ENVIRONMENTAL IMPACT ASSESSMENT

Existing Desalination Plant

Chaaya Lagoon Hakuraa Huraa Resort, Meemu Atoll, Maldives

Environmental Audit Report 2010

Proponent: Chaaya Lagoon Hakuraa Huraa

Consultant: Ahmed Zahid

Sandcays

September 2010

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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 Chaaya Lagoon Hakuraa Huraa are true, complete and accurate to the best of my knowledge and abilities.

Ahmed Zahid
EIA Consultant Registration No: EIA 08/07
1 September 2010

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 projects 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 Hakuraa Huraa (like many other such facilities in the Maldives) has been operational when the Desalination Regulation and the EIA Regulation 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 plant.

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 Hakuraa resort. However, it is noted that the resort has a 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 Chaaya Lagoon Hakuraa Huraa resort. Hakuraa, as it is generally referred to, is located in a large reef system on the south eastern rim of Meemu Atoll at 73º 32'E and 2º 51'N. Located towards the middle of one of the longest stretches of reef in the Maldives with a length of about 36km, Hakuraa is the second tourist resort in that reef with 20 sandcays out of which three are inhabited. The other resort, Medhufushi is close to Hakuraa. The inhabited island of Naalaafushi, a fishing village is located about 4 to 5 km to the north of Hakuraa Huraa just next to Medhufushi.

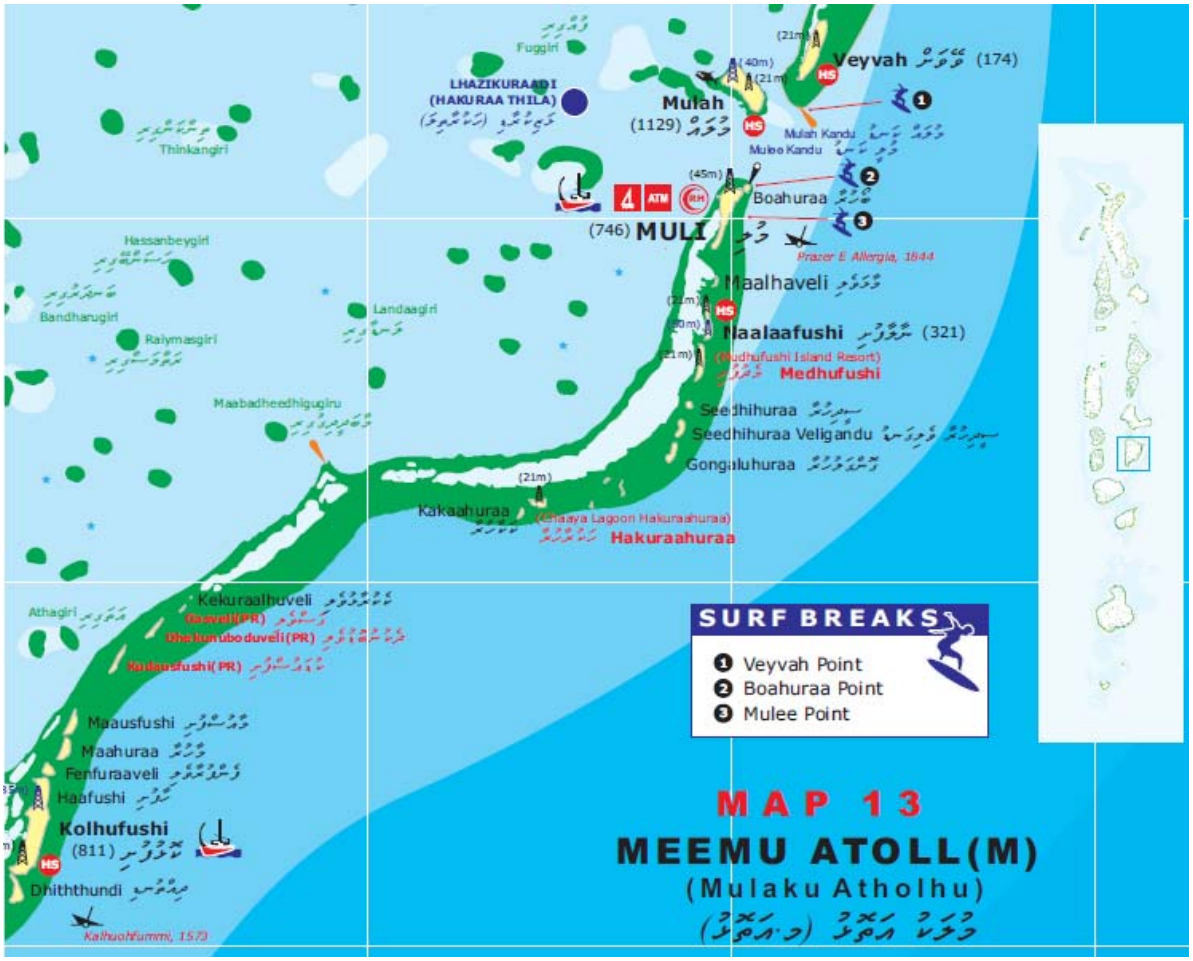


Figure 2-1: Project Location: Hakuraa Huraa in Meemu Atoll

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 Plant

Hakuraa has three RO desalination plants, each with a capacity of 65m^3 of which one plant is used for second pass filtration for production of drinking water for staff and for kitchen use. All three units were installed by Island Engineering Services, Maldives. The plants are operated by in-house operators staffed with the Engineering Department of the resort. Two of the three units were in operation when the Desalination Regulation came into force and these two units were registered with the Maldives Water and Sanitation Authority in April 2003. The other unit was installed the following year following approval from the Ministry of Tourism (letter attached in the Appendices).

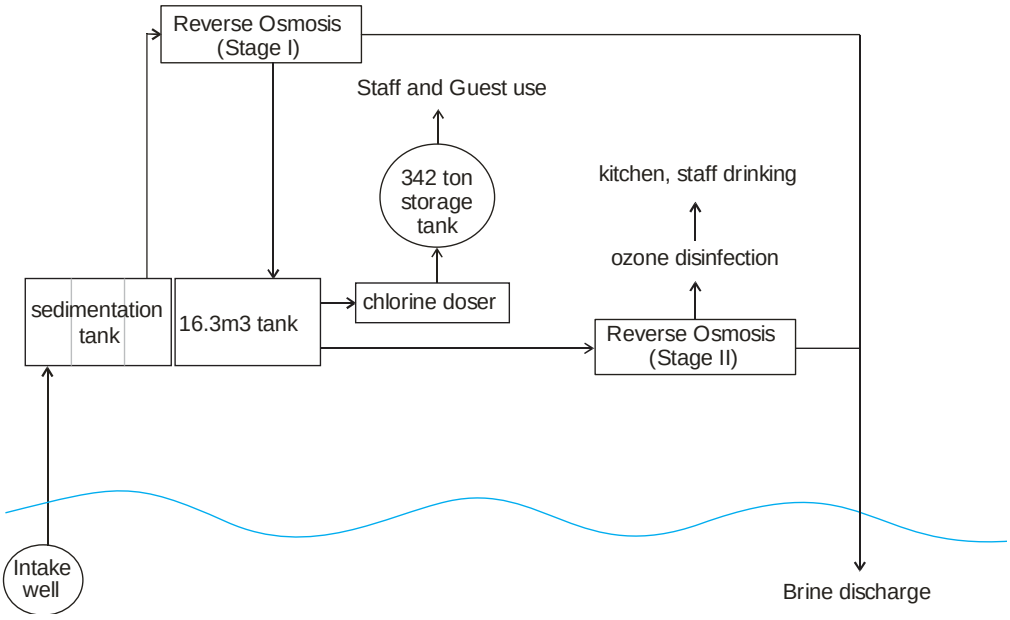


Figure 2-2: Schematic illustration of the desalination plant facilities

Feed water is drawn from the southern side lagoon. There are two intake wells. First well is about 120m from the beach near to the reef and second well is 100m from the beach and at a shallower length. The well near the reef is used during the low tide since it is in deeper waters and the other well is used only when the tide is high. The area where the second well located was quite shallow and the well can be approached by walking during the low tide.

Seawater from intake pipe is connected to sedimentation tank through a pump well. The sedimentation tank consisted of 3 chambers which has total capacity of 16.3m^3. There is also a product water receiving tank adjoining the sedimentation tank as an annexe to the sedimentation tank. The capacity of this product water receiving tank is also 16.3m^3. The product water receiving tank is also open (without cover) just like the sedimentation tank.

Chlorine (sodium hypochlorite) is used to disinfect the product water. Antiscalants and other chemicals are also used. Chemicals for plants is not a must but highly recommended since scaling will occur in the membranes when the chemicals are not used, especially when water is taken directly from the sea.

2.3 Operation and Maintenance

The desalination plant is one of the initial setups that constitute the primary operations of the resort and have been developed quite a long time ago and upgrades based on prevalent requirements of the Government have been made. The RO plants are operated and managed by the resort's Engineering Department but are maintained by Island Engineering Services Pvt. Ltd. whose main office is located in Malé. Operation and maintenance procedures manuals are easily accessible to operators.

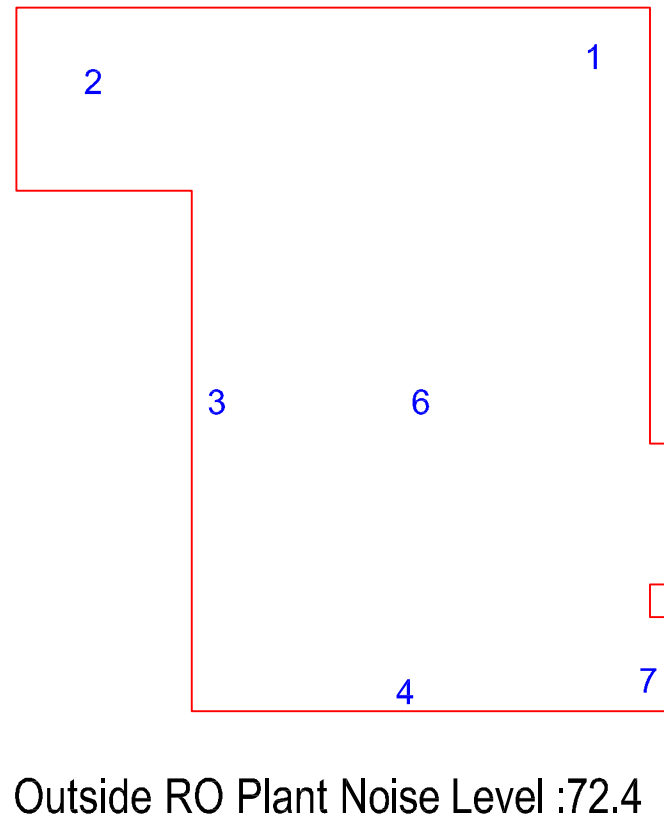
2.4 Need and Justification

While it is almost impossible to justify the desalination plants on environmental grounds, these facilities have enormous socio-economic implications on which they can be justified. Hakuraa has high demand for safe water for direct human consumption as well as 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 335 litres per capita per day of desalinated water to meet demand. With such high 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 fulfil 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.

Figure 2_3: Site Plan indicating the desalination plant facilities

Noise and Lux meter parameters.



Lux	Noise
1-150	1-86.1
2-323	2-89.5
3-115	3-90.3
4-175	4-88.4
5-054	5-83.0
6-143	6-87.7
7-081	7-86.8

Outside RO Plant Noise Level :72.4

Intake well Details

Type: Concrete
Intake Well: 4 Feet
Distance from Beach: 150m

3 Regulatory Aspects

The legal and policy instruments that are of relevance to the desalination plant under operation in Hakuraa 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 Hakuraa 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 Hakuraa 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 Hakuraa. 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 to be 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. However, in order to meet the requirements of the Desalination Regulation, the desalination plant at Hakuraa Huraa was registered with the Maldives Water and Sanitation Authority in 2003 as required by the Regulation. 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

Country/Body	Standard	Averaging Times
US EPA	<65 dB(A) <55 dB(A)	Day time Night time
Germany	<55dB(A) <40dB(A)	Day time Night time

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

	Maximum allowable log equivalent (hourly measurements), in dB(A)	
Receptor	Day (07:00 - 22:00)	Night (22:00 - 07:00)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

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).

Source: World Bank Pollution Prevention and Abatement Handbook, 1998

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 4 and 5 August 2010. 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 3m from the discharge point. Additional samples were brought to the laboratory in Malé for testing for BOD, COD and nitrates. However, only BOD could be tested at the time.

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 rainwater and groundwater of which only rainwater can be considered freshwater. However, none of these resources are used for production of water. Seawater desalination is carried out.

4.2.2 Desalinated Water Consumption

Water production statistics is not maintained in the resort. However, based on the average daily production of 142m^3 per day and a total number of consumers at 350, the resort consumes about 406 litres per capita per day. This is quite high compared to some other resorts in the same category.

4.2.3 Water Quality

Water quality testing has been done for intake and brine discharge locations as well as product water. The water quality test results from field and lab tests are given in the table below.

PARAMETER TESTED	Unit	Intake well	Brine discharge	Staff Mess	Plant	Water tank
GPS Coordinates	UTM Zone43, WGS1984					
pH		8.1	8.2	7.6	7.7	7.4
Electrical conductivity	uS/cm			970	667	696
Total Dissolved Solids	mg/l	58,500	61,800			
Dissolved oxygen	mg/l		6.3			
Biochemical oxygen demand	mg/l	CNBT	CNBT	CNBT	CNBT	CNBT
Chemical oxygen demand	mg/l	CNBT	CNBT	CNBT	CNBT	CNBT
Nitrate	mg/l	0.2	0.0	0	0	0
Phosphate	mg/l	0	0	0	0	0
Faecal coliform count	MPN/100ml	0	0	0	0	0

The above results indicate that the brine discharge location does not cause hyper salinisation of the receiving environment. This is because there is good flow in the receiving environment. BOD and COD could not be tested (CNBT) in the National Health Laboratory at the time. Additional sampling and testing will be done once the laboratory resumes undertaking these tests.

Regular testing of product water for coliforms is undertaken by the management by sending samples to the National Health Laboratory. The results of these tests are given in the Appendix. These indicate that the bacteriological quality has been well maintained. Tests have also been done for the product water of the three RO units for chemical and physical parameters. These are also annexed. The results indicate that chloride levels are very high for RO Plant 2 while all the samples show low levels of free chlorine. These variations are, however, marginal and do not constitute health or environmental problems. Free chlorine levels could vary during sample transport and testing period and appropriate sample management would be necessary. The best option would be to test pH, TDS and free chlorine on site.

Additionally, the resort also undertakes annual testing for Legionella. The result of the tests undertaken for 2010 and the certificate issued by the Laboratory is given in Appendix.

4.2.4 Water Conservation

Water conservation measures are in place. Guest and staff are made aware of the need to conserve water with information sheets and notices in guest rooms. In addition, water efficient faucets and shower heads have been fitted in all areas and guest rooms and water saving equipment are used in the kitchen, restaurant and bar. However, the flush units in some of the toilets do not flush well, therefore requires double flushing. Since the resort is heavily dependent on desalination, water conservation is of utmost importance and leaky or faulty areas shall be regularly identified and rectified. Regular water audits may be useful in that case and would results not only in the reduction of water use but also subsequent energy/fuel use.

4.3 Occupational Health

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

The resort also provides 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.

Insert figure

Figure 4-1: Illustrated summary of site conditions

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.

5.1.3 Performance

5.1.3.1 Seawater intake

High currents were observed during the tidal changes. This will result in high sedimentation of the well. The diameters of the wells are 4ft. The wells are made of concrete and it was quite full of fine sand and sediment. The wells do not have a top slab cover and no filtration media (gravel or coral) is present. It was also found out that the well was not being regularly inspected and maintained.

5.1.3.2 Sedimentation tank

The sedimentation tank is of good size. The sedimentation tank consisted of 3 chambers which has total capacity of 16.3m^3. The sea water is quite clean and settling of sediments seems well. However the tank needs attention since there is no regular cleaning maintaining. Some plumbing also needs proper fixing. The two pumps which are supplying the raw water to the tanks also require maintenance. 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.

5.1.3.3 Desalination units

The RO plants are in good working condition and the following observations have been made during the recent field visit.

- There is one operator who understands the plant quite well. However the condition of the plant is not very good. There are leaks to be fixed, especially high pressure parts including membrane vessels, lots of rusting parts, which needs fixing and maintenance.
- There are some spare parts and filters available. The chief engineer has prepared good documentation of spares and filters and now is preparing preventive maintenance schedules which are very much needed.
- Operations and maintenance manuals and catalogues and other such documents are very well managed and kept in files.
- Plant logs are well kept, needs computerization and interpretation.
- There are safety procedure signs displayed at chlorine handling area. However no protective masks and gloves are provided at site. Suits are made available for staff at the plant room.
- Operators of the facility need more training.
- No operations diagrams, instructions and warning signs are at the plant room.
- No chlorine meters used to measure chlorine in desalinated (or drinking) water.
- Water quality testing reports are not interpreted.
- Brine discharge pipe is not properly supported and it needs extension.
- Corrosion in many areas especially pumps were observed.
- Some pipes and fittings needs to be fixed to the frames of the plant properly since some were tied to it by ropes.
- There are some pressure gauges which were not working and needs replacing
- Display meters which are not working needs to be replaced.
- There are tools available at the plant room which was kept well organized.

5.1.3.4 Storage tanks

There are 3 tanks of galvanized steel installed at the island. Total capacity of these tanks is 342m^3. This amount of water is estimated to last 2 days in case the plants fail. This is assuming that the same amount of water would be used during a breakdown too. In this case, it is necessary for the resort to consider increasing the storage capacity. The Regulation on the Protection and Preservation of Environment in the Tourism Industry requires 5-day storage of desalinated water. However, assuming that the water consumption during an emergency would be reduced to 40l/p/d, the storage would last more than 5 days.

5.1.4 Water Quality

The data obtained for the purpose of this study indicate that the marine water quality is in pristine condition and that there are no hyper salinity issues at the brine discharge location.

As discussed earlier, regular biological testing of product water is undertaken by the management by sending samples to the National Health Laboratory. These indicate that the bacteriological quality has been well maintained. However, some of the parameters for weekly and monthly testing required are missing from these regular tests. Nevertheless, results are available for physical and chemical parameters tested in the past month for the three RO units. The results indicate that chloride levels are very high for RO Plant 2 while all the samples show low levels of free chlorine. Free chlorine levels could vary during sample transport and testing period and appropriate sample management would be necessary. Therefore, it may be necessary to test pH, TDS and free chlorine on site.

Additionally, the resort also undertakes annual testing for Legionella. The result of the tests indicate that Legionella has not been detected in any of the samples.

5.1.5 Operation and Maintenance

The desalination system does not appear to be well maintained. However, all manuals are available at the site of the desalination plant facility.

5.2 Audit Summary

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

Table 5-1: Environmental compliance matrix for desalination plant in Hakuraa

Environmental and socioeconomic aspects	Compliance/Performance					Remarks/Observations	Recommendations
	None	Low	Fair	Good	High		
Water quality				X		Regular water testing in place	Onsite measurements of free and residual chlorine, TDS and pH desirable.
Environmental noise					X	Noise not felt in sensitive areas	
Occupational health				X			
Risk management					X	Good housekeeping. No accidents reported	
Environmental aesthetics					X	Clean and tidy inside and outside.	
Water conservation				X		Measures for water conservation, efficient technology and a great deal of awareness exist	Annual water audits may be useful and would reduce cost to a great extent. Per capita water consumption figure is too high.
Operation of desalination plant			X			Daily logs taken, all manuals are available but poor maintenance	Improve operational performance by appropriate maintenance and system performance audits
Water quality			X			Water quality monitoring is carried out but some data are missing	Water quality monitoring needs to be improved, data shall be based on average reading of 3 samples

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/m3 (Rachel *et al* 2002). The daily water production capacity in Hakuraa Huraa is estimated to be about $142m^3$ for which an estimated maximum of 568kWh 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 Hakuraa, 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 Hakuraa Huraa.

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, the 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 Hakura, the intake is from a purpose-built well in the lagoon. The ecological impact of this setup is negligible. The location of the pipe is not a cause for concern.

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 Hakuraa 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 is not a cause for concern in the case of lagoon intakes such as that found in Hakuraa. Since the water flows into the well from the surface, entry of marine organisms is restricted.

6.1.4 Brine Concentrate Discharge

Brine concentrate is discharged directly to the lagoon where the temperature and concentration of ions rapidly increase in the receiving water. 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). Section 5.2.3 discusses the water quality analysis undertaken for the brine discharge location. There is no impact of hypersalinisation owing to the high degree of movement of the coastal waters, which aids in rapid mixing. Since this observation is based on single spot measurements, it may be necessary to do further studies to ascertain this. However, based on experience and professional judgement it can be said that the receiving water is expected to have acceptable quality and the zone of impact is a long way away from any reef areas. 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, there is a considerable distance that will help to minimize such impacts on the reef in the case for Hakuraa Huraa.

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 Hakuraa Huraa. The environmental performance evaluation exercise conducted on Hakuraa Huraa 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 Hakuraa Huraa. 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 Hakuraa. 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

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

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

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

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 Hakuraa Huraa

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

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 7-4: Sampling locations for product water from desalination plant

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

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
- 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 Hakuraa. 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

Sample type	Parameters	Min. Frequency	Purpose
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

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

Environment Protection Agency and the project consultants 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:

- Intake wells need regular cleaning, top slab cover should be installed and installing gravel or coral filter medium at the bottom will provide much cleaner water.
- Inspect the sedimentation tank regularly and empty the tank if the settled sediments are too much. Sedimentation tanks work as natural sediment removers. If these tanks are well maintained it will keep filters and membranes from blocking.

- Chlorine should be stored at proper temperature and handled carefully. Appropriate digital chlorine meter should be used for regular checking of chlorine levels. The requirements of EPA for chlorine levels in drinking water should be met.
- Product water tank should be kept clean and covered well so that no contaminating source can access the product water tank.
- Operations instructions, chemical dosing instructions, safety procedures and warning signs needs to be displayed in the plant room.
- Brine discharge pipe needs extension further in to lagoon and needs more support.
- All parts if the plant which are corroded needs to be maintained (and/or replaced) and kept well greased/oiled.
- Pressure gauges and display indicators which are not working needs to be replaced.
- Storage tanks have only 2 days of capacity. This may not be sufficient in case the plants are not working. Hence it is advised to upgrade the storage capacity.
- 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 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.
- The staff should understand how to check the pressure from the system, assess the functioning, flow and production of the plant.
- It is also recommended to undertake 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. Periodic monitoring of performance is also recommended. Monitoring environmental performance of the desalination facilities would not only demonstrate environmental compliance but also help minimize costs in the medium to long term. It is even better and worthwhile to undertake a corporate environmental monitoring programme incorporating all aspects of the operations so that cost of monitoring and subsequent operational costs are minimized.

9 References

1. Herrmann T, Schmida U (1999), Rainwater utilisation in Germany: efficiency, dimensioning, hydraulic and environmental aspects. Urban Water 1999;1(4):307–16.

2. Rachel et al (2002), the foot print of desalination process on the environment, Journal of Desalination, Vol. 152, pp. 141-154

3. SARI/Energy (http://www.sari-energy.org/PageFiles/Countries/Maldives_Energy_detail.asp#renewable) accessed on 10 February 2010.

10 Appendices

- Terms of Reference
- Photos of desalination plant inspection
- Water Quality Reports
- Tourism Ministry's approval for additional desalination unit installation

5. Special Observations and recommendations .

1. Legionella prevention and control plan has been implemented satisfactorily .
2. Suitable formats for recording purpose is attached here with

Auditees : **Mr. Kumar Gunarathne**
(Chaaya Lagoon, Hakuraa Huraa, John Keells Maldivian Resorts (Pvt) Ltd)

Auditors : Manel Perera
(MicroChem Laboratories (Pvt) Ltd, 112/1A, 1/1 Stanley Thilakarathne Mw, Nugegoda)

MANEL PERERA
B.Sc (Hons) Applied Bio Science
M.Phil (Analytical Chemistry)
Managing Director
MicroChem Laboratories (Pvt) Ltd

CC : General Manager, Mr. Michael Jayasekara, Mr. Lalith Katugampola, Chief Engineer

MicroChem Laboratories (Pvt) Ltd.

3. Water sources

Area	Findings	Corrective action	Time scale	Remarks
Are the water storage tanks protected from external contaminations ?	Yes	---	---	
Are the test reports of chemical and microbiological analysis of water available ?	Yes	---	---	Action taken fo the deviations o the microbiolog test results wer not recorde properly.
Is the water treatment area clean and free of unwanted clutter.?	Yes	---	---	
Are all the units in the water treatment plant house properly identifiable?	Yes	---	---	
Are all the units of the water treatment plant function properly?	#	---	---	

Chlorine pump was blocked at the time of audit

4. Critical Control Points verifications.

Sampling Point	Temperature ^{0}C	Chlorine Level ppm	pH	TDS ppm	Conductivity µs/cm	Hardness ppm
Storage tank water		0.1	7.14	298	600	30
Room No. 141 (Water bungalow) Hot water	58					
Room No. 141 (Water bungalow) Cold water				312	624	
Spa		0.8		307	614	
Room No. 177 Hot water	70					
Room No. 177 Cold water		1.0		310	617	
Room No. 181 Hot water	57.3					
Room No. 181 Cold water		1.0		311	623	

Inspection Report

Dated 13.01.2010

Legionella and other microbiological health hazards Control & Prevention in water management system

Chaaya Lagoon, Hakuraa Huraa.
John Keells Maldivian Resorts (Pvt) Ltd.
Maldives

1. Management Control

Area	Findings	Corrective action	Time scale
Is there a documented evidence to show that microbiological health hazards assessment covers all essential areas in the water management system?	Yes	---	---
Is the microbiological health hazards control (including Legionella) system implemented and maintained?	Yes	---	---
Is there a documented management structure defining Legionella prevention and control responsibilities?	Yes	---	---
Are staff aware of the responsibilities of Legionella prevention and control ?	Yes	---	---
Are there documented evidence of complaints and implementation of corrective actions during last six months ?	No	---	---

2. Monitoring programme

Area	Findings	Corrective action	Time scale
Is there a schematic diagram of the water management system indicating control and risk areas ?	Yes	----	---
Are regular monitoring procedures established ?	Yes	----	----
Are operational staff competent for the monitoring procedures ?	Yes	----	----
Are genuine monitoring records available (Log sheets or log books)	Yes	----	----

MicroChem LABORATORIES PRIVATE LIMITED

...Continuation Sheet

February 2010
10 / 01/ MCL/ 0099,0100,0101

ANALYSIS REPORT
MICROBIOLOGICAL EXAMINATION - SAMPLES OF WATER FOR LEGIONELLA SPECIES

ENT	:	Chaaya Lagoon , Hakuraa Huraa Republic of Maldives
IMEN	:	Water
PLE IDENTIFICATION	:	Three numbers of samples of water collected by MicroChem Laboratories (Pvt) Ltd. were given the following reference numbers. 10 / 01 / MCL / M/ 0099– Cold Water Room N0 141 10 / 01 / MCL / M/ 0100– Hot Water Room No 177 10 / 01 / MCL / M/ 0101 Water From Garden tap
IPLE COLLECTED BY	:	MicroChem Laboratories (Pvt.) Ltd
NESS	:	Mr. Kumara Gunarathne - Engineer Chaaya Lagoon , Hakuraa Huraa
E OF SAMPLE COLLECTION	:	15.01.2010
CE OF PERFORMANCE	:	Accepta Ltd., Statham House. Talbot Road , Old Trafford , Manchester M32 0FP United Kingdom
T METHODS AND PRINCIPLES	:	Membrane filtration, elution, concentration by centrifugation, culture on selective Legionella culture medium: untreated and following acid buffer treatment and heat treatment. The laboratory facilities used by Accepta to complete this analysis are UKAS certified.

ULTS :

Ref. No.	Sample Identification	Volume of the sample	Culture results
01 / MCL / M/ 0099	Cold Water Room No 141	0.5 Liter	Not Detected
01 / MCL / M/ 0100	Hot Water Room No 177	0.5 Liter	Not Detected
01 / MCL / M/ 0101	Garden Tap	0.5 Liter	Not Detected

.....
mal de Silva
crobiologist)

.....
Manel Perera
Managing Director

MANEL PERERA
B Sc (Hons) Applied Bio Science
M.Phil (Analytical Chemistry)

MAL DE SILVA
Microbiologist

MicroChem

LABORATORIES
PRIVATE LIMITED

Certificate

This is to certify that

Chaaya Lagoon, Hakuraa Huraa
Maldives

complies with the code of conduct for
Legionella Control & Prevention
under the following areas

- Risk assessment and monitoring
- Water treatment
- Hot and cold water monitoring
- Cleaning and disinfection
- Water sample analysis
- Training

This certificate is granted on 28th January 2010 and is valid until

28th January 2011

Certificate Number : MCL / 003 / 2010

.....
Managing Director
MicroChem Laboratories (Pvt) Ltd.
Sri Lanka

The code of conduct requires that the company establish an appropriate management system associated with the control & prevention of *Legionella*. This certificate is an indication of the company's commitment to comply with the code of conduct and should not be taken as proof of compliance. MicroChem Laboratories (Pvt) Ltd. does not approve specific products or services as being effective in controlling *Legionella*.

MicroChem Laboratories (Pvt) Ltd
No. 112/1A, 1/1, Stanley Thilakarathne Mawatha, Nugegoda, Sri Lanka
Tel : 00 94 115 552581, 00 94 773 152797 Fax : 00 94 115 552581, E Mail : microchem@sltnet.lk

بسم الله الرحمن الرحيم

Accreditation No: 1150/51

National Health Laboratory
Maldives Food and Drug Authority, Male' Republic of Maldives
WATER MICROBIOLOGY ANALYTICAL RESULTS

REPORT NUMBER: NHL/TR-WM/RC0560

•NAME OF CLIENT: Chaaya Lagoon Hakuraa Huraa
•PURPOSE OF TESTING: Quality Monitoring

TIME TESTED: 13:30
• COLLECTED BY: - Ibrahim Rasheedh

•LOCATION OF SAMPLE	Chaaya Lagoon Hakuraa Huraa					TEST METHOD	REFERENCE RANGE WHO Guideline for Drinking Water
	Ice Cube Machine	*Desalination Plant*	*Main Kitchen*	*Staff Kitchen*	*Guest Room*		
Requisition Form No:	*NHL/WM-2010/RQ0479*						
•Date sampled/processed	*27/04/10*	*27/04/10*	*27/04/10*	*27/04/10*	*27/04/10*		
•Time Sampled	*10:05*	*10:05*	*10:05*	*10:05*	*10:05*		
•Type of water	*Desalinated water in sterilized bags*						
Date Tested	*28/04/10*	*28/04/10*	*28/04/10*	*28/04/10*	*28/04/10*		
Sample ID	*270410WM 307*	*270410WM 308*	*270410WM 309*	*270410WM 310*	*270410WM 311*		
PARAMETER TESTED							
Total Coliform Count /100ml	0	0	0	0	0	HPA std method, 2005, W2 issue 4	0/100ml
Faecal Coliform Count (E.coli) /100ml	0	0	0	0	0	HPA std method, 2005, W2 issue 4	0/100ml

COMMENT:

Authorized by

Analyzed By
Mariyam Suhana

Technical Manager
Fathimath Liusha Hussain

Date: 29th April 2010

NOTE: •Information supplied by the 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

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Accreditation No: 1150/51

National Health Laboratory
Maldives Food and Drug Authority, Male' Republic of Maldives
WATER MICROBIOLOGY ANALYTICAL RESULTS

REPORT NUMBER: NHL/TR-WM/RC0715

•NAME OF CLIENT: Chaaya Lagoon Hakura Hura Resort
•PURPOSE OF TESTING: Quality Monitoring

TIME TESTED: 13:00
• COLLECTED BY: -

•LOCATION OF SAMPLE	Chaaya Lagoon Hakura Hura Resort		TEST METHOD	REFERENCE RANGE WHO Guideline for Drinking Water
	Staff Kitchen	Desalination Plant		
Requisition Form No:	NHL/WM-2010/RQ0606			
•Date sampled/processed	09/06/10	09/06/10		
•Time Sampled	-	-		
•Type of water	Desalinated water in sterilized bottles			
Date Tested	09/06/10	09/06/10		
Sample ID	090610WM 57	090610WM 58		
PARAMETER TESTED				
Total Coliform Count /100ml	0	0	HPA std method, 2005, W2 issue 4	0/100ml
Faecal Coliform Count (E.coli) /100ml	0	0	HPA std method, 2005, W2 issue 4	0/100ml

COMMENT:

Authorized by

Analyzed By
Milna Rasheed

Technical Manager
Mariyam Nisha

Date: 10th June 2010

NOTE: •Information supplied by the client
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Accreditation No: 1150/51

National Health Laboratory
Maldives Food and Drug Authority, Male' Republic of Maldives
WATER MICROBIOLOGY ANALYTICAL RESULTS

REPORT NUMBER: NHL/TR-WM/RC0189

•NAME OF CLIENT: Chaaya Lagoon Hakura Hura
•PURPOSE OF TESTING: Quality Monitoring

TIME TESTED: 14:00
• COLLECTED BY: -

•LOCATION OF SAMPLE	Chaaya Lagoon Hakura Hura					TEST METHOD	REFERENCE RANGE WHO Guideline for Drinking Water
	Ice Cube Machine	*Desalination Plant*	*Main Kitchen*	*Staff Kitchen*	*Guest Room*		
Requisition Form No:	*NHL/WM-2010/RQ0167*						
•Date sampled/processed	*08/02/10*	*08/02/10*	*08/02/10*	*08/02/10*	*08/02/10*		
•Time Sampled	*08:45*	*08:45*	*08:45*	*08:45*	*08:45*		
•Type of water	*Desalinated water in sterilized bags*						
Date Tested	*08/02/10*	*08/02/10*	*08/02/10*	*08/02/10*	*08/02/10*		
Sample ID	*080210WM 66*	*080210WM 67*	*080210WM 68*	*080210WM 69*	*080210WM 70*		
PARAMETER TESTED							
Total Coliform Count /100ml	0	0	0	0	0	HPA std method, 2005, W2 issue 4	0/100ml
Faecal Coliform Count (E.coli) /100ml	0	0	0	0	0	HPA std method, 2005, W2 issue 4	0/100ml

COMMENT:

Authorized by

National Health Laboratory
Male', Republic of Maldives

Analyzed By
Milna Rasheed

Technical Manager
Mariyam Nisha

Date: 09th February 2010

NOTE: •Information supplied by the client
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Accreditation No: 1150/51

National Health Laboratory
Maldives Food and Drug Authority, Male' Republic of Maldives
WATER MICROBIOLOGY ANALYTICAL RESULTS

REPORT NUMBER: NHL/TR-WM/RC0560

•NAME OF CLIENT: Chaaya Lagoon Hakuraa Huraa
•PURPOSE OF TESTING: Quality Monitoring

TIME TESTED: 13:30
• COLLECTED BY: - Ibrahim Rasheedh

•LOCATION OF SAMPLE	Chaaya Lagoon Hakuraa Huraa					TEST METHOD	REFERENCE RANGE WHO Guideline for Drinking Water
	Ice Cube Machine	*Desalination Plant*	*Main Kitchen*	*Staff Kitchen*	*Guest Room*		
Requisition Form No:	*NHL/WM-2010/RQ0479*						
•Date sampled/processed	*27/04/10*	*27/04/10*	*27/04/10*	*27/04/10*	*27/04/10*		
•Time Sampled	*10:05*	*10:05*	*10:05*	*10:05*	*10:05*		
•Type of water	*Desalinated water in sterilized bags*						
Date Tested	*28/04/10*	*28/04/10*	*28/04/10*	*28/04/10*	*28/04/10*		
Sample ID	*270410WM 307*	*270410WM 308*	*270410WM 309*	*270410WM 310*	*270410WM 311*		
PARAMETER TESTED							
Total Coliform Count /100ml	0	0	0	0	0	HPA std method, 2005, W2 issue 4	0/100ml
Faecal Coliform Count (E.coli) /100ml	0	0	0	0	0	HPA std method, 2005, W2 issue 4	0/100ml

COMMENT:

Authorized by

Analyzed By
Mariyam Suhana

Technical Manager
Fathimath Liusha Hussain

Date: 29th April 2010

NOTE: •Information supplied by the 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

بسم الله الرحمن الرحيم

National Health Laboratory
Maldives Food and Drug Authority,
Sosun Magu, Male' 200500, Republic of Maldives
Telephone # 3343538, Fax # 3304570

WATER CHEMISTRY ANALYTICAL RESULTS

REPORT NUMBER: NHL/TR-WC/RC0911

•NAME AND ADDRESS OF CLIENT: CHAA YA ISLAND DHONVELI BEACH & SPA, REP OF MALDIVES
NORTH MALE' ATOLL, PHONE (+690) 6640055, FAX (+690)6640066
H.MAIZAN BUILDING, SOSUN MAGU, TEL: (+960)3373738, FAX: (+960)3326264

TIME TESTED: 1515
COLLECTED BY: -

•PURPOSE OF TESTING: Quality Monitoring

•LOCATION OF SAMPLE	CHAA YA ISLAND DHONVELI BEACH & SPA,				TEST METHOD	REFERENCE RANGE W.H.O Guideline for Drinking Water
	R.O PLANT-1	R.O PLANT-2	R.O PLANT-3	DRINKING WATER		
Requisition Form No:	NHL/WC-2010/RQ0750					
•Date sampled	15/07/2010	15/07/2010	15/07/2010	15/07/2010		
•Time Sampled	-	-	-	-		
•Type of water	Desalinated	Desalinated	Desalinated	Desalinated		
Date tested	15/07/2010	15/07/2010	15/07/2010	15/07/2010		
Sample ID	150710WC143	150710WC144	150710WC145	150710WC146		
PARAMETER TESTED						
Physical Appearance	Clear	Clear	Clear	Clear	-	Clear & colorless
Temperature	24.1 °C	24.2 °C	24.0 °C	24.2 °C	Adapted from corning checkmate ilmeter instruction manual	-
pH	7.7	6.9	7.5	7.5	Method 4500-B ch4 page 65 electrometric method Adapted from standard methods 19th edition for the examination of water and waste water by APHA	-
Total Dissolved Solids	257 mg/L	832 mg/L	169 mg/L	1.9 mg/L	Adapted from corning checkmate ilmeter instruction manual	-
Electrical Conductivity	531 µs/cm	1668 µs/cm	350 µs/cm	5.06 µs/cm	Adapted from corning checkmate ilmeter instruction manual	-
Chloride	140 mg/L	440 mg/L	90 mg/L	0 mg/L	Adapted From Sherwood Mk II Chloride Analyzer Instruction Manual	-
Ammonia ,Nitrogen	0.00 mg/L	0.00 mg/L	0.00 mg/L	0.00 mg/L	Method 8038(Adapted from DR4000™/5000™ Spectrophotometer procedure manual)	-
Turbidity	0 NTU	0 NTU	0 NTU	0 NTU	(Adapted from DR/4000™/Spectrophotometer procedure manual) Adapted From Hach 2100 N Turbidimeter Instruction Manual	-
Iron (Total)	0.01 mg/L	0.01 mg/L	0.00 mg/L	0.00 mg/L	Method 8008 (Adapted from DR4000™/5000™ Spectrophotometer procedure manual)	-
Chlorine, Free	<0.02 mg/L	<0.02 mg/L	<0.02 mg/L	<0.02 mg/L	Method 8021, 10102, 10069 (Adapted from DR4000™/5000™ Spectrophotometer procedure manual)	-

COMMENT: -

Authorized by

Quality Manager
Aishath Mohamed

National Health Laboratory
Malé, Republic of Maldives

Date: 18th July 2010

NOTE: •Information supplied by the client

141 P01 APR 19 '04 13:39

بسم الله الرحمن الرحيم

MINISTRY OF TOURISM
REPUBLIC OF MALDIVES

PEACE AND STABILITY - KEY TO DEVELOPMENT

Ref. no: 88-TS/TR/41/2004/04

11th April 2004

Mr. Channa Jayasundara,
Manager,
FantaSea world Investments,
M. Bolifushi, Haveereehingun
Male', Republic of Maldives,

Dear Mr. Channa.

Reference is made to your letter dated 02nd March 2004, regarding the extension on the Desalination plant building at Hakuraa Club.

Regarding the above, we are pleased to inform you that permission is hereby granted to extend the Desalination plant building in strict accordance with the structural plans submitted to this Ministry.

This permission is valid for 06 (six) months from the date of this letter. Once the structure/work is complete please make arrangements for an inspection of the structures 07 days prior to commencing operation. The registered Land area of the resort is 50,546.10 Square Meter. And the built – up percentage of the resort 13.17%.

We thank you in advance for your full cooperation and wish for a successful project.

Yours sincerely,

Ahmed Salih
Deputy Director, Trade Standards

Cc: Mr. Gemunu Wickremasinghe,
Manager,
Hakuraa Club (Hakuraahuraa),
Meemu Atoll,
Republic of Maldives

Ghaazee Building, Ameeru Ahmed MaguMalé 20 - 05, Republic of Maldives
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