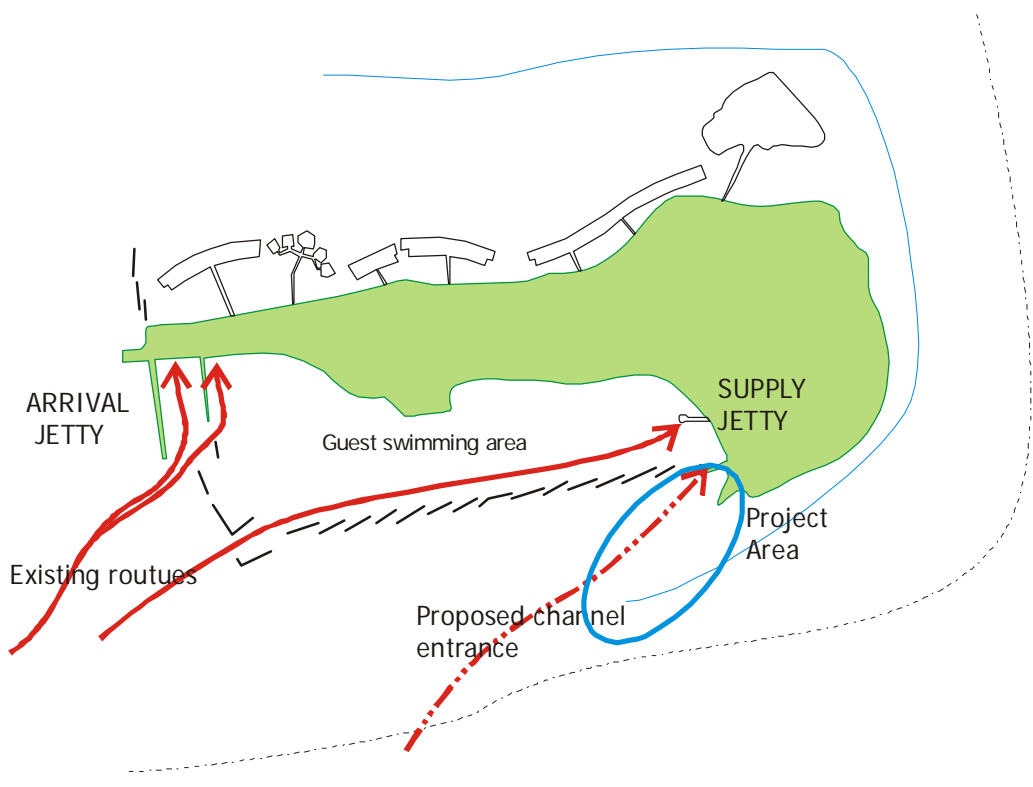


Environmental Impact Assessment for the proposed channel and harbor development at Full Moon Tourist Resort



Submitted by: Fullmoon Resort Maldives

M. S Adam [EIA01/07]

July 2008

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Declaration of the Consultant

I certify that the statements made in this Environmental Impact Assessment study are true complete and correct

M. Shiham Adam
EIA01/07
Date: 28 July 2008

Non-Technical Summary

1. Fullmoon (Furanafushi) is located only 8 km from capital Malé. The island is one of the first to be developed as tourist resort in the Maldives. The management appears to have changed more than once and the current owner Universal Resorts have been managing it since mid 1980s. Fullmoon was hit by the 2004 tsunami and was temporarily closed. It reopened for business in June 2005.
2. Fullmoon reef has a single entrance channel on the mouth of the reef on the western side. The arrival pavilion is located there. The supply jetty and harbor is inconveniently located on the far-side of island. This meant the boats travelling had to use the narrow lagoon protected the breakwaters. Unfortunately the area is also shared by the water sports department (wind surfing, guided snorkeling etc) and frequently used by the guests for unsupervised snorkeling. The area is also in front of the beach bungalows. The location of the bungalows on the far side is also too close to the supply jetty.
3. This inconvenience to the guests has been a lingering issue for some time. Guests have been repeatedly complaining about the loss of their privacy, potential danger of an accident with the boat propeller, the noise and smell of the garbage and oil pollution. The increasing boat travel frequency during peak season exacerbates the problem increasing the complaints by the guests.
4. As per the Tourism Regulations, the management approached Ministry of Tourism and Civil Aviation on the issue requesting permission for a redevelopment activity. The proposal has been to relocate the harbor and to create a new channel from the south eastern corner of the island. MoTCA view is to undertake an EIA for this work to quality granting permission for this redevelopment activity.
5. At the scoping meeting, it was clearly expressed the report has to be short focusing only on issues related to relocation and deepening of harbor and the opening up of the new channel. However, ERC emphasized the project justification was not sound and that a proper Guest Perception Survey must be undertaken as part of the EIA.
6. The EIA report provides findings of the Guest Perception Survey, description of the project area, the activities of the project and potential environmental impacts and the mitigation measures. Various alternatives were proposed and the best alternative has been selected based on the scale of the project.
7. The area proposed for redevelopment activity is at the southeastern corner of the island. The harbor basin will be moved further south and the entrance channel will be an oblique cut joining with the far-corner of the harbor basin to the reef edge. The southern sea-wall will be extended up to the harbor sea-wall. The wedge enclosed with in this area (7,000 m³ of fill material) will be filled with the excavated material.

8. The proposed activities for this work are excavation of the new harbor area and the channel area plus sheet-piling of the 350 m (575 sheet piles driven by vibration method) and construction of the quay wall.
9. The proposed method for undertaking this work is by use of an excavator mounted on shallow draft barge. The excavated material will be tipped into lorries or loaders parked on the on the barge. It is proposed that that barge be regularly towed to the beach for the lorries and loaders to unload the material to the place which requires filling. Total material excavated is only slightly more than what will required for infilling work.
10. Aside from the inevitable loss of 5,700 m² of reef habitat the environmental impacts due to proposed activities are minimal and limited to only short term. The investigation of the reef flat area revealed that area is covered by compacted rubble, consolidate rock and sand. There were hardly any live coral. Fish life poor and herbviory was average. There were no spur and groove formation indication the area does not experience heavy energy.
11. The lagoon and beach are protected by the breakwaters obliquely placed in a line which area maintained regularly on a quarterly basis which relatively major repairs once every six months. The beaches are routinely replenished by two sand pumps in the lagoon area.
12. Mitigation measures proposed include limiting the dredging activity to low-tide levels to minimize the dispersion of sediment plume. Given that the developer is proposing to under taken the development whilst resort in operation it is recommended to fence off the project area. Guests shall be informed at all times of the progress of the project and limit the project activities to the time limits set and informed in advance.
13. As part of post-project activities monitoring of the reef flat, breakwaters and beach erosion is proposed. Reef monitoring is limited to visual impaction of the on the excavated area and beach monitoring involved measuring linear distances from the from the corner o beach bungalows to the toe of the beach.
14. The conclusion is that overall the environmental impact of the project is minimal and effects are short term.

1. Introduction

Fullmoon resort (or Furanafushi) located only 8.5 km from Malé is amongst the first islands to be developed as a tourist resort in the Maldives. The resort appears to have changed management more than once and the current owner Universal Resorts have been managing it since the late 1980s. Fullmoon was badly damaged by the 2004 tsunami, as results the resort was temporarily closed for business. Most of the destruction occurred on the water bungalows on the northern side of the island. The renovation was complete in the June 2005 and officially reopened for business in July 2005.

Located close to the capital Malé, Fullmoon enjoys a reputation for the holiday and business traveler. Fullmoon is quite famous its British clientele, partly because of strong Kuoni foothold from the very beginning. Foreigners visiting Malé occasionally visit for day-excursions to Fullmoon. The resort boasts five star standards in superb tropical setting with a luxury spa complex as a bonus.

Although ideal in its location, Fullmoon has a disadvantage. The island does not have a natural lagoon and the strip of lagoon seen on the southern side of the island is artificially created. Over time and through regular 'beach-replenishment' it has acquired spotless sandy beach and lagoon area for snorkelers. One of main feature of the island the series of breakwaters placed obliquely at a distance of 100m from the shore on the southern side. The breakwaters effectively protect lagoon and the beach.

The lagoon is used for water sports activities, snorkeling and swimming but the area is also used as a water-way for the supply boats to ferry oil, garbage, daily supplies and anything else the island needs to transport from Malé and vice versa. The result has been constant complain from the guests of bad smell, oil pollution, lack of privacy, noise and inconvenience. More importantly however, the supply boats pose a risk for guest. On few occasions they have unknowingly come very close to guests swimming in the area. The management is concerned of this risk and wants to address this urgently. The management is proposing to relocate the supply jetty area and harbor and to open a new entrance channel from the south eastern side of the island.

2. Terms of Reference

A C2 screening form was submitted to the ERC and a scoping meeting was held to ascertain the scope of this redevelopment work. One of the things that came up was the lack of justification the development activity. It was agreed that a Guest Perception Survey be carried out to determine the how guest perceive of this redevelopment activity. The official terms of reference is given in Appendix 1. It was also agreed at the scoping meeting the report be kept short and address only the pertinent issues avoiding the long description of the existing environment.

3. Project Setting

Fullmoon is a resort in operation and as such no external guidelines or rules other than the tourism development and environmental regulations apply. The tourism regulations issued under the Law 2/99 pertinent to the development project are related to the development of infrastructure.

The rule says that the developer shall obtain written permission from the Ministry of Tourism and Civil Aviation for the developments that would constitute

- a) Dredging and excavations
- b) Building of the beach and over-water bungalows
- c) Pumping of sand for beach replenishment
- d) Construction of breakwaters
- e) Construction of sea-wall and revetments or groynes
- f) Opening of channels and associated work
- g) Reef blasting
- h) Research on marine environment
- i) Demolition of existing infrastructure
- j) Any activity that may have a detrimental impact on trees and freshwater lens of the island.

The regulation also states that an environmental impact assessment study must be undertaken as per Law 4/93 or rules and regulations relevant to this Law. The developer must also provide a complete set of technical drawings of the development clearly marking the beach lines (beach toe, vegetation line, tide lines)

Under the Law 4/93 an environmental impact assessment must be made before either of above the developments takes place.

More recently the by-law cutting down, uprooting and export of trees of may apply to this development project.

4: Project Description

The objective of the redevelopment activity is to create a new entrance channel for accessing supply- jetty area. The project also includes relocating and redesigning of the harbor basin and associated quay walls. The need for the project arises due to continuous complaints from the guest on the island about dangers of supply vessels steaming in the snorkeling and water sports area. Figure 1 shows a birds-eye view of the island and project location while Figure 2 gives a schematic drawing of the present situation of the transport route arrangements. Vessels entering Fullmoon reef has to enter at the southwestern corner of the island. The supply vessels have to make use of the lagoon area to steam towards the supply jetty located on the southeastern corner of the island. The area is also used by the water-sports activities and also as snorkeling and swimming area for the guests staying in the prime beach bungalows on the southern side of the island.

What has been proposed in the redevelopment activity is to open up a new channel that would have direct access to the harbor area. It is also proposed to slightly move the harbor basin to the south. This is to avoid any disturbance or inconvenience to guests occupying beach bungalows close to the existing supply jetty.



Figure 1: Over view of Fullmoon resort looking from western side towards east. The main features of the Fullmoon Resort – the breakwaters are seen. The circled area is the project area.

4.1. Need and Justification

The need for the project arises due to complaints from the guest who makes use of the area for swimming and snorkeling and also for water-sports activities. This has been a lingering issue for a while and despite the management's strategy of educating about the situation, complaints from the guests have been persistent. Most of the complaints have been:

- a) About the dangers of a potentially fatal accident happening to a guest
- b) noise the vessel makes when they steam across
- c) issue of oil pollution
- d) smell of the garbage being transported (although managements has restricted garbage transport only during the early hours of the morning)
- e) lack of privacy to the sunbathers on the beach.

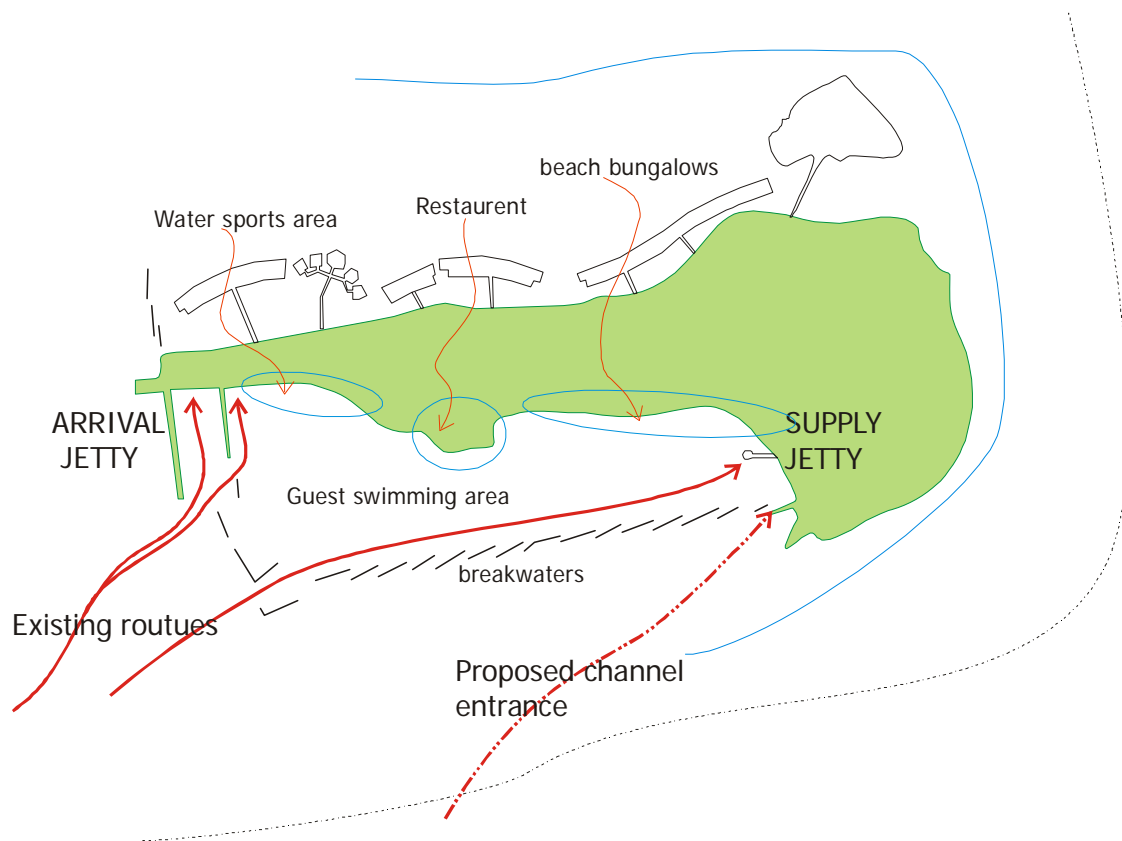


Figure 2: Supply vessels have to enter through the main (and the only) entrance to the island and have to steam in front and very close to the guest swimming area and in front of water bungalows to the supply jetty.

The most practical solution has been to open a new channel from the south eastern section of the reef serving the supply jetty. As part of the terms of the reference for this EIA a Guest Perception Survey was conducted. The results of that survey give a strong justification for the need to have a separate channel for to access the supply jetty (see Section 6).

4.2. Project Location and Area

The redevelopment activity shall takes place on the southeastern corner of the island (Figure 6). The management has a plan for undertaking the project whilst the resort is in operation. The project shall be fenced off which will be about 20,000 sq m. Most of the work shall take place the shallow reef flat in the project area. A biophysical description of the area is given in the section on Existing Environment.

4.3. Project Activities

The project context and general description of the project allows anticipating the project activities that are likely to cause environmental impact and therefore need addressing in the impact assessment report. Four main types of activities have been identified for this redevelopment project. They are:

1. Excavation of the basin and opening of the channel:

2. Sheet piling around the area
3. Construction of quay walls
4. Infilling and general building /construction work

Each activity will be discussed in detail.

Excavations: The main activity of the project would be deepening of the proposed harbor basin and channel area. The proposed harbor has an area of 4,700 m². The channel leading towards the mouth of the harbor would be 10m wide and 100 m long. Thus a total of 5,700 m² would require to be deepened. At present the area has an average depth of the 1.5 m. Both the channel and harbor needs to be -3.0 m deep. This would mean about 8,900 m³ of material would have to be removed.

The proposed method of the deepening is by use of an excavator (Figure 3). It is proposed that the excavator works from deep end and work its way towards the shore. The various alternatives and options of the exactly doing this is given in Evaluation of Alternatives



Figure 3: During the excavations works the dredger may be loaded onto a shallow draft barge (for deep harbors) or excavator sits on the site itself and works from the far end move to beach.

Sheet piling works: Sheet piling is a form of driven piling using thin interlocking sheets of steel to obtain a continuous barrier in the ground. They come in a variety of forms, shapes and material. In Maldives sheet piles is commonly used as retaining walls of the quay walls and breakwaters on the beach line. The common sheet piles used in Maldives has span width of the 24 inches (0.6096 m).

Sheet piling is proposed in the entire boundary of the harbor basin including the extension of the sea-wall to the corner of the harbor (see Appendix 2 and Appendix 3). The total length of the retaining wall that needs to be sheet piled 350m. Assuming sheet pile is 0.6096m a total of 575 sheets.

It is proposed that sheet piles will be driven using the vibration method (Figure 4). This has proven to be by far effective than driving them by hammering. The sheet piles will be driven to a maximum of 5m.

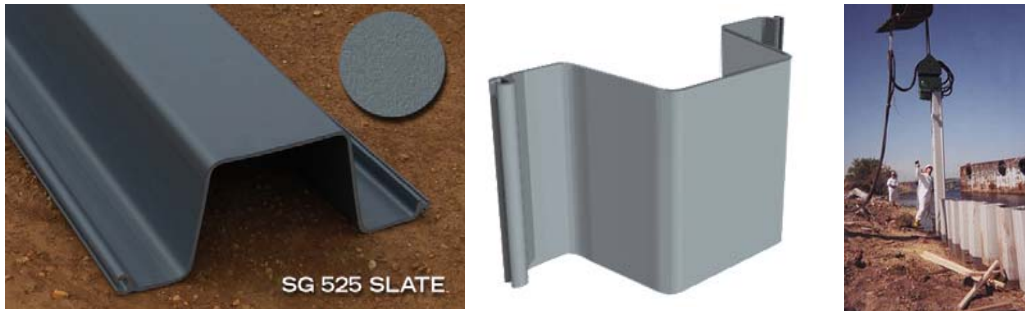


Figure 4: Typical sheet piles that will be used in Fullmoon Resort (0.609m wide). The sheet piles will be driven by vibration method (image on the left).

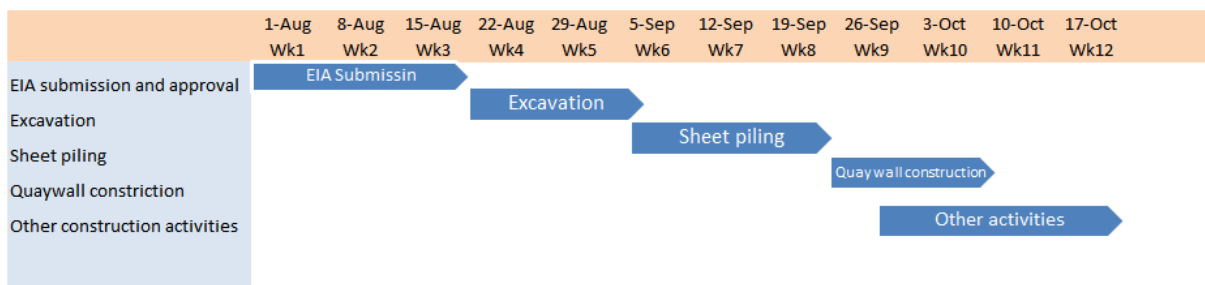
Quay walls: Once the sheet piling work has been completed along the perimeter of the basin and adjoining area (as shown in the diagram) quay walls will be constructed. It is constructed in two stages. The first stage is placing rows of cement bags (on outside) to widen the quay wall. This is followed by placing series of armored layer of stones (about 200-500 kg mass) in the shape of 30degree slope (Appendix 3). The granite rocks will be imported.

Infilling and Construction works: An area of 2,300 m² required to be filled (Appendix 2 and 3). Assuming average height of this area is 3m, this would require about 7,000m³ of material. The deepening of harbor basin and channel area would produce just about same volume of material required to for filling works. It is expected the dredged material would be largely sand, devoid of boulders and rocks. In this case the sand will simply be spread out to the area and compacted using compactors. Later the area will be landscaped.

Construction works will involve concrete works of quay wall and construction of the guard- house just adjacent to the harbor wall. These will require standard construction material and methods.

4.4. Project Schedule

The intended duration of the project is maximum three months. Given that this activity will take place while the resort in operation the duration of the project will be kept as short as possible. The work schedule is given below.



4.5. Mobilization of Equipment and Material

The main equipment mobilized to the site will be an excavator, a barge and a loader (Figure 5). Materials mobilized to the site will consist of rock boulders for construction of breakwaters, cement,

aggregates and concrete reinforcement iron-bars and river sand for construction of quay walls and other concrete fabrication. In addition to these fuel for operation of the equipment will be mobilized to the site.



Figure 5 Construction equipment that will be used on the site.

4.6. Inputs, Outputs and Risks

The input / output analysis of a project helps to define and understand the potential environmental impacts of the project in a more formal manner. Linking inputs to processes and processes to activities leads us to outputs and consequently impacts. The inputs and outputs of this redevelopment activity may be derived from the project description.

Following inputs are required for this project.

1. Construction workers and laborers: Construction workers are expatriate laborers. For the size of the project it is likely the resort management will make use of their employees for the general works. It is expected that about 10-15 people would be required for this activity. However, professional will have to be hired for the excavation and sheet-piling works generating income and distribution of money.
2. Construction materials: Materials are required for the construction of this work. Sheet piles, construction material will have to be imported from abroad.
3. Heavy machinery: It is likely that these will be provided by the contractor

The outputs of the development can be summarized as below:

1. One important output from an environmental point of view of the excavated material. Fortunately the project has identified appropriate use for this material and the volume required matches perfectly well with the material that will be excavated.
2. Construction waste: Several hundred bags of cement will have to be placed on the sides of the sheet-piled retainer. Other likely construction wastes include the wood, iron bars, etc.

A potential risk associated with this project is short-term damage to the marine environment due to sedimentation by the excavation and clearance work of the channel opening. These impacts are however, considered to be minor. Given the area is relatively a high-energy environment it would quickly be dissipated.

Over the long-term the modification would be unlikely to lead to long-term impacts. Instead the most likely scenario would be that the area quickly becomes colonized by invertebrates. The growth of coralline algae will have effect of cementing the gravel and loose debris and eventually consolidating the substrate. The overall risk of significant environmental impact is low.

5. Existing Environment

The Fullmoon reef is trapezoidal, parallel sides running north and south with its long axis along the east-west orientation. The northern side tapers south, forming a distinct mouth – the entrance to the heart-shaped lagoon. The southern swells hitting south-eastern corner of the island generate waves obliquely along the reef. A series of the breakwaters along the southern side on the reef flat protects and maintains beaches of the island.

The development area of the island is the south eastern corner, where some reclamation and beach stabilization activity has taken place earlier. A seawall has been constructed along the entire eastern side of the island. This is to protect the (futtaru) shore line. This seawall terminates at the southeastern corner.

5.1 Project Area

The proposed area for the harbor development and channel opening is in the south east corner of the island. Therefore the description that follows will focus on environmental conditions of the area which will form baseline of the existing environmental conditions of the development site. Fullmoon resort has been operation for a long time, long before the environmental regulations came into force. As such existing shore stabilization and associated work was done some time ago – well before 2000.

As mentioned earlier, the eastern seawall terminates on the eastern corner of the island. From the point of seawall the area further south has been severely eroded. A groyne constructed further south has not proved to be effective in maintaining the beach in the area. The existing shore line super-imposed with the Google Earth image shows there has been some erosion in the area (Figure 6). The area experiences high energy from the oceanic swell coming from the southeastern Indian Ocean. The intensity might have increased in the recent years following the reclamation of the vast area of reef flat on the Hulhule reef. However, except for anecdotal evidence there is no way to demonstrate the wave energy has been indeed greater in the last 5-10 years compared to earlier periods.

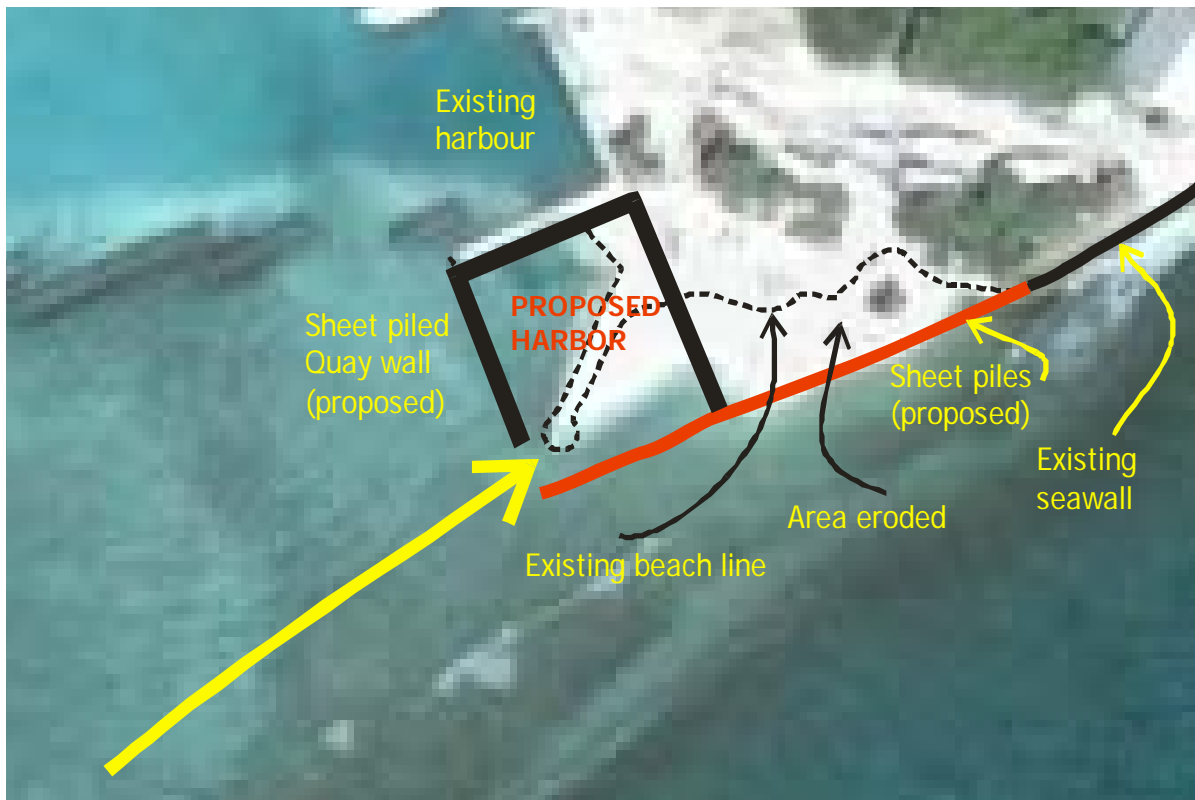


Figure 6: Details of the southeast corner of Fullmoon to show the existing the proposed structures. Note the area eroded and the existing the seawall which terminating at the corner.

5.2. Marine Environment

Methods: Field observations were undertaken on June 08, 2008. A visual survey was undertaken on the project development site. Underwater observations were restricted to the proposed channel area, keeping in line with what was agreed at the scoping meeting given in the TOR. As such no formal methodology was followed. Instead series of zig-zag swims were made starting from around the first breakwater (Figure 7). Swims were made out into reef slope and back and in out. Photographic images were taken during the swim. Following that, visual censuses of fish fauna were made. Where possible fish recorded to species level and three categories depicting their abundance (common, abundant, and rare) was noted.

Results: The time of observations was at low tide. The depth of the reef flat ranged from about 1.5 – 3.0 on the reef flat (Figure 7). The area was virtually denuded of live coral. It is a fair assessment to say that < 1% of unit area is covered by live coral. The coral in these cases were isolated colonies of Porites (< 50 cm diameter). Loose rubble, often consolidated with overgrowth of encrusting coralline algae was dominant feature of the substrate. It was obvious that herbivory (fish feeding on the algae) are keeping the area relatively 'clean' of algae. Scarid (parrot fishes) feeding marks on the rock laden with algae were seen. Although relatively few, there were small areas where sand dominated the bottom. These areas would experience high energy (local hydrodynamics) making it difficult for consolidation to occur.

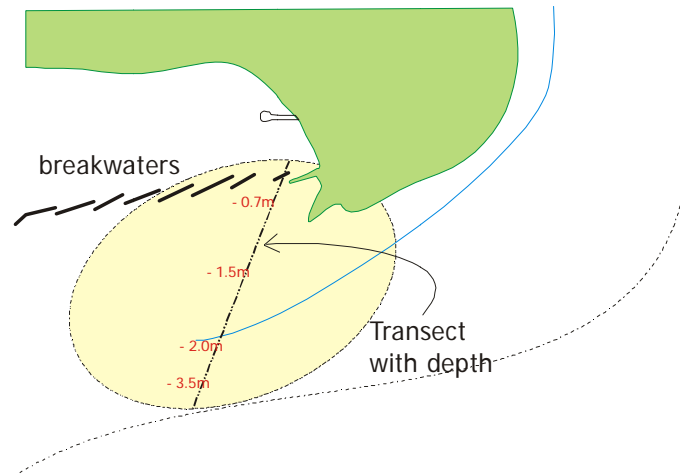


Figure 7: Survey area showing the depths the project development area.

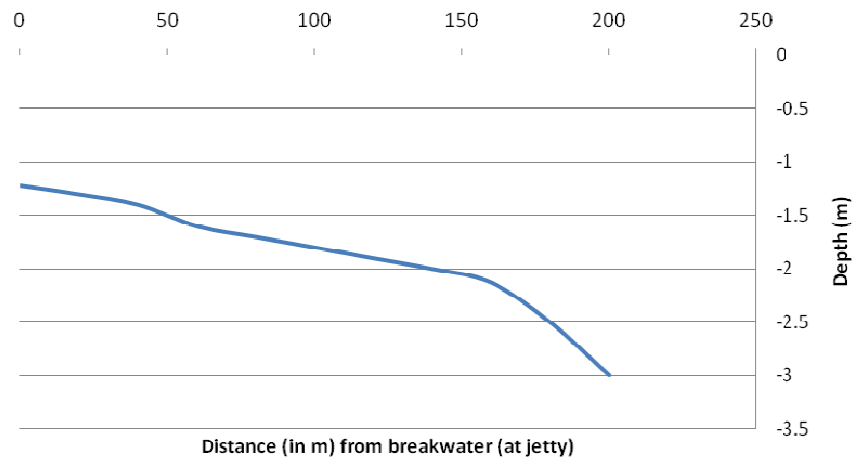


Figure 8: Profile of reef slope at the study site (see Figure 7).

There were few fish species in the area (survey was done in the afternoon 15:00 hrs). Very few scarid (parrot fishes) were seen. The common varieties were herbivorous fish. Most notable was the large school of convict surgeon fish feasting on the algal ridge.

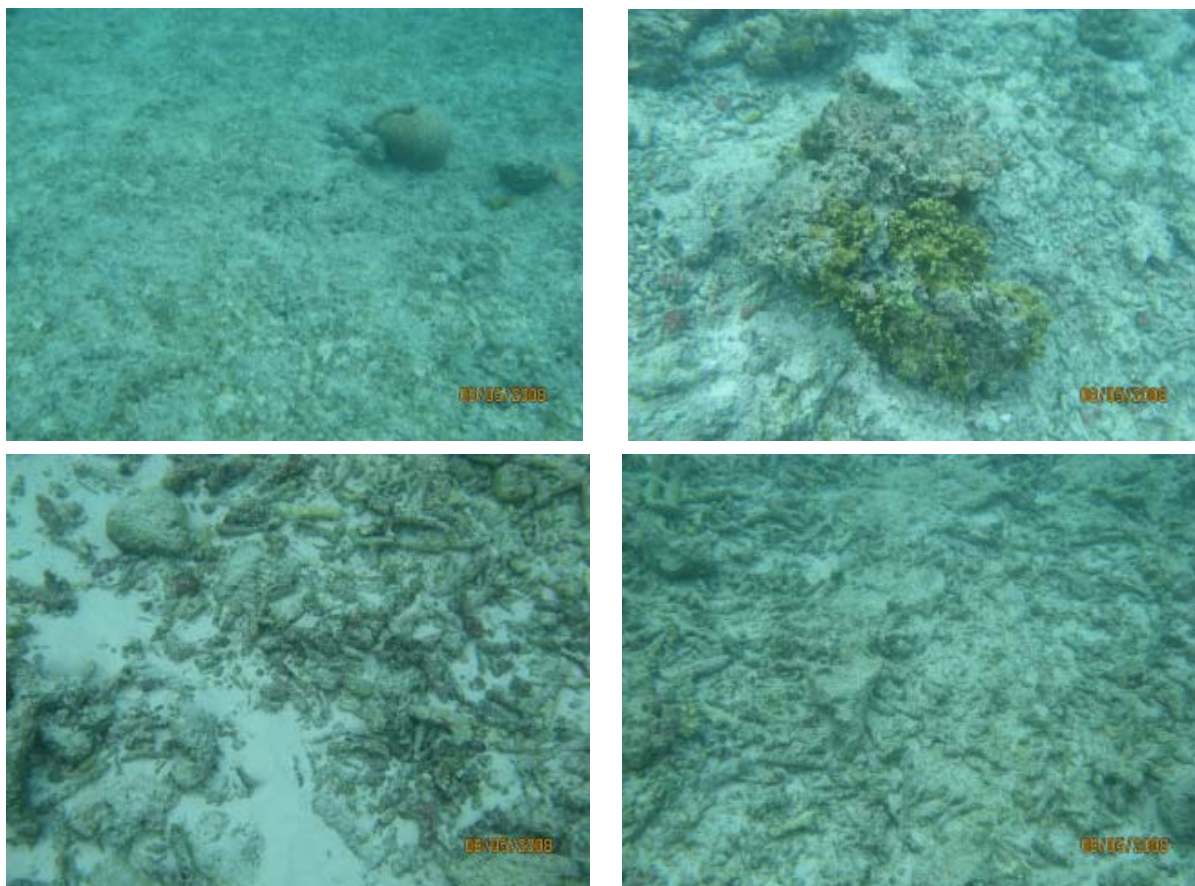


Figure 9: A sample of the bottom substrate at the survey area

Table 1: Summary of fish census.

Family	Species	Abundance
Pingipedidae	<i>Parapercis signata</i>	C
Acanthuridae	<i>Stethojulis albivittata</i>	C
Pomacentridae	<i>Pomacentrus spp</i>	VC
Labridae	<i>Halichoeres spp</i>	C
Acanthuridae	<i>Acanthurus triostegus (juve)</i>	VC
Chaetodontidae	<i>Chaetodon auriga (single)</i>	R
Chaetodontidae	<i>Chaetodon citrenellus</i>	C
Sting rays	<i>Himantura fai (sting ray)</i>	R
Fistularidae	<i>Fistularia commersonii</i>	R
Serranidae	<i>Epinephalus macrospilos</i>	R
Serranidae	<i>Epinephalus merra</i>	R
Balistidae	<i>Balistoides viridescens</i>	R
Balistidae	<i>Sufflamen bursa</i>	C
Balistidae	<i>Sufflamen chrysopterus</i>	C
Acanthuridae	<i>Acanthurus leucosternon</i>	C

5.3. Beach Environment

The beach on the southern side is protected by the breakwaters placed on the reef flat. Initially the area between the beach-line and the breakwaters was shallow reef flat. But during the construction of the resort the area was deepened.

The beach area is maintained by constant repair of the breakwaters and replenishment of beaches by the sand pump (Figure 10). Fullmoon keeps records of the maintenance works done on the breakwaters. From the dates of the invoices made to the contractors it was estimated that minor maintenance area made once every three months and major repairs are made once every six months.



Figure 10: The beach on the southern side (right) is maintained regular 'beach replenishment' using 2 sand pumps (right) which are placed in the lagoon.

The distances from the seven beach bungalows to the beach line were made for a baseline references (Figure 11). Beach profiles were not takes here. As mentioned earlier, the beaches are maintained regularly through beach replenishment works. The estimated beach profiles were about 20-25 degree slopes from the vegetation line to the beach toe.

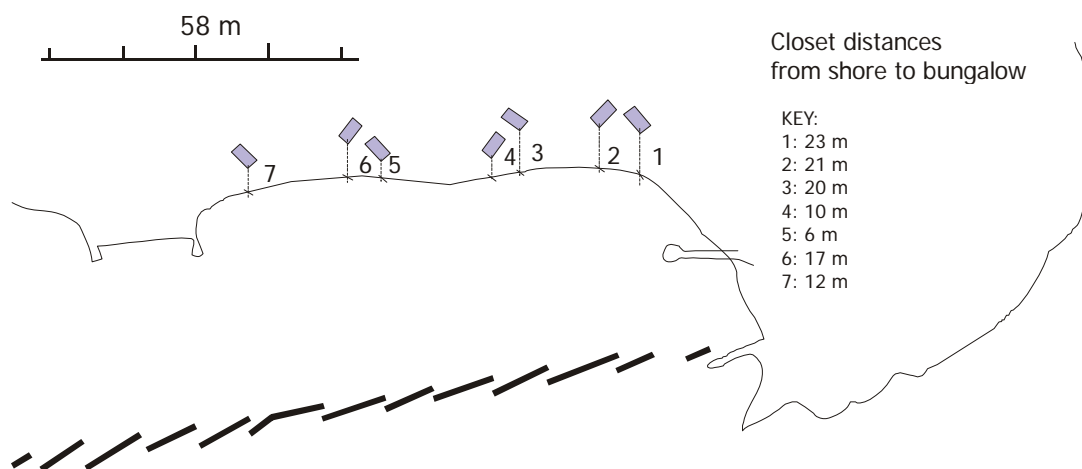


Figure 11: Scale sketch to shows the distances from the beach lines to the 7 bungalows located on the southern side of the island.

5.4 Existing Supply Jetty and Harbor

As have been mentioned the existing supply jetty and harbor is on the eastern section of the lagoon. Not only it requires the supply vessel to steam inside the lagoon close the beach, the harbor itself is located too close the prime beach bungalows (Figure 12). Guests occupying the water bungalow (see in the image in Figure 12) regularly complain of the noise during early hours of the morning and night. Normally, unloading of fuel and loading of trash and solid waste that requires to be taken to Thilafushi are loaded at times when guests would not be in the room. But these constraints have been too difficult and costly for the resort to bear in the long run.



Figure 12: Existing harbor (left) is located very close to the prime beach bungalows. The new harbor will be just right off the existing harbor (right panel).

The proposed harbor area is located just right of the existing harbor area. The area would technically be the southernmost corner of the island (cf. Figure 1, Figure 2 and Figure 11).

6. Guest Perception Survey

Considerable time was devoted to the guest perception survey. As mentioned earlier, this was highlighted in the scoping meeting – the need to convincingly demonstrate that Fullmoon resort requires the construction of this new channel.

6.1 Methodology

A structured survey was designed and was send to Fullmoon resort for administering (see Appendix 4). An introduction giving a brief statement about the problem and why this survey was required was given. There were two types of questions. One was with simple yes/no type. Others were to give a score (between 0 and 5) to get some degree of their belief for the questions posed.

A total of the 131 questionnaires were completed representing a ‘sample’ of guests in Fullmoon resort during April 2008. The survey was administered by the Fullmoon management following the instructions of the consultant. The selected guest has to complete the questionnaire a day before

their departure. Guests were not briefed about the project prior to handing the questionnaire. In some cases explanation from the management was required about the project and questionnaire. In most cases guests understood what the problem was and made an informed judgment on their view of environmental impact of the project.

The results of the questionnaire was entered into in Excel spreadsheet, cleaned and imported into SPSS for analysis.

6.2. Results

A total of the 131 questionnaires were completed during April 2008. The sample was represented by 29 countries and includes 9 not stating their nationality. British were represented by far the highest (21%) followed by Russians (12%) and Korean (10%). The composition of the nationalities in the samples reflects the nationalities of the occupancy during April. The summary of this data are presented in Figure 13 . The sample was represented by the 81 male (61%) and 45 (34%) females with 5 not stated. The largest number was people represented were in the 31-40 years age group (Table 2). Most of the people represented in the survey were people work in private companies or owners of these companies.

Of the 94 people (71% of the sample) who have seen the boats moving in and out of the harbor, only one person said they were not bothered about their movement. Thirteen people (9% of the sample) have not seen these boats moving. However, nearly all of them (12) people said they would be bothered by these movements of the boats.

The main thrust of the questionnaires were to ascertain the guests' perception on safety, noise, inconvenience and perceived environmental issues relating to the opening the channel.

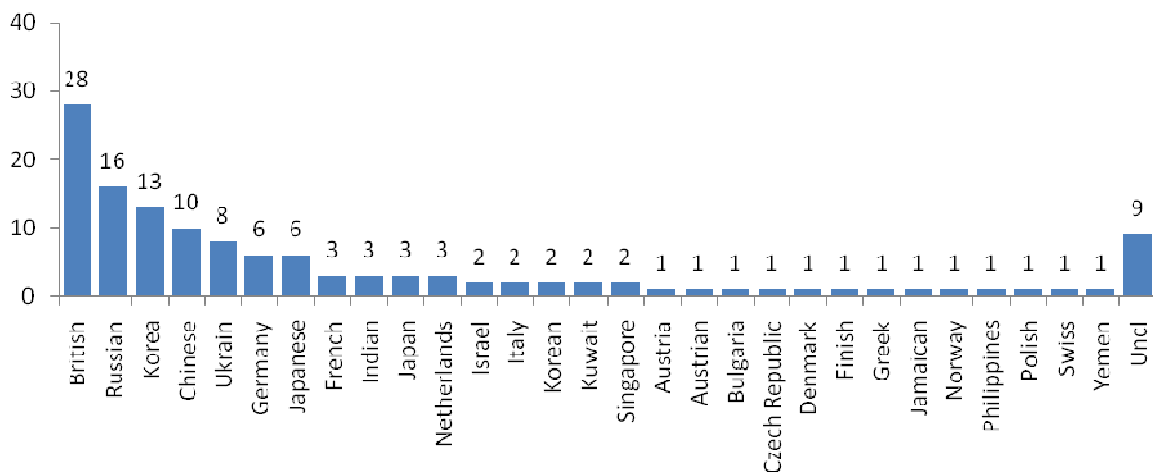
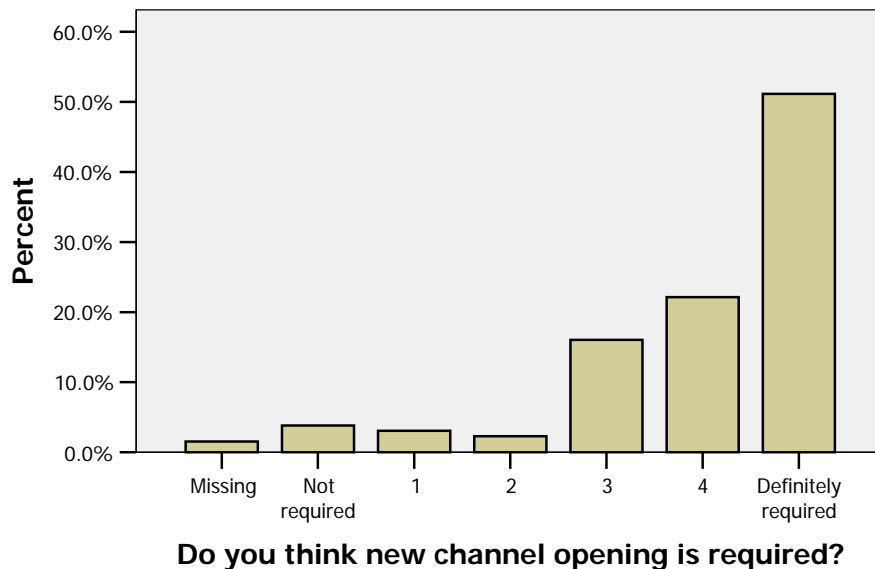


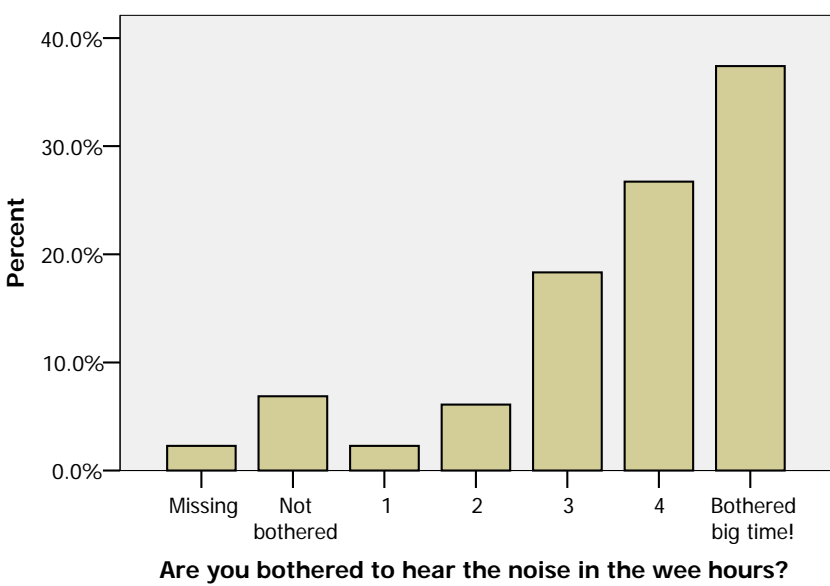
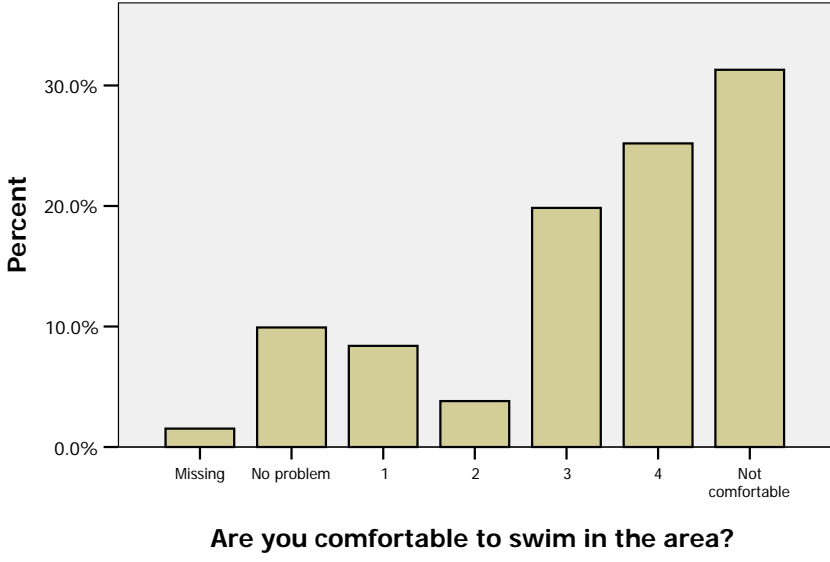
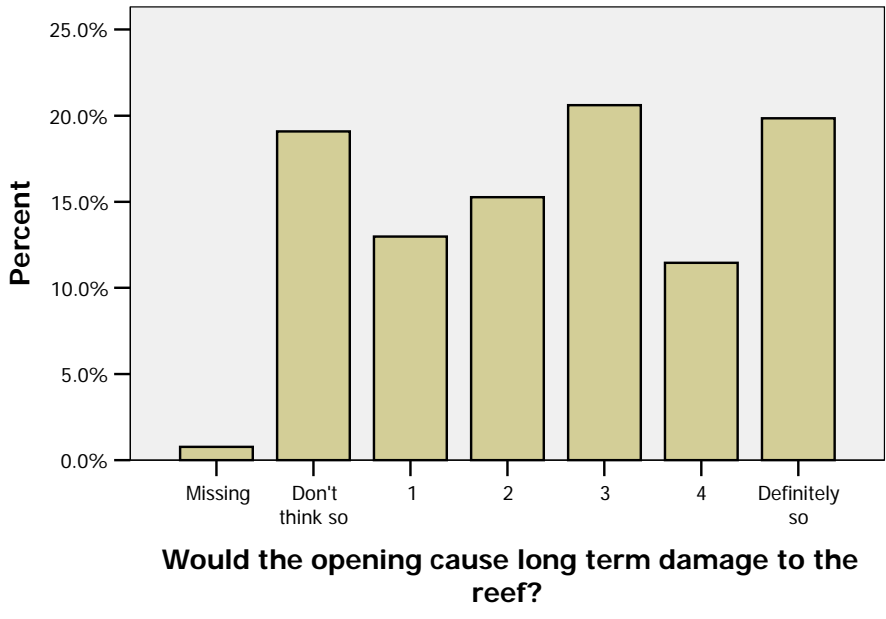
Figure 13: Number represented by country in the sample. The value on top of the bar represents actual number in that country.

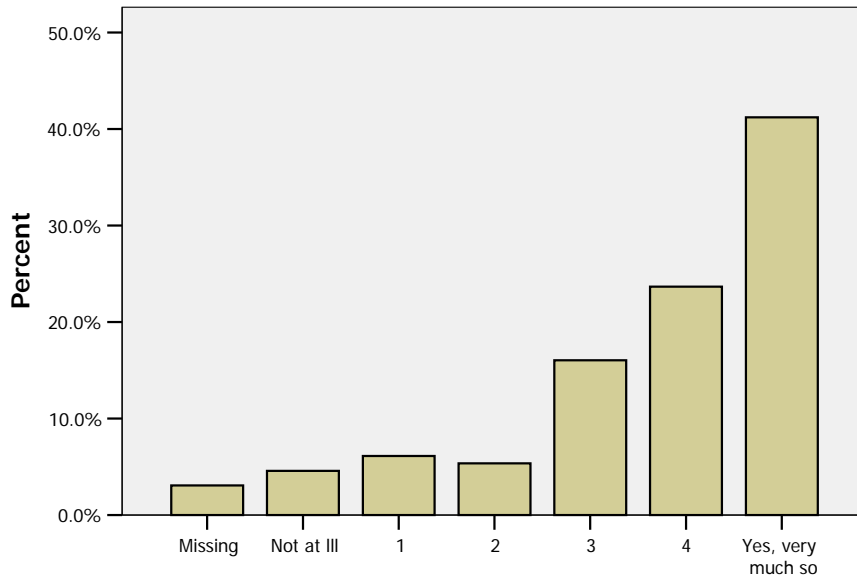
Table 2: Summary data on age group and occupation in the sample.

Age Group	Count	Percent	Occupation	Count	Percent
21 - 30 yrs	29	22%	Government	17	13%
31 - 40 yrs	51	39%	Private	57	43%
21 - 40 yrs	19	15%	Self employed	32	24%
41 - 50 yrs	10	8%	Student	1	1%
Above 61 yrs	7	5%	Retired	5	4%
Not classified	15	11%	Not classified	19	14%

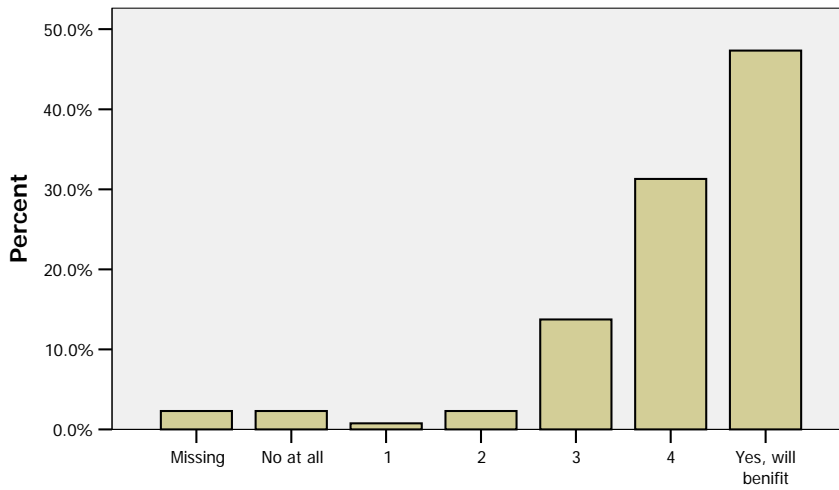
The responses to the questions are presented below in bar charts. In all the case their degrees of belief for all the answers, overwhelmingly support the idea that a new channel is required and will be better for the resort in the long term. On the question of their perception on long term damage to the environment, the answers were very varied. This result was not surprising as many of them are specialists and their judgment is mixed. In fact half respondents said it may impact in the long terms and while others say it will not do any harm. Most interesting is some their comments. A collection of those have been appended for information (Appendix 5).



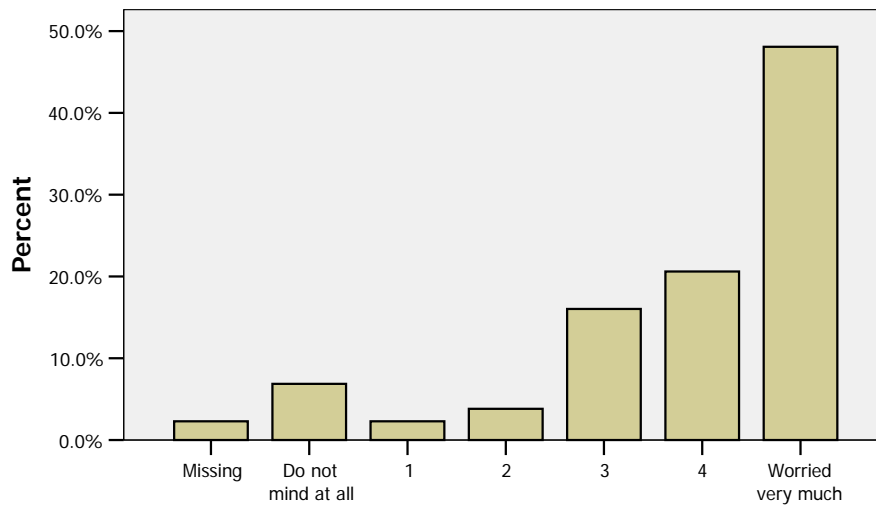




Would you be distracted at valuable time at peace?



Do you think the channel opening would benefit the resort in the long run?



Do you mind seeing the movement of supply vessels while on beach?

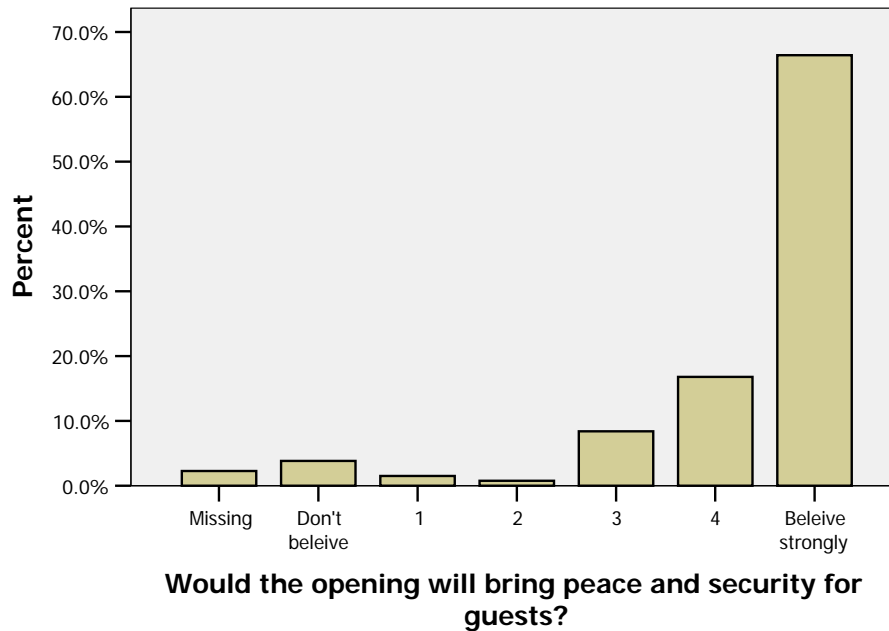
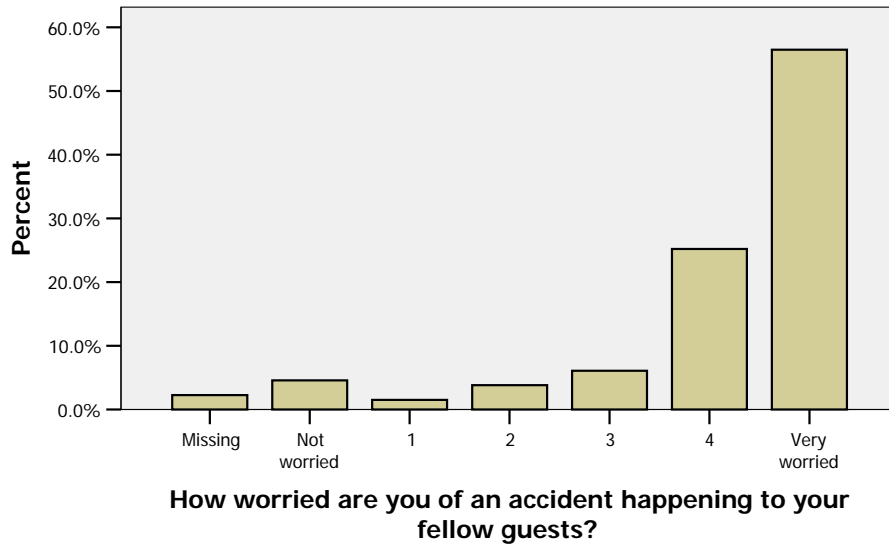


Figure 14: Summary results of questions 3-11. The panel s are self explanatory.

7. Consultation

The TOR states a ‘public consultation’ takes place. In this study this has taken to mean the guest perception survey and the consultations necessary with the relevant government agency(ies). The results of the guest perception survey are reported in detail in section 6.

Fullmoon resort is in operation and nature of the project is a redevelopment activity. As described in section 3 a letter was sent to MoTCA requesting permission to start this work. Their reply has been that permission for this activity may be granted on successful evaluation of the EIA report undertaken as per the guideline of the MEEW (Appendix 6). No other government agency/authority was consulted about this work.

8. Assessment of Direct Impacts

Deepening of the new harbor basin and creating the entrance channel will have direct impacts to the environment. The location and extent, magnitude and the duration of the impact and how it manifests in the environment depend on the methods used in the development works and choice of the design and where the project activities are located on the Fullmoon reef. It is (almost) impossible to undertake the proposed activities without an impact. The objective however, shall be to make a compromise between the choices available and to mitigate the negative impacts where possible and practical.

It is clear that developer needs this redevelopment activity to improve safety standards of the hotel and to minimize the inconvenience to the guests. The perception survey showed how the guests feel about the current situation and provided strong justification for this redevelopment work.

The direct impacts from this redevelopment activity may be divided into construction phase and operational phase.

8.1. Construction phase

Direct impacts during construction phase will include issues related to aesthetics and pollution including effects of excavation and mobilization of equipment.

Aesthetics: During the construction it is proposed that the area will be sealed off so that guests would not see any activity taking place in the area. Conveniently the site is also accessible and does not require workers or the construction equipment to be mobilized through the guest area of the island.

Pollution: Most important are the noise and the visible impacts during the deepening of basin and opening of the channel. Sheet piling and dredging works require operating heavy machinery. Vibration method of sheet piling would generate constant noise while the engine of the crane is running and intermittent noise when the vibrators are working. It is estimated that a total 7-10 days would be required to drive the proposed 500 sheet piles in the area.

Dredging works also generate constant noise whilst excavator is running. The engine noise intermittently increases every time the bucket is put into action and excavation force begins. Besides these two obvious, there will be few activities that will generate noise. The project activities will be done during the months of southwest monsoon season when the winds from are from south and southwest. The direction of the wind would be favorable as the main guest area is located upstream of the wind.

A more immediate impact from the dredging is the physical loss of the habitats of the dredged or cleared area. This loss would include live corals (very few) and other invertebrates. This is inevitable and cannot be remedied. An area of approximately 5700 m² of hard and soft substrate (including reef flat and slope area) up to a depth of 2-3 meters will have to be cleared for this activity. Coral

cover and fish life (the two most important life forms in the area) at the site was discussed in section 5.

One way to estimate the potential impact would be to estimate the fraction of impacted area as a proportion of reef habitat of Fullmoon reef (i.e., total coral bottom habitats). Using an image analysis software (CPCE V 3.4) it is estimated that total reef area is 740,500 m². The area that is going of affected is 5,700 m² which is only 0.6% of the Fullmoon reef area. Given such a small fraction is affected (directly) by this activity it is considered to be negligible.

The proposed activities may generate rubbish including solid and liquid wastes. Such wastes include bags of different synthetic materials, wood, metals and many others. Different types of oil may reach the lagoon and sea accidentally. Waste material dumped into the lagoon and reef accidentally or deliberately quickly goes out of sight but will impact the marine underwater life. Bags and ropes could kill corals and invertebrates. Fish life may be disrupted. Enhanced algal growth may lead to short term ecological imbalances in fish populations. Even small quantities of hydrocarbons may disrupt food chains and physiology of reef corals and fish.

Excavation impacts: Irrespective of the method, excavations on coral reef environments generate sedimentation. Fine sediments are set in suspension as a result of excavation. The suspended sediments may move over large areas of the reef and surrounding areas before they settle. But the extent of the spread and its settlement depends, among other things, on the local hydrodynamics which will be difficult to work out.

Nutrients levels around the excavated site may also be altered to levels where algal blooms and flashy algal growth may be enhanced. This is a short term impact which will have to be monitored. However, given the site is hydrodynamically active it is unlikely that this will be an issue.

Dredging has direct impacts on the site (perishes most of the animals living at the site) and indirect impacts on other marine habitats by the export of fine suspended sediments. Productive coral reef habitats including corals, reef fish and other reef organisms will be lost or displaced by dredging activity. Sedimentation affects corals directly and other key biological and ecological functions of reef organisms.

Excavation impacts include trapping and loss of bottom life during the removal of sediments and water by the excavator bucket. This includes many species of mollusks, worms, crustaceans and fish. Benthic fauna are particularly affected by entrainment but some epibenthic organisms may also be affected.

Dredging a channel and harbor basin would alter the natural flow of physical (e.g. sand) and biological (e.g. larval and young marine animals) components around the island. This issue will be followed up in the monitoring programme.

The most important irreversible impact of the deepening activity will be a potential (and presumably local) change of the currents and wave energy in the area. The harbor if left open would be a sink for sediments which may bring about irreversible change to the sand budget of the beach and nearshore areas. If the harbor is enclosed from both sides then beaches will reshape on either side until it reaches a new equilibrium. The impacts resulting from this will have to be monitored carefully throughout the construction and operation of the resort.

Juveniles of many reef fish (rays, and reef fish sp) spent a considerable period of their life close to beaches of islands. The young fry forage up and down beach at given times of the day and seek protection from larger animals in the food chain. This activity will be strongly hindered by the creation of an enclosed harbor basin.

A significant impact of the dredging activity is the transformation of the seascape of the reef by the channel and harbor basin. This is an impact which is irreversible and irretrievable.

Behavior of fish and invertebrates will be affected. Many pelagic lagoon fish will be forced to leave the area and will not be able to habit the area during dredging activities. This would lead to disruption of their activities and habitat.

The overall reef productivity will be affected in the short term by the sediment re-suspension. Planktonic organisms and the young of many reef organisms that habit the water column almost year around will be affected by suspended matter. This may lead to low recruitment rates of marine life for some years during and after the dredging activities.

Experience from other excavations projects show that dredge sludge can be a major problem in location where water movement is low. Cases of excavated sludge at the bottom of the lagoon close to the beach can be problematic for some time. The dredge mud is usually a thin layer and gets suspended seasonally. Dredge sludge in the near shore environment can be a major problem leading to poor environmental quality.

Equipment Mobilization: A small labour force will have to be mobilized on the island during the construction period. Construction equipment and machinery will also be mobilized. Careful management of both construction equipment and laborers is important for keeping the project area relatively clean during the construction phase. Fortunately the site is clear off vegetation and so the impacts terrestrial environment will be none.

8.2. Operational Phase

The direct environmental impacts from operational phase will be difficult to predict. This depends on the complex inter-play of change (relative to baseline or existing condition) in hydrodynamics exerting on the changed topography of the reef flat. The change in topography of the reef flat is the deepening of a channel and the harbor basin. It is important to note that harbor basin will be relatively closed and any indirect effects due to deepening of the basin will be contained within the basin itself. Pipes may be inserted in the walls to improve circulation insider the basin. In general, the indirect effects from the excavation of the basin will be only local.

The deepening of the relatively narrow channel on the reef flat/reef slope may have the same effect as spur and grooves. Most reefs have a spur and groove system which extends along the reef flat and some distance down the reef slope. This system is often extensively wide and long, depending on the reef slope.

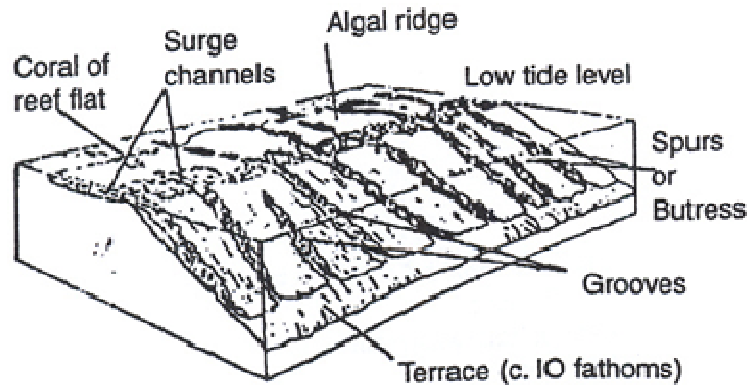


Figure 15: Reef slope structure – showing the spur and grooves.

The spur and groove system appears to be formed by erosion reinforced by the prolific seaward growth of corals on the groove. The overall result of this spur and groove system is self-reinforcing. Incoming waves cause extensive surges along the groove resulting in the re-suspension of sediment and the continual movement of reef rubble prevents effective coral growth. Less turbulent waters experienced in the spur region allow coral growth which reduces turbulence further.

In effect the spur and groove system of the reef structure acts primarily as a dissipator of the continual wave energy operating on the coastal shoreline. By dissipating wave energy before it reaches the shore the beach is protected from extensive wave action. In this respect therefore, the effect of the deepening the channel may be helpful in reducing wave/ current energy and thereby prolonging the life of the breakwaters in the area. Whatever the change it may bring it is hoped that monitoring program will be able to identify it and put in place the remedial and/or mitigation measures.

8.3. Limitations of Impact Prediction

The assessment of direct impacts is limited by uncertainty in the data and lack of long-term observation of the shore-line on the resort. Unfortunately there are hardly any resorts in the Maldives who maintain systematic records of the changes they bring to the shore line. In the case of the Full moon there is no record of the environment prior to construction of the breakwaters.

Data is also lacking on marine environment side i.e., the reef. Considerable modifications have been made to the island since its development as a resort.

The impacts which have predicted above were based on experience and sound judgment. The time limitation of EIA field data collection and report preparation is also hindrance to for adequately understanding the factors influencing the environmental conditions of the site.

9. Evaluation of Alternatives

This section briefly describes the various alternatives and why the selected choice would be the best possible alternative.

9.1. No Development Option

The resort has operated relatively normally with the existing arrangement. However, under the 'business as usual' or the 'no development' scenario it is likely that many repeat guests will drop off from the booking list. From the perception surveys there is overwhelming evidence that guests like to see this development taking place. They expect to have a peaceful and no-hassle holiday in the Maldives. Under the no-development option the resort may eventually be labeled as customer-unfriendly resulting loss of reputation among well-established travel agents. The effect would be loss of tourism revenue. In order to maintain the Fullmoon's five-star the redevelopment work is urgently required.

9.2. Choice of Site

Carefully looking at the Fullmoon resort one would immediately notice there are few choices for practically locating supply jetty and harbor (cf. Figure 1). The western end of the arrival jetty and the northern side of the island has water bungalows which is most important asset of the island.

A seemingly more practical solution may be to make use of the existing harbor (for the supply jetty) and only consider opening the channel. This will have the advantage of requiring less area to be excavated. Unfortunately the highest complains comes from the guests occupying the rooms closest to the harbor. Besides this the choice would lead to excavating a larger reef flat area because it would require a longer channel. Considering these the best practical and sensible solution would be relocate it slightly to the south which would require much shorter channel. This will also solve the problem of having to find alternative unloading and anchoring area of the supply vessels.

9.3. Sheet Piling

Several techniques are available for sheet piling and the actual choice of the technique depends among other things the site conditions and the scale of the project.

Vibratory Hammer: Vibratory installation equipment can be broken down into two basic categories- vibratory hammers-extractors and vibratory plate compactors. Vibratory hammers are crane suspended, clamp on to the top of the sheet and driven by transmitting vibratory energy. Plate compactors also expend vibratory energy but are mounted to the arm of an excavator and benefit from being able to push the sheet piling as well.

Impact Driving: The very first method of pile driving was the dead-weight drop hammer which is still in use today. Other forms of impact driving have evolved over time including hydraulic, pneumatic

and diesel hammers. These techniques are commonly used for driving foundation piles and massive caissons. Lighter weight models can be very effective in driving composite sheet piling

Among these the developer is proposing to use vibratory hammer method. It is further proposed that clamp compactor mounted on the excavator. This would also reduce the cost of the mobilizing and expensive and additional piece of heavy equipment to the site. Using an excavator for this work is convenient as the excavator is also proposed for the dredging works (see below).

9.4. Excavation

Again, there several options are available for deepening works. However, for practical purposes the choice depends on the site conditions and the depth of dredging which is required.

Use of an Excavator: This is the most common method used for dredging small areas, such as island harbors. The most popular local contractor MTCC uses this method. The method is very effective and relatively cheap. Excavators are very common equipment in the Maldives and they can easily be transported on a barge.

The common procedure is to start from the far-end of the proposed area and work towards the shore. A strategy commonly used for this is to construct a temporary causeway for the excavator to move to the area. Alternatively the excavator may be mounted on a shallow-draft barge avoiding the unnecessary excavation for the causeway. The problem in this case, however, is the extra burden of regularly removing the piled material on the barge. This can be accomplished by frequently towing the barge to a makeshift landing site. Both techniques have pluses and minuses and the actual choice depends on the site and scale of the project. The developer is proposing to use a barge and avoid excavating unnecessary areas.

Use of a Cutter Suction Dredger: A dredger is only cost effective for large projects. The method requires to lay the pipe works and dealing with large amount of sediment and water. The issue of controlling back wash and its effects is also an issue. For small projects the mobilization of a cutter suction dredger is not economically feasible besides dealing with the other environmental issues.

Use of sand pumps: Sand pumps are only effective if the area is devoid of corals. In the case of Fullmoon resort, most (>70%) of the area is hard substrate and therefore sand pump is not suitable.

9.5. Quay Wall Construction

There are two possible choices for constructing the quay wall. Whatever the method of construction adopted it requires cement bags to be laid down in the water. Once this is done, quay wall construction can begin. Prefabricated section of quay wall can be constructed on land where it can be arranged (or joined) to form the wall. Alternatively the wall can be cast *in situ*. The latter approach is more appropriate in this case for it allows to the retainer wall (sheet pile) and the cement bags to become one integral unit. Finally the armored layer of rock boulders and or stones will be arranged in a sloped fashion. Alternative to this would be use of imported stones or use the locally available ones from reefs and lagoons.

9.6. Use of Excavated Material

It is proposed that excavated material will be used to fill the voids created by alignment of the southern seawall and the harbor quay wall (Appendix 2 and Appendix 3). Fortunately, the fill volume is almost the same as volume that will be generated by the excavation. An alternative would be to throw away the material, but this will not be an option in this case.

10. Selection of Preferred Alternative and Mitigation Measures

In this section the preferred alternative and mitigation measures will be discussed.

10.1. Sheet Piling

The preferred alternative for sheet piling works would be vibration method. In order to reduce cost and avoid having to mobilize additional machinery a plate compactor mounted on the excavator will be used. The following is comparative summary of the degree of impact of the two main types of sheet piling that was considered.

Method of piling	Noise	Cost	Damage to environment	Visual impact	Required Time	Remarks
Vibration	**	**	**	*	**	
Hammering	***	**	**	*	***	

* little or no impact; ** minor; *** moderate; **** major

The environmental impact would be from vibration and local damage to the reef substrate. The intensity of vibrations may be regulated on the plate compactor. Heavy vibrations for prolonged periods may have some effect on the buildings in the area. Fortunately buildings are about 300-500 meters away from the project site and so vibration impacts would be negligible. To further reduce amount of vibration required, it is proposed that sheets will be piled only up to 10 m deep from the substrate.

Local damage to the coral reef may be unavoidable. In order to reduce the impact, the contractor will have to be educated and properly supervised. Information about the project activity will be posted at the coffee shop /bar / restaurants to inform the guests about the work and its progress. Working area will be limited to pre-informed period to minimize the inconvenience to guests. The additional financial cost of limiting to set periods will be borne by the management.

10.2. Excavation

The preferred alternative for deepening the harbor basin and opening of the channel would be by use of excavator. In this case the excavator will be mounted on a shallow-draft barge for easy access

to the site and to avoid unnecessary excavation of a temporary causeway. To improve efficiency and minimize the environmental impact it is proposed that excavated material be dumped on to lorries which will be parked on the barge. Once the lorries (may be 2) are full the barge can be towed back to shore and lorries can driven over a make-shift landing platform. Since the infilling site is adjacent to the project site, not much time is wasted by these frequent trips. The impact summary is given below.

Method excavation	Cost	Pollution	Damage to environment	Visual impact	Required time	Remarks
Excavator	**	***	**	*	**	
Excavator mounted on barge	***	****	**	**	**	
Dredger	****	****	***	***	*	
Sand pump	*	*	*	*	***	

* little or no impact; ** minor; *** moderate; **** major

It is proposed that excavation takes place during low tide. This will make the work easier and would also help to mitigate effect of sediment re-suspension. Limiting this work during low tide may slightly delay the project and increase the cost. But by limiting the sediment plume instead of spreading into the lagoon reef area may be more detrimental to the resort’s image.

10.3. Quay wall construction

The alternative method of the *in situ* construction was proposed as opposed use of pre-fabrication of the sections of the wall. *In situ* construction has the possibility falling of loose material and construction debris during construction and transportation. One way to mitigate this impact would be to have netting placed in the around the wall. Adherence to standard practices in the construction would ensure the construction work is clean and professional.

11. Environmental Monitoring

The long term environmental impact of this redevelopment works is considered minimal. However, some monitoring is proposed. The monitoring should consider the following:

1. Changes in wave strength and current (no baseline data). An indirect way of measuring the change would be noting the frequency of repair of the breakwater, particularly ones close the channel. At present major repairs are made on average once every 6 months and minor repairs once every 3 months. This may be monitored for the next 10 years.
2. Shore line changes (no baseline data): Given that the beach is continually replenished by pumping sand it may not be worth taking detailed profiles of the beach. Instead a rough overall measure would be to take perpendicular distances from the beach to the near-corner of the 7 bungalows on the southern side of the island. (cf. Figure 11). This measurement should be taken twice a year for 5 years.

3. Change in the bottom habitat. Photographic images and compare it with baseline data (provided to the management). Should be done once every years for 5 years.

12. Conclusions

The long term environmental impacts associated with the project are considered minor or negligible. The conclusion is based on evaluation of the components of the project and its proposed implementations. The environmental components that are likely to be affected to are the changes in the local hydrodynamics, sedimentation impacts on coral community on the downstream from dredging and habitat loss. However, the impacts are minor and effects are expected to disappear in no time. The change in hydrodynamics is expected to be favorable in that the wave energy will be reduced on the on the reef flat area around the channel.

This redevelopment activity is justified given by the high acceptance level of the guests minor environmental impact it creates.

13. References

English, S., C. Wilkinson, and V. Barker (1997). Survey Manual for tropical marine resources. Australian Institute of Marine Science, ASEAN – Australian Marine Science Project. Fein JS, Stephens PL (1987) Monsoons. Interscience Publication. John Wiley and Sons. NY 632 pp.

Appendices

1. TOR
2. CAD drawing of the harbor
3. Detailed drawing of the quay wall.
4. Sample of Guest Perception Survey
5. Sample of guest's comments from the survey
6. Reply from MoTCA regarding the permission (consultation)
7. Commitment letter from the developer for the monitoring work
8. Specification of the Sheet piles