4-2 Technical Note (September 9, 2004)

**TECHNICAL NOTE**
**on the Basic Design Study**
**on the Project for Rehabilitation of Betio Port**
**in the Republic of Kiribati**

The Government of Japan decided to conduct a Basic Design Study on the Project for Rehabilitation of Betio Port (hereinafter referred to as "the Project"), and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to the Republic of Kiribati (hereinafter referred to as "Kiribati") the Basic Design Study Team (hereinafter referred to as "the Team"), headed by Mr. Tadashi Ikeshiro, Resident Representative, JICA Fiji Office.

The Team conducted a field survey in the study area and carried out a preliminary analysis of collected data and information.

In the course of the field survey, both sides confirmed the main items described in the attached sheets.

Tarawa, September 9, 2004

Ryoichi Nishimura
Chief Consultant
Basic Design Study Team
Japan International Cooperation Agency

Utinia Anruti
Actg. Senior Assistant Secretary
Ministry of Communications, Transport and Tourism Development
Republic of Kiribati

Capt. Koubwere Ienraoi
General Manager / Ports Master
Kiribati Ports Authority
Republic of Kiribati

## ATTACHMENT

1. Temporary Measures to Prevent Further Damage

The Team has carried out a field survey. Based on the results of preliminary analysis made on the collected data and information, the Team proposed following temporary measures to prevent further damage and the Kiribati side agreed to perform such measures as much as possible.

(1) Temporary Measures for New Wharf Revetment

The Team proposed two types of counter measures for the revetment.

At the west end of the New Wharf Revetment, it is experienced frequent overtopping waves causing damages to top surface including apron concrete slab. To prevent further damage by overtopping waves, it is proposed to install containers along the parapet wall temporarily.

For the openings of fabric mat damaged by the wave action, it is proposed to fill with heavy materials like used concrete curb stones or similar temporarily.

(2) Temporary Measures for the Head part of West Mole Revetment

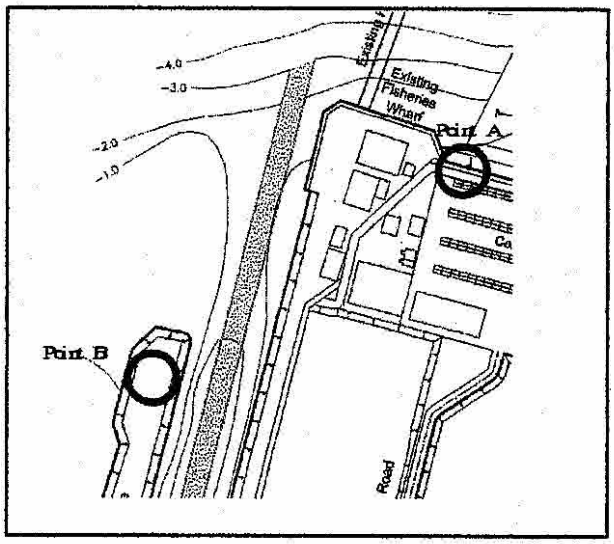
The West Mole Revetment is being damaged continuously due to its unstable structure. Also the filled sand inside the revetment is frequently washed out by overtopping waves. This section of the revetment at West Mole is very important to prevent large damage to the container yard and other facilities located in East Mole since it is functioned as breakwater.

In order to stabilize the present revetment structure, it is suggested to reinforce said revetment by bagged concrete and sand bags as shown in Attachment A.

2. Temporary Construction Yard

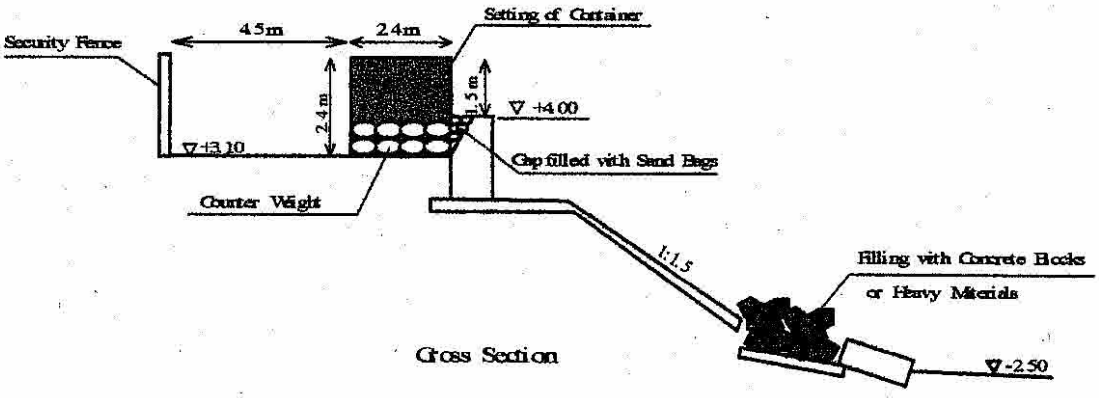
During the implementation of required rehabilitation work for the port, it is required to provide large temporary construction yard. At present, there is vacant land at the reclamation area at East Mole but KPA does not have right to use for their purpose. Therefore, it is necessary for the Ministry of Communications, Transport and Tourist Development (MCTTD) to secure the vacant lot having not less than 1 ha at the location indicated in Attachment B or elsewhere near to the port.

Attachment A

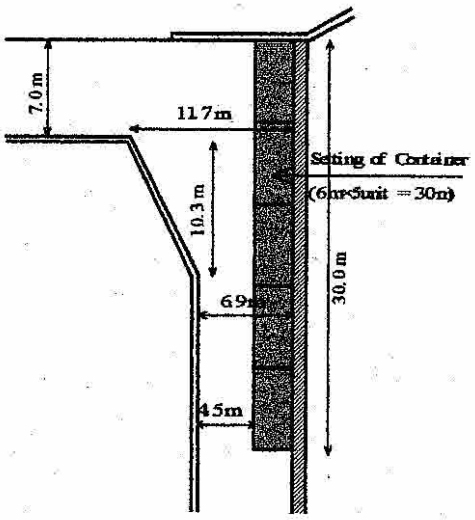



Key Plan

## Point A(New Wharf Revetment)

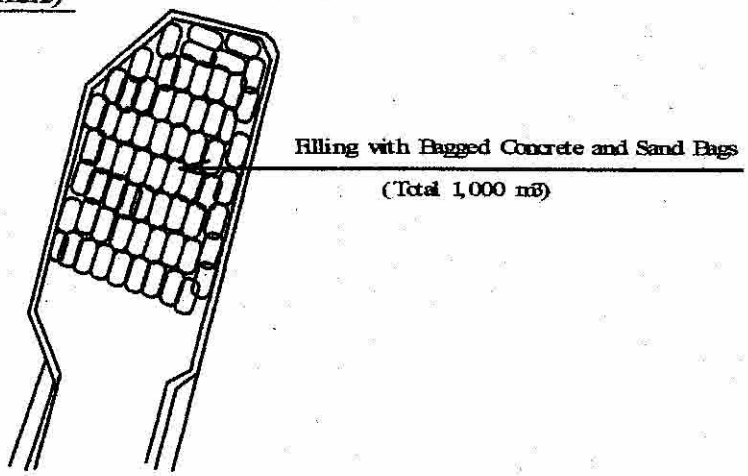



Cross Section

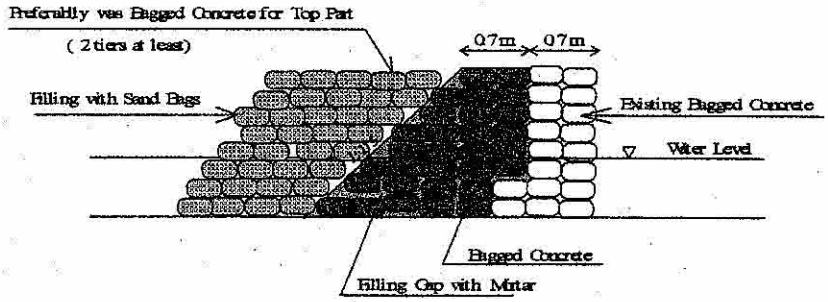



Plan

## Point B ( West Mole Revetment)

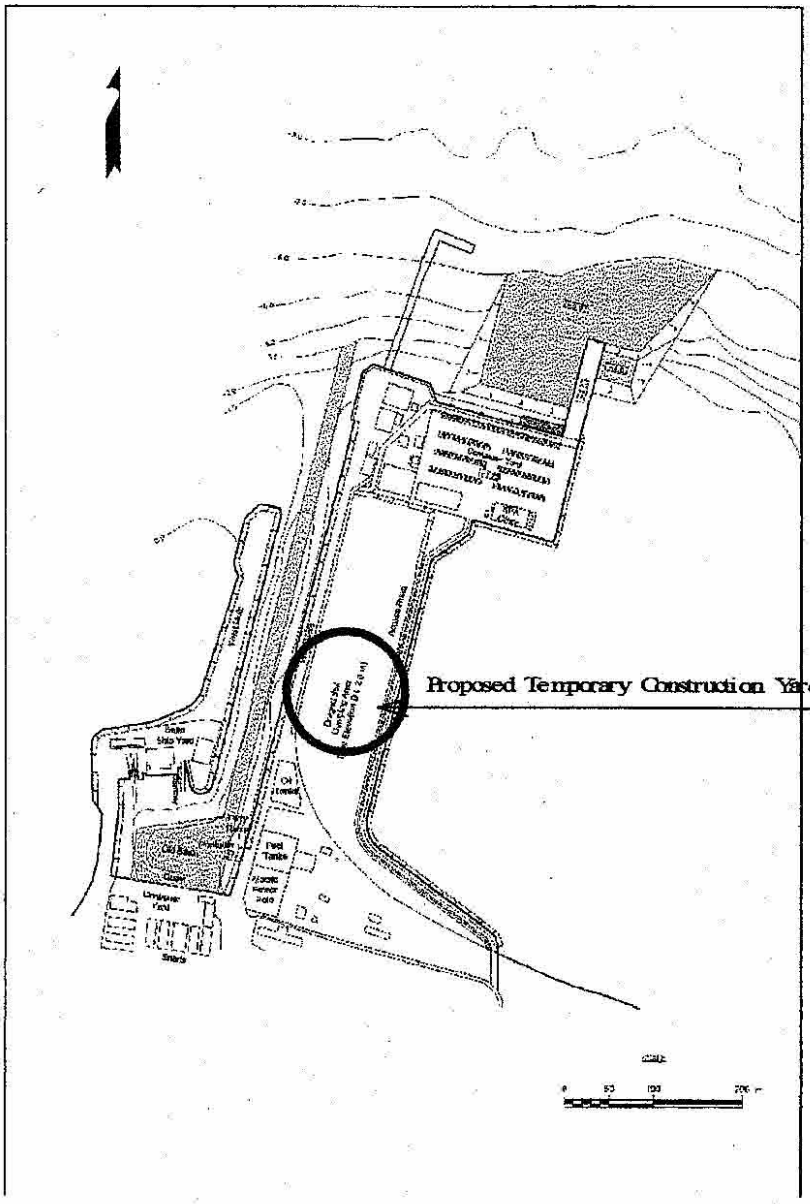



Plan




Cross Section

Attachment B



4-3 Minutes of Discussions for Explanation of Draft Final Report (December 15, 2004)

# Minutes of Discussions
# on the Basic Design Study
# on the Project for Rehabilitation of Betio Port
# in the Republic of Kiribati
# (Explanation of Draft Final Report)

In August 2004, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Basic Design Study Team on the Project for Rehabilitation of Betio Port in the Republic of Kiribati (hereinafter referred to as "the Project") to the Republic of Kiribati (hereinafter referred to as "Kiribati"), and through discussions, field survey, and technical examination of the results in Japan, JICA prepared a draft final report of the study.

In order to explain and to consult with officials concerned of the Government of Kiribati on the components of the draft final report, JICA sent to Kiribati the Draft Report Explanation Team (hereinafter referred to as "the Team"), which is headed by Mr. Tadashi Ikeshiro, Resident Representative of JICA Fiji Office, from December 10 to 16, 2004.

As a result of discussions, both sides confirmed the main items described on the attached sheets.

Tarawa, December 15, 2004

Tadashi Ikeshiro
Leader
Draft Report Explanation Team
Japan International Cooperation Agency

Tebwe Ietaake
Permanent Secretary
Ministry of Communications, Transport and Tourism Development
Republic of Kiribati

Capt. Koubwere Ienraoi
General Manager
Kiribati Ports Authority (KPA)
Republic of Kiribati

# ATTACHMENT

1. Components of the Draft Final Report
   The Government of Kiribati agreed and accepted in principle the components of the draft final report explained by the Team.

2. Japan's Grant Aid Scheme
   The Kiribati side understands the Japan's Grant Aid scheme and the necessary measures to be taken by the Government of Kiribati as explained by the Team and described in Annex-3 and Annex-4 of the Minutes of Discussions signed by both sides on August 25, 2004.

3. Items Requested by the Government of Kiribati
   As the result of discussions and study, requested components were confirmed as below;
   (Term-1)
   - Restoration of New Wharf Revetment
   (Term-2)
   - Restoration of Fishery Jetty Revetment and East Mole Revetment.
   - Procurement of Spare Parts for 80t Truck Crane procured by Japan's Grant Aid in 1997.

   Since the purpose of the Project is limited to the restoration of the damaged existing facilities, dredging equipment requested by the Kiribati side was not included in the Project component and Japan side asked self effort of Kiribati side to maintain the depth of channel and basin of the Betio Port utilizing available equipment of KPA.

4. Schedule of the Study
   JICA will complete the final report and send it to the Government of Kiribati by the end of March, 2005.

5. Other Relevant Issues
   5-1. The Team requested and the Kiribati side agreed that the Kiribati side should take following temporary measures before the end of January 2005 to prevent further damage of the port and submit a report to JICA Fiji Office by the end of January 2005 with photographs show what Kiribati side has done;
   - To place three empty containers at least at the western end of the New Wharf Revetment to prevent overtopping waves as requested in the Technical Notes signed on 9th September 2004, and
   - To place unused curb stones and concrete debris to the openings of damaged fabric mat at the location A, B, C, D, E and F shown in Figure A-2-1 of Appendix A, Draft Final Report.

   5-2. The Team requested and the Kiribati side agreed to provide one flat barge with associated tug boat owned by KPA free of charge including necessary crews for operation, fuel, maintenance, etc. for the construction work of the Project during idle time of cargo handling operation upon request by the contractor. The duration of such assistance shall not exceed 30 working days.

   5-3. The Team requested and Kiribati side agreed to take necessary action and arrangement of development application in accordance with Article 14 of Environmental Act 1999 and secure approval as early as possible. Copy of such approval shall be sent to JICA Fiji Office (copy to the consultant of the Project) on or before the end of January 2005, enabling JICA headquarter to present it to the relevant authorities concerned prior to the cabinet approval in Japan which is scheduled in the month of February 2005.

5-4. The Team requested and the Kiribati side agreed to secure approval from the authorities concerned in providing a temporary construction yard to the contractor of the Project. The temporary construction yard shall have an area of not less than one (1) ha in the vicinity of the construction site and the yard shall be provided during the period of rehabilitation work free of charge.

5-5. The Team requested and Kiribati side agreed that following port charges against consignee/consignor for importing construction materials and equipment for the Project shall not be charged to the contractor of the Project except for importing construction materials of rocks, stone aggregate, sand, rubble and cement in a form of break bulk.

- Literage
- Wharfage
- Loading/unloading charge
- Barge with tug hire costs for loading/unloading

The waiver of the above port charges for the bulk construction materials (rocks, stone aggregate, sand, rubble and cement) shall be applied, if these are transported in a form of container.

5-6. Regarding Term-1, the Team handed over the draft documents which include the technical specifications, drawings, and design report as a result of the study to Kiribati side. The Kiribati side may finalize the draft documents and drawings and use them for the future tender regarding Term-1. In such case, Kiribati side shall bear responsibility for project implementation and the outcome of the project executed through the contract between Japanese firms. Regarding Term-2, based on the study the Detailed Design may be conducted after Exchange of Note (E/N).

5-7. Both sides agreed that this draft design handed to Kiribati side from the Team is confidential and should not be duplicated or released to any outside parties.

5-8. Kiribati side requested that the 30 m section of Type III of the East Mole Revetment needs to change and apply the same structure as Type II to avoid congestion at that particular location.

5-9. Kiribati side requested additional pavement between the western end of the New Wharf Revetment and the East Mole Revetment (140 m section) for future maintenance of restored facilities by the Project. The Team will convey this request to the headquarters of JICA.

4-4 Official Letter from MCTTD (January 20, 2004)

**MINISTRY OF COMMUNICATION, TRANSPORT AND TOURISM DEVELOPMENT**
**P.O. Box 487, Betio, Tarawa, Republic of KIRIBATI**
**Phone : (686) 26004; Fax (686) 26193**

**From:** Officer In-Charge, MCTTD
**To:** JICA Chief Consultant
Mr. Ryoichi Nishimura
**Receiver's Fax No:** +81-3-5276-2655
+679-330-2452
**cc:** Mr Ikeshiro Tadashi
JICA Resident Representative
**No. of pages:** 7 pages (including this cover) **Date:** 20th January, 2005

**SUBJECT:** **EIA Clearance and Site Plan required for Kiribati Port Rehabilitation Project**

- Please find forwarded for your requirement Kiribati Development Application Clearance from the Ministry of Environment, Lands and Agriculture Development though it is critical that the provisions and conditions are strictly observed and followed by your Contractor and the KPA, and secondly the Site Plan that Cabinet has approved on Wednesday this week for your review and approval. At this stage it is impossible to provide the Cabinet's decision on this though this may be available sometime next week. The two are included in this fax for ease of reference.
- The Government of Kiribati especially the KPA is very much looking forward to the positive outcome for this big project.
- For your information the Cabinet had a meeting on Wednesday, 19th January and confirmed to us that we have the full right to use the available area as stated in the attached site plan, however, with this limited size offered, the Minister of Lands has committed himself that he is willing to find more space upon request by the KPA when desperately needed. Enclosed as mentioned is the site plan offered, i.e. between the area of Kaoki Mange and KOIL (70m x 80m).
- As already mentioned, Kiribati is very much grateful and much looking forward to the success of this project and our gratitude is conveyed to each everyone of you who have contributed in one way or other to its success. Please do convey should you need further clarification regarding the above issues.

Looking forward to your earliest feedback any time convenient to you.

Sincerely yours.

Utinia Anruti
Officer In charge, MCTTD

GOVERNMENT OF KIRIBATI
MINISTRY OF ENVIRONMENT LANDS AND AGRICULTURAL DEVELOPMENT
ENVIRONMENT AND CONSERVATION DIVISION
P.O. Box 234, Bikenibeu, Tarawa, REPUBLIC OF KIRIBATI. Phone: 686 28593 Fax: 686 28334
Email: eia.mesd2@tskl.net.ki

# DECISION BY HONOURABLE MINISTER, MELAD

on

# DEVELOPMENT APPLICATION

## (EIA Screening Form)

| | |
|---|---|
| **Proposed by (name of agency):** | **Kiribati Port Authority** |
| **Category of Development Type:** | Port Rehabilitation |
| **MELAD Proposal Number:** | DA002/05 |

In accordance with the Environment Act 1999, the Honourable Minister for Environment Lands and Agricultural Development hereby notifies, within the statutory 15 working days stated under Section 14, subsection 2 of said Act, that the above proposal:

| | |
|---|---|
| **Is exempted from Part III of the Act and will not require any form of Environmental Impact Assessment** | ✔ |
| **Requires an Initial Environmental Evaluation (IEE) as stated within Section 14, sub-section (2)(a) of the Act** | |
| **Requires an Environmental Impact Statement (EIS) as stated within Section 14, sub-section (2)(b) of the Act** | |

In cases where the Honourable Minister has determined that the Proposal is exempt from the provisions of Part III of the Act, please find the Development Consent attached.

In all other cases, a Development Consent will be issued only at such time as the Initial Environmental Evaluation (IEE) or Environmental Impact Statement (EIS) is submitted and approved by the Honourable Minister, MELAD.

Signed this day 19 th of Jan 2005

**By the Honorable Minister,**

HON. MARTIN PUTA TOFINGA
MINISTER FOR ENVIRONMENT LANDS
AND AGRICULTURAL DEVELOPMENT

If you require any further information on the decision supplied above, please contact the EIA Officer, MELAD (28583)

GOVERNMENT OF KIRIBATI
Ministry of Environment Lands and Agricultural Development
ENVIRONMENT AND CONSERVATION DIVISION
PO. Box 234 Bikenibeu, Tarawa, Republic of Kiribati.
Phone: (686) 28000 Fax: (686) 28334
E-mail: mesd2@tskl.net.ki

## The Honourable Minister, MELAD, hereby provides

# DEVELOPMENT CONSENT

## for the following project:

| | |
|---|---|
| **Proposed by (name of Agency):** | **Kiribati Port Authority** |
| **Project Title:** | Port Rehabilitation |
| **MELAD Proposal Number:** | DA002/05 |

**Your Agency or Organisation is now approved for commencement of the above-named project, subject to approval (if necessary) by Cabinet or the Land Use Planning Board. Please also note the following:**

1. An Agency or Organisation cannot carry on any development except in accordance with the conditions of the Development Consent. These conditions, if any, are attached to this Consent Form.
2. An Environmental Inspector can request that any person responsible for or substantially involved in the above development produce within a reasonable time (as laid down by Regulation) evidence of the Development Consent. A copy of this Consent should always be made available for inspection.
3. If any Environment Inspector is not satisfied that a Development Consent authorising any particular development exists, or where the person requested under this section fails within a reasonable time (as laid down by Regulation) to produce such evidence, the Inspector may issue a notice in writing requiring all persons involved in the development to immediately discontinue such development.
4. No developer shall transfer a Development Consent.

**Signed this day** 19th Jan' **of** 2005

**By the Honourable Minister (MELAD)**

HON. MARTIN PUTA TOFINGA
MINISTER FOR ENVIRONMENT LANDS
AND AGRICULTURAL DEVELOPMENT

**Honourable Martin Puta Tofinga**

**Expiring Date** ____ / ____ / _____ **Signed** _____
Day Month Year **EIAO / AEIAO**

# CONDITIONS ATTACHED TO THIS DEVELOPMENT CONSENT

## Project Management and Environmental Protection

---

**A Development Consent is proof that you, as a project developer, have complied with the requirements of Part III (Development Control and EIA) of the Environment Act, 1999. The Development Consent can be submitted alongside a project document (prodoc) or funding proposal as proof of compliance with the environmental legislation of Kiribati.**

**Certain conditions are attached to this consent for the developer to be adherent to for the duration of development and thereafter. These conditions concern the management of the project and the protection of the environment. Once construction of the project begins, environmental inspectors are empowered to visit and evaluate progress on the project, and especially to ensure these conditions are being met. In the event that the conditions are being ignored, your project can be halted until such a time, as the inspectors are content that you, as the developer, are fulfilling the requirements and conditions of the development consent.**

---

**The conditions attached to this development consent are as follows:**

1. This Consent or approval is for **Port Rehabilitation** as applied in the development application number **002/05**. If the developer changes the nature of activities this consent will loose its validity. If such unrelated activity falls within the listed prescribed developments of Section 13 of the Environment Act, the developer is required to re-apply for Development Consent again.

2. This Consent is not transferable. This means that the developer cannot pass on this consent to another developer. The developer must inform the names of contractors and sub-contractors that will be involved in this prescribed development.

3. This consent is no longer valid once the completion of the project. If a developer is found undertaking further activities after the official

completion of the project, then a developer is breach of the act and appropriate actions will be taken.

4. It is recommended that a boom shall be used during the excavation in order to avoid the spread of sediments to other sensitive areas.

5. A sample must be taken from the dredging site prior the implementation of the project for testing the content of the dredging materials whether contain hazardous chemicals or not. The analysis of the test must be submitted to the Environment and Conservation Division for further consideration.

6. The site must be surveyed thoroughly prior the construction starts to ensure that vital conditions of the area must be left untouched during the construction work. All the costs incurred for the survey shall be borne by a developer.

7. The materials, plant and systems to be used for this project shall be suited or fully adjusted to the environment of Kiribati. There shall be no degradation resulted when the facilities and equipments are operated.

8. Care shall be taken properly to ensure that no damages may be caused from the construction work.

9. Excavated materials shall be used for the backfilling as stated in the report. The unsuitable or excess excavated materials not required for the backfill shall be disposed in the area outside the construction site. A developer shall consult the Environment and Conservation Division prior the disposal of the unsuitable excess excavated materials or any other rejected material.

10. All imported construction materials and equipments shall be certified from the importer and shall be gone through the Quarantine section for further inspection once they arrive in Kiribati.

11. Other construction materials (aggregates) to be sourced locally, a developer is responsible to reapply for those materials or alternatively obtain them from valid license commercial holders.

12. Construction waste and scraped vehicles from demolition shall be transported back to Japan if necessary as stated in the report.

13. The entire work shall be inspected and monitored regularly to ensure that the work has been executed as prescribed on the drawings.

14. Lest any explosion to be carried out during the construction, a developer must consult ECD prior the implementation of the project.

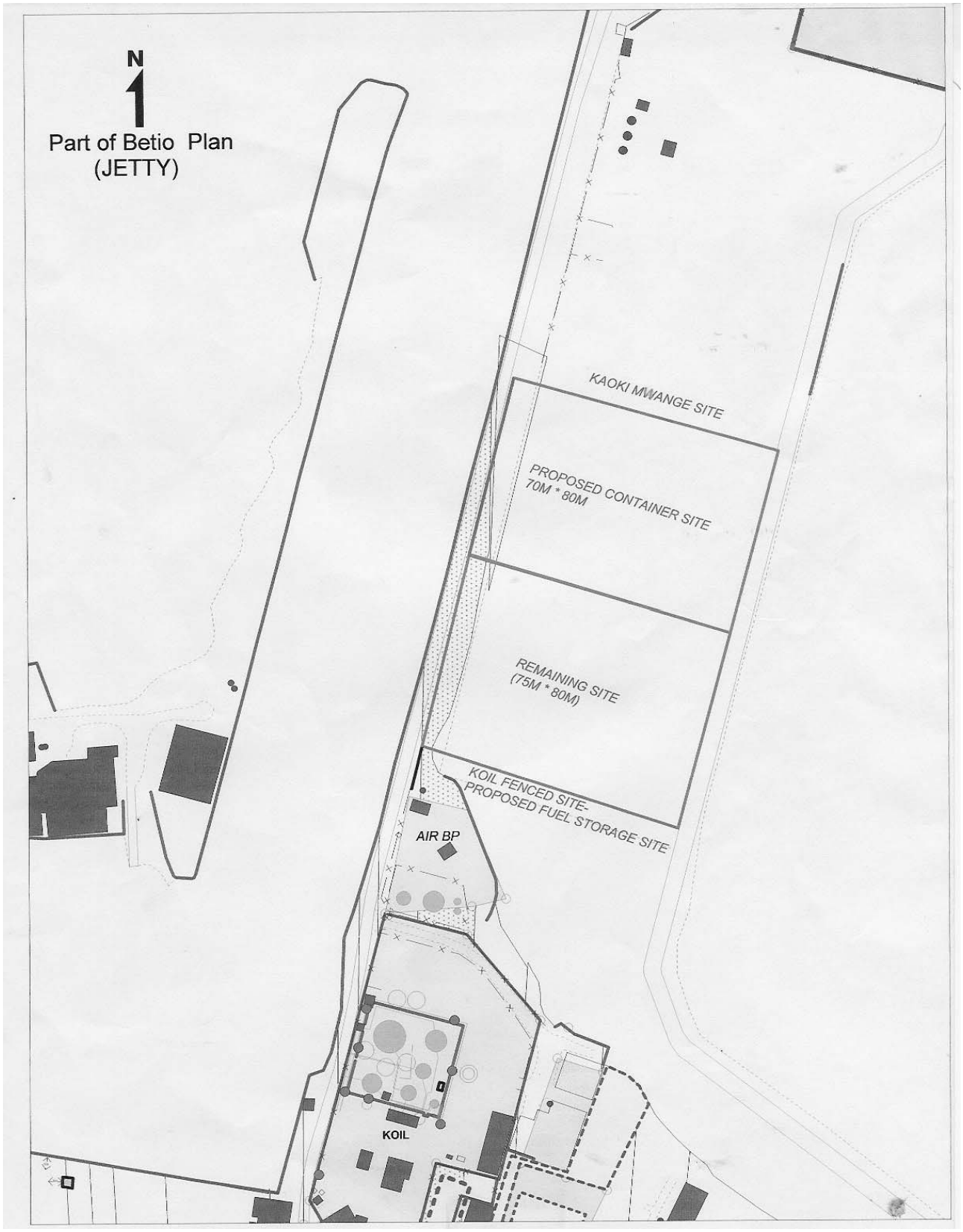
15. A developer must be liable for any environmental damages that may be caused from this prescribed development.

16. The developer must ensure that a copy of this Development Consent is made available to the Environment Inspector or other responsible authorities for inspection upon his/her request.

17. Not complying with any of the above conditions renders this consent inapplicable and action may be taken in accordance with the provisions of the Environment Act, 1999.

18. All the conditions above may be amended from time to time where deemed necessary.

If any further clarification is required on the above points please contact the EIA Officer at the Environment and Conservation Division, 686 28593.


N
1
Part of Betio Plan
(JETTY)
KAOKI MWANGE SITE
PROPOSED CONTAINER SITE
70M * 80M
REMAINING SITE
(75M * 80M)
KOIL FENCED SITE-
PROPOSED FUEL STORAGE SITE
AIR BP
KOIL

# 5. Cost Estimation Borne by the Recipient Country

## Appendix 5. Cost Estimation Borne by the Recipient Country

The Costs to be borne by Kiribati Side are estimated as shown table below.

| No. | Item | Q'ty | Unit | Unit Price (AUD) | Amount in AUD | Equivalent in Yen | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Administration Cost | 16.0 | M/M | 2,000 | 32,000 | 2,590,400 | Incl. overhead cost |
| 2 | Supplement of KPA's Equipment | | | | 11,580 | 937,401 | |
| | (Lease cost of Barge) | 18 | Days | 360 | (6,480) | (524,556) | |
| | (Lease cost of Tug) | 17 | Days | 300 | (5,100) | (412,845) | Incl. operation cost |
| 3 | Cost for Banking Arrangement | | | | 11,494 | 930,440 | |
| | (For Payment to Consultant) | 1 | LS | - | (1,390) | (112,521) | |
| | (For Payment to Consultant) | 1 | LS | - | (10,104) | (817,919) | |
| | TOTAL | | | | 55,074 | 4,458,241 | |

### 5-1 Administration Cost

(Including cost for periodical meeting, acquisition of construction permit and banking arrangement)

- Average salary: 1,000 AUD/month
- Allowance, office expenditure at 100% of total salary
- Administration Cost: 1,000 AUD/Month x 200% x 1.0 Man/Month x 16 Month

### 5-2 Provision of KPA's Equipment

(Lease of barge and tug for installation of silt screen and concrete bags)

- Flat Barge: 360 AUD/day x 18 days = 6,480 AUD
- Tug Boat: 300 AUD/day x 17 days = 5,100 AUD (including operation cost)

### 5-3 Cost for Banking Arrangement

(For payment to Consultant)

- A/P advising commission: 75 AUD for opening, 50 AUD for amendment
- Payment commission: 102,394,000 JPY / 80.95 JPY/AUD x 0.1% = 1,265 AUD

(For payment to Contractor)

- A/P advising commission: 75 AUD for opening, 50 AUD for amendment
- Payment commission: 807,837,000 JPY / 80.95 JPY/AUD x 0.1% = 9,979 AUD

# 6. Other Relevant Data

6.A Field Investigations on Damaged Facilities

6.B Water Level and Estimated Waves during Disaster

# APPENDIX 6.A FIELD INVESTIGATIONS ON DAMAGED FACILITIES

## A-1 Scope of Field Investigations on Damaged Facilities

Field investigations containing following five items have been performed and the results of investigations were described hereinafter.

1) Ocular Inspection of Damages
2) Coring of Fabric Mat
3) Measurement of Settlement
4) Excavation of Rear Side of Revetment
5) Wave Observation during HWL

## A-2 Ocular Inspection of Damages

Ocular inspection has been performed not only for the facilities constructed by Japanese Grant Aid during 1996－2000 but also for the Fishery Jetty, East Mole and West Mole revetments. The results of ocular inspection are summarized in Figures A-2-1 to A-2-3. Figure A-2-1 shows damages caused for New Wharf revetment, Figure A-2-2 for Fishery Jetty/East Mole revetments and Figure A-2-3 for East Mole revetment.

### A-2-1 New Wharf Revetment （Figure A-2-1）

New Wharf revetment having 150m long is composed of 100m fabric mat type and 50m concrete block type. The revetment has been divided by 10m each sections for recording purpose. From the west allocated Sections No. 1 to No. 10 for fabric mat type and Sections No.11 to No. 15 for concrete block type. Major findings by the inspection are described below;

a) The most severe damages of mat are observed at Sections No.1～2、No.4～5、No.7 and No.10 of fabric mat type revetment. At these Sections the damages are caused at the lower part below LWL. The bagged concrete used for urgent repair on the damaged parts were scattered on the seabed.（see Photo A-2-1 ①）
b) Cracks appear at the shoulder part of fabric mat type revetment along whole section.（see Photo A-2-1 ②） According to the hearing from KPA, the cracks at the shoulder had been observed about one year ahead of the large damage caused in November 2002.
c) From the ocular inspection by diving operation to observe inside of the damaged part, opening depth of 1 to 3 m has been observed due to displacement of coral rocks.（see Photo A-2-1 ③） Damaged parts are currently facing to the continuous wave action and backfill coral rocks and it is supposed that the reclaimed sand have being displaced continuously.
d) At the toe part of the slope, gabions for toe protection were scattered and it was observed opening of 30 to 50 cm under the gabions.

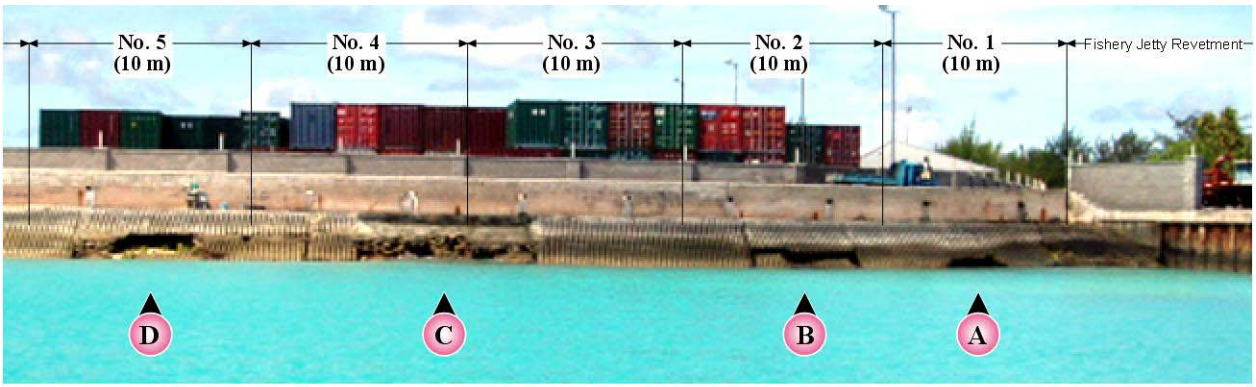
e) It was observed at Sections No. 1 to 2 that significant deposit of sand on the seabed. It is also observed that sand ripple having approximate height of 50 cm. From this fact, it is supposed that standing waves exist and erosion at the toe part.

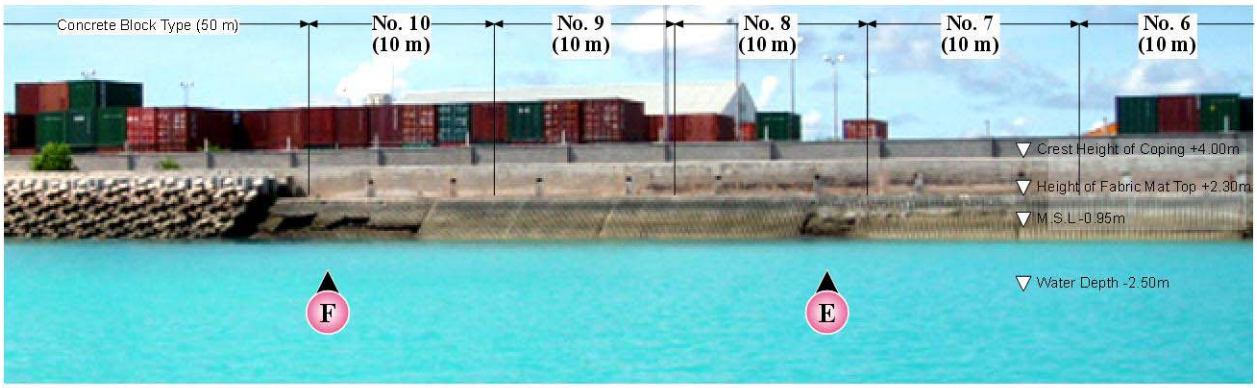
f) It was observed moss at the top of fabric mat at Sections No. 1 to 2. It reveals that the waves run-up and overtop to the road behind frequently at this section as compared with other section. Since the road is not paved, KPA had casted concrete pavement partially at Section No. 1 to 3 where backfill sand had been washed out frequently. Judging from the fact that the settlement at the unpaved ground were observed, it is supposed the overtopping wave action continues in washing out backfill sand.（see Photo A-2-1 ④） At the lower part of parapet at Section Nos. 2 to 3, air sport due to phase difference of wave action. It is suggested that the air course exists between the toe part and back of parapet wall.

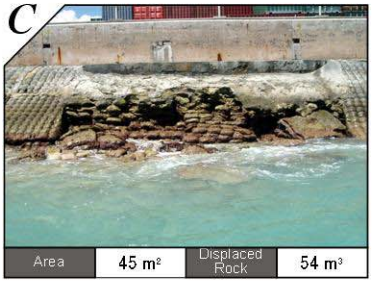
g) At Section Nos. 11 to 15 for concrete block type revetment, it was not observed any crack or damage to the concrete blocks. It was observed slight movement of gabions at toe part by diving inspection, but no movement of blocks was observed.（see Photo A-2-1 ⑤） Judging from these facts, no significant change of seabed and scouring along the concrete block type revetment.

h) No damage to concrete blocks was observed, but wire and geo-textile sheet of gabion were damaged appearing opening where coral rocks were dislocated.（see Photo A-2-1 ⑥） As a whole, rust of flame of gabion is severe. It is supposed the rust will progress and opening of wire/net will be enlarged resulted in scattering of more coral rocks and it is high possibility of collapse of whole structure in the near future.

i) Parapet concrete was constructed with joint every 10m and cracks appear every location of drain holes provided in parapet wall.（see Photo A-2-1 ⑦⑧） The cracks has been caused by bending force judged from its feature. The most significant cracks were seen at Section Nos. 2 to 3 where the gaps of cracks were about 10mm. Since the cracks and damages to the fabric mat coincide at the similar location, it is assumed that leakage of backfill due to damage of fabric mat caused concentration of external force acting to the parapet wall. According to the hearing obtained from KPA, the gaps of cracks are growing.

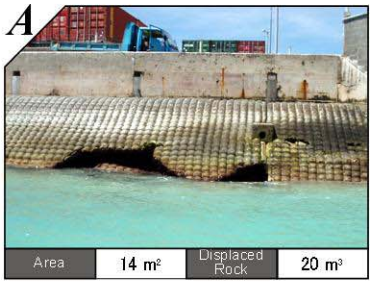


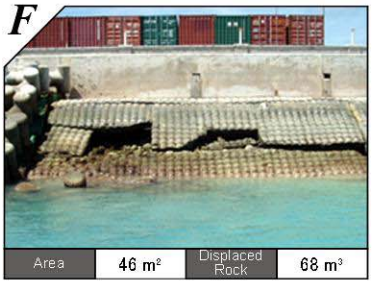




- Considerable amount of rock and bagged concrete displaced.
- Toe protection gabion scattered.
- Opening under gabion due to scouring.

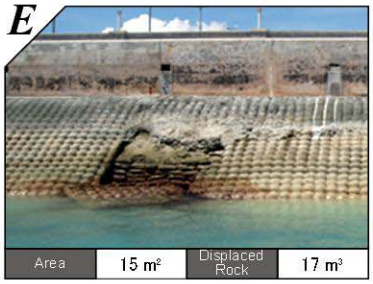

- Coral rock displaced.
- Toe protection gabion scattered.



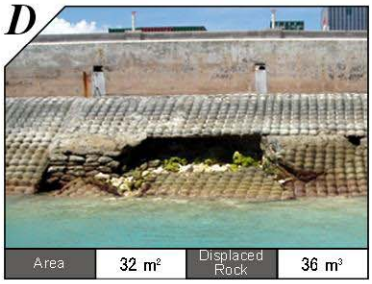

- Seabed at toe part covered by sand.
- Sand ripple due to wave reflection observed at seabed.




- Coral rock displaced.
- Toe protection gabion scattered.




- Coral rock displaced.
- Toe protection gabion scattered.




- Considerable amount of rock and bagged concrete displaced.
- Toe protection gabion scattered.
- Opening under gabion due to scouring.

Figure A-2-1 Situaton of New Wharf Revetment

① Coral rocks scattered（vicinity of No.4）

② Cracks at shoulder of fabric mat（vicinity of No.10）

③ Displacement of coral rocks

④ Repair done for apron/road（vicinity of No.1～3）

⑤ Situation of concrete block type revetment

⑥ Damage of gabion under concrete blocks

⑦ Cracks appeared at parapet wall（land side）

⑧ Cracks appeared at parapet wall（sea side）

Photo A-2-1 Situation of New Wharf Revetment

### A-2-2 Fishery Jetty Revetment ~ East Mole Revetment （Figure A-2-2）

The results of ocular inspection of Fishery Jetty Revetment extending toward Old Port are summarized below;

a) The most of the Steel sheet piles of Fishery Jetty Revetment facing to the North have 10 to 30 cm holes caused by rusting near the elevation of LWL and backfill material with residual sea water get in and come out causing settlement of apron concrete.

b) About 70 to 80 % of coping concrete at the top of sheet piles were fallen down.

c) At the western part of Fishery Jetty Revetment, 20 to 40 cm holes were observed at four locations. At the gravity type revetment by concrete block (constructed in 1970s) located between Fishery Jetty Revetment and East Mole Revetment, concrete peel off and re-bar exposed at lower part of the structure.

d) Concrete pavement has been provided by the Betio Fish Port Complex Project (completed in 2000), but a settlement of approximately 20cm caused due to leakage of backfill materials. This settlement was not recognized during the Preparatory Study of the project in December 2003. Such settlement has been observed in other part of the revetment.

e) The East Mole Revetment having total length of 610m is initially constructed in 1960s by the sloped revetment type with bagged concrete. Leakage of backfill materials was observed several locations where the bagged concrete is dislocated.

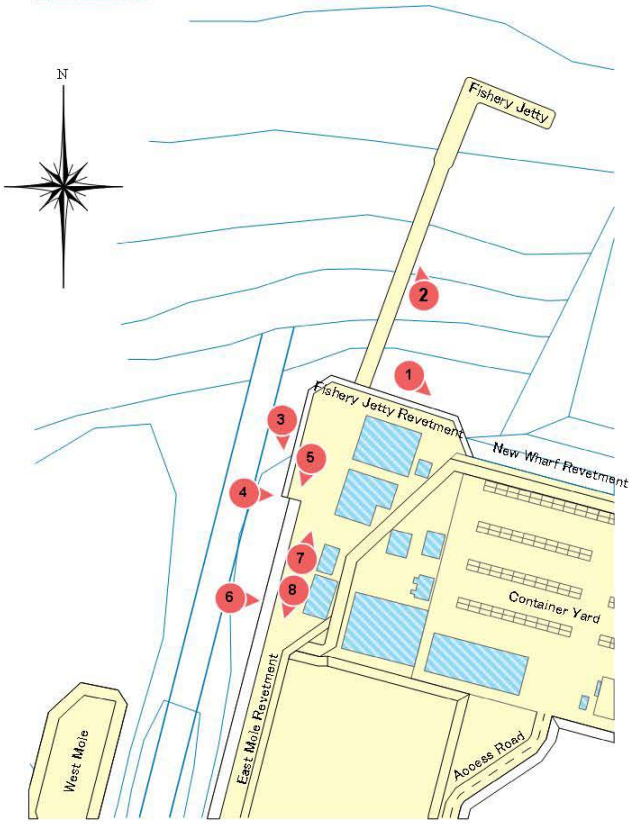
- Opening of 20 to 40 cm due to rust of sheet pile at 4 points.

- Peel off surface concrete at beam and re-bar exposed.

- Opening of 10 to 30 cm near LWL due to rust observed most of sheet piles
- Damage of coping concrete.

- Settlement about 20 cm at apron due to leaking of backfill.

- Damage of concrete at bottom part and re-bar exposed.




- Considerable displacement of bagged concrete at lower part.
- Crack at joints accelerated leakage of backfill.

- Settlement of reclaimed sand observed.

- View of fishery jetty at the same position of photo No. 7.
- Slant of concrete cover at the top of utility pipe lines.

Figure A-2-2 Situation of Fishery Jetty Revetment and East Mole Revetment

### A-2-3 West Mole Revetment at Old Port（Figure A-2-3）

Damages caused to the West Mole Revetment are significant and it is markedly at the western section. The damages caused for the West Mole Revetment are summarized below;

a) The section of the revetment at the western part and offshore side is totally damaged and disappeared. When the situation of damages examined by photos taken in December 2003 by the Preparatory Study and taken by the Basic Design Study of the project in September 2004, it is recognized some progress of damages.

b) A revetment constructed inside of the original revetment at the western section (coral rocks cemented) has been damaged many times, the it was repaired in 2003 – 2004. But the part of the section (about 8m) is collapsed again.

c) Leakage of backfill materials from inner part of the revetment is significant and it is markedly damaged at the offshore side (about 30m section) where filled materials were dislocated totally and only vertical structure by bagged concrete remains. This large scale leakage has been caused along with damages caused for fabric mat in December 2002 and it progressed after that time. At the three locations at vertical structure of offshore section, sea water move freely through the opening of revetment.

d) At the eastern section of the West Mole Revetment (facing to the approach channel to the Old Port), damages of dislocating bagged concrete, leakage of filled materials and collapse at the top part. KPA repairs repeatedly at this section.

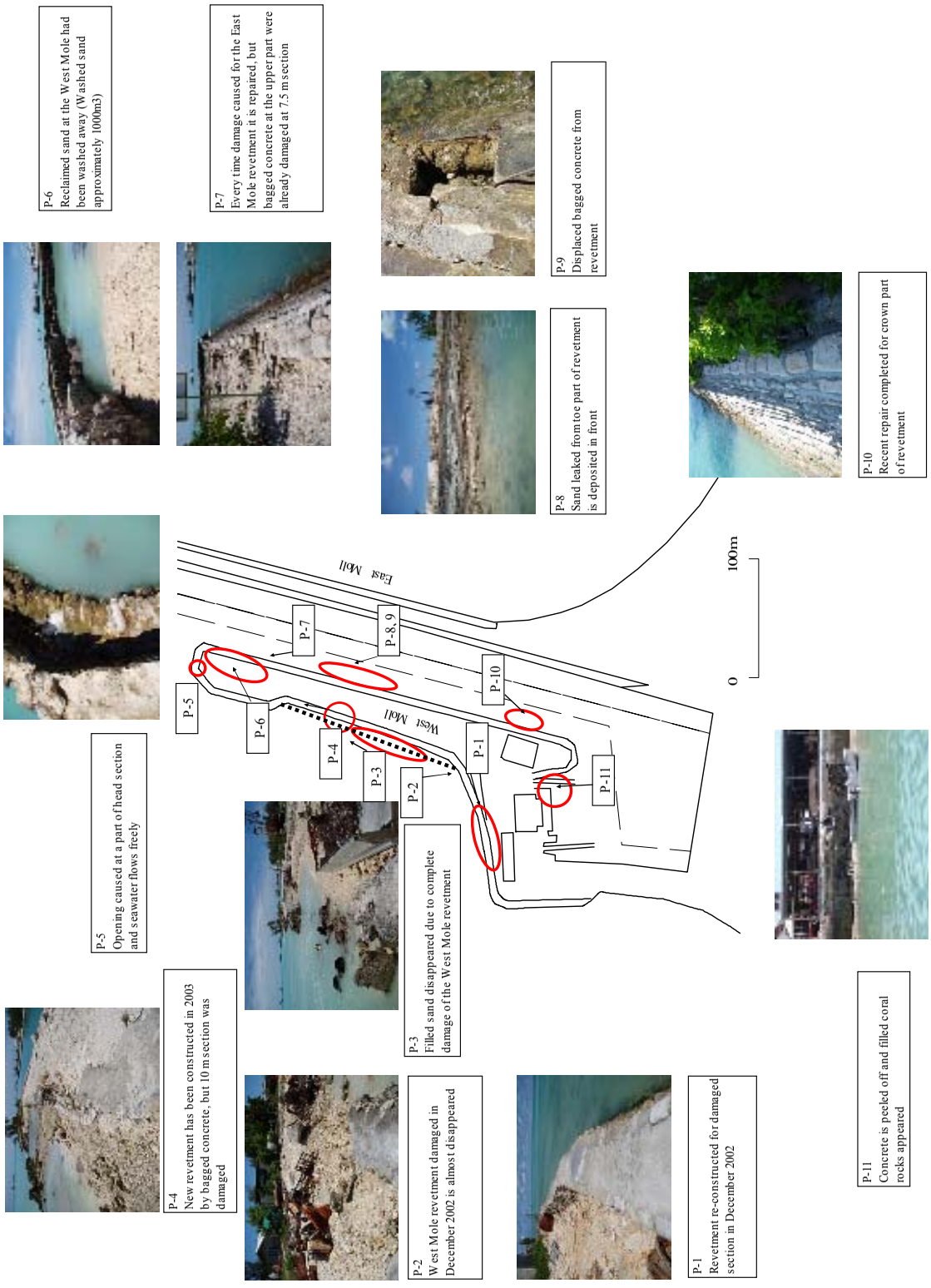



Figure A-2-3 Situation of West Mole Revetment

## A-3 Coring of Fabric Mat

In order to confirm leakage of backfilling of coral rock forming the structure of revetment, coring investigation of fabric mat has been carried out at slope and top parts and observation of cored holes has been made. Coring has been performed at 9 locations at top part and 4 locations at slope part of undamaged section of fabric mat type revetment. In addition to that, total of four cores (2 points each at slope and top parts) have been taken from the revetment located behind the container terminal. The results of coring investigation are summarized in Figure A-3-2 and major findings are described below;

a) The structure of fabric mat, as shown in Figure A-3-1, is composed of fabric mat → filter sheet → sand for level adjustment → backfill coral rock（5～20kg/pc）. At the location behind container terminal, bagged cement had been applied for backfill. The sand for level adjustment had been used to obtain smooth surface in avoiding damage to the fabric sheet during construction.

b) The sand at the damaged section of New Wharf Revetment has been leaked exposing coral rock behind.

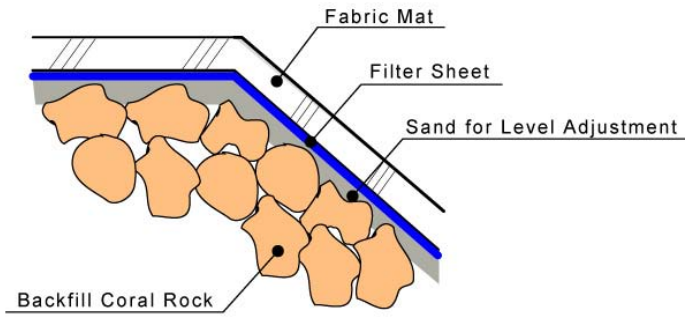



Figure A-3-1 Composition of fabric mat at New Wharf Revetment

c) As the feature of coral rocks varied, voids exist in between. Any displacement of coral rock has been observed for the undamaged section of revetment. While, displacement of rocks and existence of voids have been noticed for the damaged section. At the Section No. 5, where the damage of fabric mat is obvious, a large void with depth of 70 cm approximately has been seen.

d) Spurting of air from cored holes has been observed due to phase difference of waves acting to the revetment and spurting of sea water as well during HWL. It is concluded that transmission of air due to phase difference exist regardless of damage to the fabric mat.

e) At the undamaged revetment east of the container terminal, the sand for level adjustment exist at the position in two locations and bagged cement could be seen about 20cm underneath.

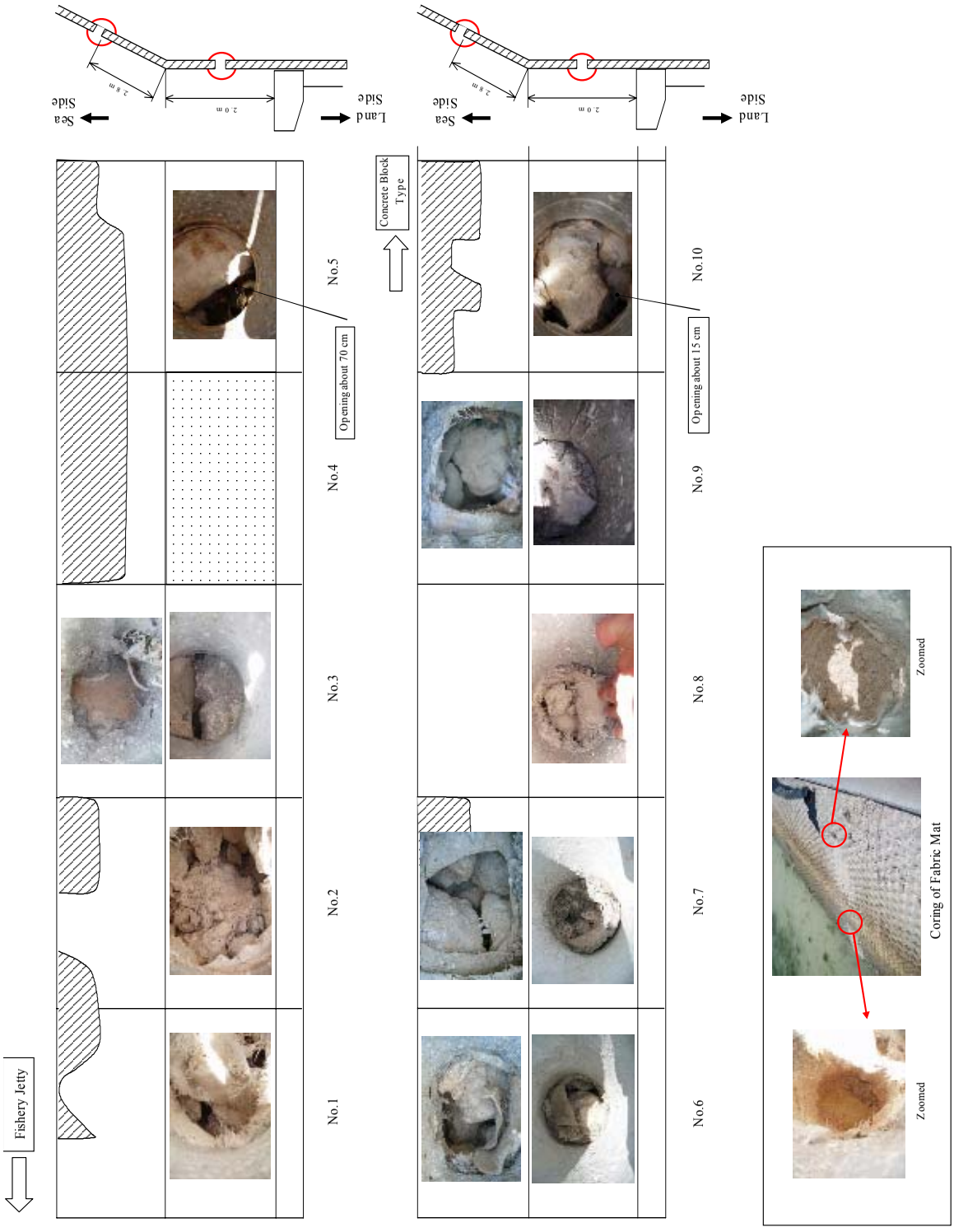



Figure A-3-2 Results of Coring Investigation

## A-4 Measurement of Settlement

Figure A-4-1 shows comparative difference of settlement at crest of parapet and top of fabric mat. Leveling survey has been carried out at both end and center of all 15 sections. Vertical ruler indicates each settlement from average value. Judging from the graph, settlement value and damages to fabric mat correlate well. It is noticed that the settlement at Section Nos. 3 to 4 indicates high value and subsidence observed near to the boarder of these sections. Settlement measured at parapet wall is less than that in fabric mat, but tendency of subsidence is noticeable at Section Nos. 3 to 4. It is difficult to evaluate the result of settlement measurement, however it is revealed that the settlement is correlated to damage of fabric mat and significant settlement is seen at the Section Nos. 3 to 4.

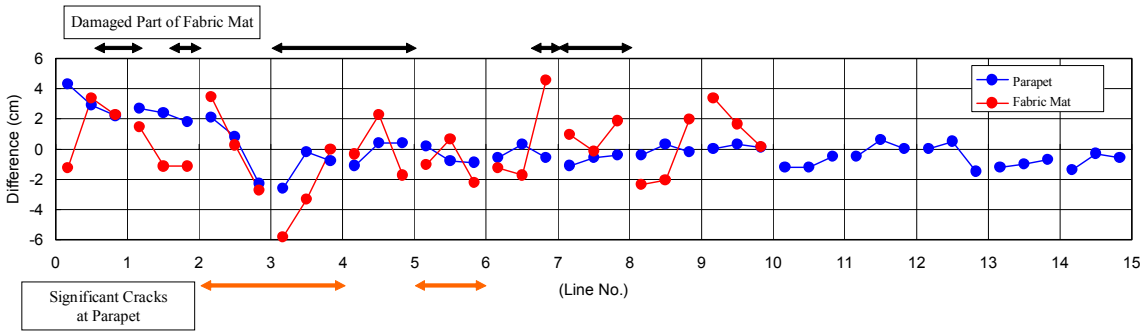



Figure A-3-1 Settlement Measurement at Parapet and Fabric Mat

## A-5 Excavation of Rear Side of Revetment

In order to confirm displacement and leakage of backfill of revetment, soil behind the revetment has been excavated. Using backhoe, top soil has been digged to obtain 1 m wide and 1.7 m deep approximately Excavation has been done at four locations (Section Nos. 1, 5, 7 and 9).

Backhoe used for investigation

Scene of excavation

Photo A-5-1 Excavation Site

[Section No.1]

This section causes significant leakage and wash out of backfill soil, then KPA had provided concrete pavement at Section Nos. 1 to 3. Under the concrete pavement, gaps of 1 to 2 cm have been observed.


Excavated hole


Opening underneath of concrete

Photo A-1-3 Section No.1

［Section No. 5］

Near the end of fabric mat, a large opening of 50cm high, 1 m wide and 1 m long has been observed.


Situation of excavated hole


Gap under parapet

Photo A-5-2 Section No.5

［Section No.7］

Noticeable opening or gap has not been observed at this section.


Situation of excavated surface ①


Situation of excavated surface ②

Photo A-5-3 Section No.7

［Section No.9］

Near the parapet wall, significant openings have been observed. The size of opening was 30 cm high, 50 cm wide and 1 m long. A drainage hole of parapet wall was located near this opening. Also gap of about 10 cm has been seen under the fabric mat.

Opening observed

Gap below fabric mat

Photo A-5-4 Section No.9

The results of excavation of rear side of revetment are summarized below;

- The site among four excavation points where wash out of top soil experience most frequently is Section No. 1 and an opening of 1 to 2 cm appeared under the concrete pavement, but it was not significant. It is not confident about existence of leakage of soil at this location, since additional soil has been spread after it was washed out. Also the soil is not well compacted causing soaking of water smoothly avoiding creation of void.
- Large openings have been found at Section Nos. 5 and 9 where damages of fabric mat have been observed. At both locations, drainage holes were located nearby. Therefore, it is supposed that leakage of backfill soil is being experienced through water course created between top soil and toe part.
- Except for the location where large damages had been caused, it is hardly found existence of leakage from road/container yard to the sea. While, significant openings have been observed near the damaged sections of fabric mat and it is likely progressing in the future. For the sections where noticeable opening is found, there is high potential of similar leakage and creation of opening in longer term.

## A-6 Wave Observation during HWL

During the field survey period of this study, the date of August 30, 2004 falls on spring tide, and then wave observation has been performed. Photo A-1-7 shows situation of waves during the time. The time of the observation was 17:00 and the tidal elevation was +2.61m（DL+1.87m）.

Photo ① shows situation of wave overtopping at Section No. 1. The tidal elevation at that time was lower than the highest higher water level recorded (+2.97 m) in March 1997 by 36 cm. The wave condition was not particularly rough, but significant overtopping waves were caused. It was appeared only at the location near Section Nos. 1 and 2 and overtopped waves were soaked into the top soil at the road.

Photo ② shows situation around the area and sea water spurt out from the boarder between paved and unpaved areas due to the phase difference of waves, thus it was confirmed sea water transmit between the backfill rocks and toe part of the revetment.

Photo ③ shows situation of core holes during HWL. It was observed sea water has spurted up from whole core holes and spurt height at those holes where damages are significant was higher. It reveals that transmission of sea water at damaged parts is much significant in compared with undamaged part.

① Situation of Overtopping Waves（Section No.1）

② Spurting of sea water at road（Section No.1）

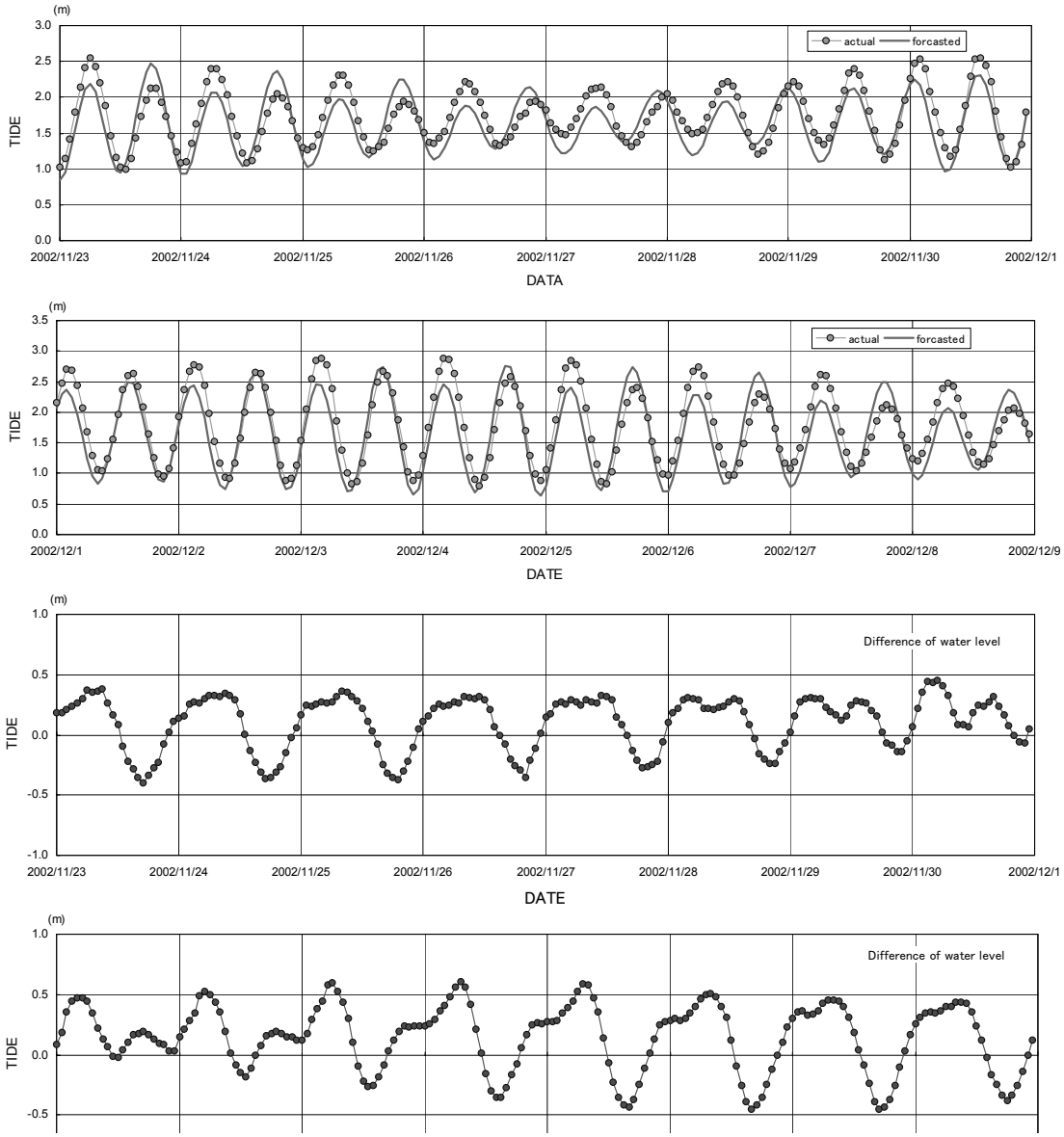
③ Spurting of sea water at cored holes

Photo A-6-1 Situation during HWL（30 August 2004）

# Appendix-6.B WATER LEVEL AND ESTIMATED WAVES DURING DISASTER

## B-1 Water Level

Figure B-1-1 shows difference of forecasted and actual water levels before and after disaster caused for the revetment. Water setup has been observed between 29 November and 6 December 2002 due to wind-drift effect inside lagoon while the strong westerly wind blows. The maximum water level of +2.88 m has been recorded on December 3.




Source） South Pacific Sea Level and Climate Monitoring Project

Figure B-1-1 Forecasted/Actual and difference of Water Levels during Disaster

After the completion of the revetment in 1999 till the time of disaster caused in December 2002, the days with water level higher than +2.83 (at the time of disaster) were extracted and tabulated in Table

B-1-1. It revealed that strong westerly wind blow recorded during higher water in the limited period between 5th to 8th September 2002 and 4th to 9th October 2002.

Table B-1-1 Higher Water with Strong Wind Record（1999 - 2002）

| Year | Month/ Date | Water Level | Wind Dir. | Wind Speed | |
|---|---|---|---|---|---|
| | | | | Mean (m/s) | Max (m/s) |
| 1999 | 23 Nov. | 2.83 | E | 5.7 | 9.8 |
| | 24 Nov. | 2.89 | | | |
| | 25 Nov. | 2.85 | | | |
| | 22 Jan. | 2.85 | E | 3.3 | 5.1 |
| 2000 | 19 Feb. | 2.83 | E | 8.7 | 10.8 |
| | 20 Feb. | 2.80 | | | |
| | 31 July | 2.81 | E | 2.8 | 4.1 |
| | 1 Aug. | 2.83 | | | |
| | 29 Aug. | 2.87 | SE | 1.8 | 4.1 |
| | 30 Aug. | 2.80 | | | |
| | 11 Dec. | 2.81 | SE | 4.1 | 6.2 |
| | 12 Dec. | 2.85 | | | |
| | 9 Jan. | 2.83 | E | 8.8 | 10.5 |
| 2001 | 10 Jan. | 2.83 | | | |
| | 11 Jan. | 2.84 | | | |
| | 8 Feb. | 2.86 | E | 6.8 | 8.5 |
| | 9 Feb. | 2.84 | | | |
| | 8 Mar. | 2.82 | E～SE | 6.0 | 11.5 |
| | 9 Mar. | 2.87 | | | |
| | 10 Mar. | 2.86 | | | |
| | 11 Mar. | 2.80 | | | |
| | 18 Aug. | 2.81 | E | 4.4 | 9.2 |
| | 19 Aug. | 2.86 | | | |
| | 20 Aug. | 2.90 | | | |
| | 16 Sept. | 2.87 | E | 4.2 | 6.3 |
| | 17 Sept. | 2.94 | | | |
| | 18 Sept. | 2.84 | | | |
| | 17 Oct. | 2.83 | E | 2.9 | 6.6 |
| | 18 Oct. | 2.81 | | | |
| 2002 | 1 Jan. | 2.85 | - | 2.2 | 4.7 |
| | 29 Jan. | 2.85 | NE | 4.1 | 7.5 |
| | 30 Jan. | 2.87 | | | |
| | 26 Feb. | 2.82 | NE～E | 4.3 | 9.7 |
| | 27 Feb. | 2.87 | | | |
| | 28 Feb. | 2.90 | | | |
| | 1 Mar. | 2.89 | | | |

| Year | Month/ Date | Water Level | Wind Dir. | Wind Speed | |
|---|---|---|---|---|---|
| | | | | Mean (m/s) | Max (m/s) |
| 2002 | 27 Mar. | 2.89 | E～S～SW～SE | 4.8 | 9.9 |
| | 28 Mar. | 2.92 | | | |
| | 29 Mar. | 2.91 | | | |
| | 30 Mar. | 2.85 | | | |
| | 26 May | 2.83 | E | 2.4 | 4.5 |
| | 11 July | 2.84 | S | 2.4 | 4.5 |
| | 12 July | 2.80 | | | |
| | 8 Aug. | 2.87 | S～E～NE | 3.6 | 8.0 |
| | 9 Aug. | 2.86 | | | |
| | 10 Aug. | 2.96 | | | |
| | 11 Aug. | 2.88 | | | |
| | 5 Sept. | 2.80 | W | 5.3 | 11.1 |
| | 6 Sept. | 2.93 | | | |
| | 7 Sept. | 2.95 | | | |
| | 8 Sept. | 2.90 | | | |
| | 4 Oct. | 2.87 | W～NW～N | 5.8 | 12.0 |
| | 5 Oct. | 2.90 | | | |
| | 6 Oct. | 2.92 | | | |
| | 7 Oct. | 2.93 | | | |
| | 8 Oct. | 2.88 | | | |
| | 9 Oct. | 2.83 | | | |
| | 4 Nov. | 2.90 | E～SE | 2.9 | 7.3 |
| | 5 Nov. | 2.92 | | | |
| | 6 Nov. | 2.88 | | | |
| | 29 Nov. | 2.40 | W | 7.2 | 17.1 |
| | 30 Nov. | 2.55 | | | |
| | 1 Dec. | 2.71 | | | |
| | 2 Dec. | 2.78 | NW | | |
| | 3 Dec. | 2.88 | | | |
| | 4 Dec. | 2.87 | | | |
| | 5 Dec. | 2.85 | | | |

Source) South Pacific Sea Level and Climate Monitoring Project

## B-2 Estimated Wave

At the end of November 2002 when disaster took place, westerly wind blow considerably longer period of 44 hours.

The waves caused damages to the revetment had been developed by strong westerly wind blow from outside of lagoon during higher water level and the wave characteristics at the time has been estimated as below. Offshore wave has been estimated applying SMB method and the following progressive waves passing through the reef have been estimated by Takayama formula. The assumed parameters for estimating nearshore waves are listed below.

Table B-2-1 Assumed Parameters for Estimating Nearshore Waves

| Item | Assumed Condition |
|---|---|
| Timing of wind more than 10m/s | AM 5:00 on 29 November to AM 0:00 on 1st December, 2002 |
| Duration of wind more than 10m/s | 44 hours |
| Average Wind Speed | 11 m/sec |
| Average Depth at the Edge of Reef | -1.5 m |
| Tidal Elevation | +2.88 (DL+2.14) |
| Distance between the edge of reef and location of estimating nearshore waves | 2,700 m |

Applying above parameters, the nearshore wave height ($H_{1/3}$) at the designated location of revetment has been assumed at 0.77 m, thus it is less than the design waves assumed by the Basic Design in 1997 ($H_{1/3}$=1.54m、$T_{1/3}$=4～5s).

Table B-2-2 Estimated Nearshore Waves

| | | |
|---|---|---|
| Offshore Wave | $H_o$ (m) | 2.70 |
| | $T_o$ (m) | 7.00 |
| Nearshore Wave | $H_{1/3}$ (m) | 0.77 |
| | $H_{max}$ (m) | 1.38 |
| | $T_{1/3}$ (m) | 7.00 |