MINISTRY OF FOREIGN AFFAIRS, TRADES,
TOURISM, ENVIRONMENT AND LABOUR
THE GOVERNMENT OF TUVALU

THE PROJECT FOR PILOT GRAVEL BEACH NOURISHMENT AGAINST COASTAL DISASTER ON FONGAFALE ISLAND IN TUVALU

FINAL REPORT (MAIN REPORT)

April 2018

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
FUTABA INC.

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● Project Overview in Photos(1/3)

<u>Beach Condition after Construction</u>

● Project Overview in Photos(2/3)

Construction and Effect of Beach Nourishment

Construction Overview

＜Location Map＞

Workflow 1 : Collection, Transport and Placement of Gravel

▲ Gravel Collection at Tips of Islands

▲ Placement of Gravel at Project Site

Workflow 2 : Construction of Groins at Project Site

▲ Placement of Core Stones from Fiji

▲ Placement of Armor Rock from Fiji

Workflow 3 : Collection, Transport and Placement of Sand

▲ Collection of Sand from Borrow Pit

▲ Placement of sand at Project Site

1. Protection Function (Wave condition during cyclone)

▲ Outside of Project Site

▲ Project Site

2. Improvement on Beach Use

▲ Playing on Beach

▲ Fishing from Groin

3. Improvement of Beach Environment

▲ Improvement of Scenery

▲ Habitat of young fish

● Project Overview in Photos(3/3)

Public Relations and Environment Education for Beach Management and Maintenance

Beach Cleaning Event (before Construction)

Beach Song Competition

Beach Tour during Construction

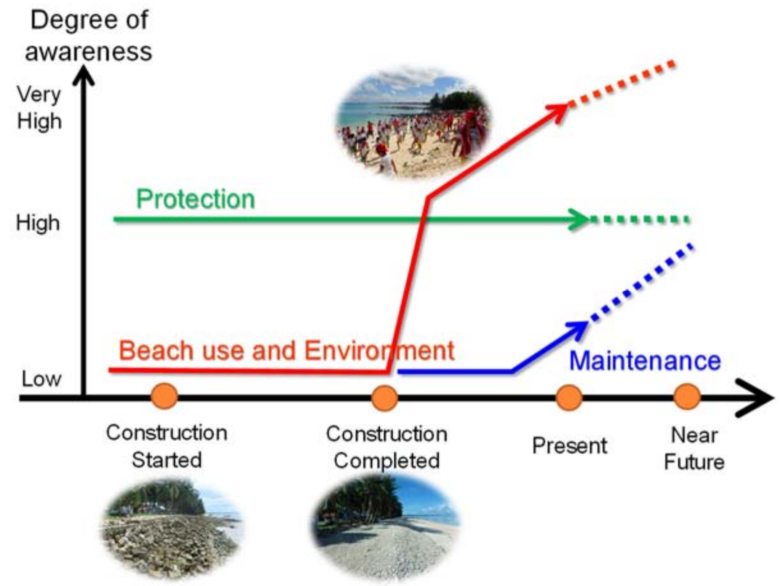
A Sequence Event including Beach Sports Festival

1. Environment Education

2. Beach Cleaning Event

3. Beach Sports Festival

Changes in Public Awareness



Changes in Activities

▲ Voluntary Beach Cleaning

▲ Propagation of new ways of beach use

- Preface -

Coastal problems such as coastal erosion, wave overtopping, storm surge, etc., are now serious in Tuvalu and other Pacific Island countries. Furthermore, the risk on coastal disaster will be increased by high waves and the rising of seawater level due to the impact of climate change. Each Pacific Island countries are undertaking coastal protection measures for disaster prevention and adaptation for climate change with worldwide support.

The coastal projects which were implemented in the Pacific Island countries were commonly just based on the "hard point of view", which was just to consider the selection and implementation of hard structure measures. On the other hand, "soft point of view", such as historical forming of original beach and island, original functions of the beach especially for beach use, relation of the beach to human life, culture and daily activities, etc., was not considered sufficiently. As a result, there were several cases that the implemented projects for coastal protection intercepted the beach from human life and activities, and induced indifference of people toward the beach.

Beach is closely related to the daily lives of the residents, giving the people various benefits and contributions. Beach is also the habitat for marine and coastal biota. Therefore, beach is required to be protected in order to maintain its function in nature. Also, historical records show that the beach is maintained and conserved by the community and residents who lived in close proximity to the beach. Keeping such relations between the beach and the people can achieve a healthy development of community with keeping nature and environment, and increase their emotional attachment to the beach.

Fongafale Island, which is the capital island in Tuvalu, has owned the degradation of coastal condition at the lagoon side due to alternation of foreshore area by U.S. Army during the Second World War and rapid concentration of the population in the last 20 years. Especially, disappearing of sandy beach and collapse of seawall made by concrete or concrete blocks led the increase of coastal disaster such as wave overtopping and storm surge, and interfered on beach use to the peoples. As the result, beach was drastically changed from that in original condition. Plenty of garbage left on the beach with bad smell before the Project.

Based on the above mentioned deteriorated condition of the beach, JICA was previously conducted two technical cooperation projects from both short-term and long-term points of view on coastal conservation, which were “The Study for Assessment of Ecosystem, Coastal Erosion and Protection/Rehabilitation of Damaged Area in Tuvalu” from 2009 to 2011 as the feasibility study to recover the beach with original image, and the science and technology cooperation project, titled “Eco-Technology Management of Tuvalu against Sea Level Rise” from 2009 to 2014 for the purpose to examine the mechanism of forming and maintaining of the island and to propose the eco-system coastal conservation measures taking into account the production, transportation and accumulation of coral sand. Based on the outcomes from each project, the Project was requested as technical cooperation project to propose to implement the short-term coastal conservation measures using a beach nourishment.

The Project of beach nourishment as the pilot scale coastal conservation measures was implemented from 2012 to 2018 in order to perform the “Ecosystem-based” and “user-friendly” type of coastal conservation measure, and to establish the community-based beach management in Tuvalu with sustainability. The propose beach nourishment is to recover the natural image of the beach, replacing the hard structure measures that were commonly applied in Tuvalu and other Pacific Island countries. The Project phase was divided into the following three phases.

Phase-1: Planning and design (Mar. 2012 to Mar. 2013)

Phase-2: Construction (Feb. 2015 to Dec. 2015)

Phase-3: Monitoring, evaluation and beach management (Jan. 2016 to Jan. 2018)

In phase-1, the technical study based on field observation, data collection and numerical approach was conducted as basic study to examine the formation of the island, littoral movement for coral gravel and sand, and to prepare the planning and design of the beach nourishment to fulfil three functions, which are “protection”, “beach use”, and “environment”. As the coral gravel and sand, which were produced at Funafuti Atoll in Tuvalu, were employed as nourishment materials, the environmental impact to the extracted area of gravel and sand was also highly taken in account. The beach will be utilized as a public beach that the local people will commonly use, the public opinion about the Project was to be highly considered into the planning and design of the beach nourishment by organizing several public consultations, regardless of age and gender.

Although the issue about the design of beach width were exposed between JICA and the Tuvalu Government, it was solved on Nov. 2014. After that, the review of detailed design which was prepared in Phase-1 was re-examined and the construction was commenced on June 2015 and completed on Dec. 2015 as Phase-2.

The beach monitoring was carried out for two years in Phase-3 to evaluate the validity and effectiveness of the nourished beach. As the result, it was observed that the discharge of filled sand and gravel was quite small and the implemented beach could keep the stable condition.

To promote the realization of beach maintenance and management by the community and locals who were the main beach users, which is called “community-based beach management”, several PR (Public Relation) and educational activities were proposed and undertaken through each phase of the Project. One of successful activities was the beach sports events which were undertaken twice in 2016 and in 2017 of Phase-3. They could realize the fun and the contribution of the beach through the activities from the event. They also realized the importance to have responsibility for maintaining the beach through the beach maintenance work being taught in school educational programs and education classes. According to the obtained results of the interview survey with the locals, it was proven that the understanding of beach nourishment and the public awareness on beach conservation and maintenance were surely enhanced by the promotional PR and education programs. As a result, the community-based beach maintenance and management has been continued even though more than two years have passed from the completion of the construction.

The Project was the first trial to employ the beach nourishment method as the “Ecosystem-based” and “user-friendly” coastal conservation measures, and the community-based beach management in Pacific Island countries. So that, the knowledge transfer for the Project was actively conducted not only to Tuvalu but also to other Pacific Island countries by promoting several seminars and opportunities for technical exchange (presentation in GEF workshop in Tonga, technical exchange in Mauritius, participation to the international conference, etc.). Also, the leaflet, guideline etc. for the nourishment was prepared, and put on the Web site and distributed to related agencies at both inner and outer countries

We hope the outcome of the Project will contribute to the people of Tuvalu and other Pacific Island countries who are facing similar coastal problems and also to enhance their understanding of beach nourishment and the awareness on coastal conservation and its maintenance.

Table of Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Long Form
APAC	International Conference on the Asian and Pacific Coasts
C/P	Counterpart
DOE	Department of Environment
DOF	Department of Fisheries
DOLS	Department of Land and Survey
EAFT	Environmental Assessment Task Force
EIA	Environmental Impact Assessment
EMP	Environmental Monitoring Plan
GCF	Green Climate Fund
GEF	Global Environment Facility
GPS	Global Positioning System
IEE	Initial Environment Examination
JAFTA	Japan Fumigation Technical Association
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
MET	Tuvalu Metrological Service
MFATTEL	Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour
MoESDDBM	Ministry of Environment Sustainable Development, Disaster and Beach Management (Mauritius)
MPUI	Ministry of Public Utilities and Infrastructures
NAPA	National Adaptation Program of Action
NGO	Non-Governmental Organization
NZ	New Zealand
PCC	Project Coordination Committee
PEAR	Preliminary Environmental Assessment Report
PR	Public Relation
PSC	Project Steering Committee
PWD	Public Works Department
R/D	Record of Discussion
SGP	Small Grants Programme
SOPAC	South Pacific Applied Geoscience Commission
SST	Sea Surface Temperature
SWAT	Solid Waste Agency of Tuvalu
TCAP	Tuvalu Climate Adaptation Project
the beach nourishment	Beach nourishment using coral gravel and sand implemented in this Project
the Project	Project for Pilot Gravel Beach Nourishment against Coastal Disaster on Fongafale Island in Tuvalu
UNDP	United Nations Development Programme

Executive Summary

The outline and obtained results through the Project are summarized below.

Planning and Design

- Necessity of coastal adaptation in Tuvalu

  Tuvalu consists of small atoll islands with a low elevation of 2 m above mean sea level; however, the present coast of Tuvalu is being threatened by coastal disaster caused by high storm waves due to cyclone or atmospheric depression especially during high tide. The impact of climate change will cause further increase of risk on coastal disaster, and therefore, urgent coastal adaptation is strongly requested.

- Typical coastal measure in Tuvalu

  Hard structure measures using coral rock, poor concrete block, and concrete seawall have been employed in Tuvalu until now as common coastal protection measures. However, such protection measures were not only less effective on protection function, but also cause further deterioration of coastal condition for beach use and environment.

- Concept of coastal adaptation

  The objective area of the Project is located at the central area (Tausa Lima) on the lagoon coast of Fongafale Island, where the residential and public facilities and places exist. It considers three functions on the selection of coastal adaptation measures, which are “protection function”, “beach use”, and “coastal environment”. Maintaining the natural landscape the same image as the original natural beach was also taken into account in the design of the beach.

- Proposed coastal adaptation measure

  To improve the deteriorated coastal condition due to anthropogenic land alteration and collapse of previous protection measures, the beach nourishment using coral gravel and sand was proposed as first trial of ecosystem-based and user-friendly type of coastal adaptation measure.

- Consideration on public consultation and consensus building

  As constructed beach will be utilized as public beach, public opinion was highly considered to put into the design of the beach nourishment. Furthermore, Tuvalu had unique social condition on the organization of community and land ownership. Therefore, public consultation and consensus building were frequently organized and implemented with a consideration of balancing factors such as gender and age throughout the Project duration.

- Basic concept of beach profile design

  The beach profile design, such as beach slope and berm height, basically follows the same condition of the existing natural beach considering the stability against wave action. As a result, the berm height was set at +4 m and the beach slope for gravel and sand was set at 1:3.5 and 1:11 respectively, to keep the consistency with the existing natural beach.

- Discussion for design of beach width

  The design of beach width was hardly discussed with the Tuvaluan government. Even though the Tuvaluan government requested to widen the beach width as much as possible to create new land space, the measurement was finally decided at 6 m for the backshore width and approximately 20 m for the average width of the beach in the mean sea level (MSL) condition considering the purpose of the Project and maintaining the stability to the beach.

- Concept of layout design

  Based on the request from the Tuvaluan side, the location of the Project site was selected in Tausoa Lima on the lagoon side of Fongafale Island as the most attractive public area. The alongshore distance was set at 177 m considering the existence of deep water area at the north and private seawall in the south. To minimize the expected future discharge of filled gravel and sand, the armor rock type groins were set at each side of nourishment area. The following considerations were taken into account in the design of groins and determined each dimension: 1) function in maintaining the nourished material, 2) impact on beach use and accessibility in alongshore direction, 3) harmony with natural landscaping, and 4) to minimize the quantity of material.

- Procurement of construction material

  Coral gravel and sand procured in Tuvalu were applied as the beach nourishment material to show the sustainability for future coastal adaptation in Tuvalu with their ownership. Armor rock for groin was imported from Fiji and Taveuni Island.

- Special consideration on environmental impact for procurement of gravel

  Environmental impact, especially impact to surrounding coast, was highly taken into account for the procurement of gravel in Tuvalu. The mechanism for gravel accumulation and movement due to wave action at the ocean side of Funafuti Atoll was examined based on the historical shoreline change by satellite image analysis. Taking into account the required quantity of gravel, impact to existing live corals during the construction work, and the construction cost as pilot-scale project as well as impact to surrounding coast, it was decided to extract the gravel from the tip of Funamanu and Papa Elise islands, which were accumulated by the effect of Cyclone Bebe in 1972.

Construction

- Bidding and construction schedule

  After the bid process conducted in the Japan International Cooperation Agency (JICA) Fiji Office from April to June 2015, the construction work commenced on 15 June 2015 by the contractor in Fiji (Cruz Holding JV) and was completed on 23 December 2015, about six months without any delay from the contracted period.

- Construction item and quantity

  Main construction items were 1) collection and transportation of gravel from the islands, 2) groin construction, 3) gravel nourishment, 4) sand nourishment, and 5) installation of backshore stone. About 3,300 m^3 for gravel and 4,500 m^3 for sand were filled into the Project area with a 177 m alongshore distance.

- Environmental consideration during construction

  The monitoring of marine environment and water quality was carried out at both the gravel taking and the construction sites through the construction period. The water quality (turbidity) and the condition of existing corals and marine life were monitored frequently during and post construction period. The results show that there were no significant environmental impacts at both the gravel taking and construction sites due to the construction activities

- Social consideration during construction

  During the construction work, consensus building and several public relation (PR) and educational activities such as beach cleaning event and beach tour for primary school students were actively conducted to enhance public awareness and understanding on beach conservation.

- Effect of the constructed beach

  After the construction of the beach, it was confirmed that the expected three functions were sufficiently emerged and these functions were well recognized and evaluated by the residents. The three functions were summarized as 1) protection against high wave, 2) improvement on beach use, and 3) improvement on beach environment and scenery.

Monitoring

- Monitoring items

  Beach monitoring at both the Project site and gravel borrow sites was continuously carried out for almost two years. The objectives of the monitoring are 1) to check the stability of the nourished beach, 2) to check the impact to the surrounding coast at both the Project site and borrow site, and 3) to examine the required adaptive measures. The main items of the beach monitoring were 1) taking photos from fixed points, 2) beach profile survey, 3) taking bird's-eye view photos using a drone, 4) wave and tide observation, and 5) interview survey.

- Monitoring results

1) The Project beach could maintain the stable condition even though it was struck by high waves during the approaching cyclone. The discharge rate for combined gravel and sand was about 3% for two years.

2) Sand, which was filled in the foreshore section, has a tendency to shift to the south in total due to littoral drift, and a part of the shifted sand that overflowed to the south beach. Also, a part of the fine contents of sand can possibly be moved to the offshore side. Total discharge rate for sand was estimated to be about 5% for two years.

3) A part of the gravel, which was filled to the backshore section, were moved to the foreshore sandy part and were scattered by continuous wave action. Due to this, the crest line of gravel section had a little retreat with approximately 1 m in average and 3 m at maximum in the north part of the Project area. However, gravel was just moved from the backshore to the foreshore side and no discharge of gravel to the outer area was observed.

4) No change in the beach slope from the initial situation just after the construction was observed at both the gravel and sand sections. This proves that the design slope was appropriate.

5) The Project beach was highly utilized by the local people for swimming, recreation and rest space, and fishing, while boat landing is also expected. Beach environment was also improved drastically based on the result of the interview survey and visual checking on site. Significant increase in the number of baby fish and crustaceans and improvement of water transparency were observed.

6) No negative impact to the surrounding coast was identified both at the Project site and the gravel borrow site in Funamanu and Papa Elise islands.

Maintenance and Management

- Necessity of community-based management

The Project beach is utilized as a public beach for the Funafuti people, who are the main users of the beach and therefore have frequent opportunities to identify the current beach condition. From this, it was realized that not the "government-based beach management" but the "community-based beach management" was necessary to maintain the beach.

- Activity for beach maintenance

  Community-based beach maintenance was carried out mainly by the Funafuti Kaupule while keeping their passion and motivation during the post construction stage. The Project beach could be kept clean due to weekly or bi-weekly routine cleaning activities.

- Application of adaptive management system

  Adaptive management system to the nourishment based on a PDCA (Plan-Do-Check-Act) system, which is monitoring, evaluation, planning of adaptive measure, implementation, and re-monitoring, was proposed and was tried to carry out in September 2017 in the post construction stage to maintain the beach in good condition and enhance the life period of the beach.

- Consideration of sustainability for adaptive measure

  Proposed adaptive measure was highly considered to employ the "simple and easy method with only low technology" to be able to take action by only the Tuvaluan side after the completion of the Project. Furthermore, the "interactive activation structure", which consists of "execution of adaptive measure", "active use for events using improved beach", and "educational activity", was proposed to ensure the sustainable execution of community-based beach management by the Tuvaluan side.

- Implementation of the proposed adaptive measure

  Removal of gravel from the sandy foreshore area and throwing it into the original gravel backshore area were undertaken by the Funafuti Kaupule using an excavator and manually by the primary school students in 1.7 years after the completion of construction. Small quantity of sand with 80 m^3 filled the north area to improve the beach condition at the foreshore sandy part.

- Necessity of public relation (PR) and educational activities on beach management

  Beach management is an activity to keep the beach area in good condition after the construction. At the beginning of the Project, there were a lot of rubbish accumulated on the beach, which showed people's bad behavior and lack of interest on the beach. Furthermore, it was anticipated that even if the beach environment had been improved by the Project, it would go back to the same bad situation in the future. Therefore, it was considered that improving their awareness was essential for proper beach management in the future. PR and educational activities were applied to improve awareness on beach environment.

- Contribution of PR and educational activities to the beach maintenance and management

  Since changing public awareness was not an issue to be done in a short period, the following step-by-step approach was set as objectives for the PR and educational activities as follows: step-1) People become interested on the beach, step-2) People experience and understand the benefits from the beach, step-3) People begin to take concrete actions on beach management.

A variety of PR and educational activities were implemented to accomplish the objectives, for example, the beach cleaning event was implemented before the construction for the purpose of step-1) and the beach sports event was conducted twice (July 2016 and September 2017) for the purpose of step-2). According to the interview survey, improvement of public awareness on the beach was confirmed and consequently, community's active participation on beach management such as on beach cleaning was observed as an outcome of the PR and educational activities.

Capacity Development, Expansion of Knowledge

- Implemented program and activities for capacity development and expansion of knowledge.

The following several programs were implemented to enhance capacity development of stakeholders and expansion of knowledge of beach nourishment: 1) Technical exchange in Mauritius on management and maintenance of gravel beach, 2) Training in Japan on management of beach nourishment, 3) Seminar on the beach nourishment, 4) Training of measurement equipment for wave and current, beach profile, bird's-eye view photos, 5) GEF ECW (Global Environment Facility Expanded Constituency Workshop), and 6) Presentation of technical papers in the International Conference on Asian and Pacific Coasts (APAC) in Philippines .

- Preparation of Technical Guideline

The technical guideline for beach nourishment was prepared as one of the results of the Project. This guideline shows the basic idea for the consideration on selection of coastal adaptation measure and for planning and design of beach nourishment to expand the knowledge for ecosystem-based and under-friendly type of coastal adaptation measure.

Future Development of Beach Nourishment Project in Tuvalu

- Understanding and demand for beach nourishment

Based on the result of the interview survey to the Tuvaluan people, they have well realized the advantage of the beach nourishment on beach use and coastal environment, and most of them really wanted the same type of measure as coastal adaptation measure in Tuvalu. They also realized the importance of taking action on beach maintenance through participation in sports event on the beach and other educational activities.

- Potential for procurement of sand to full-scale project

  Because of the existence of plenty of sand in the lagoon, there is basically no issue for securing sand in Tuvalu. However, attention should be given to the location of the borrow site taking into account the impact to the coast as well as the grain size of the nourishment material.

- Potential for procurement of gravel to full-scale project

  Two potentials to procure coral gravel are expected, which are taken from the deep channel at the south side of Funamanu Island and sorted gravel from the dredged seabed material on the lagoon. Further study is required to identify the potential volume for construction method and cost. In case that there is no feasibility to procure the gravel in Tuvalu, gravel might be imported from outer overseas countries as final selection.

1. Introduction

1.1 Background

Tuvalu, composed of small atoll islands, is getting the attention of the entire world as the elevation of the country is almost less than 2 m above mean sea level. Hence, it is projected that the island is significantly susceptible to climate change effects, particularly the subsequent sea-level rise in the future. In the meantime, the present coast in Tuvalu is already threatened with coastal disaster caused by high tidal waves due to cyclone or atmospheric depression especially during high tide. It is also pointed out that coastal erosion could accelerate the risk because lesser areas are being protected by natural coasts. Some of the past studies revealed that the main causes of the coastal erosion were the anthropogenic land alteration and the increase in environmental load due to population growth.

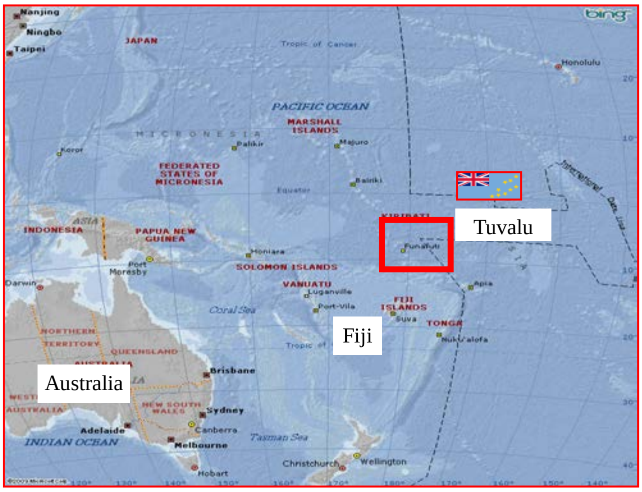


Figure 1.1.1 Location of Tuvalu

(Source : Completed JICA Development Survey Report (2011))

Facing these threats under the present and future climate conditions, the Government of Tuvalu requested the Government of Japan in 2008 to conduct a comprehensive study towards strengthening the resilience of the coastal area. A coastal protection plan for Fongafale Island was recently established with substantial assistance from the Japan International Cooperation Agency (JICA) through the project titled "The Study for Assessment of Ecosystem, Coastal Erosion and Protection/ Rehabilitation of the Damaged Area in Tuvalu" from August 2009 to January 2011. Considering the environmental impacts and unique social customs of Tuvalu, JICA formulated the plan and proposed the beach nourishment using coral gravel and sand as a countermeasure to reduce the disaster risks associated with overtopping and inundation. However, beach nourishment as one of the coastal protection measures has never been implemented in Tuvalu. In May 2011, the Government of Tuvalu requested the Government of Japan for assistance to examine the effectiveness and adequacy of the beach nourishment in Tuvalu.

1.2 Chronology of the Project

- The Government of Tuvalu and JICA concluded the Record of Discussion (R/D) on 16 November 2011 and the project has been commenced since April 2012. The project was originally divided into three phases, which were "Phase-1 (Planning and Design Stage)", "Phase-2 (Implementation Stage) and "Phase-3 (Monitoring and Evaluation Stage)". The total project period was set to 34 months.
- During the Phase-1 Stage, the issue in regard to the width of the beach was exposed from the Government of Tuvalu. This was fundamentally caused by the different understanding for the space of backshore area on coastal protection. Due to this, the Project was temporary suspended from March 2013. After the discussion in both parties, this issue could be cleared in November 2014, and the Project has been re-started from Phase-2 stage since January 2015 based on the amended R/D. The total project period was set again to 36 months.
- According to the original and amended R/D, the beach maintenance and management in the post project period was undertaken by the Tuvaluan side. However, due to insufficient knowledge and experience on such type of coastal conservation measures in Tuvalu, it was realized the necessity to support the beach maintenance and management based on the obtained monitoring result and its capacity development in Phase-3 stage. As the result of discussion between the Government of Tuvalu and JICA on 12 April 2017, both parties agreed to add the assistance for support on beach maintenance and management and required programs for capacity development.

1.3 Pre-understanding the Conditions before Commencement of the Project

(1) Conditions on the Countermeasures for Coastal Disaster

1) Fragility of the Existing Coastal Facilities and Problems in Coastal Land Use

Many coastal protection facilities have been constructed in Fongafale Island, either through public works or by individuals to prevent coastal erosion.

Figures 1.3.1 and 1.3.2 show the coastal facilities done through public works before the commencement of the Project. Coastal facilities done by private individuals are shown in Figures 1.3.3 and 1.3.4. Common protection measure before was just concrete seawall or vertical revetment using poor concrete block or coral rock. Such coastal protections did not have sufficient efficiency on protection function. Also, further deterioration on coastal use and environment was induced.

Figure 1.3.1 Damaged Revetment in front of Vaiaku Lagi Hotel

Figure 1.3.2 Damaged Revetment at the North Side of Vaiaku Pier

Figure 1.3.3 Stone Fence at North Side of Vaiaku Lagi Hotel

Figure 1.3.4 Barrier of Concrete in Oil Drum

(Source： Completed JICA Development Study (2011))

Tuvalu has a complex land ownership system. Land ownership is only possible through inheritance from the maternal or paternal family, and recognition of this ownership varies among residents. In addition, there are endless land disputes regarding ownership resulting from the loss of land caused by coastal erosion or deformation brought about by natural phenomenon. Therefore, diligence is needed in entering into agreements regarding land use.

2) Insufficient Materials and Equipment for the Implementation of the Project

Most of the heavy machineries, e.g., backhoes and loaders, owned by the Public Works Department (PWD) for transporting soil are non-operational, and almost no machinery is operating normally. Only the Solid Waste Agency of Tuvalu (SWAT) owns small-scale loaders which are being used for collecting trash. It is said that PWD, SWAT, and Kaupule (or island council), each owns and operates one 2–4 tons dump truck for transporting soil. However, procurement of spare parts for these heavy machineries owned by the organizations is difficult. The maintenance of these machineries is very poor, and the possibility for frequent breakdown of these machineries during the pilot project implementation is expected. Therefore, it will not be possible to carry out the work with these equipment in accordance with the schedule.

At present, concrete aggregates such as sand and gravel are being used in small-scale construction works and sold to the local residents at the locations and prices defined by the Kaupule. However, for large-scale construction works, concrete aggregates are being imported from Fiji, and the sea transport cost greatly contributes to the increase in construction cost.

3) Insufficient Human Resources and Capabilities of Government Organization Related to Coastal Disaster

Below are the notable causes of insufficient human resources and capabilities of government agencies and organization:

- Lack of budget and manpower on coastal protection and its maintenance work.
- Less understanding on coastal conservation including consideration of “protection function”, “coastal utilization” and “coastal environment”.
- Lack of capability for understanding of coastal measures, coastal engineering and management.

4) Insufficient Capacity and Experience in EIA

Environmental impact assessment (EIA) in Tuvalu has been made obligatory by the “Environment Protection Regulations in 2007” (This act was revised and finalized in 2014), but at present, the coming into effect of these regulations is awaited. As a result, the experience of staff in carrying out EIA was evaluated to be poor. Even though Tuvalu’s EIA guidelines are extremely detailed, it was inferred that a number of personnel in the Department of Environment have no virtual experience in evaluating a project using these guidelines. Therefore, the capacity of carrying out the initial environment examination (IEE) is insufficient, as stated above.

(2) Condition of Regional and Social Structures in Fongafale Island

1) Unique Land Ownership System

In Tuvalu, it is only possible to transfer a land to a person if the person was born in the island, and this also applies whether by sale, gift, or lease. The current laws and regulations regarding land use appear to have been created based on the traditional form of land ownership in Tuvalu. The basis of the traditional land ownership system is through blood relationships, i.e., land can be inherited from both the maternal and paternal bloodline.

2) Relationship between Immigrants from Other Islands and those Born on the Island

The administrative system in Tuvalu is shown in Figure 1.3.5. Although the Central Government, Parliament, and the Kaupule are based in Fongafale Island, they have jurisdiction over all the entities, including distant islands.

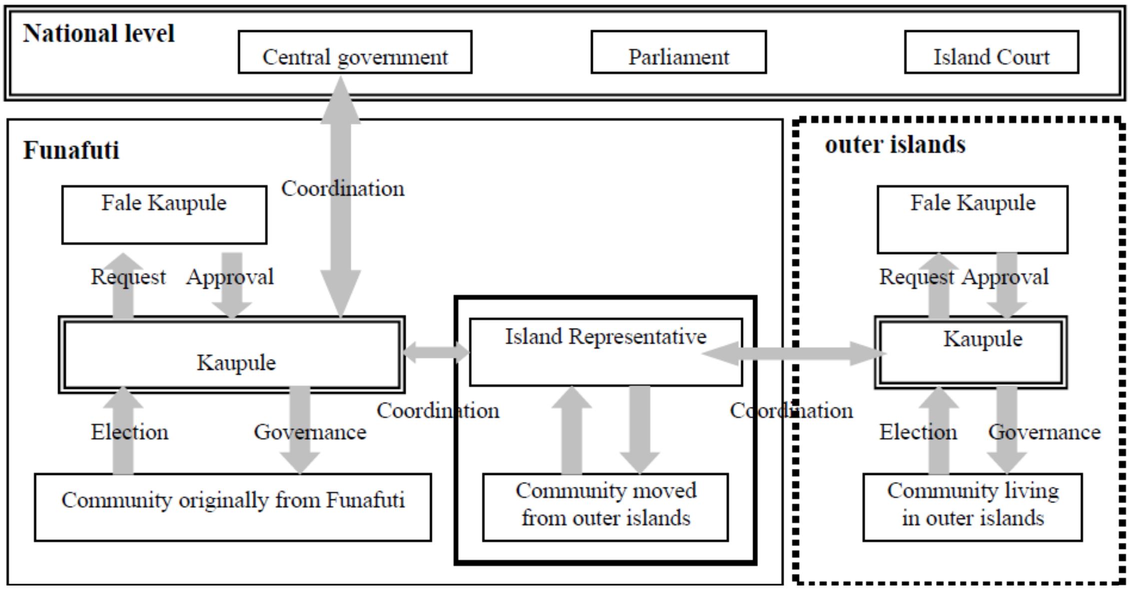


Figure 1.3.5 Administrational Organization in Tuvalu

(Source： Completed JICA Development Study (2011))

Of the total number of residents in Funafuti, Tuvalu's capital, only a quarter are natives of the island while the rest are immigrants. As stated above, those who were born in other islands have no right to land ownership, so they are in a weaker position with respect to land ownership rights compared with those who were born in Funafuti. Consequently, those with no land ownership rights mainly lived in hazardous areas that are susceptible to disasters like coastal erosion and climate change. Many households could be seen situated in the gap between the edges of borrow pits filled with trash and the outer ocean, so it is necessary to take into consideration these weakest members of the society.

3) Prohibition from Participation of Younger Generation and Women in Meetings

In community and island meetings that determine self-governance of the island, men younger than 50 years old as well as women have almost no right to speak. In particular, they have almost no participation in decision-making during meetings of the Falekaupule, a house where chiefs make decisions.

(3) Pilot Project for Gravel Nourishment

1) Alteration of Pilot Construction Site

The pilot construction site indicated in the specifications has been moved from the original proposed construction location in the completed JICA Development Survey to the south on the opposite side of the Catalina Ramp. The changed pilot construction location was in Malefatuga District. There is a community hole for Funafuti community and church in the hinterland and here are the most people gathering place in Fongafale Island.

2) Procurement of Gravel for Nourishment

In the completed JICA Development Survey, four potential possibilities were nominated as candidate borrow sources of gravel, which are a) Inside Funafuti Atoll, b) North side of runway, c) Imported from Fiji, and d) Sand spit at nearby island. However, it is necessary to re-examine the candidate of borrow sites taking into account the economic efficiency, environmental impact, characteristics as nourishment material, construction and sustainable development.

1.4 Objectives of the Project

The project will proceed on the basis of the "Record of Discussion on Project for Pilot Gravel Nourishment against Coastal Disaster on Fongafale Island in Tuvalu" as agreed upon between the Government of Tuvalu and JICA on November 16, 2011. The objectives of the Project are as follows:

- **Objective 1**
  To examine the effectiveness and adequacy of the beach nourishment using coral gravel and sand
- **Objective 2**
  To reduce the vulnerability against natural disaster (including climate change risk)

1.5 Project Area

The Project area is shown in Figure 1.5.1. The final recommended site was Malefatuga area.

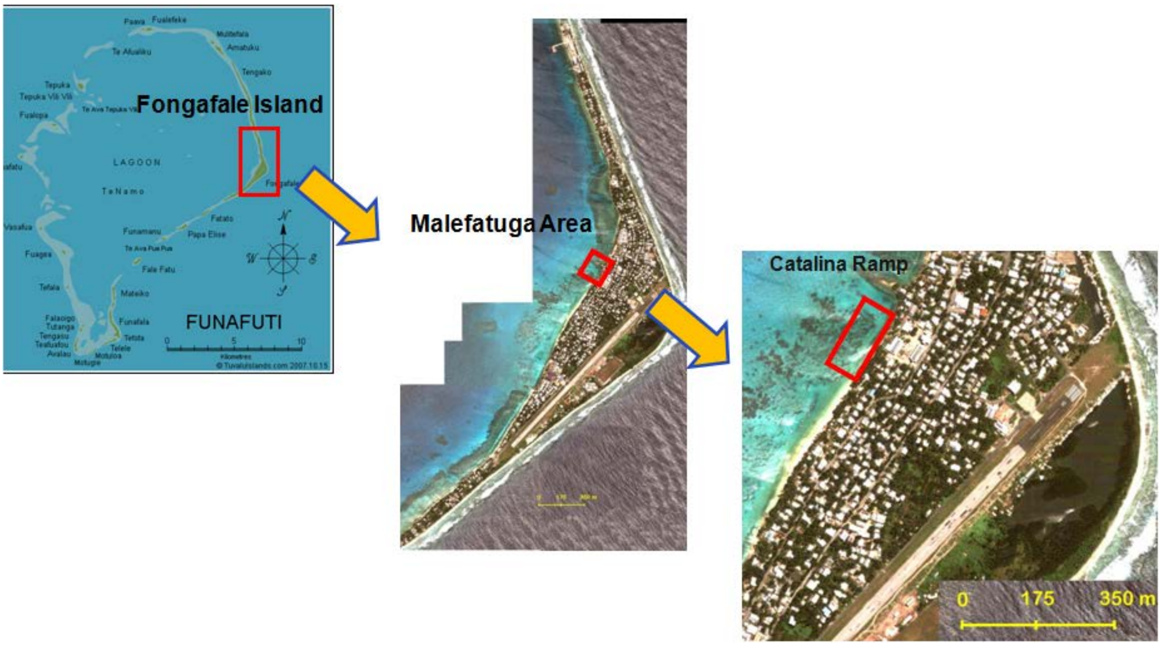


Figure 1.5.1 Project Area

(Source: JICA Expert Team)

1.6 Scope of Work

The Project originally consists of three phases, as follows:

Phase-1: Review, Basic, and Detailed Design

Phase-2: Construction

Phase-3: Monitoring and Evaluation, Technical Transfer and Capacity Development

Due to the suspension of the Project about 1.8 years after the Phase-1 stage as mentioned in Section 1.2, and also considering the necessity and importance of beach maintenance and management in the post construction stage, the scope for each phase was revised and finally set as follows:

Phase-1: Review, Basic, and Detailed Design

Phase-2: Review of Phase-1, Construction

Phase-3: Monitoring and Evaluation, Maintenance and Management, Technical Transfer and Capacity Development

The main activities for each stage as well as the work sequence of the Project are shown in Figure 1.6.1.

Phase-1 Review, Basic & Detailed Design

(1) Review the Previous JICA's Development Study and existing report
(2) Review the Current Situation fo Social and Natural Condition
(3) Field Survey, Data Collection & Analysis
(4) Support for Initial Environmental Examination (IEE)
(5) Study on Quantity and Quality of Materials for Nourishment
(6) Basic Design, Study on Construction Method, Monitoring Plan
(7) Initial Examination of Effectiveness of Pilot Construction of Nourishment
(8) Study on Influence to Surrounding Coast Due to Nourishment
(9) Detailed Design

Phase-2 Review of Phase-1, Construction, Monitoring

(10) Review of Phase-1 Study (Basic Design, Procurement of Gravel and Sand)
(11) Finalization of Detailed Design
(12) Construction Method and Cost Estimate for Pilot Construction
(13) Formulate Planning of Maintenance and Management
(14) Support for Environmental Impact Assessment (EIA)
(15) Support for Bidding for Constrction
(16) Supervising of Construction, Inspection
(17) Monitoring of Project and Gravel Mining Site, Wave Observation
(18) Public Relation and Education Before and During Construction Stage
(19) Technical Exchange for Beach Conservation in Mauritius

Phase-3 Monitoring & Evaluation, Maintenance & Management, Technical Transfer & Capacity Development

(20) Monitoring of Project and Gravel Mining Site, Wave Observation
(21) Implementation of Adaptive Measure
(22) Evaluation and Justification of Nourihment
(23) Study on Replication of Nourishment
(24) Public Relation and Education in Post Construction Stage
(25) Technical Transfer, Capacity Development (Including Training in Japan)

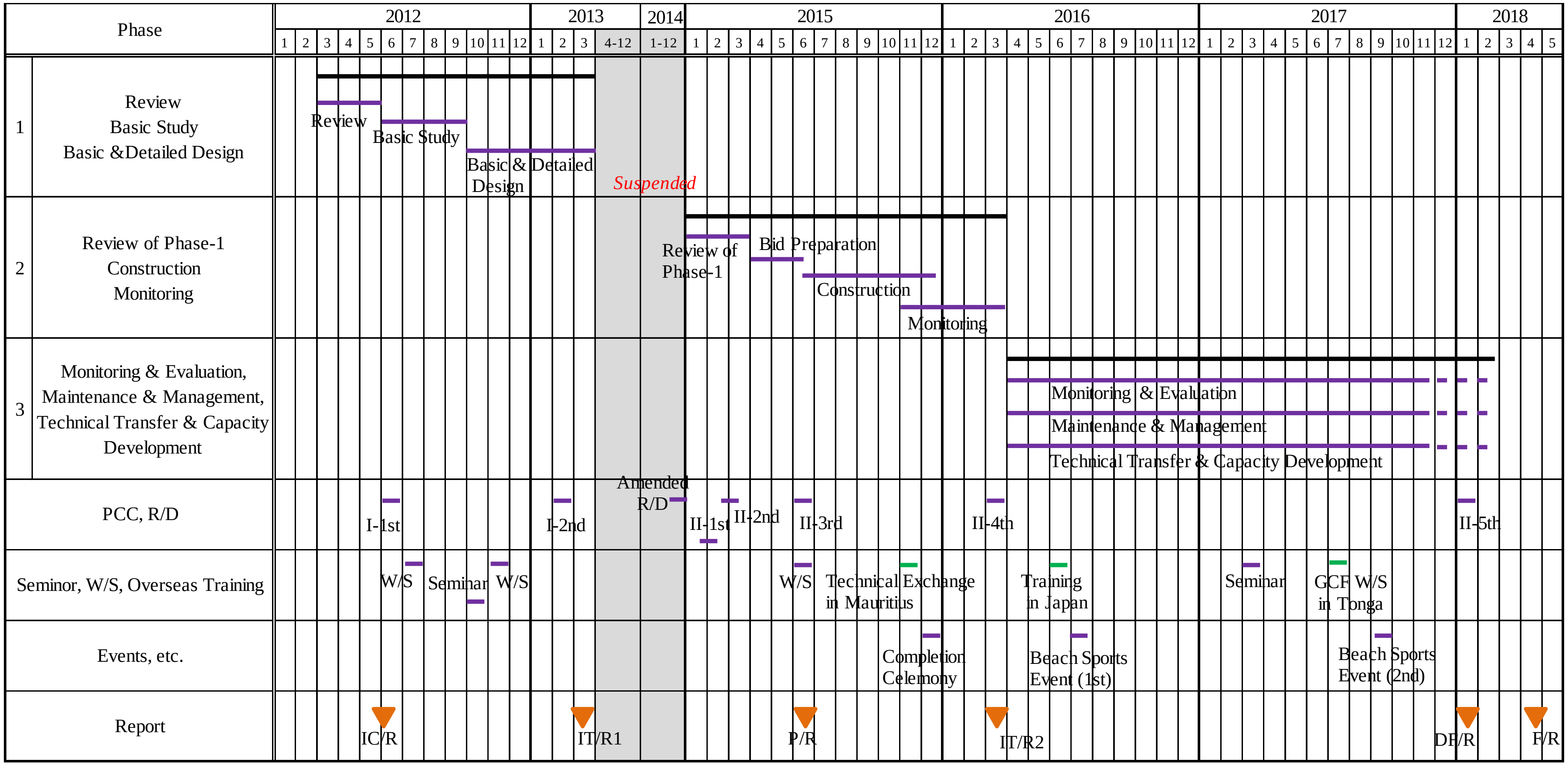
Figure 1.6.1 Main Activities and Work Sequence of the Project

(Source: JICA Expert Team)

1.7 Project Schedule

The Project was implemented in accordance with the schedule shown in Table 1.7.1.

Table 1.7.1 Implementation Schedule of the Project



(Source　JICA Expert Team)

2. Natural and Social Condition

2.1 Natural Conditions

This Chapter mainly presents information of natural condition that were reviewed at the beginning phase of the Project. Data that were collected in the Project, such as bathymetry, topography, wave and current and others are presented in Chapter 4 and Chapter 12, respectively.

(1) Meteorological Conditions

1) Winds

Wind conditions in Fongafale Island differ in four seasons in the region, i.e., summer and wet season from December to February, winter and dry season from May to September, and two transit seasons from March to April and from October to November. The seasonal wind data are summarized in Figure 2.1.1.

Annual winds are predominant from an easterly direction of east-northeast to southeast directions. Strong winds of more than 8 m/s are observed from a westerly direction of southwest to north.

During the summer season, northeasterly winds from north to east-northeast are predominant. Strong westerly winds reaching more than 12 m/s are also observed during this season.

During the winter season, southeasterly winds are predominant, but strong winds of more than 8 m/s are very rare cases.

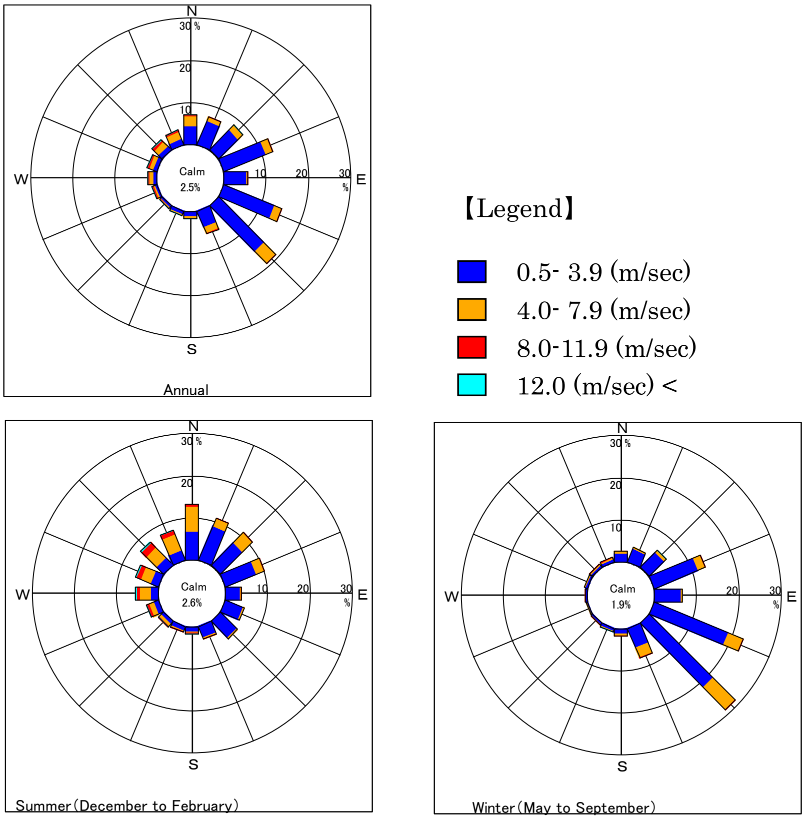


Figure 2.1.1 Wind Rose (1999-2008)

(Source: Previous JICA Expert Team, processed from SEAFRAME)

2) Precipitations

The monthly precipitation at Funafuti are shown in Figure 2.1.2. This shows a seasonal change, which is typically divided into two seasons, rainy season from December to March and dry season from April to November.

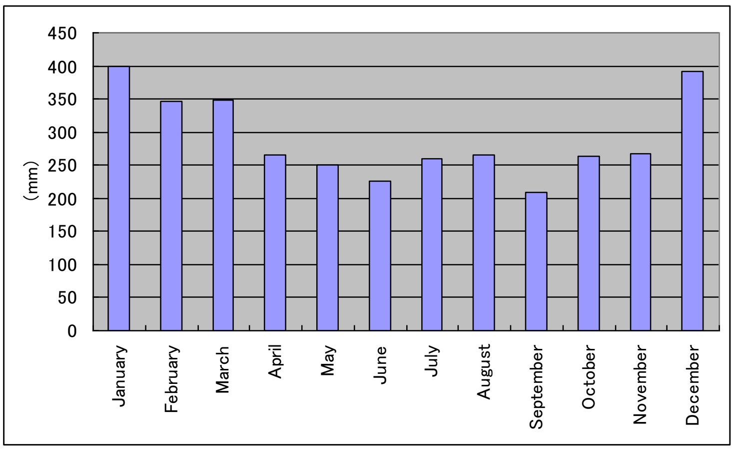


Figure 2.1.2 Monthly Mean Precipitation at Funafuti

(Source: Previous JICA Expert Team, processed from Tuvalu Meteorological Service data, 1945-2008)

3) Tropical Cyclones

The major tropical cyclones that have affected Tuvalu are listed in Table 2.1.1.

Table 2.1.1 Records of Tropical Cyclones that Affected Tuvalu

No.	Name of Cyclones	Date of Occurrence	Remarks
1	Unnamed	February 18, 1891	
2	Unnamed	January 2, 1958	
3	Bebe	October 21, 1972	
4	Ofa	1990	
5	Sina	November 1990	
6	Val	December 1991	December 4-5
7	Kina	1993	
8	Nina	1993	
9	Gavin	March 1997	March 5-7
10	Hina	March 1997	March 10-13
11	Keli	June 10, 1997	June 10-13
12	Ami	January 11, 2003	January 11-14
13	Heta	January 02, 2004	January 2-4
14	Pam	March 06, 2015	March 10-13

(Note) Date: UTC Time

(Source: Previous JICA Expert Team, processed from SEAFRAME)

Two were unnamed and occurred on February 18, 1891 and Janua Historical records show that there were three tropical cyclones which had a major impact on Tuvalu. ry 2, 1958. The other was Cyclone Bebe, which occurred in Funafuti on October 21, 1972 with the lowest recorded mean sea level pressure of 954 hPa, with a maximum 10-minute average wind speed of 80 knots and a maximum 3-second gust of about 110 knots. The storm surge was reported to be about 4 m above the mean high water level.

(2) Oceanography

1) Sea Level

The sea levels in the Pacific Islands are controlled by many factors, some periodic like the tides, some brief but violent like cyclones, and some prolonged like El Niño.

The variation of maximum water level and average water level at Funafuti SEAFRAME Station for 17 years from 1995 to 2011 are shown in Figure 2.1.3. Based on the figure, the average rate of sea level rise obtained was 4.4 mm/year.

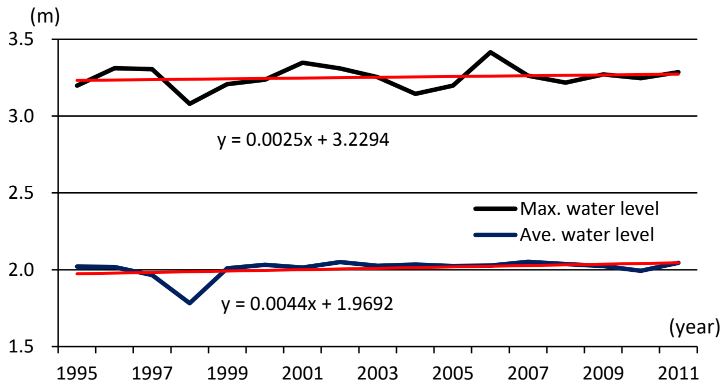


Figure 2.1.3 The Variation of Sea Level (At Funafuti: 1995-2011)

(Source: SEAFRAME data arranged by JICA Expert Team)

2) Tide

The tidal curves from February 27 to March 1, 2006 recorded the highest high water level of 3.415 m since installation at SEAFRAME Station in Funafuti, as shown in Figure 2.1.4. The graph clearly shows that the type of tides in this area is a semidiurnal tide, which has two high waters and two low waters in a day, and the height of each successive high waters and low waters are almost equal.

The tidal curve diagram at Funafuti is shown in Figure 2.1.5.

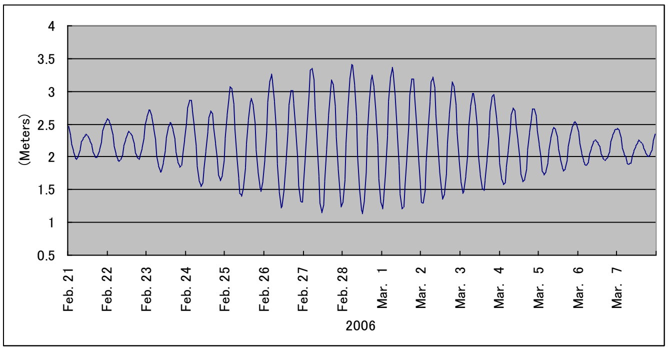


Figure 2.1.4 Tidal Curve (Funafuti: February 21, 2006-March 7, 2006)

(Source: SEAFRAME data arranged by JICA Expert Team)

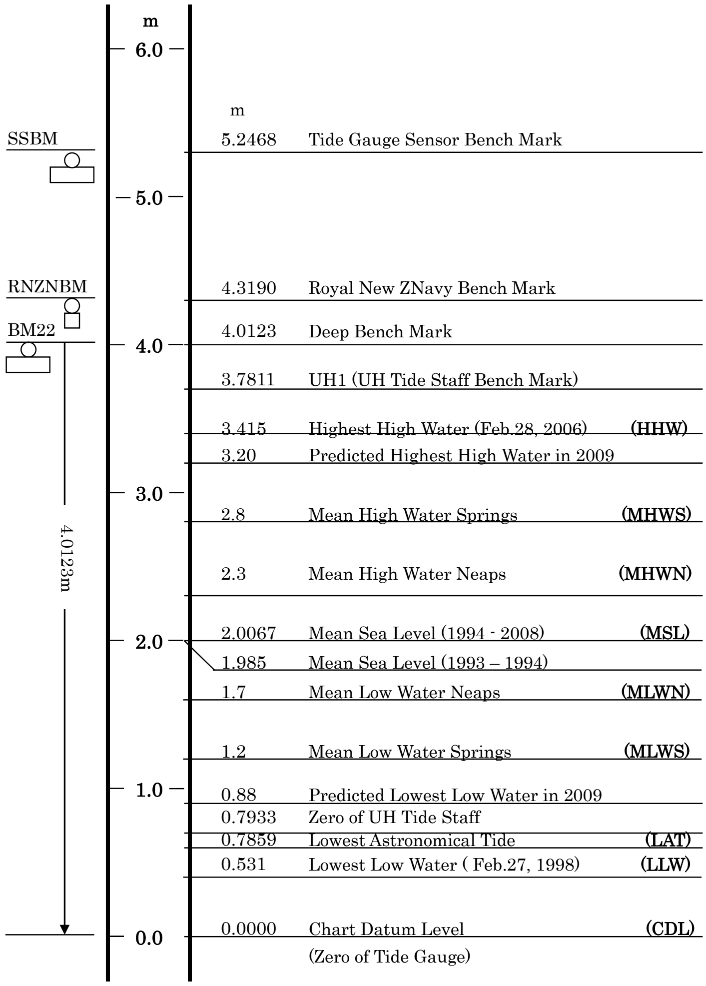


Figure 2.1.5 Tidal Diagram at Funafuti

(Source: Completed JICA Development Survey Report (2011))

3) Waves

a) Ocean Side

Wave measurements with a waverider buoy were carried out off the eastern coast of Funafuti Atoll between May 8, 1990 and April 7, 1992 with sampling interval of every three hours by the Oceanographic Company of Norway AS (OCEANOR) as part of the Wave Measurement Program funded by the Norwegian Government Agency. Figure 2.1.6 shows the measurement location (Position: 08°3l.5'S, 179°12.9'E. Water depth: 585 m).

The monthly maximum and average significant wave heights (H1/3) with wave period (Tm) recorded from 1990 to 1992 are shown in Table 2.1.2. Significant wave heights are almost constant, average significant wave height is 1.8 m, and average period is 9.2 s. Although wave climate is steady offshore, it is not necessarily the case on the coast due to the strong seasonal wind direction in this region. The maximum significant wave height is from 2.4 m to 3.4 m and the period is from 10.5 s to 14.2 s.

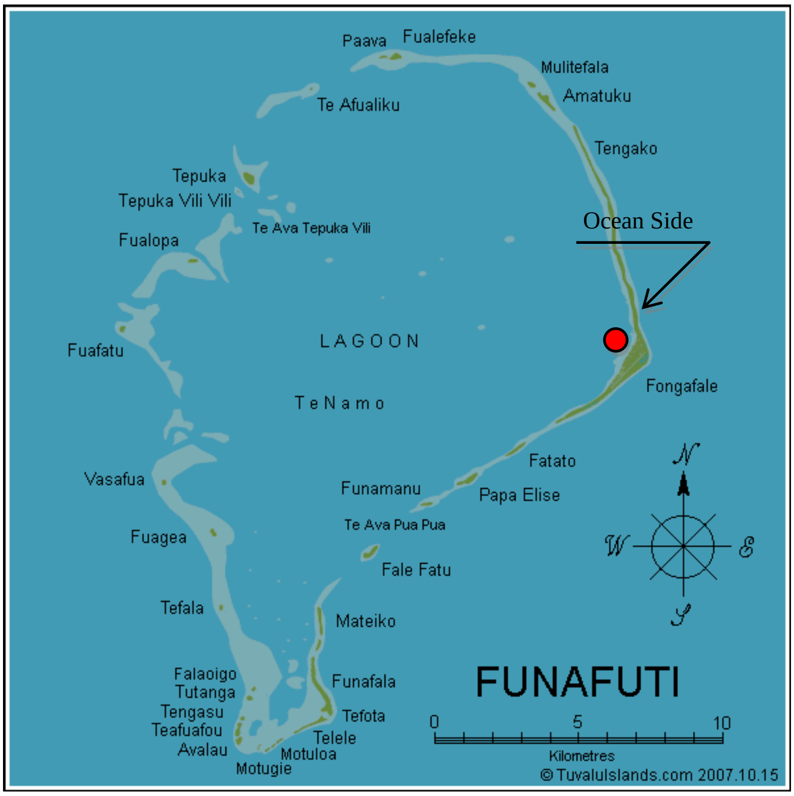


Figure 2.1.6 Location Map of Wave Observation (OCEANOR-Wave Buoy)

(Source: Completed JICA Development Survey Report (2011))

Table 2.1.2 Monthly Maximum and Average Values of Wave Records from 1990 to 1992

Month	Max. Significant Wave		Ave. Significant Wave	
	H1/3 (m)	T (sec)	H1/3 (m)	T (sec)
January	2.8	13.3	1.7	10.0
February	2.4	13.3	1.7	10.0
March	2.5	13.8	1.8	10.2
April	2.5	11.1	1.8	9.7
May	2.6	14.2	1.8	9.1
June	2.7	10.5	1.8	8.1
July	2.6	10.5	1.8	8.1
August	3.3	11.1	2.1	8.2
September	3.0	10.5	1.7	8.2
October	2.8	11.8	1.6	8.8
November	3.4	13.8	1.7	9.6
December	3.1	12.9	1.9	9.8
Annual	3.4	14.2	1.8	9.2

(Source: Completed JICA Development Survey Report (2011))

b) Lagoon Side

According to wave observation during previous investigations from November 1 to 21, 2009, the significant wave height and period are between 0.2 m and 0.3 m, and between 2.0 s and 4.0 s, respectively. From February 2, 2010 to March 19, 2010, the significant wave height and period are between 0.2 m to 1.4 m, and between 2.1 s to 4.5 s, respectively. The former is almost dry season and the latter is almost wet season.

By making these into verification data, the estimation of wave energy flux at the lagoon side of the central part of Fongafale Island by SMB method from the wind data over a period of ten years from 1999 to 2008 is shown in Figure 2.1.7.

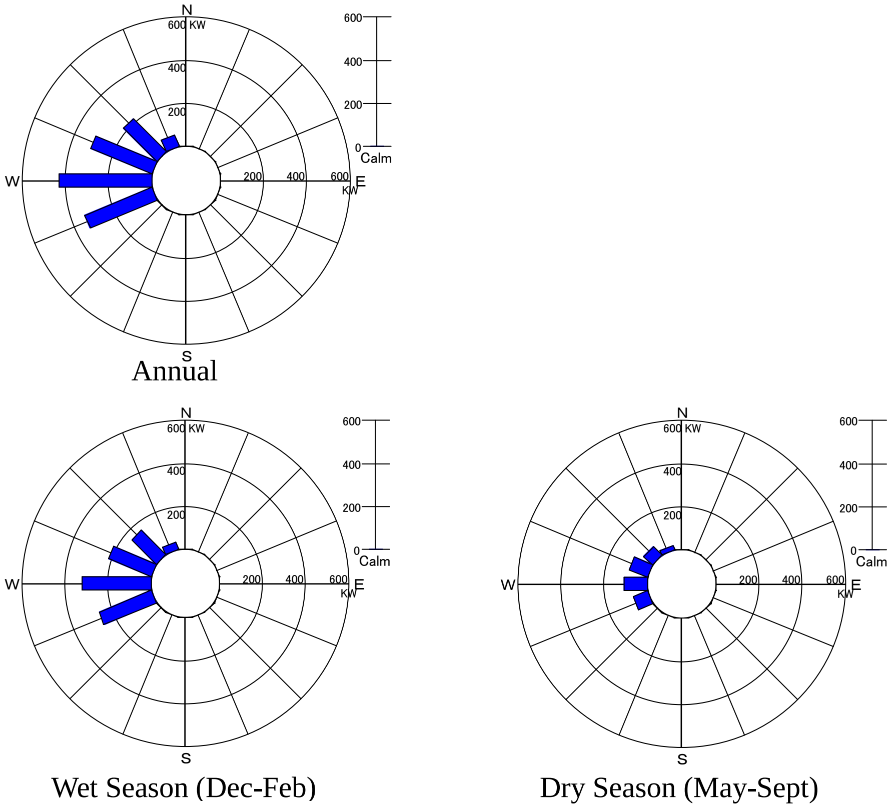


Figure 2.1.7 Estimated Wave Energy Flux

(Source: Completed JICA Development Survey Report (2011))

4) Currents

Current observations in the Funafuti Lagoon were carried out by SOPAC in 2004. The detailed deployment of current observation is summarized in Table 2.1.3 and in Figure 2.1.8.

At Station ADP-1, the maximum speed was 20 cm/s and prevailing direction was around 300° which means "going to the outer ocean from lagoon" through the channel between Paava and Te Afualiku islets. At Station ADP-2, the maximum speed was 27 cm/s and prevailing direction was around 340° which means "going to north-northwest". The maximum speed of 44 cm/s during the observation was recorded at Station ADP-3 with direction of 220° which means "going to the outer ocean from the lagoon" through the channel between Funamanu Islet and Falefatu Islet. Meanwhile, an alternative motion to the direction of 80° to 260° was observed at Station ADP-4 with weak current speeds. The current speed at Vaiaku Station CM-1 was weak as a whole with maximum speed of 12 cm/s and mean speed of 2 cm/s, and an alternative motion to the direction of 90° to 270° were observed at this point.

Table 2.1.3 Deployment of Current Meters

Station No.	Location	Water Depth	Observation Period	Duration
ADP-1	Pa'ava	30 m	Sep.18 (15:00) to Oct.22 (07:00), 2004	33 days
ADP-2	Te Ava Fuagea	27 m	Sep.18 (15:00) to Oct.04 (11:20), 2004	15 days
ADP-3	Payne Rock	24 m	Sep.18 (15:00) to Oct.22 (10:40), 2004	32 days
ADP-4	Te Atau Loa	31 m	Oct.04 (13:30) to Oct.22 (09:50), 2004	17 days
CM-1	Vaiaku	10 m	Nov.7 (12:00) to Nov.23 (12:10), 2004	16 days

(Source: ADP series, SOPAC Technical Report 50, CM-1: Completed JICA Development Survey Report (2011))

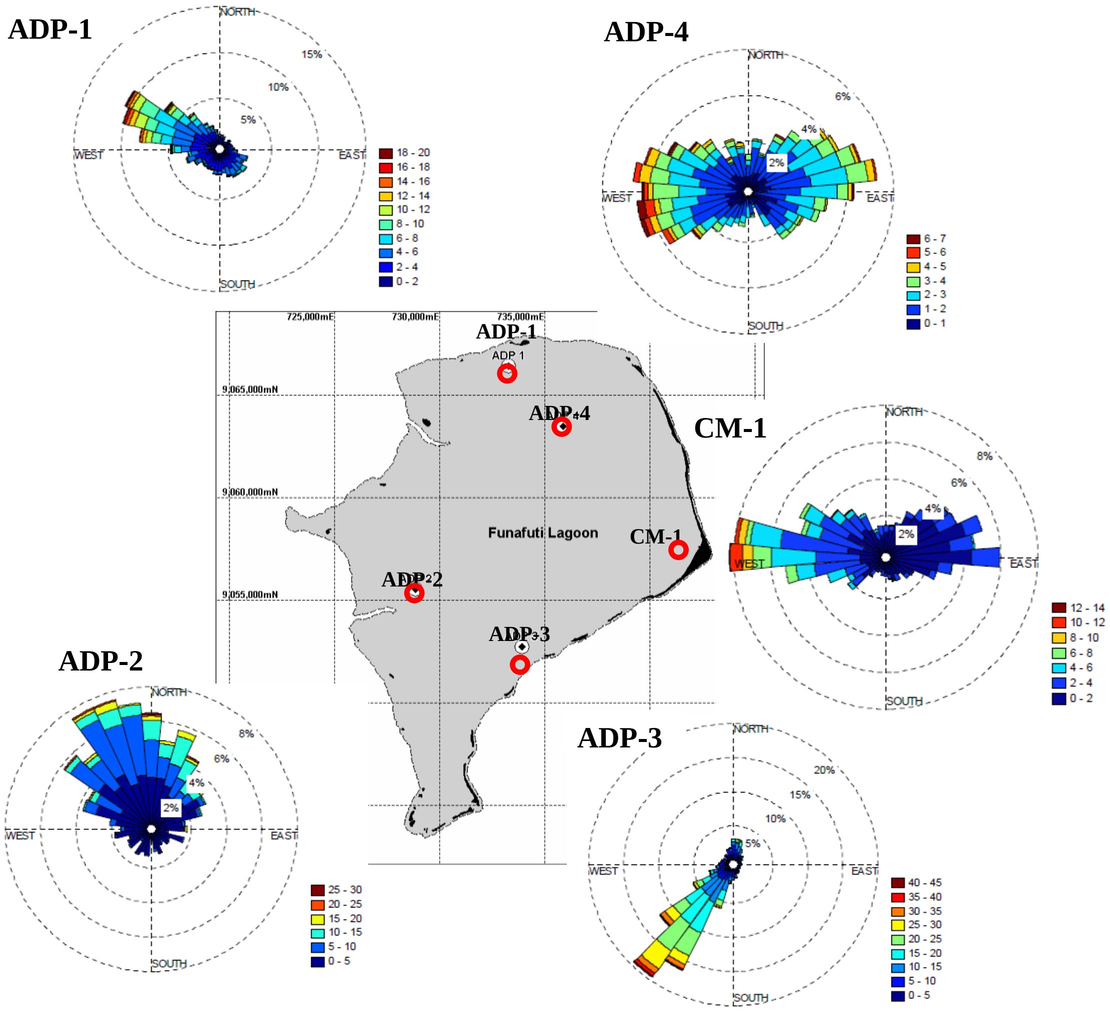


Figure 2.1.8 Current Rose Diagram

(Source: ADP series, SOPAC Technical Report 50, CM-1: Completed JICA Development Survey Report (2011))

(3) Geological Conditions

Early geological investigations of Tuvalu were driven by the debate over concepts relating to the long-term development of mid-ocean coral atolls and Darwin's subsidence theory (Darwin, 1842). Drilling exploration at Funafuti from 1896 to 1898 resulted in 340-m long cores comprising shallow-water carbonates without encountering basement volcanic (David & Sweet, 1904). Additional studies on the deep structure of Funafuti comprised a magnetic survey (Creak, 1904), and a single seismic refraction survey inside the lagoon (Gaskell & Swallow, 1953). These two data sets are interpreted to show a minimum of 500 m of limestone below the lagoon floor, with presumed underlying volcanic (Locke, 1991).

No volcanic basement was reached during the drilling campaign in Funafuti in the late 19th century, and the boundary depth was estimated at approximately 1000 m from data provided by seismic experiments.

(4) Geographical Conditions

1) Land Topography

Fongafale Islet is a long and narrow strip of extremely low elevation with a broad "V" shaped outline as shown in Figure 2.1.9. Dead coral rubbles are piled up at the ocean-side fringe of the islet up to 3 m above mean sea level, making the highest point of the islet. Other areas below 2 m above mean sea level are in a large portion of the islet.

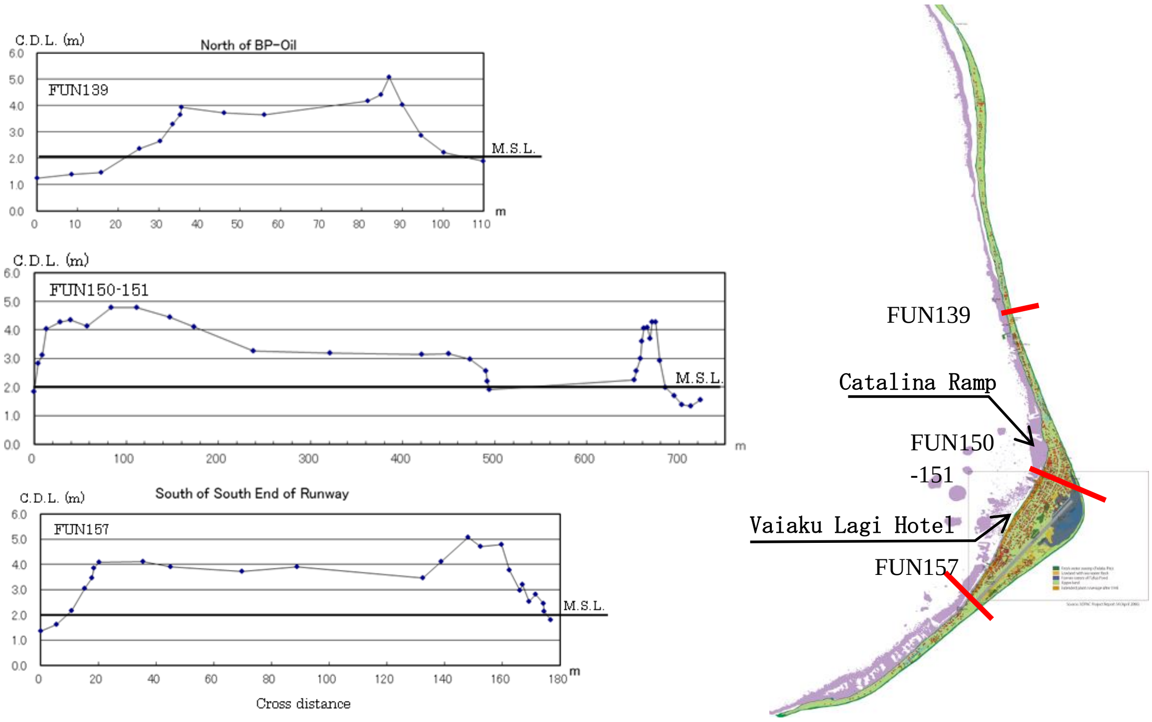


Figure 2.1.9 Geographical Features of Fongafale Island

(Source: JICA Expert Team)

2) Coast Line

Senior residents remember that there was a long, low-gradient, sandy beach prior to WWII. Modifications of the lagoon side of Fongafale Islet during WWII include a 2.3 km long piece of reclamation with coral rock seawall, a long borrow pit (often called channel) beside the seawall, and other channels normal or parallel to the seashore.

Observing the present state of the coastline along the lagoon side of the central part of Fongafale Islet, most of the beach is covered with rocks and sand that extends for about 500 m long from the north of Vaiaku Lagi Hotel to the south of Catalina Ramp.

3) Bathymetric Features

a) Ocean Side

The bathymetry in the Funafuti Atoll is shown in Figure 2.1.10. The reef flat on the ocean side is about 100 m wide in front of a storm ridge. Outside of the reef edge, depth increases rapidly and is over 1000 m in depth.

b) Lagoon Side

The lagoon side reef flat is 55 m to 350 m wide, including a 15 m to 25 m wide beach as shown in Figure 2.1.10. Inside of the lagoon, shallow places (Te Akaue) are scattered. The water depth in the central part of the lagoon ranges from 40 m to 50 m and the maximum depth can be read as 49 m on the existing chart (Funafuti Atoll, Chart No.83094). The cross section of the representation line shown in Figure 2.1.10 is shown in Figure 2.1.11.

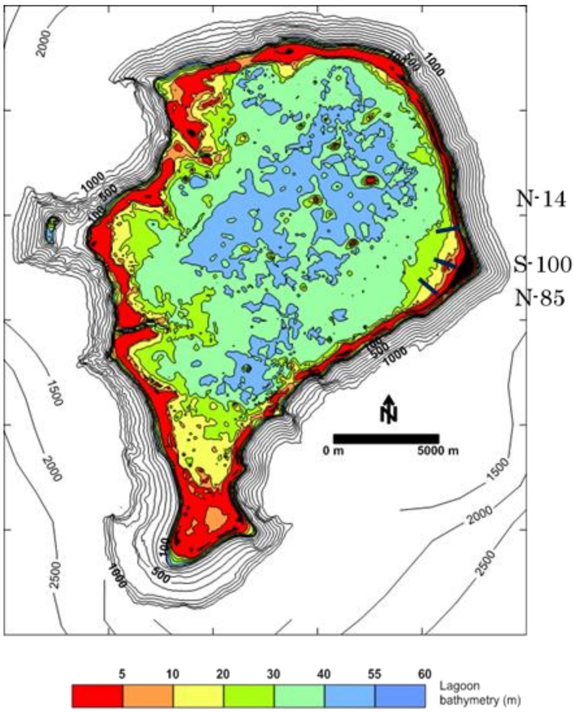


Figure 2.1.10 Bathymetric Map of Funafuti Atoll

(Source: SOPAC)

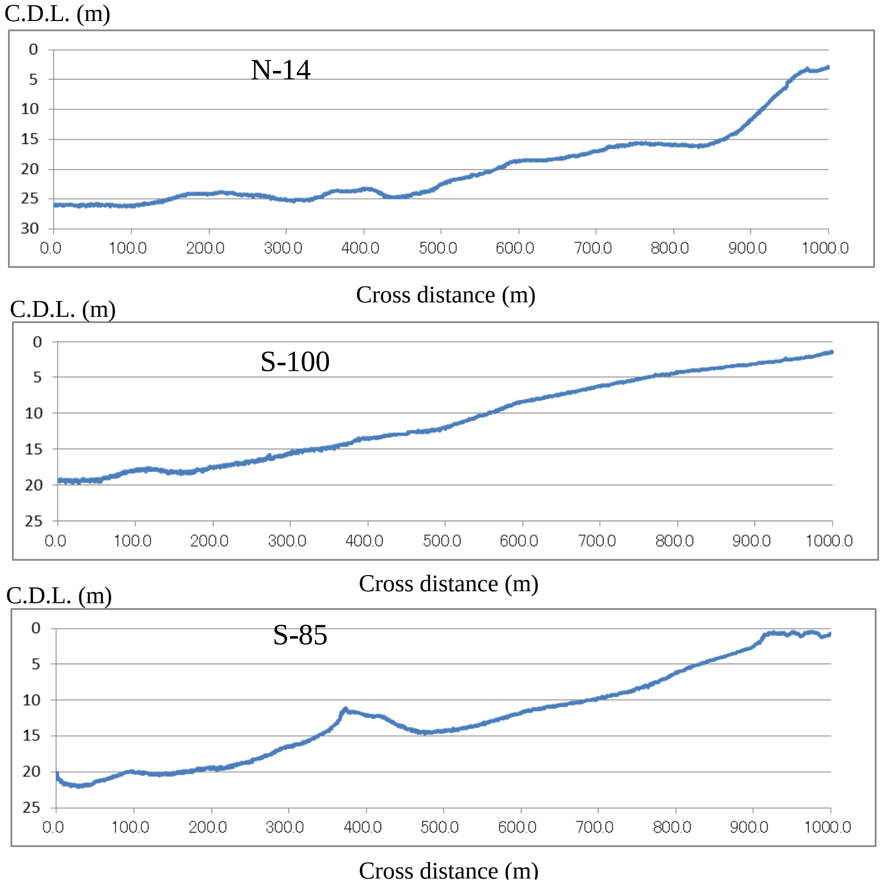


Figure 2.1.11 Cross Section of Bottom Contour Fongafale Island Lagoon Side

(Source: JICA Expert Team)

2.2 Land Ownership and Law

(1) Land Property and Ownership

The land use classification in Fongafale Island mainly consists of four types: 1) Private land, 2) Crown land, 3) Leased land to the Government of Tuvalu by private owner, and 4) communal lands owned by Funafuti Kaupule.

Initially all land area in Fongafale was belong to private land owners with acquired rights. the Government of Tuvalu rent a part of private land as leased land by private owners and use it for the government of Tuvalu purpose or leases to those who originally come from outer islands who are not eligible to posses their own land in Fongafale.

(2) Law for Coasal Area

The basic law for coastal area in Tuvalu is the “Foreshore and Reclamation Act (revised in 2008)”. According to the act, the land ownership and management body can be summarized in Figure 2.2.1.

As shown in the Figure, area of sea bed and foreshore are defined by boundaries of H.T.L.(Highest Tide Level) and L.T.L.(Lowest Tide Level). Ownership of sea bed and foreshore belong to the Government of Tuvalu, stated as “Crown Land” in the Act. On the other hand, inland area is originally owned by private owners with acquired right. Foreshore area is the Government property; however the management and permit body is Funafuti Kaupule. The Project area is in the foreshore and sea bed area as shown in the Figure.

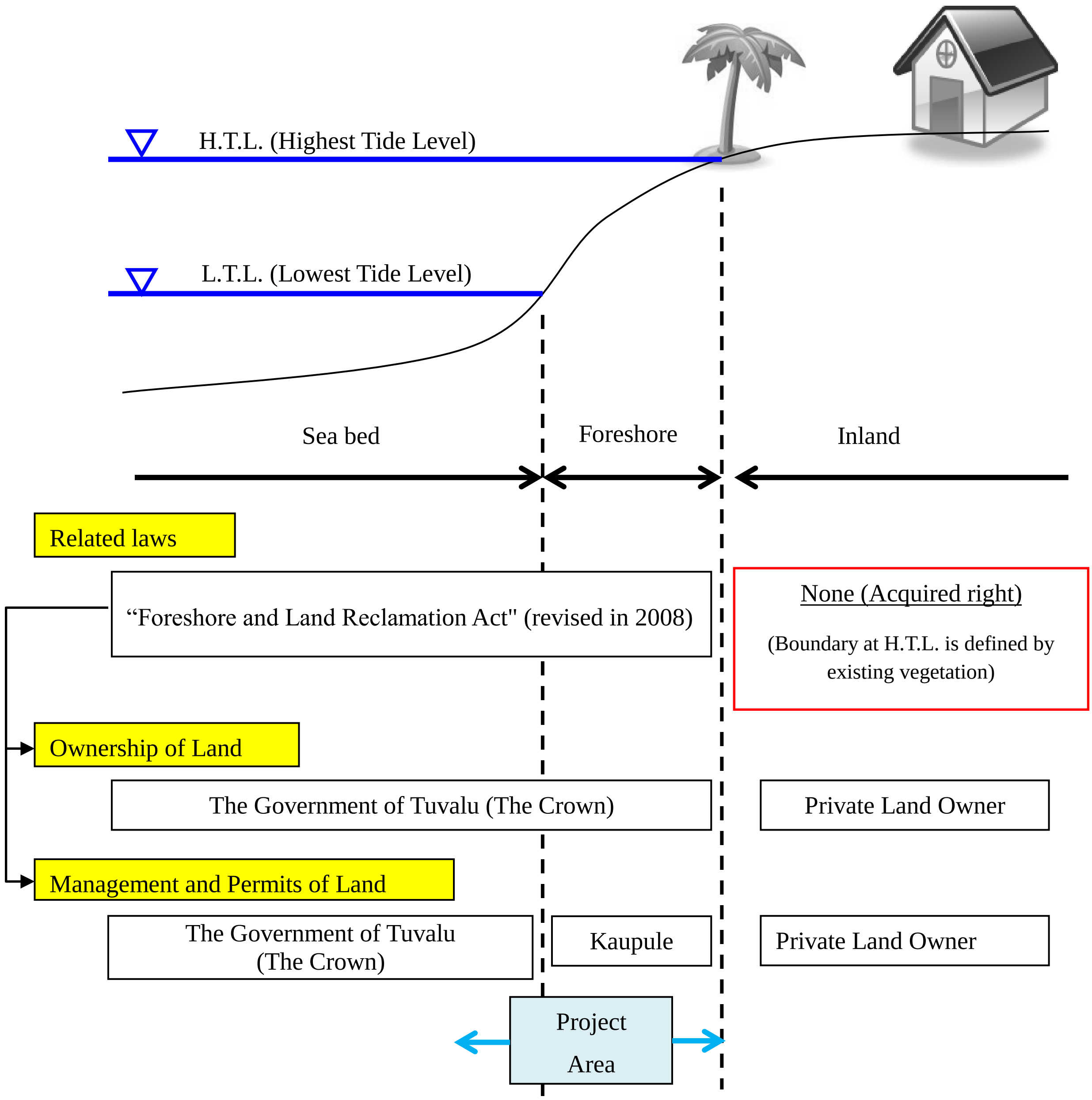


Figure 2.2.1 Boundaries of Coastal Area and its Ownership, Management and Permits Body

(Source: JICA Expert Team drew the Figure according to "Foreshore and Reclamation Act (revised in 2008)")

(3) Boundaries of Land behind the Project Area

Land behind the Project area consists of the private land and the communal land. Boundaries of the leased land (to the Government) were managed by the Government by mapping, however that of private land is mapped neither by the Government nor by Funafuti Kaupule. Land court office of Funafuti Kaupule manages some information of private land such as length, width, and owner's name; however, it is not enough information to identify exact boundaries at site. The boundaries were traditionally identified by each private owner with acquired right. Therefore, the land boundaries at the Project area was clarified through interview survey to land owners at the site and finalized through confirmation by Funafuti Kaupule. The survey results are shown in the Figure 2.2.2.

There are five private lands just behind the Project area shown as No.1-No.5 in the Figure and the rest of it along coast is communal land owned by Funafuti Kaupule (No.6). Land owner's name is not presented as it is confidential information. Boundaries of private land are shown with dotted line in the Figure and location of each boundary is shown in Figure 2.2.3.

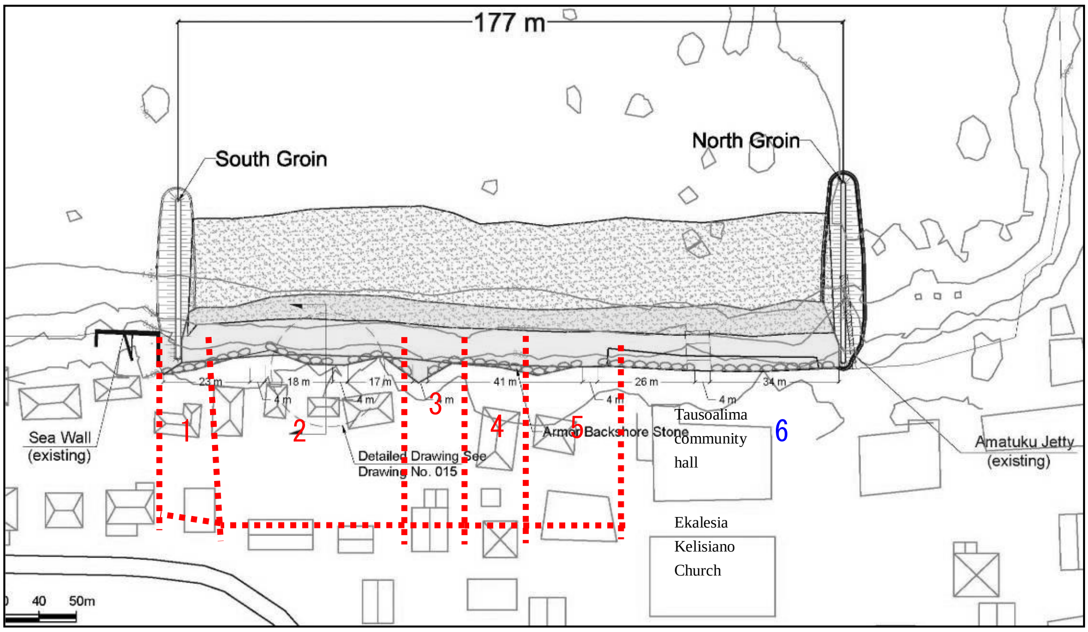


Figure 2.2.2 Boundaries of Land just behind the Project Area

(Source: JICA Expert Team)

Boundary b/w Land 1 and 2 (Boat)

Boundary b/w Land 2 and 3 (hedge)

Boundary b/w Land 3 and 4 (Tree behind)

Boundary b/w Land 4 and 5 (Foundation)

Boundary b/w Land 5 and 6 (Trees behind)

Figure 2.2.3 Boundaries of Private Land just behind the Project Area

(Source: JICA Expert Team)

3. Field Survey, Data Collection, and Analysis

3.1 Overview

The following two surveys were carried out in this study to contribute to the planning and design of gravel nourishment at the Project site:

- Sounding at the Project site
- Sand sampling and sieve analysis

3.2 Sounding

Bathymetric and topographic surveys were carried out in order to determine the present topography at the Project site. The results of the surveys were utilized for design, quantity calculation, determination of construction method, and cost estimate.

The survey works at site was conducted from June to July 2012 not only at the Project site but also at the sand spit in nearby islands.

Figure 3.2.1 shows the contour map surrounding the Project site, which was obtained in the previous study. Here, Area A is the new survey area in this study.

Meanwhile, Figure 3.2.2 shows the contour map of Area A.

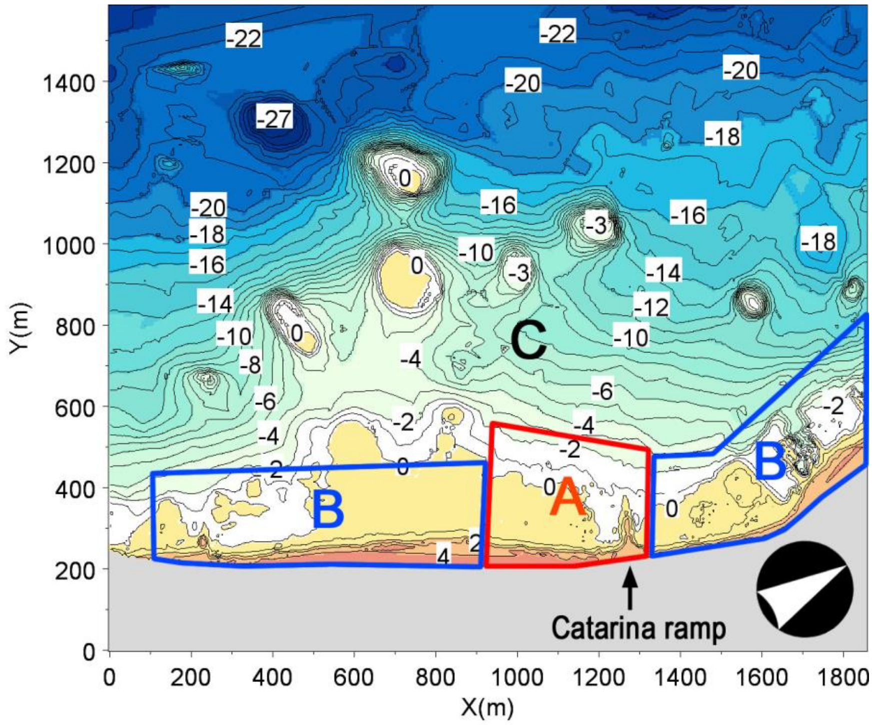


Figure 3.2.1 Contour Map Surrounding the Project Site

(Source: JICA Expert Team)

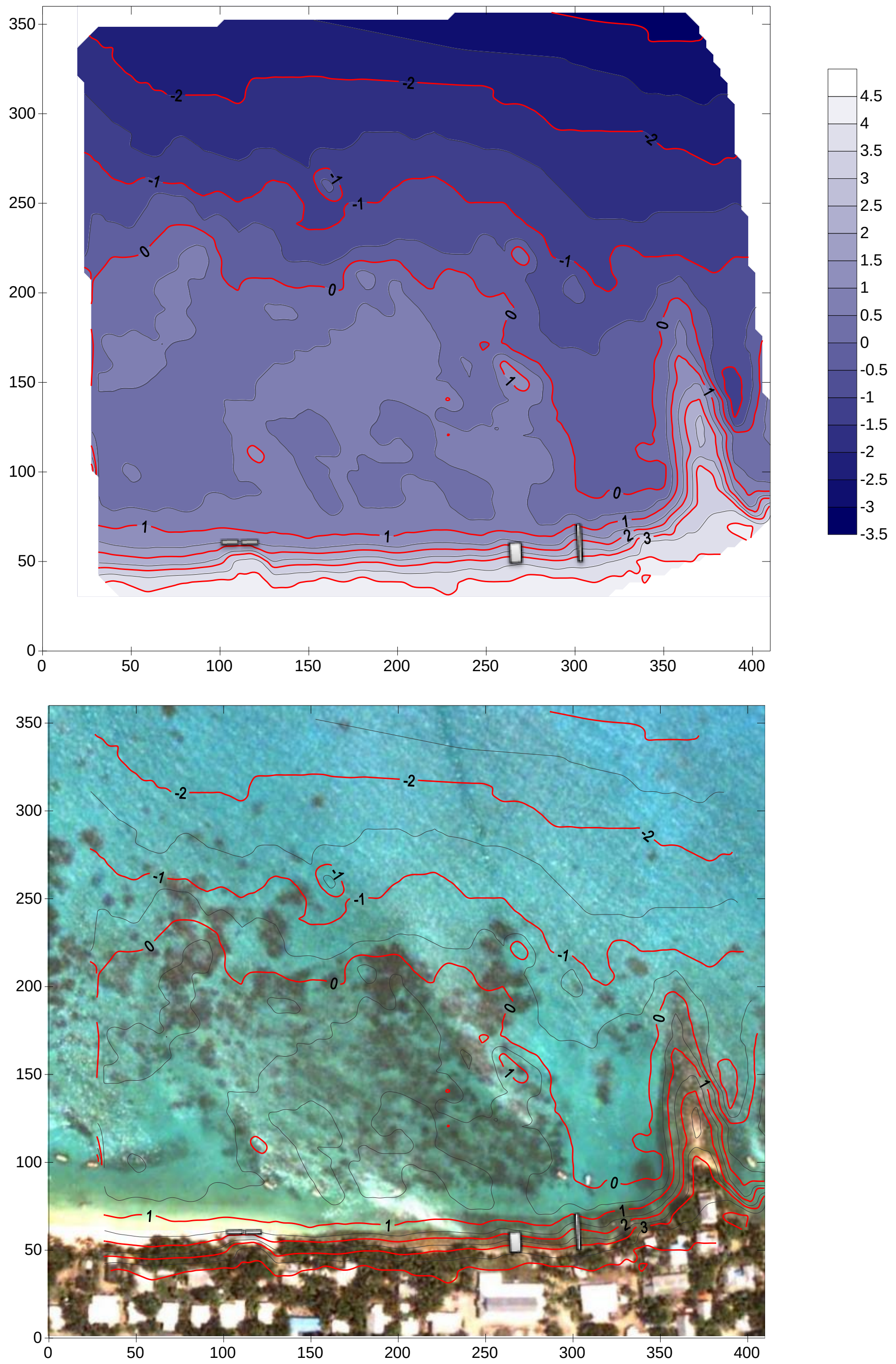


Figure 3.2.2 Obtained Contour Map (Area A)

(Source: JICA Expert Team)

3.3 Profile Survey and Sand Sampling

(1) Survey of the Existing Gravel Beaches to Determine Profiles and Grain Size

The sampling of gravel and profile survey of the existing gravel beaches were carried out at several points on the gravel beaches at the ocean and lagoon side of Fongafale Island. The obtained results were utilized for the design of gravel nourishment to determine the basic design conditions such as backshore slope and crown elevation.

Figure 3.3.1 shows the relationship between the backshore slope at gravel part and its grain size. The result shows that the backshore slope at gravel part is constant regardless of the difference in grain size of gravel. The backshore slope at the ocean side is about 1:3 to 1:4, and is steeper than that at lagoon side (1:4 to 1:5).

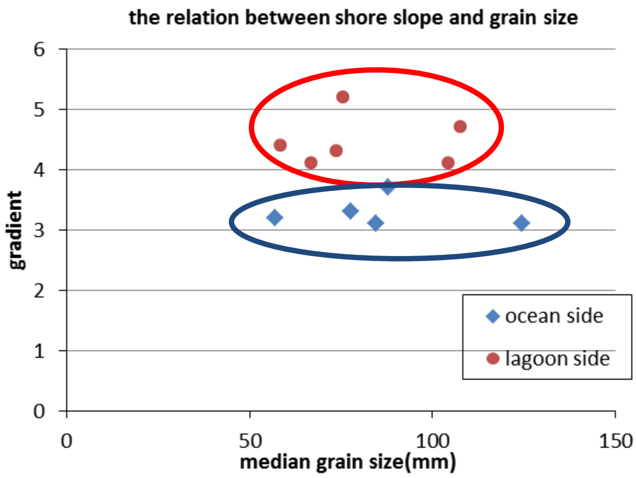
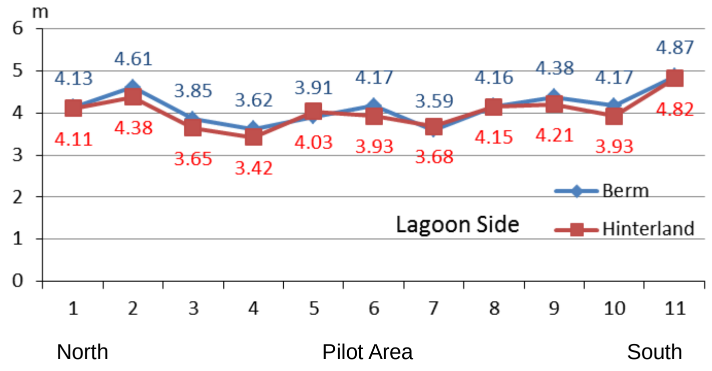


Figure 3.3.1 Relationship between Backshore Slope and Grain Size of Gravel

(Source: JICA Expert Team)

(2) Elevation of Storm Ridge and Hinterland

Figure 3.3.2 shows the elevation of storm ridge and hinterland at both lagoon and ocean side. The storm ridge at the lagoon side is distributed from elevation 3.6 m to 4.9 m, and 4.1 m on average. On the other hand, the storm ridge at the ocean side is distributed from elevation 4.3 m to 5.3 m, and 4.9 m on average.



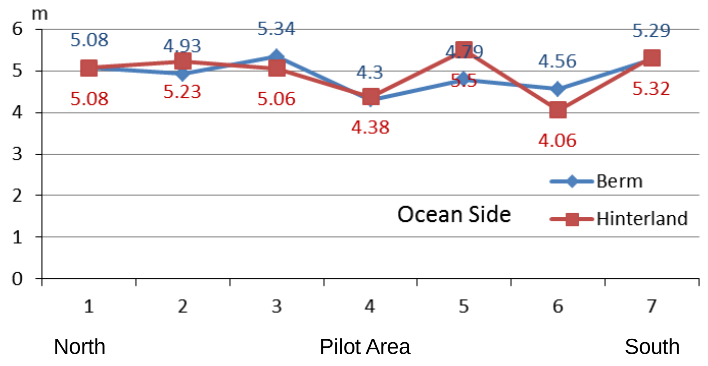


Figure 3.3.2 Distribution Storm Ridge and Hinterland Elevations

(Source: JICA Expert Team)

(3) Sand Sampling and Checking Foreshore Sandy Slope

The designed beach is a combination of gravel and sand, similar to the beach with previous natural condition at the Project site. In the planning and design, it is required to determine the desirable foreshore slope at sandy part. The foreshore slope formed by sand greatly depends on the grain size of sand. Thus, the relationship between foreshore slope and grain size of sand was examined by conducting sand sampling and survey of foreshore slope at the existing sandy beach. As sandy beaches are not limited in Fongafale Island, survey was carried out not only in said island but also in other islands where natural sandy beach exists. The points of slope measurements and sand sampling are shown in Table 3.3.1.

Table 3.3.1 Points for Slope Measurement and Sand Sampling

Location	Foreshore Slope	Grain Size (Sieve Analysis)
South of the Project Site in Fongafale Island	1:12	Undertaken in Fiji
Fualifeke Island	1:10	Undertaken in Fiji
North of Amatuku Island	1:10	Undertaken in Fiji
North of Fongafale Island	1:12	Undertaken in Fiji

(Source: JICA Expert Team)

3.4 Coastal Situation of Construction Site

(1) Coastal Survey Result

The natural gravel and 30 cm square concrete blocks are scattered in the construction site. East side is relatively open, there is a meeting place, etc. On the other hand, the west side has lush cover the trees of palm, etc. to the coast, sand is deposited as west. Sandy beach will be submerged at high tide shown in Figure 3.4.1 and Figure 3.4.2.

L.W.L.

H.W.L.

Figure 3.4.1 The East End of Construction Site (in front of community hole)

(Source: JICA Expert Team)

L.W.L.

H.W.L.

Figure 3.4.2 The West End of Construction Site

(Source: JICA Expert Team)

(2) Coastal Survey Result

The results of the coastal survey so as to overlap the previous survey results (Jun. 2012) are shown in Figure 3.4.3. Cross section C11 is gravel beach at the east of construction site, C26 corresponds to the west side of the sandy beach. Red circle of C26 is the collection points of the bottom sediment, and indicates median particle size. The beach slope is about 1:5 at gravel, about 1:10 at sand. Sediment median particle size is 0.5 mm in the foreshore, 0.2 mm at the flat shore.

Significant topographic change in the first phase is not observed.

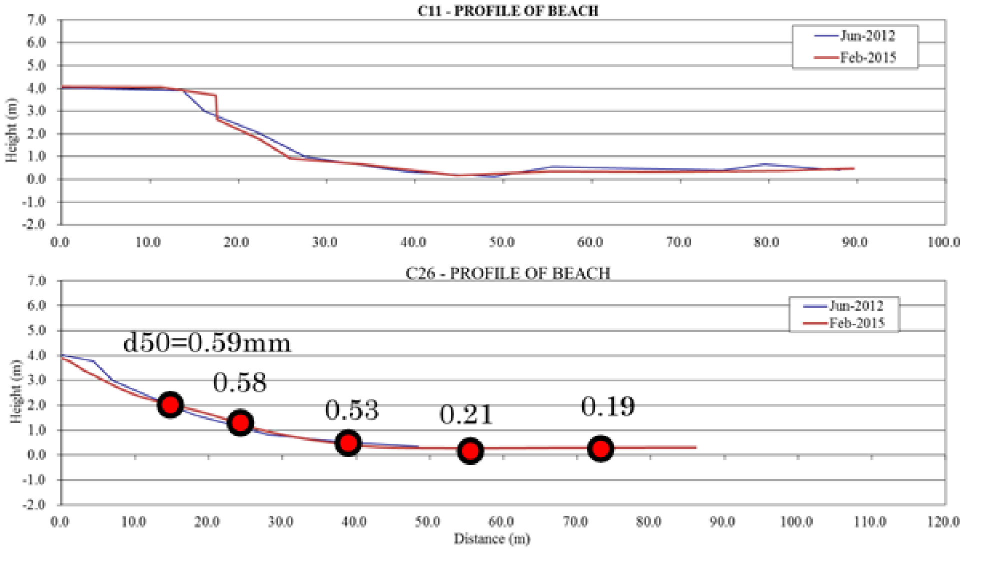


Figure 3.4.3 Cross section and Sediment median particle size

(Source: JICA Expert Team)

3.5 Coastal Situation of Planned Gravel Extraction Site

(1) Site Reconnaissance Result

Figure 3.5.1 shows the west end of Funamanu, it is viewd from the top of he storm ridge in eastward. A large amount of gravel is deposited, and storm ridge is formed. This ridge is intended, which was launched by the action of the waves from south, vertical shape is rounded. In addition, the stone mellows to provide the abrasion by the wave. Gravel deposited here becomes the main part of the beach nourishment material. On the other hand, gravel deposited enters from the left front to the right was launched from the lagon side during the cyclone Bebe, 1972. Because right ridge is higher than lagoon ridge, it is considered that the ocean side is supplied more than the lagon side.

Figure 3.5.1 Eastward from west end of Funamanu

(Source: JICA Expert Team)

Gravel, as shown in Figure 3.5.2 and Figure 3.5.3 are deposited to form berm with several width. White gravel shown in photo is the newly deposited portion, and becomes target for extraction.

West end

East end

Figure 3.5.2 Coastal Situation of Planned Gravel Extraction Site (Funamanu Island)

(Source: JICA Expert Team)

Figure 3.5.3 Coastal Situation of Planned Gravel Extraction Site (Papaelise Island)

(Source: JICA Expert Team)

(2) Coastal Survey Result

1) East of Funamanu Island

The results of the coastal survey of the east of Funamanu island so as to overlap the previous survey results (Jun. 2012) are shown in Figure 3.5.4. Cross section BM20 is gravel beach at the east of Funamanu Island, BM28 corresponds to the east end of the gravel beach. The beach slope is about 1:3 to 1:4 except tip.

Significant topographic change in the first phase is not observed except tip.

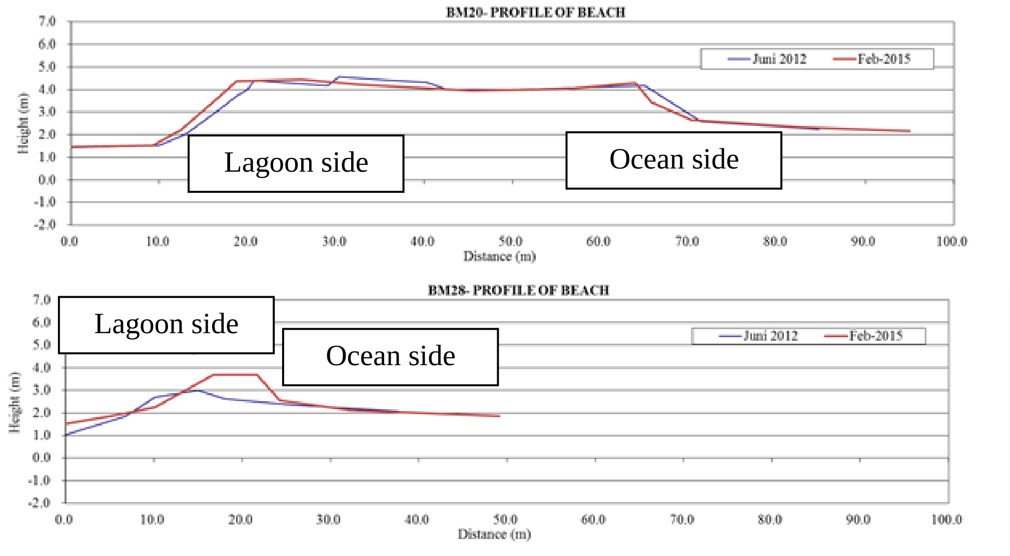


Figure 3.5.4 Cross-section (the east of Funamanu Island)

(Source: JICA Expert Team)

2) West of Funamanu Island

The results of the coastal survey of the west of Funamanu island so as to overlap the previous survey results (Jun. 2012) are shown in Figure 3.5.5. Cross section BM13 is gravel beach at the west of Funamanu Island, BM5 corresponds to the west end of the gravel beach. The beach slope is about 1:3 except tip.

Significant topographic change in the first phase is not observed except tip.

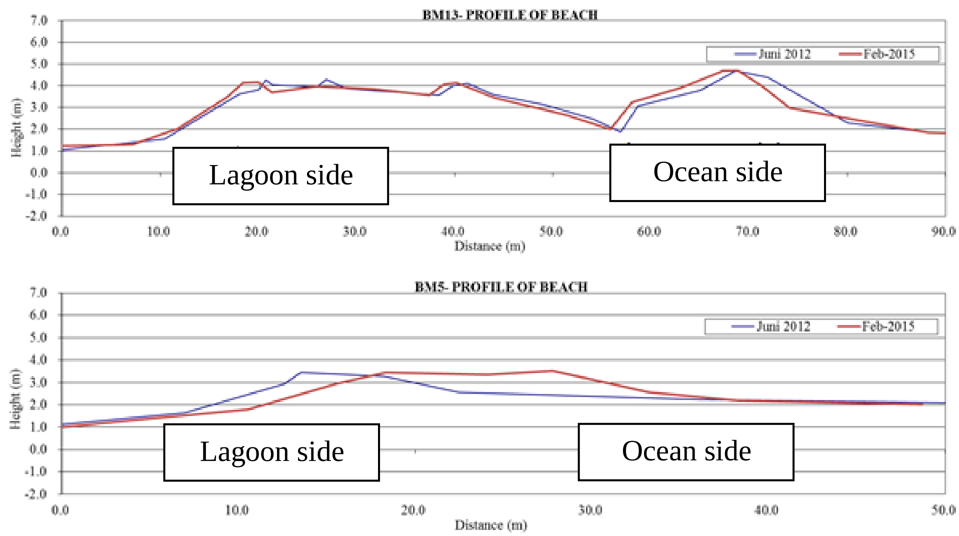


Figure 3.5.5 Cross-section (the west of Funamanu Island)

(Source: JICA Expert Team)

3) West of Papaelise Island

The results of the coastal simple survey of the west of Papaelise island are shown in Figure 3.5.6. The beach slope is about 1:3 same as Funamanu island.

Significant topographic change in the first phase is not observed except tip.

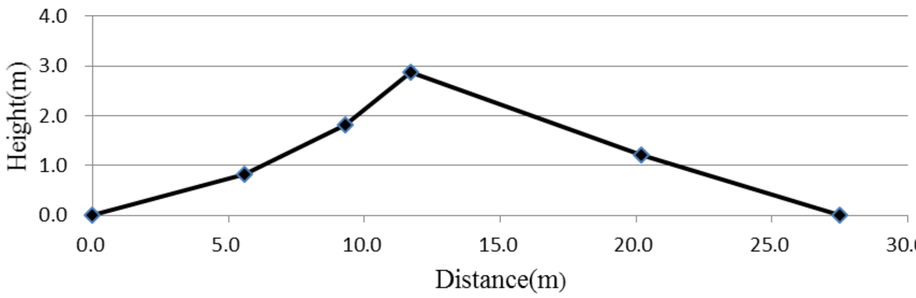


Figure 3.5.6 Cross-section (the west of Papaelise)

(Source: JICA Expert Team)

4. Quality and Quantity of Materials for the Beach Nourishment

4.1 Survey for Gravel

(1) Outline

In the Phase-1 study, four potential gravel borrow sites, which were 1) Funafuti lagoon, 2) North side of runway, 3) Import from Fiji, 4) Other islets in the Funafuti atoll, were evaluated using criteria shown in Figure. 4.1.1. And “3) Import from Fiji” and “4) Other islets in the Funafuti atoll” were selected as final candidate borrow sites for gravel (see Supporting Report-1, PP. 5-1 - 5-25 for details).

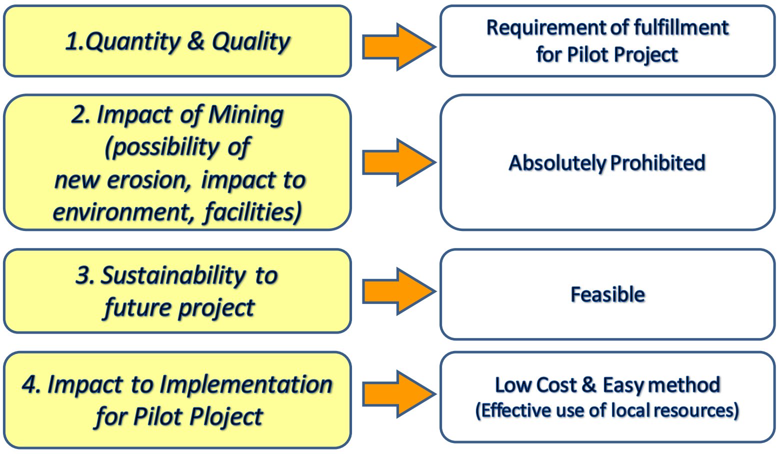


Figure 4.1.1 Criteria for Selection of Borrow Site for Gravel in Phase-1 Study

(Source: JICA Study Team)

In the Phase-2, these two final candidates were again compared and evaluated with comprehensive criteria listed below considering changes of social situations. The results of comparison study are shown in following sections.

< Comprehensive criteria to evaluate candidate borrow site for gravel in the Phase-2 >

- Economical efficiency
- Environmental impact
- Material characteristic
- Construction
- Sustainable development
- Comprehensive evaluation

(2) Summary for Comaprison Result

The results of comparison study are described as follows in accordance with study items as mentioned above.

1) Economical efficiency

Table 4.1.1 Comparison Table for Economical Efficiency

Import from Fiji	Procurement in Tuvalu (Tip of islets) (Funamanu, Papaelise)
380 AUD/m^3 (Material cost, fumigation fee, cost for sea transportation from Fiji, cost for land transportation in Tuvalu)	215 AUD/m^3 (Taking gravel at islets, cost for transportation to the site, material cost)

(Source: JICA Expert Team)

2) Environmental impact

Table 4.1.2 Comparison Table for Environmental Impact

Import from Fiji	Procurement in Tuvalu (Tip of islets) (Funamanu, Papaelise)
[Site of nourishment] According to inquiry to JAFTA (Japan Fumigation Technical Association, influence of fumigation on environment is extremely low. On the other hand, experimental proof on site has not been obtained because input of a large quantity of fumigated gravel in the shore is unprecedented. **[Countermeasures]** Implementation of monitoring after nourishment and suitable construction management	**[Gravel extraction site]** It is concerned that 1) Shoreline change with the extraction and 2) Damage of the coral with the construction. **[Countermeasures]** ● In the case of 1), the extraction of gravel should be limited to the accumulated area and the necessary volume for the Project. In addition, the monitoring of environmental impact should be conducted. ● In the case of 2), selection of construction method (e.g. prohibition of installation of temporary jetty on the reef and utilization of small barge) in order to minimize impact on corals, strict management during construction and implementation of monitoring after construction are required.

(Source: JICA Expert Team)

3) Material characteristic

Table 4.1.3 Comparison Table for Material Characteristic

Import from Fiji	Procurement in Tuvalu (Tip of islets) (Funamanu, Papaelise)
Gravel consists of crushed igneous rock and its composition and color (black/gray) are deferent from the coral stone which exists in the Tuvaluan shore originally. The shape of gravel is angular. Therefore, it is unsuitable for materials of the beach nourishment since it is common that Tuvaluan inhabitants walk barefoot.	As for gravel, shape, color and composition, there is no problem because they primitively exist in the site. The laboratory test for strength of gravel has not been carried out, but it was confirmed that strength of gravel was not inferior as materials for gravel nourishment according to the result of quality investigation on site.

(Source: JICA Expert Team)

4) Construction

Table 4.1.4 Comparison Table for Construction

Import from Fiji	Procurement in Tuvalu (Tip of islets) (Funamanu, Papaelise)
● Gravel is transported as containerized cargo from Fiji to Tuvalu and the temporary yard is needed to keep containers on land after arriving at Tuvalu. Therefore, it is necessary to discuss securement of land with Tuvaluan side and to control safety at the site. ● There is no remarkable difference about construction period in both.	● It is not necessary to keep temporary yard because gravel are transported from islets to site directly. The safety control is required during transportation of gravel. ● Same as on the left.

(Source: JICA Expert Team)

5) Sustainable development

Table 4.1.5 Comparison Table for Sustainable Development

Import from Fiji	Procurement in Tuvalu (Tip of islets) (Funamanu, Papaelise)
● It is difficult to continue because the material is supplied from other country. ● The material supply does not any problem if horizontal development to other areas is assumed. However, it is not expected that unit price of gravel can be reduced drastically as construction scale increases.	● It is a procurement method of the material which respects autonomy and independence of Tuvalu. ● It was confirmed that a large amount of gravel exists at the bottom of sea in cross-channel according to the result of diving survey that was carried out in Phase-1. It is assumed that gravel can be used for other places in consideration of horizontal development in future. ● It is possible to reduce unit price of gravel as construction scale increases considering procurement of work ship and heavy equipment transported to Tuvalu for gravel mining.

(Source: JICA Expert Team)

It is evaluated that procurement of gravel in Tuvalu is most appropriate to the Project as well as the result of Phase-1 based on comprehensive assessment from the result of comparison study as mentioned above.

(3) Determination of Source of Gravel

According to the survey result of movement mechanism of gravel including Fongafale Islands carried out in Phase-1, it is assumed that gravel supplied by waves surging from outer sea moves south in whole. In addition, it is confirmed that increase in area by accumulation of gravel is remarkable at western islands. Moreover, a large amount of gravel supplied from eastern side exists at the bottom of sea in cross-channel that is located on the south side of Funamanu Island. It is assumed that gravel has not been supplied to islets on the west of channel due to blocking of movement of gravel by the presence of the channel (see Supporting Report-1, PP. 5-12 - P.5-20 for analysis on gravel movement from south of Fongafale to westward islands).

As a result, it was necessary to satisfy following two conditions in order to minimize environmental impact on surrounding geography due to gravel mining for the Project.

- Condition 1: To do not block movement and supply mechanism of gravel due to gravel mining
- Condition 2: To do not effect major change in natural geography as much as possible due to gravel mining

According to "Condition 1", the mining site is limited to the down drift side of island considering movement mechanism. According to "Condition 2", the mining site is limited to the place where was confirmed as accumulation area from the past. Considering these conditions and necessary gravel volume, the gravel mining areas were limited to the both ends of Funamanu Island (Refer to Figure 4.1.4) and the west end of Papaelise Island (Refer to Figure 4.1.3) where gravel has accumulated. Related Parties of Tuvalu side such as central government, local government (Funafuti Kaupule) has already approved change in plan of gravel mining.

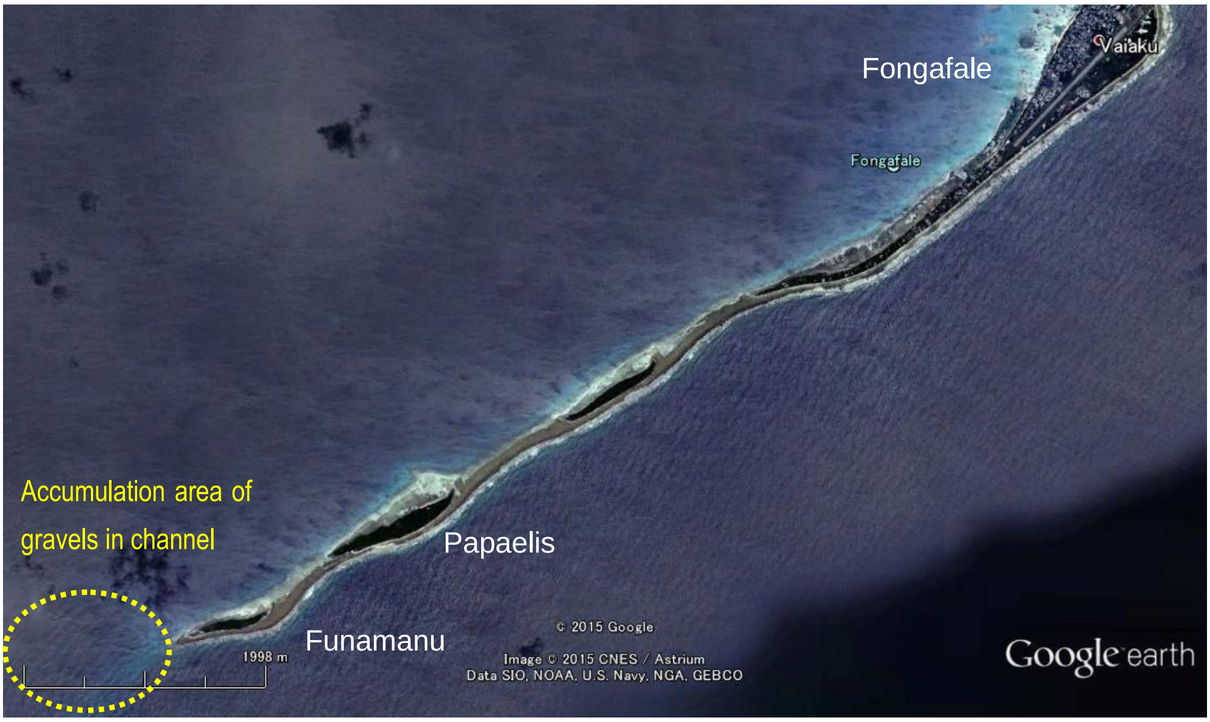


Figure 4.1.2 Location Map of Gravel Mining Site

(Source: Arranged by JICA Expert Team based on Google Map)

Figure 4.1.3 Gravel Mining Site: Papaelise Island

(Source: Arranged by JICA Expert Team based on Google Map)

Figure 4.1.4 Gravel Mining Site: Funamanu Island

(Source: Arranged by JICA Expert Team based on Google Map)

4.2 Surveys for Sand

(1) Survey Contents and Results

As survey contents of sand for nourishment, the comparison study in terms of following items was carried out based on present condition, existing information and hearing survey about two cases such as case1): sand is dredged by the Project and case 2): sand is supplied by NZ project. The comprehensive evaluation was conducted in regard to applicable sand supply method for nourishment.

- Place of sand extraction
- Method of sand extraction
- Quality of sand
- Schedule (Construction period)
- Transportation method
- Cost
- Employment and future development

(2) Review on Method of Sand Supply

The comparison study with above items is carried out as follows in terms of "sand supply by contractor of the Project" and "procurement of sand from NZ Project".

1) Sand extraction place

Table 4.2.1 Comparison Table for Sand Extraction Place

<table>
<tr><th colspan="2">Sand supply by contractor of the Project</th><th colspan="2">Procurement of sand from NZ Project</th></tr>
<tr><td colspan="2">Offshore of Fongafale (500-1,000 m offshore of the Project site, 12-14 in depth) and offshore of Fuarifeke were proposed as 1st candidate site and as 2nd candidate site for dredging sand respectively in accordance with seabed material survey and diving survey in Phase-1 (see Supporting Report-1, P. 5-28 – P.5-39 for potential borrow site for sand and its estimated volume).</td><td colspan="2">● Sand extraction site is offshore of Fongafale which includes some sites proposed by JET. The sand is planned to extract at wide areas because borrow pits are dotted in the north and south of Fongafale Island and sand is filled in borrow pits directly through sand discharging pipe (There is same information that extraction areas were not fixed but they are about 10 m in depth.).

● Sand for the Project will be transported from stock pile to the Project site on land.</td></tr>
<tr><td>Merit</td><td>It is possible to manage quality of sand and environment impact under construction management by the study team.</td><td>Merit</td><td>It is possible to avoid concern about coastal environment and safety control in the Project completely (Responsibility of NZ Project).</td></tr>
<tr><td>Risk/concern</td><td>● There is a possibility that sand with appropriate specification will not been obtained because of sand extraction site is the same as NZ project.

● There is a possibility that if construction period of NZ project overlaps with that of JICA Project (NZ project: April to October, JICA Project: August to November), construction site is thrown into confusion, which become an obstacle to safety control and construction progress.

● There is a possibility that local residents and environmental communities complain to the Project because sand extraction involves the risk of making seawater muddy and having an impact on environment as compared with other work items.</td><td>Risk/concern</td><td>● Function of waves and movement of seabed sand at the Project area might be affected if sand is dredged near the Project area and also at shallow sea.

<Risk avoidance measure>
It is necessary to discuss about minimum depth and offshore distance for sand extraction with NZ project side. JET requests strict construction management to NZ project side.</td></tr>
</table>

(Source: JICA Expert Team)

In this study, the diving survey and sand sampling were carried out (on 15th of February, 2015) at area where sand will be extracted by NZ project and quality of sand (grain size, color and composition) was confirmed.

The sampling points are shown in Figure 4.2.1. Three lines were set up at offshore of Fongafale and sample of sand was taken with 3 m interval from –6 m in depth to deep area on each three lines. The deepest area was –18 m in depth. The quality of sand of each line and each point are shown in Table 4.2.2. All samples are suitable for nourishment material judging from grain size and color but the quality is little different at each point.

Figure 4.2.1 Location Map of Seabed Material Survey for Nourishment

(Source: Arranged by JICA Expert Team based on Google Map)

Table 4.2.2 Additional Seabed Material Survey (Offshore of Fongafale)

L1-1 (-6 m)	L1-2 (-9 m)	L1-3 (-12 m)	L1-4 (-15 m)	L1-5 (-18 m)
				
● Coral shell, foraminifer ● Relatively-coarse ● Orange color generally	● Coral shell, foraminifer ● Relatively-coarse ● Orange color generally	● Coral shell ● Slightly smaller than L1-2 ● White/orange color generally	● Coral shell ● It is equal to L1-2 ● White/orange color generally	● Coral shell ● It is equal to L1-4 ● White/orange color generally
L2-1 (-6 m)	L2-2 (-9 m)	L2-3 (-12 m)	L2-4 (-15 m)	L2-5 (-18 m)
				
● Coral shell, foraminifer ● Relatively-coarse ● White/orange color generally	● Coral shell, halimeda ● Relatively-fine ● Orange/white color generally	● Coral shell, halimeda ● Relatively-fine ● Orange/white color generally	● Coral shell ● It is equal to L2-1 ● White color generally	● Coral shell ● It is equal to L2-4 ● White color generally
L3-1 (-6 m)	L3-2 (-9 m)	L3-3 (-12 m)	L3-4 (-15 m)	L3-5 (-18 m)
				
● Coral shell, foraminifer ● Relatively-coarse ● Orange color generally	● Coral shell ● It is little smaller than L3-1 ● White color generally	● Coral shell ● It is equal to L3-2 ● White color generally	● Coral shell ● It is equal to L3-2 ● White color generally	● Coral shell, halimeda ● It is equal to L3－4 ● White color generally

(Source: JICA Expert Team)

2) Method of sand extraction

Table 4.2.3 Comparison Table for Sand Extraction Method

Sand supply by contractor of the Project		Procurement of sand from NZ project	
Comparison study for sand extraction was conducted about three methods such as 1) Barge + Sand pump, 2) Barge + Clamshell bucket and 3) Barge + airlift pipe. As a result, 2)Barge +clamshell bucket was selected in consideration of construction ability of contractor in Fiji, environmental impact, risk of breakdown and so on.		It is proposed that sand is filled into stockpile by cutter suction dredger + sand discharging pipe (floating pipe). The sand of 40,000 to 50,000 m^3 will be stocked for the future maintenance by the Government of Tuvalu (The total amount of sand by NZ project is approx. 300,000 m^3). Northernmost borrow pit is the leading candidate site of stockpile but it is not determined yet.	
Merit	Nothing in particular.	Merit	It was not necessary to implement dredging work that is the most serious concern in the Project. Therefore, the risk of workability of the contractor in Fiji can be eliminated. The risk of construction by the contractor in Fiji can be reduced remarkably because the work is limited to land transportation of sand from stockpile to the Project site.
Risk/concern	The dredging method without using a special ship for dredging was proposed considering work ability and equipment of the contractor in Fiji. In Phase-1, the most serious concern was the possibility of dredging work by the contractor because past achievements and enough experience are required for the work even if the contractor can procure the dredger (On the other hand, the contractor in Japan who has enough experience for dredging work was excepted because it is assumed that the cost become more than twice).	Risk/concern	Nothing in particular.

(Source: JICA Expert Team)

3) Quality of sand

Table 4.2.4 Comparison Table for Quality of Sand

<table>
<tr><th colspan="2">Sand supply by contractor of the Project</th><th colspan="2">Procurement of sand from NZ Project</th></tr>
<tr><td colspan="2">The mean grain size (D50) of sand sampled as mentioned above is 0.5 mm at north offshore of Fongafale and 0.71 mm at south offshore of Fongafale. Sand composes of coral and shell and the quality is good.</td><td colspan="2">According to hearing survey from the consultant, the coarse sand which contains origin of foraminifer and coral will be used for backfilling of borrow pit. The fine sand which consists of decomposition of Halimeda plant will not be used as basic concept.</td></tr>
<tr><td>Merit</td><td>The quality of sand is suitable for material of nourishment considering grain size and composition according to the result of seabed material survey.</td><td>Merit</td><td>There is a possibility that sand suitable for nourishment can be obtained because fine sand will not be used for NZ project but there is no restrict specification for sand in NZ project.</td></tr>
<tr><td>Risk/concern</td><td>On the other hand, the range in which good quality sand exists is not confirmed because sand sampling points are limited. There is no guarantee that necessary volume of sand with good quality can be obtained.</td><td>Risk/concern</td><td>There is no guarantee that coarse sand in large quantity can be obtained because dredging work is conducted at very wide range.

<Risk avoidance measure>
The length of groin for prevention of sand lost is set up to extend from 1:10 in Phase-1 that was considered between grain size and slope to 1:13 in consideration of the possibility of more fine sand as compared with original assumption.</td></tr>
</table>

(Source: JICA Expert Team)

4) Schedule (Construction period)

Table 4.2.5 Comparison Table for Construction Schedule

Sand supply by contractor of the Project		Procurement of sand from NZ Project	
● In the Phase-1, construction period is assumed as 5.5 months. The procurement of armor stones from Fiji and change of construction method are required because of change of specification for groin in this phase. It is though that the period will be extended because mobilization and construction take more time as compared with original plan. It will be extended from 5.5 months in original plan to 7.0 months. ● The extraction of sand is the last phase of the Project and the construction period is assumed as 3.5 months. Therefore, the latter of sand extraction overlaps with high wave season (end of November).		● It is assumed that the sand extraction and filling into borrow pit will be carried out from April to September, 2015 at this time. It is also assumed that timing of sand filling into stockpile is around August to September of the construction end time. ● It will take 60 days to transport sand by land from stockpile to the site if two dump trucks are used in the case of 4,500 m^3 of sand volume.	
Merit	Nothing in particular.	Merit	● It is expected that high rate of operation and reliability of construction period are secured because land transportation of sand from stock pile is not restricted by oceanographic phenomena. It is also possible to carry out sand nourishment work after December since strict limitation that nourishment should be completed before November when rough wave season starts can be relaxed because of land construction.

Sand supply by contractor of the Project		Procurement of sand from NZ Project	
Risk/concern	● The term of construction for sand extraction (Approx. 4,500 m3) is the longest (Approx. 3.5 months) in other work items. The work becomes critical path of whole construction schedule because term of the work is in the latter half of the Project. ● The work is required to complete before November when rough season starts because of marine work, but it will take by the end of November. There is a risk of delay of completion period due to decline of operation rate during rough season and extension of the construction period. ● It is difficult to complete the Project by November when rough season stars even if the work starts from June as the case of the shortest construction starts. Therefore, the work is required to postpone a year and should be started from the beginning of calm season as early as possible if sand extraction is included in the Project.	Risk/concern	There is a risk that sand nourishment work cannot be done during construction period if sand filling into stockpile delays. <Risk avoidance measure> It is assumed that the construction period can be extended flexibly considering possibility of delay of sand filling into stockpile and relaxation of constraint by land construction. In addition, by delaying the start of construction about several weeks to one month (the end of June), adjustment and coordination of sand filling work into stockpile can be done.

(Source: JICA Expert Team)

5) Cost

Table 4.2.6 Comparison Table for Construction Cost

Sand supply by contractor of the Project		Procurement of sand from NZ Project	
The construction costs for sand nourishment which consist of 1) sand extraction (dredging), 2) transportation of sand and 3) sand filling are approx.79 million JP yen (Exchange rate: 1FJD=60.3 JP yen in the end of March, 2015).		The construction costs for sand nourishment which consists of 1) transportation of sand and 2) sand filling are approx.15 million JP yen (Exchange rate: 1FJD=60.3 JP yen in the end of March, 2015).	
Merit	Nothing in particular.	Merit	The construction costs can be reduced to about 20% compared with the left case.
Risk/concern	The construction costs are about five times as compared with the right case. In addition, it is assumed that the cost of overall construction is approx. 35 million JP yen.	Risk/concern	In terms of sand supply for the Project, the Government of Tuvalu and the related agencies for NZ project support basically but official letter has not been issued by the Government of Tuvalu. <Risk avoidance measure> The risk will be avoided through in-depth discussion with information sharing among the Government of Tuvalu and the related agencies for NZ project.

(Source: JICA Expert Team)

6) Employment and future development

Table 4.2.7 Comparison Table for Employment and Future Development

Sand supply by contractor of the Project		Procurement of sand from NZ Project	
Sand extraction will be completely carried out by the contractor of a third country. Therefore, it is difficult for Tuvaluan people to involve in the construction.		The condition of sand extraction is the same as the left case. On the other hand, it is assumed that sand is transported by land from stockpile in Fongafale island.	
Merit	Nothing in particular.	Merit	● There is a possibility that Tuvaluan might be employed when sand is transported from stockpile (road clean and traffic control). ● This will become a model case if sand in stockpile is used for future project in Tuvalu.
Risk/concern	The employment opportunity for Tuvaluan by this construction is low.	Risk/concern	Nothing in particular.

(Source: JICA Expert Team)

7) Overall evaluation

Table 4.2.8 Comparison Table for Overall Evaluation

Sand supply by contractor of the Project	Procurement of sand from NZ Project
● This case has various risks such as the large increase of construction cost, delay of construction period, lack of ability of the contractor in Fiji for dreading work. In addition, the possibility of employment opportunity and future development is lower than the right case. ● It is difficult to complete whole construction work within this year considering that completion period is limited (Marine work should be completed by the beginning of November) and the start of construction is after June at the earliest. ● As a result, this case is not recommended.	● Various risks can be eliminated as compared with the left case and the possibility of employment opportunity and future development is higher than left case. ● There is a risk of extension of construction period if timing of sand filling to stockpile by NZ project delays. But it is possible to rearrange construction period. Therefore, the total risk is lower than the left case markedly. ● As a result, this case is strongly recommended.

(Source: JICA Expert Team)

4.3 Summary

(1) Procurement of gravel

- The gravel mining site was set up at the both ends of Funamanu Island and the west end of Papaelise Island in consideration of necessary volume for nourishment, accumulation condition, economical efficiency, environmental impact, material characteristic, construction and sustainable development.
- The concerned parties of Tuvalu side such as central government, local government (Funafuti Kaupule) has already approved gravel mining sites through PCC and public consultations.

(2) Procurement of sand

- The sand for nourishment was determined to procure from borrow pit project by NZ aid based on the result of comprehensive evaluation between a): sand is dredged by the Project and b): sand is supplied by NZ project in terms of placement of sand extraction, method of sand extraction, quality of sand, schedule, transportation method, cost and employment and future development. However, there is a risk of extension of construction period if timing of sand filling to stockpile by NZ project delays.
- The concerned parties of Tuvalu side such as central government, local government (Funafuti Kaupule) has already approved in terms of procurement of sand through PCC and public consultations.

5. Planning and Design of the Beach Nourishment

5.1 Overview

(1) Design Principle

The basic and detailed design for the gravel nourishment was examined in Phase-1. In Phase-1, the proposed design was already presented and discussed in the previous Project Coordination Committee (PCC), which was held in February 2013, and everything was agreed upon except the width of the beach.

Due to the different opinions of the Tuvaluan side and the Japan International Cooperation Agency (JICA) on the width of the beach, the Project has been suspended for approximately two years. Therefore, it was required to reassess the previous design for the gravel nourishment taking into account the current natural and social conditions in Phase-2 and some conditions in the design which were updated from Phase-1.

To avoid confusion, this chapter mainly shows the final design of Phase-2 with a brief summary of the original design of Phase-1. Further details of the original design of Phase-1 can be referred to in the Interim Report Ch. 6, which is in the Supporting Report-2.

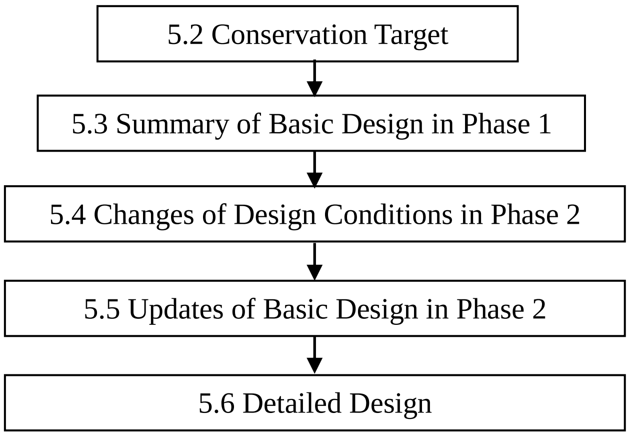


Figure 5.1.1 Flow for Design Review

(Source: JICA Expert Team)

5.2 Conservation Target

The targets in terms of protection function, environment, and utilization were set for the planning and design of the beach nourishment.

(1) Target on Protection Function

The target on protection function was determined taking into account the present beach condition at the project site.

- Wave run-up and wave overtopping into the land area and private property can be prevented.
- Further beach retreat due to beach erosion can be stopped.

(2) Target on Utilization

The target on beach utilization was determined taking into account the opinions of both the Government of Tuvalu and the community.

As presented in Chapter 8, several stakeholder meetings were held during the study to obtain the opinion of the residents and community, who mainly utilize the project beach area. The opinions and requests from the Tuvaluan side are summarized as follows:

- The people requested to recover the previous beach conditions before the occurrence of the beach erosion. The previous beach on the lagoon side was basically a sandy beach with some gravel parts.
- The project beach area is utilized mainly by the residents as a recreational and fishing boat landing space. Thus, it was requested not to disturb these activities, and if possible to even enhance these activities.
- The community hole was located at the hinterland, and the project area is one of the most important and crowded spaces in Funafuti community area. Considering this, the project beach is expected to be a model beach in the Funafuti area.

From the above opinions, the target on utilization is set as follows:

- The selected beach conservation measure should contribute to enhance the beach utilization, such as for recreation and boat landing activities.
- The selected beach conservation measure is expected to transform the beach into a model beach and the most attractive area in Funafuti community area.

(3) Target on Environment

The target on environment is as follows:

- Undertaking the beach protection measures at the project site should not cause any new beach erosion problems at the surrounding beaches.
- The implementation activity should not cause the deterioration of marine biota such as corals, fish, sea glass, etc.
- It should not cause new beach erosion problems at the borrow sites for gravel and sand.

5.3 Summary of Basic Design in Phase-1

(1) Design Condition

This section shows the summary of the basic design results in Phase-1 (see Supporting Report-2 for details).

1) Design Tide

The design tide condition is shown in Table 5.3.1.

Table 5.3.1 Design Tide Condition

H.H.W.L	CDL +3.42 m
H.W.L	CDL +2.80 m
M.W.L	CDL +2.00 m
L.W.L	CDL +1.20 m

(Source：Completed JICA Development Survey Report (2011))

2) Design Waves

Design wave condition will be used mainly for hard structure, such as groin. In Phase-1, the groin was designed as “temporary structure” as explained in Section 5.3.2 later. Thus, the design waves for 10-year return period was set as design period. However, due to change of condition in Section 5.3.2, the design waves for 30-year return period was adopted as design condition for “permanent structure”. The design offshore waves and design waves for structure are shown in Table 5.3.2 and 5.3.3, respectively.

Table 5.3.2 Design Offshore Waves

Return Period	Wave Height $(H_0)_{1/3}$ (m)	Wave Period T_0 (s)
10 years	1.2	4.2
30 years	1.9	4.2
50 years	2.2	5.6

(Source：Completed JICA Development Survey Report (2011))

Table 5.3.3 Design Wave Condition for Structure

Return Period	Wave Height $H_{1/3}$ (m)	Wave Period $T_{1/3}$(s)
10 years	1.12	4.2
30 years	1.56	4.2
50 years	1.83	5.6

(Source：Completed JICA Development Survey Report (2011))

3) Wind

Annual winds are predominant from an easterly direction of ENE to SE. Winds stronger than 8 m/s are observed from a westerly direction of SW to N. During the wet season from December to February, northeasterly winds from N to ENE are predominant. Strong westerly winds of more than 12 m/s are also observed during this season. During the dry season from May to September, easterly or southeasterly winds from ESE to SE are predominant, but winds of more than 8 m/s are rarely observed.

(2) Previous Design

1) Layout Plan

The layout plan of the beach, which was proposed in Phase-1, is shown in Figure 5.3.1. Based on the discussion with the Government of Tuvalu, the project area was decided to start from the Amatuku Jetty, at which the groin north was located, going to the south. The distance of the project area is 186 m alongshore. Two sets of groins (which are called “groins” in Phase-1) were planned to set the boundaries of the project site in order to minimize the outflow of gravel and sand from the project area to the outer area.

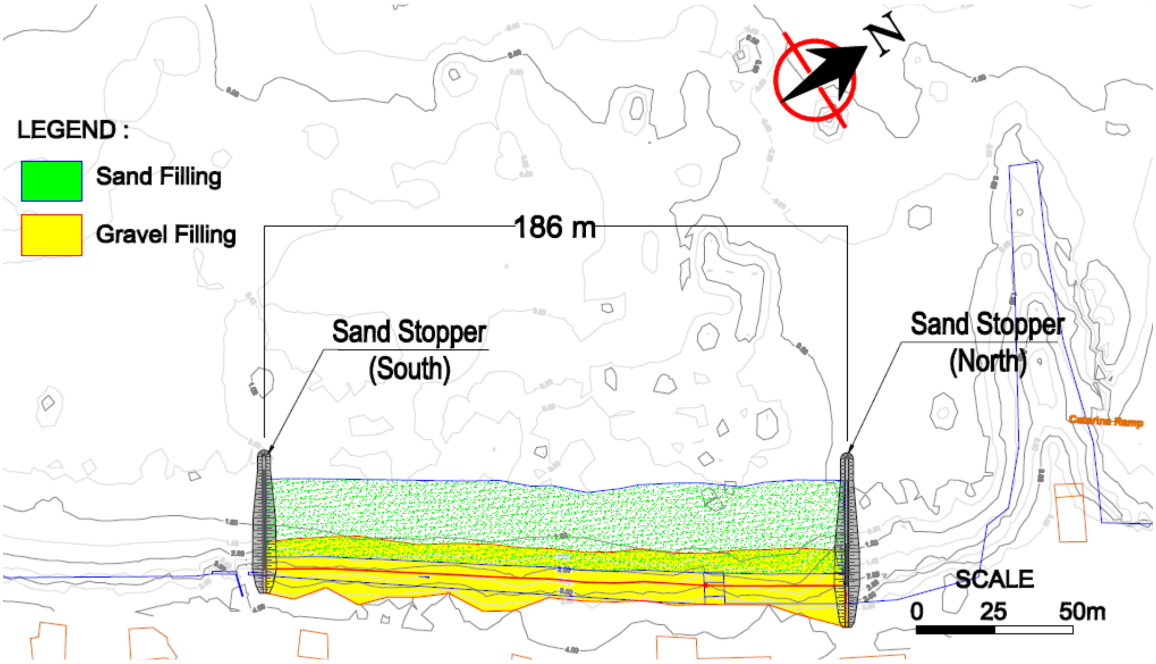


Figure 5.3.1 Proposed Layout Plan

(Source: JICA Expert Team)

2) Beach Profile

The final proposed profile of the beach in Phase-1, which was agreed in the PCC, was the combination of gravel and sand as shown in Figure 5.3.2. (see Supporting Report-2, PP. 6-9 – 6-24 for method to determine dimensions)

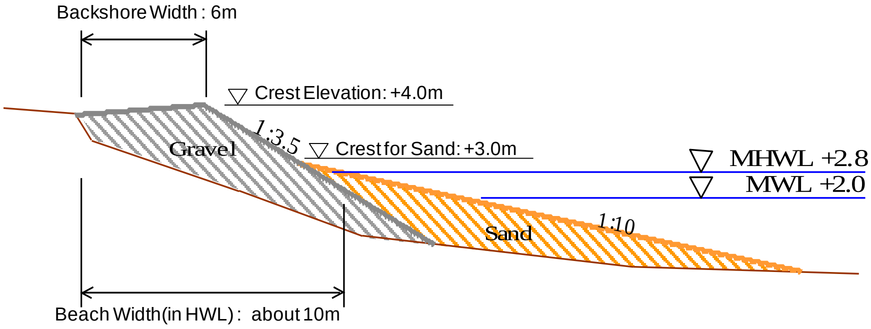


Figure 5.3.2 Proposed Profile Design

(Source: JICA Expert Team)

3) Groins

The groins proposed in Phase-1 are as shown in Figure 5.3.3. The armor layer was planned to apply net gabions taking into account as "temporaly structure". The core part was planned to construct by using sand bag filled by dredged sand from the lagoon.

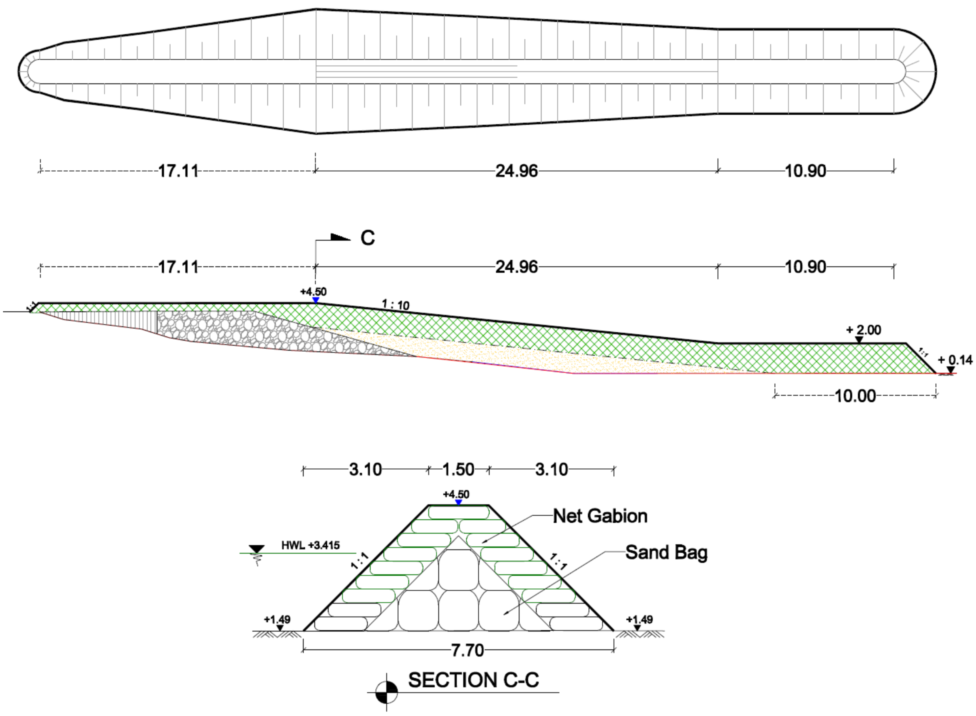


Figure 5.3.3 Groin (in the North)

(Source: JICA Expert Team)

4) Backshore Wall

The purposes of the backshore wall are as follows:

- To reduce scattering and movement of gravel into the property area during a strong wave condition;
- To avoid soil outflow from the landside during heavy rains;

- To identify the boundary between the private properties and the nourishment area, which will be a public facility; and
- To enhance beach utilization for residents by providing seating facilities alongshore.

The proposed layout of the backshore wall in Phase-1 is shown in Figure 5.3.4. Some spaces were considered to secure access for boat landing. The backshore wall was planned to be constructed using in-situ concrete as shown in Figure 5.3.5. A concrete hump was also planned to set spaces for the backshore wall to minimize the soil outflow from the landside in case of heavy rains, which is shown in Figure 5.3.6.

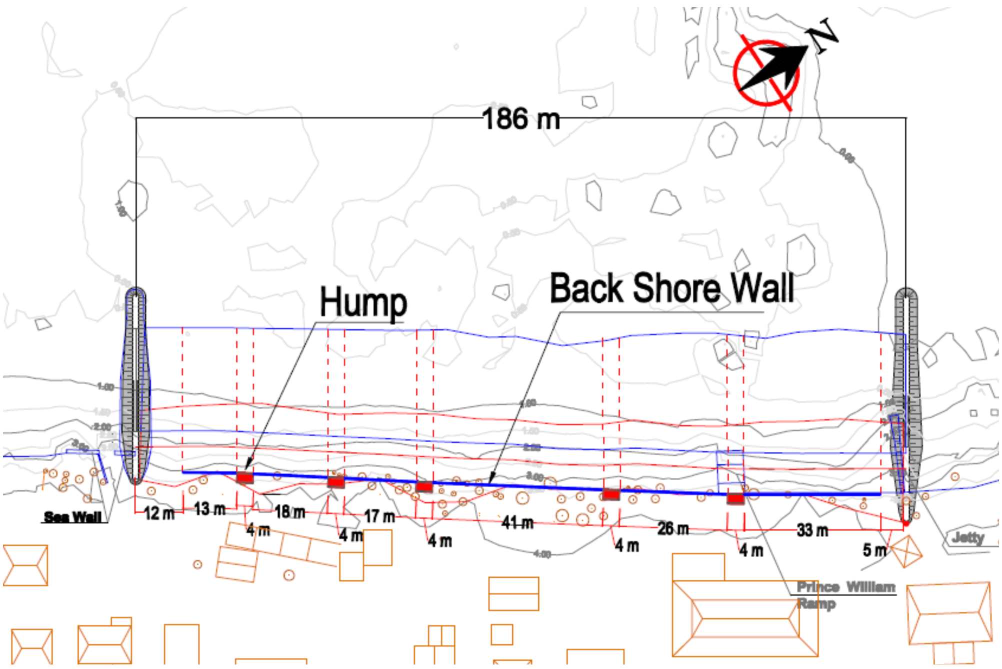


Figure 5.3.4 Layout Plan of the Backshore Wall

(Source: JICA Expert Team)

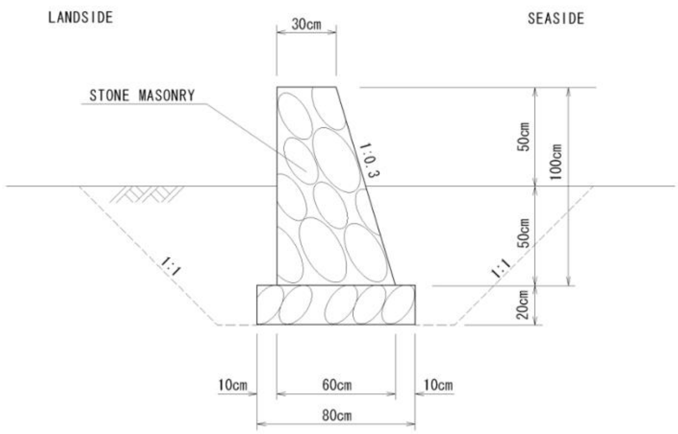


Figure 5.3.5 Typical Section of Backshore Wall

(Source: JICA Expert Team)

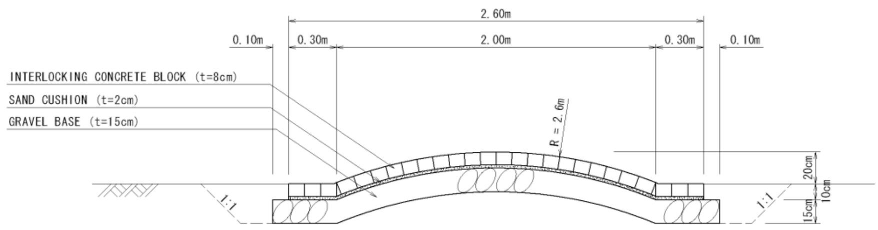


Figure 5.3.6 Typical Section of Hump

(Source: JICA Expert Team)

5) Summary of Required Volume and Source for Each Material

The required volume for each material and its sources which were assumed in Phase-1 are as follows:

Table 5.3.4 Summary of Quantities Assumed in Phase-1

Item		Quantity
Gravel Section	Design	3,070 m^3
	Source	570 m^3 re-use of the existing concrete debris on the beach
		2,000 m^3 from west tip of Funamanu Island
		500 m^3 from east tip of Funamanu Island
Sand Section	Design	3,724 m^3 (including 174 m^3 backfilled sand bag)
	Source	Offshore area of Fongafale Island and Fualifeke Island
Groins	Armor	626 m^3 net gabion
	Core	325 m^3 sand bag

(Source: JICA Expert Team)

5.4 Changes of Design Conditions in Phase-2

During the suspended period between Phases-1 and -2, which was approximately two years, there were some differences and changes in the conditions in terms of the natural, social and construction viewpoints. Some design change or modification will be required due to such differences of condition. The differences between the previous and current conditions are presented below.

(1) Natural (Coastal) Condition

1) Change in Beach Profile due to Natural Cause

The site investigation and topographic survey were carried out in February 2015 after the resumption of the Project in Phase-2 in order to check the difference in the beach condition. Basically no significant difference in the beach profile was observed due to natural cause.

2) Change in Beach Condition due to Human Cause

During the suspended period, the revetment made with concrete cube blocks of approximately 50 m length and 4 m width was constructed in front of the community hole in 2013 as shown in Figure 5.4.1. According to the information from Funafuti Kaupule, this revetment was constructed by volunteers from the community. However, some parts of the revetment collapsed due to wave actions during the rainy season in January 2015. Also, further damages occurred due to Cyclone Pam, which approached Tuvalu on the 10^{th} to 13^{th} of March 2015, causing it to almost collapse as shown in Figure 5.4.1.

Also, the concrete wall which exists at the south end of the project site and constructed by the private owner at the hinter land was a little further expanded compared with that in Phase-1 as shown in Figure 5.4.2.

(2) Social Condition

1) Continuing of Strong Demand from Funafuti Community

Even though the Project was suspended in 2013, Funafuti community still had strong demand for the beach protection project. Funafuti community had a concern of progressed beach retreat especially in front of community hall. That is why the community constructed the concrete cube revetment by themselves.

2) Cancelation of the Possibility of Extension Project by NAPA

According to the information from the representative of the National Adaptation Programme of Action (NAPA) in Phase-1, NAPA continued the same type of coastal protection project in Phase-1 after the completion of the JICA project. Taking into account this information as well as the economical point of view, the structure type of the groins was designed as “temporary structure”. However, it was confirmed that this plan was canceled and as of the moment, there will be no extension project after this JICA project. This change in condition shall be taken into consideration for the modification of the structure type of the planned groins.

May 2012

February 2015

April 2015
(After Cyclone Pam)

Figure 5.4.1 Beach Condition in front of the Community Hole

(Source: JICA Expert Team)

May 2012

February 2015

Figure 5.4.2 Private Concrete Wall

(Source: JICA Expert Team)

(3) Condition on Construction

1) Procurement of Sand

After the suspension of the Project in 2013, the new project, which is "Tuvalu Borrow Pit Rehabilitation Project" was undertaken. This project was funded by New Zealand (NZ) as a granted project by the NZ Aid Programme. This project is to rehabilitate the borrow pits in Fongafale Island to dredge sand from the Funafuti lagoon and fill it into the borrow pits. The construction work was commenced on March 2015, and completed on November 2015 (shown in Figure 5.4.3). In the planning of Phase-1, it was planned that the sand to be used as the nourishment material will be procured as one of the construction items in the Project. The Government of Tuvalu suggested to JICA the possibility of using dredged stocked sand by the

NZ Aid project taking into account the construction schedule and cost impact as a pilot scale project. Based on the discussion between the Government of Tuvalu and JICA in Phase-2, it was concluded that the stocked sand, which will be prepared in the Borrow Pit Project, can be used as the material for the nourishment in the JICA Pilot Project as far as not to cause the adverse impact to the Borrow Pit Project. The accepted volume for taking sand was 4,500 m^3.

Figure 5.4.3 Borrow Pit Project by NZ Aid (Taken on 30 May 2015)

(Source: JICA Expert Team)

5.5 Updates of Basic Design in Phase-2

Taking into account the abovementioned change in conditions after the suspension of the Project, the previous design shall be reassessed and modified as required. The modified design has been already discussed and agreed with all members in the 2nd PCC which was held on 25 February 2015.

(1) Layout

The project area is basically same as the previous design, which is from the Amatuku Jetty at the north end to the south until before the private concrete wall of approximately 180 m.

However, the exact length was a little changed from 186 m to 177 m due to the expansion of the private wall which is positioned on the foreshore of south end as shown in Figure 5.5.1.

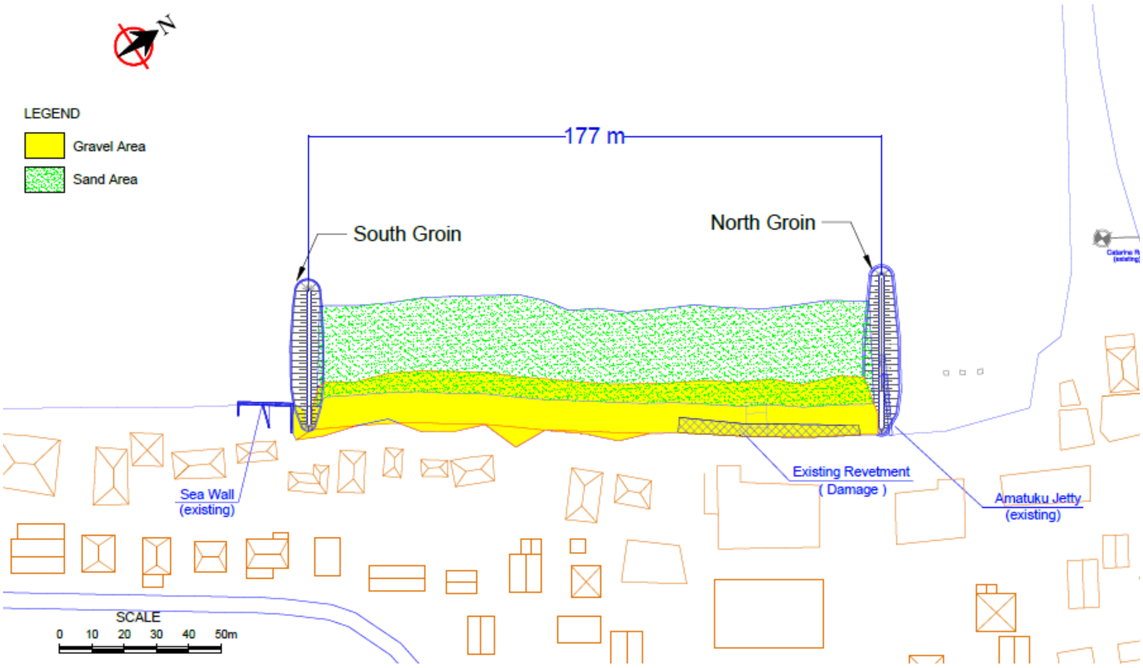


Figure 5.5.1 Final Layout Design

(Source: JICA Expert Team)

(2) Beach Profile

As mentioned many times, the design of the beach profile initially was just for construction in order to minimize the unnecessary discharge of gravel and sand. The beach profile will be changed due to wave action afterwards.

1) Gravel Section

The initial profile of gravel section (crest elevation, backshore width and foreshore slope) was set as the same as the previous design, that is;

- Crest Elevation: +4.0 m (same as that for natural beaches on the lagoon side)
- Backshore Width: 6.0 m (based on the analysis of wave run-up)
- Foreshore Slope: 1:3.5 (same as that for natural beaches on the lagoon side)

2) Sand Section

The foreshore slope for sand section was set as 1:10 in Phase-1 assuming the possibility to obtain the sand with appropriate grain size. Due to the change in condition as explained in Section 5.4.3, sand will be procured by the Government of Tuvalu from the sand stockpile. According to the information from NZ project, only coarse sand will be dredged and filled into the pit. However, there are still uncertain factors for the specifications of sand, and grain size is one of them. Taking into account the possibility that the grain size of sand is finer than expected, the design of foreshore slope is modified to be milder. The foreshore slope can be referred from the existing nearby natural beach. The foreshore slope of the existing sandy beach located in the south was obtained at 1:12 to 1:13 based on the field survey result. Considering the stability of the sandy section and quantitative point of view, the initial foreshore slope for the sand section was decided from 1:10 to 1:11. Even though this design slope is a little steeper than that of the natural beach, the foreshore slope will be changed by wave action afterward and obtain the stable slope for its own grain size. Also, for the design of groins, the length of groin has been determined taking into account the possibility to change the slope to be milder (as same as the slope of the natural beach, which is 1:12 to 1:13).

The elevation of cross point for sand and gravel on the natural beach on the south side was measured from +2.0 m to +2.8 m. Based on this information, the elevation of cross point was set at +3.0 m, same as the design in Phase-1. The final design of the beach profile is shown in Figure 5.5.2

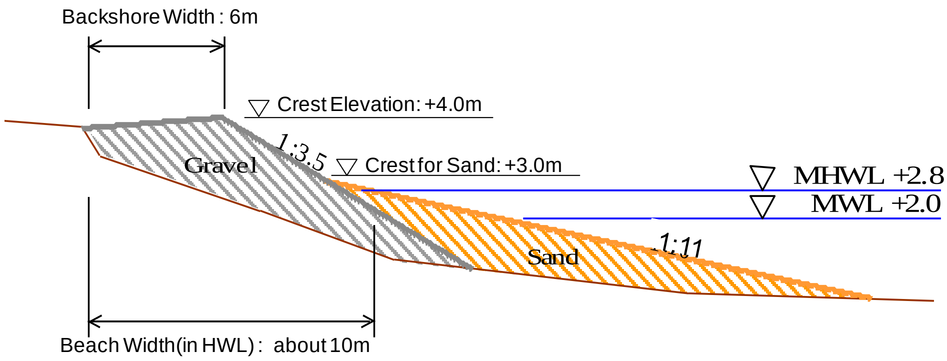


Figure 5.5.2 Final Profile Design

(Source: JICA Expert Team)

(3) Groin

1) Pre-condition

Due to the change in social condition as described in Section 5.4.2, the design of groin shall be modified from "temporary structure" to "permanent structure".

2) Principle

The principle on modification of design for groins is as follows:

- Structure type of groin, especially for armor layer shall be changed as "permanent structure".

- The section of groin shall be minimized considering the limited volume of materials and to minimize the construction cost, as far as to maintain the required function and beach use.
- The length of groin shall be determined carefully taking into account presumed stable beach slope.

3) Design Modification

a) Change of Material for Armor Layer from Gabion to Armor Rock

Due to the change of structure type from "temporary structure" to "permanent structure", the material for armor layer is altered from gabion to armor rock, because the employment of gabion could not secure the durability of a permanent structure. There are no armor rocks of any kind in Tuvalu, and therefore, it is planned to import basaltic armor rock from Fiji.

The required weight for armor rock can be determined by the stability analysis using Hadson's Formula with the design wave condition. Table 5.5.1 shows the calculated required weight and layer thickness of armor rock for the different slopes.

Table 5.5.1 Required Weight for Armor Rock

Slope	Required Weight (ton)	Layer Thickness	
		In case of 1 layer	In case of 2 layers
1:1	1.29	0.79	1.57
1:1.5	0.86	0.69	1.37
1:2.0	0.65	0.63	1.25

(Source: JICA Expert Team)

Considering the stability of armor layer, it is recommended to take 2-layer thickness. As the slope of groin was adjusted as described in the next paragraph, the size of armor rock is to be determined as follows:

For the first layer: 1.0 ton/unit

For the second layer: 0.5 ton/unit

b) Change of Material for Core Layer from Sand Bag to Gravel

Due to the change of procurement for sand, it might be difficult to secure the required sand to fill into the sand bag for core layer. Thus, core material is altered from sand bag to gravel, which will be taken from the nearby island. Based on the further field investigation, it was proposed to take gravel for core material from the west tip of Papaelise Island (Details of the gravel mining site is described in Chapter 4). For the size of the core rock, it was recommended to take 1/10～1/20 of armor rock according to the design guideline (e.g. Shore Protection Manual (1984), Rock Manual (2007)).

c) Modification of Slope, Crown Height and Width

Taking into account the points on function and beach use as permanent structure as well as the economic point of view, slope, crown height and width, were altered as follows:

Table 5.5.2 Modification of Slope, Crown Height and Width

Item		Previous (1st Stage)	After Review (2nd Stage)	Reason
Slope (North Groin)	Outer side	1:1	1:1.5	To secure the stability of armor rock and to enhance user friendly functions, it is preferred for the slope to be milder. On the other hand, it will cause an increase in the volume of materials. Thus, the slope has been adjusted taking into account the beach condition and its usage at both areas where the two groins will be constructed.
	Inner side			
Slope (South Groin)	Outer side	1:1	1:2	
	Inner side		1:1.5	
Crown Height	Trunk Part	+4.5 m (+0.5 m up from gravel elevation)	+4.2 m (+0.2 m up from gravel elevation)	To reduce the quantity for material and not to disturb the access across the groin.
	Other Part	Decrease height in keeping with 1:10 slope	Decrease height in keeping with 1:13 slope	Due to the change of expected stable beach slope from 1:10 to 1:13 to be safer for sand discharge after the nourishment
Crown Width		1.5 m	1.3 m	Due to the change of armor method from gabion to armor rock

(Source: JICA Expert Team)

d) Groin Length

The determination for length of groin is important to secure the nourished sand against the risk for sand discharge due to wave action hereafter. The position at the head part of the groin shall be determined taking into account the position of the toe part for the predicted stable foreshore slope with some clearance until the toe part of the groin. In the previous design (in Phase-1), 1:10 slope was assumed as expected from the stable foreshore slope. However, due to the change of sand procurement, 1:13 slope was re-assumed as stable foreshore slope. As a result, the total length of groin was modified as presented in Table 5.5.3.

Table 5.5.3 Groin Length

Groin	Previous (1st Stage)	After Review (2nd Stage)
North	53.0 m	51.4 m
South	43.8 m	46.1 m

(Source: JICA Expert Team)

The final design of the groin is shown in Figure 5.5.3.

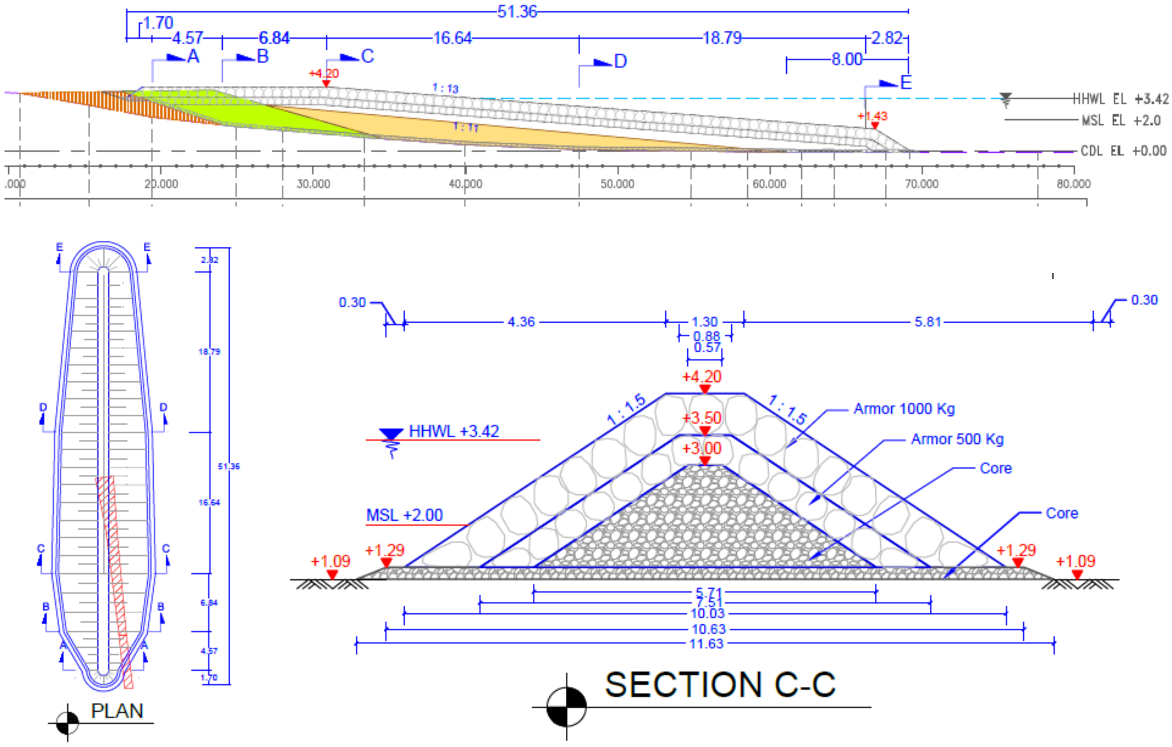


Figure 5.5.3 Final Design of the Groin (e.g., North)

(Source: JICA Expert Team)

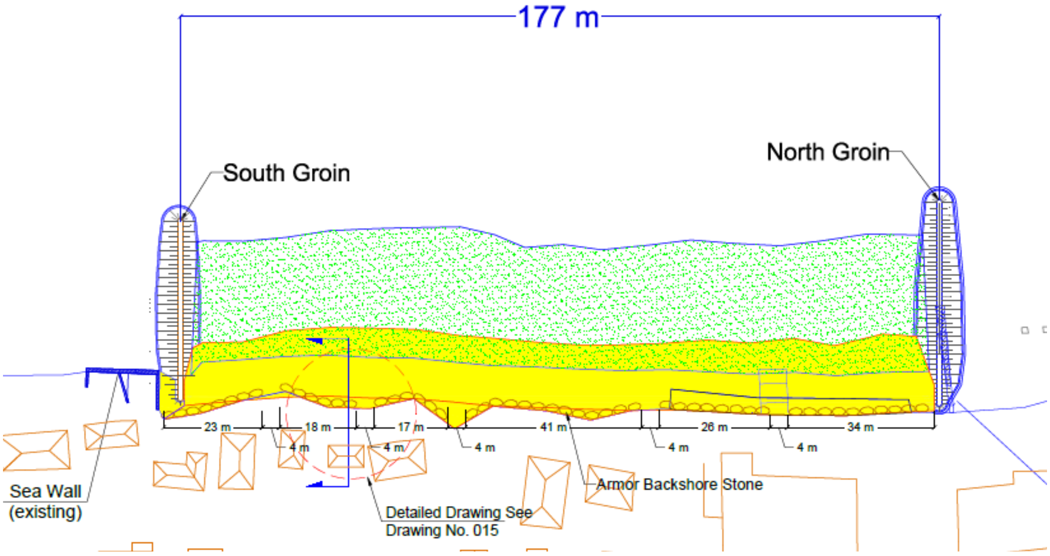
(4) Backshore Stone

In the previous design, the in-situ concrete type was assumed as the backshore wall. After reviewing, the previous proposed backshore wall was modified as "backshore stone" using armor stone with 1.0〜1.5 ton due to the following reasons:

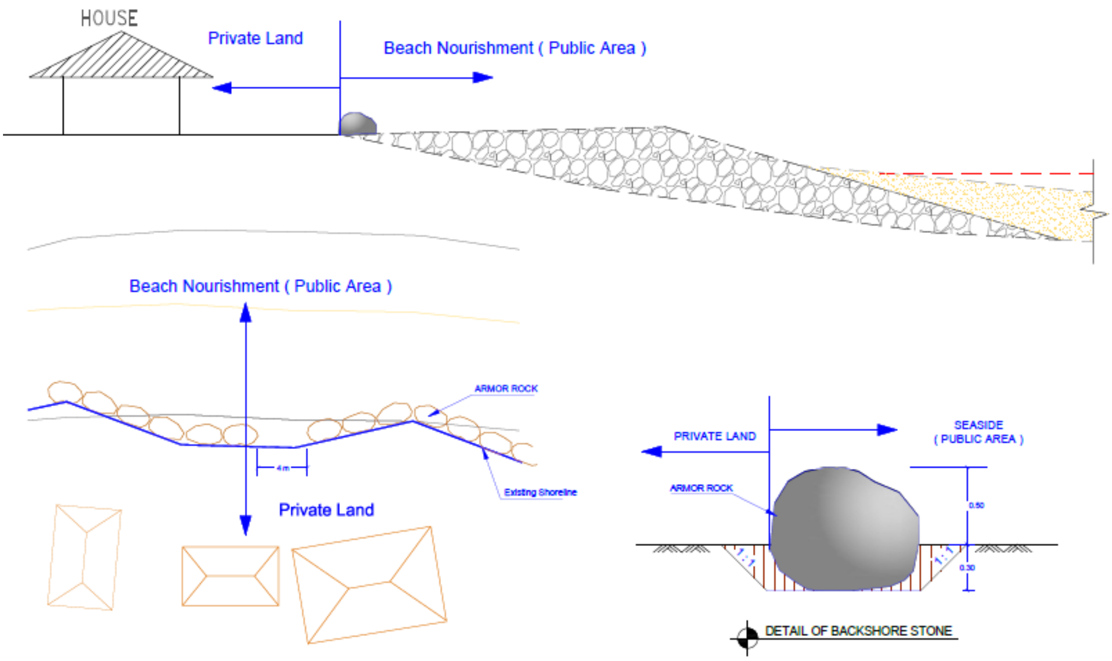
- Artificial image coastal facility made by concrete may not be suitable to the project beach from a landscape point of view.
- Taking into account the natural and construction condition in Tuvalu, some risks that will not secure the required quality are anticipated, and it might be better to minimize the concrete type construction. Also, an easy construction method is preferred.
- Due to the change of armor method for groins, armor rock will be transported from Fiji, and it is easy to transport the backshore stone (same stone as armor rock).

The previous proposed concrete hump was also eliminated based on the agreement of Funafuti community and Kaupule.

The layout and detail of the final proposed backshore armor stone are shown in Figure 5.5.4.



(1) Layout



(2) Detail of Backshore Stone

Figure 5.5.4 Final Design of Backshore Stone

(Source: JICA Expert Team)

5.6 Detailed Design

(1) Design Principle

The typical cross section of the beach nourishment has been determined in Section 5.5.2. The type of structure and the dimension of groin and backshore stone have been studied in this chapter. The stability calculations for the groin and backshore stone have been carried out to fix the dimensions.

(2) Design Standard

The Design Code of the Coastal Protection Facility in Japan (2004) is the design standard applied for the groin and backshore stone.

(3) Design Criteria

1) Design Wave Height

The conditions of a deepwater wave are as follows:

Deepwater Wave Height (30-year return period) : Ho = 1.9 m
Period (30-year return period) : To = 4.2 sec.

- Design Wave Height

Equivalent deepwater wave height has been calculated by the following formula:

Ho' = Kr Kd Ho

Where;

Ho' : equivalent deepwater wave height
Kr : refraction coefficient for the place in question
Kd : diffraction coefficient for the place in question

(Source: Design Code of the Coastal Protection Facility in Japan (2004))

The contour lines are almost parallel and there are no obstacles such as breakwaters or islands offshore of the project site. Therefore, wave refraction and diffraction have not been considered (Kr = 1.0, Kd = 1.0). As a result, the equivalent deepwater wave heights have been determined as follows:

- Equivalent deepwater wave height (30-year return period): Ho' = 1.9 m
- Period (30-year return period) : To = 4.2 sec.
- Wave length (30-year return period : Lo = 1.56 To^2): Lo = 27.5 m

The armor layer of the groin has been designed considering waves of 30-year return period. Based on the diagram of significant wave height as shown in Figure 5.6.1, the significant wave height ($H_{1/3}$: at H.H.W.L +3.28) for the design of groin has been calculated as follows:

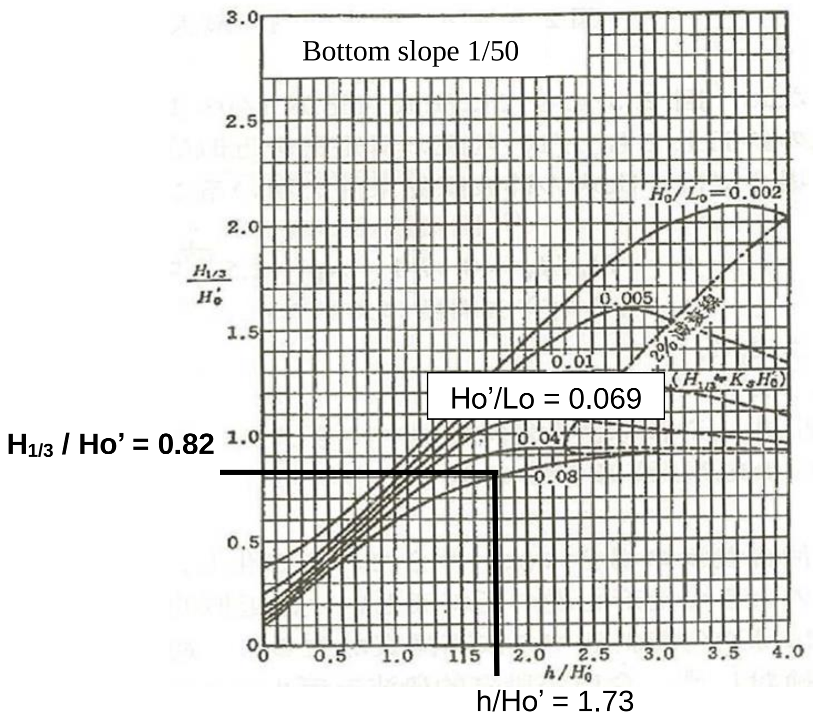


Figure 5.6.1 Diagram of Significant Wave Height

(Source: Design Code of the Coastal Protection Facility in Japan (2004))

- Water depth at the end of the beach slope (CDL +0.14) : h = 3.28 m
- h/Ho' = 3.0/1.9 = 1.73
- Ho'/Lo = 1.9/27.5 = 0.069
- $H_{1/3}$ / Ho' = 0.82 (from Figure 5.6.1)

Thus, the significant wave height has been calculated as follows:

- Significant wave height ($H_{1/3}$) = 0.82 x Ho' = 1.56 m

2) Specific Gravity and Unit Weight of Materials

The following specific gravity and unit weight have been applied for the stability calculations:

- Specific gravity for armor layer : 2.6 ton/m^3
- Unit weight for masonry stone : 18 kN/m^3

(4) Design of Groin

The groin is composed of the armor layer and the core materials. After the stability calculation of the armor layer, the materials of the groin have been selected.

1) Required Weight for Armor Layer

The armor layer of the groin has been calculated by applying the Hudson formula:

$$M = \frac{\rho_r H^3}{K_D (S_r - 1)^3 \cot\alpha}$$

Where:

M	:	minimum mass of armor layer (ton)
ρ_r	:	specific gravity of rubble stones (2.6 t/m^3, due to field survey and Technical Standards and Commentaries for Port and Harbor Facilities, 2002 in Japan)
H	:	wave height used in the stability calculation ($H_{1/3}$ = 1.56 m)
K_D	:	constant determined primarily by the shape of the armor units and the damage ratio (K_D = 2.0)
Sr (ρ_r/ρ_0)	:	specific gravity of rubble stones relative to seawater
ρ_0	:	specific gravity of seawater (1.03 t/m^3)
α	:	angle of the slope from the horizontal line (degree; cotα = 1.5)

(Source: Design Code of the Coastal Protection Facility in Japan (2004))

Based on the above formula, the required weight for the armor layer has been calculated to **0.93 ton/piece**.

2) Selection of Materials for Groin

The local materials for groin are selected as follows:

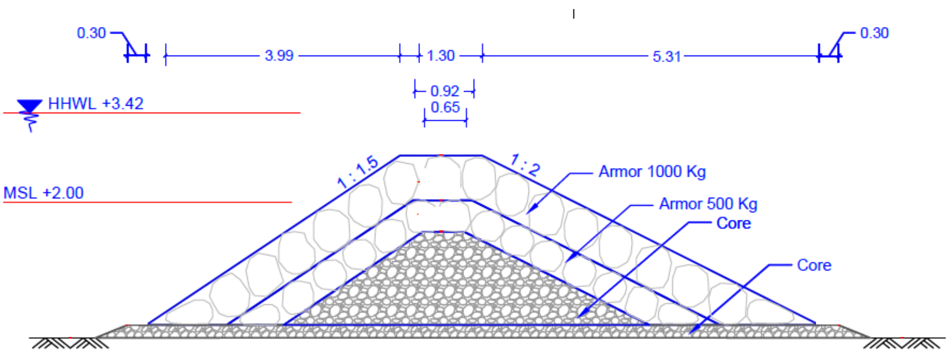


Figure 5.6.2 Typical Section of Groin

(Source: JICA Expert Team)

(5) Design of Backshore Stone

General layout of backshore stone is shown in Figure 5.6.3.

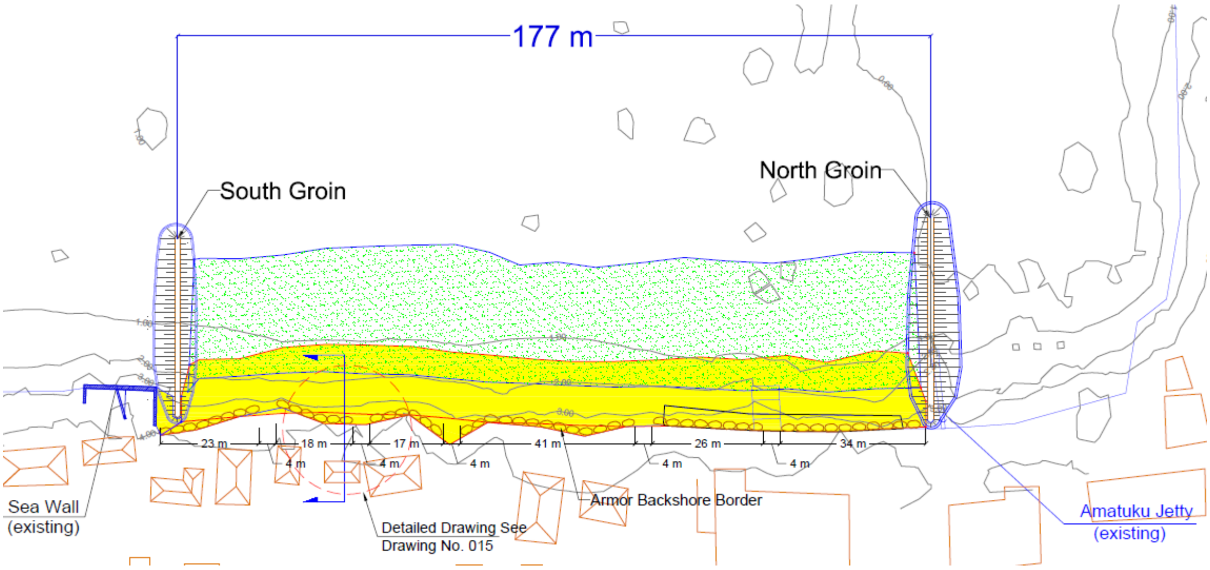


Figure 5.6.3 General Layout of Backshore Stone

(Source: JICA Expert Team)

The height of the stone is set at 0.5 m, which is suitable for people sitting in consideration of the scenery, and the ground was dug about 0.3 m to stabilize the rock. Weight of backshore stone can be calculated as 1.5 ton by rounding off from following equation.

$$W=\rho_r*V=2.6*1/3*\pi*0.8^3=1.25$$

Where

- ρ_r : specific gravity of rubble stones (2.6 t/m^3, due to field survey and Technical Standards and Commentaries for Port and Harbor Facilities, 2002 in Japan)
- V : Volume of rubble stones (m^3)
- W : Weight of rubble stones (t)

The typical section of the backshore stone is shown in Figure 5.6.4.

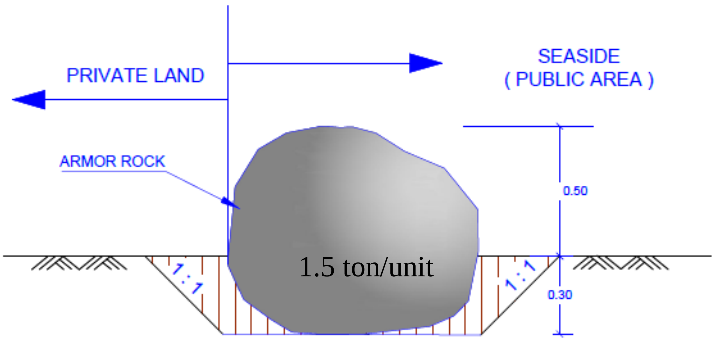


Figure 5.6.4 Typical Section of Backshore Stone

(Source: JICA Expert Team)

(6) Quantity Calculation

Based on the detailed drawing, the quantity for each material was calculated again. Table 5.6.1 shows the comparison for the summary of quantity between the previous and final one.

Table 5.6.1 Comparison for Summary of Quantity

Item	Unit	Quantity	
		Phase-1	Phase-2 (final)
1. Gravel Mining and Transportation			
- Gravel Mining	m^3	3,068.0	3,204.0
- Gravel Transportation	m^3	3,068.0	3,204.0
2. Groin			
- Unloading for Armor Stones	m^3	-	754.0
- Core Placing and Leveling	m^3	325.0	388.0
- Armor Placing and Leveling	m^3	626.0	754.0
4. Gravel Nourishment			
- Gravel Filling and Leveling	m^3	3,068.0	2,816.0
5. Sand Nourishment			
- Sand Transportation	m^3	-	3,864.0
- Sand Filling and Leveling	m^3	3,548.0	3,864.0
6. Backshore Stone			
- Stone Installation	pcs	-	200

(Source: JICA Expert Team)

(7) Design Drawings

The detailed drawing was prepared as listed in Table 5.6.2. Each drawing is attached as Supporting Report-3. These drawings were attached in the bidding document.

Table 5.6.2 List of Design Drawings

No.	Title	Scale
001	Pilot Project Location Map	as shown
002	Existing Project Site	as shown
003	General Layout of Gravel Beach Nourishment	as shown
004	Typical Cross Section	1: 200
005	Cross Section (1)	1: 300
006	Cross Section (2)	1: 300
007	Cross Section (3)	1: 300
008	Cross Section (4)	1: 300
009	Cross Section (5)	1: 300
010	Cross Section (6)	1: 300
011	Cross Section (7)	1: 300
012	Details of North Groin	as shown
013	Details of South Groin	as shown
014	Layout of Backshore Border	as shown
015	Details of Backshore Stone	1:20

(Source: JICA Expert Team)

6. Project Implementation Plan

6.1 Overview

Most construction materials and construction equipment such as backhoe excavator, wheel loader, crawler cranes, barges, and tug boats need to be procured from foreign countries, mainly from Fiji, as these are not available in Tuvalu. Moreover, sea transportation arriving at Funafuti Port from Fiji only happens occasionally, therefore, establishing an effective and efficient delivery schedule will be crucial upon implementing the pilot construction. Additionally, foremen and construction equipment operators need to be hired in Fiji, while skilled and unskilled workers can be employed in Tuvalu. Meanwhile, gravel to be used for the beach nourishment will be taken from Funamanu Island and Papaelise Island, as a result of the coastal survey on suitable mining sites.

Gravel will be collected/gathered and stockpiled on these two islands, and then will be transported by means of barges to the pilot construction site. In order to load the gravel onto the barges on Funamanu Island and Papaelise Island, sufficient water depth has to be secured at the barge mooring area. The gravel, which was transported by the barges to the pilot construction site, will be dumped directly on the site. Sand to be used for sand nourishment is located 10 km north of Fongafale Island and will be transported from the stockpile by four dump trucks.

Armor stones to be used for the groin will be loaded into the large barge in Fiji and that large barge will be towed by a tug boat to Tuvalu. Once the barge arrives at the pilot construction site, armor stones will be dumped directly on the groin area. The installation work of armor stones and the filling work of core material will be carried out from both the land side and the seaside according to the construction procedure. The work from the sea side will be carried out by the backhoe on the self-propelled barge with divers. The work from the land side will be carried out by a backhoe and wheel loader.

Other ancillary facilities include backshore stone which will be installed along the boundary of the nourishment part of gravel by the backhoe.

The pilot construction site is located inside a lagoon, providing comparatively calm oceanographic conditions, while cyclones may hit Tuvalu during the rainy season (November to March). Therefore, the implementation of the beach nourishment should be completed before the rainy season starts and this should be considered in establishing a construction plan and implementation schedule. The construction period is expected to take about 6.2 months including the mobilization and demobilization.

6.2 Main Review from Phase-1 Study

The implementation plan was initially prepared in March 2013 in the Interim Report of the study in Phase-1 (see Supporting Report-4 for details). Then in Phase-2, the plan was reviewed and finalized before the construction was started in June 2015, while considering the changes of natural and social conditions. The main points and changes from the study in Phase-1 (i.e. Interim Report) were listed in this section and the finalized implementation plan is shown in the following sections.

(1) Main Construction Materials and Equipment

- Main construction equipment, materials, foremen and heavy machine operators should be procured from foreign countries.

(2) Gravel Work

- In Phase-1, the gathering place of gravel is the west side of Funamanu Island.
- In Phase-2, after investigating on the gravel volume, it showed that gravel was not sufficient and in order to cover for the shortage of gravel, gravel should be collected from three places, the west side and east side of Funamanu Island and the west side of Papaelise Island.

(3) Groin

- In Phase-1, groins at both sides of the nourishment area will be constructed from sandbags and gabions that will serve as a temporary structure.
- In Phase-2, groins will be constructed from the core materials and the armor stones to be transported and imported from Fiji will serve as a permanent structure.

(4) Sand Work

- In Phase-1, the contractor carries out the sand mining work, transport work, filling and leveling work.
- In Phase-2, the contractor carries out the transportation of sand from the stockpile area provided by the New Zealand Aid Programme, as well as the filling and leveling work.

(5) Backshore Stone

- In Phase-1, backshore stone will be constructed from concrete debris.
- In Phase-2, armor stones to be transported and imported from Fiji will be placed on the backshore stone.

6.3 Construction Planning

(1) Procurement

1) Construction Materials

Table 6.3.1 shows the procurement schedule for the construction materials.

Table 6.3.1 List of Construction Materials

Materials	Tuvalu	Fiji
Armor stone		○
Core materials	○	○

(Source: JICA Expert Team)

2) Manpower

Table 6.3.2 shows the procurement schedule for manpower.

Table 6.3.2. List of Labor

Manpower	Tuvalu	Fiji
Foreman		○
Operator		○
Crew		○
Diver		○
Skilled Labor	○	
Unskilled Labor	○	

(Source: JICA Expert Team)

3) Construction Equipment

Table 6.3.3 shows the procurement schedule for the construction equipment.

Table 6.3.3. List of Construction Equipment

Construction Equipment	Tuvalu	Fiji
Barge (self- propelled)		○
Barge		○
Tug Boat		○
Crawler Crane		○
Backhoe Excavator		○
Wheel Loader		○
10 t Dump Truck		○

(Source: JICA Expert Team)

Figure 6.3.1 shows a self-propelled barge available in Fiji, which is suitable for the pilot construction.

Figure 6.3.1 Self-propelled Barge in Fiji

(Source: JICA Expert Team)

(2) Construction Method

1) Temporary Yard

A temporary yard for office, workshop, and storage area of heavy equipment and materials including temporary fence should be established around the Tausoalima Community Hall. The total area required for the temporary yard is assumed to be approximately 1,000 m^2. In addition, permission for its usage should be obtained from Kaupule.

Figure 6.3.2 shows the temporary yard area around the Tausoalima Community Hall.

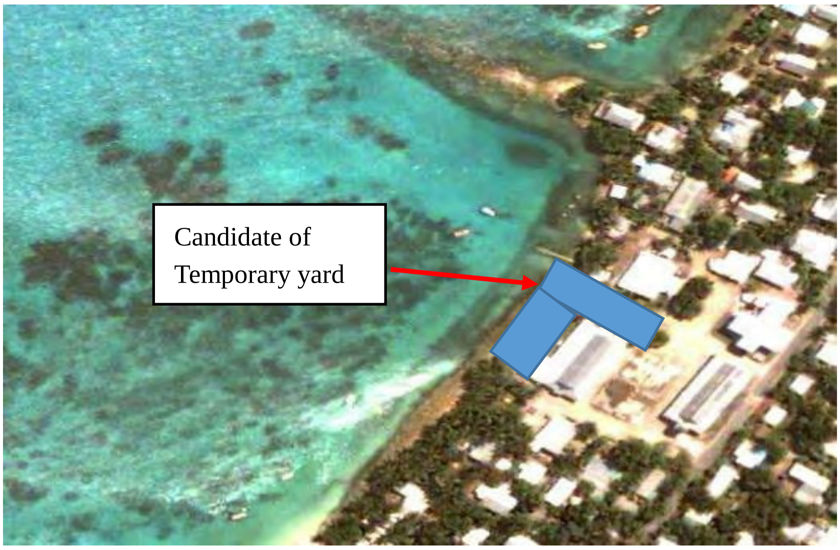


Figure 6.3.2 Temporary Yard Area Around Tausoalima Community Hall

(Source: JICA Expert Team)

2) Beach Nourishment

Because sea route to the nourishment area is narrow, nourishment work along the coastline will be carried out from the south to north in consideration of smooth material transportation. Also, in terms of the coastline section, the removal of the existing concrete debris on the coast will be done first, and then the coast will be backfilled with gravel transported from the mining area. The following explains the beach nourishment procedure including the gravel collection on Funamanu Island and Papaelise Island.

a) Removal of the Existing Concrete Debris on the Coastline of the Nourishment Area

- The existing concrete debris on the coastline will be shifted to a nearby area using a backhoe excavator prior to backfilling the nourishment area with gravel.

b) Gravel Collection

- First, a backhoe excavator for gathering gravel from the tidal area and fuel will be brought directly to Funamanu Island and Papaelise Island by a barge at high tide. The existing concrete debris on the coastline will be shifted to a nearby area using a backhoe excavator prior to backfilling the nourishment area with gravel.
- Gravel should be taken below M.H.W.L. by the backhoe excavator and they will be placed on the crown of the island. Then, excavated gravel will be collected and stockpiled at one place.
- Gravel will be collected from the west and the east side of Funamanu Island and the west side of Papaelise Island.

Figure 6.3.3 shows the location of the mining gravel, and Figure 6.3.4 to Figure 6.3.6 show the topography of each gravel collection site.

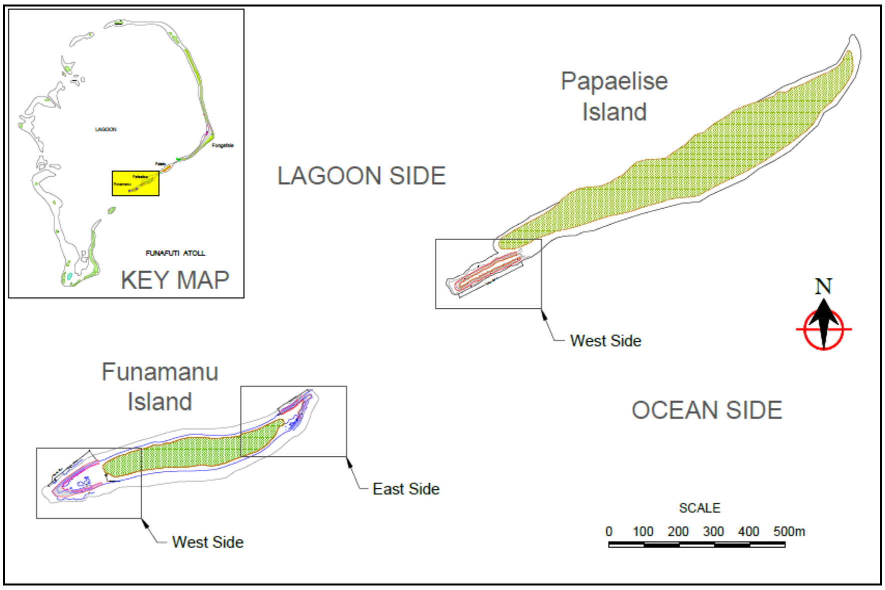


Figure 6.3.3 Location of Mining Gravel

(Source: JICA Expert Team)

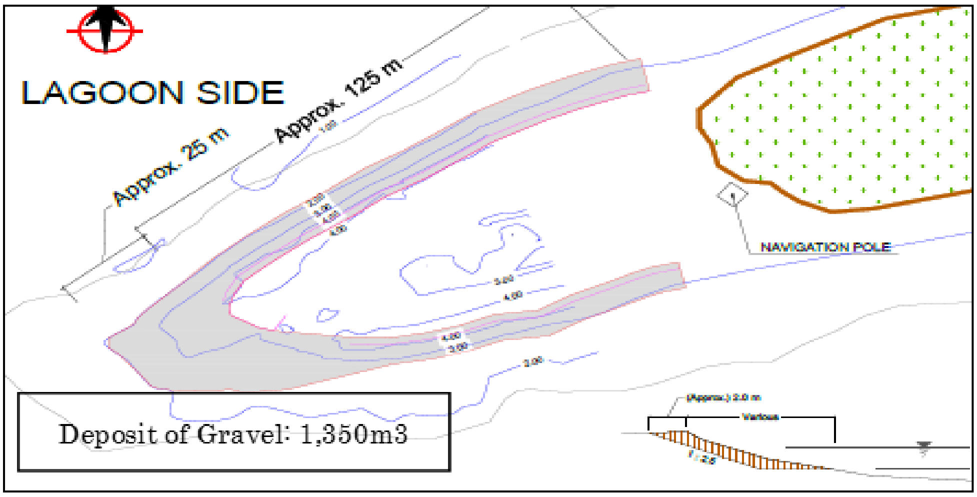


Figure 6.3.4 Location of Gravel Gathering on the West Side of Funamanu Island

(Source: JICA Expert Team)

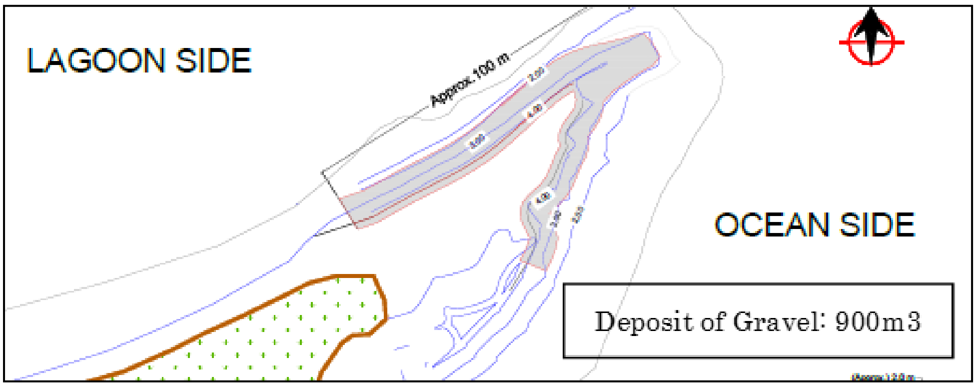


Figure 6.3.5 Location of Gravel Gathering on the East Side of Funamanu Island

(Source: JICA Expert Team)

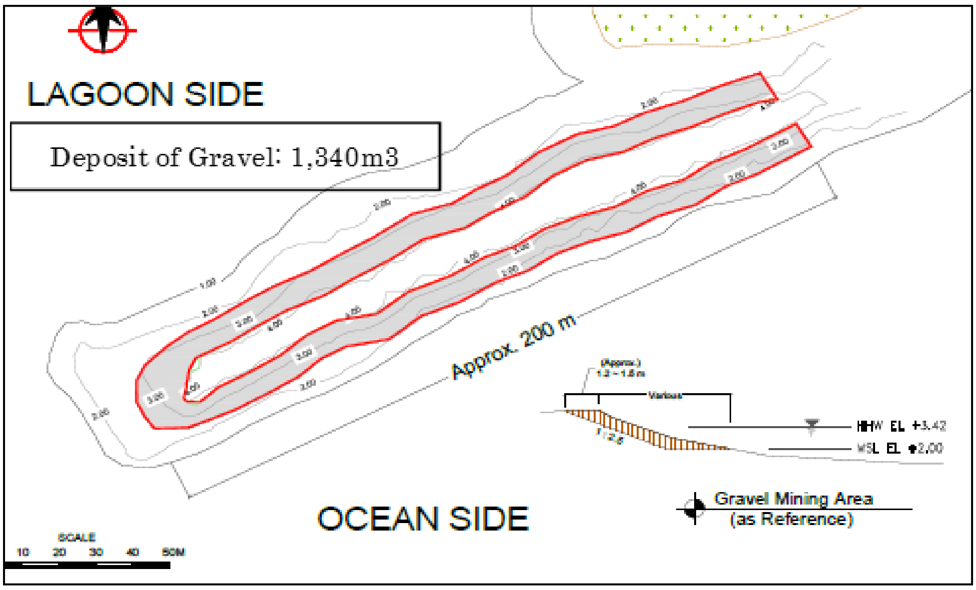


Figure 6.3.6 Location of Gravel Gathering on the West Side of Papaelise Island

(Source: JICA Expert Team)

Figure 6.3.7 shows the gathering method of gravel and position in section of gravel stockpile at a high place in Funamanu Island and Papaelise Island.

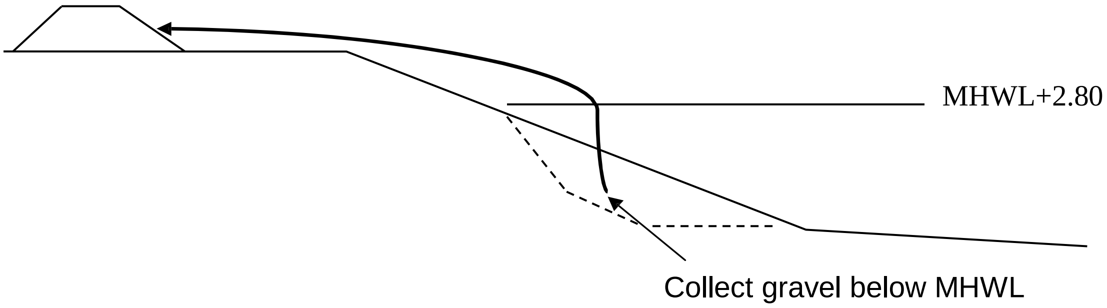


Figure 6.3.7 Gathering Method and Position in a Section of the Shoreline

(Source: JICA Expert Team)

c) Transportation of Gravel from Funamanu and Papaelise Island to Pilot Construction Site

- Gravel will be loaded onto the 20 t barge using a backhoe excavator.
- The 20-t barge will be towed by two fisher boats and will be transported using a tug boat (160 hp).
- Three 20 t barges will be towed by a tug boat (160 hp) to the construction site.
- Gravel will be dumped directly on the gravel nourishment area.

Figure 6.3.8 shows the transportation route of gravel.

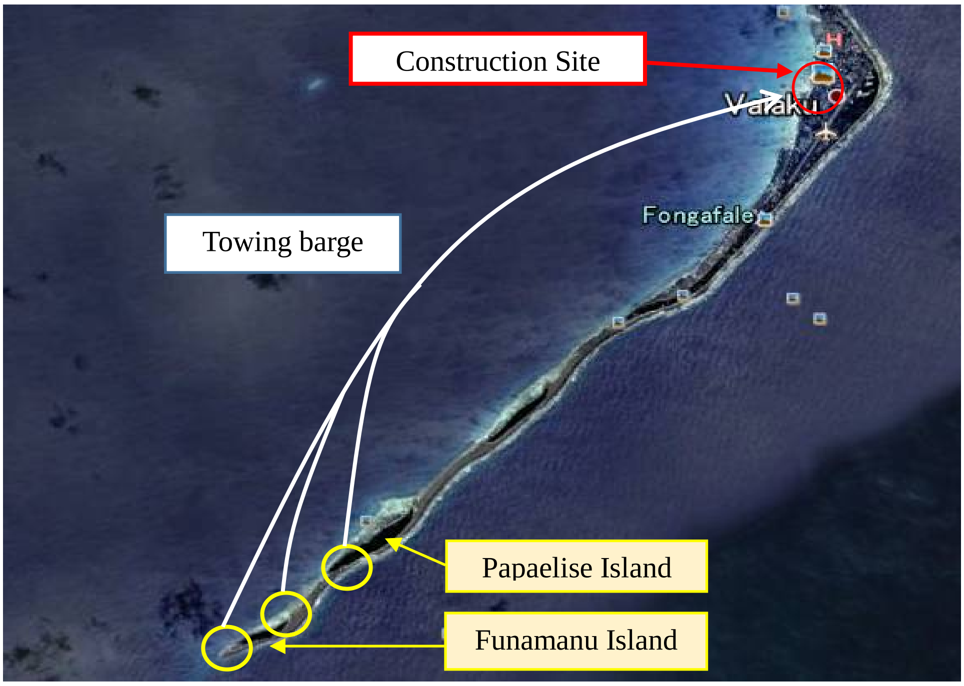


Figure 6.3.8 Transportation Route of Gravel

(Source: JICA Expert Team)

d) Filling and Leveling Gravel

- Gravel will be filled and leveled by a backhoe excavator and a wheel loader.

e) Sand Transportation

Sand to be used for the sand nourishment will be transported by four dump trucks from the stockpile located 10 km north of Fongafale Island. Figure 6.3.9 shows the transportation route of sand.

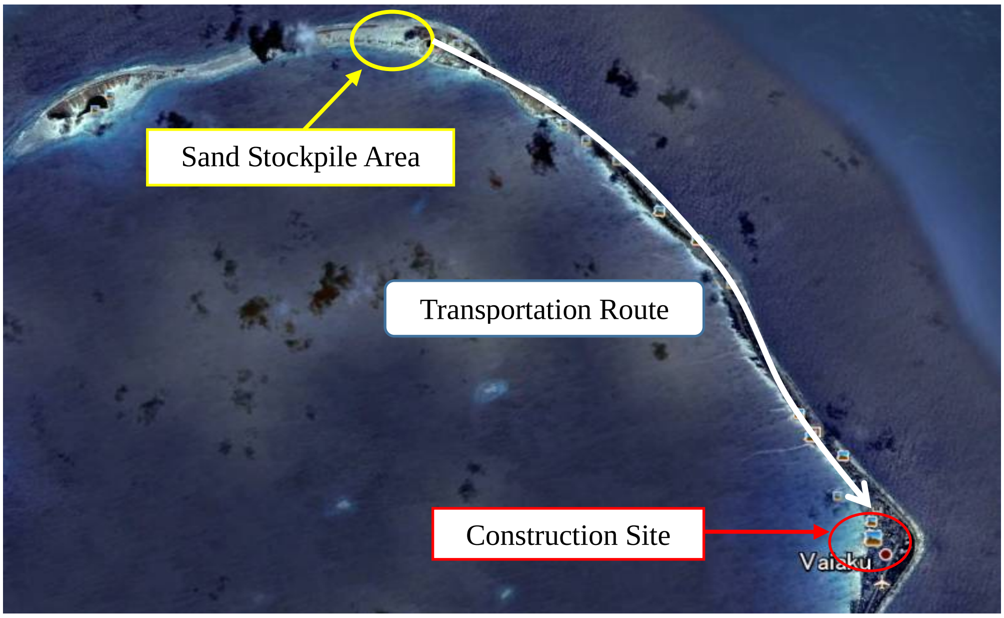


Figure 6.3.9 Transportation Route of Sand

(Source: JICA Expert Team)

f) Sand Filling and Leveling

Sand will be filled and leveled by a backhoe and a wheel loader

g) Groin

- Armor stones to be used for the groin will be loaded onto the big barge in Fiji and that big barge will be transported by the tug boat to Tuvalu.
- Once the barge arrives at the pilot construction site, armor stones will be dumped directly on the groin area.
- Installation work of armor stones and filling work of core materials will be carried out from the land side and the seaside according to the construction procedure.
- The work from the sea side will be carried out by the backhoe on the self- propelled barge with the divers. The work from the land side will be carried out by a backhoe and a wheel loader

h) Backshore Stone

- Armor stones (1.5 ton) will be installed as a backshore stone along the land boundary of nourishment part of gravel using a backhoe.

(3) Construction Flow Chart

The flow chart for the construction procedure is shown in Figure 6.3.10.

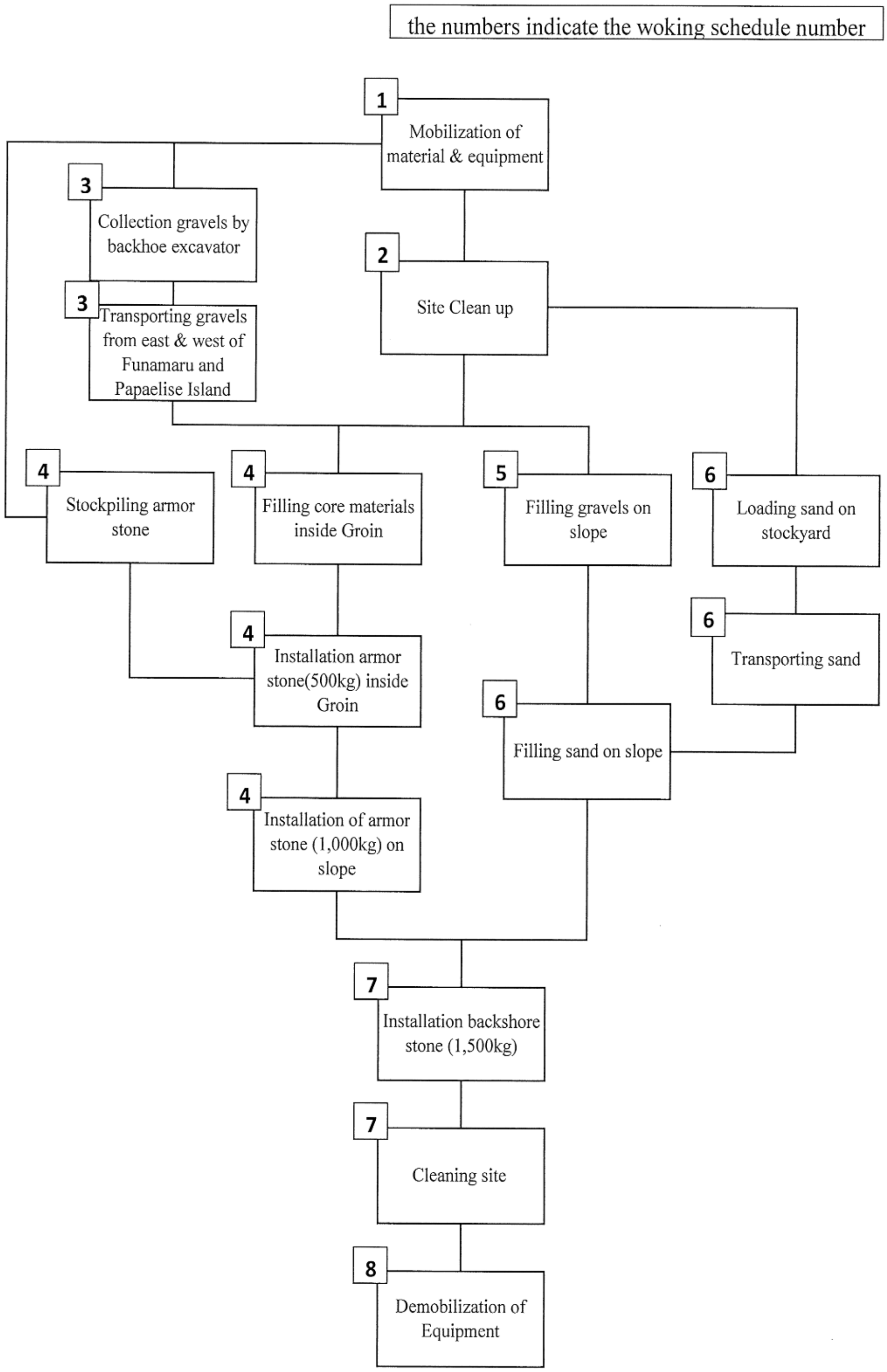


Figure 6.3.10 Construction Flow Chart

(Source: JICA Expert Team)

6.4 Implementation Schedule

(1) Construction Schedule

The construction schedule is shown in Table 6.4.1.

Table 6.4.1 Construction Schedule

Description	1st month	2nd month	3rd month	4th month	5th month	6th month	7th month
Mobilization and Preparation							
Site clean-up							
Gravel Mining							
Groin							
Gravel Nourishment							
Sand Nourishment							
Backshore Stone							
Demobilization							

(Source: JICA Expert Team)

(2) Implementation Schedule

Construction period is expected to take about 6.2 months. Activities for the pilot construction should be carried out taking into account the oceanographic conditions (i.e., during the monsoon season, implementation of the beach nourishment activities should be avoided). After the completion of the pilot construction, monitoring will be carried out at the pilot construction site. Table 6.4.2 presents the overall implementation schedule.

Table 6.4.2 Implementation Schedule (Pilot Construction and Monitoring)

Month / Work Items	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Tender Stage																								
Construction Stage																								
Monitoring Stage																								

(Source: JICA Expert Team)

6.5 Cost Estimates

(1) Condition of Cost Estimates

1) Manpower

Table 6.5.1 shows the estimated manpower cost used. Skilled and unskilled laborers are available in Tuvalu, while other manpower should be procured in Fiji.

Table 6.5.1 Implementation Schedule (Pilot Construction and Monitoring)

Description	Unit Rate (FJD/month)
Foreman	5,500
Skilled laborer	1,890
Unskilled laborer	1,220

(Source: JICA Expert Team)

2) Construction Equipment

Most of the construction equipment will be brought from Fiji and/or other South Pacific nations. A barge with a self-propelled system is suitable for the Project because sea route is narrow and shallow considering the existing water depth to the nourishment area and the gravel collection site. Table 6.5.2 shows the unit costs applied for construction equipment. The unit costs include the wage of the operators and the fuel costs.

Table 6.5.2 Construction Equipment Costs

Description	Specification	Units Cost (FJD/day)
Barge (self-propelled)	160 ton-class	8,910
Crawler Crane	50 tons	2,800
Backhoe Excavator	20 tons	1,000
Wheel Loader	2 m^3	1,200
Flat Barge	20 tons	990
Flat Barge	5000 tons	2,400

(Source: JICA Expert Team)

3) Construction Material

All the construction materials to be used for the construction works are imported. Table 6.5.3 shows the unit costs for materials.

Table 6.5.3 Material Cost

Description	Unit	Unit Cost (FJD)
Armor Stone	m^3	103
Gravel	m^3	54.1
Sand	m^3	0

(Source: JICA Expert Team)

4) Exchange Rates

The exchange rates (average Dec. 2014 to Feb. 2015) adopted for the cost estimates are as follows:

- FJD 1.00 = JPY 60.3

- AuD 1.00 = JAY 99.8

- USD 1.00 = JAY 123.5

(2) Construction Costs

Based on the preceding condition, the construction costs were estimated as shown in Table 6.5.4

Table 6.5.4 Construction Cost

Bill of Quantities 1.0 Fj$ = 60.3 Jpy

No	Description	Unit	Q`ty	Fj $		JPY	
				Unit Rate	Amount	Unit Rate	Amount
A							
1	General Requirement						
1-1	Mobilization	Ls	1	391,575	391,575	23,611,973	23,611,973
1-2	Demoblization	Ls	1	306,365	306,365	18,473,810	18,473,810
1-3	Preparatory Works	Ls	1	43,000	43,000	2,554,200	2,554,200
	Sub Total				740,940		**44,639,982**
2	Gravel Mining & Transportation						
2-1	Gravel Mining	m3	3,204	100	320,830	6,038	19,346,059
2-2	Gravel Transportation	m3	3,204	255	815,638	15,350	49,182,971
	Sub Total				1,136,468		**68,529,030**
3	Groin						
3-1	Unloading For Armor Stone	m3	754	154	116,186	9,292	7,006,016
3-2	Core Planning & Leveling	m3	388	603	234,080	36,379	14,115,035
3-3	Armor Placing & Leveling	m3	754	1,238	933,161	74,628	56,269,591
	Sub Total				1,283,427		**77,390,642**
4	Gravel Nourishment						
4-1	Site Clean up	Ls	1	8,410	8,410	507,123	507,123
4-2	Gravel Filling & Leveling	m3	2,816	71	199,952	4,282	12,057,110
	Sub Total				208,362		**12,564,233**
5	Sand Nourishment						
5-1	Sand Transportation	m3	3,864	41	158,333	2,471	9,547,480
5-2	Sand Filling & Leveling	m3	3,864	23	87,934	1,372	5,302,420
	Sub Total				246,267		**14,849,900**
6	Backshore Stone						
6-1	Stone Installation	Nos	200	87	17,341	5,228	1,045,662
	Sub Total				17,341		**1,045,662**
7	Facility Procurement						
7-1	Boat Trailer	Nos	1		11,600		699,480
7-2	Rubbish Bin	Nos	5	850	4,250		256,275
	Sub Total				15,850		**955,755**
	Total (Direct Cost)				3,632,805		**219,975,205**
B	Indirect Cost	Ls	20%		726,561		43,995,041
	Total (Direct and Indirect Cost)				4,359,366		**263,970,246**

Note: Amount is not necessarily equivalent to the product of Q'ty and unit rate in the table as actual unit rate include number of decimals

(Source: JICA Expert Team)

6.6 Summary of Construction Schedule and Cost for Phase-1 and 2

Construction schedule and cost prepared in both phases were summarized in the following sections. Those of Phase-2 were the final results of construction schedule and cost. In addition, the cost in case that sand would be procured from lagoon by dredging was shown as reference.

(1) Construction Schedule

Table 6.6.1 Construction Schedule

	Phase-1 (Initial)	Phase-2 (Final)
Construction Schedule	5.5 months	6.2 months

(Source: JICA Expert Team)

(2) Construction Cost

Table 6.6.2 Construction Cost for Phase-1 (Initial) (FJD 1.00 = JPY 52.93)

Description	FJD	JPY
General Requirement	561,100	29,699,023
Gravel Mining and Transportation	1,084,920	57,424,815
Groin	373,134	19,750,000
Gravel Nourishment	494,910	26,195,587
Sand Nourishment	1,134,252	60,035,958
Backshore Stone	96,685	5,117,548
Facility Procurement	0	0
Total (Direct Cost)	3,735,002	198,222,931
Contingencies (10%)	374,500	19,822,293
Grand Total	4,119,502	218,045,224

(Source: JICA Expert Team)

Table 6.6.3 Construction Cost for Phase-2 (final) (FJD 1.00 = JPY 60.30)

Description	FJD	JPY
General Requirement	740,940	44,639,982
Gravel Mining and Transportation	1,136,468	68,529,030
Groin	1,283,427	77,390,642
Gravel Nourishment	208,362	12,564,233
Sand Nourishment	246,267	14,849,900
Backshore Stone	17,341	1,045,662
Facility Procurement	15,850	955,755
Total (Direct Cost)	3,632,805	219,975,205
Indirect Cost (20%)	726,561	43,995,041
Grand Total	4,359,366	263,970,246

(Source: JICA Expert Team)

(3) Construction Cost in case of that Sand would be Procured from Lagoon by Dredging

Table 6.6.4 Construction Cost (Sand Procurement from Lagoon by Dredging)

Case	Fj$	JPY
This Project (sand was procured from stock area on land)	4,359,366	263,970,246
Case that sand would be procured from lagoon by dredging (as reference)	5,862,000	348,000,000

(Source: JICA Expert Team)

7. Environmental and Social Considerations

7.1 Overview

As per the Environment Protection Act (2008) and Environment Protection (Environmental Impact Assessment) Regulations 2014, an environment impact assessment must be undertaken for prescribed development activities and subsequently obtain an environmental approval from the EIA authority. An environmental approval is obtained by submitting a Preliminary Environmental Assessment Report (PEAR) and if deemed necessary a full Environmental Impact Assessment (Full EIA) report (Section 7.2 outlines the EIA procedure).

Since this Project was prescribed as a development activity under the EIA regulation, a Preliminary Environmental Assessment Report (PEAR) was initially prepared with the assistance of JICA Expert Team, taking into account the requirements of both Tuvalu's EIA regulations and JICA Guidelines for Environmental and Social Considerations 2010. However, since the requirements of the JICA guideline are more or less in line with the requirements of Tuvalu's full EIA, the contents of the prepared PEAR can be considered more or less a Full EIA. Table 7.1.1 shows the key requirements of a Full EIA and the corresponding requirements of PEAR and JICA Environmental Guideline.

Table 7.1.1 Key requirements of a Full EIA and the corresponding requirements of PEAR and JICA Environmental Guideline

Key requirements of full EIA	Requirements of PEAR	Requirements of JICA Guideline	Preparation in the Project
Description of the project	Required	Required	✓
Justification of the project	Required	Required	✓
Description of project affected area	Required	Required	✓
Analysis of alternatives including no option	Not required	Required	✓
Assessment of environmental impacts			
Direct and indirect impacts	Required	Required	✓
Accumulative impacts	Not required	Required	✓
Proposal of mitigation measures	Required	Required	✓
Monitoring plan	Not required	Required	✓
Public consultation	Not required	Required	✓

(Source: JICA Expert Team)

The PEAR was submitted to the Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour (MFATTEL) on March 2015 and subsequently was approved on April 2015 after minor revisions. Hence a Full EIA was not required. Supporting Report-5 is the final version of the PEAR with its approval letter attached.

7.2 Outline of Tuvalu's EIA Regulation

Following outlines the main procedures of the EIA approval process as stipulated in the Environment Protection (Environmental Impact Assessment) Regulations 2014:

- As an initial step of the EIA procedure, the project proponent is required to submit a PEAR, which should include brief descriptions of the development proposal, potential environmental impacts, mitigation measures and so on.
- The PEAR report will be reviewed by Department of Environment (DOE) and subsequently approved by the Minister if no significant environmental impacts are expected.
- On the other hand, if the development proposal is foreseen to have potentially significant environmental impacts, the Minister may request the project proponent to conduct and submit a Full EIA report.
- The Full EIA report will be initially reviewed by DOE and subsequently by the Environmental Assessment Task Force (EAFT). The review results and recommendations of the EAFT will then be reported to the Ministry for final decision.

Figure 7.2.1 shows the main flow of the EIA approval procedure as stipulated in the EIA Regulations.

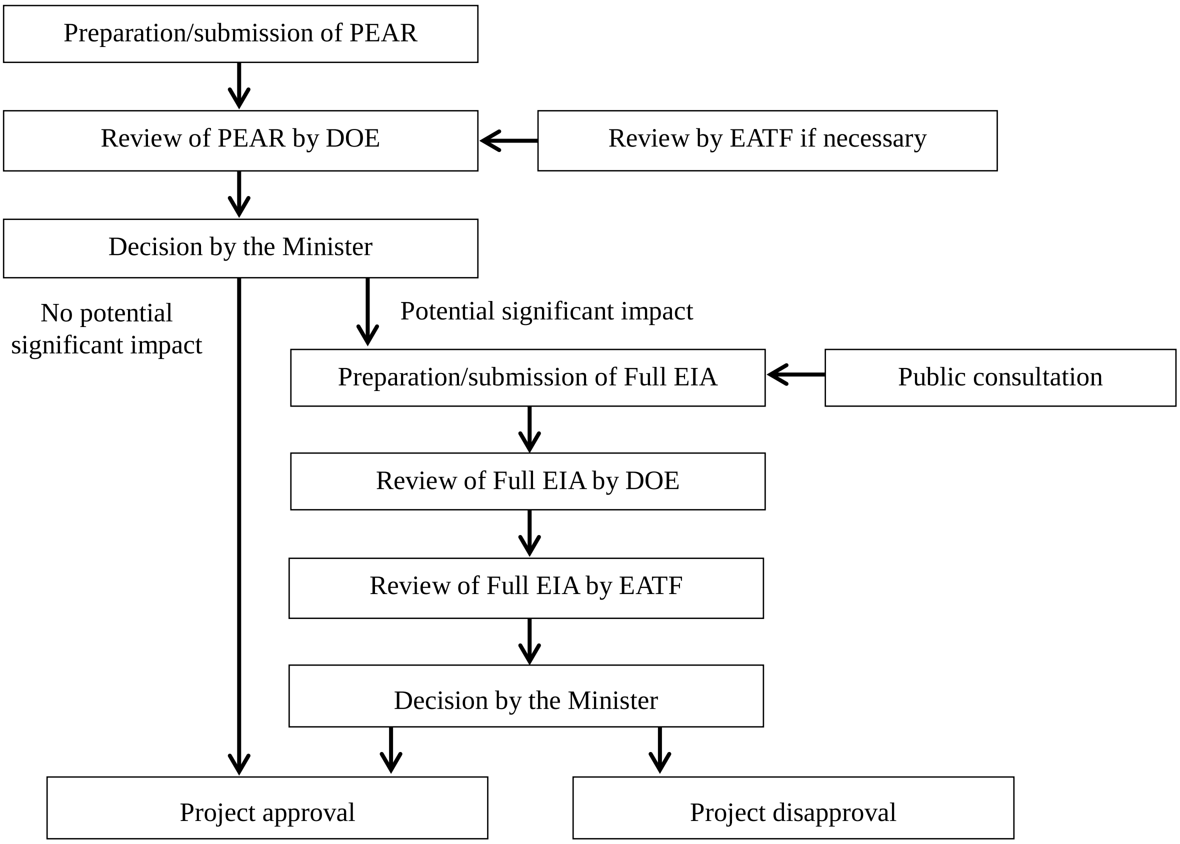


Figure 7.2.1 Main Flow of the EIA Approval Procedure

(Source: Environment Protection (Environmental Impact Assessment) Regulations 2014)

7.3 Scope of PEAR

The scope of the PEAR was identified through a scoping exercise based on JICA's "Guidelines for environmental and social considerations (2010)", which provides a list of items to be considered in the scoping process. Scoping was conducted based on information collected through field surveys, interview surveys, field reconnaissance and so on. Table 7.3.1 shows the results of the scoping including the rationale behind the rating. Items rated as having potential negative impacts were assessed and appropriate mitigation measures considered. An Environmental Management Plan and monitoring plan were also prepared based on the impact assessment.

Table 7.3.1 Results of scoping

Category			Stage	Rating	Rationale
Physical environment	1	Air pollution	C	B-	Dust and exhaust gases emitted from construction works may affect the local residents.
			PC	D	There are no air pollution sources.
	2	Water pollution	C	B-	- Sand-dumping works will generate turbid plumes. - Possible oil leakage from construction machines.
			PC	B+	The new gravel/sand is expected to improve the local seawater quality through its purification function.
	3	Soil pollution	C, PC	B+	Possible oil leakage from construction machines.
	4	Waste	C	B-	Construction wastes (e.g. solid waste, waste oil, human waste) may contaminate the environment if not managed properly.
			PC	B-	Beach users may litter on the beach.
	5	Noise/vibration	C	B-	Noise generated from construction works may become a nuisance to the local residents.
			PC	D	There are no major noise sources.
	6	Ground subsidence	C, PC	D	There are no activities that may cause ground subsidence.
	7	Offensive odor	C, PC	D	There are no odor sources.
	8	Bottom sediment	C, PC	D	There are no sediment pollution sources.
Natural Environment	9	Conservation area	C, PC	D	No impacts expected to Funafuti Conservation Area as it is located far from the Project site.
	10	Ecosystem, flora/fauna	C	B-	- Corals along the nearshore of Funamanu and Papaelise may be damaged through gravel collection works. - Benthic organisms at the Project site will be buried by gravel and sand. - Some trees along the shoreline may have to be cut if they obstruct construction works.
			PC	B+	The new gravel/sand beach is expected to provide new natural habitat.
	11	Hydrology	C, PC	D	There are no activities that may affect the hydrology.
	12	Topography	C	B-	The shoreline of Funamanu and Papaelise may be affected by gravel collection.
			PC	B-	Groin may affect the sandy beach south of the Project site.
Social Environment	13	Involuntary resettlement	C, PC	D	There will be no involuntary resettlement.
	14	Vulnerable social groups (poor, indigenous people etc.)	C, PC	D	There are no vulnerable social groups at the Project site.
	15	Livelihood, living environment	C	B+	Construction works will provide employment opportunities to the local people.
				B-	Construction works and presence of workers may become a nuisance to the local residents.
			PC	B+	The Project should improve the living conditions of the local residents by reducing the risk of disasters.
	16	Land use	C	B-	Some of the existing land use will be restricted due to construction works.
			PC	D	No restrictions or alteration of existing land use.
	17	Local resource	C, PC	B-	Gravel and sand will be procured locally, which if not collected sustainably will significantly affect the local resource.

Category			Stage	Rating	Rationale
	18	Water use	C	B-	Some of the existing water use (e.g. boat mooring, bathing) will be restricted due to construction works.
			PC	B+	The new gravel/sand beach will provide safer access to the sea.
	19	Social infrastructures and services	C, PC	D	There are no activities that may have adverse impacts on social infrastructures and services.
	20	Social institutions (social capital, local decision-making institutions)	C, PC	D	There are no activities that may have adverse impacts on social institutions.
	21	Misdistribution of benefit and losses	C, PC	D	The Project in general should mutually benefit the local people by enhancing coastal protection.
	22	Local conflicts of interest	C, PC	D	No major conflict of interest is expected.
	23	Cultural heritage	C, PC	D	There are no cultural heritages around the Project site.
	24	Landscape	C	D	While construction works will temporary change the landscape, its impacts will be insignificant due to the limited duration and scale.
			PC	B+	The landscape will improve as the current debris-comprised beach will transform into a natural gravel/sand beach.
	25	Gender	C, PC	D	There are no activities that may trigger gender issues.
	26	Children's rights	C, PC	D	There are no activities that may violate children's rights.
	27	Infectious diseases (HIV/AIDS etc.)	C, PC	D	The risk of spreading infectious diseases is low as the number of incoming foreign workers is limited.
	28	Occupational safety	C, PC	D	The risk of occupational accidents is low providing that standard safety practices are implemented.
Others	29	Accidents	C, PC	B-	Risk of accidents especially in relation to dump truck transportation.
	30	Trans-boundary and climate change impacts	C, PC	D	The Project does not involve any activities that may have trans-boundary or climate change impacts.

Legend of Project stage:

C: Construction phase

PC: Post-construction phase

Rating criteria:

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown.

D: No impact is expected.

7.4 Conclusion

Main findings of the PEAR are summarized as follows:

- One of the primary environmental concerns during the construction stage was the possibility of coral damage mainly during gravel collection works. Hence to minimize such damage, various mitigation measures were planned (e.g. entrance and exit of reef area to be allowed only during high tide to minimize contact with coral) together with a coral monitoring plan. Otherwise, since the construction is of relatively small scale and short duration, and providing that the proposed mitigation measures and monitoring programs are appropriately implemented, environmental impacts of the Project were predicted to remain within minor to moderate level.
- In order to check the long-term impacts of the Project, monitoring activities were planned to continue for few years in the post-construction phase namely for coral, marine life and shoreline topography.
- Two public consultation meetings (Funafuti community and Falekaupule) were held to explain the basic plan of the Project and likely environmental impacts and planned mitigation measures. All the participants were supportive of the Project once their concerns were answered. The minutes of the meeting are attached to the PEAR.

8. Public Consultation and Project Coordination Committee (PCC)

8.1 Overview

This chapter summarizes the implementation procedures of the public consultation and Project Coordination Committee (PCC) in obtaining an agreement on plan and design of the beach nourishment and their relative reports. Figure 8.1.1 shows the implementation flow of the public consultations/stakeholder meetings with Funafuti communities and the PCC with the Government of Tuvalu.

Phase-1

First PCC in Phase-1 on 6 June 2012

- Agreement on the contents of the inception report.
- Clarification of issues to be considered during the project period among the Government of Tuvalu, stakeholders, and JICA.

Stakeholder meeting with Funafuti communities (Jul., Oct. 2012, 7-16 Feb 2013)

- Introduction and basic explanation of the Project
- Confirmation on the degree of understanding of the Project
- Agreement on issues regarding the detailed design of the pilot project.
- Clarification of issues to be discussed and finalized before the implementation.

Second PCC in Phase-1 on 27 February 2013

- Discussion on the interim report and the vision of the pilot project

Phase-2

First PCC in Phase-2 on 4 February 2015

- Review of interim report
- Obtain agreement for basic points of the Project

Stakeholder meeting with 1) representatives of Falekaupule on 19 February, 2) Funafuti communities on 23 February, and 3) Falekaupule on 24 February 2015

- Confirmation on objective and concept of the Project
- Confirmation on the basic plan
- Request for participation in beach control after construction
- Explanation on possible environmental impact and its mitigation measure

Second PCC in Phase-2 on 25 February 2015

- Obtain agreement for final planning and design of the beach nourishment
- Request for participation in monitoring and maintenance from C/P and relative agencies

Third PCC in Phase-2 on 17 June 2015

- Obtain agreement on progress report (including contents of 2nd PCC)

Figure 8.1.1 Implementation Flow of the Public Consultation and PCC

(Source: JICA Expert Team)

8.2 Stakeholders of Public Consultation and PCC

Figure 8.2.1 shows the stakeholders involved in the public consultation and the PCC. In the figure, the area enclosed with a red line shows the stakeholders of PCC, while the area enclosed with a blue line shows the stakeholders of the public consultation. The former includes the C/P (Department of Environment, MFATTEL), the Public Works Department, Department of Land and Survey, Department of Fisheries, MET (Tuvalu Metrological Service). While, the latter includes the Funafuti communities (Funafuti Kaupule, Funafuti Falekaupule Funafuti Women Group, Fisherman Group, Masaua Group, and the community from the outer islands).

Falekaupule is the supreme decision-making body of all matters in the Funafuti communities that are of public interest or political importance. Therefore, public consultations/stakeholder meetings were conducted with permission from the Falekaupule first, then discussions with other community members were conducted, and final decisions were obtained through the meeting with the Falekaupule. The meetings for Falekaupule and other communities were conducted separately because other community members are not fully able to voice out their concerns. with the presence of Falekaupule.

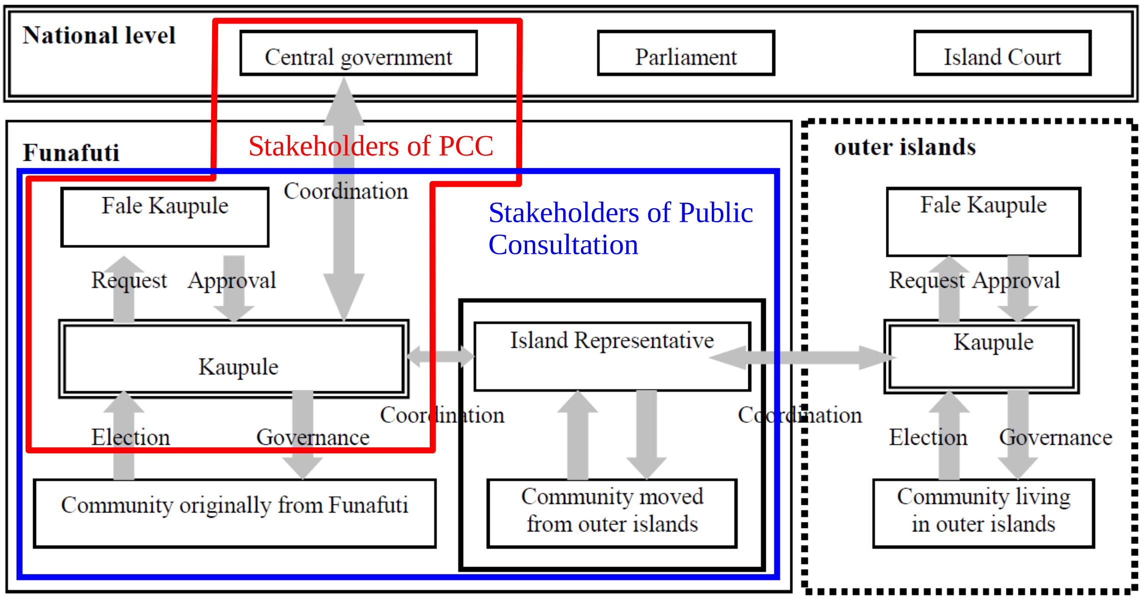


Figure 8.2.1 Stakeholders of Public Consultation and PCC

(Source: Completed JICA Development Study (2011))

8.3 Public Consultation

(1) Summary of Public Consultation in Phase-1

This section shows summaries of the public consultation results in Phase-1 while procedures and details can be referred to Supporting Report-6.

Agreements in Phase-1 and issues to be brought up to Phase-2 are summarized as follows:

1) Agreements in Phase-1

- Concept of typical cross section of the beach nourishment

Typical cross section is designed as a combination of gravel and sand to; 1) restore the original natural beach at the lagoon side, and 2) improve beach use and environment.

- Necessity of sand stoppers

Sand stoppers are needed to minimize the outflow from both ends of the Project area.

- Concept of boat landing

After the pilot construction, beaches that consist of gravel and sand can be used for boat landing. Therefore, no boat landing slope (i.e., structure) will be constructed.

- Removal of the Catalina ramp and reuse of the material for the Project (if needed)

If the construction materials are not enough, a part of the Catalina ramp would be removed and used as construction materials.

2) Issues to be brought up to Phase-2

- Location of the south boundary of the Project area

There was a strong objection against the removal of the existing seawall from the owner, which is located around the south boundary of the Project area, in the case that it is included in the Project area. Location of the south boundary of the Project area has to be finalized in Phase-2.

- Detailed design of the identification of boundaries between the public and private areas

There was a request to install structures to serve as identification of boundaries between the public and private areas to reduce the outflow of soil from the land to the lagoon. Detailed design of the identification has to be finalized in Phase-2.

(2) Stakeholder Meetings with Funafuti Communities in Phase-2

Stakeholder meetings with Falekaupule and other Funafuti communities were held on the 19th, 23rd and 24th of February 2015, respectively, as shown in Figure 8.3.1. The purposes of the meeting are: 1) confirmation on objective and concept of the Project, 2) confirmation on the basic plan of the beach nourishment, 3) request for participation in beach control after construction, and 4) explanation on possible environmental impact and its mitigation measure. The remaining issues from Phase-1 aforementioned were also discussed and agreed through the stakeholder meetings. Results of the these meeting are summarized as follows for each component.

1) Objective and Concept of the Project

Stakeholders understood and agreed on the following characteristic of the beach nourishment.

- Beach profile will change by absorbing wave energy and this is one of the most important characteristics of the beach.

2) Confirmation on the Basic Plan

Stakeholders confirmed and agreed on the following contents of basic plan:

- The pilot project area is ranging from Amatuku Jetty (north end) to near side of the existing private seawall (south end). The Project area may be slightly changed based on the final construction plan.
- Boundary stones will be placed along the boundary of the gravel part to 1) identify the boundary between the private and public areas and 2) reduce gravel scattering toward inland. Space for boat landing (i.e., no placement of these rocks) will be secured at the existing boat landing slope.
- Sand-stoppers will be placed at both ends of the Project area to reduce outflow of nourished gravel and sand.
- Gravel will be procured from the north and south tips of the Funamanu Island and south tip of Funangongo (Papaelise) Island. For the sand, a part of the stocked sand from the Borrow Pit Project by NZ is planned to be used, although it still depends in the discussion with the Government of Tuvalu.
- Concrete block wall that was constructed by Kaupule will be removed and reused as a core material of the beach nourishment and/or sand-stoppers.

3) Participation in Beach Control and Monitoring after Construction

Stakeholders agreed to participate in the following items of beach control and monitoring:

- Regulation on beach use against dumping, littering, stealing of gravel and sand, and private construction on beach area (i.e., clarification of public and private boundaries)
- Participation in beach cleaning
- Participation in beach monitoring by taking photos

4) Possible Environmental Impact and its Mitigation Measure

Stakeholders understood the possible environmental impact and its mitigation measure and agreed on temporary restriction during the implementation.

Table 8.3.1 Possible Environmental Impacts and Restriction

Possible Environmental Impacts	Temporary Restriction
・ Noise from the construction works and machines ・ Dispersion of turbid water ・ Risk of accidents ・ Damage to corals at the gravel collection site ・ Impact on adjacent shoreline topography	・ Relocation of boat mooring area ・ Need to land boat from alternative area ・ No bathing near the construction works ・ No entrance behind Tausoalima Community Hall as the space will be used as a temporary yard

(Source: JICA Expert Team)

(1) Representatives of Falekaupule (19 Feb. 2015)

(2) Other Funafuti Communities (23 Feb. 2015)

(3) Falekaupule (1) (24 Feb. 2015)

(4) Falekaupule (2) (24 Feb. 2015)

Figure 8.3.1 Photos During the Stakeholder Meetings

(Source: JICA Expert Team)

8.4 PCC (Project Coordination Committee)

The PCC was held twice, one was held as the inception meeting of Phase-2 and another was held to obtain agreements on the final plan of the beach nourishment.

(1) First PCC in Phase-2

The first PCC was held on 4 February 2015 as an inception meeting in Phase-2 and the contents included: 1) Review of Interim Report, 2) Agreement for basic points of the Project, 3) Confirmation on detailed schedule until implementation, and 4) Request for necessary actions from the Government of Tuvalu to proceed with the Project. It was attended by the members of DOE, PWD, DOLS, DOF, MET, and Kaupule.


Figure 8.4.1 Photos During the First PCC in Phase-2 (4 Feb. 2015)

(Source: JICA Expert Team)

(2) Second PCC in Phase-2

The second PCC was held on 25 February 2015 to: 1) obtain agreement for final planning and design for the beach nourishment, and 2) request for participation in monitoring and maintenance from C/P and relative agencies. It was attended by the members of DOE, PWD, DOLS, DOF, MET, and Kaupule. The results of the meeting are summarized for each component as follows:

1) Project Area

It was reconfirmed that the Project area is ranging from Amatuku Jetty, which is the north boundary, to the north side of the private seawall.

2) Procurement of Gravel

Gravel with approximate amount of 3,000 m^3 is going to be procured from both tips of the Funamanu Island and south tip of Papaelise (Funangongo) Island. Collection of gravel from Funamanu Island had been already agreed in Phase-1 by Funafuti Falekaupule, Funafuti

Kaupule, and the Government of Tuvalu. In addition, collection of gravel from Papaelise (Funangongo) Island, which had been already agreed by Funafuti Falekaupule and Funafuti Kaupule in advance, was reconfirmed and agreed in the committee.

3) Procurement of Sand from NZ Project

About 4,500 m^3 of sand is going to be transported from the sand stockpiled area prepared in the NZ Aid Project. The Borrow Pit Project Steering Committee (PSC) had already accepted the use of stockpiled sand.

4) Design of Beach Profile

The initial profile of the beach nourishment with the backshore width of 6 m and the slope of 1:3.5 was reconfirmed and agreed in the committee. It was also accepted that the initial beach profile would change by wave action after the pilot construction.

5) Installation and Design of North and South Groins and Procurement of Armor Rocks

Groins at north and south ends are going to be installed to reduce expected sand discharge due to wave action going outside of the Project area. The design of groin and procurement of armor rocks were agreed in the committee. The former is designed for beach user and its stability and the latter is going to be procured from Fiji.

6) Placement of Backshore Stones

Placing of big rocks (1.0~1.5 ton/unit) along the boundary of gravel part is planned to 1) identify the boundary between the private and public areas, and 2) reduce gravel scattering toward inland.

7) Securing Space for Boat Landing

Space for boat landing is going to be secured. Position of the space needs to be discussed with each land owner and Funafuti Kaupule before the construction work.

8) Participation to Monitoring and Maintenance from the Government of Tuvalu

Monitoring shall be conducted together with the JICA Expert Team and related C/P of Tuvaluan side as technical transfer and capacity development program. Daily maintenance shall be conducted by Funafuti communities and Kaupule, and future required adaptation measures shall be conducted by the Government of Tuvalu (Department of Environment and Public Works Department).

Figure 8.4.2 Photos During the Second PCC (25 February 2015)

(Source: JICA Expert Team)

8.5 Summary

The list below shows the summary of the items that had been agreed/reconfirmed through public consultations and PCC, and the summary of items to be confirmed with stakeholders before the pilot construction.

Items that had been agreed/reconfirmed through the public consultations and PCC

- Objective and concept of the Project
- Characteristics of the beach nourishment
- Project area and its boundaries
- Procurement of gravel from tips of Funamanu Island and west tip of Papaelise Island
- Procurement of sand from NZ Project
- Design of beach profile
- Installation and design of north and south groins and procurement of armor rocks
- Placement of backshore stones
- Securing space for boat landing
- Reuse of existing concrete blocks at the Project site
- Participation and cooperation to the monitoring and maintenance of the government and the other communities

Issues to be confirmed with stakeholders before the pilot construction

- Locations of the space for boat landing
- Details of construction schedule and the work area during construction
- Details of mitigation measures to minimize environmental impacts

9. Construction

9.1 Overview

The overview of activities from the bid process to the construction work is presented as follows:

1) Construction Period: 15 June 2015 – 23 December 2015 (6.3 months)

2) Contractor: Cruz Holding – Dalgro Joint Venture (Fiji)

3) Overall of bid and construction activities

The overall of the bid and construction activities is summarized as shown in Table 9.1.1.

Table 9.1.1 Overall of Bid and Construction Activities

22 April 2015	Invitation for the nominated bidders (Pacific Marine & Building Solutions (PMCS), Frame Tree Development Ltd., Construction Equipment Hire Ltd., Cruz Holding JV)
28 -29 April 2015	Site visit and pre-bid meeting (PMCS and Cruz Holding JV)
26 May 2015	Closing of submission and opening of bids (at the JICA Fiji Office) The lowest bidder: PMCS (Bid price: FJD 2,061,272) The second bidder: Cruz Holding JV. (Bid price: FJD 3,931,811) (Other two bidders expressed no intension)
4 June 2015	After the result of the bid evaluation, PMCS withdrew and the negotiation with Cruz Holding JV was started
12 June 2015	Concluded the contract with Cruz Holding JV (Contract price: FJD 3,881,806.09)
15 June 2015	Commencement of construction
17 September 2015	Mobilized work vessels, equipment, and armor stones from Fiji to Tuvalu
23 September 2015	Start the construction of Gravel Part Start the construction of South Groin
15 November 2015	Mobilized armor stones from Fiji to Tuvalu (second time)
18 November 2015	Start the construction of North Groin
1 December 2015	Start the transportation and placing sand from the Borrow Pit No. 2
2 December 2015	Completion of South Groin
10 December 2015	Completion of Gravel Beach
15 December 2015	Completion of North Groin
16 -18 December 2015	Installation of Backshore Stones
18 December 2015	Completion of all construction works Opening ceremony
23 December 2015	Issue of the taking over certificate
14-15 June 2016	Final inspection after defect liability period; issue of the final inspection certificate

(Source: JICA Expert Team)

4) Plan View and Typical Cross Section

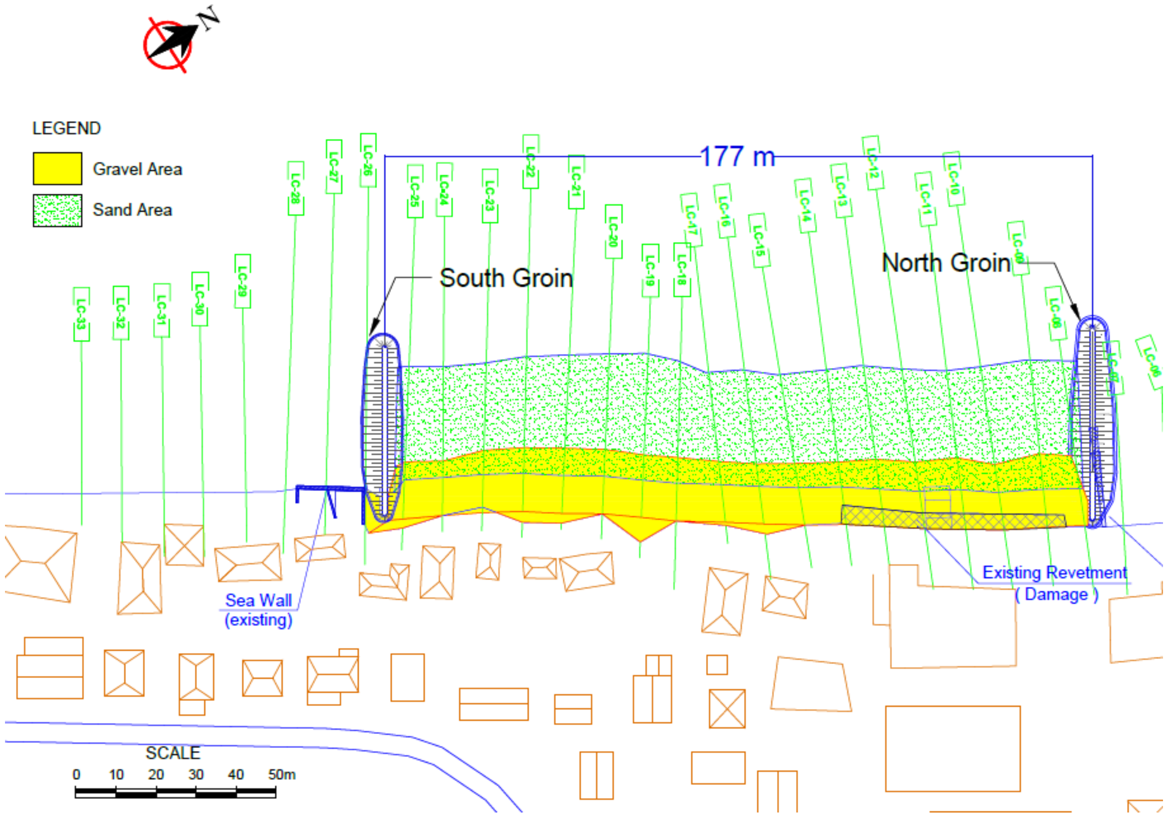


Figure 9.1.1 Plan View

(Source: JICA Expert Team)

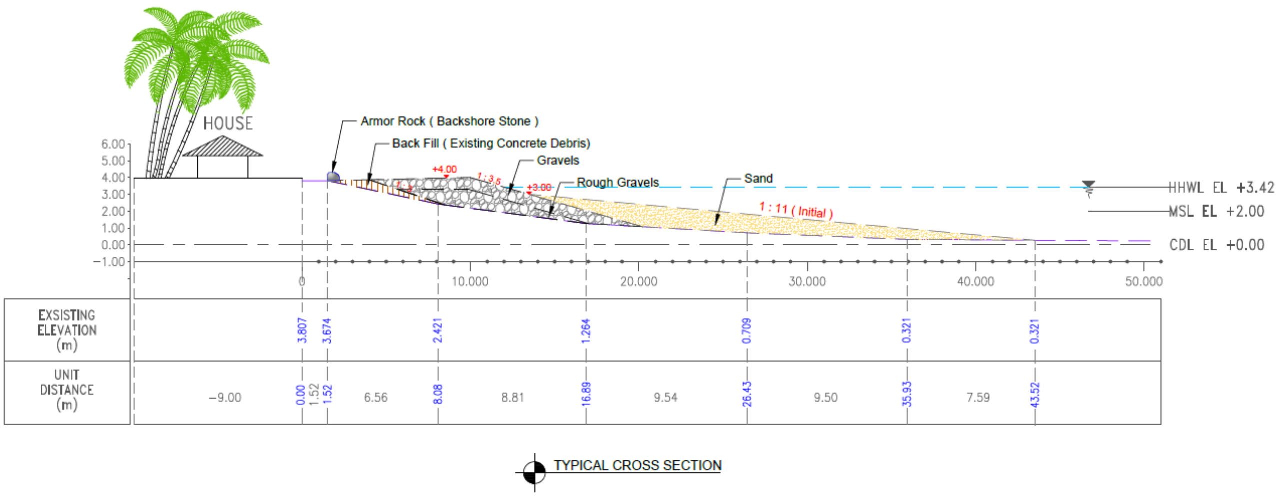


Figure 9.1.2 Typical Cross Section

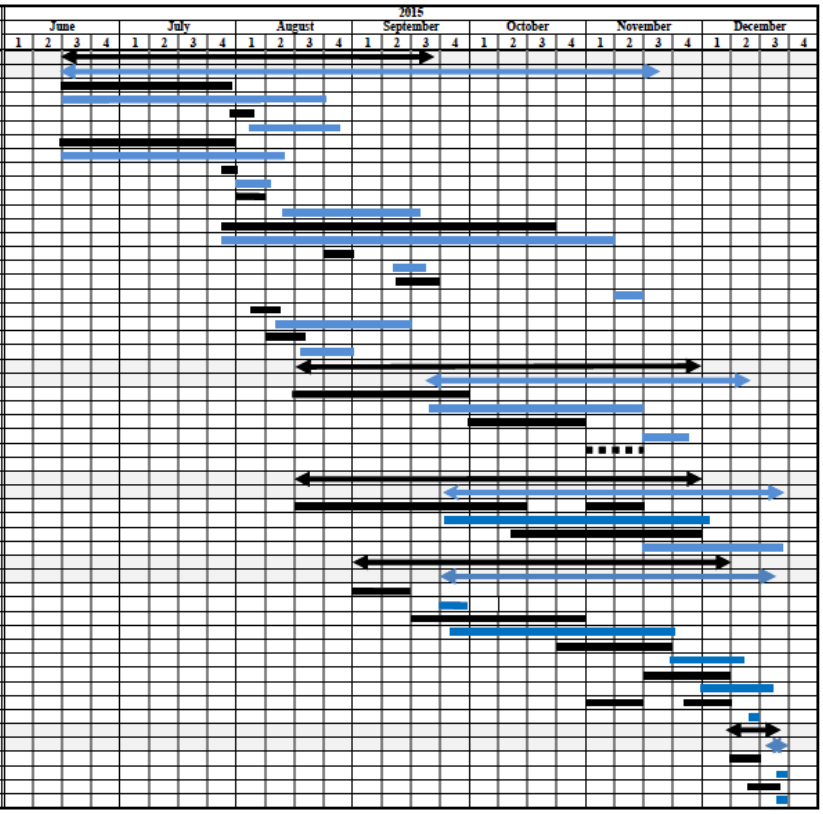
(Source: JICA Expert Team)

5) Construction Activity Schedule

Table 9.1.2 shows the construction activity schedule to compare the planned master schedule.

Table 9.1.2 Construction Process Sheet (Master Schedule and Actual)

No	Work Item	Status	Duration	Start	Finish
1	**Preparation Work**	Plan	98 days	6/15	9/20
		Actual	154 days	6/15	11/15
1-1	Preparation in Suva (Materials, tug boat, pontoon, etc)	Plan	44 days	6/15	7/28
		Actual	67 days	6/16	8/21
1-2	Transportation from Suva to Tuvalu	Plan	7 days	7/29	8/4
		Actual	21 days	8/5	8/25
1-3	Preparation in Solomon (Equipments and barge)	Plan	47 days	6/15	7/31
		Actual	60 days	6/15	8/13
1-4	Tug Boat Mobilization from Suva to Solomon	Plan	6 days	7/25	7/30
		Actual	8 days	8/1	8/8
1-5	Transportation from Solomon to Tuvalu	Plan	7 days	8/1	8/7
		Actual	36 days	8/13	9/17
1-6	Armor Rock Mining & Fumigation	Plan	85 days	7/28	10/20
		Actual	103 days	7/28	11/7
1-7	Armor Rock Transportation from Fiji to Tuvalu (1st)	Plan	7 days	8/24	8/30
		Actual	5 days	9/13	9/17
1-8	Armor Rock Transportation from Fiji to Tuvalu (2nd)	Plan	7 days	9/14	9/20
		Actual	9 days	11/7	11/15
1-9	Site Establishment	Plan	8 days	8/5	8/12
		Actual	37 days	8/12	9/17
1-10	Survey & Shop Drawing	Plan	11 days	8/7	8/17
		Actual	14 days	8/17	8/30
2	**Gravel Mining & Transportation**	Plan	108 days	8/15	11/30
		Actual	79 days	9/23	12/10
2-1	From Papaelise (for Core Material+under part of gravel B.)	Plan	47 days	8/15	9/30
		Actual	57 days	9/23	11/18
2-2	From North of Funamanu (for upper part of gravel B.)	Plan	31 days	10/1	10/31
		Actual	7 days	11/19	11/25
2-3	From South of Funamanu (for upper part of gravel B.)	Plan	30 days	11/1	11/30
		Actual	0 days		
3	**Groins**	Plan	108 days	8/15	11/30
		Actual	91 days	9/23	12/22
3-1	South Groin	Plan	88 days	8/15	11/10
		Actual	71 days	9/23	12/2
3-2	North Groin	Plan	52 days	10/10	11/30
		Actual	35 days	11/18	12/22
4	**Nourishment**	Plan	98 days	9/1	12/6
		Actual	85 days	9/25	12/18
4-1	Render Existing Materials	Plan	15 days	9/1	9/15
		Actual	6 days	9/25	9/30
4-2	Placing Rough Gravels (Under Part)	Plan	47 days	9/15	10/31
		Actual	56 days	9/25	11/19
4-3	Placing Finish Gravels (upper Part)	Plan	31 days	10/20	11/20
		Actual	22 days	11/19	12/10
4-4	Sand Transportation & Placing from Stockpile	Plan	30 days	11/7	12/6
		Actual	18 days	12/1	12/18
4-5	Placing of Backshore Stone	Plan	11 days	11/25	12/5
		Actual	3 days	12/16	12/18
6	**Finishing Work**	Plan	15 days	12/5	12/19
		Actual	4 days	12/19	12/22
5-1	Placing of Bins	Plan	6 days	12/5	12/12
		Actual	2 days	12/21	12/22
5-2	Demobilization	Plan	9 days	12/10	12/19
		Actual	4 days	12/19	12/22



(Source: JICA Expert Team)

6) Main Work Item and Quantity

Table 9.1.3 Main Work Item and Quantity

No	Work Item	Content	Specification
1	Preparation Work	➢ Preparation in Fiji and transportation for Tuvalu ➢ Preparation of work at the Project site	
2	Collection and Transportation of Gravel	➢ Collection and transportation from the atoll (Papaelise and Funamanu)	Plan volume of the gravel: 3,204 m^3
3	Groin Construction	➢ Construction of the north groin and south groin (Riprap slope embankment)	South groin Length: 46.1 m Crown Height: +4.2 m Crown Width: 1.3 m Slope: 1:2 (South), 1:1.5 (North) North groin Length: 51.3 m Crown Height: +4.2 m Crown Width: 1.3 m Slope: 1:1.5

No	Work Item	Content	Specification
4	Gravel Nourishment	➢ Placing and leveling of gravel	Estimated Volume: 2,816 m^3 Backshore Height: +4.2 m Backshore Width: more than 6 m Slope: 1:3.5
5	Sand Nourishment	➢ Taking the sand from the Borrow Pit No. 2 ➢ Transportation, placing, and leveling of sand	Estimated volume: 3,864 m^3 Slope: 1:11
6	Backshore Stone	➢ Installation of armor stone along the boundary	Estimated quantity: 200 pieces
7	Procurement of Equipment	➢ Rubbish bin ➢ Boat trailer	5 sets 1 set

(Source: JICA Expert Team)

Table 9.1.4 Estimated and Actual Quantities

No	Work Item	Estimated Quantity	Actual Quantity
2	Gravel Nourishment	3,204 m^3	3,327 m^3 (West end of Papaelise: 2,207 m^3 East end of Funamanu: 1,120 m^3)
5	Sand Nourishment	3,864 m^3	4,500 m^3
6	Backshore Stone	200 pieces	141 pieces

(Source: JICA Expert Team)

9.2 Chronology of Bidding Process

Capability and availability of the contractor for the construction had been studied from both technical and financial view points and it has been judged that the contractors should be selected from Fiji since no competent contractor existed in Tuvalu. In consideration of those situations, the following points should be taken into account when the bidding documents are to be prepared:

- Particularity of the Project: Pilot Project with limited budget, scale, and construction period,
- Particularity of the works: Beach nourishment with two layers (i.e. gravel and sand)
- Particularity of the procurement conditions in Tuvalu: No material and equipment available in Tuvalu,
- Particularity of the employment situation in Tuvalu: Unskilled workers should be employed in Tuvalu as much as possible.

Furthermore, bidding process, from notice of bids to contract awards, should be completed approximately within two months, and the support for bidding should be mainly done in Fiji. The details of the bidding process can be referred to Supporting Material-7.

9.3 Activity for Supervising

Schedule control, safety management, and quality management were the main tasks of the supervisor during the construction and a part of those activities is briefly presented as follows:

(1) Daily/Weekly Meeting with the Contractor and Stakeholders

Weekly meetings were held to confirm the construction progress and schedule with the site manager (i.e., the contractor). Weekly meetings were held on the first day of every week (i.e., mostly on Monday) and daily meetings were held the following days to check the work progress based on the weekly meeting.

In addition, the joint meeting with stakeholders, DOE, Funafuti Kaupule and the contractor, were held at a weekly basis to share the work progress and discuss any concerns among them, such as environmental effect during the work for DOE and gravel borrow area for Funafuti Kaupule.

Figure 9.3.1 Joint Meeting with DOE, Funafuti Kaupule, and the Contractor

(Source: JICA Expert Team)

(2) Safety Management

Safety management during the construction was carefully conducted based on the Japan International Cooperation Agency's (JICA) guideline and the contractor's safety management plan. Groin construction was the work to be implemented with most care because it handles heavy stones of more than 1 t and stone placement required an adjustment with the manpower. Therefore, JET directed the contractor to have at least one manager to watch on the work during the stone placement and to wear safety gears such as helmets and boots all the time. As a result, no serious accidents or injury occurred during the construction.

Figure 9.3.2 Groin Construction with Added Safety Measures

(Source: JICA Expert Team)

(3) Inspection for Procurement of Armor Stones

Armor stones were procured in Taveuni Island, Fiji for the groin and backshore stones. The size and shape of the stones were inspected at the procurement site as shown in Figure 9.3.3.

(Quarry Site)

(Size Measurement)

Figure 9.3.3 Inspection for Procurement of Armor Stones

(Source: JICA Expert Team)

(4) Inspections for the Pilot Construction (As-built)

As part of the quality management, inspections related to the pilot construction of gravel beach had been conducted using inspection sheets prepared by JET and were completed as shown in Table 9.3.1. Figure 9.3.4 shows a photo taken during the inspection of the gravel beach profile. The inspection report can be referred to the Supporting Report-8.

Table 9.3.1 Inspection Items and Implementation Date

Inspection Items	Implementation Date
Gravel Beach Profile	1 Dec., 11 Dec., 2015
South Groin	8 Dec. 2015
North Groin	16 Dec. 2015
Gravel and Sand Profile	10 Dec., 12 Dec., 19 Dec. 2015
Backshore Stone	22 Dec. 2015
Facility (Boat Trailer)	22 Dec. 2015
Facility (Rubbish bin)	22 Dec. 2015

(Source: JICA Expert Team)

Figure 9.3.4 Photo During the Inspection (Gravel Beach Profile)

(Source: JICA Expert Team)

9.4 Construction Work

(1) Preparation Work

Construction equipment and materials needed for the construction work except for sand and gravel were basically procured from other countries. Main construction equipment (excavators, roader, dump trucks, etc.) was procured from the Solomon Islands and work vessels (tug boat, pontoons, flat barge, etc.) were from Fiji.

Armor stones of the groins were procured from Taveuni Island, Fiji. The type of stone is basalt. The specific gravity is about 2.5 and the stone size with a weight of 1-2 tons was selected.

Construction equipment was transported from Fiji to Tuvalu with a flat barge (1,800 tons) and a tug boat (1,200 hp), taking three to four days to transport. The stones were transported two times. First, they were transported on 23 September for the south groin and the second one on 15 November for the north groin and backshore stones. In addition, necessary equipment was transported using a cargo ship.

After the mobilization of construction equipment and material, a temporary site office, construction boards, and safety fences were installed. Simultaneously, measurement of the construction site and survey of the sea near the area of where gravel was taken were implemented.

	
Figure 9.4.1 Inspection of Armor Stone in Taveuni Island, Fiji	Figure 9.4.2 Construction Board
	
Figure 9.4.3 Temporary Site Office	Figure 9.4.4 Transportation of Armor Stone and Equipment

(Source: JICA Expert Team)

(2) Gravel Nourishment

The contractor started collecting gravel from Funamanu and Papaelise islands and transported them to the construction site on 23 September. After that, they placed the gravel and leveled it in accordance with the designed beach profile. It took about 2.7 months to complete this work, which finished on 10 December.

First, rough gravel for the core material of the groin and lower layer of the gravel beach were taken from the west end of Papaelise Island. After that, fine gravel for the upper layer of the gravel beach were taken from the east end of Funamanu Island. According to the original construction schedule, the JICA Expert Team also planned taking gravel from the west end of the Funamanu Island. However, it was expected that the coral environment would be damaged by their work ship because of the shallow sea area and high waves from the outer sea would make the work difficult. Therefore, the JICA Expert Team decided to take gravel only in case of shortage. However, it was not necessary anymore.

To protect the coral environment at the shallow sea area, the JICA Expert Team originally planned transporting gravel with two barges (20 tons). However, in order to expedite the construction activity, the contractor used a flat barge (1,800 tons) and a tug boat (1,200 hp) for transportation of the gravel to compensate the delay in the preparation work. To consider the draft of the flat barge, the total volume of the gravel was adjusted. For this reason, about 100-200 m^3 of gravel could be transported per trip considering the tidal fluctuations. It was effective to shorten the construction period. The cycle time of gravel transportation was almost one day.

Because the water depth near the gravel collection site is about one meter in depth, the tug boat could not approach the site due to the draft limitation. So, the flat barge was pushed by the tug boat at 200 m away from the coastline. Then, the flat barge slowly approached the gravel collection site without the tug boat. To adjust the maneuvering course, the backhoe excavator on the flat barge was also used. To navigate the same course and approach the same place, some temporary buoys were installed at the entry route and landing place.

The gravel collection site was decided based on the discussions and field surveys with Funafuti Kaupule which administrates their island. Due to the request of the Funafuti Kaupule, the gravel collection site was selected on the lagoon side rather than the ocean side. Gravel were taken along the coastline in 1-2 m width. A Funafuti Kaupule’s officer was always on site during the gravel collection. The collected amount of gravel is shown in Table 9.4.1.

During and after the gravel collection, the JICA Expert Team surveyed the seabed around Papaelise and Funamanu islands in order to check the impact to the coral environment. As a result, no damages could be detected from the flat barge and the JICA Expert Team reported it to the MOE and Funafuti Kaupule.

The gravel was transported by a flat barge to the construction site. On the flat barge, the gravel was loaded onto dump trucks (10 and 20 tons) by a backhoe excavator (20 tons) and was placed at the construction site. After that, the gravel was leveled in accordance with the designed beach profile with loaders and excavators (10 tons).

During 13-16 October and 26-28 November, the gravel beach profile was deformed due to high wave actions triggered by a storm. After that, the contractor started leveling again. Before the sand nourishment work, the JICA Expert Team inspected the actual beach sections and compared it with the designed sections (Height: +4.2 m, Minimum Width: over 6 m, Gravel Slope: 1:3.5) for every 10 m distance.

Table 9.4.1 Gravel Collection Amount

Location	West End of Papaelise	East End of Funamanu	Total
Amount of gravel (m^3)	2,207	1,120	3,327
Trip (time)	13	8	21

(Source: JICA Expert Team)

Figure 9.4.5 Flat Barge in Papaelise Island

Figure 9.4.6 Gravel Collection Site (Papaelise Island)

Figure 9.4.7 Clearance between Seabed and Flat Barge

Figure 9.4.8 Transportation to Construction Site

Figure 9.4.9 Unloading Gravel from the Flat Barge

Figure 9.4.10 Placing Gravel

	
Figure 9.4.11 Leveling Work	Figure 9.4.12 After Completion of Gravel Nourishment

(Source: JICA Expert Team)

(3) Groin Work

The groin work started on 23 September after importing armor stones from Fiji. The construction schedule of the groin work is shown in Table 9.4.2.

First, in order to prevent stone penetrating into the sand layer, the gravel mat was placed using stone fragments and gravel. Second, the core materials were laid and leveled followed by the lower layer of armor stones and upper layer of armor stones. The physical property of materials is shown in Table 9.4.3. The armor stones were considered stable against the design wave action.

In consideration of the future usage, the surface of the groin was made flat as much as possible. The appropriate-sized stones were filled into the gap between the armor stones.

Core materials and armor stones were placed with an excavator. As a work space for the excavator, a temporary stage was constructed with stones near the groin. However, it was difficult to construct the tip of the groin from the temporary stage. Therefore, the excavator was placed on the flat barge and was constructed from there. When the stones were placed on the surface, the stones were hanged by the excavator and adjusted its direction and positioned as necessary. The JICA Expert Team instructed the construction method of surface of armor stones to the contractor in accordance with the guideline.

To monitor settlement of the groin, the elevation (height) at some point was measured regularly. As a result, it was not confirmed whether the groin settled after armor stones were placed.

After the construction, the JICA Expert Team inspected the length, the height of the crown, the width of the groin, and the slope in every 5 m distance. According to the original design, in order to reduce the amount of stones, the slope of the south side of the south groin was 1:2. However, the JICA Expert Team allowed that the slope could be 1:1.5 because of the hardness of the construction work.

Table 9.4.2 Schedule of Groin Work

Month	9	10	11	12	Term	Total days
South groin					9/23-12/2	71
North groin					11/18-12/22	35
						91

1st armor stone transport

2nd armor stone transport

(Source: JICA Expert Team)

Table 9.4.3 Design Weight of the Materials

Position	Gravel mat, core material	Lower layer of armor stone	Upper layer of armor stone
Weight (kg)	10-50	500-	1,000-

(Source: JICA Expert Team)

Figure 9.4.13 Placement of Gravel Mat

Figure 9.4.14 Armor Stones

Figure 9.4.15 Temporary Stage

Figure 9.4.16 Laying and Leveling of Armor Stones in the North Groin

Figure 9.4.17 Laying Armor Stones on Surface

Figure 9.4.18 Inspection after Completion

Figure 9.4.19 South Groin

Figure 9.4.20 North Groin

(Source: JICA Expert Team)

(4) Sand Nourishment

Sand for nourishment was taken from Borrow Pit No. 2, which is located in the north of Fongafale Island. In Borrow Pit No. 2, dredged sand was filled by a New Zealand Aid Project. The Government of Tuvalu and the Solid Waste Authority of Tuvalu (SWAT) agreed that the stockpiled sand of 4,500 m^3 would be used for the Project.

There are two sand collection areas: Area-A and Area-B. Area-A was a new dump area, which was filled by the dredged sand. Area-B was the existing dump area which was filled by garbage covered with sand. The JICA Expert Team planned taking sand from Area-A (2,000 m^3) first followed by Area-B.

The dredging sand from Borrow Pit No. 2 was more suitable for the beach nourishment than dredging sand from other borrow pits. Its sand contained many foraminifer and its particle size was rough (average particle size: 0.4 mm). Moreover, its color was clean gold.

In the original plan, the sand would be transported by dump trucks. However, in order to shorten the construction period, the sand was also transported by the flat barge. Simultaneously, dump trucks were also used. For this reason, the construction period for sand nourishment was reduced from one month to 18 days.

The sand was loaded onto the dump truck using an excavator (20 tons), was transported to the flat barge and was unloaded there. The load capacity of the sand for the barge was about 250-300 m^3 considering the draft of the flat barge and the tide levels.

After the flat barge arrived at the construction site, the sand was thrown directly to the beach with excavators (20 tons). During the low tide level, the sand was leveled with excavators (10 tons) and loader.

After construction, the JICA Expert Team measured the height of the inspection points in every 10 m distance and confirmed that beach gradient was 1:11.

The number of trips with the flat barge was 16. The amount of sand thrown to the site was 4,500 m^3, which was the same volume that the Government of Tuvalu agreed on. The sand volume was 16% more than the designed amount in the original plan. This was because of the adjusted amount due to factors such as, compaction caused by waves, filling into the gravel, and the amount lost in transportation.

Figure 9.4.21 Borrow Pit No. 2 (Area-A)

Figure 9.4.22 Loading the Sand onto the Flat Barge

Figure 9.4.23 Borrow Pit No. 2 (Area-B)

Figure 9.4.24 Placement of the Sand onto the Construction Site

Figure 9.4.25 Sand (Enlarged View)

Figure 9.4.26 Leveling of the Sand

Figure 9.4.27 During Construction

Figure 9.4.28 After Construction of Sand Nourishment

(Source: JICA Expert Team)

(5) Backshore Stone

The purpose of the installation of backshore stones are as follows:

- To show the border between the private area and public area (coast).
- To prevent the gravel from moving to the private area.
- To become comfortable for beach use (will be used as seats).

Backshore stones were the same as the armor stones used for the groins.

Before construction, the JICA Expert Team and residents mutually discussed the positions of the backshore stones and aperture to the boats and reached a consensus.

The backshore stones were imported from Fiji with a cargo ship on 16 December 16. And the stones (141 pieces) were installed in three days, which finished on 20 December.

Before the placement of the backshore stones, a trench (Depth: 30 cm) was constructed using an excavator and the stone was placed into the trench and was filled in with gravel. The height of the stone was 50 cm considering future beach utilization.

Figure 9.4.29 Backshore Stone on the Cargo Ship

Figure 9.4.30 Installation of the Stones

Figure 9.4.31 After Installation (Public Area)

Figure 9.4.32 After Installation (Private Area)

(Source: JICA Expert Team)

(6) Others

The Project also included providing garbage bins (5 set) and a boat trailer (1 set).

The garbage bins were made from Fiji and were imported together with the backshore stone on 16 December. They were made of steel. The height was 90 cm and the diameter was 60 cm. The foundation was made from concrete. The positions of the garbage bins were decided based on the discussion with Funafuti Kaupule.

The boat trailer was made from Fiji. The specification of the boat trailer was decided based on the discussion with Funafuti Kaupule.

Figure 9.4.33 Garbage Bin (Public Area)

Figure 9.4.34 Garbage Bin (Private Area)

Figure 9.4.35 Boat Trailer

Figure 9.4.36 Boat Trailer

(Source: JICA Expert Team)

(7) Demobilization

After the construction, construction equipment, temporary site office, and other materials were loaded on the flat barge and were demobilized from Tuvalu to Fiji on 20 December 2015. The flat barge reached Fiji on 24 December 2015.

However, Funafuti Kaupule bought the excavator (10 tons) and loader from the contractor, which were used in the Project.

Safety fences around the construction site and construction boards at the Project site were removed. The board was relocated at the new beach for the people visiting the area.

At Borrow Pit No. 2, where sand was taken, SWAT requested the installation of the safety net around Area-A, leveling of covered sand at Area-B, and rectification of the mooring places of the flat barge. After such activities were finished, SWAT inspected the sites.

At Papaelise and Funamanu islands, where gravel was taken, the marker buoys for flat barge navigation were removed and the gravel collection sites were leveled. After such activities are finished, the JICA Expert Team confirmed the sites.

After all the demobilization, the JICA Expert Team issued a taking over certificate to the contractor on 23 December 2015 and then the contractor officers (three persons) went back to Fiji on 24 December 2015. Therefore, the construction work was finished as scheduled.

On 18 December, a completion ceremony was held and participated by the Government of Tuvalu director, donor, non-governmental organization (NGO), Funafuti Kaupule, and the residents. From the JICA headquarters, Mr. Hosokawa, Mr. Hirano, and Mr. Uda participated.

	
Figure 9.4.37 Safety Fence at the Borrow Pit No. 2	Figure 9.4.38 Clean up at the Gravel Collection Site
	
Figure 9.4.39 Clean up at the Construction Site	Figure 9.4.40 Construction Board
	
Figure 9.4.41 Completion Ceremony (Tape Cut)	Figure 9.4.42 Completion Ceremony

(Source: JICA Expert Team)

9.5 Material Characteristics

(1) Sand Thrown into the Borrow Pits

At first, the New Zealand Project was planned to stock the dredging sand in Borrow Pit No. 2, for maintaining the coast and securing construction materials for the future. And the Project was planned to supply the sand, which will be used for the beach nourishment from here. But the amount of sand will not be enough from the offshore of No. 2 and it was necessary to consider supply from the other borrow pits. Therefore, material characteristics of the sand from the other borrow pits was investigated. Figure 9.5.1 shows the location of the borrow pits.

The median grain size D50 and sediment classification of each point are summarized in Table 9.5.2. The average of D50 in each borrow pit; No. 1 is the largest at 0.82 mm, 0.64 mm in No. 4, 0.51 mm in No. 2. However, No. 1 and No. 4 include a number of Halimeda and those are not suitable for the beach nourishment material. The sand in No. 2 contains little Halimeda and a lot of foraminifera. Therefore, sand from No.2 was evaluated as the most desirable nourishment materials for the Project.

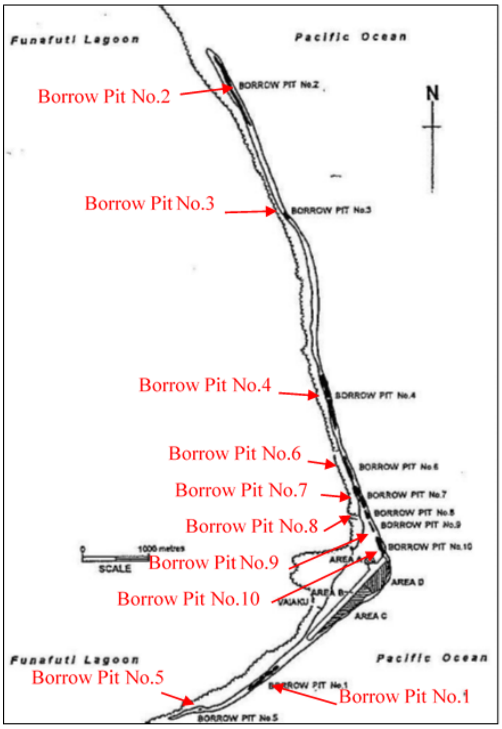


Table 9.5.1 Situations of Sand Throwing into Borrow Pits

(a). Throwing directly	(b). From Borrow Pit of (a)
Borrow Pit No.2	No.3
Borrow Pit No.4	No.6,7,8,9
Borrow Pit No.1	No.5
Borrow Pit No.10	-

Figure 9.5.1 Location of Borrow Pits

(Source: JICA Expert Team)

Table 9.5.2 Median Grain Size D50 and Sediment Classification of Each Point

Sampling Points	D50 (mm)	Sediment Classification						
		Silt	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Medium Gravel	Coarse Gravel
B/P1-1	0.83	2.1	20.4	10.4	15.7	15.1	34.3	0.0
B/P1-2	0.80	2.5	22.1	9.7	17.7	19.9	28.1	0.0
Average	0.82	2.3	21.3	10.1	16.7	17.5	31.2	0.0
B/P2-1	0.6	2.2	22.6	12.7	24.8	9.5	25.9	0.0
B/P2-2	0.41	5.8	31.1	14.2	20.7	10.5	17.8	0.0
B/P2-3	0.51	1.0	28.0	15.6	27.2	12.7	15.5	0.0
B/P2-4	0.44	2.4	30.1	16.9	27.1	10.1	13.5	0.0
B/P2-Add-1	0.44	0.3	29.1	18.9	20.0	11.0	10.4	0.0
B/P2-Add-2	0.64	0.4	19.2	14.8	30.5	18.6	16.5	0.0
Average	0.51	2.0	26.7	15.5	25.1	12.1	16.6	0.0
B/P4-1	0.46	3.5	27.4	14.1	19.3	14.4	17.6	0.0
B/P4-2	0.82	2.6	19.6	10.2	18.9	20.6	28.1	0.0
Average	0.64	3.1	23.5	12.2	19.1	17.5	22.9	0.0
Overall Average	0.60	2.0	23.0	12.7	20.3	12.2	18.0	0.0

(Source: JICA Expert Team)

(2) Sand Thrown into Pilot Area

To investigate the characteristics of the sand thrown into the site for the beach nourishment, sediments of the construction area were picked and sieve analysis was performed after the beach nourishment. Extraction points are shown in Figure 9.5.2. There are three extraction points in the crossing direction, namely: M.W.L., L.W.L., and 15 m offshore from L.W.L. For comparison, sieve analysis was also performed about natural beach on the south side from the construction area (L2, L3, L4).

Median grain size of sediments is shown in Table 9.5.3 and the typical grain size distribution curve among these sediments is shown in Figure 9.5.3. From these, the following characteristics can be pointed out:

- The median grain size of sediments of L.W.L. and H.W.L., which have formed the foreshore of natural beach is 0.12 mm to 0.15 mm and the sand of grain size smaller than 0.11 mm is deposited offshore.
- The median grain size of the beach nourishment sand is approximately 0.3 mm to 0.6 mm judging from the median grain size of L.W.L. and M.W.L. of the construction area.
- The median grain size of the beach nourishment sand greater than the median grain size of the sediment of the natural beach stays easily without any movement. However, sediment must be carefully monitored in the future, because it is considered that sediment will move to the coast direction regardless of the particle size.

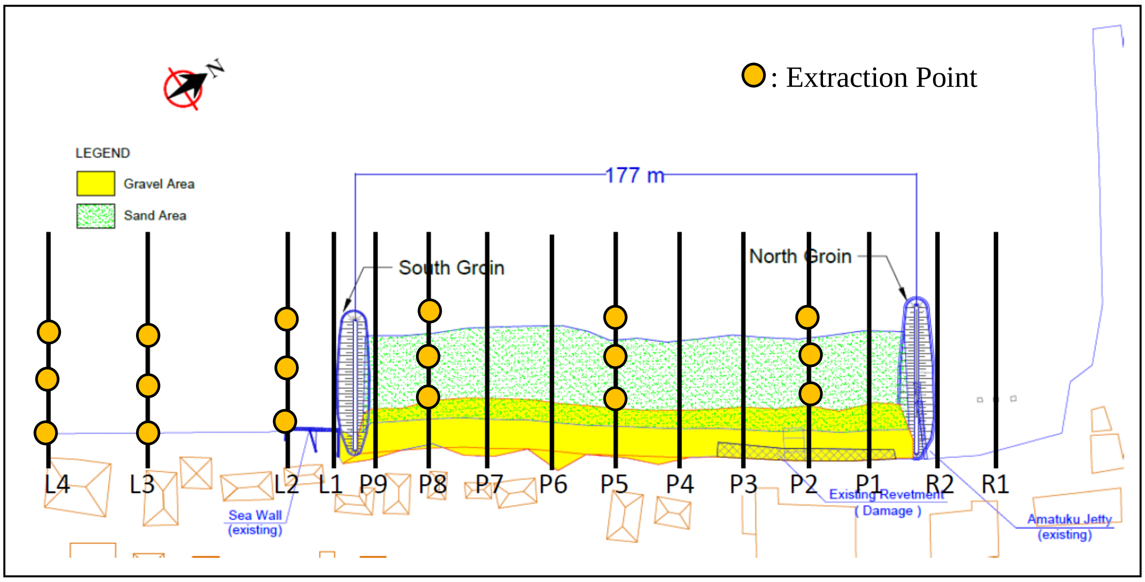


Figure 9.5.2 Sediment Extraction Location Map

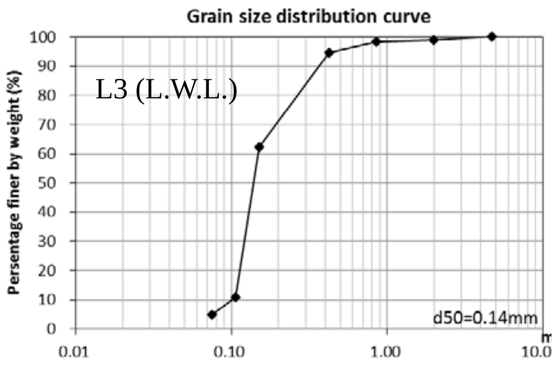
(Source: JICA Expert Team)

Table 9.5.3 Median Grain Size of Sediment

	Natural Beach			Construction Area		
	L4	L3	L2	P8	P5	P2
Offshore	0.09	0.11	0.11	0.18	0.10	0.22
L.W.L.	0.12	0.14	0.12	0.43	0.49	0.66
M.W.L.	0.15	0.13	0.12	0.34	0.27	0.29

unit: d50mm

(Source: JICA Expert Team)



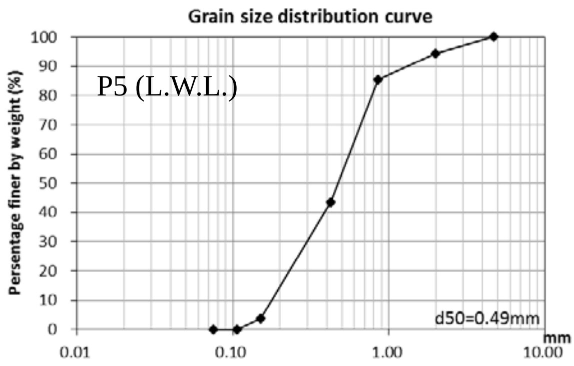


Figure 9.5.3 Grain Size Distribution Curve of Typical Sediment

(Source: JICA Expert Team)

(3) Gravel and Armor Stones

1) Gravel

Gravel were used for the beach nourishment and as core materials of the groin. Gravel used for the beach nourishment are shown in Figure 9.5.4 and gravel for the core material are shown at Figure 9.5.5. Rounded shape gravel with less than 30 cm of diameter were required for the beach nourishment to enhance accessibility and safety of beach use and most of those materials were procured from the east end of Funamanu Island. On the other hand, gravel for the core material were mainly taken from Papaelise Island, which were bigger and angular shaped compared to those used for the beach nourishment.

Figure 9.5.4 Gravel for the Beach Nourishment (Funamanu)

Figure 9.5.5 Gravel for Core Material (Papaelise)

(Source: JICA Expert Team)

2) Armor Stones

- Procurement of armor stones in Fiji

Armor stones were used for groin and backshore stone. Armor stones used for groin are shown in Figure 9.5.6 and armor stones used for backshore stone are shown in Figure 9.5.7.

With consideration of its stability and utilization, design weight was set as more than about 1 ton for both groin and backshore stones. Armor stones were procured at the quarry site in Fiji and the unit weight of those stones was confirmed at about 2.5 t/m^3 through the laboratory test conducted by the contractor. Therefore, armor stones of more than 0.5 m^3 of the volume (more than 0.8 m of a diameter) were procured to satisfy the design weight. For armor stones, the height, vertical, and horizontal length were measured and the JICA Expert Team confirmed whether the size met the requirement or not. Figure 9.5.8 shows an example of the armor stone selected at the quarry site with a length of 90 cm.

Figure 9.5.6 Armor Stones for Groin

Figure 9.5.7 Armor Stones for Backshore Stone

Figure 9.5.8 Example of Armor Stone at Quarry Site

(Source: JICA Expert Team)

➢ Measurement of the unit weight in Tuvalu

To confirm the unit weight for several armor stones, measurements were additionally conducted in Tuvalu after the transportation. The unit weight of coral gravel procured in Tuvalu was also examined to compare it with the armor stones. Figures 9.5.9 to 9.5.11 show sample stones for measurements. The coral gravel can be divided into two categories: one is gravel like a stone (Type-A) and another is gravel like a coral (Type-B). The gravel (Type-A) looks like a limestone with smooth surface. On the other hand, the surface of gravel (Type-B) has the original coral porous.

Due to limited devices and manpower for experiments on site, the simplified method was applied for the measurement. In order to weigh materials, the electric mass meter shown in Figure 9.5.12 was used and the volume of materials was measured as shown in Figure 9.5.13. At first, the test piece was put in the pot filled with water. Then, volume of overflowed water was measured as the volume of this test piece. Finally, the unit weight was calculated using measured mass and volume. Eight samples were selected taking into account the unevenness of samples and the average value was taken for each type of stone.

Figure 9.5.9 Coral Gravel Obtained in Tuvalu (Type-A)

(Source: JICA Expert Team)

Figure 9.5.10 Coral Gravel Obtained in Tuvalu (Type-B)

(Source: JICA Expert Team)

Figure 9.5.11 Armor Stone Imported from Fiji (Basaltic)

(Source: JICA Expert Team)

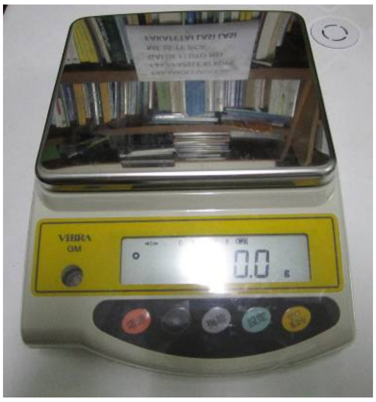


Figure 9.5.12 Electric Mass Meter

(Source: JICA Expert Team)

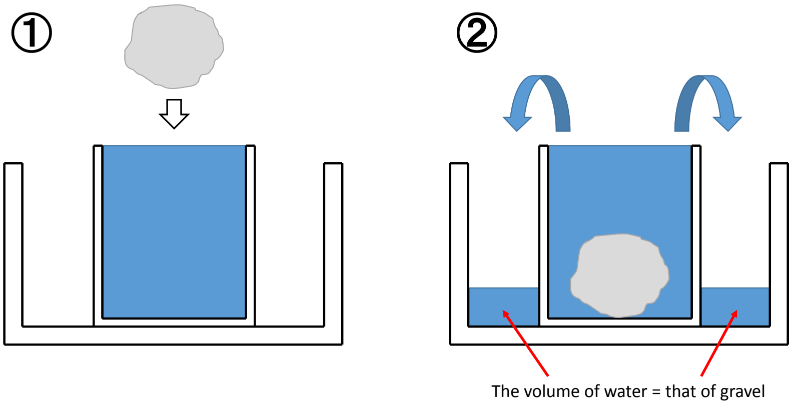


Figure 9.5.13 Method of Measuring the Volume

(Source: JICA Expert Team)

- Obtained unit weight

Obtained unit weight is shown in Table 3.5.4. As shown in this table, the unit weight of basaltic armor stones imported from Fiji was 2.54 and it was re-confirmed that the obtained result could fulfill the design requirement. The unit weight of coral gravel, which are obtained in Tuvalu, was smaller than that of the basaltic armor stones because of the difference of porosity.

Table 9.5.4 Obtained Unit Weight

Item	Type	Use	Unit Weight (t/m^3)
Armor Stones	Basalt	Armor material for Groin, backshore stone	2.54
Gravel (Type-A)	Coral	Material for gravel beach	2.39
Gravel (Type-B)	Coral	Material for gravel beach	1.98

(Source: JICA Expert Team)

9.6 Final Inspection after the Defect Liability Period

The final inspection after the defect liability period was implemented to the north and south groins, which are the permanent structures of the beach nourishment. The inspection items are listed in Table 9.6.1 and these items were inspected by visual examination, photo comparison, and leveling survey.

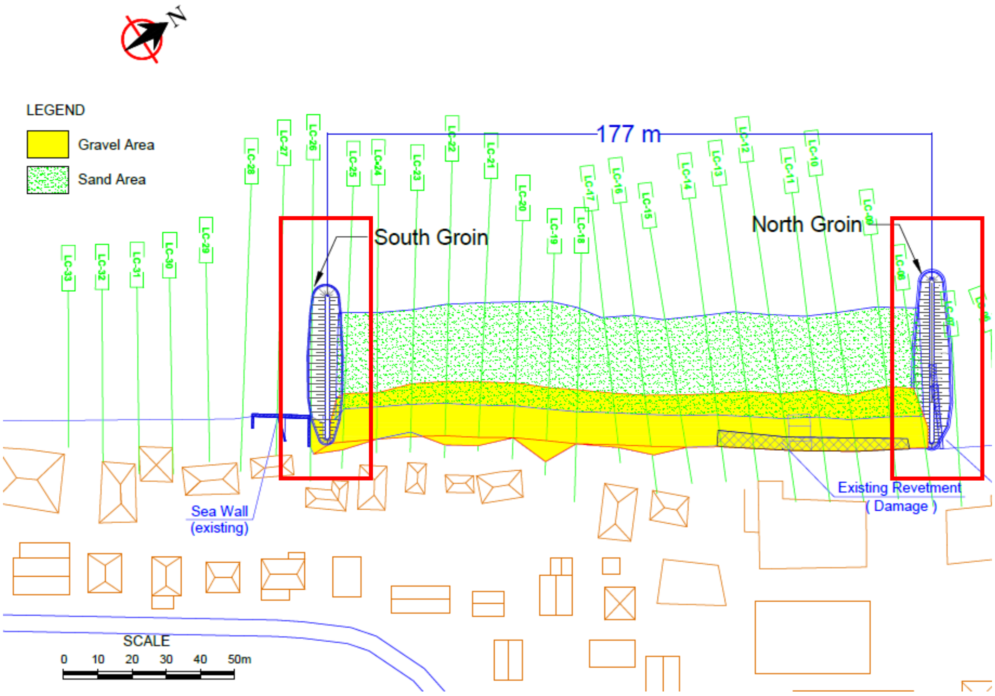


Figure 9.6.1 Location of Groins for Final Inspection

(Source: JICA Expert Team)

Table 9.6.1 Inspection Items and Requirement

Inspection Items	Requirement
Displacement of armor stones	・ Less than 1-2% of displacement rate ・ No major changes in cross section profile
Outflow of core materials (stones)	・ Neither significant outflow nor major changes in cross section profile
Condition of armor stones	・ Neither major abrasion nor degradation
Others	・ No major changes on surrounding environment that have negative impact on groin's function

(Source: JICA Expert Team)

Groin condition was evaluated by comparing two photos; one taken just after the implementation and another after six months from the implementation. Figure 9.6.2 and 9.6.3 show the comparisons of these photos for north groin and south groin, respectively. Triangle marks in the photos show the identification of the same armor stones. Based on these comparisons, no major displacement of armor stones were recognized for both north and south groins. In addition, no major changes on the cross section profile was recognized. Thus, it was confirmed that both north and south groins have remained stable since its construction.

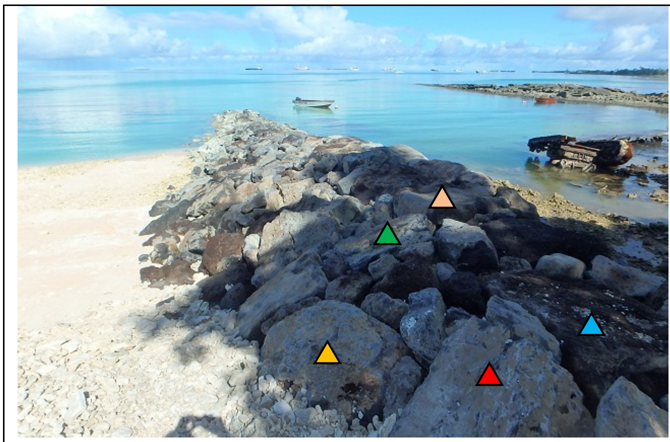
	
24 December 2015 (just after the construction)	15 June 2016 (six months after the construction)
Photo 1	
	
24 December 2015 (just after the construction)	15 June 2016 (six months after the construction)
Photo 2	
	
24 December 2015 (just after the construction)	15 June 2016 (six months after the construction)
Photo 3	

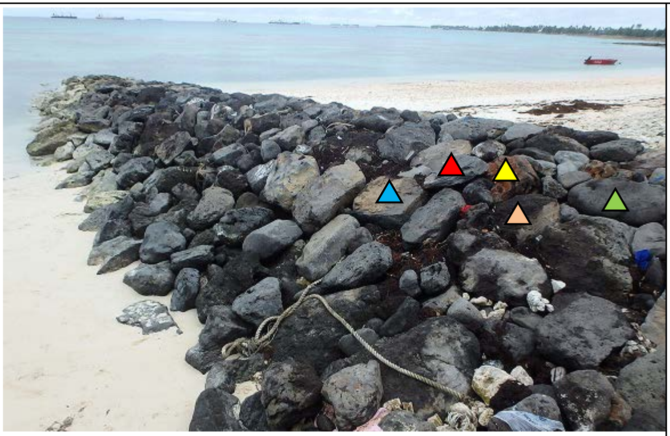
Figure 9.6.2 Comparison of the North Groin

(Source: JICA Expert Team)


24 December 2015 (just after the construction)


15 June 2016 (six months after the construction)

Photo 4


24 December 2015 (just after the construction)

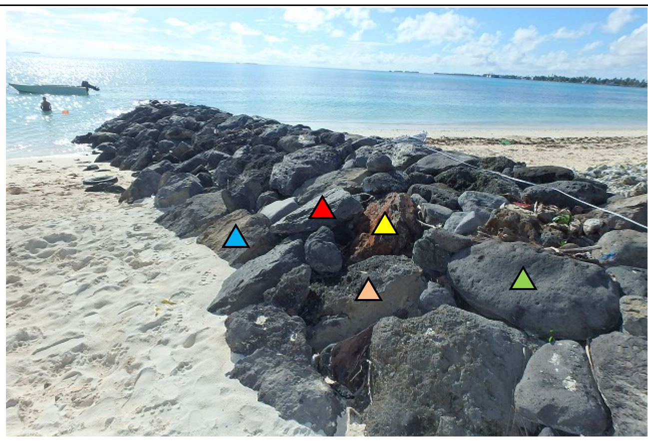
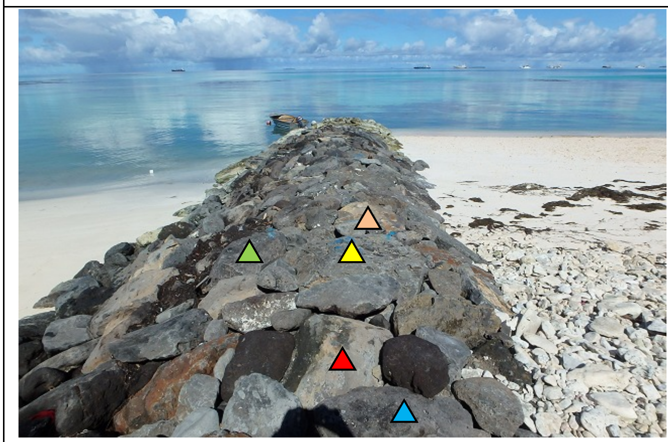

15 June 2016 (six months after the construction)

Photo 5


24 December 2015 (just after the construction)

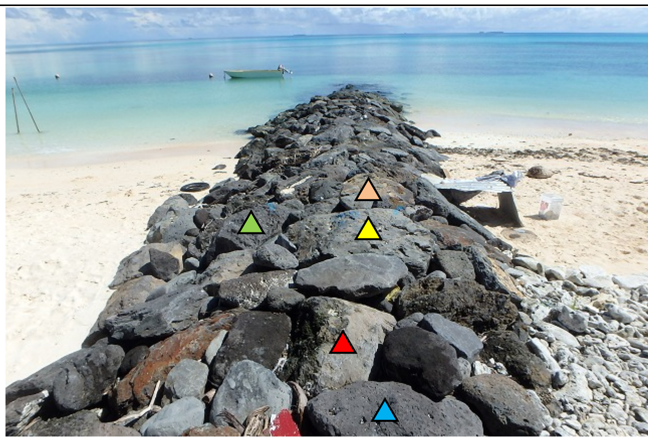

15 June 2016 (six months after the construction)

Photo 6

Figure 9.6.3 Comparison of the South Groin

(Source: JICA Expert Team)

Cross section survey was also conducted to check if changes in profile had occurred or not after the construction. The results are shown in Table 9.6.2 and Table 9.6.3. No major changes in height was observed from the survey but a slight subsidence was observed for both groins and its rate increased at seaward. This was caused by the sink of armor stones in sandy bottom due to wave action. Placement of large armor stones on sand bottom usually causes large subsidence, but the rate were repressed for these groins by the presence of gravel mat placed on the sand bottom. Subsidence of groins could occur in the future especially when high waves act on them. However, the rate of subsidence was expected to be not so large compared to what was observed in this survey.

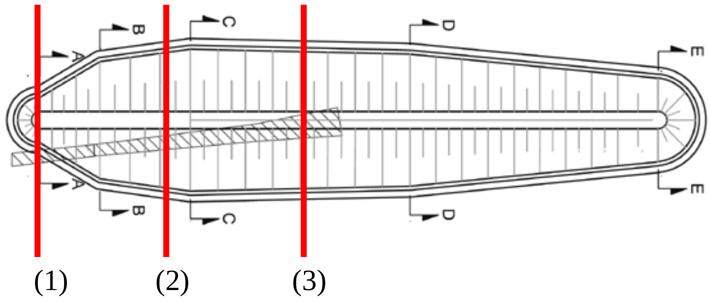


Figure 9.6.4 Survey Lines on Groins

(Source: JICA Expert Team)

Table 9.6.2 Comparison of Crown Height of North Groin

Line	16 December 2015 (just after the construction)	15 June 2016 (six months after the construction)	Difference	Design Height
1	+4.29	+4.30	+0.01	+4.20
2	+4.27	+4.20	-0.07	+4.20
3	+3.80	+3.71	-0.09	+3.80

(Source: JICA Expert Team)

Table 9.6.3 Comparison of Crown Height of North Groin

Line	16 December 2015 (just after the construction)	15 June 2016 (six months after the construction)	Difference	Design Height
1	+4.20	+4.20	+0.01	+4.20
2	+4.26	+4.20	-0.06	+4.20
3	+3.75	+3.65	-0.10	+3.73

(Source: JICA Expert Team)

9.7 Lessons Learned from the Pilot Construction

Lessons learned from the supervision works of construction are summarized in this section so that they can be referred to for future similar construction.

Table 9.7.1 shows the procurement conditions by country (i.e., Tuvalu and Fiji) for the pilot construction. As it is apparent from the table, Tuvalu is one of the most difficult countries to procure sufficient construction items. Therefore, when it comes to construction, procurement from other countries becomes one of the most important issues to be considered for the construction plan. Based on this background, lessons learned from experiences are presented as follows:

Table 9.7.1 Procurement Condition by Country for the Pilot Construction

Procurement Items	From Tuvalu	From Other Country (Fiji)
Construction Equipment	N/A	Backhoe Excavators, Pay Loader, Dump Truck
Work Vessels	N/A	Tug Boat, Flat Barge
Eligible Construction Company	N/A	Cruz Holding Ltd.
Raw Materials	Gravel and Sand	Armor Stones

(Source: JICA Expert Team)

(1) Sea transportation needs some allowance in schedule

In the pilot construction, the preparation work was delayed for about 50 days. This was caused mainly by the delay of sea transportation from Fiji to Tuvalu due to high wave condition. The transportation distance was about 1,000 km long and there were few evacuated area or ports on the way. Therefore, when preparing the construction plan, securing some allowances in schedule is desirable in consideration of sea transportation.

(2) Having self-owned vessels is a priority criterion for the selection of the contractor

Armor stones for the groin and for the backshore stone were procured from Fiji using work vessels (tug boat and flat barge). The original plan was to transport two times from Fiji; however, eventually, it needed one more transportation than expected. In actual, additional transport was arranged effectively even if this was an unscheduled matter. In other words, by having self-owned vessels, the contractor (Cruz Holdings) was able to procure one more transport. If they hired vessels from others, they will not be able to work on this effectively due to the restrictions of hiring period or contracts. Since the procurement of materials from other country is dominant for construction in Tuvalu, to have self-owned vessels is nothing but a priority criterion for the selection of the contractor.

(3) Supervisor is required not only for construction but also for consensus building

The following three issues related to the possessive rights were the initial concerns in implementing the construction accordingly. Therefore, an agreement letter for each issue was prepared prior to the implementation.

- Boundaries between the public and private properties on the beach area
- Possessive rights of gravel borrow site
- Possessive rights of sand borrow site

However, in actual, the Project encountered strong objection related to sand ownership from residents in the middle of construction and was forced to stop the construction for several days, at least temporarily. With a limited national land, possessive rights in Tuvalu is so complicated and can be the cause of conflicts especially for construction works. Therefore, the capability of consensus building is definitely one of the most important abilities required for the supervisor and it is desirable to allocate such supervisor for a project to carry on the construction works effectively.

(4) Better to avoid cyclone season for construction

Cyclone season in Tuvalu begins in October and the most critical period is from January to March. In actual, the construction that started on September was forced to stop the work twice for about a week due to cyclones, one in October and another in November. Some parts of the gravel beach collapsed and needed a few days of repair. In addition, on 29 December 2015, which was just after the completion of the construction on 24 December, Tuvalu was affected by the worst cyclones in 2015 and suffered serious damages on houses and coastal area. While no serious damages were observed on the Project beach, the beach at the reclamation area implemented by the Tuvaluan government was severely eroded for about 20 m due to high waves by cyclones. Therefore, when it comes to construction works, especially on coastal area, it is better to avoid the cyclone season from October to March or to put some allowance for construction schedule considering temporary stoppage of work due to the cyclones.

(5) Since the coral is the most precious resource of Tuvalu, no project can be justified if it spoils the corals

In the middle of the construction, concerns of impact on corals were raised by DOE and the Project was forced to temporarily stop the construction for a week. Concerns were raised due to the change of vessels for gravel transportation on shallow reef area, from small pontoon to large flat barge. These issues were accordingly solved after an explanation to the DOE that even large barge would not hit the sea bed with corals because the working hours was only set during high tide. This occasion made JET and the contractor rediscover that coral reef is the most precious resource in Tuvalu and if construction work would cause serious damage on corals, it could be aborted entirely. JET and the contractor decided not to take gravel from the west tip of Funamanu Island where the area was considered to have higher risks in damaging corals. As described, in the construction work, special care on coral reef have to be paid more than adequately.

(6) Construction site can be used as a field of environmental education

In general, entries to the construction site are not allowed due to safety purposes. On second thoughts, however, since the beach conservation project aims to restore nature, the process of the construction is a process of nature restoration as well, which is a very useful opportunity for students to see and learn. JET invited primary school students to the site a few times in the middle of construction and explained to them the purposes and procedure of the construction as part of the environmental education activities. This kind of activities can be continued after construction.

9.8 Effects of the Construction of the Beach Nourishment

The effects expressed by the construction of the beach nourishment were presented in this section. The beach nourishment was implemented to expect user and environment friendly functions as well as to protect the land against beach erosion and wave over topping. Taking into account such points of view, the outcome of the Project will be discussed as the following points and presented in the following sections:

1) Protection function

2) Coastal utilization

3) Coastal environment

(1) Comparison Before and After the Construction

Figures 9.8.1 to 9.8.3 show the comparison photos before, during, and after the construction from the same position. The previous beach condition changes drastically; and a beautiful beach space with gravel and sand is formed.

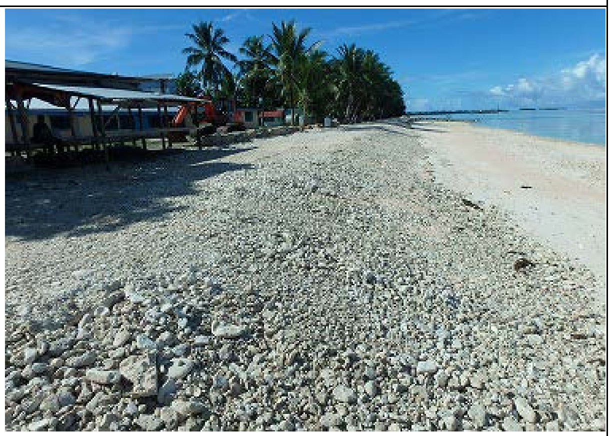
 Before the Construction (21 February 2015)	 Before the Construction (21 February 2015)
 During the Construction	 During the Construction
 After the Construction (24 December 2015)	 After the Construction (24 December 2015)

Figure 9.8.1 Comparison of Photos Before, During, and After the Construction

(Source: JICA Expert Team)


Before the Construction (21 February 2015)


Before the Construction (21 February 2015)


During the Construction


During the Construction


After the Construction (24 December 2015)

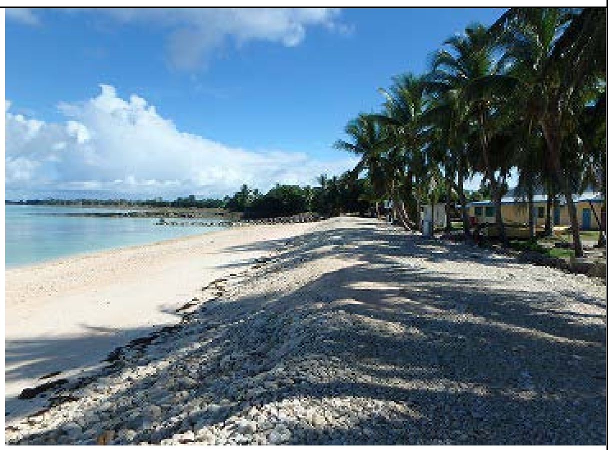

After the Construction (24 December 2015)

Figure 9.8.2 Comparison of Photos Before, During, and After the Construction

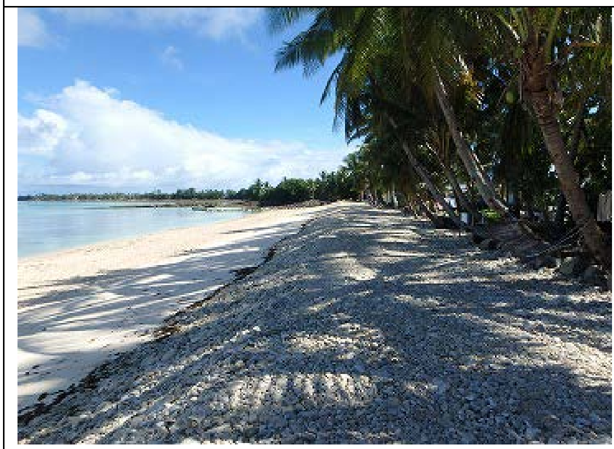
(Source: JICA Expert Team)

Before the Construction (21 February 2015)

Before the Construction (21 February 2015)

During the Construction

During the Construction



After the Construction (24 December 2015)

After the Construction (24 December 2015)

Figure 9.8.3 Comparison of Photos Before, During, and After the Construction

(Source: JICA Expert Team)

(2) Protection Function

After the completion of construction on 24 December 2015, Cyclone Ula was approaching Tuvalu. During this storm period, south or southwest strong waves hit the lagoon side on Fongafale Coast. This is only the opportunity to discuss the effects on protection of land, even though the wave condition during this period was not to the highest extreme condition.

From the result of the interview survey from the residents who are living near the coastal area on the lagoon side, the following information could be obtained:

Before the Project, wave intruded up to their property, easily. However, there was no wave intrusion at their property at this time even in the high wave condition (see Figure 9.8.4). The common opinions from the residents are that forming the gravel beach is surely effective to protect the land. On the other hand, some of the residents anticipated the gradual loss of gravel due to the same degree of storm frequently hitting.

As a result, the function to protect the land can be surely achieved as far as the beach maintains the present condition (width). However, it is not sure that the beach can maintain the necessary width for a long time or not under the same condition since hitting of storms is frequent. Continuous monitoring is still required to evaluate the validity of the proposed beach.

Figure 9.8.5 shows the wave condition in both areas inside and outside of the Project area during the king tide at 5:30 PM on 9 February 2016. At that time, the tide condition was +3.18 m according to the tide table. The land area at the Project site seems safer than the outside of the Project area.

Before the Implementation

After the Implementation

Figure 9.8.4 Comparison of Wave Condition Before and After the Implementation (in high wave condition)

(Source: JICA Expert Team)

Outside of the Project Area

Inside of the Project Area

Figure 9.8.5 Comparison of Wave Condition Inside and Outside of the Project Area during the King Tide (9 February 2016, 5:30 PM, +3.18 m from Tide Prediction)

(Source: JICA Expert Team)

(3) Coastal Utilization

After the Project, a lot of scenes are evident showing that the Project beach is well utilized by the local people. Children play using both spaces of the sandy area and shallow water area as shown in Figure 9.8.6. The groin and backshore stones are also well utilized as expected (Figure 9.8.7).

Figure 9.8.6 Beach Use at the Shallow Water and Sandy Area

(Source: JICA Expert Team)


Figure 9.8.7 Use of Constructed Coastal Facilities

(Source: JICA Expert Team)

(4) Coastal Environment

The water transparency after the Project in front of the beach seems to have improved compared with that before the Project. The change of water transparency might be due to the brightness of seabed and deterrent effect against the diffusion of original seabed material with fine particle by filling of white colored coral sand.

According to the information from some residents, fishes seem to have increased in comparison prior to the implementation of the Project. A lot of fishes can be seen easily especially near the groin as shown in Figure 9.8.9.

Landscape was improved significantly as shown in Figure 9.8.10.


Figure 9.8.8 Water Transparency (13 February 2016)

(Source: JICA Expert Team)

Figure 9.8.9 Fishes in the North Groin

(Source: JICA Expert Team)

Before the Implementation	After the Implementation

Figure 9.8.10 Comparison of Coastal Landscape

(Source: JICA Expert Team)

10. Monitoring Plan

10.1 Overview

The beach monitoring work has been undertaken periodically since the completion of pilot construction in December 2014. The monitoring is divided into four items as:

1) Coastal hydraulic condition

2) Beach change at the Project site and surrounding areas

3) Beach change at the gravel borrow site

4) Marine environment

Even though such monitoring works are mainly undertaken by the Japan International Cooperation Agency (JICA) Expert Team, the Tuvaluan counterpart (C/P) will also join as much as possible, to participate in the technical transfer and capacity development programs.

The objective, method/equipment, and related C/P for each monitoring work are shown as follows:

Table 10.1.1 Items and Method of Monitoring for Hydraulic Condition

Item	Objective	Method / Equipment	C/P
Wave and Current Observation	To know the external condition for beach change	Bottom mounted Wave-current Meter (Wave Hunter)	Fisheries MET Office
Data Collection for Tide	To know the external condition for beach change	Data collection from MET Office in Tuvalu and website (Australian Mythological Services)	MET Office
Data Collection for Cyclone Record	To know the impact to beach change due to special event	Data collection from MET office in Tuvalu and website	MET Office

(Source: JICA Expert Team)

Table 10.1.2 Items and Method of Monitoring for Beach Change at the Project Site and Surrounding Areas

Item	Objective	Method / Equipment	C/P
Change in Beach Profile	To know the change in beach profile and remaining rate for sand and gravel	Beach profile survey using auto level and scale tape	Environment Dept., Land and Survey Dept.
Change in Shoreline	To know the local change in position of shoreline surrounding the Project site including the Tuvaluan Reclamation Project site	Positioning survey using handy-type GPS	
Change in Condition of Beach	To know the local change of beach condition in and surrounding the Project site	Taking photos from fixed points and aerial photographs by Drone	Environment Dept., Kaupule

Item	Objective	Method / Equipment	C/P
Satellite Image	To know the overall change in position of shoreline surrounding the Project site including the Tuvaluan Reclamation Project site	Comparison of shoreline using satellite image	Land and Survey Dept.

(Source: JICA Expert Team)

Table 10.1.3 Items and Method of Monitoring for Beach Change at the Gravel Borrow Site

Item	Objective	Method / Equipment	C/P
Change in Beach Profile	To know the change in beach profile in the west tip of Papaelise and east tip of Funamanu	Beach profile survey using auto level and scale tape	Environment Dept., Land and Survey Dept.
Change in Shoreline	To know the local change in position of shoreline in the west tip of Papaelise and east tip of Funamanu	Positioning survey using handy-type GPS	
Change in Condition of Beach	To know the local change of beach condition in the west tip of Papaelise and east tip of Funamanu	Taking photos from fixed points and aerial photographs by a drone	Environment Dept., Kaupule
Satellite Image	To know the overall change in position of shoreline in the west tip of Papaelise and east tip of Funamanu	Comparison of shoreline using satellite image	Land and Survey Dept.

(Source: JICA Expert Team)

Table 10.1.4 Items and Method of Marine Environment

Item	Objective	Method / Equipment	C/P
Water Quality (Turbidity Measurement)	To know the impact to water quality due to the Project	Measurement of water turbidity using handy-type turbidity meter	Environment Dept.
Existing Corals	To know the impact to existing corals on the island (gravel taking area) due to the Project	Transect survey at fix points	Environment Dept.
Marine Life	To know the impact to marine biota at the Project site due to the Project	Transect survey at fix points	Environment Dept.
Trial of Coral Transplantation	To know the feasibility for artificial coral transplantation in Tuvalu atoll	Fixing of coral fragment to basement stone and visual checking	Environment Dept.

(Source: JICA Expert Team)

The schedule for each monitoring work is shown in Figure 10.1.1. The details for each monitoring work are presented in Section 10.2 to 10.5 and results are shown in Chapter 11.

No.	Monitoring Item		2015		2016												2017											
			11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Monitoring for Hydraulic Condition	Wave Curent Observation		△			△			△						△				△	maintanance			△			△	
		Data Collection for Tide and Cycline		△			△			△						△				△				△			△	
2	Monitoring for Beach Change in and surrounding the Project Site	Survey Work on Site		△	△	△	△			△						△				△			△		△		△	
		Sateliite Image			△													△										
		Aerialphotograph by Drone			△		△				△					△											△	
3	Monitoring for Islands (Gravel Taking Area)	Survay Work on Site		△			△			△						△				△							△	
		Satellite Image			△													△										
		Aerialphotograph by Drone														△											△	
4	Monitoring for Marine Environment	Water Quality (Turbidity Measurement)		△	△	△	△			△										△								
		Existing Coral and Marine Life		△						△										△							△	
		Trial of Coral Transplanation		△	△	△	△			△										△								

Figure 10.1.1 Schedule for Each Monitoring Item

(Source: JICA Expert Team)

10.2 Coastal Hydraulic Condition

The following items are the monitoring items for coastal hydraulic condition around the Project site.

1) Tide observation

2) Wave observation

3) Appearance of cyclone

Tide observation has been collected from MET Office in Tuvalu and website (Australian Meteorological Services) to know the external condition for beach change. Wave observation has been observed by wave-current meter (Wave Hunter) during monitoring period to know the external condition for beach change. Wave-current meter and its installation location are shown in Figure 10.1.2. Appearance of cyclone has been collected from MET office in Tuvalu and website (Wikipedia, the free encyclopedia) to know the impact to beach change to special event.

Tide data is recorded every hour. Wave-current meter was installed in February 2015 after the data was collected in August 2015, December 2015, June 2016, and December 2016, it has been re-installed. In April 2017, the data was collected and wave-current meter has been brought back to Japan, after inspection and maintenance, it was re-installed in August 2017. After that, the data was collected and wave-current meter has been re-installed in November and wave observation is currently under observation. Recording of data is carried out by observation for ten minutes at 0.2 second sampling interval every two hours.

During the monitoring period, storms that affected Tuvalu have been observed eight times. These details are summarized in following Chapter 11.

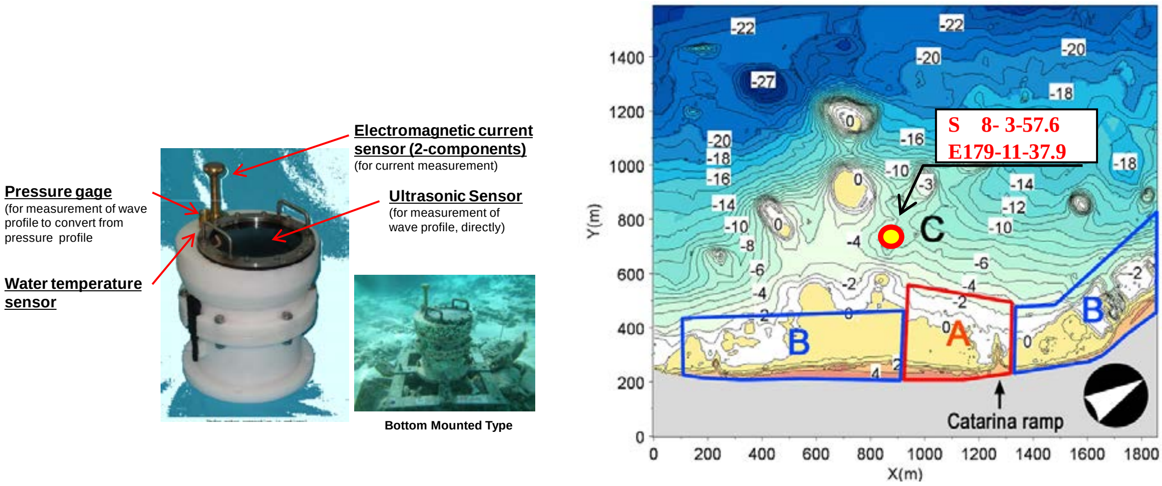


Figure 10.2.1 Wave-Current Meter and Installation Location

(Source: JICA Expert Team)

10.3 Beach Change at the Project Site

The following items are the monitoring items for beach change at the Project site:

1) Change in Beach Profile

2) Change in Beach Condition

3) Change in Shoreline at Surrounding Project site

Change in Beach Profile has been measured by using the auto level and scale tape. Change in Beach Condition has been checked by the result of site investigation in each monitoring period together with photos taken from the fix points. Change in Shoreline at Surrounding Project site has been analyzed by conducting the positioning survey using Global Positioning System (GPS) on site, and by comparison of satellite image before and after the pilot construction. The new project of reclamation and a beach nourishment has also been undertaken by the Government of Tuvalu at about 700 m on the south side from the Project site. This Government of Tuvalu project commenced in November 2015 and the dredging work was completed in January 2016. This period was almost at the same timing of the Project period, and some impact was anticipated. Thus, the area for the Government of Tuvalu has also been covered into the positioning survey using GPS.

Beach condition is expected to change drastically in the early stage after the completion of construction in order to be on stable condition, based on the experience of other similar projects for beach nourishment. Taking into account this natural process, the monitoring for beach change has been planned to be conducted monthly in the first three months from January to March 2016.

On 27 December 2015, which was just after three days from the completion of construction, Cyclone Ula reached Tuvalu. Due to this, strong winds and waves continued to attack the island especially the lagoon side of Fongafale Island for almost two weeks. The strongest wind happened on 28 to 29 December. The coastal area on the lagoon side was damaged by the strong winds. The roofs of several houses were blown away by strong winds and plenty of big trees fell down. The Project beach was also influenced by hitting of high waves as well as other coast on the lagoon side. However, this event was useful to justify the stability of the beach and degree for change in beach profile.

The monitoring for beach change was carried out for 10 times in total from December 2015 to November 2017. Obtained results are presented in Chapter 11.2.

10.4 Beach Change at the Gravel Borrow Site

The following items are the monitoring items for the island:

1) Change in Beach Profile

2) Change in Beach Condition

3) Change in Shoreline at Surrounding Gravel Taking Area

1) Change in Beach Profile has been measured by using the auto level and the scale tape. 2) Change in Beach Condition has been checked by the result of site investigation in each monitoring period together with photos taken from fix points. 3) Change in Shoreline at surrounding gravel taking area has been analyzed by comparison of satellite image before and after the gravel taking and aerial photographs by Drone.

Gravel extraction was conducted in the eastern end of Funamanu and in the western end of Papaelise on the lagoon side. The monitoring of the impact on the recovery situation of extraction area and surrounding coasts will be continued by the above method.

10.5 Marine Environment

The JICA Expert Team implemented environmental monitoring during the construction and post-construction periods in accordance with the Environmental Monitoring Plan (EMoP) proposed under the approved Project’s Preliminary Environmental Assessment Report (PEAR). In addition, after the construction works were completed, the JICA Expert Team implemented on trial basis coral transplantation along the shallow reef area of Papaelise. This section summaries the results obtained for the following monitoring activities (Three monitoring reports have been submitted to the Department of Environment (DOE) and are attached as Supporting Report-9):

1) Water quality

2) Coral

3) Marine life

4) Trial of coral transplantation

Water quality monitoring (item 1) above) was measured using portable turbidity meter and purposes of measures for each phase are as follows: 1) Construction phase: to monitor the impacts of construction works (i.e., sand-placement work) on water quality using turbidity as an indicator, 2) Post-construction phase: to monitor the impacts of the beach nourishment on water quality using turbidity as an indicator.

Coral monitoring (item 2) above) was conducted by visual examination and photo recording to monitor whether the corals distributed inside the barge entrance route of Papaelise and North Funamanu are not damaged through gravel-transporting activities.

Marine life monitoring (item 3) above) was conducted by visual examination and photo recording to monitor the impacts of the beach nourishment works on the marine life adjacent to the Project site.

Monitoring of coral after transplantation (item 4) above) was conducted by visual examination and photo recording by divers to examine the possibility of coral transplantation as a mitigation measure against coral damage.