ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Proposed installation and operation of desalination plant at Kudarikilu Island, Baa Atoll

Prepared by:

CDE Pvt Ltd

Submitted by:

Mr. Ismail Shafeeu, Ma. Summit

Date

January 2012

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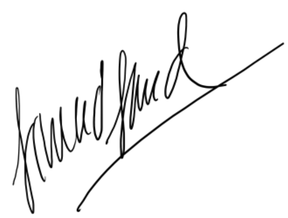
Lead consultants declaration

I certify that statements made in this Initial Environmental Examination are true, complete and correct to the best of my knowledge and available information.



Dr. Simad Saeed (EIA 13/2007)

Proponents declaration

As the proponent of the proposed installation and operation of desalination plant project at B. Kudarikilu, I guarantee that I have read the report thoroughly and that to the best of my knowledge all information provided here is accurate and complete.

1 Introduction

1.1 Purpose of report

What is this report?	This Environmental Impact Assessment (EIA) report presents and addresses the potential environmental and social impacts of the proposed installation and operation of a desalination plant facility.
Why this report?	This document was prepared to fulfill the requirements of Environmental Protection and Preservation Act of the Maldives (4/93), more specifically the clause 5 of this Act which states that a report should be submitted before implementation of any project that may have a potential impact on the environment. This EIA report is prepared in conformance to the Environmental Impact Assessment regulations, 2007 of the Maldives and the Terms of Reference issued by the Environmental Protection Agency of the Maldives on 2nd January 2012 (Appendix A), after the EIA scoping meeting.
Who is this report addressed to?	Ministry of Housing and Environment
Who is submitting this report?	Mr. Ismail Shafeeu (A-043292)

1.2 Project

Project title:	Installation of desalination and plant and water supply network.
Type of development:	This is a new developmental project formulated under a Corporate Social Responsibility (CSR) program to provide supplementary clean and safe desalinated water.
Location of project:	Kudarikilu, Baa Atoll, Maldives.
Duration of project:	8 months.
Licensing agencies:	- Environmental Protection Agency - National Planning Council - Ministry of Housing and Environment
Project financer:	Static Company Private Limited.

1.3 Proponent

Full name:	Mr. Ismail Shafeeu
National identification number:	A-043292
Company:	Static Company Private Limited
Address:	Ma. Summit Maaveyo Magu Male' Maldives
Telephone:	+(960)3310313
Fax:	+(960) 3326405
Email:	Ismail.shafeeu@static-company.com
Company profile	The proponent of this project is Mr. Ismail Shafeeu, who is the managing director of Static Company Private limited: a company registered in the Maldives. The company builds and supplies reverse osmosis desalination plants under its own registered brand name of Aqua Reef. In addition the company also specializes in design of mechanical and electrical networks contracting, supply of power generation and distribution.

1.4 EIA consultant

Full name:	Simad Saeed, PhD
National identification number:	A-028105
EIA license number:	EIA 13/2007
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EIA team members:	Mohamed Faizan, Lubna Moosa, Mohamed Ali, Nashwan Abdul Matheen, Mariyam Jaidha and Mohamed Muan

1.5 Structure of report

This report is organized into 10 chapters:	Chapter 1 - Introduction Chapter 2 - Project description Chapter 3 - Existing environment Chapter 4 - Legal and policy framework Chapter 5 – Stakeholder views Chapter 6 - Impact identification Chapter 7 - Significant impacts and mitigation measures Chapter 8 - Alternatives Chapter 9 - Environmental Monitoring plan Chapter 10 - Environmental management plan

2 Project description

2.1 Project location

Atoll:	*Maalhosmadhulu dhekunuburi.*
Island:	*Kudarikilu* (Figure 2-1).
GPS co-ordinates:	5^{o} 17' 54.47"N, 73^{o} 04' 13.05"E.
Distance from atolls capital:	21.7 km from atoll capital (*Eydhafushi*).
Nearest inhabited island(s):	*Kamadhoo* (~7.6 km) and *Kendhoo* (~7.1 km).
Nearest resort(s):	*Anantara Kihavah Villas, Maldives (~1.24 km) and Four Seasons Resort Maldives Landaagiraavaru* (~4.5 km)
Protected area(s):	*Angafaru*, *Hanifaru*, *Dhigali Haa* and *Olhugiri*. All these areas are outside a radius of 10 km from the island.
Location of proposed desalination plant facility:	North western corner of island (Figure 2-2).
Approved land use plan:	Approved land use plan appendix H.

Figure 2-1 Location of Kudarikilu

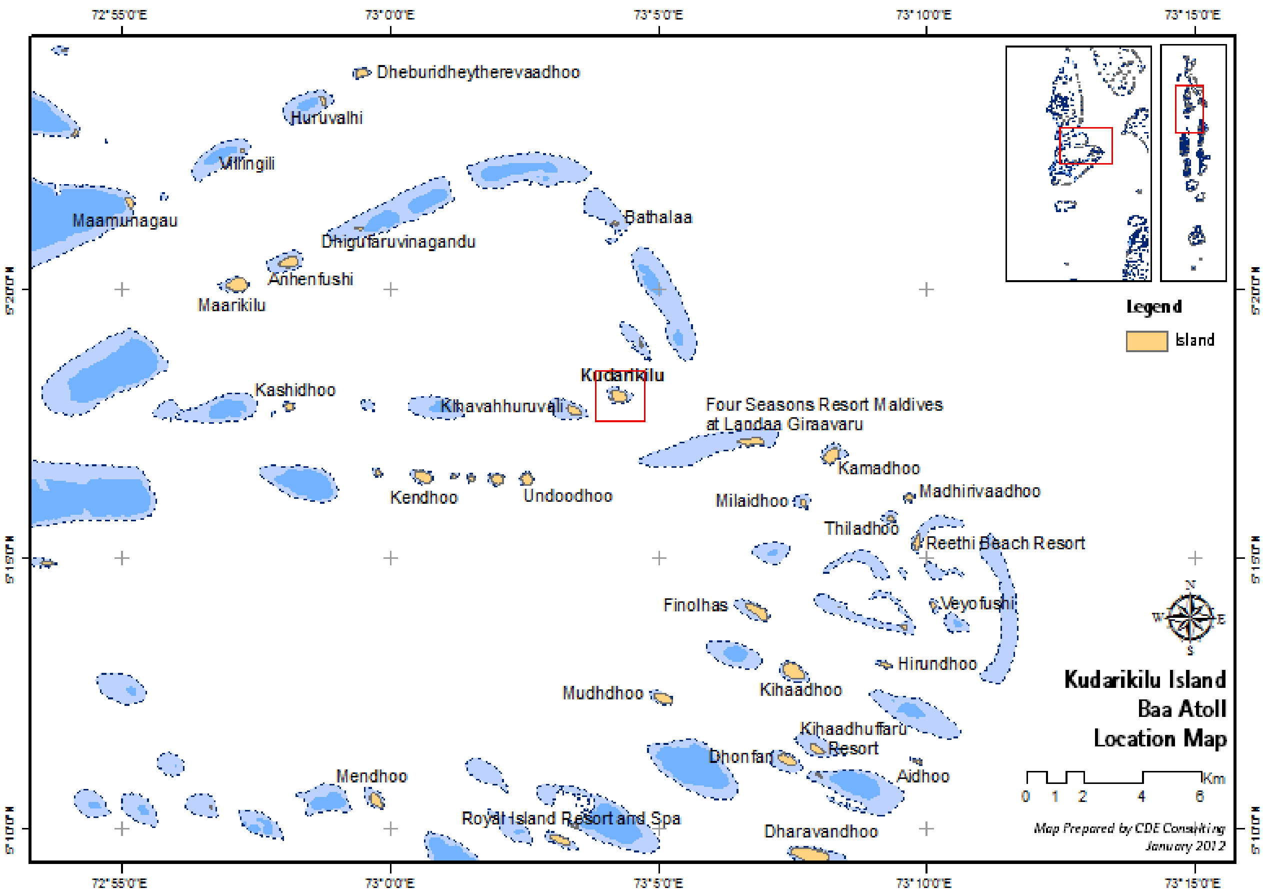
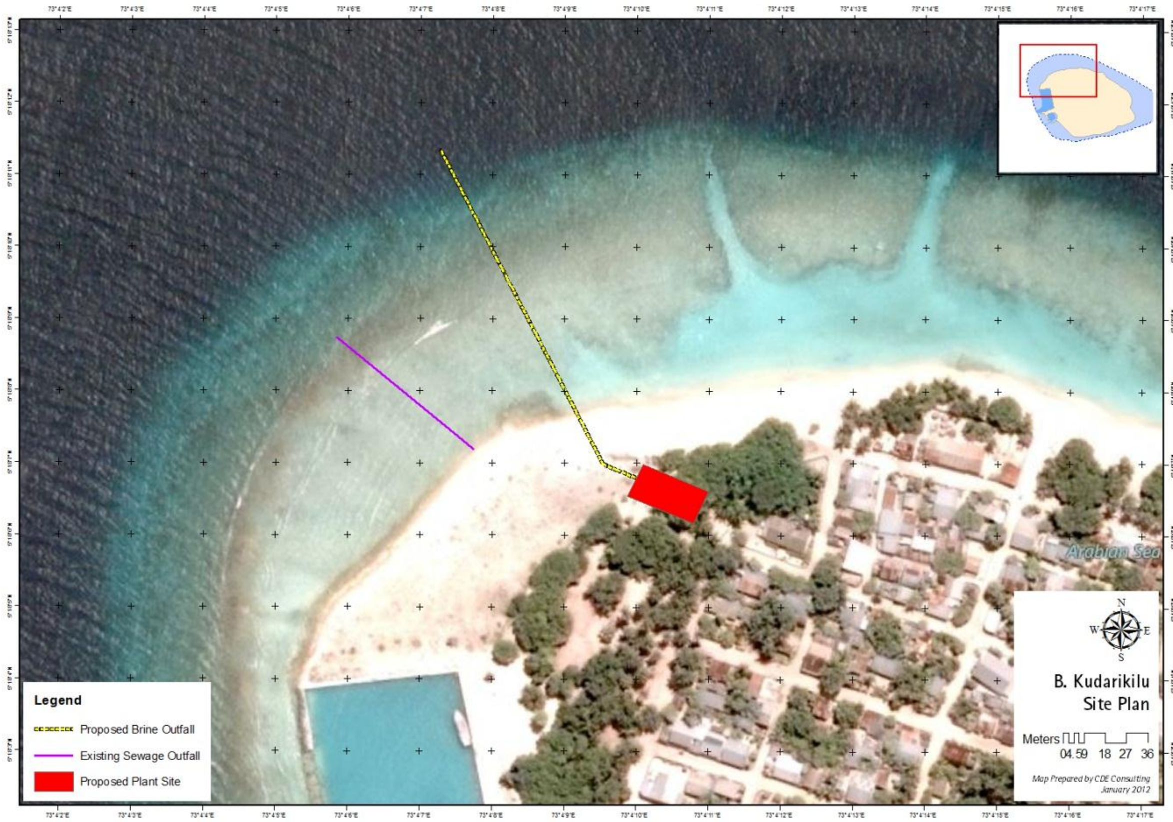


Figure 2-2 Proposed desalination plant facility and brine discharge location



2.2 Project components

The main project components include:

1. Installation of desalination plant
2. Drilling and construction of water intake boreholes
3. Laying of brine discharge pipeline
4. Construction of water storage tanks
5. Construction of fuel storage
6. Laying of water supply network
7. Operation of desalination plant

8. Water intake from borehole
9. Brine disposal
10. Operation of product water pumps
11. Handling and storage of chemicals

2.2.1 Installation of desalination plant

Activity 1 - Site preparation:
- Mobilization of workforce, equipment's, machineries and vehicles to site.
- Vegetation clearance.
- Demolition of any existing structures.
- Setting up lay down area at project site.

Activity 2 - Civil works and construction:
- Earth works.
- Concrete works, piling and structures.
- Building fit out.
- Electrical installation.
- Plumbing installation.
- Installation of desalination plants (2 plants of 25 TPD plants), power generator (43 Kw) and other instrumentations

2.2.2 Drilling and construction of boreholes

Borehole design details: Borehole size shall be 6 Inch in diameter x 2 Holes. (Refer appendix C for detailed drawing)

Activity 1 - Site preparation
- 5 m × 5 m area will be cleared
- Drilling equipment will be placed in position
- Location of proposed boreholes are presented in appendix E.

Activity 2 - Borehole drilling: Main equipment used shall be borehole drilling rig, mud pump, compressor and the method shall be rotary mud drilling which is most suited for Maldives. Borehole drilling will be carried out in conformance to the EPA's borehole drilling guidelines.

2.2.3 Laying brine discharge pipeline

Pipe material:	Unplasticized Polyvinyl chloride (uPVC)
Dimensions:	100 - 75 mm diameter, 166.61 m length
Pipe laying method:	Onshore pipe shall be placed under ground at 600 mm from the surface at minimum. Offshore area pipe shall be anchored to the sea bottom with the help of custom fabricated concrete anchor blocks.

2.2.4 Construction of water storage tanks

Material:	Mild steel, circular
Number of storage tanks:	6 tanks
Dimensions:	4.6 m diameter, 4.8 m height
Capacity of tanks:	70 cbm per tank
Construction method:	Self-standing tanks, interconnected by PVC pipes

2.2.5 Construction of fuel storage tank

Tank construction material:	Mild steel, rectangular
Number of storage tanks:	1 tank
Dimensions:	1.2 m (height) × 1.2 m (width) × 2 m (length)
Capacity of tanks:	2.88 cbm
Construction method:	4 mm Mild Steel welded tanks with 35 mm steel angle bar support inside.
Safety features:	All standard safety features such as Fuel Level indicator, Over flow, Drain valve shall be installed. A bund wall will be constructed around the tank with concrete floor.

2.2.6 Laying of water supply network

Pipe material:

- High Density Polyethylene (HDPE)

Dimensions of pipe network:

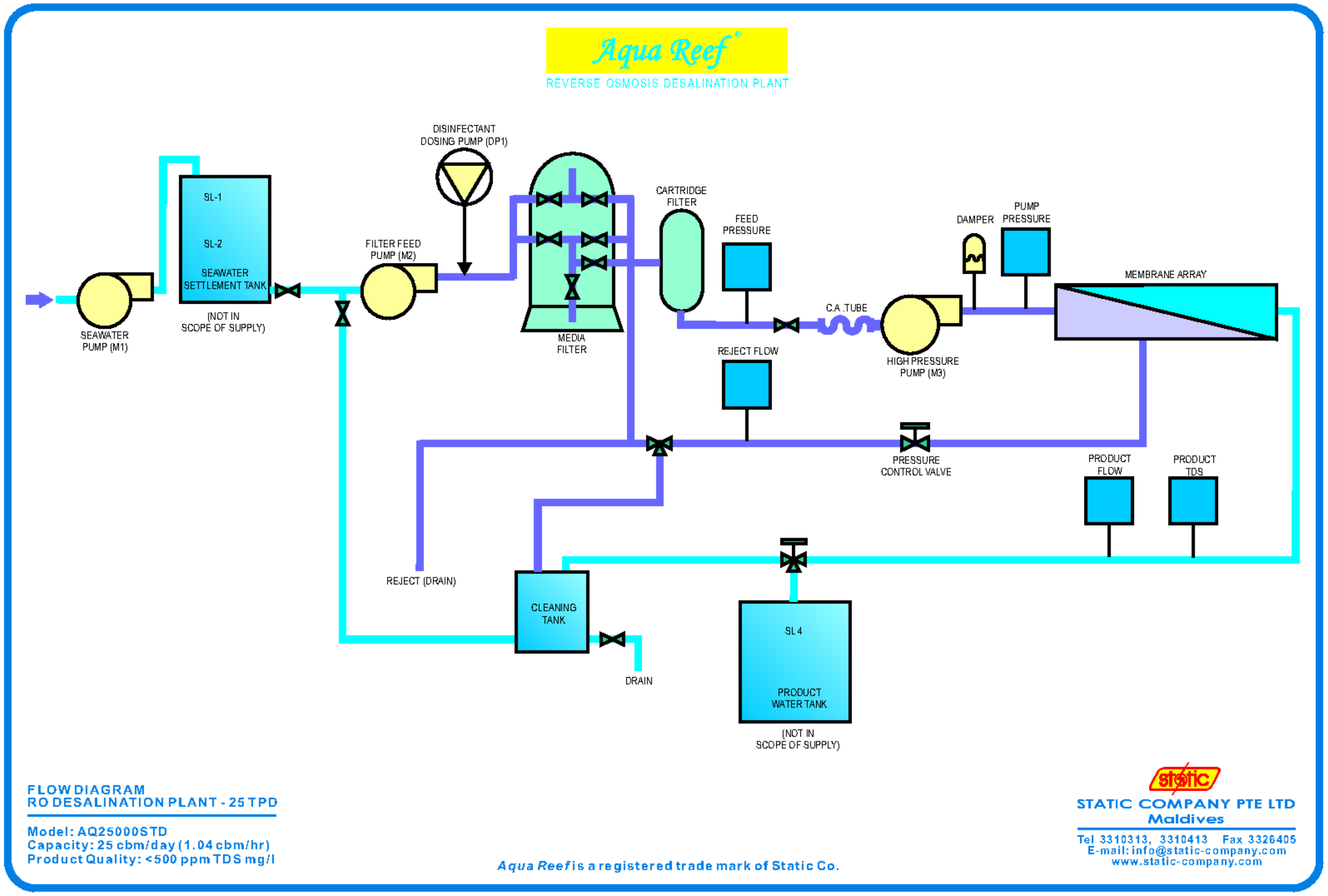
  - 75 mm dia, 873.35 m length
  - 63 mm dia, 916.85 m length
  - 25-20 mm dia, 1813.83 length for laterals
- Water supply layout is presented in appendix G.

Pipe laying method:	- Excavation will be done to a depth of 0.6 m using an excavator. - Dewatering water will be discharge elsewhere on the island, with a help of a pump if required. - Proposed minimum cover of the pipelines is 0.6 m

2.2.7 Operation of desalination plants

Desalination plant process flow:	Process flow diagrams proposed model of RO desalination plans (25 TPD) is presented in Figure 2-3.
Specifications:	Detailed specification of a 25 TPD desalination plant is presented in appendix B.

Figure 2-3 Process flow diagram for RO desalination plant - 25 TPD



2.3 Project schedule

Task detail	Weeks																															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1. EIA report																																
Data Collection																																
Report Preparation Works																																
Submission of EIA Report																																
EIA Report Approval / Decision Statement																																
2. Water Network																																
Mobilization																																
Purchasing of materials																																
Temporary setup works																																
Delivery of Plant House Construction Materials																																
Plant House Construction																																
Building Water Tanks & a Fuel Tank.																																
RO Plant Setup works																																
Procurement of Pipeline Materials																																
Network pipe laying works																																
Construction of boreholes																																
Installation of Reject and Borehole pipe lines																																
Installation of RO Plant & Genset																																
Testing of Network Pipeline																																
Meter Connection Works																																
Testing and commissioning of the total system																																
Handing over																																
3. Demobilization																																

2.4 Summary of inputs and outputs

The types of waste that will go into the development and from where and how this will be obtained are given in Table 2-1 and the type of outputs what is expected to happen to outputs are given in Table 2-2.

Table 2-1 Major inputs of the projects

Input resource(s)	Source/Type	Method of obtaining materials
Construction		
Construction workers	Local and foreign, mainly foreign	Recruiting agencies, etc.
Engineers and Site supervisors	Local and foreign	Advertise in local papers, social networks, etc.
Construction material	Timber; electrical cables and wires, DBs and MCBs, PVC pipes, light weight concrete blocks, reinforcement steel bars, sand, cement, aggregates, telephone cable CAT 5, PVC conduits, floor and wall tiles, gypsum boards, calcium silicate boards, zinc coated corrugated metal roof, paint, varnish, lacquer, thinner...etc	Import and purchase where locally available at competitive prices – Main Contractor’s responsibility.
Water supply (during construction)	Groundwater and/or rainwater	Wells and/or rainwater tanks as designated by island council
Electricity/Energy (during construction)	Diesel	Generator set
Machinery	Excavators, concrete mixers	Import or hire locally where available
Food and Beverage	Mainly imported sources except a few locally available products.	Import and purchase locally
Fuel, Kerosene and LPG	Light Diesel, LPG Gas, Petrol, Lubricants	Local suppliers
Operation		
Electricity supply	Diesel	Existing power supply
Operational staff	To be decided	Recruiting agencies
Operational staff	To be decided	Recruiting agencies
Raw water	Borehole	Borehole uptake

Table 2-2 Major outputs of the project

Products and waste materials	Anticipated quantities	Method of disposal
Construction		
Green waste from site clearance	Small quantity	Burnt or mulched on site
Construction waste (general)	Small quantities	Combustibles: Burnt/incinerated Others: Sent to designated landfill
Waste oil	Small quantities	Transferred to designated waste management
Hazardous waste (diesel)	Small quantities	Barrelled and sent to designated waste management site
Operation		
Brine	Moderate quantities	Discharged through the ocean outfall
Chemical waste	moderate quantities	Disposed at allocated waste management facility

2.5 Labour Requirements

Labour requirement for the project is estimated as shown in Table 2-3.

Table 2-3 Labour Requirement

Supervisor	1
Engineer	2
Tradesman	6
Labourers	20

2.6 Waste Disposal

All waste generated will be disposed at the nearest designated disposal site.

3 Existing environment

This section is divided into the following subsections:

- Study methodologies
- Study area
- Climatic conditions
- Tides, currents and waves
- Terrestrial environment
- Marine environment
- Social environment

3.1 Study methodologies

Vegetation survey: Vegetation at the proposed site was sparsely distributed; hence all floras that occurred within the proposed site boundary were recorded with their frequency of occurrence.

Water assessment: Seawater samples were collected in clean 1.5 L PET bottles at the proposed brine discharge location and the sewage discharge location.

The following parameters were tested at the sewage outfall site: Temperature, pH, salinity, turbidity, Total Suspended Solids, phosphate, nitrate, ammonia, sulphate, BOD and COD.

The following parameters were tested at the proposed brine discharge site: Temperature, pH, salinity, E. conductivity, TDS, dissolved oxygen and turbidity.

pH and temperature were tested on-site using PCD 6500 which was calibrated prior to testing.

Remaining parameters were tested at Maldives Water and Sewerage Companies laboratory. The results were not available at the time of submission of this report; the results will be submitted to the EPA when the laboratory issues the results

Feed water samples were not collected during the field assessment, as feed water is proposed to be collected from boreholes. Water samples will be collected tested and results submitted to EPA once the boreholes are drilled for the project.

Photo quadrat survey: Quadrat measuring 0.5 m^2 was placed at 20 random locations at reef area of the proposed brine discharge site. The photographs were then analyzed using *Coral Point Count with Excel Extension 3.5* software.

Fish census: Fish censuses were taken at location where photo quadrat survey was conducted. The snorkeler swam a distance of 50 m along the reef edge noting down the fishes observed. All fishes observed in a 5 m belt along the 50 m transect line was recorded with their abundance. Abundance level was recorded as follows: Single (1), Few (2-10), Many (11-100) and Abundant (>100).

Beach profiling: The measurement of beach profiles involves standard practice of surveying with a staff and a dumpy level. Measurements were taken along the beach profile line at different intervals that displayed distinctive morphological feature such as beach ridge, high water mark, an erosion scarp, dip, rise, or other significant break in the beach slope up to a minimum distance of 30m from the benchmark.

Surface current flow: Drogue was used to measure the surface current flow around the island. It was assumed that the drogue moves at nearly the small speed as the current.

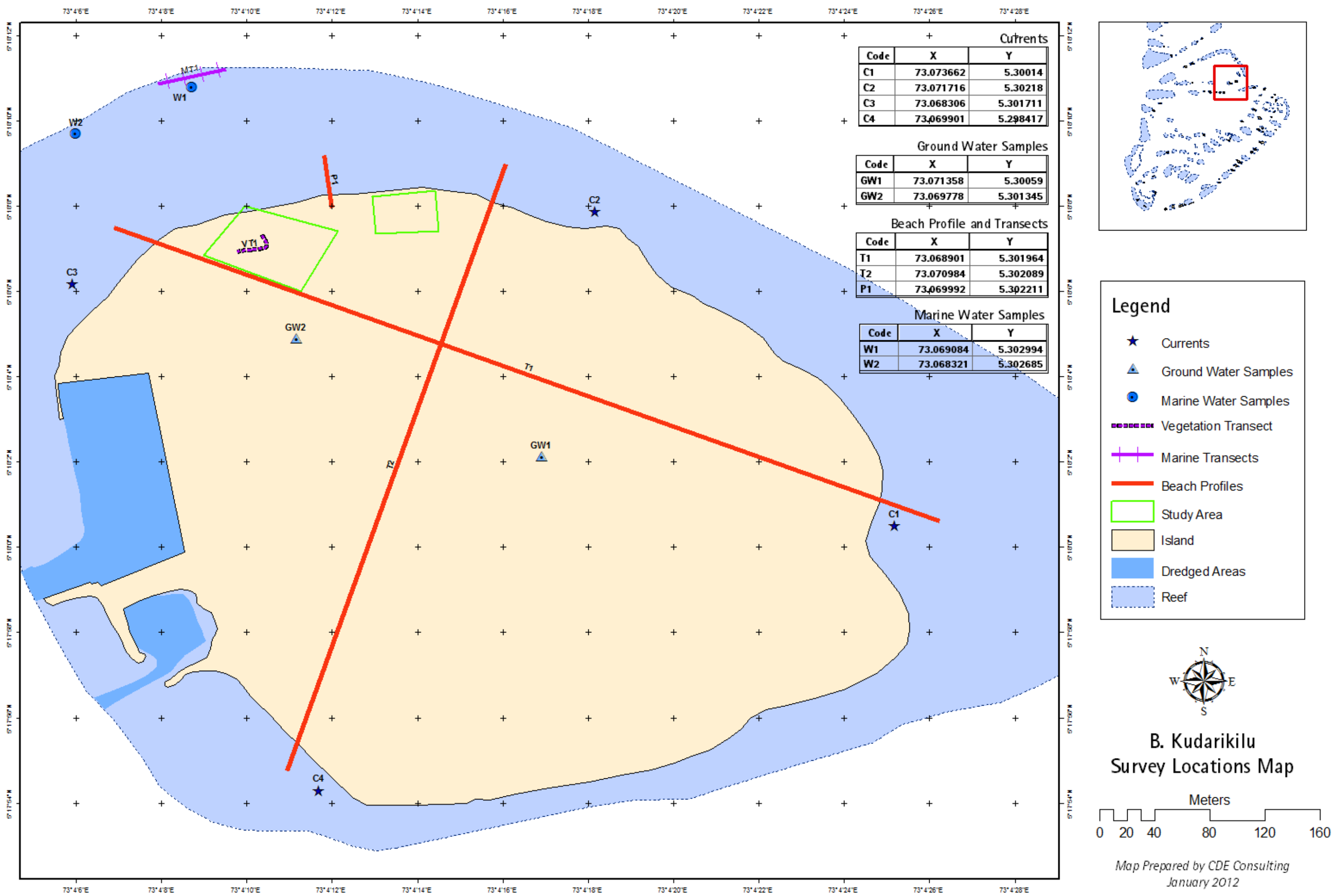
Orange colored coconuts were used as drogues. Orange colored coconut was chosen as it only floats slightly on seawater, it is visible from afar and it is also biodegradable making it safe for the environment.

The drogue was thrown into the water from the beach. The direction and time moved by the drogue for a distance of 10 m was recorded. Direction was measured using a standard compass and time was measured using a stop watch.

3.2 Study area

The study area is presented in Figure 3-1.

Figure 3-1 Survey location map



3.3 Climatic conditions

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C (MHAHE, 2001) and relative humidity ranging from 73% to 85%. The country receives an annual average rainfall of 1,948.4 mm. There is considerable variation of climate between northern and southern atolls. Table 3-1 summarizes the key meteorological findings for Maldives.

Table 3-1 Summary of meteorological findings for Maldives

Parameter	Data
Average Rainfall	• 9.1 mm/day in May, November • 1.1 mm/day in February
Maximum Rainfall	• 184.5 mm/day in October 1994
Average air temperature	• 30.0 °C in November 1973; 31.7 C in April
Extreme Air Temperature	• 34.1 °C in April 1973; 17.2 C in April 1978
Average wind speed	• 3.7 m/s in March • 5.7 m/s in January, June
Maximum wind speed	• W 31.9 m/s in November 1978
Average air pressure	• 1012 mb in December; 1010 mb in April

3.3.1 Monsoons

Monsoons of Indian Ocean govern the climatology of the Maldives. Monsoon wind reversal plays a significant role in weather patterns. Two monsoon seasons are observed: the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. Monsoons can be best characterized by wind and rainfall patterns. The southwest monsoon is the rainy season which lasts from May to September and the northeast monsoon is the dry season that occurs from December to February. The transition period of southwest monsoon occurs between March and April while that of northeast monsoon occurs from October to November.

3.3.2 Winds

The monsoons are relatively mild due to the country's location near the equator and strong winds and gales are infrequent in the Maldives. However, storms and line squalls can occur, typically in the period May to July. The winds usually get stronger in the southwest monsoon especially during June and July. During storms the impact is greater on the northern atolls than on the southern atolls. The northeast and southwest monsoons have a dominant influence on the winds experienced in the Kaafu atoll. The southwest monsoon, with winds predominantly between SW and NW, lasts from May to October. In May and June, winds are mainly from WSW to WNW, and in July to October, winds between W and NW predominate. The northeast monsoon, with winds predominantly from NE to E, lasts from December to February. During March and April, winds are variable. During November, winds are W, becoming variable soon, winds can occasionally exceed 30 knots (force 7 Bf) from the NE sector. During the southwest monsoon winds have it has been reported that on one occasion winds have exceeded 40 knots (force 8-9 Bf) from the west sector. Generally, however, winds during the northeast and southwest monsoons are around 10-15 knots (force 5 Bf).

Table 3-2 Summary of general wind conditions from National Meteorological Centre

Season	Month	Wind
NE - Monsoon	December January February	- Predominantly from NW-NE. - High Speeds from NE
Transition Period 1	March April	- From all directions. Mainly W. - High Speeds from W.
SW - Monsoon	May June July August September	- Mainly from W. - High Speeds from W.
Transition Period 2	October	- Mainly from W. - High Speeds from W

Figure 3-2 Monthly Frequencies of Wind Direction in Central Maldives based on National Meteorological Centre

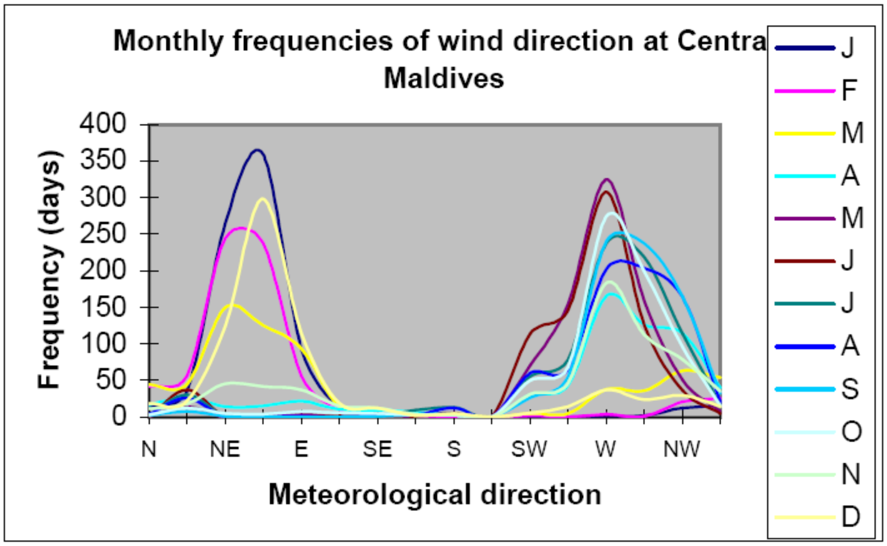


Figure 3-3 Year Wind Frequencies Recorded at Hulhule Meteorological Centre

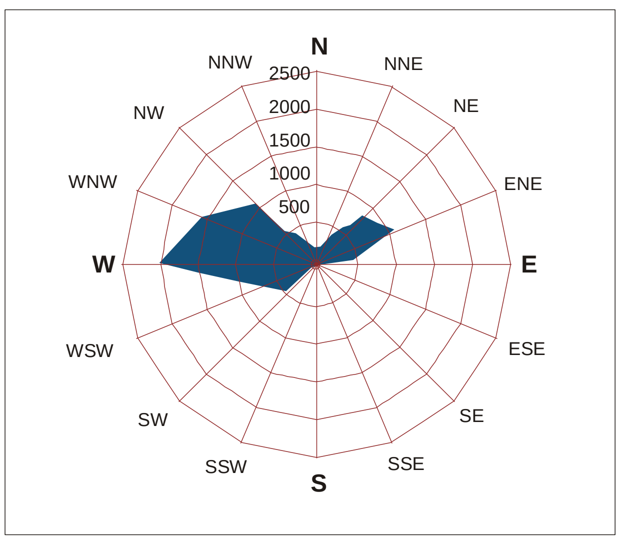
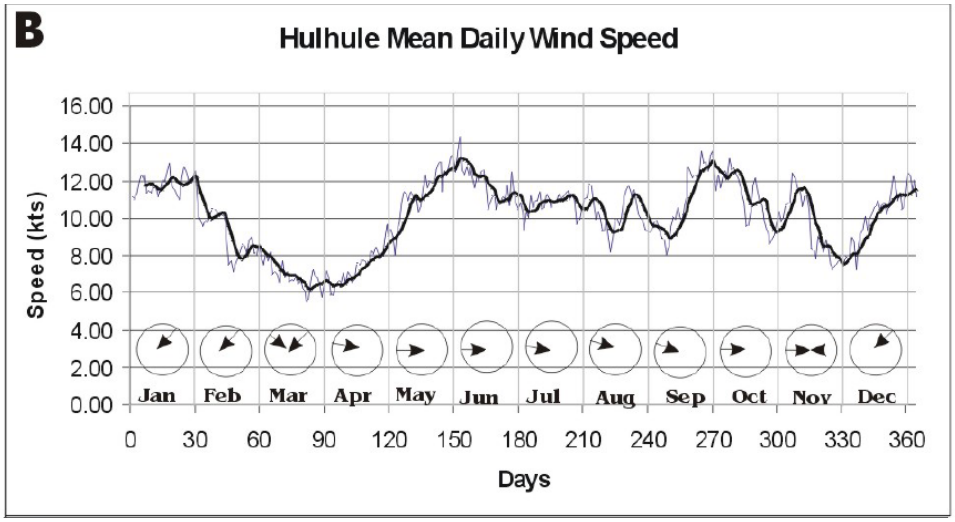


Figure 3-4 Mean Daily Wind Speed and Direction Recorded at National Meteorological Center



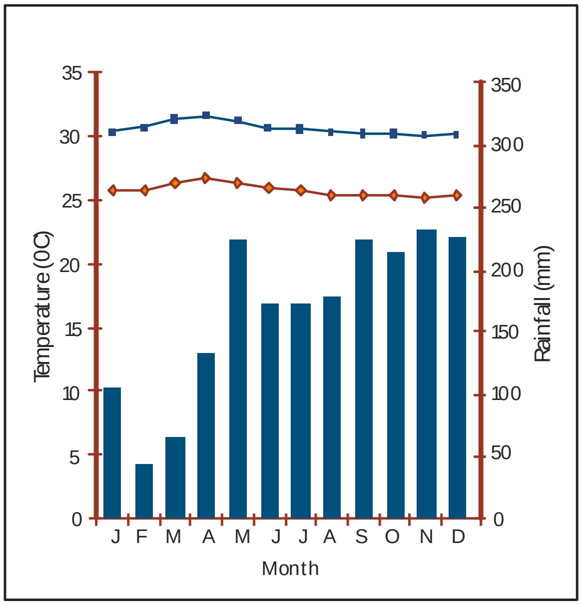
3.3.3 Rainfall

Annual average rainfall in Maldives is about 1900mm. There is a marked variation in rainfall across Maldives with an increasing trend towards south. The annual average rainfall in north is 1977mm and for south is 2470mm.

The southwest monsoon is known as the wet season with monthly average rainfall ranging from 125-250 mm. The northeast monsoon is known as the dry season with average monthly rainfall of 50-75 mm.

On average, the NE monsoon months have 5 days a month with rainfall exceeding 1mm. The southwest monsoon is the wet season, with monthly average rainfall ranging from 125 mm to 250 mm. During the SW monsoon months, each month will on average have 10 to 15 days with rainfall exceeding 1 mm. Open water evaporation rates are in the range of 6 mm per day and transpiration from plants is also high. The relative humidity generally ranges between 75 to 80%.

Figure 3-5 Summary of mean rainfall and temperature values recorded at Male' International Airport.



3.3.4 Temperature

Daily temperatures of Maldives vary little throughout the year with a mean annual temperature of 28 °C. The annual mean maximum temperature recorded for Male' during the period 1967-1995 was 30.4 °C and the annual mean minimum temperature for the same period was 25.7 °C. The highest recorded temperature for Male' was 34.1 °C on 16th and 28th of April 1973. The hottest month recorded was April 1975 with a maximum monthly average temperature of 32.7 °C, the next highest being 32.6 °C in April 1998. The lowest minimum average temperature of 23.7 °C was recorded in July 1992.

3.4 Tides, currents and waves

3.4.1 Tides

During spring tides, the tidal range is between about 90-110 cm and during neap tides the range can be as little as a few centimeters. The height of the tide is also affected by the weather. Winds from different directions influence the raising and lowering of the water level and situations of high sea levels on the outside of the atolls are caused by storm surges and wave set-up. The water also stands higher with a low barometer, to what extent is uncertain. Maximum water levels are estimated to be in order of MSL+1m. The tides observed in the country are twice daily (semidiurnal), and typical spring and neap tidal ranges are approximately 1.0 m and 0.3 m respectively.

Maximum spring tidal range in the central and southern atolls is approximately 1.1 m. There is also a 0.2m seasonal fluctuation in regional mean sea level, with an increase of about 0.1 m during February – April and decrease of 0.1 m during September – November. Table 3-3 shows tidal variations for Malé Airport.

Table 3-3 Tidal levels

Tide level	Reference to Mean Sea Level
Highest Astronomical Tide (HAT)	0.64m
Mean Highest High Water (MHHW)	0.34m
Mean Lower High Water (MLHW)	0.14
Mean Sea Level (MSL)	0.00m
Mean Higher Low water (MHLW)	-0.16m
Mean Lower Low water (MLLW)	-0.36m
Lowest Astronomical Tide (LAT)	-0.56m

3.4.2 Currents

Currents which affect the sea area around the Maldives are caused by one or more of the following systems:

- Oceanic currents
- Tidal currents
- Wind-induced currents
- Wave-induced currents

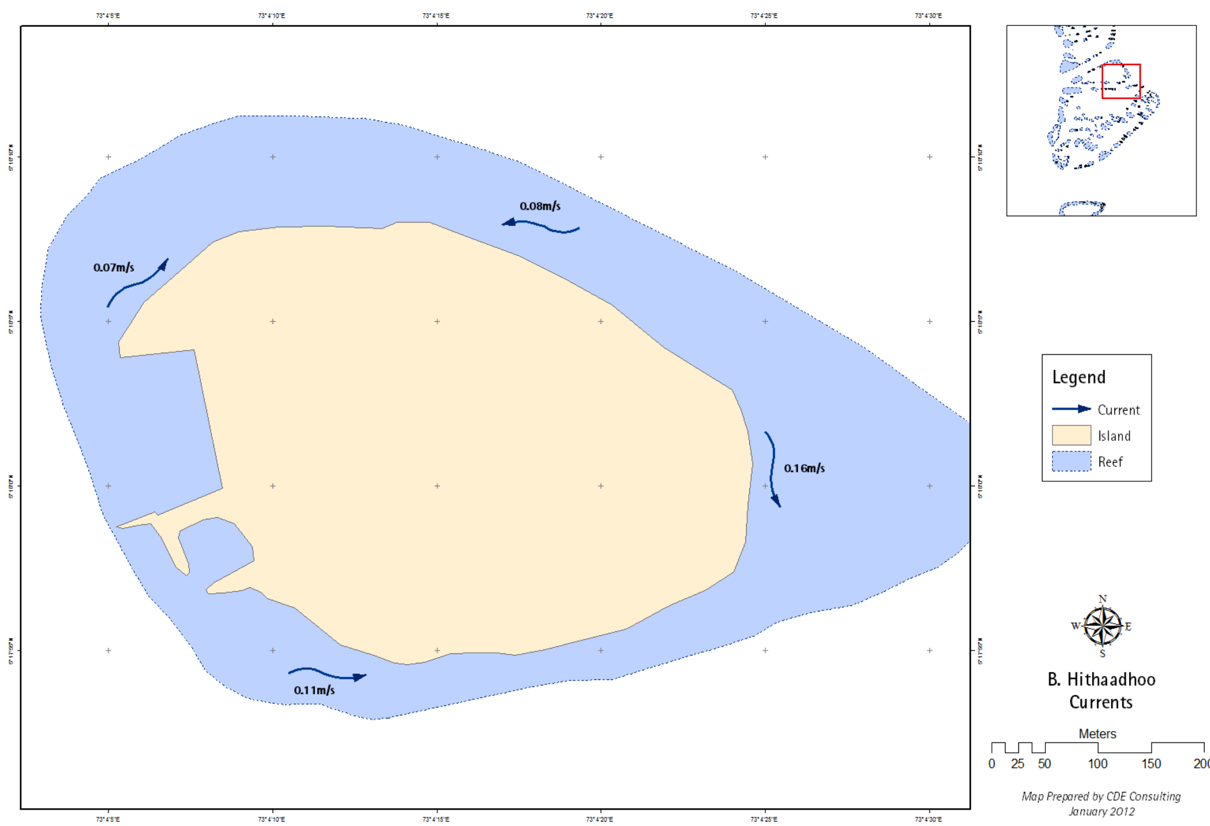
The oceanic currents flowing across the Maldives are notorious for their strength. The exposure of the Maldives to the vast Indian Ocean ensures that an immense body of water is constantly flowing across the plateau on which the atolls are built. In the Arabian Sea, as you get closer to the equator, the prevailing winds become more and more indicative of the oceanic surface current. Thus, wind (especially during monsoons) can be a major factor affecting current velocity and direction, and currents can be of great strength (wind-induced currents). For example: currents in the channels near Malé have been recorded at 4 knots or more. Inside an atoll, current speeds are more settled. Oceanographic currents are driven by two monsoonal winds, namely the westerly and easterly wind. The westerly flowing current tend to dominate from January to March while the easterly currents dominate from May to November. The changes in current flow patterns occur in April and December. The current velocities are about 0.5 m/s, only in May values may increase to 0.8 m/s.

The vertical water movements associated with the rise and fall of the tide are accompanied by horizontal water motion termed tidal currents. These tidal currents have the same periodicities as the vertical oscillations, but tend to follow an elliptical path and do not normally involve simple to- and-from motion. Generally the tidal currents are eastward in flood and westward in ebb. Tidal currents, which flow according to the height of the tide, are generally not strong. There is a strong diurnal influence which governs the tides in the Maldives, but in general the tidal range is less than 1m.

On a more local scale, especially on the reef flats, wave-induced currents (cross-shore and/or long-shore) also form an important factor affecting the current regime.

Observation during the field visit showed that the surface flow rates were moderate ranging from 0.07 m/s to 0.16 m/s (Figure 3-6).

Figure 3-6 Surface current flow recorded during field visit



3.4.3 Waves

The swell and wind waves experienced on the Maldives are governed mainly by the two monsoon periods. Swell caused by cyclonic storms in the area west of Australia may also reach the southern atolls of the Maldives on occasion.

The swells and wind waves experienced by the Maldives are conditioned by the prevailing biannual monsoon wind directions, and are typically strongest during April – July in the south-west monsoon period. During this season, swells generated north of the equator with heights of2-3m with periods of 18-20 seconds have been reported in the region.

The Maldives also experiences swells originating from cyclones and storm events occurring well south of the equator. It is reported that the swell waves from southeast to south-south-east occur due to strong storms in the southern hemisphere in the area west of Australia with direction towards the Maldives.

The swell waves that reached Malé and Hulhule in 1987 had significant wave heights in the order of 3 meters. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves. Due to the shallow depths on the reef flat, significant wave breaking (energy dissipation) will take place at the reef's edge, reducing the wave height of waves which pass over the reef flat.

3.4.4 Tsunami and waves

Although records are inexact, it would appear that earthquake-generated tsunamis of greater than 1.0m in height have occurred on three occasions in the Indian Ocean since 1883. A tsunami of the magnitude experienced on 26th December 2004, which was approximately 4.0m in height, is an extremely rare event. In the morning of 26th December, three hours and 18 minutes after the Sumatran earthquake, the tsunami reached the shores of Maldives islands. Sea-level station records show a southward decrease in the amplitude of the tsunami tidal-record signal from ~1.8m above mean sea level (MSL) at Hanimaadho in the north, ~1.5m for Hulhule, Malé in the central region, and ~0.8m for Gan in the south. The sea-level station data are filtered and do not show absolute heights of the tsunami. Uncorrected tsunami water levels measured by UNEP showed a range from barely measurable to 3.25m, with most measurements in the 2.0 to 2.6m range. Tsunami inundation heights ranged from 0.65m in south Malé to 3.20m in L. Fonadhoo. The tsunami's height typically decreased from east to west as it travelled across islands. Many islands reported the tsunami approaching from the west, quite probably because it refracted around the ends of the islands. Eyewitness accounts often referred to several (usually three) waves approaching in rapid succession (30 seconds to minutes) with minimal draining of water between waves. Wave effects were most pronounced on eastern shores, but flooding and damage to coastal infrastructure was widespread among the islands. The tsunami arrived in Maldives during daylight hours near low tide.

3.5 Terrestrial environment

3.5.1 Vegetation survey

Plant species at site :

- Sea trumpet (*Cordia subcordata*)
- Coconut palms (*Cocos nucifera*).
- Breadfruit tree (Artocarpus altilis)
- Lettuce tree (Pisonia grandis).

Vegetation was sparsely distributed within the project boundary; Figure 3-7 presents the frequency of occurrence of these plant species.

Figure 3-7 Frequency and type of plant species at site

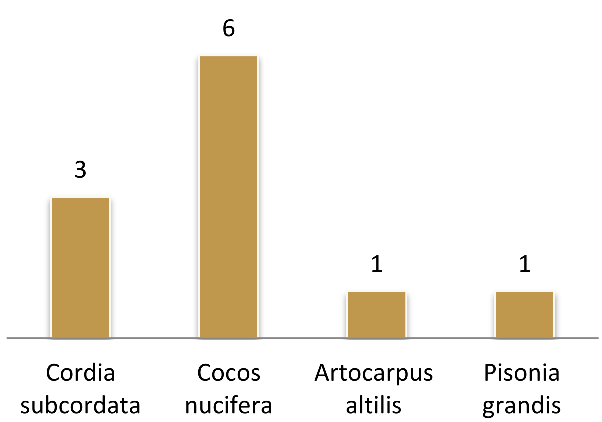
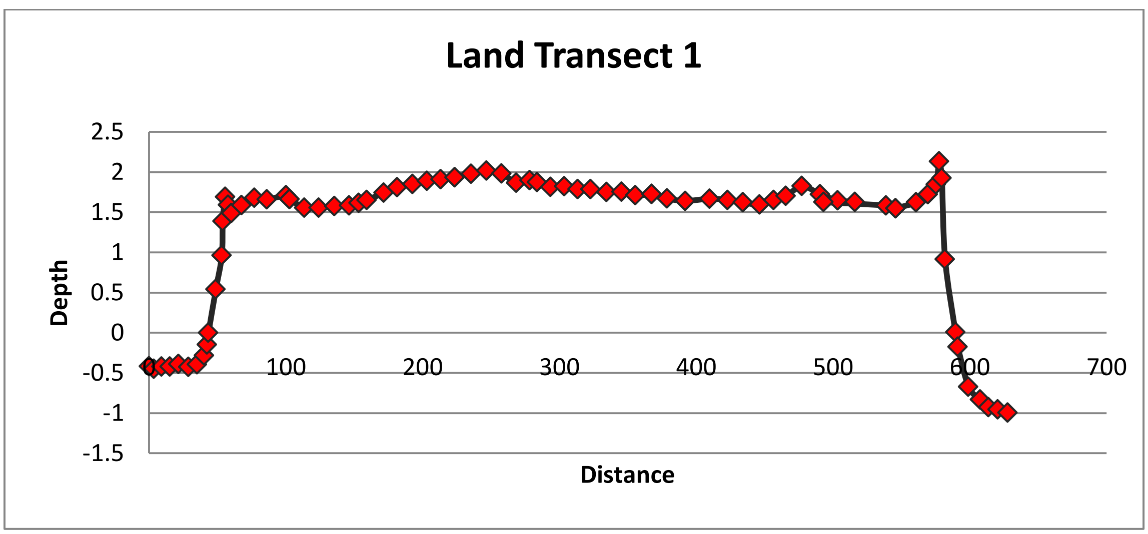
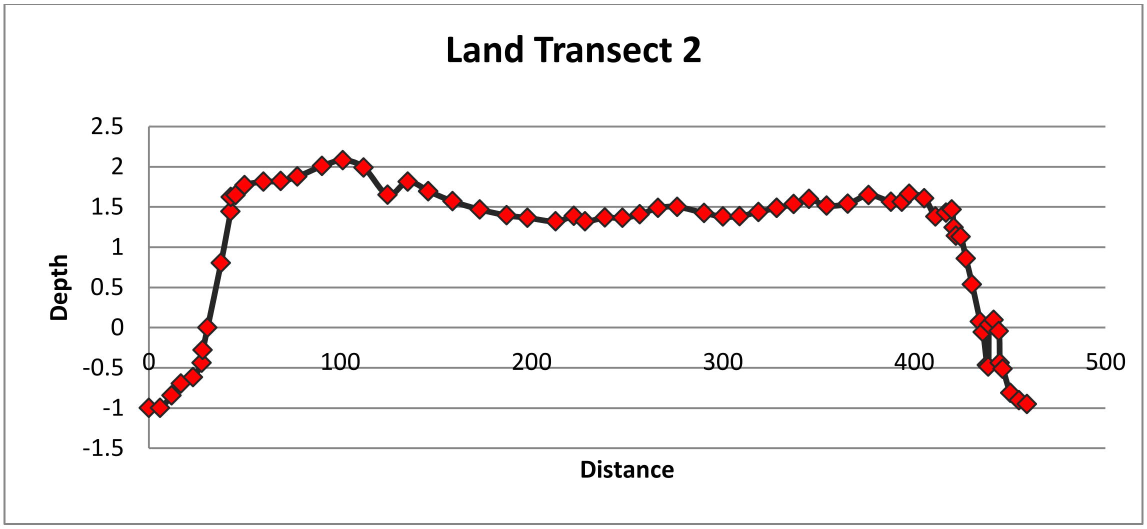


Figure 3-8 Vegetation observed at project site

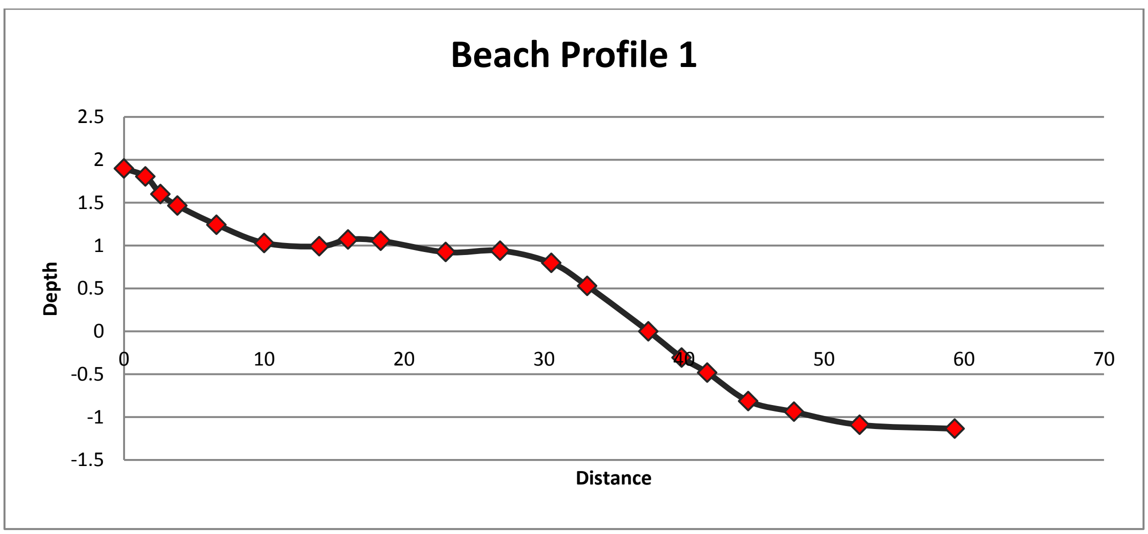
3.5.2 Land transects and beach profiles



Land Transect 1 was taken on a road of the island which lay in a North-west to South-east direction as shown in the map below. The transect starts from, approximately 45m in the North-western lagoon of the island and ends approximately 40m in the South-eastern lagoon. The transect shows that the island is generally level, but with a gradual mound just before the middle of the island. The South-eastern end of the island is the highest point along the transect and also has a steeper and deeper slope compared to the North-western side of the island along the transect.



Land Transect 2 was taken on a road of the island which lay in a North-east to South-west direction. The transect starts from approximately 30m in the North-eastern lagoon and ends approximately 25m in the South-western lagoon. The transect shows that the North-eastern end of the island is more elevated than the South-west. Besides this the island remains relatively flat without significant changes in elevation. The abnormal shape of the transect at the South-western end is due to the presence of beach rocks in the lagoon.



This profile was taken on the end of the island, between Transect 1 and Transect 2. The transect starts from a wall enclosing a compound and ends 20m in the lagoon. The profile shows that the beach is relatively flat and gradually slopes down into the lagoon.

Figure 3-9 Coastal conditions at proposed project site

Figure 3-10 location map of land transects and beach profiles

3.6 Marine environment

Marine protected areas: No marine protected areas within a 10 m radius of project site

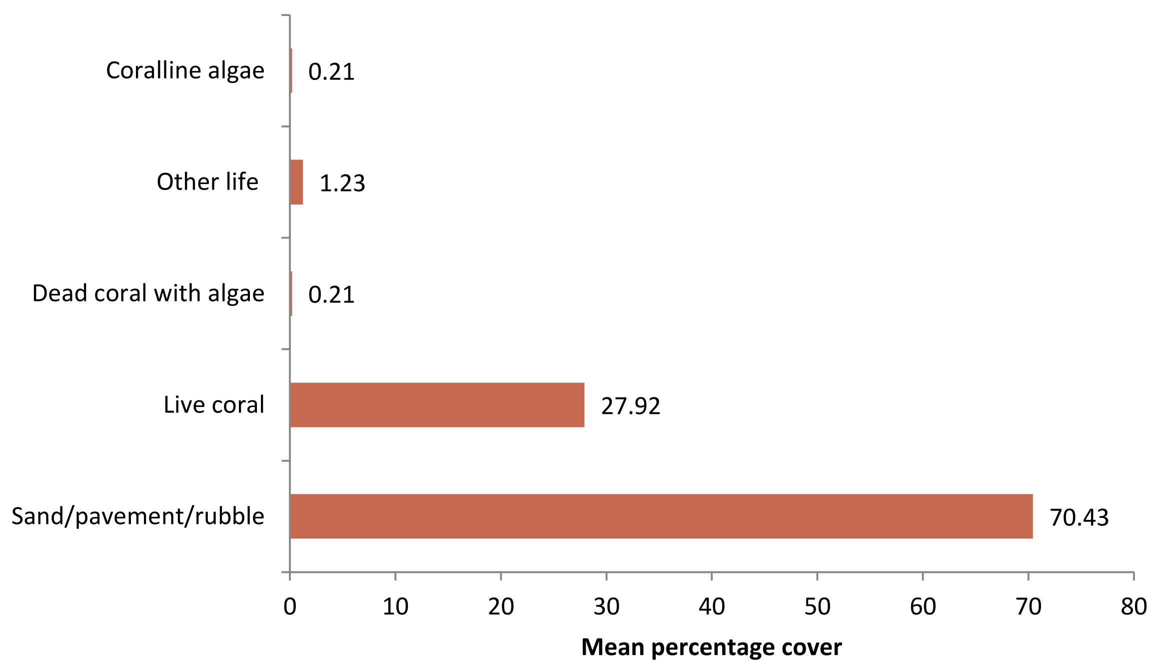
Sensitive marine sites: There is no literature available suggesting occurrence of sensitive marine sites nearby the proposed project location.

Long term studies need to be carried out to determine such sites occurring near the proposed project location.

Coral reef health: Coral reef is healthy at the proposed brine discharge location: live coral making up almost 28% of the surveyed area (Figure 3-11).

Dominant coral families observed include: Pocillioporida, Faviidae and Acroporidae. In addition Gorgoninan Seafans were observed protruding along the reef slope.

Figure 3-11 Results of photo quadrat survey at brine discharge location

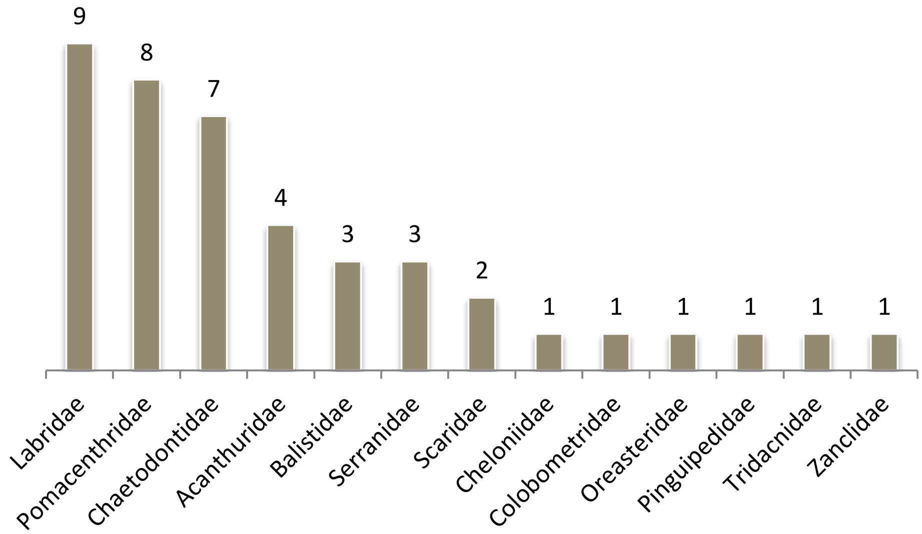


Fish population: A total of 41 different species belonging to 13 different fish families were recorded at the proposed brine outfall location.

Highest number of species were recorded from families Labridae (9 species) and Pomacentridae (8 species). (Figure 3-12)

Results of the fish census is presented in appendix C.

Figure 3-12 Number of fish species in respect to their fish families



Protected and endangered species: Single Hawksbill turtle (*Eretmochelys imbricata*) - this is a protected species and listed critically endangered by IUCN.

Figure 3-13 Reef condition at proposed brine outfall site

3.7 Social environment

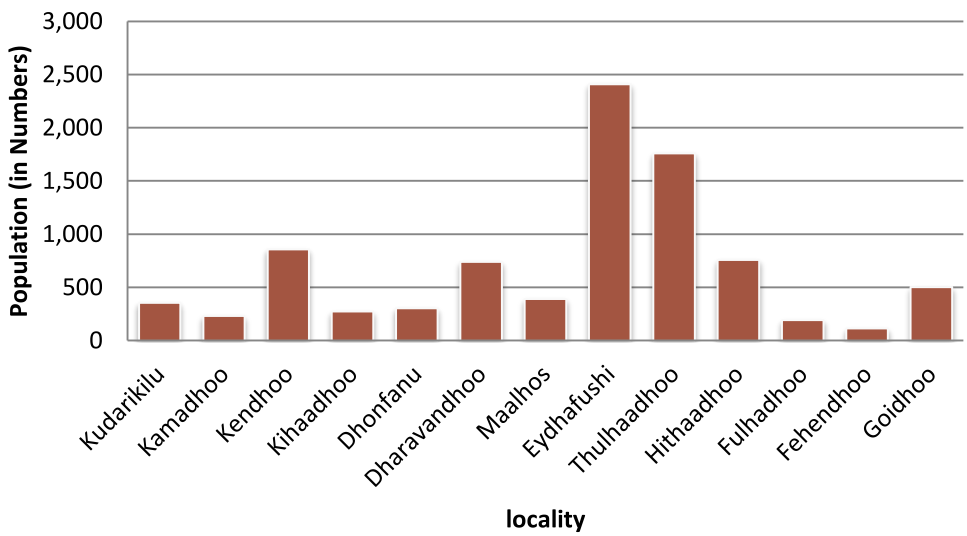
3.7.1 Population structure

3.7.1.1 Total population

The total registered population of *Kudarikilu* is 574 people with 290 males and 284 females.

The total enumerated population from Maldives Population and Housing Census of 2006 is reported as 355 people. *Kudarikilu* has the fifth smallest population in the atoll and shares 3.71% of the total population of *Baa* atoll. Figure 3-14 below represents population sizes for the thirteen administered islands in the atoll.

Figure 3-14 Population Size by Locality, B Atoll, Census 2006



Source: Ministry of Planning and National Development, 2008

3.7.1.2 Gender ratio

According to census 2006, there are more females than males in *Baa* atoll. Likewise, the population of *Kudarikilu* has more females than males with a sex ratio of 81 males per 100 females. But the current population of *Kudarikilu* as of April 2011 shows that there are more males than females with a sex ratio of 102 males per 100 females.

3.7.1.3 Annual growth rate

According to census 2000 and census 2006, the population of *Baa* atoll had a small negative growth with a rate of -0.51. Likewise, the population of *Kudarikilu* shows a negative growth with a rate of -1.48. Table 3-4 below shows the population figures for census 2000 and 2006 of *Baa Kudarikilu.*

Table 3-4 Kudarikilu population census figures for 2000 and 2006

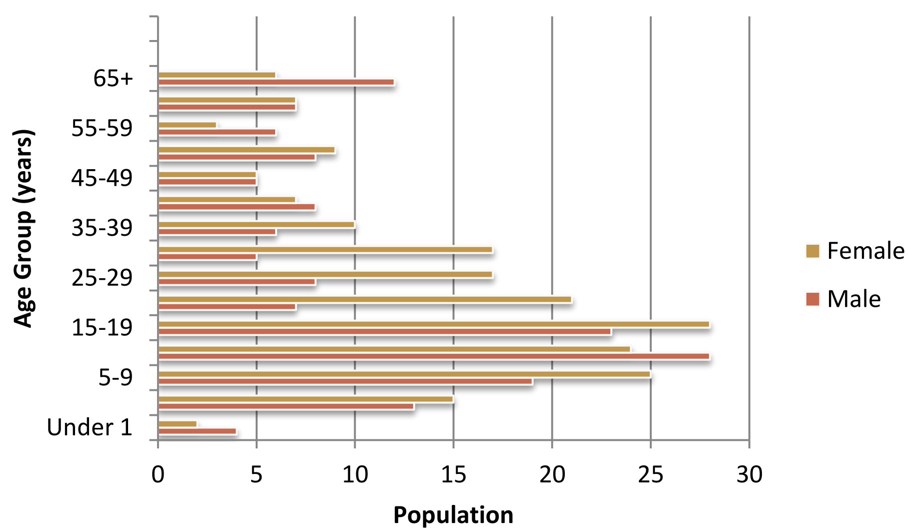
	Census 2000	Census 2006
Total Population	388	355
Male	184	159
Female	204	196

Source: Ministry of Planning and National Development, 2000 and 2008

3.7.2 Dependency ratio

The general structure of *Kudarikilu* population is shown in Figure 3-15 below. The dependent population is at 42%, which comprises of 37% children and 5% elderly. The working age population comprises of more than a half of the population with 58%.

Figure 3-15 Population Structure of B. Kudarikilu, census 2006

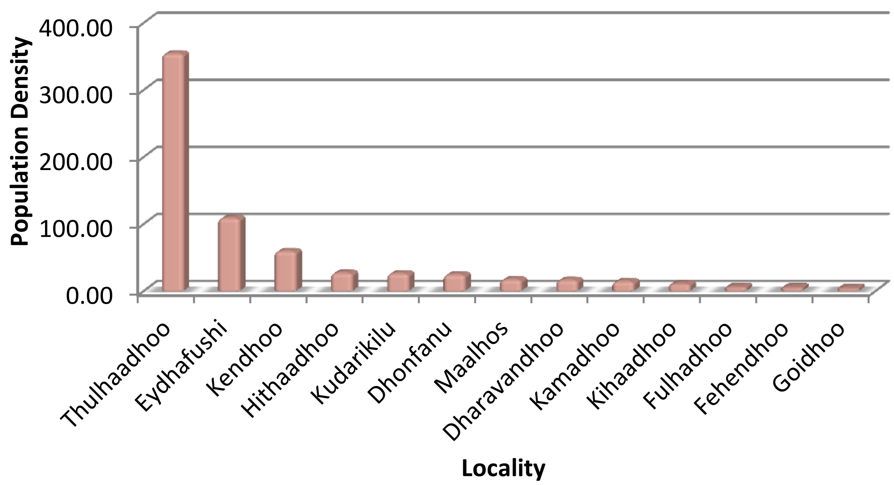


Source: Ministry of Planning and National Development, 2008

3.7.2.1 Population density

Kudarikilu is the third smallest administered island in *Baa atoll* with 13.7 hectares in size. It is also the fifth most populous island in the atoll with a population density of 26 persons per hectare. Figure 3-16 below represents population densities for all thirteen administered islands of *Baa* atoll*.*

Figure 3-16 Population Density by Locality, B. Atoll, Census 2006



Source: Ministry of Planning and National Development, 2008

3.7.3 Administrative and institutional capacity

3.7.3.1 Education sector

There is one education institutes established in *Kudarikilu* which is an Island level school, with a student population of 107, i.e.: 55males and 52 females according to the island information form of April 2010.

3.7.3.2 Heath sector

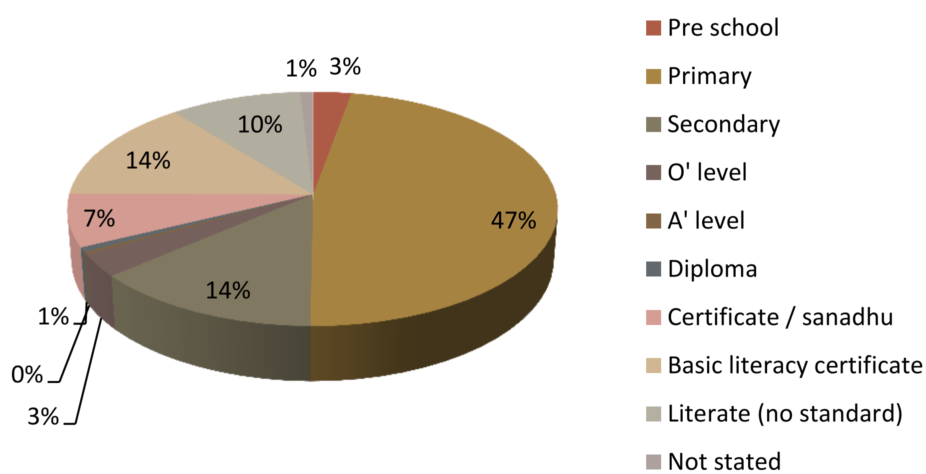
The main health service facility in *Kudarikilu* is the island health center, where it employs 03 foreigners which is 01 male and 02 female.

3.7.4 Education attainment

According to census 2006, literacy rate for *Kudarikilu* population is 98.42%. The literacy rate for female population is higher than that of males (96.43% males compare to 100% females). Likewise, illiteracy rate is higher among male population compare to that of females (3.57% males compare to 0% females).

In education attainment, nearly half of the population has received primary education (47%). A further 10 % of this population reported as literate, 14% have attained secondary education and 3% reported to have received GCE O'level level qualification. Figure 3-17 below shows education attainment rates for *Kudarikilu* population based on census 2006.

Figure 3-17 Education Attainment Levels, B. Kudarikilu, Census 2006



Source: Ministry of Planning and National Development, 2008

3.7.5 Employment

As of April 2010, there are 24 foreigners working in Kudarikilu: 08 in education sector, 03 in health sector, and 13 in other sectors. Currently, there are a total of 9 foreigners working in *Kudarikilu*.

3.7.5.1 Employment and unemployment rates

According to census 2006, the total number of economically active population in *Kudarikilu* is 141. Among these 124 are employed and 17 are unemployed. The economically not active population is reported as 80 people.

Among the 13 administered islands in the atoll, labor force participation rate is the fourth smallest in *Kudarikilu* with 62.7%. Unemployment rate for *Kudarikilu* is reported as 12.1%. Much of the unemployment among the female population with 17.5% of females unemployed compare to 4.9% males.

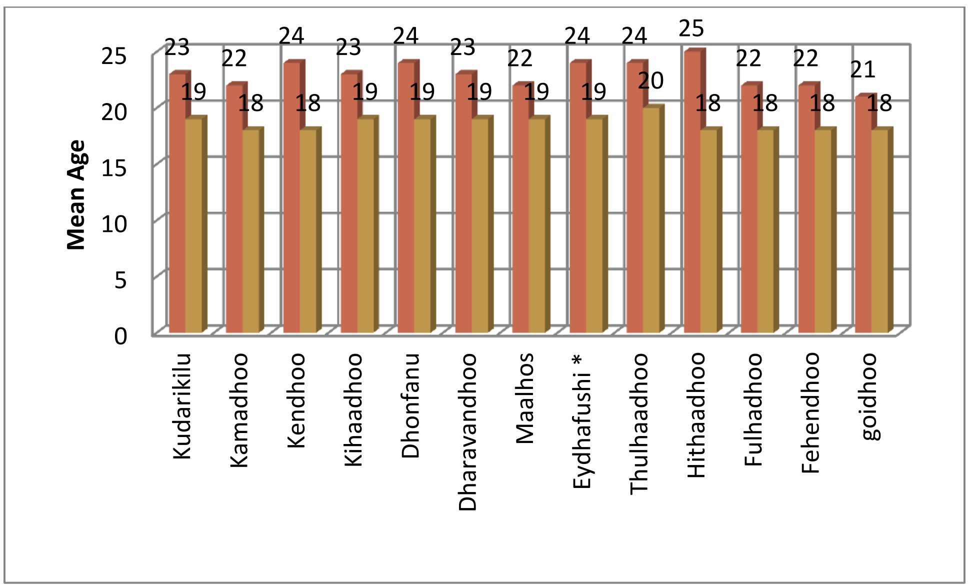
3.7.5.2 Main employment sectors

The main employment sectors in *Kudarikilu* according to April 2010 include fishing, *Fangi vinun*, construction work*, Ronu veshun*, carpentry and sewing.

3.7.6 Marriage

Females tend to have their first marriage much younger than that of males in *Maldives.* Likewise, females in *Baa* atoll also have their first marriage at a younger age than that of males. According to statistical year book of 2010, *Kudarikilu* female population tends to have their first marriage at the age of 19 whilst males do so at 23. Figure 3-18 below shows the mean age at first marriage by locality and sex for *Baa* atoll

Figure 3-18 Mean Age at First Marriage by Gender, Baa. Atoll, statistical year book 2010



Source: Ministry of Planning and National Development, 2010

3.7.7 Infrastructure and services

- **Households:** The total number of houses as in April 2010 in *Kudarikilu* is 95, and 28 plots for housing and a further 121 land plots can be given for housing.
- **Power:** Electricity is currently generated from one engine owned by the public sector and provides electricity for all households in the island for 24 hours a day.
- **Toilet Facility:** According to April 2010, 75% of the households in *Kudarikilu* have toilets connected to septic tank.

- **Water Supply:** At the moment, 98% of the households in *Kudarikilu* use rainwater as the main source of drinking water.
- **Transport and Communication:** There a total of 04 registered boats used for sea transportation. Additionally, there are 102 other vehicles used for land transportation. Furthermore, there is one Agency post office located in Kudarikilu.

4 Legal and policy framework

Maldives Environmental Protection and Preservation Act (Law number: 4/93):

The key points applicable from this Act to this project is summarized below:

- An EIA shall be submitted to EPA before implementation of any developing project that may have potential to the environment
- Project that has any undesirable impact on the environment can be terminated without compensation
- Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government
- The government of the Maldives reserved the right to claim compensation for all damages that are caused by activities that are detrimental to the environment

The project will adhere to all clauses of this Act.

Land Act (Law number: 1/02):

The Land Act provides for allocation and releasing of land for different needs as well as releasing of public land for housing. The Act also states the conditions that govern the using of, owning, selling, renting and transferring of ownership of public and private land.

An approved land use plan is available for Kudarikilu.

Environmental Impact Assessment Regulation, 2007:

The Environment Ministry issued the EIA Regulation in May 2007, which guides the process of undertaking the Environmental

Impact Assessment in the Maldives. This Regulation provides a comprehensive outline of the EIA process, including the application to undertake an EIA, details on the contents, format of the IEE/EIA report, the roles and responsibilities of the consultants and the proponents as well as minimum requirements for consultants undertaking the EIA.

This EIA has been undertaken in accordance with the EIA Regulations 2007 of the Maldives.

Desalination plant regulation: This regulation requires the registration of desalination systems that will be operated for use by population exceeding 200 or for large scale agricultural of tourism activities or for the purpose of implementing project(s) that involves economic or industrial operations. Prior to establishment of desalination system, an EIA must be carried out in accordance to the guidelines provided by Ministry of Environment.

If the noise level inside the plant facility is above 85 dB(A), ear mufflers should be provided to those working in the

The desalination plant will be registered

Draft solid waste management regulation: This regulation is currently in draft form; EPA is planning to finalize the regulation in the near future.

Project will be executed in conformance to the draft regulation.

Regulation on cutting trees: Clause 5 (a) of the regulation states that prior to the commencement of any projects(s) that would require indiscriminate removal and export of trees/palms from one island to another for the purpose of agriculture, development/redevelopment, construction or any other purpose, it is mandatory under the regulation to prepare an EIA report stating clearly the details of the project with all necessary information and submit the same through Ministry of Environment, and the project can only commence upon grant of written approval of the Ministry.

Environmental Permits required for project: Environmental Impact Assessment (EIA) decision note - The most important environmental permit to initiate project work would be a decision regarding this EIA. The EIA Decision Note shall govern the manner in which the project activities must be undertaken. This EIA report assists decision makers in understanding the existing environment and potential impacts of the project. Therefore, the Decision Note may only be given to the Proponent after a review of this document following which the Ministry may request for further information or provide a decision if further information is not required. In some cases, where there are no major environmental impacts associated with the project, the Ministry may provide the Decision Note while at the same time requesting for further information.

5 Stakeholder views

Methodology: A sample of 29 households was randomly selected from the island 97 households.

The following information was collected from each interviewee:

- Name
- national identification number
- Address
- View on the project
- How much they were willing to for the service

Appendix F shows the raw data collected.

Key points raised by of island councilors regarding project:

1. Since water is a basic need and a duty owed to the residents, the project is most welcomed by the council.
2. Overall condition of water on the island is good; however in a previous survey carried out by the council they have observed contaminants.
3. Council have not recorded any water shortages on the island to-date, but it is observed that demand for water increases during the north-east monsoon
4. Council prefers to locate the desalination plant facility near the secretariat of the council.

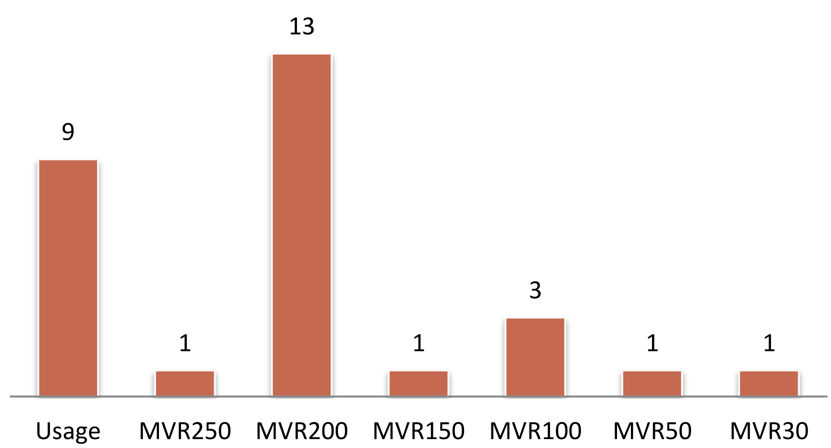
Key points raised by residents of island regarding project:

1. All the households surveyed agree to carry out the project as they believe it will contribute positively towards the increasing population and for the development of the island in future.
2. They believe that the rates charged should not be very high, as water being a basic necessity, whereas the cost of

living is hiking day by day. So that it might be unaffordable for them.

3. About 45% of the households questioned are willing to pay MVR 200 as a top price for each month and 35% are willing to pay according to their own usage. Willingness of the households questioned is shown in the following graph. 9 households expressed that they are willing to pay based on consumption of water.

Figure 5-1 Results of range sample households are willing to pay for service



6 Impacts identification

Potential impacts are identified and evaluated in three stages. The first stage identifies the environmental and socio-economic components that may be impacted from the proposed project. The second stage assesses impact of each project activity on the environmental and socio-economic components. The following sections provide details of the evaluation of impacts.

6.1 Nature of Potential Impacts on Key Components

Nature of potential impacts is defined here as no impact, adverse impact or beneficial impact. Table 6.1 provides the nature of potential impacts from the proposed project on environmental and socio-economic components during both construction and operation stage. Where impacts are not applicable to different components, this is indicated as 'na'. Some components may be affected both adversely and beneficially from the project.

Table 6-1 Impact identification matrix for construction stage

Environmental & Socio-economic Components	Construction stage			Operation stage		
	No impact	Positive impact	Negative impact	No impact	Positive impact	Negative impact
Air quality			*			*
Noise levels			*			*
Groundwater quality			*		*	*
Groundwater availability			*		*	*
Soil & topography			*	*		
Terrestrial flora & fauna			*			
Mangroves and wetlands	na			na		
Seawater quality			*			*
Coral reefs			*			*
Marine flora & fauna	*					*
Equity	*				*	
Public safety			*			*

Public health			*		*	*
Services						
Employment opportunities		*			*	
Business opportunities					*	
Cost of living						*

6.2 Identification of Significant Impacts

Environmental and socio-economic components that may be impacted by the project as identified in Table 6.1 are further evaluated to identify significant impacts. Assessments of the impacts are conducted using the four criteria of magnitude, significance, duration and distribution as described below.

1. Magnitude: Refers to the quantum of change that will be experienced as a consequence of the impact.

2. Significance: Refers to the importance of the impact's consequence or implications (ecological social, economic). An impact of small magnitude could have a very high significance and vice-versa (e.g. siltation of a small reef area with rare coral species has low magnitude but very high significance). The degree of reversibility of an impact (i.e. duration of its effects) is considered part of its significance.

3. Duration: Refers to the temporal scale (i.e. duration, frequency) of the impact. It does not take into account the duration of the impact's effects.

4. Distribution: Refers to the spatial scale of the area impacted (e.g. a small portion of a reef or an entire lagoon)

The four criteria are detailed using scale and attributes given in Table 6.2.

Table 6-2 Scale of each criteria used to weigh impacts

Criteria	Scale	Attributes
Magnitude Change caused by impact	-3	Major negative change
	-2	Moderate negative change
	-1	Minor negative change
	0	No change
	1	Minor positive change
	2	Moderate positive change
	3	Major positive change
Significance Impact implications/ reversibility of impact's effects	0	Insignificant
	1	Limited implications/Easily reversible or Limited benefits
	2	Broad implications/ Reversible with costly implications or broad benefits

	3	Nationwide implications/Irreversible or nationwide benefits
Duration Duration/ Frequency of impact	0	None
	1	short term
	2	medium term
	3	long term
Distribution Spatial distribution of impact	0	None
	1	Site level
	2	Island level
	3	Entire atoll or nationwide

Estimates for negative impacts represent a 'worst case scenario' based on the assumption that the project will undergo full scale development with no consideration for its environmental and social consequences. Values are attributed by the EIA team on the basis of direct observation of surveyed sites, professional judgment and pre-existing experience in development projects of similar nature.

The results of the process can be seen in Table 6-3 and Table 6-4 and, graphically displayed in Figure 6-2 and Figure 6-3.

In evaluating impacts, the following features of the project and conditions of existing environment are taken into account.

- Operation of machinery during construction stage is expected to be short term for construction period only and during certain hours of the day. Noise and dust generated from construction activities are therefore considered to be insignificant and unlikely to have significant impacts on health of people.
- Dewatering is not required in the construction of structures and not expected during laying of pipe network as depth of pipes will be no more than 0.6m below surface. Hence, groundwater is unlikely to be exposed to risk of spills. Without the need for dewatering groundwater availability is not anticipated to be significant.
- Vegetation clearance for desalination plant building is expected to be minimal. No large trees will be removed. Vegetation removed will be replanted elsewhere in the island. Although vegetation in the area may be altered due to clearing, loss of flora and fauna is expected to be negligible. Further, laying of pipes will not require cutting down of trees as the network will follow existing roads.
- Anchoring of brine discharge pipeline will not require excavation although there may be some disturbance to the sea bed. As reef in the area is in good condition, sedimentation caused by anchoring activities may adversely affect the reef in the area. However, given that anchoring method is the least destructive option and construction activities will be for a short period of time, any adverse impact is likely to be limited and easily reversible.

- Construction activities can pose risk to safety of people at work sites including people and workers. Sign boards will be used on safety in all work areas and work will be supervised to ensure safety of community members and workers. Therefore, construction activities are unlikely to have significant impacts on safety of people and workers.
- Pumping groundwater for desalination has the potential to cause drawdown of ground water which may lead to salinization and depletion of groundwater lens. In detailed studies undertaken to date on groundwater aquifer size in Addu atoll, the base of the freshwater lens ranges between 2m in Maradhoo and 24m in Gan, with Gan being an exceptionally large aquifer (Falkland 2001). Borehole will be drilled to a depth of 30m and drawn at a rate of 4.2 cbm/hour. Due to the unconfined nature of the freshwater lens, the proposed pumping may have some drawdown effect. However, considering the depth at which water is withdrawn, the pumping rate and the location of the borehole on the edge of the freshwater lens, it is considered that the drawdown effect on groundwater lens of the island will be minimal and therefore insignificant.

Table 6-3 Evaluation of impacts of project activities on environmental and socio-economic components

		Environmental																		Social										Economic					
	Project activities	Air quality		Noise & Vibration		Groundwater		Soil/Topo		Flora & fauna		Wetland		Marine water		Marine flora & fauna		Reef		Equity		Public safety		Public health		Services		Drought risks		Employmen t opportuniti		Busi opportunitie s		Cost of Living	
Construction Stage	**Installation of desalination plant**	-1	1	-1	1	-1	1	0	0	-1	1			0	0	0	0	0	0	0	0	-1	1	-1	1	0	0			2	1	1	1	0	0
		1	1	1	1	1	1	0	0	2	2			0	0	0	0	0	0	0	0	1	1	1	1	0	0			1	3	1	3	0	0
	Drilling and construction of water intake boreholes	-1	1	-2	1	-1	1	0	0	-1	1			0	0	0	0	0	0	0	0	-1	1	-1	1	0	0			1	1	1	1	0	0
		1	1	1	1	1	2	0	1	1	1			0	0	0	0	0	0	0	0	1	1	1	1	0	0			1	3	1	3	0	0
	Laying of brine discharge pipeline	-1	1	-1	1	-1	0	-1	0	-1	0			-1	1	-1	1	-1	1	0	0	-1	1	-1	1	0	0			1	1	1	1	0	0
		1	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	0	0	1	1	1	1	0	0			1	3	1	3	0	0
	Construction of water storage tanks	-1	1	-1	1	-1	1	0	0	-1	1			0	0	0	0	0	0	0	0	-1	1	-1	1	0	0			1	1	1	1	0	0
		1	1	1	1	1	2	0	0	2	2			0	0	0	0	0	0	0	0	1	1	1	1	0	0			1	3	1	3	0	0
	Construction of fuel storage	-1	1	-1	1	-1	1	-1	0	-1	1			0	0	0	0	0	0	0	0	-1	1	-1	1	0	0			1	1	1	1	0	0
		1	1	1	1	1	2	1	1	2	1			0	0	0	0	0	0	0	0	1	1	1	1	0	0			1	3	1	3	0	0
	Laying of water supply network	-1	1	-1	1	-1	1	-1	1	-1	1			0	0	0	0	0	0	0	0	-2	1	-1	1	0	0			1	1	1	1	0	0
		1	1	1	1	1	1	1	1	1	1			0	0	0	0	0	0	0	0	1	1	1	2	0	0			1	3	1	3	0	0
Operation Stage	**Operation of desalination plant**	-2	3	-1	1	3	3	0	0	0	0			0	0	0	0	0	0	3	2	0	0	3	2	3	2			1	1	0	0	0	0
		3	3	3	1	3	2	0	0	0	0			0	0	0	0	0	0	3	2	0	0	3	2	3	2			3	3	0	0	0	0
	Water intake from borehole	-1	1	0	0	-1	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0			1	1	0	0	0	0
		3	3	0	0	2	2	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0			3	3	0	0	0	0
	Brine disposal to ocean	-1	1	0	0	0	0	0	0	0	0			-1	0	-1	2	-1	2	0	0	0	0	0	0	0	0			1	1	0	0	0	0
		3	3	0	0	0	0	0	0	0	0			3	2	3	2	3	2	0	0	0	0	0	0	0	0			3	3	0	0	0	0
	Supply of product water	-1	1	-1	1	2	2	0	0	1	1			0	0	0	0	0	0	3	2	0	0	2	2	3	2			1	1	0	0	-2	2
		3	3	3	1	3	2	0	0	3	2			0	0	0	0	0	0	3	2	0	0	2	2	3	2			3	3	0	0	3	2
	Handling & storage of chemicals	0	0	0	0	-1	1	-1	1	0	0			0	0	0	0	0	0	0	0	-2	1	-2	1	0	0			1	1	1	1	0	0
		0	0	0	0	3	2	1	2	0	0			0	0	0	0	0	0	0	0	1	1	1	1	0	0			3	3	1	3	0	0
	Waste management	0	0	0	0	3	2	-1	1	0	0			0	0	0	0	0	0	0	0	-2	1	-2	1	0	0			1	1	1	1	0	0
		0	0	0	0	3	2	1	2	0	0			0	0	0	0	0	0	0	0	1	1	1	1	0	0			3	3	1	3	0	0

Table 6-4 Nature and magnitude of impacts on environmental and socio-economic components

		Environmental									Social					Economic				
	Project activities/Causal factors	**Air quality**	**Noise level**	**Groundwater**	**Soil**	**Flora & fauna**	**Wetland**	**Marine water**	**Marine flora & fauna**	**Reef**	**Equity**	**Safety**	**Health**	**Services**	**Drought risk**	**Employment**	**Buss opps**	**Cost of Living**	**Negative**	**Positive**
Construction Stage	Installation of desalination plant	-0.01	-0.01	-0.01	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.07	0.07	0.00	-0.11	0.15
	Drilling and construction of water intake boreholes	-0.01	-0.02	-0.02	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.04	0.04	0.00	-0.09	0.07
	Laying of brine discharge pipeline	-0.01	-0.01	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.04	0.04	0.00	-0.09	0.07
	Construction of water storage tanks	-0.01	-0.01	-0.02	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.04	0.04	0.00	-0.11	0.07
	Construction of fuel storage	-0.01	-0.01	-0.02	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.04	0.04	0.00	-0.10	0.07
	Laying of water supply network	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00	0.04	0.04	0.00	-0.11	0.07
Operation Stage	Operation of desalination plant	-0.67	-0.04	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.44	0.44	0.00	0.11	0.11	0.00	-0.67	2.22
	Water intake from borehole	-0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.00	-0.11	0.00
	Brine disposal to ocean	-0.11	0.00	0.00	0.00	0.00	0.00	0.00	-0.15	-0.15	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.00	-0.41	0.00
	Supply of product water	-0.11	-0.04	0.30	0.00	0.07	0.00	0.00	0.00	0.00	0.44	0.00	0.20	0.44	0.00	0.11	0.11	-0.30	-0.41	1.46
	Handling & storage of chemicals	0.00	0.00	-0.07	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00	0.11	0.11	0.00	-0.15	0.00
	Waste management	0.00	0.00	0.44	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00	0.11	0.11	0.00	-0.07	0.44

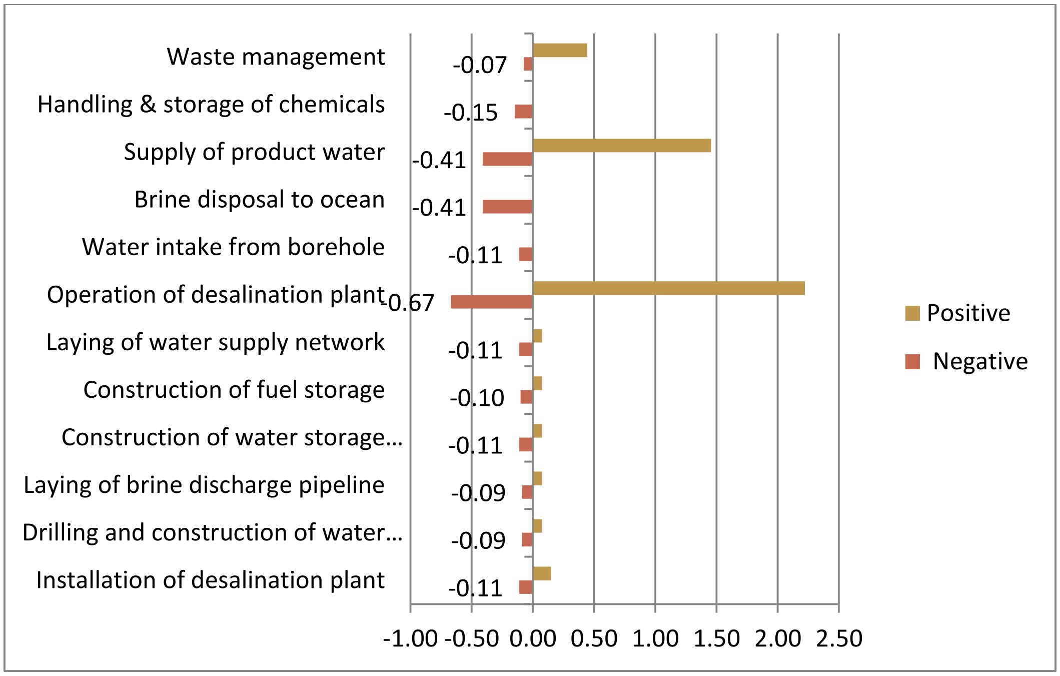


Figure 6-1 Indication of significance of impacts by project activities

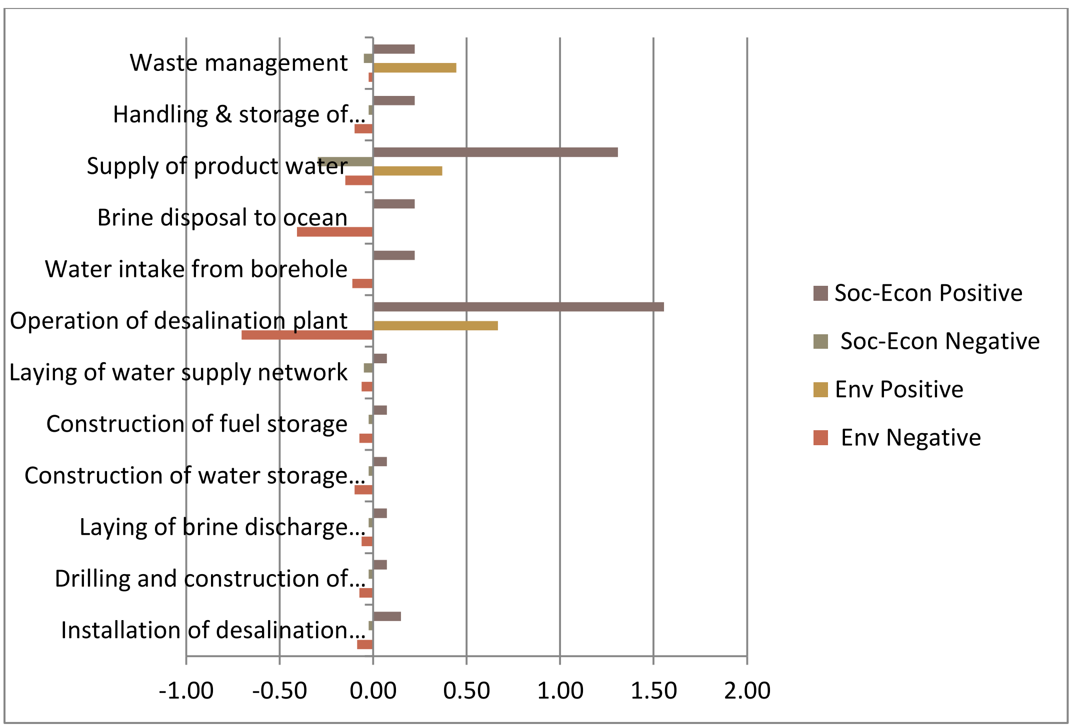


Figure 6-2 Negative and positive environmental and socio-economic impacts for each project activity

According to Figure 6.1 and Figure 6.2, project activities that have significant impacts are:

- Operation of desalination plant
- Brine disposal to the ocean
- Supply of product water
- Handling and storage of chemicals
- Waste management

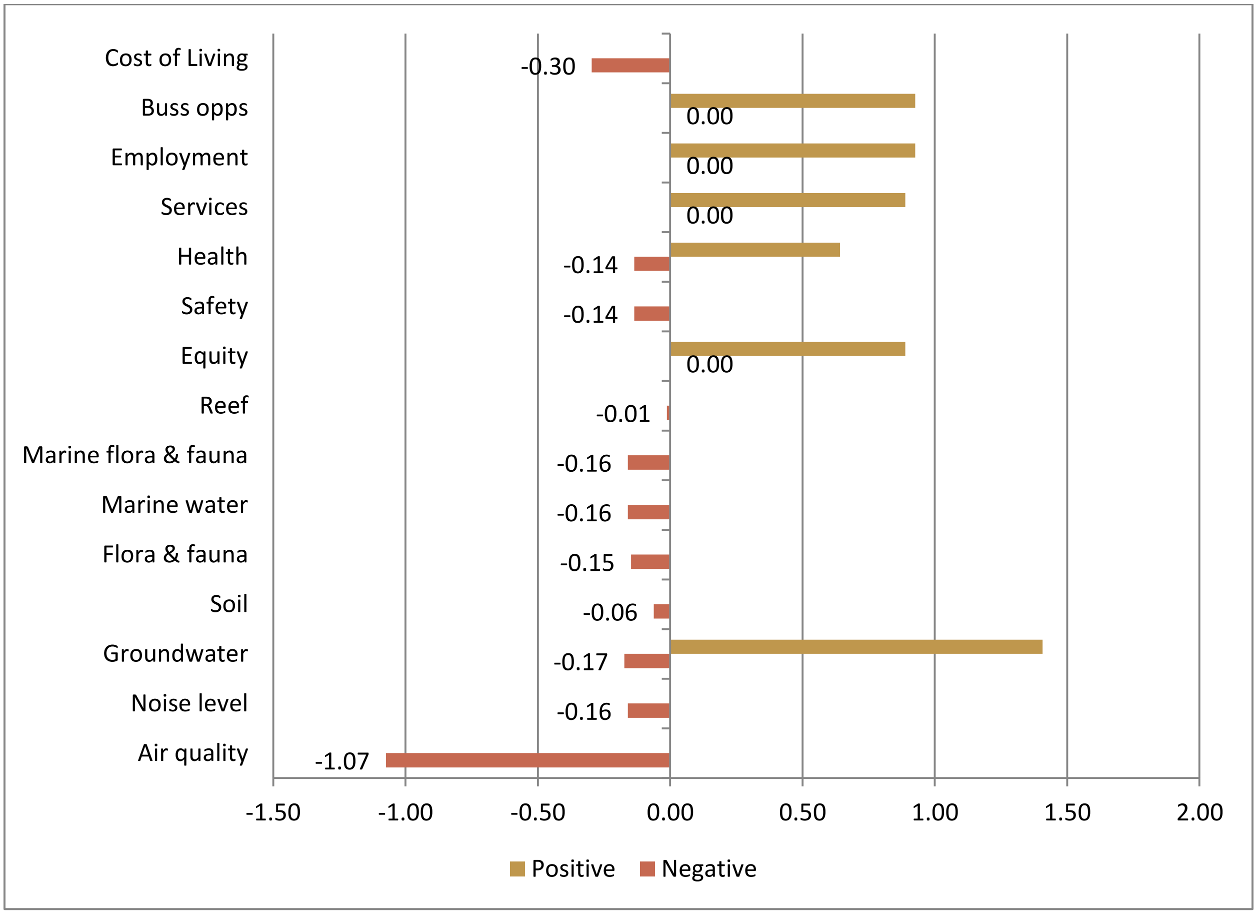


Figure 6-3 Environmental and socio-economic components that are most affected by the project

According to Figure 6.3, the environmental and socio-economic impacts that are most adversely affected by the proposed project are:

- Air quality –power consumption particularly for the operation of desalination plant.
- Groundwater – potential contamination risks during construction stage and handling of chemicals during operation stage.
- Marine biodiversity and reef – potential risk from brine disposal as the condition of the reef in the area is good.
- Noise level – operation of machinery during construction and operation of desalination unit and water pumps during operation stage.

Significant impacts are discussed in detail in Chapter 7 and mitigation measures are proposed to eliminate or minimize adverse impacts where possible.

7 Significant Impacts and Mitigation Measures

7.1 Significant impacts

7.1.1 Air quality degradation

The possible cause for air quality degradation that has significant adverse impacts is the operation of desalination plant.

Energy use is a major factor in the environmental assessment of desalination projects. Energy use associated with the operation of a desalination plant includes the electrical energy produced on site. The total energy demand of the facility comprises the energy for the desalination process, for air conditioning, for lighting and office supplies, as well as the fuel energy used for maintenance visits and employee vehicles. The specific energy demand refers to the energy demand of the desalination process only.

Power requirement for the proposed RO plant will be met by the existing power available from the island. However, additional generators may be required to cater for the future power demand of the RO plant. Since power is generated using diesel generators, air quality will mainly be affected by emissions of greenhouse gases (mainly CO_2), acid rain gases (NOx, SOx) or fine particulate matter (PM10).

There is no air quality standards followed in the Maldives. Generally air quality is regarded as good. It is anticipated that emissions from the proposed project will contribute considerably to other existing or projected air emissions (cumulative impacts) due to the additional power requirement.

Mitigation measures

- Use high grade fuels and appropriate filters in power generation.
- Regular service of generator set, desalination unit and water pumps.
- Explore renewable energy technology options for feasibility.

7.1.2 Degradation of Marine Environment

RO plants generate concentrated brine solution as the effluent from the desalinating process. Brine solution has the potential to kill marine organisms where it is discharged into the marine environment. The brine discharged might contain all or some of the following constituents:

- High salt concentration
- Chemical used during pretreatment stage
- High total alkalinity as a consequence of increasing the calcium carbonate
- (change of pH), calcium sulfate and other elements in the seawater

- Higher temperature of the discharge brine due to the high temperature is used in the desalination facility.

- Toxic metals, which might be produced if the discharge brine has contact with metallic materials used in the plant facilities

It is noted that biocides such as chlorine is used for pre-treatment and periodical membrane and pipe cleaning. Such chemicals in brine may harm the marine environment if they are discharged into the marine environment without treatment. Marine assessment of the proposed brine outfall location shows that the percent of live coral in the area is insignificant. Land and Marine Environmental Resources Group Pvt Ltd (2010) notes that the chloride level of reject water from Male' water supply system is approximately 30% higher than feed water. It is also noted that temperature of the brine from RO plants are near ambient temperature since RO plants do not heat feed water unlike distillation plants. The de-chlorination process of the RO plants may marginally reduce the pH of the waste brine compared to the feed water.

Similarly, heavy metal concentration of the brine generated from RO plants is relatively low. RO facilities are less likely to release heavy metals as they are usually constructed largely of corrosion resistance stainless steel. The RO process also adds treated and cleaning chemicals that can include metals such as iron. However, Land and Marine Environmental Resources Group Pvt Ltd (2010) reports that Iron and Manganese levels tested in reject water by MWSC for Male' water supply system shows that the levels are lower than WHO and EPA guidelines. Based on this observation, it is considered that impact of heavy metal in brine on marine environment will be minor.

Brine will be discharged 20 m from the reef and at 2.4 m depth into the open sea. Adequate flushing and dilution of the effluents is anticipated bringing the effluent to the background salinity of seawater quickly. However, reef at the proposed location is in good condition with reef integrity increasing with depth. Therefore, in spite of expected minimal impact of brine, it is recommended that the location of brine outfall be changed as a mitigation measure.

7.1.3 Groundwater contamination

The operation of a desalination plant requires the routine transport, storage and handling of hazardous materials. These may include chemicals used for:

- Pre-treatment of the intake water against biofouling, scaling, corrosion, etc.;

- Cleaning of the plant to remove biofilms, scales, etc.;

- Membrane preservation during transport and shutdown;

- Product water disinfection and stabilization.

In addition, as power is generated on-site chemicals include diesel as well. In handling and storage of such chemicals, precautionary measures are generally taken to minimize hazards. Under reasonably foreseeable accident conditions, the risk of fire, explosion or release of hazardous materials into the environment is therefore low. However, despite all precautionary measures, a small risk remains that workers, the public or the environment is unexpectedly exposed to hazardous materials. The likelihood of an accident is low; however, in the unforeseen event that hazardous material is released, impacts may be severe (UNEP 2008).

The release of cleaning chemicals in larger quantities by accidental spills during routine transport, handling and storage may cause localized soil contamination. Chemicals may affect water quality if spilled and washed into groundwaters. For example, high and low pH values of strongly alkaline or acidic cleaning solutions could affect the natural pH of the groundwater. Accidental spills into the groundwater may affect the local fauna and flora.

In the Maldives, groundwater contamination can be an irreversible impact due to the absence of impermeable layers to separate the freshwater lens in independent reservoirs. Accordingly, any point sources of pollution would cause the contamination of the entire island groundwater resources. If human consume such contaminated groundwater, it may lead to serious health risks leading to increased public and private health costs. Furthermore, contamination of groundwater will force the local community to rely on rainwater or desalinated water that will be costly. Rainwater can be costly due to the need for increased storage capacity.

To avoid any pollution or contamination of the natural resources, the following measures will be undertaken for better storage and handling of hazardous chemicals and fuel.

Mitigation Measures

- All chemical will be stored in a separate storage section of the RO plant building.
- In transportation, the danger of spilling chemicals into the sea or the coral environment as well as on the island will be reduced by tight fittings and appropriate material.
- Precautions to avoid spilling of chemicals will also be given by instructions to the staff.

7.1.4 Noise pollution

During construction stage, noise pollution and vibrations are likely to be caused by:

- Operation of machinery such as small excavators, dump trucks and concrete machines during construction, excavation and dewatering.
- Drilling of borehole.
- Construction works related to buildings and structures.

Increased noise levels from operation of machinery including drilling and construction works may cause some nuisance to people in the area at the time of undertaking work. Nonetheless, any unfavourable disturbance to public would be short term and limited to duration of construction.

Mitigation Measures

- Vehicles and machinery will be tuned and well maintained to minimise noise emissions.
- Construction work will be carried out during day time to minimise nuisance to the local community.
- Construction work will be carried out in as short a duration as possible.

Furthermore, power generation and operation of desalination plants generate noise that may pose a potential health risk to the people who are working in the area and may cause nuisance to those living nearby the site. For SWRO plants, noise levels of over 90 dB (A) have been reported (UNEP 2008). Major sources of noise during operation of desalination unit include the intake pumps, the RO high pressure pumps and other pumps and equipment such as the different pumps and equipment of the pre-treatment and cleaning systems. The facilities would normally be installed in buildings which may include additional noise attenuation measures, thereby reducing the noise emissions to surrounding areas.

It is reported that continuous exposure to noise levels exceeding 85dBA for more than 8 hours a day is considered hazardous and it is recommended that workers should not be exposed at any time to sound levels exceeding 115dBA, without the use of hearing protectors. Hence, the following mitigation measures are recommended to minimise the impact of noise pollution.

Mitigation Measures

- Make the desalination plant building soundproof as appropriate to anticipated noise levels.
- Provide personal protective equipment such as earmuffs to all staff working in the RO plant.
- Working shifts must be no longer than 8 hours.

7.1.5 Increased cost of living

When the water supply system is operationalized, a consumption-based user fee is expected to be introduced. Given the current economic situation of the country and the high inflation rate, levying a charge on the user will increase the cost of living. This may be taken as an additional burden on the community by some people.

7.2 Cost of mitigation measures

Costs are estimated for the proposed mitigation measures where applicable as shown in Table 7.1.

Table 7-1 Estimated costs of proposed mitigation measures

Mitigation measure	Estimated cost
Use high grade fuels and appropriate filters in power generation.	Project cost
Regular service of generator set, desalination unit and water pumps.	USD750 per month
Explore renewable energy technology options for feasibility.	USD5000

Change proposed location of brine outfall to alternative location	No cost
All chemical will be stored in a separate storage section of the RO plant building.	Project cost
In transportation, the danger of spilling chemicals into the sea or the coral environment as well as on the island will be reduced by tight fittings and appropriate material.	Project cost
Precautions to avoid spilling of chemicals will also be given by instructions to the staff.	USD200
Vehicles and machinery will be tuned and well maintained to minimise noise emissions.	USD5000
Construction work will be carried out during day time to minimise nuisance to the local community.	No cost
Construction work will be carried out in as short a duration as possible.	No cost

8 Alternatives

8.1 No project option

The no project option takes the following into account.

- The island continues without a desalination plant to source freshwater.

The advantages and disadvantages of the no project option are discussed below:

Advantages

- Environmental problems related to development can be avoided

- No developmental cost to the proponent

- Air, noise and brine discharge related pollution due to the operation of desalination plant can be prevented

Disadvantages

- No desalination plant facility will be established to provide sufficient desalinated water to the island.

- Residents of Hithadhoo, keep on using the contaminated groundwater of the island further degrading it.

- Environmental and social problems related to absence of an operational desalination plant facility will exacerbate.

8.2 Alternative brine discharge location

Location:	Existing sewage outfall of the island (Figure 2-2).
Justification:	Sewage is discharge at this location and the coral coverage is significantly low at this site. Main benthic substrate is made up of dead rocks and coral rubble (Figure 8-1).
Change of proposed brine outfall location:	Proponent has changed the initially proposed brine discharge location, after the field assessment to the proposed alternative site (appendix G).

Figure 8-1 Alternative brine discharge location

8.3 Alternative energy source

The option looks into use of a renewable energy source to power the desalination plants.

Advantages

- Use of solar panels concurrently with the power generator to power the desalination plant, this will reduce the total amount of fossil fuels burned, and the amount of Green House Gases released into the atmosphere.

- Solar panels will reduce the overall running cost of the desalination plant.

Disadvantages

- Capital cost of installation of solar panels is very high.

9 Environmental monitoring plan

9.1 Introduction

Environmental monitoring and auditing is an essential component of any project. Under the EIA regulations of Maldives, a detailed monitoring plan is a mandatory component of any EIA. Major areas that will impact the environment should be included in the monitoring programme. In this regard, the project components should specify the location of monitoring points, the parameters to be analysed, and the frequency of such analyses. An appropriate time interval can be planned for monitoring activities that will address the major areas of concern. For the purpose of this project, monitoring should be done for all components of the project that have the potential to influence the environment.

9.2 Construction phase monitoring

Table 9-1 Monitoring programme for construction phase

Monitoring aspect	Indicators	Methodology	Sampling frequency
Marine environment			
Coral reef health	- Percentage of coral cover (both live and dead) - Percentage of recently damaged corals - Numbers, species composition, and structure of fish populations	Photo quadrat survey Fish census At the brine discharge location	Once on completion of construction
Physical conditions of marine environment	Turbidity level	Along the brine discharge pipeline	Once on completion of construction
Seawater quality	Temperature, Salinity, Total Dissolved Solids and pH	Water samples taken from brine discharge location will be tested at a certified laboratory	Once on completion of construction
Terrestrial environment			
Noise level	Ambient noise at perceived high noise areas Workplace noise at perceived high noise areas	Noise meter	Twice during the construction phase

9.2.1 Other monitoring needs

The following aspects will be monitored during the construction stage:

- Daily monitoring to ensure that the cleared areas and other construction processes are not creating any significant dust nuisance for the local environment.
- Daily monitoring of vehicle re-fuelling and repair to ensure that these exercises are carried out on hardstands and to ensure that they are done properly. This is to reduce the potential of soil and groundwater contamination from spills. Spot checks should be conducted by the site supervisor.
- Undertake daily assessment of the quantity of solid waste generated and provide verification of its ultimate disposal.

9.3 Operation phase monitoring

After the completion of the project, monitoring will be continued during the operation phase. The results on the indicators will be used to evaluate changes and impacts on the environment during operation of the water and sewer network. The monitoring programme will be required to ensure the implementation of the recommended mitigation measures and to assess the effectiveness of these measures. Additional locations and parameters with increased or reduced frequency will be identified based on the results of monitoring. Table 9-2 outlines the monitoring programme for the operation phase.

Table 9-2 Monitoring programme for operation phase

Monitoring aspect	Indicators	Methodology	Sampling frequency
Marine environment			
Coral reef health	- Percentage of coral cover (both live and dead) - Percentage of recently damaged corals - Numbers, species composition, and structure of fish populations	Photo quadrat survey Fish census At the brine discharge location	Every 6 months.
Seawater quality at brine outfall	Temperature, Salinity, Total Dissolved Solids and pH	Water samples to be tested at certified laboratory	Every 6 months.
Terrestrial environment			
Noise	Ambient noise Workplace noise	Noise level measuring device	Every 6 months.
Emissions from power generator	CO_2, SO_2 and NO_2	Air quality measuring	Every 6 months

		equipment	
Consumption of chemicals	Volume/quantity of all chemicals stored and used in the desalination plant facility	Daily logs	Daily (if applicable)

9.4 Monitoring Report

A detailed environmental monitoring report is required to be compiled and submitted to the Environmental Protection Agency yearly based on the data collected for monitoring the parameters included in the monitoring programme given in this Chapter. This report may be submitted to the relevant Government agencies in order to demonstrate compliance. The report will include details of the site, strategy of data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed. In addition to this more frequent reporting of environmental monitoring will be communicated among the environmental consultant, project proponent, the contractors and supervisors to ensure possible negative impacts are mitigated appropriately during and after the project.

9.5 Cost of Monitoring

The cost of monitoring is estimated to be US$ 5000 annually. Professional consultants will be hired to undertake the monitoring and the necessary equipment for monitoring will be procured.

9.6 Commitment to Monitoring

The proponent is fully committed to undertake the monitoring programme given in this Chapter. Letter of Commitment is provided in Appendix I.

10 Environmental management plan

This section presents management measures that are required to mitigate adverse environmental and social impacts during the construction and operational phase of the proposed project.

The main objectives of the environmental management plan are to:

- Produce a framework for constructional and operational phase impacts, including practicable and achievable performance requirements and systems for monitoring, reporting and implementing corrective actions
- Provide evidence of compliance to legislation, policies, guidelines and requirements of relevant authorities
- Reduce adverse effects on the environment

10.1 Environmental management system

The environmental management framework for the proposed project is based on the standards and policies set out by the Environmental Protection Agency of the Maldives.

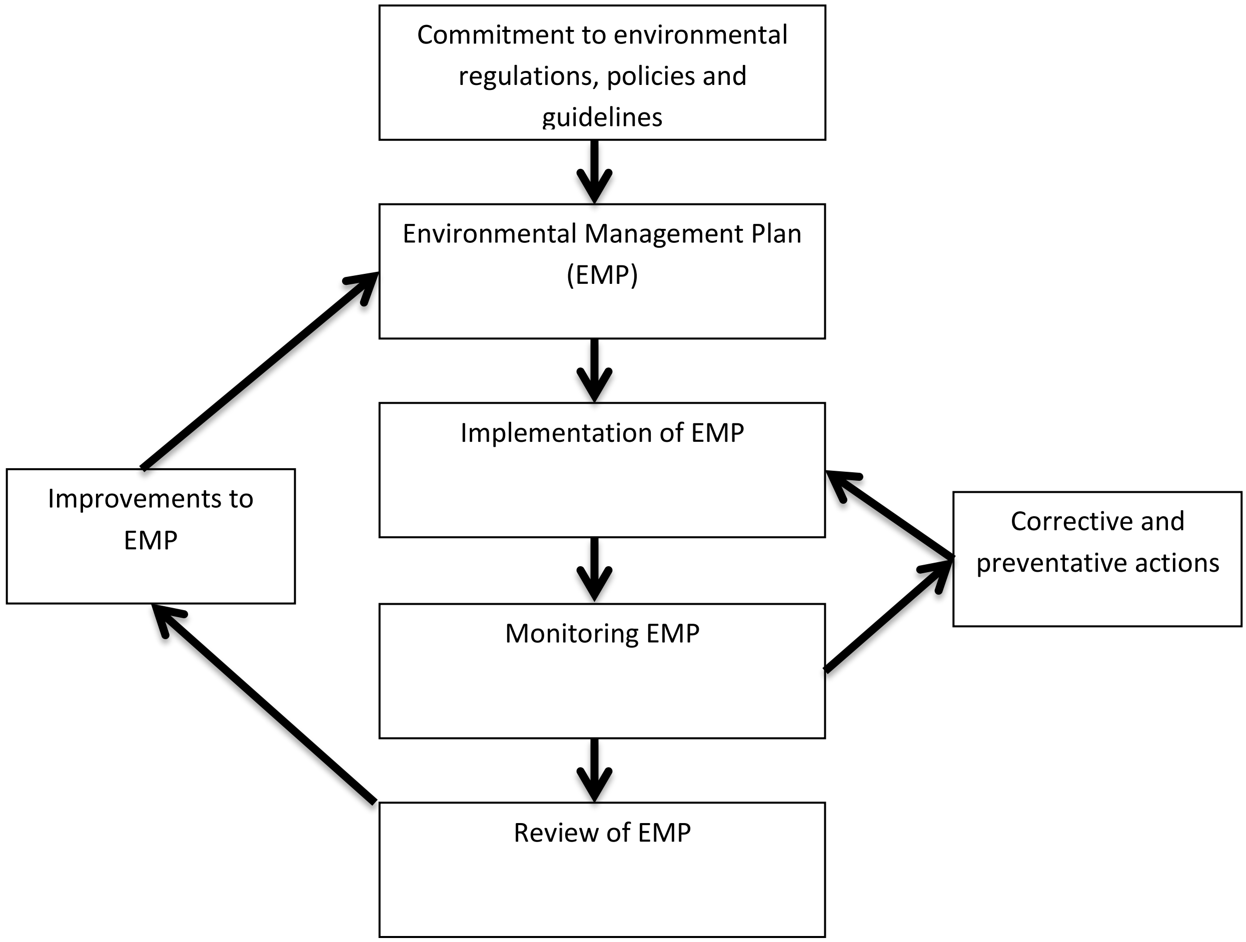
- **Environmental Management Planning and establishment of key performance indicators:** The EMP specifies environmental management measures and required performance standards

- **Desalination plant infrastructure and operations**: The aspects of the desalination plant facility will be established and operated according with the EMP.

- **Monitoring and corrective action**: The implementation of EMP measures will be monitored. Any inconsistencies between the EMP and its on-site implementation will be identified and addressed through corrective actions

- **Auditing, reviews and improvement**: The EMP will be reviewed. Improvements to the EMP will be made as necessary to achieve desired environmental outcomes.

The environmental management strategy is demonstrated in the following figure:



10.2 Management structure and responsibilities

The following parties are involved in the construction and operation of the desalination plant facility:

- Project proponent
- Environmental consultant
- Environmental Protection Agency (EPA)

The roles and responsibilities of the parties involved are described below:

Project proponent

- Responsible for the constructional and operational stage of the proposed desalination plant facility
- Preparation of EMP
- Detailed designs of the desalination plant infrastructures and facilities (operational related)
- Monitoring of the performance of the desalination plant facilities

- Submission of annual environmental monitoring reports as required by the EPA

Environmental Consultant

- Preparation of EMP
- Monitoring of performance of the desalination plant facilities with the EMP
- Auditing the EMP annually to ensure desired outcomes are achieved
- Amendments to the EMP as per results of the annual audits
- Preparation of annual environmental monitoring report to the EPA

Environmental Protection Agency

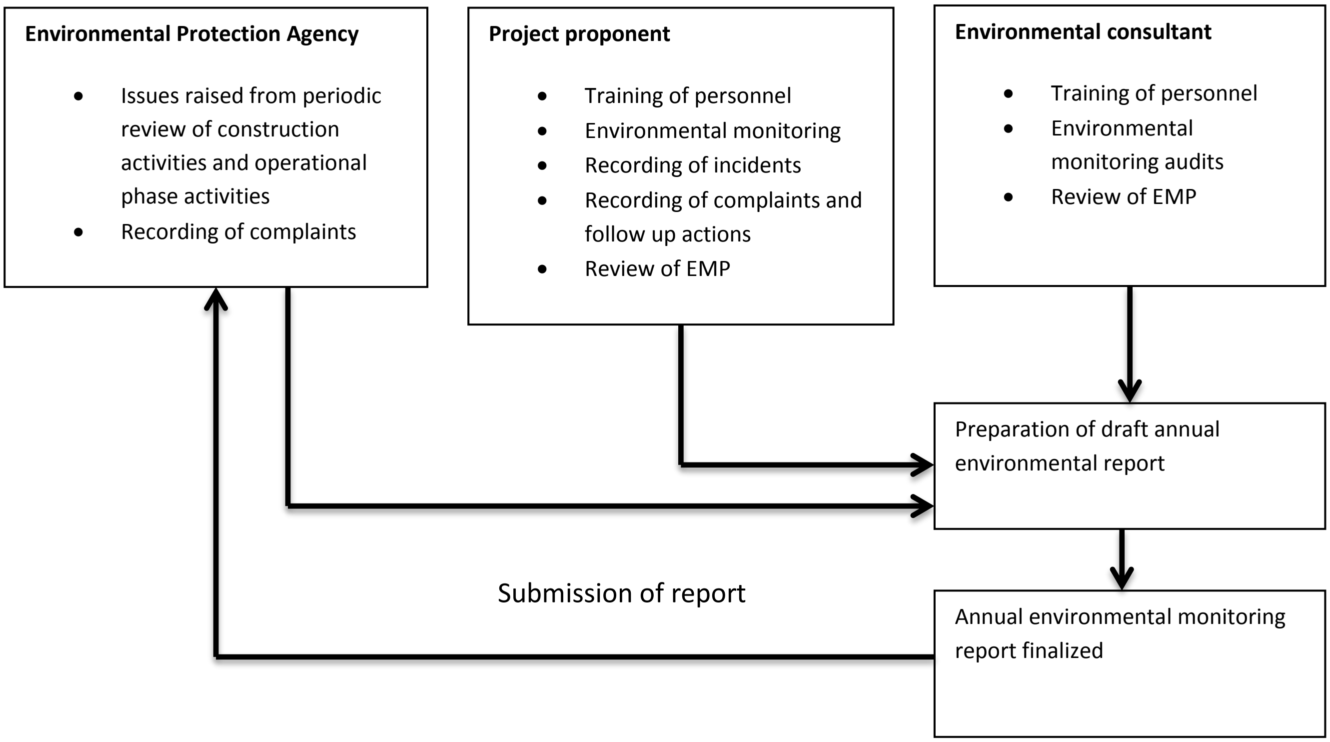
- Review annual environmental monitoring report
- Intervention in the event of a breach in environmental permit conditions

10.3 Reporting requirements

Reporting shall be undertaken to provide evidence of the ongoing implementation of the EMP and will cover training activities, site conditions and operations, monitoring data, details of non-conformances, incidents, complaints and follow up action, results of audits and reviews. Reporting shall be undertaken by the project proponent and the Environmental Consultant.

The reporting shall constitute an annual report of the environmental performance of the desalination plant facility.

The annual environmental reporting process is summarized in the diagram below:



All non-compliances and complaints during the constructional and operational phase of desalination plant facility are to be reported to EPA.

The environmental management plan for constructional phase of the project is provided in Table 10-1 and Table 10-2 presents the EMP for the operational phase of the desalination plant facility.

Table 10-1 Environmental management plan for construction phase

Activity	Management measures	Responsible party	Timing
Training of staff and contractors	All construction workers and project management staff will be provided information on general environmental issues, compliance with environmental permits and EMP. All staff involved with environmental monitoring will be provided training in environmental monitoring procedures.	Project proponent & Environmental Consultant	Before commencement of construction activities

Documenting non-conformances and corrective actions	All non-conformances to the environmental permit conditions, observed during monitoring will be documented. Necessary corrective actions and preventative actions will be identified Corrective actions will be implemented, with systematic follow ups to ensure effectiveness of these measures	Project proponent & Environmental consultant	Continuous during construction phase
Control of air emission (Air emissions generated from vehicles and machineries used for earthworks, borehole drilling etc. Point source and fugitive emissions from construction activities.	Vehicles and machinery tuned and maintained. Construction work to be completed within the shortest possible period. Ground/soil kept damp. Any waste generated will be disposed to the existing waste management site regularly	Project proponent	Continuous during construction phase
Control of noise (Noise and vibrations generated from equipment and machineries)	Nearby communities notified of construction activities and concerns addressed. Construction workers will be provided with proper noise protection gear	Project proponent	Before commencement of construction activities.

Control of water contamination (Operation of machinery. Laying of brine discharge pipeline)	Oil, solid waste and hazardous waste handled carefully and transported in sealed containers. All paints, lubricants, and other chemicals used on site stored in a secure and bunded location. Littering and accidental disposal of construction wastes avoided by preplanning. All raw materials stored away from the vicinity of the coastal areas. General refuse stockpiled in one central area. Construction activities carried out under the supervision of an experienced person. Regular visual inspection of surrounding marine environment for waste	Project proponent	Continuous during construction phase
Waste management (Waste generated from construction activities, the construction workforce will generate domestic and sewage waste)	All waste segregated, stored temporarily and transferred to the existing waste management site.	Project proponent	Continuous, during construction phase

Table 10-2 Environmental management plan for operation phase

Activity	Management measures	Responsible party	Timing
Training of staff and contractors	All desalination plant facility staff and project management staff will be provided information on general environmental issues, compliance with environmental permits and EMP All staff involved with environmental monitoring will be provided training in environmental monitoring procedures, to ensure they have the necessary practical skills to carryout environmental monitoring Desalination plant operation training to staff involved in operations to ensure adequate performance of the facility	Project proponent & Environmental Consultant	Before commencement of operations of the desalination plant facility
Documenting non-conformances and corrective actions	All non-conformances to the environmental permit conditions, observed during monitoring will be documented. Necessary corrective actions and preventative actions will be identified	Project proponent & Environmental consultant	Continuous during operation of desalination plant facility

	Corrective actions will be implemented, with systematic follow ups to ensure effectiveness of these measures		
Control of noise (Noise generated by operation of desalination plant)	The following measures will be placed to manage noise at the desalination plant facility: - Fine tuning and regular maintenance of desalination plant	Project proponent	Continuous during operation of desalination plant facility

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Appendix A - Terms of reference

Appendix B (1) - Specifications of Aqua Reef 25 TPD

Appendix B (2) - Flow diagram of Aqua Reef - 25 TPD

Appendix C - Borehole design

Appendix D - Fish census

Appendix E (1) - Plant house layout

Appendix E (2) - Plant house roof layout

Appendix F - Stakeholder views (raw data)

Appendix G - Water supply network layout

Appendix H - Approved land use plan

Appendix I - Commitment letter for monitoring and mitigation measures