

ENVIRONMENTAL IMPACT ASSESSMENT

For the Proposed Water Supply and Sewerage System

HDh. Nalhivaram

Proponent: Global Wings Pvt. Ltd.



January 2012

Table of Contents

TABLE OF CONTENTS	I
TABLE OF FIGURES	V
TABLE OF TABLES.....	V
1 INTRODUCTION	1
1.1 INTRODUCTION	1
1.2 AIMS AND OBJECTIVES OF THE EIA	1
1.3 METHODOLOGIES	2
1.4 EIA IMPLEMENTATION	2
2 PROJECT SETTING	3
2.1 APPLICABLE POLICIES, LAWS AND REGULATIONS.....	3
2.1.1 Environmental Protection and Preservation Act	3
2.1.2 Land Act	3
2.1.3 Third National Environment Action Plan	3
2.1.4 National Biodiversity Strategy and Action Plan	4
2.1.5 Consultation and Public Participation Laws	4
2.1.6 Regulation on Cutting Trees.....	4
2.1.7 Regulation on Environmental Liability	5
2.2 INTERNATIONAL CONVENTIONS, TREATIES AND PROTOCOLS	5
2.3 WATER AND WASTEWATER REGULATIONS, POLICIES, STANDARDS AND GUIDELINES.....	5
2.3.1 General guidelines for domestic wastewater disposal	7
2.3.2 Design Criteria for Sewerage Systems	8
2.3.3 Design Requirements under CSR Projects	8
2.4 OTHER DEVELOPMENTS.....	9
2.5 ENVIRONMENTAL PERMITS REQUIRED FOR THE PROJECT	9
2.5.1 EIA Decision Statement.....	9
3 PROJECT DESCRIPTION.....	11
3.1 GENERAL CONTEXT OF THE STUDY.....	11
3.2 PROJECT SCHEME	11
3.3 THE PROPONENT	12
3.4 PROJECT LOCATION AND STUDY AREA.....	12
3.5 THE PROJECT	13

3.5.1	Brief Description of the Proposed Concepts	13
3.5.2	Project Duration.....	15
3.5.3	Environmental Design Consideration	15
3.5.4	Effluent Collection and Disposal	15
3.5.5	Proposed Sea Outfall Locations	15
3.5.6	Process and Materials	16
3.5.7	Construction Materials	16
3.6	IMPLEMENTATION SCHEDULE	16
3.7	IMPLEMENTATION PHASE ACTIVITIES	16
3.7.1	Site Preparations.....	16
3.7.2	Mobilization of Equipment and Materials	17
3.7.3	Workforce and Services	17
3.7.4	Material Transport	17
3.7.5	Waste Management	17
3.7.6	Pollution Control and Waste Minimization.....	17
3.7.7	Health and Safety.....	18
3.8	OPERATIONAL PHASE ACTIVITIES.....	18
3.8.1	Effluent Disposal	18
3.8.2	Brine Disposal	18
3.8.3	Sewage Treatment.....	18
3.8.4	Feed water Intake	19
3.8.5	Sludge Handling	19
3.9	PROJECT INPUTS AND OUTPUTS	19
3.10	NEED AND JUSTIFICATION	20
4	PROJECT ALTERNATIVES	25
4.1	NO PROJECT OPTION	25
4.2	ALTERNATIVE OUTFALL.....	26
5	METHODOLOGY	27
5.1	GENERAL DATA COLLECTION METHODOLOGIES	27
5.1.1	Groundwater and marine water quality	27
5.1.2	Ocean Currents	27
5.1.3	Condition of the House Reef.....	28
6	EXISTING ENVIRONMENT.....	29
6.1	GENERAL METEOROLOGICAL CONDITIONS	29
6.1.1	Wind.....	30

6.1.2	Rainfall	31
6.2	NATURAL HAZARD VULNERABILITY	31
6.3	EXISTING COASTAL AND MARINE ENVIRONMENT	32
6.4	OCEANOGRAPHY	32
6.4.1	Waves.....	32
6.4.2	Water Currents	33
6.5	MARINE ENVIRONMENT	34
6.5.1	Currents	34
6.5.2	The Reef System and Reef Aesthetic	35
6.5.3	Reef Survey	35
6.5.4	Marine Water Quality	37
6.6	TERRESTRIAL ENVIRONMENT	38
6.6.1	Geological Settings and Hydrogeology	38
6.6.2	Current Sewage Disposal Practices.....	39
7	STAKEHOLDER CONSULTATIONS	40
7.1	SCOPING MEETING	40
7.2	CONSULTATIONS WITH THE PROPONENT	40
7.3	COMMUNITY CONSULTATION	40
8	IMPACTS AND MITIGATION MEASURES.....	42
8.1	IMPACT IDENTIFICATION	42
8.2	IDENTIFYING MITIGATION MEASURES	43
8.2.1	Mitigation Options	43
8.3	EXISTING ENVIRONMENTAL CONCERNS	43
8.3.1	Natural Hazard Vulnerability.....	43
8.4	OVERALL IMPACTS OF THE PROPOSED PROJECT	44
8.5	IMPACTS FROM IMPLEMENTATION	46
8.5.1	Mobilization	46
8.5.2	Machinery	46
8.5.3	Impacts from Materials.....	47
8.5.4	Impacts from Excavation.....	47
8.5.5	Installation of Sewage and Brine Outfalls	48
8.5.6	Changes in Coastal Water Quality.....	49
8.5.7	Impacts on Baitfish, Reef-fish and Other Marine Organism	49
8.5.8	Health and safety	49
8.6	OPERATION IMPACTS	50

8.6.1	Impacts from Operation of Sewage System	50
8.6.2	Transport Related Impacts.....	51
8.6.3	Socio-Economic Impacts	51
8.7	UNCERTAINTIES IN IMPACT PREDICTION	55
9	ENVIRONMENTAL MONITORING.....	56
9.1	INTRODUCTION	56
9.2	MONITORING REQUIREMENTS.....	57
9.2.1	Coral Reef Monitoring.....	57
9.2.2	Water Quality Monitoring.....	58
9.2.3	Monitoring dewatering impacts	58
9.2.4	Socio-Economic Aspects	58
9.3	RECOMMENDED MONITORING PROGRAMME.....	59
9.4	COST OF MONITORING.....	60
9.5	MONITORING REPORT.....	61
10	DECLARATION OF THE CONSULTANTS	62
11	SOURCES OF INFORMATION	63
	APPENDIX 1: TERMS OF REFERENCE	66
	APPENDIX 2: COMMITMENT LETTER FROM THE PROPONENT TO UNDERTAKE MONITORING.....	69
	APPENDIX 3: IMPACT IDENTIFICATION CHECKLIST	70

Table of Figures

Figure 3-1: Nolhivaram located between the regional airport and the capital of HDh. Atoll.....	12
Figure 3-2: Proposed sewerage system	23
Figure 3-3: Proposed water supply system	24
Figure 4-1: Alternative locations	26
Figure 6-1: General wind rose diagram for the Maldives (source MEEW 2005).....	31
Figure 6-2 Location of drogoue tests conducted around Nolhivaram	34
Figure 6-3. Quadrate Survey north corner	37

Table of Tables

Table 2-1: Recommended effluent quality standards.....	7
Table 3-1: Matrix of key inputs	19
Table 3-2: Matrix of major outputs	19
Table 4-1: Advantages and disadvantages of the no project option	25
Table 6-1 Key meteorological information in Maldives	29
Table 6-2 Summary of seasons in the Maldives	30
Table 6-3 Water quality results	37
Table 6-4 Groundwater quality results	39
Table 8-1 Matrix of key components which may impact to environment during implementation and in operation phase.....	45
Table 8-2: Summary of socio-economic and environmental impacts of the proposed project	52
Table 8-3: Summary of mitigation measures	53
Table 9-1: Coral reef system monitoring programme matrix	57
Table 9-2: Monitoring water quality	58
Table 9-3: Indicators for monitoring of socio-economic aspects of the project.....	59
Table 9-4: Estimated cost of the proposed monitoring programme (annual)	60

1 Introduction

1.1 Introduction

This EIA report has been prepared in order to meet the requirements of Environment Protection and Preservation Act of Maldives (Law No 4/93), in particular Clause 5 of this Act, to assess environmental impacts from proposed water supply and sewerage system in HDh. Nolvivaram. Clause 5 of Environmental Protection and Preservation Act (Law No. 4/93) of the Maldives states that an Environmental Impact Assessment (EIA) study need to be carried out before implementing any development project which may have potential impacts on the environment. Additionally, under Clause 1 of this Act (Law No 4/93) it is very clear that the natural environment and its resources are a national heritage that needs to be protected and preserved for the benefit of future generations. Hence protection and preservation of these resources of this country including land, fresh water, flora and fauna, beaches, reefs, lagoons and all natural habitats are important for the sustainable development of the country.

This report will identify the potential impacts of the proposed project and will recommend mitigation measures to minimize such impacts during construction and operation phase. This report will also look at the justifications for undertaking the proposed project components including alternatives to proposed components or activities in terms of location, design and environmental considerations. At the end of the report a mitigation plan and a monitoring programme before, during and after the development work would also be included.

The findings reported in this report are based on qualitative and quantitative assessments undertaken during a site made to HDh. Nolvivaram in January 2012 and professional judgments. The key limitation similar to other such studies is unavailability of long term site-specific baseline data; hence the impact assessment methodology has been restricted to field data collected, experience and professional judgment on similar settings across Maldives and elsewhere. Long term data relevant to this report on specific aspects such as meteorology and climate were collected from global databases through secondary sources and published reports on Maldives.

This EIA report has been produced in accordance with the EIA Regulations 2007, published by Ministry of Environment, Energy and Water which at present is enforced by Environment Protection Agency (EPA) of the Maldives under Ministry of Housing and Environment (MHE).

1.2 Aims and Objectives of the EIA

This report addresses the environmental concerns of the proposed water supply and sewerage system development project at HDh. Nolvivaram. It helps to achieve the following key objectives.

- Allow better project planning through identification of key impacts and measures for mitigating these impacts
- Ensure efficient resource use, minimize serious and irreversible damage to environment
- Ensure and allow informed and environmentally sound decision making
- To demonstrate the commitment by the proponent on the importance of environmental protection and preservation.

1.3 Methodologies

Established and widely accepted methods have been applied in this EIA study. This study was based mainly on data collected during a field investigation visit made to HDh. Nolvivaram by a team of surveyors from Sandcays Pvt. Ltd. in January 2011 and published literature on similar settings. Sandcays Pvt. Ltd is an environmental consultancy firm registered in the Maldives. The data collection methods are described in detail under Section 5.

1.4 EIA Implementation

This EIA has been prepared by Ahmed Zahid who is also the lead EIA consultant of the proposed project. He has over 15 years of experience in the field of Environmental Impact Assessment in the Maldives. Zahid has been involved in several small island coastal, harbour, land reclamation, water/sewerage project and resort development project EIA's undertaken in the Maldives.

Once the EIA has been submitted it is expected that the review process will not take more than 4 weeks. The review process may result in the requisition of additional information. This EIA has been prepared based on an approved term of reference (TOR) given in Appendix 1.

2 Project Setting

The proposed project takes place in the Maldives environment. Therefore, the extent to which the project conforms to existing plans, policies, guidelines, regulations and laws of the Maldives needs to be considered. Under EIA regulation 2007, all prescribed activities in Schedule D of EIA regulation 2007 are required to carry out a detailed EIA study to obtain environmental clearance before commencing any physical work on the project. Water supply (desalination) and sewerage system development is a prescribed activity under Schedule D of Maldives EIA Regulations 2007 formulated under the umbrella law of Maldives Environment Protection and Conservation Act (Law No.4/93). Hence, this section will look at the context in which the project activities take place and the legal/policy aspects relevant to activities anticipated in the proposed project.

2.1 Applicable Policies, Laws and Regulations

2.1.1 *Environmental Protection and Preservation Act*

The Articles of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the following aspects of environmental management, which are relevant, understood and adhered to in the proposed project.

- An EIA shall be submitted to EPA before implementing any developing project that may have a potential impact 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 Penalty for Breaking the Law and Damaging the Environment are specified in the Law.
- The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

2.1.2 *Land Act*

The land Act of Maldives (Law No. 1/02), formulated in 2002, makes legal provisions for releasing of lands for different needs, releasing of public land for housing and the conditions that govern the owning, selling, renting and transfer of ownership of public and private land. This Act may have some relevance to the project, especially with reference to components such as treatment plant.

2.1.3 *Third National Environment Action Plan*

The Third National Environment Action Plan or NEAP 3 published in 2009 was divided into principles, results and goals to achieve the results. The NEAP 3, 2009 is founded on ten fundamental principles. Principle 1 states that

environmental protection is a responsibility of every individual. Some of the fundamental principles prescribed in NEAP 3, which have been incorporated into this environmental impact assessment exercise include informed decision making, continuous learning and improvement and most importantly the complementing role of environmental protection in socio-economic development.

2.1.4 *National Biodiversity Strategy and Action Plan*

The goals of the National Biodiversity Strategy and Action Plan are:

- Conserve biological diversity and sustainably utilize biological resources.
- Build capacity for biodiversity conservation through a strong governance framework, and improved knowledge and understanding.
- Foster community participation, ownership and support for biodiversity conservation.

In implementing the proposed project activities care need to be taken to ensure that the national biodiversity strategies are adhered to.

2.1.5 *Consultation and Public Participation Laws*

In the Maldives public participation has been limited to the review stages of the EIS until recently. However with the EIA Regulation 2007, which considers public consultation as an important and integral part of the EIA process, public consultation is a requirement for all EIA reports. Hence, this EIA has also taken public views into consideration. In fact, public consultation was conducted in order to take public opinion, views and expectations into the project and not simply to fulfil the obligations under the EIA Regulation.

2.1.6 *Regulation on Cutting Trees*

The Regulation on cutting down, uprooting, digging out and export of trees and palms from one island to another was issued by the Ministry of Environment in 2006. Clause 5 (a) of the Regulation states that prior to the commencement of any project(s) that would require the 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 Environmental Impact Assessment report.

Article 8 (a) requires permission be obtained from Ministry of Environment, if more than 10 coconut palms that are of a six of 15 ft (from base of the palm to the tip of the palm frond) are cut, uprooted or relocated to another island. The regulation also ensures the replacement of the vegetation that is lost by imposing the planting of two palms for every palm tree that is cut or uprooted (Article 2 (d)). Logging on inhabited islands must be done under supervision of the islands chief or an official appointed by the island chief (now Island Council) (Article 8 (c)).

The proposed sewerage project in Nolvivaram involves some clearing of land for infrastructure development, especially at pumping station locations. No major trees are expected to be felled under the project.

2.1.7 Regulation on Environmental Liability

The Environmental Liability Regulation (Regulation 2011/R-9) came into force on 17 February 2011 covers a wide range of issues which enable charging penalties and compensation due to environmental pollution and environmental damages. Apparently, the key objective of the environmental liability regulation is to practice polluter pay principles in the Maldives.

2.2 International conventions, treaties and protocols

Some of the international conventions, treaties and protocols of relevance to the proposed project may be identified as follows:

- **United Nations Convention on Climate Change (UNFCCC) and the Kyoto Protocol** which aims at minimising greenhouse gases to reduce or combat potential impacts of global climate change, global warming and associated effects such as sea level rise, which are thought to have devastating impacts on the Maldives, a fragile small island nation. The aspects of the proposed project that apply to this convention are the importation and transport of raw material to site using diesel based vessels, use of excavators and other machinery in the construction phase, especially their emissions as well as the use of pumps which consume electricity from diesel generators emitting greenhouse gases. These are unavoidable impacts; however, efforts should be made to minimize all such impacts. These are discussed in the impacts mitigation section.
- **United Nations Convention on Biological Diversity (UNCBD)** with the objective of “the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding”. Maldives was one of the first nations to ratify UNCBD. Maldives has developed the National Biodiversity Strategy and Action Plan (NBSAP) in 2002. Formulation of NBSAP was through wide consultation and extensive stakeholder participation. As mentioned earlier, there has been extensive consultation and environmental surveys undertaken to ensure that biological diversity is not affected due to the implementation of this project.

2.3 Water and Wastewater Regulations, Policies, Standards and Guidelines

In the past decade or so, as regulator of water and wastewater, Maldives Water and Sanitation Authority (MWSA) has mainly focused on regulating the service provider, Malé Water and Sewerage Company, MWSC and environmental controls have not been given adequate emphasis. With the functions MWSA incorporated into the functions of Environment Protection Agency formed in early 2009, it is believed that much will be done in improving the regulatory framework for water and sewage disposal.

Although several attempts have been made to introduce regulations and standards, they are still at a draft stage. Consequently, upon increasing requests from donors under the tsunami relief assistance programmes, the Maldives Water and Sanitation Authority drafted the General Guidelines for Domestic Wastewater Disposal in the Maldives in March 2006. This document was developed by the staff of MWSA at the time. The document was later revised by a technical team from South Africa and disclosed for internal use and comments in January 2007 as National Wastewater quality Guidelines. These guidelines were publicized on MEEW website in 2008 along with a Water and Sanitation Policy Statement but were later removed and never used and made public. Later in May 2010, EPA discussed with stakeholders draft documents developed with technical assistance from JICA. These are

- Guideline of Sewerage Concept Design and Design Review (Draft)
- Standard Procedure of Sewerage concept Design
- Standard Check-list of Outsourced Design (Draft)

Despite the draft of several documents relating to wastewater and sewerage system design the only document made publicly available is the General Guidelines for Domestic Wastewater Disposal. Therefore, this document has been discussed in detail in this EIA report.

The Maldives adheres to WHO guidelines for its drinking water standards. However, due to the small size of the islands and the time water remains within the waterworks, free chlorine levels have been set below WHO guideline values. This adjustment has been made mainly due to public complaints of chlorine levels in their drinking water but has not been technically justified. Therefore, this has been recently revised.

Currently, there are no surface water quality standards for the Maldives, but this issue has been addressed in the “Guidelines for Domestic Wastewater Disposal” in the Maldives. The pristine nature of the Maldivian waters requires high standards to be met. Given the existing concerns of raw sewage disposal and wastewater disposal within the coastal zone, there should be surface water quality standards that ensure that the pristine state of the coastal waters of the country as a whole is not affected. There are also standards set by the Ministry of Tourism for the tourist resorts. These are derived from stringent international standards.

Effluent quality standards are also non-existent in the Maldives. Some standards were recently drafted by a South African team. These were disclosed for internal use and comments in January 2007 as National Wastewater quality Guidelines. These guidelines were publicized on MEEW website in 2008 along with a Water and Sanitation Policy Statement but were later removed and never used and made public. Later in May 2010, EPA discussed with stakeholders draft documents developed with technical assistance from JICA in which some effluent quality standards were laid down. However, none of these documents have been finalized and made available to the public. Therefore, for reference, the standards given in Table 2-1 are suggested. These effluent quality standards are based on standards of some developed countries and, especially WHO standards.

Table 2-1: Recommended effluent quality standards

Parameter	Description	Standard
Temperature	An important determinant because of its effects on chemical reaction, reaction rates, aquatic life and suitability for beneficial uses	<40 ° C
pH	Hydrogen ion concentration is an important quality parameter of both natural water and wastewater. Concentration range suitable for the existence of most biological life is quite narrow and critical	5-9
BOD ₅	Most widely used parameter of organic pollution applied to both wastewater and surface water is the 5-day biochemical oxygen demand (BOD ₅). Treated effluents should usually meet this criterion.	20-60 mg/l
COD	Chemical oxygen demand (COD) test is used to measure the contents of organic matter of both wastewater and industrial water. This test is also used to measure organic matter in wastewater that contains compounds that are toxic to biological life. COD of wastewater is in general higher than BOD, because more compounds can be chemically oxidized than can be biologically oxidized.	120 mg/l
Total Suspended Solid (TSS)	This is also one of the most important contaminants of concern in wastewater treatment. Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged in the environment.	150 mg/l

2.3.1 General guidelines for domestic wastewater disposal

“General Guidelines for Domestic Wastewater Disposal 2006” was a result of a series of questions raised by donors following the tsunami of December 2004 due to the absence of any regulations or guidelines to follow in the design of sewerage systems. Although the Guidelines were the first public document demanding the application for a permit and subsequent approval before installation of a sewerage system in the Maldives, the guidelines lack legal backing. The guidelines require all wastewater management systems to meet prescribed criteria for the use of groundwater, design for easy access for maintenance and durability and undertake monitoring and provide facilities for sampling final effluent. Monitoring requirements have been set for monthly monitoring and annual monitoring of groundwater quality.

It is evident from the guidelines that the guidelines have been set for domestic wastewater since it is stated that industrial effluents require special permits from the Authority. Also, the guidelines have been set specifically for wastewater disposal into the groundwater aquifer as receiving water quality objectives have been set only for groundwater and analysis schedule is also for groundwater. The guidelines also focus mainly on on-site wastewater disposal systems, with specific reference to septic tanks. However, it is stated that:

“Where a sea outfall is used it should be placed away from areas such as commercial harbours or areas designated for recreational purposes. The sea outfall must be placed in such a way that the effluent will be flushed out into the deep sea, where it can be diluted and dispersed so that the impact on the marine environment is reduced. Untreated wastewater shall not be disposed into the near shore lagoon.”

The Guidelines also provides for Environmental Impact Assessment for sewerage project and states that:

“All sewerage projects have to undertake the Environmental Impact Assessment (EIA) as required by Ministry of Environment, Energy and Water (now Ministry of Transport, Housing and Environment) and then submit the EIA

Decision Note to the Authority. The EIA must in particular assess the impact of the proposed project upon the island's water resources and receiving waters, including an assessment of the groundwater sustainable yield, quality and anticipated impacts/changes resulting from the project."

The Guidelines were a good starting point but needs to be reviewed in view of existing concerns, especially with regard to legitimacy and authority. The recent developments including the South African and JICA documents are very much improved and would be useful if they can be publicised.

2.3.2 Design Criteria for Sewerage Systems

In early 2007, MWSA prepared design criteria for sewerage systems. These include design standards, testing requirements, submittals and drawing standards, impact analysis procedures and service fee requirements. Some important considerations are that:

- All buildings shall be connected to sewer lines
- Storm water drainage can be deviated to sewers with special permission
- Sewerage system design shall allow for sewage resulting from future landuse and new reclamation
- Sewerage systems shall be designed with a single outfall. If multiple outfalls are required, pumping stations shall be provided
- All systems shall have a bypass sea outfall
- An operation and maintenance manual shall be furnished for all sewerage projects

These design criteria has been taken into consideration in finalizing the design for the proposed sewerage system in Nohivaram. Since its implementation, the Design Criteria has been used by engineers in designing sewerage systems for the islands of the Maldives. However, as indicated in the water and sanitation policy statement, there is a need to increase awareness about the Design Criteria and further discussion with engineers and other technical personnel working in the sector to address current concerns is important. It is believed that the Design Criteria has been subject to some criticism especially with regard to specific references to water consumption and pipe diameters. Such issues are being given further consideration by the Water Section of the EPA.

2.3.3 Design Requirements under CSR Projects

Design requirements for water supply and sewerage under CSR projects have been provided to all Proponents under CSR scheme. These requirements specify the type of system (gravity system with the least number of force mains and potential for treatment in five years), type of sizes of pipes for the different pipelines, design period and other design criteria. These have been taken into consideration in developing the preliminary design that goes with the EIA report. Detailed design will further elaborate on those requirements.

2.4 Other Developments

As has been indicated earlier, there are several shortcomings in the water and sanitation sector, which needs to be addressed soon. The new administration is trying to address the shortcomings of this very important sector by formulating policies and strategies which are discussed in the recently published Strategic Action Plan, “Aneh Dhivehiraajje”. In this strategic plan, water and sanitation is recognized as a basic human right and universal access without prejudice is the key target and strategy. The goals of the sector highlighted in the Action Plan includes protection and preservation of freshwater resources, private sector involvement for service provision regulated by the Government, renewable energy use for water supply and sanitation and groundwater protection. Some of the important policies outlined in the Action Plan include improving accessibility, prioritize water and sanitation in development planning and implementation, establish effective maintenance procedures, facilitate private sector investment, strengthening legal and institutional framework, water resource management for environmental preservation and water safety for public health.

In terms of strengthening the legal framework, the Strategic Action Plan refers to the existence of a draft National Water Act, and stresses the need for a separate Sanitation Act. While there is ample research and strategic planning throughout the world to integrate water and sanitation, it is questionable why the Maldives is opting to two different pieces of legislation for Water and Sanitation. The Action Plan also identified that there would be a legal framework for the establishment and management of provincial utilities companies, which have been formed recently with the objective of managing water supply, sewerage and electricity services in the islands. The Proponent, Upper North Utilities Ltd. is amongst those companies.

In addition to the Act(s) or legislative aspects, some of the important strategies that have been highlighted include (1) seeking the most appropriate sewerage systems for the Maldives, (2) establishing mechanism for wastewater research in the country, (3) seeking immediate measures to stop groundwater pollution, (4) integrating water resource planning into landuse planning, (5) establishing effective water resource monitoring programmes, (6) preparing an inventory of natural catchments and (7) developing water safety plans and water quality monitoring capacity at island level.

2.5 Environmental Permits required for the Project

2.5.1 *EIA Decision Statement*

The most important environmental permit to initiate the proposed water and sewerage system in Nohivaram would be a decision regarding this EIA from the Environmental Protection Agency (EPA). The **EIA Decision Statement**, as it is referred to, 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 Statement may only be given to the Proponent after a review of this document following which the EPA 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 EPA may provide the Decision Statement while at the same time requesting for further information.

3 Project Description

3.1 General context of the study

In the Maldives, water and sewerage infrastructure development and institutional reforms process, until 2004 tsunami was at a very slow pace - the sector, apparently, was ignored. Similar to other developing regions across the globe particularly in small islands states, sanitation and sewerage infrastructure projects in Maldives have been less favoured by politicians. The 2004 tsunami disaster which hit part of Maldives is considered to be the benchmark of beginning water supply and sewerage infrastructure development work across Maldives, particularly in outer islands outside Male'. Nearly 4.5% islands across Maldives until 2004 tsunami were developed with sewerage systems on various system designs including simplified shallow small bore gravity sewers, shallow gravity sewers with household septic tanks and gravity lagoon outfalls', with gravity sewers with household catch pit to beach wells and conventional deep gravity sewers etc. Still the progress in bringing the development of sanitation sector is slow apparently due to lack of good will and commitment. According to government sources by end of 2010 improved island wide sewerage systems have been established 11% islands.

The project as per the concept design available to consultant at the time this report was compiled has been designed to cover the entire community. The system has been proposed to develop with gravity main sewers, lift stations, road manholes, main sumps and forced sea outfalls.

This EIA study will help to identify and assess environmental impacts (positive and negative) and to recommend mitigation measures for minimizing or eliminating the negative impacts during construction and operation phase. This study will also cover the socio-economic aspects of the community and their perception towards implementing the proposed sewerage project.

Similar to other such projects, this project also will have direct and indirect impacts to the environment including loss of vegetation, impacts to terrestrial and aquatic species and contamination of soil, impacts to groundwater aquifer and marine environment etc. The impacts depending on the intensity, duration and type will be of short and long term, reversible and irreversible. Therefore, measures to mitigate and alternatives have been suggested that may either eliminate or minimize impacts to environment.

3.2 Project Scheme

The project is one of the water supply and sewerage projects that have been formulated under CSR (Corporate Social Responsibility) scheme. CSR is a concept where business establishments integrate social and environmental concerns in their business operations or commitments given by such business establishments to contribute to sustainable economic development through improved livelihood. Providing access to clean safe

water and improved sewerage facilities in island communities across Maldives have been one of the priorities of government. The concept has not been widely practiced among the business communities in Maldives perhaps due to absence appropriate government policies.

3.3 The Proponent

The proponent of the proposed water supply and sewerage project in HDh. Nolvivaram is Global Wings Pvt. Ltd., a company registered in Maldives under the laws and regulation of Maldives.

3.4 Project Location and Study Area

Nolvivaram is a medium-sized Island located in the Haa Dhaalu Atoll. It is located at about 277 km from Malé and around 4 km from Kulhudhuffishi, capital of Haa Dhaalu Atoll and midway between the Regional Airport in Hanimaadhoo and Kulhudhuffushi. It can be easily reached by air and sea. The island's population lives in the middle of the island leaving ample green space on all sides around the island. Hence, agriculture is well practiced with betel, coconuts, bananas, chillies and breadfruit being the dominant agricultural produce. Fishing is the main economic activity while involvement in the tourism sector by the youth is on the increase.

The proposed study area comprises the island and lagoon and reef areas at proposed and potential outfall locations around the island.

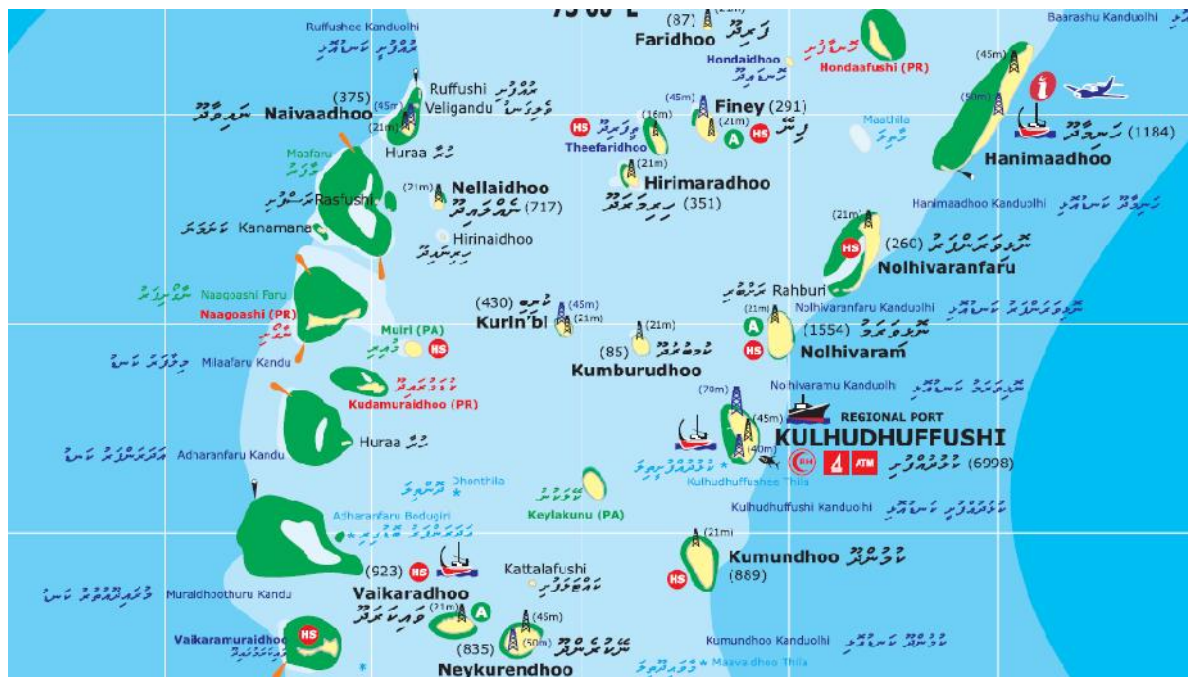


Figure 3-1: Nolvivaram located between the regional airport and the capital of HDh. Atoll

3.5 The Project

The proposed project involves the design and installation of a water supply and sewerage system in Nolhivaram, Haa Dhaalu Atoll, Maldives. The proposed sewerage system is a small flow sewerage system conveying sewage and wastewater through gravity sewers, rising mains and pumping stations, treatment plant at a second phase and ultimately disposed off beyond the reef. The proposed water supply system is a reverse osmosis desalination plant with metered connections to households.

The scope of the project involves hydraulic studies, environmental impact assessment, socio economical assessment and other studies to assess the problems that would satisfactorily help to achieve the project objectives to install a technically sound and environmentally sustainable as well as socially acceptable sewerage system. Therefore, a conceptual layout for a sewerage system was developed based on the findings of the above mentioned studies. It is proposed for Nolhivaram to have a comprehensive sewerage network with a single outfall. In the initial design finalized in 2009, a vacuum sewerage system has been proposed. A preliminary design was therefore developed based on the initial survey but completely abandoning the design proposed earlier for a vacuum system as it is required under the CSR project that a gravity system with pumping stations has to be proposed. It is also required that the maximum depth of excavation should be 2.5m below the ground surface, therefore lift stations had to be provided. Taking this into consideration and in lieu of minimizing the electricity demand for the proposed sewerage system, the Engineer has proposed minimal number of lift stations in the preliminary design. Further analysis to minimize the number of lifting stations would be made during the detailed design stage. The proposed preliminary design for sewerage system is given in Figure 3-2. The proposed water supply network and facilities are given in Figure 3-3.

3.5.1 *Brief Description of the Proposed Concepts*

The appropriate locations for the sewage outfall, brine discharge, seawater intake and pumping station was determined in consultation with the engineer and the EIA team based on proposed concept as well as Landuse Plans given by the Ministry of Housing and Environment. These locations were later communicated with the Island Council during the field surveys. Potential locations were also identified as alternatives as it may be possible that these locations could change during the detailed design stage depending on further consultations and design requirements. Reasons why EIA was undertaken at concept stage is that it will give the EIA consultant the opportunity to directly communicate environmental issues and concerns with the proposed sewerage system design engineers and project clients which in turn will save cost, time and avoid mistakes which may cause serious environmental problems. In fact, EIA is a project planning tool that aids in the design of the project to avoid environmental impacts to the greatest possible extent. Therefore, this report will discuss the general components involved in the water supply and sewerage project. These components are discussed below.

A. Sewerage System

Key components included in the sewerage system proposed for HDh. Nolhivaram are as follows

1. Sewer Network: Island wide sewer network has been proposed to covers all existing households and potential developments for a period of 30 years.
2. Household catchpits: A catchpit will be constructed for each lateral connection.
3. Laterals: Lateral connections from main sewers will be provided to households in which wastewater generated within the household shall flow via a catch pit to main sewer.
4. Road Manholes: Manholes will be developed at defined intervals along the main sewers, particularly at each road junctions and road crossings
5. Lift Stations: Lift stations (LS) or intermediate pump stations (IPS) have been proposed to be developed in the system. Lift stations may be required in the event required gravity slope is not attained to reach the flow into the main pump station (PS). Design with minimal no. of lift stations would be proposed.
6. Pump Station: A single main pump station has been proposed. This means all wastewater generated in households will be divided and passed into the main pump stations for discharge via sea outfall.
7. Sea Outfall: A single sea outfall has been proposed. The location of the proposed outfall is given in Figure 3-2.

B. Water Supply System

Key components included in the water supply system proposed for HDh. Nolhivaram are as follows:

1. RO plant: Installation of reverses osmosis seawater desalination plant of appropriate capacity
2. Sea Water Intake: A source water intake line will be installed to provide feed water
3. Storage tanks: Storage tanks of sufficient capacity will be built
4. Water Network: Island wide network will be developed to provide water to households
5. Household meters: Household connections will be developed with metered connections
6. Brine discharge: Reject water discharge pipe installed at appropriate location close to RO facility

3.5.2 *Project Duration*

Sewerage projects are usually built in twelve months from the date of signing the agreement. However, this project formulated under CSR is given a deadline of 6 months to implement the project which may not be sufficient due to logistical difficulties. Project duration depends on the location, weather, and availability of materials, project management team and availability of funds. The actual work schedule has not been made available to consultant at the time this report was prepared.

3.5.3 *Environmental Design Consideration*

In terms of design the most important and pressing issues to consider are

- Technical and financial sustainability
- Community acceptability
- Protection and improvement of groundwater and
- Protection of the fragile marine environment in the lagoon and around the reef.

The characteristics of groundwater aquifer, effluent quality, influent quality and marine water quality have been considered and further consideration will be given in setting the final design.

3.5.4 *Effluent Collection and Disposal*

The estimated daily volume of wastewater generated in the island for a population of 1637 people (Census, 2006) is at 196 m³. Wastewater generated in houses flow into a house catch pit under gravity which then flow into main sewers via lateral connections into main sewers and collection sump or main pump stations. The wastewater that enters into main sewer lines will be lifted with the help of intermediate lift stations positioned in places where the levels are below the designed depth. Wastewater which flows into main sumps will be pumped into sea via sea outfalls. In other word the wastewater effluent will be discharged into sea (receiving water body) for disposal through further dilution and dispersion.

3.5.5 *Proposed Sea Outfall Locations*

One effluent sea outfall has been proposed on the southern side of the island. The location has been chosen based on the communities views and landuse plan provided.

3.5.6 Process and Materials

The process will be similar to that of other such developments in Maldives. All raw materials required for development have to be transported to the island by sea transport. These activities will be processed on a work schedule which is not made available to consultant at the time this report was prepared.

3.5.7 Construction Materials

Construction materials will include PVC pipes, cement, electrical cables, circuit boards, main circuit boards, reinforcing steel bars, river sand, aggregates, PVC conduits, diesel, petrol, tar, PVC adhesive, timber etc. These are the basic materials that are used for such developments.

3.6 Implementation Schedule

The implementation of the proposed water and sewerage system is expected to be started as soon as the approval including EIA has been obtained from concerned government authorities. The project is expected to be completed in 6 months from the date of getting the final design approved from EPA. This project similar to other CSR sewerage projects is supposed to complete according to the process flow chart made available to proponent as part of the agreement made between proponents and government. A detailed schedule has not been made available at this stage. Copies of the detailed schedule will be submitted to the Environmental Protection Agency before construction begins

3.7 Implementation Phase Activities

In the construction phase key activities includes, site preparation for development which includes clearing of vegetation where necessary for pump stations, land surveys for proper levelling, excavations for sewer and water network lines, mobilization of materials and equipment, material transport, power generation facilities, sewer outfall and staff mobilization

3.7.1 Site Preparations

Site preparation considered to be one of the key elements of any such projects which include fixing of secure place (house) for material storage and administrative work or build a site office attached to material storage facility in an appropriate location. Other important preparation work include

1. Identification of exact locations for lift stations, pump stations, manholes, and sewer outfalls, water meter locations
2. Carry out ground level surveys and build a level profile on each section of the proposed networks

3. Appoint staff for site management and material stock control
4. Clear vegetations and make access to areas where work will be carried out (e.g. locations for pump stations)

3.7.2 Mobilization of Equipment and Materials

Site mobilization involves mobilization of workforce, machineries/equipment and construction materials to Nolhivaram to begin physical work. Materials, equipment/machineries and all other related items will be transported to the island by sea.

3.7.3 Workforce and Services

This is one of the key components that need appropriate management on site during the construction phase. In the proposed water and sewerage system in Nolhivaram an estimated 100 staff including labourers, engineers and supervisors will be sited on the island. The exact number is not known at this stage

3.7.4 Material Transport

All materials that are required for the implementation of the proposed project need to be transported to the island. The transportation will mainly be on *Dhoni*. Transportation of materials is considered to be one of the key activities that cause impact to environment mainly due to accidental spills and direct/indirect physical damage to coral reefs due to careless boating activities and emission of greenhouse gases which will be further discussed under impact analysis.

3.7.5 Waste Management

A considerable site waste will be generated including organic refuse (vegetations) during site clearing. These leafy and biodegradable organic materials (e.g. leaves, shoots etc) and other off site waste will be disposed through municipal solid waste stream.

3.7.6 Pollution Control and Waste Minimization

No doubt that pollution control/waste minimization going to be some of the key aspects of any developments. Cleaner production through appropriate waste minimization and pollution control measures have been on the agenda of many development projects in other parts of the world. However, this has not been given attention in development projects such as water supply and sewerage in Maldives, although it is written in our development agendas.

3.7.7 *Health and Safety*

Workers health and safety is also an important aspect that needs careful consideration during the implementation from beginning till end. Protection of employees from likely adverse effects will be one of the core duties of the proponent or contractor. All machineries and equipment must be operated by trained and experienced personals wearing necessary safety gears. In the event, if there is any need an employee to work on a different work site, he/she must be given appropriate training before the work. These elements fully will be applied on workers.

3.8 Operational Phase Activities

Key activities identified throughout the operation of the proposed water supply and sewerage system would be desalination plant, sewage effluent disposal, brine reject disposal, sludge disposal (if sludge separated through STP) and operation of pump stations/lift stations.

3.8.1 *Effluent Disposal*

Wastewater including black and grey water generated in the island will be collected into sewage treatment plant or pump station. If STP is not in place, sewage effluent will be discharged into the ocean via sea outfall on condition that an STP will be installed within 5years period from the date of commissioning the system. This has been discussed during the scoping meeting held at EPA on 27 December 2011. In case if STP is in place effluent either will be discharged into the ocean or applied on land for groundwater recharge if the effluent quality meets BOD of effluent at 5mg/l or less (wastewater disposal guideline of MWSA, 2007). As per the information provided by the proponent the sewage system proposed for Nolhivaram is with treatment. However the type of treatment is not decided at the time this report was compiled. Sewage generated in households flow into main sewer via catch pits and laterals which then flow into pump stations with the help of intermediate lift stations for final disposal.

3.8.2 *Brine Disposal*

Brine concentrate generated during seawater desalination will be disposed into ocean either via sewage effluent or separate. It is advantageous of disposing brine concentrate via sewage effluent if the effluent is dilute compare to the brine concentrate.

3.8.3 *Sewage Treatment*

Sewage treatment as discussed in Section 3.8.1 will be undertaken if it is required. The scoping meeting held on 27 December 2011 at EPA clearly indicates treatment is required before effluent is disposed to environment. However, the timing of putting STP in place is made flexible as discussed in Section 3.8.1 due to high cost

anticipated. As per the wastewater disposal guideline of MWSA, 2007 the BOD of effluent shall be less than 40mg/l which is quite stringent.

3.8.4 *Feed water Intake*

Source water for seawater desalination will be drawn from beach well on the southern side of the island as shown in Figure 3-3.

3.8.5 *Sludge Handling*

As the sewerage system is with treatment it will generate sludge which needs to be disposed of carefully. The quantity of sludge as per the small size of population (860) of Nolhivaram will be small hence it can be pumped into a sludge drying bed where water can be drained back to the STP.

3.9 Project Inputs and Outputs

The project has inputs in terms of human resources, and natural resources and machinery. The main output of the project is island wide community sewerage system implemented in Nolhivaram. The inputs and outputs are summarised in Table 3-1 and Table 3-2.

Table 3-1: Matrix of key inputs

Input resource(s)	How to obtain resources
Construction workers	Contractor's responsibility
Management and maintenance staff	Appointed by proponent
Construction materials:- timber, cement, electrical cables, circuit boards, main circuit boards, reinforcing steel bars, river sand, aggregates, PVC pipes, diesel, petrol, tar etc	Import and purchased where locally available at competitive prices – Contractor's responsibility
Water (during construction)	Rainwater harvested
Electricity/Energy (during construction)	Diesel-based electricity
Machinery and equipment	Contractor's responsibility
Sulphate resistant cement	Imported or locally purchased
Fuel (e.g. diesel, petrol)	Locally purchased
PVC Adhesives	Imported or purchased locally

Table 3-2: Matrix of major outputs

Products and waste materials	Anticipated quantities	Method of disposal
Waste oils from machinery	Minute	Re-used to other applications
Cleared green waste	Minor	natural decompose
Wastewater effluent	major	Disposed into sea where dilution and dispersion happens
Timber, cardboard, gunny bags and scrap metals (construction site waste)	Moderate	Recovered, reused , recycled
Used oil (waste oil), grease	minute	Reused
Solid waste (kitchen waste, waste from accommodation blocks)	Major/moderate	Taken for disposal through island SW system

3.10 Need and Justification

The proposed sewerage project is one of the most important development projects to be undertaken in the island, which has been in the pipeline for quite some time. The island community has great expectations towards the project. It has become the main priority of the island community given that their main water supply, i.e. the groundwater lens, is being contaminated from inappropriate sewage disposal practices at household level. The proposed system is expected to improve the biological quality of the groundwater lens and have several positive health and socio-economic impacts. Water supply is met through harvested rainwater on roof top which in principle is not appropriate for drinking without treatment. Dependence on rainfall also carried the risk of water scarcity during the dry season.

In addition to the improvements in environmental quality which itself has economic benefits, there are several other socio-economic benefits of proper water supply and sewage and wastewater disposal. These include:

- Protection of the groundwater aquifer, which is the main source of water for the communities as well as the plants. This in turn helps in reducing morbidity and mortality due to water-borne diseases.
- Health benefits due to improvements in environmental health
- Increased standard of living and suitability of the island for economic activities such as tourism

The proposed project targets at further achieving some of these and attempting to achieve a long-term solution to the above mentioned issues of aesthetic quality of the beaches and coastal waters and nuisance caused by seagrass. In short, the project aims to achieve the following objectives:

- Addressing the water and wastewater situation in the island
- Increase the economic value of the island.
- Provide a sustainable means of wastewater disposal
- Improve the overall public health of the island

The proposed system of simplified sewerage with sea outfall(s) has been chosen for the following reasons.

- Groundwater aquifer is the primary water resource for the people of the Maldives. Even in Malé, the capital, where the aquifer is highly contaminated and salty, most people depend on the groundwater aquifer to meet their non-potable water demands. Therefore, people of Nolhivaram cannot afford to keep on disposing their sewage and wastewater into the aquifer. The aquifer needs to be protected from faecal matter for its longterm sustainability.
- White sandy beaches and clear azure blue lagoon are important natural assets for the islands of the Maldives, and the quality of the beaches and the lagoonal waters needs to be protected and preserved for the benefit of present and future generations. Therefore, the proposed system has deep sea outfalls

disposing into good mixing and dispersing zones ensuring that the faecal coliforms do not reach the nearshore environment.

- The deep sea outfalls are not possible with gravity flow sewers laid in some islands in the past. Therefore, sewage pump stations are necessary and have been incorporated in the design of the proposed system. In order to minimize the depth of excavation, lift stations are proposed that will pump the effluent to the pumping station at the end of the network.

Septic tanks have been purposely avoided in the proposed design because of the high cost involved. It is important to avoid septic tanks if possible since septic tanks take a great proportion of the project cost. Also, there has been ownership problems associated with septic tanks and sometimes catchpits for that matter when household plots get divided. Furthermore, septic tanks only remove less than 50% of the BOD and therefore still require deep sea outfalls, which will be achieved with pumping stations. Additionally, people do not like to have a system in which they may have to do the work of emptying the septic tanks since most of the householders cannot do it themselves.

The proposed system will improve the biological quality of the groundwater resource to a great extent including the potential smell in the water which is a result of faecal matter being disposed into the groundwater lens. This results in high levels of nitrates and phosphates in the water in addition to faecal contamination. The system is expected to improve this situation dramatically. Although it will take some time for the system to get back to acceptable levels in terms of biological contamination and subsequent increase in nutrients in the water, the rate at which this is achieved would be high. Malé would be a good example to consider when discussing about the impacts of improper sewage disposal. When Malé was without a sewerage system, all faecal matter was disposed into the ground. With the rapid increase in population, the groundwater became smelly and almost unusable in areas where the pressure on the groundwater aquifer was high. The smell was initially from ammonia. Later with sewage in catchpits and other areas becoming septic, hydrogen sulphide gas became a major problem. Since a proper sewerage system would be installed in Nolhivaram at a time when the groundwater is still in good condition, the system will help to alleviate most of these problems which became evident in Malé.

In terms of salinisation of the groundwater lens, the constructional impact would be small, related to some amount of dewatering, especially with the proposed revision to incorporate lift stations. However, the main impact would be felt during the operational phase when the groundwater would be used for toilet flushing. However, it has been seen in many islands, including larger islands such as L. Gan, L. Fonadhoo and even FuahMulah, where there are no sewerage systems, that the main contributor to groundwater salinisation is the use of pumps and high pumping rates. In fact, it is known that in most of the islands, there are no sewer connections. Yet with high pumping rates and increasing population, the groundwater lens is becoming more saline in addition to the deterioration in chemical and biological quality. Therefore, it can safely be argued that an increase in salinisation

of the groundwater lens would become apparent in most of the islands, whether a sewerage system exists or not. Even in places where the sewerage system pumps all water out to the lagoon such as K. Gulhi, Lh. Hinnavaru and Lh. Naifaru, there is no data to suggest that the groundwater has become more saline due to the sewerage system. Some of these islands have groundwater of a quality similar to other similar islands where there is no sewerage system.

Recharge of groundwater aquifer with treated effluent has not been considered to help in anyway except further pollute the groundwater aquifer given that tertiary treatment to achieve very low levels of BOD or COD is not possible within the framework of the proposed project. According to the USGCRP team (Carter et al 2001), “the size of the groundwater lens is directly related to the size of the island... (and) also related to the normal amount and type of precipitation (e.g., heavy downpours recharge lenses, while light rain generally does not)”. Therefore, the type of rainfall that occurs in the Maldives with high intensity-high duration-low frequency rainfall is useful for the development of groundwater lenses in low-lying islands. It is also important to note that the aquifer (like a rainwater tank) has its own capacity and not every drop of rainwater will percolate to contribute to the freshwater lens. This argument also supports the belief held by the consultants that aquifer recharge is not easily possible by grey water recharge.

Figure 3-2: Proposed sewerage system

Figure 3-3: Proposed water supply system

4 Project Alternatives

This section looks at alternative ways of undertaking the proposed project. There are two basic options: (1) leave the problem as it is (no project option), or (2) take measures to resolve the problem (undertake the project options). If the project were to continue, it would be necessary to take economic, ecological and social aspects of the project into consideration and ensure that these concerns exist within a delicate balance. Neither the economic benefits nor the social and ecological concerns can be avoided. Therefore, it is important to consider all options and ensure that the best available option(s) is/are chosen to solve the issues/problems.

Alternatives have been considered only for the sewerage system as alternatives for the water supply system is not considered appropriate. However, alternative locations for the water and sewerage facilities have been highlighted in Figure 4-1.

4.1 No project option

It should be noted that the “no project” option cannot be excluded without proper evaluation. In this report this alternative was considered as the baseline against which to evaluate the other options. The no project option takes the following into consideration:

- Existing setup is sufficient for the present time
- Existing safety and other socio-economic impacts will remain or may continue to worsen
- Existing public frustration will continue to worsen causing greater political and social issues.

The main advantages and disadvantages of the no-project option are given in Table 4-1.

Table 4-1: Advantages and disadvantages of the no project option

Strategy	Advantages	Disadvantages
Allow groundwater contamination to continue	Costs related to improving the situation may be avoided in the short term	Burden of diseases due to poor sanitation may increase Long term socio-political problems may arise Greater long term costs An important water resource will eventually be lost and alternatives sources sought
Try to improve the situation by providing appropriate guidelines (soft interventions such as minimize use of pumps, improved septic tank quality, etc.)	May minimize groundwater contamination Short term costs may be avoided	Contamination of groundwater will continue although at a slower rate Will not address current concerns adequately

4.2 Alternative Outfall

Sewage is best suited to be disposed in to the ocean at depths greater than 10 or preferably 15m. In determining the location of outfall, consultants often ensure that raw sewage is disposed to a location where there is good mixing and where recreational waters would not be under threat of pollution. Taking these principles into consideration, it is best to avoid the lee of the island during both northeast and southwest monsoon. Therefore, the west and eastern sides of Nolhivaram shall be avoided and north and south sides considered for outfall location. The proposed outfall location is towards the northwest and it is considered to be appropriate. However, the preferred alternatives of northeast corner and southeast corner of the island would be more suitable given that the western beaches would be best suited for use during the northeast monsoon as well as calmer days during southwest monsoon. Also, the harbour and other industrial activities are on the eastern side. Therefore, the location of water and sewerage facilities, brine discharge and outfall on the eastern half of the island would be more appropriate.



Figure 4-1: Alternative locations

5 Methodology

This section covers methodologies used to collect data on the existing environment. The key environmental components of the project considered were terrestrial, coastal environment and marine environment. In order to study the existing environment of the island, a field visit was made to Nolvivaram early January 2012.

5.1 General Data Collection Methodologies

Existing environment of the study area were analysed using appropriate scientific methods. Field surveys were undertaken to get further understanding of the existing environment of the island. Field surveys were carried out during a field visit made to the island in January 2012 to collect baseline data. The following components of the existing environment were assessed.

- Terrestrial Environment
 - Terrestrial vegetation, groundwater quality, estimation of groundwater aquifer, estimation of aerial extent of groundwater aquifer, terrestrial fauna.
- Marine Environment
 - Coastal environment, shoreline, back reef, fore reef, reef flat, marine water quality, fishes, protected species, endangered species etc.

5.1.1 *Groundwater and marine water quality*

Groundwater quality was measured in several locations around the island to provide a representative sample. Similarly, marine water quality was tested at all potential outfall locations. Water quality was measured in situ using YSI potable water quality loggers. Parameters tested include temperature, electrical conductivity, salinity, total dissolved solids, dissolved oxygen and pH.

Samples were brought to Malé for testing in one of the laboratories, National Health Laboratory or MWSC lab. These samples are currently under testing and the results will be sent to the EPA as soon as they are available.

5.1.2 *Ocean Currents*

Ocean and lagoon current was measured by conducting drogue tests on selected locations around the island. A purpose built drogue with a GPS (Trimble Juno) was made to create spaghetti diagrams of the ocean currents.

5.1.3 *Condition of the House Reef*

Marine environment was surveyed to assess and obtain baseline data of the existing marine environmental conditions. Both quantitative and qualitative methods were used to assess the benthic substrate at the survey sites including Manta Tow survey, quadrants and visual assessments were used to quantify benthic types. .

This study was complemented with extensive underwater photographs of the areas in question. Methodologies adopted for these surveys are internationally accepted (English et al. 1997) and are widely used to assess the status of coral reefs in the Maldives as well.

5.1.3.1 *Quadrats Survey*

Quadrats surveys were carried out to assess the benthic types and coral species at the survey sites. It was carried on five different sites around the reef line including proposed outfall locations. It is one of the survey technique widely applied for ecological sampling.

Quantitative percent cover data of morphological characteristics of the reef community is obtained using this method and it can be repeated over time to obtain temporal changes. In this EIA study during the field visit made in Jan 2012, a square shape quadrat 1m x 1m was used for reef flat sampling.

6 Existing Environment

This section covers the existing environmental of proposed work site. In this case the work site is Nolvivaram island where and island wide sewerage system will be developed. The key environmental components of the project under consideration are described below.

- Vegetation of the island
- Coral reef systems – status and health of coral reef system
- Groundwater aquifer – quality and quantity
- Marine and coastal environment – oceanography, marine water quality and oceanic currents
- Meteorological conditions – local wind, current, rainfall and tides
- Socio economic – public perceptions, the status, health and wellbeing of the community

6.1 General meteorological 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 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. Table 6-1 provides a summary of key meteorological findings recorded for Maldives.

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. These are discussed in more detail in the following subsections. 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. However, according to Elliot *et al*, 2003 due to proximity to the equator, the monsoon seasons in Maldives are not as well defined as they are in Sri Lanka. The monsoons in Maldives are best defined in the northern part of the country where a distinct monsoon seasons including the strong southwest monsoon from June through September and a noticeable northeast monsoon from December through February occurs

Table 6-1 Key meteorological information in Maldives

Parameter	Data
Average Rainfall	9.1mm/day in May, November 1.1mm/day in February 1900mm annual average
Maximum Rainfall	184.5 mm/day in October 1994
Average air temperature	30.0 °C in November 1973 31.7 °C in April

Parameter	Data
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

The climate of the Maldives varies slightly from South to North of the country. As pointed out by Elliot *et al*, 2003 the monsoon in north region is more pronounced and distinct. In Maldives, meteorological data are not recorded in all islands across Maldives. It has been recorded regional airports. General meteorological conditions prevailing in the region based on meteorological data for Hulhulé and Hanimaadhoo has been used to understand climatic factors affecting Nohivaram. Table 6-2 below shows summary of four seasons in Maldives.

Table 6-2 Summary of seasons in the Maldives

Season	Months
North East-Monsoon (Iruvai moosun)	December
	January
	February
Transition Period - 1 (Hulhangu Halha)	March
	April
South West-Monsoon (Hulhangu moosun)	May
	June
	July
	August
	September
Transition Period - 2 (Iruvai Halha)	October
	November

6.1.1 Wind

Wind has been shown to be an important indirect process affecting formation, development and seasonal dynamics of the islands in the Maldives. Winds often help to regenerate waves that have been weakened by travelling across the reef and they also cause locally generated waves in lagoons. Therefore winds are important here, as being the dominant influence on the hydrodynamics around the island (waves and currents). With the reversal of winds in the Maldives, NE monsoon period from December to March and a SW monsoon from April to November, over the year, the accompanying wave and current processes respond accordingly too.

The two monsoon seasons have a dominant influence on winds experienced across Maldives. These monsoons are relatively mild due to the country's location close to the equator and strong winds and gales are infrequent. However, storms and line squalls can occur, usually in the period May to July; gusts of up to 60 knots have been recorded at Male' during such storms.

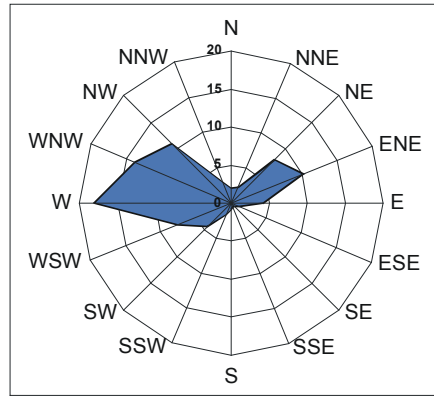


Figure 6-1: General wind rose diagram for the Maldives (source MEEW 2005)

Changes in wind directions need to be taken into consideration in determining the most favourable time period of proposed work. The development work will disturb the floor sediments to some extent and form sediment suspension which depending on the wind speed, direction and ocean current will move until naturally settles down.

The extreme northern part of the region experience wind climate with a strong southwest monsoon from May through August and a moderate northeast monsoon from December through February. The Maldives experience strong ocean wind at speed of 6m/s to 7.5m/s at a height of 10m during June, July and August (Elliott *et al*, 2003).

6.1.2 *Rainfall*

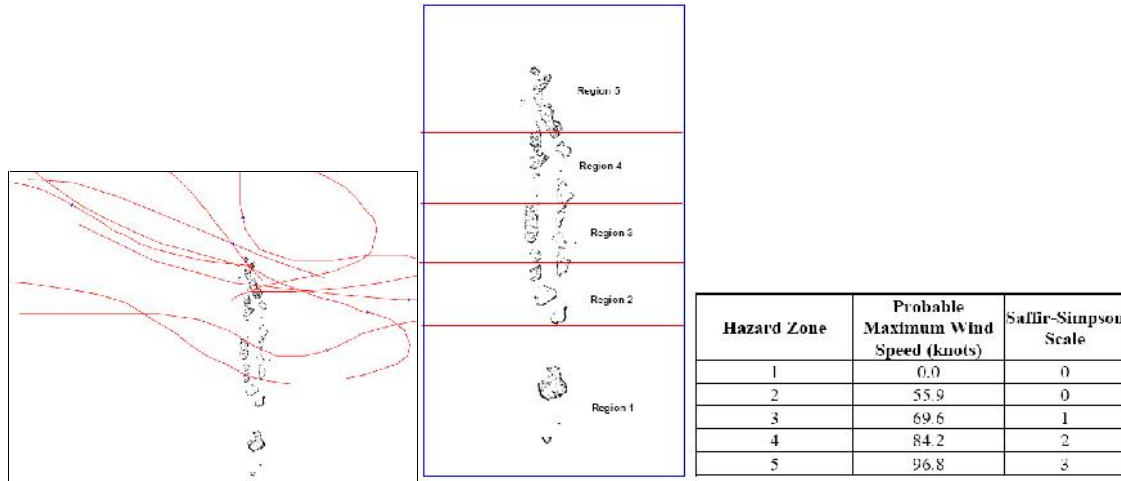
The northeast monsoon is known as the dry season with average monthly rainfall of 50-75 mm. The intensity of rainfall is a concern in the Maldives since intensity is high with low frequency. It is sometimes believed that the interval of rainfall (frequency) is important in considering the groundwater recharge potential from precipitation.

6.2 Natural Hazard Vulnerability

An island's natural vulnerability depends on geographic and geomorphologic characteristics of the island. These include geographic features of the island and location of the island with respect to the country, the formation of the island, location of the island respect to the atoll, orientation of the island, region of the country where island is located, level of protection to the island from the reefs and other islands; area of the inland lake found on the island, width of the island's house reef, coastal defence structures on the island, shape of the island and the area of the island. Although Maldives is generally considered to have moderate risk to natural hazards or disasters, islands across Maldives experience varying degree and magnitude of natural disasters.

Referring to Suffir-Simpson Scale, Nolhivaram is considered at high vulnerable zone when cyclonic winds and storm surges over the Maldives are concerned and also low risk when tsunamis and earthquakes are concerned.

The island fall hazard zone 5 at Suffir-Simpson Scale 2, the maximum probable wind speed expected to be at 96.8 knots as shown in the following figures. Sea level rise due to climate change has uniform hazard throughout the country (RMSI/UNDP 2005).



The stormy weathers around the world are affecting coral reef systems directly and indirectly due to global climatic changes. Intense storms can wipe out the natural coral “recruitment” process (Daily Science, April 29, 2008) as a direct effect of climatic change. Healthy coral reef systems are vital assets to many economies around the world on which large numbers of island communities depend on range of fisheries activities including Maldives. In Maldives for instance according to NAPA (2006) local demand on reef fishery has increased in recent years. Therefore, the concern of natural hazard vulnerability on corals reefs in Maldives is very high, which needs a solution through local and global effort.

6.3 Existing Coastal and Marine Environment

The island oriented north south direction is formed with small lagoon portion in the western side of the island. Along the eastern side beginning from southern tip to north end the long stretch is rocky shoreline. It absents lagoon along the stretch. The eastern side is continuously subjected to strong swells and wave actions. The reef system around the island is not live in other word there is no healthy reef system. There are some patch corals in the western side lagoon at outer rim of the lagoon (branching coral formation)

6.4 Oceanography

6.4.1 Waves

Wave energy also plays a key role in the movement and settlement of sediments and suspended solids, and is also a crucial factor controlling coral growth and reef development. Studies by Lanka Hydraulics (1988a & 1998b) on Malé reef indicated that two major types of waves in Maldives coasts: wave generated by local

monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during May-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.

Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives (Goda, 1988). The swell waves that reached Malé and Hulhule in 1987, thought to have originated from a low pressure system of west coast of Australia, had significant wave heights in the order of 3 metres.

6.4.2 *Water Currents*

Studies on current flow within a reef flat in Male' Atoll suggests that wave over wash and tides generate currents across the reef platforms, which are also capable of transporting sediments (Binnie Black & Veatch, 2000). However, available information suggests that tidal currents are not strong due to small tidal range.

Generally current flow through the Maldives is driven by the dominating two-monsoon season winds. Westwardly flowing currents are dominated from January to March and eastwardly from May to November. The change in currents flow pattern occurs in April and December. In April the westward currents flow are weak and eastward currents flow will slowly take place. Similarly in December eastward currents flows are weak and westward currents will take over slowly.

Studies on current flow process within a coral atoll have shown that waves and tides generate currents across the reef flats, which are capable of transporting sediments on them. Currents, like waves are also modified by reef morphology. Under low-input wave conditions (0.5m heights) strong lagoonward surge currents (>60cm/sec) are created by waves breaking at the crest. Studies on current flow across reef platforms have shown that long-period oscillations in water level cause transportation of fine-grained sediments out of the reef-lagoon system, while strong, short duration surge currents (<5sec.) transport coarse sediments from the breaker zone to seaward margin of the back reef lagoon. Always sediment accumulates at the lee of high-speed current zones. Generally zones of high current speed (jets or rips, 50-80cm/sec) are systematically located around islands.

6.5 Marine Environment

Key marine environmental components identified of relevance to the proposed study are ocean current, marine water quality and reef ecology. Focus was given to elements which is relevance to the proposed water supply and sewerage system in Nolhivaram in particular of the ocean outfalls associated to the proposed system.

6.5.1 Currents

Study of current around the island identified to be one of the key aspects relevance to the proposed sewerage system in Nolhivaram. Flow of water current would play a key role in assessing the pattern of sewage dispersion. In order to assess the current around the island in particular of the proposed out fall locations drogue tests were conducted.

6.5.1.1 Drogue Tests

In order to assess the current pattern around the island drogue tests were done including the proposed locations for sewer out falls. The results of the drogue tests are shown in the figure below.

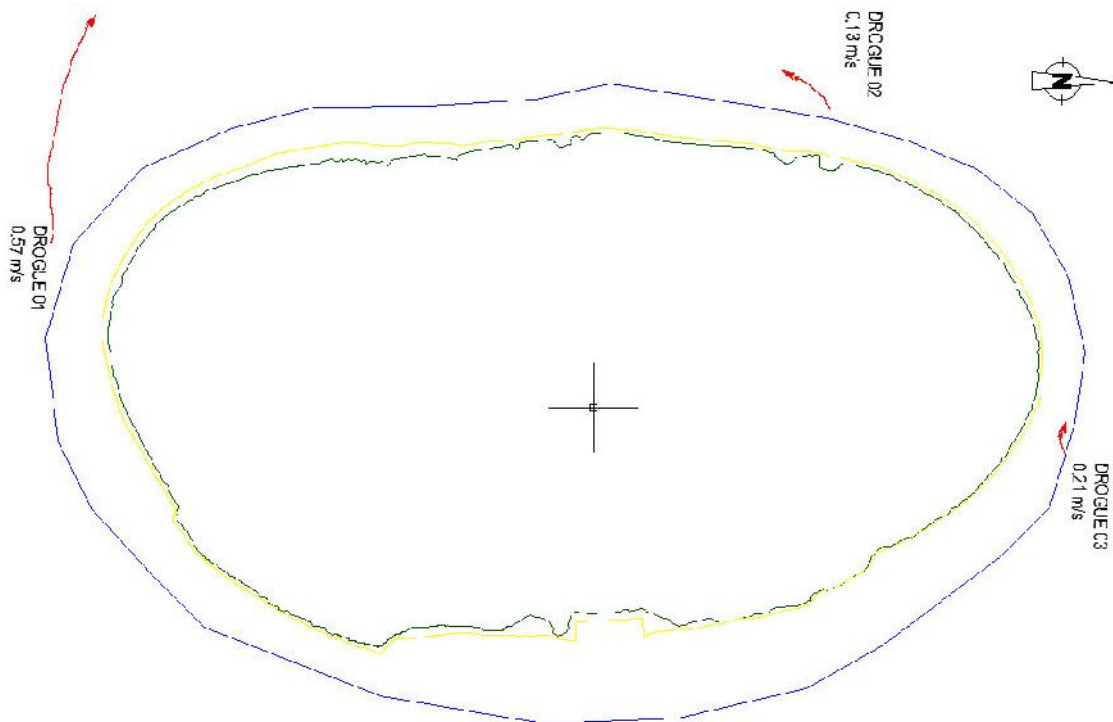


Figure 6-2 Location of drogue tests conducted around Nolhivaram

6.5.2 *The Reef System and Reef Aesthetic*

There is well developed healthy reef system around the island. Large branching corals are dominated species along with young isolated tabular and massive corals were observed as indicated in Figure 6.3. The reef system is aesthetically appealing. The reef survey carried out at five reef sites shows that reef system around the island appealing and rich in biological diversity. The live corals indicated the reef ecological system around the island is rich.

6.5.3 *Reef Survey*

Reef survey was conducted at three locations from Q1 to Q5 on reef flat as indicated in Figure 6.3

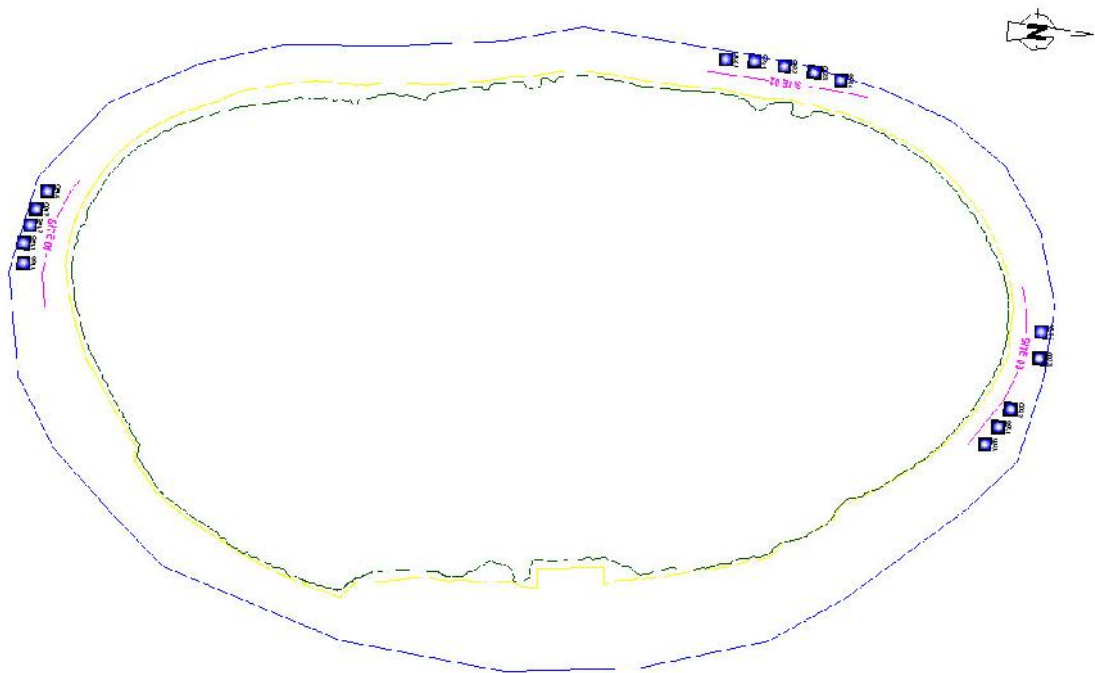


Figure 6-3: Quadrate sampling locations

6.5.3.1 Southern end corner

More than 67.19% corals are dead at southern side of the reef flat where sewage outfall has been proposed while live coral cover is less than 32.81% as shown in figure below.

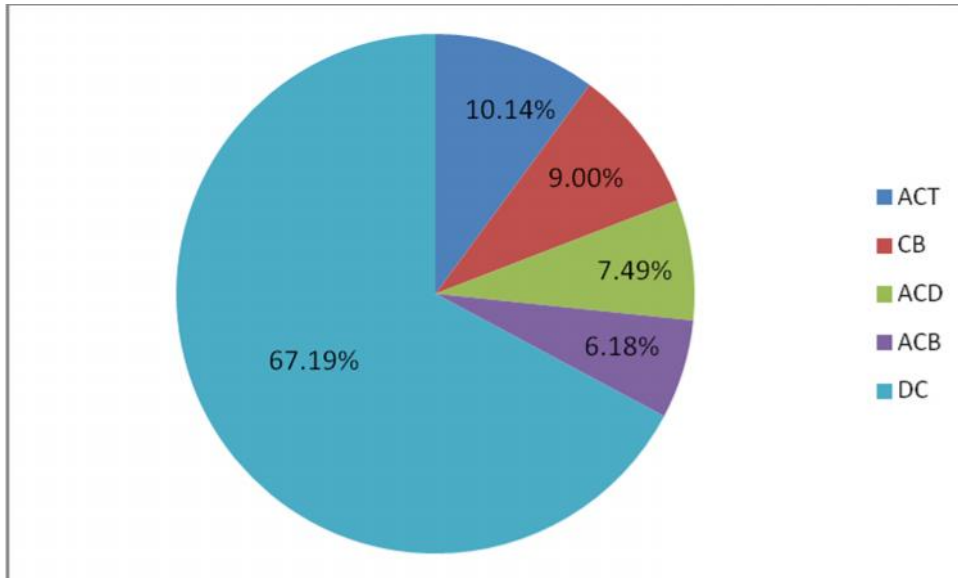


Figure 6-4. Quadrate survey at South end corner

6.5.3.2 East Side

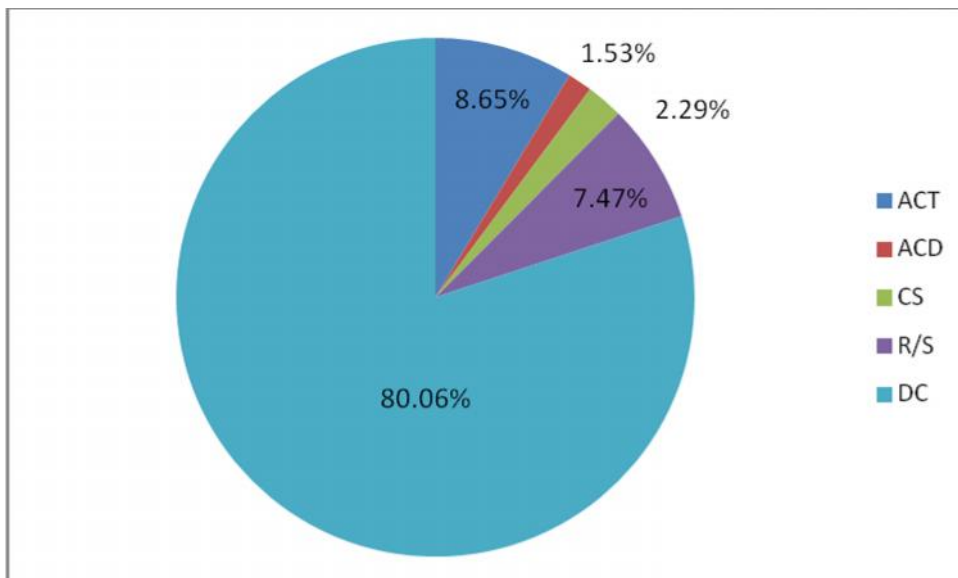


Figure 6-5 Quadrate Survey at East side

6.5.3.3 Northern corner

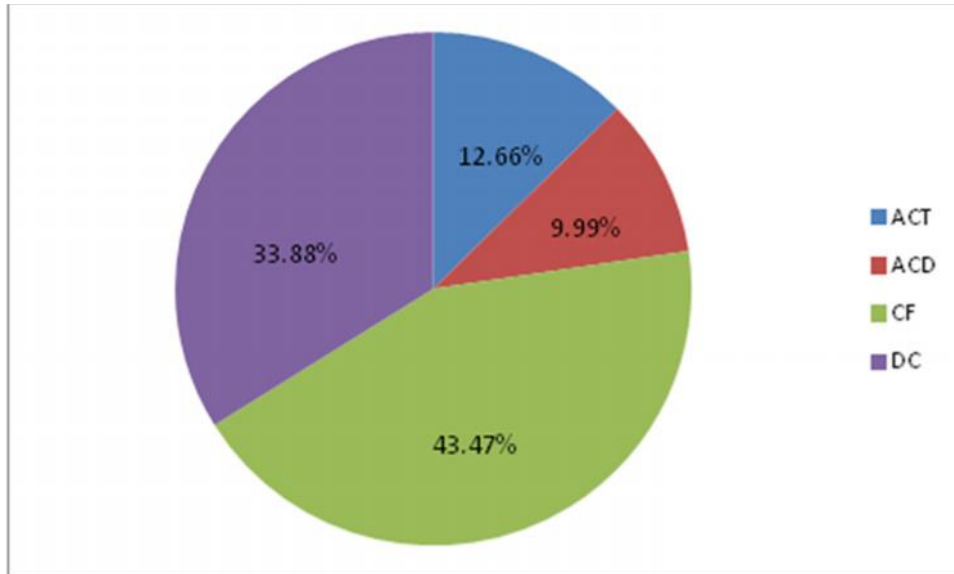


Figure 6-3. Quadrant Survey north corner

6.5.3.4 Overall Comparison Reef Sites

The results of the quadrat survey indicate more live healthy corals on northern side compared to the southern side of the island.

6.5.4 Marine Water Quality

Seawater samples collected from four different locations where survey was conducted, parameters such as Electrical Conductivity, Total Dissolved Solids, Dissolved Oxygen and pH were tested in situ as shown in Table 6-3. These results show that water quality is good at the time of survey.

Table 6-3 Water quality results

	Units	WQ1	WQ2	WQ3
GPS Location	WGS84	N 735638.4208	N 723207.013	N 737985.809
		E 276023.708	E 275574.220	E 276354.760
Temperature	°C	28.19	27.78	28.14
E. Conductivity	mS/cm	51.69	51.69	51.65
TDS	g/l	33.60	33.60	33.57
Salinity	%	33.90	33.91	33.87
DO	mg/l	4.49	3.29	7.37
pH	NA	8.12	7.97	8.00

6.6 Terrestrial Environment

The terrestrial environment is similar to other inhabited islands across Maldives. The island is wide and elongated in the north east to south west orientation. However, the unique feature noted in the island is that along all main roads trees are planted on centre of the road.

6.6.1 *Geological Settings and Hydrogeology*

In general the islands in Maldives are small, low lying and flat with common type of vegetation. There are two lakes on the island- one at the north end and the other in the southern end. However these types of freshwater lakes so far are not considered with any environmental value. The natural freshwater resource available in the island is groundwater. The fresh groundwater aquifers generally are formed as freshwater lenses floating on salt water which depends on island width, recharge rate and the ease of transmission of freshwater through soil (Falkland *et al*, 2007, cited in Mustafa, 2010). According to the USGCRP team (Carter et al 2001), “the size of the groundwater lens is directly related to the size of the island also related to the normal amount and type of precipitation (e.g., heavy downpours recharge lenses, while light rain generally does not)”. Therefore, the type of rainfall that occurs in the Maldives with high intensity-high duration-low frequency rainfall is useful for the development of groundwater lenses in low-lying islands. This argument also supports the belief held by the consultants that aquifer recharge is not easily possible by grey water recharge.

6.6.1.1 Size of Groundwater Lens

The size of groundwater lens depends on several factors. Key factors which are considered in measuring the size of the groundwater aquifers in small islands are size of the island, width of the island, rainfall pattern and extraction of groundwater. Assuming estimated average ratio of groundwater lens area (ha) and area of island (ha) at 0.45 using data collected from northern islands in Maldives (Falkland, 2001, Southern and Northern Regional Development Project)

The estimated aerial extension of groundwater lens (ha) = $0.45 \times 221\text{ha} = 100\text{ha}$.

6.6.1.2 Groundwater Quality

Groundwater quality from existing open wells was tested from four different houses as shown in Table 6-4. The idea was to make an estimation of the quality of water particularly in terms of salinity and bacterial contamination from onsite sewage disposal systems.

Table 6-4 Groundwater quality results

No.	House	Temp	E-Cond	TDS	Sal	Do	pH
		oC	ms/cm	g/l	ppt	mg/l	
1	Nookuri	27.1	1.074	0.698	0.53	8.95	8.31
2	Dhondhunburege	27.79	1.497	0.973	0.75	0.72	7.5
3	Zameen	27.49	0.911	0.592	0.45	1.26	7.51
4	Thalhamdheege	26.84	1.609	1.046	0.81	2.01	7.22
5	Meadows	26.54	0.756	0.491	0.37	9.52	7.67
6	Aania	27.54	1.37	0.891	0.68	1.85	7.25
7	Honeymoon	26.36	1.5	0.975	0.75	1.99	7.4
8	Court	26.86	0.884	0.574	0.43	2.64	7.55
9	Dhihaaru	28.09	0.739	0.48	0.36	1.33	7.44
10	Iruzuvaage	27.69	2.511	1.633	1.29	6.27	7.19
11	Nazaru	27.93	1.313	0.854	0.65	2.36	7.29
12	Hithigasdhoshuge	27.24	2.32	1.508	1.18	1.54	7.02
13	Fannu	27.58	1.279	0.831	0.63	2.5	7.32
14	Mumuhu	27.11	0.988	0.642	0.48	3.24	7.33
15	Heera	27.48	0.971	0.631	0.48	2.44	7.35
16	Ocean Leed	26.66	1.34	0.871	0.67	6.45	7.19
17	Ran Guraage	26.74	1.41	0.917	0.7	1.46	7.2
18	West Side	27.45	1.045	0.679	0.51	1.28	7.2
19	Hasthee	27.41	0.888	0.577	0.43	0.33	7.17
20	Moonimaage	27.07	0.99	0.643	0.49	1.15	7.26

6.6.2 *Current Sewage Disposal Practices*

Sewage effluent generated at houses is discharged into the ground via soak pits and filter wells. It is the similar practice widely practiced across Maldives. There are advantageous and disadvantageous from disposing effluents into the ground within house plots. The key advantage is that avoids rapid salinization. The key disadvantage is that it continuously pollutes the aquifer with domestic sewage which deteriorates the aquifer in terms chemical and biological contamination.

7 Stakeholder Consultations

The key stakeholders involved in the project includes Ministry of Housing and Environment, Environmental Protection Agency, Global Wings Pvt Ltd, Atoll and Island Council

7.1 Scoping Meeting

The scoping has been held at EPA on 27 December 2011. Key issues discussed in the scoping meetings include the designs including the sewer and water network, pump stations, and lift stations, sea outfalls and user fee pays.

7.2 Consultations with the Proponent

Consultations were held with the proponent, in order to find out further information about the detailed design of the proposed sewerage systems. As mentioned earlier that the project is under CSR where Global Wings Pvt. Ltd as the developer gives commitment towards the development of sewerage infrastructure in Nolhivaram in return government leases an island to Global Wings for resort development.

7.3 Community Consultation

A lengthy community consultation meeting was held with island councillors and members selected from the community. Three council members were attended to the community consultation meeting held in Nolhivaram on 13th January 2012. Information regarding the proposed sewerage system was given by survey team members represented from Sandcays Pvt. Ltd. The interactive consultation held were discussed as follows including question and answers

- Explanation of the proposed concept design - household catch pit, main sewer, lift stations, manholes, pump stations and sea outfalls
- Why the community need an island wide sewerage system
- The importance of EIA for the project
- Why lift stations are proposed
- Sea outfalls, its locations, the disadvantage of sea outfall proposed on eastern side of the island
- Impacts to groundwater after the sewerage system developed - the elevation of salinity would depend on the rate of extraction and recharge.

- Sewerage user tariff system – explained a fee will be charged for operation, maintenance and management of the system

The key issue raised by the community members was groundwater salinity at post development phase and outfall locations. Since they are planning to lease some parts of the island for resort development, this was identified. How to establish the outfall pipe through the vegetated area was also an issue raised in the meeting.

8 Impacts and Mitigation Measures

This section covers potential environmental impacts identified and measures to mitigate these impacts due to the proposed sewerage system in Nolhivaram. The potential environmental impacts during implementation and operational phases of the proposed project components and appropriate mitigation measures are elaborated in the following sections.

8.1 Impact Identification

Impacts on the environment from various activities of the proposed development have been identified through:

- A consultative process within the EIA team, the Project Engineer and the Proponent
- Purpose-built checklists
- Existing literature and reports on similar developments in small island environments and other research data specific to the context of the Maldives
- Baseline environmental conditions
- Consultants experience of projects of similar nature and similar settings

Possible negative impacts on the environment have been considered in worst-case scenario to recommend mitigation measures in the best possible ways so that these impacts would be minimized and perhaps eliminated in the implementation phase.

Impacts on the environment were identified and described according to their location/attribute, extent (magnitude) and characteristics (such as short-term or long term, direct or indirect, reversible or irreversible) and assessed in terms of their significance according to the following categories:

1. **Negligible** – the impact is too small to be of any significance;
2. **Minor adverse** – the impact is undesirable but accepted;
3. **Moderate adverse** – the impact give rise to some concern but is likely to be tolerable in short-term (e.g. sediment suspension during dredging) or will require a value judgement as to its acceptability;
4. **Major adverse** – the impact is large scale giving rise to great concern; it should be considered unacceptable and requires significant change or halting of the project.
5. **Beneficial impact**- the impact represents a positive outcome in terms of either improving the existing quality of environment.

6. **Significant beneficial impact** – the impact represents highly desirable outcome in terms of improving the existing environment.

8.2 Identifying Mitigation Measures

Where an identified impact can be mitigated, mitigation measures are identified and discussed along with the identification of the impact. The mitigation measures proposed will help to alleviate or eliminate environmental problems before they occur. Mitigation measures are important because if identified impacts are significant and/or important, it would be necessary to identify and implement mitigation measures. Mitigation measures are selected to reduce or eliminate the severity of any predicted adverse environmental effects and improve the overall environmental performance and acceptability of the project. Where mitigation is deemed appropriate, the proponent should strive to act upon effects, in the following **order of priority**, to:

1. Eliminate or avoid adverse effects, where reasonably achievable.
2. Reduce adverse effects to the lowest reasonably achievable level.
3. Regulate adverse effects to an acceptable level, or to an acceptable time period.
4. Create other beneficial effects to partially or fully substitute for, or counter-balance, adverse effects.

8.2.1 *Mitigation Options*

Possible mitigation options include:

- Design alterations (e.g. recharge treated effluent into ground etc.) - operational
- Work method alterations (e.g. changes in construction scheduling etc.)
- Provision of environmental protection and health and safety equipment (e.g., provision of first aid and personnel protection gears such as helmets, safety shoes etc)
- Changes in management practices (e.g., contractor's awareness on environmental issues, keeping work areas clean, provide key environment information to workers)
- Changes in operation (e.g. operational procedures, specific responsibilities for clean up and maintenance).
- Environmental monitoring during civil works and operational phase

8.3 Existing Environmental Concerns

8.3.1 *Natural Hazard Vulnerability*

Although Maldives is not considered in a zone of hurricane and cyclones, Maldives is subjected to some of the climatic and non climatic natural hazards. The climatic natural hazards include prolonged dry period, flooding and storm surges and that of non climatic natural hazards include the impact of seismic activities. A clear

example is the recent devastating tsunami occurred close to Sumatra, Indonesia in December 2004 killing more than a million people in the region including 26 deaths in Maldives.

8.4 Overall Impacts of the Proposed Project

The environmental impacts that may be associated with the proposed sewerage system are summarised by using a simple matrix and a purpose built checklist given in the Appendix 5. The matrix given in Table 8-1 shows the types of environmental impacts that may be associated with the water supply and sewerage system, which includes implementation phase and operation phase.

Table 8-1 Matrix of key components which may impact to environment during implementation and in operation phase

Environment Component	Implementation Phase						Operation Phase				
	Excavation for pipe laying, manholes, lift stations and pump stations	Clearance of vegetation for pump stations/lift stations	Installation of pump stations/lift stations	Installation of road manholes and household catch pits	Installation of sewage and brine ocean out falls	Material Transport to work site	Untreated wastewater discharge into ocean	Desludging of main sumps and lift stations and manholes	Use of Power	Extraction of groundwater for toilet flushing	Brine Discharge
Marine											
Corals					X	X	X				
Reef fish					X		X				
Lagoon bottom					X		X				
Coastal waters					X	X	X				X
Oceanography					X		X				X
Terrestrial											
Flora	X	X	X	X	X	X				X	X
Fauna	X	X	X	X						X	X
Soil	X	X	X	X	X	X				X	
Groundwater	X		X	X	X					X	
Air		X	X	X	X	X	X	X	X	X	

8.5 Impacts from Implementation

Implementation phase will have the major, direct short-term impacts and some secondary long-term impacts on the environment. The proposed water supply and sewerage system development mainly will involve excavation for pipe laying and pump stations and ocean outfalls.

8.5.1 *Mobilization*

8.5.1.1 Impacts

The transport and supply of material, barges, excavator, truck and any other machinery may have impacts that may arise from:

- Accidental spillage of construction materials (e.g cement).
- Accidental oils and other chemical spills.
- Accidental grounding of large vessels such as barges.
- Propellers' wake can break fragile corals.
- Anchor damage from the vessels.
- Hazards of transport of material and machinery to site including overtopping of barges.

8.5.1.2 Mitigation

Precautionary measures need to be in place while loading and unloading of such materials and machineries at work sites under supervision at all times throughout the cycle of the process.

8.5.2 *Machinery*

8.5.2.1 Impacts

In addition to accidental damage caused to corals from barges and other machinery, these machines run on diesel fuel, which will have fuel management and handling issues in addition to carbon emissions. Poor handling and management of diesel and other fuel as in many islands, often lead to contamination of the aquifer. Some degradation of the marine environment is also likely. Moreover, improper handling of fuel could result in accidents and mishaps such as fires, which has in the past had caused major damages.

8.5.2.2 Mitigations

Efforts must be made to avoid accidental spillages from machinery including overtopping leading to severe spillages. Machines must be operated by experienced operators and make sure machines are clean all the time. Avoid throwing of cleaning materials and changed oils into the environment.

8.5.3 *Impacts from Materials*

8.5.3.1 Impacts

Materials such as cement and fuel for machineries have the potential to damage the marine and terrestrial environment. Both terrestrial and coastal activities can pollute the environment including soil, aquifer and coastal water due to accidental spill of oil and chemicals. Sometimes these materials are thrown into the environment due to absence of appropriate supervision at work sites.

Pollution of the lagoon and reef system can be caused by waterborne and windblown debris escaping from the construction. Reefs also get damaged due to boating activities including mooring, loading and unloading of materials.

8.5.3.2 Mitigations

Efforts must be made to avoid any such contamination of the environment in particular of handling of fuel, chemicals, and construction materials. Workers and helpers must be provided information. Other aspects to be considered include to

- Avoid boating activities in low tide
- Avoid damage to coral reefs through proper navigations
- Avoid loading, unloading and boating activities at night times

8.5.4 *Impacts from Excavation*

8.5.4.1 Impacts

Excavation will be undertaken for pipe laying, manholes, lift stations and pump stations. If the excavation happens to dredge below water table it would affect water table. It may require dewater for installation of these components associated into the system. Impacts associated in the excavation includes

- Emission of greenhouse gas
- Loosens sub soil layer

- Dewatering might induce salinization
- Accidents and falls

8.5.4.2 Mitigation

The mitigation measures include

- To ensure appropriate supervision and monitoring
- Complete the work as soon as possible
- Keep the workers informed with these aspects to minimize the impacts
- Avoid mass extraction of water at one time
- Avoid excessive excavation
- Wear safety and protection measures (personnel protection equipment)

8.5.5 *Installation of Sewage and Brine Outfalls*

8.5.5.1 Impacts

The key impacts of sewage outfalls would be degradation of marine water quality due to sedimentation, discharge of sewage effluent, damages to coral reefs and loss of habitat. Construction of sewer outfall would impact to coastal water, lagoon bottom and reef. During construction and mobilization of equipments would cause re-suspension of bottom sediments. Depending on the current movement, the suspended fine sediments may move to healthy corals which in turn may get killed due to excessive sedimentations.

8.5.5.2 Mitigation

The mitigation measures include

- To ensure appropriate supervision and monitoring
- Carry out the work in low tide
- Complete the work as soon as possible
- Keep the workers informed with these aspects to minimize the impacts
- Avoid construction of solid structures inside water
- Avoid washing tools, equipments etc into lagoon
- Use physical barriers to avoid effects of sedimentation on reefs

8.5.6 *Changes in Coastal Water Quality*

Sewage outfall development would cause excessive rate of suspended particles in water which change turbidity level in turn will affect the quality and intensity of light reaching reef organisms. Additionally it would cause stagnation of water if there is no proper circulation within the discharge point. Hence it will affect coral metabolism, productivity and growth of reef building corals. The effects of turbidity on corals may be lethal, sub-lethal or acute or chronic depending on the intensity and duration of disturbance. In many cases the marine water where sewage effluent discharged get contaminate with faecal coliform and elevate the BOD and COD level.

8.5.6.1 Mitigation

Precautions need to be taken at all times during construction work inside water. Supervision and monitoring need to be in place making sure that these impacts are minimized. Avoid discharge of untreated sewage into marine environment.

8.5.7 *Impacts on Baitfish, Reef-fish and Other Marine Organism*

As a result of sewerage system development along with sewage outfalls, associated activities and consequential impacts on the physical and biological environments, the marine organisms such as juvenile fish found in the area will be impacted and may decline in its numbers and diversity as well as eventual death in certain species. Sedimentation may also reach short distances within the same reef and causing similar threats to species. However, the magnitude of the impacts will be determined by current flow patterns and resilience of the species in the region. Measure of current is hence very important to determine the flow pattern around the island. In absence appropriate data to assess the direction, sewage effluent might flow into lagoon harbour.

8.5.7.1 Mitigation

Mitigation measures to these impacts include monitoring and supervision of all work sites, in particular of installation of sewage outfall and exaction and installation of catch pits, road manholes, main pump stations, sewer line etc. which are likely of causing impact to environment

8.5.8 *Health and safety*

The main health and safety issues during the construction stage would be in the operation of heavy machinery and equipment such as excavators with the risk of toppling. Falls and accidents due to carelessness in the project site has been a concern in many construction sites and must be addressed during the planning and implementation stages.

Noise levels felt by workers can be a health issue too. However, noise levels at the project site would not be too high and would be intermittent and not continuous. Therefore, acceptable average daily exposure levels would not be exceeded for construction workforce.

8.6 Operation Impacts

The operational phase will impose threats to the marine environment and groundwater aquifer that are of a continuous nature and are often difficult to deal with due to the complexity of certain impacts. The groundwater impacts will be of significant.

8.6.1 *Impacts from Operation of Sewage System*

8.6.1.1 Impacts

According to World Resource Institute (WRI), 2000, 41% of reef systems in the Pacific region are under medium-high pressure from human developments. The impact to environment due to anthropogenic physical structures such as breakwaters, access channels and harbours on the coastal processes and marine flora and fauna, can be quite significant and often permanent. Some of these include:

- Change in near shore hydrodynamics.
- Erosion and loss of vegetation at the low energy areas during either monsoons.
- Sedimentation and turbidity resulting in poor water quality which negatively impacts vitality of marine organisms.
- Alteration of bottom substrate.
- Degradation of sea water quality due to increased sediment or turbidity.
- Loss of coral reefs

The long term impact of the proposed project is difficult to quantify due to the lack of past monitoring and research on this aspect in the Maldives and specifically that of the project site. However, the impact is expected to be moderate in scale and long term.

8.6.1.2 Mitigations

Mitigation measures are dependent on the long term monitoring. It is important to consider regular and consistent monitoring of littoral transport patterns over a period of about three years to understand the specific impacts of the coastal developments.

8.6.2 *Transport Related Impacts*

8.6.2.1 Impacts

The use of diesel as well as petrol in vehicular engines and operation of machines cause emissions of carbon dioxide, sulphur dioxide and nitrogen oxides with fine particular matter. Carbon dioxide being the primary greenhouse gas and the main contributor to global warming, likely future carbon emissions would be a cause for concern, as the impact cumulatively adds to the global burden of carbon emissions.

8.6.2.2 Mitigations

Mitigation these aspects include

- Use light fuel where appropriate
- Avoid unnecessary operation of vehicles, machines and boats
- Keep in place appropriate transport management system
- Keep in place appropriate logistic management system during construction and operation phase

8.6.3 *Socio-Economic Impacts*

8.6.3.1 Impacts

The social economic impacts from the proposed water supply and sewerage system will be positive and negative; in terms of job opportunities it is positive. The negative impact would be that it will damage groundwater aquifer by elevating salinity level depending on the rate of extraction for flushing. The positive impacts would be that people would be satisfied with the system and will minimize groundwater contamination from domestic sewage.

8.6.3.2 Mitigation

The mitigation measures would be to inform islands communities about the proposed sewerage system. Involve community members within the implementation phase until handed over to utility for operation.

Table 8-2: Summary of socio-economic and environmental impacts of the proposed project

Activity	Causal Factors	Impact	Short Term Effects	Long term Effects	Impact Significance
CLEARING OF VEGETATION ON LAND AND COASTLINE (PIPE LAYING, PUMP STATIONS, OUT FALLS)	Reduced number of trees on the island	Loss of vegetation Loss of habitats for birds and domestic animals Elevated atmospheric CO ₂	Disappearance of birds Nesting birds lose their habits	Contributed global warming Contributes global warming	Moderate Moderate
	INSTALLATION OF SEWER AND WATER NETWORK	Alters groundwater quality Elevated atmospheric emissions Discharge of oil, chemical and wastewater into ground	Poor water quality Atmospheric pollution Pollutes soil, water	Elevated salinity Contributes global warming loss of freshwater, and soil	Change of water quality and changes life style Contributes global warming Disappearance of freshwater aquifer
INSTALLATION OF PUMP STATIONS, LIF STATIONS AND MANHOLES, SEWER OUTFALLS	Re-suspension of fine sediments	Water quality degradation	Increased water turbidity		Low
	Imported material use	Introduction of alien matter			Low/moderate
MACHINERY & EQUIPMENT	Heavy machinery operation and construction	Local noise and air pollution	Temporary disturbance to particularly habitats/people	None	Insignificant
	Accidental damage from operation of barges, etc.	Local damage to reefs			Low to moderate
	Accidents during machinery and material transport to site	Oil and waste spillages to oceans/reefs	Sudden death of marine life to water quality deterioration		Low to moderate
WASTEWATER DISPOSAL INCLUDING BRINE	Discharges or accidental spill of motor oils, lubricants, hydraulic fuels, other chemicals such as antifoulants and paints in vessels	Marine water pollution	Contamination of marine biota and fisheries resources	Decrease in fish and live corals	Low to moderate
	Discharge of wastewater effluent				
HANDLING AND TRANSPORT OF GOODS AND MATERIALS	Loading/unloading noise Dust and air emissions	Air and noise pollution		Disturbance to terrestrial and marine ecological systems	Low
	Transport including road transport	Increased risk of accidents Increased pollution	Increased casualties, air and noise pollution	Increased casualties, air and noise pollution	Low
INFLOW OF GOODS AND MATERIALS	Increased traffic of vessels to and from the island	Increased inter-island transport and inter-atoll transport Creation of business opportunities Direct and reliable supply of goods	Increased sales to related local business establishments	Creation of employment	Positive

Table 8-3: Summary of mitigation measures

Mitigation measures for minimizing impacts		Implementing responsibility	Technology/equipment	Time frame	Cost
Design Phase	Identify areas for development on land and marine Clearly identify and mark the areas required clearing of vegetation and coral reefs Design all development on the principle of cleaner production	Project engineer/design engineer/consultant	Conventional Gravity with STP and RO plant	To be decided	
Construction phase	Adoption of early warning mechanism through regular monitoring for level of suspended solids and /or turbidity during construction works Ensure proper and efficient operation Selection of appropriate development windows (e.g. execute coastal and marine work in low tide) Monitor suspended solids in water flowing out and spreading Contain marine and coastal work sites to avoid sediment flow away from work site Completion of work as soon as possible but by avoiding working at night Minimized felling of old trees Replant on another location any old coconut palm removed from work site Minimize clearing of vegetation Avoid any spilling into the ground that can contaminate soil and groundwater Keep sensitive areas protected from damage (e.g. grave yard) Avoid discharge of untreated sewage/wastewater effluent into ocean Minimize removal of corals for sewer, jetty and detached water villas development	EIA Consultant Contractor	Chose appropriate technologies and equipment environmentally sound	To be decided	
Operation phase	Monitor coastal water, beach profile as well as other areas at designated locations, groundwater quality Ensure enforcement from government regulatory bodies	Utility, Island Council and EPA, MHE		To be decided	
Mitigation measures for mitigating impacts of machinery and equipment		Implementing responsibility	Technology/equipment	Time frame	Cost
Design Phase	Plan for the use of appropriate equipment. Provide appropriate working windows	Project engineer		To be decided	
Construction phase	Ensure proper monitoring of construction activities Establish strict regulations and safety measures for machinery operation Locate storage area on the island Provide effective management of fuel handling area and other dangerous substances storage	Contractor		To be decided	
Mitigation measures for mitigating impacts of waste disposal		Implementing responsibility	Technology/equipment	Time frame	Cost
Design Phase	Design for appropriate solid waste disposal such as provision of disposal facilities and collection procedures Establish appropriate mechanism for waste management employed with trained and informed personals	Project engineer developer	Chose appropriate technologies	Detailed design stage	
Construction phase	Construction waste must be disposed appropriately Construction debris shall not be disposed in the marine environment	Contractor/developer			

Operation phase	Produce and enforce strict regulations for liquid and solid waste disposal from vessels and in the service jetty area Disposal of solid waste including fish waste, wastewater and waste oil disposal other than designated areas shall be prohibited Fuelling of boats and vessels on sea shall be closely supervised and monitored Signboards indicating "Keep the environment clean" shall be placed on jetties, water villas, and all service areas Ensure emergency procedures in case of spill out of dangerous substances are in place Appropriate solid waste collection facilities shall be placed on the resort	Developer/operator			
Mitigation measures for mitigating impacts of goods and material handling		Implementing responsibility	Technology/equipment	Time frame	Cost
Design Phase	Raising awareness and utilizing environmental best practice Careful planning to ensure minimal disturbance to accessibility to island	Project engineer/ Consultant/developer			
Construction phase	Development shall be carried out in a manner it will not affect or minimize the effects on the existing ecological system	Contractor/developer			
Operational phase	Produce and enforce hazardous material handling and storage procedures Ensure emergency procedures in case of spill out of dangerous substances are in place. Identify clear responsibilities. Enforce health and safety procedures at all work sites	Operator	Implement good housekeeping, provide training and raise awareness		

8.7 Uncertainties in Impact Prediction

Environmental impact prediction involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or social conditions in a particular place. There is also no long term data and information regarding the particular site under consideration, which makes it difficult to predict impacts. However, the level of uncertainty, in the case of Nolvivaram may be expected to be low due to the experience of similar projects in similar settings in the Maldives. Nevertheless, it is important to consider that there will be uncertainties and to undertake voluntary monitoring as described in the monitoring programme given in the EIA report.

9 Environmental Monitoring

9.1 Introduction

Nolhivaram does not have an island-specific monitoring programme. Therefore, it is recommended that the Island Council initiate an integrated, island-wide environmental monitoring programme. There are several benefits in such a programme including:

- Impacts on the island of different projects ongoing including solid waste management, water supply, harbour and sewerage projects can be undertaken in a coordinated manner
- Since all projects impact upon the same environmental resources and aspects, the cumulative impacts of all projects combined is better understood
- A holistics approach to environmental management can be adopted
- Cost of monitoring would be reduced and more parameters can be monitored.

Therefore, it would be useful to undertake such an integrated monitoring programme. In that case, the following environmental components would be useful to monitor.

- Ground water of the island to monitor the improvements
- Waste management aspects
- Island shorelines and vegetation
- Coral reef monitoring for reef health and marine biodiversity around the outfall and a control point
- Surface water at existing outfall locations to monitor improvements in sea water quality especially the lagoon
- Socio-economic aspects

In case of adopting a project-specific monitoring programme, it is perhaps only useful to monitor groundwater and surface water quality at designated locations. This report discusses the monitoring requirements specifically for these parameters. However, monitoring requirements for other parameters such as reef and socio-economic aspects are also included for reference in case an island-wide monitoring programme were to be considered.

The proposed monitoring programme shall be undertaken by environmental consultants during the construction period. The monitoring programme shall continue for a period of at least 5 years in order to understand the impacts and benefits of the system. Annual monitoring reports (summarizing the findings from the annual monitoring) need to be submitted to the EPA at the end of each year including monitoring records and field inspections during the construction phase.

It is important that information and experience gained through the monitoring activities are fed back into the EIA evaluation and analysis system to improve the quality of future assessment studies.

9.2 Monitoring Requirements

9.2.1 Coral Reef Monitoring

Table 7-1 shows the coral reef monitoring programme recommended for short and long-term evaluation of the reef system and ambient marine environment. Depending on the logistics available some of the elements in the above matrix can be omitted, however, it is strongly recommended that these methods are included in the monitoring programme.

Table 9-1: Coral reef system monitoring programme matrix

Methods	Frequency of Monitoring	Purpose
Ambient Environmental Parameters to include Temperature, Salinity, Turbidity/light penetration, Currents	Twice every month during construction phase; once every three months thereafter	Important to the 'health' of living marine resources, reefs and fish populations and other benthos
Manta Tow Technique	Once every year or following a significant natural event e.g. coral bleaching, COT infestation, storm damage etc.	Broad scale qualitative and Semi-quantitative assessment of general status of the reef system / coral and other benthic recruitment
Water quality test	Once every three months	Quantitative assessment of Nitrogen and Phosphorous contents, chlorophyll A and other parameters such as total and faecal coliform and streptococci counts

Research in the Caribbean and in the Great Barrier Reef of Australia has established the critical levels of nitrogen and phosphorous which must not be exceeded if reefs are to remain healthy without being overgrown by weedy algae (Lapointe et al., 1992, 1993, Bell, 1992). These concentrations are:

- Nitrogen: 0.014 ppm N or 0.040 ppm NO₃
- Phosphorous 0.003 ppm P or 0.007 ppm PO₄

9.2.2 *Water Quality Monitoring*

Table 9-2: Monitoring water quality

Impact Area	Data sought	Min. Frequency	Purpose
Groundwater	pH, E-Conductivity, TDS, total and faecal coliforms, nitrates, nitrites, BOD and phosphorus, H ₂ S gas	Every three months initially, then every six months	To ensure effectiveness of the proposed systems To base groundwater protection measures
System performance	Inspect and report leaks in sewerage system	Once a year	To ensure appropriate performance
Lagoon	pH, E-Conductivity, TDS, total and faecal coliforms, nitrates, BOD and phosphorus	Every three months initially, then every six months or annually	To ensure effectiveness of the proposed systems
Sea outfall/marine	pH, E-Conductivity, TDS, total and faecal coliforms, nitrates, nitrites, BOD, phosphorus and chlorophyll-A	Every three months initially, then every six months or annually	To ensure effectiveness of the proposed systems

9.2.3 *Monitoring dewatering impacts*

The water quality and water levels of selected houses would be monitored just before, during and after the project to understand the changes due to dewatering. The parameters to be monitored from each well would be pH, E-Conductivity, total and faecal coliforms, nitrates and tidal water level variations. This impact specific monitoring will be undertaken only during the period of the impact.

9.2.4 *Socio-Economic Aspects*

One of the key aspects of sustainable sanitation is the contribution that a proper sewerage system makes towards overall health of the population and community development. Therefore, such systems must be able to demonstrate their contribution towards social and community development through economic contributions and awareness creation.

A healthy environment should in turn mean opportunities for improved health and community development for the residents of Nolhivaram. Another key indicator of system sustainability will be the community's capacity to maintain and operate the system without undue financial or mental stress. A monitoring protocol to review costs associated with operation and maintenance of the system should be a component of the operating manual. In the first year following the implementation of the system, resident concerns should be promptly addressed, noted and resolved. A survey of residents to assess and track their level of satisfaction with system should also be undertaken following the first year of system operation, so that issues might be addressed before they become serious.

Table 9-3: Indicators for monitoring of socio-economic aspects of the project

Indicator	Assessment question	Source of information
1. Access to water No of households using different types of water by purpose E.g. Households using ground water for cooking / drinking/ washing/ bathing/ agricultural purposes. Households using purified water for drinking/washing/bathing/agricultural purpose	What are the changes occurring regarding the access to safe water?	Island Council records Focus Group Discussion
2. Incidence of water borne diseases Diarrhoea Typhoid Cholera	What are the changes occurring regarding the incidence of water borne disease?	Health Center records Focus group discussions
3. Employment Number of direct employment created due to the project	Are jobs and income earning opportunities created due to the project?	Record in the Council Office
4. System performance and satisfaction, e.g. how does the present system compared with previous system, how satisfied are people with the new system on a given scale (Likert)		

9.3 Recommended Monitoring Programme

Outlined here are minimum project specific monitoring requirements that should be considered. This monitoring programme for the proposed project includes at least three monthly monitoring and covers the three stages of the project implementation.

Stage 1: Immediately before starting works

Stage 2: During civil works

Stage 3: Operational stage for two years

The monitoring needs of each stage are discussed in detail below:

Stage 1

- Groundwater quality for pH, Conductivity, TDS, DO, nitrates, phosphates, faecal and total coliforms (to be sampled and tested prior to project implementation)
- Marine water quality – BOD, faecal coliforms, dissolved oxygen and chlorophyll A (to be sampled and tested prior to project implementation)
- Public expectations (covered in this EIA)

Stage 2

- Groundwater quality for pH, Conductivity, TDS, DO, nitrates, phosphates, faecal and total coliforms
- Marine water quality – BOD, faecal coliforms, dissolved oxygen, chlorophyll A
- Public complaints and issues raised

Stage 3

- Groundwater quality for pH, Conductivity, TDS, DO, nitrates, phosphates, faecal and total coliforms
- Marine water quality – BOD, faecal coliforms, dissolved oxygen and chlorophyll A
- Public satisfaction/dissatisfaction of the system

For water quality monitoring, site conditions during monitoring such as smelly groundwater, rainy day or outfall within 5m of sampling location must be identified. Sampling conditions including sampling depth, time and GPS location shall be provided.

9.4 Cost of monitoring

The following table outlines a cost estimate for the monitoring assuming the monitoring will be undertaken by environmental consultants and most of the parameters would be tested in-situ.

Table 9-4: Estimated cost of the proposed monitoring programme (annual)

No	Details	Unit cost (MRF)	Total (MRF)
1	Transport cost	10,000.00	30,000.00
2	Field allowance for 2 staffs for 2 days	1,000.00	4,000.00
3	Accommodation and food and miscellaneous for 2 staffs for 2 days	500.00	2,000.00
4	Monitoring equipment	5,000	30,000.00
5	Water quality testing and analysis	1,500	1,500.00
	Total		67,500.00

Alternatively, samples can be taken by designated person (such as the sewerage system operators) and sent to Malé for testing at the Public Health Laboratory. The costs of this would be much less compared to the costs given above. However, this would be quite impractical as the community may not have a particular need to

assess the water quality. However, the Environment Protection Agency and the project consultants who have an obligation to measure the accuracy of the impacts assessed as well as monitor the environmental benefits of the proposed project would have several reasons to undertake adequate monitoring. This is why the commitment of the Proponent to undertake monitoring has been made mandatory under the EIA Regulations. Hence, the commitment statement from the proponent is based on the estimates given in Table 9-4.

9.5 Monitoring Report

A detailed environmental monitoring report is required to be compiled and submitted to the Environment Protection Agency of the Ministry of Transport, Housing and Environment yearly based on the data collected for monitoring the parameters included in the monitoring programme given in this report. EPA may submit the report to the relevant Government agencies in order to demonstrate compliance of the Proponent.

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 works.

10 Declaration of the consultants

This EIA has been prepared according to the EIA Regulations 2007. I certify that the statements in this Environmental Impact Assessment study are true, complete and correct to the best of my knowledge and abilities.

Ahmed Zahid (EIA 08/07)

15 Jan 2012

11 Sources of Information

- B. Lapointe, M. Littler, & D. Littler, 1993, Modification of benthic community structure by natural eutrophication: The Belize Barrier Reef, *Proceedings of the 7th International Symposium on Coral Reefs*, p. 317-328, Guam
- Beswick, R. (2000). *Water Supply and Sanitation, A Strategy and Plan for the Republic of Maldives*, Parts 1 & 2, Ministry of Health, Republic of Maldives.
- Brown, B. E. and J. C. Ogden (2003). Coral bleaching. *Scientific American* 268:64-70.
- Brown, et al (1990), *Effects on the degradation of local fisheries in the Maldives. Final Report to Overseas Development Administration.*
- Brown, et al (1990), *Effects on the degradation of local fisheries in the Maldives*, Final Report to Overseas Development Administration.
- Carter, L. M., et al (2001), [Potential Consequences of Climate Variability and Change for the US Affiliated Islands of the Pacific and Caribbean](#), pp. 315-349 in *The Potential Consequences of Climate Variability and Change: Foundation Report*, Report by the National Assessment Synthesis Team for the US Global Change Research Program, Cambridge University Press, Cambridge, UK, 620pp., 2001
- Allison W R. (1996). Snorkeler damage to reef corals in the Maldive Islands, *Coral Reefs* 15: 215-218
- Clark, S., Akester, S. and Naeem, H. (1999). *Conservation and Sustainable Use of Coral Reefs: Status of Coral Reef Communities in North Male' Atoll, Maldives; Recovery Following a Severe Bleaching Event in 1998*, MacAlister Elliot and Partners Ltd.
- English, S., Wilkinson, C. and Baker, V. (1997). *Survey Manual for Tropical Marine Resources* (2nd edition), Australian Institute of Marine Science
- Falkland, A. (2001), *Report on Integrated Water Resources Management and Sustainable Sanitation for 4 Islands*, Maldives, Maldives Water and Sanitation Authority, Maldives
- Freeze, R.A., and Cherry, J.A. (1979), *Groundwater*, Englewood Cliffs, N.J., Prentice-Hall Inc., 604 pp
- Government of Maldives (2009), "Aneh Dhivehiraajje", the Strategic Action Plan 2009-2013, GoM.
- Great Barrier Reef Marine Park Authority, GBRMPA (2005), Sewage discharge policy March 2005, Sewage discharges from marine outfalls to the Great Barrier Reef Marine Park

- GWP consultants (2005), *Water Resources Tsunami Impact Assessment and Sustainable Water Sector Recovery Strategies*, September 2005
- GWP consultants (2006), *Final Report on Water Resources Assessments in Addu Atoll and Sustainable Water Supply and Sanitation Strategies*, Maldives
- Haveeru Daily, Sep 2010, <http://www.haveeru.com.mv/english/details/32526>
- Johnson, et al (2007), *Environmental Impact Assessment for the proposed sewerage system in Kulhuduhuffushi, Haa Dhaalu Atoll*, Asian Development Bank
- Kenchington, R.A., The Republic of Maldives, pp 184-204. *Managing Marine Environment*, Taylor and Francis New York Inc. (1990)
- Marine Research Centre (2003), Socio-economic assessment and monitoring of coral reef resources at Vaavu atoll, Maldives. Ministry of Fisheries, Agriculture and Marine Resources. Global Coral Reef Monitoring Network-South Asia Region. Retrieved on: November 31, 2005 from website <http://ioc.unesco.org/gcrmn/MRC%20socioeconomic%20study.pdf>
- MWSA (2006), *General Guideline for Domestic Wastewater Disposal*, Maldives Water & Sanitation Authority
- MWSA (2007), *Design Criteria for sewerage systems*, MWSA, Maldives
- NDC, Pakistan and MWSC, Maldives (2003), *Final Report on Development of Water Supply and Sewerage System in Atolls*, Maldives
- P. Bell, 1992, Eutrophication and coral reefs: some examples in the Great Barrier Reef lagoon, *Water Research* **26**: 553-568
- RMSI/UNDP, 2005, *Developing a Disaster Risk Profile for Maldives*, Volume 1: Main Report, UNDP Maldives
- Roe D, Dalal-Clayton & Hughes, R (1995), *A Directory of Impact Assessment Guidelines*, IIED, Russell Press, Nottingham, UK
- Terrados et.al. (1998). Changes in the community structure and biomass of seagrass communities along gradients of siltation in SE Asia, *Estuarine Coastal and Shelf Science* **46**, 757-68.
- The United Kingdom Hydrographic Office (2005), *Admiralty Tide Tables – Indian Ocean and South China Sea*, Vol3 (NP203)
- USACE (1999), *Small wastewater systems*, USACE, Washington

Water Solutions (2007), *EIA for the sewerage system in R. Ungoofaaru*, UNICEF, Maldives

Waterhouse, J. and Johnson, J. (2002), *Sewage Discharges in the Great Barrier Reef Region*.

WS and LHI (2006), *Environmental Impact Assessment for the development of sewerage system in HA. Dhidhdhoo*, MEEW, Maldives

Appendix 1: Terms of Reference

Appendix 2: Commitment letter from the proponent to undertake monitoring

Appendix 3: Impact Identification Checklist

Project: Water Supply and Sewerage System Development, HDh. Nolhivaram				Impact Significance					
Proponent: Global Wings Pvt. Ltd.				Negligible	Minor	Moderate	Major	Beneficial	None
Contractor:									
Date: 18 December 2011									
Topical issues	Yes	Maybe	No						
A: Air									
<i>Will the project result in:</i>									
a. Emission of air pollutants to an undesirable concentration or deteriorates ambient air quality (e.g CO ₂ , SO _x , NO _x etc)?		✓				✓			
b. Objectionable odors?			✓	✓					
c. Emission of hazardous air pollutants regulated by MHE/EPA?			✓	✓					
B: Water									
<i>Will the project:</i>									
a. Affects groundwater aquifer of the island?	✓						✓		
b. Alter the volume of existing aquifer?	✓					✓			
c. Affects marine water quality?	✓					✓			
d. Changes in current or water movement around the island?		✓				✓			
e. Alters the course of flow of water around the island?			✓			✓			
f. Contaminates marine water?	✓					✓			
C: Land/beach									

<i>Will the project results in:</i>									
a. Alteration of lands?		✓					✓		
b. Reclamation of land to increase land?		✓					✓		
c. Disposal of excavated soil material into land?			✓						✓
d. Alteration of natural beach formation?		✓						✓	
D: Natural resources									
<i>Will the project</i>									
a. Affect the coral reefs?		✓					✓		
b. Cause significant damage to the reef system?			✓	✓					
c. Cause damage to vegetation	✓							✓	
E: Solid waste/wastewater/spent oil									
<i>Will the project:</i>									
a. Generate significant quantity of solid waste or litter?	✓							✓	
b. Generate significant volume of wastewater?	✓							✓	
c. Generate significant volume of spent oil?	✓						✓		
F: Noise									
<i>Will the project</i>									
a. Increase noise level?		✓						✓	
b. Expose people (workers) to excessive noise?		✓					✓		
G: Energy									
<i>Will the project</i>									
a. Use substantial amounts of energy or fuel?	✓							✓	
H: Transportation									
<i>Will the project result in</i>									

a. Addition of new vessels and boats?	✓					✓			
b. Alteration of present pattern of access facility?	✓					✓			
I: Accident risk									
a. Involve the risk to health of workers, staff etc?									
b. Involve the release of potentially hazardous substances (e.g. oil, chemicals, or other toxic substances) in the event of accidents or upset conditions		✓				✓			
J: Human health									
Will the project									
a. Create any health hazard?		✓				✓			
b. Expose people to potential health hazard?		✓				✓			
K: Economic									
Will the project									
a. Have any adverse effect on national economy?	✓								✓
b. Have any adverse effect on income of island communities?	✓								✓
c. Have effect on employment?	✓								✓
d. Will it create new market and business opportunities?	✓								✓