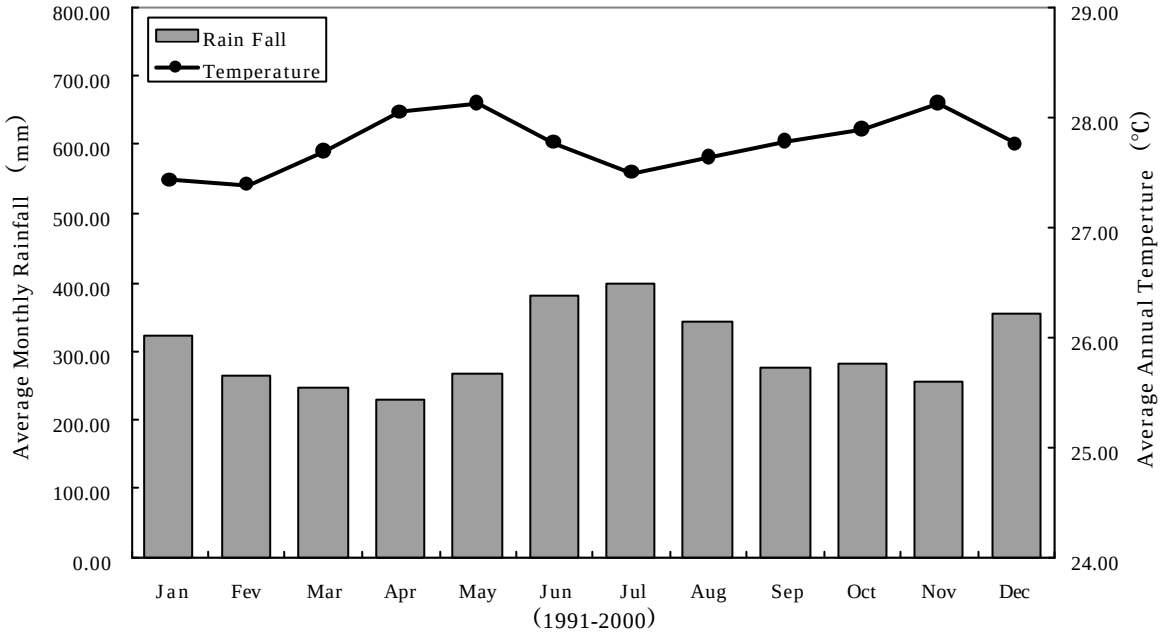
1-3 Natural Condition

1-3-1 Meteorological Condition

(1) Temperature and Precipitation

Palau has a tropical oceanic climate characterized by high temperatures and high humidity with a mean temperature of 27.8℃, a mean humidity of about 82%. And a lot of rainfall is measured with a mean annual precipitation of 3,620 mm. The rainy season extends from June through October and the dry season extends from November through May. Figure 1.3.1-1 shows the mean monthly temperature and precipitation observed at Koror for the past 10 years.

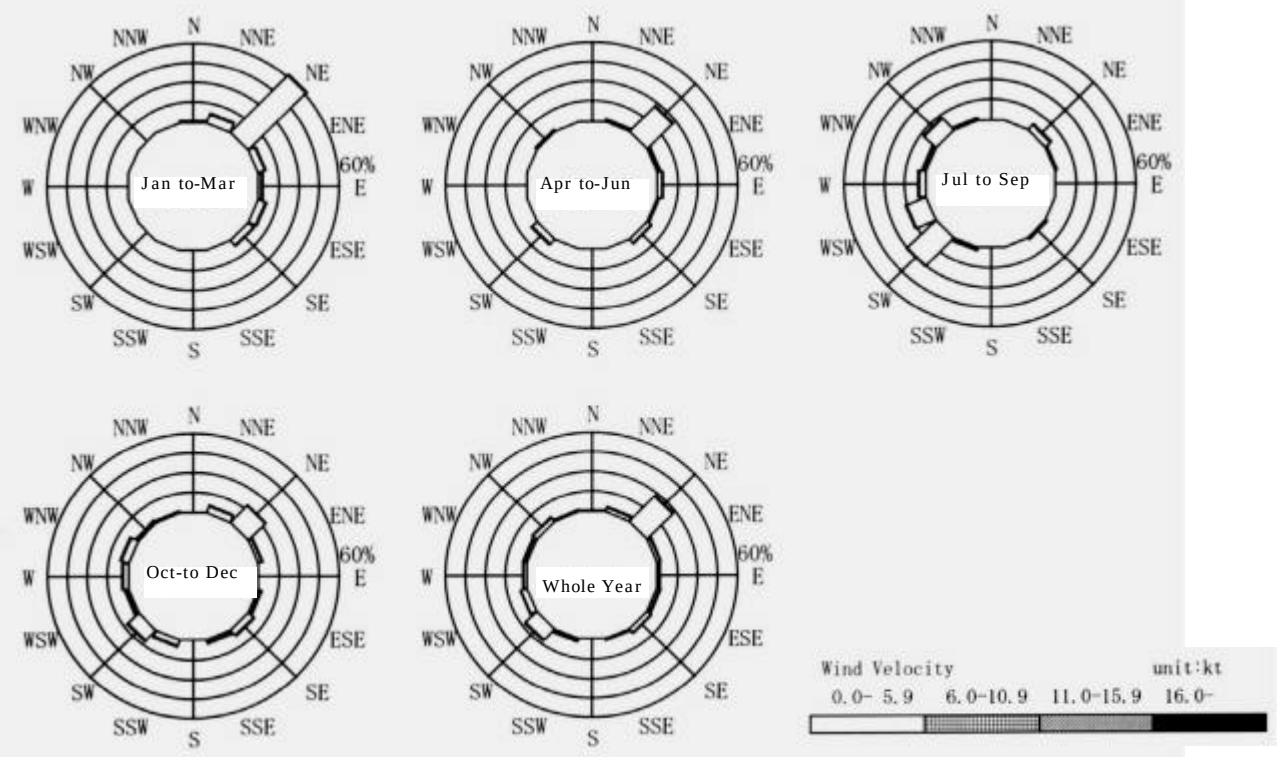


Source: National Weather Station, Koror

Figure 1.3.1-1 Monthly Temperature and Precipitation in Koror

(2) Wind

As indicated in Figure 1.3.1-2, the predominant wind direction is northeast from January to June and southwest wind is prevailing from July to September. The wind speed less than 10 knots/hr (5.1 m/s) appears 85% through the year. The frequency of wind occurrence in excess of 21 knots/hr (10.8 m/s) is very low as merely 1.4%.



Source: National Weather Station, Koror (1993 - 1999)

Figure 1.3.1-2 Wind Rose Observed at Kayangel Island

(3) Typhoon

Palau is located in the central part of the Pacific Ocean near the equator in the almost typhoon free zone which extends from 10° north latitude to 10° south latitude. Normally, weather condition is very calm with predominant weak easterly wind of trade wind, and it is very rare to be hit by a typhoon. Table 1.3.1-1 shows a list of typhoons with a maximum wind speed of over 30 m/s that significantly affect Palau. In past 50 years, Palau has experienced 16 significant typhoons in total and 4 typhoons with a maximum wind speed of over 50 m/s. In recent 10 years, no significant typhoon, however, has been recorded.

Among the above typhoons, Typhoon Mike recorded in 1990 is one of the biggest, which passed about 20 km north of Kayangel Islands according to the typhoon track as shown in Figure 1.3.1-3. She gave great damages to the country particularly in the northern part including Kayangel State with maximum wind speed of 67 m/s, lowest atmospheric pressure of 915 hPa observed on November 11, 1990.

Table 1.3.1-1 List of Significant Typhoon

Year	Typhoon	Max. Wind Speed	Period
1947	Frorr	45 m/s	Nov 13
1951	Iris	31 m/s	May 1
1951	Wanda	34 m/s	Nov 18
1952	Emma	36 m/s	Mar 30
1959	Gilda	54 m/s	Dec 15 - Dec16
1963	Crrmen	34 m/s	Aug 10
1964	Louise	58 m/s	Nov 16 - Nov 17
1964	Opal	63 m/s	Dec 11
1966	Irma	34 m/s	May 12
1967	Sally	31 m/s	Mar 1
1967	Emma	45 m/s	Nov 1
1970	Nancy	49 m/s	Feb 23
1976	Marie	36 m/s	Apr 6 - Apr 8
1984	Agnes	45 m/s	Nov 2
1988	Skip	45 m/s	Nov 5
1990	Mike	67 m/s	Nov 10～Nov11

Source: National Weather Station, Koror

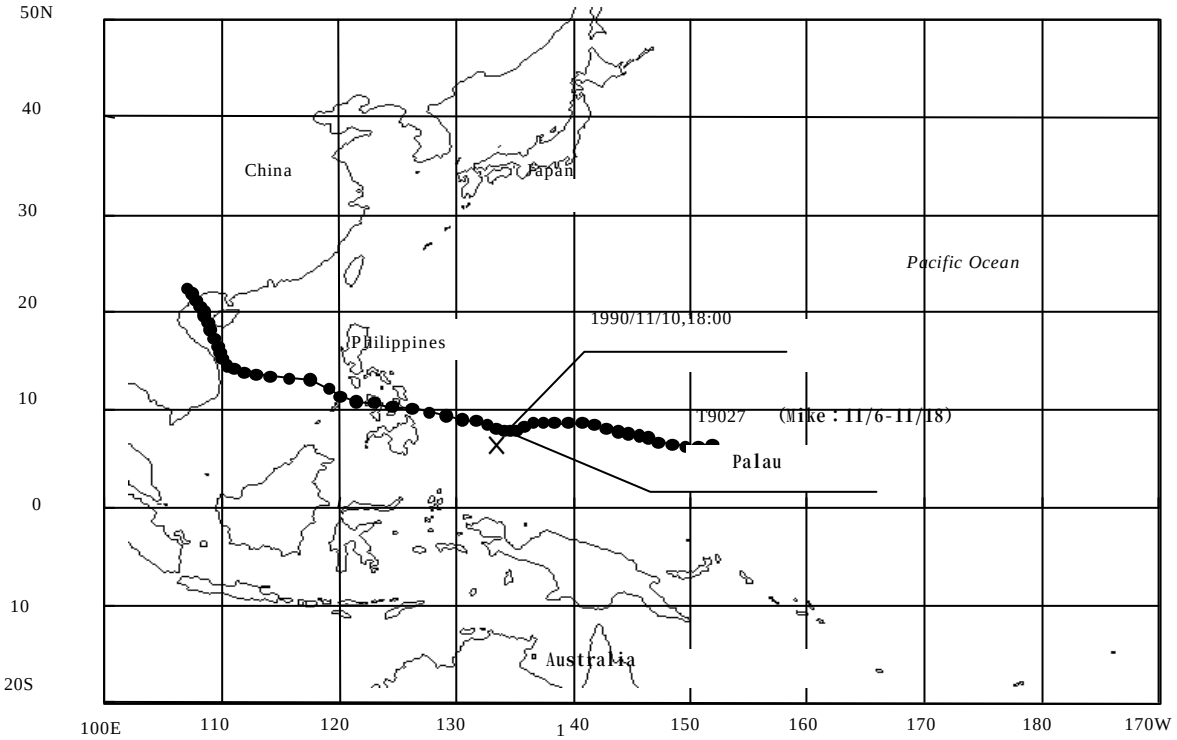


Figure 1.3.1-3 Track of Typhoon Mike, 1990

1-3-2 Sea Condition

Sea condition observation comprising tide, wave and current are carried out during the field survey. Continuous measurements for every 20 minutes are made by a ultrasonic multipurpose wave gauge in the period of 15 days from July 9 to July 24, 2001 at one point in Ulach Channel and in the period of 1 day on July 24-24, 2001 off the existing jetty. Survey points are a channel dredging area in Ulach Channel and a jetty construction area in front of the existing jetty as shown in Figure 1.3.2-1.

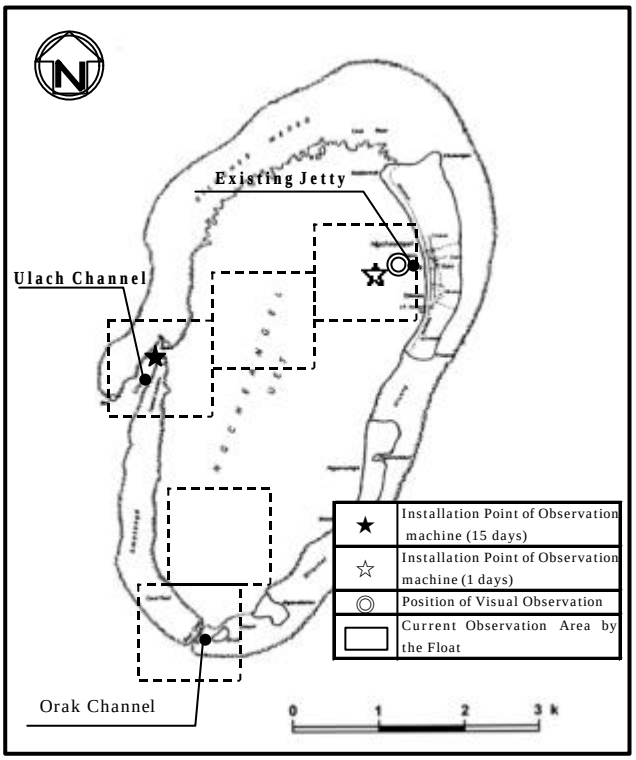


Figure 1.3.2-1 Sea Condition Observation Points

(1) Tide Observation

Figure 1.3.2-2 shows a tide bar for Ulach Channel based on local observation during the field survey period. The tidal range of 2.3 m is comparatively large.

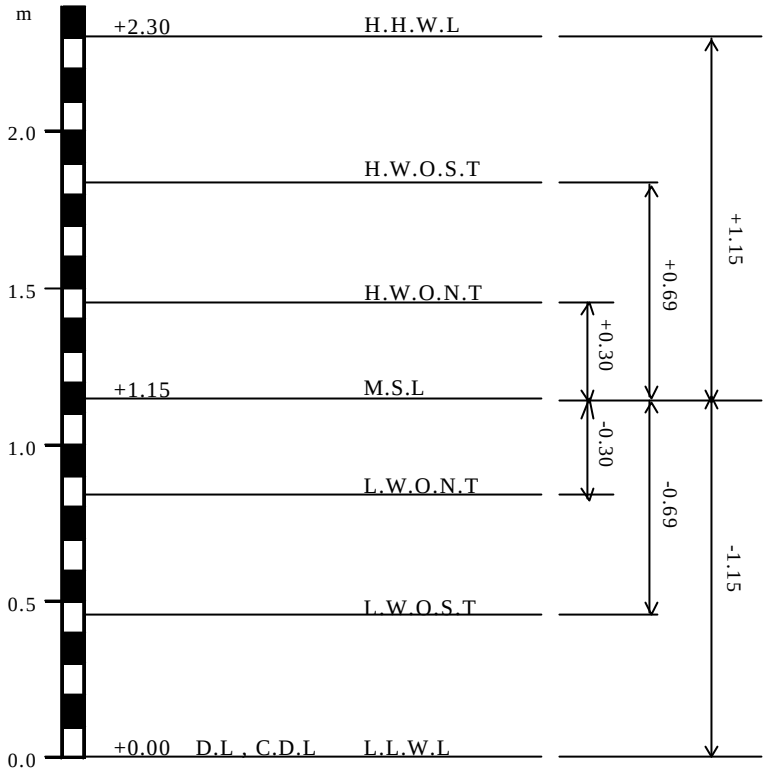


Figure 1.3.2-2 Tide Condition at Kayangel Island

(2) Wave Observation

Table 1.3.2-1 gives the maximum wave dimensions during the observation period at Ulach Channel and the front area of the existing jetty. The significant wave height in both area during the observation period is about 0.3 m. Based on the visual wave observation during the field survey, predominant wave directions are from south west to west.

Table 1.3.2-2 shows the wave appearance and correlation between wave height and wave period summarized based on the visual wave observation data within Kayangel Atoll by National Weather Station, Koror (for a period between March 1993 and February 1999). A wave height less than 0.3 m occupies about 98% through the year, which suggests that the lagoon area of Kayangel Atoll shows very calm wave condition.

Table 1.3.2-1 Maximum Wave Dimensions Observed by Field Survey

Location	Significant wave		Maximum wave	
	$H_{1/3}$ (m)	$T_{1/3}$ (s)	H_{max} (m)	T_{max} (s)
Ulach Channel	0.35	5.1	0.53	5.6
Off Existing Jetty	0.27	4.2	0.53	3.6

Table 1.3.2-2 Wave Appearance Observed in Kayangel Atoll

Wave Height (feet) \ Period (S)	1.0 Below	1.1 ~ 2.0	2.1 ~ 3.0	3.1 ~ 4.0	4.1 ~ 5.0	5.1 ~ 6.0	6.1 ~ 7.0	7.1 ~ 8.0	8.1 Over	Total occurrence rate (%)
0.0 (0cm) ~ 0.5 (15cm)	51.17%	20.90%	9.51%	2.38%	0.24%	0.03%	0.03%			84.27%
0.6 (18cm) ~ 1.0 (30cm)	0.70%	3.11%	2.66%	5.56%	1.47%	0.00%	0.07%	0.03%		13.60%
1.1 (34cm) ~ 1.5 (46cm)		0.03%	0.03%	0.52%	0.77%	0.10%				1.47%
1.6 (49cm) ~ 2.0 (61cm)				0.03%	0.17%	0.10%		0.03%		0.35%
2.1 (64cm) ~ 2.5 (76cm)				0.07%	0.03%	0.14%				0.24%
2.6 (79cm) ~ 3.0 (91cm)				0.03%				0.03%		0.07%
3.1 (94cm) Over										0.00%
Occurrence rate (%)	51.87%	24.05%	12.20%	8.60%	2.69%	0.38%	0.10%	0.10%	0.00%	100.00%

Source: National Weather Station, Koror (March 1993 to February 1999)

(3) Wave Hindcasting

The design wave at the location of the construction sites has been estimated by the computer simulation of wave deformation analysis in shallow water area on the basis of the hindcasted offshore waves.

In hindcasting of offshore waves, Typhoon Mike of the largest observed recently in Palau is set as the model typhoon where the estimation point is offshore deep water area off Kayangel Atoll at N 8°4', E 134°40'. Based on the wave estimation results, the design offshore wave is calculated as wave height in offshore area (H_0) = 8.0 m and wave period (T_0) = 10.1 s.

Wave conditions at the construction sites are estimated by the wave deformation analysis on the basis of the design offshore wave.

From the results of wave deformation analysis for different wave directions, the maximum wave height in the project area of the access channel and the jetty are estimated as shown in Table 1.3.2-3. Design wave condition at the access channel is set as 1.92m in wave height, 8.0s in wave period and WNW wave direction. As for the jetty construction area as shown in Table 1.3.2-4, design wave height of 1.12m and wave period of 8.0s are obtained by the design offshore wave induced from W direction.

Table 1.3.2-3 Design Wave Dimensions at Access Channel

Wave Direction	SW	SW	WSW	WSW	W	W	WNW	WNW	NW	NW
H_0 (m)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
T_0 (s)	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
Wave Height Ratio R (H/H_0)	0.22	0.22	0.23	0.23	0.23	0.23	0.24	0.23	0.22	0.23
H ($H_0 \times R$) (m)	1.76	1.76	1.84	1.84	1.84	1.84	1.92	1.84	1.76	1.84

Table 1.3.2-4 Design Wave Dimensions at Jetty Construction Site

Wave direction	SW	SW	WSW	WSW	W	W	WNW	WNW	NW	NW
H_0 (m)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
T_0 (s)	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
Wave Height Ratio R (H/H_0)	0.10	0.10	0.12	0.12	0.14	0.13	0.13	0.12	0.11	0.10
H ($H_0 \times R$) (m)	0.80	0.8	0.96	0.96	1.12	1.04	1.04	0.96	0.88	0.80

(4) Current Condition

Regarding the overall current condition inside Kayangel Atoll, the area around Ulach Channel shows westerly strong currents with very high velocity, which flows from the open sea into the atoll during flood tide and a comparatively slow easterly current from inside the atoll outward toward the open sea during ebb tide. In the area extending from Orak Channel located on the south side of Kayangel Atoll to the vicinity of the existing jetty, current from the south from the open sea into the atoll is predominant during the period of both flood tide and ebb tide.

Based on the above current observation, the current pattern as indicated in Figure 1.3.2-3 is surmised for inside of Kayangel Atoll.

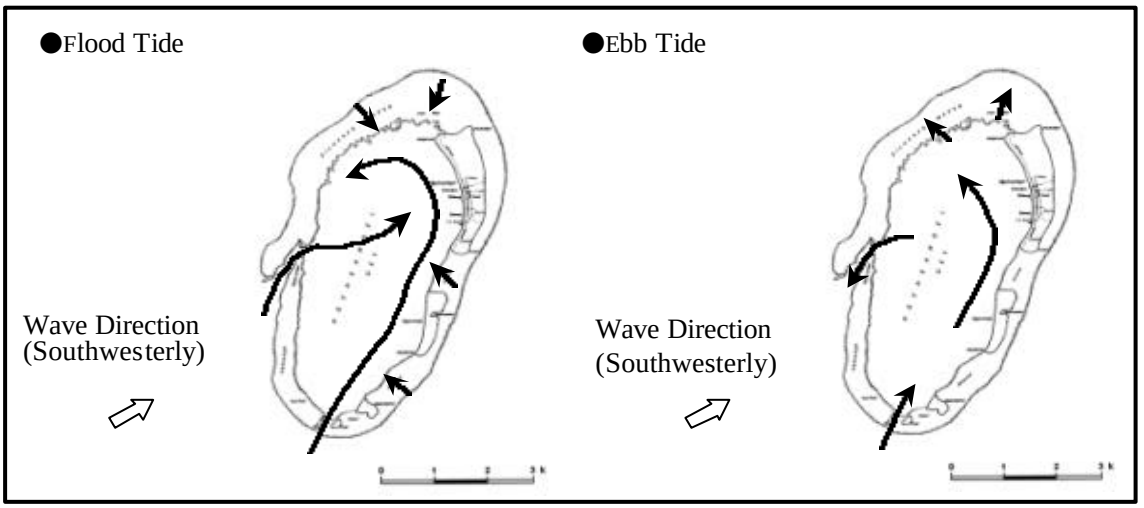


Figure 1.3.2-3 Current Pattern Inside Kayangel Atoll

1-3-3 Topographic Condition

The topographic and bathymetric features of the project area of Ulach Channel and the existing jetty are shown in Figures 1.3.3-1 and 1.3.2-2.

In the vicinity of the entrance of Ulach Channel facing to the open sea, the water depth increases sharply in the range -5 m to -50 m. However, in the central part of the channel, the water depth is shallow with a depth ranging from -2.0 m to -5.0 m, and the water depth in the vicinity of the channel exit is much shallower, ranging from -1.0 m to -2.0 m. Shallow water area with depths of less than -1.0 m at some places is widely distributing from the channel exit to the north side of the access channel. Furthermore, on the west side of the channel, the boulder reefs with water depth from -1.0 m to 0 m are widely distributing on seabed with water depths of at least -2.0 m beyond.

As shown in Figures 1.3.3-2 and 1.3.3-3, the bathymetric conditions adjacent to the jetty construction site are constituted by shallow water area with very mild slope, the gradient being about 1/60 to 1/90. Offshore distance to the area of water depth -2.0 m is measured as 140 m out from the shore. Furthermore, the gradient of the adjacent beach is relatively steep as about 1/15. The distance from the expected tip of the jetty facility with a depth of -2.0 m is measured as 142 m, and the distance to area with -1.0 m water depth is 87 m.

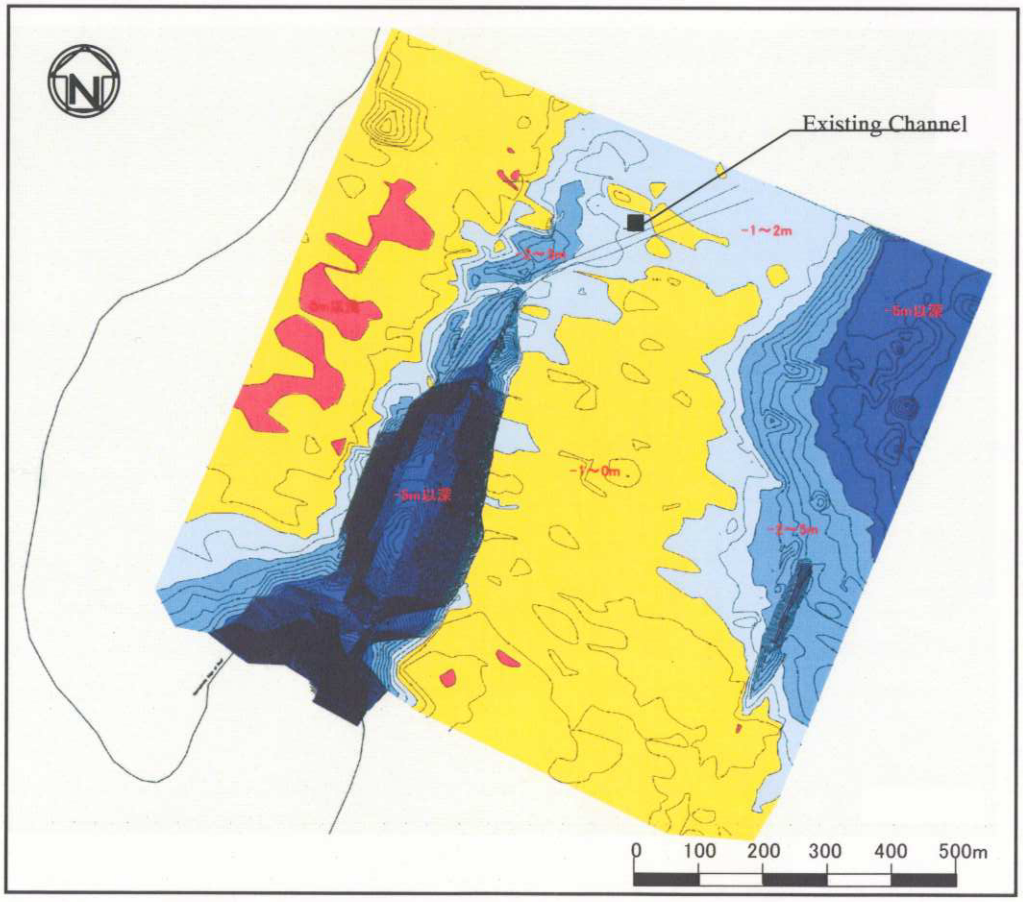


Figure 1.3.3-1 Bathymetry in the Vicinity of Ulach Channel

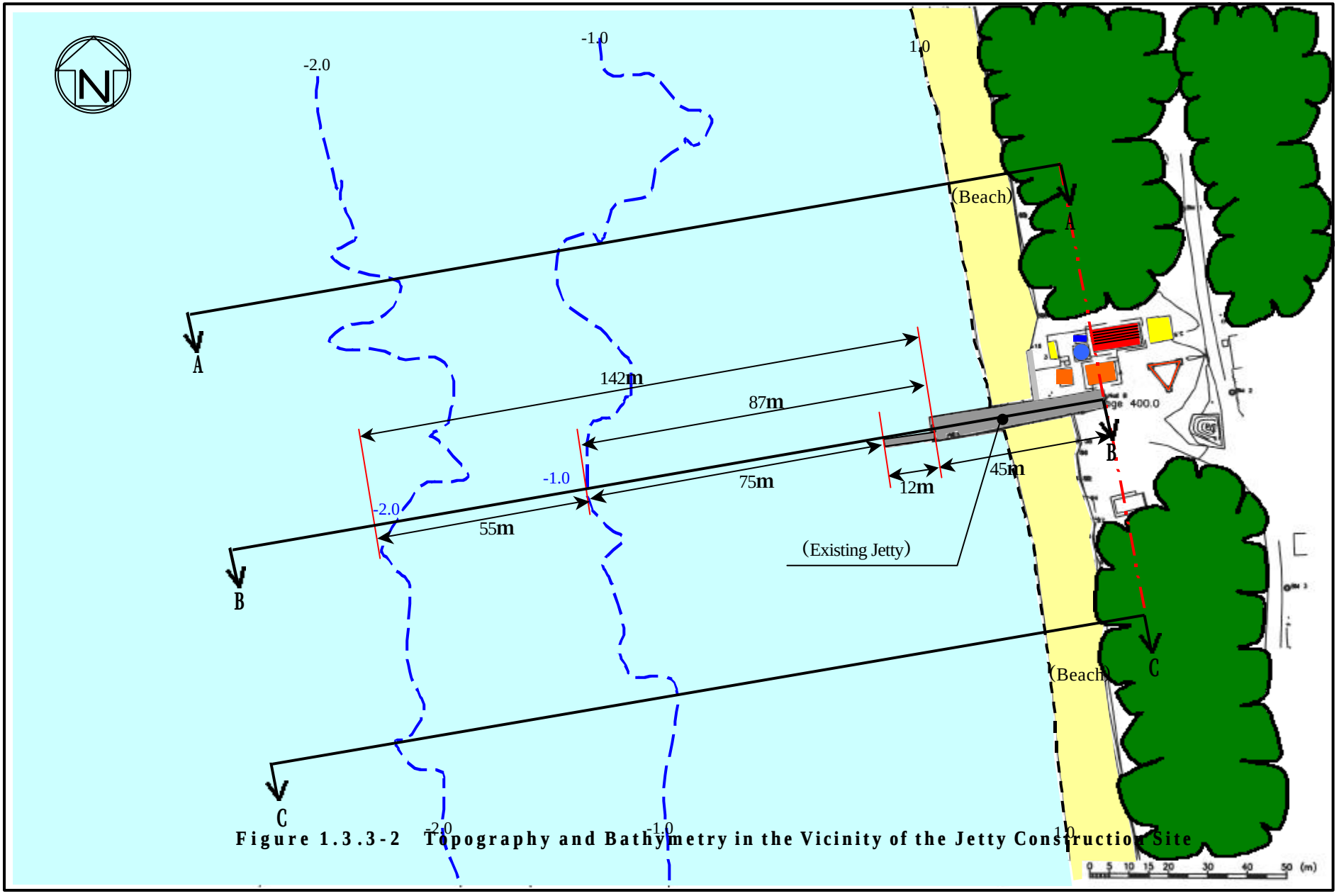


Figure 1.3.3-2 Topography and Bathymetry in the Vicinity of the Jetty Construction Site

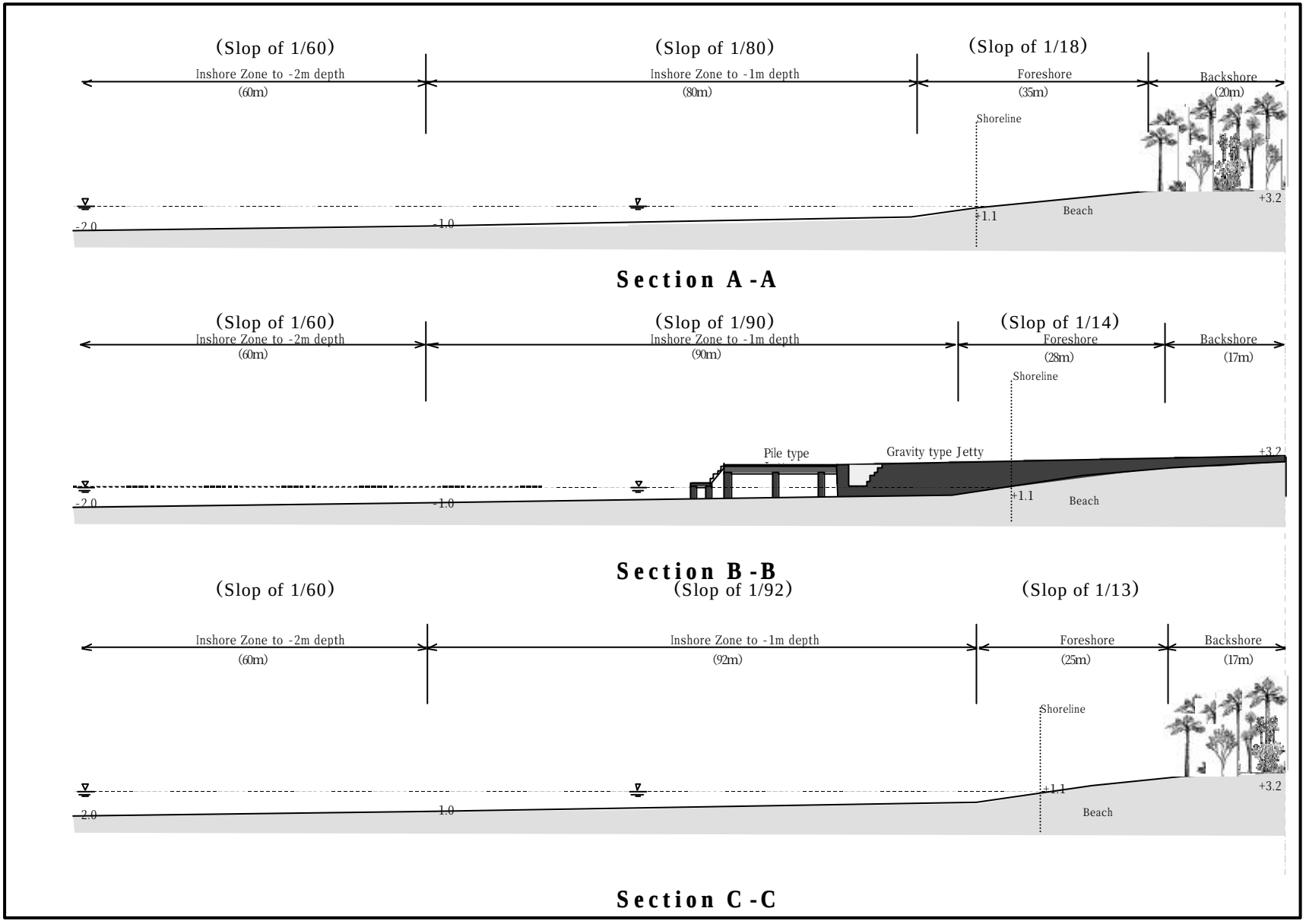


Figure 1.3.3-3 Sectional Profile in the Vicinity of the Jetty Construction Site

1-3-4 Sediment Condition

Bottom sediment are sampled at a total of 14 points as shown in Figure 1.3.4-1, comprising 9 points in the vicinity of the jetty construction site and 4 points in Ulach Channel. According to the test results of grain size distribution, the bottom sediments consist of fine sand (D_{50} = 0.15 mm) from St.5 to St.8 within Ulach Channel. Grain sizes of the sediments in the vicinity area of the existing jetty are comparatively coarse, namely D_{50} = 1.0 - 1.5 mm on the sandy beach and gradually become smaller in the offshore direction as D_{50} = 0.2 - 0.5 mm.

From the wide distribution of seaweed ground, the sedimentation phenomena adjacent to the existing jetty are supposed not so obvious. Additionally, according to the visual observation during the field survey, the predominant direction of littoral drift is surmised to be from south to north.

Table 1.3.4-1 Grain Size of Sediment

No.	Grain Size (D_{50} mm)
1	0.52
2	0.85
3	0.20
4	0.28
5	0.45
6	0.15
7	0.14
8	0.16
9	1.30
10	0.80
11	1.30
12	0.80
13	1.00
14	1.40

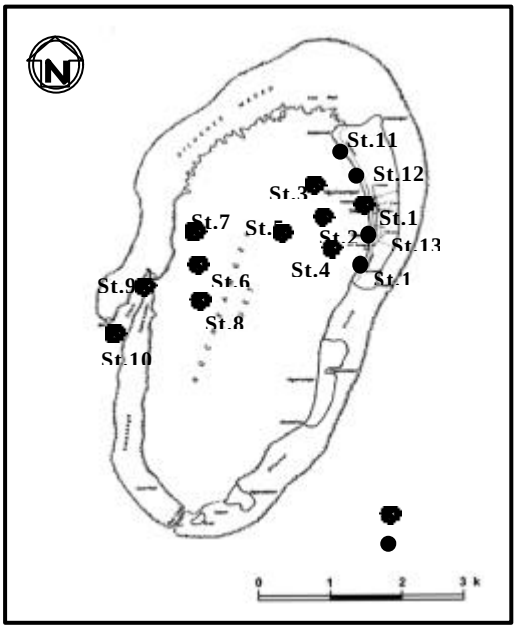


Figure 1.3.4-1 Sediment Sampling Points

1-3-5 Soil Condition

The bore holing survey are conducted at the jetty construction site adjacent to the existing jetty and the access channel dredging area in Ulach Channel. The boring logs and the N value of the standard penetration tests are shown simultaneously in Figures 1.3.5-1 and 1.3.5-2. The following is a general description of the sub ground conditions in the vicinity of the expected project facility construction sites.

(1) Jetty Construction Site

The boring survey in the vicinity of the jetty construction site is carried out at 3 points, namely near the beachline of the existing jetty (BH.1), at a point 50 m offshore from the beachline (BH.2) and at a point 100 m offshore from the beachline (BH.3). The geological structure consists generally of sandy layers with silt. And N values become larger in deeper stratum and reach more than 50 at deeper portion of -6.0 m. Regarding BH.1 located on land, stratum of coral rock with silt and sand mixed appears at depths of -2.0 m to the ground surface.

(2) Access Channel Dredging Site in Ulach Channel

One point of bore holing (BH.4) is carried out in the vicinity of Ulach Channel at the exit from the existing access channel. Base on the coral reef topography, the surface crust consists of coral limestone with an N value of about 70. At depths greater than -2.0 m, coral sandy stratum with finger coral mixed in with an N value of 25 to 50.

1-3-6 Seismic Condition

Palau has not experienced any earthquakes severe enough to be recorded. U.S. Building Code is applied and is set as Zone 3 for seismic factor required for design of buildings. However, this standard is not applied to civil structures. Thus the jetty structure will be designed under the equivaqlent seismic condition of U.B.C. Zone 3.

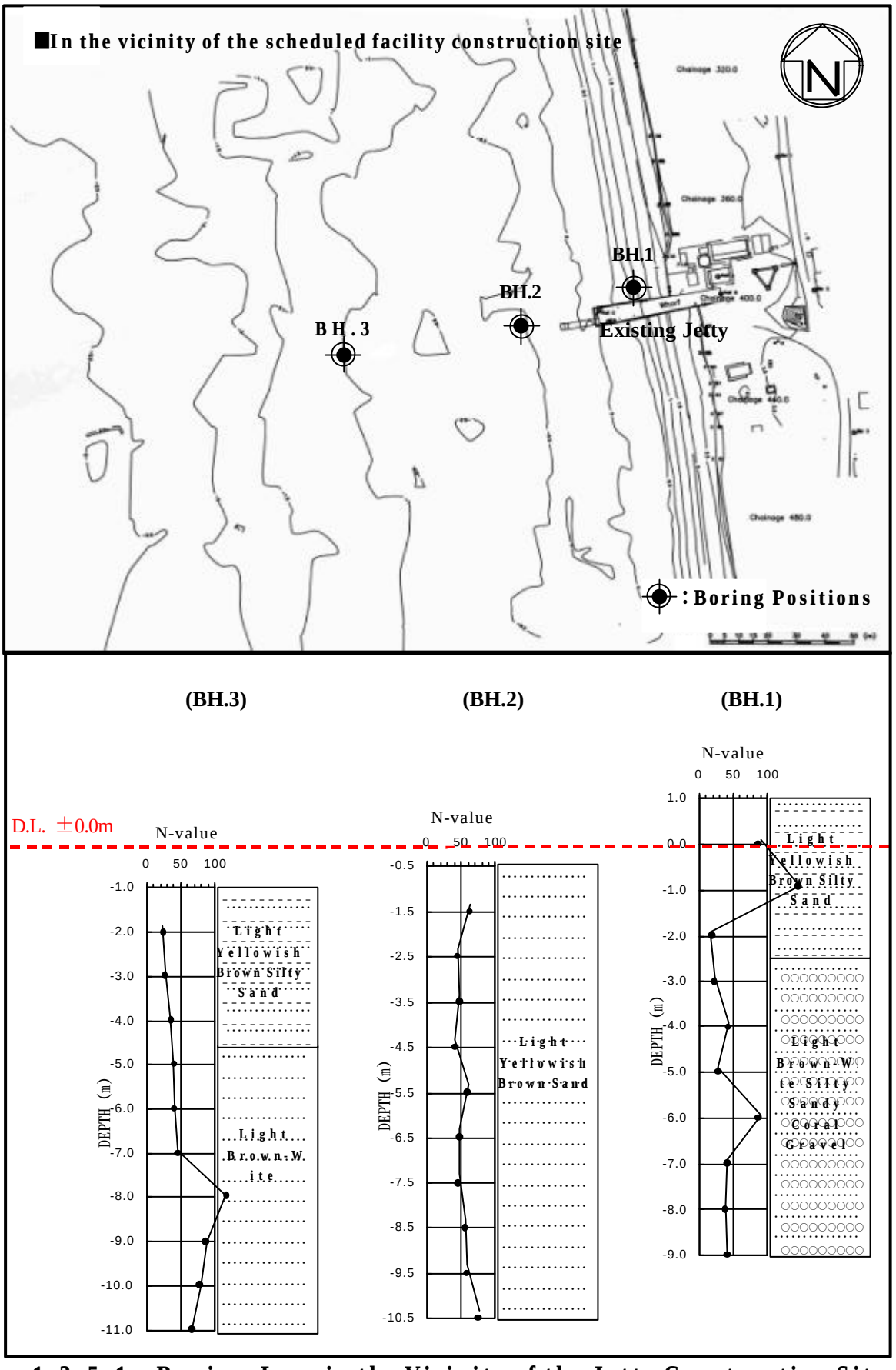


Figure 1.3.5-1 Boring Logs in the Vicinity of the Jetty Construction Site

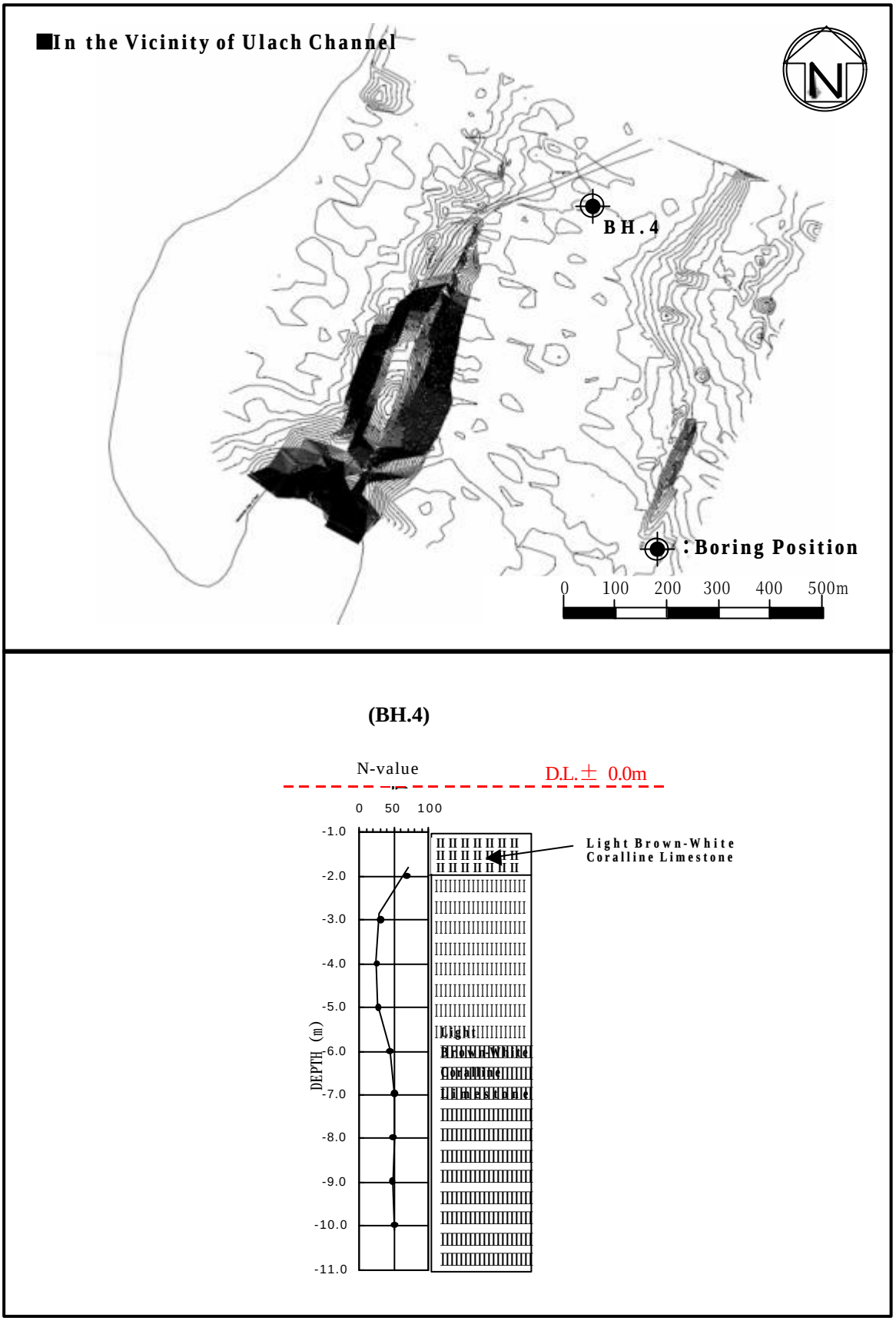


Figure 1.3.5-2 Boring Log in Ulach Channel

1-4 Maritime Environmental Condition

Visual observations on maritime environmental condition such as coral, seaweed and other factors are carried out at the project site, i.e. in the vicinity of the existing jetty and in Ulach Channel. As well, water quality survey is undertaken.

1-4-1 Maritime Environment off Existing Jetty

In the shallow water area off the existing jetty, there is a large-scale sea grass ground extending 1 km offshore and 300 m alongshore as indicated in Figure 1.4.1-1. As shown in Photos 1.4.1-1, 1.4.1-2 and 1.4.1-3, the species of sea grass vary place by place. However, ryuukyuu sugamo (*Thalassia Hemprichii Ascherson*), and eel grasses (*Cymodoccea Roturdata and Springodium Isoetifolium*) are predominant. A few small-scale stocks of sea iris (*Enhalus Acoroides*) as shown in Photos 1.4.1-4 are to be sporadically observed near the south side of the jetty. Those stocks are also the habitat of quite a lot of three-arm cactus grass (*Halimeda Incrassata*) and white pith ivy (*Caulerpa Cupressoides*).

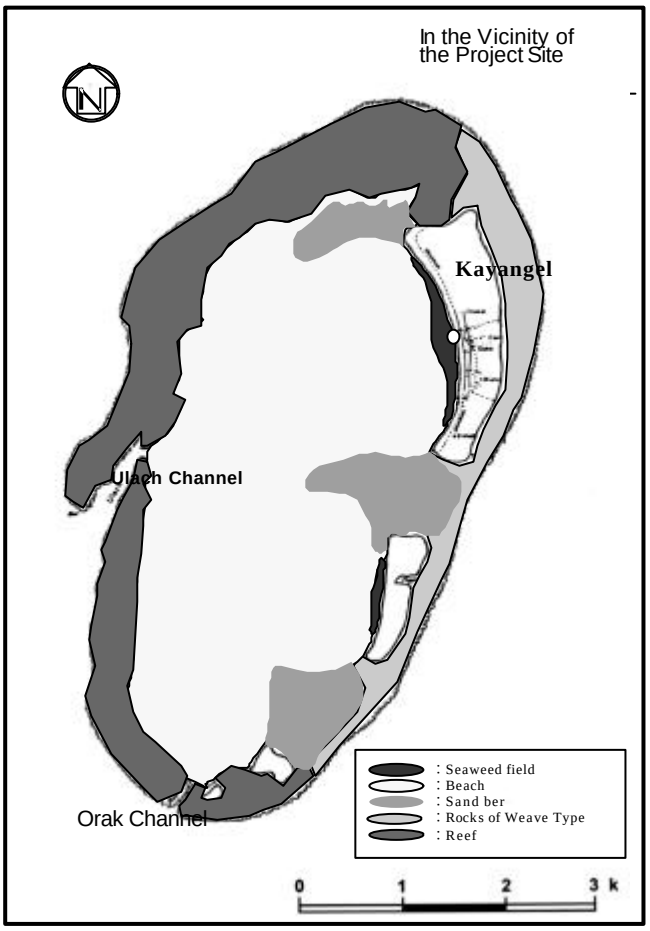


Figure 1.4.1-1 Sea Grass Ground Distribution

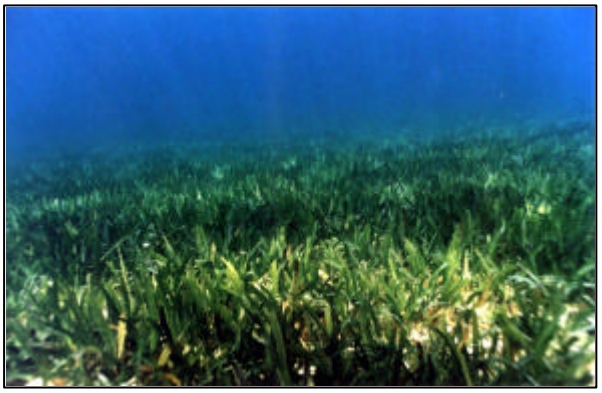


Photo 1.4.1-1 Seaweed Ground off Existing Jetty (1)

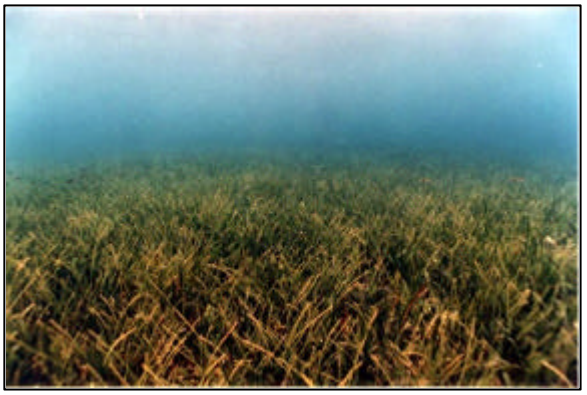


Photo 1.4.1-2 Seaweed Ground off Existing Jetty (2)

Photo 1.4.1-3 Seaweed Sample off Existing Jetty

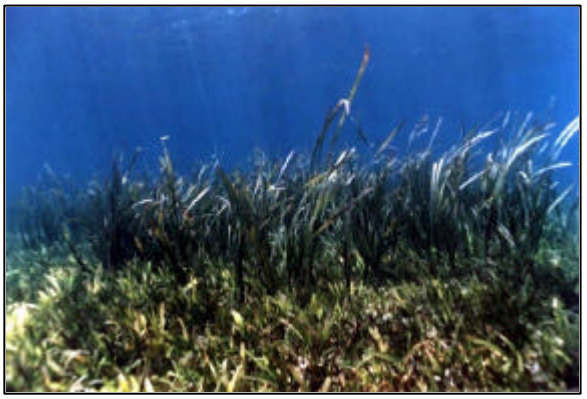


Photo 1.4.1-4 Seaweed Ground off Existing Jetty (3)

Photo 1.4.1-5 Coral off Existing Jetty (1)

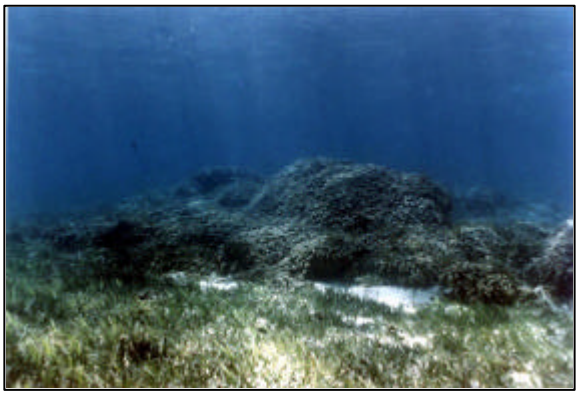


Photo 1.4.1-6 Coral off Existing Jetty (2)

As for coral, small-scale stocks of Palau coral (*Palauastrea Ramosa*) and conical coral (*Turbinaria Mesenterina*) are observed sporadically at several places in offshore area as shown in Photos 1.4.1-5 and 1.4.1-6.

As for fish, fry of goby, butterfly fish, cuvier and horse mackerel as well as valenciennes, but no particularly rare and valuable species are observed in this area.

1-4-2 Maritime Environment in Ulach Channel

As shown in Photos 1.4.2-1 to 1.4.2-3, Ulach Channel and the surrounding sea area consist of coral rocks with sand and dead remains of coral between them, and most of the coral having perished. In the area, only a small part of the coral has survived and is still alive and growing. From the results of our interviews with officials of Palau Government and local residents, it appears that the live coral was practically annihilated by abnormal warming of the seawater by the El Niño phenomenon.

Typical species of the corals observed during the field survey are shown in Photos 1.4.2-4 to 1.4.2-6, namely family of *Acroporidae*, *Porites Lutea*, *Acanthastrea Echinata* and *Coscinaraea Columna* as well as species of *Fungia Scutaria* family to be recognized sporadically in coral debris grounds. No precious and valuable species are confirmed by visual observation.

As for fish, species of wrasse, valenciennes, schlegel and the leather fish are found, which are those generally seen all over Palau. And the habitats of very rare fish species are not observed.

Additionally, sea turtles such as blue sea turtle and tortoiseshell turtles are observed inside the lagoon. Form interview with local fishermen, there are no dugong in the vicinity area. And in interviews with officials of Environmental Quality Protection Board, the maritime area around Kayangel Islands is not the habitat of any particularly precious species or species to be preserved.

Photo 1.4.2-1 Sea Bottom Condition in Ulach Channel (1)

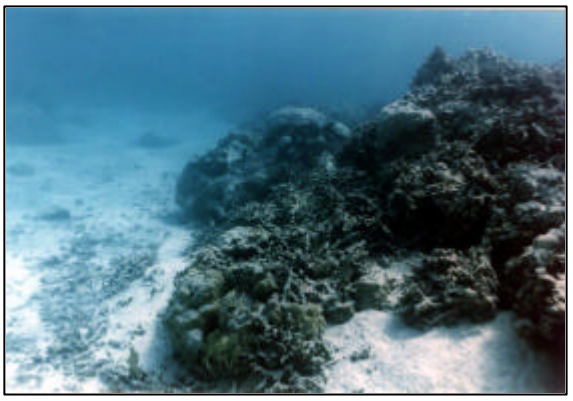


Photo 1.4.2-2 Sea Bottom Condition in Ulach Channel (2)

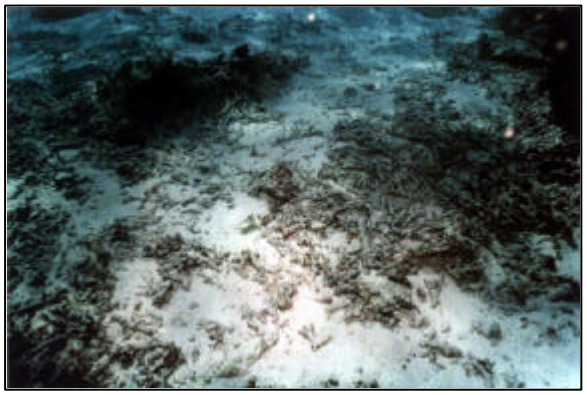


Photo 1.4.2-3 Sea Bottom Condition in Ulach Channel (3)

Photo 1.4.2-4 Typical Coral in Ulach Channel (1)

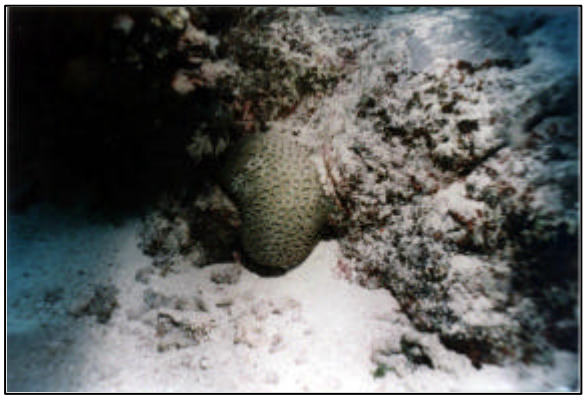


Photo 1.4.2-5 Typical Coral in Ulach Channel (2)

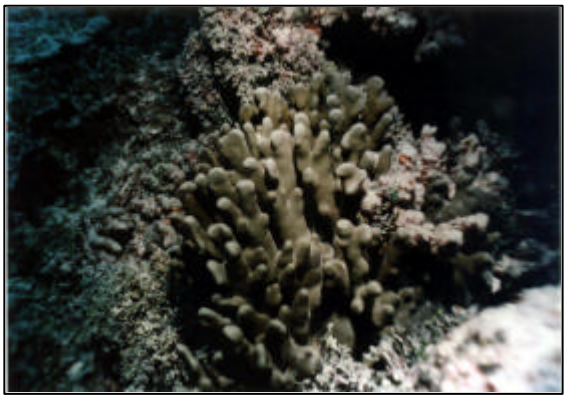


Photo 1.4.2-6 Typical Coral in Ulach Channel (3)

1-4-3 Water Quality Condition

Water quality survey is carried out with respect to 6 points indicated in Figure 1.4.3-1 in the period of two days corresponding to flood tide and ebb tide. The survey items are water temperature, salinity, pH, dissolved oxygen (DO) and chemical oxygen demand (COD). In particular, the vertical distribution over different water depths against temperature and salinity are measured at each point.

The water quality is very pure in those areas, no difference having been observed significantly between inside and outside the reef or between surface layers and bottom layers. Furthermore, water transparency extends for more than 30 m according to hearing to local divers. That can be ascribed to the fact that there are no sources of pollution discharged to those waters, such as rivers or large quantities of wastewater discharge from living activities

The survey results for each survey item are described below.

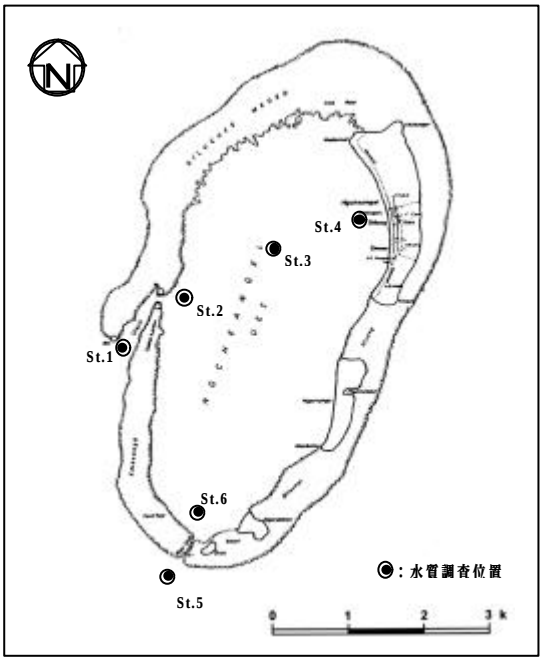


Figure 1.4.3-1 Sampling and Survey Points of Water Quality

(1) Water Temperature

The water temperature ranges from 27.8 to 29.6℃, no difference is observed between high and low tide or in vertical distribution. There is a tendency, however, for the water temperature to be slightly higher inside the lagoon than outside of it.

(2) Salinity

The salinity range is measured to be from 33.4 to 34.0 PSAl. Although no difference is noted between high and low tides or in vertical distribution, the figures tended to be somewhat lower in the vicinity of the jetty construction site.

(3) pH

The pH values in sea area off Japan are said to be in the range from 8.0 to 8.3. In this survey, they are somewhat higher, showing about 8.4.

(4) Dissolved Oxygen (DO)

The values for dissolved oxygen (DO) are in the range from 6.27 to 7.70 mg/l, the general tendency being higher values during flood tide. The Japanese Fishery Standards requires to be 6 mg/l or more.

(5) Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is under 1 mg/l in all of the survey points. That meets the requirement of the Japanese Fishery Standards where under 1 mg/l in sea waters in general is set forth.

CHAPTER 2

CONTENTS OF THE PROJECT

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Objectives of the Project

The jetty facility of Kayangel State, the only port facility of the State located on the isolated island, is a multipurpose facility not only used for fishing activities like preparation of fishing boats for fishing operations, idle berthing between operation and landing of fish catches but also serving port functions like embarking and disembarking of passengers and unloading of daily commodities, construction materials, fuel and others. That being the case, it will be necessary to consider not only fishing port functions but also other port functions in planning the facilities and equipment to be included in the project besides also taking into consideration Kayangel State's environmental aspects.

In this project the following items will be formulated as the basic concepts of the project for developing a fishery base including port activities.

i) Ensuring the safe navigation of fishing boats and other calling boats
ii) Eliminating the restriction of the dock use due to by tide level.
iii) Improvement of efficiency of cargo handling works at the dock
iv) Environmental aspects

2-1-2 Project Component Requested by the Palau Government

The project components requested by the Government of Palau as indicated below will be covered in the basic design study.

i) Construction of Jetty
ii) Dredging of Access Channel
iii) Installation of Navigation Aids
iv) Introduction of Cargo Handling Equipment

Furthermore, in the course of the discussions with the Palau Government installation of lighting facilities, a flag pole warning for boat operations and stairways for passenger's embarkation and disembarkation were also requested as auxiliary facilities for the jetty. As for navigation aid facilities, it was requested that one beacon be installed on the jetty for safe navigation along the access channel in view of the fact that the jetty is located

3.5 km away from the access channel. And in the way of cargo handling equipment, a crane truck was requested as being most appropriate.

2-1-3 Justification of the Project Components

The existing jetty facility is Kayangel State's only the fishing and commercial port facility and represents both a base for the production activities of the State, which is depending on fisheries, and a physical distribution base for transportation of people as well as commodities and materials essential to their daily lives. The existing jetty, which was constructed by the people of the State themselves, is subject to limitation of use of the dock because of the shallow water depth alongside it. As for the access channel namely Ulach Channel, a natural channel making use of a gap in the atoll reef that is used as an access to the inside of the atoll, it does not have sufficient water depth, and the fact that its navigation beacons have been damaged by Typhoon Utor (June and July, 2001) during the field survey has made navigation of calling boats even more dangerous.

Thus, the jetty facility and the access channel facility of Kayangel State have many problems in terms of both utilization and safety, and therefore it is considered to be urgent and justifiable to implement this fishery facilities improvement project in order to settle those problems.

2-1-4 Examination of the Project Components

Examination of the justifiability of the requested project components is mentioned as followings.

(1) Civil Facilities

1) Jetty Facility

The existing jetty facility is a simple structure constructed by installing a pile-type jetty at the front of a concrete dock. The water depth at the end of the jetty is insufficient, the tip of the dock sometimes being exposed above the water surface during low tide. In those areas, the tidal range is considerably wide, fishing boats and other calling boats being able to use the facility only while the tide level is at least a certain height. Not only the are unable to dock during low tide, but also boats berthed at that time even become grounded. Securing appropriate dock water depth is therefore serious for the dock facility.

As for the jetty portion of the existing facility, the structure is so simple and is not strong enough for heavy cargo handling. In order to handle heavy cargoes, it is necessary to wait for a high tide level and accomplish the landing at the dock portion of the facility.

Both the existing dock and jetty portion of the jetty tip have super attenuated and deteriorated, there observing local scouring of the foundation portion and corrosion of the pile piles.

Considering from such limitation of use of the jetty, the present situation regarding cargo handling and the degree of deterioration of the existing facilities, it is concluded therefore to be necessary to improve the facility through improvement of the jetty.

2) Dredging of Access Channel

In order to approach to the jetty facility inside the atoll, calling boats have to pass through the atoll reef of the shallow water depth. Ulach Channel, which is used as the access channel to the inside of the atoll, is a natural channel located on a gap in the atoll reef. It is a simple channel made by removal of obstructing coral boulders by people of the State without any channel dredging to increase the water depth having been undertaken. During low tide the channel depth becomes less than 50 cm in some area, barring passage of boats with deep drafts, which means that they have to wait until the tide level is high enough and even then have to face dangerous navigation conditions. Because of those dangerous conditions, there is frequent occurrence of accidents caused by touch with underwater obstacles and resulting in damage to both hulls and outboard engine propeller.

The access channel being one of the basic facilities of the fishing port, it is concluded to be necessary to carry out improvement, too, for effective utilization of the jetty facility. Dredging of the Ulach Channel is considered to be indispensable for the sake of securing sufficient channel depth and channel width as a means of eliminating the tide waiting to enter or leave the port and ensuring safe navigation in the channel.

3) Installation of Navigation Aids

In the way of navigation aids indicating the location of the access channel there has been installation of one entrance buoy and two light beacons. However, Typhoon Utor (Typhoon # 4, 2001) struck those facilities during our field survey in July 2001, missing away the entrance buoy, knocking down one of the light beacons and damaging the marker panel and

lantern part of the other light beacon. Because of that damage to those navigation aids, it has become dangerous for calling boats to pass through the access channel even in the day time and impossible during the night.

In view of the above situation, it has been concluded to examine installation of the navigation aids along with improvement of the access channel. Navigation beacons will have to be newly provided since the degree of damage of the existing ones would make it difficult to re-use.

A navigation marker will also be installed on the jetty facility to show its location for safe navigation inside the atoll, where between it and the access channel located at distance of 3.5 km to its west.

(2) Equipment

1) Cargo Handling Equipment

Presently the cargo handling at the jetty is done almost entirely manually. Heavy cargoes that cannot be handled manually includes fuel drums and construction materials. Due to the lacking equipment designed for handling heavy cargoes, construction machinery owned by the state government is adopted in the different purpose, resulting in the dangerous cargo handling works. Furthermore, there is expected to be increased in the volume of handling of fuel drums with increase in consumption of fuel by operation of the new power plant, which will make it necessary to take measures to ensure greater efficiency and safety of heavy cargo handling works.

It has therefore been determined to introduce cargo handling equipment not only for more effective use of the jetty facility but also for ensuring that the cargo handling works will be more efficient and safer.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Concepts

(1) Basic Concepts of Facility and Equipment Plan

The facility and equipment plans included in the Project are to be implemented taking into consideration of the following basic concepts.

i) Enabling fishing boats in Kayangel State and other general calling boats to safely navigate, to dock and to load and unload regardless of the tide level.

ii) Enabling the cargo handling works at the dock to be carried out safely

and efficiently.

iii) Enabling safe accomplishment of embarkation and disembarkation of passengers at the dock.

iv) Making the facilities and equipment easy to use, taking into account the existing fishing operation and other relevant activities.

v) Making the design of the structures reflecting appropriately the natural conditions.

vi) Making the plans harmonious so as not to cause any drastic change in the surrounding natural environment or residential environment.

vii) Minimizing the maintenance works of the project facilities.

viii) Establishing a rational project implementation plan through appropriate selection of construction methods and appropriate construction work schedule.

ix) Being compatible with the construction works and current activities such as fishing, other port activities and daily village life.

x) According with Palau's laws, regulations and standards relating to the construction works.

(2) Basic Concepts of Facility Plan

The facility planning is to be carried out on the basis of the following basic concepts taking into account the actual local situation regarding fishing activities and the situation regarding utilization of the existing jetty.

1) Project Location

The existing jetty is located in the central part of the beach on the lagoon side of Kayangel Island. In the area behind the jetty, there are fishery facilities that include an ice-making facility provided on the basis of Japanese Grant Aid Program in 1996. Kayangel State's village and public facilities, too, have been developed on the south side of the jetty. It is appropriate from the viewpoint of land utilization to select the location of the existing jetty as the site for construction of the new jetty, which will be planned as an extension of the existing jetty.

Since the jetty facility is situated in the central part of a sandy beach consisting of coral sand, in the structural planning of the jetty facility it is necessary to minimize the effect on the littoral drift and beach deformation.

2) Utilization Conditions

Since the existing jetty is only the dock facility of Kayangel State,

which is entirely dependent on maritime transportation for physical distribution, not only fishing port functions relating to fishery activities but port functions relating to other boats, too, will have to be taken into account in setting utilization conditions. Therefore, the boats to be covered by the project plans are not just the fishing boats in Kayangel State, but also other related boats that can be expected to call at the port. Furthermore, the facility will be such as to make it possible for cargo handling equipment to be introduced for the sake of greater efficiency of cargo handling works at the dock.

3) Layout Plan

The jetty will be designed as a longitudinal type of jetty in the direction perpendicular to the beach, since the project site is a sandy shallow beach with gentle slope. The tip of the jetty will be positioned in waters with a depth sufficient for the fishing boats and other boats covered by the project to berth at any time regardless of the tide level. The jetty will consist of a dock portion for separate use purposes of fishing port activities such as landing of fish catches and other dock activities such as loading / unloading of cargoes, other cargo handling works and embarkation / disembarkation of passengers, an abutment on the land side and an access bridge portion that connects each other.

(3) Access Channel Facility

The access channel facility will be planned on the basis of the following basic concepts regarding the existing access channel named Ulach Channel.

1) Channel Location

Ulach Channel is a channel utilizing a natural gap in the atoll reef that is located 3.5 km west of the jetty facility. The access channel facility will be planned as improvement of the existing Ulach Channel by dredging to increase the water depth and channel width.

2) Channel Section Plan

The water depth and channel width of the access channel will be planned so that the fishing boats and other boats calling the port in Kayangel State can navigate and approach the jetty facility without any tide waiting time and regardless of the tide level. Considering the present traffic condition of the access channel, its width will be set for accommodation of

one-way traffic.

The access channel's width will be given sufficient lane width to ensure safe passage of boats taking into account the fact that the atoll is situated where intruding wave are breaking and creating higher waves and strong currents.

3) Channel Alignment Plan

The alignment of the access channel will be planned on the premise of rectilinear form since it is desirable in terms of boat maneuverability for the normal line form to be close to a straight line.

4) Environmental Aspect

In case of that coral grows in the vicinity of Ulach Channel, the areas that require environmental protection such as those with rare coral, will be avoided in formulation of the access channel alignment plan. Furthermore, silt protectors will be equipped for the dredging work to prevent diffusion of turbidity due to dredging works. And in view of prohibition of ocean dumping of dredged materials, dredged material will be disposed of on land in Kayangel Island.

(4) Navigation Aids Facility

At the time of improvement of the access channel, navigation beacons will be installed as navigation aids.

1) Layout Plan

On the basis of meeting the requirement that the navigation beacons clearly indicate the channel alignment set in the access channel planning, the minimum quantity of navigation beacons required for safe navigation of boats will be included. A navigation beacons will also be installed on the jetty for the safety of navigation within the atoll since a distance of about 3.5 km to the access channel. As for the buoy indicating the entrance of Ulach Channel that is missing away by a typhoon in July 2001 during the field survey, the layout plan will be based on the premise that the Government of Palau is responsible to restore it.

2) Type of Navigation Aids

Since the water depth is comparatively shallow around the access channel, the navigation beacons will basically be those of the fixed foundation

type, without use of the floating buoy type. The beacons adopted will also be equipped a lantern for night navigation.

(5) Cargo Handling Equipment

A fixed type or a mobile type of crane could be proposed as the cargo handling equipment at the jetty, but since there would be the problem of corrosion if a fixed-type crane were to be installed at the dock, the mobile type, which can be moved away in garage for protection from the severely corrosive environment when not in use, will be adopted. Considering the cargo handling condition at the existing jetty, the commodity type and volumes of cargo handled, the mobile-type cargo handling equipment is set as a crane truck, which will be able to engage in both cargo loading and unloading operations and cargo transportation. The specifications of the truck with a crane will be set on the basis of the types of commodity and weights of the handled cargo as well as the jetty height and the boat particulars.

(6) Design Standards

In Palau, no particular standards have been set for design of maritime structures, the implementing organization setting its own standards to serve as a basis for design of structures. In this project, the design of the fishing port structures will be made under the Japanese standards for fishing port structures, "Technical Guidelines for Fishing Ports," and "Technical Standards for Port Facilities" which supplement them.

2-2-2 Basic Plan

(1) Basic Design Condition for Planning

1) Traffic Condition of Fishing Boat and General Boat

There are eleven fishing boats registered in Kayangel State. The frequency of fishing operation depends very much on weather conditions: about 20 days a month from February to April, when sea conditions are comparatively calm, and 5 to 6 times a month from May to June and from December to January, when sea conditions are relatively rough. The total annual number of fishing operation days is estimated as 120 to 130 days. The fishing grounds frequently operated are located in the area around Kayangel, and the fishing operations are mainly one-day excursions, the boats leaving out at 6 to 7 o'clock in the morning and returning at 5 to 6 o'clock in the evening in the case of trolling line and hand line fishing. Fishing trip

starts at about 8 o'clock at night and returning next morning in the case of spear gun and harpoon fishing using snorkels. The average fish catch per boat is estimated as 17 to 22 kgs/day.

A medium-size fishing boat operates as a regular fishery product transportation, making the voyage from Kayangel State to Koror State about once a week. Regular round-trip operations are also made every other week by a passenger boat "North Star" owned by the State Government, on Friday and on Sunday, and by a speedboat that sails 3-4 times a week depending on the volume of cargoes to be transported, consisting mainly of essential commodities and materials. Besides that, a state patrol boat controls the State's territory waters mainly for marine resource protection and rescue purposes. Furthermore, with commencement soon of operation of a new power plant, the Palau Public Utility Corporation (PPUC) will be starting transportation of fuel for the plant by a boat.

Besides those regularly calling boats, tourist boats, National Government's and NPO's boats and ferryboats, barge and tugboat carrying construction materials and other heavy cargoes sometime visit the port.

2) Design Boat Dimensions

Table 2.2.2-1 gives the dimensions of the fishing boats registered in Kayangel State. And Table 2.2.2-2 shows the ship particulars of the general boats owned by State Government, namely middle size fishing boat, passenger boat, patrol boat and other relevant boats.

Table 2.2.2-1 Registered Fishing Boats in Kayangel State

No.	Length Overall	Draft	Breadth	Tonnage	Outboard Engine
1	7.0 m	0.3 m	1.8 m	0.9 GT	200 HP
2	7.0 m	0.3 m	1.8 m	0.9 GT	140 HP
3	7.0 m	0.3 m	1.8 m	0.9 GT	140 HP
4	7.0 m	0.3 m	1.8 m	0.9 GT	115 HP
5	7.0 m	0.3 m	1.8 m	0.9 GT	50 HP x 2
6	7.0 m	0.3 m	1.8 m	0.9 GT	90 HP
7	6.4 m	0.3 m	1.8 m	0.6 GT	200 HP
8	6.1 m	0.3 m	1.8 m	0.6 GT	115 HP
9	6.1 m	0.3 m	1.8 m	0.6 GT	90 HP
10	6.1 m	0.3 m	1.8 m	0.6 GT	85 HP
11	2.7 m	---	---	---	---

Table 2.2.2-2 General Boats Owned by Kayangel State

No.	Boat Name	Category	Length Overall	Draft	Breadth	Tonnage
1	North Star	Passenger Boat	13.6 m	1.2 m	4.05 m	10 NT
2	Speed Boat	Passenger/ Cargo Boat	8.8 m	0.9 m	2.43 m	2 GT
3	Velasco II	Fishing Boat	11.0 m	1.1 m	3.05 m	3 GT
4	Patrol Boat	Maritime Conservation	7.0 m	0.3 m	1.83 m	0.9 GT

The design boat particulars of the representative boats for the planning of the jetty and the access channel as based on the information on the fishing boats and other general boats given above are set as shown in Table 2.2.2-3.

Table 2.2.2-3 Boat Particulars for Facility Design

No.	Boat Name	Applied Facility	Length Overall	Draft	Breadth	Number of Boat
1	North Star	Jetty, Channel	13.6 m	1.2 m	4.05 m	1
2	Velasco II	Jetty	11.0 m	1.1 m	3.05 m	1
3	Speed Boat	Jetty	8.8 m	0.9 m	2.43 m	1
4	Fishing Boat (Maximum)	Jetty	7.0 m	0.3 m	1.81 m	5
5	Fishing Boat (Average)	Jetty	6.3 m			11

Among the boats that do not call with regular schedules, there is the KB Queen owned by National Government, the Peliliu Star owned by Peliliu State and the Regina IV owned by Angaur State. For reference, Table 2.2.2-4 gives the particulars on the KB Queen, the largest of ferry boats, as well as those on National Government's, tourist and NPO's boats.

Table 2.2.2-4 Other Cargo Boats and General Boats Calling Kayangel State

Ship Name	Category	Length Overall	Draft	Breadth	Tonnage
KB Queen	Cargo Ferry	33.2 m	1.9 m	7.0 m	159 GT
Tourist Boat	Passenger Boat	7.0～8.8 m	0.3～0.9 m	1.8～2.3 m	
National Gvrn't Boat	Passenger Boat	7.0～8.8 m	0.3～0.9 m	1.8～2.3 m	
NPO's Boat	Passenger Boat	7.0～8.8 m	0.3～0.9 m	1.8～2.3 m	

(2) Design Condition

1) Tide Condition

As indicated in Table 2.2.2-5, the tidal range in Kayangel Island is observed as 2.3 m.

Table 2.2.2-5 Design Tide Level

Tide Condition	Tide level
H.H.W.L.	D.L.＋2.30 m
M.W.L.	D.L.＋1.15 m
L.L.W.L.	D.L.±0.00 m

2) Wave Condition

Concerning the design waves, the design offshore wave has been set by wave hindcasting on the basis of Typhoon Mike, which passed closely on the north side of Kayangel State in 1991, and wave height in front of the jetty and on the atoll reef has been estimated by wave deformation analysis. Table 2.2.2-6 gives the dimensions on the design waves at the project sites of the jetty and the access channel.

Table 2.2.2-6 Design Wave Condition

Design Wave	Wave Height (H)	Wave Period (T)
Offshore Wave	8.0 m	10.1 s
Jetty Front	1.12 m	10.1 s
Channel Entrance	2.64 m	10.1 s
Channel Exit	1.92 m	10.1 s

3) Load Condition

Surcharge	:	0.50 tf/m^3 (normally),
	:	0.25 tf/m^3 (under earthquake condition)
Approach Speed of Boat	:	0.5 m/s
Tractive Force	:	3.0 tf/post (boat of 10 GT class),
	:	1.0 tf/post (fishing boat)
Seismic Factor	:	0.08
Traffic Load	:	Crane truck introduced in the Project

4) Specific Gravity of Construction Material

Reinforced Concrete	:	2.45t/m^3(in air),
	:	1.42t/m^3(in water)
Plain Concrete	:	2.30t/m^3(in air),
	:	1.27t/m^3(in water)
Armor Stone	:	2.60t/m^3 (in air),
	:	1.57t/m^3:(in water)
Backfilling Material	:	1.80t/m^3(in air),
	:	1.00t/m^3(in water)
Sea Water	:	1.03t/m^3

(3) Basic Plan of Jetty Facility

1) Basic Concept of Jetty Layout

Since the dimensions of the fishing boats registered in Kayangel State are smaller than those of the general and middle size fishing boats owned by State Government, and the different utilization condition in which they use the mooring facility, the part of the jetty used by bigger boats and that used by fishing boats will be separated. In other words, since in the case of smaller fishing boats the draft is smaller and the frequency of utilization of the jetty is higher, their convenience will be considered by locating their berthing dock at the part of the jetty comparatively near to the land area. Since, on the other hand, the general boats owned by State Government have larger draft and lower frequency of berthing at the dock, their utilization of the jetty will be at the tip away from the land. Figure 2.2.2-1 is a conceptual diagram of division of functions at the jetty facility as based on the local movement lines of fishery activities and general cargo, passengers, etc. and on division of the jetty by boat utilization categories.

There will not be provision of any breakwater since the waves within Kayangel Atoll through the year are very calm, remaining below the height of 30 cm, the limit for boat unloading operations, 98.0% of the year. The

occurrence rate of wave heights above 60 cm, the limit for berthing is only 0.3%. In case of stormy sea condition in lagoon area, fishing boats and other berthing boats in the lagoon have to evacuate in safe area or to be lift on the beach.

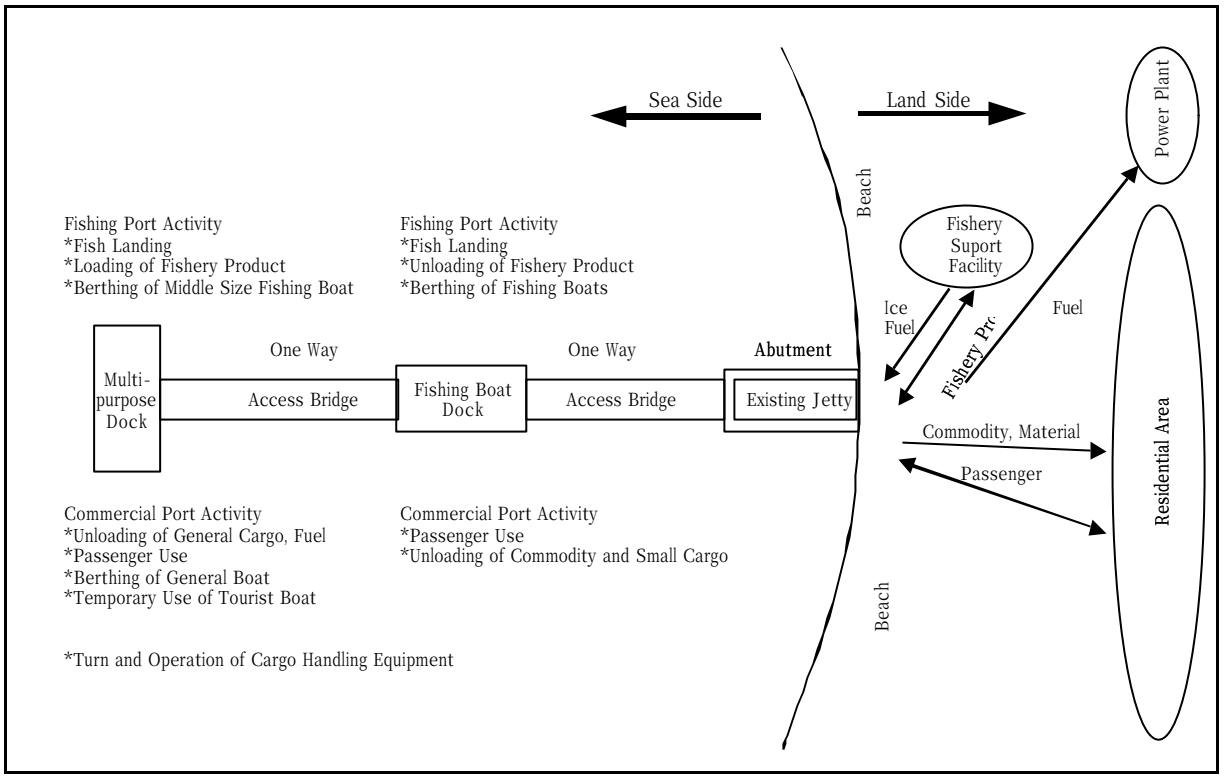


Figure 2.2.2-1 Concepts of Jetty Layout Plan

The jetty facility is divided functionally into a multipurpose dock, a fishing boat dock, an abutment and access bridges connecting them. The boats that will be making use of the different docks are set as follows.

The boats covered by the project for use of the multipurpose dock at the tip of the jetty belong to the following 4 types. The KB Queen and other cargo ferries are not covered by the Project because of the fact that their ship particulars are much larger with very low frequency of ship call than those of the boats covered by the Project.

i) Passenger boat : passenger boat owned by the State Government (North Star)
ii) Fishing boat : medium-size fishing boat (Velasco II)
iii) Cargo boats : speed boats
iv) Other boats : boats other than those owned by the State government and tourist boats

The fishing boat dock will be designed for accommodation of the 11 fishing boats registered in Kayangel State, including berthing of them on both north and south sides of the dock.

2) Layout Plan of Jetty

The respective layout plan contents of the multipurpose dock, the fishing boat dock, the access bridge portions and the abutment of the jetty are indicated below.

a) Layout Plan of Multipurpose Dock

The configuration dimensions of the multipurpose dock located at the tip end of the jetty will be set taking into account of utilization of the medium-size fishing boat (Velasco II), the passenger boat (North Star) and speed boat owned by state government and other general boats as well as the maneuverability of the crane truck to be introduced for cargo handling at that dock.

Considering the situation regarding dock use of the boats in Kayangel State expected to use the multipurpose dock, the berthing frequency of the speedboats will be the highest among the design boats, and those of the other boats will be low, about once a week in the case of the medium-size fishing boat "Velasco II" and twice every other week in the case of the passenger boat "North Star", the largest boats covered by the Project. The design dimensions of the multipurpose dock will be basically dictated by the maneuverability expected for the cargo handling equipment (crane truck), the area required for its turn and back on that dock.

As indicated in Figure 2.2.2-2, the way the cargo handling vehicle will turn is first to position its chassis longitudinally and then have it turn by cutting back. Assuming a loaded weight of the crane truck rated 3 to 4 tons, the necessary jetty width for it to turn will be set as indicated below.

Since stairways will be provided at the front of dock for landing fish catches and unloading cargoes and embarkation and disembarkation of passengers, the width of those steps will be taken into account.

Length of Multipurpose Dock

= Length Required for Turning Crane Truck + Allowance

= 21.0m ＋ 1.0m ＝ 22.0m

Width of Multipurpose Dock

= Required Width for Turning Crane Truck

+ Width of Stair + Allowance

= 8.0m + 1.0m + 1.0m = 10.0m

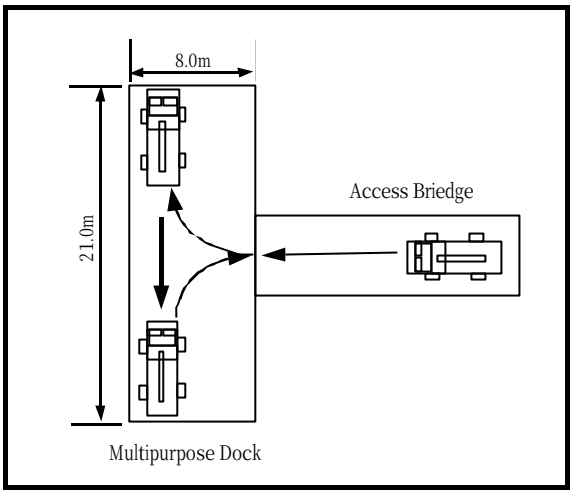


Figure 2.2.2-2 Required Turning Distance of Crane Truck

Thus, the configuration of the multipurpose dock at the tip of the jetty is determined by a length of 22.0 m and a width of 10.0 m as indicated in Figure 2.2.2-3. In that case, berthing combinations of the main boats such as that indicated in Table 2.2.2-7 are allowable at the dock. Furthermore, with a dock width of 10 m it will be possible to berth a boat sized around 8.0 m at each end, meaning that those places can be used as idle berthing. At those berths, there will be provision of traps for embarkation and disembarkation of boat crews. Furthermore, there will be provision of fenders, mooring bits and other necessary accessory facilities at the part of the dock where boats come and berth alongside.

Table 2.2.2-7 Boat Combination Berthing alongside Multipurpose Dock

Number of Berthing Boats	Boat Name	Length Overall	Boat Name	Length Overall
1	North Star	13.6m	———	———
2	Velasco II	11.0m	Speed Boat	8.8m
2	Speed Boat	8.8m	30' Class Boat	8.8m

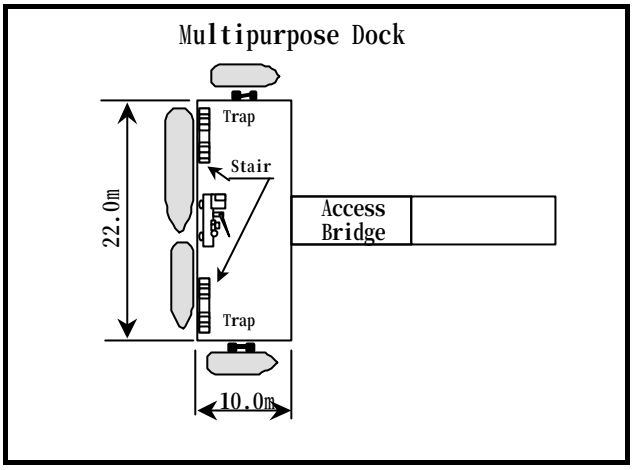


Figure 2.2.2-3 Schematic Layout of Multipurpose Dock

b) Layout Plan of Fishing Boat Dock

The fishing boat dock is for the purposes of fish catch landing, preparatory works for fishing operations and idle berthing of the 11 fishing boats registered in Kayangel State. The length of the dock will be planned on the assumption that the fishing boats moor on both sides of the jetty.

The required length of the fishing boat dock will be set as follows on the assumptions of parallel mooring in two rows and three berths on each side of the jetty. The required length will be taken including allowance of 15% of boat overall length.

Required length of Fishing Boat Dock
= Required Berth Length x Number of Berths

Berth Length of Parallel Berthing
= Boat Length + Allowance (Boat Length x 0.15)

Assuming that the fishing boat length is taken as the average of the figures given in Table 2.2.2-3, parallel berth length and the required length of the dock are calculated as indicated below. The required length of the fishing boat dock is therefore set at 23.0 m.

Berth Length of Parallel berthing
=6.3m＋6.3m×0.15＝7.2m

Required Fishing Boat Dock Length
=6.3m×3 boats＋6.3m×0.15×（3＋1）=22.7**m** ⇒ 23.0m

Stairs to be used for landing of fish catches will be provided at the middle berth, and traps for embarkation and disembarkation of fishermen and boat crews will be provided at the berths on both sides. There will also be provision of auxiliary facilities of guard net for preventing fishing boats from going under the jetty structure and those necessary for berthing.

On the basis of the above planning procedures and considerations, a dock with a length of 23.0 m for use by fishing boats will be provided at the central part of the jetty, the jetty width there being set as the width of the access bridge plus the width of the steps. Figure 2.2.2-4 summarizes the layout plan of the fishing boat dock.

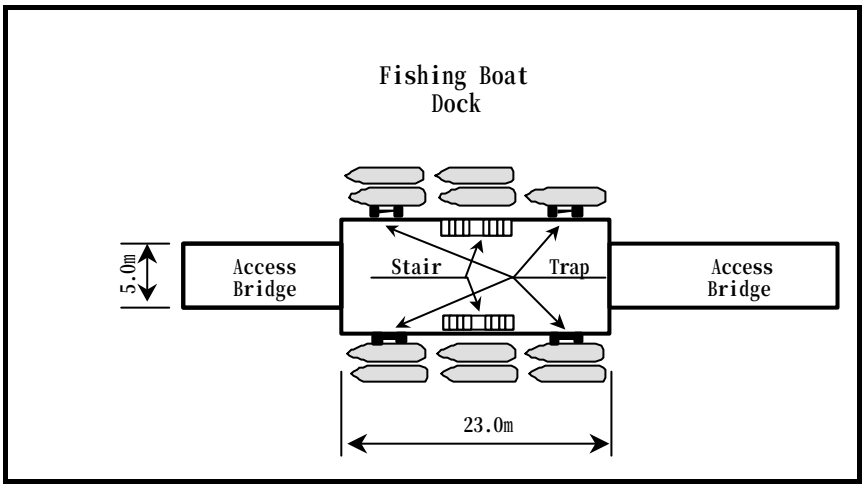


Figure 2.2.2-4 Schematic Layout of Fishing Boat Dock

c) Basic Plan of Access Bridge

The access bridge of the jetty will be used as connection bridges between docks and land for movement of the crane truck and users, such as fishermen, passenger and resident people. In setting the width, it is necessary to ensure safety of use and avoid overlapping of movement line. Bridge width will be comprised of the portions such as the road, sidewalks and curbing for prevention of falling of vehicles into the sea.

The road will consist of just one lane for one-way traffic considering the small traffic volume, and its width will be the minimum 3.0 m. As for sidewalks, it is desirable that there be one on each side of the road considering the movement lines of people. Normally the sidewalk width should be 1.5 m, but in view of the small volume of traffic it will be reduced to 70 cm, enough space for one adult person to walk along. The width of the curbing with handrails is set as 30 cm.

From the above, the width of the access bridge of the jetty will be set at

5.0 m as shown in Figure 2.2.2-5.

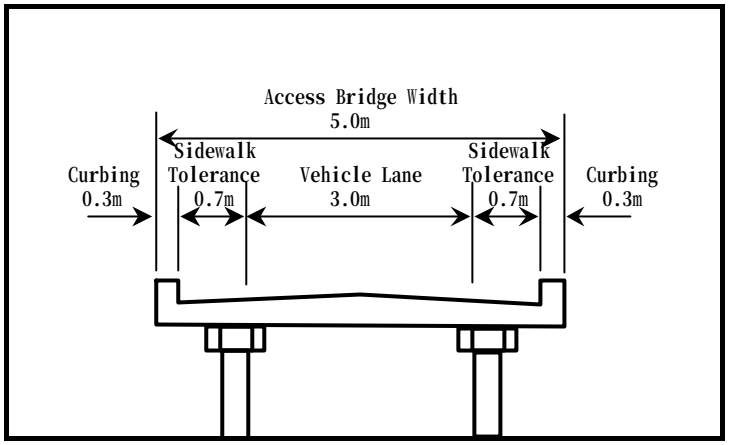


Figure 2.2.2-5 Contents of Access Bridge Width

3) Structural Plan of Jetty

a) Structural Plan of Main Jetty

As indicated in Figure 2.2.2-6, there are four possible types of jetty structures, namely the pipe pile type, the sheet pile type, the gravity type and the pontoon type.

From the viewpoint of environmental aspects, those different structural types can be evaluated as follows. In the case of the gravity type and the sheet pile type of structure, waves and currents cannot permeate through them, which means that they would obstruct littoral drifts and coastal currents in surrounding area, resulting in beach deformation (erosion/deposition) and change in current condition and its pattern, with considerable consequent negative effects on the scenery and coral, sea grass grounds and other parts of the ecological system. As for the pontoon type of structure, like the pipe pile type it does not have much negative impact on the environment, but there would be problems like stability with respect to the external forces such as waves and current, and problems in operation and maintenance.

Therefore the pipe pile type of structure, which will have the least environmental impact, will be adopted considering that that construction method will be applicable considering sub-ground foundation conditions characterized by wide distribution of compacted coral sand layers in spite of some distribution of thin coral rock layers.

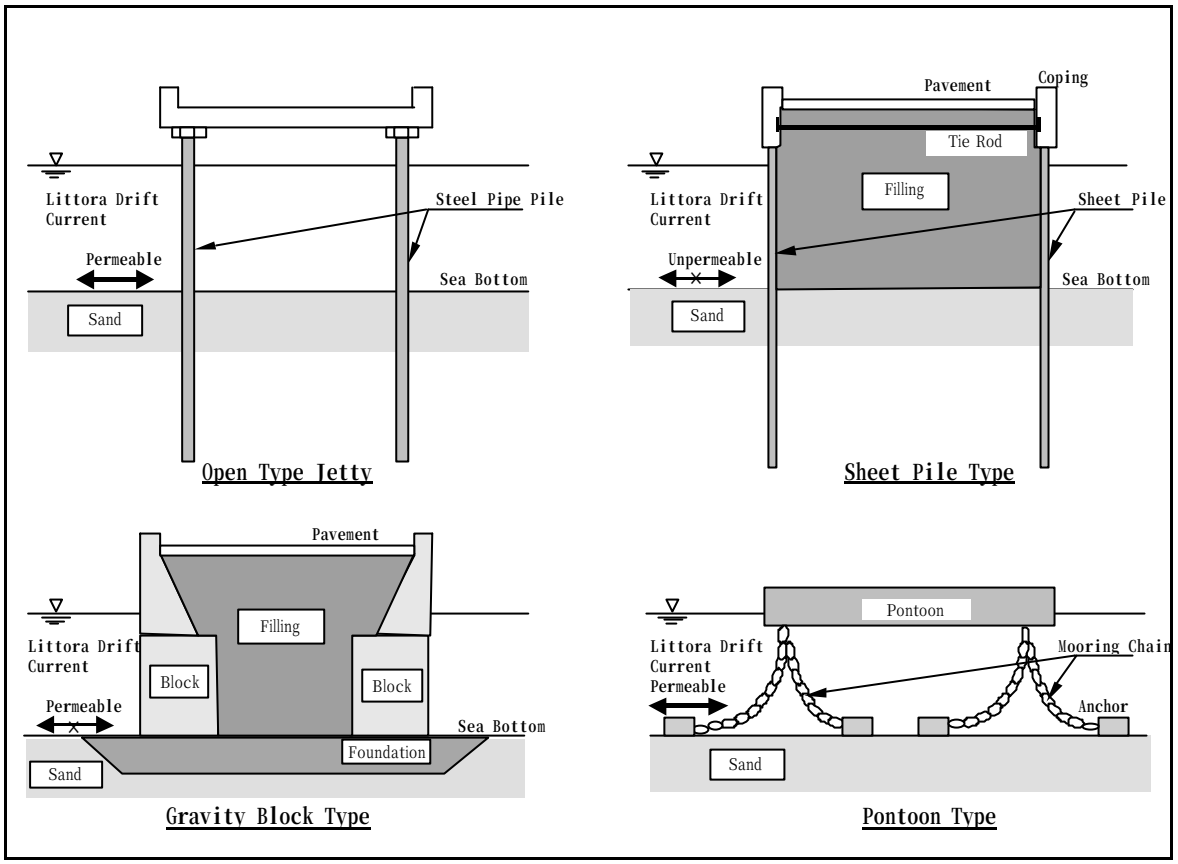


Figure 2.2.2-6 Structural Types for Jetty Facility

b) Structural Plan of Abutment

Since the jetty is to be newly installed at the same place where the existing jetty is located, either removal or improvement of the dock portion of the existing jetty will be subjects to be settled.

The land side portion of the existing jetty consists of a dock with a concrete structure, the foundation part of which is observed to have suffered local scouring that has resulted in its deterioration. Since the concrete-pile type jetty portion of the extremity of the existing dock has suffered deterioration with corrosion of piles, it will be removed because of insufficient jetty structure strength and crown width and area.

Removal of the existing dock part would generate a lot of construction material disposal that would have to be disposed of on the island. Therefore, because of environmental considerations in this project, the existing dock will be made effective use of instead of being demolished. As indicated in Figure 2.2.2-7, its abutment part will be improved by adding an attached armor wall around it with concrete, the armor concrete wall being of the vertical type and having a thickness of 0.75 m.

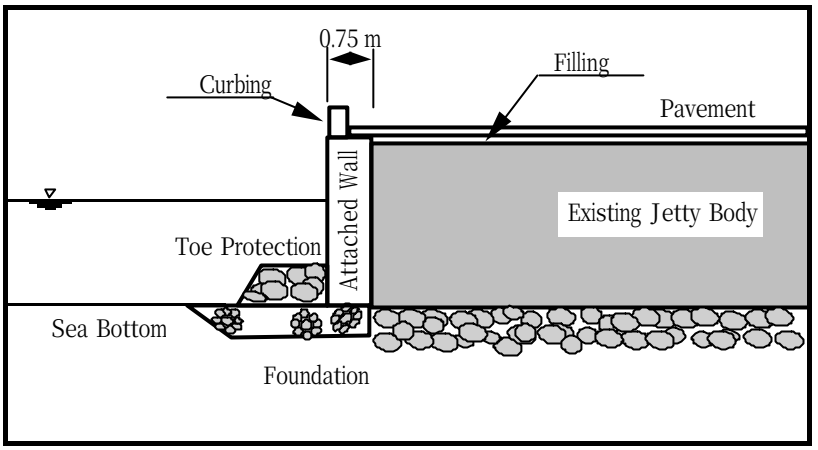


Figure 2.2.2-7 Improvement of Existing Abutment

4) Crown Height of Jetty

The crown height of the jetty will be determined, taking into account the ground height of the hinter land, the crown height set from the viewpoint of utilization and the crown height set on the basis of the wave conditions. The setting method of the crown height for a pipe pile open type jetty structure is indicated below.

a) Ground Height of Hinter Area

The ground height of the surrounding hinter land of the jetty is obtained as follows on the basis of the results of topographic surveying. Kayangel Island generally has about the same ground height as the hinterland of the jetty, and it is therefore surmised that if the crown height of the jetty is made the same as the ground height of the hinterland, there will not be much occurrence of wave overtopping or overflow that would surmount the jetty.

Ground Height of Hinter Area = D.L. + 3.2 m

b) Crown Height for Dock Utilization

Such jetty crown height is set on the basis of the crown height of the berthing dock of a fishing port taking into account tide level, the size of the fishing boats and the utilization type. Dock crown height is set on the basis of the following standards for the different uses.

Crown Height of Fishery Dock

= H.W.L. (Design High Tide Level) + Number (Table 2.2.2-8)

Table 2.2.2-8 Crown Dock Height Recommended for Utilization

Tidal Range (H.W.L.－L.W.L.)	Design Boat Tonnage (GT)			
	0～20	20～150	150～500	500 or More
0.0m～1.0m	0.7m	1.0m	1.3m	1.5m
1.0m～1.5m	0.7m	1.0m	1.2m	1.4m
1.5m～2.0m	0.6m	0.9m	1.1m	1.3m
2.0m～2.4m	***0.6m***	0.8m	1.0m	1.2m
2.4m～2.8m	0.5m	0.7m	0.9m	1.1m
2.8m～3.0m	0.4m	0.6m	0.8m	1.0m

Therefore the crown height of the jetty is set as follows on the basis of a tidal range of D.L. +2.3 m and a boat tonnage of less than 20 GT.

Crown Height of Dock

= H.W.L. + 0.6 m = D.L. + 2.3 m + 0.6 m = D.L. + 2.9 m

c) Crown Height for Design Wave Condition

The crown height of the jetty is to be such that there is the required clearance for ensuring that the slab part of the jetty is not subject to wave action. It is set as follows as the height obtained on the basis of a clearance of about the design wave height above the design high tide level (H.W.L.) with allowance plus the jetty slab thickness:

Required Clearance

= Design High Water Level

+ Wave Height of Design Waves + Allowance

Jetty Crown Height

= Jetty Slab Thickness + Required Clearance

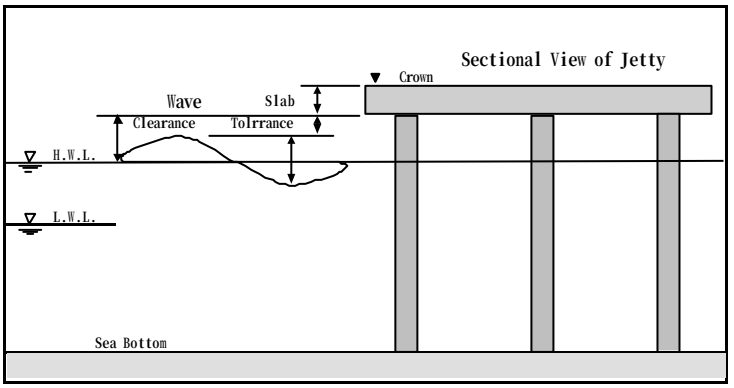


Figure 2.2.2-8 Schematic View of Wave Action to Jetty

Therefore with a design high tide level of D.L. +2.3 m and a design wave height in front of the jetty of 1.12 m, the jetty crown height is calculated to be D.L. + 3.7 m.

Crown Height = D.L. 2.3 m + 0.3 m + 1.12 m = D.L. + 3.7 m

d) Determination of Jetty Crown Height

Table 2.2.2-9 shows the jetty crown heights according to the different methods of the design criteria. The crown height set from the viewpoint of utilization is the lowest, and that set from the viewpoint of wave conditions is the highest. There is a difference of about 30 cm between the crown height set from the viewpoint of utilization and the ground height of the hinterland, and it is considered that there would not be much occurrence of problems in terms of utilization if the crown height were to be set as same as the ground height of the hinterland.

Therefore the jetty crown height is set at D.L. + 3.2 m, the same as the ground height of the hinterland.

Table 2.2.2-9 Alternate Crown Height of Jetty

Design Condition	Crown Height
a) Ground Height of Hinterland	D.L.+3.2m
b) Dock Utilization	D.L.+2.9m
c) Design Wave Condition	D.L.+3.7m

5) Water Depth of Jetty Front

The position of the multipurpose dock at the tip of the jetty will be set so that the larger boats owned by the State Government that make use of it will be able to berth at any time regardless of the tide level.

The design dock water depth is set as per the following equation on the basis of the maximum fully loaded draft of the design boats using the dock and an allowance for conditions like squat and trim of the boat caused by wave motions. The design boat with the largest draft that will be berthing at the multipurpose dock is the passenger boat “North Star” of 1.2 m draft. Furthermore, the stipulated allowance for setting the design dock water depth in the case of a soft seabed foundation is 0.5 m

The position of installation of the multipurpose dock will be in the offshore area with a depth of D.L. -1.7 m.

Design Water Depth of Multipurpose Dock

= Maximum Draft + Allowance

= 1.2 **m** + 0.5 **m** = D.L. -1.7 **m**

On the other hand, the required water depth for the fishing boat dock is set on the basis of the drafts of the 11 registered fishing boats. Since the registered fishing boats are all FRP boats with a outboard engine and a length of about 7.0 m, the location of that dock will be in the area with a depth of at least 50 cm, considering a draft of 30 cm and some allowance due to wave motions.

Design Water Depth of Fishing Boat Dock = D.L. -0.5 m

6) Extension of Jetty

Figure 2.2.2-9 shows the seabed bathymetric profile in front of the existing dock. Since the offshore area where the design water depth for the multipurpose dock of D.L. -1.7 m can be obtained are 116 m offshore from the front edge of the existing dock, the alignment of the dock will be set in that position. As for the fishing boat dock, which has to be located in areas with a depth of D.L. -0.5 m, it is considered appropriate to place it at least 35 m offshore from the front edge of the existing dock

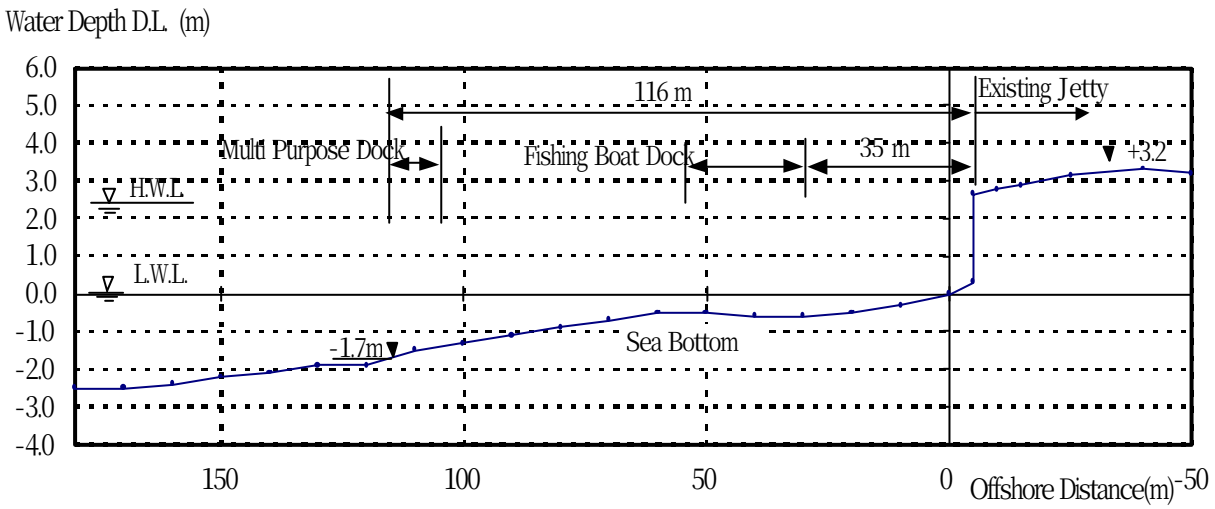


Figure 2.2.2-9 Offshore Distance for Multipurpose Dock and Fishing Boat Dock

7) Auxiliary Facility Plan

The jetty facility is to be provided with the following auxiliary facilities.

a) Emergency Flagpole

In case of rough sea conditions, the National Emergency Management Board issues emergency order of prohibiting voyage, such prohibition being indicated by a red warning flag. A flagpole for that purpose will therefore be provided at the multipurpose dock at the tip end of the jetty.

b) Stairways and Traps

During the low tide, where the tidal range is considerably wide, reaching a maximum of 2.3 m, it is difficult to go between the fishing boats and the jetty at low tide, so that stairways and traps will be provided there for safety operation and convenience. Such stairways and traps will be provided at two places each at the multipurpose dock and the fishing boat dock. Traps for access to and from the jetty will be provided for the crews of the idle berthing boats, namely one at each end of the multipurpose dock and one at each side of the two berths of the fishing boat dock where stairways are not provided. Furthermore, means of preventing the fishing boats from going under the fishing dock will be provided at each berth there.

c) Fender

Both the multipurpose dock, where the passenger boat and other general boats will berth, and the fishing boat dock will be provided with fenders. As indicated in Table 2.2.2-10, the fenders for fishing boats will be set according to their design boat size. The design boat size for the planning of such auxiliary facilities are set as 5 GT type, regardless the boat berthing along the dock is small fishing boats with less than 2 GT.

Table 2.2.2-10 Size of Fender for Fishing Boat

Boat Tonnage	Boat Length	Approach Speed	Fender Height
5 GT	11.0 m	0.5 m/s	130 mm
10 GT	13.0 m	0.5 m/s	150 mm

Fender heights of 150 mm and 130 mm are set for the multipurpose dock and the fishing boat dock, respectively, on the basis of the energy absorption calculated on the basis of coverage of 10 GT and 5 GT boats, respectively, and an approach speed of 0.5 m/s. Fender length is set at 2,500 mm since the dock crown height will be D.L. + 3.2 m and the mean low tide

level will be D.L. + 0.58 m.

The specifications of the fenders for the multipurpose dock and the fishing boat dock will therefore basically be the fishing port types 150mm (H) × 2,500mm (L) and 130mm (H) x 2,500mm (L), respectively.

d) Mooring Bit

The mooring bits will be of the post type and will be selected on the basis of calculation of boat tractive force based on 10 GT and 5 GT fishing boats for both the multipurpose dock and the fishing boat dock as in the case of the fenders.

The interval of installation of the mooring posts will basically be 5.0 m, which corresponds to a dock water depth of less than -3 m as based on the fishing port technical standards indicated in Table 2.2.2-11.

Table 2.2.2-11 Interval of Bit

Water Depth of Dock	Bit Interval
-3.0m or Less	5.0m
-3.0m to -5.0m	7.5m
-5.0m or More	10.0m

e) Curbing

Since the crane truck will be traveling on the jetty, for prevention of its falling off the jetty there will be installation of curbing at the necessary places on the multipurpose and fishing boat docks and their access bridge of the jetty.

f) Lighting Facility

Since the jetty will also be used during night time, lighting facilities will be installed on the multipurpose dock and the fishing boat dock. As for the illumination intensity of the lighting, in view of the fact that there will probably not be very high frequency of use of the jetty at night, it will be set at 15 lux, the lowest figure according to the fishing port technical standards.

8) Schematic Layout Plan of Jetty

Figure 2.2.2-10 summarizes the layout plan of the jetty as based on the jetty facility contents set forth in the above.

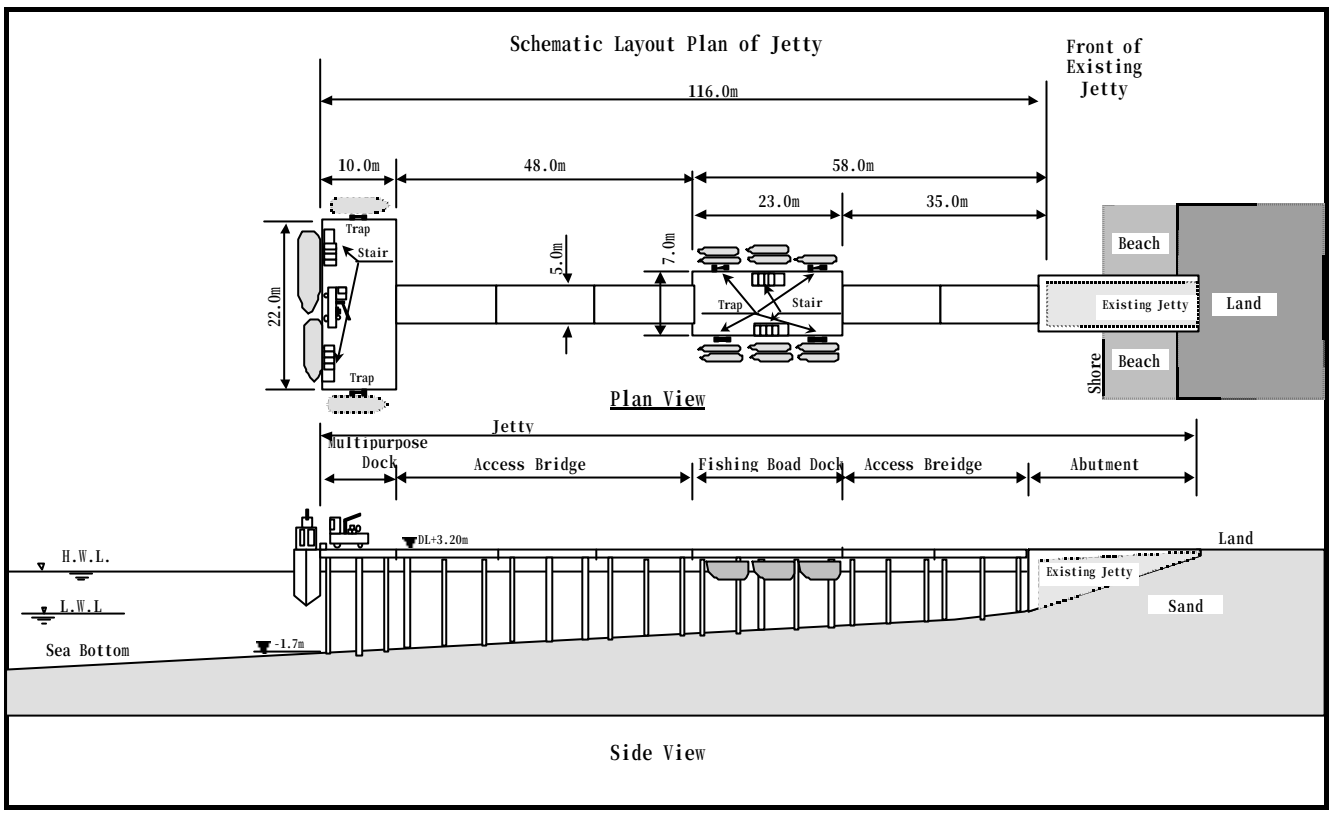


Figure 2.2.2-10 Schematic Layout Plan of Jetty

(4) Basic Plan of Access Channel Facility

Ulach Channel for the access channel facility, which passes through the atoll reef, is located in shallow waters with considerable distribution of underwater obstacles consisting of coral boulders. Furthermore, from the fact that the reef edge on the outer sea side of the atoll is characterized by abrupt change in water depth, the waves intruding in become higher on the atoll area, and strong currents occur. In case of rough waves and swells generated by typhoons and other stormy waves, the waves break on the atoll, creating an extremely dangerous condition for navigation of boats. That being the case, the basic planning of the access channel facilities will be carried out paying attention to the safety of navigation of boats passing into and out of the atoll.

1) Basic Plan of Access Channel Depth

The water depth of the access channel has to be sufficient for the largest design boats using it to be able to navigate in fully loaded condition and adding allowance for boat motion due to wave action, trim and squat of boat. Figure 2.2.2-11 gives a schematic diagram of the access channel cross section.

Design water depth of the access channel is set as follows according to the sea bottom condition of the navigation channel. Applying the design boat draft of 1.2 m as the maximum draft of the boats covered by the project for the access channel, the draft of the passenger boat "North Star" owned by Kayangel State Government, an allowance of 1.0 m of the access channel water depth is set at D.L. - 2.2 m.

Design Water Depth

= Maximum Draft of Design Boat + Allowance

$= 1.2\ \mathbf{m} + 1.0\ \mathbf{m} =$ D.L. -2.2 **m**

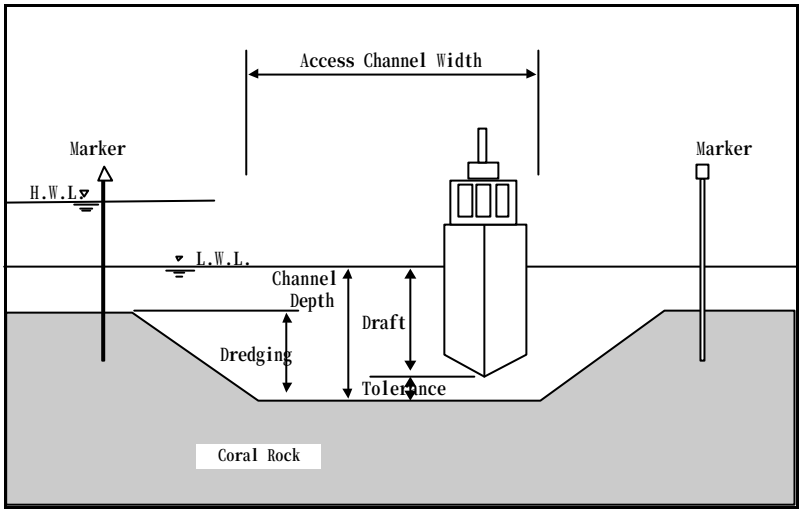


Figure 2.2.2-11 Schematic Section View of Access Channel

2) Basic Plan of Access Channel Width

Access channel width is determined taking into account, among other conditions, the size of the boats that will be navigating through it, the volume of sea traffic and bathymetric condition, waves and other sea conditions. As indicated in Figure 2.2.2-12, navigation channel width is set as 5 to 8 times the breadth of the design boats that will be using it as a two-way traffic and within the ranges indicated in Table 2.2.2-12 according to the location of the navigation channel.

Table 2.2.2-12 Standard Width of Access Channel

Location	Channel Width
Open Sea to Outer Port	**6 B～8 B**
Outer Port to Inner Port	**5 B～6 B**

(**B**: Boat Breadth)

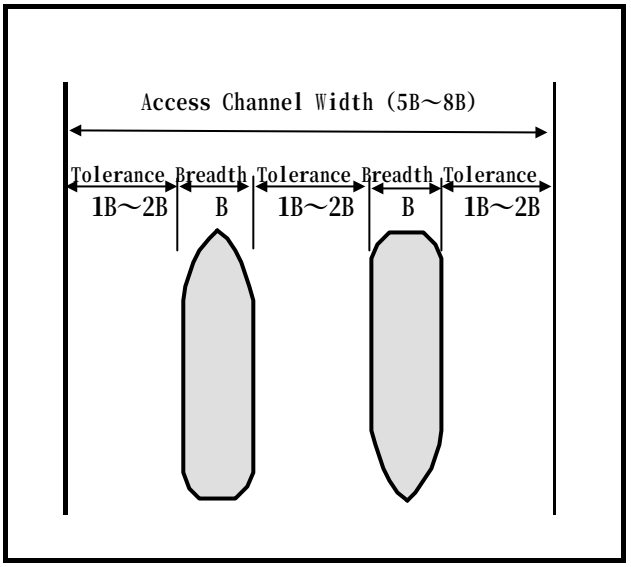


Figure 2.2.2-12 Concepts of Access Channel Width

In case of Ulach Channel, the channel width will be set as one-way traffic in view of its small traffic volume. The tolerance for the width of the access channel is set at twice of the boat breadth at maximum of tolerance, considering the severe sea condition due to location of the navigation channel on an atoll reef and for safety of navigation. The design width of the navigation channel is therefore set as 20.0 m on the basis of the passenger boat "North Star" as representing the design boat covered by the project.

Access Channel Width

= Maximum Breadth of Design Boat+ Allowance(Breadthx2) x 2 Sides

＝5 x Maximum Breadth of Design Boat

＝5 x 4.05 m = 20.25 m ⇒ 20.0 m

Therefore, the access channel cross section is set as a design water depth of D.L. －2.2 m and a design width of 20.0 m.

Since the tidal range of the surrounding waters of Kayangel State is considerable wide in excursion range of 2.3m, fishing boats and other calling boats larger than those covered by the project will be able to pass through the access channel by tide waiting until the tide level is higher in certain extent to enable her navigation. Considering an mean tide level of 1.0 m, it will be possible for boats with a draft of up to 2.2 m to navigate the channel. That means that the national government's cargo ferryboat namely the KB Queen and other cargo boats engaged in coastal transportation will be able to access to Kayangel State by passing through the access channel.

3) Side Slope of Access Channel

The standard gradient of the slope on both sides of the access channel will be set according to the sea bottom properties of the dredging area. Since he boring survey result shows that the sub-soil conditions of Ulach Channel consist of intermixed layers of soft coral limestone and hard sandy material, the slope gradient of the access channel is set as 1 : 1.0 according to the guideline.

4) Alignment Plan of Access Channel

The access channel alignment will be a straight line selected for minimization of dredging volume and for navigation safety. The existing channel is favorable for small boats, since the water depth there is deeper than in the surrounding area with sufficient water depth. However, in case that the design water depth of the access channel is set at D.L. -2.2 m, the extension of the navigation channel becomes considerably longer on the existing channel alignment, and it is necessary to bend the alignment at some points and to provide a curved corner, which is not desirable from the viewpoint of safe navigation. Therefore, the new alignment of the access channel will be employed as the alignment plan.

Figure 2.2.2-13 shows the location of the alternate alignment plans, and Table 2.2.2-13 summarizes their respective alignment extensions and estimated dredging volumes. Since the results of comparison of each alternatives show that the volume of dredging is smallest in the case of Alternative No. 2, the alignment of the access channel will be set on the basis of Alternative No. 2.

Table 2.2.2-13 Approximate Dredging Volume for Alternate Channel Alignment

Alignment Plan	Extension (m)	Approx. Dredging Volume (m^3)
Alternative (1)	480 m	10,800 m^3
Alternative (2)	380 m	9,800 m^3
Alternative (3)	380 m	11,200 m^3
Alternative (4)	400 m	10,800 m^3
Alternative (5)	440 m	12,000 m^3

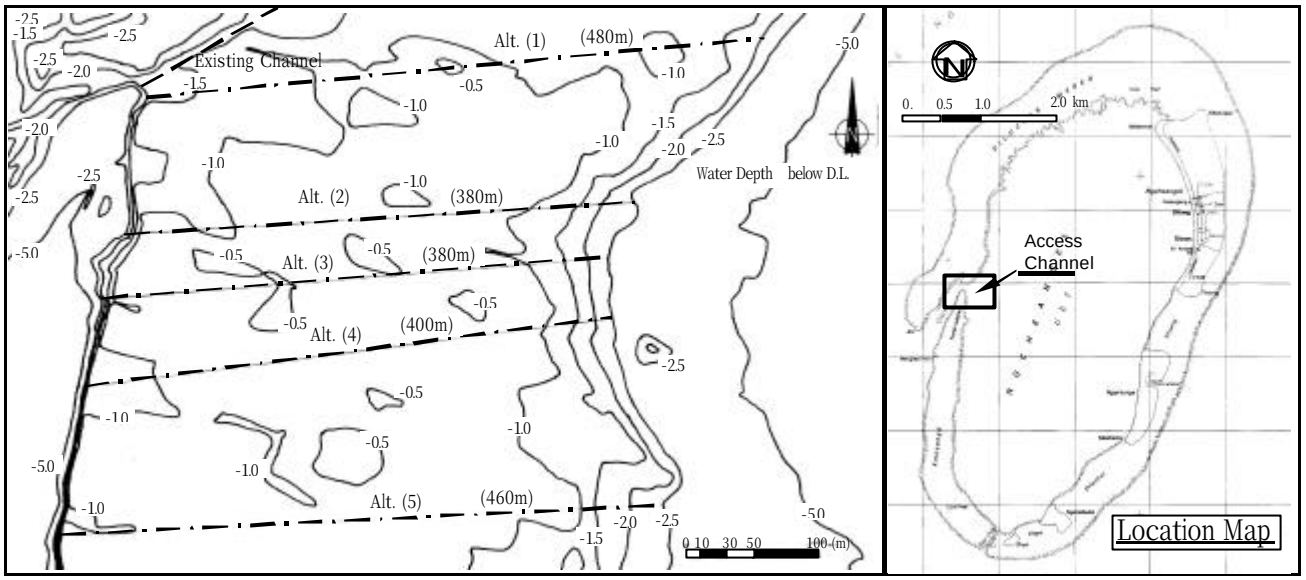


Figure 2.2.2-13 Alternatives of Access Channel Alignment

(5) Basic Plan of Navigation Aids

Since the position of the access channel alignment will be different from the existing channel alignment and since the existing navigation beacons recently damaged by a typhoon cannot be moved and be reused, navigation beacons indicating the new access channel alignment will be newly provided as the navigation aids.

1) Location of Navigation Aids

One pair of navigation beacons will be installed at the entrance of the access channel and another pair at its exit so as to recognize the locations of the two ends. Another navigation marker will be installed at the tip of the jetty so that calling boats that have passed through the access channel will be able to safely navigate inside the atoll while keeping the location of the jetty in sight. Figure 2.2.2-14 shows the positions of installation of the navigation channel beacons.

2) Contents of Navigation Aids

Each navigation beacons will be provided with a lantern to ensure safe navigation during nighttime, the lighting ranges as indicated in Table 2.2.2-14.

At the entrance of the access channel, there will be installation of navigation beacons with a longer lighting range so that boats calling into port from outside can easily ascertain the location of the channel. In view of the fishing grounds are located in the waters within 12 nautical miles of Kayangel Atoll, the lighting range of the entrance beacons will be set as 5.0 nautical

miles so that the fishing boats can recognize easily on the way back from the fishing ground. And in order to be able to distinguish the entrance beacons from the exit beacons of the access channel, their flashing interval will be 2 flashes each cycle. As well, the lighting range of the beacons at the channel exit will be much shorter than that of the channel entrance with one flash each time. Since the distance between the access channel and the jetty is about 3.5 km, the lighting range of the navigation marker installed at the jetty will be 3.0 nautical miles.

The lighting part of the beacons will be of the LED type lantern for the sake of outstanding durability and ease of maintenance. The navigation beacons and marker will be of the fixed foundation type, not buoy type, and will be painted with every 5 year durability.

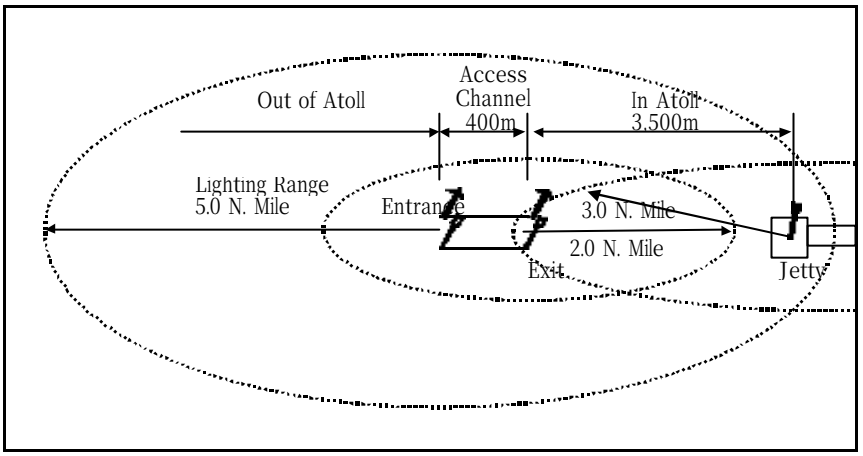


Figure 2.2.2-14 Location of Navigation Aids and Lighting Range

Table 2.2.2-14 Specifications of Navigation Aids

Location	Q'ty	Type	Lantern	Light Color	Light Character	Lighting Range
Channel Entrance	Starboard, Portside	Beacon	LED, Solar Battery	Green Red	Fl. 4(2) s (0.5+0.5+0.5+2.5)	5.0 n. mile
Channel Exit	Starboard, Portside	Beacon	LED, Solar Battery	Green Red	Fl. 4 s (0.5+3.5)	2.0 n. mile
Jetty		Beacon	LED, Solar Battery	Yellow	Fl. 4 s (0.5+3.5)	3.0 n. mile

3) Height of Beacon

The height of the navigation beacons at the access channel is basically to be a height, which will not be affected by waves during design high water level. The beacon height selected on that basis is 3.0 m above design high

water level. At the jetty the navigation marker height will be about 2.0 m on the jetty crown for easy maintenance.

Height of navigation beacons:

Access Channel Site:

Design High Water Level + Wave Height

= D.L. + 2.3 m + 3.0 m = D.L. + 5.3 m

Jetty Site:

Jetty Crown Height + Marker Height

= D.L. + 3.2 m + 2.0 m = D.L. + 5.2 m

The foundation of the navigation beacons to be installed at the access channel will be of the steel pipe pile type since a pile driving machine will be used for construction of the jetty. In comparison with the concrete footing foundation, the steel pipe pile type is superior in stability against waves and currents as well as being advantageous in terms of ease and cost of installation. The navigation marker on the jetty will be installed on the jetty slab using anchor bolts.

(6) Basic Plan of Cargo Handling Equipment

The dimensions of the crane truck will be set according to the conditions of the cargo handling works and cargo loading / unloading works. The crane mounted on the truck will be evaluated according to the working radius and the weight of the cargo handled as indicated in Figure 2.2.2-15.

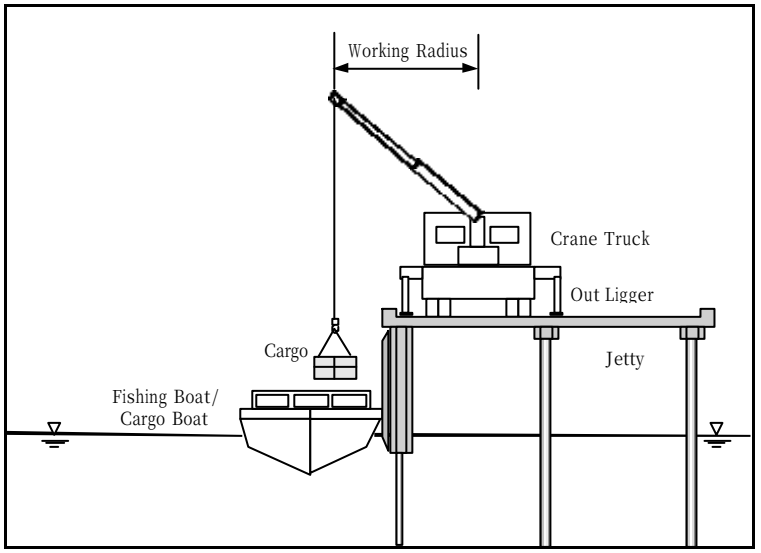


Figure 2.2.2-15 Schematic View of Cargo Handling Works on Dock

1) Working Radius

The working radius consists of the distance from the crane's swiveling center to the hoisting position of the fish catches or cargoes on the fishing boats or cargo boats.

Distance to Curbing Edge	1.5 m
Width of Curbing	0.3 m
Fender Height	0.15 m
Position of Cargo on Boat	2.0 m
Total	3.95m ⇒ 4.0 m

2) Load Condition

Regarding the heavy cargoes handled at the dock, the drums of fuel for the power plant facility will be landed about once a week. Although not frequently, cement, concrete aggregate, lumber and other construction materials are also unloaded at the dock. The concrete aggregate is handled in bags measuring about 0.9 m x 0.9 m x 0.9 m. The weight of such heavy cargoes handled will therefore be taken as cargo weights in setting the hoisting load of the crane.

The respective weights of the fuel drums and the bagged concrete aggregate are as follows. On that basis, the hoisting load of the crane is set at about 1.0 t.

Fuel drums	230 kg
Bags of Aggregate	1,000 kg

3) Hoisting Range

The hoisting range of the crane will be calculated as a height between the cargo on the deck of the cargo boats and the loading platform of the truck.

Cargo Boat Deck	D.L. +0.3 m (L.W.L. 0.0m+0.3m)
Truck Platform	D.L. +4.2 m (Jetty Height + Truck Height 1.0m)
Hoisting Range	3.9 m ⇒ 4.0 m

4) Hoisting Capacity

The handling capacity of the crane will be selected according to the maximum hoisting moment of 4.0 tm calculated on the basis of work radius

and hoisting load.

Maximum Hoisting Moment
= Work Radius x Hoisting Load
＝1.0 t×4.0 m＝ 4.0 tm

5) Load Capacity of Truck

The load capacity of the truck will be set so as to carry 2 bags of concrete aggregate and to be capable of mounting the required crane. Furthermore, in view of working efficiency and safety operation, a standard size of crane with a somewhat longer crane boom will be selected.

Cargo Load (1.0t x 2 bags of Aggregate)	2.0 t
Estimated Dead Weight of Crane	1.5 t
Total	3.5 t

6) Spare Parts

Repair work is available in Palau, but it usually takes time to procure spare parts for repairing. Since the crane truck to be provided will be the only cargo handling equipment in Kayangel State, in case of the break down of the cargo handling equipment, cargo handling would not be possible during the time for procurement of the spare parts and repairing work. And the situation without cargo handling equipment would give a serious inconvenience to the fishery activities and transportation activities of the State. Therefore, spare parts respectively for the crane and the truck estimated to be sufficient for one year will be included.

(7) Summary of Project Components

The project components are summarized as shown in Table 2.2.2-15.

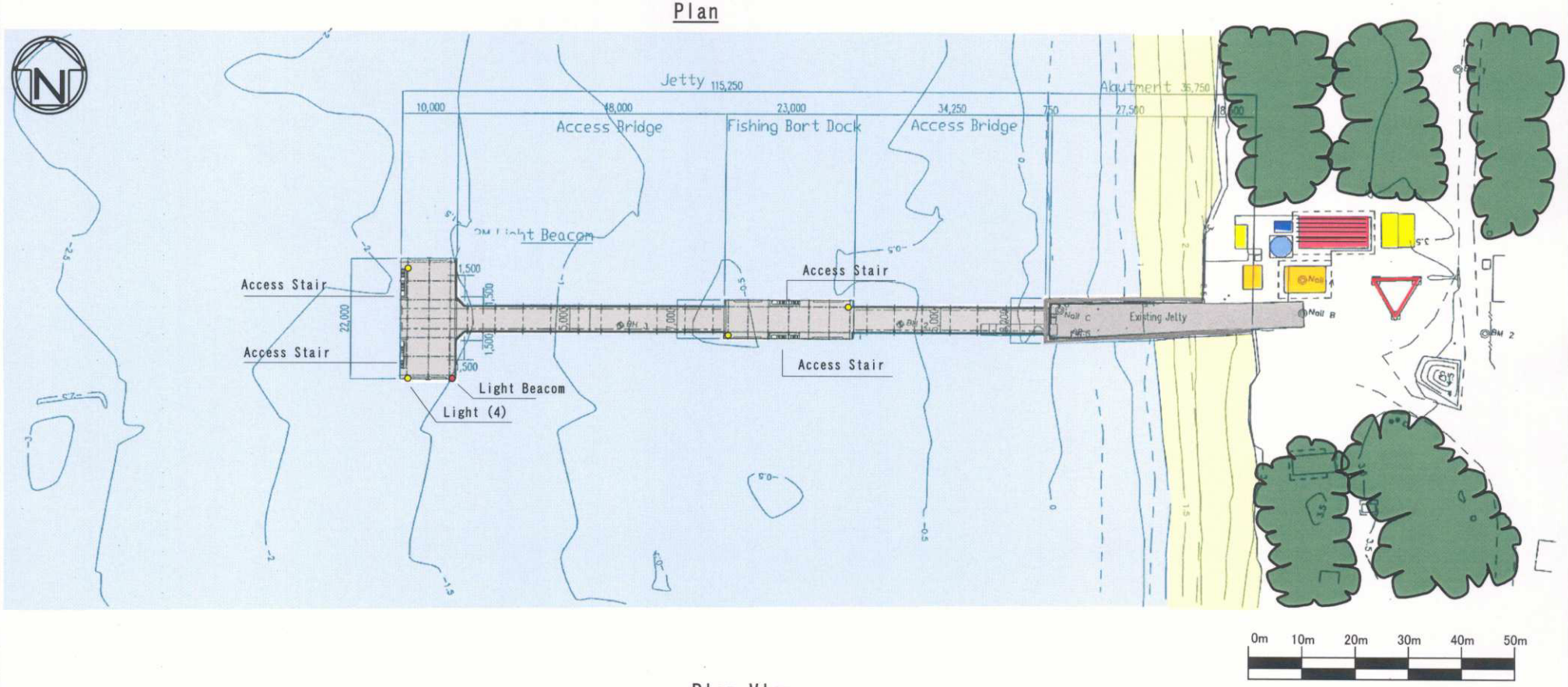
Table 2.2.2-15 Summary of Project Components

Components	Contents	Design Dimension
Jetty	Extension of Jetty: 116m Area of Jetty: 796m^2 Multipurpose Dock Size: 22m x 10m (4 berths) with 2 Stairways, 2 traps Fishing Boat Dock Size: 23m x 7m (6 berths) with 2 Stairways, 4 traps Abutment (Exiting Dock Improvement)	Crown Height : D.L. +3.2m Water Depth of Dock: Multi. Dock : D.L. -1.7m Fishing. Dock : D.L. -0.5m
Channel Dredging	Ulach Channel Extension: 380m Total Dredging Volume: 9,800m^3	Design Depth: D.L. -2.2m Design Width: 20m
Navigation Aids	Location Channel Entrance.: 1 pair Channel Exit: 1 pair Multipurpose Dock: 1 set	Lantern Range Channel Ent. : 5.0 n. mile Channel Exit : 2.0 n. mile Multi. Dock : 3.0 n. mile
Cargo Handling Equipment	Crane Truck with Spare Parts	Crane: Work Radius 4.0m or more Hoisting Load 1.0 t or more Truck: Loading Capacity 3.5t or more

2-2-3 Basic Design Drawing

List of Basic Design Drawings

Plan



Plan Vlew

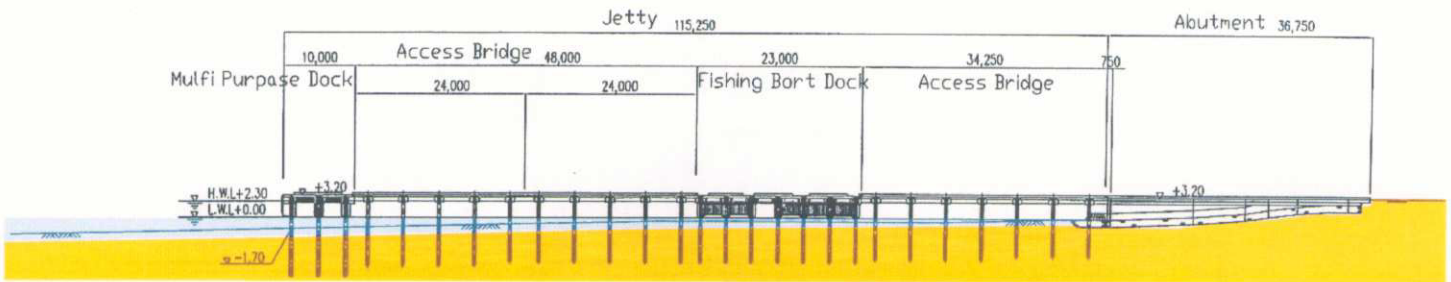


Figure 2.2.3-1 General Layout Plan of Jetty

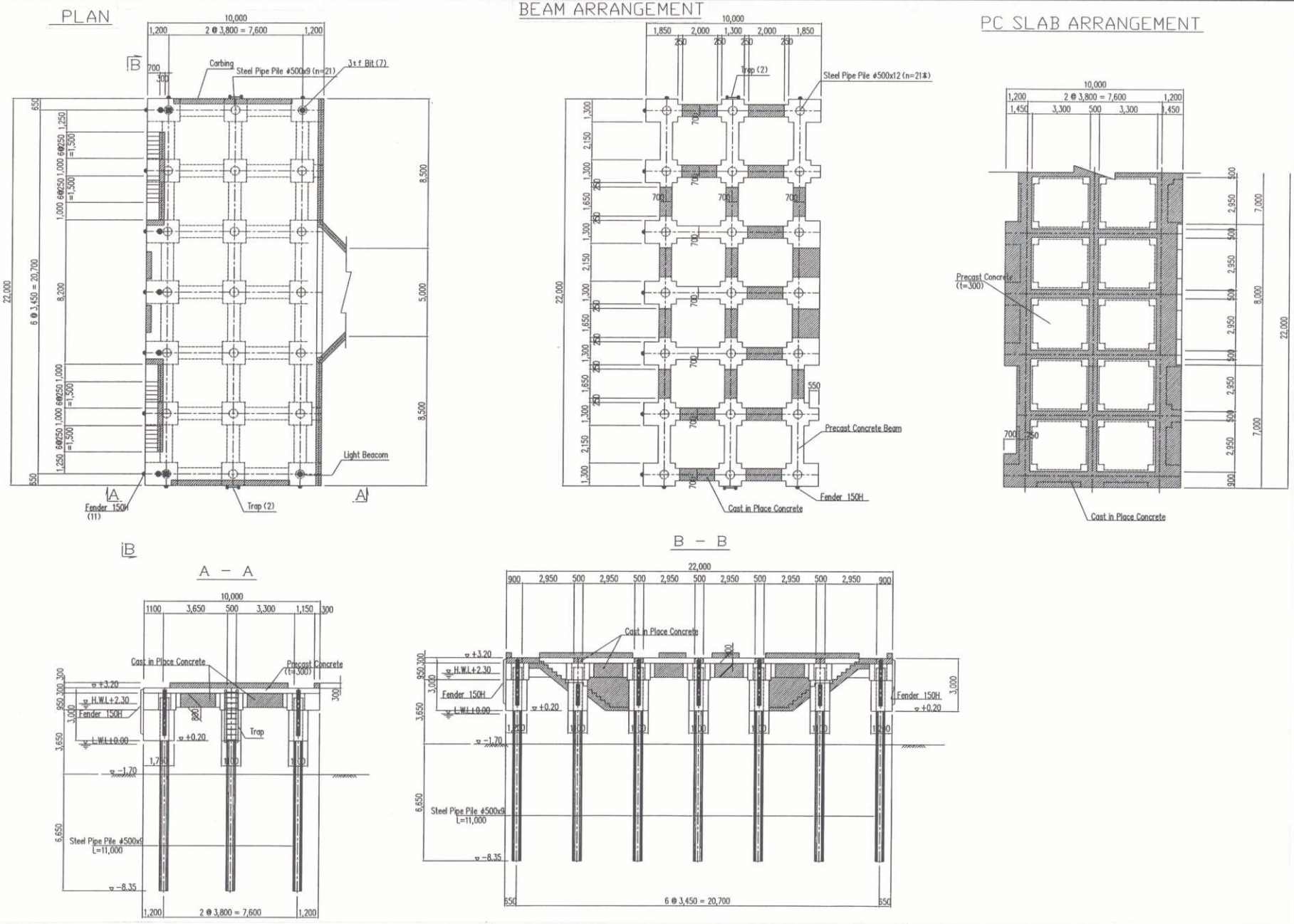


Figure 2.2.3-2 Details of Multipurpose Dock