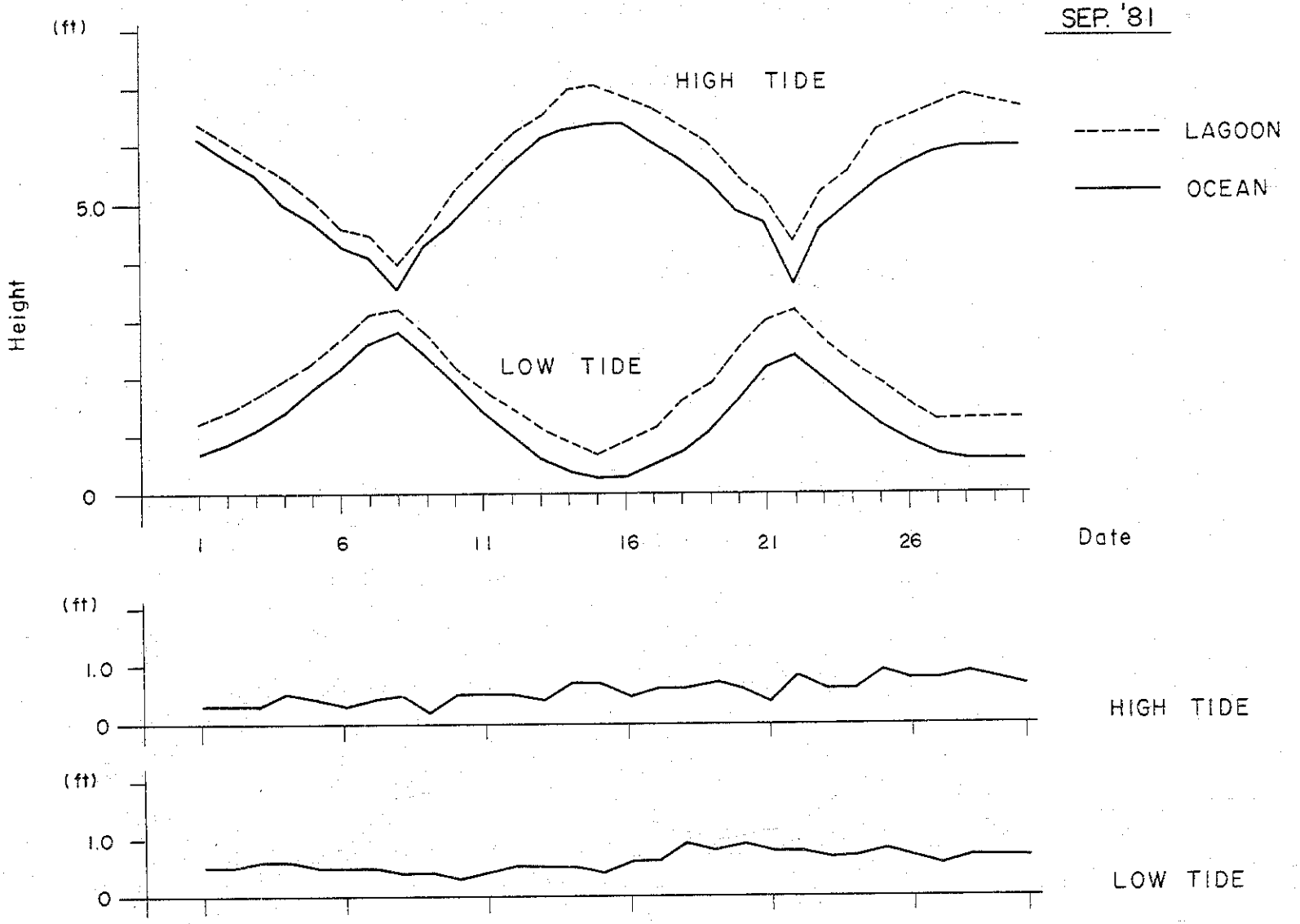


Fig. 5 Tidal Difference between LAGOON and OCEAN side (3)

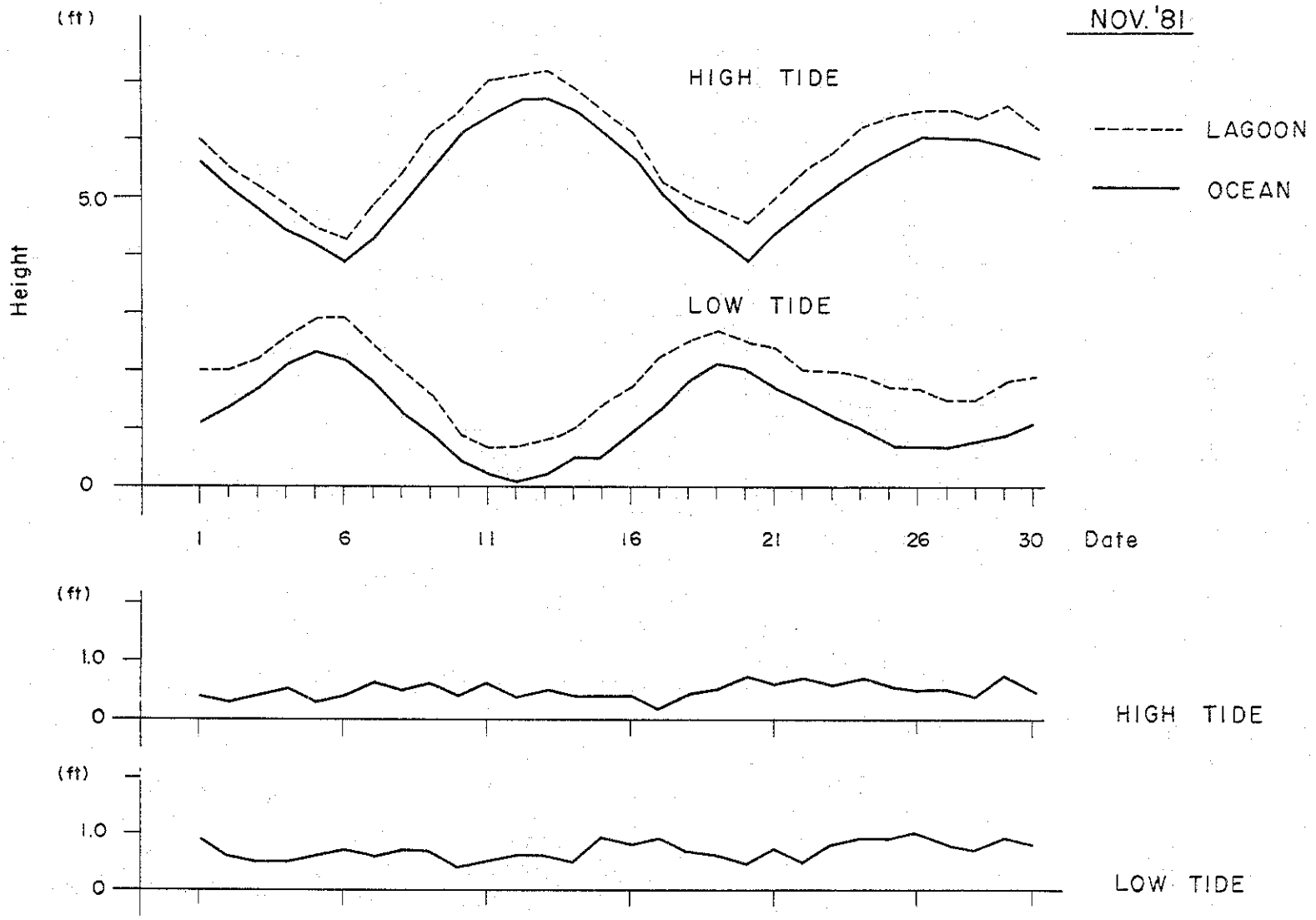


Fig. 6 Tidal Difference between LAGOON and OCEAN side (4)

Methodology 1. Estimation of the Catch of Pelagic Fishes per Trolling Operation

The catch of pelagic fishes per trolling operation is estimated by the following formula:

$$Y = \frac{1,000 \times A \times B}{C}$$

where,

Y: Catch of pelagic fishes per trolling operation (kg)

A: Fish landing at MFCA per annum (tons/year)

B: Ratio of pelagic fishes to the whole fish landing at MFCA

C: Total number of landing times for pelagic fishes at MFCA

Data source:

A: Unpublished data from MFCA, average quantity of 1978 and 1979 (see Table 18,19)

B: Unpublished data from MFCA (see Table 5)

C: Unpublished data from MFCA (see Table 7)

The catch of pelagic fishes per trolling operation is estimated as follows:

$$Y = \frac{1,000 \times 154.2 \times 0.725}{960}$$

$$= 116.5 \text{ kg}$$

Methodology 2. Estimation of the Number of Times of Trolling Operation per Fishing Boat of D.U.D. Area

The number of times of trolling operation per fishing boat of D.U.D. area is estimated by the following formula:

$$Y = \frac{A \times B}{C \times D}$$

where,

Y: Number of times of trolling operation per fishing boat of D.U.D. area per annum

A: Total number of landing times for pelagic fishes at MFCA

B: Catch ratio of pelagic fishes in D.U.D. area to those in the whole Majuro

C: Ratio of fish landing at MFCA to the total catch in Majuro

D: Number of fishing boats in D.U.D. area

Data source:

A: Unpublished data from MFCA (see Table 7)

B: Unpublished data from MFCA (see Table 5)

C: FAO (quoted by Koshimura and Horibe (1981)

D: Results of interview (see Table 9)

The number of times of trolling operation per fishing boats of D.U.D. area is estimated as follows:

$$Y = \frac{960 \times 0.99}{0.65 \times 50}$$

$$= 29.2 \text{ times per annum}$$

Accordingly, 2.4 times per month

Methodology 3. Estimation of Per Capita Local Fish Consumption

Estimation of per capita local fish consumption in Majuro Atoll is estimated by the following formula:

$$Y_1 = \frac{1,000 \times A}{B \times C} \quad \text{(gross weight)}$$

$$Y_2 = \frac{1,000 \times A \times D}{B \times C} \quad \text{(net weight)}$$

where,

Y: Per capita local fish consumption (kg/year)
A: Fish landing at MFCA per annum (tons/year)
B: Population of Majuro Atoll (average population in 1978 and 1979) (person)
C: Ratio of fish landing at MFCA to the total catch in Majuro
D: Edible rate

Date source:

A: Unpublished data from MFCA, average quantity of 1978 and 1979 (see Table 18,19)
B: Majuro Development Plan (1981) (calculated by proportional allotment of the population of Majuro Atoll in 1973 and 1980)
C: FAO (quoted by Koshimura and Horibe, 1981)
D: Food Balance Sheet, Japan (1981)

Per capita local fish consumption in Majuro Atoll is estimated as follows:

$$Y_1 = \frac{1,000 \times 154.2}{10,400 \times 0.65}$$

$$= 22.8 \text{ kg/year in gross weight}$$

$$Y_2 = \frac{1,000 \times 154.2 \times 0.53}{10,400 \times 0.65}$$

$$= 12.1 \text{ kg/year in net weight}$$

Methodology 4. Estimation of Per Capita Canned Fish Consumption

Per capita canned fish consumption is estimated by the following formula:

$$Y = A \times \frac{B}{C \times D} \times \frac{1}{E}$$

where,

- Y: Per capita canned fish consumption (kg/year)
- A: Amount of imported canned fish, current price in 1978 (US dollar)
- B: US dollar exchange rate, average rate in 1977 (yen/$)
- C: Average unit price of canned fish, current price in 1977 (yen/kg)
- D: Consumer price index (Increase rate of retail price in 1978 and 1979)
- C×D: Average unit price of canned fish, current price in 1978 (yen/kg)
- A×B/(C×D): Quantity of imported canned fish (kg)
- E: Population of the Marshall Islands, average population in 1978 and 1979

Data source:

- A: Majuro Development Plan, Draft (1981)
- B: Main Economic Indicators (OECD, 1981)
- C: Trade Statistics in Japan (Fisheries) (1978)
- D: Majuro Development Plan, Draft (1981)
- E: Majuro Development Plan, Draft (1981) (calculated by proportional allotment of the population of the Marshall Islands in 1973 and 1980)

Per capita canned fish consumption is estimated as follows:

$$Y = 272{,}000 \times \frac{1}{320 \times 1.095} \times \frac{1}{29{,}000}$$

$$= 6.4 \text{ kg/year}$$

Methodology 5. Estimation of Per Capita Poultry Consumption

Per capita poultry consumption is estimated by the following formula:

$$Y_1 = A \times \frac{B}{C} \times \frac{1}{D} \qquad \text{(gross weight)}$$

$$Y_2 = A \times \frac{B}{C} \times \frac{1}{D} \times E \qquad \text{(net weight)}$$

where,

Y: Per capita poultry consumption (kg/year)
A: Amount of imported poultry, current price in 1978 (US dollar)
B: Consumer price index (Increase rate of average retail price in 1978 and 1979)
C: Imported unit price, current price in 1979 (US dollar/kg)
D: Population of the Marshall Islands, average population in 1978 and 1979 (person)
E: Edible rate
B/C: Imported unit price, current price in 1978 (US dollar/kg)
A×B/C: Quantity of imported poultry

Date source:

A: Majuro Development Plan, Draft (1981)
B: Majuro Development Plan, Draft (1981)
C: FAO (1980). International price of developing countries
D: Majuro Development Plan, Draft (1981) (calculated by proportional allotment of the population of the Marshall Islands in 1973 and 1980)
E: Food Balance Sheet, Japan (1981)

Per capita poultry consumption is estimated as follows:

$$Y = 260{,}000 \times \frac{1.095}{1.28} \times \frac{1}{29{,}000}$$

$$= 7.7 \text{ kg/year in gross weight}$$

$$Y = 260{,}000 \times \frac{1.095}{1.28} \times \frac{1}{29{,}000} \times 0.77$$

$$= 5.9 \text{ kg/year in net weight}$$

Methodology 6 Estimation of Velocity of Tidal Current Resulting from Opening of the Channel

According to the tide table, the height of tide in the lagoon side is higher than that of the ocean side both at the high tide and low tide. Accordingly, a current will be generated from the lagoon side to the ocean when a channel is opened.

It is very difficult to estimate the velocity of the generated current because of influence from the wave and channel cross section. However, tentatively, we deem that a flow will occur from the lagoon to the ocean upon setting a supposition that the channel has a uniform cross section having a certain roughness factor and by disregarding the wave influence. There is Bress' difference equation for calculation of flow in a uniform cross section, and we use the equation in estimating the current velocity in this report.

Difference equation for

$$\left(\frac{\alpha Q^2}{2gA_2^2} + h_2\cos\phi + Zb_2\right) - \left(\frac{\alpha Q}{2gA_1^2} + h_1\cos\phi + Zb\right)$$

$$= -\frac{1}{2}\left(\frac{Q^2}{K_1^2} + \frac{Q^2}{K_2^2}\right)(x_2 - x_1)$$

where, d : Energy compensation factor (≒1) related to velocity distribution

Q : Flow rate

g : Gravity acceleration (9.8 m/sec^2)

A : Water cross section

h : Water depth

Zb: Channel floor height

K : Water conductivity of channel cross section

$$K^2 = \frac{1}{n^2}A^2R^{4/3}$$ (n: Manning's roughness factor)

The subscripts of 1 and 2 indicate the cross section of upstream and downstream, respectively.

Channel Cross Section

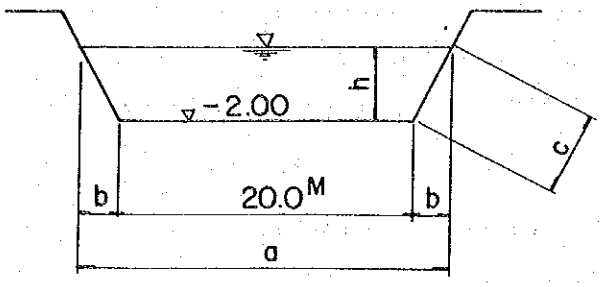


Table 22 Maximum Water Velocity at High Tidal Range

n=0.05 x_2-x_1=45 m

	Lagoon side	Ocean side
h (m)	4.32	3.98
a (m)	24.32	23.98
b (m)	2.16	1.99
c (m)	4.83	4.45
A (m^2)	95.7	87.5
WP (m)	29.7	28.9
R (m)	3.2	3.0
$\frac{1}{K^2}= n^2 \cdot 1/A^2 \cdot R^{4/3}$	5.79^{10-8}	7.55^{10-8}
Q (m^3/sec)	288	
V (knot)	6.1	

Table 23 Mean Water Veolocity at High Tidal Range

n=0.05 $x_2 - x_1 = 45$ m

	Lagoon side	Ocean side
h (m)	3.968	3.8
a (m)	23.968	23.8
b (m)	1.984	1.9
c (m)	4.436	4.249
A (m^2)	87.2	83.2
WP (m)	28.9	28.5
R (m)	3.0	2.9
$\frac{1}{K^2} = n^2 \cdot 1/A^2 \cdot R^{4/3}$	7.610^{10-8}	8.65^{10-8}
Q (m^3/sec)	197	
V (knot)	4.5	

Table 24 Maximum Water Velocity at Low Tidal Range

n=0.05 $x_2 - x_1 = 230$ m

	Lagoon side	Ocean side
h (m)	2.25	1.91
a (m)	22.25	21.91
b (m)	1. 25	0.955
c (m)	2.516	2.135
A (m^2)	47.5	40.0
WP (m)	25.0	24.3
R (m)	1.9	1.6
$\frac{1}{K^2} = n^2 \cdot 1/A^2 \cdot R^{4/3}$	4.71^{10-7}	8.35^{10-7}
Q (m^3/sec)	46	
V (knot)	2.1	

The calculation is made under idealistic conditions and the maximum velocity at high tidal range is 6.1 knots. However, in the actual case, there is the setup of waves from the ocean and the conceivable situation is that either the difference of tidal heights is not much or the tidal height at the ocean side is higher than that of the lagoon side. Also, most of the fishing boats are equipped with outboard motor and can sail swiftly, a current of about 6 knots, if it occurs, will not create a problem.

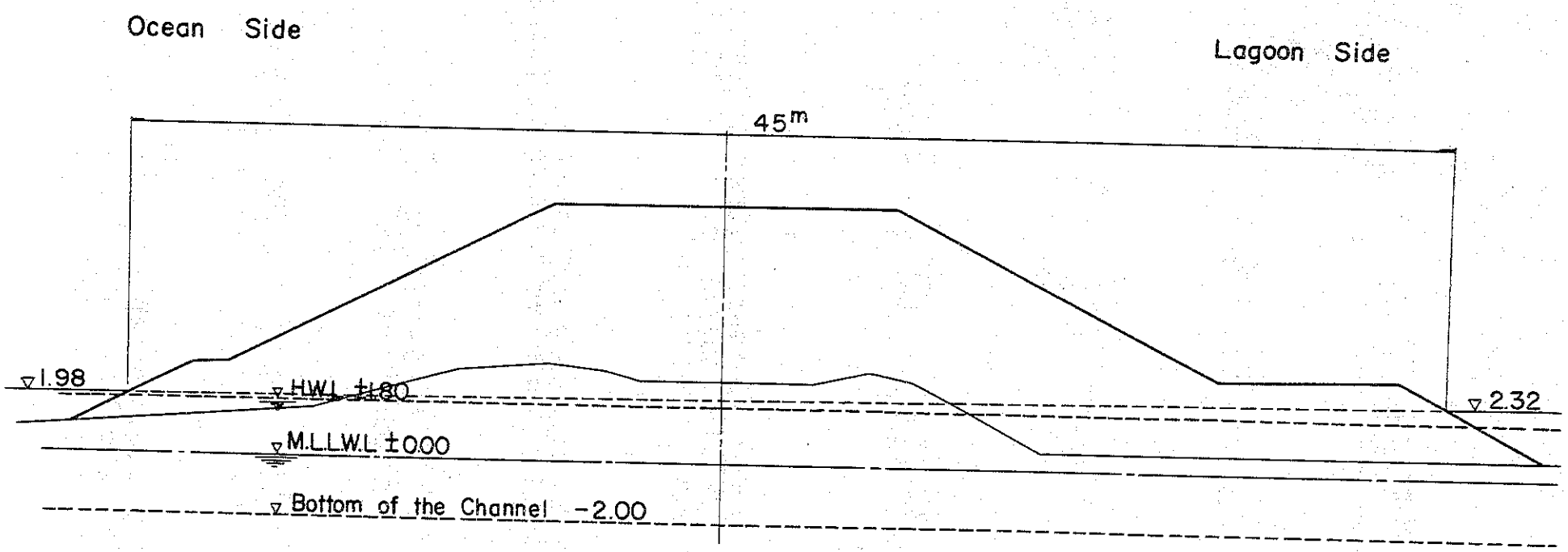


Fig. 7 Cross Section of the road at the channel

Table 25. Cost benefit analysis of the project (1/3)

Unit: 1,000 yen*

INTEREST RATE			0 %		3 %		4 %	
YEAR	COST	BENEFIT	PRESENT VALUE (COST)	PRESENT VALUE (BENEFIT)	PRESENT VALUE (COST)	PRESENT VALUE (BENEFIT)	PRESENT VALUE (COST)	PRESENT VALUE (BENEFIT)
1982	239300	0	239300	0	239300	0	239300	0
1983	2400	12700	2400	12700	2300	12330	2308	12212
1984	2400	13400	2400	13400	2262	12631	2219	12389
1985	2400	14100	2400	14100	2196	12903	2134	12535
1986	2400	14800	2400	14800	2132	13150	2052	12651
1987	2400	15600	2400	15600	2070	13457	1973	12822
1988	2400	16500	2400	16500	2010	13819	1897	13040
1989	2400	17300	2400	17300	1951	14066	1824	13147
1990	2400	18200	2400	18200	1895	14367	1754	13299
1991	2400	19200	2400	19200	1839	14715	1686	13490
1992	2400	20300	2400	20300	1786	15105	1621	13714
1993	2400	21500	2400	21500	1734	15532	1559	13966
1994	2400	22600	2400	22600	1683	15851	1499	14116
1995	2400	23900	2400	23900	1634	16275	1441	14354
1996	2400	25200	2400	25200	1587	16660	1386	14552
1997	2400	26600	2400	26600	1540	17073	1333	14770
1998	2400	28000	2400	28000	1496	17449	1281	14949
1999	2400	29700	2400	29700	1452	17969	1232	15247
2000	2400	31300	2400	31300	1410	18385	1185	15451
2001	2400	32900	2300	32900	1369	18762	1139	15616
2002	2400	34700	2400	34700	1329	19213	1095	15837
TOTAL			287300	438500	275005	309712	271916	278155

Remarks: *: present value in 1982

Table 26. Cost benefit analysis of the project (2/3)

Unit: 1,000 yen*

INTEREST RATE			4.2 %		4.3 %		5 %	
YEAR	COST	BENEFIT	PRESENT VALUE (COST)	PRESENT VALUE (BENEFIT)	PRESENT VALUE (COST)	PRESENT VALUE (BENEFIT)	PRESENT VALUE (COST)	PRESENT VALUE (BENEFIT)
1982	239300	0	239300	0	239300	0	239300	0
1983	2400	12700	2303	12188	2301	12176	2286	12095
1984	2400	13400	2210	12342	2206	12318	2177	12154
1985	2400	14100	2121	12463	2115	12427	2073	12180
1986	2400	14800	2036	12554	2028	12506	1974	12176
1987	2400	15600	1954	12699	1944	12639	1880	12223
1988	2400	16500	1875	12891	1864	12817	1791	12313
1989	2400	17300	1799	12971	1787	12884	1706	12295
1990	2400	18200	1727	13096	1714	12996	1624	12318
1991	2400	19200	1657	13258	1643	13144	1547	12376
1992	2400	20300	1590	13453	1575	13325	1473	12462
1993	2400	21500	1526	13674	1510	13530	1403	12571
1994	2400	22600	1465	13794	1448	13636	1336	12584
1995	2400	23900	1406	14000	1388	13826	1273	12675
1996	2400	25200	1349	14166	1331	13977	1212	12728
1997	2400	26600	1295	14350	1276	14145	1154	12795
1998	2400	28000	1243	14497	1224	14276	1099	12827
1999	2400	29700	1193	14757	1173	14519	1047	12958
2000	2400	31300	1144	14925	1125	14670	997	13006
2001	2400	32900	1098	15056	1078	14784	950	13020
2002	2400	34700	1054	15240	1034	14950	905	13078
TOTAL			271346	272374	271067	269545	269209	250834

Remarks: * present value in 1982

Table 27. Cost benefit analysis of the project (3/3) Unit: 1,000 yen*

INTEREST RATE			7 %		10 %	
YEAR	COST	BENEFIT	PRESENT VALUE (COST)	PRESENT VALUE (BENEFIT)	PRESENT VALUE (COST)	PRESENT VALUE (BENEFIT)
1982	239300	0	239300	0	239300	0
1983	2400	12700	2243	11869	2182	11545
1984	2400	13400	2096	11704	1983	11074
1985	2400	14100	1959	11510	1803	10594
1986	2400	14800	1831	11291	1639	10109
1987	2400	15600	1711	11123	1490	9686
1988	2400	16500	1599	10995	1355	9314
1989	2400	17300	1495	10774	1232	8878
1990	2400	18200	1397	10593	1120	8490
1991	2400	19200	1305	10444	1018	8143
1992	2400	20300	1220	10319	925	7827
1993	2400	21500	1140	10215	841	7536
1994	2400	22600	1066	10035	765	7201
1995	2400	23900	996	9918	695	6923
1996	2400	25200	931	9773	632	6636
1997	2400	26600	870	9641	575	6368
1998	2400	28000	813	9485	522	6094
1999	2400	29700	760	9402	475	5876
2000	2400	31300	710	9261	432	5630
2001	2400	32900	664	9097	392	5379
2002	2400	34700	620	8967	357	5158
TOTAL			264725	206412	259732	158459

Remarks: *: present value in 1982

Minutes

JAPANESE SURVEY TEAM

Minutes of Discussions

In response to the request made by the Government of the Marshall Islands for a construction project of the Majuro Fishing Boat Channel at Majuro Atoll (hereinafter referred to as "the Project"), the Government of Japan has sent, through the Japan International Co-operation Agency (hereinafter referred to as "JICA"), a team headed by Mr. S. Sakai to conduct a basic design survey for eighteen (18) days, from 12 December, 1981. The team had a series of discussions and exchanged views with the authorities concerned, and carried out an investigation of the proposed site.

As the result of the study and discussions, both parties have agreed to recommend to their respective Governments to examine the results of the survey attached herewith towards the realization of the project.

21 December, 1981

Sunao Sakai
Team Leader
The Japanese Survey Team

Charles T. Domnick
Chairman
Marshall Islands Maritime Authority

MINUTES

1. The objective of the Project is to provide a necessary small fishing boat channel, a bridge over the channel, approach roads and appurtenant facilities and equipment for ease of access from Majuro Lagoon to the southern fishery grounds for the Majuro fishermen at the proposed site (hereinafter referred to as "the Fishing Boat Channel and the Bridge").

2. The proposed site of the Project will be located on the Long Island road approximately 1/4 mile from the Majuro New Port facilities (hereinafter referred to as "the Project Site").

3. The Japanese Survey Team will convey to the Government of Japan the desire of the Government of the Marshall Islands that the former take necessary measures to cooperate in implementing the Project and provide the Fishing Boat Channel and the Bridge and other items listed in Annex I within the scope of Japanese economic cooperation in grant form.

4. The Government of the Marshall Islands will take the necessary measures, in the event that the grant assistance by the Government of Japan is extended to the Project, to:

a. Provide data and information necessary for the design and the construction of the Fishing Boat Channel and the Bridge.

b. Secure the lands necessary for the construction of the Fishing Boat Channel and the Bridge.

c. Clear the Project Site before the start of construction.

d. Provide the other items listed in Annex II.

e. Ensure prompt unloading and customs clearance in the Marshall Islands of imported materials and equipment for the construction, and to facilitate their internal transport.

----/page 2

f. Exempt any Japanese nationals concerned from customs duties, internal taxes and other fiscal levies imposed in the Marshall Islands for the supply of goods and services for construction.

g. Provide and accord all necessary permission, licenses and other authorizations deemed advisable for carrying out the Project.

h. Bear all the expenses, other than those to be borne by the Grant, necessary for the construction of the Fishing Boat Channel and the Bridge.

i. Clear the earth moving permit of the Corps of Engineers, USPOD, and the environmental permit of the Trust Territory Environmental Protection Board before the start of construction.

5. The specifications for the design of the Fishing Boat Channel and the Bridge, including the approach roads, are listed in Annex III.

ANNEX I

Items requested by the Government of the Marshall Islands, the cost of which will be borne by the Government of Japan, are as follows:

1. A small fishing boat channel;
2. A bridge over the channel, including approach roads with railings;
3. Temporary road during construction period;
4. Utility appurtenances
   a. Lighting
   b. Traffic control devices
   c. Navigation aids
   d. Water supply mains of the Project Site;
5. Temporary work to remove water pipes;
6. Supervising and detailed designing services.

ANNEX II

Items, the cost of which will be borne by the Government of the Marshall Islands, are as follows:

1. Water supply mains to the Project Site;

2. Electrical power main line to the Project Site;

3. Telephone lines and equipment;

4. Provision of space necessary for such construction as temporary offices, working area, stock yards, etc.

5. Items (1) and (2) shall be completed prior to the start of site work.

ANNEX III

Items, the specifications of which will be applied to the design of the Fishing Boat Channel, the Bridge and the Approach Roads, are as follows:

1. Navigation width: 20.0 meters
2. Navigation height: 5.0 meters above H.W.L.
3. Depth of the channel: 2.0 meters below L.W.L.
4. Number of traffic lanes: two lanes
5. Widths of the bridge and the road: 8.5 meters (1.0 m. + 6.5 m. + 1.0 m.)
6. Design speed of road: 25 miles per hour
7. Gradient of the approach roads: 5 percent
8. Live load: H 20 (M 18) and HS 20 (MS 18) loadings (AASHTO)
9. Design criteria for bridge and structure:
   a. AASHTO and/or ASTM or equivalent shall be applied.
   b. The allowable unit stresses and the standard for construction materials shall be derived by applying the JIS and Design Specification for Highway Bridge of Japan.
10. Metric system will be acceptable to the design analysis and/or the drawings.

JICA