ENVIRONMENTAL IMPACT ASSESSMENT

Existing Desalination Plant facility

Thulhaagiri Island Resort, Malé Atoll, Maldives

Environmental Audit Report 2011

Proponent: Thulhaagiri Island Resort

Consultant: Ahmed Zahid

October 2011
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DECLARATION BY CONSULTANT

I hereby certify that the data contained in this audit report represent the site conditions and the analytical summaries incorporated into this report are based upon data collected and analyzed by ourselves in a manner consistent with the requirements of the Environmental Protection Agency. Any deviations in the data collection methodologies have been highlighted.

I further certify that the statements made in this environmental assessment or audit for the desalination plant at Thulhaagiri Island Resort are true, complete and accurate to the best of my knowledge and abilities.

Ahmed Zahid
EIA Consultant Registration No: EIA 08/07
16 October 2011
1 Introduction

This report has been prepared in order to assess the environmental performance of the existing desalination plant for the purpose of registration of the plant according to the requirements of the Environmental Protection Agency. This report focuses only on the desalination plant and no other operations of the resort are incorporated within the context of this report.

Environmental Impact Assessment is required for the registration of desalination plant under the Desalination Regulation of the Maldives. Also, desalination plant project fall within the list of projects requiring Environmental Impact Assessment study under the Environmental Impact Assessment Regulation of the Maldives. However, since the desalination plant in Thulhaagiri Island Resort (like many other such facilities in the Maldives) has been operational when the Desalination Regulation, the EIA Regulation. Approval came into effect, the scope for this Environmental Impact Assessment has been based on that of an environmental audit of the existing facilities, focusing on the environmental compliance and performance of the existing desalination facility.

Therefore, this report will include a compliance and performance audit. The compliance audit or review will assess how well the project implementation complies with the existing environmental policies or requirements by the registering authority and the performance audit will assess the actual environmental impacts of the project and how well the impacts have been mitigated during the construction as well operational phase. The performance audit will also include a review of the existing monitoring programme, discussing the deficiencies and suggesting improvements for future monitoring.

There have not been any legal requirements for environmental monitoring as there has not been any EIA report for the resort facilities under consideration. Therefore, this report is based on the findings of site investigations carried out by the consultant and necessary information provided by the management and technical staff at Thulhaagiri Island resort. However, it is noted that the resort needs to improve the existing system in place to monitor environmental performance indicators of which water quality tests undertaken in the recent past by the Proponent have been used in preparing this report.

In addition to discussing the findings of the audit, a matrix will be presented which summarises the status of environmental compliance and performance for activities involving the operation and maintenance of the facility. This report will also provide recommendations for further environmental improvements to the desalination plants.
2 Description of Audited Facilities

2.1 Location

The audited facility is the desalination plant in Thulhaagiri Island Resort. Thulhaagiri, as it is generally referred to, is located on the south of Male Atoll at 73° 29’E and 4° 18’N.

Figure 2-1: Project Location: Thulhaagiri Island Resort in Kaafu Atoll

As per the requirements of the Terms of Reference, this section provides full description of the existing water supply infrastructure using maps at appropriate scales. Details of water supply requirements, land use, capacity, intake arrangements, pump house details, brine reject arrangements, and disinfection and reticulation mechanism have been considered here. The following figure shows the desalination plant and associated infrastructure on the resort with respect to the overall layout of the resort.

2.2 Desalination Plants

Thulhaagiri Island has two RO units of 100m3/day, producing a total of 200m3/day capacity. Both the plants are operated by the dedicated staffs that are in-charge of both desalination facility and power house. The product water is stored in a 38.0m3 steel tank which distributes to all taps, toilets, bathtubs, restaurants and other
facilities. The tank has storage capacity of 03 days which need to be extended to at least 5 days of capacity. However the size of the island being small, lands for additional storage tanks are quite limited.

Feed water is drawn from a 4-inch pipe placed 300 ft from beach, 15 from reef edge and the brine concentrate is discharged with a shorter pipe about over 30ft from the beach from end of a coral wall made to prevent erosion. The currents are quite high there and waves are almost consistently colliding with the breakwater walls providing sufficient mixing of the brine and sea water. The location of intake pipe is quite deep and quite clear of sediments.

Seawater from intake pipe is connected to sedimentation tank through a pump well. The pumps are located in a small pump house not far from the plant house. The intake water passes through a sedimentation tank or settling tank to help minimize clogging of the membranes from silt present in the water. The sedimentation tank is about 6.5 m³ capacity. The desalting process at the plant uses a reverse osmosis (RO) membranes which reduces the salt content greatly producing freshwater for use in washing, bathing and flushing toilets and brine, which is returned to sea via a lagoon outfall. Freshwater from the plant is pumped into the storage tank.

### 2.3 Operation and Maintenance

The first plant was installed 10 years ago while the second plant was installed recently on 2011. The first plant was imported from Singapore and second plant was assembled in Maldives. Till today most of the maintenance and repair works are carried out by the operations engineer. The operators are well aware of maintenance and daily operations.
2.4 Need and Justification

While it is almost impossible to justify the desalination facility on environmental grounds, these facilities have enormous socio-economic implications on which they can be justified. Thulhaagiri has average to low demand for safe water for non potable water for toilet flushing and overall management of the resort’s landscaping and other needs. It is estimated that the resort produces about 100 cubic meters per day (at the time of inspection). Since the resort occupancy was almost full at the time of inspection it is expected that this amount of production is sufficient and it will get lower during low season. Since the island has production capacity of 200m3/day they meet the demand very well. Even with these much demand for water, it would be almost impossible to supply water using rain and groundwater. In addition, the Tourism Regulations prohibits the use of groundwater for any purpose and encourages the installation of desalination plant. Therefore, desalination is the normal practice and the feasible means of catering for the water supply demands in Maldivian resorts.

The Environmental Protection Agency requires that desalination plants are operated only under license from the Agency. Environmental assessment (including audit and monitoring) is a requirement for the registration as well as renewal of the registration. This report will fulfill such requirements for the renewal of registration of desalination plant and help in the verification of regulatory environmental compliance. The report will also provide a status of the current management practices and identify opportunities for improvement.
3 Regulatory Aspects

The legal and policy instruments that are of relevance to the desalination plant under operation in Thulhaagiri Island Resort are the Environmental Protection and Preservation Act, EIA Regulations, Regulation on the Protection and Conservation of the Environment in the Tourism Industry, Desalination Regulation of the Maldives and to some extent the National Energy Policy. These legal as well policy instruments and their relevance to the desalination infrastructure in Thulhaagiri are discussed below.

3.1 Environmental Protection and Preservation Act

The main legal instrument pertaining to environmental protection and preservation for sustainable development in the Maldives is the Environmental Protection and Preservation Act (Law No. 4/93) passed by the Citizen’s Majlis in April 1993. The following clauses of the Environmental Protection and Preservation Act (Law No. 4/93) are relevant to the project:

Clause 5a: An impact assessment study shall be submitted to the Ministry of Environment, Energy and Water (as it is called at the time the Law was amended but now Ministry of Housing and Environment, referred to as Ministry of Environment here) before implementing any development project that may have a potentially detrimental impact on the environment.

Clause 5b: The Ministry of Environment shall formulate the guidelines for EIA and shall determine the projects that need such assessment as mentioned in paragraph (a) of this clause.

Clause 6: The Ministry of Environment has the authority to terminate any project that has an undesirable impact on the environment. A project so terminated shall not receive any compensation.

Clause 9a: The penalty for minor offences in breach of this law or any regulations made under this law, shall be a fine ranging between Rf5.00 (five Rufiyaa) and Rf500.00 (five hundred Rufiyaa), depending on the actual gravity of the offence. The fine shall be levied by the Ministry of Environment, Energy and Water or by any other government authority designated by that Ministry.

Clause 9b: Except for those offences that are stated in (a) of this clause, all major offences under this law shall carry a fine of not more than Rf100,000,000.00 (one hundred million Rufiyaa), depending on the seriousness of the offence. The fine shall be levied by the Ministry of Environment, Energy and Water.

Clause 10: 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. This includes all activities...
mentioned in Clause No. 7 of this law as well as those activities that take place outside the projects that are identified here as environmentally damaging.

Clauses 9 and 10 are of specific relevance to this Audit. The EIA Regulations, which came into force in May 2007, has been developed by the powers vested by the above umbrella law.

### 3.2 EIA Regulations

The EIA Regulations, which came into force in May 2007, has been developed by the powers vested by the above umbrella law. The EIA Regulations have been the basis for Environmental Impact Assessment in the Maldives and since its advent it had helped to improve the quality of EIAs undertaken in the country. Today, registered consultants are required to sign EIAs, the EIAs are reviewed by two independent reviewers and final decisions based on the reviews. This Audit would also be subject to these requirements and review criteria.

Schedule D of the EIA Regulations lists the different environmental projects that require an Environmental Impact Assessment study and desalination plants have been included in the list. However, the desalination infrastructure in Thulhaagiri was developed prior to the EIA Regulations or the Environmental Protection Act. Therefore, the development of the facilities were not scrutinised by an EIA study. With the recent Desalination Regulation of the Maldives, EIA has been mandated for the registration of these facilities. Hence, an environmental assessment in the form of an Audit was required for the re-registration of the facilities as there has not been any EIA done in the past for these developments in Thulhaagiri Island. Although the EIA Regulations have not set out the requirements for environmental audits, contents of environmental impact assessment has been given in Schedule E and format for monitoring reports have been given in Schedule M. Therefore, these requirements have been taken into consideration in preparing this Audit report.

### 3.3 Regulation on Protection and Conservation of Environment in the Tourism Industry

The Regulation on the Protection and Conservation of the Environment in the Tourism Industry came into effect on 20 July 2006. Section 6 of the Regulation deals with water supply in tourist facilities. It requires every resort to have a desalination plant registered according to the Desalination Regulation and requires that daily logs of water quality are recorded and maintained. It also asks for the provision of water storage sufficient for 5 days supply.

It further states that groundwater shall not be used for drinking by guests or staff, and shall not be supplied to guest rooms or toilets of guest rooms or for use by staff. Furthermore, any type of oil (e.g. used engine oil) or any other chemical which may damage the environment shall not be drained to the ground.
3.4 National Energy Policy

As one of the first countries to sign and ratify the Kyoto Protocol in 1998 and as a member of the UN Framework Convention on Climate Change, the Maldives is committed to implement national policies towards sustainable energy management and reduction of greenhouse gas emissions. The President has recently announced that the Maldives would work towards becoming the world’s first carbon neutral country by 2020. The National Energy Policy introduced subsequently is focussed on this goal. As such the National Energy Policy looks at existing issues, constraints and emerging issues. The policy addresses issues of energy supply, consumption, environment, renewable energy, energy efficiency and sustainability. Sustainable supply and consumption is the main focus of the policy.

The key policies outlined in the National Energy Policy are:

- Policy 1: Provide all citizens with access to affordable and reliable supply of electricity
- Policy 2: Achieve carbon neutrality by Year 2020
- Policy 3: Promote energy conservation and energy efficiency to reduce costs
- Policy 4: Increase national energy security by diversifying energy sources
- Policy 5: Promote Renewable Energy Technologies
- Policy 6: Strengthen the institutional and legal framework of the energy sector

According to the policy document, only 3% of energy is from biomass and solar energy while the rest is from refined petroleum products with diesel fuel accounting to 83% of the total energy consumption in the Maldives. Desalination including bottling plants is also dependent on this energy supply by diesel fuel. Therefore, there is a great deal of work that needs to be done if carbon neutrality were to be achieved by 2020.

3.5 Desalination Regulation of the Maldives

The Desalination Regulation of the Maldives came into force from 2002 when this plant was operational. The Desalination Regulation states the requirements for application, plant capacity determination, intake and source water, plant operation and maintenance, brine discharge as well as water quality monitoring requirements. The Environmental Protection Agency is currently in the process of reviewing the Desalination Regulation to incorporate the current regulatory requirements as well as administrative framework. This regulation is the only regulation currently in force for the water and sanitation sector and has been established with the primary objective of safeguarding public water supplies, the environment and the interests of service providers.
3.6 Relevant Standards

3.6.1 Water Quality

Currently, there is no national water quality standard in force. The World Health Organisation’s Guidelines for Drinking Water Quality are used for reference.

3.6.2 Noise

Similarly, there are no national standards for noise. Noise is one of the major environmental problems associated with desalination plants. The only requirement with regard to noise emissions is the clause in the Desalination Regulation which specifies that adequate noise protection gear shall be provided to staff working in the desalination plant house if the noise inside the premises are higher than 85dB(A).

In the absence of local standards, internationally acceptable noise standards have been adopted in addressing noise emanating from the desalination plant. Table 3-4 gives noise standards implemented by USEPA and Germany, which is similar to European standards.

Table 3-1: Some selected noise standards

<table>
<thead>
<tr>
<th>Country/Body</th>
<th>Standard</th>
<th>Averaging Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>US EPA</td>
<td>&lt;65 dB(A)</td>
<td>Day time</td>
</tr>
<tr>
<td></td>
<td>&lt;55 dB(A)</td>
<td>Night time</td>
</tr>
<tr>
<td>Germany</td>
<td>&lt;55dB(A)</td>
<td>Day time</td>
</tr>
<tr>
<td></td>
<td>&lt;40dB(A)</td>
<td>Night time</td>
</tr>
</tbody>
</table>

The noise standards enforced by the USEPA for residential areas are 65dB (A) during day time and 55dB (A) during night time, slightly lower than the corresponding German standards of 55dB (A) and 40dB (A).

Table 3-2: Noise standards according to World Bank Pollution Prevention and Abatement Handbook 1998

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Maximum allowable log equivalent (hourly measurements), in dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential, institutional, educational</td>
<td>Day (07:00 - 22:00) 55</td>
</tr>
<tr>
<td>Industrial, commercial</td>
<td>70</td>
</tr>
</tbody>
</table>

In cases where the baseline noise level is already above these levels, the plant noise should not cause an increase of more than 3dB (A).

4 Existing Environment

This section provides baseline information regarding the relevant environmental characteristics of the study area. These include ground and marine water quality for standard parameters given in the approved Terms of Reference and also the quality of the product water from the desalination plant. Product water quality is regularly assessed at site, therefore, that data would be used to assess compliance and performance. Additional water quality assessment for product water would be done only if there is non-compliance with reference to in-house water testing undertaken in the past few months. Brine discharge location would be assessed in terms of tides, currents and flow of discharge. The coral cover along the brine discharge pipe or intake pipe or part of the pipes that run on reef areas where live corals can be found was not investigated as there are no pipes running on area with live coral cover.

Noise levels in the vicinity of the desalination plant and how they affect recreational quality and public and occupational health would be assessed. These noise levels would also represent noise levels related to the powerhouse operation.

4.1 Methodology

Existing environment was studied using standard methods used in EIA studies. Field visit was undertaken on 30 September 2011. Checklists were used to assess site conditions with specific reference to desalination plant facilities. Water quality was assessed using YSI field water quality logger, which was calibrated day before the field trip. Water quality was assessed, as given in the TOR, at mid point where it is shallower than 1m and at about 1m where it is deeper than 1m. Water quality at the receiving environment for the brine discharge was taken at about 5m from the discharge point. Further tests were carried out at MWSC laboratory.

Noise was measured using an IEC Type 2 noise meter. Spot SPL measurements which were recorded are presented in this report. Sensitive areas in the vicinity of the powerhouse and desalination plant were included. Other relevant and useful observations were also recorded on site.

4.2 Water Resources and Supply

4.2.1 Water Resources

Available water resources are groundwater and seawater of which only groundwater can be considered freshwater. Rainwater is not collected due to the unavailability of land for additional storage tanks. Groundwater cannot be depended on either due to the small size of the aquifer or the restrictions on its use imposed by the Tourism
Regulations, which forbids the use of groundwater for any purpose in resorts. Therefore, seawater desalination has to be carried out.

**Table 4-1: Ground water quality**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.82</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>28.75</td>
</tr>
<tr>
<td>Electrical Conductivity (uS/cm)</td>
<td>1215</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>790</td>
</tr>
<tr>
<td>Salinity (ppt)</td>
<td>35.56</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>2.73</td>
</tr>
</tbody>
</table>

4.2.2 Desalinated Water Consumption

Water production statistics is not maintained in the resort. However, based on the average daily production of 100m³ per day and a total number of consumers at 488, the resort consumes about 204 litres per capita per day. This is average compared to some other resorts in the same category.

4.2.3 Water Quality

The management of the resort has recently started monthly testing of product water. The desalinated water is being chlorinated by an automated dosing system which was installed recently. Hence the water quality and preventive measures are becoming a priority for the operators and management.

4.2.4 Water Conservation

Water conservation measures are not given a priority but there are certain measures implemented to save water. Guest and staff are aware of importance of water conservation; however such steps need to be practiced. Since the resort is mainly dependent on desalination, water conservation results not only in the reduction of water use but also energy/fuel use.

4.3 Occupational Health

Adequate personal protective equipment is provided. A list of such equipment is given below. The plant room is air-conditioned with adequate noise insulation.

The resort needs to provide health and safety training to the staff working in the powerhouse and the desalination plant facility. The Engineering Department is equipped with the necessary skills while fire fighting equipment is provided in all areas of the resort.
There are no occupational health hazards in the work environment. All hazardous areas are well managed and all risks are minimized. No visible fuel spills have been observed. There are also no wet surfaces in any of the work areas.
5 Environmental Compliance and Performance

This section will identify operational impacts of the desalination plant facilities to verify environmental compliance and address environmental performance issues. As such, the following would be considered:

- Identify if the brine is discharged in appropriate location.
- Discuss the short term as well as long term effects of any emissions or discharges on the environment, especially the health of the staff.
- Identify any information gaps and evaluate their importance for decision-making.
- Determine how well the existing infrastructure complies with existing environmental policies and regulations.

5.1 Desalination Plant

5.1.1 Emissions

The atmospheric emissions and GHG emissions related to the desalination plant have not been done due to inadequate data. However, it is noted that the emissions would be well below all international standards due to the small scale of the operations.

5.1.2 Noise levels

Noise levels for the desalination plant as well as powerhouse are well within acceptable levels which was 78db inside the plant house and 71db outside the plant house area.

5.1.3 Performance

5.1.3.1 Seawater intake

The intake is located on the reef edge. It is 4-inch UPVC pipe located at about 3 metre below mean sea level. The pipe was installed about 10 years ago and has not had any negative impact on the growth of the reef. There is quite high coral growth in this area and current seems fairly low, hence minimising the sediment movement. Clogging of filters is very low and sedimentation tank shows very less settlement of sediments proving that the location of intake is good.

The pipe is laid using concrete blocks to anchor it on the reef. There might have been some damages to coral during installation. However, the installation was carried out 10 years ago and no sign of severe damage was observed. However the pipe needs to be observed and maintained by the staff on a regular basis.
The following table shows the water quality from intake water.

**Table 5-1: Intake water quality**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.18</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>29.54</td>
</tr>
<tr>
<td>Electrical Conductivity (μS/cm)</td>
<td>53990</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>35100</td>
</tr>
<tr>
<td>Salinity (ppt)</td>
<td>35.56</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>10.80</td>
</tr>
</tbody>
</table>

### 5.1.3.2 Brine Discharge

The brine discharge pipe is located on the beach at the northeastern side. It was initially in the lagoon, however, due to recent changes in the island shoreline, the pipe is now on the shore. The pipe is buried in the sand with some rock covering it. There is growth of moss between the rocks. In order to improve the aesthetics of the beach in this area, it is recommended to remove the rocks and extend the pipe into the lagoon at about 10m from the shore.
5.1.3.3 Sedimentation tank

The sedimentation tank slightly small for a 200m³/day facility however the settling of sediments and blockages are not observed due to the intake water being quite free of sediments. The sedimentation tank consisted of 3 chambers which has total capacity of 6.5m³. The sea water is quite clean and settling of sediments seems well. The staff in-charge informs that the tank is not cleaned regularly due to low settlements of sediments. However the foot valves and the pipes are showing some sediment attached to it which could mean that regular observation and maintenance is required for the tank. The two pumps which are supplying the raw water to the tanks are working well but need some servicing. These will improve the overall performance and reduce energy demand. Sedimentation tanks work as natural sediment removers and if these tanks are well maintained it will keep filters and membranes from blocking. There is scope for improvement on the preventive maintenance of the sedimentation tank.

5.1.3.4 Desalination units

Table 5-3: Desalination Plant details

<table>
<thead>
<tr>
<th>Plant</th>
<th>Capacity</th>
<th>Brand/Model</th>
<th>Country of Manufacture</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100 m³/day</td>
<td>Watermac / WMRO 100</td>
<td>Singapore</td>
<td>Good/ but needs repair and maintenance</td>
</tr>
<tr>
<td>2</td>
<td>100m³/day</td>
<td>SWRO 100T</td>
<td>Maldives (Assembled)</td>
<td>V. Good</td>
</tr>
</tbody>
</table>

There are of two plants of 100m³/ day each adding up to 200m³/day of production. The first plant was established quite long ago (approximately 10 years ago) and was registered in EPA). The plants were installed by suppliers from Singapore. The first plant was imported and installed by Watermac Singapore and the second plant was assembled and installed by a Maldivian company. It was observed the chief engineer has good experience and knowledge of the plants and its O&M. However other staff needs to be trained on these areas.
The first plant of $100\text{m}^3$/day is in working condition but has some leaks at the end of membranes. The plant room is kept dry and well maintained.

### Table 5-2: Product Water quality

<table>
<thead>
<tr>
<th></th>
<th>Product Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.75</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>30.40</td>
</tr>
<tr>
<td>Electrical Conductivity (uS/cm)</td>
<td>543</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>353</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>6.18</td>
</tr>
</tbody>
</table>

The following are the findings and issues:

- The head operator is technically very capable of managing and maintaining the plants and facility.
- First plant of $100\text{m}^3$/day has leaks at end of membranes and rusting parts.
- Filter units needs cleaning and regular backwashing
- Sedimentation tanks needs regular observation and thorough cleaning
- Some lights in the panel boards are not working
- There are pressure gauges, valves and plant display meters which needs replacing
- Clamps and other rusting parts needs replacement
- The plant house is clean and dry, very well managed and maintained.
- No leaks on the floor or inside the plant chassis.
- There are some spare parts and filters available. Proper spare parts list has to be prepared.
- Plant catalogues and manuals are available except high pressure pump manual for the second plant.
- Plant logs are not recorded regularly. It was also observed that the operator is not very familiar with pressure and other theoretical aspects of desalination.
- Protective masks and gloves have to be provided at site. No display of chemical procedures and warning signs were seen.
- The head operator is very capable of O&M of the plant, other operators’ needs training.
- No operations diagrams, instructions and warning signs are at the plant room.
- No disinfection of water.
- Water quality testing has not been carried out regularly but it was started recently.
- Some pipes and fittings need to be fixed and rusting parts needs oil and grease.
- There are some pressure gauges which were not working and needs replacing
5.1.3.5 Disinfection and Chemical Usage

Chlorine is used for the disinfection of desalinated water plant. It is estimated that 10 kg of chemical is used per month. The chemical is stored in a dry and clean area inside the plant house. Means of protection such as gloves and masks are not made available in the area and warning signs, preparing methods and safety precautions are not displayed.

5.1.3.6 Product Water Storage

The product water from the plant goes to a small concrete tank (transfer tank) from which it is pumped to the storage tank. This small tank is about 1600 litres concrete tank and is located outside of the plant house. This tank is very clean the top is well covered.

The main storage tank is made of steel and has capacity of 38.3m³ which can store up to 3 days of water. The tank is well maintained, covered and painted.

5.1.3.7 Operation and Maintenance

The staffs in charge are well aware of repairs and maintenance. However scheduled preventive maintenance, record keeping, spare parts management which is essential to keep up with the EPA standards are not practised yet. Also training for these areas is required.

There are tools, basic safety equipment including fire extinguishers present and are well managed. There are also some spare parts available and replacements like filters and chemicals are made available to them.

Plant logs are not taken regularly and needs to be carried out as per EPA guidelines. It seems the purpose of the log keeping is not well understood however the operators can identify the problems at very early stage and major maintenance are frequently carried out.

The plant house is well managed and kept. There are almost no leakages and the floor is kept dry.
5.2 Audit Summary

The following matrix provides a summary of environmental compliance of the desalination plant.

Table 5-4: Environmental compliance matrix for desalination plant in Thulhaagiri

<table>
<thead>
<tr>
<th>Environmental and socioeconomic aspects</th>
<th>Compliance/Performance</th>
<th>Remarks/Observations</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality</td>
<td>X</td>
<td>No regular water testing in place</td>
<td>Onsite measurements of free and residual chlorine, TDS and pH desirable. Needs regular water testing.</td>
</tr>
<tr>
<td>Environmental noise</td>
<td>X</td>
<td>Noise not felt in sensitive areas</td>
<td></td>
</tr>
<tr>
<td>Occupational health</td>
<td>X</td>
<td>Good housekeeping. No accidents reported</td>
<td></td>
</tr>
<tr>
<td>Risk management</td>
<td>X</td>
<td>Clean and tidy inside and outside.</td>
<td></td>
</tr>
<tr>
<td>Water conservation</td>
<td>X</td>
<td>Measures for water conservation, efficient technology and a great deal of awareness exist</td>
<td>Annual water audits may be useful and would reduce cost to a great extent. Per capita water consumption figure is too high.</td>
</tr>
<tr>
<td>Operation of desalination plant</td>
<td>X</td>
<td>Daily logs not taken regularly, all manuals are not available, average maintenance</td>
<td>Improve operational performance by appropriate maintenance and system performance audits.</td>
</tr>
<tr>
<td>Water quality</td>
<td>X</td>
<td>Water quality monitoring is recently started</td>
<td>Water quality monitoring needs to be improved, data shall be based on average reading of 3 samples.</td>
</tr>
</tbody>
</table>
6 Mitigation and Management of Negative Impacts

This section will identify possible measures to prevent or reduce significant negative impacts to acceptable levels with particular attention paid to intake system, brine disposal, emission and noise control and operation and maintenance issues. Cost the mitigation measures, equipment and resources required to implement those measures will also be estimated.

6.1 Desalination

Desalination plants are energy intensive, depending on diesel fuel as solar desalination is not well developed. For this reason they are not considered environment-friendly. However, desalination plants are regarded by some as a tool to preserve natural water resources and therefore as mean to protect environment and the question whether desalination systems are environmentally friendly is not necessarily relevant. Yet, this section looks at the different impacts of the desalination plant and how some of the impacts can be mitigated.

6.1.1 Intensive energy use

The intensive use of energy by the desalination plant results in indirect environmental impacts, since the energy requirements of the plant increase the production of electricity, the burning of fossil fuels and in turn the contribution to global warming. Based on various publications, it is estimated that the amount of electricity required to produce 1m$^3$ of water varies between 3.5-4.5 kWh/m$^3$ (Rachel et al 2002). The daily water production capacity in Thulhaagiri Island is estimated to be about 100m$^3$ for which an estimated maximum of 450kWh of electricity is consumed for desalination daily. Burning of this fossil fuel contributes to global emission of greenhouse gas which in turn contributes the global warming and climatic change. The CO$_2$ emissions from burning of fuel in Thulhaagiri, however, are expected to comply with USEPA standards, which have generally been used in the Maldives, in the absence of local standards. Yet, it is important to minimize water utilisation to the greatest possible extent to minimize net cumulative effect of the operations in Thulhaagiri Island Resort.

6.1.2 Alternative water resources

Rainwater and groundwater are the only sources of water available for the island. However, use of groundwater is restricted and rainwater catchment is limited by the size of the island. Therefore, desalination has been adopted. However, it may be worthwhile considering the use of groundwater for flushing toilets, which would minimize desalinated water production. However, Tourism Regulations do not allow the use of groundwater for some unknown reasons. There are no technical papers supporting this policy.
6.1.3 **Source water intake**

Any seawater desalination facility would require an intake system capable of providing a reliable quantity of clean seawater with a minimum ecological impact. There are basically two options for source water intake and they are seawater and groundwater. For seawater, there are two options, i.e. take from 5m beyond the reef or inner lagoon, as prescribed in the Desalination Regulation. In Thulhaagiri, the intake is at about 5m from the reef edge and the pipeline is located above the reef with concrete anchor blocks. The ecological impact of this setup is moderate since the setup was installed years ago and damage to the coral and reef during installation is not seen now due to the healthy growth of the reef.

For groundwater, there are two options (groundwater direct from the water lens) and brackish water using a borehole drawing water from below the water lens at about 10m below the water table. These options need to be studied further, if they were to be adopted by Thulhaagiri in the future. Of these, the option of drawing direct from the water lens would reduce costs dramatically, however, may not be allowed as per the requirements of the Tourism Regulations. Even the deep borehole option is expected to be cheaper than the seawater intake option in that the draw water would be generally free of sediments thereby increasing membrane life. However, most resorts use the seawater intake possibly due to ease of installation and for some potential for anoxious conditions resulting in ammoniacal or hydrogen sulphide smell in the product water if groundwater were used.

The trapping of marine organisms against the intake screens by the velocity and force of water flowing to it (impingement) and smaller marine organisms passing through the intake screens and getting into process equipment (entrainment) are two key impacts of desalination. This would be a cause for concern in the case of reef intakes such as that found in Thulhaagiri. In order to mitigate the impact, the intake end has been capped with a filter restricting entry of marine organisms.

6.1.4 **Brine Concentrate Discharge**

Brine concentrate is discharged on the beach covered by rocks. It has been recommended to move the pipe into the lagoon at about 10m from the beach. Even if the discharge is closer to the reef area, there will be negligible impact on the reef given the small size of the plant or the small volume of discharge. The TDS of receiving water usually increase by 50-80% due to the discharge of the concentrate without treatment and that of differential temperature remains 0-1°C (Sommariva *et al.*, 2004). Although the brine contains materials originated from sea (source water), its high specific weight and the potential presence of additional chemicals introduced in the pre-treatment may harm the marine ecology within the zone of discharge, if it was discharged directly onto the reef. However, this depends on the volume and the concentration levels present in the brine. In Thulhaagiri, the house reef is over 50m from the shoreline even when the brine discharge pipe is extended to 10m from shore.
6.1.5 Impacts on groundwater

Pipes of seawater laid over the aquifer pose a danger to it as these pipes may leak and salt water may penetrate the aquifer. The aquifers of small islands in Maldives usually are extended to the coastal periphery around the island. Therefore laying of pipes carrying seawater and brine necessitates the use of proper sealing techniques. It may also be useful to install leak detectors. However, small leaks from the intake or brine discharge is not expected to have irreversible, significant impacts on the groundwater. Therefore, this is not recommended.

6.2 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 the facilities under consideration may be expected to be low due to the experience of similar projects in similar settings in the Maldives and the fact that the desalination facilities have been operational for quite a number of years. Nevertheless, it is important to consider that there will be uncertainties and to undertake voluntary monitoring as described in the monitoring programme given in this report.
7 Environmental Management and Monitoring Plan

7.1 Introduction

This section will cover the management and monitoring needs of the desalination plant facilities in Thulhaagiri. The environmental performance evaluation exercise conducted on Thulhaagiri showed that there are limited environmental management issues with reference to desalination plant. In fact, there is good environmental management and performance. However, there are no written environmental management strategies and monitoring data is lacking. Data relating to environmental management and monitoring helps to not only demonstrate compliance but also helps to measure the effectiveness of or the success of the environmental impact mitigation measures. There are number of good reasons why an effective environmental management plan is needed for any such development, which can be summarised as follows.

- It can help manage environmental matters in a coordinated manner
- It can provide information that can be used for documentation and verification of environmental impacts
- It can help to provide an immediate warning whenever a predicted indicator approaches a predetermined critical level
- It can provide information that can be used for evaluating the effectiveness of implemented mitigation measures
- It can provide information for better decision making and future improvement of environmental quality.

7.2 Environmental Management Plan

The following outlines the environmental management and monitoring needs of the desalination plant infrastructure on Thulhaagiri Island Resort. It is important to note that some of these measures are currently in place and the resort has an acceptable level of environmental management although there are certain areas in which environmental management is poor due to lack of written procedures and guidelines. Therefore, it may be necessary to have a Resort Environmental Management and Safety Management Action Plan developed for the entire resort operation, which could serve as a manual for environmental management.
7.2.1 **Fuel and Hazardous Chemicals**

The following table outlines the possible impacts, management objectives, performance targets and monitoring indicators for fuel and hazardous chemicals management in Thulhaagiri. Please note that although hazardous chemicals are included here, not all hazardous chemicals are covered under the scope of this report.

**Table 7-1: Environmental Management Plan for fuel and hazardous chemicals**

<table>
<thead>
<tr>
<th>Potential Impacts</th>
<th>Management Objectives</th>
<th>Performance Targets</th>
<th>Monitoring Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine pollution from diesel fuel spills.</td>
<td>Resort has the right to refuse fuel deliveries from tankers not complying with national maritime and spill prevention regulations or policies.</td>
<td>No deliveries from tankers with inadequate fuel line evacuation and flow monitoring equipment.</td>
<td>Number of marine spill incidents.</td>
</tr>
<tr>
<td></td>
<td>Diesel transfers to be closely supervised by tanker captain and allocated resort staff.</td>
<td>No leaks from fuel line couplings or resort fuel lines.</td>
<td>Number of leak incidents involving coupling or resort fuel line.</td>
</tr>
<tr>
<td></td>
<td>Crew and resort staff maintains visual surveillance during transfer operations.</td>
<td>No marine oil spill incidents.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Couplings and fuel lines are evacuated and regularly checked (eg pressure-tested).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil contamination and/or groundwater pollution from fuel, lubricant or chemical leaks and spills.</td>
<td>All liquid chemicals stored in appropriate containers on impermeable floored areas.</td>
<td>No liquid chemicals, fuel or oil stored on open ground.</td>
<td>Number of petrol or oil drums kept on open ground.</td>
</tr>
<tr>
<td></td>
<td>Fuel and oil drums are stored on sealed floors or spill trays.</td>
<td>No lubricant servicing or repairs on open unprotected ground.</td>
<td>Number of sites with contaminated soils.</td>
</tr>
<tr>
<td></td>
<td>Floor coverings or strong plastic ground sheets at all oily service and repair areas.</td>
<td>No build-up of oily leaf litter in diesel bund and oil traps.</td>
<td>Number of bund and oil trap inspections and clean ups.</td>
</tr>
<tr>
<td></td>
<td>Regularly clean out oil traps in diesel tank bund.</td>
<td>No diesel fuel leaks from underground fuel lines.</td>
<td>Annual diesel line pressure-testing results.</td>
</tr>
<tr>
<td></td>
<td>Pressure-testing of below-ground diesel pipelines.</td>
<td>No fuel or chemical leak or spill that threatens groundwater quality.</td>
<td>Number of land spill and leak incidents.</td>
</tr>
<tr>
<td>Explosion or fire from ignition or mixing of volatile or flammable chemicals during storage, use or disposal</td>
<td>Flammable chemicals protected from ignition sources by appropriate storage, equipment, warning signs, training &amp; supervision</td>
<td>No fuel, gas or chemical fires or explosions.</td>
<td>Number of chemical ignition accidents.</td>
</tr>
<tr>
<td></td>
<td>Minimise risks by staff training, protective clothing and equipment, and using MSDS information.</td>
<td>All incompatible chemicals are stored and handled separately.</td>
<td>Number of hazardous chemical incidents reported by staff.</td>
</tr>
<tr>
<td>Injury and health risks from contact/exposure to hazardous chemicals.</td>
<td></td>
<td>No injuries or illnesses caused by contact or exposure to chemicals.</td>
<td>Number of chemical accidents requiring medical attention.</td>
</tr>
</tbody>
</table>
7.2.2 Desalination plant and associated facilities

The types and likelihood of potential environmental and health risk issues posed by the resort’s water supply system (including cooling water discharge) can be summarised as follows.

Table 7-2: Hazards and risks associated with water distribution and effluent disposal system

<table>
<thead>
<tr>
<th>Source</th>
<th>Potential Effect/Hazard</th>
<th>Likelihood /Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Plant</td>
<td>Marine impact from metals and hydrocarbons entering the cooling water stream</td>
<td>Very low risk if heat exchangers are checked regularly for excessive corrosion and replaced according to manufacturer’s recommended life span.</td>
</tr>
<tr>
<td>Brine and cooling water discharge</td>
<td>Coral deaths by concentrated natural salts and warm water discharge</td>
<td>Low risk due to long distance between discharge pipe and reef (even after extending)</td>
</tr>
<tr>
<td>Leaks in water distribution circuits</td>
<td>Undetected leaks cause wasteful RO water and diesel fuel</td>
<td>Moderate risk unless flow rates along pipeline circuits are checked regularly and pressure tests undertaken to locate suspected leaks.</td>
</tr>
<tr>
<td>Water quality testing</td>
<td>Diarrhoeal infections</td>
<td>Low risk if regularly tested and free chlorine levels maintained</td>
</tr>
</tbody>
</table>

The above list shows the important components of the island’s water system that requiring regular monitoring and the management plan for the desalination plant and associated facilities is given below.

Table 7-3: Environmental Management Plan for desalination plant facilities in Thulhagiri

<table>
<thead>
<tr>
<th>Potential Impacts</th>
<th>Management Objectives</th>
<th>Performance Targets</th>
<th>Monitoring Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine impact of intake cooling water and brine discharge</td>
<td>Avoid corrosion of heat exchanges by regular inspection and servicing</td>
<td>No exceedence of EPA criteria for metals and hydrocarbons in outfall (if such criteria exist)</td>
<td>Monitor metal and total petroleum hydrocarbon content of discharge</td>
</tr>
<tr>
<td>Incorrect treatment of potable water supply causes health risks to guests and staff</td>
<td>Adequate treatment, testing and maintenance of potable water supply is conducted on a priority basis</td>
<td>Levels of contaminants and pathogens meet Water Quality Standards</td>
<td>Monitor faecal coliform and chlorine weekly</td>
</tr>
<tr>
<td>Wastage of RO water due to leakage in the reticulation circuits.</td>
<td>Identify and stop leaks in reticulation circuits on a priority basis.</td>
<td>Water losses via leaks is &lt;3% of the total annual output from RO plant.</td>
<td>Monitor flow rates regularly and do pressure tests if leak is suspected.</td>
</tr>
</tbody>
</table>

7.2.3 Management of Product Water Quality

The following is an outline of the management plan for the management of desalinated water produced for potable as well as other purposes.

Strategy: Operate plant in accordance with manufacturer instructions and service agreements. Monitor pathogen and contaminant levels regularly to ensure supply meets accepted standards depending on the use.

Responsibility: Chief Engineer/Assistant Engineer, Services Manager
Monitoring/Reporting: Collect representative and discrete samples of product water supplied to guest and staff facilities from the water storage tank and at least three different supply points on the distribution system. At least three samples must be taken at each point and submitted for laboratory analysis. Following lab analysis, the results must be reviewed and correct actions taken promptly as and when necessary. The following sampling points must be considered at minimum. In addition sparkling water and ice machine water must be tested regularly. Individual results for each sample are to be filed, and a summary of the year's results provided in Periodic or Annual Monitoring Report.

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Product Water Sample Point Type</th>
<th>Location of Sampling Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RO treated water storage tank</td>
<td>Storage tank no.</td>
</tr>
<tr>
<td>2</td>
<td>Staff distribution supply point</td>
<td>Staff Unit No. ; bathroom basin faucet (tap)</td>
</tr>
<tr>
<td>3</td>
<td>Restaurant supply point</td>
<td>Restaurant kitchen ; basin faucet (tap)</td>
</tr>
<tr>
<td>4</td>
<td>Guest distribution supply point</td>
<td>Guest Unit No. ; bathroom basin faucet (tap)</td>
</tr>
</tbody>
</table>

7.3 Monitoring Requirements

In case of adopting a monitoring programme on seawater desalination it is useful to monitor:

- Fuel consumption (for desalination separate from other electricity needs)
- Marine water quality at source water intake and brine discharge locations
- End of intake pipe for entrainment risks
- Water quality in the sedimentation tank
- Product water quality
- Regular checking of system performance and components

7.3.1 Fuel Data

Fuel consumption data, storage and handling and fuel spill incident reporting are aspects mainly related to the powerhouse operations. However, desalination is also an energy-intensive process and energy requirements have to be separately monitored. Fuel consumption data will help to monitor efficiency as well as emissions related to the desalination plant operations. However, air quality monitoring would not be necessary due to the small size of the operations.

7.3.2 Water Quality

Conducting a good water quality monitoring programme is extremely important for several reasons apart from demonstrating compliance. Water quality monitoring is currently based on product water only. Besides routine
product water quality monitoring, water quality monitoring at the intake, sedimentation tank and brine concentrate discharge location would be necessary.

### 7.4 Recommended Water Quality Monitoring Programme

Outlined here is the water quality monitoring requirements that should be considered for the desalination plant operations in Thulhagiri. This programme shall change if the facilities or resort infrastructure related to facilities are to be changed. Monitoring programmes are to have full spectrum of base line data on various aspects associated with the operation of seawater desalination facilities on the island.

Water quality monitoring programme is for weekly, six monthly and annual basis considering the EPA and WHO guidelines. In addition, daily testing of pH, electrical conductivity and free and residual chlorine on site is recommended.

**Table 7-5: Monitoring water quality**

<table>
<thead>
<tr>
<th>Sample type</th>
<th>Parameters</th>
<th>Min. Frequency</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| Product water (desalinated water)        | pH, E-Conductivity, dissolved oxygen, free and residual chlorine, total and faecal coliforms | Weekly         | - To ensure the quality of water produced  
- To meet standards  
- To assure compliance |
| Product Water (desalinated water)        | Chloride, Nitrate, Phosphate, Ammonia, Iron, Total trichloromethanes, Sodium, Pottassium, Calcium, Total Hardness | Six monthly    | - To ensure the quality of water produced  
- To meet standards  
- To assure compliance |
| Intake Water (settling tank)             | Salinity, Nitrate, Phosphate, Manganese, TOC, Calcium, Sodium, Pottassium, Calcium, Bromine, Bisulphate, Mercury, Copper, Lead, Boron, Arsenic, Flouride, Phenolic compounds, Anionic detergents, Cadmium, Chromium, Cyanide | Annually for two years then revise frequency depending on results | - To ensure the quality of water produced  
- To meet standards  
- To assure compliance |
| Zone of feed water intake                | Temperature, pH, Salinity, Turbidity, Total Suspended Solids, TDS, dissolved oxygen, BOD and COD | Every six months | To ensure the quality of feed water and assure compliance |
| Zone of Brine Concentrate discharge      | Temperature, pH, E-Conductivity, TDS, Chloride, BOD and COD                | Every six months | To ensure the quality of water at brine discharge and assure compliance |
7.5 Cost of monitoring

The following table gives an estimated cost for the monitoring assuming the monitoring will be undertaken by the resort in collaboration with environmental consultants. Transport, food and accommodation for environmental consultants have not been incorporated. This estimate is based on the monitoring programme and management plan outlined earlier and assuming six monthly monitoring by environmental consultants.

**Table 7-6: Costs of annual monitoring**

<table>
<thead>
<tr>
<th>No</th>
<th>Details</th>
<th>Unit cost (US$)</th>
<th>Total (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Field allowance for 2 consultants for 1 day (two trips)</td>
<td>400.00</td>
<td>800.00</td>
</tr>
<tr>
<td>2</td>
<td>Monitoring equipment depreciation and other charges (two trips)</td>
<td>570.00</td>
<td>1,140.00</td>
</tr>
<tr>
<td>3</td>
<td>Laboratory charges</td>
<td>1,500.00</td>
<td>1,500.00</td>
</tr>
<tr>
<td>4</td>
<td>Compliance reporting (annual report)</td>
<td>2,500.00</td>
<td>2,500.00</td>
</tr>
<tr>
<td>5</td>
<td>Digital colorimeter for on-site testing of free and residual chlorine</td>
<td>900.00</td>
<td>900.00</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>6,840.00</strong></td>
</tr>
</tbody>
</table>

Environment Protection Agency and the project consultants who need adequate data to make accurate impact assessment and improve impact assessment methodologies would have several reasons to undertake monitoring at adequate intervals. Project proponents or developers or operators often find impact assessment and monitoring unnecessary for which reason the commitment of the Proponent to undertake monitoring has been made mandatory under the EIA Regulations. The purpose of providing estimated costs for monitoring is to quantify such commitments. It also indicates that monitoring is not a costly exercise given the benefits of long term cost reductions as well as compliance and environmental performance benefits associated with monitoring.
8 Conclusions and Recommendations

In conclusion, the project’s environmental performance can be rated good. The findings of this report indicate that there is compliance with general requirements of environmental infrastructure management, especially desalination plant, which form the focus of this report. There are adequate health and safety measures and there are adequate provisions to build awareness and training on health and safety including fire safety. Machinery and equipment are in working condition but there are maintenance issues as identified in this report.

The following recommendations are made:

- Extend the brine discharge pipe further into the lagoon.
- Replace cartridge filters and backwash sand filters regularly.
- Clean the sedimentation tank and inspect the sedimentation tank regularly. Sedimentation tanks work as natural sediment removers. If these tanks are well maintained it will keep filters and membranes from blocking.
- Check the chlorine levels at the site. The requirements of EPA for chlorine levels in drinking water should be met.
- Operations instructions, chemical dosing instructions, safety procedures and warning signs needs to be displayed in the plant room.
- Pressure gauges flow meters and plant displays which are not working needs to be replaced.
- Small storage tank (transfer tank) outside the pump house needs to be cleaned regularly and protected from pollutants.
- Preventive maintenance is the most important part of smooth operation of any facility. Due to lack of importance given to these areas many industries suffer huge cost of replacing bigger and expensive parts. For an example maintaining filters well will make membrane life longer. To do this the staff must keep the logs regularly, they should be able to interpret the logs, and they should also know by looking at the pressure gauges when the filters need to be backwashed or replaced.
- The plants need regular maintenance. This includes regular checking of plant operation, pumps and modules for leaks, oiling and applying grease.
- The staff should understand how to check the pressure from the system, assess the functioning, flow and production of the plant. Hence training in these areas are required.
- Documents such as manuals and catalogues must be easily accessible to operators for reference and guidance.
- The staffs that are operating the system seem to be very committed and interested in the operations. However they need training in the technical knowhow of the function of plants, maintenance and keeping the water quality constant.
- Proper stock keeping of spare parts, filters and chemicals must be practiced. Especially, care must be taken to store chemicals in appropriate atmosphere.
- It is also recommended to undertake an Energy Audit as well as a Water Audit annually. This will help minimize costs dramatically and improve performance of utilities.
- An Environmental Management System or Environment and Safety Management Plan needs to be in place to show the resort’s commitment to maintain good compliance and performance in matters relating to health, safety and environmental protection and conservation.
9 References


10 Appendices

- Terms of Reference
- Commitment Letter
- Water Quality Results
Terms of Reference for the Environmental Audit for existing Desalination plant at Thulhagiri Island Resort, K. Thulhagiri, Maldives.

The following TOR is based on the similar audits carried out in the past few months, for undertaking the Environmental Audit report for the existing desalination plant in Thulhagiri Island Resort, K. Thulhagiri, Maldives. While every attempt has been made to ensure that this TOR addresses all of the major issues associated with development proposals, they are not necessarily exhaustive. They should not be interpreted as excluding consideration of matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the audit report.

1. **Introduction** - The Ministry of Housing and Environment requires that desalination plants in the Maldives are registered. In order to carry out the registration process, environmental clearance required from the EPA, i.e. a Decision Statement regarding the environmental impact assessment of water infrastructure. In order to provide such clearance, the EPA requires that an Environmental Impact Assessment be done for proposed new or upgraded projects and an Environmental Audit be done for existing facilities. Since there are no upgrades or additional components to the desalination infrastructure at Thulhagiri Island Resort, an Environmental Audit will be done for the purpose of registering the desalination plant Thulhagiri Island Resort.

2. **Study Area** - The study will be focused on the desalination infrastructure existing on the island. The specific areas include the desalination plant including the seawater intake and brine discharge locations.

3. **Scope of Work** - The following tasks will be performed:

   **Task 1. Description of the Project Components**: Provide a full description of the existing power and water supply infrastructure using clearly labeled maps, and also include a scaled site plan. Details to include details of water supply requirements, land use, capacity, storage capacity, intake arrangements, pump house details, exhaust and brine reject arrangements, and disinfection and reticulation mechanism.

   **Task 2. Description of the Environment**: Where baseline data is to be collected, careful consideration must be given to the design of the methodology and sampling programme. Data collection must focus on key issues needing to be examined for the EIA. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that the data collected is suitable for use as a baseline to monitoring impacts.

   Assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area (and disposal sites).

   **a) Physical environment**: brief description of groundwater quality at the desalination plant location. Marine water quality at the location of intake and brine discharge locations. Marine water quality parameters shall include dissolved oxygen (DO), BOD, E- Conductivity/salinity and pH. Groundwater quality shall include dissolved oxygen, TDS or E- Conductivity, TIC, COD, BOD, nitrate and phosphate. Quality of the product water from desalination plant shall also be assessed, especially for pH, E- Conductivity and coliform bacteria (E-coli and Total coliforms). Describe the general states of the groundwater in terms of the size and quality of the water lens. In addition borehole quality profiles should
2.1. CORAL REEF, FISH & INVERTEBRATES MONITORING

2.1.1. Pilot study: Manta tow: The manta tow technique is used to assess broad changes in the benthic communities or coral reefs where the unit of interest is often an entire reef or large portion thereof (English et al. 1994). Therefore this technique can be used to perform preliminary assessments to design a comprehensive monitoring study.

- Tow an observer, using a rope and manta board, behind a small boat powered by an outboard motor. Tows are carried out at a constant speed around the perimeter of a reef and are broken into units of 2 minutes duration (English et al. 1994).
- During each 2 minute tow, observations are made on several variables (e.g. percent cover of live coral, dead coral and soft coral). Additional information may be collected, dependent on the survey objectives, e.g. percent cover of sand and rubble.
- This technique is not recommended for fish counts. A pilot study for fish is not necessary since reef fish will inhabit the healthiest available reef. Exclusive fish and invertebrates surveys will be carried out in the main study.

2.1.2. Line Intercept Transects (LIT): It is the standard method recommended by the Global Coral Reef Monitoring Network (GCRMN) to determine percentage cover and colony size for management level monitoring, and obtains information on percentage cover of benthic communities e.g. hard coral, soft coral, sponges, algae, rock, dead coral. The community is characterized using lifeform categories which provide a morphological description of the reef community.

- These categories are recorded on data sheets by divers who swim along lines which are placed roughly parallel to the reef crest at depths of 3 metres and 10 metres at each site (English et al., 1994).
- Place 5 x 20m long replicate transects at each of the two depths (shallow: 3 m and deep: 9-10 m depths). If permanent transects are used, place metal stakes, hammered deep into the substratum (at least 0.5m). If a typical reef flat, crest and slope is present, the shallow transects will be located on the reef slope, approximately 3 metres below the crest. The deeper transects will be located approximately 9-10 metres below the crest. If the site is on a reef without a well defined crest, then transect depth should be approximated to a depth below mean water mark. If there is little or no coral at 10m then transects should be laid at 6-8m and not differ.
- A representative number of sites around the island should be surveyed including those that are directly and indirectly affected by construction. A “control” site shall be selected and test sites thereafter. These shall be sufficient to make a quantitative assessment of the impacts caused by construction all around the island.
- Observers must be as consistent as possible when recording benthic lifeforms. The same observers should collect data at all sites and, where possible, during repeat surveys.

2.1.3. Coral Recruitment Plates: The larval supply of coral species is examined by estimating the number of new corals settling on replicated units of substratum (terracotta tiles). The tiles are deployed at 5 metres depth on a regular basis (e.g. monthly) and are collected after exposure for equal amounts of time, 3 months is recommended. After collection they are examined microscopically to count the new corals. Year round sampling should be undertaken to determine the period, or periods, of recruitment.
and nutrition security - fisheries, agriculture, other - etc.

- Impacts on tourism, and
- Social destabilization of the island community.

The key outcomes from each stakeholder and key informant consultation ought to be included in the EIA. Follow up consultation will validate the success of the project, failures and suggest improvements.
11th October 2011

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Nikagas Magu
Malé Maldives

Dear Sir,

This is in reference to the Environmental Audit of the existing desalination plant in Thulhaagiri Island Resort, North Male Atoll. As operator of the desalination plant, we assure you our commitment to undertake regular monitoring and audit of the desalination plant according to the requirements of the Desalination Regulation and to follow up on the recommendations of the Audit report.

Thanking you.

Sincerely,

Mohamed Naeem
Managing Director
**WATER QUALITY TEST REPORT**

Test Report No : 1025/2011/05

Sample Source : Ground Water & Sea Water
Sample Location : Thulhaagiri
Sample Collection Form no : F269
Sample Date : 05\textsuperscript{th} October 2011
Date of Analysis : 05\textsuperscript{th} October 2011
Issued To : Sand Cays Pvt. Ltd

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ANALYSIS RESULT</th>
<th>TEST METHOD</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SEA WATER (Intake)</td>
<td>GROUND WATER</td>
<td></td>
</tr>
<tr>
<td>Nitrate</td>
<td></td>
<td>1.4</td>
<td>PM</td>
</tr>
<tr>
<td>Phosphate</td>
<td></td>
<td>0.00</td>
<td>PM</td>
</tr>
<tr>
<td>COD</td>
<td>173</td>
<td>6.51</td>
<td>PM</td>
</tr>
</tbody>
</table>

**Keys:**

**UNITS:** mg/l: Milligrams per litre,

**TEST METHODS:** PM: Photometry,

**Notes:**

1. This report, in full or in part, shall not be published, advertised, used for any legal action, unless prior permission has been secured from MWSC.
2. This tests report is ONLY FOR THE SAMPLE TESTED.

**Analyzed by:**

Ali Salim, Assistant Lab Technician

**Checked by:**

Mohamed Eyman, QCO

**Approved by:**

Adam Rasheed, SWQAQO

END OF THE REPORT
National Health Laboratory  
Maldives Food and Drug Authority,  
Soasun Magu, Male' 200500, Republic of Maldives  
Telephone # 301 4310, Fax # 301 4307

WATER MICROBIOLOGY ANALYTICAL RESULTS  
REPORT NUMBER: NHL/TR-WM/RC0903

**NAME AND ADDRESS OF CLIENT:** Thulhaagiri Island Resort,  
K.Atooll, Tel: (+960) 664 5960  
Happy Market Pvt Ltd,  
Baranu Magu, Tel: (+960) 331 3523

**PURPOSE OF TESTING:** Quality Monitoring

**TIME TESTED:** 12:30  
**COLLECTED BY:** Mothaha

<table>
<thead>
<tr>
<th>LOCATION OF SAMPLE</th>
<th>Thulhaagiri Island Resort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Restaurant</td>
<td>Guest Room</td>
</tr>
<tr>
<td>Guest Restaurant</td>
<td>Product Tank</td>
</tr>
<tr>
<td>Requisition Form No: NHL/WM-2011/RC0932</td>
<td></td>
</tr>
<tr>
<td>Date Sampled/Processed</td>
<td>08/08/11</td>
</tr>
<tr>
<td>Time Sampled</td>
<td>09:00</td>
</tr>
<tr>
<td>Type of water</td>
<td>Desalinated water in sterilized bottle</td>
</tr>
<tr>
<td>Date Tested</td>
<td>08/08/11</td>
</tr>
<tr>
<td>Sample ID</td>
<td>080811WM 73</td>
</tr>
<tr>
<td>REFERENCE RANGE</td>
<td>WHO Guideline for Drinking Water</td>
</tr>
<tr>
<td>TEST METHOD</td>
<td></td>
</tr>
<tr>
<td>PARAMETER TESTED</td>
<td></td>
</tr>
<tr>
<td>Total Coliform Count (100ml)</td>
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</tr>
<tr>
<td>Faecal Coliform Count (E.coli) (100ml)</td>
<td>0</td>
</tr>
</tbody>
</table>

**COMMENT:**

**DATE:** 09th August 2011

**AUTHORIZED BY:** Technical Manager  
Marilyam Nista

**NOTE:** Information obtained by this Laboratory is not for duplication or advertisement without prior approval from NHL.

This Result is valid only for this sample. This report is not for duplicate or advertisement without prior approval from NHL.
# Water Chemistry Analytical Results

## Report Number: NHLTR-WC/RC0223

**Name and Address of Client:** Thulhaagiri Island Resort, Katooll, Tel. (+960)8645666, Happy Market Pvt Ltd, Buru bu Magu, Tel: (+960)3313923

**Purpose of Testing:** Quality Monitoring

<table>
<thead>
<tr>
<th>Parameter Tested</th>
<th>Guest Room</th>
<th>Product Tank</th>
<th>Main Restaurant</th>
<th>Staff Restaurant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Requisition Form No:</strong></td>
<td>NHLWC-2011/RQ0731</td>
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<td>NHLC-2011/RQ0731</td>
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<tr>
<td><strong>Date Sampled:</strong></td>
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<td>09/09/2011</td>
<td>09/09/2011</td>
<td>09/09/2011</td>
</tr>
<tr>
<td><strong>Time Sampled:</strong></td>
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<td>09:00</td>
<td>09:00</td>
</tr>
<tr>
<td><strong>Type of Water:</strong></td>
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<td>Desalinated</td>
<td>Desalinated</td>
<td>Desalinated</td>
</tr>
<tr>
<td><strong>Date Tested:</strong></td>
<td>09/08/2011</td>
<td>09/08/2011</td>
<td>09/08/2011</td>
<td>09/08/2011</td>
</tr>
<tr>
<td><strong>Sample ID:</strong></td>
<td>008011WC42</td>
<td>008011WC43</td>
<td>008011WC44</td>
<td>008011WC45</td>
</tr>
<tr>
<td><strong>Physical Appearance:</strong></td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
</tr>
<tr>
<td><strong>pH:</strong></td>
<td>6.7</td>
<td>6.5</td>
<td>6.5</td>
<td>6.4</td>
</tr>
<tr>
<td><strong>Total Dissolved Solids:</strong></td>
<td>336 mg/L</td>
<td>321 mg/L</td>
<td>323 mg/L</td>
<td>320 mg/L</td>
</tr>
<tr>
<td><strong>Electrical Conductivity:</strong></td>
<td>653 μS/cm</td>
<td>638 μS/cm</td>
<td>642 μS/cm</td>
<td>636 μS/cm</td>
</tr>
</tbody>
</table>

**Test Method**
- Clear & colorless
- Method 4500-B-1 of Standard methods for the examination of water and wastewater by APHA
- Adapted from copper cathode titer instruction manual

**Comment:**

**Authorized by:**

Khadecja Nashwa

**Date:** 09th August 2011

**Note:** Information supplied by client
This laboratory is not accredited for the test marked by *

This result is valid only for this sample. This report is not for duplicate or advertisement without prior approval from NHL.
16th October 2011

Ahmed Zahid,
Managing Director,
Sand Cays Pvt Ltd.,
Male',
Maldives.

Dear Sir,

Re: Unavailability of Testing Services at MWSC WQA Laboratory.

It is with regret that we inform you that the following tests are unavailable in our Laboratory at the time of your request (03rd October 2011, Tulhaagiri) due to the shortage of reagents/chemicals;

- Biological Oxygen Demand (BOD)
- Total Hydrocarbon (THC)

With increase in demand for such tests we are in the process of upgrading our laboratory such that the above tests are always available in our Laboratory.

Sincerely yours,

Male’ Water & Sewerage Company Pvt. Ltd.

Adam Rasheed
Senior Water Quality Assurance Officer

Ibrahim Akram
Asst. Manager Marketing