Chapter 4 Study on Middle and Long-Term Countermeasures

4-1 Precondition of the study

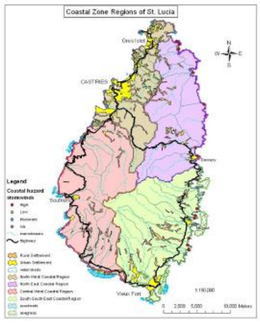
Table 4-1-1 shows preconditions to be considered for the study of middle and long-term countermeasures clarified by data collected and hearing survey from related organizations. St. Lucia side confirmed the relevancy of Table 4-1-1 that is the preconditions of the study of middle and long-term countermeasures in this study although the conceptual plan that is shown in the national plan shall be possible to change in its implementation stage.

Preconditions are 1) condition to national plan, 2) condition with shoreline usage by fishing boats, 3) condition with difficulty to relocate Fisheries Complex, 4) condition with shoreline role as tourism resources 5) condition with shoreline usage by fishing activities. Especially, Chief Fisheries Officer referred to ecosystem value by sandy beach that sandy beach shape is necessary to cultivate proper sea weeds by sand accessibility in view of conservation of fishery resource. In addition, Permanent officer indicated that south side beach from the jetty is important resource for resident and tourist and they have promotion policy to the conservation of sandy beach shape and the convenience.

Table 4-1-1 Study of preconditions

(1) National Plan	1) Redevelopment of waterfront a) Enhancement of Vendors Arcade b) Reconstruction of Entertainment Center c) Preservation of sand beach d) Construction of beach facilities e) Construction of board walk 2) Improvement of fishing village a) Expansion of berthing function b) Construction of fuel supply facility 3) Preservation of natural beach (Southside of beach)
(2) Shoreline usage by fishing boats	1) Conservation of landing function of fishing boats in front of Vendors Arcade
(3) Difficulty to relocate Fisheries Complex	1) Existence of Fisheries Complex building
(4) Shoreline role as tourism resources	1) Conservation of shoreline shape 2) Construction of sunbathing beach
(5) Shoreline usage by fishing activities	1) Conservation of beach coast (for the fishing by beach seine net)

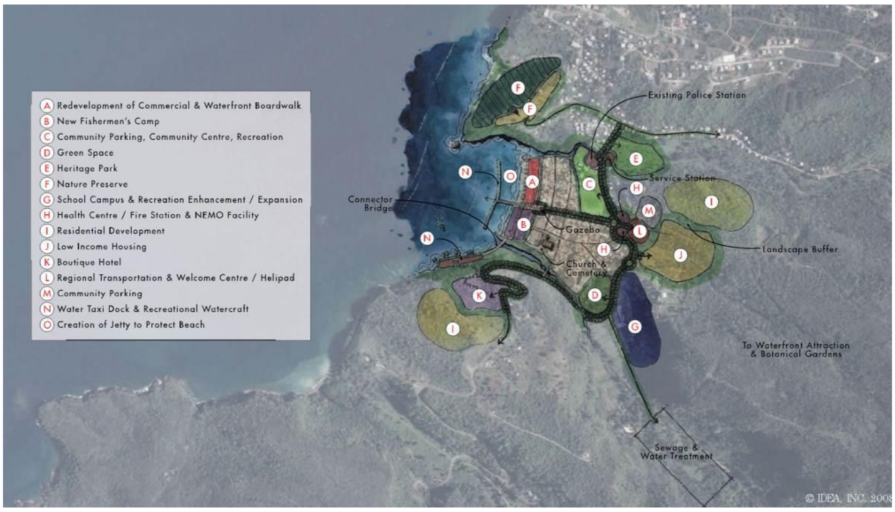
4-1-1 Precondition by National Plan



Source: Ministry of Physical Development, Environment and Housing, Government of Saint Lucia
Figure 2: Coastal Zone Regions of Saint Lucia

Coastal Zone Management Plan has been established as National Plan at St. Lucia in 2007. This concept shows the development initiatives of the base Sections where the Coastal Management Zone were set up for whole land of St. Lucia. Anse La Raye is located at Northern Coastal Zone and the long term concept of Anse La Raye Section is shown there. This concept is considered as the guideline of development and the adjustment is done for each development plan.

This plan is the existing plan and will not be restricted by this concept though, middle and long-term countermeasures thinking of the section development initiative are necessary to study.



Source: National Land Policy Ministry of Physical Development, Environment & Housing

Source: The Canaries/Anse La Raye Management Plan: National Vision Plan West Central Quadrant

Figure 4-1-1-1 Anse La Raye Management Plan

ACTION ITEMS

Community Development Initiatives

- Transportation Plan: Water taxi and ferry link. One way road system within village, local transportation plaza. Lighting opportunity for new perimeter roadway and town entry features. Helipad for emergency support and to form part of the NEMO network.
- Waterfront Redevelopment Plan: Vendor arcade to support "Seafood Fridays." Entertainment centre. Protected swimming beach and beach facilities. Boardwalk.
- Housing Plan: Improvement of existing housing stock. Redevelop vacant and derelict plots. General area beautification. Provision of new developments for all levels of housing requirements.
- Educational and Vocational Development Plan: Creation of a village campus to meet the needs of the whole community's learning – from pre-school through vocational learning to support local business and tourism opportunities.
- Social Services Plan: Community recreation facilities, support services centre. Polyclinic.
- Fishermen's Village Improvement Plan: Expansion of berthing facilities to support local traffic and yachting. Provision for local fueling. Market area (combine with farmers).
- River Improvement Plan: Protection of the water intakes, filtration system to clean discharge, storm water drainage improvement.
- Local sewerage and water management plan.

Tourism Initiatives

- Boutique hotel site to south of village.
- Community "hotel" – programme to encourage home owners to offer an in-family tourism experience through training and support in provision of facilities.
- Regional Transportation & Welcome Centre offering local tourism information and rest facilities to those exploring the area.
- Parks Initiative: Including the development of a heritage park at the entrance to the village, and a Natural Coastal Preserve to the south of the village. Addition of botanical gardens and further recreational facilities to the Venus Waterfalls.
- Tourism Offer Development: Provision of support services in developing both existing and new excursions, tours and attractions.
- Village Information Centre and internet café based in the old police station.

Initiatives for Surrounding Areas

For surrounding areas such as Anse Galet, Millet, and Theodorine, community needs must be assessed, including required services and transportation links, the development and maintenance of parks and recreational space and roadway linking, development, and improvements to open up new areas for agriculture and residential/community development. Sensitive areas like marine reserves and historic sites must be protected. Expansion of attractions, such as the Millet Nature Reserve and Bird Sanctuary, and development of new attractions, like Venus Waterfall and Botanical Gardens, will increase available eco-tourism based activities in the area. Growth of boutique resort developments around the area is recommended, possible locations include Anse Galet.

Source: The Canaries/Anse La Raye Management Plan: National Vision Plan West Central Quadrant

4-1-2 Precondition with shoreline usage by fishing boats

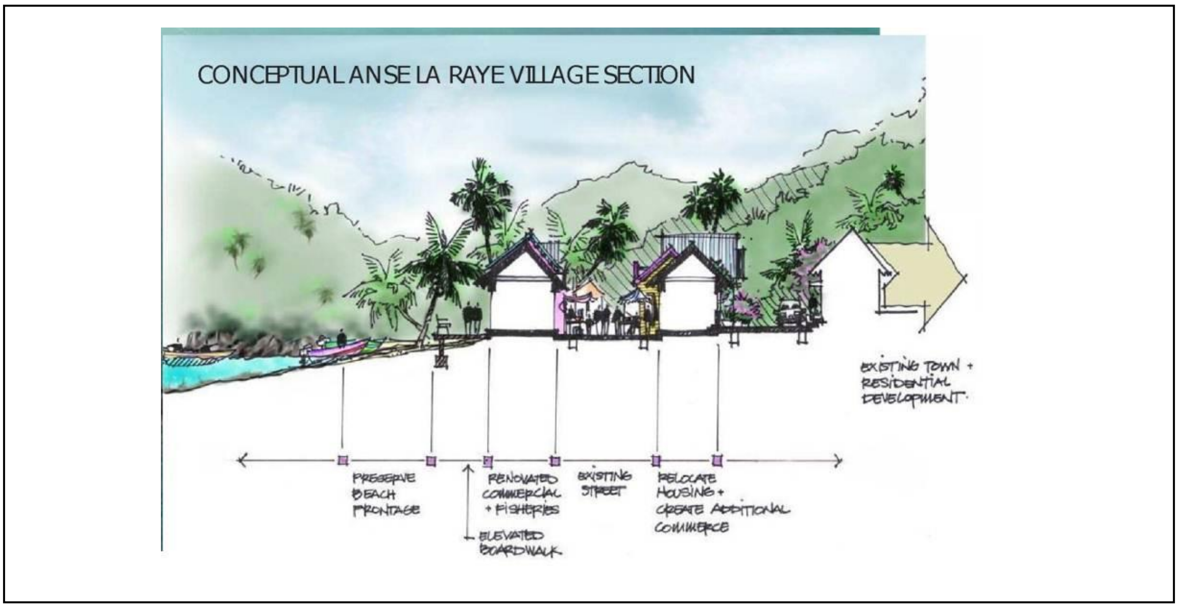
Project shoreline is functioned as the storage place of fishing boats and the spaces between Fisheries Complex and Fishing Gear Lockers 1 and Vendors Arcade itself are functioned as evacuation passages for fishing boats at the time of unusual weather like hurricane. Therefore, the front area of Vendors Arcade where is the objective area of this study is required to have countermeasures keeping up the function of boat passage. In particular, it is required not so as to damage bottom of fishing boats using enough sand when the boats get inside to Vendors Arcade.

4-1-3 Precondition with difficulty to relocate Fisheries Complex

There are no land existed to relocate Fisheries Complex in Anse La Raye and Canaries Sections and study for the prevention measures by relocation is difficult.

4-1-4 Precondition with shoreline role as tourism resources

Anse La Raye is the historically important place where France Army has firstly landed at the period under France ruling. It also works out by tourism and fisheries industries representing old cityscape at backside town and Fish Friday. As shown in above (1) concept, development initiative together with fisheries and tourism is directed. The project shoreline is not used for sunbathing by tourists, however it is said that beautiful shoreline of Anse La Raye Bay is valuable as the sightseeing objective. And, the village is vitalized by tour event representing Fish Friday based on the landscape together with old cityscape and the shoreline. In the meantime, the said concept shows construction of sunbathing beach. Therefore, the conservation of shoreline shape is strongly required.



Source：The Canaries/Anse La Raye Management Plan: National Vision Plan West Central Quadrant

Figure 4-1-4-1 Anse La Raye Beach Plan

4-1-5 Precondition with shoreline usage by fishing activities

Fishing by beach seine net is popular in Anse La Raye shoreline. The beach seine net is installed by fishing boats in the bay and it is pulled up utilizing beach. Therefore, countermeasures to influence any restrictions to the fishing by beach seine net are difficult. In particular, the preservation of sandy beach is required.

Photo 4-1-5-1 Fishing by beach seine net using sandy beach

4-1-6 Intention of St. Lucia concerning conservation of beach shape

The conservation of beach shape is closely connected with the beach recovery tendency and the study direction of middle and long-term countermeasure has been discussed based on the site survey and the result of analysis. The thought of St. Lucian side are as follows,

1) As beach is in recovery tendency therefore, they expect a countermeasure to remain current beach shape
2) Beach occupies important role on fisheries activity (beach sine net, hauling fishing boats and rest, storage of fishing net or hook rig and etc.)
3) It is necessary to maintain current beautiful beach shape as tourism resource.
4) Plan is going on so as to be able to swim at the south side of beach and make place for recreation by tourists and resident. The beach shape is important.
5) Even if offshore facility like detached breakwater is necessary protecting the situation at the abnormal weather, the change of beach is going to be avoided as much as possible.
6) In addition, sand of beach is important for ecosystem of fisheries resource so that clean ecosystem is kept.

4-2 Basic policy of countermeasure

4-2-1 Basic understanding of beach deformation at Anse La Raye Bay

Basic understandings of beach deformation at Anse La Raye Bay are as follows,

1) Sandy beach was formed by sheltered area of headland.
2) The coast has a tendency of shoreline recession with 60 cm per year in the long run.
3) It is difficult to relocate the place where there are various artificial structures are already existed at the backshore. Although shoreline is generally fluctuated by waves, the existence of artificial structures in the fluctuating width makes beach become irreversible and the coast line can not be returned. This is the situation of the beach at Anse La Raye Bay.

In addition to the above basic understandings, the following matters have become apparent by this survey.

4) Beach in front of Fisheries Complex has been stable about last half year.
5) It is estimated that the area with 5 m to seaside from Fisheries Complex is in unstable situation since the sand is easily moved by waves.
6) Anse La Raye is the calmest beach out of 3 natural beaches (Roseau Bay beach, Anse La Raye beach and Tikaya Village beach) including 2 coasts around.
7) Hurricane Thomas brought large volume of sand to river mouth at the south side of Anse La Raye Bay and the deposited sand has moved gradually to north by wave's action. It gets to the period for recovery of coastline now.
8) The cliff surrounding Anse La Raye Bay becomes one of the supply sources of sand. And, there is a possibility that sand will be supplied from the river by such as landslide of inland area caused by hurricane Thomas.
9) Recovery speed of coastline will be clarified with the analysis of the result of additional survey. However, with the result of present simulation, it is found that more than 2 years time shall be necessary until the sand transport reaches to north side beach detouring the jetty.
10) If the sand at the water being lower than complete critical depth of 5m out of deposited sand at the river mouth now evenly moves to the beach at Anse La Raye Bay, the coastline will be advanced 10.0 m and it is considered that the shoreline is advanced in comparison with the time of BD stage in 2006.
11) After the deposited sand is returned by hurricane Thomas to south side river mouth at the Anse La Raye Bay, the beach goes back to the beach where 40 to 50 cm per year are retreated as far as some sand is supplied.
12) As described the above, under the situation where the shoreline is advanced, the influence to fisheries facilities can not be avoided at the time of abnormal weather since the backshore ground level is lower than run up height by the waves with a return period of 30 years. Some sort of countermeasure is necessary.

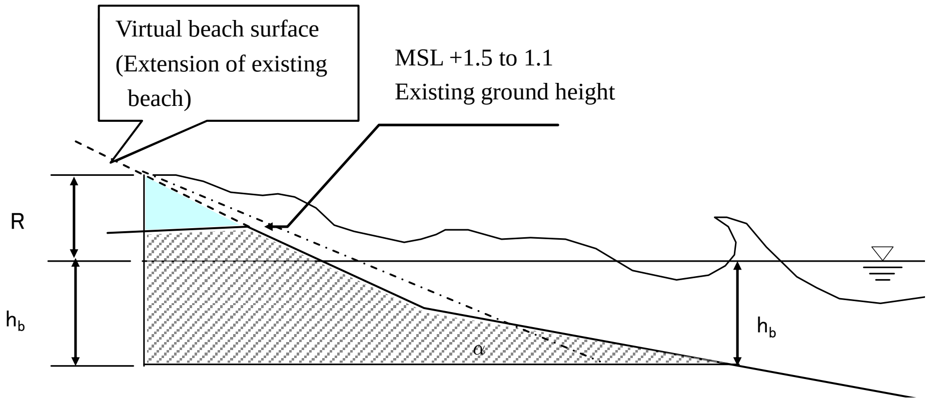


Figure 4-2-1-1 Calculation of run-up wave height by advanced virtual slope method

Table 4-2-1-1 Run-up wave height by wave with a return period of 30 years

Wave condition	Tide Level condition	Run-up height
Wave with a return period of 30 years	M.S.L.+1.02m	+2.40m
Wave with a return period of 30 years	M.S.L.+0.68m	+2.06m

4-2-2 Basic policy for middle and long-term countermeasures

Beach situations at the stages of short, middle and long-term countermeasures upon basic understandings of the necessity and issue of middle-term and long-term countermeasures shown in 3-4-2 and the beach deformation at the Anse La Raye Bay described in 4-2-1 are as follows,

1) It has been the situations at the stage of short-term countermeasure that the shoreline has been recessed, beach has been subsided, backshore has been lost and the foundation of fisheries facilities has been scored.
2) At the stage of middle-term countermeasure, it will be the situation that the beach is in the course of recovering stage to the shoreline and backshore at the time of 2006, Basic Design Stage.
3) At the time of long-term countermeasure, the recovery phase is ended and the beach is in the situation to return to eroding beach as far as some sand is supplied.

While, as shown in 4-1, as the beach at Anse La Raye Bay is defined as important local tourism resources as well as occupying the important position in fisheries function,
the study goal on countermeasure in short-term, middle-term and long-term are as follows,

1) Study goal for short-term countermeasure: Protection for scoring of building foundation, uneven subsidence and others by recessing beach.
2) Study goal for middle-term countermeasure: Partial recovery of beach geometry as well as protecting scoring of building foundation, uneven subsidence and others improving and reinforcing the short-term countermeasure.
3) Study goal for long-term Countermeasure: Protection for fisheries function including beach geometry and remove the fear from incoming waves at the time of abnormal weather.

Table 4-2-2-1 shows the basic understanding of three countermeasures based on the beach recessing structure at Anse La Raye Bay shown in Chapter 3, that are 1. Natural Recovery (Countermeasure-1), 2. Beach recovery by sand fill (Countermeasure-2), 3. Protection by structures (Countermeasure-3).

Table 4-2-2-1 Basic understanding of each countermeasure

	Short-Term	Middle-Term	Long-Term
Countermeasure-1 (Natural Recovery)		Countermeasure-3	Countermeasure-3
Countermeasure-2 (Beach recovery by sand fill)		Countermeasure-3 Partial recovery of beach geometry by sand filling and back-filling method.	Security of beach width by beach nourishment so as to be functional at the time of anomalous weather and the execution of periodical maintenance beach nourishment
Countermeasure-3 (Protection by Structures)	Protection for scoring of building foundation and uneven subsidence due to the possible progress of recession	Reinforcement not so as to be crucially damaged by abnormal weather as well as mending the short-term countermeasure	Execution of waves control measure by constructing detached breakwater (submerged breakwater, artificial reef) and etc.

Protective measure was executed by structure due to the rapid beach recession at the short-term countermeasure phase. After that, it was known that the beach is in recovering trend by this analysis. There found three choices at the middle-term countermeasure phase that are measure-1 to wait for natural recuperative power, measure-2 to intend beach recovery and measure-3 to protect by structure. However, it is predicted that the natural recovery to make shoreline as of September, 2011 advanced 12 m in about 5 years. However, as the advancement of shoreline in front of Vendors Arcade is delayed in comparison with surroundings, it was already learned that positive sand filling contributes to the advancement of shoreline as analyzed in Chapter 3. Therefore, at middle-term countermeasure phase based on the premises shown in 4-1, strengthening the protection like scouring and uneven subsidence of Fisheries Complex by reinforcing measure-3 that was executed at the short-term countermeasure and recovering fisheries functions by partial recover of beach geometry are necessary. As the shoreline in front of project facilities will be advanced about 12 m in about 5 years and the south side shoreline shall return to recessing beach after advancement of 18 m, at the stage of long-term countermeasure, it is necessary to maintain fisheries functions with the countermeasure of measure-2 (maintain shoreline position and beach width once advanced by sand filling works) and measure-3(maintain beach by wave control).

4-2-3 Problems to be solved of middle and long-term countermeasures for each fishery facility

Table 4-2-3-1 shows the problems to be solved of each facility at the stages of middle and long-term countermeasures based on the basic policy of middle and long-term countermeasures

Table 4-2-3-1 Problems to be solved of each facility on middle & long-term countermeasures

Facility	Problems to be solved of middle-term countermeasure	Problems to be solved of long-term countermeasure
Jetty and the ancillary facility	1) Countermeasure for exit of water drain	1) Location of rubble stones at the foundation of the jetty for securing beach in front of Vendors Arcade
Arcade	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season. 2) Security of backshore width for the function of hauling fishing boats. 3) Protection for scoring of arcade foundation at the time of run-up waves with a return period of 30 years. 4) Recovery of beach geometry	1) Retaining backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years
Fisheries Complex	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season. 2) Protection for scoring of foundation of Fisheries Complex at the time of run-up waves with a return period of 30 years. 3) Recovery of beach geometry 4) Retention of people's passage for north and south movement	1) Retention of backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years
Fishing Gear Lockers I & II	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season.	1) Retention of backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years
Work Shop	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season.	1) Retention of backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years
Septic Tank	1) Impact mitigation of run-up waves produced by swell of long-term period in winter season.	1) Retention of backshore width 2) Stability of foreshore 3) Mitigation of run-up height by waves with a return period of 30 years

4-3 Design and construction work for middle-term countermeasure

4-3-1 Design policy

(1) Installation of protective line

3 times of Topographic survey and Bathymetric Survey were executed on September 20, 2006, September 8, 2011 and January 18, 2012 throughout Anse La Raye Bay. Figure 4-3-1-1 shows the figure superposing 3 times of shoreline positions. This understands that the present shoreline is advanced than that of 2006. It is predicted that the shoreline will be further advanced over the years. The position of shoreline in front of Fisheries facilities as of 2011 was not changed than that of 2006. However, the south side beach has been undoubtedly recessed. Worse yet, subsidence of the beach have been generated in 2011 and the short-term countermeasure was executed as emergency response due to the loss of backshore.

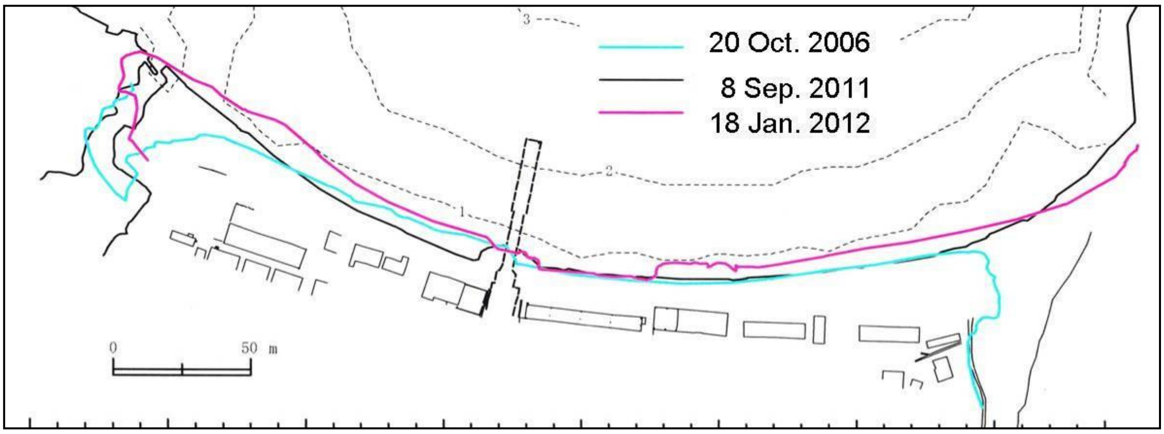


Figure 4-3-1-1 Variance of shoreline position (2006, 2011, 2012)

Figure 4-3-1-2 shows the cross-section shapes in front of Vendors Arcade, Fisheries Complex and Fishing Gear Lockers at the time of 2006 (Basic Design Stage). At that time, there exists backshore width with about 7 to 10 m and the ground level was about MSL +1.5m. There were fishermen's explanations at the time of basic design stage that the shoreline is recessed and the width of backshore was wider in the past therefore, it is considered that the coast would have been recessing tendency already. Since the construction work was completed already after execution of basic design study upon agreement with St. Lucia. Therefore, the assumption is made on shoreline position and backshore width and height at a time of 2006 as the protective line (line that does not retreat any longer).

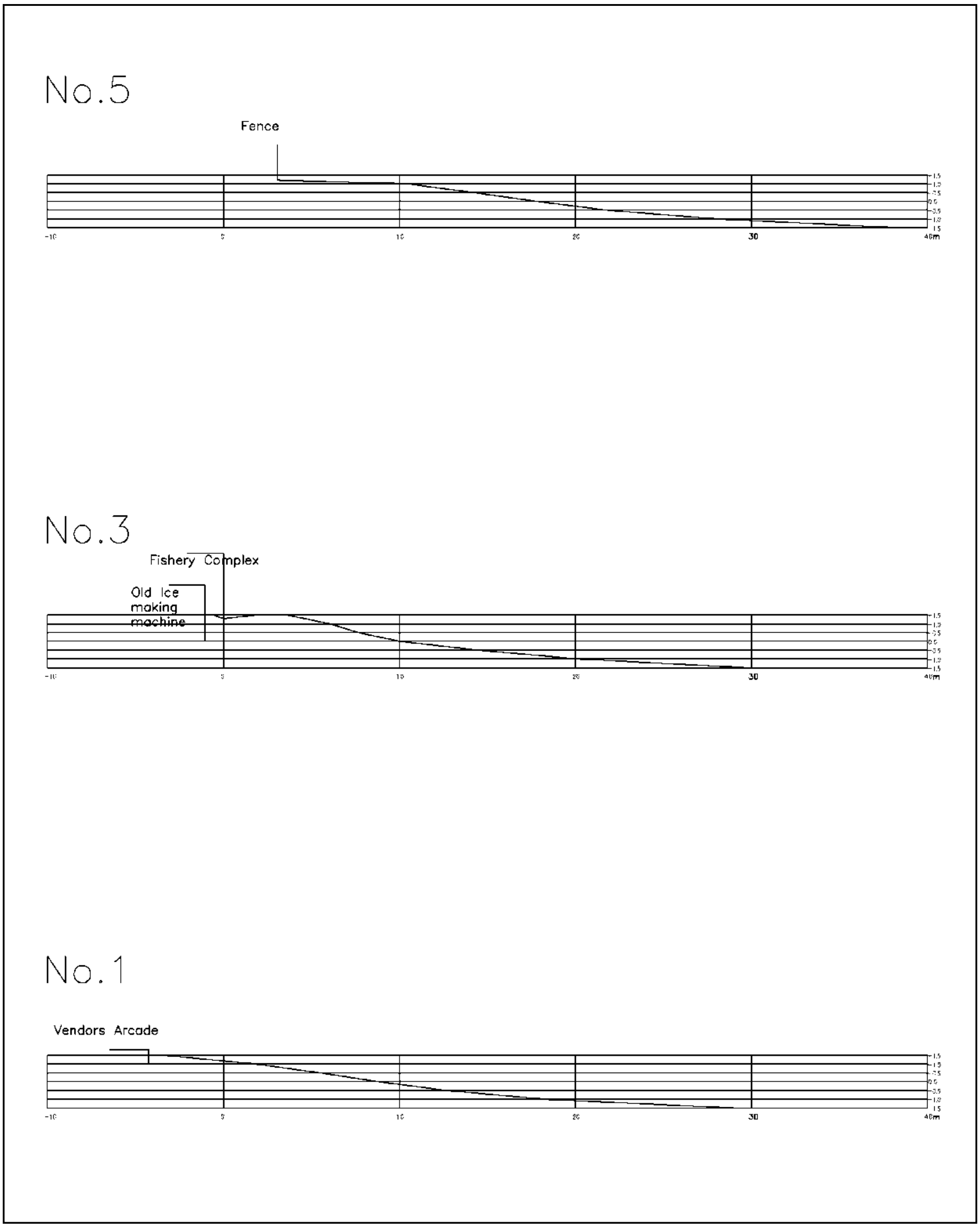


Figure4-3-1-2 Beach cross section as of 2006 (Protective line)

(2) Protective method

As emergency countermeasure for recession of shoreline, subsidence and loss of backshore, the countermeasure for scoring by armor stone works was executed at the short-term countermeasure and this has produced some effects. The armor stone works in front of Fisheries Complex is stable fitting in foreshore slope though the head part of stones has gone to offshore side a little bit.

Figure 4-3-1-3 shows the figure to superpose cross-sections in 2006, 2011 and 2012. This understands that foreshore slope around Fisheries Complex and Vendors Arcade becomes steep in comparison with the front area of north side warehouse. It is necessary to reinforce the head part of armor stones by putting heavier stones so as to be functioned against waves with a return period of 30 years at the middle-term countermeasure. And as Vendors Arcade is located at the center part of bay where waves is strong and the protection by armor stone works is desired being the same as Fisheries Complex, this place must keep beach geometry since this shall be the place for hauling fishing boats and the evacuation route at the time of rough weather. The advancing tendency of shoreline at this place is slower comparing with s surrounding areas. Therefore, the impact by run-up waves shall be lightened amplifying backshore width by sand filling.

It is inevitable to add sand observing the beach situation after the sand filling work is completed. As to this point, it is necessary to confirm the intention of St. Lucian side to execute the maintenance sand fill. As to the front end of Fishing Gear Lockers, protective work like the armor stone works that was executed at the short-term countermeasure for the front end of Vendors Arcade, shall be installed and covered by sand not so as to be scored by run-up of long period waves like swell in winter season or waves with a return period of 30 years.

The beach geometry shall be restored as well as the armor stone works in front of Fisheries Complex shall be enhanced in its head area. The armor stones at the foundations of facilities shall be remained as it was for the scoring protection and the other areas shall be once removed and excavate and re-install stones and sand cover them and the beach geometry shall be restored. The enhanced part at the head shall be exposed in order to keep the absorving waves function.

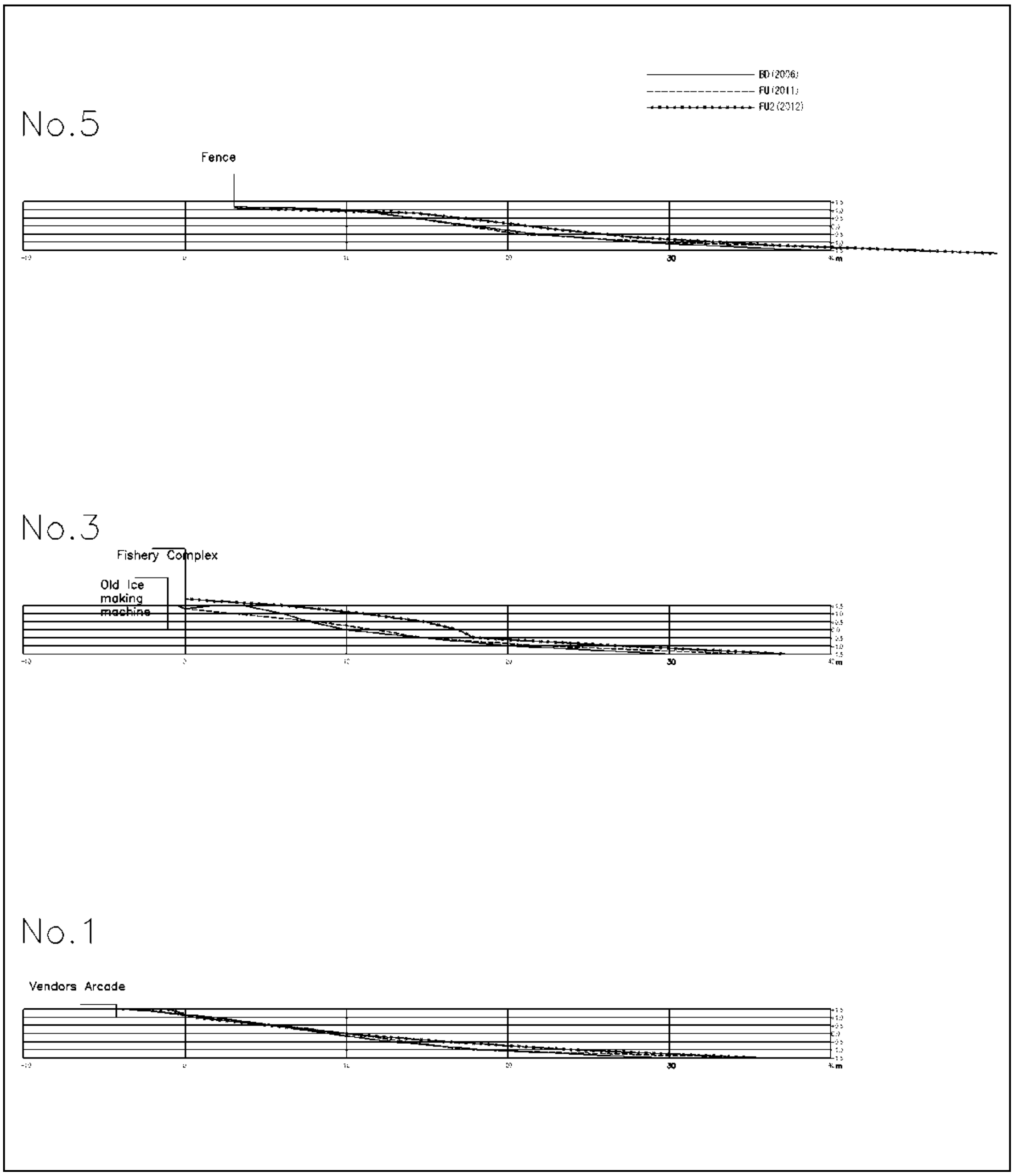


Figure 4-3-1-3 Comparison of cross section in 2006, 2011 and 2012

4-3-2 Design condition

(1) Waves condition

1) Waves analysis

The place is facing to Caribbean Sea side of Lesser Antilles. In the total sea area from west side of the Atlantic Ocean to Caribbean Sea, the occurrence frequency of E-direction wind that is considered to be influenced by trade wind is dominant. (Average wind distribution data by Global Objective Analysis of Meteorological Office (refer to Figure 4-3-2-1)) In connection with this, E-direction waves generated by this wind at the east side of Lesser Antilles are dominant. These waves do not directly come to the spot of Anse La Raye though the invading waves from straits of north and south ends of St. Lucian Island. While, although the occurrence frequency is low, waves generated by W-direction wind in Caribbean Sea come directly to the point. Here, generating waves in the Atlantic Ocean and Caribbean Sea are predicted using Global Objective Analysis Data and One Point Model. Generating waves in the Atlantic Ocean is combined with the generating waves in Caribbean Sea after deformation calculation of invading waves is done and the wave condition at the point is known. Wave analysis method is shown in Figure 4-3-2-2.

2) Result of wave analysis

In accordance with the method shown in the above a), wave analysis was made at the point of Anse La Raye. The point is located at the mouth of Anse La Raye Bay (water depth is about -30m). As described previously, frequency table of waves generated in the Atlantic Ocean and in Caribbean Sea and waves that two waves are combined at the mouth of Anse La Raye is obtained. The results are shown in Tables 4-3-2-1, 4-3-2-2, 4-3-2-3. And the wave distribution chart for the waves in Anse La Raye Bay is shown in Figure 4-3-2-3.

With these, waves with the maximum around 7 m come to the east coast of St. Lucia. While, waves with the maximum around 1.5 m are generated in Caribbean Sea and the occurrence ratio of wind direction NNW is the most and occupies about 70% and SSW is about 25%. Combining these waves, the occurrence ratio of waves height over 1 m and 2 m are 20% and 1.1% respectively in Anse La Raye Bay. And the occurrence ratio of wave direction NNW is about 48%, about 20% for N and about 18% for SSW in order. In view of seasonal aspect, high waves tend to come from N and NNW from winter to spring season.

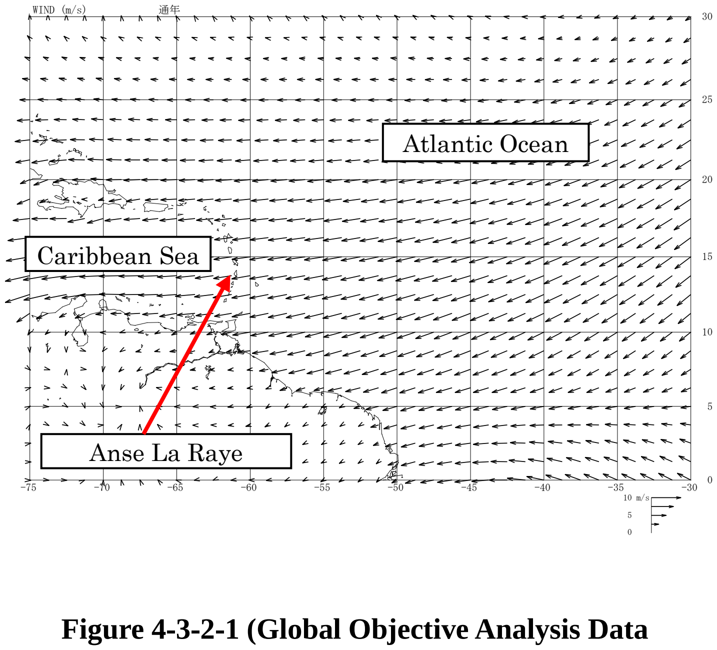


Figure 4-3-2-1 (Global Objective Analysis Data 2002 to 2006)

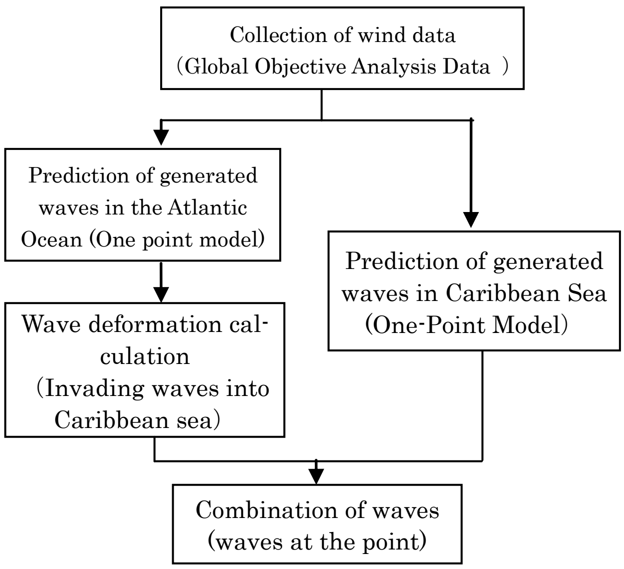


Figure 4-3-2-2 Wave analysis method at the point of Anse La Raye

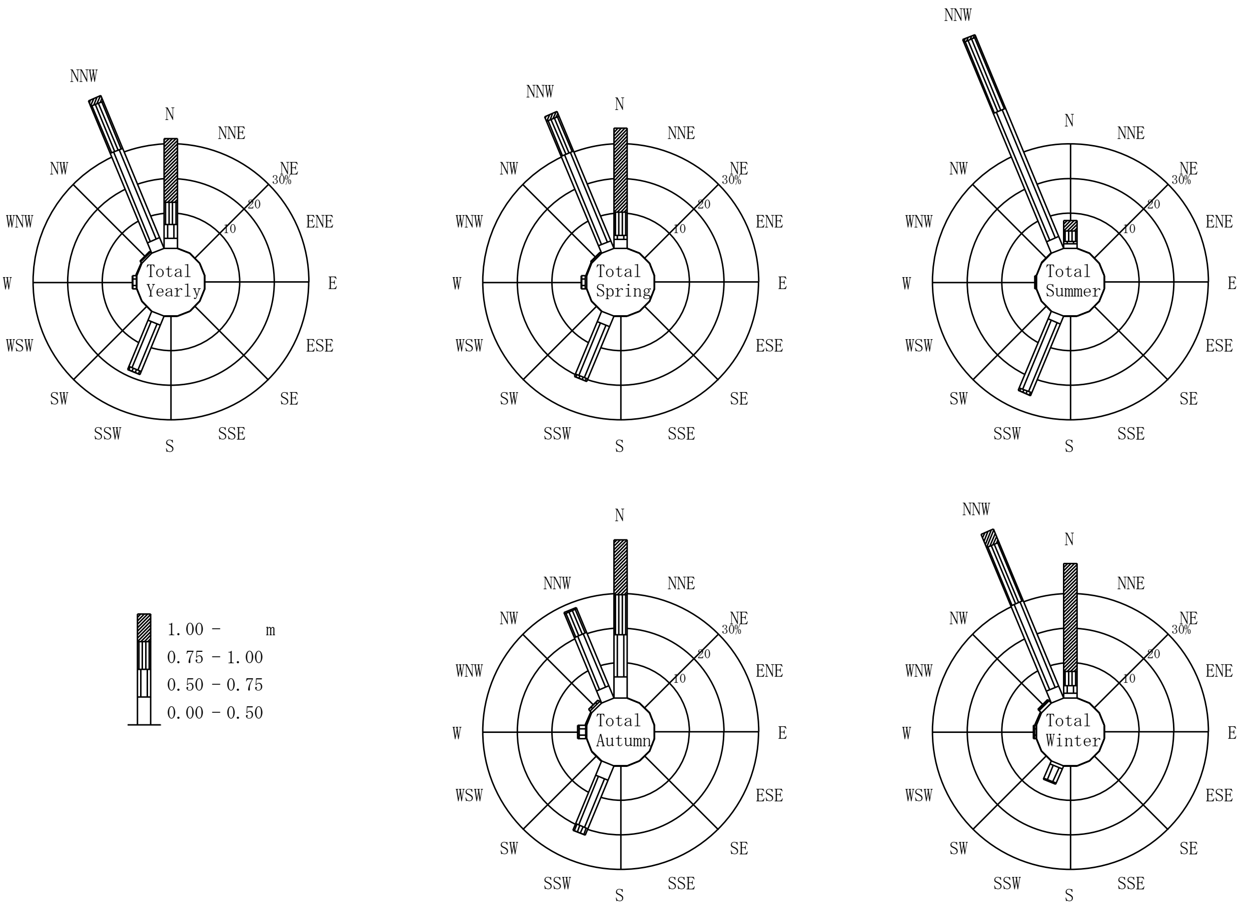


Figure 4-3-2-3 Distribution figure of wave direction

(At the mouth of Anse La Raye Bay, Prediction by the data of Global Objective Analysis during 2002 to 2006)

Table 4-3-2-1(1) Frequency table of wave height class in wave direction

(Predicted figure by Global Objective Analysis Data for offshore waves at east side of St. Lucia for all year during 2002 to 2006)

WAVE DIRECTION WAVE HEIGHT (M)	U.K.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
CALM	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
0.00 – 0.50	0 .0	0 .0	48 .1	42 .1	109 .2	111 .3	9 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	319 .7
0.50 – 1.00	0 .0	0 .0	1481 3.4	715 1.6	1854 4.2	864 2.0	299 .7	6 .0	10 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	5229 11.9
1.00 – 1.50	0 .0	0 .0	1852 4.2	1448 3.3	2244 5.1	2256 5.1	528 1.2	34 .1	12 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	8374 19.1
1.50 – 2.00	0 .0	0 .0	1491 3.4	1313 3.0	2398 5.5	3492 8.0	442 1.0	14 .0	9 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	9159 20.9
2.00 – 2.50	0 .0	0 .0	1339 3.1	938 2.1	2738 6.2	3899 8.9	345 .8	3 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	9262 21.1
2.50 – 3.00	0 .0	0 .0	1004 2.3	1089 2.5	2413 5.5	2482 5.7	142 .3	1 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	7131 16.3
3.00 – 3.50	0 .0	0 .0	469 1.1	239 .5	1158 2.6	1017 2.3	40 .1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	2923 6.7
3.50 – 4.00	0 .0	0 .0	187 .4	76 .2	461 1.1	212 .5	17 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	953 2.2
4.00 – 5.00	0 .0	0 .0	56 .1	46 .1	148 .3	112 .3	4 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	366 .8
5.00 – 6.00	0 .0	0 .0	3 .0	0 .0	62 .1	14 .0	3 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	82 .2
6.00 – 7.00	0 .0	0 .0	0 .0	0 .0	25 .1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	25 .1
7.00 –	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
TOTAL	0 .0	0 .0	7930 18.1	5906 13.5	13610 31.1	14459 33.0	1829 4.2	58 .1	31 .1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	43823 100.0

Table 4-3-2-1(2) Frequency table of period class in wave height

(Predicted figure by Global Objective Analysis Data for offshore waves at east side of St. Lucia for all year during 2002 to 2006)

WAVE PERIOD (S) WAVE HEIGHT (M)	CALM	0– 1	1– 2	2– 3	3– 4	4– 5	5– 6	6– 7	7– 8	8– 9	9–10	10–11	11–12	12–13	13–14	14–	TOTAL
CALM	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
0.00 – 0.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	2 .0	13 .0	33 .1	131 .3	89 .2	51 .1	0 .0	0 .0	0 .0	0 .0	319 .7
0.50 – 1.00	0 .0	0 .0	0 .0	0 .0	0 .0	17 .0	369 .8	937 2.1	1185 2.7	1161 2.6	481 1.1	413 .9	471 1.1	92 .2	68 .2	35 .1	5229 11.9
1.00 – 1.50	0 .0	0 .0	0 .0	0 .0	0 .0	53 .1	1948 4.4	2216 5.1	1266 2.9	945 2.2	844 1.9	537 1.2	368 .8	168 .4	27 .1	2 .0	8374 19.1
1.50 – 2.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	2222 5.1	3353 7.7	1343 3.1	764 1.7	627 1.4	481 1.1	246 .6	63 .1	43 .1	17 .0	9159 20.9
2.00 – 2.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	917 2.1	4947 11.3	1755 4.0	895 2.0	292 .7	139 .3	141 .3	116 .3	57 .1	3 .0	9262 21.1
2.50 – 3.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	12 .0	4039 9.2	1774 4.0	662 1.5	209 .5	167 .4	96 .2	86 .2	64 .1	22 .1	7131 16.3
3.00 – 3.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	1173 2.7	1251 2.9	169 .4	163 .4	91 .2	21 .0	32 .1	23 .1	0 .0	2923 6.7
3.50 – 4.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	42 .1	634 1.4	168 .4	59 .1	38 .1	7 .0	5 .0	0 .0	0 .0	953 2.2
4.00 – 5.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	236 .5	109 .2	10 .0	10 .0	1 .0	0 .0	0 .0	0 .0	366 .8
5.00 – 6.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	71 .2	11 .0	0 .0	0 .0	0 .0	0 .0	0 .0	82 .2
6.00 – 7.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	1 .0	24 .1	0 .0	0 .0	0 .0	0 .0	0 .0	25 .1
7.00 –	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
TOTAL	0 .0	0 .0	0 .0	0 .0	0 .0	70 .2	5470 12.5	16720 38.2	9477 21.6	5076 11.6	2809 6.4	1927 4.4	1351 3.1	562 1.3	282 .6	79 .2	43823 100.0

Table 4-3-2-2(1) Frequency table of wave height class in wave direction

(Predicted figure by Global Objective Analysis Data for generating waves in Caribbean Sea for all year during 2002 to 2006)

WAVE DIRECTION / WAVE HEIGHT (M)	U.K.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
CALM	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
0.00 − 0.25	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	905 2.1	22 .1	3 .0	237 .5	203 .5	237 .5	1061 2.4	2668 6.1
0.25 − 0.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	2476 5.7	5 .0	0 .0	226 .5	70 .2	338 .8	3298 7.5	6413 14.6
0.50 − 0.75	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	7830 17.9	4 .0	0 .0	642 1.5	46 .1	177 .4	23597 53.8	32296 73.7
0.75 − 1.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	27 .1	0 .0	0 .0	0 .0	0 .0	7 .0	2117 4.8	2151 4.9
1.00 − 1.25	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	1 .0	232 .5	233 .5
1.25 − 1.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	54 .1	54 .1
1.50 − 1.75	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	8 .0	8 .0
1.75 − 2.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
2.00 − 2.25	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
2.25 − 2.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
2.50 − 2.75	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
2.75 − 3.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
3.00 −	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
TOTAL	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	11238 25.6	31 .1	3 .0	1105 2.5	319 .7	760 1.7	30367 69.3	43823 100.0

Table 4-3-2-2(2) Frequency table of period class in wave height

(Predicted figure by Global Objective Analysis Data for generating waves in Caribbean Sea for all year during 2002 to 2006)

WAVE PERIOD (S) / WAVE HEIGHT (M)	CALM	0− 1	1− 2	2− 3	3− 4	4− 5	5− 6	6− 7	7− 8	8− 9	9−10	10−11	11−12	12−13	13−14	14−	TOTAL
CALM	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
0.00 − 0.25	0 .0	0 .0	0 .0	0 .0	0 .0	849 1.9	1203 2.7	325 .7	116 .3	52 .1	74 .2	36 .1	2 .0	11 .0	0 .0	0 .0	2668 6.1
0.25 − 0.50	0 .0	0 .0	0 .0	0 .0	0 .0	3213 7.3	1964 4.5	815 1.9	220 .5	68 .2	44 .1	26 .1	24 .1	18 .0	12 .0	9 .0	6413 14.6
0.50 − 0.75	0 .0	0 .0	0 .0	0 .0	0 .0	7588 17.3	14623 33.4	6647 15.2	2368 5.4	495 1.1	205 .5	143 .3	131 .3	19 .0	39 .1	38 .1	32296 73.7
0.75 − 1.00	0 .0	0 .0	0 .0	0 .0	0 .0	63 .1	1691 3.9	394 .9	3 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	2151 4.9
1.00 − 1.25	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	39 .1	170 .4	24 .1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	233 .5
1.25 − 1.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	12 .0	42 .1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	54 .1
1.50 − 1.75	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	8 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	8 .0
1.75 − 2.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
2.00 − 2.25	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
2.25 − 2.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
2.50 − 2.75	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
2.75 − 3.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
3.00 −	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
TOTAL	0 .0	0 .0	0 .0	0 .0	0 .0	11713 26.7	19532 44.6	8401 19.2	2731 6.2	615 1.4	323 .7	205 .5	157 .4	48 .1	51 .1	47 .1	43823 100.0

Table 4-3-2-3(1) Frequency table of wave height class in wave direction

(Predicted figure by Global Objective Analysis Data for waves at mouth of Anse La Raye Bay for all year during 2002 to 2006)

WAVE DIRECTION WAVE HEIGHT (M)	U.K.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
CALM	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
0.00 - 0.25	0 .0	315 .7	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	204 .5	0 .0	0 .0	35 .1	10 .0	53 .1	234 .5	851 1.9
0.25 - 0.50	0 .0	930 2.1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	1006 2.3	1 .0	0 .0	40 .1	40 .1	160 .4	1237 2.8	3414 7.8
0.50 - 0.75	0 .0	1755 4.0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	6338 14.5	3 .0	0 .0	411 .9	49 .1	121 .3	12232 27.9	20909 47.7
0.75 - 1.00	0 .0	2792 6.4	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	438 1.0	1 .0	0 .0	86 .2	3 .0	19 .0	6445 14.7	9784 22.3
1.00 - 1.25	0 .0	3786 8.6	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	3 .0	658 1.5	4447 10.1
1.25 - 1.50	0 .0	1904 4.3	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	76 .2	1980 4.5
1.50 - 1.75	0 .0	1198 2.7	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	9 .0	1207 2.8
1.75 - 2.00	0 .0	627 1.4	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	1 .0	628 1.4
2.00 - 2.25	0 .0	405 .9	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	7 .0	412 .9
2.25 - 2.50	0 .0	106 .2	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	106 .2
2.50 - 2.75	0 .0	62 .1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	62 .1
2.75 - 3.00	0 .0	18 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	18 .0
3.00 -	0 .0	5 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	5 .0
TOTAL	0 .0	13903 31.7	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	7986 18.2	5 .0	0 .0	572 1.3	102 .2	356 .8	20899 47.7	43823 100.0

Table 4-3-2-3(2) Frequency table of period class in wave height

(Predicted figure by Global Objective Analysis Data for waves at mouth of Anse La Raye Bay for all year during 2002 to 2006)

WAVE PERIOD (S) WAVE HEIGHT (M)	CALM	0- 1	1- 2	2- 3	3- 4	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-	TOTAL
CALM	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
0.00 - 0.25	0 .0	0 .0	0 .0	0 .0	0 .0	112 .3	198 .5	173 .4	120 .3	105 .2	98 .2	18 .0	27 .1	0 .0	0 .0	0 .0	851 1.9
0.25 - 0.50	0 .0	0 .0	0 .0	0 .0	0 .0	920 2.1	931 2.1	614 1.4	316 .7	253 .6	185 .4	101 .2	70 .2	8 .0	16 .0	0 .0	3414 7.8
0.50 - 0.75	0 .0	0 .0	0 .0	0 .0	0 .0	3356 7.7	8051 18.4	5228 11.9	2478 5.7	730 1.7	476 1.1	298 .7	220 .5	65 .1	7 .0	0 .0	20909 47.7
0.75 - 1.00	0 .0	0 .0	0 .0	0 .0	0 .0	122 .3	4484 10.2	3261 7.4	813 1.9	436 1.0	400 .9	148 .3	108 .2	11 .0	1 .0	0 .0	9784 22.3
1.00 - 1.25	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	243 .6	2061 4.7	1080 2.5	561 1.3	249 .6	107 .2	90 .2	33 .1	21 .0	2 .0	4447 10.1
1.25 - 1.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	20 .0	413 .9	796 1.8	362 .8	158 .4	133 .3	71 .2	24 .1	0 .0	3 .0	1980 4.5
1.50 - 1.75	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	134 .3	597 1.4	237 .5	87 .2	50 .1	39 .1	43 .1	17 .0	3 .0	1207 2.8
1.75 - 2.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	27 .1	202 .5	175 .4	86 .2	64 .1	32 .1	19 .0	23 .1	0 .0	628 1.4
2.00 - 2.25	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	130 .3	57 .1	139 .3	57 .1	24 .1	5 .0	0 .0	0 .0	412 .9
2.25 - 2.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	19 .0	39 .1	19 .0	26 .1	3 .0	0 .0	0 .0	0 .0	106 .2
2.50 - 2.75	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	15 .0	30 .1	10 .0	7 .0	0 .0	0 .0	0 .0	0 .0	62 .1
2.75 - 3.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	2 .0	9 .0	7 .0	0 .0	0 .0	0 .0	0 .0	0 .0	18 .0
3.00 -	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	5 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	5 .0
TOTAL	0 .0	0 .0	0 .0	0 .0	0 .0	4510 10.3	13927 31.8	11911 27.2	6568 15.0	2999 6.8	1914 4.4	1009 2.3	684 1.6	208 .5	85 .2	8 .0	43823 100.0

3) Wave condition to be used for topographic change

From the predicted wave values in the above, 5 representative waves were selected as shown in Table 4-3-2-4 and the occurrence ratio of wave direction in each month is calculated and the occurrence frequency was obtained. The occurrence frequency of each month in wave direction is as per Table 4-3-2-5.

Table 4-3-2-4 Condition of representative waves

No.	Wave Direction	Wave Height (m)	Period (S)	Occurrence Ratio (%)	Operating Days for a year
1	N	0.98	6.80	31.7	115
2	NNW	0.74	5.86	47.7	174
3	NW	0.62	5.79	0.81	3
4	W	0.52	6.71	1.30	5
5	SSW	0.66	9.50	18.2	66

Table 4-3-2-5 Occurrence ratio in monthly wave direction

Direction / Month	N	NNW	NW	W	SSW	Total
1	0.282	0.646	0.000	0.005	0.067	1.000
2	0.301	0.577	0.033	0.009	0.068	1.000
3	0.427	0.437	0.000	0.004	0.132	1.000
4	0.399	0.324	0.006	0.030	0.237	1.000
5	0.215	0.517	0.010	0.011	0.245	1.000
6	0.099	0.614	0.000	0.002	0.286	1.000
7	0.070	0.727	0.000	0.008	0.196	1.000
8	0.358	0.661	0.001	0.002	0.265	1.000
9	0.358	0.286	0.017	0.009	0.330	1.000
10	0.526	0.222	0.015	0.049	0.184	1.000
11	0.487	0.343	0.007	0.018	0.136	1.000
12	0.576	0.367	0.010	0.009	0.038	1.000
All Year	0.317	0.477	0.008	0.013	0.182	1.000
Operating days	115	174	3	5	66	365

4) Design wave (waves at the time of abnormal weather)

At the time of Basic Design stage, the estimated offshore waves at the bay are calculated as per Table 4-3-2-6 based on the study of 1) Past examples of design offshore waves, 2) Wave with a return period of 30 years by the prediction result of offshore waves in Soufriere and Choiseul, 3) Offshore waves by model hurricane "Lenny".

Table 4-3-2-6 Result of wave transformation calculation (Estimated offshore waves at the point of the existing jetty)

Wave	Waves in Caribbean Sea (Offshore Wave)		Refraction Co-efficient (around existing jetty)	Condition of estimated offshore wave	
Wave with a return period of 30 years	Height(H_0)	6.10m	0.49	Height(H_0')	2.99m
	Period(T)	12s		Period	12s
	Direction	W		Incident wave direction	N86° W
Model Hurricane (at 1° south side route of Lenny)	Height(H_0)	7.15m	0.49	Height(H_0')	3.50m
	Period(T)	12s		Period	12s
	Direction	W		Incident wave direction	N86° W

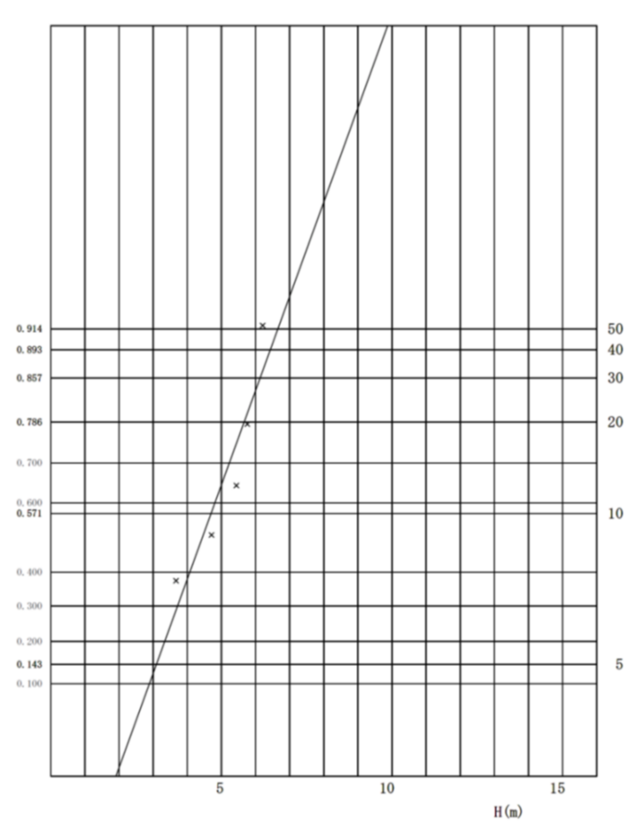


Figure 4-3-2-4 Recurrence period (Effective period: 50 years)

In this study, it is necessary to obtain wave condition at shallow water. The wave conditions in each water depth were calculated based on the estimated offshore wave height and the result is as per Table 4-3-2-7.

Table 4-3-2-7 Wave conditions in water depth

Water Depth (MSL)	Water Depth (*)	Period	Estimated Offshore Wave Height	Bottom Slope (inverse)	Wave Steepness	Ratio for water depth/wave height			Signifi-cant Wave Height
	D(m)	T(s)	H_0'(m)	1/slope	H_0'/L_0	h/H_0'	$H_{1/3}/H_0'$	eta/H_0'	$H_{1/3}$(m)
0.3	1.32	12	2.99	20	0.013	0.441	0.507	0.128	1.517
0.4	1.42	12	2.99	20	0.013	0.475	0.535	0.125	1.599
0.5	1.52	12	2.99	20	0.013	0.508	0.563	0.121	1.682
0.6	1.62	12	2.99	20	0.013	0.542	0.590	0.117	1.765
0.7	1.72	12	2.99	20	0.013	0.575	0.618	0.114	1.848
0.8	1.82	12	2.99	20	0.013	0.609	0.646	0.110	1.931
0.9	1.92	12	2.99	20	0.013	0.642	0.673	0.107	2.013

(*): Water depth including the tide level rising at the time of abnormal weather

(2) Tide condition

Harmonic analysis of the data of water level variance was made through 15 day-night continuous observation record at the time of Basic Design and calculated harmonic constant that is coefficient of sine wave making up tide level. Based on this, each tide level size in the mouth of Anse La Raye Bay has obtained shown in Figure 4-3-2-5. This result shall be the tide level condition in this study as well. And, the standard height of contour map shall be M.S.L. that is Trig. Datum of St. Lucia in the same way of Basic Design stage.

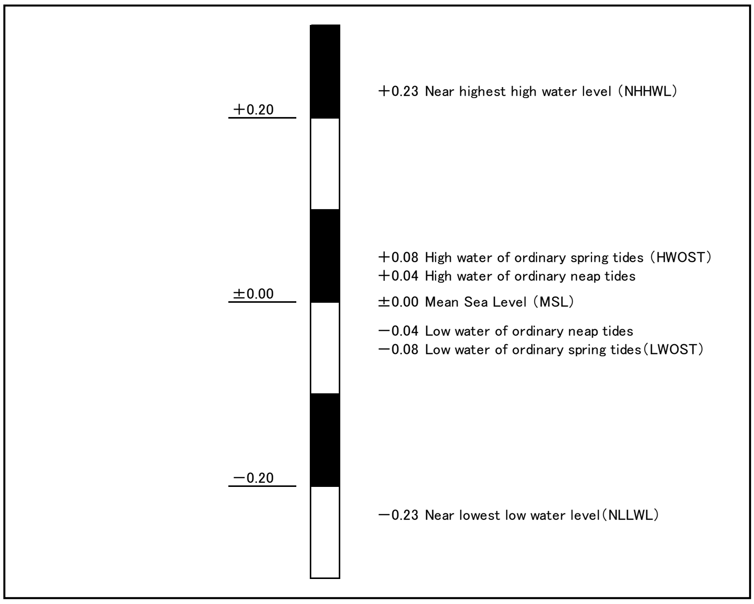


Figure 4-3-2-5 Tide level in Anse La Raye

(3) Bottom sediment in Anse La Raye Bay

Figure 4-3-2-6 shows collection spots of bottom sediment at the bathymetric survey in September, 2011. Figure 4-3-2-4 shows the grain size distribution of bottom sediment at each point. Table 4-3-2-8 shows the grain size at each point by transit percentage. S8 is the deposited soil at south side river mouth, S1 to S4 are around shorelines and S5 to S7 is around the area of 1.5 m water depth.

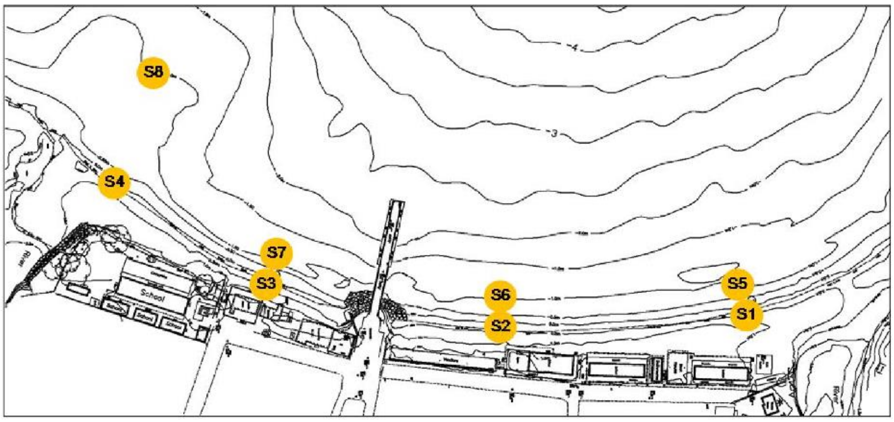


Figure 4-3-2-6 Collection spots of bottom sediment (September, 2011)

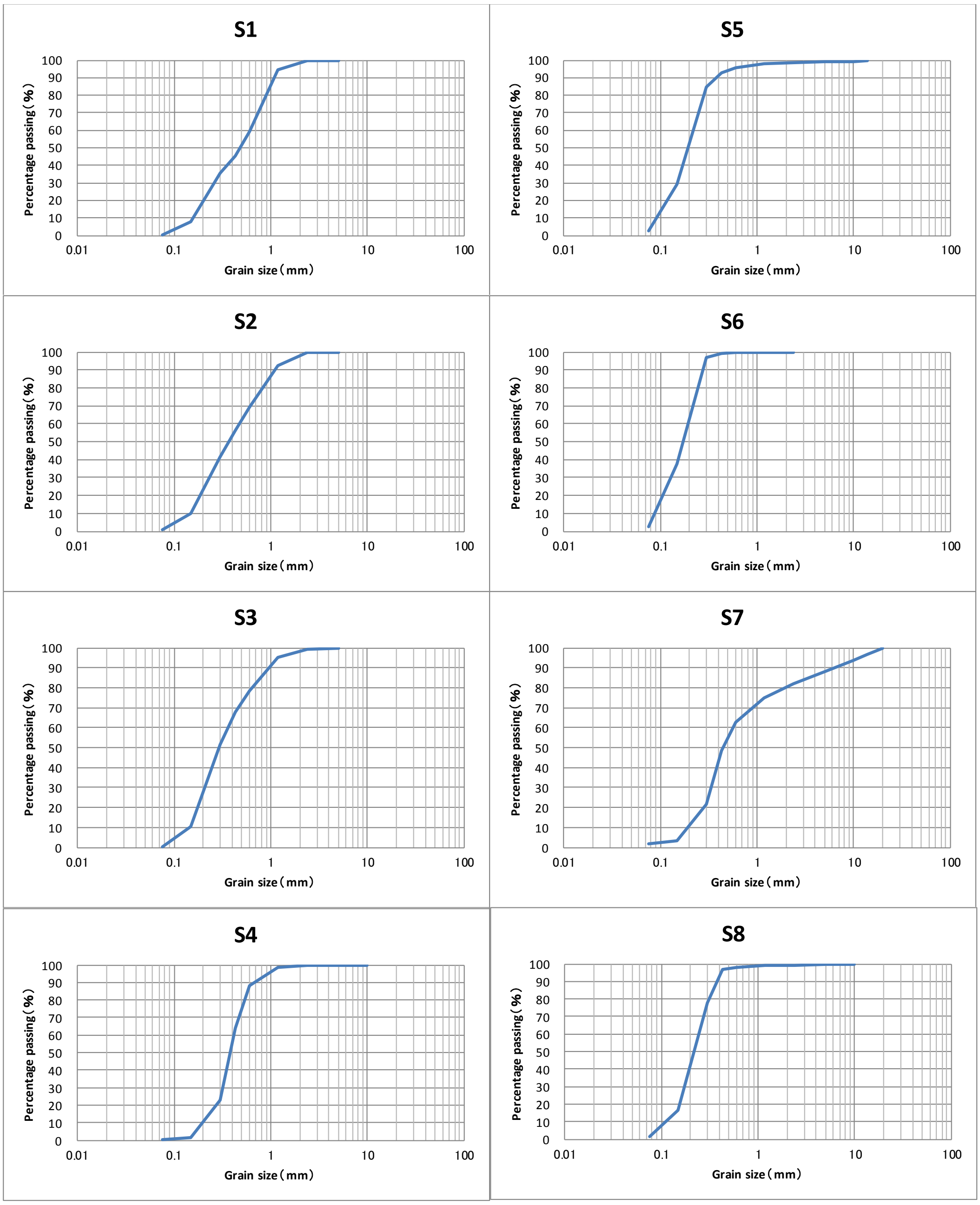


Figure 4-3-2-7 Grain size distribution of bottom sediment

Table 4-3-2-8 Grain size by transit percentage in each point (unit: mm)

	S1	S2	S3	S4	S5	S6	S7	S8
D(95)	1.23	1.62	1.17	0.97	0.57	0.29	11.55	0.14
D(84)	1.00	0.97	0.79	0.57	0.30	0.27	3.20	0.34
D(50)	0.48	0.37	0.29	0.38	0.20	0.18	0.43	0.23
D(16)	0.19	0.18	0.17	0.25	0.11	0.08	0.16	0.09
D(5)	0.12	0.11	0.11	0.18	0.08	0.08	0.16	0.09

4-3-3 Cross section design

(1) Front face of Fisheries Complex

1) Head part of armor stone works

Installation water depth at the head part of armor stone works is MSL-0.8m. As shown in Table 4-3-2-7, the wave height of this water depth becomes H1/3＝1.931m, T=12.0sec for H0'=2.99m of estimated offshore wave height. This is considered to be front wave height at the time of wave with a return period of 30 years. The weight of armor stone for this wave height can be calculated as follow,

$$W = \frac{\rho_r \cdot H_D^3}{Ns^3 (Sr-1)^3} = 0.31\text{ton}$$

Where

W: mass of surface armor stone in slope(tf)	0.17
ρ_r: air volume weight of armor stone and etc. (tf/m3)	2.65
S_r: specific gravity of armor stone for sea water (tf/m3) :	ρ_r / ρ_w
P_w: sea water density	1.03
N_s: stability number	2.5
H_D: design significant wave height (m)	1.931

Therefore, the head part of armor stone works (area with the width of 3 m to land side from the area with the water depth of 0.8 m) shall be armored by the armor stones with the weight about 400 to 500 kg.

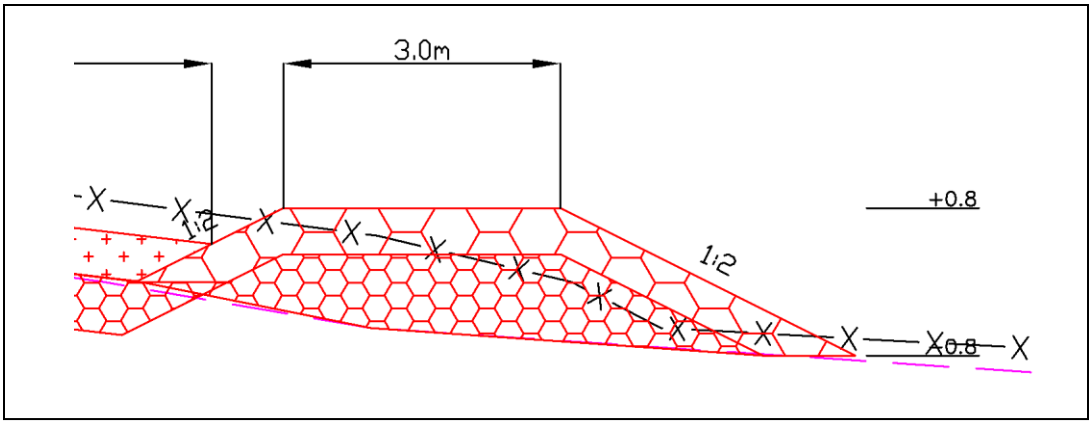


Figure 4-3-3-1 Cross section of armor stone head

2) Foundation part of Fisheries Complex

Front face of foundation of Fisheries Complex is covered by armor stones by short-term countermeasure. As this part has a function to prevent scoring building foundation, 3 m width of armor stones in front of facilities shall be left as they were now. It is difficult to re-install rubble stones in front of Fisheries Complex since electric cables have been installed there. On landscaped aspect, sand coverage is allowed but the crown height of armor stones shall be kept as it is.

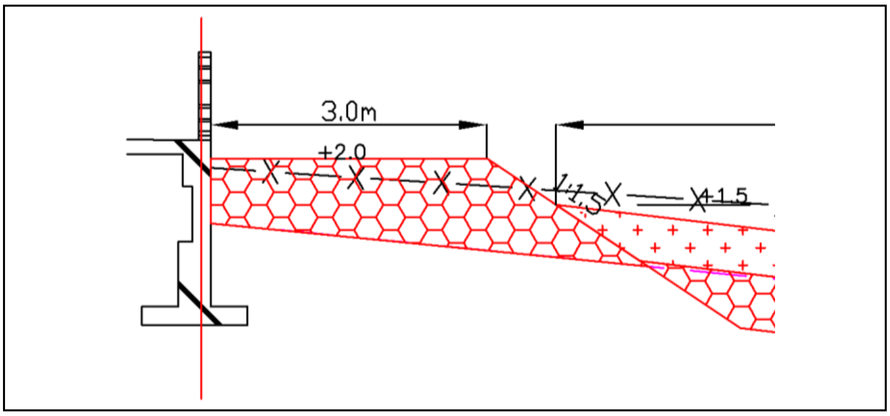


Figure 4-3-3-2 Cross section of armor stones at foundation part of Fisheries Complex

3) Armor stone main works

The work between head part of armor stones and the covering armor stones work for the foundation of Fisheries Complex is called as armor stone main works. This area shall be covered by sand in order to secure the north-south accessibility for fishermen. There will be unevenness between surrounding sandy beach and the crown height of the area to be an obstacle for smooth north-south accessibility if the present armor stone main works will be covered by sand. Therefore, the present armor stone main works shall be once removed and dig down about 60 cm and the area shall be backfilled by sand upon execution of re-armor stone main works.

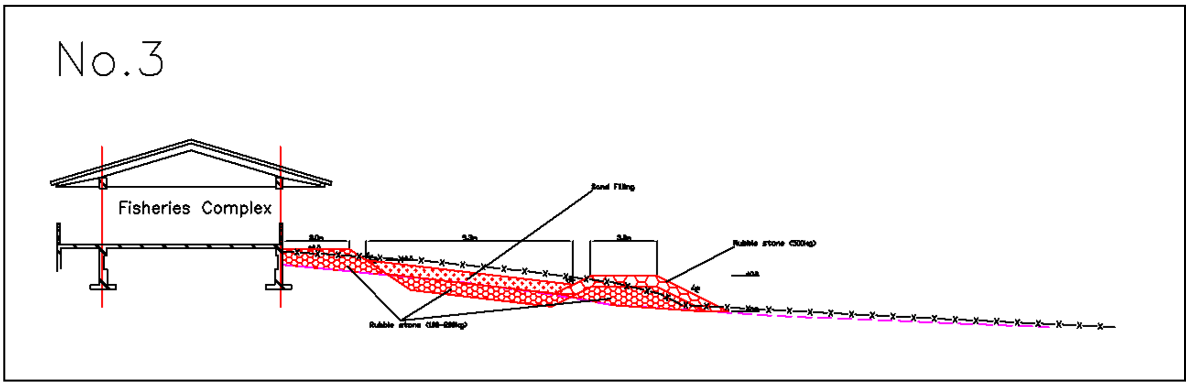


Figure 4-3-3-3 Cross section of armor stone main works

(2) Front face of Vendors Arcade

1) Armor stone works for front face of Vendors Arcade Floor

This part was covered by sand after installing armor stones by the short-term countermeasure. As the cross-section of covering armor stone was installed so as to be level off, uneven part with beach slope was appeared at the head part and armor stones was exposed so that the bottom of hauling fishing boats may be possibly damaged. Therefore, the armor stone covering works shall be executed to meet with beach slope.

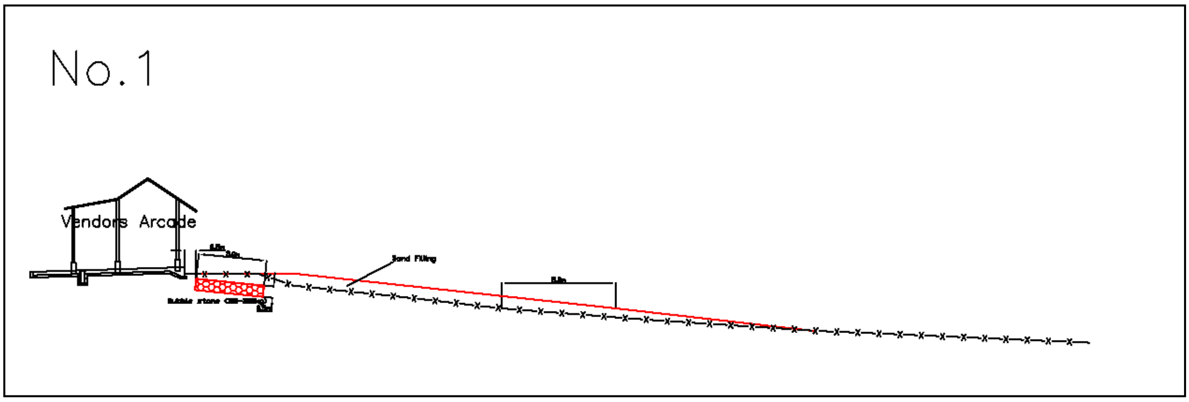


Figure 4-3-3-4 Cross section of armor stone works in front of Vendors Arcade

2) Sand filling works at front face of Vendors Arcade

Judging from the cross-section of beach in front of Vendors Arcade shown in Figure 4-3-3-5, sand is about to be deposited around the area at 1 m water depth and it is considered that the shoreline shall be advanced and the backshore shall be formed as the time goes on. However, the speed of formation will be slow and to plan the advancement of shoreline and the formation of backshore with sand filling shall be effective in order to prevent scoring of foundation floor slab of Vendors Arcade. And, the value as tourism resources shall be improved by forming backshore.

The backshore that can be seen in Figure 4-3-3-5 was generated by installation of armor stones and it is the situation to be influenced by wave run-up like the exposure of armor stones at its head part. This shall be improved by sand filling to form about 5 m from the head part of armor stone works.

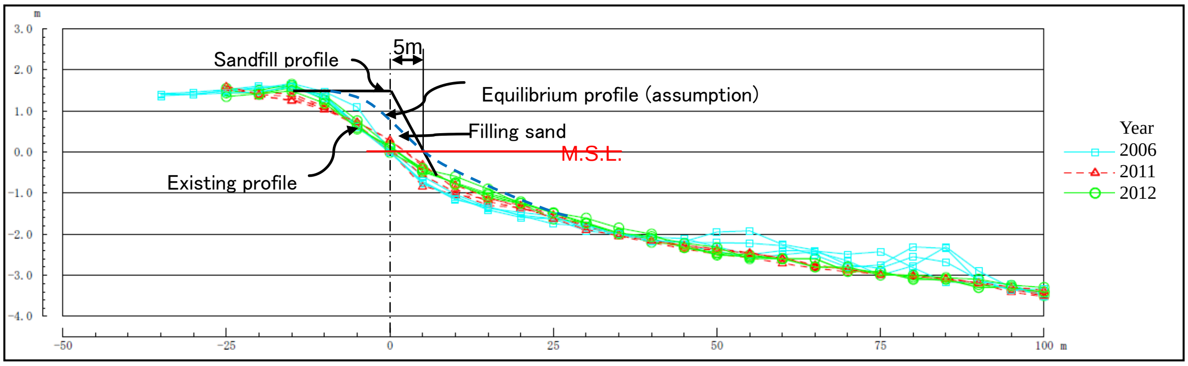


Figure 4-3-3-5 Cross section in front of Vendors Arcade

It is considered that the crown height of sand filling shall be MSL +1.5 m and its width shall be 8 m including armor stone works is expected. The fill material is considered to be procured from south side beach since they have affinity of grain size, soil condition and etc. with present beach and the cost is cheap. As the grain size of sand in front of Vendors Arcade is D50: 0.37 mm and the one of the south side of beach is D50:0.48 mm, the underwater equilibrium beach profile by sand filling work according to Dean discriminant becomes 1 or less as shown below, and equilibrium profile soil volume (V) can be obtained with the next formula,

$$W(AN/DC)^{3/2}+(AN/AF)^{3/2}=0.917 <1 \text{ (Intersecting profile)}$$

$$V=WB + (3/5W^{5/3}A_N A_F) / (AF^{3/2}-AN^{3/2})^{2/3}$$

Where,

W: crown width of sand fill (5m), B*crown height of sand fill (1.5m), Dc: critical depth (5m), A_F, A_N: value obtainable from Table 4-3-3-1 and the critical depth is set as 5 m shown in Chapter 3. N indicates the sample collection position of sand at the current beach in front of Vendors Arcade and F indicates its at the river mouth of north side river.

From Table 4-3-3-1, A_N＝0.139$m^{1/3}$、A_F=0.1498$m^{1/3}$ (A_F<A_N)

Therefore, it becomes V= 16.28m3/m

As the length of beach in front of Vendors Arcade is 48 m, the sand filling volume becomes total= 16.28 m^3/m x 48 m =781.5m3

Table 4-3-3-1 A value

Table III-3-3

Summary of Recommended A Values (Units of A Parameter are $m^{1/3}$)

D(mm)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	0.063	0.0672	0.0714	0.0756	0.0798	0.084	0.0872	0.0904	0.0936	0.0968
0.2	0.100	0.103	0.106	0.109	0.112	0.115	0.117	0.119	0.121	0.123
0.3	0.125	0.127	0.129	0.131	0.133	0.135	0.137	0.139	0.141	0.143
0.4	0.145	0.1466	0.1482	0.1498	0.1514	0.153	0.1546	0.1562	0.1578	0.1594
0.5	0.161	0.1622	0.1634	0.1646	0.1658	0.167	0.1682	0.1694	0.1706	0.1718
0.6	0.173	0.1742	0.1754	0.1766	0.1778	0.179	0.1802	0.1814	0.1826	0.1838
0.7	0.185	0.1859	0.1868	0.1877	0.1886	0.1895	0.1904	0.1913	0.1922	0.1931
0.8	0.194	0.1948	0.1956	0.1964	0.1972	0.198	0.1988	0.1996	0.2004	0.2012
0.9	0.202	0.2028	0.2036	0.2044	0.2052	0.206	0.2068	0.2076	0.2084	0.2092
1.0	0.210	0.2108	0.2116	0.2124	0.2132	0.2140	0.2148	0.2156	0.2164	0.2172

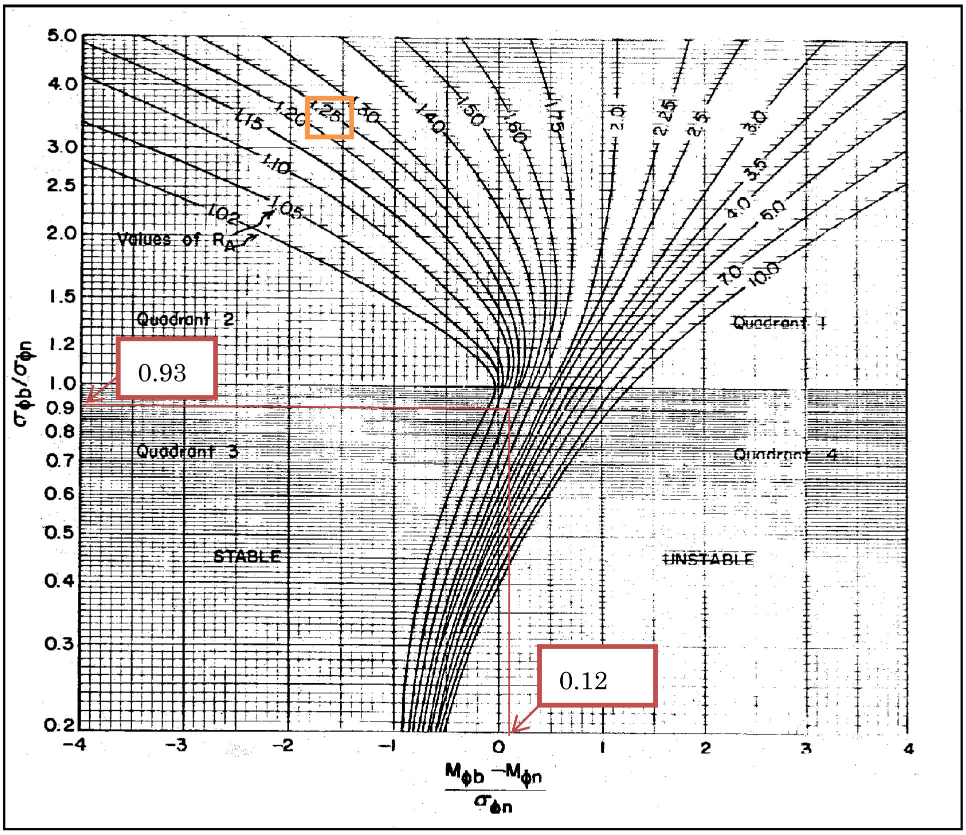
Notes:

(1) The A values above, some to four places, are not intended to suggest that they are known to that accuracy, but rather are presented for consistency and sensitivity tests of the effects of variation in grain size.

(2) As an example of use of the values in the table, the A value for a median sand size of 0.24 mm is: A = 0.112 $m^{1/3}$. To convert A values to $feet^{1/3}$ units, multiply by $(3.28)^{1/3}$ = 1.49.

Source: Coastal Engineering Manual 2008

And, actual filling sand volume will need an extra according to the grain size distribution. The extra rate shall be 1.25 under the study with grain size condition previously described based on the Figure 4-3-3-6 that calculates the rate. Therefore, the sand filling volume becomes 781.5 m3 x 1.25= 976.875m3 and the necessary sand filling volume becomes 1172.25 m3 ≒1200m3 make an allowance for 20% of construction loss.



(Source: Coastal Engineering Manual 2008)

Figure 4-3-3-6 Extra rate of filling material

Where 1.25 is obtained calculated by the following formula from Table 4-3-2-8.

$$\frac{\sigma_{\varphi b}}{\sigma_{\varphi n}} = \frac{\left[\frac{(\varphi_{84}-\varphi_{16})}{4} + \frac{(\varphi_{95}-\varphi_{5})}{6}\right]_b}{\left[\frac{(\varphi_{84}-\varphi_{16})}{4} + \frac{(\varphi_{95}-\varphi_{5})}{6}\right]_n}$$

$$\frac{M_{\varphi b} - M_{\varphi n}}{\sigma_{\varphi n}} = \frac{\left[\frac{(\varphi_{16}+\varphi_{50}+\varphi_{84})}{3}\right]_b - \left[\frac{(\varphi_{16}+\varphi_{50}+\varphi_{84})}{3}\right]_n}{\left[\frac{(\varphi_{84}-\varphi_{16})}{4} + \frac{(\varphi_{95}-\varphi_{5})}{6}\right]_n}$$

Safety on the crown height, MSL+1.5m of this equilibrium profile is studied against run-up height by waves as a few times generation in a year. The study is made by waves with a return period of 5 years as a few times generation in a year. The offshore wave height with a return period of 5 years becomes 3.1 m from Figure 4-3-2-1. When obtaining approximate offshore wave height multiplying refraction coefficient, it becomes Ho'=1.51 m. And when obtaining run-up height R with the method shown in 4-4-1 Chapter 4, it becomes Ho'=0.46, after this, R=1.52*0.46+0.68=1.38ｍ＜MSL＋1.5m (crown height of sand filling work). Where, considering the water level rise only by absorption in case of the direct hit (center of hurricane passes through project site) by hurricane with the center pressure of 960 hPa and the water level is set as M.S.L.+0.68m adding anomaly (+0.45m) to nearly maximum tide level （M.S.L.+0.23m）. Like this, the crown height of sand fill is safe with the condition in the run-up height generated a few times in a year. However, as the run-up height of waves with a return period of 30 years shown in 4-4-1 is 2.4 m and even under the relational expression of the wave height of long period wave and the run-up height by Kato and others, it exceeds sand filling crown height, MSL+1.5m in order to secure the protective line, wide enough width of sand filling width becomes necessary.

$$RL=(\eta)0+0.96\cdot(HL)0+0.31=2.446m$$

Where RL: Run-up height to beach (m), (η)0: Water level of shoreline, (HL)0: Wave height of long period wave at the shoreline, as 4-3-2 shows (η)0=0.68m, (HL)0=1.517m

(3) Front Face of Fishing Gear Lockers

1) Front Face of Fence

Fence is installed in front of Fishing Gear Lockers for the purpose of security. The fence was installed by St. Lucian side and it is difficult to remove. It is considered that the foundation of fence support is not comparatively long due to the simply made facility. It is considered that the armor stone works in front of the fence being the same as the one for the scouring protection of floor foundation of Vendors Arcade can be functioned in order to prevent the scoring of Fishing Gear Lockers. Therefore, the same size of armor stone works (Figure 4-3-3-7) with Vendors Arcade shall be installed and covered by sand to secure convenience for fishermen and the landscape. Now, Figure 4-3-3-8 shows the superposition of a number of survey lines in front of Fishing Gear Lockers. With this, it understands that level installation of armor stone works can be functioned well since the backshore is formed in comparison with Vendors Arcade. And this area is considered to be formed scarp easily although it is small and the shore line is easy to be fluctuated since this locates near the river mouth of north side river. Therefore, as the wave run-up of long period swell is considered to be reached to the front face of Fishing Gear Lockers, the protection measures shall be executed.

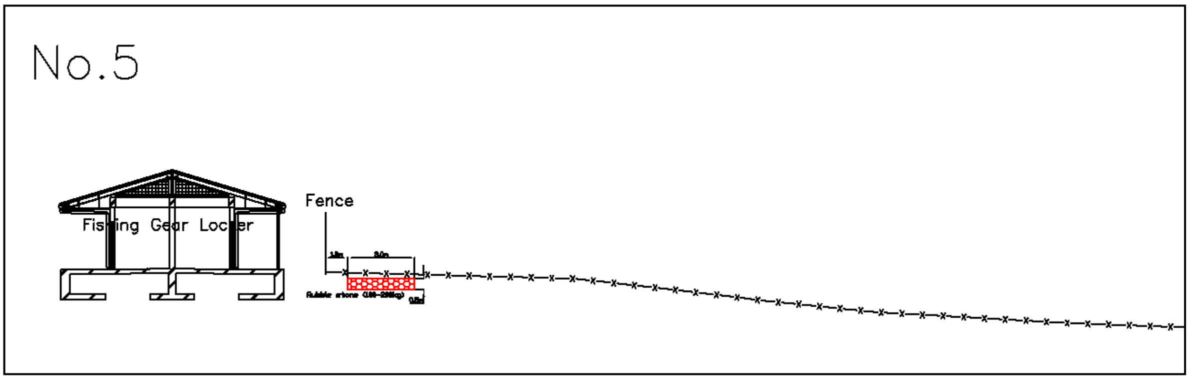


Figure 4-3-3-7 Cross section of armor stone works in front of Fishing Gear Lockers

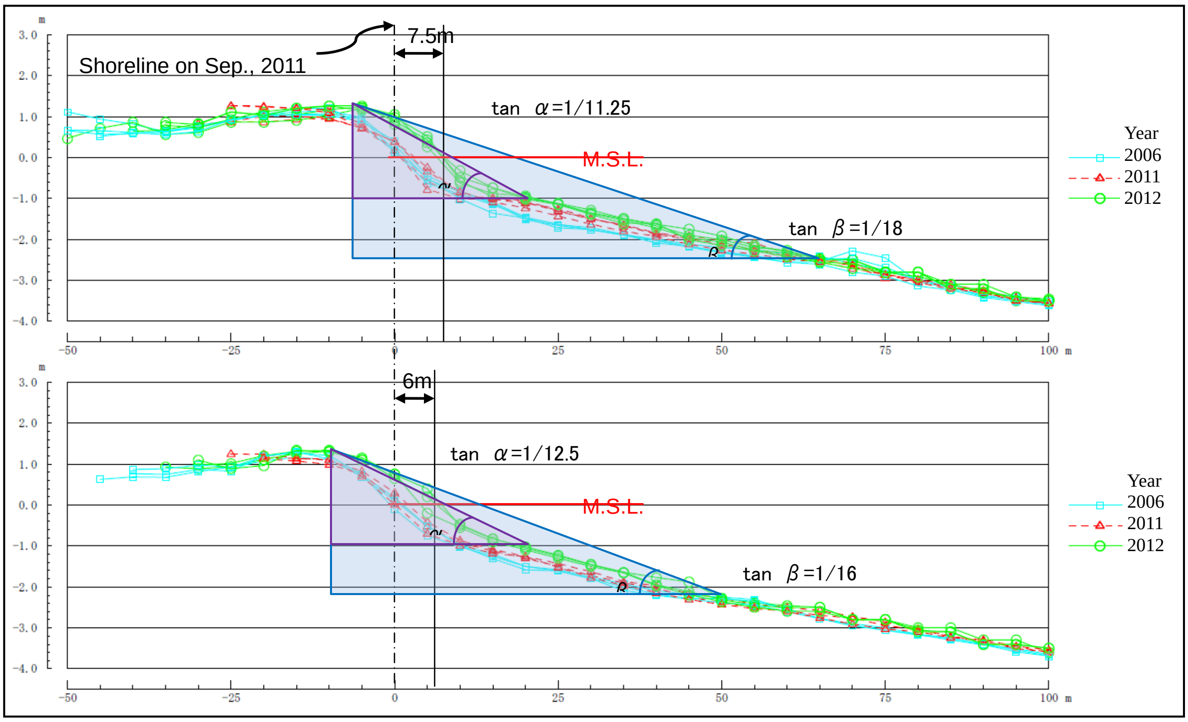


Figure 4-3-3-8 Beach profile in front of Fishing Gear Lockers

4-3-4 Alignment plan

Figure 4-3-4-1 is an alignment plan based on the sectional design shown in Figure 4-3-3. The coast line position and backshore width at the time of Basic Design stage in 2006 from north side Fishing Gear Lockers to Vendors Arcade.

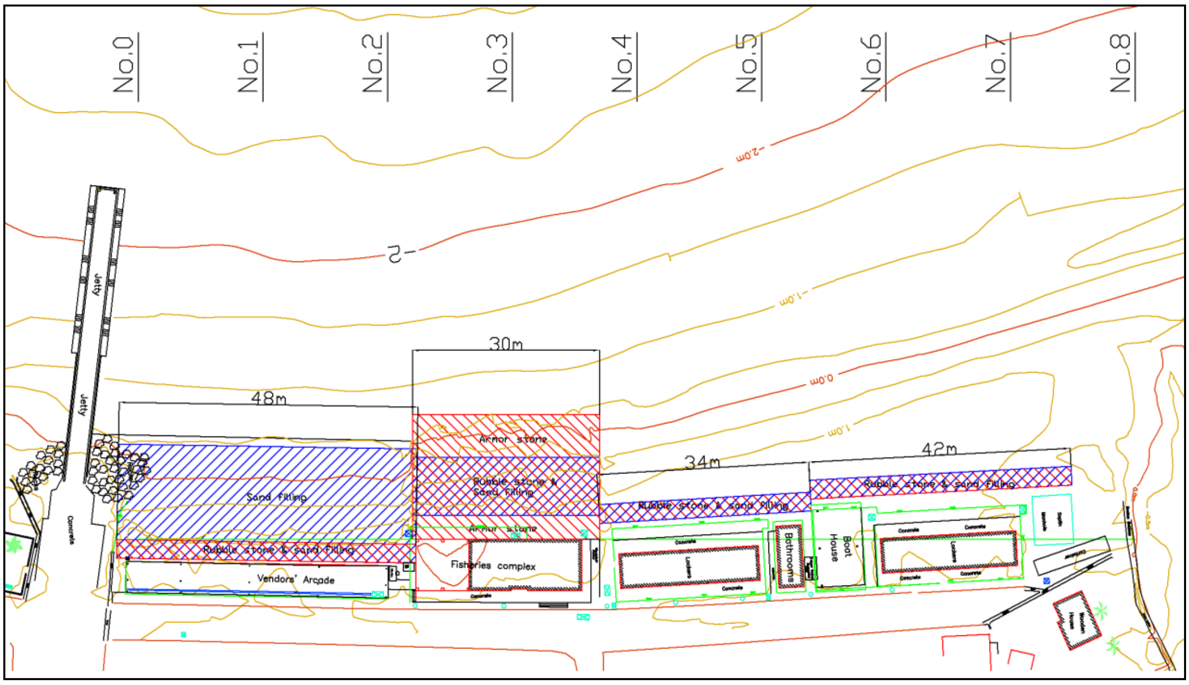


Figure 4-3-4-1 Alignment plan

4-3-5 Construction plan/ procurement plan

Considering that local contractor shall execute the construction work, plan is made on the selection of proper construction method, execution plan, procurement plan for material and equipment, construction schedule and quality plan and the construction works shall be executed under supervisor in accordance with proper construction supervision standard.

(1) Construction policy/procurement policy

1) The facilities to be constructed with this project is civil facilities to protect land facilities constructed in the "The Project for Improvement of Fishery Infrastructure in Anse La Raye" from damage of beach recession.

2) Protective measure was already executed in front of Fisheries Complex and Vendors Arcade as short-term countermeasure and conspiring reduction of construction cost and shortening work period by diverting these material effectively and shall solve the problem that pointed out as the issues on landscape and usage at the time of short-term countermeasure.

3) Construction with the material and equipment to be able to purchase locally in St. Lucia shall be the base.

4) Construction period for this project requires 3 months after tender.

(2) Consideration on construction work/procurement

1) Work permit

Application of simple procedure shall be made immediately after discussion of S/W.

2) Influence to neighboring activities

Although the construction period is off season for sight-seeing, Fish Friday is held every Friday. And, as an impact on beach fishing activities is given during construction period, close contact with Department of Fisheries and neighborhood and smooth site operation shall be required.

3) Hurricane

Construction work must be completed by the middle of September due to the hurricane season.

(3) Construction supervision plan/Procurement supervision plan

The consultant shall dispatch a resident engineer who has enough experiences to the project site and supervise construction works. And, inspection and instruction to improve construction works upon progress of construction works shall be made.

1) Supervision policy

a) The completion of facilities without delay based on the execution plan communicating and reporting closely to both government organizations and persons in charge shall be aimed.

b) Prompt and proper direction and advise against contractor for the facilities construction to meet with the design documents shall be made.

c) Top priority shall be given to local construction method with local materials as much as possible.

d) Proper direction and advise shall be made to maintenance management after completion of facilities and the smooth operation shall be encouraged.

2) Supervision and procurement management work

a) Cooperation on construction contract

Selection of contractor and construction contract by JICA shall be supported.

b) Checking and confirmation of shop drawing and others

Inspection for shop drawings, construction material submitting by contractor shall be made.

c) Inspection witness and direction of construction works

Inspection shall be made for each progress control upon needs during construction period and instruct contractor. And, depending on the work situation, work plan and construction schedule shall be studied and instruct the contractor. Report on work progress status shall be made to JICA and Department of Fisheries.

(4) Quality control management plan

The quality control of this project shall be made in accordance with "Common Specification of Fishing Port Construction" and "Common Specification of Port and Harbor Construction"

(5) Procurement plan for material and equipment

Main material and construction machineries to be necessary for this project are as follows,

1) Main material

a) Rubble stone with the unit weight from 100 to 200 kg (diverting stones used at short-term countermeasure and fill in the gap by procurement)

b) Sand filling (Collecting from Anse La Raye beach)

c) Rubble stones with unit weight 400 to 500 kg (procurement locally in St. Lucia)

2) Construction machinery

a) Backhoe（1.0m3）

b) Dump Truck（10t）

Procurement source of all these materials and equipment is supposed to be local.

(6) Construction schedule

Construction schedule is shown in Table 4-3-5-1

Table 4-3-5-1 Construction schedule

	M1	M2	M3
Preparation & Temprary Works			
Protective Works (in front of Fishing Gear Locker and Work Sop)			
Protective Works (in front of Fisheries Complex)			
Protective Work (in front of Vendors Arcade)			
Sand Fill Works (in front of Vendors Arcade)			
Clean-up			

4-3-6 Project cost

(1) Project cost

The project cost of this plan is estimated as 19,760 thousand yen and the breakdown is shown in Table 4-3-6-1.

Table 4-3-6-1 Breakdown of project cost (thousand yen)

Construction Works	Cost
1) Protective Work (in front of Vendors Arcade)	2,294
2) Protective Works (In front of Fisheries Complex)	14,086
3) Protective Works(in front of Fishing Gear Lockers and Work Sop)	1,584
4) Sand Fill Works(in front of Vendors Arcade)	1,796
Total	19,760

※Indirect costs are included in each work

(2) Estimation condition

a) Estimated time : The estimated time is January, 2012

b) Exchange rate : 1US$=80.75yen, 1EC$=30.04yen

(US rate: Average TTS rate for 6 months from April, 2011 to September 2011 at the Bank of Tokyo, Mitsubishi, UFJ Ltd.)

(EC rate: Fixed rate of 1 EC$=US$2.6882)

4-3-7 Point of concern for implementing cooperation project

The following points are necessary to consider when cooperation project is implemented as middle-term countermeasure.

1) The protective function that was made in short-term countermeasure shall be enforced in the middle-term countermeasure, the fear by incoming waves at the time of abnormal weather like wave with a return period of 30 years shall be yet unsolved due to the low ground elevation. However, scouring and uneven subsidence of Fisheries Complex building can be protected from the run-up wave with return period of 30 years.

2) Sand filling was made at the front face of Vendors Market and the shoreline was advanced to 5 m. However, the possibility can not be denied to generate the recession of shoreline, as beach itself is always fluctuated. In case of the generation of shoreline recession, the sand maintenance supply shall be needed.

3) The beach shall be rapidly transited to equilibrium beach slope after the completion of construction works of middle-term countermeasure. It is necessary to collect basic data to contribute to sand maintenance supply by the execution of sounding survey at the stage that stable foreshore slope to some extent is maintained.

4) The shoreline shall be in the situation that the shoreline is advancing around 10 years after completion of middle-term countermeasure works. During this period, it is necessary to know

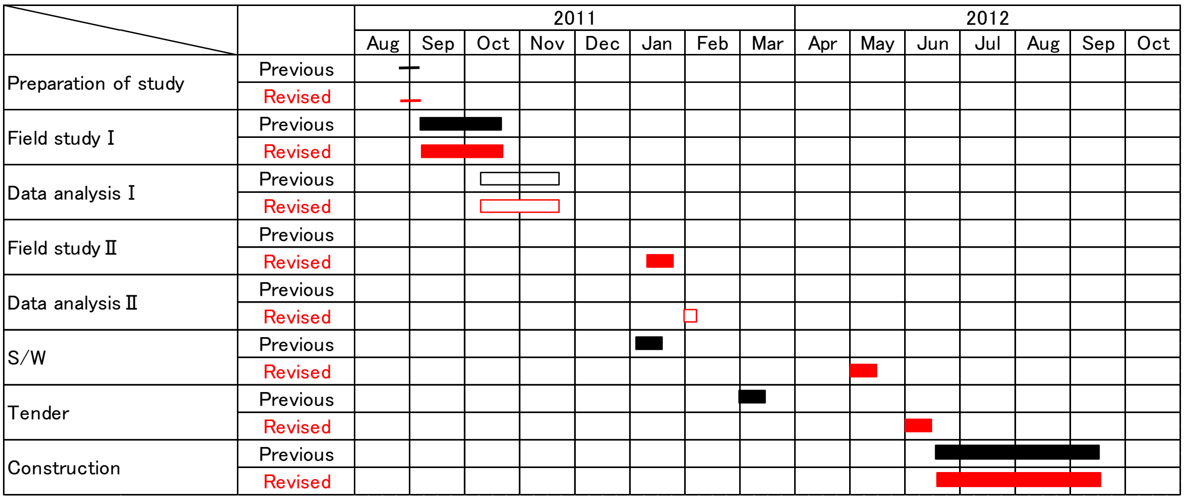
the fluctuation status of shoreline by fixed-point observation and periodical sounding surveys in order to contribute to the understanding of the effect of middle-term countermeasure and the study of long-term countermeasure.

5) The maintenance management of facilities is unavoidable in order to maintain functions of facilities at the middle-term countermeasure. The head part of armor stones installed in front of Fisheries Complex in case that rubble stones are scattered by abnormal weather like hurricane is necessary to be refilled in order to keep the crown height and width. The sand filling works in front of Vendors Arcade is necessary to maintain the crown height of the sand filling works and proper maintenance sand fill is necessary.

4-3-8 Project execution plan

Table 4-3-8-1 shows revised schedule by the execution of additional survey changing from the original schedule.

Table 4-3-8-1 Project execution plan



St. Lucian side is required to commence the procedure to get the work permit at the stage that the execution of middle-term countermeasure works is agreed by SW Discussion. After issuance of the work permit, the tender by Japanese side is held. The middle-term countermeasure work is required to complete before hurricane season.

4-4 Recommendation for long-term countermeasure

4-4-1 Extraction and selection of alternative plan

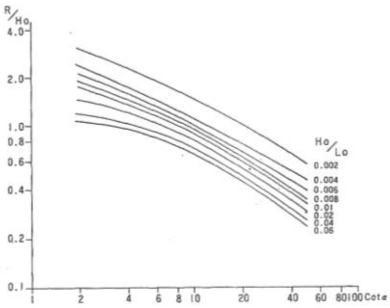
The purpose of study for the long-term countermeasure was indicated as "to get rid of fear from incoming waves at the time of abnormal weather protecting function of fisheries facilities including beach environment". Table 4-2-2-1 shows the basic thoughts of long-term countermeasure. Table 4-2-3-1 shows the problem of long-term countermeasure. With these, the alternative plan of long-term countermeasure is divided into next two plans.

1) The idea to accomplish the purpose of long-term countermeasure with maintenance of restored shoreline and the backshore and conservation of landscape of natural beach. (Beach nourishment method)
2) The idea to maintain restored beach with the construction of offshore structure for wave control although this beach shall return to recessed one even once restored. (Method to install offshore structure for wave control)

The fear by incoming waves at the time of abnormal weather (wave with a return period of 30 years) is that the backshore height is lower than that of run-up waves. The resolution of fear can be attained by the mitigation of influence of waves with a return period of 30 years. The above mentioned two ideas can be considered as the countermeasure. And so, the calculation of run-up height is made before the study of each alternative plan.

(1) Run-up height at the time of abnormal weather

The wave run-up height is calculated by advanced virtual slope method that is widely used on the appraisal of wave run-up height to complicated seashores in “Technical Standards and Commentary for Shore Protection Facilities”. The calculation table and beach profile of project site are shown in Figure 4-4-1-1 and Figure 4-4-1-2. The calculation is made by presuming wave run-up height R and the advanced virtual slope is calculated and it repeats until the concordance between the obtained wave run-up height and the presumed one.



Source: Technical Standards and Commentary for Shore Protection Facilities

Figure 4-4-1-1 Wave run-up height chart by advanced virtual slope method

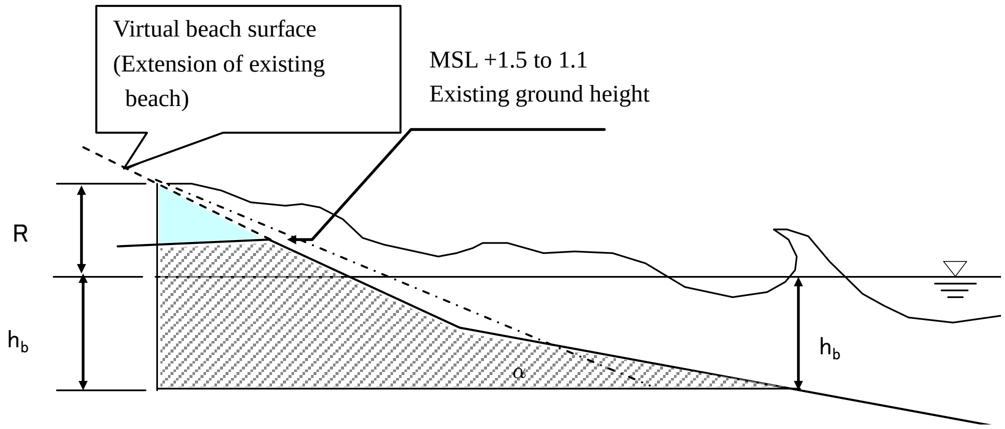


Figure 4-4-1-2 Estimated beach profile of Project site

Calculation condition is shown below.

1) Condition of waves and tide

The result of wave transformation calculation is as per conditions wave with a return period of 30 years shown in 4-3-2. The tide level shall be M.S.L.+1.02m obtained by adding maximum tide level deflection of storm surge (+0.79m) to nearly maximum tide (M.S.L. +0.23m) and the wave steepness (Ho'/Lo) shall be 2.99／224≒0.0133 and the breaking water depth (Hb) shall be 4.5 m based on the ratio between water depth and wave height (h／Ho') ≒1.5 at the point where there is the peak of wave height using wave height calculation chart in surf zone shown in Figure 4-4-1-3.

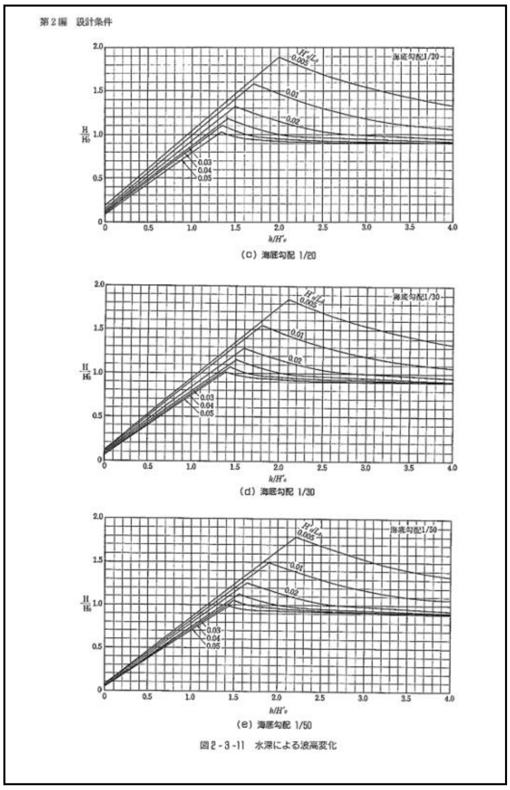


Figure 4-4-1-3 Wave height calculation chart in surf zone

2) Bottom condition

Sea bottom slope condition is shown in Figure 4-4-1-4. (Water depth is shown with the value from mean sea level) According to the advanced virtual slope method shown in Figure 4-4-1-1, the virtual slope shall be 1/30 at the water depth from -5m to +2m.

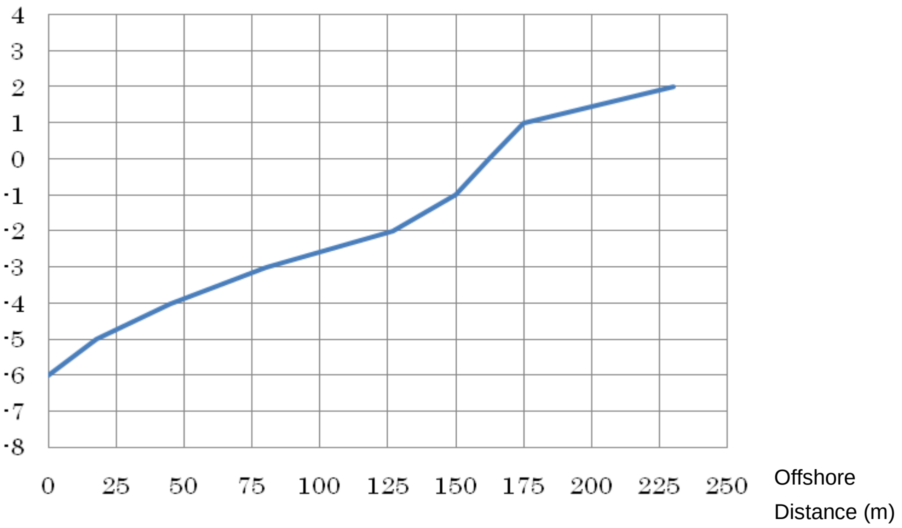


Figure 4-4-1-4 Bathymetric chart

3) Calculation result

a) Current situation

According to the calculation chart of run-up height (Figure below), R/Ho' is about 0.46. After this, R＝2.99*0.46+1.02=2.40(m). As the backshore ground level is +1.5m therefore, the difference between the run-up height shall be the fear.

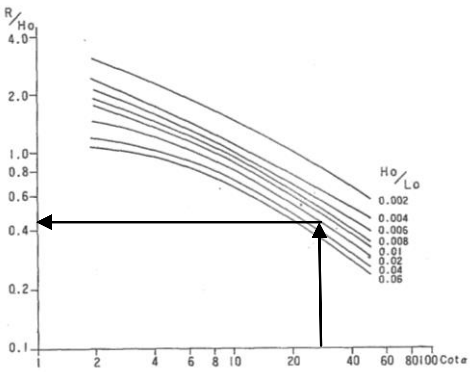


Figure 4-4-1-5 Calculation of run-up height

(1) Beach nourishment method

As mentioned in middle-term countermeasure, the influence by the run-up of a few generation waves in a year can be mitigated if the backshore height is more than +1.5m however, the run-up height of waves with a return period of 30 years becomes MSL + 2.4 m and it is not enough if the backshore height is MSL+1.5m (ground height), In order to solve the fear the wide enough backshore width becomes necessary. The middle-term countermeasure is to construct the MSL +1.5 m so as to cope with the run-up waves with waves generated a few times in a year. While, it is predicted that the foreshore in front of fisheries facilities in Anse La Raye Bay beach advances about 12 m from the shoreline as of September, 2011 in five years ahead. After that, as it is returning to eroding beach with 60 cm average in a year, it takes 20 years to return to the shoreline as of 2006 by simple arithmetic. As a matter of course, the speed shall be accelerated under the circumstances to continue long period wave for long time as it was generated this time.

Beach nourishment method is to maintain shoreline once advanced and construct and maintain the backshore height with more than MSL +1.5 m and the width of backshore shall be the one to be able to mitigate the fear of run-up height by waves with a return period of 30 years in order to solve the fear at the time of incoming wave with a return period of 30 years. The wider width of backshore is better though to maintain berthing function of the jetty shall be the point of concern. In case that shoreline advances around 12 m, judging from the equilibrium slope of this beach, no impact is given to the berthing function of the jetty. Therefore, beach nourishment works make shoreline advanced 12 m as soon as possible and attain the backshore height as more than MSL+1.5 after the execution of middle-term countermeasure.

As shown in Chapter 3, after middle-term countermeasure executed (sand filling works was done in September, 2012), In case that necessary survey is executed concerning the advancement of shoreline in sand filling works around one year and the sand filling works is done in two years later (3 years after middle-term countermeasure), as the result of simulation the shoreline would be advanced about 8m.

By comparison, as it was studied at 4-3-3 alignment design, if sand is considered to be procured with the same grain size as current beach,

$$V=WB+ (3/5W^{5/3}A_NA_F)/ (A_F^{3/2}-A_N^{3/2})^{2/3}$$

Where,

W: crown width of sand fill (12m, however, assumed as crown width of 5 m advanced portion since 8m was already advanced), B: crown height of sand fill (1.5m), Dc: critical depth (5m), A_F, A_N: value obtainable from Table 4-3-3-1 and the critical depth is set as 5 m as shown in Chapter 3.

Therefore, the beach nourishment volume shall be enough to input almost the same volume that was installed at foreshore in front of Vendors Arcade with middle-term countermeasure. i.e. 16.28m3/m x 300m=4,884m3 plus extra rate and construction loss, it becomes 7,326m3 to be procured as sand filling work volume.

Figure 4-4-1-6 shows assumed cross-section of sand filling works. And, Table 4-4-1-1 shows estimated cost of beach nourishment works. The cost of beach nourishment works is cheaper than the offshore structure that is explained later. However, maintenance beach nourishment is inevitable since this beach is originally reseeding beach. As the beach becomes retreating stage with yearly average 60 cm at the stage that beach nourishment works is completed, lost portion of beach i.e. if the section area of beach regards as 5 m3, 5m3/m x 0.6m/m x 300m=900m3/year and in anticipation of 25% of allowance and 20% of construction loss, the sand volume of sand filling works becomes 1,350m3/year.

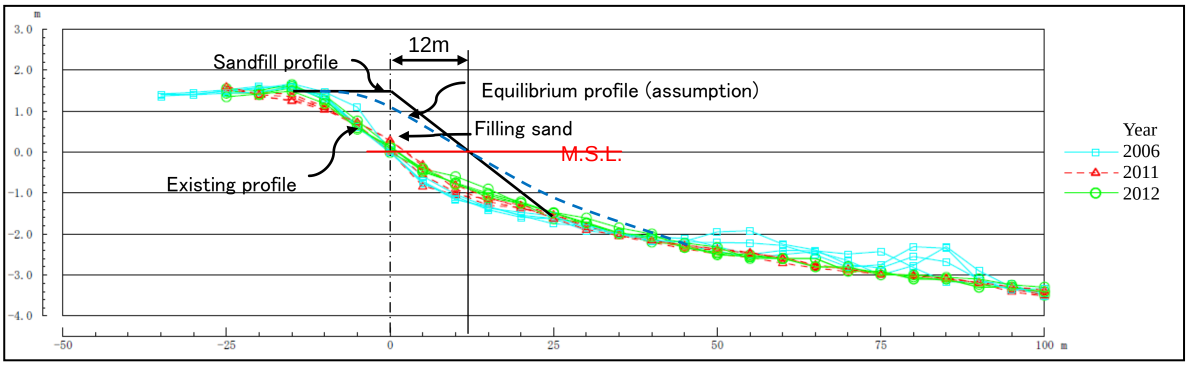


Figure 4-4-1-6 Assumed cross-section of sand filling work

Table 4-4-1-1 Summary of estimated construction cost of sand fill method

Breakdown (including in-direct cost)	Cost (1,000 yen)
Sand (import)	42,000
Sand Accessibility	19,000
Filling Work	2,000
Total	63,000

Table 4-4-1-2 Annual maintenance cost of sand filling work

Breakdown (includig indi-rect cost)	Cost (1,000 yen)
Sand (import)	8,000
Sand Accessibility	4,000
Filling Work	500
Total	12,500

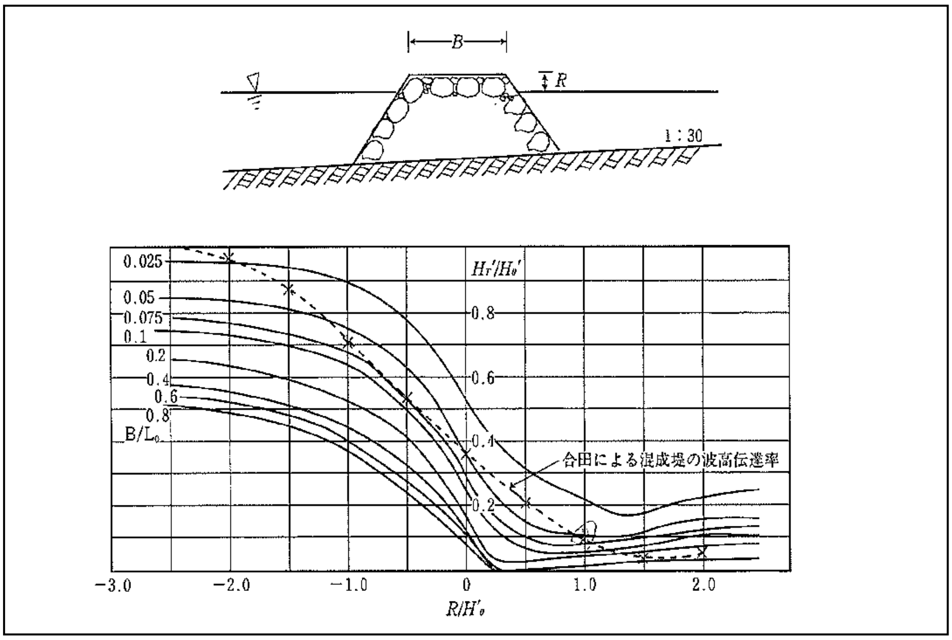
(2) Offshore structure to control waves

Revetment and detached breakwater or submerged breakwater is considered to be proper as the method by offshore structure to control waves. As the backshore ground level is MSL+1.5m and the wave run-up height is MSL+2.40m in addition, it is necessary to prevent the overtopping waves, the revetment becomes necessary to be large scale structure. Furthermore, since the fishing boats are stored on the beach, slipway construction in a part of revetment must be necessary to secure storage place for fishing boats. Since it is necessary to prevent wave run-up to urban area, the installation of openable gate is necessary on the slipway at the revetment. It is however concerned its maintenance of the gate at the time of abnormal weather and the structure has no other choice but weak for such weather. Therefore, the countermeasure to control waves in front of beach and mitigate run-up waves at the beach shall be effective.

1) Mitigation of wave run-up by a detached breakwater

As the ground level is M.S.L. +1.5m and the high tide level is M.S.L. +1.02m, the clearance (R) becomes 0.48 m. Therefore, if the detached breakwater is constructed at the water depth (MSL+2.8m) near the head of the jetty, as the run-up height ratio（R/Ho'） is 0.475 against estimated offshore wave height Ho', in order not to be overtopped the clearance (R=0.48m) by estimated offshore wave height Ho' that makes below 0.475/0.48m＝0.99m i.e. wave transmission coefficient of structure (HT’/Ho’) is good with figure below 0.99m/2.8m＝0.35.

According to the calculation chart of wave transmission coefficient of armor stone breakwater shown in Figure 4-4-1-7, if the crown height of detached breakwater is the same as the tide level （M.S.L.+1.02m）, B/Lo becomes about 0.05 and the above control conditions shall be cleared. Therefore, the crown width (B) shall be B=0.05Lo and B=0.05x224m=11.2ｍ.



Source: Page 51 of 2006 Guide for Fishing Port and Fishing Facility Design

Figure 4-4-1-7 Wave transmission coefficient by armor stone breakwater

2) Installation area and scale of detached breakwater

Length, opening width and installation area of detached breakwater are studied based on the installation water depth. Figure 4-4-1-8 shows the layout concept of detached breakwater. With this, the protection line (Base Line) can be set at the installation places such as Fisheries Complex and 10 m of the backshore width (Design beach width: W) by the middle-term countermeasure. Installation distance of detached breakwater (Y) can be set as 100m-12m=88m from Figure 4-4-1-9. The installation water depth(ds) becomes MSL+2.8m－1.02m＝1.78m.

It is necessary to install detached breakwater so as to make situation tombolo always generated by the detached breakwater at design beach. In general, it is said that tombolo is generated under the relation between the length of detached breakwater (Ls) and the installation distance (Y) with the figures approximately Ls/Y=0.5 to 0.67. It becomes Ls=44m to 58.96m when actual conditions apply to these result. Here, as the stability of beach and the protection of backside land facilities shall be attained by a few numbers of detached breakwaters considering the beach utilization, the length of one detached breakwater shall be 60 m and the opening width (Lg) shall be less than 24 m reading from Figure 4-4-1-9 when tombolo is expected to be gradual incurve. In case that the length of one detached breakwater shall be 60 m and opening width (Lg) shall be Y/ds=88m/1.78m=49.4, if gradual incurve is expected, it becomes Ls/Lg>2.. Therefore, it will be Lg=Ls/2.5＝60m/2.5=24m or less. i.e. it is good to install the detached breakwater with 60 m in length and 25 m in the opening width.

Total length of beach is about 300 m and there is the jetty at the nearly center of the beach. The project site by Grant Aid Cooperation is 160 m of north side including the jetty. It makes separation about 30 m from the jetty which area is affected by fishing boat operation and one 60 m length detached breakwater, 25 m opening and one 30 m detached breakwater totaling two breakwaters shall be installed in 120 m length zone. As the end part of the jetty is opened with 60 m, installation of revetment there becomes necessary. And the recession of shoreline is also generated at 140 m portion in south side of the beach and the installation of 60 m detached breakwater is expected to be installed if possible.

And there are incoming rivers at both north and south ends and it will be possible to have blockage of river mouth by tombolo due to the installation of detached breakwater. Therefore, at the same time, the installation of training wall at the river mouth shall also be necessary. Figure 4-4-1-10 shows layout plan of detached breakwater and the idea of river mouth training wall. The above study is the study for the proposal of long-term countermeasure and it is necessary to decide beach shape, length of detached breakwater, size of training wall, size of revetment and etc. based on the survey result of detailed wave condition, beach sand grain size, sea bottom slope and etc. breakwater.

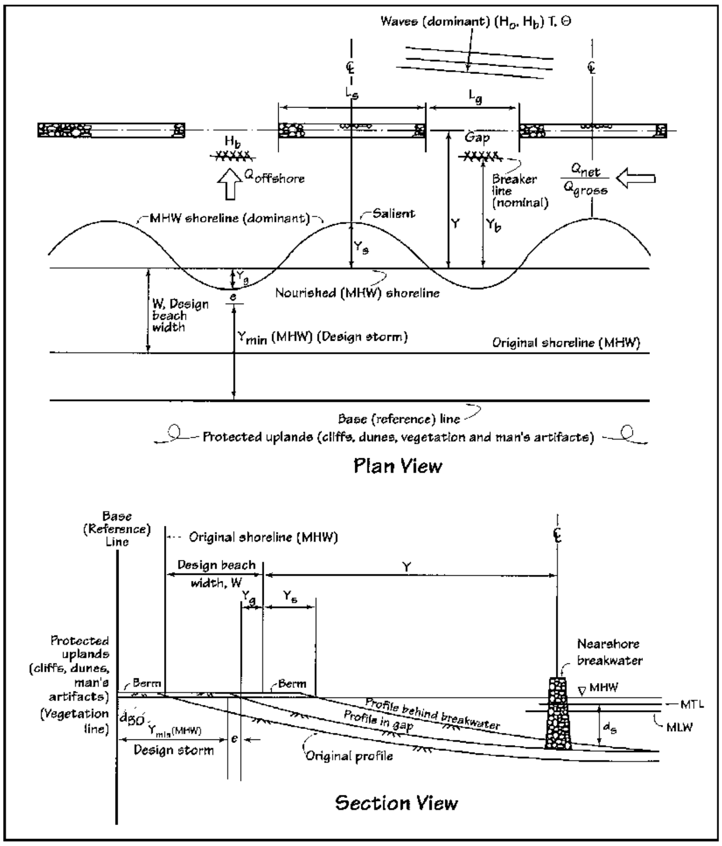


Figure 4-4-1-8 Basic concept of detached breakwater alignment

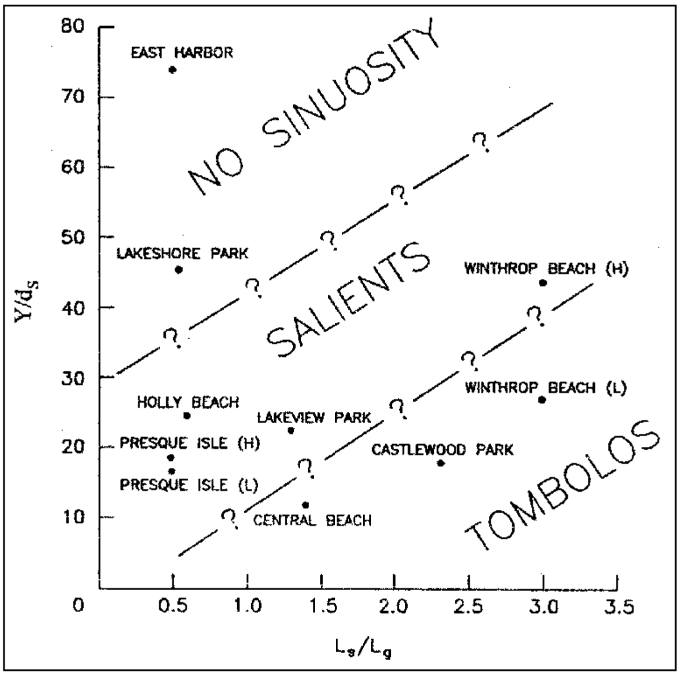


Figure 4-4-1-9 Generation situation of sand bar with proportion of detached breakwater length and opening width and installation distance and installation water depth

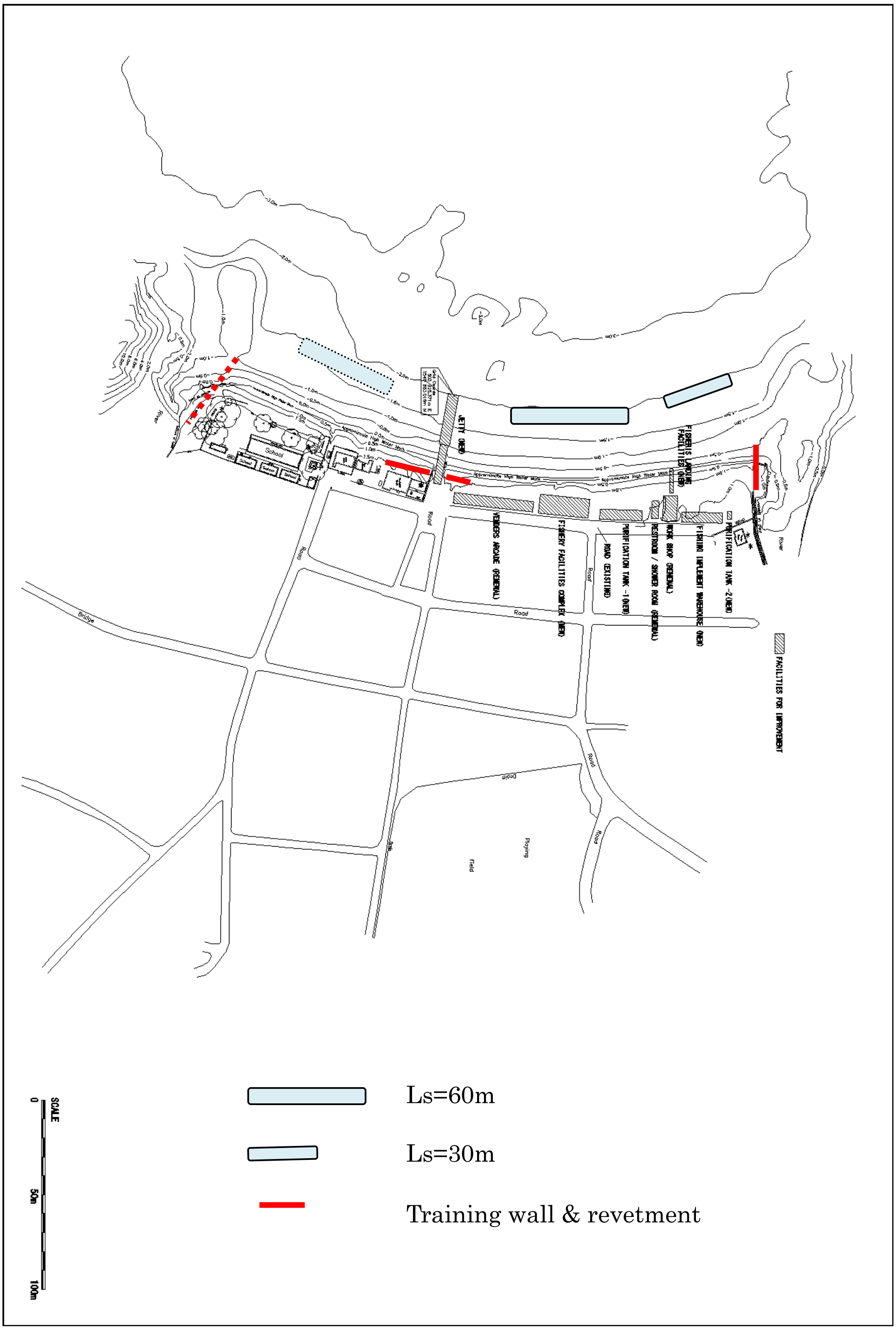


Figure 4-4-1-10 Plot plan (draft) of detached breakwater, river training wall and revetment

3) Schematic cross-section of detached breakwater

Detached breakwater is predicted to be constructed by stone with 4t/stone judging from design wave height at the head part of the jetty. And the cross-section is shown in Figure 4-4-1-11.

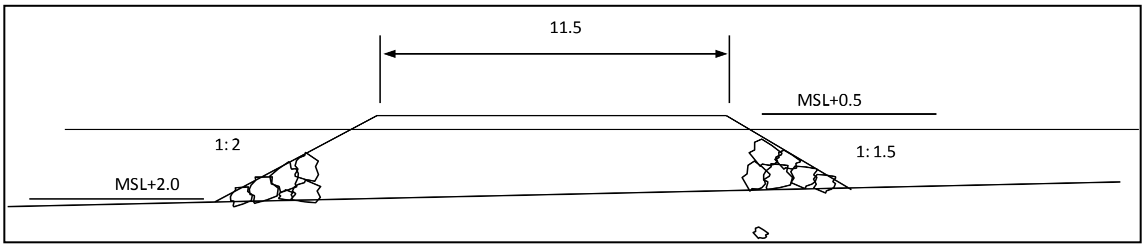


Figure 4-4-1-11 Cross-section of detached breakwater

And, this detached breakwater is to be installed using crane from land side after construction of temporary road. This installation works need filling direction and rough leveling by diver.

4) Estimated Cost

Table 4-4-1-3 is shown the estimated construction cost of northern part in the Plot Plan. Table 4-4-1-4 is shown the estimated construction cost of Total Cost of Anse La Raye Bay. This estimated cost shows construction cost including indirect cost. Out of this, the direct temporary cost is the cost for necessary temporary road for the installation works of detached breakwater and installation works of two detached breakwaters include each installation and removal works of temporary road. Necessary stone materials for the construction of detached breakwaters shall be about 4 t/stone for the stability and procure them at south side of St. Lucian Island. All construction works shall be executed by land side on temporary road. This cost does not include the cost for design and construction supervision.

Table 4-4-1-3 Estimated construction cost (Northern part)

Detached breakwater①	111,000
Detached breakwater②	56,000
Training wall	8,000
Revetment	10,000
Temporary works	177,000
Total	362,000

Table 4-4-1-4 Estimated construction cost (Total cost)

Detached breakwater①	111,000
Detached breakwater②	56,000
Training wall	8,000
Revetment	10,000
Detached breakwater③	111,000
Training wall②	8,000
Revetment②	10,000
Temporary works	265,500
Total	579,500

Unit cost: 1,000yen

4-4-2 Recommendation for long-term countermeasure

Two alternatives are shown in 4-4-1 as the long-term countermeasure; 1) sand filling work and 2) offshore structure work to control waves. The features of both methods are as follows,

1) Landscape of pocket beach formation in Anse La Raye Bay can be maintained in case of sand filling work.
2) Landscape of pocket beach shape is fluctuated in case of offshore structure works to control wave

As the fisheries facility function, both methods are the same although the landscape of pocket beach shape is differed each other. Initial cost of beach nourishment works is cheaper than that of offshore structure works to control waves but, the cost to maintain beach shape becomes continuously necessary. Concerning continuous maintenance cost, it has to wait for future detailed survey however, as the shoreline is recessed 60 cm every year, it is considered that the maintenance beach nourishment with 5m2 x 0.5 m x 300 m = 900m3/year and 25% of extra ratio≒1,200 m3 /year is necessary if beach cross-section area is assumed as 5m2. While, the maintenance beach nourishment volume is differed upon grain size of sand material.

Selecting long-term countermeasure is necessary to judge from total point of view such as 1) Local thought around Anse La Raye area, 2) Utilization of coastal line by fishing boats, 3) Role of coastal line as tourism resources, 4) Utilization of coastal line by fishing activities. Table 4-4-2-1 shows the correspondences to preconditions of middle and long-term countermeasures. In the selection of long-term countermeasure, it is necessary to consider the correspondences shown in Table 4-4-2-1 and the naturalness as much as possible as mentioned in Chapter 3.

Table 4-4-2-1 Precondition of middle and long-term countermeasures and correspondence to long-term countermeasure

Preconditions of middle and long-term countermeasure		Beach Nourishment method	Offshore structure to control waves
(1) National Plan	1) Redevelopment of waterfront a) Enhancement of Vendors Arcade b) Reconstruction of Entertainment Center c) Preservation of sand beach d) Construction of beach facilities e) Construction of board walk 2) Improvement of fishing village a) Expansion of berthing function b) Construction of fuel supply facility 3) Preservation of natural beach (Southside of beach)	・Landscape of Natural beach is kept ・Beach facilities can be developed easily due to securing of wider backshore width ・It is possible to have partial trouble for the mooring function of the jetty in case that the shore line is much advanced. ・Sand filling is unavoidable in order to keep natural beach	・Beach shape is variable Mooring function of fishing boats is improved with the offshore wave control ・Consideration on uniformity of landscape is necessary for the development of beach facility because of its creation of artificial landscape ・Sand filling is not required
(2) Shoreline usage by fishing boats	1) Conservation of landing function of fishing boats in front of Vendors Arcade	・The function of lifting up of fishing boat is kept ・The beach access of fishing boats is easy	・The function of lifting up of fishing boat is kept ・The beach access of boat handling is difficult
(3)Difficulty to relocate Fisheries Complex	1) Existence of Fisheries Complex Building	・The fear of scouring is solved as enough foreshore width is secured	・The fear of scouring is solved as foreshore becomes stable by offshore wave control
(4)Shoreline role as tourism resources	1) Conservation of shoreline shape 2) Construction of sunbathing beach	・Wider backshore is formed and the shape of coastline is kept	・The shape of coastline is varied.
(5)Shoreline usage by fishing activities	1) Conservation of beach coast (for the fishing by beach seine net)	・Ongoing utilization by beach seine net fishing is possible	・Beach seine net fishing becomes difficult due to the offshore detached breakwater

Chapter 5 Execution of Middle-Term Countermeasure of the Project

5-1 Presentation and discussion of Scope of Works

5-1-1 Schedule of presentation and discussion of Scope of Works

The scope of works was concluded after presentation and discussion of Interim report of middle-term countermeasure. Table 5-1-1-1 shows the schedule of site survey for scope of works. Table 5-1-1-2 shows the list of interview during the site survey.

Table 5-1-1-1 Schedule of site survey

No. of day	Year/Month/Date		Eiichi Matsuura, Mr. Chief Consultant/Port engineering
1	2012/6/30	Sat	Narita JL006(11:20)→(10:20)JFK AA2035(14:25)→(17:55)Miami
2	2012/7/01	Sun	Miami AA2297(10:15)→(14:35)St. Lucia Site survey
3	2012/7/02	Mon	Presentation and discussion of IT/R and Presentation and discussion of Draft of S/W Site survey
4	2012/7/03	Tue	Site survey Sign of S/W
5	2012/7/04	Wed	Submission of the materials of approval of development by DCA、 Hearing survey of the contractors
6	2012/7/05	Thurs	Hearing survey of the contractors
7	2012/7/06	Fri	Site survey
8	2012/7/07	Sat	Report writing
9	2012/7/08	Sun	Report writing
10	2012/7/09	Mon	Verify of the approval of development by DCA, Site survey
11	2012/7/10	Tue	Verify of the approval of development by DCA, Site survey
12	2012/7/11	Wed	Verify of the approval of development by DCA, Reporting to the office of JICA St. Lucia
13	2012/7/12	Thurs	St. Lucia AA4895(7:48)→(09:40)SanJuanAA1416(14:10)→(18:15)JFK
14	2012/7/13	Fri	JFK JL005(13:25)→
15	2012/7/14	Sat	Narita(16:25)

Table 5-1-1-2 List of interview

Name of attendants	Position and Affiliation
Mr. Hubert Emmanuel	Permanent Secretary Ministry of Agriculture, Food Production, Fisheries and Rural Development
Ms. Sarah N, George	Chief Fisheries Officer Ministry of Agriculture, Food Production, Fisheries and Rural Development
Mr. Augustin Poyotte	Chief Architect Ministry of Physical Development
Mr. David Desir	DCA/ Ministry of Physical Development.
Ms. Judith Ephraim	Ministry of Sustainable Development
Ms. Petronila Polius	Fisheries Extension Officer Fisheries Dept.
Ms. Sarita Williams-Peter	Biologist Fisheries Dept.
Ms. Sherkina Innocent	Fisheries officer Fisheries Dept.
Ms. Stephia Gusteve	Fisheries officer Fisheries Dept.
Mr. Nariaki Mikuni	JICA Expert
Mr. Kyouhei Mizutani	Resident Representative of JICA St. Lucia Office
Mr. Hiroshi Izaki	Team Leader of S/W mission
Mr. Naoki Mine	Cooperation Planning of S/W mission
Mr. Eiichi Matsuura	Chief Consultant / ECOH CORPORATION

5-1-2 Result of presentation and discussion of IT/R

5-1-2-1 Discussion of plans for middle-term countermeasure

After the presentation of contents of IT/R、the following discussion have been executed.

(1) The plans for middle-term countermeasure have been understood with the member of participants of the meeting.

(2) There is a question about the character of filling sands. Some bad experience of stability of beach with the different character of sand compared with existing sand. No problem of filling the sand will be occurred due to using the existing beach sands in Anse La Raye Bay.

(3) In the event of outcrop of rubble stones in front of Vendors Arcade, it will be the possibility of damages of bottom part of fishing vessels. The request of smoothly re-installation of rubble stone and the training of pulling up the fishing vessels using the boat slider will be executed before sand filling works. We agreed the re-installation and test of pulling up the fishing vessels with boat slider.

(4) The possibility of easy access to the jetty and gear lockers through the beach in front of Fisheries Complex was understood. The beach landscape will be slightly changed with the shoreline breakwater and the change of beach landscape was understood.

5-1-2-2 Approval of Development by DCA

The submission of the additional materials for the meeting of DCA is required concerning the outline of middle-term countermeasure, traffic management plan and the drawings.

(1) The proposal of middle-term countermeasure is identified the requested contents.

(2) The traffic management plan was requested of submission by Chief Architect. The same construction works will be done and we are mutual understood using the traffic management plan of short- term countermeasure.

(3) The requested materials by DCA were submitted to the officer in charge of DCA through internet. The materials are 1) Proposal of middle-term countermeasure、2) Tender Drawings, 3) Bird’s eye view plan, and 4) Traffic management plan.

(4) The chief fisheries officer and the office member are followed up the meeting of DCA for the approval of development. Chief Architect is joined the board member of DCA.

5-1-3 Recommendation of long-term countermeasure

Anse La Raye Bay Beach will return the eroding condition without the additional sand supply based on the long-term beach process after ending the shoreline advancing process for the time being. Therefore two alternative plans for long-term countermeasure is proposed and following understandings were shared.

(1) Beach nourishment plan

1) For identification of Beach Nourishment Plan under IT/R, it is very important of shoreline monitoring after the completion of middle-term countermeasures. The monitoring survey is

baseline survey for implementing the proper beach nourishment plan. It is clear understood with the member of the meeting.

2) It is clear understood that the maintenance of beach nourishments annually is necessary for the keeping the shoreline shape.

(2) De-touched breakwaters plan

1) It is not innovated the de-touched breakwaters plan for beach landscape and the condition of marine environment.

5-1-4 Result of presentation and discussion of Scope of Works

5-1-4-1 Major undertaken by Saint Lucia

(1) Concerning the article 4 of Scope of Works (S/W), St. Lucian side has inquiry as follows;

(2) Article (3) and (5) under Major undertaken by Saint Lucia are the concerning issues for recommending of middle-term countermeasure and additional materials for acquisition of approval of development. These articles are understood by major undertaken by St. Lucia.

(3) Article (6) are the fixed term. Mr. Mikuni, JICA Expert indicates the non-problems occurred because the foreign materials will not use.。

(4) Other issues about VAT, which will be induced in October of this year are understood for exemption of internal tax.

5-1-4-2 Major undertaken by JICA

Concerning of request of writing in some words for confirming of pulling up the fishing vessels over the surface of rubble stone prior to sand filling, it is clear to writing in some words in the article of Major undertaken by JICA.

5-1-4-3 Indicated issues of Scope of Works

Team leader, Mr. Izaki indicated as follows;

1) The approval of development for middle-term countermeasure by DCA should be acquired soonest;

2) Long-term countermeasure should be implemented by St. Lucia side, and

3) Expectation of best support for the construction works of middle-term countermeasure.

After then S/W was signed and concluded.

5-1-5 Relationship between the status of beach condition and middle-term countermeasure

The following issues could be indicated based on the relationship between the status of beach condition and middle-term countermeasures.

(1) Status of shoreline advanced (Shoreline is keeping on advance)

We could identified the shoreline is advancing by the topographic and sounding survey at the time of start on the follow-up study and additional survey. It is keeping of condition of shoreline advancing at the time of field survey of scope of works. The recovery speed of shoreline in the south beach at the jetty is more advancing compare with north beach. This means the direction of sand drift is to the north from the deposited of sand area in front of the south river mouth. IT/R is shown as the prediction that the shoreline will be advance of average 12m during more five years based on the shoreline of September, 2011.

(2) Status of beach condition in front of Vendors Arcade（Necessity of man-made support to be advancing of the shoreline）

The beach in front of Vendors Arcade is advanced compare with the shoreline of the additional survey. But the speed of advancing is quite slow than other area. It is assumed that the drifting sand to the north is protected by the area of rubble stone for the protection of the foundation of the jetty. The sand filling works will be advanced the shoreline and the speed of sand drift to the north will be higher. After sand filling works, it is expected that the advanced speed of shoreline in Anse La Raye Bay is more forwarding and the shoreline is tally advanced.

(3) Status of Rubble Stone in front of Fisheries Complex (Necessity of countermeasure in the view pint of long term)

The ruble stone for protection of Fisheries Complex is deformed the shape along with advancing the shoreline. The position of up-lifting sand on the rubble stone is functional for the protection of recession of shoreline recession and for the protection of beach retreat protection. Middle-term countermeasure will be installed the armor stone (500kgPlus) as the shoreline breakwaters. It is assumed that the function of protection of beach retreat is over for reducing the wave run up by the shoreline breakwater. However, the rubble stone will be installed underground and backfilling of sand as the protection of the retreating of shoreline.

(4) Status of beach configuration in front of gear lockers, workshop, washroom and septic tank （reducing of wave power for the long period wave in winter season）

The north beach in front of gear lockers, workshop, toilets and septic tank is keeping the width of backshore or more in September 2011 and this beach have a tendency toward more advance with the condition of beach cliff. The same treatment of rubble stone in front of Vendors Arcade will be executed for the protection of score of foundation in the middle-term countermeasure.

(5) Status of advancing of south beach (More advancing tendency of south beach)

The shoreline of south beach is largely advanced due to the sand drift to the north from the deposited sand in the river mouth. The large volume of deposited sand is still remained. The south beach is probably more advanced. The shoreline of south and north beach will be conformed of one line in future. At that time the shoreline of the bay is unison and advanced more. IT/R predict the advanced shoreline is 18m.

(6) Status of borrower site of filling sand for middle-term countermeasure（Probability of collecting the filling sand）

The foreshore area in front of Vendors Arcade will be back filled of sand for man-made advancing the shoreline in middle-term countermeasure. The deposited sand in front of south river mouth and beach cliff of its surrounding area is expected to borrowed sand for the material of backfilling. This cliff has a large volume of sand and its tendency of conforming of the cliff is continued. It is clear that transported sand volume of 1,300m3 is easily. In the case of execution of works, the borrower site of the back filling sand is necessary change the site to the river mouth of the north river according to the condition of shoreline advance and the stability of backshore of the south beach. As well it is necessary to consider the borrow site of filling sand to the river mouth of north river according to delay the execution of works because of no damaged for the stabilization of backshore and the shoreline advancing in the South side beach.

5-2 Assistance of tender

The study switched to the stage of tender process after conclusion of Scope of Works. Followings are the considering issues for tender and supervising process.

5-2-1 Type of tender

Tender process was managed by JICA Dominican republic office and Tender has been held with the type of designated competitive bidding.

5-2-2 Preparation of tender documents

Draft of Tender Documents has been submitted to JICA Dominican Republic Office.

5-2-3 Short list of construction companies of coastal works in Saint Lucia

Following five construction companies were assumed as the contractor which has an ability of coastal works.

Table 5-2-3-1 Short list of construction companies of coastal works in Saint Lucia

Company Name	Contact Person	Contact Number	Business Address	Email Address
C. O. Williams Group of Companies	Mr. Ossie Mohammed	758-452-0094	Bois D'Or-ange, Box 1485 Cas-tries, St. Luica	omohammed@cowstlucia.com
C. O. Williams Group of Companies	Mr. Rayneau Gajadhar	758-450-1087 /712-4600	Corinth Main Rd, Box GM 652, Cas-tries, St. Lu-cia	info@cie-rgltd.com
O B Sadoo Engi-neering Services Ltd in St Lucia	Mr. Owen Sadoo	758-451-5087 / 719-9720	Cul De Sac, Box BJ 0010, Cas-tries, St. Lu-cia	owensadoo@hotmail.com
Takao & Sons Elec-trical-Mechanical and Engineering Contractors Ltd	Mr. Felipe M Jimenez Kawashiro	758-723-2280 / 767-613-1333	Black Bay, P. O. Box 514 Vieux Fort, St. Lucia	takao-ka-intl@hotmail.com
Jamecob's Quality Construction Ltd	Mr. Vaughn Charles	758-458-2197 / 717-6290	Cul de Sac, Box RB2401 Rodney Bay, Gros Islet, St. Lucia	vaughn.charles@gmail.com

5-2-4 Prequalification and condition of the contract

As the future works, we should consider the condition of prequalification. It is necessary to be considered the following condition of prequalification.

(1) The contract price during consecutive two years

The contract price per a year of the constructors in St. Lucia is a widely fluctuation year by year except the two major constructors, C. O. Williams Group of Companies and C. O. Williams Group of Companies. The one of condition of prequalification is the contract price during consecutive two years. The contract price condition will be loosed like as follows:

a. to have done at least one construction works with the contract price not less than ten million Japanese yen during last two years.

(2) Price of tender documents

The price of tender documents is usually thirty thousand Japanese yen (J¥30,000) for the project of Grant Aid in Japan. It is proper to the price of ten thousand Japanese yen (J¥10,000 or EC$300) due to the small scale project of middle-term countermeasure. The tender documents shall be returned to the client at the time of tender.

(3) Performance security and advance payment security

Normally the success tenderer is obliged the Performance Security of Ten percent (10%) of と the contract price. In addition of the Performance Security, the advance payment security is needed for the bond of insurance of the works. It is over bearded for the constructors in St. Lucia due to the small scale of management.

(4) Payment schedule

The term of the middle-term countermeasures work is only three months and the timing of completion works is not easy to be divided due to the consecutive works. Therefore we should consider the payment schedule like seventy percent (70%) as the advanced payment, thirty percent (30%) as the final payment.

(5)Experiments of the construction works for Japan ODA project

The contract is the general contract in the case of Japan Grant Aid project. The contractor has one year warranty after the completion date. For the smooth implementation of the works, the experiments of the construction work for Japan ODA project as the condition of prequalification.

5-2-5 Tender schedule

Tender has been held after the day when the permission of development by DCA was acquired. The permission of development by DCA was submitted on 7th November, 2012. Table 5-2-5-1 shows the actual schedule of tender process managed Dominican Republic Office.

Table 5-2-5-1 Schedule of tender process managed by JICA Dominican Republic Office

	Year/Month/Day		Official Member		Consultant Member
			JICA(1)	JICA(2)	Eiichi Matsuura, Mr.
			Team Leader	Cooperation Planning	Chief Consultant Port Engineering
1	2012/11/29	Thu	Invitation/Deliver of Tender Documents/Inquiry		
2	2012/11/30	Fri	Deliver of Tender Documents		
3	2012/12/01	Sat			
4	2012/12/02	Sun			NRT – JFK - MIAMI
5	2012/1203	Mon	Arrangement of inquiry		MIAMI – St. Lucia
6	2012/12/04	Tue	ditto		Technical support
7	2012/12/05	Wed	ditto		ditto
8	2012/12/06	Thu	ditto		ditto
9	2012/12/07	Fri	Reply of Inquiry		ditto
10	2012/12/08	Sat	ditto		ditto
11	2012/12/09	Sun	ditto		ditto
12	2012/12/10	Mon	ditto		ditto
13	2012/12/11	Tue	ditto		ditto
14	2012/12/12	Wed	ditto		ditto
15	2012/12/13	Thu	ditto		ditto
16	2012/12/14	Fri	Tender Publicly of Tender		ditto
17	2012/12/15	Sat	Evaluation of Tender		ditto
18	2012/12/16	Sun	Evaluation of Tender		ditto
19	2012/12/17	Mon	Clarification of Tender		ditto
20	2012/12/18	Tue	Negotiation of the Contract		ditto
21	2012/12/19	Wed	Deliver the Award of Tender		St. Lucia – Sun Juan- JFK
22	2012/12/20	Thu	Preparation of the Contract		JFK
23	2012/12/21	Fri	Signature of the Contract		NRT

5-2-6 Result of tender

Based on the list of construction companies which are implemented the coastal works in Saint Lucia listed in Table 5-2-3-1, the invitation letter for the designated bidding to the listed five companies. Four companies are participated to the tender. All participates were submitted the satisfied tender documents and Tender was held on two o’ clock in the afternoon 14th December 2012 at the meeting room of Department of Fisheries, Saint Lucia. C.O.WILLIAMS Group of Companies was bided the lowest price of the tender. After the negotiation of the contract C.O. WILLIAMS Group of Companies was decided the contractor of the contract and the contract was concluded on 20th December 2012.

Table 5-2-6-1 Result of tender

Negotiation Status	Name of Companies	Bidding Price in US$
1	C.O.Williams Group of Companies	181,347.32
2	Takao & Sons Electrical-Mechanical and Engineering Contractor Ltd.	187,570.78
3	Construction & industrial Equipment Ltd.	454,121.09
4	O.B. Sadoo Engineering Service Ltd.	906,294.86

5-3 Supervision of works

5-3-1 Outline of works

(1) Project name

THE FOLLOW-UP COOPERATION ON THE PROJECT FOR IMPROVEMENT OF FISHERY INFRASTRUCTURE IN ANSE LA RAY, SAINT LUCIA

(2) Client

JICA DMINICAN REPUBLIC OFFICE

(3) Consultant

ECOH CORPORATION

(4) Contractor

C.O. Williams Construction Ltd.

(5) Construction period

January 14, 2013 ～ March 27, 2013

(6) Major construction items

1) Temporary works

Construction of temporary road: 300m

Reinforcement of the drainage at south side base of the jetty: 25m

Laying 350mm diameter pipe at north side base of the jetty: 6m

Safety measure: Lump sum

Mobilization and demobilization: Lump sum

2) Protective works in front of Vendors Arcade:

Length 48m, Installation and leveling of rubble stone (100-200kg) 87m3

3) Protective works in front of Fisheries Complex:

Length 30m, Installation and leveling of rubble stone (100-200kg) 184m3

Installation and leveling of armor stone (500kg) 123m3

4) Protective works in front of Fishing Gear Lockers:

Length 76m, Installation and leveling of rubble stone (100-200kg) 137m3

5) Sand filling works in front of Vendors Arcade:

Excavation and loading of sand 977m3, Transportation, installation and leveling sand 1,173m3

6) Survey prior and after completion of the work

Topographic Survey: 21,850 m2

Bathymetric Survey: 59,000 m2

5-3-2 Project management

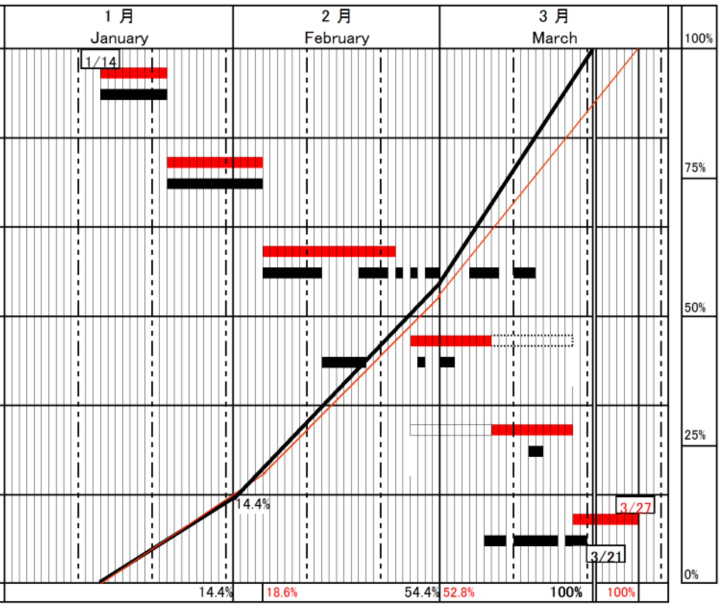
The survey prior to the construction works was conducted on 14th January 2013, the construction works was commenced. The Consultant conducted the final inspection on 15th March 2013 and the construction works were completed on 21th March 2013. The project management has been implemented (1) Schedule Control, (2) Quality and Outcome control and (3) Safety Control.

(1) Schedule control

Table 5-3-2-1 shows the result of schedule control.

Table 5-3-2-1 Status of schedule control

No.	工 事 箇 所 (Construction Place)	工事金額 (US$)	割合 (%)
1	Preparation& Temporary Works 準備･仮設工		
2	Protective Works (in front of Fishing Gear Locker) 漁具倉庫前保護工	33,750.15	18.6
3	Protective Works (in front of Fisheries Complex) 水産複合棟前保護工	56,169.06	31.0
4	Protective Works (in front of Vendors Arcade) ベンダーズ･アーケード前保護工	15,995.48	8.8
5	Sand Filling Works (in front of Vendors Arcade) ベンダーズ･アーケード前覆砂工	75,432.63	41.6
6	Clean-Up 後片付け (工事終了時の地形･深浅測量も含む)		
	Total/合計	181,347.32	100%



Note ; 2から5の工事箇所については工事金額がBQで明確ですが、Temporary Works等については明確になっていないので2から5の工事金額の比率で分け、2から5の各工事金額にプラスしました。

Red ; Schedule
Black ; Actual Result

(2) Quality /outcome control

The Consultant conducted the following inspections before the final inspection;

1) Laying of rubble stones in front of Fishing Gear Lockers, laying of rubble stones
2) Covering of sand in front of Fisheries Complex
3) Laying of rubble stones and covering of sand in front of Vendors Arcade.

(3) Safety control

The Project Board in which a construction period and the construction area were shown was installed in two places of the site. Moreover, around construction place by stretching the yellow tape urged to cautions. The guard man was stationed at the entrance of construction vehicles.

(4) Monthly meeting

The Monthly Meeting by Client, the Department of Fisheries, the Consultant and Contractor has not been held.

(5) Minor modification of design

The underground buried cable was discovered in the position of a place and about 1m below ground which excavated the north side of the Fishing Gear Lockers 1. This underground buried cable is taken into the distribution box in the fence of the Fishing Gear Lockers 1in about 10m position. In order not to damage an underground buried cable, about 10m shifted to the sea side 1m, and excavate and laying stone were performed.

(6) Major modification of design

Nothing

(7) Completion photos of construction works

Photo 5-3-2-1 Completion of protection of Fishing Gear Lockers

Photo 5-3-2-2 Completion of protection of Fisheries Complex (1)

Photo 5-3-2-3 Completion of protection of Fisheries Complex (2)

Photo 5-3-2-4 Completion of protection of Vendors Arcade

Photo 5-3-2-5 Panoramic view at completion (North side beach)

Photo 5-3-2-6 Panoramic view at completion (South side beach)

5-4 Coastal geomorphological change due to completion of middle-term countermeasures

5-4-1 Change of coastal geomorphology

(1) Change of depth contour

Five times of bathymetric and topographic survey with the same area has been executed in Anse La Raye Bay from the time of Basic Design Study. Figure 5-4-1-1 presents the change of depth contour in the bay, which is measured with reference to the result of survey on October 2006. The depth contours run the parallel to the shoreline although the area of pendent is at the offshore of south river mouth. The depth contour in September 2011 (Red Line) shows the large sand deposited area at the south river mouth. These sands have been supplied by Hurricane Tomas. The wave reflection energy toward this deposited area induced the large geomorphological change to the north side beach of this area. The sand of north side beach was pulled to the south beach by this wave reflection energy. The north side beach of this deposited area was appeared the shoreline retreat and sunk of backshore. After then this deposited area was begun to supply the littoral drifting sand to the south beach. The result of survey at the additional study on January 2012 indicated the beginning of sand supply to the beach. It is understood that the sand deposited area is shrinking year by year. We could identify the advance of shoreline and the one shoreline between south and north beach of jetty by the result of survey on March 2013 which has been executed after completion of middle-term countermeasures. Now shoreline in Anse La Raye Bay is conformed a beautiful curve.

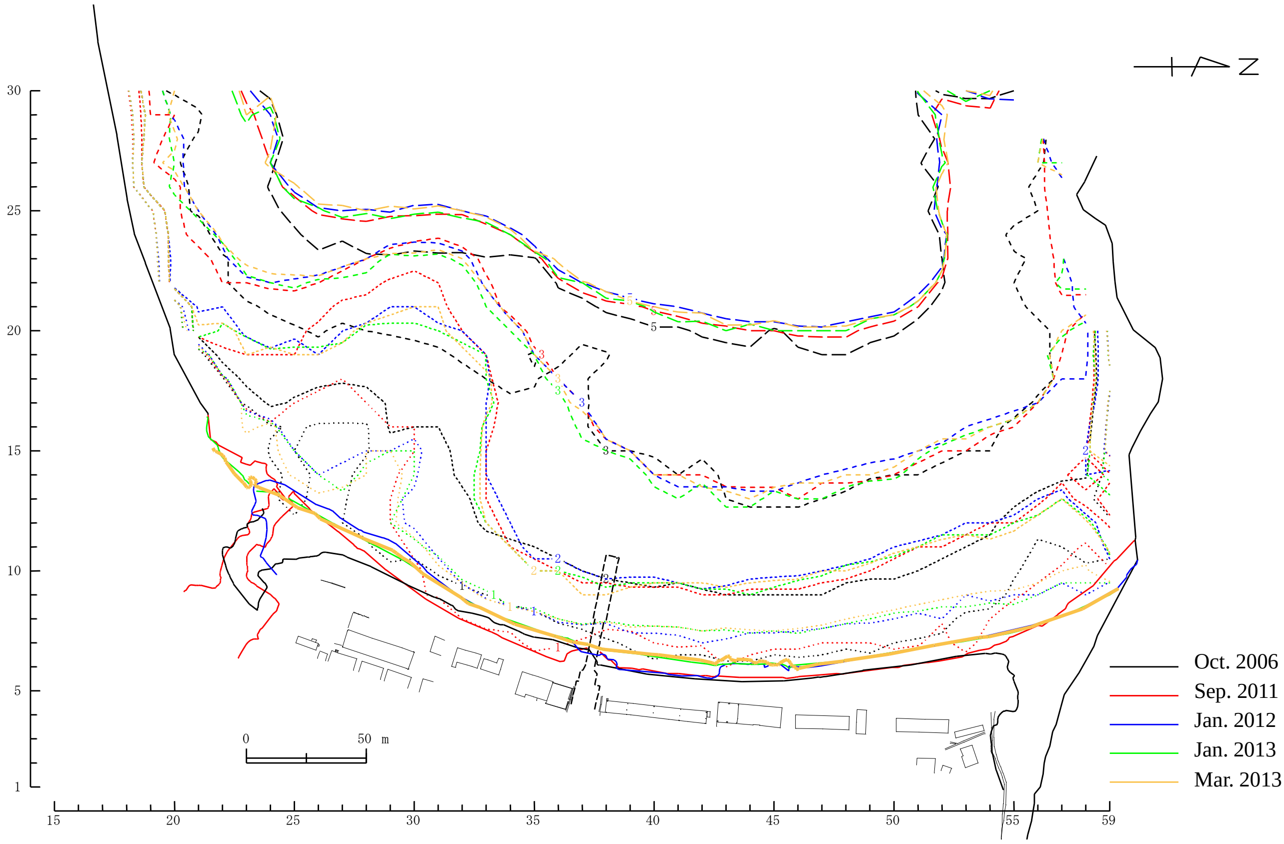


Figure 5-4-1-1 Change of depth contour（October 2006～March 2013）

(2) Sand Movement in the Anse La Raye Bay

Figure 5-4-1-2 shows the change of water depth between October 2006 and March 2013. It is understood that the sand deposition is especially pronounced in the bay. The area of deeper than water depth of 6 meters is steep slope and so the deposited sand of this area could not return to supply the sand for recovering in shallow waters. The sand of lower than water depth of 5 meters is main source of littoral sand drift. The advancement of shoreline and formulation of backshore are caused by this littoral sand drift. We could understand that the advancement of shoreline and formulation of backshore will be continued because the deposited area in front of the south river mouth is still remained largely on Figure 5-4-1-1.

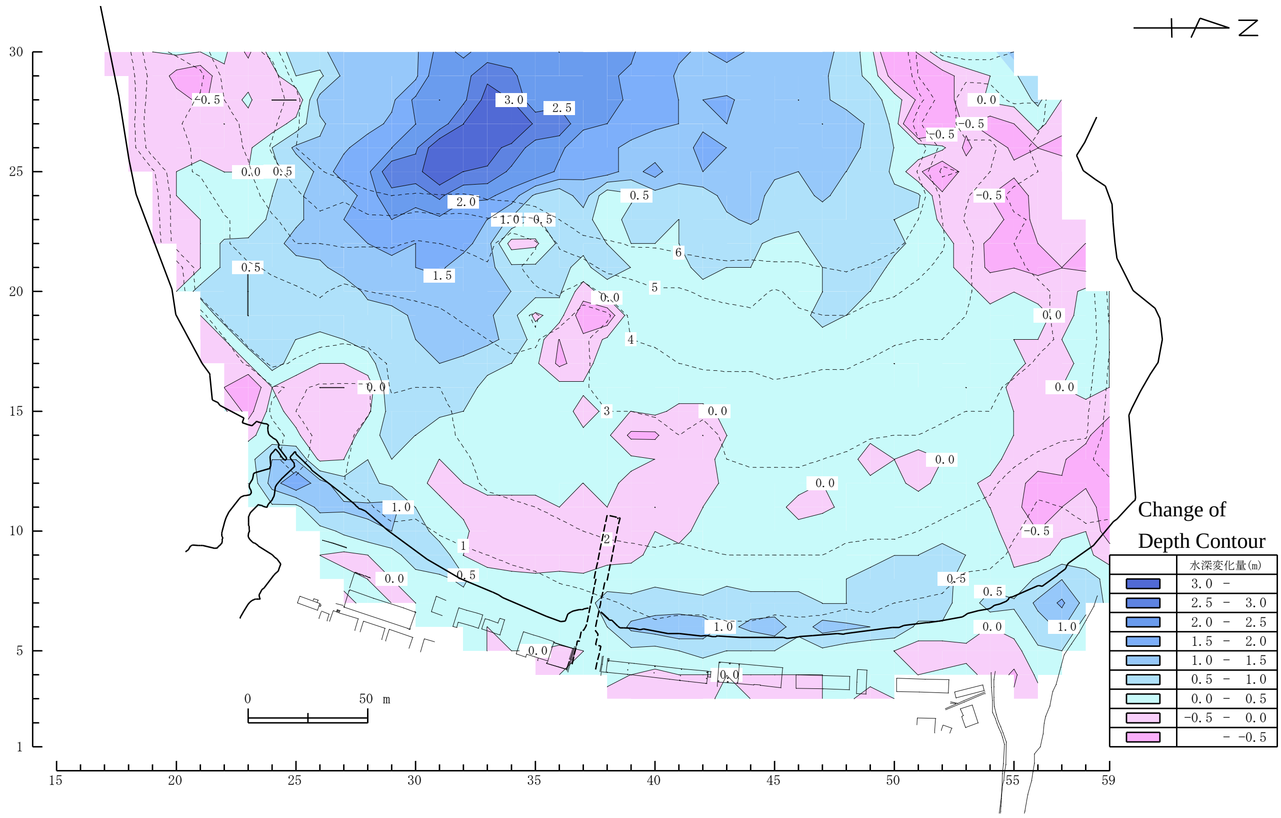


Figure 5-4-1-2 Water depth change between October 2006 and March 2013

（Depth contour is on October 2006）

(3) The relationship between the shoreline prediction and the position of shoreline after completion of middle term countermeasures

Figure 5-4-1-3 presents the position of actual shoreline at the survey result on March 2013 and the prediction of shorelines. It is clear understood that the actual shoreline position is similar to the prediction line of one year after, because the position of actual shoreline is 6 months passed from the beginning of prediction. Therefore we could say that the shoreline will be advancing as followed with the predicted shoreline.

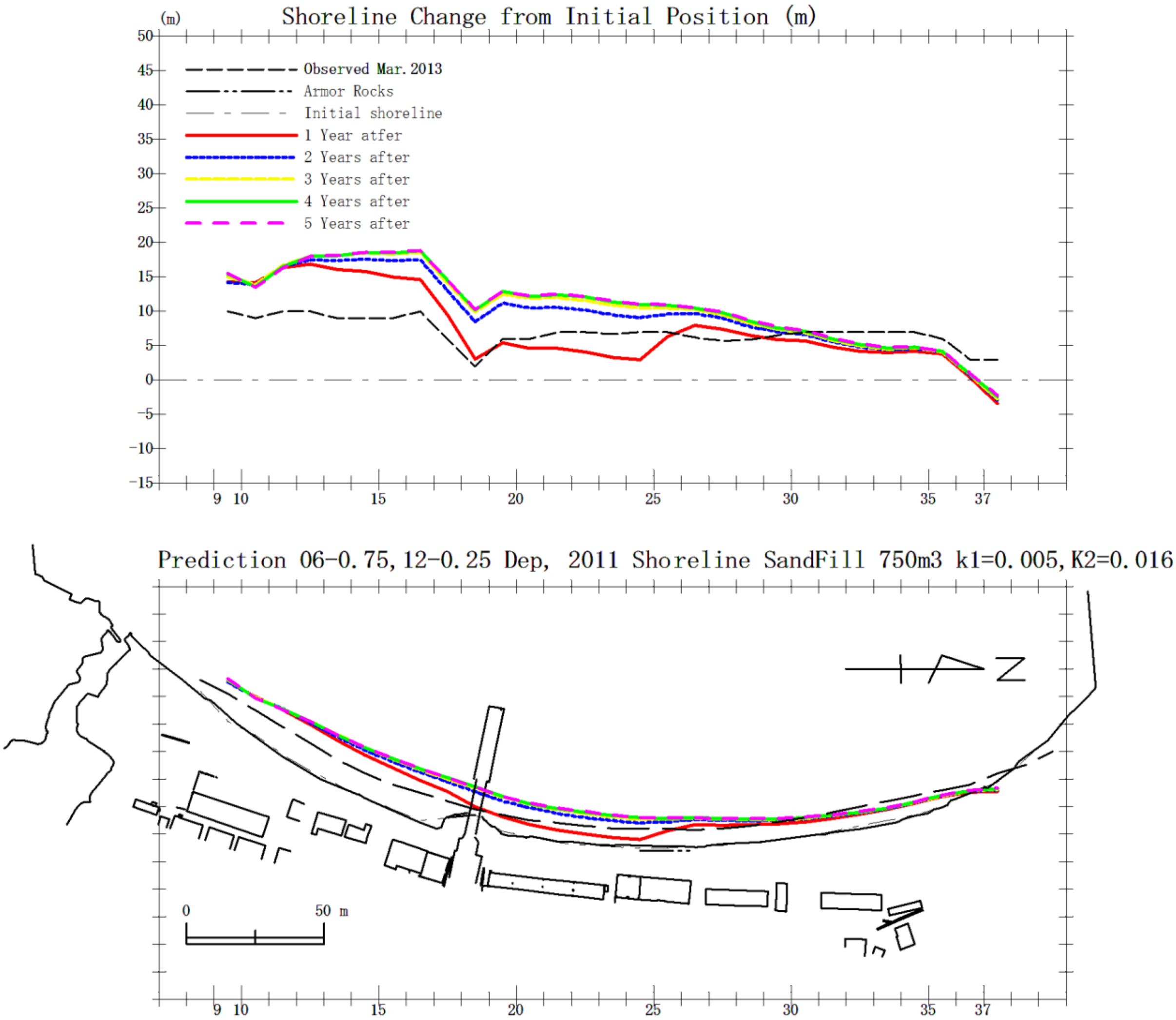


Figure 5-4-1-3 Relationship of shoreline between prediction and actual

5-4-2 Change of cross section

Figure 5-4-2-1 shows the line of location f cross section. The geomorphology change of five times result of survey is indicated referred with the shoreline on the survey of October 2006. However the area from line 1 to 8 which is the mouth of North River is omitted for analysis because of widely change of the sea bottom.

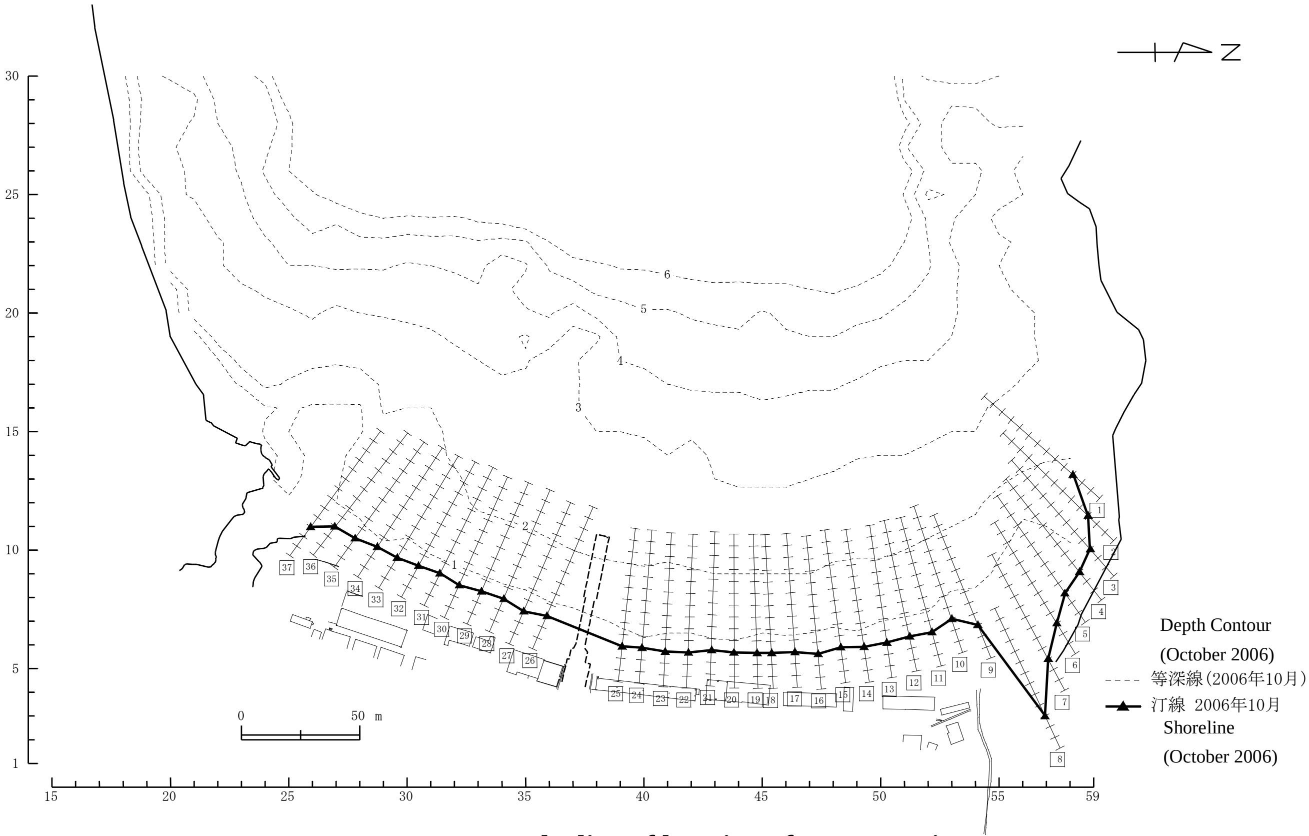


Figure 5-4-2-1 The line of location of Cross Section

(1) Cross section from the mouth of North River to the front beach of Fishing Gear Lockers II (Line 9-13)

This area is from the left hand side bank of the river to the south ward. This area is the vary change of geomorphology of sea bottom. Figure 5-4-2-2 shows the change of cross section of line 12 which is the center of Fishing Gear Lockers II. The shoreline advanced about 5 m to the shoreline on October 2006. The sea bottom beyond 60 m from shoreline is stable.

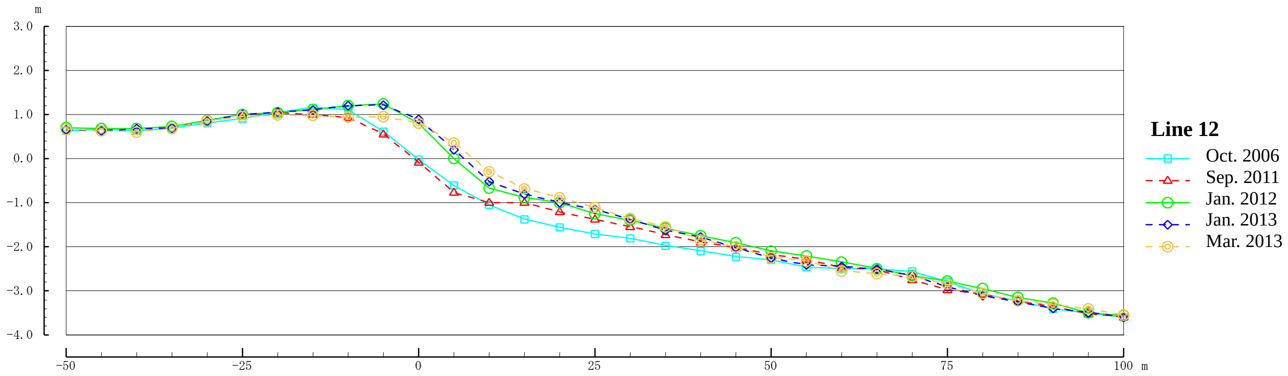


Figure 5-4-2-2 Change of Cross Section on Line 12

(2) Cross section from the workshop to the front beach of Fishing Gear Lockers I (Line 14-17)

Figure 5-4-2-3 presents the change of cross section in the front beach of Fishing Gear Lockers I (Line 16). The result of survey on September 2011 which is the field study of Follow up Cooperation Study is indicated that the backshore settled down slightly and shoreline advanced few meters from the shoreline on October 2006. On January 2012, the backshore is recovered and shoreline is advanced 8 m by the littoral sand drift.

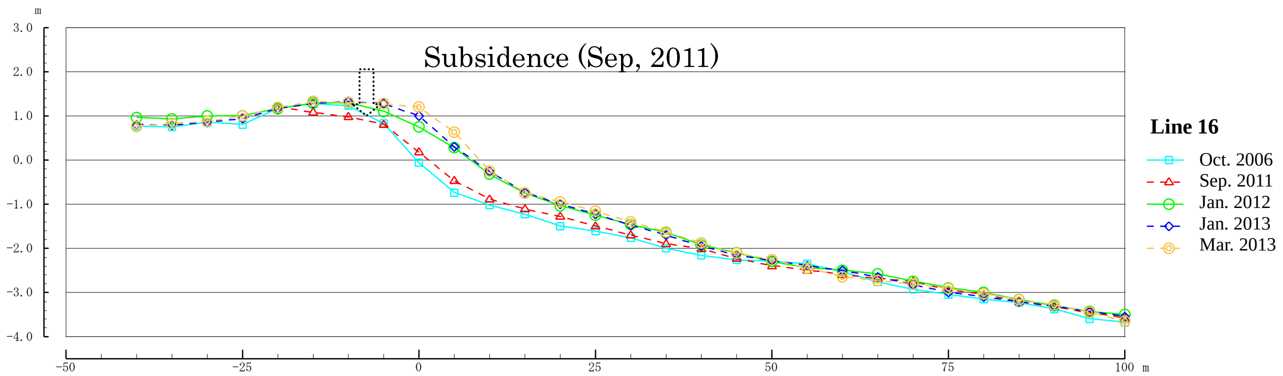


Figure 5-4-2-3 Change of Cross Section on Line 16

(3) Cross section of the front beach of Fisheries Complex (Line 18-21)

Figure 5-4-2-4 shows the change of shore geomorphology in the front beach of Fisheries Complex (Line 20). The location of shoreline is no change between the results of survey on September 2011 and October 2006. But it is understood that the backshore area settled down widely. From January 2012 the shoreline has been advancing and the height of backshore has been recovering higher than 1.5 m above sea level.

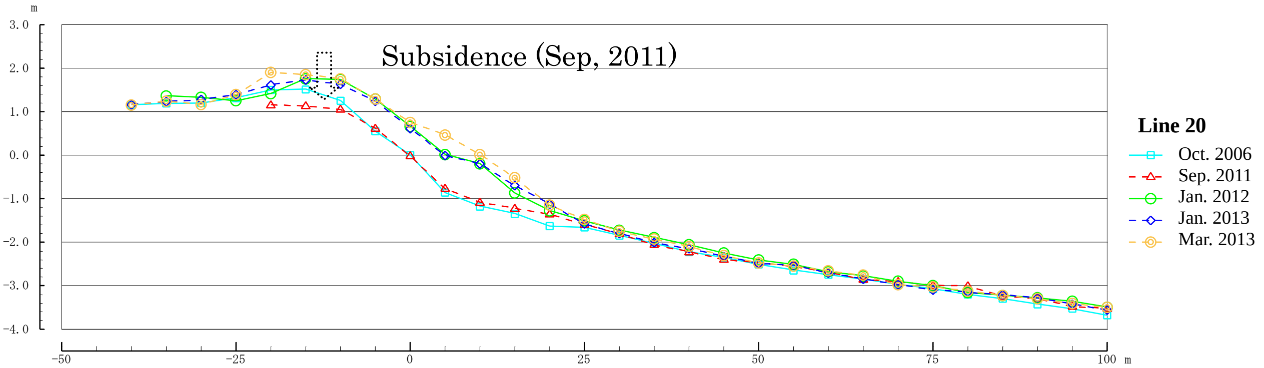


Figure 5-4-2-4 Change of Cross Section on Line 20

(4) Cross section of the front beach of Venders Arcade (Line 22-25)

Figure 5-4-2-5 shows the change of shore geomorphology in the front beach of Vendors Arcade (Line 23). The location of shoreline on September 2011 is no change and the backshore settled down and it is appeared the deposited tendency in the water depth of one meter. On January 2012, the backshore was recovered slightly and the area of water depth of one meter was indicated the tendency of deposition. It is appeared of the tendency of advancing of the shoreline. On March 2013, the shoreline is advancing and the backshore is widening by sand covering works of middle -term countermeasures.

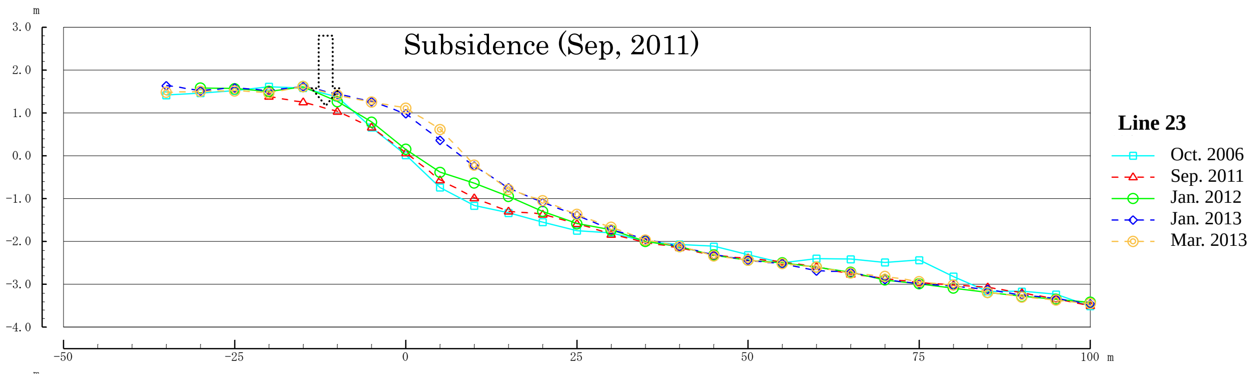


Figure 5-4-2-5 Change of Cross Section on Line 23

(5) Cross section from the south of Jetty to the front beach of Old Locker of Fisheries Cooperation Society (Line 26-29)

Figure 5-4-2-6 shows the change of cross section from south of jetty to the south beach of jetty (line 26). On September 2011, the shoreline retreated about 10 m and the backshore settled down more than 80 cm. On January 2012, the height and width of backshore were recovered.

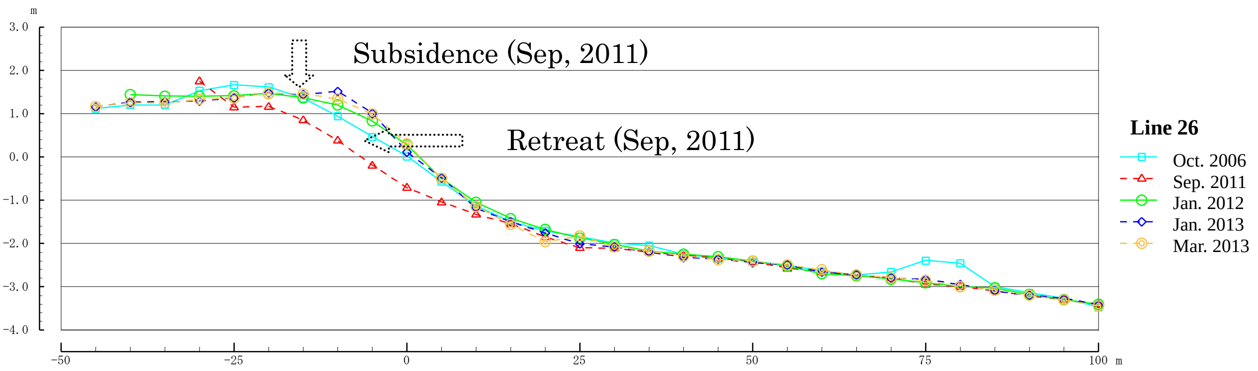


Figure 5-4-2-6 Change of Cross Section on Line 26

(6) Cross section from the washing area to the river mouth of south river (Line 30-37)

Figure 5-4-2-7 shows the change of cross section from the washing area to the river mouth of south river (line 30). In this area it is appeared the tendency of retreat of shoreline and settled down of backshore on September 2011. On January 2012, the location of shoreline and the height of backshore were recovered to the same level of October 2006. The wide backshore is restored. On March 2013, the backshore is wider and higher comparing with on October 2006 and the stable beach is formulated in this area.

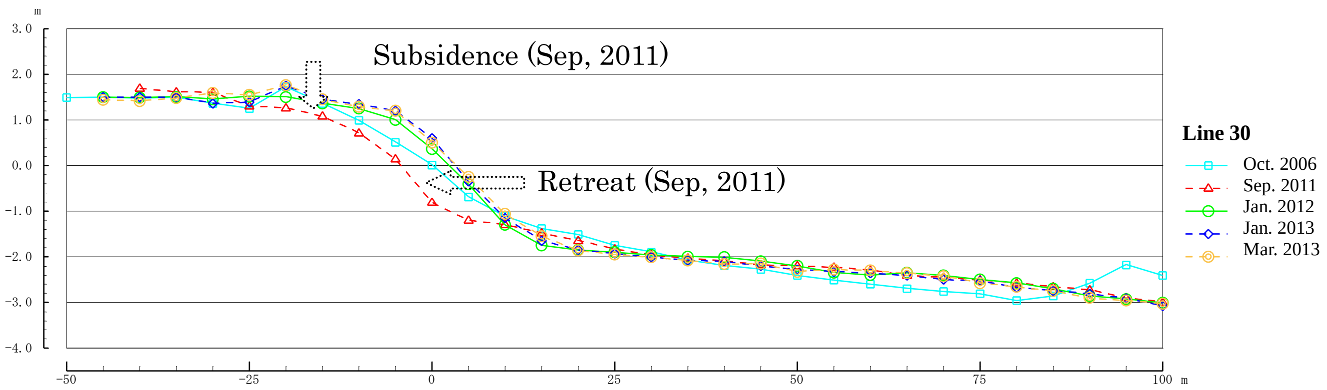


Figure 5-4-2-7 Change of Cross Section on Line 30