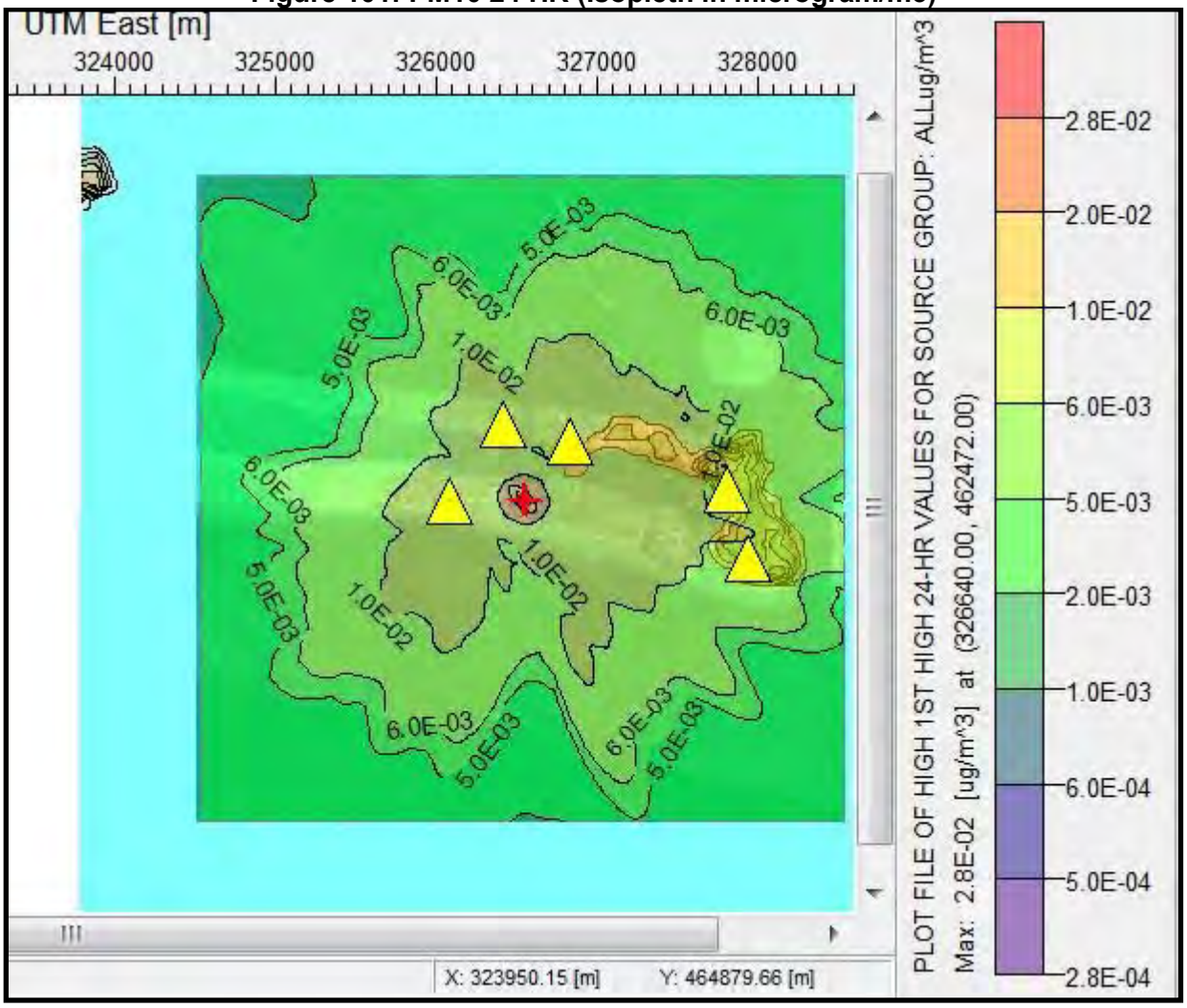
Environmental Impact Assessment

Document Stage: Draft
Project Number: 51077-003
March 2020

MLD: Greater Malé Waste-to-Energy Project – Waste to Energy Plant PART B

Prepared by Ministry of Environment of the Republic of Maldives for the Asian Development Bank.

Figure 101: PM10 24 HR (Isopleth in microgram/m3)

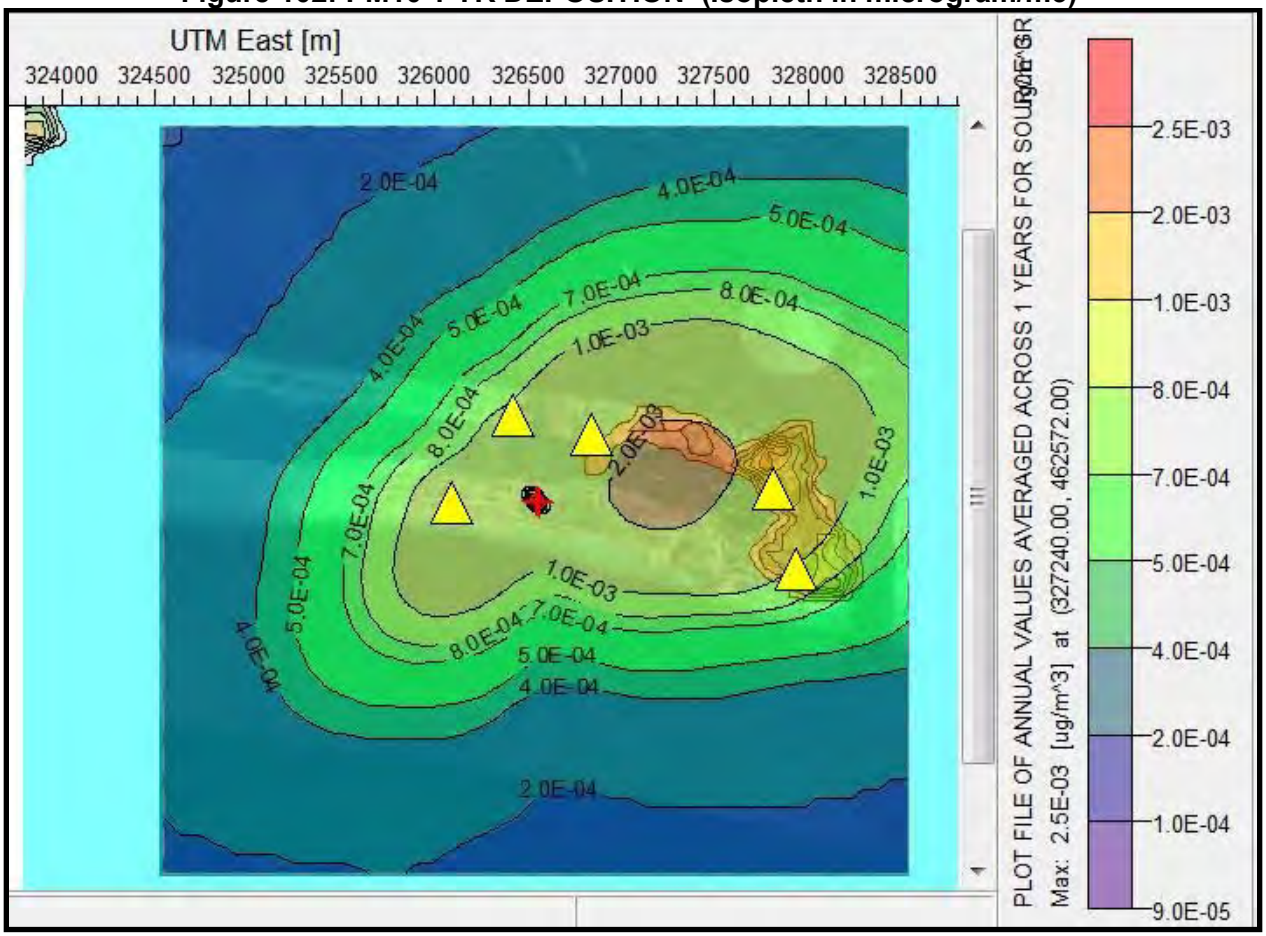


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 102: PM10 1 YR DEPOSITION (Isopleth in microgram/m3)

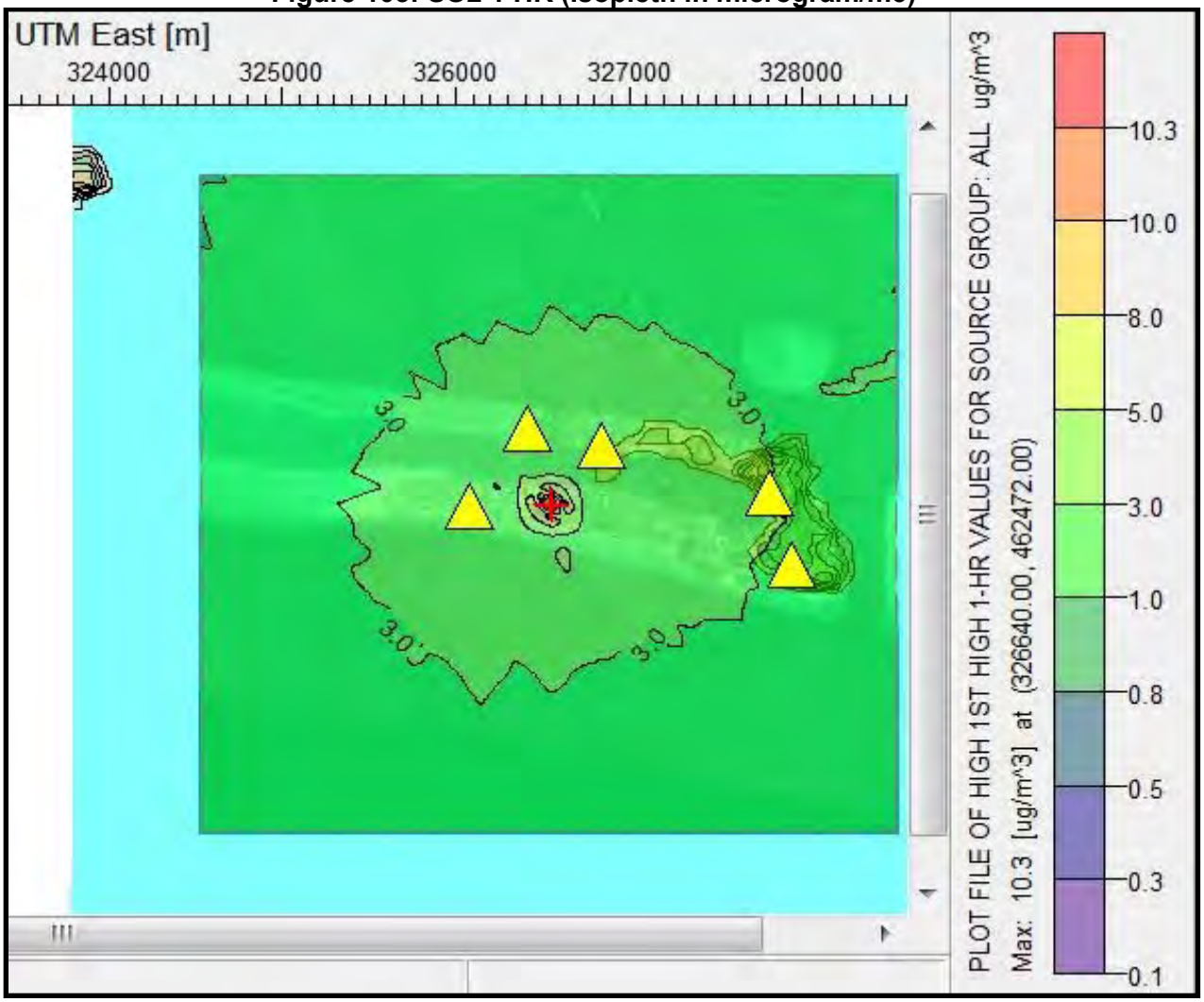


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 103: SO2 1 HR (Isopleth in microgram/m3)

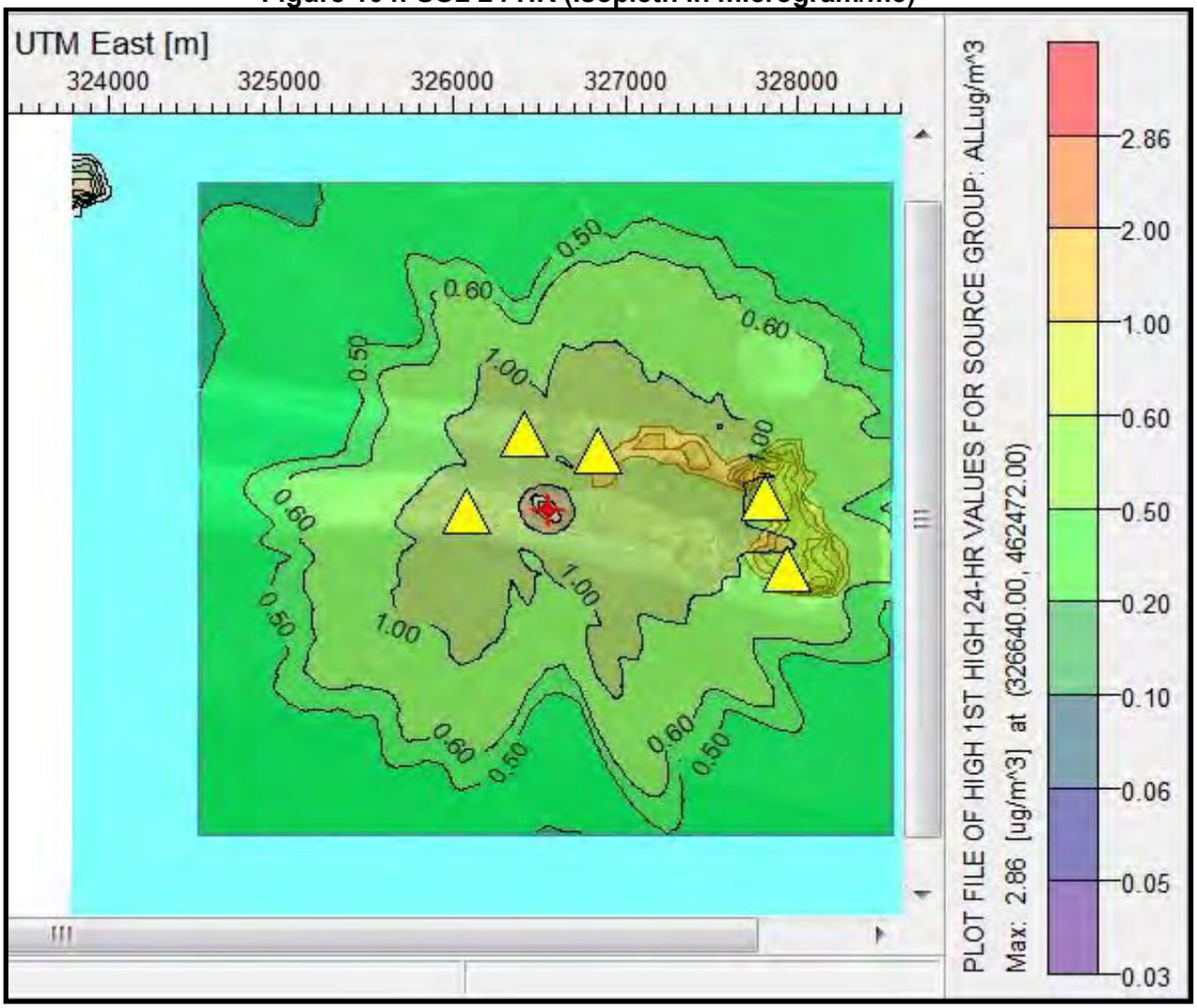


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 104: SO2 24 HR (Isopleth in microgram/m3)

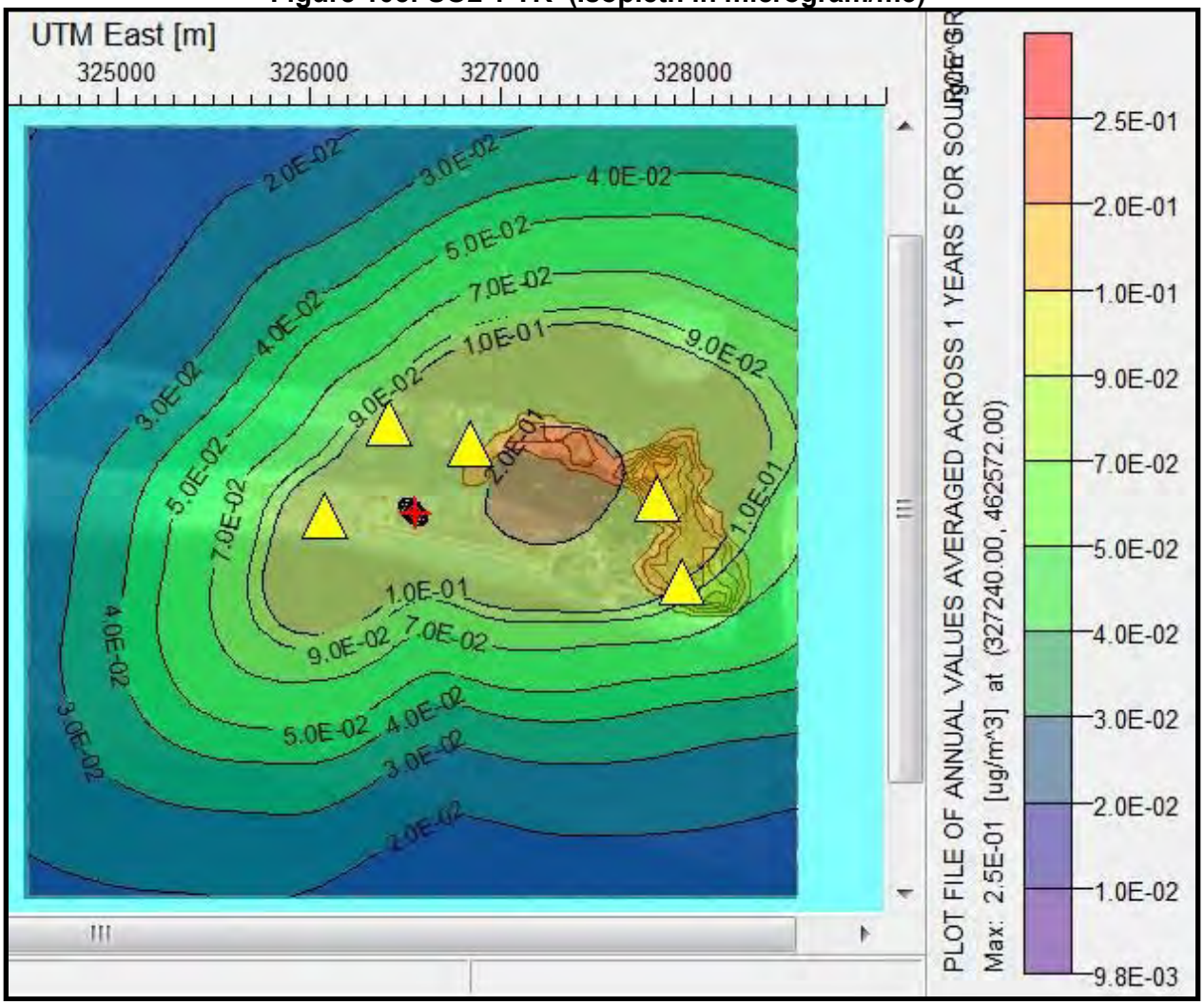


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 105: SO2 1 YR (Isopleth in microgram/m3)

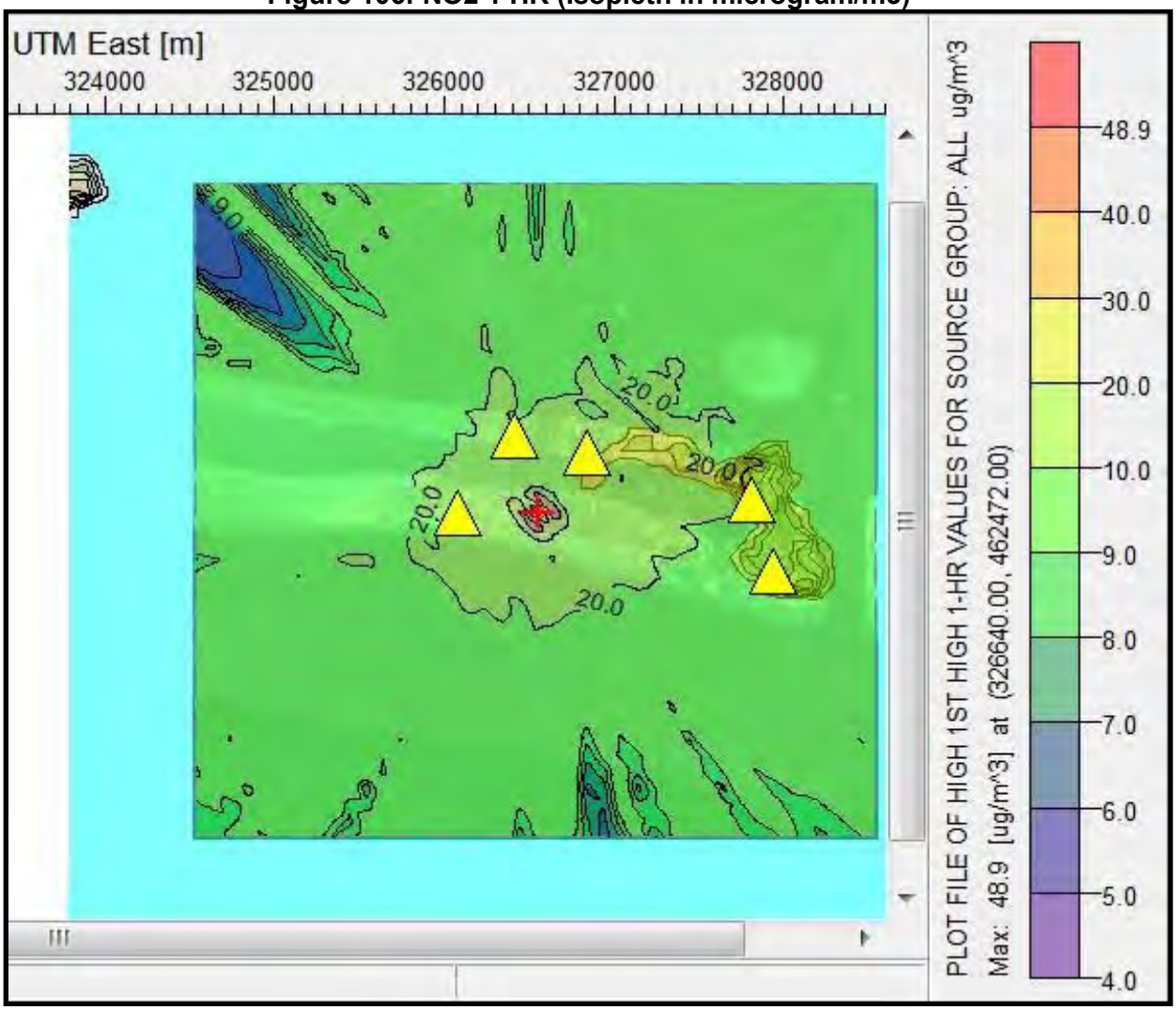


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 106: NO2 1 HR (Isopleth in microgram/m3)

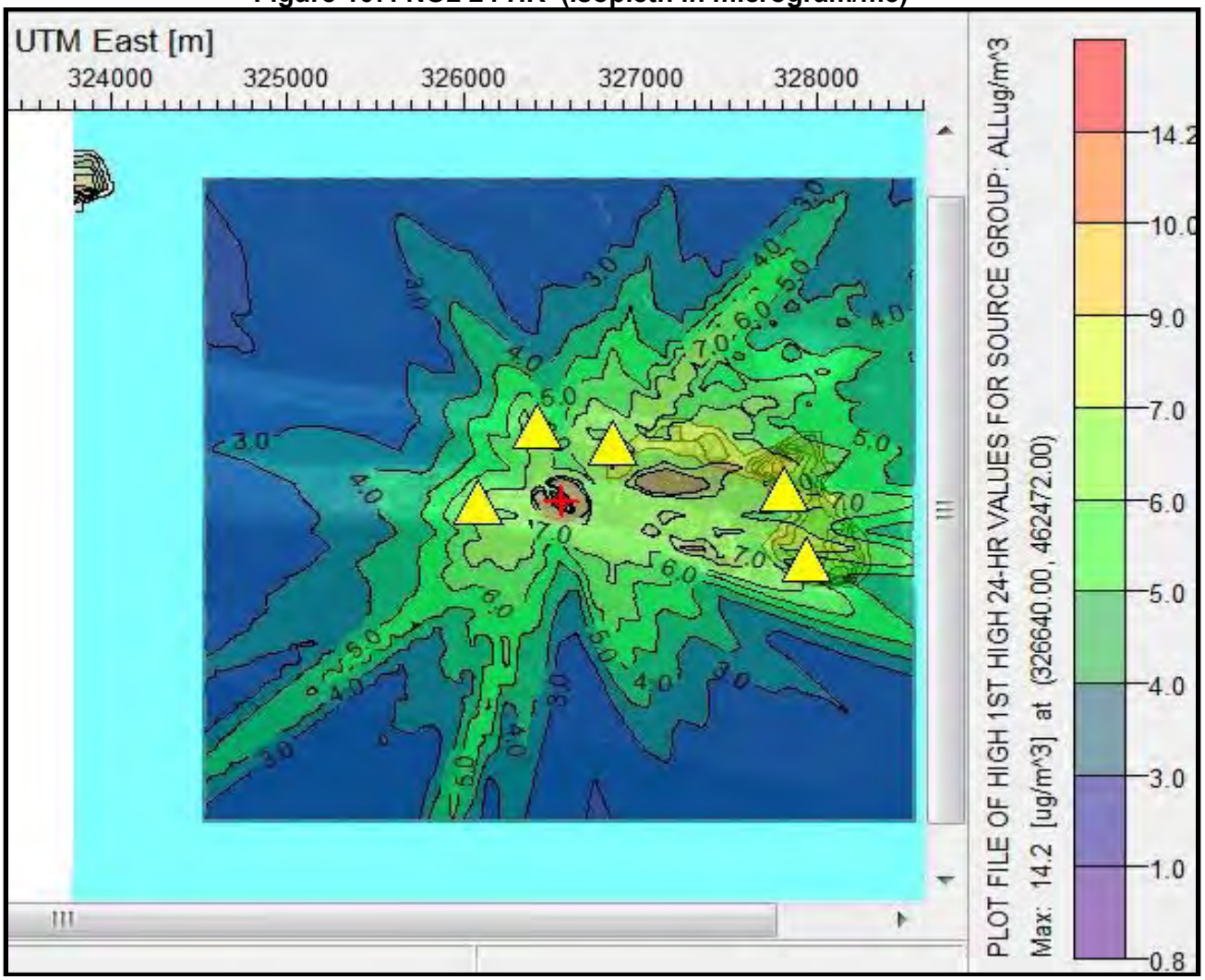


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 107: NO2 24 HR (Isopleth in microgram/m3)

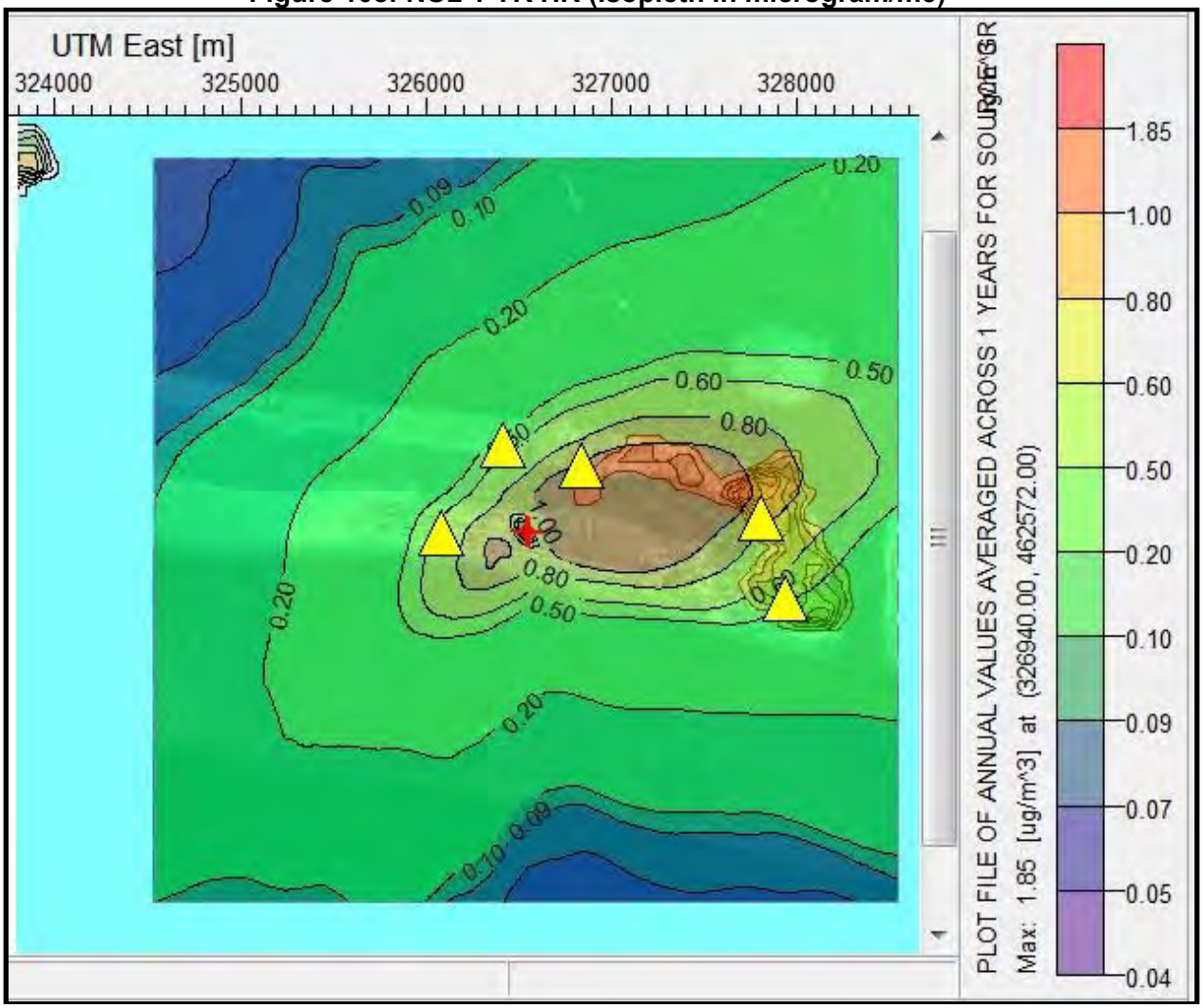


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 108: NO2 1 YR HR (Isopleth in microgram/m3)

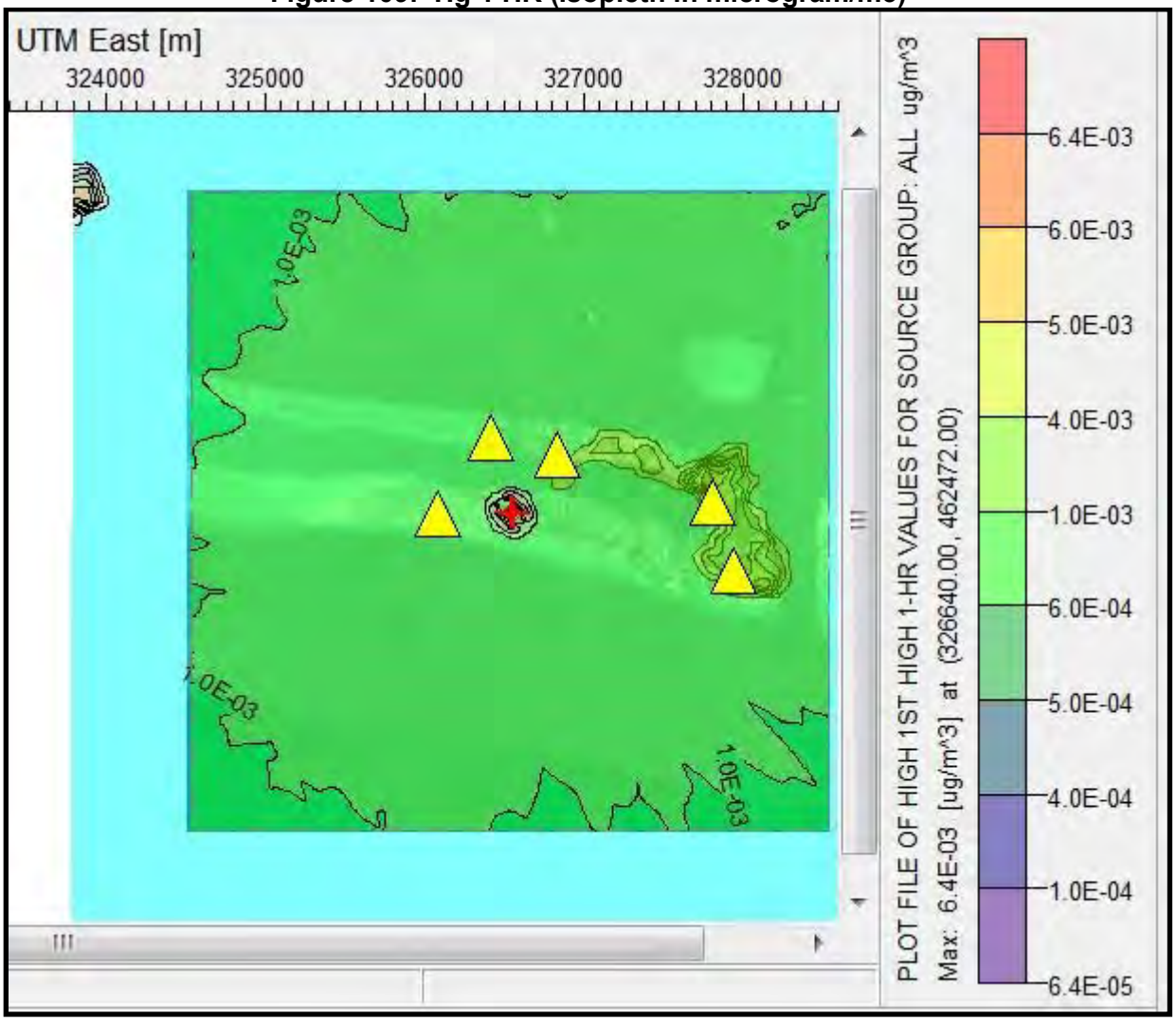


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 109: Hg 1 HR (Isopleth in microgram/m3)

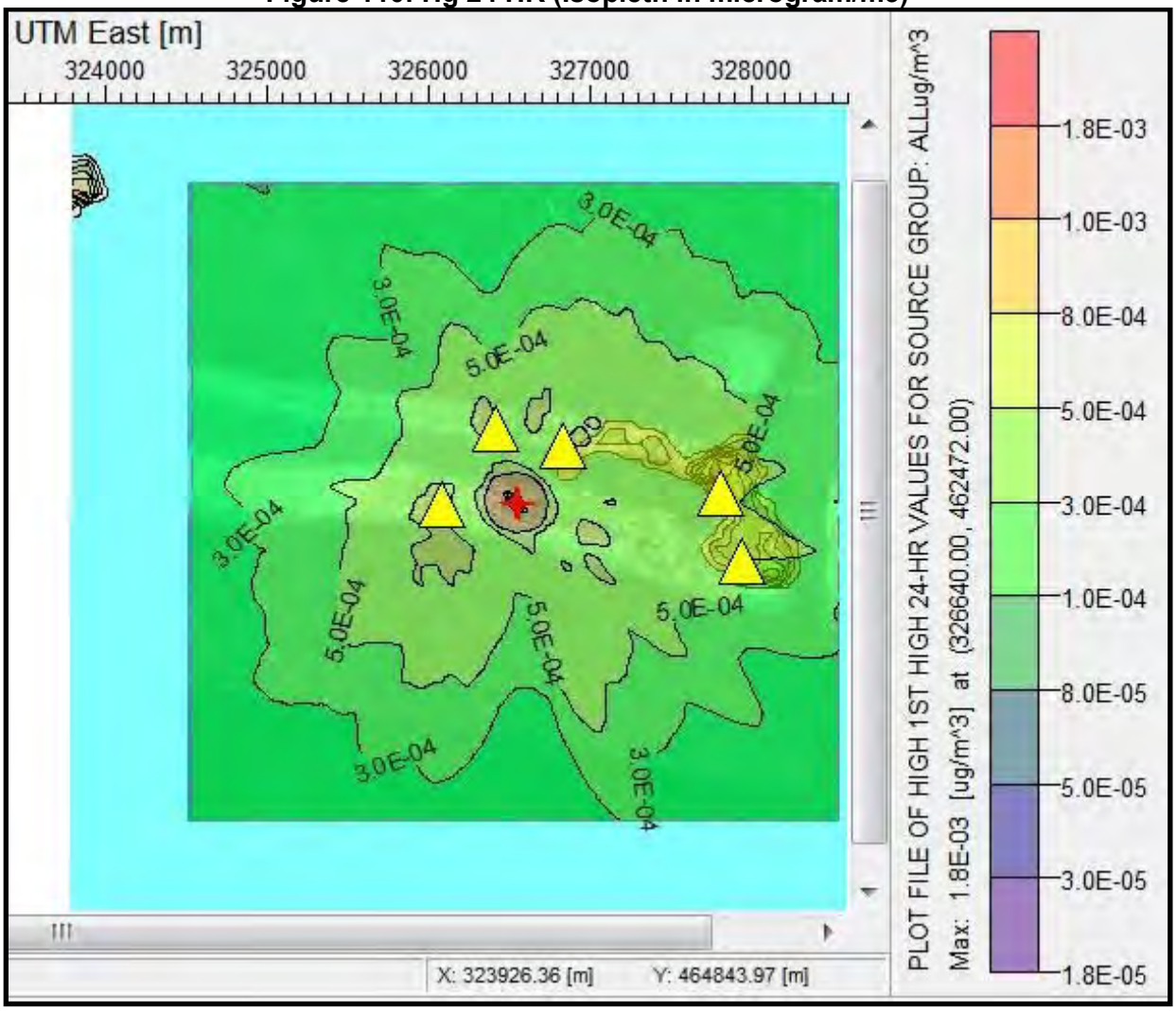


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 110: Hg 24 HR (Isopleth in microgram/m3)

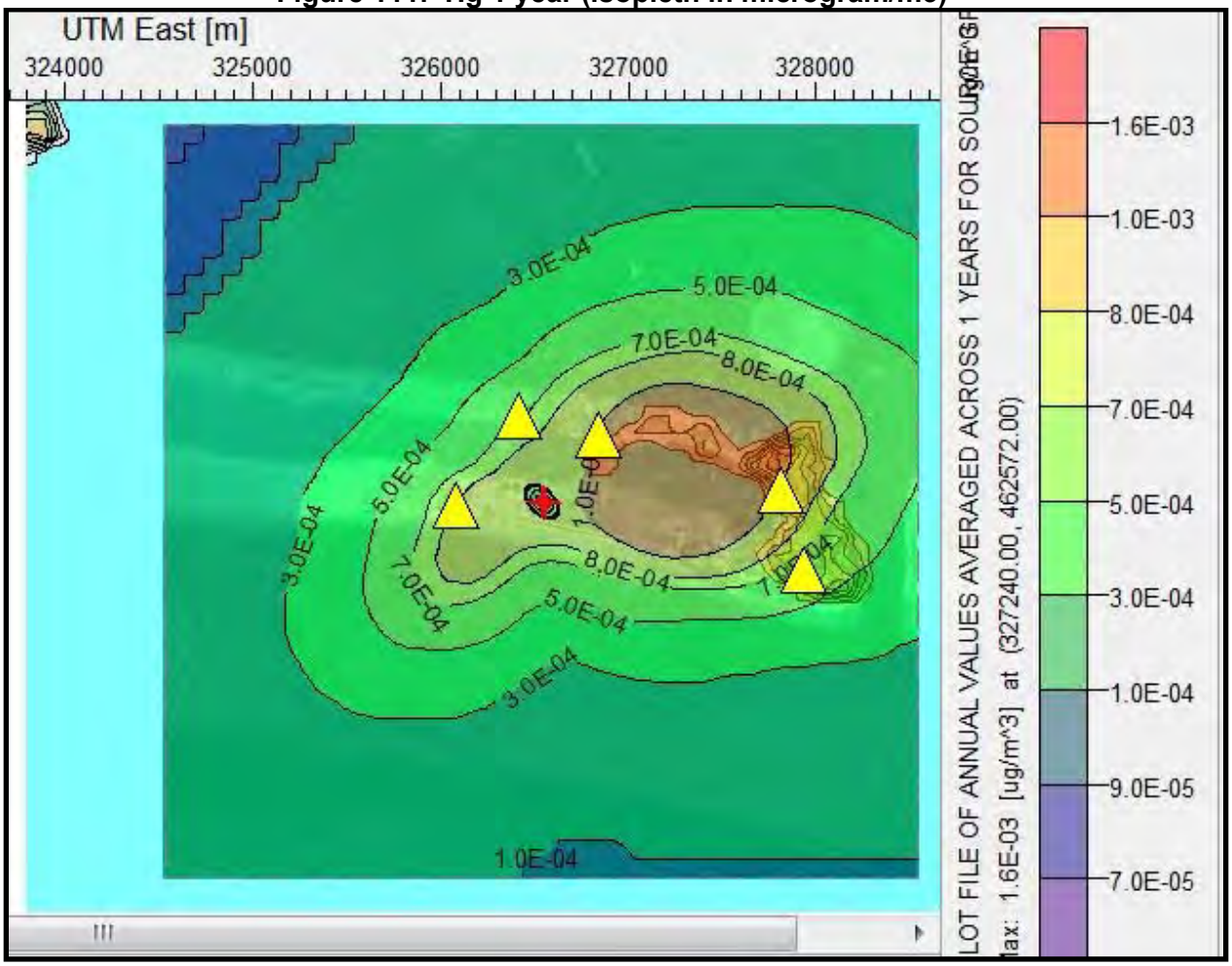


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 111: Hg 1 year (Isopleth in microgram/m3)

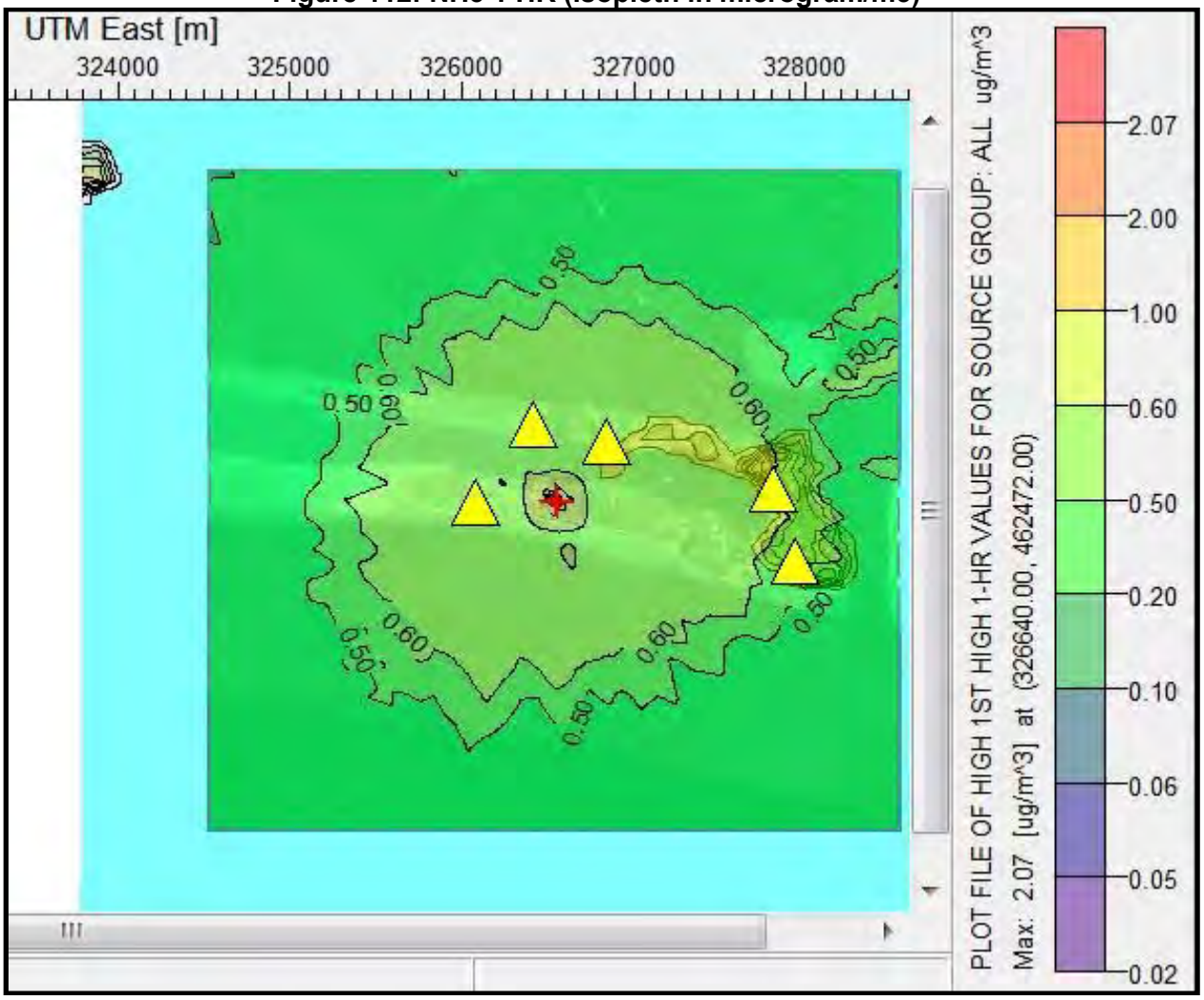


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 112: NH3 1 HR (Isopleth in microgram/m3)

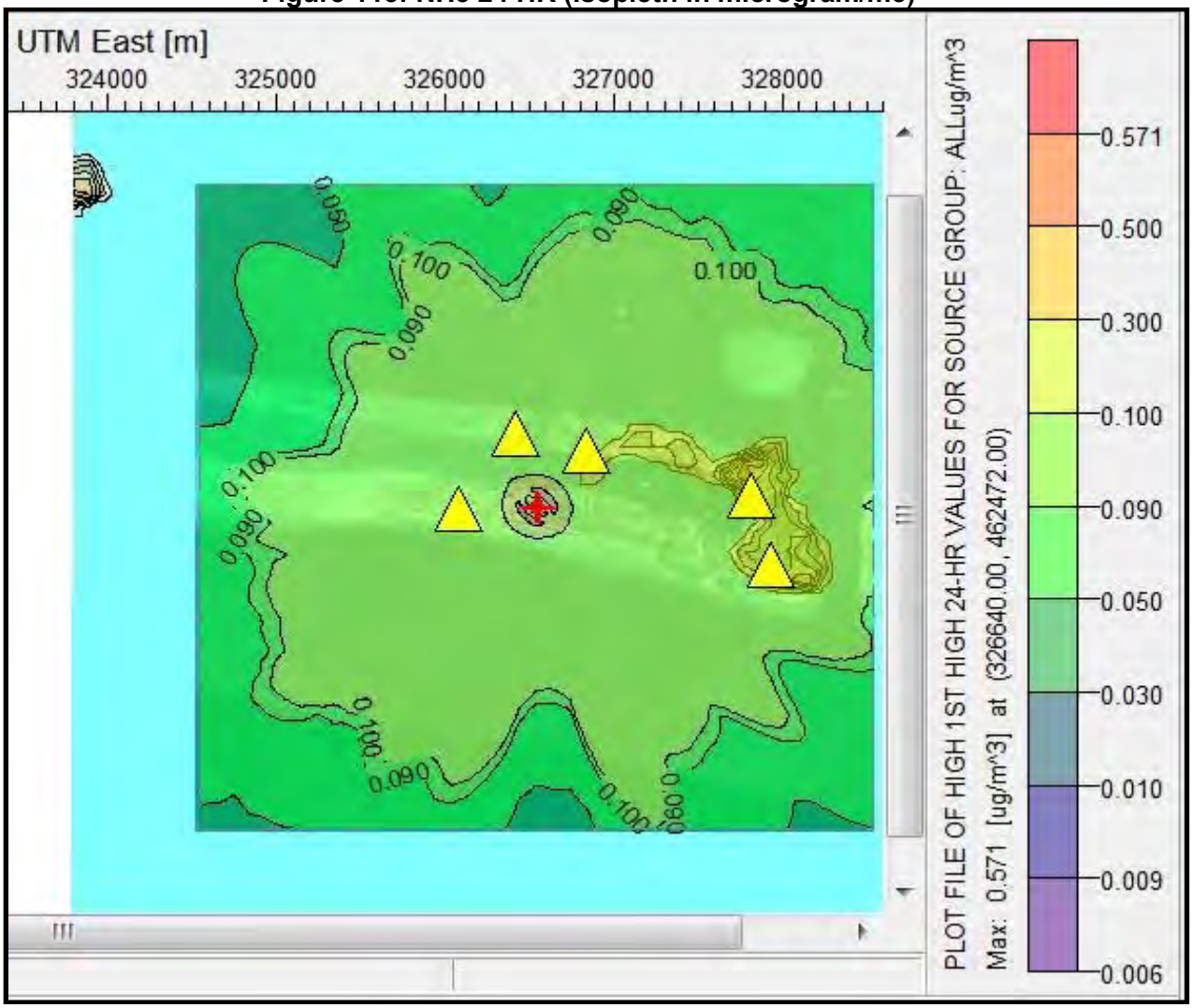


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 113: NH3 24 HR (Isopleth in microgram/m3)

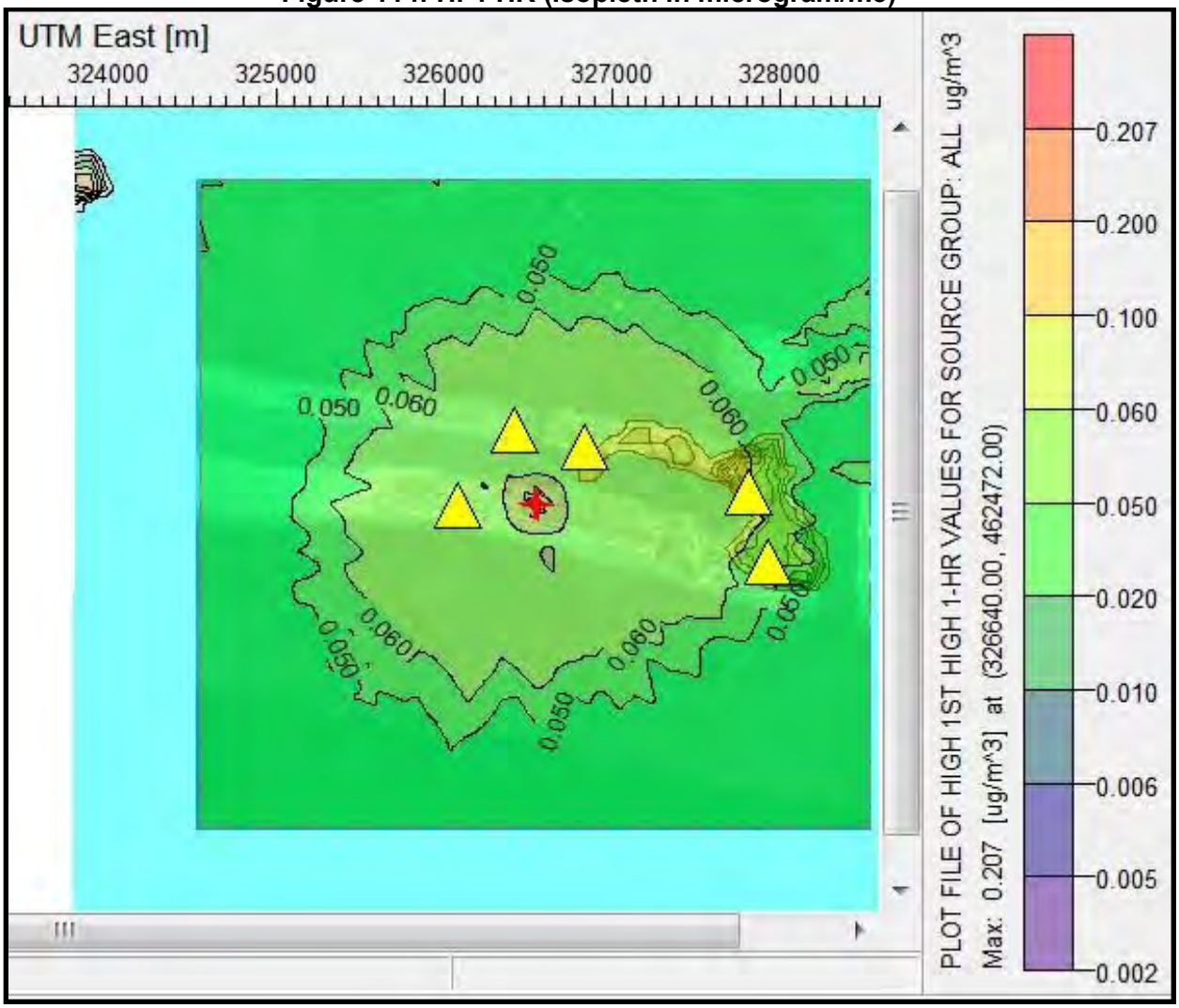


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 114: Hf 1 HR (Isopleth in microgram/m3)

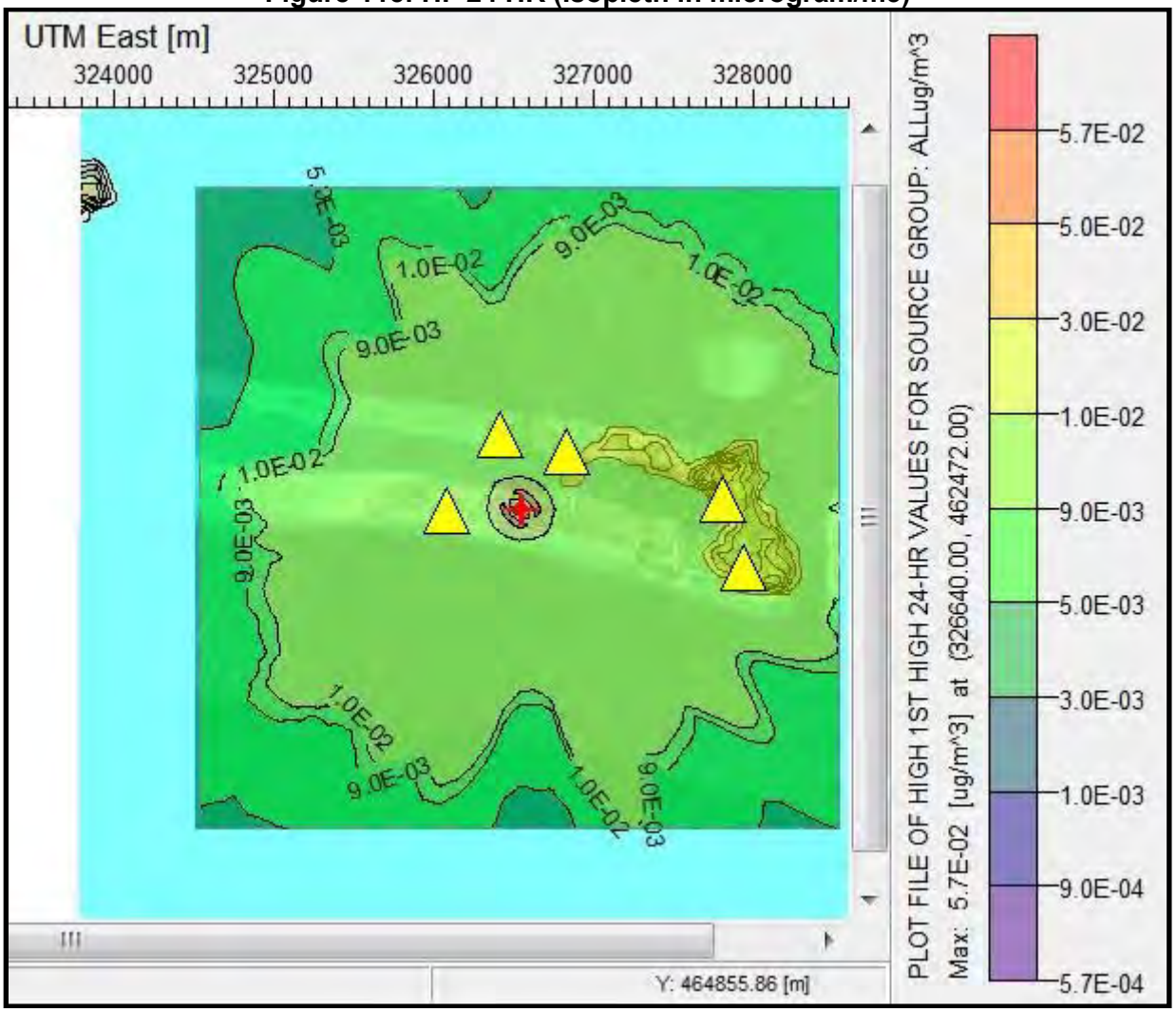


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 115: HF 24 HR (Isopleth in microgram/m3)

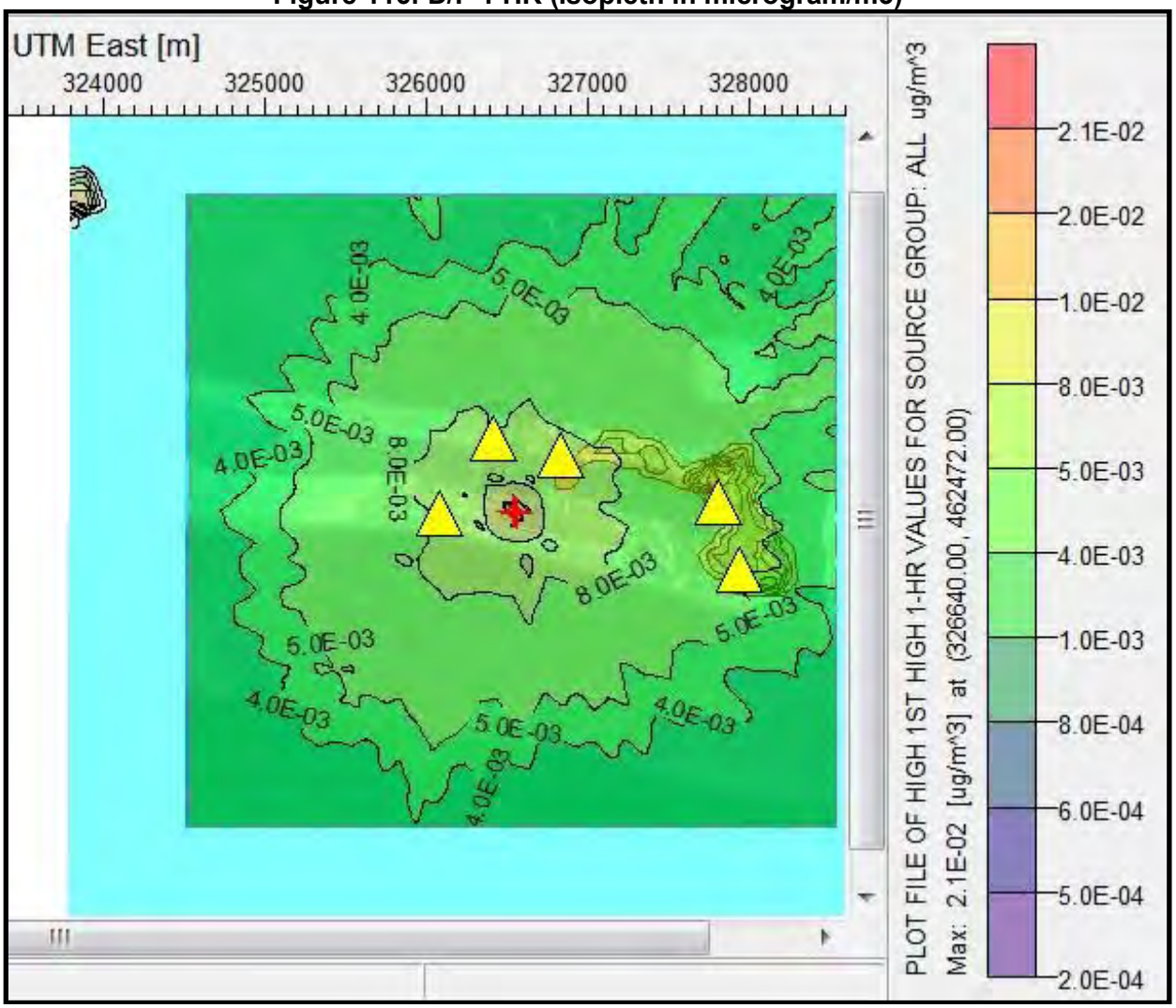


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 116: D/F 1 HR (Isopleth in microgram/m3)

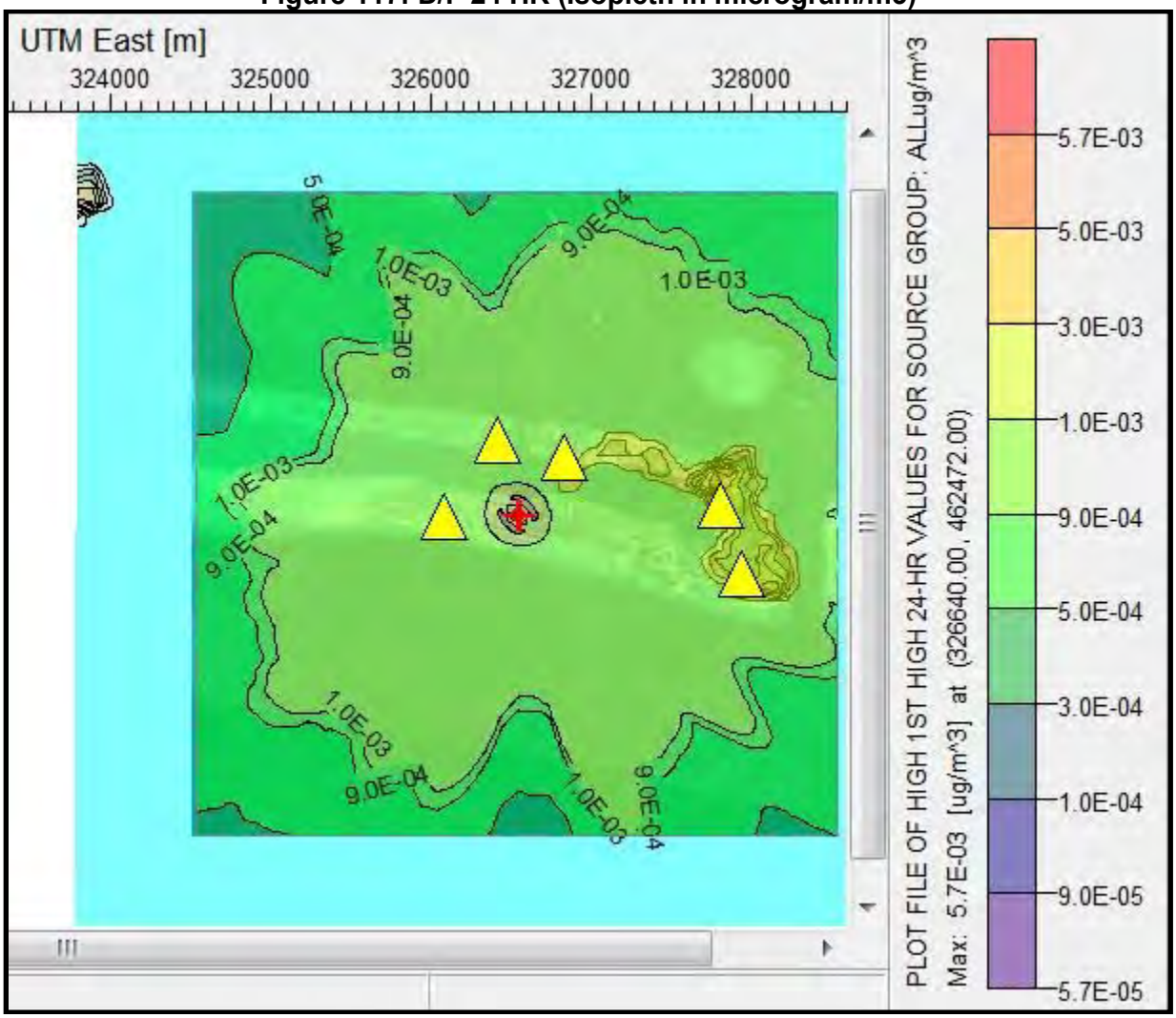


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 117: D/F 24 HR (Isopleth in microgram/m3)

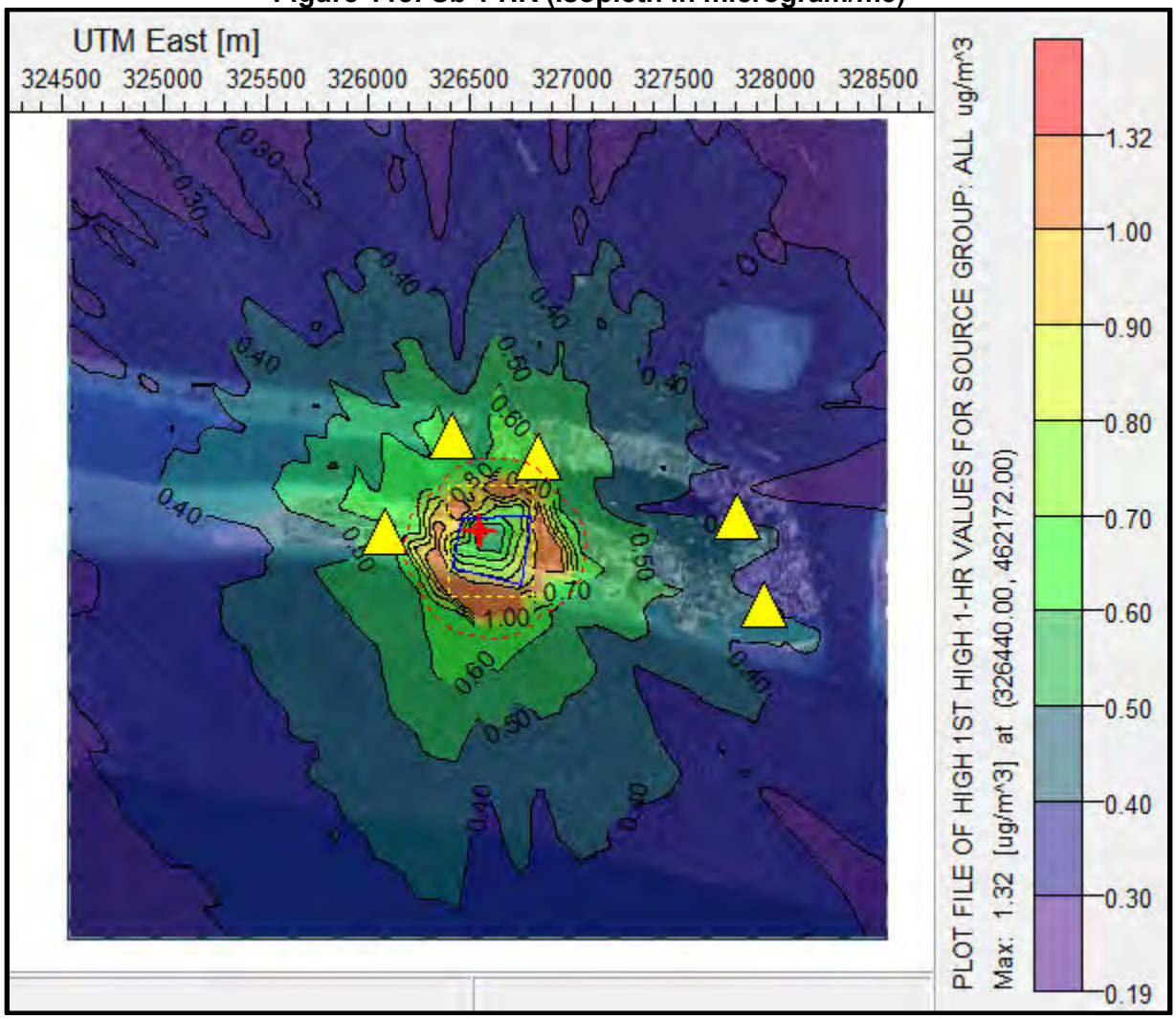


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 118: Sb 1 HR (Isopleth in microgram/m3)

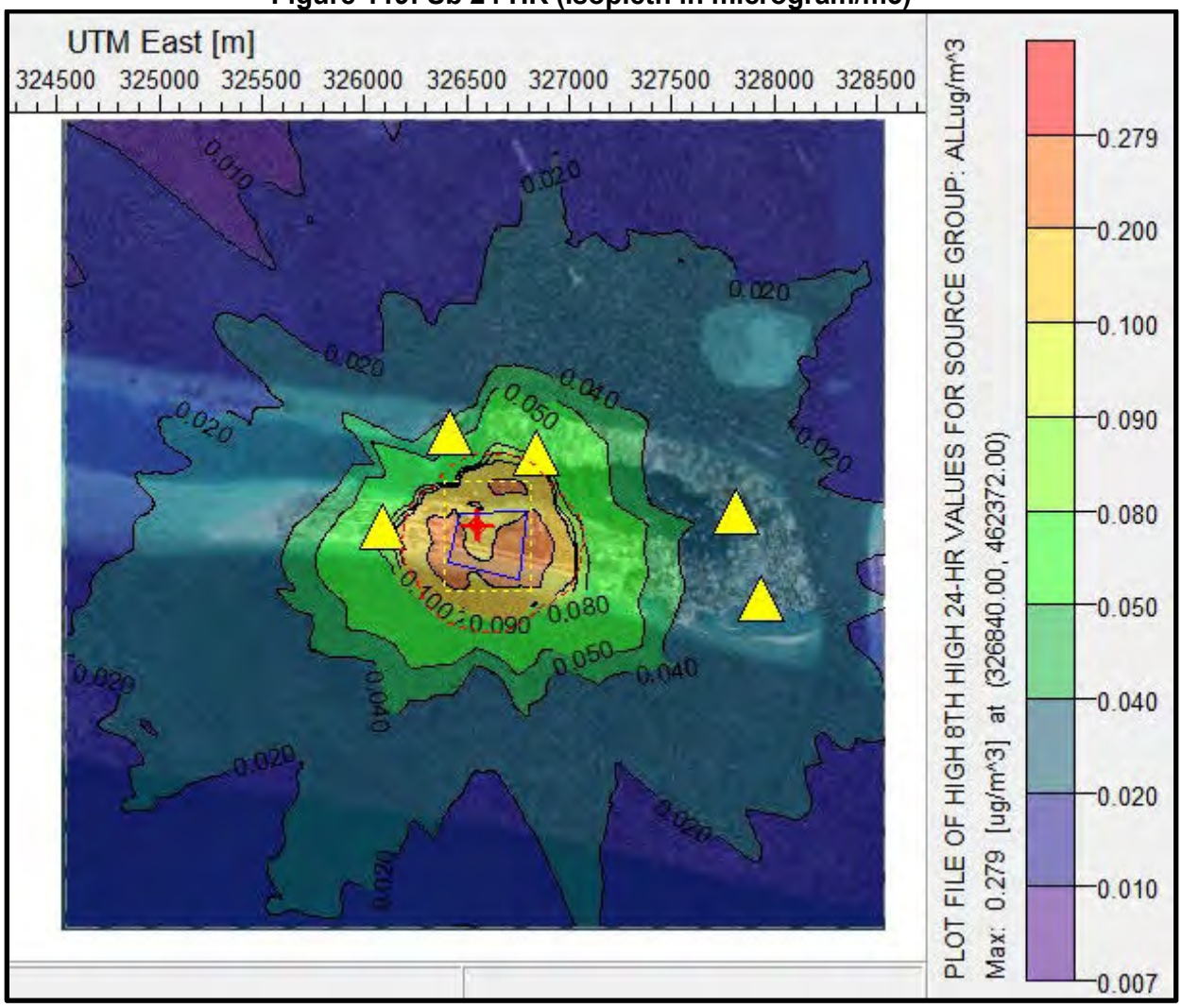


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 119: Sb 24 HR (Isopleth in microgram/m3)

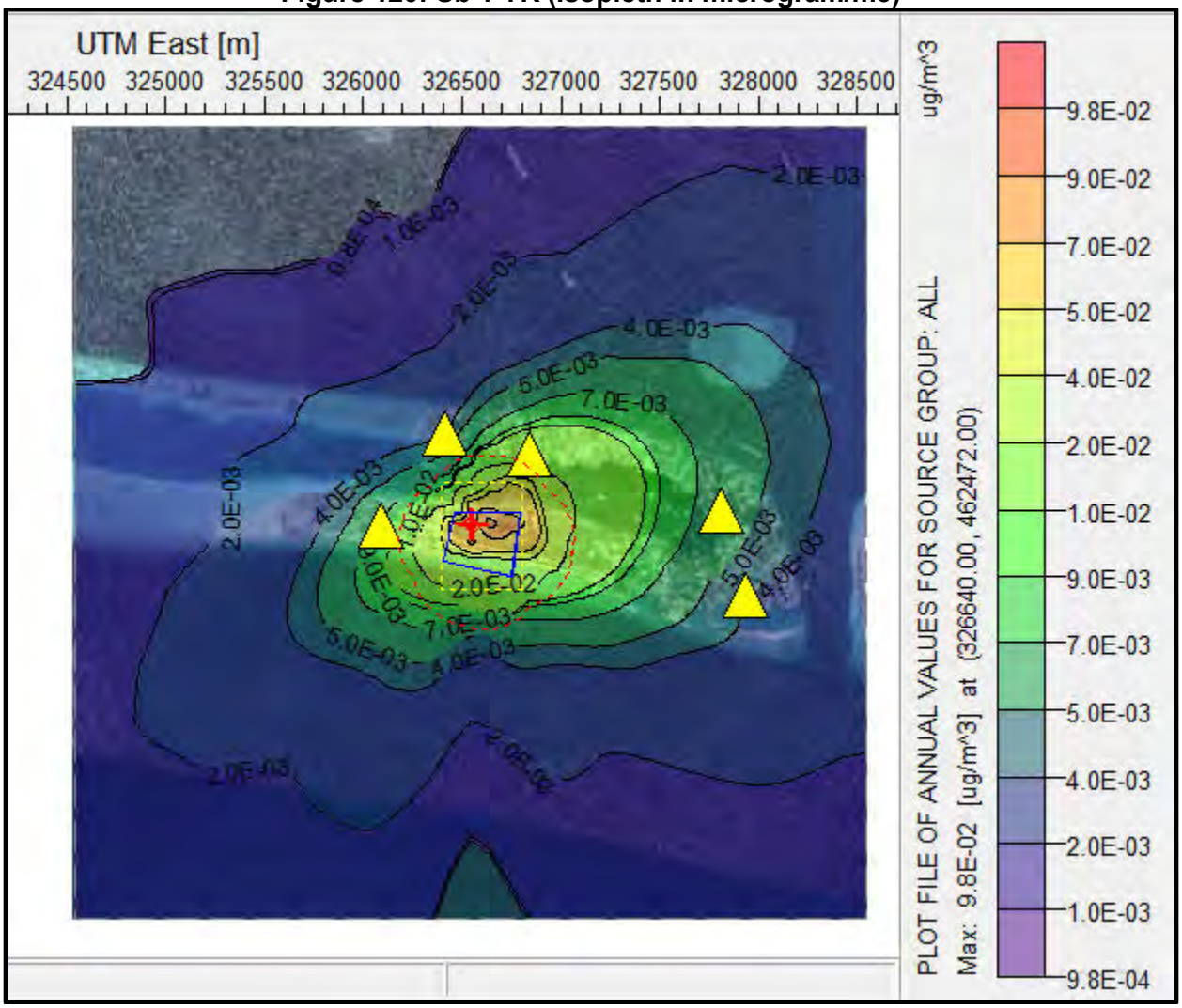


LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 120: Sb 1 YR (Isopleth in microgram/m3)



LEGEND:

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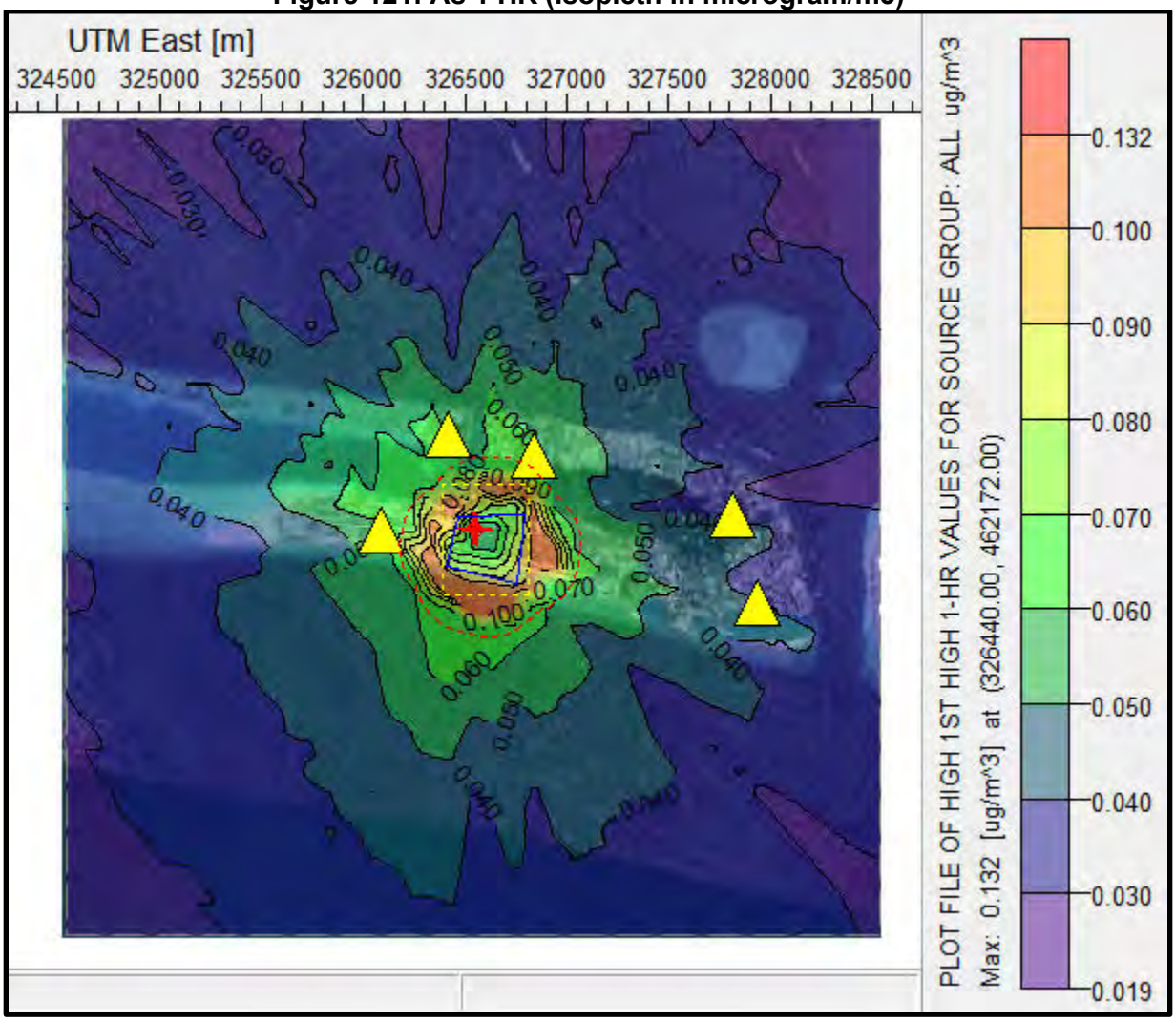
	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 121: As 1 HR (Isopleth in microgram/m3)



LEGEND:

Yellow Triangles refer to identified Area Sensitive Receptor (ASRs)

	Long	Lat
ASR1	327812	462536
ASR2	327938	462105
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 122: As 24 HR (Isopleth in microgram/m3)

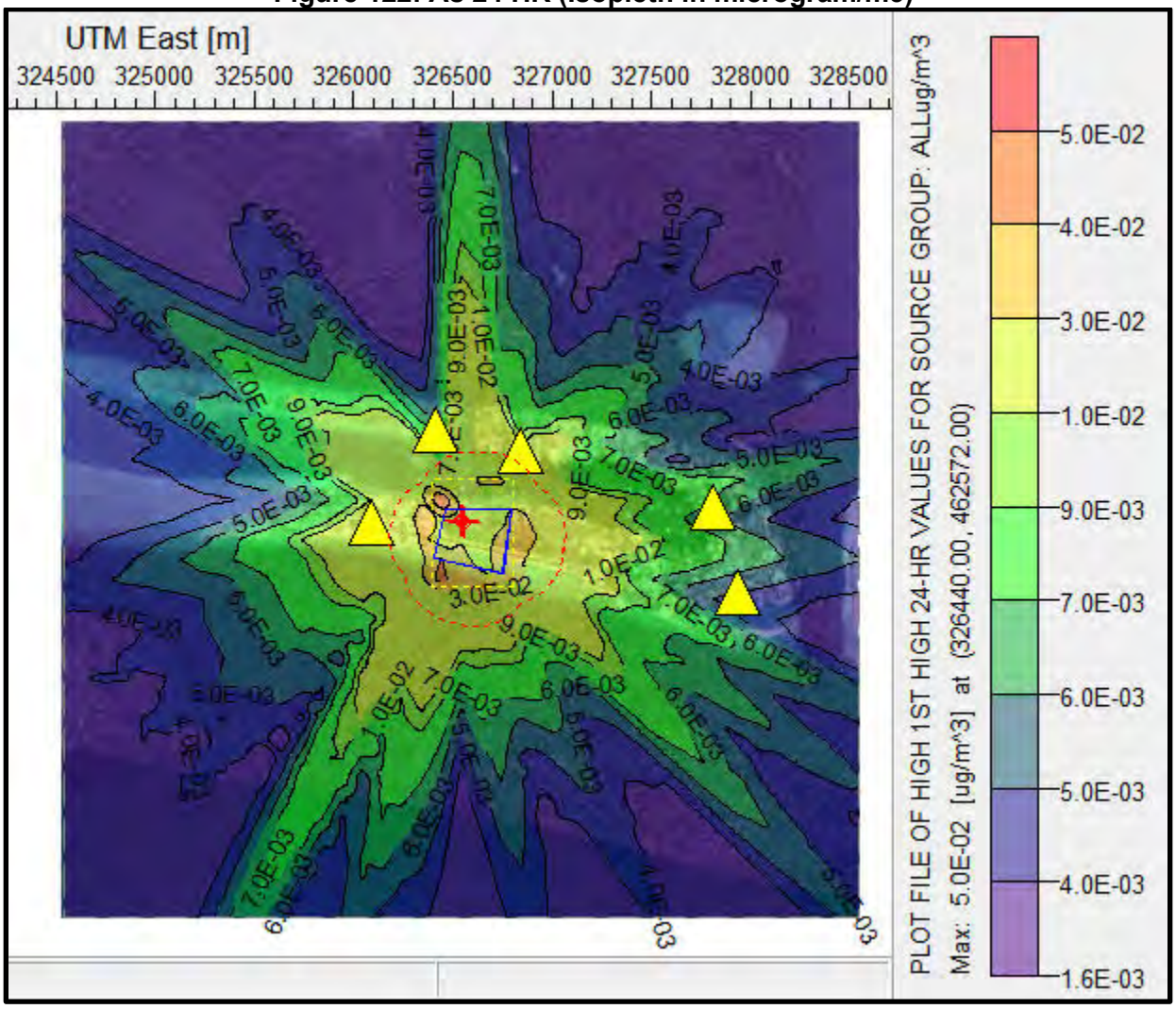


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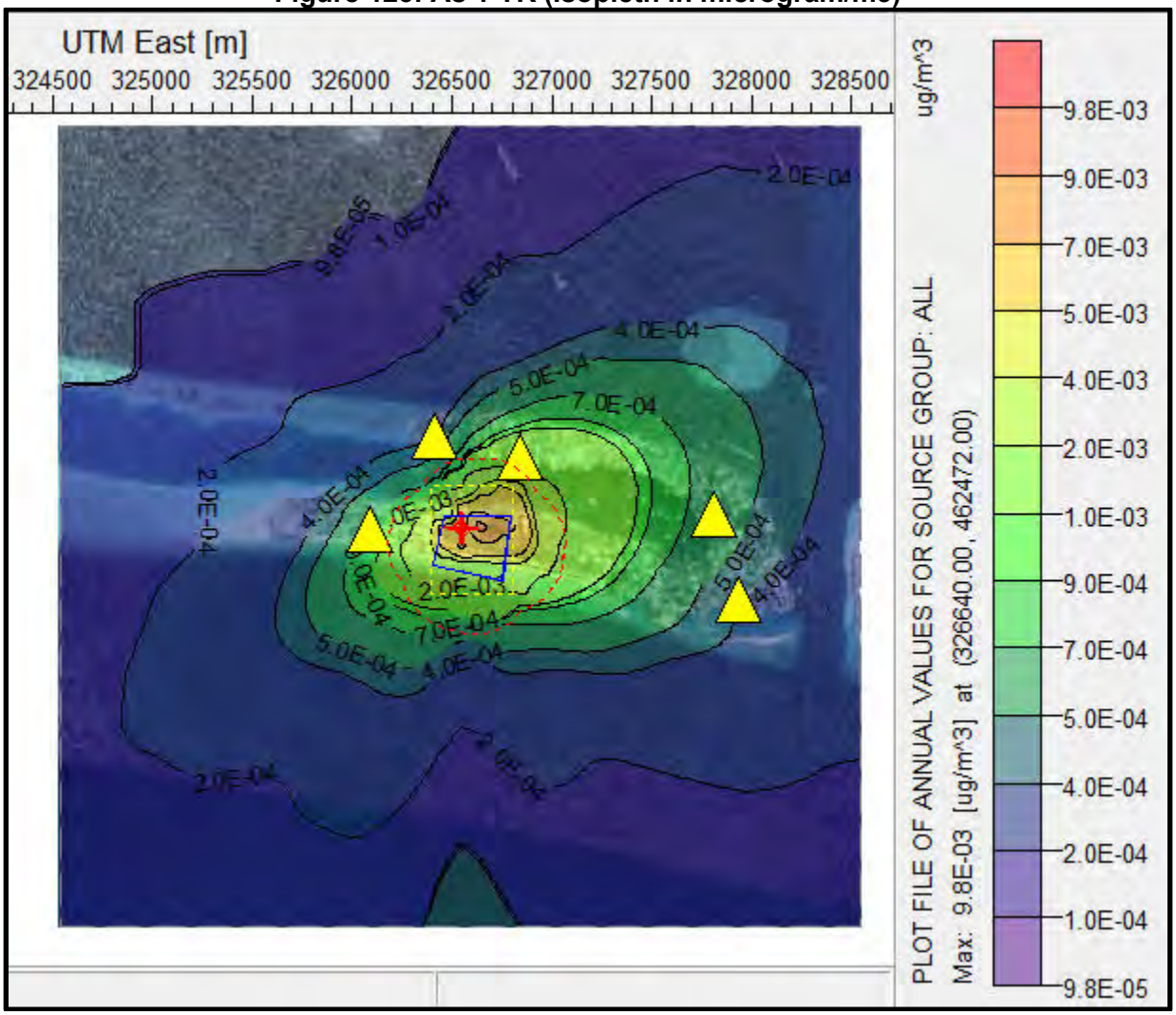
Figure 123: As 1 YR (Isopleth in microgram/m3)



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	Long	Lat
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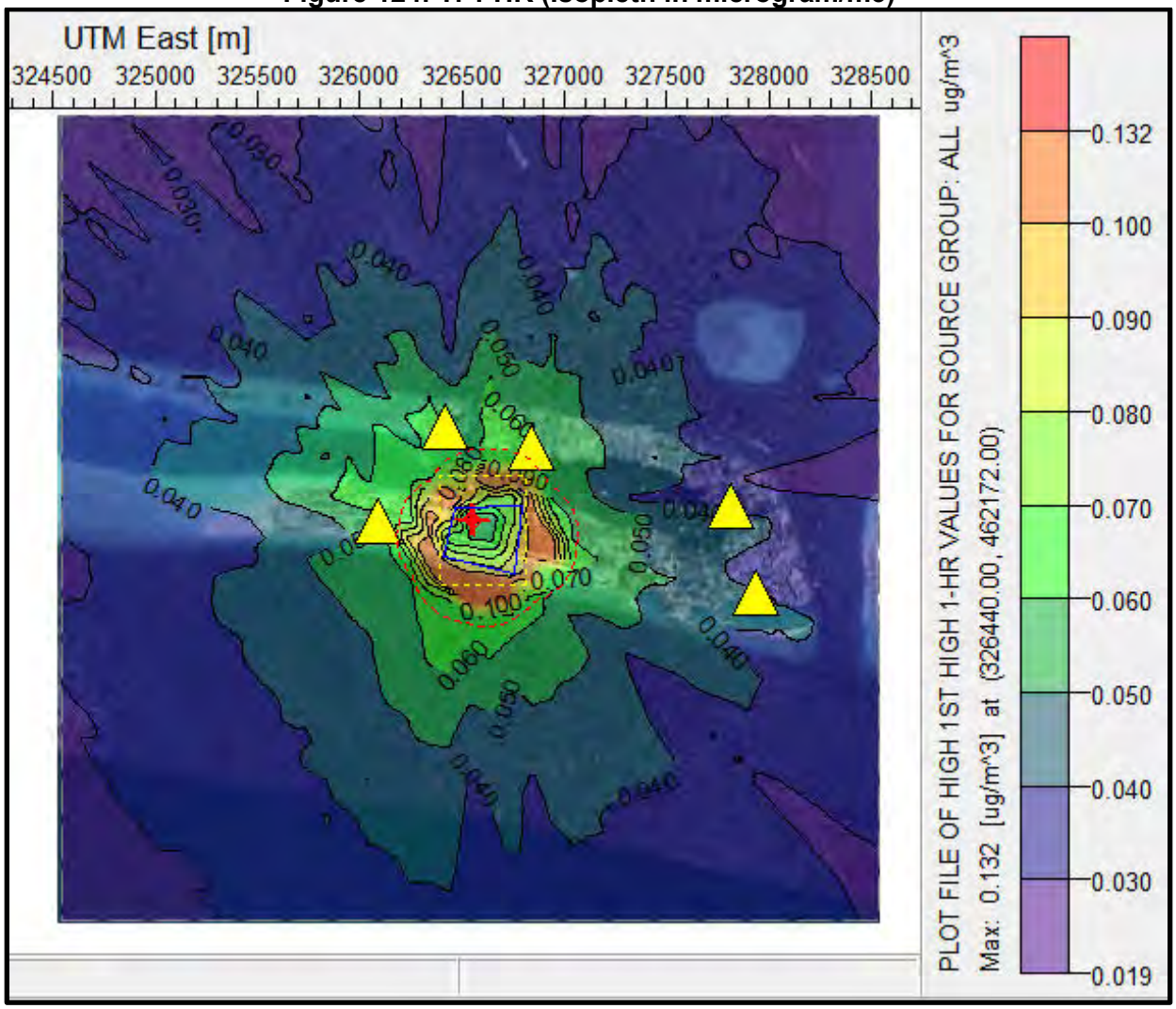
ASR4	326087	462455
ASR5	326416	462929

Figure 124: Tl 1 HR (Isopleth in microgram/m3)



LEGEND:

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	Long	Lat
ASR1	327812	462536
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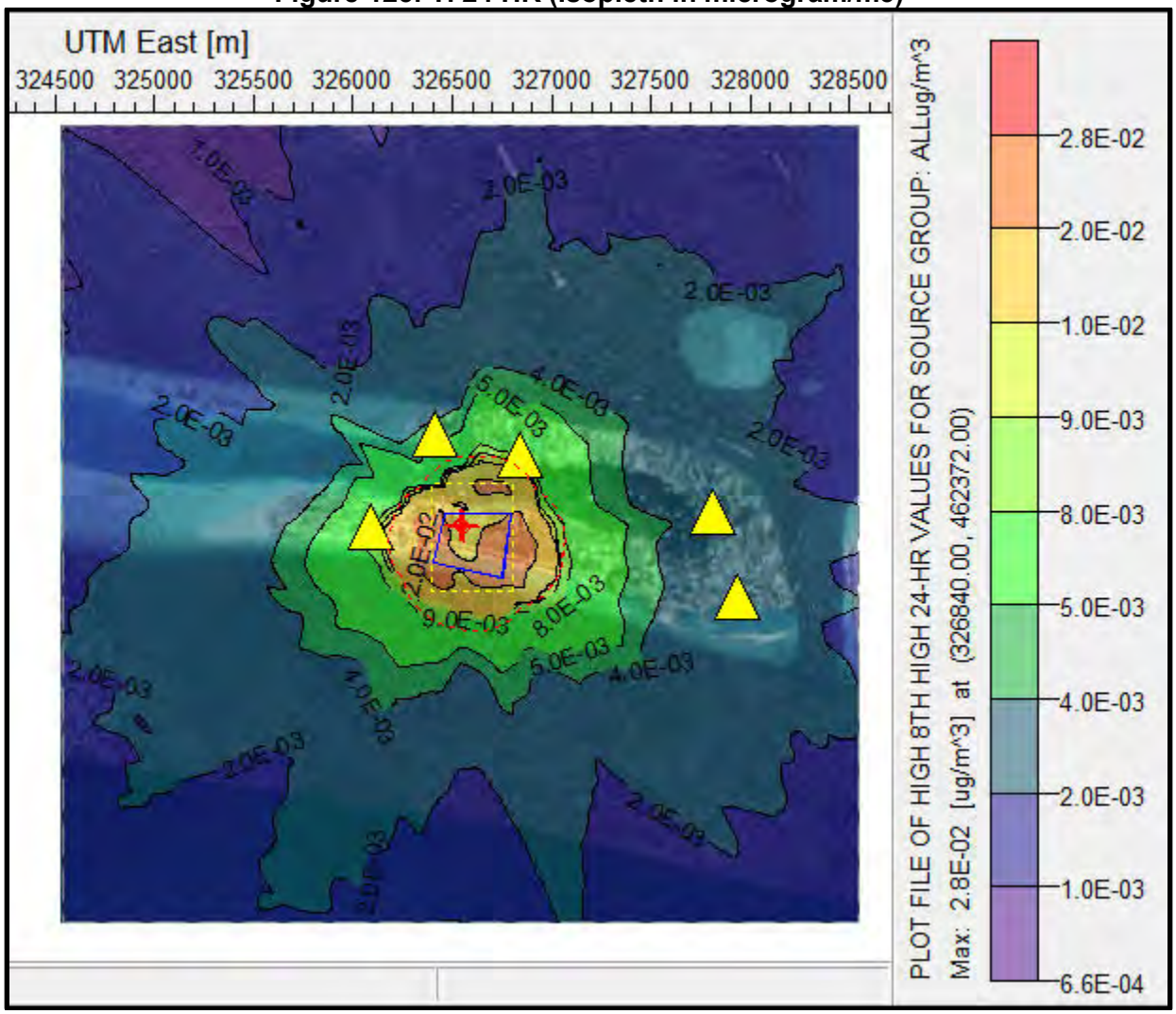
ASR3	326839	462822
ASR4	326087	462455
ASR5	326416	462929

Figure 125: TI 24 HR (Isopleth in microgram/m3)



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	Long	Lat
ASR1	327812	462536
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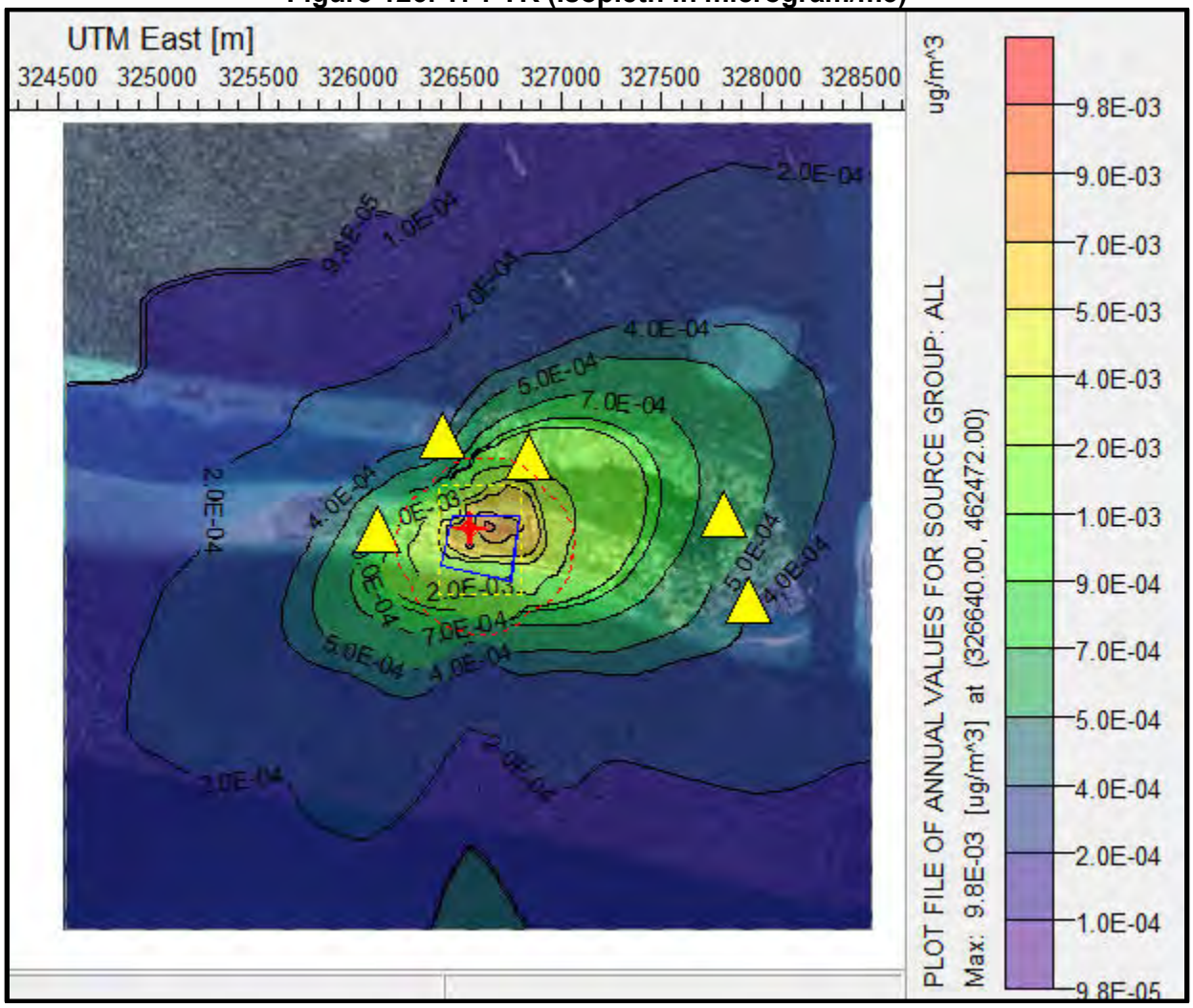
ASR4	326087	462455
ASR5	326416	462929

Figure 126: TI 1 YR (Isopleth in microgram/m3)



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ASR4	326087	462455
ASR5	326416	462929

477. For all the above parameters, controlled emissions have been validated to be in compliance with the TA Luft Standards as provided in the Austal2000 Report and with the USEPA standards and the WHO Air Quality Guidelines.

478. **Results**. AERMOD validation of the Austal2000 model results shows slightly higher results than the Austal2000 report but still within TA Luft Standards and USEPA Standards. For the deposition results, Total Dust, SO2, NO2 and Hg are confirmed to be way below the 1-year TA Luft precipitation standards. Three groups of toxic heavy metals were also run in the AERMOD validation model to show the potential maximum ground level concentrations using the design emission data. However, the results of the run for these group of heavy metals are for presentation only considering that there are no standards to compare them with.

479. Based on the design emission of the proposed WTE plant, proposed stack height of 50 meters in the Austal2000 report was found to be favorable considering all predicted ground level concentrations in the AERMOD validation model are below the TA Luft and USEPA standards. The complete report on the AERMOD Modeling is in Appendix 7.

Table 46: Summary Maximum Ground Level Concentration - AERMOD

MAXIMUM GROUND LEVEL CONCENTRATION						German Standards (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the WHO Standards	Non-degraded[a] >25%	Degraded[a] >10% short term >1% long term)
Parameters	Ave. Time	Conc (ug/Nm3)	Deposition (g/m2)	X	Y	Conc (ug/Nm^3)	Deposition (g/m2)	Conc (ug/Nm^3)	Conc (ug/Nm^3)	%		
Total Dust	1 hour	7.60628	0.00754	327040	462672	-	-	-	-	-	-	-
Total Dust	24 hours	3.18863	0.03805	327140	462572	-	-	-	-	-	-	-
Total Dust	1 year	0.34134	0.43994	326840	462572	-	0.35	-	-	-	-	-
PM10	1 hour	0.10288	0.00037	326640	462472	-	-	-	20	0.51	N	N
PM10	24 hours	0.02844	0.00078	326640	462472	50	-	150	50	0.06	N	N
PM10	1 year	0.0025	0.02508	327240	462572	40	-	50	20	0.01	N	N
SO2	1 hour	10.3398	-	326640	462472	350	-	212	-	4.88	N	N
SO2	24 hours	2.85793	-	326640	462472	125	-	365	20	14.29	N	Y
SO2	1 year	0.25302	-	327240	462572	50	-	79	-	0.32	N	N
NO2(NOx)	1 hour	48.91013	-	326640	462472	200	-	100 ppb	200	24.46	N	Y
NO2(NOx)	24 hours	14.16085	-	326640	462472	-	-	-	-	-	-	-
NO2(NOx)	1 year	2.1	-	324540	460472	40	-	53 ppb	40	5.25	N	Y
Hg	1 hour	0.00643	-	326640	462472	-	-	-	-	-	-	-
Hg	24 hours	0.00178	-	326640	462472	-	1	-	-	-	-	-
Hg	1 year	0.00157	-	327240	462572	-	0.05	-	-	-	-	-
NH3	1 hour	2.06667	-	326640	462472	-	-	-	-	-	-	-
NH3	24 hours	0.57123	-	326640	462472	-	-	-	-	-	-	-
NH3	1 year	0.00147	-	326340	461872	-	-	-	-	-	-	-
HCl	1 hour	2.06667	-	326540	462472	-	-	-	-	-	-	-
HCl	24 hours	0.57123	-	326540	462472	-	-	-	-	-	-	-
HCl	1 year	0.00147	-	324540	460472	-	-	-	-	-	-	-
Hf	1 hour	0.20705	-	326640	462472	-	-	-	-	-	-	-

MAXIMUM GROUND LEVEL CONCENTRATION						German Standards (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the WHO Standards	Non-degraded[a] >25%	Degraded[a] >10% short term >1% long term)
Hf	24 hours	0.05723	-	326640	462472	-	-	-	-	-	-	-
Hf	1 year	0.00015	-	324540	460472	-	-	-	-	-	-	-
D/F	1 hour	0.02058	-	326640	462472	-	-	-	-	-	-	-
D/F	24 hours	0.00569	-	326640	462472	-	-	-	-	-	-	-
D/F	1 year	0.00002	-	324540	460472	-	-	-	-	-	-	-
Sum of Metals (Sb)[b]	1 hour	1.31607	-	326440	462172	-	-	-	-	-	-	-
Sum of Metals (Sb)[b]	24 hours	0.49540	-	326440	462572	-	-	-	-	-	-	-
Sum of Metals (Sb)[b]	1 year	0.09818	-	326440	462472	-	-	-	-	-	-	-
Sum of Metals (As)[c]	1 hour	0.13161	-	326440	462172	-	-	-	-	-	-	-
Sum of Metals (As)[c]	24 hours	0.04954	-	326440	462572	-	-	-	-	-	-	-
Sum of Metals (As)[c]	1 year	0.00982	-	326440	462472	-	-	-	-	-	-	-
Sum of Metals (Tl)[d]	1 hour	0.13161	-	326440	462172	-	-	-	-	-	-	-
Sum of Metals (Tl)[d]	24 hours	0.04954	-	326440	462572	-	-	-	-	-	-	-
Sum of Metals (Tl)[d]	1 year	0.00982	-	326440	462472	-	-	-	-	-	-	-

[a] Compared with applicable standards where available.
[b] Sum of metals: Antimony, Chromium, Copper, Manganese, Vanadium, in, Lead, Cobalt, Nickel
[c] Sum of metals: Arsenic / cadmium and its compounds (expressed as As and Cd), benzo (a) pyrene, water-soluble cobalt compounds (expressed as Co), chromium (VI) compounds (expressed as Cr)
[d] Sum of metals: Thallium and its compounds and cadmium

480. **Recommendations**. With regard to the results of modeling, the following were recommended:

(i) Retain the four existing ambient air quality monitoring stations as recommended by the AUSTAL2000 modeling. However, additional monitoring stations should be installed or established at the ASR2, ASR3 and ASR5 areas due to presence of residential/accommodation areas. See Figure 128. The map shows the Area Sensitive Receptor primary impact areas and location of recommended Ambient Air Quality Monitoring Stations. In cases of exceedance, these areas are likely to be affected.; and
(ii) Validation modeling should be conducted during the starting months of normal operation using actual CEMS and stack testing results to simulate actual operation of the plant.

481. Furthermore, in order to minimize generation of air pollutants from the WTE plant and to reduce the impact to the surrounding environment, the following were also recommended:

(i) Boilers should be regularly maintained, while structures such as the stacks and ducts should be regularly checked to avoid fugitive dusts sources and particulate accumulation;
(ii) Control devices such as the Dry Scrubber and Baghouse should undergo regular checkup and maintenance;
(iii) Solid wastes should have acceptance criteria in terms of waste characteristics;
(iv) Waste should be dried to eliminate moisture, which is a precursor to incomplete combustion that results to higher particulate matter (PM) and carbon monoxide (CO) generation;
(v) Periodic watering of roads to minimize generation and resuspension of dust particles;
(vi) Forestation and plantation at the perimeter-buffer areas to serve as vegetation walls that can help control dispersion of air pollutants;
(vii) Regular ambient air quality monitoring should be conducted in hot spots and impacts areas based on the results of the modeling report. Actual ambient monitoring may be treated as validation of model results; and
(viii) Every modification and installation of new sources should be considered as additional contribution to emission of the plant. Hence, modeling updates should also be conducted to determine assimilative carrying capacity of the area based on the impacts of the new modification or installation.

Figure 127: Recommended monitoring sites.

3. Additional Measures to Mitigate Impacts on Ambient Air Quality During Operation Phase

482. **Offset Activities Within Thilafushi**. The government plans to stop fires on Thilafushi and start baling waste by July 2020 as interim SWM solution to stop open dumping until the WTE facility is commissioned. It is expected that once these measures are implemented the air quality at the sampling locations will improve. The rehabilitation of the existing dumpsite will have the end view of shutting down the operation of the dumpsite. This activity will serve as the biggest offset to substantially reduce the impact of the WTE Plant operation to ambient air quality. Monitoring the benefits of this offset will continue throughout the operation phase and included in the environmental monitoring plan developed in this EIA report.

483. **Use of cleaner fuels or technologies**. The DBO Contract provides performance guarantees that will ensure use of cleaner fuels and technologies that have already been proven in other countries. These performance guarantees will ensure that the WTE plant will comply with the emission standards.

4. Water Pollution Due to Cooling Water and Brine

484. In Section IV (Alternatives Analysis), three alternative locations have been assessed on where the cooling water discharge pipe could be positioned at the 500-meter coastal stretch south of the project site. These alternative locations were tagged as M8, M9, and M10 in Figure 11. As initial step in the analysis, underwater marine survey was undertaken to profile the characteristics of the coral reef and extent of marine life, including pelagic species, along this stretch at various depths. Results show that profiles at these three tagged locations are identical and reveal the very few (or none at all) marine species at depth of less than 10m. The results further reveal that no significant marine life such as live corals, fishes or other pelagic organisms can be found at greater depths. This finding is particularly valid at the depth of more than 20 meters, wherein the seabed/reef wall is characterized by large expanse of rocks with rubbles scattered and no evidence of live corals anymore. Thus, the selection of the best option from among the three alternatives has been based on the slope of the reef instead. From engineering point of view, the discharge pipe can be anchored best in a gradually sloping seabed. Visual observation during the underwater survey suggest that the M8 section has the best slope to position the discharge pipe.

485. In the same alternatives analysis, the next step undertaken was to determine at which depth the outfall should be positioned at the M8 section. A hot water dispersion modeling was carried out to assess the rate of heat dissipation of hot water at various depths (10 m, 20 m, and 30 m). It was found that the deepest position at 30m has the least potential impact on the marine environment. At this depth, the dissipation of heat from the cooling water is fastest. Even with the worst-case scenario (high influence scenario) at the depth of 10m, the excess temperature will already reduce to less than 1°C within few meters (in the near-field modeling) and to $5x10^{-6}$ °C within the 90m range (in the far-field modeling). According to the model results, this excess temperature is very low and negligible in coastal environment. Comparison of the heat dissipation under the worst case (high influence) scenario and best-case scenario is illustrated below. Figure 120 depicts one example of modeled heat dissipation scenario at 10 m depth, while Figure 121 depicts one example of modeled heat dissipation scenario at 30 m depth.

Figure 128: Thermal Dispersion towards West at Scenario with 10 degrees at a depth 10 m

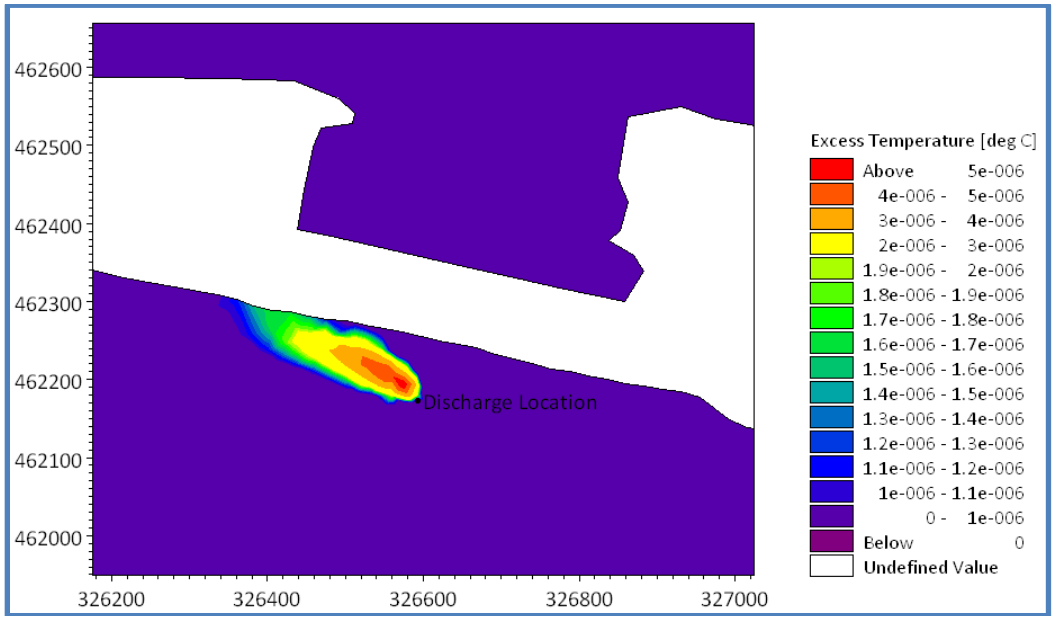
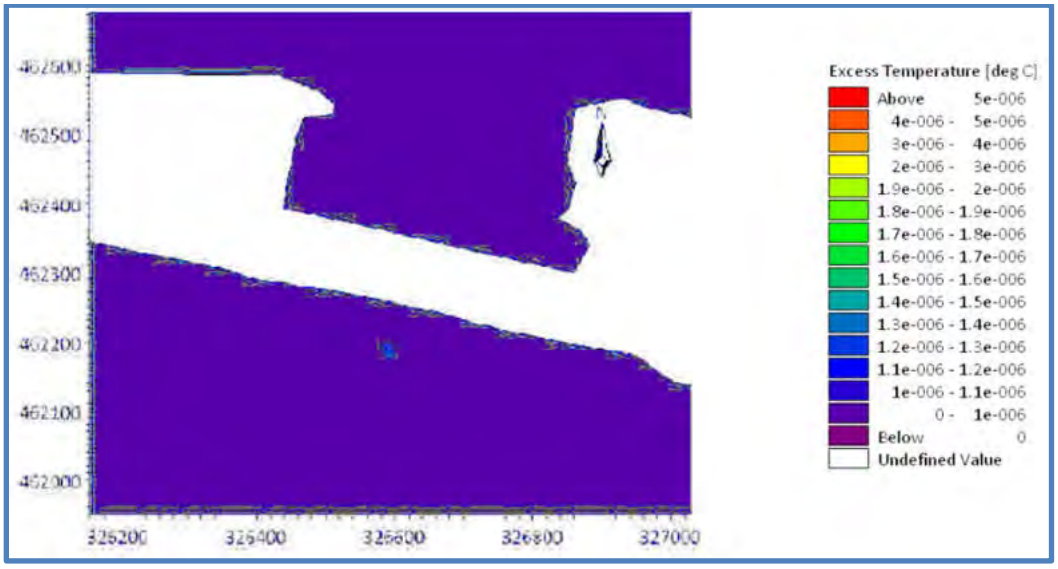


Figure 129: Thermal Dispersion towards West at Scenario with 10 degrees at a depth 30 m



486. However, as a precautionary measure, the outfall is recommended to be positioned at the depth of 30 m, which is the best-case scenario in the model. The location is much more defensible because at this depth, no marine life exists based on the underwater survey. The cooling water discharge will not pose any impact at this region.

487. The brine that will be generated from the desalination process will need to be disposed or discharged back to the sea. However, doing so may impact marine life at the discharge point. As

a measure, the brine will be discharged through the cooling water discharge line. The volume of brine that will be generated from the desalination process is expected to be small compared to the volume of cooling water that will be used in the condenser cooling process. Hence, no significant change in the salinity of the cooling water is expected. This measure shall be integrated in the detailed design of the WTE plant by the DBO contractor.

5. Air, Water, and Land Pollution Due to Disposal of Ash and Other Residuals

488. The handling, treatment and disposal of ash and other residuals from the operation of the WTE plant will follow EHS Guidelines on Waste Management Facilities. The DBO Contractor will be required to integrate in the detailed design the following measures:

(i) Design the furnace to, as far as possible, physically retain the waste within the combustion chamber (e.g. narrow grate bar spacing for grates, rotary or static kilns for appreciably liquid wastes), and use a waste throughput rate that provides sufficient agitation and residence time of the waste in the furnace at sufficiently high temperatures, including any ash burn-out areas, in order to achieve a total organic carbon (TOC) value in the ash residues of below 3 weight percent and typically between 1 and 2 weight percent.
(ii) Manage bottom ash separately from fly ash and other flue gas treatment residues to avoid contamination of the bottom ash for its potential recovery;
(iii) Separate remaining ferrous and non-ferrous metals from bottom ash as far as practicably and economically viable, for their recovery;
(iv) Treat bottom ash on or off-site (e.g., by screening and crushing) to the extent that is required to meet the specifications set for its use or at the receiving treatment or disposal site (e.g., to achieve a leaching level for metals and salts that is in compliance with the local environmental conditions at the place of use);
(v) Bottom ash and residuals should be managed based on their classification as hazardous or non-hazardous materials. Hazardous ash should be managed and disposed of as hazardous waste. Non-hazardous ash may
(vi) be disposed of in an MSW landfill or considered for recycling in construction materials.[42]

6. Water Pollution Due to Discharge of Landfill Leachate

489. The leachate generated from the WTE Plant will be the leachate coming from the landfill cells. In order to avoid discharging untreated leachate to the marine environment, the construction of the landfill shall follow the following requirements that are included in the bidding documents:

(i) The landfill shall accommodate residues from the incineration facility (APC residues and non-marketable bottom ash).
(ii) The base liner system shall be of impermeable nature and shall prevent any leachate seepage towards the subsoil beneath the base liner system.

7. Socio-economic impacts

490. The project is expected to generate employment opportunities for waste collection, transportation, operation of the machineries and plants, and administrative support.

[42] EPA (http://www.epa.gov)

8. Community and Occupational health and safety

491. Operation of the WTE plant and its components poses significant occupation health and safety risks. To reduce the risks, contractors will be required to appoint health and safety officers for each site and to ensure regular briefing of the construction workforce on health and safety issues. The contractor shall establish its health and safety plans to be adopted at each site following international best practices and the World Bank EHS guidelines on construction and decommissioning activities.

492. The machineries and plants require different chemicals and hazardous substances for operation. There is invariably a risk when such chemicals are handled. Although the WTE Plant is located away from residents, there is a considerable safety risk to workers at the plant and also surrounding environment in the event of any leak or spill.

493. Similar to impacts and measures during construction phase, the DBO Contractor shall integrate during detailed design applicable international good practices on community and occupation health and safety in its operation of the WTE, such those included in World Bank EHS Guidelines on Waste Management Facilities (footnote 37). The most significant occupational health and safety impacts typically associated with workers at waste management facilities occur during the operational phase and include accidents and injuries, chemical exposure, and exposure to pathogens and vectors. Minimum requirements shall be the following:

494. **Accidents and Injuries**. Physical hazards encountered at waste management facilities are similar to those at other large industrial projects. Solid waste workers are particularly prone to accidents involving trucks and other moving equipment, so traffic management systems and traffic controllers are recommended. Accidents include slides from unstable disposal piles, cave-ins of disposal site surfaces, fires, explosions, being caught in processing equipment, and being run over by mobile equipment. Other injuries occur from heavy lifting, contact with sharps, chemical burns, and infectious agents. Smoke, dusts, and bioaerosols can lead to injuries to eyes, ears, and respiratory systems.[43] In addition to other standard measures adopted in most industrial facility operations, the applicable procedures following international best practices are recommended to prevent, minimize, and control accidents and injuries at the WTE plant and its associated facilities.

495. **Chemical Exposure**. Chemical hazards encountered at waste management facilities are similar to those at other large industrial facilities, such as toxic and asphyxiating gases, and are addressed in the General EHS Guidelines. However, the full composition of wastes and their potential hazards is often unknown. Even municipal solid waste (MSW) often contains hazardous chemicals, such as heavy metals from discarded batteries, lighting fixtures, paints, and inks. The following procedures are recommended, whichever are applicable, to prevent, minimize, and control chemical exposure at the WTE plant:

(i) Control and characterize incoming waste (see waste receipt, unloading, processing and storage);
(ii) Provide adequate personnel facilities, including washing areas and areas to change clothes before and after work;
(iii) Ventilate enclosed processing areas (e.g., dust in waste size reduction areas, VOCs driven off by high temperatures during composting);

[43] Refer to Cointreau. S. (2006) for additional information.

(iv) Monitor breathing zone air quality in work areas at processing, transfer and disposal facilities. Direct-reading instruments that measure methane and oxygen deficiency are of primary importance; these include combustible gas indicators, flame ionization detectors, and oxygen meters. At waste treatment/disposal facilities, volatile organics should also be analyzed in the biodegradation gases being collected and/or vented. In waste handling, sorting, and composting facilities, monitoring for organic dust is needed;
(v) Prohibit eating, smoking, and drinking except in designated areas; and
(vi) Provide air filtered and air-conditioned cabs for heavy mobile equipment used at landfills as necessary.

496. **Pathogens and Vectors**. Workers can be exposed to pathogens contained in manure and animal excreta found in MSW from the disposal of sludge, carcasses, diapers, and yard trimmings containing domestic animal waste. Uncontrolled dumping of MSW attracts rats, flies, and other insects that can transmit diseases. Processing of MSW can also generate bioaerosols, suspensions of particles in the air consisting partially or wholly of microorganisms, such as bacteria, viruses, molds, and fungi. These microorganisms can remain suspended in the air for long periods of time, retaining viability or infectivity. Workers may also be exposed to endotoxins, which are produced within a microorganism and released upon destruction of the cell and which can be carried by airborne dust particles. The following measures are recommended to prevent, minimize, and control pathogens and vectors at the WTE plant:

(i) Provide and require use of suitable personal protective clothing and equipment;
(ii) Provide worker immunization and health monitoring (e.g., for Hepatitis B and tetanus);
(iii) Maintain good housekeeping in waste processing and storage areas;
(iv) Use automatic (non-manual) waste handling methods if practical;
(v) Clean and wash with disinfectant the cabins of heavy mobile equipment used at regular intervals;
(vi) Grade the area properly to prevent ponding (to minimize insect breeding areas);
(vii) Use integrated pest-control approaches to control vermin levels, treating infested areas, such as exposed faces and flanks with insecticide, if necessary;
(viii) Provide and require use of dust masks or respirators under dry and dusty conditions. Charcoal-filled respirators also reduce odor perception;
(ix) Provide prompt medical attention for cuts and bruises. Cover open wounds to prevent contact with the incoming loads or feedstock; and
(x) Fully enclose the waste management site with fencing so that no livestock or wildlife is able to come in contact with the waste, which contains significant potential to enable the spread of livestock and zoonotic disease, as well as spillover disease to wildlife. Provide daily cover of wastes to minimize the attraction to birds, which can become infected with avian influenza and other bird diseases that can then be carried off-site.

497. **General Occupational and Environmental Health Issues Associated with Waste Scavenging.** The presence of informal sector workers laboring in municipal or mixed waste disposal sites in search of commercially valuable materials is a common place occurrence in developing countries. The causes and dynamics are the result of complex social, cultural, labor, and economic factors that are clearly outside of the scope of this guidance document. However, the following principles, if applicable, should be considered in managing the occupational, health, and safety risks at the WTE site:

(i) Waste scavenging should not be allowed under any circumstances in hazardous and non-hazardous industrial waste management facilities;
(ii) Facilities dedicated to the management of MSW should work with government entities in the development of simple infrastructure that can allow for the sorting of waste, helping groups of scavengers form cooperatives or other forms of micro-enterprises, or formally contracting them to provide this function. The outright displacement of scavenging workers as an occupational health and safety management strategy, without the provision of viable alternatives, should be avoided;
(iii) Operators of existing facilities with scavenging workers should exercise commercially viable means of formalizing their work through the creation of management programs that include:

(a) Allowing only registered adults on the site, excluding children and domestic animals. Striving to provide alternatives to access to childcare and education to children;
(b) Providing protective gear, such as shoes. face masks, and gloves;
(c) Arranging the disposal layout and provide sorting facilities to improve access to recyclables while reducing their contact with other operations, thus minimizing potential hazards;
(d) Providing water supply for washing and areas for changing clothes;
(e) Implementing education campaigns regarding sanitation, hygiene, and care of domestic animals;
(f) Providing a worker health surveillance program including regular vaccination and health examinations.

498. **Physical, Chemical, and Biological Hazards.** Visitors and trespassers at waste management facilities may be subject to many of the hazards described for site workers. In particular, waste pickers, looking for recyclable materials and food scraps for animal feeding, often work informally at waste transfer and disposal sites, especially MSW facilities, typically living adjacent to the site in poor housing conditions, with minimal basic infrastructure for clean water and sanitation. Waste pickers may be encounter numerous risks, including contact with human fecal matter, paper that may have become saturated with toxic materials, bottles with chemical residues, metal containers with residue pesticides and solvents, needles and bandages (containing pathogenic organisms) from hospitals, and batteries containing heavy metals. Exhaust fumes of waste collection trucks traveling to and from disposal sites, dust from disposal operations, and open burning of waste all contribute to potential occupational health problems.[44] Recommended measures to prevent, minimize, and control physical, chemical, and biological hazards to the community around the WTE site include:

(i) Restrict access to waste management facilities by implementing security procedures, such as:

(a) Perimeter fencing of adequate height and suitable material, e.g. chain link, stock proof palisade;
(b) Lockable site access gate and buildings; o Security cameras at key access points linked to recording equipment and remote access CCTV, where required;

[44] Sandra Cointreau, The World Bank Group, Occupational and Environmental Health Issues of Solid Waste Management Special Emphasis on Middle- and Lower-Income Countries, Urban Papers UP-2, July 2006.

(c) Security alarms fitted to buildings and storage areas; o Review of site security measures annually or whenever a security breach is reported
(d) Use of a site visitor register; o Immediate repair of fencing/access points if damaged; and
(e) Lighting of site during night time where necessary. As this may cause light nuisance to neighbors, the lighting installations should be selected to minimize ambient light pollution.

499. **Workers Accommodation During Operations.** The accommodation of workers shall be established following international best practices to ensure welfare of workers is protected.[45] The DBO Contractor shall consider the following requirements in building these camps and accommodation facilities at the site, if any.

(i) The temporary campsite location should:

(a) Be free from any risk of flooding.
(b) Be sited a reasonable distance and have clear physical separation from any construction work, equipment and/or machinery.
(c) Provide clear separation between the camp and construction area through such means as a footpath, fence, etc.
(d) Where possible, be sited outside the boundary of the construction zone.

(ii) The site design should ensure:

(a) Adequate space to accommodate the number of workers throughout the project period, for accommodation, meals, toilets, bathing, etc.
(b) Considerations for needs of all types of workers: e.g. women, local laborers or travelers, etc.
(c) Adequate drainage is provided to prevent any stagnant water which can attract mosquitos and vermin and spread disease among workers,
(d) Buildings are structurally sound and can withstand wind and rain.
(e) Ensure that the worker camp area will have adequate ground surfacing (e.g. gravel, wood sheeting, grass) such that residents may move freely between buildings in their off time without walking through mud and water.
(f) Designated area for small fires during colder months, located a safe distance from buildings and any flammable materials.

(iii) The workers' accommodation should comply with the following requirements:

Dimensions and Design

(a) The height of room shall not be less than 2.4 meters.
(b) The sleeping area or resting area shall not be less than 3 m^2 per person.

[45] From the draft Construction Code of Practice developed for urban development projects in Kathmandu, Nepal. This COP was developed with reference to the following: "Workers' accommodation: processes and standards: A guidance note by IFC and EBRD", IFC and EBRD, 2009 https://www.ebrd.com/downloads/about/sustainability/Workers_accomodation.pdf; and "Malaysian standards of temporary construction site workers' amenities and accommodation – code of practice. (MS 2593, 2015) http://www.sirim.my/srmc/documents/Aug-Sept-2014/12D024R0_PC.pdf

(c) Separate bed for each worker provided, with minimum of 1m space between each bed.
(d) Separate sleeping areas are provided for men and women, except in family rooms if needed.
(e) Sleeping area should be separate from cooking/canteen areas, and far enough distance from toilets to avoid odors.
(f) Where possible, prefab-type structures could be considered.

Light and Air

(a) Both natural and artificial lighting are provided and maintained in living facilities. It is best practice that the window area represents not less than 5% to 10% of the floor area. Emergency lighting is provided.
(b) For cold weather months, accommodation must be such that the temperature is kept at a level of around 20 degrees Celsius notwithstanding the need for adequate ventilation.
(c) In warmer months, adequate ventilation (either cross-ventilation and/or fans) is provided.

Materials

(a) Roofing materials must be such that the structure can withstand high winds without risk of collapse and be leak-free during rainy season.
(b) Flooring material should be easily cleanable and free of bare nails or other sharp objects.

Provisions/furnishing

(a) Each worker is provided with a comfortable mattress, pillow, cover and clean bedding.
(b) Double or triple-deck bunk beds are prohibited. Double deck bunks may be used in special circumstances but must be approved by the Engineer.
(c) Each resident is provided facilities for the storage of personal belongings, such as a locker or shelving unit.
(d) Every resident is provided with adequate furniture such as a table, a chair, a mirror and a bedside light (small solar lights may be a good option). These may be shared among several workers.
(e) Separate storage provided for work boots and PPE. Drying/airing areas may need to be provided for PPE depending on conditions.
(f) Mosquito nets are provided in areas where mosquitos are present and/or at the request of workers.
(g) Rubbish bin with cover provided in each room and emptied regularly.
(h) Electrical outlets provided for charging mobile phones, radio, etc. Ensure that electrical wiring is done properly and presents no risk of electrical fire.
(i) All doors and windows should be lockable and be provided with mosquito screens.

(iv) The workers kitchen area should comply with the following requirements:

(a) The minimum area of kitchen should be not less than 4.5 m^2 and the minimum width should be more than 1.5 meters.

(b) Adequate height of kitchen should be not less than 2.25 meters.
(c) Provide where clean drinking water is always available – ensure that any open water tanks are covered.
(d) Kitchens are provided with facilities to maintain adequate personal hygiene including a sufficient number of washbasins designated for cleaning hands with clean water and materials for hygienic hand-drying.
(e) In order to enable easy cleaning, it is good practice that cooking stoves are not sealed against a wall, and benches and fixtures are not built into the floor.
(f) Design should consider if the kitchen within the camp will be used to service all workers for all meals (e.g. meals prepared for day laborers as well as residents) or will be limited to self-preparation of meals by residents.
(g) Wall surfaces adjacent to cooking areas are made of fire-resistant materials.
(h) Food preparation tables are equipped with a smooth, durable, easily cleanable, non-corrosive surface made of non-toxic materials.
(i) All cupboards and other fixtures have a smooth, durable and washable surface.
(j) All kitchen floors, ceiling and wall surfaces adjacent to or above food preparation and cooking areas are built using durable, non-absorbent, easily cleanable, non-toxic materials.
(k) Cooking gas canisters provided
(l) Fire extinguisher provided outside of cooking area.
(m) Rubbish bin(s) provided with cover
(n) Adequate facilities for cleaning, disinfecting and storage of cooking utensils and equipment are provided.

(v) The workers toilets should comply with the following requirements:

(a) Toilets should be located within same general area as accommodation, but at least 30 meters away from sleeping area/kitchen. Should not be more than 60m away.
(b) Toilets should be located at least 30 meters away from any water wells.
(c) An adequate number of toilets should be provided to workers. Standards range from 1 unit per 15 persons to 1 unit per 6 persons.
(d) Toilet rooms shall be located so as to be accessible without any individual having to pass through any sleeping room
(e) Toilet dimensions should be at least 1.5 m × 0.75 m (minimum width)
(f) Toilet facilities should be installed so as to prevent any odors reaching dining facilities or sleeping areas.
(g) Separate facilities provided for men and women.
(h) An adequate number of handwash facilities is provided to workers. Standards range from 1 unit per 15 persons to 1 unit per 6 workers. Handwash facilities should consist of a tap and a basin, soap and hygienic means of drying hands.
(i) Toilets should be constructed such that they are structurally sound during high winds and free from leaks during rains.
(j) Every toilet should be provided with natural lighting and natural ventilation by means of ≥ 1 openings, providing a total area of >0.2 m^2 per toilet. Such openings shall be capable of allowing a free, uninterrupted passage of air.

(k) In addition, all toilet rooms should be well-lit, with natural lighting and artificial lights at night.
(l) Ensure no discharge of toilets and showers that will contaminate water sources or common areas
(m) Sanitary and toilet facilities are designed to provide workers with adequate privacy, including ceiling to floor partitions and lockable doors
(n) Ensure toilets have rubbish bin in each cubicle

(vi) The shower and washing facilities should comply with the following requirements:

(a) An adequate number of shower facilities is provided to workers. Standards range from 1 unit per 15 persons to 1 unit per 6 persons.
(b) Shower/bathing facilities are provided with an adequate supply of clean water.
(c) Separate facilities for men and women.
(d) The flooring for shower facilities should be of hard washable materials, damp-proof and properly drained.
(e) Suitable light, ventilation and soap should be provided.
(f) Adequate space and hooks must be provided for hanging clothes/towels while bathing.
(g) Area for washing/drying clothes provided, including washbasin, soap and drying lines. Either piped water to the basin or standpipe for filling basins should be within close distance.
(h) Ensure area drains well and doesn't create a muddy environment.

(vii) Optional Amenities and Other Good Practices that should be followed as applicable:
(a) Paint the camp buildings to present a tidy and satisfactory appearance – this will help encourage workers to keep their camp in good condition.
(b) Provide signage in kitchen area, canteen, toilets, and other common areas to encourage good hygiene practices, cleanliness of kitchen and personal spaces, worker conduct, worker responsibilities, safety evacuation plan, etc.
(c) Involve laborers in design of the camp, e.g. to get their inputs on siting of buildings, and any specific needs of women.

9. Residual Impacts

500. The residual wastes from the waste incineration are bottom ash, slag and the residues from flue ash. Bottom ash and slag is a valuable fraction which may potentially be used for many purposes such as covering material for landfill, ballast layer or reinforcement layer in road construction or filler/aggregate for construction blocks. A study was commissioned under the project on the potential use of incinerator bottom ash for commercial purposes. Conclusion on the study says that the incinerator bottom ash has the potential for use in the construction industry. A copy of the complete report is in Appendix 6.

501. Under any circumstances that these options are not feasible, the sanitary landfill will be able to accommodate the residual wastes. The hazardous residues from the flue gas cleaning (fly ash) will be conditioned safely in sealed bags and disposed in a controlled way at the sanitary landfill. Similarly, the fly ash collected from flue gas cleaning is cooled down, stored in big bags and disposed in the same sanitary landfill.

10. Cumulative Impacts

502. As of the assessment, there are no other similar planned projects that will be established or put up in Thilafushi or adjacent islands. Therefore, the WTE plant will not contribute to any cumulative negative impact with other sources of similar impacts in Thilafushi, and/or any existing project or condition, and/or other project-related developments that are realistically defined at the time the assessment. The future plan of the project to expand by 50% will not have any cumulative negative effects because it will instead address the potential environmental impact of increased solid waste generation in the future. Nevertheless, a strategic environmental assessment will be undertaken in the future to evaluate the cumulative and other potential environmental impacts of future SWM projects in Thilafushi, and Maldives in general, including the planned expansion of the WTE plant by 50%.

11. Greenhouse Gas Emissions

503. The operation of the WTE Plant will be a potential source of greenhouse gas emissions due to the inherent combustion processes involved in plant operations. This GHG emission poses a potential transboundary impact on endangered species and habitats. However, comparing with the current practice of landfilling solid wastes in Maldives, the incineration process will greatly reduce the volume of the waste (in the form of residual ash) that need to be disposed in sanitary landfills. Therefore, the production of greenhouse gases due to landfilling will be reduced. The WTE plant will generate electricity for the industries on Thilafushi, replacing their dependence on fossil fuel use for power generation. Summing these all leads to an overall reduction of greenhouse gas emission by the Maldives. A complete accounting and analysis of GHG emission by the WTE Project resulted to GHG emission reduction of approximately 40,000 tCO2e/year, which is the average annual reduction across the project life cycle. Table 53 shows the summary of estimated GHG emission reduction from the WTE Plant. The complete report on the GHG emission inventory and analysis is in Appendix 8.

Table 47: Estimated GHG Emission Reduction from the WTE Plant

Year	Reference emissions		Project emissions		Emission reductions		Accumulated GHG ERs	
	GHG total	CO2 only	GHG total	CO2 only	GHG total	CO2 only	GHG total	CO2 only
Unit	tCO2e	tCO2	tCO2e	tCO2	tCO2e	tCO2	tCO2e	tCO2
2025	36,380.2	36,380.2	38,941.4	36,428.2	-2,561.2	-48.0	-2,561.2	-48.0
2026	61,931.4	54,930.2	43,075.9	40,276.0	18,855.5	14,654.2	16,294.3	14,606.2
2027	69,230.3	56,260.8	43,959.7	41,098.5	25,270.6	15,162.3	41,564.9	29,768.5
2028	75,150.0	57,518.6	44,799.4	41,880.0	30,350.6	15,638.6	71,915.5	45,407.1
2029	78,794.1	57,414.2	44,742.2	41,826.8	34,051.9	15,587.4	105,967.4	60,994.5
2030	81,741.5	57,425.0	44,757.8	41,841.3	36,983.7	15,583.7	142,951.1	76,578.2
2031	84,114.3	57,426.5	44,764.5	41,847.5	39,349.8	15,579.0	182,300.9	92,157.2
2032	86,078.3	57,430.1	44,768.9	41,851.6	41,309.4	15,578.5	223,610.3	107,735.7
2033	87,740.1	57,435.1	44,770.5	41,853.1	42,969.6	15,582.0	266,579.9	123,317.7
2034	89,173.8	57,440.9	44,769.2	41,851.9	44,404.6	15,589.0	310,984.5	138,906.7
2035	90,432.4	57,448.1	44,764.3	41,847.3	45,668.1	15,600.8	356,652.6	154,507.5
2036	91,552.3	57,456.0	44,755.9	41,839.5	46,796.4	15,616.5	403,449.0	170,124.0
2037	92,560.9	57,465.4	44,743.7	41,828.2	47,817.2	15,637.2	451,266.2	185,761.2
2038	93,477.5	57,476.2	44,727.6	41,813.2	48,749.9	15,663.0	500,016.1	201,424.2
2039	94,306.5	57,478.3	44,581.7	41,677.4	49,724.8	15,800.9	549,740.9	217,225.1
2040	95,071.9	57,509.3	44,456.4	41,560.8	50,615.5	15,948.5	600,356.4	233,173.6
2041	95,763.1	57,538.8	44,331.6	41,444.6	51,431.5	16,094.2	651,787.9	249,267.8
2042	96,392.8	57,569.0	44,207.0	41,328.7	52,185.8	16,240.3	703,973.7	265,508.1
**2043	96,392.8	57,569.0	44,207.0	41,328.7	52,185.8	16,240.3	756,159.5	281,748.4
**2044	96,392.8	57,569.0	44,207.0	41,328.7	52,185.8	16,240.3	808,345.3	297,988.7
Total	1,692,677.0	1,124,740.7	884,331.7	826,752.0	808,345	297,989		

Table 48: Summary of Impacts Due to Operation of the Project.

Potential Impact	Assessment
Water pollution and impacts on marine environment	Long-term, Negative, Significant
Air pollution and noise	Long-term, Negative, Significant
Impacts on biodiversity	Long-term, Negative, Significant
Socio-economic impacts	Long-term, Positive, Significant
Occupational health and safety	Long-term, Negative, Significant
Residual wastes	Long-term, Negative, Significant
Greenhouse gas emission	Long-term, Positive, Significant

VII. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

504. This section provides the outcomes of the stakeholder consultations undertaken during the project preparatory stage. The objectives of the consultations are to ensure that project information is accurately and properly disseminated to all stakeholders, and to engage these stakeholders to participate in the environmental assessment process. The consultation process is also a way to ensure that all issues from the stakeholders about the project are considered in the environmental management planning and ultimately addressed in the environmental management plan. Stakeholder consultations also provide valuable guidance and direction to safeguard the interests of the stakeholders, developers and the environment. This section outlines the consultations that were carried out with stakeholders and the community.

505. The approach for stakeholder consultations was to have an interaction with key stakeholders on issues that matter to them and those that are of material value for the project.

The stakeholders were grouped into internal, external and others including private and civil society.

506. The internal stakeholders comprise the project proponent, Ministry of Environment, project management unit (PMU) and the Maldives EPA. The external stakeholders include other government regulators and service providers. Other stakeholders include NGOs and the civil society. Interviews with relevant persons from these groups were undertaken. During interviews, discussions focused on the perceptions on the project, the selected locations, environmental or social impacts when implementing the project, energy use and efficiency, harbor and road use, and other aspects. The consultations explored on issues with locations, concerns and suggestions for improving project implementation.

507. In 2017, the first round of stakeholder consultations commenced and undertaken by PMU. The initial stakeholders consulted were the community people at Thilafushi, the diving community in Maldives, and Bluepeace Maldives, which is an NGO active in the environment sector. Table 55 below summarizes the issues and views gathered during these consultation activities.

Table 49: Summary of Consultations in 2017

Date of Consultation	Organization / Group Consulted	Issues / Views on the Project
July 2017	Community Living in Thilafushi The people living on Thilafushi were consulted during July 2017 as part of the EIA work. The method included selecting people randomly who live on the island and asking them a set of questions regarding the project and their experience on the island and	• Everyone surveyed in the island noted, that waste management is a big issue at the island. They do not think that waste management, treatment and disposal is being properly carried out by the authority. • Major issues the people noted were the smoke and the mosquitos. Some days, the smoke becomes so thick it becomes difficult for them to live. Similarly, mosquitos become a big issue during the rainy season. • Most of the people surveyed noted that the Thilafushi is seen as a dump site. Hence the overall hygienic condition of the island is low. • Some of residents noted that the area allocated for the waste management is small and the waste has become piled into mountains on the islands. Some noted that the waste mountains are growing rapidly, and they are do not know what will happen in the future • The island has a water supply network and desalinated freshwater is available on the island. However, the island does not have a proper sewerage network.

Date of Consultation	Organization / Group Consulted	Issues / Views on the Project
	how they expect the project would affect them. The following are the major outcomes of the interviews with the residents of the island.	• The roads on the islands are poorly maintained and the condition gets worse after each rainy season. Hence the transportation within in the islands is difficult. • Everyone noted that Thilafushi is connected to Malé via a regular ferry which starts early morning but stops early evening. However, the island is an isolated and not much recreation activity is available on the island.
24 October 2017	Bluepeace Maldives Bluepeace Maldives is an NGO active in the area of environment and development. Bluepeace was consulted on 24th October 2017 at Water Solutions. Following are the main outcomes and summary of the discussion of the stakeholder meeting.	• Bluepeace has been advocating to improve conditions on Thilafushi for a long time. Bluepeace has been voicing the view that Thilafushi is fast becoming a serious ecological and health problem in the Maldives and something drastic needs to be done to improve the waste management practices at Thilafushi. • People could find garbage floating inside and outside of the lagoon during high tides on a daily basis. The floating waste becomes a navigation hazard. • Bluepeace strongly feels the solution to the issue of Waste can only be addressed within a National Framework for Solid Waste Management in the Maldives. There are a number of studies by different organizations on Solid Waste Disposal for the Maldives, including hazardous waste. Most of the studies have gathered dust on bookshelves. • The proposed project is important to develop the regional waste management facility at Thilafushi and in addition is needed to treat the existing waste mountain at the island. • Bluepeace strongly feels there is a need to undertake a detailed study on the environmental impact of landfilling which had been carried out at Thilafushi using waste collected.

Date of Consultation	Organization / Group Consulted	Issues / Views on the Project
	Diving Community of Maldives The diving community is one group of groups who have raised various concerns about waste management issues from Thilafushi for many years but have not been able to achieve any meaningful outcome due to the nature of the issue. Divers have always been exploring the reef around Thilafushi and other reefs in the nearby regions and considers that Thilafushi reef is also among the good diving sites in the	• According to Raazee, who is the Operations Manager of Best Dives managing many dive centers including the dive center in Centra Rasfushi located in the island of Giraavaru and Jumeriah Vittaveli, a lot of change that has been taking place at Lions Head over the years. This change is considered to be partly attributed to the waste management that began in Thilafushi. A reduced number of fishes has been observed, most importantly sharks. However, the shark population according to Raazee declined because of uncontrolled shark fishing throughout the Maldives and not necessarily because of Thilafushi. This site is now no longer considered as a protected site by many divers and most resorts avoid this site due to the thick smoke from Thilafushi and also due to the fact that most visitors are also aware of the famous garbage island. • The name, Lions Head was given to the dive site due to the presence of a large rock outcrop from the reef which resembles the head of a lion. The protected dive site popularly known as “Lions Head” was one of the most dived sites in the region and famous for shark watching. In the early 1980’s this was one of the top shark points in North Malé region. Dive schools from around the nearby resorts use this dive site on their daily dive roster. • Another industry expert, Hussain Rifau who has more than 20 years of diving in liveaboards, indicated that the decline in fish population cannot be attributed to Thilafushi alone as no proper studies have been done to verify this. It is not proven but may likely be a cause. Nevertheless, liveaboards do not dive here and one reason is that they do not want to give the impression to high paying divers that their dive site is contaminated with garbage. • The creation of Thilafushi has not necessarily increased garbage in the house reef. As it happens that the Thilafushi reef is open to a channel, currents are very high and any floating solid waste material is quickly taken away from the house reef and this is

Date of Consultation	Organization / Group Consulted	Issues / Views on the Project
	region. Various experienced divers representing dive schools, veterans of diving and people who have vast knowledge of the changes that took place in the nature of diving in the region were consulted and the following are some of the outcomes of the discussions and general comments made by these stakeholders.	why considering the condition of Thilafushi, the house reef is still quite appealing and does not contain a lot of garbage as one would expect. The focus is the southern side of the house reef which is exposed to the channel. • According to Adam Shareef who managed Ocean Dive Desk until 2012, Lions Head or a part of Thilafushi house reef was included in the list of dive sites during their operational period. However, with the worsening of Thilafushi island and as its waste management issues grew bigger, dives to this site were discontinued not because the dive site is not appealing, but due to the poor visible nature of Thilafushi. It became an unpractical routine to take divers who pay US $ 45 to 60 per boat dive to be taken close to an island where large chunks of garage are visible in the island; open burning is done with smoke plumes and frequent garbage dhoonis and boats bring garbage to the island. All these visible features were negative factors for divers and regardless of the contamination status of the reef, divers would not be comfortable to dive in such a place. This is the main reason why no resorts nor any dive centers operating in Malé region do not take divers to this site. • Despite the poor state of Thilafushi, the south-east corner of Thilafushi has a very interesting geographical formation with caves, overhangs and large gorgonians and similarly the south-west also has interesting caves and reef formation. These are features that many divers look for in a dive site.

508. In 2018, a second round of consultation activities took off targeting various institutional and organizational stakeholders under the project. Table 56 below summarizes the issues and views gathered during these consultation activities.

Table 50: Summary of Consultations in 2018

Date of Consultation	Organization / Group Consulted	Issues / Views on the Project
20 September 2018	Ministry of Environment (MOE)	• The project is one of the most significant projects for the Maldives as the outcome of this project would pave way for the government to address the biggest environmental issue currently faced. The success of this project is therefore essential for sustainable environmental management in the Maldives.
20 September 2018	Waste Management Corporation (WAMCO)	• As WAMCO is the operator of the waste management facilities, they are not involved in designing of any waste management project during the design stage and most of it would be undertaken by Ministry of Environment. As such, they have not been part of the decision-making process that decided the technology for the management and disposal of waste at Thilafushi.
20 September 2018	Greater Malé Industrial Zone Limited (GMIZ)	• GMIZ indicated that they are working on a new master plan for Thilafushi and a ring road is planned south of the proposed landfill site. • GMIZ indicated that they are considering making a channel on the southern side of the island to allow flushing in the bay area of Thilafushi. No detail of the concept for this development has been prepared regarding this project. • GMIZ enquired whether the traffic of landing crafts would increase in the future for the transportation of waste from project area. It was explained that the landing craft movement would reduce as the collection of waste and transportation would be carried out in an organized schedule. Hence the operationalization of the Regional Waste Management Facility at Thilafushi for Project area at Thilafushi would not create additional vessel movements inside the Thilafushi lagoon.
20 September 2018	Ministry of National Planning and Infrastructure (MPNI)	• MPNI indicated that the most important aspect of this project is to ensure that the Regional Waste Management Facility does not interfere with the Greater Malé Connectivity Project (GMCP). GCMP is a vision by the government to connect Thilafushi to Malé via Gulhifalhu and Villingili. This project thus aims to connect the greater Malé region through a bridge connection that

Date of Consultation	Organization / Group Consulted	Issues / Views on the Project
		would eventually be connected to a ring road on south of Thilafushi that is been planned by GMCP. There is a plan to develop a regional port on the western side of Thilafushi and the road connections would allow connectivity to the entire greater Malé islands. This project will not interfere with the road nor its width as the road is already designed and under construction. • Thus, MPNI does not foresee any issues this project will have on any of their projects currently implemented as well as GMPC.
20 September 2018	Parley Maldives	• Certainly, the existing landfill at Thilafushi is the most significant source of pollution in the entire region around the central Maldives. The garbage collected on the island is washed away during high tides and during other abnormal tidal surges as Thilafushi was reclaimed to a very low level. • Parley has been actively involved in reducing and recycling the plastic bottles in Thilafushi. Over 36 months, they have exported 504 containers, 40 feet each. • Each container costs US$ 5000 for logistics and export charges. • They are working with many local logistic companies in trying to reduce the plastic waste. As such, a few companies have been and are giving support to transport plastic bottles from islands to Thilafushi collection center. • According to Parley, their work of recycling plastics has some conflicting issues with WAMCO as they do not want third parties to get involved in waste management. WAMCO's business model was developed based on waste quantity and any reduction in waste quantity is bad for their business. • When parley got engaged in collecting plastics from Malé, it reduced the overall burden on WAMCO by reducing by two the daily trips to Thilafushi. • Parley raised the concern that the proposed Regional Waste Management Facility at Thilafushi for Project area has been designed based on incineration of waste. They expressed strong views regarding the importance of source segregation and establishment of a sorting facility at Thilafushi to sort the waste.

Date of Consultation	Organization / Group Consulted	Issues / Views on the Project
		It was explained that the incineration, or WTE process ensures breakdown of any plastics introduced to the plant through high temperatures and residence time in the furnace, although it was agreed that source separation both decreases the burden on waste transfer and incineration and increases scope for re-use and re-cycling.

509. Following are the list of people who had been consulted as part of this EIA.

Table 51: List of Institutions / Groups Consulted

Person Consulted	Institution
Director General	Ministry of Environment
Environmental Analyst	Ministry of National Planning and Infrastructure
Assistant Project Officer	Ministry of National Planning and Infrastructure
Director General	Environmental Protection Agency
Assistant Director	Environmental Protection Agency
Assistant Project Officer	Environmental Protection Agency
Assistant Oceanographic Observer	Environmental Protection Agency
Manager of Projects Implementation	GMIZ
Deputy Manager of Operations	GMIZ
Operations Officer	WAMCO
Facilities Manager	WAMCO
Executive Director	Bluepeace
Executive Director	Parley
Environment Consultant	Water Solutions
Environment Consultant	Water Solutions
Waste Management Specialist	Kocks Consult GmbH
Dive master	Freelance dive guide
Operations Manager	Best Dives Maldives
Former shareholder	Ocean Dive Desk of Maldives

A. Follow-On Consultation Activities and Focus Group Discussions

510. After undertaking the targeted consultation activities in 2017–2018, several follow-on consultation activities and focus group discussions (FGDs) were held and spearheaded by PMU in 2019, with two consultation activities observed by ADB representatives. Summary of these consultation activities and FGDs is presented in Table 58 below. Compilation of all minutes of consultation activities is attached as Appendix 9.

Table 52: Summary of Follow-on Consultations and Focus Group Discussions

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
5 August 2019	Ministry of Environment	10	Representatives of various	• General dislike of the existing dumpsite.

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
			national and local government offices Representatives of various tourist resorts around Thilafushi	• Concern on the methane that would be formed in the capped waste and that it may explode. • Clamor to close the existing dumpsite and undertake sampling to determine the impact of leachate. • Concern on impact to the food chain due to heavy metals potentially assimilated in fishes found in Thilafushi. • Inquiry on the basis of design of the WTE, including the life or length of operation, measures to minimize disposal of bottom ash in landfill, impact of population and economic growth, etc. • Clarifications on the German model used in air dispersion modeling. • Operations of many resorts are getting affected due to proliferation of flies and smokes from the existing dumpsite. • Concerns on the floating wastes found around Thilafushi that float to the seas. • Concerns that some resorts and individuals would still continue dump in the sea if they did not want to pay for the services of WAMCO. • Monitoring on the health of the people to ensure they are not impacted by the project. • Concern on potential impact of the project to traffic situation in Thilafushi.
6 August 2019	Ministry of Environment	8	Workers/ employees in Thilafushi Representatives of NGOs	• raised concern wastes dumped at the port at Thilafushi and inquired if there was any mechanism to monitor the waste being dumped to the port. • Raised the issue of recycling of plastic wastes instead of incinerating them. • Concerns on unutilized lots/sites in Thilafushi that become a hub for many migrant workers. It was also noted that these placed had very poor living standards and that it needed to be looked into.

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				• Concern on the destruction of the coral reefs because of discharge of cooling water. • Suggestion to segregate wastes to minimize hazardous residuals. • Concern on health risks and status in Thilafushi (irritation of eyes, ears and skin, and also difficulty in breathing and an overall decline in health) which is the reason of increased absenteeism, affecting the productivity.
30 August 2019	Jumhoori Park, Male', Maldives	12	Female Expatriates / Domestic Workers from India	• All the participants have not been to Thilafushi yet. However, they understand that the island is where wastes are disposed. • The group felt that improving the waste management at Thilafushi will improve the condition of people working at the island.
30 August 2019	Jumhoori Park, Male', Maldives	12	Male foreign workers from Bangladesh	• Some of the participants has been to Thilafushi and understand the current situation at the island. All aware that the island is where wastes are disposed. • The group felt that improving the waste management at Thilafushi will improve the condition of people working at the island.
30 August 2019	Jumhoori Park, Male', Maldives	6	Local residents of Male	• The group is supportive of the project and felt that improving the waste management at Thilafushi will improve the condition of people working at the island.
1 September 2019	Thilafushi	9	Male local and foreign workers at Thilafushi	• All workers understand the situation and aware of the current impact (e.g. smoke) of the existing dumpsite to the local people of Thilafushi.
1 September 2019	Thilafushi	8	Male local and foreign workers at Thilafushi	• Concern on hearing some explosions due to burning of bottles of canisters from the dump site at night time • Inquiry on when the smoke from the existing dumpsite will be stopped. They view the need to stop this as it endangers the health of the local people. • They are optimistic about the project and hope that the smokestack for the WTE plant will

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				not emit black smoke as what they see now from the existing dump site. • The groups are supportive of the project and felt that improving the waste management at Thilafushi will improve the condition of people working at the island.
1 September 2019	Thilafushi	13	Male local and foreign workers at WAMCO	• Bad experiences working at the existing dumpsite and its surroundings, including the irritation of eyes and catching throat infection due to the smoke from the dumpsite. Taking sick leave becomes a normal case. • Views that the smoke from the dump site can be reduced if more equipment are provided to manage the dumped wastes. • Happy to continue work at Thilafushi if the waste management is improved. • No worries on losing their jobs when the project is completed. • The groups are supportive of the project and felt that improving the waste management at Thilhafushi will improve the condition of people working at the island.
2 September 2019	Thilafushi	10	Male local and foreign workers at MTCC	• Concern on the need to stop work because the smoke from the dumpsite. • Smoke entering indoors. • Urgent need to address the smoke emission from the dumpsite and better waste management at the island. • Issue on workers getting sick which they believe it is due to the smoke. • Need to improve the situation at Thilafushi dump site. • The WTE project will improve situation at Thilafushi. This will eventually help improve their services by attracting good and experience professional to work at their site. • The group felt that improving the waste management at Thilhafushi will improve the condition of people working and living at the

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				island. Everyone welcomes the project said they are hoping the implementation of the project would commence soon. They said they hope that the big stack at the new waste to energy plant will not have any visible smoke when it becomes operational.
2 September 2019	Thilafushi	7	Male local workers at GMIZ	• The group felt that improving the waste management at Thilhafushi will improve the condition of people working and living at the island. Everyone welcomes the project said they are hoping the implementation of the project would commence soon. They said they hope that the big stack at the new waste to energy plant will not have any visible smoke when it becomes operational.
4 September 2019	Ministry of Environment	13	Residents of Malé and Hulhumale	• Inquiry on the rationale of using incineration instead of implementing 3Rs. • Incinerating high calorific materials such as plastics will discourage/disincentivize the use of single plastic. • Incineration does not encourage sorting or segregation of wastes. • Treatment of hazardous and medical wastes. • Ownership of the energy that will be generated by the WTE plant. • Clarification on the capacity of the WTE plant and if it foresees decline in the waste generation in the future. • Inquiry on the publication of the EIA report and whether or not the people can submit comments.
28 October 2019	MNU Auditorium, Male	12	Residents of Male, Representatives of civic groups/NGOs	**Timing and venue of the public consultation** • Some of the participants raised concern that the timing of the public consultation was not ideal as it falls within the official working hours. A participant also suggested that the University Auditorium was not ideal and that the closed space would discourage people from attending the public consultation. It was suggested that future public

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				consultations should be held after the official working hours in the evening and at a public space such as the “Jumhooree park” to encourage more people to attend. ○ *ME informed that the points mentioned would be taken into consideration for future public consultations* **High-level Technology fund** • A participant inquired what was meant by the high-level technology fund ○ *ME informed they would clarify and inform later. Towards the end of the discussion it was informed that a High-Level Technology Fund is a multi-donor trust fund that provides grant financing to encourage more widespread adoption of high-level technology (HLT) to address development challenges in ADB's developing member countries* **Capacity building** • A participant inquired since there is capacity building in GMEIWMP, what was already being done to acquire information ○ *ME informed that a firm would be hired for capacity building activity and that that the firm would be working throughout the project to build the capacity of the stakeholders, including island communities.* **Involvement of Women**. • A participant inquired why involvement of women was specified in awareness raising. ○ *ME noted that the project aims to increase the involvement of women throughout the different activities planned in the project and as such even the committee under the Grievance Redress Mechanism also specifies that the president of the island’s*

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				women's committee be included. Women had been involved in all stages of the project development. **Reduction of Waste** • A participant inquired the plans to reduce waste. Another participant added that instead of incinerating, the solution would be to reduce wast, and decrease the import of items that would create waste. ○ *ME informed that under the project there were plans to increase community awareness with regard to waste reduction. The EIA consultant added that there would be a focus on 3R under the community awareness and behaviour change strategies.* • A participant raised concern that incineration was being used as the solution to reduce waste and stressed that incineration and re-using the 'gunk' from the incineration plant was not the solution. ○ *In the management of waste, even after carrying out successful waste reduction strategies, there will be residual waste that need to be treated and disposed. Incineration has been recommended as an optimum technology for the Maldives. ME informed that the bottom ash could be utilised for road development and that currently a feasibility study was being undertaken.* • A participant inquired if the government's pledge to reduce waste to 3 percent would have an impact on the operation of the plant. ○ *The proposed waste management strategy had taken account to waste reduction strategies. The proposed system would have no impact with*

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				current change of policy to ban the use of single use plastic by 2024. **Public involvement for the whole project** • A participant raised concern that the public consultation was only for the regional waste management facility and not for the whole project. • Moreover, it was added that public involvement should have been at an earlier stage, before incineration was chosen as the way forward to manage waste, as it is similar to the World Bank waste management project in Vandhoo which had failed. ○ *ME noted that the waste management project for Zone III has been formulated based on the lesson learnt from the Vandhoo Project. Vandhoo project was s a Design and Build project, and the project had failed because the operator of the facility was different and the Government took a while to handover the facility to WAMCO to run the facility. The current project for the Zone III is a DBO, Design, Built and Operate, building on the lessons from Vandhoo case.* • A participant added that they were not aware of the level of consultations which had taken place with regard to the project. And that since all government infrastructure development projects (such as the Gulhifalhu Reclamation, development of resorts on shallow, development of harbours in the islands) are related, it needs to be considered, and Mministries and other big companies needs to be consulted before undertaking such a project. ○ *ME informed that stakeholder consultations had taken place at all the stages of project*

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				formulation from feasibility to EIA. During the feasibility stage, stakeholders were consulted and stakeholder meetings were held. During the designing stage of the project, stakeholders were consulted. Various stakeholders and communities meeting were held for the EIA for this project in the past 24 months. During these meetings, relevant ministries, resorts and companies had also been invited to participate in the stakeholder meetings and workshops. • Many participants suggested that a multi sectoral discussion should be held for the consultation to be more meaningful. It was also noted that the outcome of the stakeholder meetings was not known to the public. • A participant inquired how much the comments received from the public would be incorporated. Another participant also inquired if the minutes of the meeting would be available. o *ME informed that the project formulation has been guided by the inputs from stakeholders in different stages of the project. The minutes of the consultations will be included in the EIA* **Sustainability of the project** • A participant inquired how the project aligns to the SDG goals 1,2,3. He also added that the project had no engagement of the community. He also stressed that civil society should be part of the project instead of creating mega-companies. He also questioned if such a project would be financially sustainable and the dollar value of the cost to the community. He also inquired how the project would affect the human capital and enhance human development. He also drew examples of the Male' Sewerage Project which in his

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				opinion had failed and did not work as designed, because there was no proper oversight from the regulator of the company. He also highlighted that a gap between the design, installation and operation of a project could affect the sustainability of the project, thus a systematic approach would be needed. Another participant also questioned if the approach was sustainable. ○ *ME noted that the various stakeholders including NGOs and Civil Society groups has been engaged in the project development. The project aims to build the overall institutional capacity in the country. And as such, improving the institutional capacity of EPA is a priority. Moreover, since it's a DBO (Design Build Operate) project, the operational issues would be minimized, and local capacity would be developed before the operation is handed over to the Ministry/WAMCO at the end of the DBO period.* • A participant inquired if ME could assure that project would be sustainable and the sustainability plans of the project. Similarly, another participant also questioned the sustainability of the project and inquired if all these aspects had been considered. ○ *ME informed that lessons from similar projects were being considered, and feasibility studies were undertaken to ensure the project was viable.* **No solution for bottom ash** • A participant raised concern that there was no solution for the bottom ash produced from the WTE facility. And stressed that before the project starts there should a proper way for it to be utilised as currently it's only a study which is being undertaken.

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				○ *EIA consultant briefed that currently there is work going to study the alternative uses for the bottom ash. Presently the study is being focused to use the bottom ask on the production of paving blocks and other similar kind of use in the construction industry. It was also noted that a key objective of the project is to address the waste issue in Thilafushi.* **Producer responsibility and consideration of other government projects** • A participant inquired about the details of the grant and loans and suggested that producers should take responsibility of the waste they generate, and if not, it would be a misusing state funds. As such, she highlighted that resorts are one of the biggest generators of waste and that currently waste from all resorts are being taken to Thilafushi. Thus, the participant questioned how thoroughly the project had considered all these issues and stated that the project seems like a reactionary project and a band-aid solution. She also inquired if the increasing number of resorts and other infrastructure projects had been considered. Another participant also inquired if the population growth in the Greater Male' region had been considered. ○ *EIA consultant briefed the waste to energy facility for the zone III is being financed by ADB through a grant/concessional loan. Resorts bring the waste to Thilafushi because current regulations require the waste from the resorts to be brought to Thilafushi for disposal. The feasibility considered that waste generated from the resorts in the zone III would be brought to Thilafuishi for treatment and disposal. WAMCO will be*

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				collecting the waste from the resort and the resorts will pay collection fee to WAMCO which includes the cost of treatment/disposal. The feasibility study considered the populations in the zone III, including the planned increase of resort beds in the region. **EIA** • A participant also informed that they had been requesting for the EIA and was yet to receive it. Another participant also questioned the results of the EIA, as the participant stated that Thilafushi was dead in terms of biodiversity thus the results were questionable. ○ *ME informed that the EIA would be shared once the EIA is finalised. It was mentioned that the EIA and annexes including the studies that is part of the EIA would be made available at the ADB website soon for comments. It would be made available on the website for a period of 3 months. EPA would also publish it on their website, once the ME submits the final EIA to EPA.* **Inefficiency and ineffectiveness of ME and EPA** • Participants raised concern over the ineffectiveness of Ministry of Environment and the Environmental Protection Agency. It was noted that they do not hear back from the organisations in a timely manner for other matters that they have contacted to those institutions. It was also noted that EPA should have the capacity monitor air emission levels from the project. ○ *PM noted that the project would response on any queries regarding this waste project. ME noted that part of the project is to build the capacity of EPA and strengthen institutional capacity*

Date of Consultation	Location	No. of Participants	Description /Affiliation of Participants	Issues and Views Raised by Participants
				to monitor the air pollution emissions. Air pollution emission stations are recommended to be established at Thilafushi to monitor the impacts of stack emission on Thilhafushi. **Other waste** • A participant inquired how hazardous waste, medical waste, construction and demolition waste, and end of life vessels would be handled at Thilafushi when this project is completed. o *ME noted that all the hospitals and health care facilities are required to have autoclaves to treat the medical waste before it is sent to Thilhafushi for treatment and disposal. The proposed facility can manage the hazardous waste in the household. The facility would store any other hazardous waste received. The facility can receive end of life vehicles. ME noted that the facility at Thilhafushi is a municipal solid waste incinerator facility. Government is developing another facility to treat hazardous waste.*

511. In summary of the outcome of the consultations undertaken, the overall impression suggests support of all stakeholders on the project with the view that the solid waste management system in Thilafushi and project area is improved. Main concern of stakeholders is the request to stop the continuous emission of smoke from the existing dumpsite in Thilafushi as they perceive it to be the major cause of health problems in the island. All issues raised that are related to potential impacts of the project have been taken into consideration in this EIA, particularly in providing mitigation measures to avoid or minimize these impacts. As part of full disclosure policy in ADB projects, this EIA report shall be made available to the public and could provide comments on its contents, if any. These comments shall be reviewed and included in further enhancing the EIA report.

B. Future Consultation Activities

512. MOE, through the PMU, will continue to conduct meaningful consultations[46] with all stakeholders to ensure they are engaged throughout the design, construction, commissioning and

[46] Per ADB SPS, meaningful consultation is a process that (i) begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle;1 (ii) provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people; (iii) is undertaken in an atmosphere free

operational phases of the project. Meaningful consultation will be a continuing activity in order to establish a foundation of mutual trust and provide a forum for the exchange of information, through which any issues can be raised with the project team and addressed by agreed action where necessary. This will involve:

(i) Public meetings as the main forum through which the local community will be informed about the progress of the project and any elements that may affect them (such as temporary restrictions in access during the construction period, the timing of deliveries of large equipment items, etc.). These meetings could be held according to need, and the program will be agreed in advance and published on government gazette and in the local press.
(ii) Additional meetings will be held on an ad hoc basis with institutional stakeholders, including government officials where necessary. The aim will be to inform all relevant agencies of project progress and allow discussion and resolution of any specific issues as they may arise.
(iii) Focus group sessions could be again be held with the local community when needed, to discuss and organize specific activities and to deal with any issues that can be handled in this way.

513. The PMU will also be supported by a public awareness and community capacity building (PACCB) consultant, a consulting firm that will help generate awareness and strengthen skills in waste collection, segregation, compositing, recycling, and O&M targeting the poor and women, including community awareness campaign for strengthening disaster risk reduction and climate change readiness. PACCB is responsible for the IEC initiatives and public awareness on waste-to-energy as described in Appendix 3 of the Project Administration Manual.

C. Information Disclosure

514. The Ministry of Environment, through the PMU, will comply with the disclosure requirements of ADB SPS and national law, and will ensure that the final EIA report will be disclosed and made available for review by the local community and other stakeholders. PMU will submit a copy of the EIA report to ADB for final review and disclosure on ADB website. PMU will also disclose the ADB-approved version of the EIA report on the project website. For any updating of the EIA in the future, PMU will ensure that the updated or revised EIA report is submitted to ADB for another review and disclosure on ADB website. Similarly, all other reports such as quarterly environmental monitoring reports produced throughout the construction and operation stages of the project will also be reviewed and disclosed in the same way.

515. In compliance with the Maldives EIA Regulation, the EIA report will be submitted to the Maldives EPA for its consideration before such report is reviewed and approved. The Maldives EPA will make the report public on their website. The public can access the full EIA report from the Maldives EPA's website (www.epa.gov.mv). The project-affected groups and local nongovernment organizations can provide their comments/inputs to Maldives EPA in their deliberation, within 28 working days before the Maldives EPA makes a decision regarding acceptance of the Maldives EPA report for the project.

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of intimidation or coercion; (iv) is gender inclusive and responsive, and tailored to the needs of disadvantaged and vulnerable groups; and (v) enables the incorporation of all relevant views of affected people and other stakeholders into decision making, such as project design, mitigation measures, the sharing of development benefits and opportunities, and implementation issues.

VIII. GRIEVANCE REDRESS MECHANISM

516. The project will adopt the grievance redress mechanism (GRM) as outlined in the EIA report. This will ensure that consultation, disclosure and community engagement continue throughout project implementation. The grievance redress mechanism will allow for concerns and grievances about the project's social and environmental performance raised by individuals or groups from among project-affected communities to be received and to facilitate resolution of those concerns and grievances. The Grievance Redress Mechanism includes 3 tiers. Every effort shall be given to find an amicable solution before higher tiers could be engaged. The project GRM will not supersede any legal government grievance procedures. Affected people are to be informed about the mechanism through media and public outlets. This participatory process shall ensure that all views of the people are adequately reviewed and suitably incorporated in the design and implementation process. An information board providing the contact details will be made available at the project site at Thilafushi, and a register of grievances will be maintained at MOE.

A. First Tier (DBO Contractor)

517. An individual or an interest group can contact DBO Contractor for grievances.

(i) At the project location there will be an Information Board listing the names and contact telephones/emails.
(ii) If the complaint is resolved within 10 days, DBO Contractor must communicate the decision to the aggrieved party in writing.
(iii) If no satisfactory solution is reached through the Tier I process, the aggrieved party may notify the MOE, in writing of the intention to move to Tier II.

B. Second Tier (PMU/MOE)

518. An individual or an interest group can contact PMU/MOE for grievances.

(i) At the project location there will be an Information Board listing the names and contact telephones/emails.
(ii) If the grievance cannot be resolved informally by contacting DBO Contractor, an aggrieved party must submit a complaint on the Tier 2 by sending an email to secretariat@environment.gov.mv
(iii) If the complaint is resolved within 15 days MOE must communicate the decision to the aggrieved party in writing.
(iv) If a complaint requires more time to address, this requirement must be communicated to the aggrieved party in writing and the aggrieved party must consent and sign-off the request for the extension to take effect. An extension can be made to an additional 15 days.
(v) Complaint Form. A copy of the form should be provided to the aggrieved party as evidence of receipt. The complaint form should be available from the website of MOE.

C. Third Tier (Judiciary)

519. An individual or an interest group has the option of going to established judiciary system of the Maldives.

(i) The legal system is accessible to all aggrieved persons.
(ii) Assistance from the MOE would be available only for vulnerable person as per this grievance mechanism.
(iii) In cases where vulnerable person(s) are unable to access the legal system, the Attorney General´s office will provide legal support to the vulnerable person(s).
(iv) The verdict of the Courts will be final.
(v) A vulnerable person(s) for the purpose of this project is a person who is poor, physically or mentally disabled/handicapped, destitute, and disadvantaged for ethnic or social reasons, an orphan, a widow, a person above sixty-five years of age, or a woman heading a household.

520. The affected persons can also direct contact (in writing) the ADB Project Officer at ADB headquarters. The complaint can be submitted in any of the official languages of ADB's Developing Member Countries. This may be done at any time by sending the written complaint to the following address:

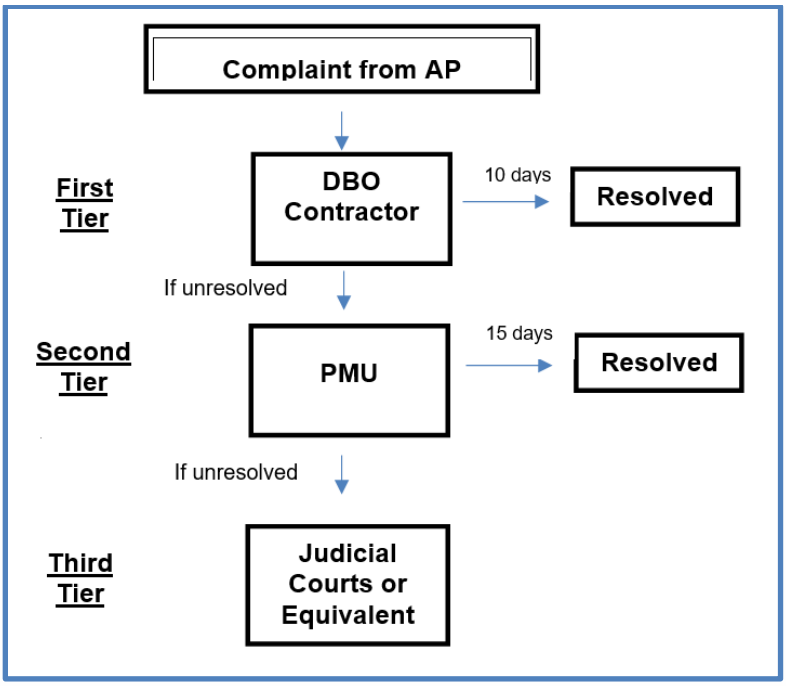
Project Officer – Greater Malé Environmental Improvement and Waste Management Project
South Asia Urban Development and Water Division
South Asia Regional Department
Asian Development Bank
6 ADB Avenue, Mandaluyong City 1550
Metro Manila, Philippines

521. The APs can also use the ADB Accountability Mechanism (AM) through directly contacting (in writing) the Complaint Receiving Officer (CRO) at ADB. The complaint can be submitted in any of the official languages of ADB's DMCs. The ADB Accountability Mechanism information will be included in the Project Information Document to be distributed to the affected communities, as part of the project GRM.

522. The GRM notwithstanding, an aggrieved person shall have access to the country's legal system at any stage through the Maldives judicial or appropriate administrative system. This can run parallel to accessing the GRM and is not dependent on the negative outcome of the GRM.

523. The flow diagram of resolving complaints under the GRC is shown in Figure 131 below.

Figure 130: Grievance Redress Mechanism Diagram



IX. ENVIRONMENTAL MANAGEMENT PLAN

A. Objectives

524. Environmental Management Plan (EMP) is the document through which mitigation measures are proposed following the assessment of the impacts of a project. The EMP sets out the mitigation measures to these impacts, monitoring plan and institutional arrangements that need to be observed during construction and operation of the WTE plant. The budgets to cover the cost of implementing the EMP, including costs associated with implementing the GRM, are also provided.

525. The purpose of the EMP is to ensure that the activities are undertaken in a responsible, non-detrimental manner with the objectives of: (i) providing a proactive, feasible, and practical working tool to enable the measurement and monitoring of environmental performance on-site; (ii) guiding and controlling the implementation of findings and recommendations of the environmental assessment conducted for the project; (iii) detailing specific actions deemed necessary to assist in mitigating the environmental impact of the project; and (iv) ensuring that safety recommendations are complied with.

526. The EMP also sets out the mitigation measures that the DBO Contractor is required to provide during project design, construction and operation, and the manner in which the PMU requires the mitigation to be provided. The EIA report will be included in the DBO bidding and contract documents, so by accepting the contract, the chosen DBO Contractor will be legally obliged to implement all specified mitigation measures; including the allocation of budget to implement all mitigation measures and monitoring activities required in the EMP, and provisional sum that will ensure funding for any budget shortfall or for addressing any unanticipated impacts during the construction and operation phases of the project. The methods to be used for site preparation, construction, operation, and commissioning, as well as associated arrangements to ensure sound environmental management and safety at all times, are already defined in the bid

documents. The DBO Contractor shall prepare a site-specific EMP (SEMP) based on the EMP presented in this EIA report in order to make it relevant to the construction and operation phases. The DBO Contractor shall prepare SEMP describing specific design features that will ensure environmental protection and setting out the working methods, management, and mitigation and monitoring measures that will be put in place, for each of the various construction activities, during the implementation of the project. The scope of the SEMP shall address all of the issues itemized in the EMP in this EIA report. The SEMP shall have the same level or stricter set of measures than those included in the EMP of this EIA report. The SEMP shall consider ISO 14001 when detailing the environmental management system in place. The DBO Contractor shall submit the updated EMP to PMU. PMU shall submit a copy of the updated EMP to ADB for review and disclosure.

527. However, if there will be significant changes in the final detailed design compared to the preliminary design used in the EIA, the DBO Contractor shall update the EIA report, including the EMP and EMOP, accordingly, including budget that will cover implementation of any added mitigation measures and monitoring activities. The DBO Contractor shall submit the updated EIA to PMU, and the PMU shall submit the updated EIA to ADB for final review and disclosure.

528. The DBO Contractor will be required to (i) establish an operational system for managing environmental impacts (ii) carry out all of the monitoring and mitigation measures set forth in the EMP and SEMP; (iii) implement any corrective or preventive actions set out in safeguards monitoring reports that PMU will prepare from time to time to monitor implementation of this EIA and EMP; and (iv) allocate a budget for compliance with these EMP measures, requirements, monitoring activities and actions, including provisional sum where to draw budget for any shortfall in the initial budget estimates and for addressing any unanticipated impacts during construction and operation phases of the project.

B. Institutional Arrangement

529. **Implementation Arrangements**. The executing agency is the Ministry of Finance (MOF). The implementing agency is the Ministry of Environment (MOE) which establish a project management unit (PMU) comprising officials and staff from MOE. The PMU will be continuously strengthened with external experts as may be needed through the project implementation. The project steering committee chaired by Minister, through the MOE, will provide overall guidance and strategic directions to the project. The PMU will be supported by a project management, design and supervision consultant (PMDSC), a professional engineering and management consulting firm. PMDSC will assist in the delivery of the different project components, which include the design, construction and initial operations (including capacity building of EPA, MOE and PMU in monitoring operations) of WTE facility and associated landfill of air pollution control residuals and non-marketable incineration bottom ash. PMDSC will act as MOE's representative during the design and build period and the first two years after the successful commissioning of the WTE plant (operation period). PMDSC will have a national and international environmental safeguards specialist consultant responsible for overseeing implementation of environmental safeguards on behalf of MOE and PMU. The terms of reference for PMDSC is attached as Appendix 10. The DBO Contractor will be responsible for the design and implementation of the project, and other responsibilities as indicated in the DBO contract documents. The PMU will also be supported by a public awareness and community capacity building (PACCB) consultant, a consulting firm that will help generate awareness and strengthen skills in waste collection, segregation, compositing, recycling, and O&M targeting the poor and women, including community awareness campaign for strengthening disaster risk reduction and climate change readiness.

530. **Project Management Unit.** MOE has set up a PMU at its Waste Department. The PMU will oversee the implementation of the project by the DBO Contractor. PMU staff comprise eight staff as follows: (i) Project Director (part-time, Director General of Department), (ii) Project Manager, (iii) Procurement Specialist, (iv) Finance Specialist, (v) Safeguard Specialist, (vi) Civil Engineer, (vii) Information, Education and Communication (IEC) Specialist, and (viii) administrative assistant. The Project Director (part-time) is empowered to take official decisions, while remaining PMU staff (full time) are recruited from the market. The PMU will be supported by the PMDSC and PACCB consultants for project management, capacity building, monitoring, and technical design and supervision support.

531. **Terms of Reference for PMU Environment Officer.** Key tasks and responsibilities of the PMU environment officer are as follows:

(i) Ensure that EIA report with the EMP is updated based on final detailed designs, in coordination with the DBO Contractor;
(ii) Ensure that EIA report with the EMP is included in DBO bidding and contract documents;
(iii) Ensure that costs for implementing the EMP, including those special cost indicated in Table 61, are included in the BOQ (or equivalent) of the DBO bidding and contract documents;
(iv) Ensure that the DBO Contractor's SEMP is consistent with the EMP. The SEMP shall have the same level of detail or stricter mitigation measures than the EMP;
(v) Provide oversight on environmental management aspects of the project and ensure EMP and SEMP are implemented by the DBO Contractor;
(vi) Establish a system to monitor environmental safeguards of the project, including monitoring the indicators set out in the monitoring plan of the EMP;
(vii) Confirm compliance of DBO Contractor with obtaining statutory clearances or permits required under the project, including environmental clearances as applicable;
(viii) Review, monitor, and evaluate the effectiveness with which the EMPs are implemented, and recommend necessary corrective actions to be taken as necessary;
(ix) Consolidate monthly environmental monitoring reports from DBO Contractor and submit quarterly monitoring reports to ADB and required reports to Maldives EPA;
(x) Ensure timely disclosure of final EIA report in locations and form accessible to the public;
(xi) Address any grievances brought about through the grievance redress mechanism in a timely manner;
(xii) Provide assistance to DBO Contractor's EHS Manager (as may be needed) on delivering orientation to DBO Contractor's personnel regarding environmental management arrangements for the project;
(xiii) Visit worksites during construction phase and WTE plant site during operation phase, and provide guidance relating to supervision and compliance monitoring;
(xiv) Provide necessary support to the external environmental expert consultant who will be retained under the project (see below description of external environmental expert); and
(xv) Provide inputs to progress reports and the project completion report.

532. **PMDSC Environmental Safeguards Specialists.** The PMDSC Environmental Safeguards Specialist Consultants will have the following responsibilities:

(i) Assist PMU in meeting requirements of ADB SPS and government on environment, occupational health and safety, and labor standards.
(ii) Assist PMU in obtaining all necessary permissions and complying with statutory requirements;
(iii) Ensure DBO Contractor submits requirements per EMP and government clearances/permits,
(iv) Provide support to DBO Contractor in preparing the site-specific EMP (SEMP) to ensure ADB SPS and conditions in government clearances are incorporated accordingly;
(v) Assist PMU in updating the EIA for any change in scope, design, location, or unanticipated impacts that are not reported in the EIA;
(vi) Review any changes in the DBO Contractor's design and support PMU in ensuring environmental assessment, impacts avoidance and mitigation measures are reflected in the SEMP and updated EIA
(vii) Assist the DBO Contractor and the PMU in all EPA related clearances, and ADB's no-objection, and monitor and control construction and assembly compliance against the updated EIA, ADB SPS, and SEMP;
(viii) Monitor the contractors' compliance with all safety requirements as stated in DBO contract and SEMP, during and prior to any construction activity.
(ix) Assist in preparation of accident report and keeping accident records on-site as required;
(x) Monitor the implementation of the SEMP during construction and pre/post construction phases;
(xi) Assist PMU in continuing stakeholders engagement, consultations, information disclosure and addressing complaints/grievances;
(xii) Develop public awareness program and materials to support wider understanding of the project, potential impacts and measures to ensure impacts are avoided, mitigated and affected people, if any, are compensated;
(xiii) Assist PMU in preparation of environmental monitoring reports
(xiv) Coordinate with external environmental experts on results of independent monitoring and support PMU to prepare corrective actions, if required
(xv) Provide and organize trainings/workshops/seminars on environmental safeguards, occupational health and safety, and labor standards
(xvi) Assist PMU in review of contractor's health and safety program and in monitoring its implementation;
(xvii) Support PMU during ADB review missions;
(xviii) Support PMU in developing data management system on environmental safeguards; and
(xix) Other tasks related to environmental safeguards, occupational health and safety, and labor standards.

533. **DBO Contractor**. The DBO Contractor will have primary responsibility for implementing the EMP during the construction stage and will:

(i) Appoint a qualified full-time environmental health and safety (EHS) manager to manage implementation of the EMP and monitoring plan;
(ii) Ensure that sufficient number of engineers/staffs are trained effectively on the implementation of the EMP and SEMP who will assist the EHS manager, subject

to internal manpower arrangements. No shift schedules shall be without either the EHS manager or at least one trained engineer/staff on EMP and SEMP implementation;

(iii) Obtain necessary environmental license(s), permits, etc. from relevant agencies as prior to commencement of civil works contracts;

(iv) Undertake all necessary studies required in this EIA report, such as, climate vulnerability and risk assessment at the proposed site, among others as may be deemed necessary;

(v) Prepare all work program and pre-approved project plans required for implementing the EMP during construction phase as follows:

a. Construction Waste Management Plan;
b. Occupational Health and Safety Plan following international best practices on occupational health and safety such as those in Section 4.2 of IFC EHS Guidelines on Construction and Decommissioning Activities;
c. Construction Camp Development and Management Plan;
d. Spill Control and Containment Plan;
e. Marine and Beach Area Construction Work Plan;
f. Erosion Control Plan for pipeline works; and
g. Traffic Management Plan around the construction site to ensure easy access and passage of workers and employees of establishments at two sides of the project site;

(vi) Prepare all work program and pre-approved project plans required for implementing the EMP during operation phase as follows:

a. Operation and Maintenance Manual;
b. Waste Screening Procedure / Plan to ensure all waste inputs to the facility comply with quantity and quality requirements, including accounting of hazardous / halogenated organic components in wastes, if practical;
c. In-house Solid Waste Management Plan;
d. Occupational Health and Safety Plan following international best practices on occupational health and safety such as those in IFC EHS Guidelines on Waste Management Facilities;
e. Spill Control and Containment Plan; and
f. Emergency and Disaster Preparedness and Response Plan;

(vii) Implement all mitigation measures in the EMP and activities in the Monitoring Plan, including allocation of budget to implement the EMP/SEMP, monitoring program and measures for any unanticipated impacts during the construction and operation phases of the project;

(viii) Ensure that all workers, site agents, including site supervisors and management participate in training sessions delivered by the project proponent;

(ix) Ensure compliance with environmental statutory requirements and contractual obligations;

(x) Participate in resolving issues as a member of the Grievance Redress Committee;

(xi) Respond promptly to grievances raised by the local community or any stakeholder and implement time-bound environmental corrective actions or additional environmental mitigation measures as necessary;

(xii) Based on the results of EMP monitoring, cooperate with the PMU to prepare and implement time-bound corrective action plans, as necessary; and

(xiii) Provide necessary support to the external environmental expert consultant who will be retained under the project (see below description of external environmental expert);

534. **External Environmental Expert**. In compliance with the requirement of ADB SPS, the project, as a Category A undertaking with significant impacts and risks, shall retain an external environmental expert consultant who will verify monitoring information. The environmental expert shall have expertise on WTE project operations and experience in management and monitoring of environmental impacts of such kind of development projects. The environmental expert shall be retained starting from the time the DBO Contractor mobilizes up to the operation phase. The environmental expert will coordinate and work closely with PMU and the DBO Contractor when planning or fielding monitoring activities, including requests for information or documents that will facilitate the task. Per ADB SPS, the environmental expert shall not be involved in day-to-day project implementation or supervision of the project and will report directly to ADB, or occasionally through the PMU. The terms of reference of the environmental expert is attached as Appendix 11.

C. Environmental Management Plan

535. Table 59 shows the Environment Management Plans (stage-wise) summarizing the potential adverse environmental impacts, proposed mitigation measures, responsible parties, and cost of implementation. This EMP will be included in the DBO bidding and contract documents and will be further reviewed and updated, including the specific costs, during detailed design phase. Table 60 shows the proposed Environmental Monitoring Plan (EMOP) for the project. It includes all suggested environmental parameters, description of sampling stations, frequency of monitoring, applicable standards, and responsible parties. Likewise, the EMOP will be further reviewed and updated during the detailed design phase.

Table 53: Environmental Management Plan Matrix

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
Pre-Construction / Design Stage							
Invitation for Bids	• Bidding documents are issued without the EMP and/or the EIA prepared for the project	• No bidding documents shall be issued without having the mitigation measures and monitoring requirements in the EIA report included in the safeguard clauses of technical specifications in bidding and contract documents.	• Bidding and contract documents include safeguard provisions	During drafting of bidding and contract documents Before the issuance of bidding documents for IFB Before awarding of contracts	PMU - Ministry of Environment	Ministry of Environment	None.
Locating intake and outfall of cooling/thermal water.	• Damage to reef and marine ecology around Thilafushi island due to high temperature and high concentration (brine solution). .	• If necessary, undertake coral and benthic study following Reef Check protocol. • Confirm that the pre-identified best location for intake and outfall is acceptable to the DBO Contractor. If changes are planned, the DBO Contractor shall ensure that withdrawal cooling water and discharge of cooling water will have no or minimum impact to underwater ecosystem. • Contract documents to include performance guarantee by the facility that hot water discharge shall have maximum temperature difference of 3 degrees Celsius from the ambient temperature. • Undertake hot water dispersion modeling along the planned area of discharge. Ensure that this area is with no or least	Planned and implemented Numerical modeling output for 4 seasons	Once to review modeling output. Once during finalization of outfall configuration	DBO contractor through a preapproved agency	PMU	Part of DBO Contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		marine species that could be affected based on the underwater ecology study (as described above). • If there will be changes in the location of cooling water discharge location, the DBO Contractor shall conduct confirmatory numerical modeling for brine discharge– both near and far-field, covering all 4 seasons (2 monsoon and 2 inter-monsoon) to ensure the location of discharge will not have significant impact to marine environment. • Ensure that design considers achievement of proper mixing and rapid dilution within a small area around the outfall. • Consider in the design the combined outfall for hot water and treated wastewater to minimize impact to marine ecosystem.					
Locating ambient air quality monitoring stations	Improper locations of sampling locations leading to underestimated ambient air quality condition and health risk to people.	• Contract documents to include performance guarantee for the facility that emissions comply with applicable standards. • Conduct wind data gathering for various seasons of the year to map projected wind directions at any season during plant operations. • Design smokestacks with height that will ensure emissions will have no or minimum impact to surrounding receptors within the direct and indirect impact zones. • Undertake air dispersion modeling to show and	• Ambient air monitoring station site map	Once of during the detail design stage	DBO contractor	PMU	Part of DBO Contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		understand the behavior and movement of components of flue gas from the stacks. • Based on the dispersion modeling, identify the appropriate sampling locations for ambient air quality in Thilafushi island and other islands nearby, if necessary and practical. • Undertake baseline ambient air quality data gathering with due consideration of the direction of flow of smoke from the existing dumpsite					
Locating proper drainage system around the facility	Disturbance to and impedance of flow in natural drainage around the island.	• Identify and demarcate drainage lines within and around the WTE site, including approach roads. Ensure that these channels do not disturb or impede natural flow of storm water from the island to the sea. • Provide cross drainage structures wherever necessary along the new approach roads. • Integrate the above considerations in the final drainage plan for the project site.	• Site drainage plan	Once of during the detail design stage	DBO contractor	PMU	Part of DBO Contract
Physical integrity of proposed project site.	Failure of site to withstand proposed project infrastructures.	• Integrate results of geotechnical study undertaken by the government to the design of project infrastructures.	• Geotechnical study report. • Recommendations of geotechnical study integrated in detailed design.	Continuing during detailed design stage.	DBO contractor	PMU	Part of DBO Contract
	Failure of site to withstand climate change, including extreme	• Undertake and include results of climate vulnerability and risk assessment (CVRA) in the design of the project.	• CVRA report • Recommendations of the CVRA report integrated in detailed design.	Continuing during detailed design stage.	DBO contractor	PMU	Part of DBO Contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
	weather events.	• Provide site protections based on the risks identified in the CVRA.					
Work program and pre-approved plans	Unprecedented and multiple environmental impacts due to poor or inappropriate plans integrated in the design of the project.	• Develop the following plans that shall be included in the final detailed design and implemented during construction stage: o Construction Waste Management Plan. o Occupational Health and Safety Plan following international best practices on occupational health and safety such as those in Section 4.2 of IFC EHS Guidelines on Construction and Decommissioning Activities. o Construction Camp Development and Management Plan. o Spill Control and Containment Plan o Marine and Beach Area Construction Work Plan o Erosion Control Plan for pipeline works o Traffic Management Plan around the construction site to ensure easy access and passage of workers and employees of establishments at two sides of the project site. • Develop the following plans or manuals that shall be utilized during operation stage: o Operation and Maintenance Manual	• Work plans included in the final detailed design of the project • Work schedule for each plan included in the overall schedule of project implementation.	Once prior to start of construction works.	DBO contractor	PMU	Part of DBO Contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		○ Waste Screening Procedure / Plan to ensure all waste inputs to the facility comply with quantity and quality requirements, including accounting of hazardous / halogenated organic components in wastes. ○ In-house Solid Waste Management Plan. ○ Occupational Health and Safety Plan following international best practices on occupational health and safety such as those in IFC EHS Guidelines on Waste Management Facilities. ○ Spill Control and Containment Plan. ○ Emergency and Disaster Preparedness and Response Plan.					
Consents, permits, clearances, no objection certificate (NOC), etc.	Stoppage of activities due to lack of permits or clearances from the local and national governments.	• Obtain all necessary consents, permits, clearance, NOCs, prior to start of civil works.	• Clearances and approvals	Once prior to start of construction	DBO contractor	PMU	No additional costs
Shifting of Utilities	Damage to existing utilities that will disturb operations of establishments or businesses near the site.	• Identify and include locations and operators of these utilities in the detailed design to prevent unnecessary disruption of services during the construction phase. • Prepare a contingency plan to include actions to be done in case of unintentional interruption of services, such as the following:	• Maps showing utilities and likely disruptions	Once prior to start of construction.	DBO contractor	PMU	No additional costs

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		○ In case of water supply disruption, provide temporary water supply source for the affected establishments. ○ In case of power interruption, provide prior notice to affected establishments. If interruption is unscheduled due to unforeseen incidents, provide a standby generator set to serve as temporary power supply to affected establishments. • Identify the list of affected utilities and operators and coordinate closely with relevant government departments.					
Locating sites for construction work camps, areas for stockpile, storage and disposal	Greater level of impact or pollution due to location of worker camp, raw material storage areas and temporary waste/spoil storage sites	• Except disposal sites, all the work sites (camps, storage, stockpiles etc.) will be located within the selected site. • No construction camp shall be located on the beach or overwater. • Material shall be brought to site as and when required, and temporary storage of material (pipe, sand etc.,) shall be made near the work site. • No temporary storage shall be located at the lagoon section • Waste shall be disposed in existing approved disposal sites; any new sites shall be developed considering siting guidelines, maintained and operated accordingly	• List of preapproved sites for construction work camps, areas for stockpile, storage and disposal • Construction Waste Management Plan	Once prior to start of construction	DBO contractor	PMU	No additional costs

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
Sourcing of construction materials	Environmental impacts (air, water, soil, biodiversity, etc.) at the source.	• Obtain construction materials for this project from the licensed quarries acceptable to government • For new borrow sites to borrow fill material and backfill material, prior permission must be obtained from Maldives EPA, and the environmental impacts of the operation should be properly examined and mitigated as necessary • Make efforts to minimize the overall material requirement for the project by adopting various approaches –balanced cut and fill, re-use as much excavated material from this project as possible • Submit to PMU on a monthly basis, documentation (materials quantities with source).	Permits issued to quarries/sources of materials	Once prior to start of construction	DBO contractor	PMU	No additional costs
Delivery route for construction materials and equipment	Port congestion at Thilafushi due to transport of construction equipment and raw materials at site	• Identify a separate berth location for loading and unloading construction heavy equipment and raw materials that will not disrupt day-to-day activities in the island. Avoid use of the common ports being used by locals. • If no other areas available, execute agreement with WAMCO to use WAMCO's berths/docking ports when delivering heavy equipment and big-sized construction materials to the site.	Maps showing delivery routes.	Once prior to mobilization by DBO Contractor	DBO contractor	PMU	No additional costs
Final Detailed Design Components	Air and marine water pollution due to inappropriate	• Ensure the final detailed design will integrate the following mandatory requirements:	Detailed design that uses recommendations of the EIA report.	Continuing during detailed design stage.	DBO Contractor	PMU	Part of DBO contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
	components included in the detailed design.	○ Use of best practical incineration technology as recommended in the EIA. ○ Use of stack height recommended in the EIA. If circumstances on the basis of the recommended stack height have changed (e.g. change in dimensions of the WTE plant building structure), ensure to use a stack height that is based on a new modeling calculation. ○ Installation of air pollution control device that will ensure emissions comply with the emission standards as indicated in the EIA. ○ Ensure to include installation of a continuous monitoring system (CEMS) as a mandatory requirement in the design. ○ Appropriate sampling port at the stack for random grab sampling activities. ○ Leachate treatment plant designed based on (i) maximum expected volume of leachate generated, and (ii) full capacity operation of the WTE plant. ○ Residual waste landfill designed based on (i) maximum volume of fly ash and bottom ash generation, and (ii) full capacity operation of the WTE plant.					

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		○ Provision of a sampling port for thermal water (heated cooling water) at appropriate and accessible location along the cooling water line.					
Additional Baseline Data Gathering	Inaccurate predicted impacts and proposed measures due to lack of robust baseline will lead to unforeseen environmental pollution or damage.	• During the detailed design phase of the project, the baseline survey shall be conducted to include monthly (air quality) and quarterly (marine water quality and underwater ecology survey) baseline data. In particular, the DBO Contractor shall: ○ Undertake ambient air quality measurements (monthly), marine water quality analysis, and marine underwater ecology survey (quarterly) on first year after DBO contractor mobilization, at the identified sampling locations in the EIA report (and any other locations in and around Thilafushi island as may be deemed by the DBO Contractor as important sampling locations); ○ follow required sampling methodologies, including appropriate averaging time for ambient air quality measurements as indicated in the WHO Ambient Air Quality Guidelines; and ○ include results of analyses in the updating of the EIA,	Results of monthly ambient air quality measurements (TSP, PM_{10}, $PM_{2.5}$, SO_x, NO_x). Results of quarterly marine water quality analysis (to follow parameters used in the first sampling activities). Results of quarterly marine underwater ecology survey (to follow parameters, methodologies and locations used in the first set of surveys in the EIA process).	Monthly sampling (air quality) and quarterly sampling (marine water quality and underwater ecology survey) for minimum of 1 year after DBO contractor mobilization (to establish baseline conditions prior to works).	DBO Contractor	PMU	Part of DBO contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		and consider these results in the final detailed design of the project as applicable.					
Construction Stage							
Physical Characteristics							
Overall project site management	Poor environmental management by DBO Contractor	• Designate one full time and qualified Environment, Health and Safety (EHS) Manager who will be in charge of overall EMP implementation and other tasks as required in the EIA report. He/She shall be in place from the day of mobilization of DBO contractor. • In addition to the EHS Manager, designate one qualified trained engineer on EHs and EMP/SEMP implementation for every shift during construction stage who will assist the EHS Manager (either in his/her presence or absence) at all times. • Coordinate with the PMU on confirmatory surveys determined during design stage that need to be conducted once the DBO Contractor is selected; and complete these studies as required with support of external experts.	• Included in manpower requirements as indicated in bidding documents and final contract documents. • Hired EHS Manager and selected engineers trained on EHS and EMP/SEMP implementation based on required qualifications.	One-off during mobilization, and continuously throughout the contract period	DBO Contractor	PMU	Part of DBO contract
Marine Traffic	Port congestion at Thilafushi due to transport of construction equipment and raw materials at site	• Avoid using the docking ports used by the local people and industries in Thilafushi when transporting construction heavy equipment and raw materials at the site. • Transport and unload heavy equipment and raw materials at nighttime when marine traffic is	• No disturbance to normal day-to-day movement of locals at the port and in the island. •	At least quarterly and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		low within and around the island. • Utilize the exclusive docking port area being used by WAMCO.					
Topography landforms, geology, and soils and river morphology and hydrology	Raw materials for construction (e.g. sand, gravel or crushed stone) will be extracted from sources causing changes in topography and landforms (if on land such as other islands in Maldives) or river morphology and hydrology (if on the river in other countries).	• Utilize readily available sources with environmental clearance and license. • Borrow areas and quarries comply with environmental requirements. • Coordinate with local authorities for quarrying at various parts of Maldives where these raw materials are sourced. Alternative sources should be identified.	Records of sources of materials	At least quarterly and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO contract
Marine water quality	Trenching and excavation, run-off from stockpiled materials and chemical contamination from fuels and lubricants may result to silt-laden runoff during rainfall, which may cause siltation	• Implement spoils management plan. • Reuse excess spoils and materials. • Temporary storage areas for excess spoils prior to disposal should be located as far as possible from the edge of the island or seawalls. • Disposal site in designated areas only. • Earthworks during dry season. Avoid earthworks during heavy rainy days, especially during	• Areas for stockpile storage of fuels and lubricants and waste materials; • Number of silt traps installed along trenches leading to water bodies; • No visible degradation to nearby drainage, water bodies due	At least quarterly for both visual inspections and water quality sampling, and results reported by DBO Contractor to PMU.	DBO Contractor	PMU	Part of DBO contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
	and degradation in the quality of marine water around Thilafushi.	monsoon season, to prevent run-off. • Stockyards are covered when possible and provided with drainage canals around. • Install temporary silt traps or sedimentation basins along drainage leading to the lagoon and sea. • Fuel, other petroleum products, and toxic and hazardous chemicals or substances stored at storage areas away from water drainage and protected by impermeable lining and bunded 110%. • Take precautions to minimize the overuse of water • Divert all wash water generated from site into sedimentation ponds prior to discharge to canals. • During excavations, water accumulation in the pits / should be disposed of only after being diverted in sedimentation basis or equivalent and clarified prior to discharge. • Conduct water quality monitoring at least quarterly or as necessary.	to construction activities • Marine water quality testing				
Air quality	Work at the dry season and transporting construction materials may increase dust, carbon, monoxide, sulfur oxides, particulate	• Use of physical controls such as water sprays, covers, compaction, screening, enclosure, windbreakers, binders and/or road surfacing to avoid or minimize airborne dust from construction activities and vehicle movements. Undertake water spraying several times of the day or as often as needed	• Location of stockpiles. • Number of complaints from sensitive receptors. • Heavy equipment and machinery with air pollution control devices.	At least quarterly and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
	matter, nitrous oxides, and hydrocarbons in air environment	especially on windy days / dry seasons. • Cover delivery trucks during transport. • Construction vehicle's speed limited to 30 kilometers per hour (kph). • Prohibition of open burning of solid waste. • Minimize stockpile height. • If dust generation is significant, provide a dust screen of appropriate height • Workers and staff should be provided with dust masks & instructed to use them on site • Conduct work in stages to reduce dust impacts; clearing and then conducting construction in only a portion of the site at a time. • Control access to work area, prevent unnecessary movement of vehicles, workers, public trespassing into work areas; limiting soil disturbance will minimize dust generation • Contractor's environmental manager should monitor these activities and take action to apply the mitigation if dust production becomes significant. • Use tarpaulins to cover loose material (soil, sand, aggregate) when transported by trucks • Clean wheels and undercarriage of haul trucks prior to leaving construction site/quarry • Stabilize surface soils where loaders, support equipment and	• A certification that vehicles are compliant with Maldives vehicle emission standards. • Ambient air quality tests.				

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		vehicles will operate by using water and maintain surface soils in a stabilized condition • Ensure that all the construction equipment, machinery is fitted with pollution control devices, which are operating correctly. • Ensure that only those vehicles and equipment in good condition, and are in good maintenance are used for project construction • Vehicles / equipment should have a valid permits or licenses issued by relevant government agency. • Maintain record of these permits or licenses of all vehicles at all times for ready inspection at the work sites.					
	Degradation of ambient air due to operations of concrete batching plant.	• Ensure that batching plant is installed with built-in air pollution and dust control system for fugitive emissions and dust from loading area. • Provide dust screen around the components that generate emissions or fugitive dusts. • Ensure that plant is well operated and maintained at all times according to O&M manual of batching plant (provided by the equipment manufacturer). • The concrete loading area is equipped with a leak-proof concrete floor, from which all drainage is collected and treated as necessary prior to discharge. • Mixer trucks and mixer drums are washed out only in a	• Visual inspection. • Visual inspection report.	Daily or as necessary and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO contract

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		designated area, which should be equipped with a leak-proof floor, from which drainage is collected and treated as necessary. • All chemicals used in concrete preparation are properly stored, whether dry, in powder or granular form, or as liquids, at storage areas away from water drainage and protected by impermeable lining and bunded 110%. Storage facilities should be as specified in the appropriate international standard and should include equipment to extract dust and completely contain any spillage from leaks.					
Acoustic environment	Temporary increase in noise level and vibrations by excavation equipment, and the transportation of materials, equipment and people.	• Prepare work schedule and consult with local community and administration. • Maintain low noise levels. Noise level at the boundary of site shall not exceed 70 dB(A) during day and 50 dB(A) during night unless necessary to carry out construction works. • When possible, schedule noisy works at nighttime when most establishments in Thilafushi are closed. Minimize any high noise-generating activities during the daytime. • Use low noise generating equipment. Use modern vehicles and machinery with low noise emissions. Minimize noise from construction equipment by using vehicle silencers, fitting jackhammers with noise-	• Number of complaints from sensitive receptors; • Use of silencers in noise-producing equipment • Use of sound barriers or enclosures for generators, if any; • Noise level measured at daytime and nighttime at pre-determined locations at site.	At least quarterly noise level measurement and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		reducing mufflers, and use portable street barriers to minimize sound impact to surrounding sensitive receptor. • Minimize drop heights for construction materials. • No use of horns unless necessary. • Avoid loud random noise from sirens, air compression, etc. • Avoid using multiple high noise generating equipment and activities simultaneously. • Install temporary or portable acoustic barriers around stationary construction noise sources. • Warning signs in noise hazard areas. • Identify vibration risk to nearby structures. Take caution working in such areas. • Conduct noise level monitoring at least every quarter or as necessary.				
Aesthetics	Indiscriminate disposal of solid waste (construction and domestic) around the site. Interference with the enjoyment of the area and creation of unsightly or offensive conditions	• Prepare and implement a Construction Waste Management Plan (CWMP) to identify specific steps on handling and disposal of all solid waste from construction activities, including the following: ○ Reuse as much waste sand in this project as possible; ○ Finding alternative beneficial uses for any unused sand, for example as infill in other construction works;	• Number of complaints from sensitive receptors; • Worksite clear of all types of wastes • Worksite clear of any wastes unutilized materials, and debris • Transport route and worksite cleared of dirt	Daily or as necessary and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		○ Disposal of debris and bulky solid waste materials after construction stage. ○ Minimizing stockpile size. ○ Clearing wastes regularly. ○ Avoiding stockpiling of excess spoils. ○ Covering delivery trucks during transportation. ○ Cleaning roads. ○ Using screening enclosure shade cloth, temporary walls around construction site. ○ Cleaning site regularly. ○ Following the principle of "Reduce, Reuse, Recycle, and Recover". • When applicable, solid wastes from the site shall be returned to the manufacturer of raw materials they were generated from, or dispose as per their specifications. • Hazardous waste shall be stabilized, encapsulated, and disposed as per internationally accepted practices. Provision will be made for secure storage of hazardous waste. • Residual and hazardous wastes such as oils, fuels, and lubricants shall be disposed of in approved disposal sites and/or third-party sources approved by Maldives EPA. • Prohibit burning of construction and/or domestic waste; • Ensure that wastes are not haphazardly thrown in and around the project site; provide proper collection bins, and					

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		create awareness to use the dust bins. • Conduct site clearance and restoration to original condition after the completion of construction works.					
Biological Characteristics							
Marine Biodiversity	Threat to marine and terrestrial species, or other marine animals due to (i) poaching or leisure catching by workers in the project area, and (ii) marine pollution.	• Implement the Marine and Beach Area Construction Work Plan. • Implement the Erosion Control Plan for pipeline works. • Ensure that all construction activities are conducted strictly within the site footprint (including offices, car parking and other activities that might normally be located in an exterior contractor's area). • Prohibit any deliberate killing or harming of animals on or off-site; any hunting or fishing at the site or in nearby areas by site personnel; preventive actions shall be put in place by contractor for protected marine species. • Ensure that all construction work or other activities near the site perimeter are conducted with particular care and include measures to reduce noise and dust to minimum possible. • Create awareness in all site staff & workers on the importance of the marine animals/species and plants around the site and their vulnerability. • To protect site personnel, training should also be provided	• Visual site inspection. • Visual site inspection reports. • Marine water quality tests. • Marine and Beach Area Construction Work Plan • Erosion Control Plan for pipeline works • Spill Control and Containment Plan	Daily or as necessary for visual inspection and reported by DBO Contractor At least quarterly for marine water quality testing and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		to enable them to recognize, and deal safely and humanely with all animals that may be encountered. • Implement the Spill Control and Containment Plan. • Marine works should be scheduled to occur in the north east monsoon season when the sea conditions are calmer to limit the spread of sediment around this operation. • Conduct the excavation, and deposit the excavated material in a more controlled manner minimizing the area that is disturbed. • Avoid the need to re-excavate by choosing right time (calmed sea conditions again), and quickly lowering the pipes into trench and refilling. • Limit the size of the construction area on the beach and to avoid any encroachment outside the specified area. • Monitor the turbidity & DO levels due to spread of sediment throughout the trenching operation and work should be stopped if levels exceed pre-determined values as per the guideline below: o The turbidity of the water is to be measured (ISO 7027) at the edge of the construction zone during trenching and backfilling activities; o When the turbidity exceeds the minimum of the					

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		background turbidity plus 20% or 100 NTU, the trenching is to cease until the turbidity returns to the background level plus 10%.					
Socio-economic Characteristics							

Existing provisions for pedestrians and other forms of transport	Potential road closures due to construction activities.
	
	Hauling of construction materials and operation of equipment on-site can cause traffic problems.
		• Implement the Traffic Management Plan that will elaborate the following:
		  ○ Suitable transportation routes.
		  ○ Safe passage for vehicles and pedestrians.
		  ○ Temporary road diversions and for provision of traffic aids if transportation activities cannot be avoided during peak hours.
		  ○ Scheduling of material deliveries on low traffic hours, particularly at nigh time when most establishments in Thilafushi island are already closed.
		• Erect and maintain barricades if required.
		• Consult with business and institutions for work schedules.
		• Erect display boards around strategic locations about nature, duration of construction and contact for complaints and/or issues about the project.
		• Complete quickly any work that is near adjacent establishments.
		• Restore damaged properties and utilities.
			• Traffic Management Plan. Traffic route during construction works, including number of permanent signs, barricades, and flagmen on worksite;
			• Number of complaints from sensitive receptors;
			• Some signage placed at the subproject location.
			• Number of walkways, signage, and metal sheets placed at subproject location
				Prior to start of construction, and weekly or as necessary during construction stage, and reported by DBO Contractor	DBO contractor	PMU	Part of DBO Contractor cost.

Socioeconomic status	Staffing will be required during construction. This can result	• Engage the local workforce. If not available in Thilafushi Island, engage workers from nearby islands including Malé if	• Employment records;	Monthly or as necessary and reported	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
	in an increase in local revenue.	available and sufficiently qualified. • Secure construction materials from local market, whenever available.	• Records of sources of materials • Records of compliance with labor act of Maldives.	by DBO Contractor			
Other amenities for community welfare	Civil works may result in an impact to the sensitive receptors such as residents, businesses, and the communities. Excavation may also damage infrastructure located alongside the roads.	• Before any excavation work, reconfirm location and nature of existing infrastructure, if any, identified during detailed design stage. • Minimize repeated disturbance to locals by integrating forms of infrastructures such as temporary safe walkways in areas with ongoing excavation works. Provide alternate routes in the area if necessary, to allow smooth movement of workers and vehicles in the area. • Inform through continuous meaning consultations with local people about nature, duration and possible impacts of the construction and integrate their concerns. • Promptly relocate infrastructure materials if found to be obstructing or disturbing free movement of local people. • Take prior permission from local authority for water use. • Restore damaged properties and utilities to pre-work conditions.	• Number of complaints from sensitive receptors	Daily or as necessary and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.
Community health and safety	Construction works will impede the access of residents and	• Restrict work force in designated areas. • Identify stockyard areas in consultation with local administration.	• The number of permanent signs, barricades, and flagmen on worksites per	Daily or as necessary and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
	business in limited cases. Construction works will raise danger to community people.	• Work on private land to require written permission of landowners. • Prefer small mechanical excavator for excavation works. • Prohibit alcohol and drugs on site. • Prevent excessive noise. • Code of conduct for workers includes restricting workers in designated areas, no open defecation, no littering, no firewood collection, no fire except designated places, no trespassing, no residence at construction sites, and no obligation to potentially dangerous work. • Follow international best practices on community health and safety such as those in Section 4.3 of IFC Environmental Health and Safety (EHS) Guidelines on Construction and Decommissioning Activities. These requirements are discussed in Section VI of the EIA report. • Maintain a complaint logbook in workers camp and take action promptly of complaints.	Traffic Management Plan. • Number of complaints from sensitive receptors. • Number of walkways, signs, and metal sheets placed at the subproject location. • Agreement between contractor and WAMCO in case of using WAMCO's property for storage or use. • Agreement between contractor and private property owners in case of using the latter's land for storage and use.				
Workers Health and Safety	There is invariably a safety risk when construction works such as excavation and earthmoving are conducted	• Comply with labor act of Maldives. • Implement the Occupational Health and Safety Plan, which shall follow all occupational health and safety requirements discussed in Section VI of the EIA report.	• Occupational Health and Safety Plan • Equipped first-aid stations • Medical insurance coverage for workers	Daily or as necessary and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
	in urban areas. Workers need to be mindful of the occupational hazards, which can arise from working at height and excavation works.	• Provide compulsory health and safety orientation training to all new workers to ensure that they are apprised of Occupational Health and Safety Plan including rules of work, use of personal protective equipment (PPE), preventing injury to fellow workers, etc. • Restrict public access to worksites. • Provide PPE to workers and ensure their effective usage. For example, require workers to (i) wear ear plugs while in noise hazard areas, and (ii) wear high visibility clothes or reflectorized vests at all times. • Document procedures to be followed for site activities. • Maintain accident reports and records. • Make first aid kits readily available. • Maintain hygienic accommodation in work camps. • Ensure uncontaminated water for drinking, cooking and washing. • Ensure clean eating areas. • Ensure sanitation facilities are readily available. • Provide medical insurance coverage for workers. • Provide orientation for guest visitors. • Ensure that visitors do not enter hazard areas unescorted. • Ensure moving equipment is outfitted with audible backup alarms.	• Number of accidents • Records of supply of uncontaminated water • Condition of eating areas of workers • Record of orientation training • Availability of personal protective equipment at construction site • Percentage of moving equipment outfitted with audible back-up alarms • Signage for storage and disposal areas • Condition of sanitation facilities for workers • Report summary on daily toolbox talks for workers.				

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		• Chemical and material storage areas need to be marked clearly. Display MSDS, train staff on storage and handling. • Hearing protection equipment enforced in noisy environment. • Conduct of daily toolbox talks to reiterate repeatedly all the above measures and prioritize safety briefings; leanings from previous incidents, their causes and risks, and other safety procedures as may be identified. • Conduct periodic safety audit, identify and remove potential hazards. • Ensure that qualified first aid is provided at all times; equipped first-aid stations shall be easily accessible throughout the work sites and camps. • For works in the marine environment, ensure that: ○ all persons engaged in the marine construction are competent swimmers. ○ Lifejackets are provided to workers and worn at all times. ○ Properly functioning ship-to-shore communications are provided. ○ No work during rough sea conditions. ○ Emergency rescue team is available at all times at the site during the marine work (such as rescue boat with divers).					

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		• Provide caution & information boards (traffic, safety, information etc.,) • Do not allow unauthorized / public entry into work sites / facilities • Undertake all necessary public safety measures, precautions • Ensure proper maintenance and cleanliness of the site and facilities Demarcate assembly area for emergencies • Provide medical aid facilities (first aid, doctor on call etc.,)					
Labor Camps	Indiscriminate environmental impact and pollution due to labor camps	• Avoid establishing labor camps by employing local workers as far as possible. • In unavoidable cases, establish camp within the site; and implement the Construction Camp Development and Management Plan (CCDMP). • Follow the layout plan included in the CCMP. • The CCDMP will consider all construction camp requirements discussed in Section VI of the EIA report, which, among others, are the following: ○ The camp, if possible in Thilafushi Island, is at least 50 m away from water bodies. ○ Clear separation of the workers living areas from material storage areas and work sites with fencing and separate entry and exit ○ Provision of proper liquid waste and solid waste	• Visual inspection. • Visual inspection reports. • CCDMP	Weekly and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		collection, treatment and disposal system. ○ Provision of drinking water, water for other uses, and sanitation facilities (e.g. separate toilets for men and women). ○ Livability at the highest standards possible at all times; living quarters provided with standard materials, space, and proper lighting and ventilation. ○ Fire safety, medical facilities.					
Post-Construction / Operation Stage							
Overall project site management	Poor environmental management by DBO Contractor	• Designate one full time and qualified Environment, Social, Health and Safety (EHS) Manager who will be in charge of overall EMP implementation and other tasks as required in the EIA report. He/She shall be in place from the day of mobilization of DBO contractor. • In addition to the EHS Manager, designate one qualified trained staff member on EHS and EMP/SEMP implementation for every shift who will assist the EHS Manager (either in his/her presence or absence) at all times. • Coordinate with the PMU on confirmatory surveys determined during the design stage that need to be conducted by the DBO Contractor during operation stage; and complete as required with support of external experts.	• Included in manpower requirements as indicated in bidding documents and final contract documents. • Hired EHS Manager and selected staff trained on EHS and EMP/SEMP implementation based on required qualifications. • Operation and Maintenance Manual • Waste Screening Procedure / Plan • Emergency and Disaster Preparedness and Response Plan	One-off during mobilization, and continuously throughout the contract period, and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		• Implement the Operation and Maintenance Manual. • Implement Waste Screening Procedure / Plan to ensure all waste inputs to the facility comply with quantity and quality requirements, including accounting of hazardous / halogenated organic components in wastes • Implement the Emergency and Disaster Preparedness and Response Plan					
Physical Environment							
Aesthetics	Indiscriminate disposal of solid waste (construction and domestic) around the site. Interference with the enjoyment of the area and creation of unsightly or offensive conditions	• Implement the Solid Waste Management Plan for the operation of WTE facility to identify specific steps on handling and disposal of all solid wastes from the operation of the facility. • When applicable, solid wastes from the WTE plant shall be returned to the manufacturer of raw materials they were generated from, or dispose as per their specifications. • Hazardous waste shall be stabilized, encapsulated, and disposed as per internationally accepted practices. Provision will be made for secure storage of hazardous waste.	• Solid Waste Management Plan • Number of complaints from sensitive receptors; • Worksite clear of all types of wastes • Worksite clear of any wastes unutilized materials, and debris • Transport route and worksite cleared of dirt	Daily or as necessary and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.
Air quality	Degradation of ambient air quality.	• Consult with local community to present the day-to-day operation of the WTE plant. This will enable locals learn about the operations and identify the potential sources and time/duration of emissions.	• Number of complaints from sensitive receptors. • Machineries with air pollution control devices.	At least quarterly and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		• Ensure efficient functioning of the air pollution control device of the plant and CEMS. • Use of physical controls such as water sprays, several times of the day or as often as needed especially on windy days / dry seasons. • Greenery and plantation at the perimeter to help control dispersion of air pollutants. All plant species to be introduced shall be endemic or native species in Maldives. Avoid introduction of invasive alien species by following guidance reference document issued by the MOE; • Cover delivery trucks during transport. • Vehicle speed limited to 30 kilometers per hour (kph). • Prohibition of open burning of solid waste. • Vehicles / equipment should have a valid permits or licenses issued by relevant government agency. • Maintain record of these permits or licenses of all vehicles at all times for ready inspection at the work sites.	• A certification that vehicles are compliant with Maldives vehicle emission standards. • Ambient air quality tests. • Stack emission tests. • CEMS real time print reports.				
Marine water quality	Degradation in the quality of marine water around Thilafushi due to discharge of effluent from the WTE plant.	• Ensure efficient and continuous functioning of the leachate treatment plant. • Stockyards are covered when possible and provided with drainage canals around. • Install temporary silt traps or sedimentation basins along	• Areas for stockpile storage of fuels and lubricants and waste materials; • Number of silt traps installed along trenches leading to water bodies;	At least quarterly for both visual inspections and water quality sampling, and results reported by	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		drainage leading to the lagoon and sea. • Fuel, other petroleum products, and toxic and hazardous chemicals or substances stored at storage areas away from water drainage and protected by impermeable lining and bunded 110%. • Divert all wash water generated from site into sedimentation ponds prior to discharge to canals. • Conduct treated leachate water quality monitoring at least quarterly or as necessary.	• No visible degradation to nearby drainage, water bodies. • Marine water quality tests • Effluent water quality tests. • Thermal water temperature tests.	DBO Contractor to PMU.			
Acoustic environment	Noise pollution due to plant operations.	• Consult with local community to present the day-to-day operation of the WTE plant. This will enable locals learn about the operations and identify the potential sources and time/duration of noise generation. • Maintain low noise levels. Noise level at the boundary of site shall not exceed 70 dB(A) during day and 50 dB(A) during night. • Use low noise generating equipment. Use modern vehicles and machinery with low noise emissions. • No use of horns unless necessary. • Avoid loud random noise from sirens (except sirens for emergency alarms), air compression, etc.	• Number of complaints from sensitive receptors; • Use of silencers in noise-producing equipment • Use of sound barriers or enclosures for generators, if any; • Noise level measured at daytime and nighttime at pre-determined locations at site.	At least quarterly noise level measurement and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		• Avoid using multiple high noise generating equipment and activities simultaneously. • Install temporary or portable acoustic barriers around stationary machineries (e.g. generator sets). • Warning signs in noise hazard areas. • Conduct noise level monitoring at least every quarter or as necessary.					
Biological Characteristics							
Biodiversity	Threat to marine species or animals due to unmanaged or mismanaged cooling water intake infrastructures	• Implement the Spill Control and Containment Plan • Ensure that intake is operated as per the design • Conduct monitoring of marine species infringed in the intakes. Undertake corrective measures if required. • Proper handling of live aquatic organisms (fishes, crabs, turtles etc.,) that enter intake and trapped at fine screen. Ensure to return these organisms or species back into the sea at locations away from the intake and outfall structures. • Wastes collected from the intake line and screens be disposed as per the internationally accepted procedures. These wastes shall not be mixed with brine for disposal or in the sea or by open dumping. They may be disposed as feed to the incinerator.	• Spill Control and Containment Plan • Inspection and incident reports, including photo documentations.	Daily or as frequent as possible by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
	Threat to marine species or animals due to unmanaged or mismanaged thermal water (heated cooling water) discharge.	• Ensure cooling water system and condenser system of the WTE plant operate at designed efficiency. • Ensure to maintain the mandatory temperature required for thermal water (heated cooling water) being discharged to the sea. • Maintain the thermal water (heated cooling water) discharge flowrate as per design. • Conduct temperature monitoring of thermal water (heated cooling water) on a daily basis or as necessary.	• Inspection and temperature monitoring reports.	Daily or as frequent as possible by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.
Socio-Economic Characteristics							
Marine Traffic	Port congestion at Thilafushi due to delivery of solid wastes.	• Continuing coordination with WAMCO to ensure use of the exclusive berth or docking port area for waste delivery at all times.	• Complaints from locals due to disturbance to normal day-to-day movement of locals at the port and in the island. • Visual inspection reports.	At least quarterly and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.
Workers Health and Safety	There is invariably a safety risk to workers, occupational hazards, which can arise from working within and around the WTE Plant.	• Comply with labor act of Maldives. • Implement the Occupational Health and Safety Plan. • Provide compulsory health and safety orientation training to all new workers to ensure that they are apprised of Occupational Health and Safety Plan including rules of work, use of personal protective equipment (PPE), preventing injury to fellow workers, etc.	• Occupational Health and Safety Plan • Equipped first-aid stations • Medical insurance coverage for workers • Number of accidents • Records of supply of uncontaminated water	Daily or as necessary and reported by DBO Contractor	DBO Contractor	PMU	Part of DBO Contractor cost.

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		• Restrict public access to the WTE Plant. • Provide PPE to workers and ensure their effective usage. For example, require workers to (i) wear ear plugs while in noise hazard areas, and (ii) wear high visibility clothes or reflectorized vests at all times. • Document procedures to be followed for site activities. • Maintain accident reports and records. • Make first aid kits readily available. • Maintain hygienic accommodation in workers accommodation or camps. • Ensure uncontaminated water for drinking, cooking and washing. • Ensure clean eating areas. • Ensure sanitation facilities are readily available. • Provide medical insurance coverage for workers. • Provide orientation for guest visitors. • Ensure that visitors do not enter hazard areas unescorted. • Ensure moving equipment is outfitted with audible backup alarms. • Chemical and material storage areas need to be marked clearly. Display MSDS, train staff on storage and handling. • Hearing protection equipment enforced in noisy environment. • Conduct of daily toolbox talks to reiterate repeatedly all the	• Condition of eating areas of workers • Record of orientation training • Availability of personal protective equipment at construction site • Percentage of moving equipment outfitted with audible back-up alarms • Signage for storage and disposal areas • Condition of sanitation facilities for workers • Report summary on daily toolbox talks for workers.				

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		above measures and prioritize safety briefings; leanings from previous incidents, their causes and risks, and other safety procedures as may be identified. • Conduct periodic safety audit, identify and remove potential hazards. • Ensure that qualified first aid is provided at all times; equipped first-aid stations shall be easily accessible throughout the work sites and camps. • For maintenance works in the marine environment, ensure that: ○ all persons engaged in the marine construction are competent swimmers. ○ Lifejackets are provided to workers and worn at all times. ○ Properly functioning ship-to-shore communications are provided. ○ No work during rough sea conditions. ○ Emergency rescue team is available at all times at the site during the marine work (such as rescue boat with divers). • Provide caution & information boards (traffic, safety, information etc.,) • Do not allow unauthorized / public entry into WTE Plant. • Undertake all necessary public safety measures, precautions					

Field or Activity	Potential Impact / Issue	Mitigation Measures	Parameter / Indicator of Compliance	Monitoring Frequency	Implementation Agency	Monitoring Agency	Estimated Cost
		• Ensure proper maintenance and cleanliness of the site and facilities Demarcate assembly area for emergencies • Provide medical aid facilities (first aid, doctor on call etc.)					

D. Environmental Monitoring Plan

536. Monitoring is the systematic collection of information over a long period of time. It involves the measuring and recording of environmental variables associated with the development impacts. Monitoring is needed to:

(i) Compare predicted and actual impacts;
(ii) Assess the effectiveness of mitigation measures;
(iii) Obtain information about responses of receptors to impacts;
(iv) Enforce and ensure legal standards and statutory requirements are complied with;
(v) Prevent and take remedial measures for negative environmental issues resulting from inaccurate predictions;
(vi) Minimize errors in future assessments and impact predictions;
(vii) Make future assessments more efficient;
(viii) Provide information for environmentally responsible project management; and
(ix) Improve the EIA and monitoring process.

537. Impact and mitigation monitoring will be carried out to compare predicted and actual impacts occurring from project activities and determine the efficiency of the mitigation measures. This type of monitoring will be targeted at assessing project-related impacts on the physical and biological resources, economic development, and/or socio-cultural resources including communities surrounding the project site.

538. Table 55 below show the environmental monitoring plan (EMOP) covering the construction and operational phases of the project. Costs for the monitoring activities shall be borne by either the DBO Contractor or PMU depending on whose responsibilities these activities are as indicated in the EMP.

Table 54: Environmental Monitoring Plan

Activity	Location	Parameters to be Monitored	Means of Monitoring	Frequency	Implementation Responsibility
Construction Stage					
Ambient air quality sampling and monitoring	Pre-identified monitoring stations at Thilafushi Island (the same sampling locations as during baseline data gathering). Other additional location/s as may be needed and identified during construction stage.	TSP, PM_{10}, $PM_{2.5}$, SO_x, NO_x	Mandatory ambient air quality monitoring using appropriate instruments; and Visual inspection	Quarterly (24-hour at sampling locations used during baseline data gatherin)	DBO Contractor to implement monitoring activity (PMU to check compliance)
Noise level monitoring	West side boundary (nearest establishments) of the WTE plant (the same locations as used during baseline data gathering). Other additional pre-identified noise level monitoring site/s at Thilafushi Island.	Day time and nighttime noise levels dB(A)	Ambient noise level monitoring equipment	Once prior to start of construction works (both day time and night time); Once during conduct heavy construction work expected to generate high noise level (either or both day time and night time, depending on when such heavy construction work is undertaken); Monthly during normal construction activities (both day	DBO Contractor to implement monitoring activity (PMU to check compliance)

Activity	Location	Parameters to be Monitored	Means of Monitoring	Frequency	Implementation Responsibility
				time and night time)	
Marine water quality monitoring	Pre-identified sampling locations at the northern and southern sides of the construction site (same sampling points as used during baseline data gathering).	BOD, DO, TSS, Oil and Grease, Fecal Coliform	Grab sampling at northern and southern sea sides relative to the location of construction site.	Once every quarter	DBO Contractor to implement monitoring activity (PMU to check compliance)
Groundwater quality monitoring	Pre-identified sampling wells, as used during baseline data gathering.	Oil and Grease, Fecal Coliform, Presence of petroleum and other chemicals use in the baseline data.	Grab sampling from deep wells.	Once every quarter	DBO Contractor to implement monitoring activity (PMU to check compliance)
Condition of disposal areas	All designated disposal areas	General condition of area, estimated capacity of disposed spoils, estimated remaining capacity that can be accommodated.	Visual inspection, Actual measurements in the area.	Weekly or monthly depending on the frequency of spoil disposal	DBO Contractor to implement monitoring activity (PMU to check compliance)
Condition at construction camp sites	Construction camp site.	All good housekeeping practices as specified in the EMP.	Visual inspection, Interview with occupants.	Weekly	DBO Contractor to implement monitoring activity (PMU to check compliance)
Assessment of occupational health and safety measure implementation	(i) Construction work site; and (ii) Construction camp site.	All occupation health and safety measures as specified in the EMP	Visual inspection, Interview with workers at sites and occupants at camp sites	Weekly	DBO Contractor to implement monitoring activity (PMU to check compliance)
Assessment of community health and safety measure implementation	Vicinity of construction work site and around Thilafushi Island.	All community health and safety measures as specified in the EMP	Visual inspection, Interview with locals.	Weekly	DBO Contractor to implement monitoring activity (PMU to check compliance)
Construction of cooling water lines, intake, and discharge points.	Construction site and previously identified alignment	Exact locations if complying with pre-approved and	Visual inspections.	Continuous as the construction	DBO Contractor to implement monitoring

Activity	Location	Parameters to be Monitored	Means of Monitoring	Frequency	Implementation Responsibility
	and location of cooling water lines, intake location and outfall location.	recommended locations per EIA report.		progresses (by DBO Contractor). Random inspection by PMU but at least once a week.	activity (PMU to check compliance)
Post-Construction					
Demobilization of construction heavy equipment	Construction site	Schedule of transport of heavy equipment to ensure no disruption or disturbance to marine traffic around Thilafushi Island.	Schedule of demobilization Visual inspection	Continuing or as needed during the demobilization activities.	DBO Contractor to implement monitoring activity (PMU to check compliance)
Site clearing	Construction site	Types of construction wastes remaining at site. Disposal site of remaining construction wastes.	Visual inspection of wastes and location of disposal site.	Continuing or as needed during the site clearing activities.	DBO Contractor to implement monitoring activity (PMU to check compliance)
Operation Stage					
Stack emission sampling and monitoring.	Stack sampling ports	TSP, SO_x, NO_x, Organic Carbon, CO, HCl, HF, Hg and its compounds, NH_3, Cd, As, Dioxins/Furans, sum of heavy metals and their compounds.	Mandatory stack emission sampling using appropriate instruments. Mandatory emission monitoring through CEMS. Visual inspection.	At least annually for stack emission sampling. Continuous monitoring through installed CEMS. Daily visual monitoring	DBO Contractor to implement monitoring activity (PMU to check compliance)
Ambient air quality sampling and monitoring	Pre-identified monitoring stations at Thilafushi Island (the same sampling locations as during baseline data gathering).	TSP, PM_{10}, $PM_{2.5}$, SO_x, NO_x	Mandatory ambient air quality monitoring using appropriate instruments; and Visual inspection end	Once every quarterly at the identified baseline sampling locations	DBO Contractor to implement monitoring activity (PMU to check compliance)

Activity	Location	Parameters to be Monitored	Means of Monitoring	Frequency	Implementation Responsibility
	Other additional location/s as may be needed and identified during operation stage.				
Noise level monitoring	West side boundary (nearest establishments) of the WTE plant (the same locations as used during baseline data gathering). Other additional pre-identified noise level monitoring site/s at Thilafushi Island.	Day time and nighttime noise levels dB(A)	Ambient noise level monitoring equipment	Once prior to start of operations (both day time and night time); Once every time generator set is utilized (either or both day time and night time, depending on when the generator set/s is/are used); Monthly during normal operating conditions (both day time and night time)	DBO Contractor to implement monitoring activity (PMU to check compliance)
Marine water quality monitoring	Pre-identified sampling locations at the northern and southern sides of the WTE site (same sampling points as used during baseline data gathering).	BOD, DO, TSS, Oil and Grease, Fecal Coliform	Grab sampling at northern and southern sea sides relative to the location of WTE site.	Once every quarter	DBO Contractor to implement monitoring activity (PMU to check compliance)
Effluent quality sampling and monitoring	Effluent sampling ports of leachate treatment plant and wastewater treatment plant	COD, BOD5, Total Inorganic Nitrogen, Nitrate, Sulfur, Phosphorus, Lead, Cadmium, Chromium, Hexavalent	Mandatory effluent quality monitoring using appropriate instruments; and Visual inspection	Monthly (grab sampling) Daily (visual)	DBO Contractor to implement monitoring activity (PMU to check compliance)

Activity	Location	Parameters to be Monitored	Means of Monitoring	Frequency	Implementation Responsibility
		Chromium, Mercury, Nickel, Zinc, Copper, Arsenic			
Cooling water discharge monitoring	Sampling port along thermal water discharge line	Temperature, Physical condition surrounding the outfall location	On the spot/ on-site temperature monitoring using appropriate instruments; and Visual inspection (through diving activity) to monitor the vicinity of the outfall	Daily or as frequent as necessary by DBO Contractor Once every quarter	DBO Contractor to implement monitoring activity (PMU to check compliance)
Groundwater quality monitoring	Pre-identified sampling wells, as used during baseline data gathering.	Oil and Grease, Fecal Coliform, Presence of petroleum and other chemicals.	Grab sampling from deep wells.	Once every quarter	DBO Contractor to implement monitoring activity (PMU to check compliance)
Condition at WTE workers accommodation, if any.	Workers accommodation.	All good housekeeping practices as specified in the EMP.	Visual inspection, Interview with occupants.	Weekly	DBO Contractor to implement monitoring activity (PMU to check compliance)
Assessment of occupational health and safety measure implementation	WTE plant	All occupation health and safety measures as specified in the EMP	Visual inspection, Interview with workers at WTE plant.	Weekly	DBO Contractor to implement monitoring activity (PMU to check compliance)
Assessment of community health and safety measure implementation	Vicinity of WTE plant and around Thilafushi Island.	All community health and safety measures as specified in the EMP	Visual inspection, Interview with locals.	Weekly	DBO Contractor to implement monitoring activity (PMU to check compliance)

Figure 131: Recommended Ambient Air Quality Monitoring Stations in Thilafushi Island

E. Reporting

539. **DBO Contracto**r. The DBO Contractor will be required to submit monthly monitoring reports to PMU during the implementation phase of the project. PMU may require DBO Contractor submit any additional information and reports that will be needed to fulfill the reporting obligation of MOE to ADB and Maldives EPA.

540. **PMU Reporting to ADB**. PMU will prepare and submit reports to ADB and Maldives EPA. PMU will prepare reports to be sent to ADB on a quarterly basis during construction phase and semiannual basis during the operation phase. Semiannual reports during operation are to be prepared and submitted until ADB issues a project completion report. The suggested outline of quarterly environmental monitoring reports is attached as Appendix 12. To facilitate monitoring and enable responses to emerging issues, monthly reports will be prepared by the PMU.

541. **PMU Reporting to Maldives EPA**. PMU will likewise prepare and submit reports to Maldives EPA as required by the schedule and report structure shown in Environmental Impact Assessment Guidelines by Maldives EPA. A detailed environmental monitoring report is to be compiled and submitted to the Maldives EPA on the format provided in the Maldives EPA's Environmental Impact Assessment Guidelines, following monitoring activities at each stage.

542. The monitoring report shall include details of the site, means of data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed.

543. Currently, Maldives does not have specific set of national standards for monitoring waste to energy plants. Hence an attempt could be made during the environmental monitoring stage to compare the performance of the environmental monitoring program with internationally recognized standards using the baseline that had been established with this study.

F. Cost of EMP Implementation

544. **Table 59** shows that most of the mitigation measures proposed by this EIA study comprise activities that are standard practice on most modern construction sites (e.g., preparing and implementing a site EHS Plan, planning access routes to avoid sensitive areas, etc.). Even the less commonly encountered measures (e.g., limiting the size construction areas to reduce ecological damage, conducting hot water outfall construction in calm conditions to limit the spread of disturbed sediment, etc.) would not be unusual for contractors who are used to working in similar environments. Most of the mitigation specified by this EMP therefore requires normal or good site practice and applies construction standards to which an experienced international contractor would work as a matter of course. The costs of these mitigation measures will therefore be covered by the DBO Contractor's normal budget estimates for project design, construction and operation. Indicative cost estimated for EMP implementation and monitoring activities are included in the EIA report and DBO bid documents. The exact and more specific budget for EMP implementation, monitoring, capacity development, and other safeguards requirements will be determined once the DBO contractor is on board and will be included in the Final EIA report.

545. However, there are some measures that contractors would not normally budget for, and these are the measures that are required because of the unique aspects of this project site. These include ecological marine surveys of coral reef to collect data and plan mitigation for the at-risk of marine environment; data collection and revised numerical modeling studies; turbidity monitoring

to reduce the spread of suspended sediment; and longer-term monitoring of the impacts of the project on marine benthos and fish.

546. The estimated cost of these activities is shown in Table 61 below. These based on the cost of similar exercises on other projects in Maldives and elsewhere. This shows that the total cost of implementing those aspects of the EMP that will not be covered by standard budgets for plant design, construction and operation. These costs would be included in bidding documents, and DBO Contractor can provide budget and quote in the budget as per the requirement of EMP in bidding document towards environmental surveys and social and environmental awards campaigns.

Table 55: Costs of the Monitoring Program[a]

Description	Total ($)
1. Design Stage	
Confirmatory surveys (protected/rare species of flora, fauna)	50,000
Green buffer zone	30,000
Numerical Modeling	50,000
Preparation of various plans suggested in the EMP	45,000
2. Construction Stage	
Environment & ecological monitoring	100,000
replantation of trees	50,000
3. Operation Stage	
Environmental Monitoring	50,000
4. Implementation support	
External environmental expert, supervision, monitoring etc.	150,000
Total	**525,000**

[a] These are only the costs that are not normally covered in standard budget line items of a BOQ.

G. Future Review and Revision of Documents

547. This EIA was conducted in the pre-tender period based on feasibility study and preliminary design. Guidance on potential approaches to construction and operation was obtained from experienced engineers and solid waste management experts, and descriptions of the likely construction and operation processes were prepared accordingly, adopting the basic operational parameters provided by the feasibility study and draft tender documents for the DBO contract. Potential impacts of the project were assessed on the basis of these descriptions and with the aid of primary baseline data on the existing environmental conditions gathered at the project site and its surroundings, secondary information obtained from published literature, and new data from surveys conducted during the EIA process.

548. The EIA report and EMP will be updated at detailed design stage and revisited at key stages throughout the project and will be updated at each stage to reflect any changes in design or approach, and to amend the impact assessment and mitigation and monitoring proposals as may be necessary. This process will also allow any unforeseen impacts to be documented, mitigated and monitored. The EIA report will be reviewed and updated, if necessary, by the DBO Contractor at the following key stages:

(i) after finalization of designs;
(ii) during construction (months 6 and 18);
(iii) at the end of facility commissioning (i.e. before operations begin); and
(iv) at the end of the first and second years of facility operation.

549. The review and revision process will be conducted by the DBO Contractor with the assistance of the external environmental expert hired under the project, and to be reviewed and approved by the Maldives EPA. It should be emphasized that it may not be necessary to revise the document at each stage, as this should only be done to address significant deviations from what is presented in this EIA report or its latest version in the future.

550. If there will be significant changes in the final detailed design compared to the preliminary design used in the EIA and/or if during the detailed design phase there will be identified associated facilities relative to the project per definition of ADB SPS, the DBO Contractor shall update the EIA report, including the EMP and EMOP, accordingly. The DBO Contractor shall submit the updated EIA report to PMU, and the PMU shall submit the updated EIA report to ADB for final review and disclosure.

X. CONCLUSION AND RECOMMENDATIONS

551. The EIA of GMWEP has been prepared based on review of technical specifications of the project as included in the DBO bid documents, primary and secondary information of the site and its surroundings. The overall findings of this EIA are:

(i) The project will result in significant environmental benefits because the current condition in Thilafushi and the project area will be improved;
(ii) During construction, the project will not have significant adverse environmental impacts and potential adverse impacts are manageable through the effective implementation of the EMP;
(iii) During operations, the project will have potential impacts on ambient air quality, marine water quality, marine ecology, noise, and occupational and community health and safety. However, with the performance guarantees required to be complied by the DBO contractor, significant impacts are avoided, and residual impacts can be mitigated by measures specified in the EMP; and
(iv) No social impacts pertaining to land loss, land fragmentation, physical displacement, loss of income, loss of productive land, potential income loss for fishermen and preventing fishing-related activities and fishing routes.

552. In view of the results of the studies undertaken in this EIA, following are the major recommendations that DBO Contractor shall undertake:

(i) Engage external expert(s) for verification of environmental monitoring reports and EMP implementation. External expert(s) are not involved in day-to-day project implementation or supervision;
(ii) Establish the ambient air quality monitoring stations in Thilafushi and Villingili as identified in the AUSTAL2000 and AERMOD air dispersion modeling studies and utilize these stations for monitoring activities during the operation phase as indicated in the environmental monitoring plan. The proposed locations are in Figure 128;
(iii) Conduct validation modeling during the starting months of normal operation of the WTE plant using actual CEMS and stack testing results to simulate actual operation of the plant;
(iv) Conduct validation of the thermal dispersion model during the starting months of normal operation of the WTE plant using actual temperatures taken within the thermal plume as described in MIKE 21 model and CORMIX;

(v) Install the cooling water discharge line at section M8 and position the outfall of the discharge line at a distance of 70 meters from the shoreline and 30 meters deep from the sea surface. See Figure 15;
(vi) Install the intake of the cooling water line at the vicinity of M1-M8. Ensure that position of the inlet opening is at minimum distance of 15 meters from the outfall and away from the direction of the cooling water jet plume. See Figure 24; and
(vii) Continuous monitoring around Thilfushi island to confirm the extent of biodiversity in various seasons of the year, including assessment of features pertinent to critical habitats. This is to ensure pre-construction works conditions and biodiversity risks are considered in the design, construction and operation, and to examine and mitigate the potential impacts of the project on areas significant for biodiversity.

553. Mitigation measures during operation phase are described in the EMP of this EIA report. Apart from all the mitigation measures in the EMP, the following are further recommendations that DBO Contractor shall consider:

(i) A system with controlled burning and a good air pollution control system should be included in the WTE plant design;
(ii) Incinerator with a stack height of minimum 45.7 m (per air dispersion modeling calculations) to reduce the impacts of air pollutants on the surrounding environment. Increasing this height further will be more favorable;
(iii) Environmental and occupational health and safety procedures for all processes should be established and enforced;
(iv) There should be strict inspection and testing during the installation of the HDPE membrane (or similar) and the various protective / drainage layers for the landfill;
(v) Preventive measures should be implemented to avoid loss of waste during transport and loading / off-loading;
(vi) There should be appropriate sanitation facilities and workshops (for machinery), as well as secure storage facilities for fuel and chemicals, including toxic and hazardous wastes;
(vii) Boilers should be regularly maintained, while structures such as the stacks and ducts should be regularly checked to avoid fugitive dusts sources and particulate accumulation;
(viii) Control devices such as the Dry Scrubber and Baghouse should undergo regular checkup and maintenance;
(ix) Solid wastes should have acceptance criteria in terms of waste characteristics;
(x) Periodic watering of roads to minimize generation and resuspension of dust particles;
(xi) Greenery and plantation at the perimeter or buffer areas to serve as vegetation walls that can help control dispersion of air pollutants. All plant species to be introduced shall be a known species that thrive in Thilafushi or Maldives. If necessary, the DBO Contractor shall obtain permission from relevant agency of the government to ensure such plant is endemic or native species in Maldives;
(xii) Ensure to follow the government policy on preventing introduction of invasive alien species in the island. In particular, DBO Contractor to use as reference the guidance issued by the MOE attached as Appendix 13;
(xiii) Regular ambient air quality monitoring should be conducted in hotspots and impact areas based on the results of the modeling report. Actual ambient monitoring may be treated as validation of model results; and
(xiv) Every modification and installation of new sources should be considered as additional contribution to emission of the plant. Hence, modeling updates should

also be conducted to determine assimilative carrying capacity of the area based on the impacts of the new modification or installation.

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- Nashfa Nashidh, Junior Environmental Consultant
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- Mohamed Affan Shakir, Hydrographic Surveyor (National Building Practitioners Registration Number: BP09218)
- Hamdhulla Shakeeb, Survey Specialist

XII. REFERENCES

AECOM (2011) Engineering Investigation and Environmental Studies for Integrated Waste Management Facilities or managing municipal solid waste (MSW) Hong Kong
Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste
DI (2015), Soil testing on Reclamation - Hulhumalé Phase 2 Development Dredging and Reclamation Works, Dredging International NV, Malé.
Directive 2010/75/EU of the European Parliament and the Council (Technical Provisions Relating to emission standards for waste incineration plants and waste co-incineration plants any time).
EU Industrial Emission Directives (IED).
Kylefors, K. (2002) Predictions of Leaching from Municipal Solid Waste (MSW) and Measures to Improve Leachate Management at Landfills, Doctoral Thesis, Department of Environmental Engineering, Lulea University of Technology, Sweden.
Hay, J. E. (2006). Climate Risk Profile for the Maldives. Malé, Maldives: Ministry of Environment and Energy and Water.
Jameel, A. (2007). Developing a Disaster Profile for Maldives, A thesis for the master's degree. Christchurch, New Zealand: University of Canterbury.
Jiang, X.Q., Mei, X.D., and Feng, D. (2016) Air Pollution and Chronic Air Way Diseases: What should people know and do? Journal of Thoracic Disorders, 8, E31-E40.
Johnson, C.A, Richner, G.A., Vitvar, T., Schittle, N., and Eberhard, M. (2008) Hydrological and geochemical factors affecting leachate composition in MSW incinerator bottom ash. Part 1; The Hydrology of Landfill, Lostorf, Switzerland
Maniku, H. A. (1990) Changes in the Topography of the Maldives, Forum of Writers on Environment (Maldives), Malé
MEE (2018). Feasibility Study for an Integrated Solid Waste Management System for Zone 3 (including Greater Malé) and Design of the Regional Waste Management Facility at Thilafushi, Ministry of Environment and Energy.
MEE (2017) EIA for the Proposed Reclamation of Thilafalhu for the establishment of the Regional Waste Management Facility for Zone 3, Kaafu Atoll, Ministry of Environment and Energy, Malé.
MEE (2017) EMP for the establishment of Island Waste Management Center in L. Hithadhoo, Ministry of Environment and Energy and Energy, Malé.
MEE (2017) State of the Environment 2016, Ministry of Environment and Energy and Energy
MEE (2017) Environment & Social Assessment & Management Framework Climate Change Adaptation Project (MEE, 2014) Ministry of Environment and Energy and Energy, Malé.
MEE (2016) Second National Communication of the Maldives to the United Nations Framework Convention on Climate Change, Ministry of Environment and Energy and Energy, Malé
MEE, (2015) Development of High-resolution Regional Climate Model for the Maldives, Ministry of Environemnt and Energy, Malé, Maldives
MEE (2014) Environment & Social Assessment & Management Framework Climate Change Adaptation Project, Ministry of Environment and Energy and Energy, Malé.
MEE, (2013), Guidance Manual for Climate Risk Resilient Coastal Protection in the Maldives, Ministry of Environment and Energy and Energy, Maldives
Ministry of Housing, Transport and Environment (2009), Third National Environment Action Plan, Ministry of Housing, Transport and Environment, Malé, Maldives
MEE (2012) Environmental and Social Impact Assessment for North Regional Waste Management Facility Construction and Operation (MEE, 2012), Ministry of Environment and Energy and Energy, Malé.
MEE (2012) ESIA for Construction and Operation North Regional Waste Management Facility at R. Vandhoo (MEE, 2012) Ministry of Environment and Energy and Energy, Malé.
MEE (2011), EIA for the proposed solid waste management facility at Thilafushi, Kaafu Atoll Maldives, Ministry of Environment and Energy and Energy, Malé.

MEEW (2005) State of the Environment of the Maldives 2004, Ministry of Environment and Energy, Energy and Water, Malé
MHAHE (2001) First National Communication of the Maldives to the United Nations Framework Convention on Climate Change, Ministry of Home Affairs, Housing and Environment, Malé
MPND (2005a) National Recovery and Reconstruction Plan, Ministry of Planning and National Development, Malé
Woodroffe, C. D. (1989) Maldives and Sea Level Rise: An Environmental Perspective, University of Wollongong, Wollongong
Naseer, A. & Hatcher, B. G. (2004) Inventory of the Maldives' coral reefs using morphometrics generated from Landsat ETM+ imagery. *Coral Reefs,* 23**,** 161-168.
UNDP (2006) Developing a Disaster Risk Profile of the Maldives, UNDP, Malé, Maldives
UNEP (2002) State of the Environment (SOE) report, Maldives, United Nations Environment Program.
Water Solutions Pvt. Ltd, (2008). Maps of Maldives, the complete guide to the Atolls and Islands of Maldives. Malé: Water Solutions Pvt. Ltd, Maldives
Woodroffe, C. D. (1992) Morphology and evolution of reef islands in the Maldives Seventh International Coral Reef Symposium, 1217 - 1226

Rapid Environmental Assessment (REA) Checklist

Instructions:

(i) The project team completes this checklist to support the environmental classification of a project. It is to be attached to the environmental categorization form and submitted to the Environment and Safeguards Division (SDES) for endorsement by the Director, SDES and for approval by the Chief Compliance Officer.

(ii) This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB's (a) checklists on involuntary resettlement and Indigenous Peoples; (b) poverty reduction handbook; (c) staff guide to consultation and participation; and (d) gender checklists.

(iii) Answer the questions assuming the "without mitigation" case. The purpose is to identify potential impacts. Use the "remarks" section to discuss any anticipated mitigation measures.

Country/Project Title: MLD / Greater Malé Waste-to-Energy Project

Sector Division: SAUW

Screening Questions	Yes	No	Remarks
A. Project Siting Is the project area…			The WTE project will be located in Thilafushi, an island on the southern rim of North Malé atoll, and on the eastern line of atolls within the archipelago. Thilafusi is an island classified as industrial zone and about 9.5km from Malé, the capital city of Maldives. In terms of geographic coordinates, Thilafushi is located at 04° 11' 00" N and 73° 26' 44" E.
▪ Densely populated?		✓	The island is classified as industrial island with no residential area. Population density is low. Baseline socio-economic profile shows there are no communities in Thilafushi. It is estimated that there 140 companies and less than 1,500 workers in the whole island.
▪ Heavy with development activities?		✓	Most locators in the island do not engage in heavy development activities. Survey shows that most establishments are warehouses and workshops only.
▪ Adjacent to or within any environmentally sensitive areas?			
o Cultural heritage site		✓	Not applicable. No cultural heritage site in the island.
o Protected Area	✓		The project site is located near 3 protected areas (Lions Head – 1 km away; Hans Hass – 2 km away; and Kuda Haa – 5 km away). Assessment of likely impacts of the project to these protected areas has been included in the EIA.
o Wetland		✓	Not applicable. No wetland in and around the island.
o Mangrove		✓	Not applicable. No mangrove in and around the island.

Screening Questions	Yes	No	Remarks
o Estuarine		✓	Not applicable. No estuarine in and around the island.
o Buffer zone of protected area		✓	Not applicable. No buffer zone in and around the island.
o Special area for protecting biodiversity		✓	Not applicable. Apart from the protected areas mentioned above, there is no other special area for protecting biodiversity in and around the island.
o Bay		✓	The island is situated within a large atoll (Kaafu Atoll). The project site is bordered by marine waters on its northern and southern boundaries. However, these coastal/marine waters are not regarded as sensitive or protected areas.
B. Potential Environmental Impacts Will the Project cause…			
▪ impacts associated with transport of wastes to the disposal site or treatment facility		✓	Not applicable. The project does not include component associated with transport of wastes.
▪ impairment of historical/cultural monuments/areas and loss/damage to these sites?		✓	There are no historical or cultural monuments in Thilafushi Island.
▪ degradation of aesthetic and property value loss?		✓	**Not anticipated.** The project will improve the existing situation in Thilafushi Island.
▪ nuisance to neighboring areas due to foul odor and influx of insects, rodents, etc.?		✓	**Not anticipated.** The current condition (dumpsite and unscientific waste management) will significantly improve due to the closing down and eventual rehabilitation of the existing dumpsite.
▪ dislocation or involuntary resettlement of people?		✓	**Not applicable.** The project will not cause or involve dislocation and involuntary resettlement of people.
▪ disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		✓	**Not applicable.** The project site is a newly built site in an industrial island (with no displaced humans or residential areas). The island is also not a host to any indigenous peoples or vulnerable groups.
▪ risks and vulnerabilities related occupational health and safety (OSH) due to physical, chemical, biological, and radiological hazards during project construction and operation?	✓		**Anticipated during construction and operation phases.** OHS risks are inherent to construction activities and WTE plant operations. These impacts will be mitigated by measures in the EMP and bidding documents following internationally recognized best practices and standards, such as the World Bank EHS Guidelines on Construction and Decommissioning Activities, and Guidelines on Waste Management Facilities.
▪ public health hazards from odor, smoke from fire, and diseases transmitted by flies, insects, birds and rats?		✓	**Not anticipated.** The project will improve the existing situation in Thilafushi Island.

Screening Questions	Yes	No	Remarks
▪ deterioration of water quality as a result of contamination of receiving waters by leachate from land disposal system?	✓		**Anticipated during operation.** The project includes a residual wastes landfill that will accommodate bottom ash and fly ash. The residual waste landfill cells may produce leachates that could potentially impact water quality of groundwater and marine waters. As measure included in the EMP and bidding documents, the landfill cells will be designed following internationally recognized best practices and standards for bottom ash/fly ash landfills to ensure no leachate will seep into the ground or flow out to the marine waters surrounding the project site.
▪ contamination of ground and/or surface water by leach ate from land disposal system?	✓		**Anticipated during operation.** The residual wastes landfill may produce leachates that could potentially impact water quality of groundwater and marine waters. However, as measure included in the EMP and bidding documents, the landfill cells will be designed following internationally recognized best practices and standards for bottom ash/fly ash landfills to ensure no leachate will seep into the ground or flow out to the marine waters surrounding the project site.
▪ land use conflicts?		✓	**Not applicable.** The project will utilize land that has been newly developed for the purpose.
▪ pollution of surface and ground water from leachate coming from sanitary landfill sites or methane gas produced from decomposition of solid wastes in the absence of air, which could enter the aquifer or escape through soil fissures at places far from the landfill site?		✓	**Not anticipated.** The project does not include any solid waste landfilling. During operation phase of the WTE plant, wastes that will be used as buffer will be baled and stored in storage areas protected with flooring and linings that will prevent seepage of leachate.
▪ inadequate buffer zone around landfill site to alleviate nuisances?		✓	Buffer zone and greenery is included in the design for the WTE plant.
▪ road blocking and/or increased traffic during construction of facilities?		✓	**Not anticipated.** The transport of construction materials will utilize an exclusive route being used by the government in transporting solid wastes to Thilafushi island. This route is different from the route being taken by locals, including private and commercial marine vehicles in the island.
▪ noise and dust from construction activities?	✓		**Anticipated**, but duration is short-term, site-specific within a relatively small area. Measures to mitigate these impacts are included in the EMP and bidding documents following internationally recognized best practices and standards. Environmental monitoring is included in the EMP.
▪ temporary silt runoff due to construction?	✓		**Anticipated**, but duration is short-term, site-specific within a relatively small area. Measures to mitigate this impact are included in the EMP and bidding documents following internationally recognized best practices and standards.
▪ hazards to public health due to inadequate management of landfill site caused by inadequate institutional and financial capabilities for the management of the landfill operation?		✓	**Not applicable.** The project includes institutional and financial capabilities for the management of the facilities.

Screening Questions	Yes	No	Remarks
▪ emission of potentially toxic volatile organics from land disposal site?	✓		**Anticipated.** The design of landfill for the bottom ash and fly ash includes cover and engineering measures to ensure no emissions of potentially toxic volatile organics.
▪ surface and ground water pollution from leachate and methane gas migration?	✓		**Anticipated.** Leachate will be generated during operations. However, the leachate collection and treatment system will be lined to ensure groundwater and marine waters are not polluted. Generation of methane gas is not anticipated.
▪ loss of deep-rooted vegetation (e.g. tress) from landfill gas?		✓	**Not applicable.** The project does not involve solid waste landfill operation.
▪ explosion of toxic response from accumulated landfill gas in buildings?		✓	**Not applicable.** Generation of methane gas is not anticipated.
▪ contamination of air quality from incineration?	✓		**Anticipated.** Air emission from the WTE plant will potentially contaminate the air and deteriorate ambient air quality in the island. However, this impact will be mitigated by the engineering design and requirements of the project. The DBO Contractor will be required to comply with a set of performance guarantees, which includes assurance that air emission will comply with internationally accepted emission standards for incinerator plants.
▪ public health hazards from odor, smoke from fire, and diseases transmitted by flies, rodents, insects and birds, etc.?		✓	**Not anticipated.** The project will improve the situation in Thilafushi Island. The shutting down of operation and eventual rehabilitation of the existing dumpsite will reduce the proliferation of disease vectors affecting the island and other nearby islands. During operation phase, the EMP will define measures to mitigate hazards following internationally recognized best practices and standards, such as the World Bank EHS Guidelines on Waste Management Facilities.
▪ health and safety hazards to workers from toxic gases and hazardous materials in the site?	✓		**Anticipated during construction and operation phases.** The EMP includes measures to mitigate impacts, such as the mandatory use of personal protective equipment by workers. Regular training will also be conducted to ensure that workers are aware of construction hazards and risks of chemicals during O&M.
▪ large population influx during project construction and operation that causes increased burden on social infrastructure and services (such as water supply and sanitation systems)?		✓	**Not anticipated.** Similar to workers of other industries in Thilafushi island, most workers of the project are expected to be residents of nearby islands such as Gulhi Fahlu, Villingili and Male. For workers who will be staying at the project site, the DBO Contractor will be required to establish a workers' camp with complete facilities.
▪ social conflicts if workers from other regions or countries are hired?		✓	**Not anticipated.** Priority in employment will be given to local residents of Maldives. Workers from other regions or countries will be considered only if no counterpart expertise is available locally.

Screening Questions	Yes	No	Remarks
▪ risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during construction and operation?	✓		**Anticipated.** Fuels and other chemicals will be used during the construction and operation of the WTE plant, and these may raise risks of explosions or fires at the site. However, the EMP will define measures to manage these risks, including the implementation of proper handling and storage of these chemicals, following internationally recognized best practices and standards, such as the World Bank EHS Guidelines on Construction and Decommissioning Activities, and Guidelines on Waste Management Facilities.
▪ community safety risks due to both accidental and natural hazards, especially where the structural elements or components (e.g., landfill or incinerator) of the project are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning?	✓		**Anticipated.** These risks are potential in the operation of the WTE plant. However, the EMP will define measures in order to manage these risks based on internationally accepted best practices and standards, such as the EHS Guidelines on Waste Management Facilities. Operational area will be clearly demarcated and access will be controlled. Only workers and project concerned members will be allowed to visit the WTE plant site.

A CHECKLIST FOR PRELIMINARY CLIMATE RISK SCREENING

Screening Questions		Score	Remarks[1]
Location and Design of project	Is siting and/or routing of the project (or its components) likely to be affected by climate conditions including extreme weather related events such as floods, droughts, storms, landslides?	2	Project location is in an island in Maldives that will likely be affected by floods due to rains or sea level rise.
	Would the project design (e.g. the clearance for bridges) need to consider any hydro-meteorological parameters (e.g., sea-level, peak river flow, reliable water level, peak wind speed etc.)?	2	Project location is in an island in Maldives that will likely be affected by floods due to rains or sea level rise. Therefore, the project design needs to consider the impact of flooding and sea level rise.
Materials and Maintenance	Would weather, current and likely future climate conditions (e.g. prevailing humidity level, temperature contrast between hot summer days and cold winter days, exposure to wind and humidity hydro-meteorological parameters likely affect the selection of project inputs over the life of project outputs (e.g. construction material)?	0	No significant effect
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	0	No significant effect
Performance of project outputs	Would weather/climate conditions and related extreme events likely affect the performance (e.g. annual power production) of project output(s) (e.g. hydro-power generation facilities) throughout their design life time?	0	No significant effect

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

Responses when added that provide a score of 0 will be considered low risk project. If adding all responses will result to a score of 1-4 and that no score of 2 was given to any single response, the project will be assigned a medium risk category. A total score of 5 or more (which include providing a score of 1 in all responses) or a 2 in any single response will be categorized as high risk project.

Result of Initial Screening (Low, Medium, High): High Risk

Prepared by:

Ninette Pajarillaga, Environment Specialist, SAUW

[1] If possible, provide details on the sensitivity of project components to climate conditions, such as how climate parameters are considered in design standards for infrastructure components, how changes in key climate parameters and sea level might affect the siting/routing of project, the selection of construction material and/or scheduling, performances and/or the maintenance cost/scheduling of project outputs.

Compliance with Terms of Reference Issued by the Maldives Environmental Protection Agency for the Conduct of EIA for the WTE Plant.

Scope of work — The EIA shall include but not necessarily be limited to the following tasks:	**Compliance**
Task 1. Description of the Proposed Project	
• Describe the RWMF (incinerator & ash disposal cells) and associated infrastructure (harbor, fuel storage, power supply etc.) to be developed including location, plant layout and its position using maps and drawings where appropriate. • Describe the current operational condition of Thilafushi, including the tonnage of waste received, method of waste management, operator of the facility, number of staff employed, and difficulties faced. • Describe the need and justification for the proposed facility and the methodology employed. • Provide detailed description of the proposed facilities. Describe the level of waste treatment that will occur. • Describe the methodology for air quality measurement. • Describe how hazardous waste are going to be processed. • Describe how electronic waste is going to be processed. • Describe how plastic is going to be processed. • Describe how all organic and inorganic waste is going to be processed. • Describe the steps involved from waste collection to transport to delivery to final location. • Describe the lessons learnt that was adopted from current operations at regional waste management facility at Vandh00. • Describe the operations of the RWMF including waste catchment area to be serviced by the facility, and waste type, volumes and composition to be received at the facility. Indicate the project life span, • Identify the emission releases likely to be of concern and the environmental aspects of the project area which may potentially be impacted by the proposal. • Describe the type of incinerator plant to be installed including specifications, performance characteristics and operational flow diagrams. Provide details of the ash disposal cells including capacity, dimensions, design specifications and phased development plans. • Describe the lifetime of the sanitary landfill site, for how many years is the sanitary landfill designed. • Provide requirements for new infrastructure to service the project such as water supply and sewerage infrastructure. Describe details of all equipment and vehicles that are going to be procured for the new operations. • Provide details of the amount of energy that will be generated from the waste to energy component and how it will be utilized.	Task 1 refers to various requirements covered under Phase 1 and Phase 2, including rehabilitation of the existing dumpsite. The draft EIA is intended to be submitted for the ADB approval process. Therefore, Section I and Section II of the draft EIA report discuss items related to the WTE Plant only. The draft EIA does not include detailed discussions on the activities under Phase 1 and rehabilitation of the existing dumpsite (although background information is included). Since the project will be awarded as a DBO contract, many of detailed information required are not completely described. In a separate submission to Maldives EPA, Ministry of Environment may submit additional document that would discuss compliance with the other

• Describe the model of management that will be adopted for the operations. • Justify the final elevation of structures (including as ash disposal cells) with reference to the height above the mean high tide, highest annual tides and risk of flood inundations during seasonal high tide regimes. • Describe the existing condition of the site and how Thilafushi is going to be restored. • Describe all project inputs and outputs. Including equipment and resources required both for construction and operational phase. Provide a detailed schedule of the project. • Describe how this project facilitates to achieve the 3R concept of waste management. That is reduce, reuse and recycle concept.	required items under Task 1.
Task 2. Description of the Environment - Assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area, focused on the marine, terrestrial and air environment. Aspects of the environment shall be described to the extent necessary for assessment of the environmental impacts of the proposed development. The extent and quality of the available data shall be characterized indicating significant information deficiencies and any uncertainties associated with the prediction of impacts. This section should provide details of the environment in the vicinity of the proposed development site. Data collection methodology used to describe the existing environment shall be detailed. All survey locations, sampling points, reef transects, vegetation transects, manta tows and soil sampling sites shall be referenced with Geographic Positioning System (GPS). All marine water samples shall be taken at a depth of 1m below the mean sea level or mid water depth for shallow areas. Baseline data collection shall focus on key issues needing to be examined for the EIA Consideration of likely monitoring requirements shall be borne in mind during survey planning, so that the data collected is suitable for use as a baseline for impacts monitoring. All available data from previous studies, if available shall be presented. Information required includes the following:	Compliance in Section V.
<u>Physical environment;</u>	

• Describe the meteorology (rainfall, wind, waves and tides), sea currents, surface hydrology, climatic and oceanographic conditions in the area, and bathymetry of the hot-water outfall location. • Describe the existing air quality within project site at Thilafushi and at the nearest islands. Ambient Air Quality measuring the following parameters: Particulate matter (PMIO, PM2), Sulphur dioxide (S02), Oxides of nitrogen (NOx), Methane (CH4), Carbon monoxide (CO), Cadmium (Cd), Lead (Pb), Mercury (Hg), Hydrocarbons (HCs). Measurements should be made from all locations from which data was taken in 2011 ELA report. • Dispersion model for air pollution taking into account wind direction. • Describe noise sources contributing to ambient noise levels (day/night) at the nearest and adjacent islands. • Sensitive noise receptors adjacent to all project components shall be identified and typical background noise estimated based on surveys at representative sites. A justification for an ambient noise baseline (dBA) at the nearest and adjacent inhabited islands shall be provided. Ambient Noise should be measured from the facility location, harbor location and also from the waste transfer road location. • An indication of the quality and quantity of water resources in the vicinity of the project site should be given including spatial and temporal monitoring to accurately characterize baseline groundwater characteristics and present water uses. Groundwater quality measuring following parameters pH, color, odor, turbidity, Electrical Conductivity, nitrate, phosphate, chloride, total dissolved solids, mercury, lead, arsenic, manganese, cadmium, iron, Total Coliform and polyaromatic hydrocarbons. From all locations from which water quality was assessed in 2011 and from the reclaimed areas following 2011. • Marine water quality should be assessed. The following parameters needs to be investigated. This includes Temperature, pH, salinity, Total Suspended Solids (TSS), phosphate, nitrate, ammonia, sulphate, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Arsenic and Total Coliform. Assessment should be undertaken at all waste transfer routes and from locations from which data was taken in 2011 report. • Currents data should be measured from the harbor and channel locations and from the lagoon. Comparisons should be made with the data collected from 2011 EIA report. Dispersion model of waste in water should be presented, taking into account currents.	
<u>Biological environment:</u>	

• Description of the terrestrial environment of the site including current condition of the site, • Assessment of the marine environment should be undertaken from all locations from which data was taken in 2011 ELA report. This assessment should cover coral cover and fish census information. • Plankton Assessment from 5 different locations around Thilafushi. • Areas of special sensitivity including coral reefs and marine protected areas near Thilafushi shall be marked on a map and described. This shall include environmentally sensitive areas, protected areas and significant dive sites.	
Socio-cultural environment:	
• Describe the natural features and landscapes of the project site which may have a cultural significance. • Describe the visual amenity from the nearest and adjacent islands to Thilafushi. • Describe any Structures on the project site which may have cultural or religious significance. • Provide details of the land use plan in Thilafushi. This shall refer to current and future envisioned development projects.	
Hazard Vulnerability	
• Vulnerability of proposed project area to flooding and storm surges need be described.	
Task 3. Legislative and regulatory considerations — Identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that applies to the project. Outline the pertinent policies, regulations and standards governing project location, land use, environmental quality, and public health and safety. Relevant sections of the regulations need to be highlighted and how the project complies with these sections indicated. Specific attention needs to be given to the waste management regulation and waste policy and how the project complies with these documents and how the relevant approvals will be attained.	Compliance in Section III.
Task 4. Determination of Potential impacts of proposed project — Identify the major issues of environmental and social concern and indicate their relative importance to the design of the project. Distinguish construction and postconstruction phase impacts, significant positive and negative impacts, and direct and indirect impacts. Identify impacts that are cumulative, unavoidable or irreversible. Particular attention shall be given to impacts associated with the following:	Compliance in Section VI.

Site preparation. construction and commissioning:	
• RWMF construction impacts including a description of the relevant parts and nature of the works, an indicative construction timetable, including expected commissioning and start-up dates and hours of operation, and a description of major work programs for the construction phase, including an outline of construction methodologies. • Commissioning impacts — including a description of the regional waste management facility commissioning process.	
Incinerator operation:	
• Describe solid waste management activities during operations, with particular reference to waste collection, transport, sorting, incinerator loading, and disposal of incinerator ash. • Characteristics of any hazardous materials resulting from or involved in the project, indicating appropriate management strategies (e.g. handling, storage, treatment, disposal). • Provide an inventory of projected annual emissions for each relevant greenhouse gas, with total emissions expressed in 'C02 equivalent' terms.	
Air Quality:	
• Characterize the nature of emissions to air likely to be produced during the incineration process including flue gas composition, volumes, expulsion height, ejection velocity and temperature. • Describe the pollution control equipment, techniques and the features of the incinerator designed to suppress or minimize emissions to air. • Air dispersion modelling outcomes which estimate the effect of the expected emissions from the proposed incinerator on ambient air quality within the air shed with particular reference to the nearest and adjacent islands. The air dispersion modelling exercise shall evaluate the extent and concentration of following pollutants which are typical constituents of solid waste combustion: sulfur dioxide, nitrogen oxides (as nitrogen dioxide), TSP, PM2.5 and PM 10. Air emissions shall be stated in respect stack and ground level concentrations, using a dispersion model.	
Ground Water	
• Provide details of potential impacts on the quality of ground and marine waters. Reference shall be made to leachate from ash disposal, the potential of wastewater to contaminate ground and marine water, and impact on current and future potential groundwater usage from the Thilafushi.	

• Describe the pollution control equipment and design features of the proposed development for prevention and minimization of contamination of groundwater resources.	
Natural Environment	
• The proximity of the facility to any sensitive areas shall be described. Describe measures to be taken to avoid and minimize potential adverse impacts of the proposal on sensitive terrestrial and aquatic environments. • Describe potential issues relevant to sensitive areas, or areas which may have low resilience to environmental change a rising from the construction, operation of the project including clearing, salvaging or removal of vegetation. Areas of special sensitivity include coral reefs, marine protected areas and communities. The capacity of the environment to assimilate discharges/emissions shall be assessed. Short-term and long-term effects shall be considered with comment on whether the impacts are reversible or irreversible. The discussion shall cover all likely direct and indirect environmental harm due to the project on flora and fauna particularly sensitive areas. • If construction and operation of the project are likely to cause adverse impacts on sensitive areas or areas which may have low resilience to environmental changed describe environmental offsets that would counterbalance the impact on these values.	
Noise Amenity,	
• Describe the impacts of noise generated during the construction and operation of the proposed facility on nearest and adjacent islands. An analysis of noise impacts shall include the estimated noise levels generated by the proposed development assessed against typical background levels on the islands, and the impact of noise at all potentially sensitive receivers compared with an acceptable international standard. • If noise is likely to cause an adverse impact propose measures to minimize or eliminate these effects, including details of any screening, lining, enclosing or bunding of facilities, or timing schedules for construction and operations.	
Socio-cultural:	

• Describe the impacts of the proposed development on the natural features and landscapes of the project site which may have socio - cultural significance. Use sketches, diagrams, elevation drawings to portray the near views and far views of the completed structures and their surroundings from visually sensitive locations. • Describe measures to be taken to avoid and minimize potential adverse impacts of the proposal on visual amenity. Justify the proposed development with particular reference to potential for visual amenity. • Describe the impact of the proposed development on any structures which may have cultural or religious significance. Describe measures to be taken to avoid, manage or mitigate potential impacts on these structures during construction and operation of the proposed development. • The methods used to identify the significance of the impacts shall be outlined. One or more of the following methods shall be utilized in determining impacts; checklists, matrices, overlays, networks, expert systems and professional judgment. Justification shall be provided to the selected methodologies. The report shall outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative and unavoidable.	
Task 5. Alternatives to proposed project — Describe alternatives including the "no action option" should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative" which represents current conditions. This section shall include a comparison of the technologies and methods for management and control of contaminants which may potentially impact on the environment including alternatives for ash disposal. All alternatives shall be compared according to international standards and commonly accepted standards as much as possible. Mitigation options shall be specified for each component of the proposed project. A cost benefit analysis needs to be presented in this section for the different alternative methods of waste management proposed. Analysis from environmental, social and economic perspective needs to be presented.	Compliance in Section IV
T**ask 6. Environmental Management Plan (mitigation 'monitoring)** — The Project's environmental management plan (EMP) shall consists of a set of mitigation, monitoring, and institutional measures to be taken during implementation and operation to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels. In cases where impacts are unavoidable	Compliance in Section IX. However, specific details on institutional arrangements are yet to be agreed upon between ADB and the

arrangements to compensate for the environmental effect shall be given. The plan shall include off-set measures if mitigation measures are not feasible, cost-effective, pr sufficient. Specifically, the EMP shall:	Government of Maldives.
Mitigation and management of negative impacts	
• Identify and summarizes all anticipated significant adverse environmental impacts (coral reef and marine environment, air and groundwater (as applicable); • Describe each mitigation measure, including the type of impact to which it relates and the conditions under which it is required, together with designs, equipment descriptions, and operating procedures, including: - General operating procedures for managing and mitigation risks to the environment from general facility, operations including waste collection, transport, incinerator loading, hazardous waste handling, fuel, transfer and storage, litter management disposal of incinerator ash and residues, - Manufacturer's operational guidelines specifically outlining safety and emission control procedures as well, as recommended maintenance practices. - General operating procedures for implementing back-up measures that will act in the event of failure of primary measures to minimize the likelihood of adverse air impacts. • Estimate any potential environmental impacts of these measures; • Provide linkage with any other mitigation plans required for the project.	
Monitoring	
• Provide (a) a specific description, and technical details, of monitoring measures, including the parameters to be measured, methods to be used, sampling locations, frequency of measurements, detection limits (where appropriate), and definition of thresholds that will signal the need for corrective actions; and (b) monitoring and reporting procedures to; - (i) Ensure early detection of conditions that necessitate particular mitigation measures, and - (ii) Furnish information on the progress and results of mitigation. Specifically, the plan shall address physical groundwater quality, air emissions, coral reef and marine environment (as applicable).	
Capacity Development and Training	
Specifically, the EMP shall provide a specific description of institutional arrangements who is responsible for carrying out the mitigation and monitoring measures (e.g., for operation, supervision,	

enforcement, monitoring of implementation, remedial action, financing, reporting, and staff training). EMP shall cover steps to strengthen environmental management capability in the agencies responsible for its implementation.	
Implementation Schedule and Cost Estimates	
The EMP shall provide (a) an implementation schedule for measures that shall be carried out as part of the project, showing phasing and coordination with overall project implementation plans; and (b) the capital and recurrent cost estimates and sources of funds for implementing the EMP. This shall be presented for mitigation, monitoring, and capacity development required for the implementation of the EMP.	
Task 8. Stakeholder Consultation — The stakeholder consultation process shall provide opportunities for stakeholders, community involvement and education. It may include interviews with individuals, public communication activities, interest group meetings, production of regular summary information and updates (i.e. newsletters), and other consultation mechanisms to encourage and facilitate active stakeholder consultation. Stakeholders consultation should cover Ministry of Environment and Energy, Greater Male' Investment Limited, WAMCO, EPA, STELCO, Maldives Energy Authority (MEA), Energy Department (MEE), Waste Department (MEE), nearby resorts, Male' City Council, Ministry of Housing and Infrastructure, existing businesses in Thilafushi, existing workers of the facility, NGOs and the general public shall be consulted. Stakeholder consultation processes (community engagement) for all parts of the EIA shall be integrated. Sufficient information about the development and the consultation process shall be provided to the community at an early stage and in accessible and culturally appropriate ways. Information about the development should inform the community about the benefits, disadvantages, trade-offs, potential issues and implications as required, enabling them to formulate their views. Information about the consultation processes conducted and their results shall be provided including: The methodology adopted, a list of stakeholders consulted during the program and how their involvement was facilitated, the processes conducted to date and the future consultation strategies and programs including those during the operational phase of the project, Recommendations on how the project might address concerns raised during public consultation. List of those who are consulted including their names and contacts should be provided in the EIA report,	Compliance in Section VII.

Task 8. Climate Change Risk Assessment — Review of literature on climate change specific to the Maldives shall be carried out. Following this, climate change considerations shall be suggested for the project, including sea level rise, tropical cyclonic winds, storm surges, probable maximum precipitation. Climate change adaptation considerations for the design shall be discussed.	Compliance with this task is covered across the different sections of the EIA report, but not explicit because the assessment is yet to be undertaken through a CVRA. Since the project will be awarded under a DBO contract, the risks due to climate change will be integrated in the final detailed design that is to be undertaken during design phase.
Presentation- The environmental impact assessment report, to be presented in digital format, shall be concise and focus on significant environmental issues. It shall contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations of or any references used in interpreting those data. The environmental assessment report shall be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2012 and relevant amendments.	Yet to be complied.
Timeframe for submitting the EIA report — The developer shall submit the completed EIA report within 6 months from the date of this Term of Reference.	

FOR DISCUSSION ONLY

Comparative Analysis of Maldives Framework and ADB Safeguard Policy Statement

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
Policy Principle 1: Use a screening process for each proposed project, as early as possible, to determine the appropriate extent and type of environmental assessment so that appropriate studies are undertaken commensurate with the significance of potential impacts and risks.			
Key element (1) Use a screening process to determine the appropriate extent and type of environmental assessment	The **EIA regulations**, in particular Part III elaborates the process by which screening is used to identify proposals that have little or no environmental impact that are separated by projects that require an in-depth study. Schedule D of the EIA regulations list of projects that need to undertake an EIA because of likely severity of impacts. Proposals not listed in Schedule D are required to submit a Development Proposal Screening Form (Schedule C 1 of EIA Regulations) that is submitted to the Ministry of Environment where a decision is made either to approve the project or determine if further information is required through the preparation of an IEE needs (Schedule C 3 of EIA Regulations provides the Development Proposal Screening Decision Form). For projects falling under Schedule D an EIA application needs to be submitted along with TORs for the EIA to the Ministry of Environment for approval with or without proposed revisions. An EIA then should be prepared based on the TORs approved by the Ministry of Environment	Full Equivalence	None required
Policy Principle 2: Conduct an environmental assessment for each proposed project to identify potential direct, indirect, cumulative, and induced impacts and risks to physical, biological, socioeconomic (including impacts on livelihood through environmental media, health and safety, vulnerable groups, and gender issues), and physical cultural resources in the context of the project's area of influence. Assess potential trans-boundary and global impacts, including climate change. Use strategic environmental assessment where appropriate.			

[1] There are relevant provisions of the Environment Protection and Preservation Act of 1993, Environmental Protection Regulations of 2007 that deal with environmental assessment and management..

[2] "Full Equivalence" denotes that the Maldives legal requirement(s) are in complete harmony with the corresponding ADB Safeguard Objective, Scope and Trigger, Policy Principle or Key Element thereof. "Partial Equivalence" denotes that the Maldives legal requirement is in partial harmony with the corresponding ADB Safeguard Objective, Scope and Trigger, Policy Principle or Key Element; and "No Equivalence" denotes that no Maldives legal requirement can be found that corresponds to the particular ADB Safeguard Objective, Scope and Trigger, Policy Principle or Key Element.

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
Key element (1) Identify indirect as well as direct impacts	**Schedule E of the EIA Regulations** requires that the direct and indirect environmental impacts on bio-physical, economic and human environment, including impacts on human well-being be assessed	Full compliance	None required
Key element (2) Identify cumulative impacts	The **EIA Regulations**, defines "EIA" as a means of identifying, predicting, evaluating and mitigating the biophysical, social, cumulative, economic and other relevant effects of a proposed development and "Cumulative Impacts" as the contained effect on the environment of two or more activities, or parts of projects, including synergistic projects Similarly, the EIA Regulations require the project proponent to provide information on other similar projects in the area and IEEs and EIAs done for those projects	Full equivalence.	None required
Key element (3) Identify induced impacts	**The EIA Regulations** requires the assessment of indirect impacts, which are defined as "indirect results….as those caused by an action or actions and are later in time or further removed in distance, but are still reasonably foreseen, and includes growth-regulating effects and other effects to induced changes in the patterns of land-use, population density or growth rate and related effects on air, water and other natural systems, including ecosystems"	Full equivalence	None required
Key element (4) Identify physical impacts	**Schedule E of the EIA Regulations** requires that the direct and indirect environmental impacts on bio-physical, economic and human environment, including impacts on human well-being be assessed and that includes the description and direct and indirect impacts on the following: - Soil, relief, landforms, land use and drainage systems - Surrounding infrastructure and drainage; and - Beach systems, including composition, stability, tide and wave dynamics	Full Equivalence.	None required
Key element (5)	**Schedule E of the EIA Regulations** requires that the direct and indirect environmental impacts on bio-physical, economic and human environment, including the impacts on the following biological elements:	Full Equivalence.	None required

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
Identify biological impacts	- Flora, fauna, rare or endangered species, sensitive habitats of ecological importance, including mangroves and wetlands; and - Marine environment, including sandy and rocky bottoms, coral reefs and sea grass beds		
Key element (6) Identify socioeconomic impacts (including on livelihood through environmental health and safety, vulnerable groups, and gender issues)	In the **EIA Regulations**, "EIA" is defined as a means of identifying, predicting, evaluating and mitigating the biophysical, social, cumulative, economic and other relevant effects of a proposed development and "the Human Environment" as the natural and physical environment and the relationships of people. **Schedule C.1 of the EIA Regulations Part 3** requires the EIA to identify and assess the impacts on public well-being, public health, public safety, public transport, employment and economic status.	Partial Equivalence There is no reference in the EIA legislation regarding need to assess impacts on vulnerable groups and gender issues.	For full equivalence, the EIA Regulations should include assessment of the impact on vulnerable groups and gender related impacts.
Key element (7) Identify impacts on physical cultural resources	**Part II (2) of the EIA Regulations** requires EIAs and IEEs to consider effects of development programs on:…….(d) material assets and cultural heritage. **Schedule E of the EIA Regulations** requires description of natural, economic and human environment, that includes among other things…..socio-economic characteristics….., including unique cultural characteristics.	Full equivalence	None required
Key element (8) Identify impacts in the context of the project's area of influence	There is reference to defining the boundaries of the area affected by the development project, but no specific reference to the context of the project's area of influence, although the **EIA regulations** refers to induced impacts relating to changes patterns of land-use, population density or growth rate and related effects on air, water and other natural systems, including ecosystems, that might extend beyond the boundaries of the project area	Full equivalence	None required
Key element (9) Assess potential trans-boundary impacts	There is no explicit reference to "assessment of trans-boundary impacts" in the legal framework.	No Equivalence.	For full compliance, new or revised legislation/regulations should require assessment of trans-boundary impacts
Key element (10) Assess potential global impacts, including climate change	**Part II Section 4 of the EIA Regulations** requires that project proponents take into account all policies and legislation, including commitments as Party to relevant International Conventions and Protocols	Full Equivalence	None required

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
Key element (11) Use strategic environmental assessment	There is no explicit reference to conduct of strategic environmental assessment in the legislation	No equivalence	To achieve full compliance the EIA regulations or similar legislation should require the conduct of SEAs, including assessment of plans, programs and policies
Policy Principle 3: Examine alternatives to the project's location, design, technology, and components and their potential environmental and social impacts and document the rationale for selecting the particular alternative proposed. Also consider the no-project alternative.			
Key element (1) Examine alternatives to the project's location, design, technology.	**Schedule E of the EIA regulations** discusses the need for consideration of alternatives such as: (i) To identify and describe at least 3 alternatives, one of which should be the no-development option, define clear criteria to evaluate the alternatives, and determine the preferred alternative; (ii) Discuss whether the project be undertaken elsewhere, perhaps an alternate locations with less likely impacts; and (iii) Include discussion of alternative ways in which the project can may be carried out to cause less harm to the environment. (iv) Discuss the preferred alternative and why it was selected	Full equivalence	None required
Key element (2) Consider the no-project alternative	**Schedule E of the EIA regulations** requires the need to: (i) To identify and describe at least 3 alternatives, one of which should be the no-development option, define clear criteria to evaluate the alternatives, and determine the preferred alternative;	Full equivalence	None required
Policy Principle 4: Avoid, and where avoidance is not possible, minimize, mitigate, and/or offset adverse impacts and enhance positive impacts by means of environmental planning and management. Prepare an environmental management plan (EMP) that includes the proposed mitigation measures, environmental monitoring and reporting requirements, related institutional or organizational arrangements, capacity development and training measures, implementation schedule, cost estimates, and performance indicators. Key considerations for EMP preparation include mitigation of potential adverse impacts to the level of no significant harm to third parties, and the polluter pays principle.			
Key element (1) Avoid, and where avoidance is not possible, minimize, mitigate, and/or offset adverse impacts	**The EIA Regulations** recognizes the following explicit mitigation actions to emanate from the EIA process: (a) Avoiding the impact altogetherby not taking a cetain action or a part of an action (b) Minimizing negative impacts by limiting the degree and magintude of the action and its implementation	Full equivalence	None required

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
and enhance positive impacts by means of environmental planning and management	(c) Optimizing the positive impacts of development (d) Rectifying the impact by repairing, rehabilitating or restoring the affected environemnt (e) Reducing or eliminating the impact over time by conservation operations during the life of the action; and (f) Compensating for the impact by replacing or providing substitute resources or environments		
Key element (2) Prepare an environmental management plan (EMP)	**Schedule E of the EIA Regulations "Contents of an IEE of EIA study"** outlines the Content of an IEE study or EIA study report that development proponents are expected to prepare and submit to the Ministry of Environment for review and provision of environmental clearance of a development project, that includes a report with proposed measures to mitigate adverse environmental impacts.	Full equivalence	None required
Key Element (3) Prepare an environmental management plan (EMP) that includes the proposed… environmental monitoring and reporting requirements	**Schedule E of the EIA Regulations "Contents of an IEE of EIA study" under title "Environmental Monitoring"** requires the preparation of an environmental monitoring plan that includes provisions for on-site monitoring during (i) site preparation; (ii) construction/implementation and (iii) decommissioning phases, as well as the longer-term maintenance requirements **Schedule M of the EIA Regulations "Format for Environmental Monitoring Reports"** requires the submission of summary reports at 2 monthly intervals and a final report at the end of the decommissioning phase or as specified in the Environmental Decision Statement to be submitted to the Ministry	Full Equivalence	None required
Key Element (4) Prepare an environmental management plan (EMP) that includes… related institutional or organizational arrangements	**Schedule I of the EIA Regulations "Review of IEE or EIA study"** Number 7: "Mitigation" requires the mitigation measures or "EMP' Plan to define in specific, practical terms the costs, manpower, equipment, timing and technology needed	Partial Equivalence While, the EMP is required to provide for manpower requirements for its implementation, it is not explicit in terms of requiring institutional or organization arrangements for its implementation	To attain full equivalence, the EMP should explicitly require the definition of institutional or organization arrangement
Key Element (5) Prepare an environmental management plan (EMP) that includes the	**Schedule I of the EIA Regulations "Review of IEE or EIA study"** Number 7: "Mitigation" requires an assessment of institutional capacity to carry out mitigation measures	Partial Equivalence The requirement for capacity development and training for	To attain full equivalence, the legislation should made explicit reference for including capacity building and training

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
proposed... capacity development and training measures		implementation of EMP is implicit, rather than explicit in the legislation	needs in the EMP
Key Element (6) Prepare an environmental management plan (EMP) that includes the proposed …implementation schedule	**Schedule I of the EIA Regulations "Review of IEE or EIA study"** Number 7: "Mitigation" requires the mitigation measures or "EMP' Plan to define in specific, practical terms the costs, manpower, equipment, timing and technology needed	Full Equivalence	None required
Key Element (7) Prepare an environmental management plan (EMP) that includes the proposed… cost estimates	**Schedule I of the EIA Regulations "Review of IEE or EIA study"** Number 7: "Mitigation" requires the mitigation measures or "EMP' Plan to define in specific, practical terms the costs, manpower, equipment, timing and technology needed	Full Equivalence	None required
Key element (8) Prepare an environmental management plan (EMP) that includes the proposed …performance indicators	**Schedule M of the EIA Regulations "Format for Environmental Monitoring Reports"** is comprehensive, including requirements for monitoring and reporting on (i) implementation of mitigation measures; (ii) monitoring results, including date, time frequency and duration; (iii) presentation of environmental quality performance and standards; (iv) presentation of monitored parameters, etc.	Full Equivalence	None required
Key Element (9) Key considerations for EMP preparation include mitigation of potential adverse impacts to the level of no significant harm to third parties, and the polluter pays principle.	The legislation is implicit in terms of the requirement to avoid or minimizing the impact on the environment or human health and safety	Partial Equivalence There is no explicit reference to the polluter play principle	To attain full equivalence, the legislation should explicitly made requirement for ensuring that the developer or polluter pay if there is damage to the environment or third party
Policy Principle 5: Carry out meaningful consultation with affected people and facilitate their informed participation. Ensure women's participation in consultation. Involve stakeholders, including affected people and concerned nongovernment organizations, early in the project preparation process and ensure that their views and concerns are made known to and understood by decision makers and taken into account. Continue consultations with stakeholders throughout project implementation as necessary to address issues related to environmental assessment. Establish a grievance redress mechanism to receive and facilitate resolution of the affected people's concerns and grievances regarding the project's environmental performance.			
Key element (1) Carry out meaningful	**Schedule E of the EIA Regulations** lists the Public Consultation requirements as follows:	Partial equivalence	For full equivalence, the EIA Regulations should explicitly

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
consultation with affected people and facilitate their informed participation	That the IEE and EIA process and report should include: (a) A list of persons consulted including persons in statutory bodies, atolls and island offices, community groups and NGOs, local residents, local fishermen, tourism operators and others likely to be affected by the proposed development (b) Information on how, when and where consultations were conducted, e.g. stakeholder meetings in affected area, individual meetings, questionnaires; and (c) Summary of outcome of consultations, including the main concerns identified.	There is no clear timeline established when consultation should occur, if consultation should take place throughout project implementation and the means for resolution of any affected person's concerns	identifying the different stages at which consultation should take place (e.g. early in EIA process, before finalization of EIA and during project implementation and monitoring) as well as means to address people's concerns and grievances
Key element (2) Ensure women's participation in consultation	There is no explicit reference to women's participation in the consultative process, although reference to consultation in the EIA regulations.	No equivalence	For full equivalence the EIA Regulations should explicitly require consultation and participation of women in the EIA process and during project implementation
Key element (3) Involve stakeholders, including affected people and concerned nongovernment organizations, early in the project preparation process.	While there is explicit reference in **Schedule E of the EIA Regulations** of the requirements for involving stakeholders and affected people as outlined below, it does not specify the stages (including early in project preparation process) that consultation is mandatory: That the IEE and EIA process and report should include: (a) A list of persons consulted including persons in statutory bodies, atolls and island offices, community groups and NGOs, local residents, local fishermen, tourism operators and others likely to be affected by the proposed development (b) Information on how, when and where consultations were conducted, e.g. stakeholder meetings in affected area, individual meetings, questionnaires; and (c) Summary of outcome of consultations, including the main concerns identified.	Partial equivalence There is no reference in the legislation to the stages and timing of consultations	To attain full equivalence, the EIA Regulations should explicitly identifying the different stages at which consultation should take place, including early in the project preparation process
Key element (4) Establish a grievance redress mechanism	There is no explicit reference to establishment of a grievance redress mechanism at the project level.	No equivalence	For full equivalence the EIA Regulations should specify mechanisms for addressing people's grievances both during the EIA process and during project implementation
Policy Principle 6: Disclose a draft environmental assessment (including the EMP) in a timely manner, before project appraisal, in an accessible place and in a form and language(s) understandable to			

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
affected people and other stakeholders. Disclose the final environmental assessment, and its updates if any, to affected people and other stakeholders.			
Key element (1) Disclose a draft environmental assessment (including the EMP) in a timely manner, before project appraisal, in an accessible place.	The EIA Regulations require public consultations, and the invent that the project is complex and sufficiently controversial, the Ministry of Environment can request additional public consultation. This would take place before the EA report is finalized.	Partial equivalence There is no guidance on the disclosure of draft EA (and EMP), including timing, location and language	To achieve full equivalence, the EIA Regulations should clearly specify the timing, location, language and other specifies regarding the disclosure of the draft EA (and EMP)
Key element (2) Disclose the final environmental assessment, and its updates if any, to affected people and other stakeholders	There is no guidance in the legislation regarding the disclose of the final EA report and EMP, although the decision of approval or environmental clearance has to be disclosed	No equivalence	For full equivalence, the EIA Regulation should explicitly specify the need for disclosure of the final EA and EMP reports in an accessible location and in a language that is understandable to the affected people and other stakeholders
Policy Principle 7: Implement the EMP and monitor its effectiveness. Document monitoring results, including the development and implementation of corrective actions, and disclose monitoring reports.			
Key element (1) Implement the EMP and monitor its effectiveness.	**The EIA Regulations, Schedule J "Environment Decision Statement"** issued to the developer by the Ministry of Environment, Item 2 (i) (ix) requires that all mitigation measures proposed in the EIA report for the construction phase and operational phase as outlined in page/s (as per the EIA Report) shall be fully implemented.	Full equivalence	None required
Key element (2) Document monitoring results, including the development and implementation of corrective actions, and disclose monitoring reports.	**The EIA Regulations, Part IV Item 13 "Environmental Monitoring and Mitigation** has the following instructions: (i) The proponent shall fund and conduct environmental monitoring and implementing mitigation measures for the development proposal if specified and required by virtue of the Environmental Decision Statement (ii) The proponent shall regularly submit summary environmental monitoring reports….. (iii) The proponent shall maintain records of all monitoring data and on request make these available to the Ministry of Environment (iv) The proponent shall submit a final environmental monitoring and mitigation report to the	Partial equivalence There is no requirement for public disclosure of the monitoring results, disclosure is limited to submission to government agencies	For full equivalence, the EIA Regulations should specify requirement for public disclosure of monitoring results

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
	Ministry of Environment when the project is completed or at such time as may be specified in the Environment Decision Statement (v) The Ministry of Environment may request to put in place necessary additional measures based on the finding of the monitoring reports		
Policy Principle 8: Do not implement project activities in areas of critical habitats, unless (i) there are no measurable adverse impacts on the critical habitat that could impair its ability to function, (ii) there is no reduction in the population of any recognized endangered or critically endangered species, and (iii) any lesser impacts are mitigated. If a project is located within a legally protected area, implement additional programs to promote and enhance the conservation aims of the protected area. In an area of natural habitats, there must be no significant conversion or degradation, unless (i) alternatives are not available, (ii) the overall benefits from the project substantially outweigh the environmental costs, and (iii) any conversion or degradation is appropriately mitigated. Use a precautionary approach to the use, development, and management of renewable natural resources.			
Key Element (1) Do not implement project activities in areas of critical habitats, unless (i) there are no measurable adverse impacts on the critical habitat that could impair its ability to function, (ii) there is no reduction in the population of any recognized endangered or critically endangered species, and (iii) any lesser impacts are mitigated.	**The EIA Regulations** defines natural environment as: (i) Natural features consisting of physical and biological formations or groups of such formations (ii) Geological and physiological, geomorphical, lithostratigraphical, palaeontological and hydrological functions and precisely declined areas which constitute the habitat of threatened species of fauna and flora; and (iii) Natural sites of precisely delineated areas of value from the point of view of science, scenic value, conservation or natural beauty. The **EIA Regulations Schedule B** further requires development to ensure that economic development is sustainable and that any development project assess the "presence or absence of critical ecosystems" that would "Environmental Sensitive Areas" (ESA) that have been identified by the Ministry of Environment. If such an ESA has been identified in the development area, that that site should be either removed for consideration for future development or that development could to take place, taking into consideration the conservation of the sensitive area, there by mitigating the negative impacts.	Full Equivalence	None required
Key Element (2) If a project is located within a legally protected area, implement additional programs to promote and enhance conservation aims of the protected area	The **EIA Regulations Schedule B** further requires development to ensure that economic development is sustainable and that any development project assess the "presence or absence of critical ecosystems" that would "Environmental Sensitive Areas" (ESA) that have been identified by the Ministry of Environment. If such an ESA has been identified in the development area, that that site should be either removed for consideration for future development or that development could to take place, taking into consideration the conservation of the sensitive area, there by mitigating the negative impacts. However **Schedule B of the EIA Regulations** clarifies that if a site/island or its surrounding reef is part of the island/reef ecosystem included in the ESA sites listed for special protection, such sites should not be	Partial Equivalence	To attain full equivalence, the legislation should be explicit if development can take place in protected areas or ESAs, and if so under what conditions and what added measures are necessary for enhancing conservation of the area

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
	considered for any development. Also, any site/island selected for development must have at least a 20 m space (measured from the seaward edge inland) for maintenance of an undisturbed band of vegetation that could serve as a "no-development" buffer zone, or else it should be removed from any development activity		
Key Element (3) In an area of natural habitats, there must be no conversion or degradation, unless (i) alternatives are not available; (ii) the overall benefits from the project substantially overweigh the environmental costs, and (iii) any conversion or degradation is appropriately mitigated	While, the legislation recognizes the need to ensure that development is excluded from specially designed environmentally sensitive sites, **the EIA Regulations** calls for evaluation of alternatives ways to development that cause less harm of the environment (that is defined as fauna, flora and natural habitats….)	Partial equivalence There is no explicit requirement for evaluating cost and benefits of damaging the environment (including natural habitats) in decision-making on conversion or degradation of natural habitats	To attain full equivalence, the legislation should specify the options for conversion and/or degradation of natural habitats including assessment of costs and benefits of conversion and mitigation options
Key Element (4) Use a precautionary approach to the use, development, and management of renewable natural resources	**Schedule B of the EIA Regulations** states that development that is in harmony with the natural environment is the preferred approach for the Maldives and environment is defined as the fauna, flora, natural habitat and the human environment. However, there is no specific reference to use of a precautionary approach to management of renewable natural resources	No Equivalence	To attain full equivalence, the legislation should require the explicit use of a precautionary approach to use and management of renewable natural resources
Policy Principle 9: Apply pollution prevention and control technologies and practices consistent with international good practices as reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety Guidelines. Adopt cleaner production processes and good energy efficiency practices. Avoid pollution, or, when avoidance is not possible, minimize or control the intensity or load of pollutant emissions and discharges, including direct and indirect greenhouse gases emissions, waste generation, and release of hazardous materials from their production, transportation, handling, and storage. Avoid the use of hazardous materials subject to international bans or phaseouts. Purchase, use, and manage pesticides based on integrated pest management approaches and reduce reliance on synthetic chemical pesticides.			
Key element (1) Apply pollution prevention and control technologies and practices consistent with international good practices.	The main piece of legislation that provides regulations for the protection and prevention of pollution is the **Environment Protection and Preservation Act of 1993** Under section 1 of Act, requires the Government and citizens to give special attention to the protection of its environment including both sea and the atmosphere. The relevant Government authorities shall also provide guidelines for the protection and preservation and everyone is required to respect such guidelines. Under section 7(a), any type of wastes, oils, poisonous gases or any substance that may have harmful	Partial equivalence While the EPPA does not make reference to international standards of pollution management	For full equivalence, guidelines are required as stipulated by the EPP Act to manage and deal with the pollution of air, water, land based on internationally recognized standards

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
	effects on the environment shall not be disposed of within the territory of the Maldives. In cases where the disposal of such substances becomes absolutely necessary, they shall be disposed of only within those areas designated for such purposes by the Government. If such waste is to be incinerated, appropriate precautions should be taken to avoid any harm to the health of the population. Similarly, the Act also states that wastes that are harmful to human health and the environment shall not be disposed of anywhere within the territory of the country and permission should be obtained from the relevant authority at least 3 months in advance of any trans-boundary movement of such wastes through the territory of the Maldives.		
Key Element (2) Adopt cleaner production processes and good energy efficiency practices	**Schedule E of the EIA Regulations "Project Description**" requires the project proponent to identify measures to be adopted to promote sustainable development, including cleaner production, renewable energy systems) during the implementation and operational phases of the project	Full Equivalence	None required
Key Element (3) Avoid pollution, or, when avoidance is not possible, minimize or control the intensity or load of pollutant emissions and discharges, including direct and indirect greenhouse gases emissions, waste generation, and release of hazardous materials from their production, transportation, handling, and storage.	**Environment Protection and Preservation Act** in Article 7 and 8 address the issues related to waste disposal and hazardous toxins. **Article 7 "Waste disposal, Oil and Poisonous Substances"** states that (a) Any types of waste oil, poisonous gases or any substance that may be harmful on the environment shall not be disposed within the territory of the country (b) In case, where the disposal of substances stated in (a) becomes absolutely necessary, they shall be disposed within the areas designated by the government. If such wastes are incinerated, appropriate precautions should be taken to avoid harm to the health of the population **Article 8 Hazardous/Toxic or Nuclear Wastes** states that such wastes that is harmful to human health and the environment shall not be disposed in the territory of the country, Permission is required for any transboundary movement of such wastes through the territory of the Maldives	Partial Equivalence There is no recognition of load minimization and control, including measures for generation, release, handling and storage	To attain full equivalence, the legislation should require avoidance and control of emission and discharge loads and handling, production and storage of such materials
Key Element (4) Avoid the use of hazardous materials subject to international bans or phase-outs	The legislation (Environmental Protection and Preservation Act) refers to disposal of hazardous wastes and transboundary movement of such wastes, but is silent on its use and phase-outs	Partial Equivalence	To attain full equivalence, the legislation should deal explicitly with the use of hazardous materials on the basis of international norms and phase out schedules
Key Element (5) Purchase, use, and	There is no specific legislation that governs the purchase, use and management of pesticides in the	No Equivalence	To attain full equivalence, the legislation should provide

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
manage pesticides based on integrated pest management approaches and reduce reliance on synthetic chemical pesticides.	Maldives. The Environment Protection and Preservation Act deals more broadly with the impacts of development related activities on the environment (fauna, flora, natural resources, etc.) and on the health and well being of the people. The direct and indirect impacts on air, water, and other natural systems (that likely refers to soil, renewable and non-renewable natural resources.		guidance on the purchase, use and management (production, transport, storage, handing, disposal) of chemicals use in agriculture
Policy Principle 10: Provide workers with safe and healthy working conditions and prevent accidents, injuries, and disease. Establish preventive and emergency preparedness and response measures to avoid, and where avoidance is not possible, to minimize, adverse impacts and risks to the health and safety of local communities.			
Key Element (1) Provide workers with safe and healthy working conditions and prevent accidents, injuries, and disease.	**Articles 73 -76 of The Employment Act of 2008,** provides coverage of measures for the safety and protection of employees at the work place…….. Such measures shall include:- i. implementation of a safe work place and procedures, procurement of secure tools and machinery for carrying out work, and ensuring the continued safety of the same; ii. provide safe materials to work with; iii. provide protective equipment and safety equipment in the event that the nature of work is such that it is not possible to eliminate or control health hazards arising out of the work; iv. provide education and training to employees on the use of protective gear and safety equipment, and disseminate to employees information on all issues of related concern; v. conduct regular health checks for employees engaged in work involving chemical or biological materials that may cause a hazard to physical health or employees involved in any work that may cause physical ill health; vi. provide or arrange for appropriate medical care for employees injured while carrying out employment; and vii. arrange the facilitation of first aid to employees in emergencies or accidents. 74. The following are duties imperative upon every employee:- i. maintenance of safe work practices at work to avoid danger to the safety and well being of the employee and co-workers which may be caused by inattentiveness to safety and security measures; ii. assist the employer and co-workers in maintenance of measures designed to ensure health and safety in the work place; iii. use safety equipment and protective gear as instructed in accordance with the training and education provided for use of such equipment and gear; iv. report to the employer any damage, loss of or destruction of protective gear or safety equipment; v. inform the employer or his designated supervisor immediately of the occurrence of any incident which the employee believes may cause danger and which the employee is unable to resolve; vi. inform the employer or his designated supervisor of any accidents or damage sustained occurring at	Full equivalence	None required

(A) ADB Safeguard Policy Statement	(B) Corresponding Legal Provisions of the draft of the Law on EIA [1]	(C) Extent of Equivalence [2]	(D) Recommended Gap-filling Measures
	work or related to work.		
Key Element (2) Establish preventive and emergency preparedness and response measures to avoid, and where avoidance is not possible, to minimize, adverse impacts and risks to the health and safety of local communities	**The Disaster Management Act of 2006** recognizes that it is the state responsibility to protect its people, their property and the natural and built environment they live in from natural and man-made disasters as well as requiring the government to act to manage risks, ensure preparedness, relief and recovery through capacity building, and establishing partnerships with organized local communities and international organizations, as well as preparing a national disaster management plan and national emergency operations plan. The intent is to promote an integrated and coordinated system of disaster management with emphasis on prevention and mitigation, communication, public awareness, knowledge, community participation, etc.	Full Equivalence	None required
Policy Principle 11: Conserve physical cultural resources and avoid destroying or damaging them by using field-based surveys that employ qualified and experienced experts during environmental assessment. Provide for the use of "chance find" procedures that include a pre-approved management and conservation approach for materials that may be discovered during project implementation.			
Key Element (1) Conserve physical cultural resources and avoid destroying or damaging them by using field-based surveys that employ qualified and experienced experts during environmental assessment.	The **EIA regulations** requires the need to conserve and protect cultural resources	Partial equivalence The legislation lacks mention of the need to use field-based surveys and qualified experts during the EIA process	To attain full equivalence, the legislation should require the use of field based surveys and qualified experts to assess impacts on cultural resources during EIA preparation
Key Element (2) Provide for the use of "chance find" procedures that include a pre-approved management and conservation approach for materials that may be discovered during project implementation	None	There is no guidance on how to deal with "chance finds"	For full equivalence, the EIA regulations or other legislation should provide for the us of "chance find" procedures

ENVIRONMENTAL AUDIT OF THE THILAFUSHI RECLAMATION PROJECT

I. INTRODUCTION

1. ADB Safeguard Policy Statement (SPS) requires that for projects involving facilities and/or business activities that already exist or are under construction, the borrower/client will undertake an environment compliance audit, including on-site assessment, to identify past or present concerns related to impacts on the environment. The objective of the compliance audit is to determine whether actions were in accordance with ADB's safeguard principles and requirements for borrowers/clients and to identify and plan appropriate measures to address outstanding compliance issues.

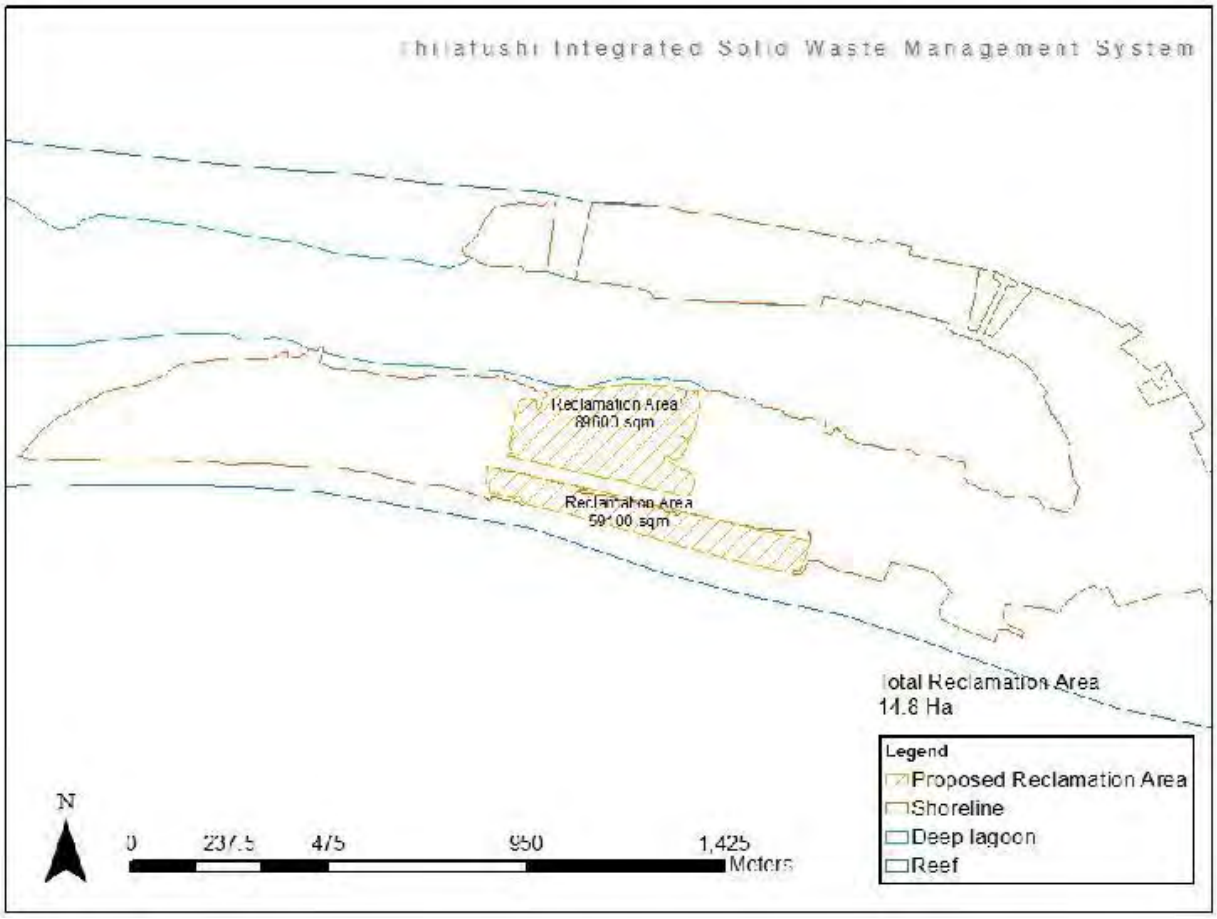
2. The proposed Waste-to-Energy (WTE) Facility Project at the island of Thilafushi in Maldives will be financed by ADB together with Asian Infrastructure Investment Bank (AIIB). This WTE Facility Project is part of Phase 2 of the Government of Maldives initiative to set up an integrated Regional Waste Management Facility (RWMF) for Zone 3. As part of the environmental impact assessment (EIA) of the WTE Facility Project, all past and present projects associated with the RWMF have been assessed if any of these is/are considered existing or associated facility/ies per definition of ADB SPS. Evaluation showed that the RWMF project component named as "Reclamation of 15 hectares of land at Thilafushi for development of the Regional Waste Management Facility (RWMF) for Zone 3" (Reclamation Project) has been identified as an existing facility relative to the WTE Facility Project. Therefore, an environmental audit is required.

3. As such, an environmental audit has been carried out for the Reclamation Project. Since the Reclamation Project has been completed, the methodology adopted for this audit is documentary review in nature. The environmental safeguard documents of the project were reviewed to identify if it has complied with the relevant national laws, rules and regulations, and to determine if there were issues identified during the implementation of the project that remained outstanding or relevant to the present. The audit was also supplemented by visit to the completed project site (the reclaimed land) and interviews with the people who have been involved in the project implementation.

II. DESCRIPTION OF THE LAND RECLAMATION PROJECT

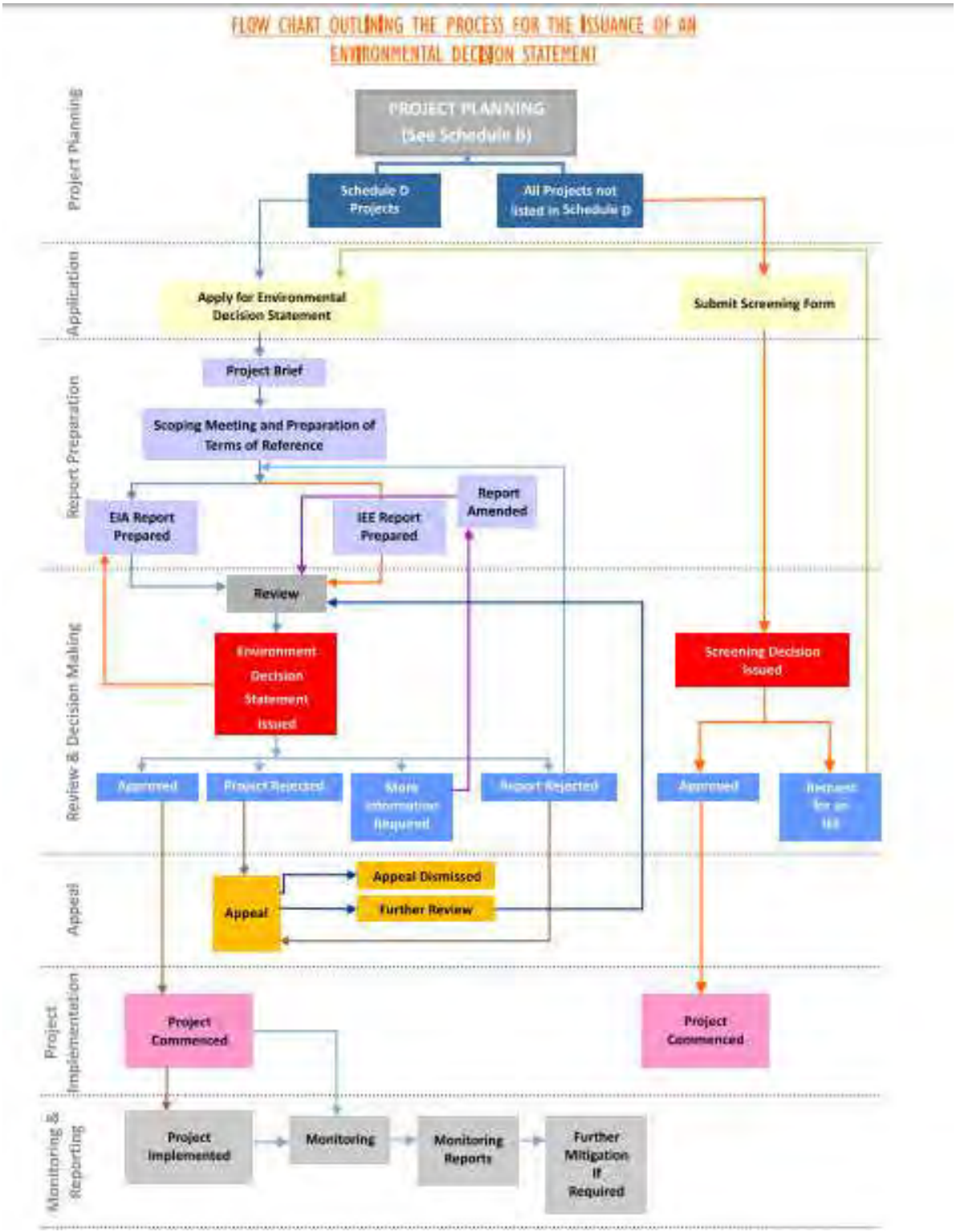
4. The Reclamation Project involved a dredging and a reclamation component to create the additional land in Thilafushi Island. The reclaimed land is planned as additional site for the various components of the RWMF, including the WTE Facility Project, which this environmental audit has been carried out for.

5. The material for the reclamation was obtained from dredging in the deep seas around Thilafushi Island. The project was designed to reclaim a total area of 15 hectares with an estimated volume of 525,000 cubic meters of dredged materials. The project was also designed to elevate the reclaimed land to a height of +2.0m from mean sea level. The design of the Reclamation Project also included a coastal protection component to protect the created land from erosion. The coastal protection was built by building a revetment using geo-textile containers. Geo-textiles, bags and tubes were filled with sand and placed on the boundary of the reclaimed land as a revetment. The revetment was constructed to a height of +2.5 m from mean sea level. Figure below shows the area that was reclaimed.



III. ENVIRONMENTAL COMPLIANCE OF THE PROJECT

6. **Environmental Impact Assessment**. In 2017, an environmental impact assessment (EIA) was undertaken for the project. The EIA process was based on the requirements of EIA Regulation (2012/R-27), the Government of Maldives governing EIA regulation for all projects in the country. This regulation provides the detailed guidelines outlining the EIA process, including the roles and responsibilities of proponent (in this case the Ministry of Environment) and consultant undertaking the EIA. In summary, the project took all the necessary steps in order to finish the EIA and secure approval from the Maldives Environmental Protection Agency (EPA). The following illustration depicts the steps followed:



7. As a result, an EIA report was prepared and submitted to the Maldives EPA. A copy of the EIA report is available to public through the Maldives EPA website. The EIA report is also available from the Ministry of Environment. The front cover of this EIA report is attached as Annex 1 to this audit document.

8. On 17 December 2017, the Maldives EPA issued an approval of the EIA through Environmental Decision Statement No. 203-EIARES/438/2017/180. A copy of this approval document is attached as Annex 2 of this audit document.

9. On 21 February 2018, the contract for the project was awarded to Maldives Transport and Contracting Company Plc. After the award, significant development happened when the proposed methodology under the project was changed due to economic and technical issues. In particular, the initial plan to use Cutter Suction Dredger (CSD) was changed to use of Trailing Suction Hopper Dredger (TSHD). Accordingly, among many other reasons, use of TSHD was deemed more economical compared to use of CSD due to reduced reclamation time. Consequently, the reduction of reclamation time was also deemed as tantamount to having lesser environmental impacts arising from the activities. In view of this, an addendum to the EIA was prepared and submitted to Maldives EPA for approval.

10. On 07 May 2018, the Maldives EPA issued an approval of the First Addendum to the EIA through Environmental Decision Statement No. 203-EIARES/438/2018/87. Accordingly, the mitigation measures proposed in the initial EIA were sufficient for the project. The front cover of the Addendum to the EIA is attached as Annex 3 of this audit document. Also, a copy of the approval document of the First Addendum to the EIA is attached as Annex 4 of this audit document.

11. **Compliance with the conditions of the EIA**. The Environmental Decision Statement provides the conditions with which the proponent should comply with during the implementation of the Reclamation Project. Below is a summary of these conditions and the corresponding compliance by the proponent:

Conditions	**Status of Compliance**
1. In the event the project activity has not commended within one (1) year from the date of issue, of if the duration of this Environmental Decision Statement has not been extended, this Environmental Decision Statement shall be considered null and void. In order to extend the duration of this Environmental Decision Statement, the Proponent shall write to the Minister for an extension according to Clause 14 of the 2nd Amendment to the Environmental Impact Assessment Regulations 2012.	Complied. The project has been completed prior to the expiry of the Environmental Decision Statement.
2. In the evert the project activities has been delayed for more than one (1) year due to unforeseen circumstances, the Ministry shall have the discretion to extend the duration of the Environmental Decision Statement, or to terminate it. In such circumstances the proponent shall write to the Minister for an extension clearly stating out the reasons for the delay.	Complied. The project has been completed prior to the expiry of the Environmental Decision Statement.
3. The Minister, or his designate, may issue a cessation order requiring persons working on	Complied.

a Development Proposal to cease working until the order is withdrawn, if: (a) This Environmental Decision Statement has been withdrawn or; (b) There has been a breach of the conditions of this Environmental Decision Statement.	
4. It is the Developer's responsibility to undertake all project activities in accordance with the relevant laws and regulations of the Maldives.	Complied. The Developer has not been issued any notices or violation (or similar forms) and the project was completed without any breach of relevant laws and regulations.
5. The Developer shall submit environmental monitoring report as outlined in Paragraph viii of this Environmental Decision Statement. Failure to submit the requisite monitoring report may result in the suspension or revocation of the permit under this Decision Statement.	Complied. One Environmental Monitoring Report have been submitted and reviewed as part of this audit. The monitoring report confirmed that overall the environmental performance of the project is acceptable and further monitoring was recommended.
6. The Developer is aware that under the National Environment Protection Act (Law No. 4/93) and the Environmental Impact Assessment Regulations the Ministry reserves the right to terminate any activity without compensation if found that such an activity has caused significant, irreversible impacts on the environment.	Complied. No termination of activities happened.
7. All mitigation measures proposed in the EIA report for all the phases of the project shall be fully implemented.	Complied. No termination of activities happened. It is viewed that all mitigation measures have been implemented.
8. The environmental monitoring program outlined in the Environmental Impact Assessment Report shall be undertaken and implemented and summary environmental monitoring reports shall be submitted to the Ministry.	Complied. Environmental Monitoring Reports and Physical Progress Reports have been prepared and submitted to the Ministry.
9. The date of expiry stated in this Environmental Decision Statement is the duration given to commence the project activities approved under this Environmental Decision Statement.	Complied. The project was accomplished within the duration of the Environmental Decision Statement.
10. Once the project activities have started, the Proponent must inform the Environmental Protection Agency, the date of commencement of project activities.	Complied. Accordingly, this activity was monitored closely by the Maldives EPA.

IV. CONCLUSION

12. The Reclamation Project has long been accomplished prior to this environmental audit. No actual dredging activities was observed as part of this audit. However, based on all documents and records reviewed, statutory requirements were complied with and that the necessary

environmental impact assessment was undertaken and approved by the government. There is an indication that the environmental performance of the reclamation project was satisfactory, and that the development activities did not cause any significant adverse impacts to the environment.

Annex 1

ENVIRONMENTAL IMPACT ASSESSMENT

Reclamation of 15 hectares of land at Thilafushi for development of the Regional Waste Management Facility for Zone 3

DRAFT

June 2017

Proposed by
Ministry of Environment and Energy

Prepared by
Ahmed Jameel (EIA P07/2017)
Ibrahim Faiz (EIA P05/2017)
Akeed Ahmed (EIA T/2017)

For Water Solutions Pvt. Ltd

Annex 2

Environmental Protection Agency
އެންވަޔަރަންމަންޓަލް ޕްރޮޓެކްޝަން އޭޖެންސީ

ތިމާވެށްޓަށް އަސަރު ކުރާ މިންވަރު ބެލުމުގެ ރިޕޯޓު ގަބޫލުކުރުން

APPROVAL OF ENVIRONMENTAL IMPACT ASSESSMENT

Number: 203-EIARES/438/2017/180 ނަންބަރު:

ތިމާވެށީގެ ގޮތުން ނިންމިގޮތުގެ މިޔުނުން ދޫކުރަނީ ކ. ތިލަފުށި ޒޯން 3ގައި ރީޖަނަލް ވޭސްޓް މެނޭޖްމަންޓް ފެސިލިޓީއެއް ގާއިމު ކުރުމަށް 15 ހެކްޓަރުގެ ބިމެއް ހިއްކުމުގެ މަޝްރޫއުގެ މަސައްކަތްކުރުމުގައި ގެނޭ ގޮތުން މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް އެންޑް އެނަރޖީގެ ފަރާތުން 20 ނޮވެމްބަރ 2017 ގައި ފޮނުއްވައިދެއްވި ހުށަހެޅުމާއި އަދި 12 ޑިސެމްބަރ 2017 ގައި އިތުރު މަޢުލޫމާތު ހުށަހެޅުއްވުމާއި ތިމާވެށްޓަށް އަސަރުކުރާ މިންވަރު ބެލުމުގެ ރިޕޯޓާއި ބެހޭ ގޮތުން ނިންމިގޮތް އެންގުމަށްޓަކައެވެ. މި މަޝްރޫއުގެ އީ.އައި.އޭ ކޮންސަލްޓަންޓުންނަކީ އަލްފާޟިލް އަޙްމަދު ޖަމީލް (EIA P07/2017) އަދި އަލްފާޟިލް އިބްރާހީމް ފާއިޒް (EIA P05/2017) އެވެ.

This Environmental Decision Statement is issued for the purpose of communicating the decision regarding the Environmental Impact Assessment for ***Reclamation of 15 hectares of Land for Development of Regional Waste Management Facility at Thilafushi (Zone III), Kaafu Atoll,*** *which was submitted for evaluation on* ***20th November 2017 by Ministry of Environment and Energy.*** *The EIA consultants of this project are* ***Mr. Ahmed Jameel (EIAP07/2017) and Mr. Ibrahim Faiz (EIA P05/2017).***

1. This Environmental Decision Statement has been issued on behalf of the Environmental Protection Agency (hereinafter referred to as the Ministry) pursuant to the Environmental Impact Assessment Regulations 2012 (2012/R-27) to advise that the Ministry has decided that the proposed Development Proposal can proceed according to the Environmental Impact Assessment Report.

1. ތިމާވެށްޓަށް އަސަރުކުރާ މިންވަރު ބެލުމުގެ ރިޕޯޓު ގަވާއިދު 2012 ގެ ދަށުން (މި ލިޔުމުގައި މީގެ ފަހުން މިނިސްޓްރީ ކަމަށް ބުނެފައި ހުންނާނީ) މިގަވާއިދުގެ ތަންފީޒީ އިދާރާ، އެންވަޔަރަންމަންޓަލް ޕްރޮޓެކްޝަން އޭޖެންސީގެ ފަރާތުން މި ތިމާވެށީގެ ގޮތުން ނިންމިގޮތުގެ ލިޔުން ދޫކުރަނީ މަތީގައި ބަޔާންކޮށްފައިވާ ތަރައްގީގެ މަޝްރޫއު ތިމާވެށްޓަށް އަސަރުކުރާ މިންވަރު ބެލުމުގެ ރިޕޯޓުގައި ބަޔާންކޮށްފައިވާ ގޮތަށް ކުރިއަށް ގެންދިޔުމަށް ހުއްދަ ދިނުމަށެވެ.

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2. The decision has been made by the Ministry on the following conditions:

   i. In the event the project activity has not commenced within one (1) year from the date of issue, or if the duration of this Environmental Decision Statement has not been extended, this Environmental Decision Statement shall be considered null and void. In order to extend the duration of this Environmental Decision Statement, the Proponent shall write to the Minister for an extension according to Clause 14 of the 2nd Amendment to the Environmental Impact Assessment Regulations 2012.

   ii. In the event the project activities has been delayed for more than one (1) year due to unforeseen circumstances, the Ministry shall have the discretion to extend the duration of the Environmental Decision Statement, or to terminate it. In such circumstances the proponent shall write to the Minister for an extension clearly stating out the reasons for the

delay.

iii. The Minister, or his designate, may issue a cessation order requiring persons working on a Development Proposal to cease working until the order is withdrawn, if:

a) This Environmental Decision Statement has been withdrawn or;

b) There has been a breach of the conditions of this Environmental Decision Statement.

iii. [illegible]

iv. It is the Developer's responsibility to undertake all project activities in accordance with the relevant laws and regulations of the Maldives.

iv. [illegible]

v. The Developer shall submit environmental monitoring report as outlined in Paragraph viii of this Environmental Decision Statement. Failure to submit the requisite monitoring report may result in the suspension or revocation of the permit under this Decision Statement.

v. [illegible] VIII [illegible]

vi. The Developer is aware that under the National Environment Protection Act (Law no. 4/93) and

vi. [illegible] (4/93 [illegible]

[illegible] 3 [illegible] 15 [illegible]

the Environmental Impact Assessment Regulations the Ministry reserves the right to terminate any activity without compensation if found that such an activity has caused significant, irreversible impacts on the environment.	ގަވާއިދު 2012 ގ ތަކުރާ ކުރެއްވުމުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ބާރު ވަނީ ވަޒާރާއަށް ކަމަކާ ގުޅިގެން ކުރެވޭ ކަންތައް ހުއްޓާ ލުމަކީ ވަރަށް ބޮޑު ނުކުރެވޭ ގޮތަށް ބަދަލު ގެނެވޭ ކަންތައް ކުރެވިފައިވާ ކަމަށް ފެނިއްޖެ ނަމަ ވަޒާރާއަށް ވެ ދާ ގޮތެވެ.
vii. All mitigation measures proposed in the EIA report for all the phases of the project shall be fully implemented.	vii. ތަކުރާ ކުރެއްވުމުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ ތަކުރާ ކުރެއްވުމުގެ ހުރިހާ ވިލާތަކުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ
viii. The environmental monitoring program outlined in the Environmental Impact Assessment Report shall be undertaken and implemented and summary environmental monitoring reports shall be submitted to the Ministry.	viii. ތަކުރާ ކުރެއްވުމުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ ތަކުރާ ކުރެއްވުމުގެ ހުރިހާ ވިލާތަކުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ
ix. The date of expiry stated in this Environmental Decision Statement is the duration given to commence the project activities approved under this Environmental Decision Statement.	ix. ތަކުރާ ކުރެއްވުމުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ

x. Once the project activities have started, the Proponent must inform the Environmental Protection Agency, the date of commencement of project activities.

x. ފްރޮޖެކްޓް ފަށާފައި ހުރިއިރު، ފްރޮޖެކްޓް ފެށުނު ތާރީޚު ފެނަ ފަރާތުން ފެނުން ރައްކާތެރިކަން ބެލެހެއްޓުމުގެ ޕްރޮޓެކްޝަން ޕްލޭންސީ ދަންނަވަންވާނެ.

Date of Issue: 17th December 2017

Date of expiry: 17th December 2018

Name: Yazeed Ahmed

Designation: Director, Environment Assessment

Signature:

ދަށްވި ތާރީޚު: 17 ޑިސެންބަރ 2017

ބޭނުންކުރެވޭ ތާރީޚު: 17 ޑިސެންބަރ 2018

ނަން: ޔަޒީދު އަޙްމަދު

ވަޒީފާ: ޑިރެކްޓަރ، ފެނުން ރައްކާތެރިކަން ބެލެހެއްޓުމުގެ ދާއިރާ

Annex 3

FIRST EIA ADDENDUM TO

Reclamation of 15 hectares of land at Thilafushi for development of the regional waste management facility for zone 3, Kaafu Atoll, Maldives

PROPONENT

MINISTRY OF ENVIRONMENT AND ENERGY

Prepared By:
Firdous Hussain: EIA P21/ 2016
Maldives Transport and Contracting Company Plc

April 2018

Annex 4

Environmental Protection Agency

އެންވަޔަރަންމަންޓަލް ޕްރޮޓެކްޝަން އެޖެންސީ

ތިމާވެށްޓަށް އަސަރު ކުރާނެ މިންވަރު ބެލުމުގެ ރިޕޯޓު ގަބޫލުކުރުން

APPROVAL OF ENVIRONMENTAL IMPACT ASSESSMENT

Number: 203-EIARES/438/2017/180 ނަންބަރު:

ތިމާވެށީގެ ގޮތުން ނިންމިގޮތުގެ ބަޔާން ދޫކުރީ ކ. ތިލަފުށި ޒޯން 3ގައި ވޭސްޓް މެނޭޖްމަންޓް ފެސިލިޓީއެއް ގާއިމް ކުރުމަށް 15 ހެކްޓަރުގެ ބިމެއް ހިއްކުމުގެ މަޝްރޫޢުގެ މަސައްކަތްކުރުމަށްޓަކައި ގެނެވޭ ގޮތުން މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް އެންޑް އެނަރޖީގެ ފަރާތުން 20 ނޮވެމްބަރު 2017 ގައި މުރާޖަޢާކުރުމަށް ހުށަހަޅުއްވާފައިވާ އަދި 12 ޑިސެމްބަރު 2017 ގައި އިތުރު މައުލޫމާތު ހުށަހަޅުއްވާފައިވާ ތިމާވެށްޓަށް އަސަރު ކުރާނެ މިންވަރު ބެލުމުގެ ރިޕޯޓާއި ބެހޭ ގޮތުން ނިންމިގޮތް އަންގައިދިނުމަށެވެ. މި މަޝްރޫޢުގެ އީ.އައި.އޭ ކޮންސަލްޓަންޓުންނަކީ އަލްފާޟިލް އަޙްމަދު ޖަމީލް (EIA P07/2017) އަދި އަލްފާޟިލް އިބްރާހީމް ފާއިޒް (EIA P05/2017) އެވެ.

This Environmental Decision Statement is issued for the purpose of communicating the decision regarding the Environmental Impact Assessment for ***Reclamation of 15 hectares of Land for Development of Regional Waste Management Facility at Thilafushi (Zone III), Kaafu Atoll,*** *which was submitted for evaluation on* ***20th November 2017 by Ministry of Environment and Energy.*** *The EIA consultants of this project are* ***Mr. Ahmed Jameel (EIAP07/2017) and Mr. Ibrahim Faiz (EIA P05/2017).***

1. This Environmental Decision Statement has been issued on behalf of the Environmental Protection Agency (hereinafter referred to as the Ministry) pursuant to the Environmental Impact Assessment Regulations 2012 (2012/R-27) to advise that the Ministry has decided that the proposed Development Proposal can proceed according to the Environmental Impact Assessment Report.

1. ތިމާވެށްޓަށް އަސަރު ކުރާނެ މިންވަރު ބެލުމުގެ ރިޕޯޓު ހެދުމާބެހޭ ގަވާއިދު 2012 ގެ ދަށުން (މި ލިޔުމުގައި މިގެ ފަހުން މިނިސްޓްރީ ކަމަށް ބުނެ ކިޔަވާފައިވާ) މިފަދައިން ތަންފީޛު ކުރުން، އެންވަޔަރަންމަންޓަލް ޕްރޮޓެކްޝަން އެޖެންސީގެ ފަރާތުން މި ތިމާވެށީގެ ގޮތުން ނިންމިގޮތުގެ ބަޔާން ދޫކުރެވޭނީ މިގޮތަށް ބަލާފައިވާ ތަރައްޤީގެ މަޝްރޫޢު ތިމާވެށްޓަށް އަސަރު ކުރާނެ މިންވަރު ބަލާފައިވާ ރިޕޯޓުގައި ބަޔާންކޮށްފައިވާ ގޮތަށް ކުރިއަށް ގެންދިޔުމަށް ހުއްދަ ދިނުމެވެ.

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2. The decision has been made by the Ministry on the following conditions:

    i. In the event the project activity has not commenced within one (1) year from the date of issue, or if the duration of this Environmental Decision Statement has not been extended, this Environmental Decision Statement shall be considered null and void. In order to extend the duration of this Environmental Decision Statement, the Proponent shall write to the Minister for an extension according to Clause 14 of the 2nd Amendment to the Environmental Impact Assessment Regulations 2012.

    ii. In the event the project activities has been delayed for more than one (1) year due to unforeseen circumstances, the Ministry shall have the discretion to extend the duration of the Environmental Decision Statement, or to terminate it. In such circumstances the proponent shall write to the Minister for an extension clearly stating out the reasons for the

delay.

iii. The Minister, or his designate, may issue a cessation order requiring persons working on a Development Proposal to cease working until the order is withdrawn, if:

a) This Environmental Decision Statement has been withdrawn or;

b) There has been a breach of the conditions of this Environmental Decision Statement.

iv. It is the Developer's responsibility to undertake all project activities in accordance with the relevant laws and regulations of the Maldives.

v. The Developer shall submit environmental monitoring report as outlined in Paragraph viii of this Environmental Decision Statement. Failure to submit the requisite monitoring report may result in the suspension or revocation of the permit under this Decision Statement.

vi. The Developer is aware that under the National Environment Protection Act (Law no. 4/93) and

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the Environmental Impact Assessment Regulations the Ministry reserves the right to terminate any activity without compensation if found that such an activity has caused significant, irreversible impacts on the environment.	ގަވާއިދު 2012 ގ ތަކުރާ ކުރެއްވުމުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ބާރު ވަނީ ވަޒާރާއަށް ކަމަކާ ގުޅިގެން ކުރެވޭ ކަންތައް ހުއްޓާ ލުމަކީ ވަރަށް ބޮޑު ނުކުރެވޭ ގޮތަށް ބަދަލު ގެނެވޭ ކަންތައް ކުރެވިފައިވާ ކަމަށް ފެނިއްޖެ ނަމަ ވަޒާރާއަށް ވެ ދާ ގޮތެވެ.
vii. All mitigation measures proposed in the EIA report for all the phases of the project shall be fully implemented.	vii. ތަކުރާ ކުރެއްވުމުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ ތަކުރާ ކުރެއްވުމުގެ ހުރިހާ ވިލާތަކުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ
viii. The environmental monitoring program outlined in the Environmental Impact Assessment Report shall be undertaken and implemented and summary environmental monitoring reports shall be submitted to the Ministry.	viii. ތަކުރާ ކުރެއްވުމުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ ތަކުރާ ކުރެއްވުމުގެ ހުރިހާ ވިލާތަކުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ
ix. The date of expiry stated in this Environmental Decision Statement is the duration given to commence the project activities approved under this Environmental Decision Statement.	ix. ތަކުރާ ކުރެއްވުމުގެ ތެރެއިން ވެދާނެ ކަންކަން ހުއްޓާ ލުމުގެ ގޮތުގައި ކަންކަން ކުރެއްވުމުގެ ކުރިން ކުރެވޭ ބަލަހައްޓަން ވާ ގޮތް ބަޔާންކޮށްފައިވާ

x. Once the project activities have started, the Proponent must inform the Environmental Protection Agency, the date of commencement of project activities.

x. ފްރޮޖެކްޓް ފަށާފައި ހުރިއިރު، ފްރޮޖެކްޓް ފެށުނު ތާރީޚު ފެނަ ފަރާތުން ފެނުން ރައްކާތެރިކަން ބެލެހެއްޓުމުގެ ޕްރޮޓެކްޝަން ޕްލޭންސީ ދަންނަވަންވާނެ.

Date of Issue: 17th December 2017

Date of expiry: 17th December 2018

Name: Yazeed Ahmed

Designation: Director, Environment Assessment

Signature:

ދަށްވި ތާރީޚު: 17 ޑިސެންބަރ 2017

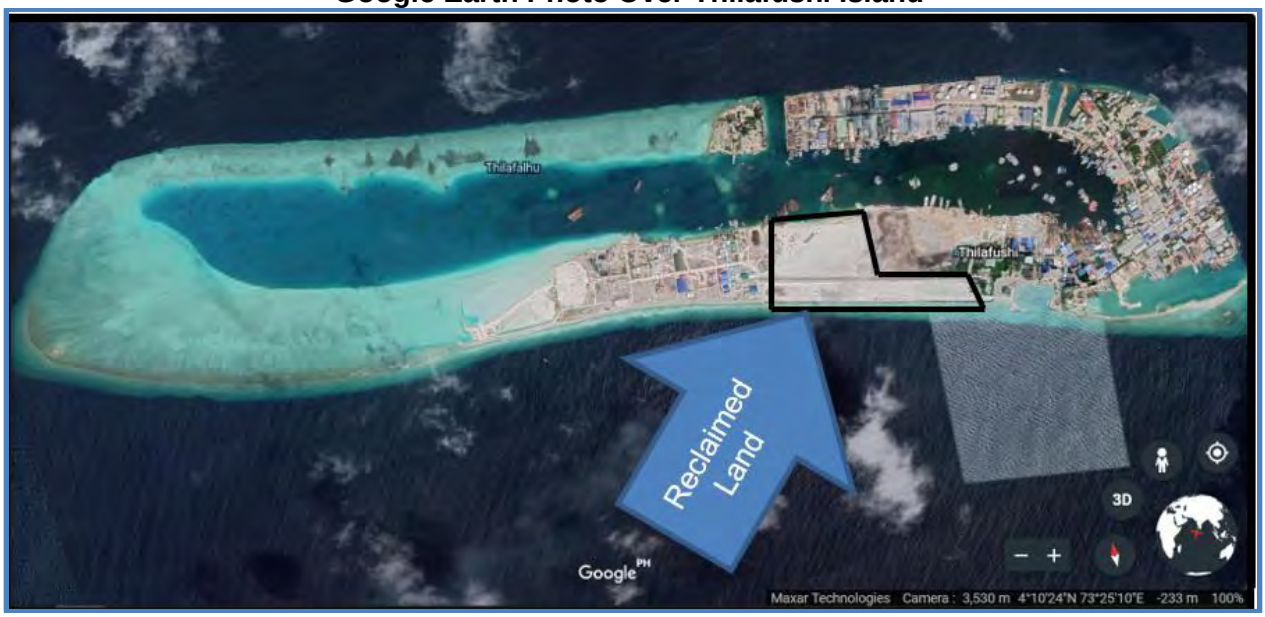
ބޭނުންކުރެވޭ ތާރީޚު: 17 ޑިސެންބަރ 2018

ނަން: ޔަޒީދު އަޙްމަދު

ވަޒީފާ: ޑިރެކްޓަރ، ފެނުން ރައްކާތެރިކަން ބެލެހެއްޓުމުގެ ދާއިރާ

Annex 5

Google Earth Photo Over Thilafushi Island



Technical Assistance Consultant's Final Report

Project Number: 51077-001

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Maldives: Greater Male Environmental Improvement and Waste Management Project - Market Study on the Reuse of Incinerator Bottom Ash and Construction and Demolition Waste in the Maldives

Asian Development Bank

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TABLES

FIGURES

ABBREVIATIONS

ADB	Asian Development Bank
CDW	Construction Demolition Waste
CIF	Cost, Insurance and Freight
IBA	Incinerator Bottom Ash
IBA (r-IBA)	Recycled Incinerator Bottom Ash
MSW	Municipal Solid Waste
MSWI	Municipal Solid Waste Incinerator
SWM	Solid Waste Management
tpd	Tons per day
WTE	Waste-to-Energy
TA	Technical Assistance
RCA	Recycled Concrete Aggregates
RC	Recycled Aggregates
STO	State Trading Organization

1. Project

1.1. Project Description

Greater Male' is centrally located in Maldives and is the capital city of the nation. The Male' island and its 32 inhabited islands are categorized as Zone 3 in the National Solid Waste Management Policy. Greater Male' Region lack a proper waste management system. For the last 30 years, waste has been collected, transferred by sea, dumped and burnt at an open dump site at Thilafushi, an island 6km away from Male'. The current practice of waste management poses an environmental and public safety issue. Some waste, often in plastic bags, are lost to the sea during transportation and toxic leachate from the Thilafushi dump site contaminate the ground water. The smoke from burning of waste causes air pollution. The current practice of waste management is not sustainable.

The Greater Male' region (Zone 3) produces 774 tons per day (tpd) of mixed solid waste. The breakdown of waste is given in Table 1 and Table 2 shows the composition of Municipal Solid Waste (MSW). Due to the rapid urbanization and tourism development in Zone 3, it is expected the waste generation would increase to 924 tpd by 2022.

Table 1. Breakdown of Waste by Type

Type	**Amount** (tons per day)	
Construction Demolition Waste	530	68%
Household	149	19%
Resort	48	6%
Commercial	27	3%
Airport	9.3	1.2%
Industrial	6	0.8%
Market	2.5	0.3%
Hazardous	1.5	0.2%
End-of-life vehicles	0.65	0.1%

Table 2. Composition of Municipal Solid Waste

Type of Municipal Solid Waste	
Organic	53%
Paper and cardboard	12%
Plastic	11%
Hazardous (medical)	8%
Metal	3%
Glass	3%
Others	11%

As an alternative to the current unsustainable practice of burning mixed solid waste, Greater Male' Environmental Improvement and Waste Management Project (Project), supported by the Asian Development Bank (ADB), is going to strengthen the solid waste management (SWM) in Zone 3. The Project will establish an integrated SWM system including collection, transfer, treatment using advanced waste-to-energy (WTE) technology, disposal, recycling, dumpsite closure and remediation, public awareness in reduce-reuse-recycle (3R), and strengthening institutional capacities for service delivery and environmental monitoring. The Government will implement the Project in two phases;

Phase 1 includes Construction Demolition Waste (CDW) processing facility (200 tpd capacity).

Phase 2 will consist of a WTE incineration of 500 tpd of Municipal Solid Waste (MSW) and the flammable fraction of the CDW

The incineration process reduces the waste to energy, Incinerator Bottom Ash (IBA) and fly ash. The fly ash will be disposed in a landfill. The IBA can also be disposed in a landfill. However, it is expected 100 to 125 tpd of IBA would be generated and land scarcity in Zone 3 limits the disposal of IBA in landfills. Alternatively, IBA could be treated further to produce recycled IBA (r-IBA) and reused as a building material.

CDW is mixed waste generated from construction and demolition activities. Soil and sand is not considered as CDW in this report as it is usually reused as backfill material. Disposal of CDW in landfills is also challenging due to land scarcity. CDW can be processed as recycled aggregates that could be used in various applications in the construction industry.

1.2. Objective of Technical Assistance

The objective of this assignment is to assess the potential market for IBA and CDW reuse in the Maldives.

1.3. Scope of Technical Assistance

The scope of this Technical Assistance (TA) is to conduct a market assessment for potential IBA and CDW reuse in the Maldives. Current use of aggregates with the aim of identifying potential applications, required national standards, costs, and current and projected demand for recycled IBA and CDW in the Maldives is analyzed. Detailed tasks of this assignment include:

(i) Identify suitable applications for treated IBA and CDW reuse in the Maldives through literature review and surveys.

(ii) Review applicable national standards for the reuse of treated IBA and CDW for the potential applications as identified in (i) and summarize the required material characteristics (e.g. chemical, physical).

(iii) Conduct interviews/surveys with key stakeholders to understand their views on potential reuse, product requirements, and willingness to pay for treated IBA and CDW.

(iv) Collect information on cost and demand of similar construction materials (to IBA and CDW) currently used in the Maldives.

(v) Conduct a market demand analysis for reusing treated IBA and CDW in the Maldives including projections for next 5, 10 and 15 years

(vi) Recommend possible ways/alternatives for maximize IBA and CDW demand/reuse and sustainable business models for the Greater Male context.

(vii) Prepare comprehensive report on the activities (i) to (vi) with key recommendations for IBA treatment and CDW plant design and operation

2. Suitable Applications for Incinerator Bottom Ash

Incineration of MSW releases the energy during combustion. The waste reduces in weight by about 70%. IBA accounts for about 80% of the incombustible residue left [1]. The remaining of the residue is fly ash. Incombustible metals, glasses, ceramics, slag and sand mixture form as IBA and is rich in heavy metals, chlorides, oxides and organic pollutants. IBA require removal of ferrous and non-ferrous metals and further treatment to enhance its reusability. The type of treatment process adopted affects the leaching property and consequently the reusability of r-IBA. Common oxides and heavy metals found in IBA are given in Table 3. The composition of the oxides and heavy metals depend on the characteristics of the MSW but SiO_2 is generally the most abundant oxide in IBA[2].

IBA is similar in its size and appearance to aggregates and hence can be used as a substitute to aggregates in applications aggregates are required. The main factors affecting the reuse of IBA is the suitability of IBA for treatment and processing, the

[1] Lynn, C., Dhir, R., & Ghataora, G. (2016). Municipal incinerated bottom ash characteristics and potential for use as aggregate in concrete. *Construction and Building Materials*, 504-517.

[2] Lam, C. H., Ip, A. W., Barford, J. P., & McKay, G. (2010). Use of Incineration MSW Ash: A Review. *Sustainability*, 1943-1968.

attainability of required properties for a given application, and the environmental impact from the reuse of IBA [3].

Reuse of IBA has been studied for the past 40 years. Lynn, Dhir, & Ghataora (2016) studied 76 publications published since 1979 over 18 countries[4] (Figure 1). Reuse of IBA is most prevalent in Europe. In Asia, reuse of IBA is prevalent in countries like Taiwan, Singapore and Japan where land is scarce.

Table 3. Oxides and heavy metals in incinerator bottom ash[2]

Oxides		Heavy Metals	
SiO_2	K_2O	Ag	Mn
Al_2O_3	Na_2O	As	Ni
CaO	SO_3	Ba	Pb
Fe_2O_3	P_2O_5	Cd	Se
MgO	TiO_2	Co	Zn
		Cr	Sn
		Cu	Sr
		Hg	V

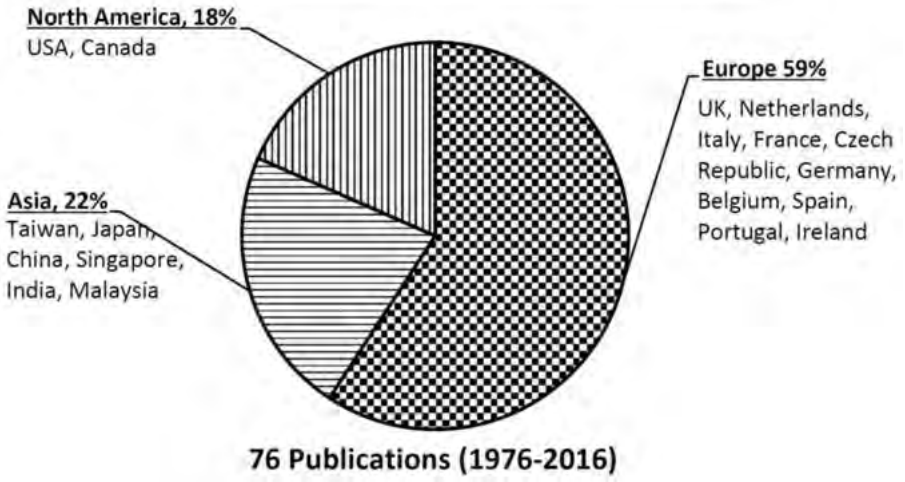

Figure 1.Global distribution of publications on MIBA in concrete applications[4]

[3] Lam, C. H., Ip, A. W., Barford, J. P., & McKay, G. (2010). Use of Incineration MSW Ash: A Review. *Sustainability*, 1943-1968.

[4] Lynn, C., Dhir, R., & Ghataora, G. (2016). Municipal incinerated bottom ash characteristics and potential for use as aggregate in concrete. *Construction and Building Materials*, 504-517.

There are two main literature that had collected the fragmented studies done and reviewed them in a single work. The work of Lam, Ip, Barford, and McKay[5] categorized the utilization of IBA and fly ash into seven different applications; cement and concrete production, road construction, glasses and ceramics, agriculture, stabilizing agent, adsorbents and zeolite production. Incinerator fly ash is utilized as a stabilizing agent and in zeolite production. Since the scope of this TA is only IBA, applications for incinerator fly ash will not be discussed. Lynn, Dhir, & Ghataora, (2016) had reviewed 76 publications and focused the work on the reuse of IBA as aggregates in concrete applications[6]. Additionally, there is literature that support the utilization of IBA in land reclamation works in Singapore and Japan. The utilization of r-IBA as raw materials in glass, ceramic and blasting grit production is supported by studies[5]. However, there is no glass and ceramic production industry in Maldives and hence reuse of r-IBA for glass and ceramic production is not a practical application in Maldives.

Existing literature was reviewed and the following utilizations of r-IBA are evaluated to determine their potential in Maldives.

i. Cement manufacturing
ii. Concrete production
iii. Masonry and pavement block production
iv. Road construction
v. Land reclamation
vi. Coastal protection systems

[5] Lam, C. H., Ip, A. W., Barford, J. P., & McKay, G. (2010). Use of Incineration MSW Ash: A Review. *Sustainability*, 1943-1968.

[6] Lynn, C., Dhir, R., & Ghataora, G. (2016). Municipal incinerated bottom ash characteristics and potential for use as aggregate in concrete. *Construction and Building Materials*, 504-517.

2.1. Cement Manufacturing

Calcareous materials like limestone and argillaceous materials like shale and clay are raw materials for cement production. These raw materials provide the reactants CaO, SiO_2, Fe_2O_3 and Al_2O_3 required for cement production. These oxides are also present in IBA (Table 3). Hence, IBA can be used as a substitute raw material in cement manufacturing[7]. However, corrosion of the cement kiln due to chloride ions and heavy metals in IBA can limit its reusability in cement manufacturing. Treatment of IBA is essential to reduce the effects of chloride and heavy metals. Pan, Huang, Kuo, and Lin used the washing treatment process and the cement produced conformed to the Chinese National Standards of Type II cement [8], suggesting the technical feasibility of utilizing treated IBA in cement production.

Maldives does not have a cement manufacturing industry. However, exporting the treated IBA to a cement manufacturer in an Asia is a possible option that could be explored. The requirements of Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal should be met for exporting the treated IBA.

2.2. Concrete Production

Treated IBA can be used as coarse aggregates and fine aggregates in concrete. The physical characteristics of IBA is an important factor that defines the properties of concrete made using IBA.

One of the physical properties of IBA that influence other physical properties of IBA and consequently the properties of concrete made with treated IBA is porosity. The porosity of IBA is higher than that of natural aggregates. Consequently, the absorption of IBA is

[7] Lam, C. H., Ip, A. W., Barford, J. P., & McKay, G. (2010). Use of Incineration MSW Ash: A Review. *Sustainability*, 1943-1968.

[8] Pan, J. R., Huang, C., Kuo, J.-J., & Lin, S.-H. (2008). Recycling MSWI bottom and fly ash as raw materials for Portland cement. *Waste Management*, 1113-1118.

higher. An averaged value of the water absorption is 9.7% and ranges over 2.4 – 15.0 %[9]. The porosity and absorption influence the bond between the cement paste and IBA. Aggregates are used as a fill material for concrete and can take up three quarters of the volume of concrete. Hence the high porosity and absorption of IBA used in concrete increases the porosity and absorption of the hardened concrete.

The high porosity of IBA contributes to the low specific gravity of IBA. The average specific density of IBA is 2.32[8]. This is comparably less than the typical specific density of natural aggregates. The specific density of natural aggregates is between 2.6 and 2.7[10]. The specific density depends on the treatment process as well.

Table 4 summarizes Lynn, Dhir, and Ghataora's review of the 76 publications focusing on the reuse of IBA in concrete[9]. As observed from Table 4, the performance of concrete produced with IBA is lower than concrete with natural aggregates. The workability is reduced due to high absorption of IBA. The compressive strength and tensile strength is lower. The current construction practices are very traditional in Maldives. It is a common practice to add water on site to the concrete mix to improve the workability. However, uncontrolled addition of water can further reduce the compressive strength of concrete. A reduction in compressive strength is translated to a reduction in flexural tensile strength of concrete. Concrete with lower tensile strength is susceptible to early cracking. Furthermore, the presence of chloride ions in IBA with close proximity to the reinforcing steel increases the risk of reduced durability. The existing literature lack a focus on long-term durability.

The practical utilization of IBA in concrete applications is in the early stages[9]. Due to the poor performance of concrete with IBA as aggregates, unreliable workmanship and the associated risks and lack of long-term durability studies, the reuse of r-IBA in structural concrete applications in Maldives is not recommended.

[9] Lynn, C., Dhir, R., & Ghataora, G. (2016). Municipal incinerated bottom ash characteristics and potential for use as aggregate in concrete. *Construction and Building Materials*, 504-517.
[10] Neville, A. M., & Brooks, J. J. (2010). *Concrete Technology.* Harlow: Pearson Education Limited.

Table 4. Effect on properties of concrete when r-IBA replaced natural aggregates

Property of Concrete	Change in property when aggregates replaced with IBA
Slump	Reduces
Cohesiveness	Remains cohesive
Segregation	No segregation
Bleeding	Bleeding reduces
Setting time	Increases
Compressive strength	Decreases
Tensile strength	Decreases
Elastic modulus	Decreases
Shrinkage	Increases
Creep	No significant change
Absorption	Increases
Chloride corrosion	Higher risk
Sulfate attack	No expansion due to sulfate attack
Carbonation resistance	Carbonation depth decreases

2.3. Masonry and Pavement Block Production

Concrete masonry blocks are extensively used in the construction industry. They are mainly used in non-load bearing masonry walls. Concrete masonry blocks used for majority of projects are locally produced. Sand quarried from lagoons are used as fine aggregates in block production. Use of local quarried sand is not a sustainable use of natural resources. Furthermore, the chloride content of the blocks due to the sand quarried from the sea floor can be high. However, supply of local quarried sand is limited and hence some large-scale block producers depend on imported sand.

The unit weight of masonry blocks with IBA is less than normal masonry blocks. This is due to the lower specific gravity of IBA. Since, the absorption of IBA is higher, the water demand during production is higher. The compressive strength of masonry and pavement

blocks with IBA is lower. However, since the strength demanded from masonry products is lower, the target strength is achieved in non-load bearing, load bearing, paving and interlocking blocks[11]. Fire resistance performance is comparable to the products made with natural aggregates and no adverse shrinkage cracking is observed when IBA is used as a fine aggregate. Additionally, concrete paving blocks made with IBA exhibited excellent slip resistance and can be classified as having low potential for slip as per BS EN 1333[11].

Furthermore, full-scale operations had been conducted with masonry and pavement blocks made with IBA. There has been reports of spalling in projects carried out in the nineties. This is due to corrosion of the ferrous metal in IBA. However, with advanced treatment methods, the problem of spalling can be easily resolved. Most of the full-scale operations can be deemed successful[11].

Quality of masonry and pavement blocks made with IBA as aggregates is slightly inferior to similar products with natural aggregates. However, the requirements of masonry and pavement products is less than those of structural concrete. Therefore, review of literature suggests that the performance of the products with IBA can be of acceptable standards[11].

Concrete masonry blocks are extensively used in non-structural applications in Maldives and the reuse of r-IBA is a more sustainable use of materials than the current use of chloride rich quarried sand. Therefore, utilization of r-IBA in concrete masonry and pavement block production has high potential in Maldives.

2.4. Road Construction

Reuse of IBA in road construction is one of the applications where IBA is utilized most in Europe. The research of IBA utilization in road construction is well progressed and

[11] Lynn, C., Dhir, R., & Ghataora, G. (2016). Municipal incinerated bottom ash characteristics and potential for use as aggregate in concrete. *Construction and Building Materials*, 504-517.

translated to field applications in countries like Belgium, Denmark, Germany and Netherlands[12].

A typical road cross-section has the wearing course as top surface, the base course and then the sub-base layer. Interlocking concrete blocks has been mostly used for the wearing course layer in Maldives though the use of bituminous asphalt in new roads is increasing. The sub-base layer is constructed on the subgrade, compacted natural soil as the foundation for the road. The base course and the sub-base is constructed with graded aggregates. Treated IBA can replace the natural aggregates used for the base course and sub-base layer[12]. IBA can be used in unbound form, hydraulically bound or bitumen bound form.

Hydraulically bound IBA is often stabilized with cement or lime when used in base layers. Singh and Kumar studied the geotechnical properties of MSWI ash mixed with cement[13]. The particle sizes of the MSWI ash used by Singh, et.al ranges from 75 microns to 1.18mm and suggests the study used IBA. Singh, et.al found that the California Bearing Ratio (CBR) value, Unconfined Compressive Strength (UCS) and Split Tensile Strength (STS) of MSWI increases when mixed with cement and suggests the MSWI mixed with cement can be used as an alternative material for road bases. However, the study of Singh, et.al did not focus on the environmental impacts of MSWI when used in ground works. A similar study in China also indicate the IBA mixed with cement satisfy the strength requirements for use on base and sub-base layers of heavy highway traffic[14]. However, the use of cement can increase the cost of the road construction.

Lynn, Ghataora, and Dhir had done an evaluation of the global experimental data on the use of IBA in road construction[15]. The analysis confirms that unbound IBA meets the grading requirement after standard processing and can be compacted well with

[12] Lam, C. H., Ip, A. W., Barford, J. P., & McKay, G. (2010). Use of Incineration MSW Ash: A Review. *Sustainability*, 1943-1968.

[13] Singh, D., & Kumar, A. (2017). Geo-environmental application of municipal solid waste incinerator ash stabilized with cement. *Journal of Rock Mechanics and Geotechnical Engineering*, 370-375.

[14] Tang, Q., Gu, F., Chen, H., Lu, C., & Zhang, Y. (2018). Mechanical Evaluation of Bottom Ash from Municipal Solid Waste Incineration Used in Roadbase. *Advances in Civil Engineering*.

[15] Lynn, C. J., Ghataora, G. S., & Dhir, R. K. (2017). Municipal incinerated bottom ash (MIBA) characteristics and potential for use in road pavements. *International Journal of Pavement Research and Technology*, 185-201.

performance similar to that of sandy gravel. Unbound IBA meets the requirements of a material suitable for sub-base and is widely used in Denmark and Netherlands. IBA bound with a stabilizing agent like cement or lime can be processed to satisfy the requirements of a sub-base or base-course material by adjusting the binder content. Laboratory results of hydraulically bound IBA shows low density and elastic modulus. However, performance measured in full-scale projects suggests hydraulically bound IBA can be satisfactorily used despite lower laboratory results. Additionally, there are full-scale projects that provides evidence that low contents of IBA can be used to form bituminous bound bases and wearing course layers.

Environmental impact of the IBA used in road construction is as important as the mechanical properties. Lynn, Ghataora, and Dhir, had done an evaluation of global literature published on the environmental impacts of IBA as a road construction material[16]. Lynn, Ghataora, and Dhir's analysis concluded that IBA in unbound form poses the highest risk of leaching heavy metals and contaminants to the ground water but the risk could be minimized by treatment prior to utilization[16]. However, IBA bound with cement or bitumen restricts the leaching and the leachate concentrations were below the utilization and water quality limits. Therefore, the environmental impacts of the reuse of IBA in road construction does not limit its utilization.

Roads in most islands in Maldives are not leveled and paved. Only the capital city Male', Hulhumale' and Villimale' have all the roads paved, either with interlocking concrete paving blocks or asphalt. Some of the larger islands like Laamu Atoll Gan, Seenu Atoll Gan and Fuvahmulah have the main road paved with asphalt. The islands without paved roads create an opportunity for the reuse of IBA. Currently, there are eight road development projects in eight different islands in the tender phase. Similarly, future airport developments are potential applications for the utilization of IBA. However, according to Regional Airports there are no long-term development plans and the recent increase in new airports was politically rationalized.

[16] Lynn, C. J., Ghataora, G. S., & Dhir, R. K. (2018). Environmental impacts of MIBA in geotechnics and road applications. *Environmental Geotechnics*, 31-55.

2.5. Land Reclamation

The utilization of IBA in land reclamation is published in literature. However, this application is only limited to countries like Singapore and Japan where land is scarce.

In Singapore, IBA and marine clay originating from excavation works are solid wastes. It was proposed to use a mixture of stabilized IBA and marine clay as a fill material for land reclamation[17]. The mechanical properties and environmental impact assessments were tested. The literature concluded the reuse of IBA and marine clay matrix is feasible from both geotechnical and environmental perspective[18]. However, it should be highlighted that the polymer-based cementious stabilizer Chemlink SS-331H is a proprietary product.

In Japan, approximately 78% of MSW that is disposed in coastal landfill sites is MSWI ash and 20% of the MSW is disposed in coastal landfills, mostly located in port areas of Tokyo, Nagoya and Osaka[19]. Various studies had showed the geotechnical properties of the landfills improved. Nguyen, Inui, Ikeda, and Katsumi had taken waste mixture samples just before being disposed at coastal landfill site in Osaka Bay area and studied the time dependent geotechnical properties of waste mixtures submerged in landfill leachate or seawater. The composition of the waste mixture was approximately 50% of MSWI ash, 30% of gravel materials like slags, and 20% surplus soil. The study concluded that the shear strength increases and deformation decreases with time and hence waste mixture layers studied could be used as foundation layers with adequate bearing capacity after closure of the coastal landfill sites[20].

[17] Guo, L., & Wu, D. -Q. (2018). Study of leaching scenarios for the application of incineration bottom ash and marine clay for land reclamation. *Sustainable Environment Research*, 396-402.

[18] Guo, L., & Wu, D.-Q. (2017). Study of recycling Singapore solid waste as land reclamation filling material. *Sustainable Environment Research*, 1-6.

[19] Nguyen, L. C., Inui, T., Ikeda, K., & Katsumi, T. (2015). Aging effects on the mechanical property of waste mixture in coastal landfill sites. *Soils andFoundations*, 1441-1453.

[20] Nguyen, L. C., Inui, T., Ikeda, K., & Katsumi, T. (2015). Aging effects on the mechanical property of waste mixture in coastal landfill sites. *Soils andFoundations*, 1441-1453.

Land reclamation activities had rapidly increased over the last five years with several islands being reclaimed as a solution to land scarcity. Sand for reclamation is quarried from borrow sites in lagoons.

The reuse of IBA as a landfill material can be a potential alternative to the use of natural sand dredged from the lagoons. However, large quantities of sediments are required for some land reclamation projects and IBA generated might not be adequate for a single project. However, there is the opportunity for blending stabilized IBA with natural sediments during land reclamation. Further research is required to support the reuse of IBA as a blended material in land reclamation.

The duration and frequency of land reclamation is different to IBA generation. Frequency of reclamation projects are discrete and the duration is relatively shorter compared to the large volume of sediments mobilized. However, IBA generation is more continuous and subjected to maturation period as well. If r-IBA is planned to use, large volumes of IBA might be required to be stored for a long period of time. Therefore, even though the reuse of IBA in land reclamation or land filling might be a technically potential application, there might be operational limitations.

2.6. Coastal protection systems

Maldives being a coastal country, reuse of IBA in coastal protection systems can be a potential application. However, literature review revealed that the reuse of IBA in coastal protection systems is an area where there is a gap in literature.

One of the applications for reuse of IBA can be in concrete for quay walls and jetties. However, these are structural applications and due to inadequate performance of concrete with IBA, reuse of IBA in construction of quay walls and jetties is not recommended.

Crushed rocks are commonly used as revetments and breakwaters in Maldives. Alternatively, tetrapods made from concrete can be used and since it is not a structural application IBA can be used as aggregates in tetrapod production. However, durability is a concern and require further research to fully validate this application. A solution to ensure durability can be to design a tetrapod with an inner core made of compacted and hydraulically bound IBA and a more durable shell made of concrete with natural aggregates.

An alternative to tetrapod could be geo-bags. Currently sand, often sourced close to the project site is used as a fill material. Since, IBA can be used in road base layers with acceptable leachate performances, stabilized IBA can potentially be used as a fill material for geo-bags. However, this application is subjected to further research and the intermittent frequency of coastal protection projections should be considered.

3. Suitable Applications for Construction Demolition Waste

Recycling of CDW is practiced widely in some countries. In some countries, approximately 90% of the CDW are recycled[21]. BS 8500 (2002) defines two types of aggregates; Recycled Concrete Aggregates (RCA) and Recycled Aggregates (RC). RCA should have minimum 95% crushed concrete and RC is defined as 100% masonry based crushed aggregates. The quality of both types of CDW aggregates is poor compared to natural aggregates. This is primarily due to the mortar adhered to the natural aggregates. The production method influence the quality and composition of CDW aggregates.

Acceptability of CDW aggregates depends on the properties of fresh and hardened concrete incorporating CDW aggregates more than the properties of CDW aggregates itself. Table 5 summarizes the properties of fresh and hardened concrete with CDW aggregates compared to concrete with natural aggregates. As observed from Table 5 the properties of concrete with CDW aggregates is lower than conventional concrete. However, Brito and Saikia had proved that when the partial replacement ratio is less than 30%, the properties of CDW incorporated concrete is comparable to that of conventional concrete and both normal and high-strength concrete could be prepared using CDW aggregates[21]. Furthermore, Brito and Saikia claim that properties of concrete with CDW aggregates could be improved through the mix design[21].

Compared to IBA, CDW aggregates has more potential for reuse in structural concrete in Maldives. The majority of buildings have a concrete frame as the structural form and quay walls and jetties are made of concrete as well. RCA can be used to produce structural concrete and RC can be incorporated into concrete masonry block making. However, since construction of most residential buildings follow traditional methods and concrete is mostly batched volumetrically on site, the risk is high for the reuse of CDW as aggregates in concrete of residential buildings. The risk can be reduced when concrete mixes are designed and tested and batched using a batching plant. Currently, there are very few

[21] Brito, J. d., & Saikia, N. (2013). *Recycled Aggregate: Use of Industrial, Construction and Demolition Waste.* London: Springer

ready-mix concrete producers. Additionally, many old buildings that are being demolished had used sand quarried from lagoons and coral fragments as aggregates. Consequently, the concrete is rich in chloride ions and had caused severe corrosion in old buildings and is one of the main reasons for demolition. Hence, reuse of aggregates made from old buildings constructed using coral fragments would lead to corrosion and would not be accepted by consultants in the industry. Therefore, CDW aggregates should be used in Maldives with caution.

Table 5. Effect on properties of concrete when CDW replaced natural aggregates

Property of Concrete	**Change in property when aggregates replaced with IBA**
Workability	Reduces
Density	Lower
Air-content	Increases
Bleeding	Reduces
Compressive strength	Lower
Split tensile strength	Lower
Flexural strength	Lower
Modulus of Elasticity	Lower
Creep	Increases
Drying shrinkage	Increases
Water absorption	Increases
Chloride permeability	Increases

4. Review of national standards and required material characteristics

Construction Act of 2017 (Act No. 4/2017) and Environment Protection and Preservation Act of 1993 (Act No. 4/93) are the two legislations that could be related to IBA and CDW.

Environment Protection and Preservation Act confers power on a ministry responsible for environment to formulate policies and regulations. Environment Protection and Preservation Act briefly states in clause 7 and 8 that waste, oil and toxic material should be disposed in areas designated by the government, should not damage the environment and if waste burning is adopted it should not harm human health. Ministry of Environment has formulated a National Solid Waste Management Policy in 2008 and revised it in 2015. Ministry of Environment has also issued a Waste Management Regulation (Regulation No. 2013/R-58). Consultation with relevant staff of Ministry of Environment revealed that there are no specific environmental national standards related to IBA and CDW. However, clause 3.1 of Annex 1 of Waste Management Regulation states that International standards should be referred to in cases where there are no national standards. There are no universal standards. Standards differ in each country and reflect factors unique to the specific country. Table 7 shows European Union's minimum waste acceptance criteria for the different categories of waste[22].

Construction Act sets the general principles and confers the power on the ministry to issue regulations to control production, import, testing and use of construction materials. However, currently there are no regulations formulated. Material testing and ensuring compliance to specifications is not widely practiced in Maldives. In circumstance where testing is conducted, only the grading of aggregates and compressive strength of concrete and sometimes masonry blocks is tested. However, when used in non-load bearing walls compressive strength of blocks is not critical. There is no specific standard followed by all the professionals in the construction industry. Some of the standards

[22] Liu, A., Lin, W. Y., & Wang, J. Y. (2015). A review of municipal solid waste environmental standards with a focus on incinerator residues. *International Journal of Sustainable Built Environment*, 165–188.

followed include Australian Standards, British Standards, Indian Standards and standards of American Society for Testing and Materials (ASTM). There are no specific national standards on IBA or CDW. The grading requirements often followed in Maldives is given in Table 6.

Table 6. BS 882:1992 grading requirement for fine aggregates

Sieve size	**Percentage by mass passing sieve**
10 mm	100
5 mm	89-100
2.36 mm	60-100
1.18 mm	30-100
600 μm	15-100
300 μm	5-70
150 μm	0-150*
* For crushed rock sands the permissible limit is increased to 20%	

Table 7. Leaching limits as set out in Council Decision 2003/33/EC

Element or substance	Inert wastes			Non-hazardous wastes			Hazardous waste acceptable at non-hazardous waste landfills			Hazardous waste acceptable at hazardous waste landfills		
	L/S = 2 L/kg	L/S = 10 L/kg	C_0 percolation test	L/S = 2 L/kg	L/S = 10 L/kg	C_0 percolation test	L/S = 2 L/kg	L/S = 10 L/kg	C_0 percolation test	L/S = 2 L/kg	L/S = 10 L/kg	C_0 percolation test
	mg/kg	mg/kg	mg/L	mg/kg	mg/kg	mg/L	mg/kg	mg/kg	mg/L	mg/kg	mg/kg	mg/L
As	0.1	0.5	0.06	0.4	2	0.3	0.4	2	0.3	6	25	3
Ba	7	20	4	30	100	20	30	100	20	100	300	60
Cd	0.03	0.04	0.02	0.6	1	0.3	0.6	1	0.3	3	5	1.7
Cr (total)	–	–	–	4	10	2.5	4	10	2.5	25	70	15
Cu	0.9	2	0.6	25	50	30	25	50	30	50	100	60
Hg	0.003	0.01	0.002	0.05	0.2	0.03	0.05	0.2	0.03	0.5	2	0.3
Mo	0.3	0.5	0.2	5	10	3.5	5	10	3.5	20	30	10
Ni	0.2	0.4	0.12	5	10	3	5	10	3	20	40	12
Pb	0.2	0.5	0.15	5	10	3	5	10	3	25	50	15
Sb	0.02	0.06	0.1	0.2	0.7	0.15	0.2	0.7	0.15	2	5	1
Se	0.06	0.1	0.04	0.3	0.5	0.2	0.3	0.5	0.2	4	7	3
Sn	–	–	–	–	–	–	–	50	–	–	–	–
Zn	2	4	1.2	25	50	15	25	50	15	90	200	60
Cl^-	550	880	450	10000	15,000	8500	10,000	15,000	8500	17,000	25,000	15,000
F^-	4	10	2.5	60	150	40	60	150	40	200	500	120
SO_4^{2-}	560	1000	1500	10,000	20,000	7000	10,000	20,000	7000	25,000	50,000	17,000
Phenol index	0.5	1	0.3	–	–	–	–	–	–	–	–	

5. Stakeholder Product Acceptance and Product Requirements

Stakeholder were identified and interviewed individually. Maldives National Association of Construction Industry (MNACI), contractors, masonry block producers and consultants were interviewed. There were challenges in arranging interviews as some were not available for the interview. Twelve participants were interviewed. Three main questions were asked after a brief explanation of the project, potential applications of r-IBA and processed CDW, and the characteristics and performance of IBA and CDW in various applications. Figure 2 shows the results of the interview. The general response was good with 75% viewing the reuse of IBA and CDW as a good initiative and 65% were willing to buy and use the product. However, almost all the participants imposed a condition on the willingness to buy or use the product. The willingness of potential stakeholders was subjected to the compliance with standard requirements. Some of the participants (25%) view that if the performance of the product made using IBA or CDW satisfy the standards and is similar to the performance of product made with natural aggregates the price of IBA or CDW could be similar to that of natural aggregates. However, 35% of the participants believe the price of IBA or CDW should be 40 – 60% of the price of natural aggregates. A quarter of the participants did not respond to the price question.

It was observed that most of the contractors believe the use of IBA or CDW depend on the approval of consultants and did not suggest any product requirements, other than strength. However, consultants had given additional requirements such as absorption percentage and grading. In general, all participants believed that IBA and CDW aggregates should conform to international standards.

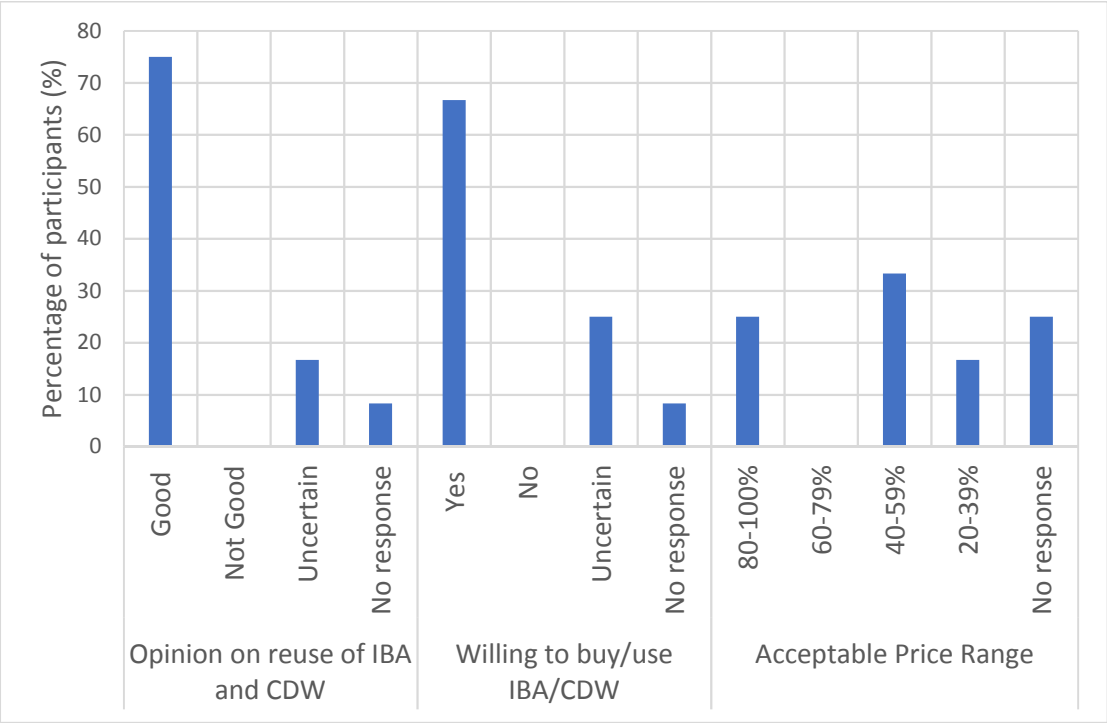

Figure 2. Results of stakeholder consultations on the reuse of IBA and CDW

6. Cost of similar construction materials and current demand

IBA and CDW are substitute products for coarse and fine aggregates used in construction industry. Hence, the demand for IBA and CDW products are expected to be similar to the demand for aggregates. Aggregates is one of the major materials used in construction. The current demand for aggregates should be reflected by the demand in the construction industry. Hence, the trends in the construction industry was first analyzed. The gauges used to determine the current demand is the construction related imports, loans to construction industry, and the building permits issued.

The construction industry is performing progressively as indicated by the gauges. In the first quarter of year 2018, loans for construction of residential housing, guest houses and new resorts observed an annual increase of 19%. During the first half of year 2018 the annual growth in credit to construction industry was registered as 23% and the growth maintained in the third quarter.

Construction related imports is another indicator of the demand in construction industry. The construction related imports increased 51% during the first half of the year 2018 and during the third quarter the growth was 39%. Statistics provided by Maldives Customs Service shows that about 792,800 tons of course aggregates and 495,300 tons of fine aggregates (sand) were imported to Maldives in year 2018 (Table 9). The value of imports of aggregate amounts to USD 48.9 million.

The demand for masonry blocks was captured through interviews. Maldives National Association of Construction Industry (MNACI), one of the largest contractors in Maldives and one of the current major suppliers of concrete masonry blocks to the Greater Male' Region were interviewed. Attempts to access archived information of Maldives Road Development Corporation was not successful. Maldives Road Development Corporation, before its recent liquidation, used to be one of the largest concrete masonry and pavement block production facility in the country. Currently, there are several block producers. Majority of block production facilities operate on a small scale and production is limited to approximately 1000 to 3500 blocks per day. Some of the large contractors operate their own production facilities and produce quantities sufficient for their own projects. Small scale block producers use local sand while in large-scale production, imported manufactured sand is used but local sand is also used to a limited extent.

The composition of the masonry block varies. Some production facilities had adopted a volumetric ratio of 1 units of cement to 5 or 6 units of sand while some production facilities can increase the sand content. Hollow rectangular blocks and solid rectangular blocks are manufactured in Maldives. The width of the blocks currently produced in the market is four inches.

The market rate of unit cost of local sand is approximately USD/kg 0.015. The typical market rate of four inch hollow blocks produced using local sand is USD 0.39 per block, though USD 0.34 per block is available from some of the large-scale producers. The unit price of four inch solid blocks produced using local sand is US 0.52. However, unit price of four-inch masonry hollow blocks produced using imported manufactured sand is USD

0.97. The average production rate of one of the major suppliers interviewed is 15,000 blocks per day. Considering the known masonry block producers in Male' and Hulhumale' and their observed production, it is estimated that approximately 83,000 blocks are produced per day in Male' and Hulhumale'. Estimating 3.5 kg of sand is required per block, production at this rate requires approximately 291 tpd of sand in Male' and Hulhumale'. Adopting 20% as the optimum aggregate replacement level[23], it is estimated 58 tpd of r-IBA are required. The estimated IBA generation of 100 – 125 tpd is more than the quantity required as of year 2019. The demand for r-IBA could be increased through means of government controls on the use of local sand quarried from lagoons.

The current CDW generation is 530 tpd. The proportion that could be recycled and reused is 482 tpd[24]. However, the CDW processing facility proposed to be implemented has a capacity of 200 tpd. The composition of the CDW (Table 8) shows 42.6% of CDW arriving at Male' waste transfer station is concrete and 41% is sand and soil, and 8.1% is rock and gravel resulting from excavation[23]. It is assumed that sand and soil from excavation works will be reused for backfill and landscape works and thus is excluded from the scope of the TA. Therefore, the recycled concrete yield of the processing facility operating at maximum capacity can be estimated as 85 tpd (42.6% of CDW). However, to be conservative for demand estimation purposes, the yield of recycled aggregates is assumed to be same as 200 tpd, the maximum capacity of the processing plant.

There is no data in the feasibility study[23] that suggests concrete and masonry walls are identified separately. On the contrary it seems structural concrete and masonry walls are identified as a single group of concrete. The properties of aggregates derived from structural concrete and concrete masonry walls differ significantly and would influence the potential application for reuse of CDW and the corresponding demand. Additionally, many old buildings that are being demolished had used sand quarried from lagoons or

[23] Lynn, C., Dhir, R., & Ghataora, G. (2016). Municipal incinerated bottom ash characteristics and potential for use as aggregate in concrete. *Construction and Building Materials*, 504-517.

[24] Water Solutions and Kocks Ingenieure. (2018). *Feasibility Study for an Integrated Solid Waste Management System for Zone III and Preparation of Engineering Design of the Regional Waste Management Facility at Thilafushi.*

beaches and coral fragments as aggregates. Consequently, the concrete is rich in chloride and had caused severe corrosion and cracking in old buildings. One of the main reasons for demolition is structural damage due to corrosion. Reuse of aggregates made from old buildings constructed using coral fragments would lead to corrosion. Given the uncertainty, it is recommended the concrete processed at the CDW processing plant to be crushed and used as sand for concrete masonry block making. Therefore, it can be assumed that 200 tpd of sand would be generated as recycled concrete.

Approximately 291 tpd of sand is required for block production in Male' and Hulhumale'. The current demand for sand (fine aggregates) in block production is less than the generation of 200 tpd of recycled aggregates and 100 – 125 tpd IBA, out of which 58 tpd can be used for replacement of sand.

Table 8. Estimated composition by weight of CDW[25]

Estimated Composition by Weight for All Loads

Paper	**0.5%**	
Unwaxed OCC		0.5%
RC Paper		0.0%
Plastic	**0.5%**	
Non-bag Film		0.5%
Polystyrene Packaging		0.0%
Rigid Plastic		0.0%
RC Plastic		0.0%
Metal	**0.2%**	
Major Appliances		0.0%
HVAC Ducting		0.0%
Other Ferrous & Non-Ferrous		0.0%
RC Metal		0.2%
Organic	**0.0%**	
Prunings, Trimmings, Branches, Stumps		0.0%
RC Organic		0.0%
Carpet	**0.0%**	
Carpet		0.0%
Carpet Padding		0.0%
RC Carpet		0.0%
Aggregates & Dirt	**91.8%**	
Dirt, Sand, Soil		41.0%
Concrete		42.6%
Asphalt Paving		0.0%
Brick, Ceramic, Porcelain		0.0%
Rock, Gravel		8.1%
RC Aggregates & Dirt		0.0%

Roofing	**0.0%**	
Roofing		0.0%
RC Roofing		0.0%
Insulation	**0.0%**	
Insulation		0.0%
RC Insulation		0.0%
Wood	**7.1%**	
Clean Recyclable Lumber, Pallets, Crates		7.1%
Other Untreated & Recyclable Wood		0.0%
Painted, Stained, Treated Wood		0.0%
RC Wood		0.0%
Gypsum	**0.0%**	
Clean Gypsum Board		0.0%
Painted Gypsum Board		0.0%
RC Gypsum		0.0%
Misc. C&D	**0.0%**	
Glass	**0.0%**	
Electronics	**0.0%**	
HHW	**0.0%**	
Special	**0.0%**	
Mixed Residue	**0.0%**	
TOTAL	**100.0%**	

[25] Water Solutions and Kocks Ingenieure. (2018). *Feasibility Study for an Integrated Solid Waste Management System for Zone III and Preparation of Engineering Design of the Regional Waste Management Facility at Thilafushi.*

7. Forecasted demand

The long-term demand is captured using the same three gauges; the construction related imports, loans to construction industry, and the building permits issued. Historic data was obtained and analyzed to see long-term trends. Future projections were done based on historic data and the current situation of the Greater Male' region.

Statistics published by Maldives Monetary Authority shows rapid growth in construction-related imports over last five years[25] (Figure 3). However, a sudden decline in imports was observed in year 2009. This is because of the Global Financial Crisis in year 2009. Despite global recovery from the financial crisis, significant growth in years 2011 to 2012 was not observed because of the restrictions imposed by India on imports of aggregates. Prior to year 2009, construction industry had been experiencing rapid growth for five to six years. The growth in the construction industry since year 2013 is due to numerous public sector investment programme (PSIP) infrastructure projects, private sector investment in real-estate and expansion in tourism sector. As observed from Figure 3, consumption of construction materials is increasingly observed in private and tourism sector. This suggests the growth in resort development and residential property construction.

Loans to construction industry over recent years exhibit industry growth and support the trend observed from construction-related imports. Credit to tourism sector and construction industry has been increasing since second quarter of year 2015 (Figure 4). Growth in tourism sector is mainly due to lending for construction of guesthouses and new resort development. The growth in lending to the construction industry is due to lending for residential and housing purposes[26].

[26] Maldives Monetary Authority. (2018). *Annual Report 2017*

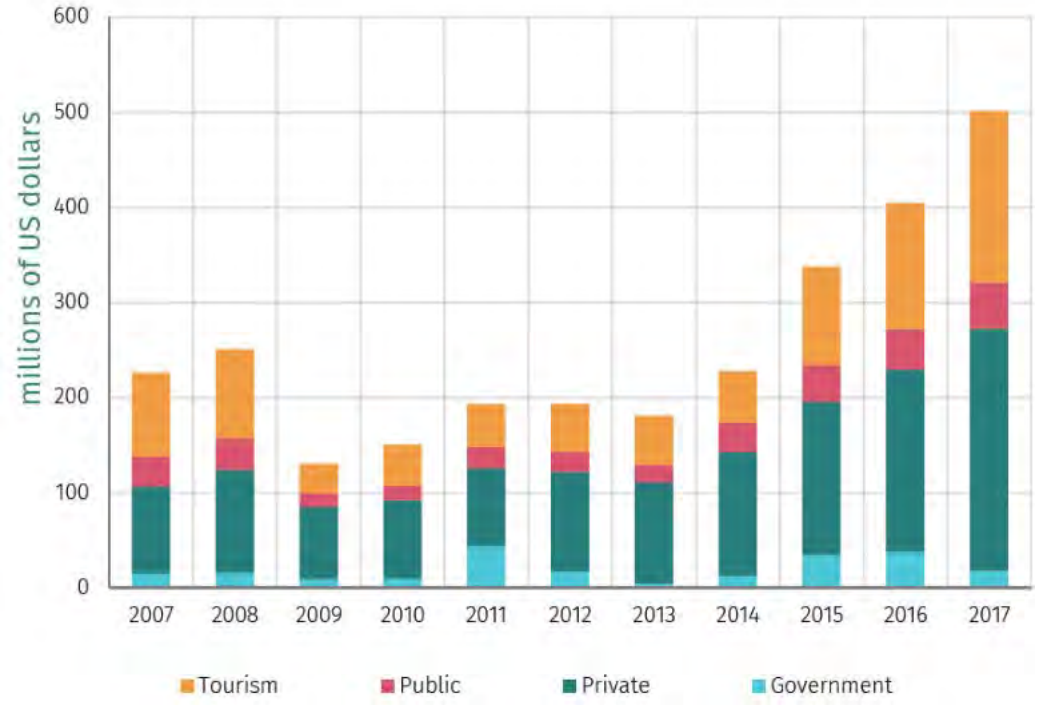

Figure 3. Construction related imports by sector[27]

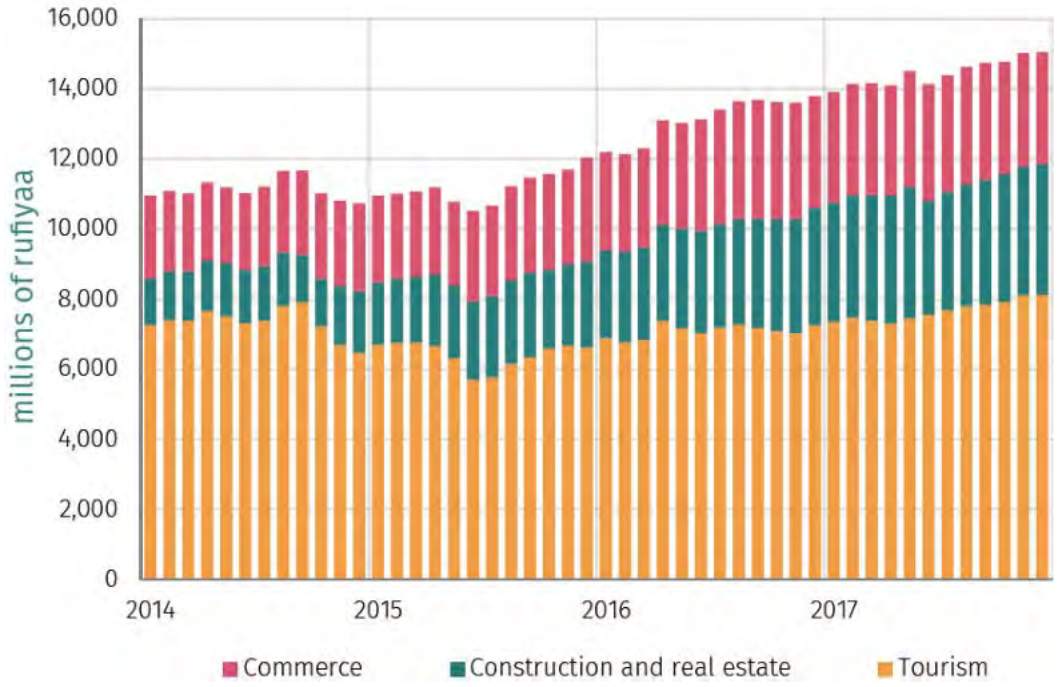

Figure 4. Loans and Advances to the Private Sector by Major Sectors[27]

[27] Maldives Monetary Authority. (2018). *Annual Report 2017*

Building permits is a key indicator of activity in construction industry. There are two types of permits; a permit given to commence construction and a permit given to use the building following completion of construction. Permits are well documented in Male' and Hulhumale'. Building permits available for the last fifteen years is collected and historic trends analyzed (Figure 5). Construction industry prior to year 2009 was a very robust industry with construction permits more than 500 permits annually. The industry was experiencing double digit growth rates[28]. However, the industry came to a halt in year 2009 due to the Global Financial Crisis and it is estimated to have contracted sharply by 16% in 2009 due to delays in major resort development projects owing to declines in capital inflows. Growth for the five years following year 2009 may have been affected by political instability and restrictions in availability of aggregates from India[29]. Since year 2013, with the increase in supply of aggregates, construction of residential buildings has been rapidly increasing and construction activity is similar to the trend observed before the financial crisis.

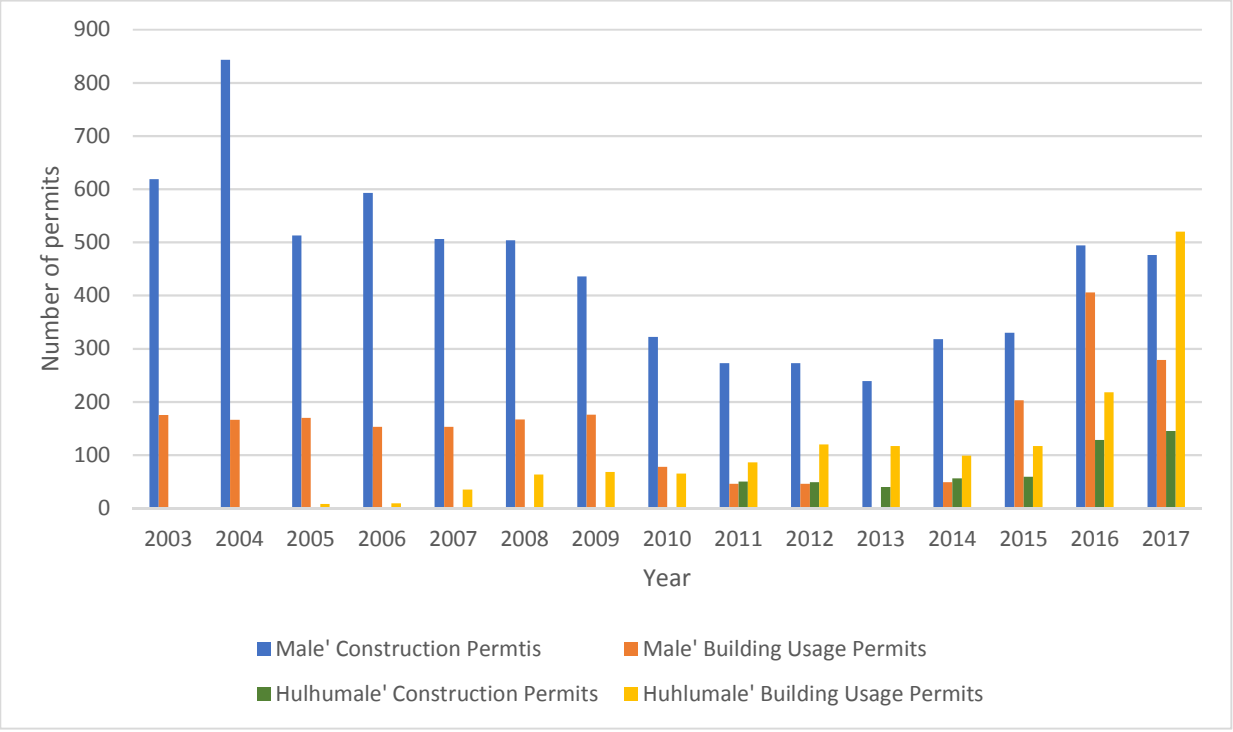

Figure 5. Building permits[30]

[28] Maldives Monetary Authority. (2010). *Annual Report 2009.*
[29] Maldives Monetary Authority. (2014). *Annual Report 2013.*
[30] National Bureau of Statistics, 2004 - 2017

Table 9. Imports of course aggregates and fine aggregates (sand)[31]

Year	Aggregates		Sand	
	Quantity (t)	CIF (MVR)	Quantity (t)	CIF (MVR)
2004	159,426	59,094,523	186,889	57,867,960
2005	191,518	76,128,976	245,979	86,542,799
2006	184,765	82,932,844	258,055	88,612,134
2007	355,762	186,032,748	432,665	200,161,633
2008	327,331	162,881,687	368,997	166,039,942
2009	184,180	86,776,242	165,230	63,140,895
2010	204,082	85,637,549	120,016	53,566,753
2011	267,540	136,810,147	153,877	88,147,309
2012	242,781	138,694,729	84,535	59,297,401
2013	180,492	147,359,782	133,699	105,190,451
2014	270,519	201,915,402	185,217	151,766,876
2015	536,523	344,320,685	226,981	155,857,347
2016	555,891	315,681,933	474,183	168,811,604
2017	803,326	425,625,230	330,156	177,082,708
2018	792,798	413,483,330	495,321	340,574,712

Historic data suggests that the construction industry has been a robust industry. The industry has potential growth due to the undeveloped reclaimed Gulhifalhu island and the recently reclaimed Hulhumale' phase 2. The relative annual growth rates of the last decade, (Figure 6) shows a positive growth. The exception is the year following Global Financial Crisis, where industry experienced a decline. The rate of growth is estimated by finding the average of the percentage growth of the three key indicators in years 2013 – 2017 (Table 10). Over the recent five years, the construction activity in Greater Male' Region has been restored close to the situation before the financial crisis. This is observed from the number of building permits in Figure 5. The average growth in construction related imports, credit to construction industry and construction permits is 22%, 26% and 17%, relatively. The average growth of these three key indicators is 22%.

[31] Maldives Customs Service (2018)

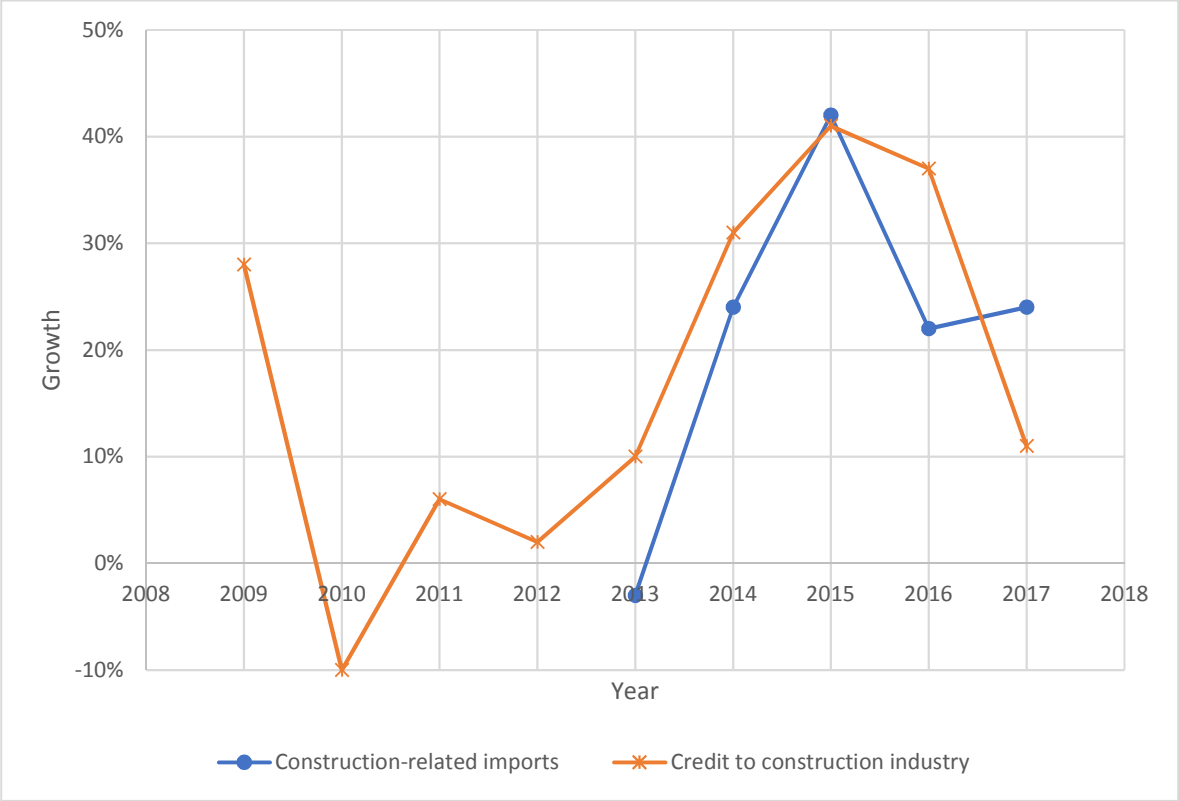

Figure 6. Growth of construction industry relative to preceding year

Table 10. Growth of key indicators of construction industry

Year	Construction-related imports	Credit to construction industry	Construction Permits	Building usage Permits
2017	24%	11%	0%	28%
2016	22%	37%	60%	95%
2015	42%	41%	4%	116%
2014	24%	31%	34%	26%
2013	-3%	10%	-13%	-30%
2012		2%	0%	26%
2011		6%	0%	-8%
2010		-10%	-26%	-41%
2009		28%	-13%	6%

Future total demand in aggregates were estimated based on historic import quantities. The data was obtained from Maldives Customs Services. Quantities of aggregates and sand (fine aggregates) imported to Maldives over last 15 years is shown in Figure 7. It is

believed the import quantity of sand obtained is only for river or natural sand and there might be quantities imported in various other names. The trend observed in aggregate imports mirrors the trend observed in the key indicators of the construction industry.

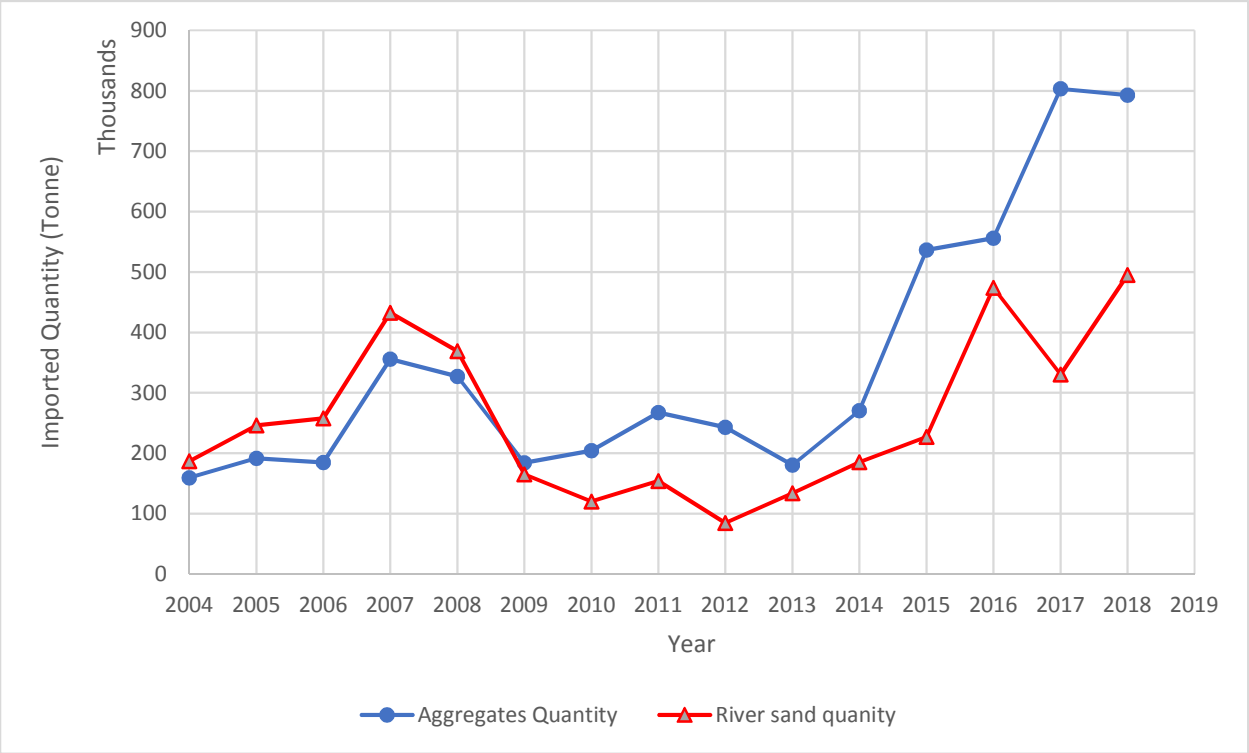

Figure 7.Imports of course aggregates and fine aggregates (sand) over 15 years [32]

Future demand projections are estimated based on historic values using exponential smoothing. Data since year 2011 is taken because Global Financial Crisis is an considered as an extreme and rare event and considering the two years following year 2009 would have affected the accuracy of the forecast. Figure 8 and Table 11 shows the demand forecast of aggregates in the industry for the next 15 years. Figure 9 and Table 12 shows the demand forecast of sand in the industry for the next 15 years. These are the total demand of the industry for aggregates and sand.

[32] Maldives Customs Service (2018

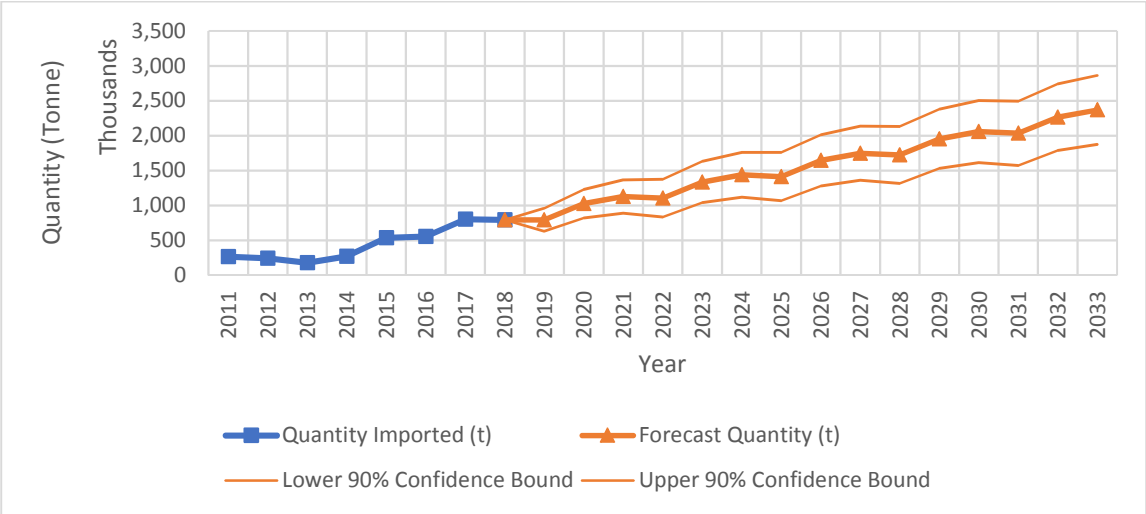

Figure 8. Forecast of course aggregates for 15 years (2018 - 2033)

Table 11. Forecast of course aggregates for 15 years (2018 - 2033)

Year	Quantity Imported (t)	Forecast Quantity (t)	Lower 90% Confidence Bound (t)	Upper 90% Confidence Bound (t)
2011	267,540			
2012	242,781			
2013	180,492			
2014	270,519			
2015	536,523			
2016	555,891			
2017	803,326			
2018	792,798	792,798	792,798	792,798
2019		794,590	630,542	958,638
2020		1,025,770	820,513	1,231,027
2021		1,128,784	889,223	1,368,346
2022		1,104,500	834,815	1,374,185
2023		1,335,679	1,038,913	1,632,446
2024		1,438,694	1,117,056	1,760,333
2025		1,414,410	1,069,571	1,759,249
2026		1,645,589	1,279,015	2,012,163
2027		1,748,604	1,361,461	2,135,747
2028		1,724,320	1,317,546	2,131,094
2029		1,955,499	1,529,999	2,380,999
2030		2,058,514	1,615,032	2,501,996
2031		2,034,230	1,573,378	2,495,082
2032		2,265,409	1,787,819	2,743,000
2033		2,368,424	1,874,620	2,862,227

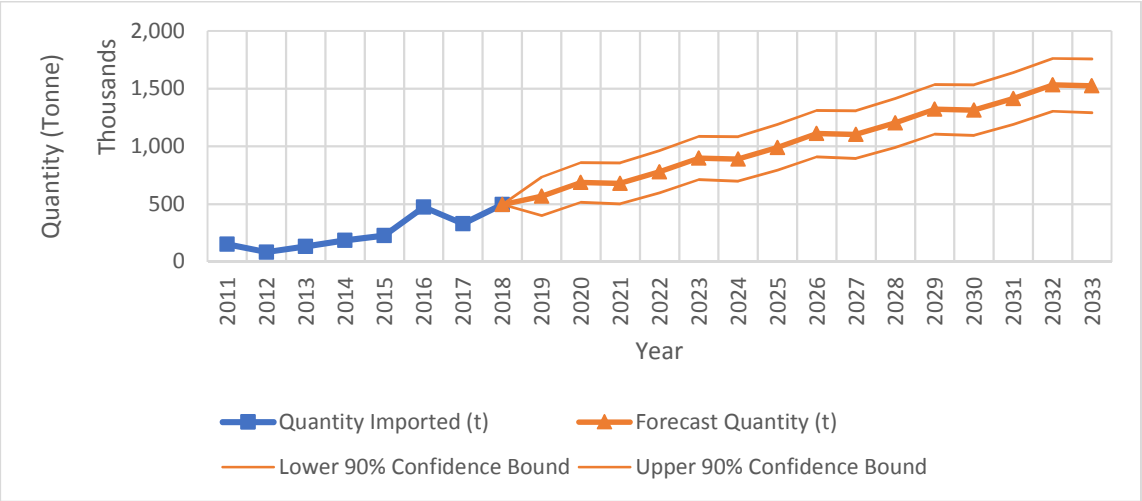

Figure 9. Forecast of fine aggregates (sand) for 15 years (2018 - 2033)

Table 12. Forecast of fine aggregates (sand) for 15 years (2018 - 2033)

Year	Quantity Imported (t)	Forecast Quantity (t)	Lower 90% Confidence Bound (t)	Upper 90% Confidence Bound (t)
2011	153,877			
2012	84,535			
2013	133,699			
2014	185,217			
2015	226,981			
2016	474,183			
2017	330,156			
2018	495,321	495,321	495,321	495,321
2019		568,631	401,394	735,869
2020		688,224	515,758	860,690
2021		680,146	502,565	857,726
2022		779,772	597,143	962,401
2023		899,364	711,822	1,086,906
2024		891,286	698,919	1,083,653
2025		990,912	793,766	1,188,059
2026		1,110,505	908,692	1,312,317
2027		1,102,427	896,018	1,308,835
2028		1,202,053	991,080	1,413,026
2029		1,321,645	1,106,204	1,537,086
2030		1,313,567	1,093,715	1,533,419
2031		1,413,193	1,188,952	1,637,434
2032		1,532,786	1,304,240	1,761,332
2033		1,524,708	1,291,904	1,757,511

There is no historic data available to use exponential smoothing to forecast the sand required for concrete masonry block making. The current demand is approximately 291 tpd of sand for block production in Male' and Hulhumale'. The demand of sand required for concrete masonry block making in the next 15 years is forecasted by assuming a linear growth equal to the estimated industry growth rate of 22%. However, computing growth at a rate of 22% for 15 years result in an exponential growth and is not realistic. Hence, linear growth at 22% is only computed for five years and used as historical values to use exponential smoothing to forecast for the next 10 years. The forecasted demand is shown in Figure 10 and the quantities are given in Table 13. The projected quantity of IBA and recyclable CDW is estimated in the feasibility study (Table 14). The projected IBA and recyclable CDW quantities are compared with the forecasted demand of sand required in block production (Figure 11). The quantity of CDW aggregates is initially more than the forecasted demand of sand used in block production. However, since year 2021, the demand of sand, including the lower bound, is more than the total IBA and CDW recyclables generated.

Figure 10. Demand forecast of fine aggregates (sand) required in concrete masonry block production for 15 years (2018 – 2033)

Table 13. Demand forecast of fine aggregates (sand) required in concrete masonry block production for 15 years (2018 – 2033)

Year	Forecast Quantity (t)	Lower 90% Confidence Bound (t)	Upper 90% Confidence Bound (t)
2018	90,210		
2019	110,056		
2020	134,269		
2021	163,808		
2022	199,845	199,845	199,845
2023	223,809	214,076	233,542
2024	251,494	240,607	262,380
2025	279,178	267,246	291,110
2026	306,862	293,965	319,760
2027	334,547	320,748	348,346
2028	362,231	347,583	376,880
2029	389,916	374,462	405,370
2030	417,600	401,377	433,823
2031	445,285	428,325	462,244
2032	472,969	455,301	490,637
2033	500,653	482,301	519,006

Table 14. Projection of IBA and CDW aggregates generation (Feasibility Study, 2017)

Year	Recyclables of CDW	IBA generated
2018	151572	
2019	153664	
2020	155787	
2021	157944	
2022	160134	
2023	162358	43125
2024	164617	43125
2025	166911	43125
2026	169242	43125
2027	171608	43125
2028	174012	43125
2029	176454	43125
2030	178934	43125
2031	181453	43125
2032	184012	43125
2033	186611	43125

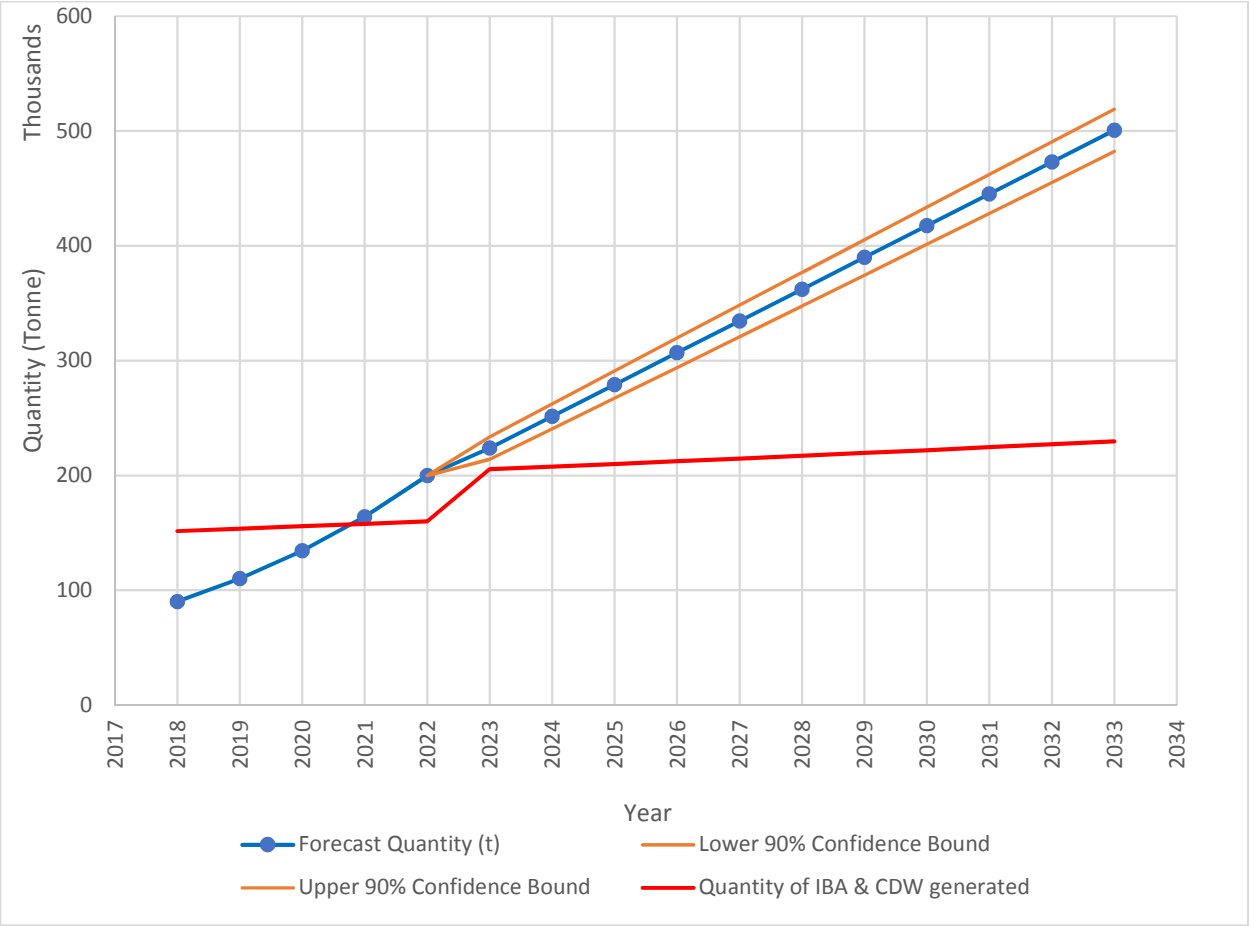

Figure 11. Comparison of forecasted sand required for concrete block production against IBA and CDW generated

A sensitivity analysis was done to evaluate consumption of IBA and CDW in various market share scenarios. The Figure 11 represents IBA and CDW consumptions when 100% market penetration is adopted. Three alternative scenarios were considered; 90%, 80% and 60% of the market share (Figure 12 and Table 15), instead of the 100% market share represented in Figure 11. When 100% market penetration is possible, all the IBA and CDW generated can be consumed by the block production industry. However, when market share reduces to 90% of the forecasted demand, not all IBA and CDW that is generated is consumed in year 2023. Similarly, when market share reduces to 80% of the forecasted demand, there are some IBA and CDW left over in years 2023 and 2024. When the market share reduces to 60% of the forecasted demand, there are some IBA and CDW left over in years 2023 to 2028. The left over IBA and CDW could be used for

other purposes like screeds as suggested by the participants interviewed. It is recommended to try to achieve 100% market share. This can be achieved easily by drastically reducing the price of IBA and CDW. IBA and CDW are substitute products to natural aggregates and price is the driving factor that drives demand in substitute products.

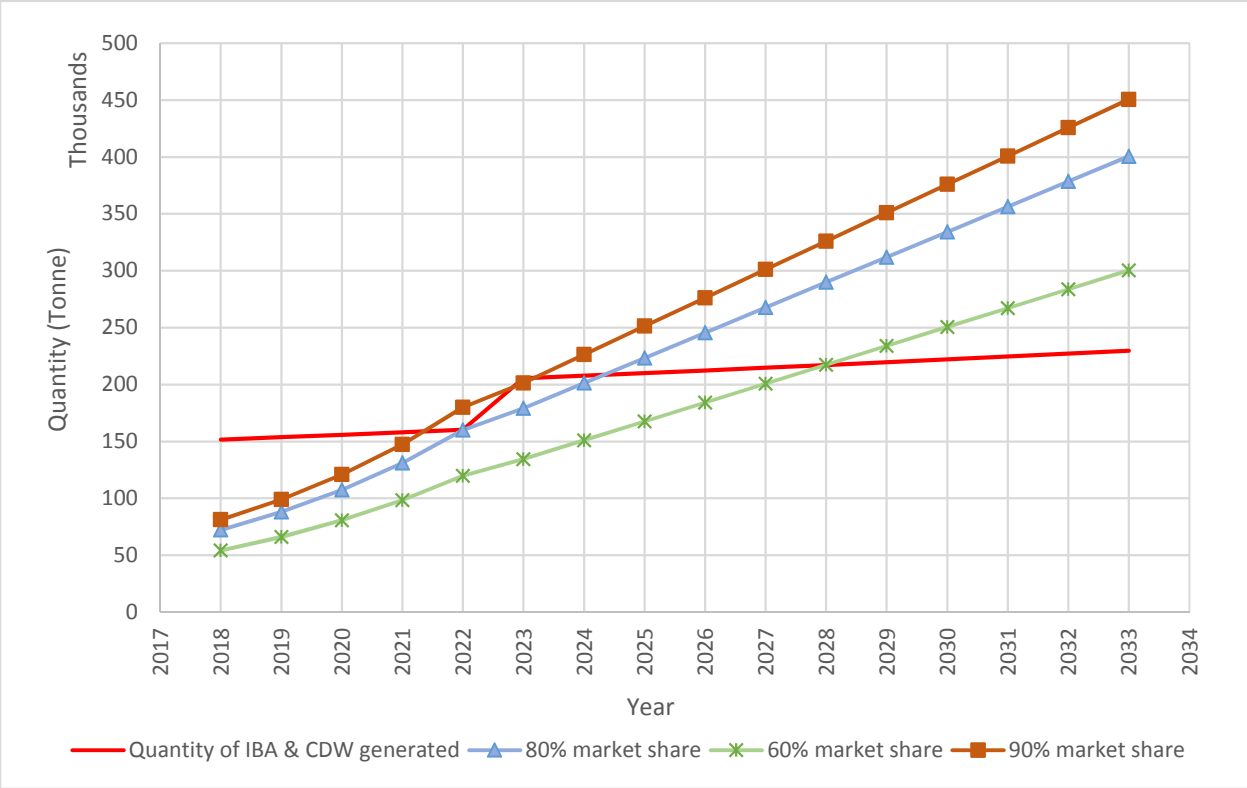

Figure 12. Sensitivity analysis of demand for IBA and CDW in concrete masonry block production

Table 15. Sensitivity analysis of demand for IBA and CDW in concrete masonry block production

Year	90% market share				80% market share				60% market share			
	20% IBA (t)	Unused IBA (t)	80% CDW (t)	Unused CDW (t)	20% IBA (t)	Unused IBA (t)	80% CDW (t)	Unused CDW (t)	20% IBA (t)	Unused IBA (t)	80% CDW (t)	Unused CDW (t)
2018			81,189	70,383			72,168	79,404			54,126	97,446
2019			99,051	54,613			88,045	65,619			66,034	87,630
2020			120,842	34,945			107,415	48,372			80,561	75,226
2021			147,427	10,517			131,046	26,898			98,285	59,659
2022			179,861	0			159,876	258			119,907	40,227
2023	40,286	2,839	161,143	1,215	35,809	7,316	143,238	19,120	26,857	16,268	107,428	54,930
2024	45,269	0	181,075	0	40,239	2,886	160,956	3,661	30,179	12,946	120,717	43,900
2025	50,252	0	201,008	0	44,668	0	178,674	0	33,501	9,624	134,005	32,906
2026	55,235	0	220,941	0	49,098	0	196,392	0	36,823	6,302	147,294	21,948
2027	60,218	0	240,874	0	53,527	0	214,110	0	40,146	2,979	160,582	11,026
2028	65,202	0	260,807	0	57,957	0	231,828	0	43,468	0	173,871	141
2029	70,185	0	280,739	0	62,387	0	249,546	0	46,790	0	187,160	0
2030	75,168	0	300,672	0	66,816	0	267,264	0	50,112	0	200,448	0
2031	80,151	0	320,605	0	71,246	0	284,982	0	53,434	0	213,737	0
2032	85,134	0	340,538	0	75,675	0	302,700	0	56,756	0	227,025	0
2033	90,118	0	360,470	0	80,105	0	320,418	0	60,078	0	240,314	0

8. Sustainable Business Model

The reuse of IBA and CDW as an exported alternative raw material in cement manufacturing, in structural concrete, as a fill material for road bases and sub-base layers, and fill material for land reclamation can be technically feasible as suggested by literature review. However, the financial feasibility or technical uncertainties in the Maldives context limits the reuse of IBA and CDW in many applications that might be viable in other countries.

Considering the logistics involved, the quantity of IBA available for exporting to a cement manufacturer is too small to achieve economies of scale. Similarly, uncertainties in the characteristics of CDW and low performance of IBA replaced concrete limits the reuse of IBA and CDW in structural concrete. The reuse of IBA in road construction is practiced widely in Europe and IBA is used for land reclamation in Japan port areas. However, due to the intermittent frequency and the large volumes of materials required for road and reclamation projects, the reuse of IBA or CDW is not viable for such projects in Maldives.

Concrete masonry block making is an application that has potential for the reuse of IBA and CDW aggregates in Maldives. Based on literature review, the replacement of sand with IBA is technically feasible. The performance of the blocks with r-IBA meets the required standards. Moreover, the demand forecast of sand required in 2023, the planned year to commence incineration of waste, is greater than the amount of IBA generated. Hence, all the IBA produced can be utilized. Similarly, it is recommended to crush CDW to sand size particles and reuse it for masonry block making. The forecasted demand of sand required for block production and the CDW aggregates generated become equal in year 2020, and then the demand is higher than supplied by CDW aggregates. Hence, all the CDW produced can be utilized in the block making industry, assuming 10% market penetration.

There are two business options. The first option is the CDW processing plant operator adopting forward integration and become either a supplier of IBA and CDW aggregates as raw materials to the market or starting a block production business. The consultant

does not recommend the first option because the amount of IBA and CDW aggregates generated is much less than the market demand. To create a demand for the product, the operator should ensure reliability of the availability of the product in quantities demanded by the market. This concern was raised by one of the large contractors interviewed. The contractor noted he would be willing to purchase IBA and CDW at a lower cost for his block production if a continuous stream of raw materials is ensured. The contractor highlighted that IBA and CDW depends on the availability of waste, which can be variable, and hence questioned the reliability of the availability. Furthermore, IBA and CDW would probably be used to replace part of the natural sand used. Hence, contractors or block producers would like to get all the required sand from one place. In such cases, the operator might be required to get into the business of importing sand.

The second option is to use an intermediately aggregate supplier like State Trading Organization (STO) instead of directly selling it to the market. This option is more recommendable because it eliminates the risks and costs associated with trading with the market directly. STO is one of the major aggregates supplier and has established customer bases and distribution networks. Hence, adopting the second option is financially more attractive.

Table 16 shows the price comparison of different types of sand used for block production. The price of IBA and CDW aggregates are the prices suggested by the consultant in the feasibility study. As observed the unit price of IBA and CDW aggregates are significantly cheaper. Since the materials are substitute goods, a drastic reduction in price would increase the demand for the IBA and CDW aggregates, provided the performance is assured.

Table 16. Price comparison of sand used for concrete masonry block production and IBA and CDW

	Price (MRV/Mg)	**Price (USD/Mg)**
Sand (fine aggregates)	794.18	51.5
Local sand	225	14.59
IBA	77.1	1 – 5
CDW aggregates	33.55	1 – 2.18

9. Recommendations

Concrete masonry block and pavement block production is a potential application for utilization of IBA and CDW in Maldives. Use of IBA and CDW in non-structural applications such as use in floor screed concrete could be a potential market too.

The demand forecast shows the generation of IBA and CDW could be less than the demand required by the block production industry, provided 100% market penetration is possible. It is recommended that Government should promote the use of IBA and CDW through campaigns to assure the technical and safety suitability of the waste products.

The general response of stakeholders consulted is promising and many are willing to accept the product if the price is significantly lower than natural aggregates and the performance of the product meets the standards, often international standards.

There are no existing local standards directly related to IBA or CDW, mainly because these are new products in the Maldivian market. However, new regulations governing the reuse of IBA and CDW should be expected soon as Ministry of Environment is in the process of formulating environmental regulations to IBA and CDW. Hence, it is suggested that treating of IBA and CDW is critical to ensure the characteristics and performance confirms to international best practices and consequently the acceptance of r-IBA and processed CDW as a building material in Maldives.

It is recommended to introduce the products to the market through intermediately aggregates supplier. Additionally, the price should be significantly lower than natural aggregates to drive the demand for IBA and CDW.

10. References

Brito, J. d., & Saikia, N. (2013). *Recycled Aggregate: Use of Industrial, Construction and Demolition Waste.* London: Springer.

Guo, L., & Wu, D. -Q. (2018). Study of leaching scenarios for the application of incineration bottom ash and marine clay for land reclamation. *Sustainable Environment Research*, 396-402.

Guo, L., & Wu, D.-Q. (2017). Study of recycling Singapore solid waste as land reclamation filling material. *Sustainable Environment Research*, 1-6.

Lam, C. H., Ip, A. W., Barford, J. P., & McKay, G. (2010). Use of Incineration MSW Ash: A Review. *Sustainability*, 1943-1968.

Liu, A., Lin, W. Y., & Wang, J. Y. (2015). A review of municipal solid waste environmental standards with a focus on incinerator residues. *International Journal of Sustainable Built Environment*, 165–188.

Lynn, C. J., Ghataora, G. S., & Dhir, R. K. (2017). Municipal incinerated bottom ash (MIBA) characteristics and potential for use in road pavements. *International Journal of Pavement Research and Technology*, 185-201.

Lynn, C. J., Ghataora, G. S., & Dhir, R. K. (2018). Environmental impacts of MIBA in geotechnics and road applications. *Environmental Geotechnics*, 31-55.

Lynn, C., Dhir, R., & Ghataora, G. (2016). Municipal incinerated bottom ash characteristics and potential for use as aggregate in concrete. *Construction and Building Materials*, 504-517.

Maldives Monetary Authority . (2014). *Annual Report 2013.*

Maldives Monetary Authority. (2010). *Annual Report 2009.*

Maldives Monetary Authority. (2018). *Annual Report 2017.*

Neville, A. M., & Brooks, J. J. (2010). *Concrete Technology.* Harlow: Pearson Education Limited.

Nguyen, L. C., Inui, T., Ikeda, K., & Katsumi, T. (2015). Aging effects on the mechanical property of waste mixture in coastal landfill sites. *Soils andFoundations*, 1441-1453.

Pan, J. R., Huang, C., Kuo, J.-J., & Lin, S.-H. (2008). Recycling MSWI bottom and fly ash as raw materials for Portland cement. *Waste Management*, 1113-1118.

Singh, D., & Kumar, A. (2017). Geo-environmental application of municipal solid waste incinerator ash stabilized with cement. *Journal of Rock Mechanics and Geotechnical Engineering*, 370-375.

Tang, Q., Gu, F., Chen, H., Lu, C., & Zhang, Y. (2018). Mechanical Evaluation of Bottom Ash from Municipal Solid Waste Incineration Used in Roadbase. *Advances in Civil Engineering*.

Water Solutions and Kocks Ingenieure. (2018). *Feasibility Study for an Integrated Solid Waste Management System for Zone III and Preparation of Engineering Design of the Regional Waste Management Facility at Thilafushi.*

Fly Ash Management Plan
(Handling of Air Pollution Control Residues)
Greater Male Waste-to-Energy Project

1 Generation of Air Pollution Control Residues

As per Employer's Requirements (ERQ) of the envisaged DBO Contract, the Air Pollution Control (APC) system shall consist of a semi-dry or dry system that will generate hazardous residues containing the acid and organic flue gas components and heavy metals in a soluble form which require careful handling. The volume of APC residues depends on the type of absorbent used to clean the flue gases. According to a preliminary mass balance prepared during the feasibility study around 50 kg APC residues per tonne of waste will be generated. In total, approx. 8,500 tonnes are expected to be generated every year if the facility runs at full capacity. According to the European BAT Reference Document for Waste Incineration (BREF) Document that is to be applied, APC residues including the fly ash that is retained by the APC system must not be commingled with the boiler ash and the bottom ash.

APC residues are regarded in all countries that are incinerating waste as hazardous due to their heavy metal content in an easily leachable form. Subject to the absorbent and, of course, the type of waste incinerated, the composition of the APC residues may be characterised as listed in Table 1 (heavy metals highlighted in dark grey).

Table 1: Components of the residues of a semidry/dry APC system[1]

Element	Content in mg/kg
Ca	110,000 – 350,000
K	5,900 – 40,000
Mg	5,000 – 14,000
Na	7,600 – 29,000
Si	36,000 – 120,000
Cl	62,000 – 380,000
S	1,400 – 25,000
Al	12,000 – 83,000
Fe	2,600 – 71,000
As	18 – 530
Ba	51 – 14,000
Cd	140 – 300
Cr	73 - 570
Cu	16 – 1,700
Hg	0.1 – 51
Mn	200 – 900
Mo	9 – 29
Ni	19 – 710
Pb	2,500 – 10,000
Sb	300 – 1,100
V	8 – 62

[1] according to Chandler, Eighmy, Hartlém, Hjelmar, Kosson, Sawell, von der Sloot, Vehlow: Municipal solid waste incinerator residues (1997), cited in Management of APC residues from WtE Plants, ISWA 2008

Zn	7,000 – 20,000

Besides the combustion conditions in the furnace (2 sec, 850°C), the homogeneity of the conditions across the furnace cross section and a sufficient turbulence in the post combustion chamber is an important parameter to control the dioxin and furan contents of the APC residues. Measurements in UK from 2004 revealed concentration between 800 and 1,750 ng TEQ/kg while eluates did not show a significant level above background contamination which was between 0.4 and 2 pg/l[2].

2 Envisaged APC residue treatment and other nations current disposal practices

Because no worldwide methodology or guideline on how to deal with APC residues in an environmentally sound and technically feasible manner has been established, most nations do follow their own approach which again is subject to the local conditions such as availability of disposal sites, national legislation and the costs of the APC residue treatment.

In Germany, APC residues from dry/semi-dry system are usually stored in old salt mines as backfilling material (only if water ingress can be ruled out). Facilities in France with bicarbonate as absorbent apply an extraction of heavy metals at pH 9 and thus try to reuse the bicarbonate (which yet contains chloride) from the so obtained brine. As disposal option for the heavy metals, hazardous waste landfills are used. Dutch facility uses big bags with inlet liners and douses the APC residues during unloading with water to trigger pozzolanic reactions. By this, the APC residues solidify while the inlet liners of the big bags prevent water seepage into the big bags.

In the USA, APC residues are stored mostly in hazardous waste landfills. Some facilities use the bottom ash to stabilise the APC residues (due to pozzolanic effect of bottom ash after dousing with water).

Some Japanese facilities (appr. 30) vitrify both the bottom ash and APC residues, thus obtaining a highly concentrated and salt-rich residue (which is difficult to handle though). Costs for this kind of treatment are significant and can be as high as $500/tonne of residue.

Deliberately, a stabilisation/solidification of the APC residues or any other treatment method was not explicitly prescribed to allow the DBO Contractor to develop a solution that meets the local requirements. Adding cement, for example, can, subject to the absorbent used in the APC system, triple the amount of residues to be landfilled which may be a costly undertaking in the Maldives. Hence, other pozzolanic reaction inducing additives have to be selected if the Contractor opts for such a solution. Space requirements for storing the stabilised bricks while they undergo the transformation was another factor which cannot be ignored. A plant to process around 25 tonnes per day requires 40mx20m, most of the space for storage to allow the bricks to solidify – up to 8 weeks.

[2] Testing of residues from incineration of municipal solid waste, UK Environment Agency, 2004

Whether and to what extent, the DBO Contractor will use the residues after the bottom ash treatment to trigger a pozzolanic reactions, shall be left to the sole discretion of the Contractor which is in line with the general principles of a DBO contract to stimulate the competition of the bidders to present the technically most robust but an economically attractive solution.

Because the Maldives do not have a comprehensive environmental regulatory framework yet, the European standards that according to the BREF Document do require a separate handling of the bottom ash and the APC residues are regarded as the best option to maximise the reuse of the bottom ash and to concentrate the toxic substances within the smallest volume of residues, i.e. the APC residues. Since the BREF Document does not define the landfilling and the treatment of the APC residues and a DBO Contractor may have a preference for the one or other treatment option, it shall be left to the DBO Contractor to develop the solution against the standards that are defined in the ERQ.

During the design review, the Contractor has to provide the full documentation of for the APC residue handling. In the event it does not meet good international industrial practice or does not achieve the desired design standards, the Employer has any right to request modification.

3 Design Build Requirements as per ERQ

To avoid any impact to the environment and to the Contractor's personnel safety, the Contractor's design shall consider the following for conveying and loading APC residues:

- APC residues shall not be mixed with bottom or boiler ash prior to the bottom ash treatment.
- APC residues shall be conveyed in closed conveying systems that end up in storage silos whose exhaust air can be dedusted via a central dedusting system.
- The top of the bag filter housing shall be enclosed and shall be connected to the central dedusting system (while pulling/replacing bag-filter hoses).
- Discharging the APC residues from the silos into water-tight jumbo bags (with inlet) or into the transfer vehicles shall be carried out via dust-tight discharging chutes.
- APC residues shall be treated by either stabilization/solidification or via triggered pozzolanic reaction prior to landfilling to limit the leachability of heavy metals.

The ERQ request the Contractor to design and construct the landfill for the APC residues according to the European Landfill Directive 1999/31/EC and its latest amendment 2018/850/EC. The design of the landfill – i.e. whether a single compartment or different compartments for the APC residues and the remaining bottom ash – shall be subject to the design considerations of the Contractor. In any case, the Contractor shall take account of the following:

- The barrier system shall encompass an artificially completed/reinforced geological barrier (thickness shall be not less than 0.5 m) that can offer an equivalent protection as defined in the European Landfill Directive 1999/31/EC for hazardous wastes. An impermeable artificial liner for at least the compartment that is designated for the APC residues shall be provided. Given that Maldivian soils do not offer a geological barrier having a hydraulic conductivity of less than 10^{-9} m/s and a thickness of more

than 5 m, the artificial geological barrier is the only way to apply to multi-barrier system.

- The compartment, if any, for the residues from the bottom ash processing shall be provided with an artificially completed geological barrier. Its thickness shall not be less than 0.5 m and shall meet the hydraulic resistance requirements for non-hazardous waste as stipulated in the European Landfill Directive.
- The barrier system shall be designed to allow minimizing the leachate generation by dividing the compartments into cells that will accommodate waste subsequently according to the filling plan of the landfill.
- The lower level of the engineered barrier shall be no deeper than 1.5 meters above mean sea level and in accordance with the applicable environmental standards;
- Prior to construction, the Contractor shall prepare a test pad to demonstrate the effectiveness of the proposed engineered barrier.
- In the design of the Contractor, a composite cover system shall be included (see also operational requirements).

For the leachate management, the Contractor shall take into consideration the following:

- The design shall warrant a minimized leachate generation applying means, such as, but not limited to, constructing a shed above the hazardous waste compartment, separating not contaminated water from leachate by installing gate valves, constructing bunds to control the leachate flows, etc.
- The design of the Contractor shall take account of that leachate from different compartments for APC residues and residues from the bottom ash processing are collected and treated so that the leachate discharge standards are met any time. Applying strictest discharge standards is the only way to control the APC residue disposal in the Maldives case.
- The Contractor shall design and build or organize a system for the safe collection, transport and disposal of the LTP concentrate.
- Subject to its design, the Contractor shall re-inject the concentrate after the leachate treatment in the air pollution control system or shall evaporate it. In the latter case, the residues shall be disposed on the landfill so that no accumulation of the highly soluble material is to be concerned.
- Monitoring wells to detect any potentially escaping leachate shall be installed.

4 Requirements during Operation Service Period

Focusing on the APC residues, during landfilling the Contractor shall consider:

- APC revenues shall be disposed safely to landfill meeting the European standards (1999/31/EC) as defined for hazardous waste. Safe disposal means that APC residues shall be unloaded either into water-tight jumbo bags in a semi-solid state (after dousing with water) or shall be stabilized/solidified. Given that APC residues are the only type of hazardous waste, no acceptance tests are needed.
- The Contractor shall dispose of all APC residues and any other residual wastes (i.e. excluding bottom ash for recycling and valuable wastes to be exported for reuse) to the dedicated landfill cells located within the Site, in accordance with the approved

Residual Waste Plan which requests the Contractor to assign the landfill areas for the disposal of the APC residues.

- The method of APC residue disposal shall be as detailed in the Contractor's approved Operation and Maintenance Plan and the Contractor's approved Annual Residual Waste Plan. The Contractor shall arrange all APC disposal as necessary to achieve the most efficient use of the available landfill volume.
- The Contractor shall minimize the generation of leachate by applying control measures including, but not limited to, closing gate valves where appropriate, covering landfill areas that are not needed as working face with impermeable liners, preparing an optimized Residual Waste Plan.
- During the Operation Service Period, the Contractor shall prepare a closure plan that shall including the following:
    - A stability calculation of the envisaged final shape of the landfill body demonstrating its stability considering appropriate friction and slippage coefficients of the materials landfilled and the cover layers applied.
    - A contour layer to smoothen the final shape of the landfill body.
    - A complemental dual cover system for the hazardous APC residues so that in the event one layer fails the other layer can withstand the ingress of water. In the event a mineral layer is applied, the layer shall provide a calculated percolation rate similar to a mineral layer of at least 0.5 m thickness having a permeability coefficient of not greater than $5x10^{-10}$ m/s at a constant water head of 0.3 m. If a geomembrane is used, its thickness shall be not less than 2.0 mm.
    - A leakage control system shall be applied for the dual cover system.
    - A sufficiently dimensioned drainage layer (thickness $\geq$ 0.3 m, permeability coefficient $\geq 5x10^{-3}$ m/s).
    - A recultivation layer incl. a natural vegetal cover (thickness > 0.5 m) that meets the local conditions
- The leakage control system shall be operated after closure of the landfill (sub)cells. Samples shall be taken every quarter and fingerprint analyses shall be carried out.
- Samples from the monitoring wells shall be analyzed regularly (at least once per quarter) for parameters such as PAHs, phenols, cadmium, chromium (hexavalent and total), copper, iron, lead, mercury, nickel, zinc.

Requirements towards the APC residues handling and the components necessary to retain APC residues include:

- The Contractor shall handle and dispose of all APC residues and ensure that processing is conducted in a manner that prevents fugitive emissions and escape of dust.
- Bag filter hoses shall be replaced only if the central dedusting system is operational.
- Unloading the silos shall be carried out using dust-tight unloading chutes only.
- The area around the APC residues silo shall be kept clean at all times and spills shall be dealt with immediately.
- The driver of the APC residues transport vehicle shall be required to use personal protective equipment during loading and unloading to prevent the inhalation of dust and fumes.

Environmental and Social Impact Assessment for the Regional Solid Waste Management Facility (RSWMF) Thilafushi

Marine Survey Report

Thilhafushi house reef. Photo by: Water Solutions

Prepared by: Abdul Aleem (EIA P03/2019), Mohamed Umar (EIA P02/2019) & Abdulla Fazeel

23rd September 2019

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1 Introduction

The marine environment survey of Thilafushi covered the shallow lagoon, deep lagoon, reef-flat, and reef slope of the house reef of areas of Thilafushi Island. Thilafushi consists of deep, shallow lagoon, reef flat and reef slope areas. More than half of the shallow lagoon or reef flat area is now reclaimed. The south wing of Thilafushi is wider compared to north wing. The widest reef flat area is on the south wing on the west side of the reef. The enclosed deep lagoon area towards east is well protected with very restricted water movement. This area is used by vessels as a mooring basin. The stagnant water coupled with waste dumping in this area has degraded the lagoon environment on the east side. The deep lagoon of this area has very low visibility, the bottom substrate of the deep lagoon consists mainly of sand. Towards the east of deep lagoon, the bottom substrate is mainly mud and garbage debris.

2 Scope of work

The marine survey at Thilafushi has been conducted to cover the marine component of the TOR for the EIA for the Establishment of the Regional Waste Management Center for Zone III issued by EPA. Hence the TOR requested to assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area, focused on the marine environment. Aspects of the environment shall be described to the extent necessary for assessment of the environmental impacts of the proposed development. The extent and quality of the available data shall be characterized indicating significant information deficiencies and any uncertainties associated with the prediction of impacts.

All available data from previous studies, if available shall be presented. Information required includes the following:

Assessment of the marine environment should be undertaken from all locations from which data was taken in 2011 EIA report. This assessment should cover coral cover and fish census information. Plankton Assessment from 05 different locations around Thilafushi. Areas of special sensitivity including coral reefs and marine protected areas near Thilafushi shall be marked on a map and described. This shall include environmentally sensitive areas, protected areas and significant dive sites.

3 Methodology

A coral reef survey of Thilafushi reef was carried out to establish a baseline of the existing coral reef environment. The baseline assessment assessed the diversity and abundance of coral reef, fish, and significant invertebrates that are commonly associated with the reef environment of Maldives. The method involved determining percentage of various benthic substrate (categories) using standard benthic categories for coral reef benthic substrate sampling as described by Hodgson et.al (2006) in Reef Check Instruction Manual: A Guide to Reef Check Coral Reef Monitoring.

Site selection for the marine survey was based on the location of the WTE, existing dumpsite, and proposed hotwater outfall and seawater intake and as well as control sites for future monitoring purposes. At survey sites M1 to M7 benthic composition and fish abundance was surveyed at depths of 5 meters and 10 meters and at survey sites M8 to M10, surveys were done to a depth of 30 metres along the reef profile. A Manta Tow survey was conducted along 500 metres from M9 to M10 along the reef edge on the southern side of Thilafushi at both 5 and 10 metres. The inner lagoon was not surveyed as the area is not of ecological importance.

The marine benthic and fish surveys at Thilafushi Island was focused on 10 sites. Plankton tows and water samples were done at 7 sites on 23rd – 24th April 2018. Marine surveys were done at marine sites M1 to M7 on 23rd – 24th April 2018 2018. Three sites, M8 to M10 were surveyed on 1st September 2019 as more detail marine survey was requested to locate the hot water discharge location on southern side of Thilafushi. These three sites were chosen within a 500 m zone on the southern side of Thilafushi as shown in Figure 3. M8 was one of the potential site to locate the hot water discharge outfall.

Figure 1: Marine surveyed locations with coordinates in 23rd – 24th April 2018 and 1st September 2019

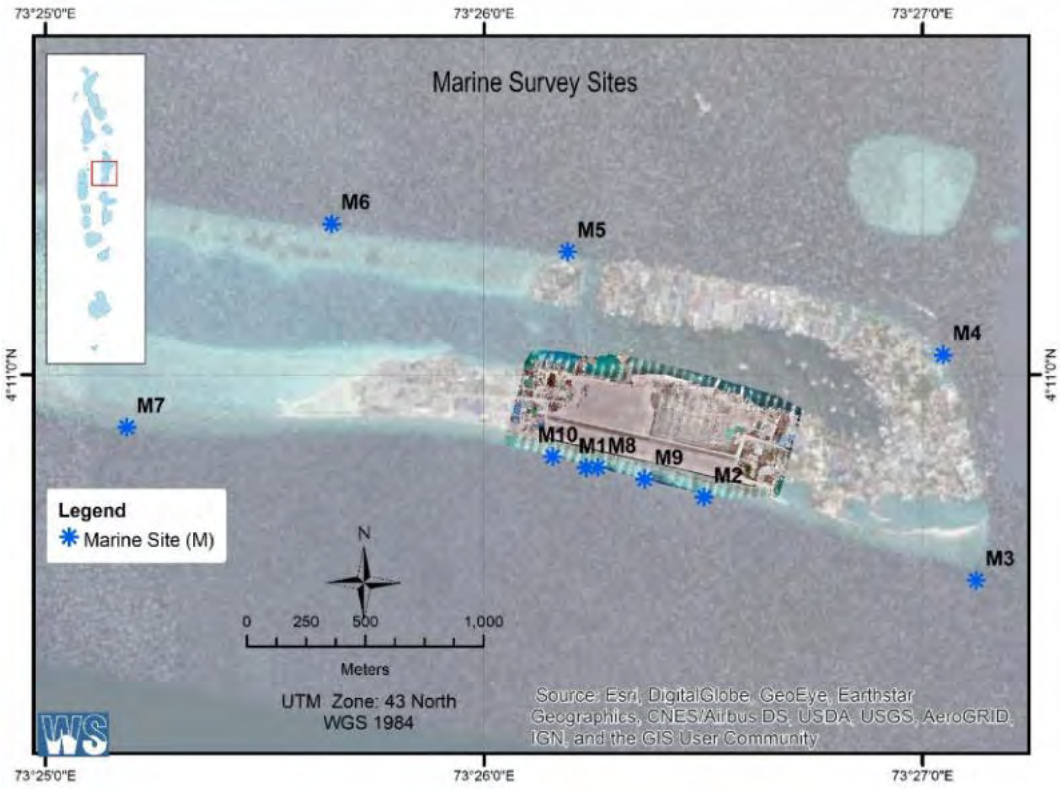


Figure 2: Marine surveyed locations with coordinates in 23rd – 24th April 2018 and 1st September 2019

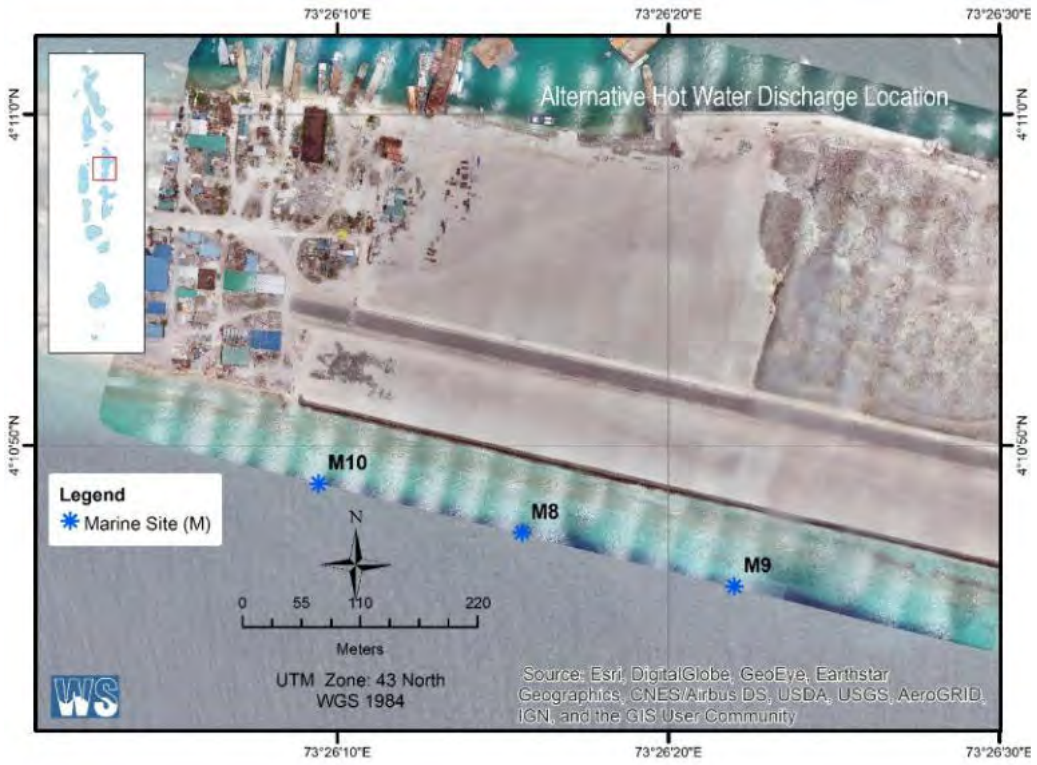


Figure 3: Marine surveyed locations on 1st September 2019

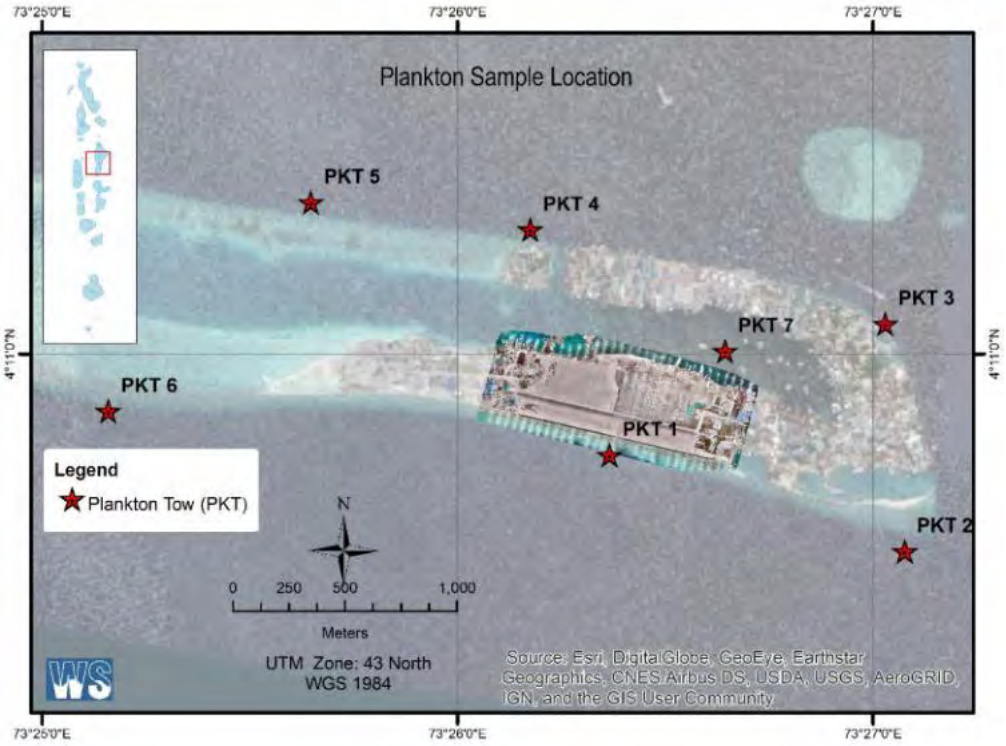


Figure 4: Plankton tows and water sampled location on 23rd – 24th April 2018

3.1 Benthic Survey

All surveys were carried out by underwater SCUBA diving. The marine surveys were carried out by surveyors who had been trained to undertake Reef Check surveys as outlined in the Reef Check Instruction Manual: A Guide to Reef Check Coral Reef Monitoring (2006). Based on the Guide to Reef Check Coral Reef Monitoring (2006) photo quadrat surveys were done in order to measure the benthic composition 10 sites (M1-M10) located on areas on the outer reef around Thilafushi island. At the survey sites M1 to M7 benthic composition and fish abundance was surveyed at depths of 5 meters and 10 meters. At survey sites M8 to M10, marine surveys were done to a depth of 30 metres along the reef profile.

3.1.1 Surveys in April 2018

The photo quadrat surveys were undertaken at marine site M1 to M7. A transect line of 20 metres at each site is set out, the surveyor then places a half a metre quadrat made from PVC along the transect line and takes a photo directly from vertically above. The second photo is then taken along in the same manner after approximately 1 m away from the first photo. In this manner, photos are taken along the transect line and in total, 10 photos on each transect line are taken. In each of the sites 4 transects were place in two depths (5 & 10m). The surveys were undertaken on 23-24 April 2018.

3.1.2 Reef profile Survey in September 2019

Marine survey sites M8 to M10, were three additional sites surveyed using photo quadrat methods. Unlike the conventional reef transect surveys, the three sites were assessed for benthic composition by undertaking photo quadrates from the top reef up to 30 metres, along the reef profile.

Before start of the survey, the starting points were marked using a plastic bottle tied with a rope and weight at its end. The weight rested at the top reef, approximately 5 metres from the reef slope. This allowed the divers to descent from the exact required location up to 30 metres.

Photos were taken using the half metre quadrat made from PVC along the transect line (vertical) and takes a photo directly from above. The second photo is then taken along in the same manner after approximately 1 below the first photo. In this manner, photos are taken along the transect line.

3.1.3 Manta Tow survey in September 2019

A Manta Tow survey was conducted along 500 metres from M9 to M10 along the reef edge on the southern side of Thilafushi at both 5 and 10 metres. Manta towed was conducted by swimming along the stretch and recording the observations on an underwater slate. The tow at 5 metres was undertaken with the help of a boat which towed the swimmer along the survey stretch using a rope.

The parameters observed include percentage cover of live coral, other benthic organisms, substrate diversity of the reef in terms of benthic and pelagic life. Overall status of the reef along this stretch was determined based on this survey and the results are outlined below.

4 Data Processing methodology

Analysis of the photos was done using a computer program called, CPCe (Coral Point Count with Excel extensions). This is an internationally recognized software used all over the word to assess the benthic composition of the reefs. In this programme, photographs are analyzed using pre-defined benthic categories. Depending on the type of survey, these categories can be user defined at any given level. Users can have very complex levels ranging from individual coral families or have broader assessment categories. As the objective of this survey was to assess the impact of dredging and reclamation, it made sense to use a broader categories. Hence, benthic categories adopted by the Reef Check protocol were utilized. A text file containing these categories was created and imported to CPCe. The Reef Check protocol allows categorizing life forms followed under the Reef Check protocol, which emphasizes on benthic composition categorizing such as hard corals, sand, rock and others. The emphasis is not on recording corals to their species levels, but rather the general coral and other life forms such as hard and soft corals. This method is more accurate as the percentage of healthy coral cover and other life forms can be more accurately recorded even by a non-experienced surveyor.

The following are definition of benthic categories used in this survey.

- **HC:** All living coral including bleached coral; includes fire, blue and organ pipe corals
- **SC**: Include zoanthids but not anemones (OT)
- **DC**: Coral that has died within the past year; appears fresh and white or with corallite structures still recognizable
- **ALG**: All macro-algae except coralline, calcareous and turf (record the substrate beneath for these); Halimeda is recorded as OT; turf is shorter than 3cm.
- **SP**: All erect and encrusting sponges (but no tunicates).
- **RC**: Any hard substrate; includes dead coral more than 1 year old and may be covered by turf or encrusting coralline algae, barnacles, etc.
- **RB**: Reef rocks between 0.5 and 15cm in diameter
- **SD**: Sediment composed of particles of less than 0.5cm in diameter; in water, falls quickly to the bottom when dropped.
- **SI**: Sediment that remains in suspension if disturbed; recorded if color of the underlying surface is obscured by silt.
- **OT**: Any other sessile organism including sea anemones, tunicates, gorgonians or non-living substrate.
- **SG**: All types of sea grass observed categorized in the field SG.

Each of the 10 photos from transect are imported, cropped and prepared for analysis. The CPCe program then generates a matrix of random points overlaid on the image for each point to be visually identified. Users can then input the defined categories for each photo and once all the photos are analysed, the results are displayed on a table.

5 Results of the marine survey

5.1 Status of site 1 (M1)

Site 1 was selected from the Southern rim of the island reef. The site was chosen as the site was adjacent to the proposed waste rehabilitation centre. The substrate at the site is dominated by rock at depths of 5 (58 ± 14.2%) and 10 (64.5 ± 2.78) meters respectively. Hard coral cover was observed to be moderate at the site at depths of 5 (19.5 ± 5.91) and 10 (21 ± 2.68) meters. Massive porites were the dominating the group of hard coral observed at the site at both the depths. Fishes observed to be abundant at a depth of 5 meters were surgeon fishes, damselfishes and butterfly fishes. Fishes observed to be abundant at a depth of 10 meters were anthias, damselfishes and triggerfishes. The following graph outlines the status of site 1(M1) at depths of 5 and 10 meters.

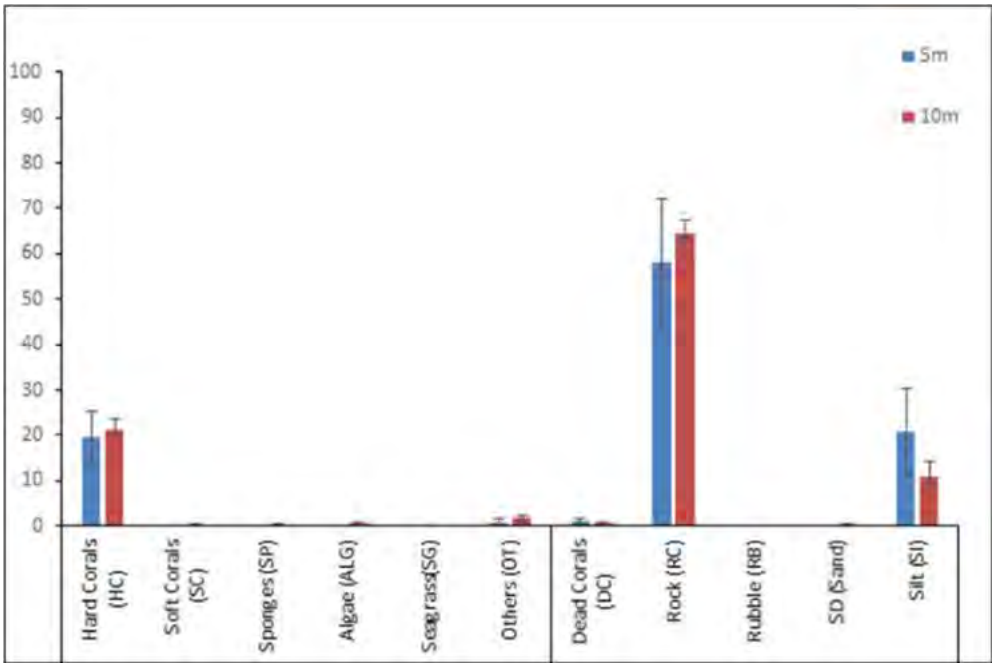


Figure 5: Percentage benthic composition at site 1(M1) at depths of 5 and 10 meters ± Standard Error (SE) (23rd April 2018).

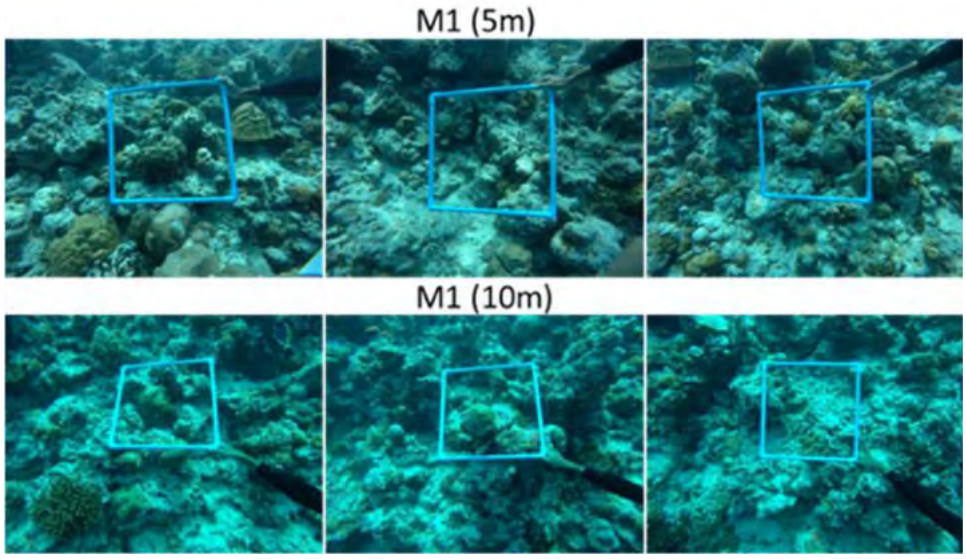


Figure 6: Photos taken from site 1 at depths of 5 and 10 meters (M1) (23rd April 2018).

5.2 Status of site 2 (M2)

Site 2 was selected from the Southern rim of the island reef east of site 1. The site was chosen as the site was adjacent to the proposed waste rehabilitation centre. The substrate at the site is dominated by rock at depths of 5 (71.25 ± 3.86%) and 10 (63 ± 6.14) meters respectively. Hard coral cover was observed to be moderate at the site at depths of 5 (22.25 ± 2.95) and 10 (23.25 ± 5.17) meters. Massive porites were the dominating group of hard coral observed at the site at both the depths. Fishes observed to be abundant at depth of 5 meters were anthias, surgeon fishes, damselfishes, parrotfishes, triggerfishes and butterfly fishes. Fishes observed to be abundant at depth of 10 meters were anthias, damselfishes, butterfly fishes and triggerfishes. The following graph outlines the status of site 2(M2) at depths of 5 and 10 meters.

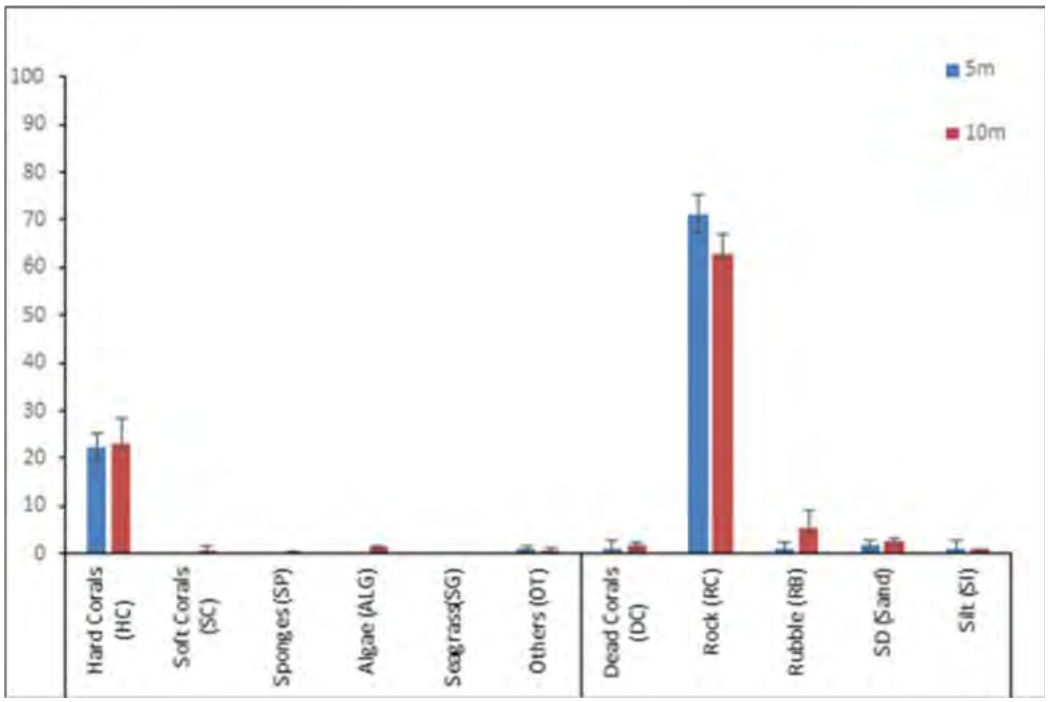


Figure 7: Percentage benthic composition at site 2 (M2) ± SE (24th April 2018).

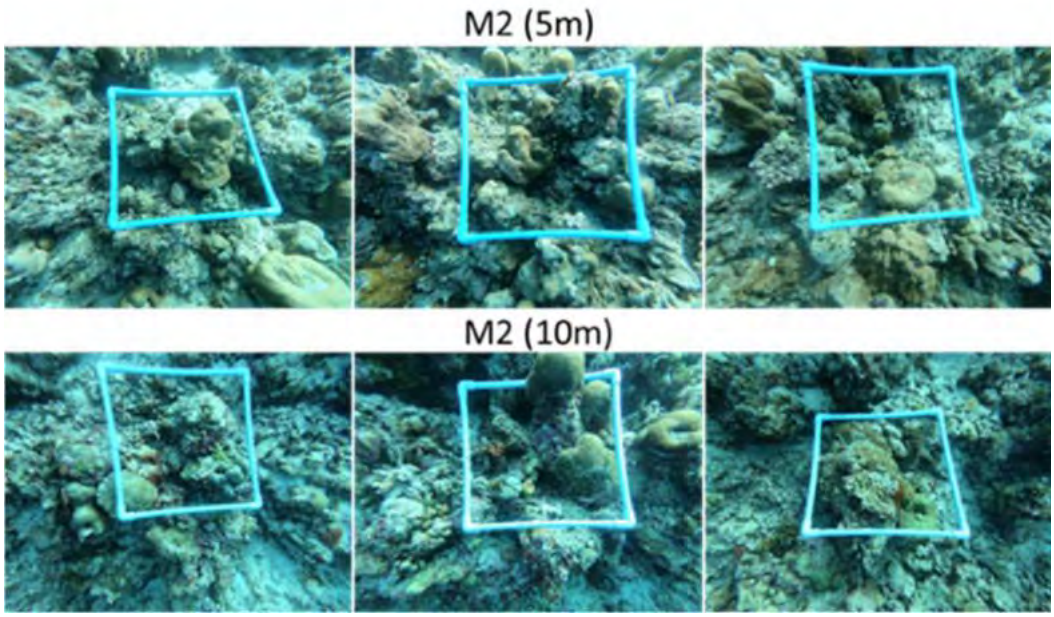


Figure 8: Photos taken from site 2 (M2) (24th April 2018).

5.3 Status of site 3 (M3)

Site 3 was selected from the Southern eastern corner of the island reef. The site was chosen as a control site as well as to get a broader understanding of the ecological baseline around the reef. The substrate at the site is dominated by rock at depths of 5 (76.25 ± 2.10%) and 10 (65.75 ± 2.46) meters respectively. Hard coral cover was observed to be moderate at the site at depths of 5 (17 ± 2.48) and 10 (16.5 ± 0.65) meters. Massive porites were the dominating group of hard coral observed at the site at both the depths. Fishes observed to be abundant at a depth of 5 meters were surgeon fishes and jacks and trevallies. Fishes observed to be abundant at a depth of 10 meters were anthias, damselfishes and triggerfishes. The following graph outlines the status of site 3(M3) at depths of 5 and 10 meters.

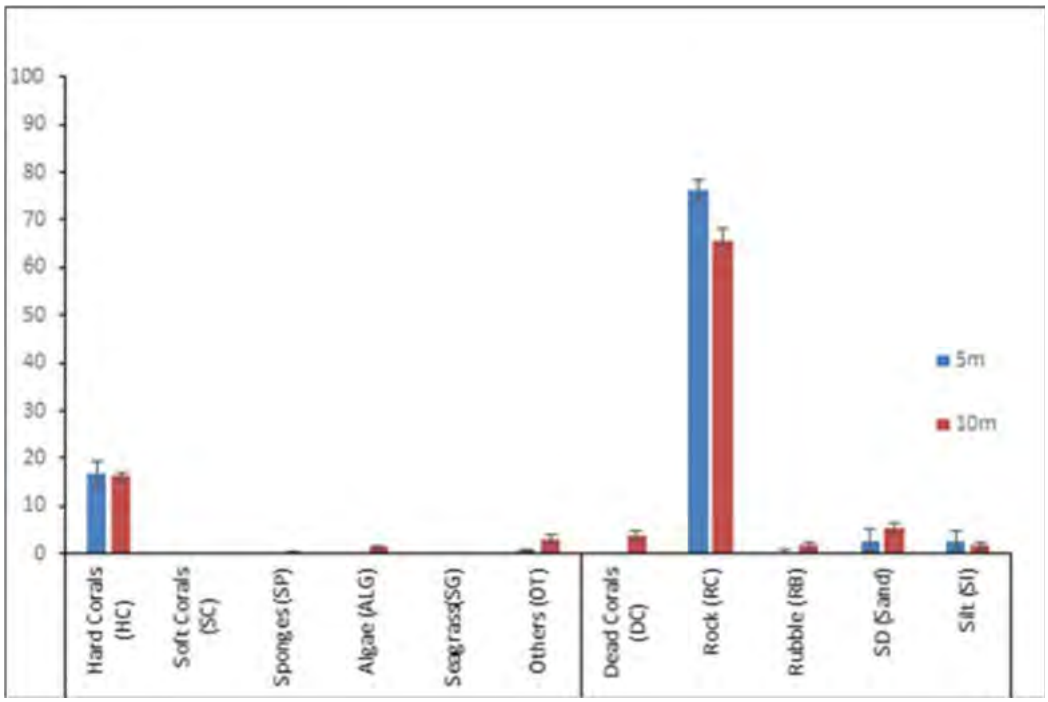


Figure 9: Percentage benthic composition at site 3 (M3) ± SE (23rd April 2018).

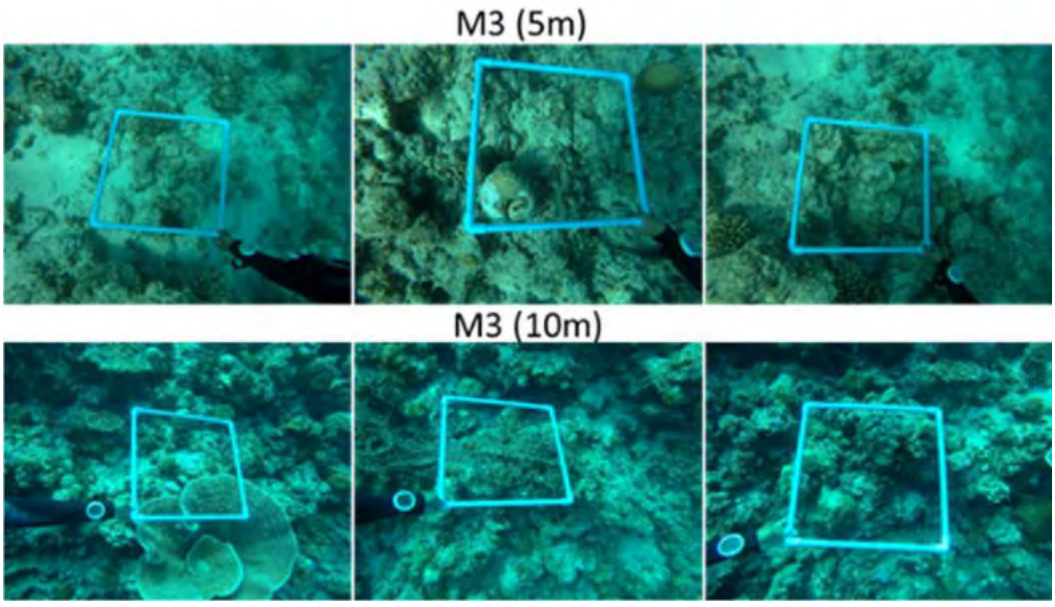


Figure 10: Photos taken from site 3 (M3) (23rd April 2018).

5.4 Status of site 4 (M4)

Site 4 was selected from the North-eastern rim of the island reef. The site was chosen as a control site as well as to get a broader understanding of the ecological baseline around the reef. The substrate at the site is dominated by rubble at depths of 5 (67 ± 4.49%) and 10 (60 ± 6.42) meters respectively. Hard coral cover was not observed at the site at depths of 5 and 10 meters. Fishes observed to be abundant at a depth of 5 meters were surgeon fishes, butterfly fishes and fusiliers. Fishes observed to be abundant at a depth of 10 meters were only fusiliers. The following graph outlines the status of site 4(M4) at depths of 5 and 10 meters.

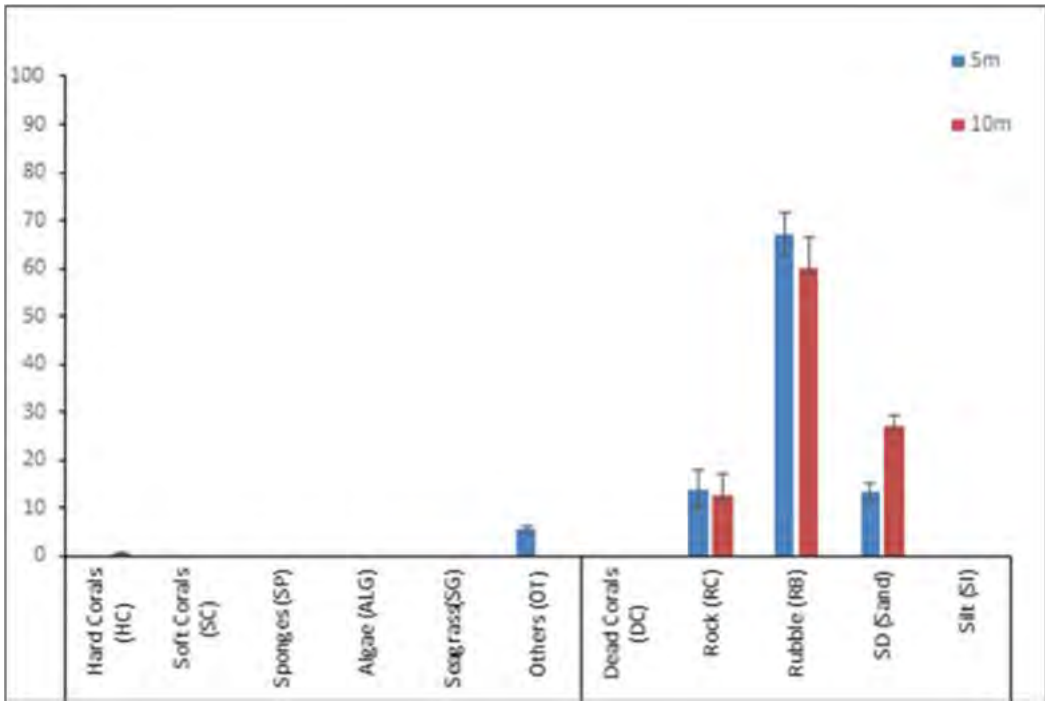


Figure 11: Percentage benthic composition at site 4 (M4) ± SE (24th April 2018).

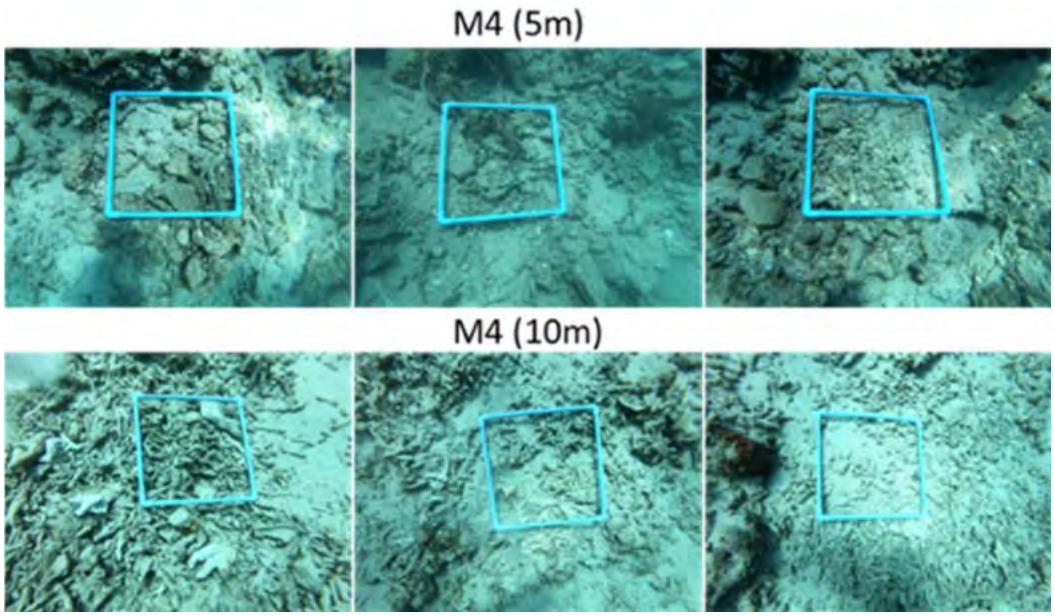


Figure 12: Photos taken from site 4 (M4) (24th April 2018).

5.5 Status of site 5 (M5)

Site 5 was selected from the Northern rim of the island reef close proximity to the entrance channel. The site was chosen as a control site as well as to get a broader understanding of the ecological baseline around the reef. The substrate at the site is dominated by rock at depths of 5 (46.75 ± 6.28%) and 10 (51.5 ± 5.81) meters respectively. Hard coral cover was observed to be low at the site at depths of 5 (5 ± 1.58) and 10 (4.25 ± 0.75) meters. Massive porites were the dominating group of hard coral observed at the site at both the depths. Fishes observed to be abundant at a depth of 5 meters were surgeon fishes and parrotfishes. Fishes observed to be abundant at a depth of 10 meters were surgeon fishes, damselfishes and triggerfishes. The following graph outlines the status of site 5(M5) at depths of 5 and 10 meters.

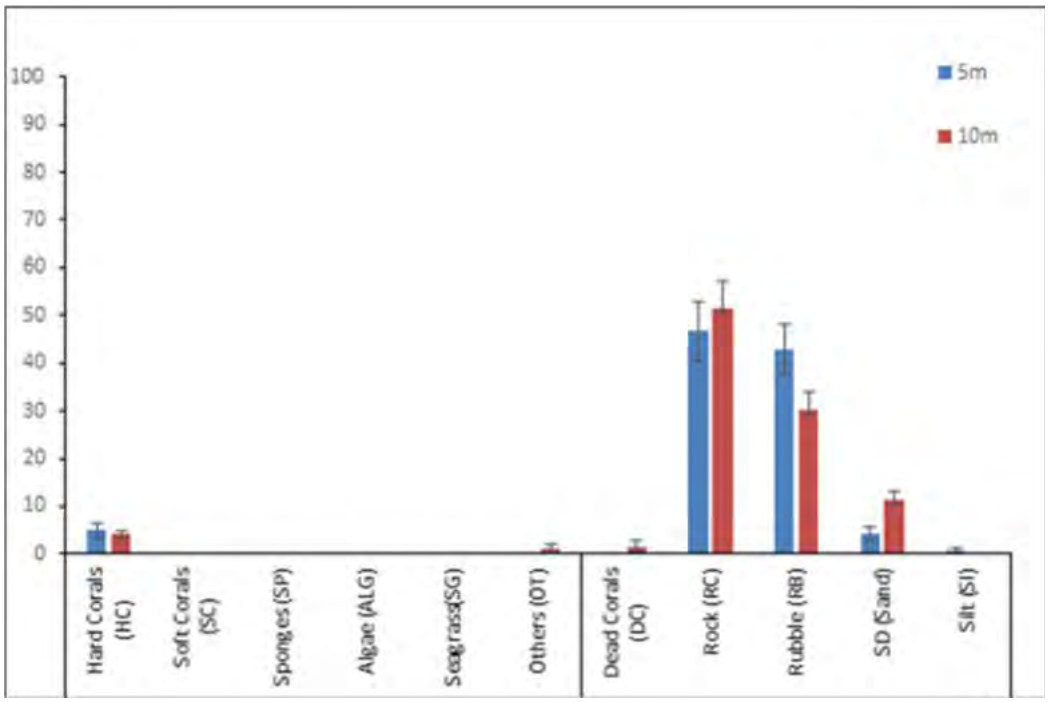


Figure 13: Percentage benthic composition at site 5 (M5) ± SE (24th April 2018).

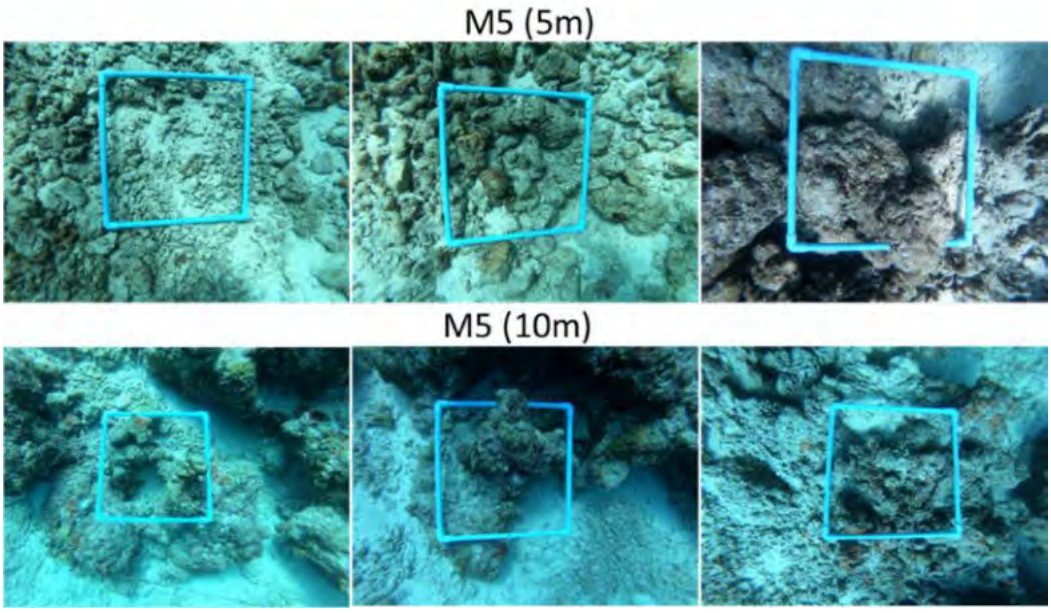


Figure 14: Photos taken from site 5 (M5) (24th April 2018).

5.6 Status of site 6 (M6)

Site 6 was selected from the Northern rim of the island reef west of site 5. The site was chosen as a control site as well as to get a broader understanding of the ecological baseline around the reef. The substrate at the site is dominated by rock at depths of 5 (80.5 ± 4.19%) and 10 (36.5 ± 5.85) meters respectively. Hard coral cover was observed to be low at the site at depths of 5 (8.75 ± 2.53) and 10 (14 ± 2.58) meters. Particular group of hard corals were not observed to dominate the substratum. A diverse group of corals from groups such as Acropora, Pocillopora and Porites were observed at the site. Fishes observed to be abundant at a depth of 5 meters were surgeon fishes, wrasses, triggerfishes, damselfishes and butterfly fishes. Fishes observed to be abundant at a depth of 10 meters were surgeon fishes, damselfishes, triggerfishes and butterfly fishes. The following graph outlines the status of site 6(M6) at depths of 5 and 10 meters.

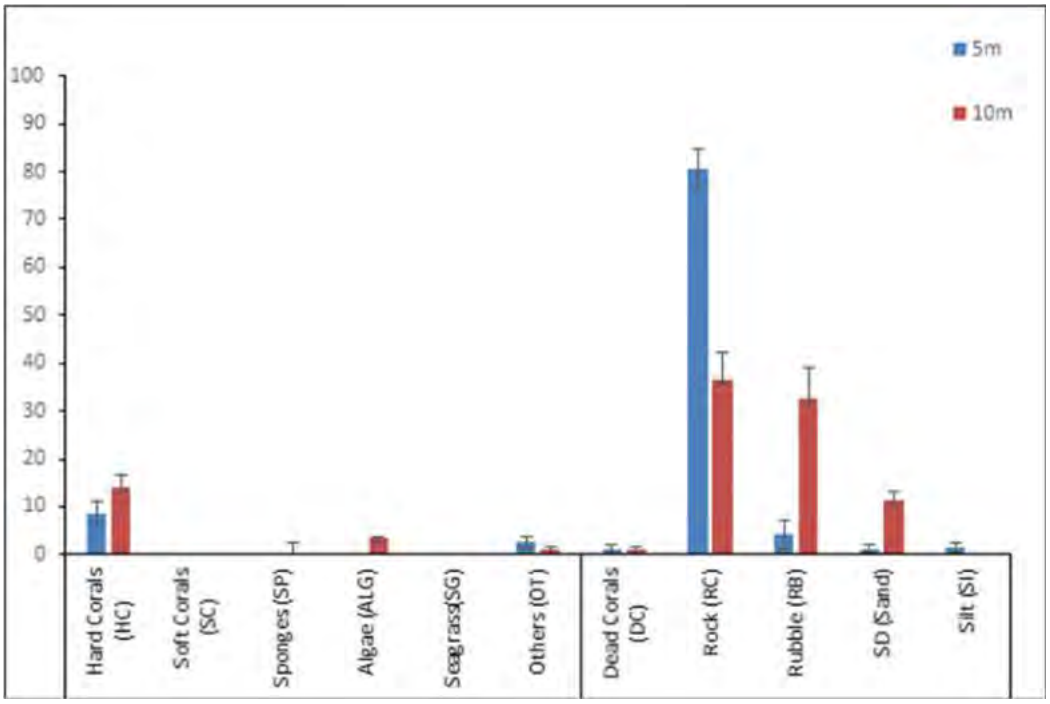


Figure 15: Percentage benthic composition at site 6 (M6) ± SE (24th April 2018).

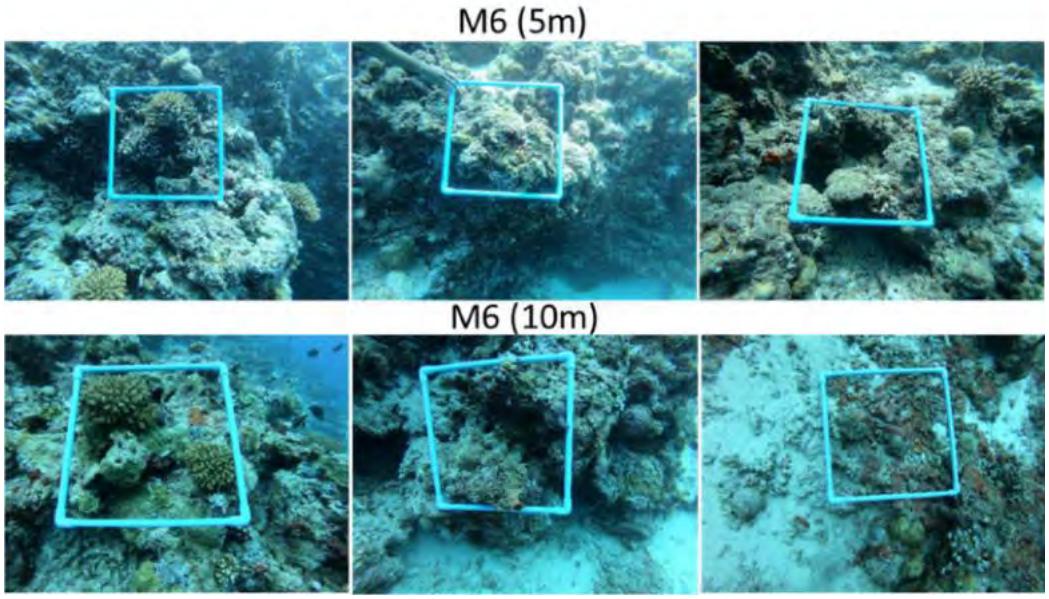


Figure 16: Photos taken from site 6 (M6) (24th April 2018).

5.7 Status of site 7 (M7)

Site 7 was selected from the Southern rim of the island reef west of site 1. The site was chosen as a control site as well as to get a broader understanding of the ecological baseline around the reef. The substrate at the site is dominated by rock at depths of 5 (76 ± 5.87%) and 10 (77.75 ± 3.33) meters respectively. Hard coral cover was observed to be low at 5 meters (5 ± 1%) and moderate in 10 meters (17.5 ± 3.2). Massive porites were the dominating group of hard coral observed at the site at both the depths. Fishes observed to be abundant at a depth of 5 meters were surgeon fishes, damselfishes and butterfly fishes. Fishes observed to be common at a depth of 10 meters were surgeon fishes. The following graph outlines the status of site 7(M7) at depths of 5 and 10 meters.

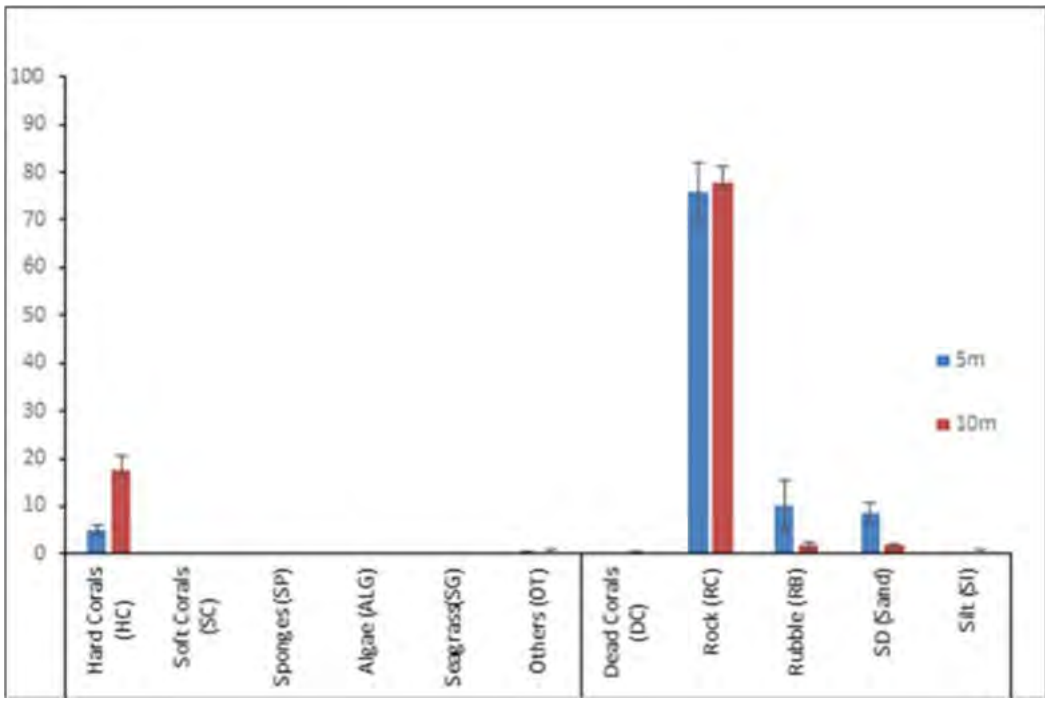


Figure 17: Percentage benthic composition at site 7 (M7) ± SE (23rd April 2018).

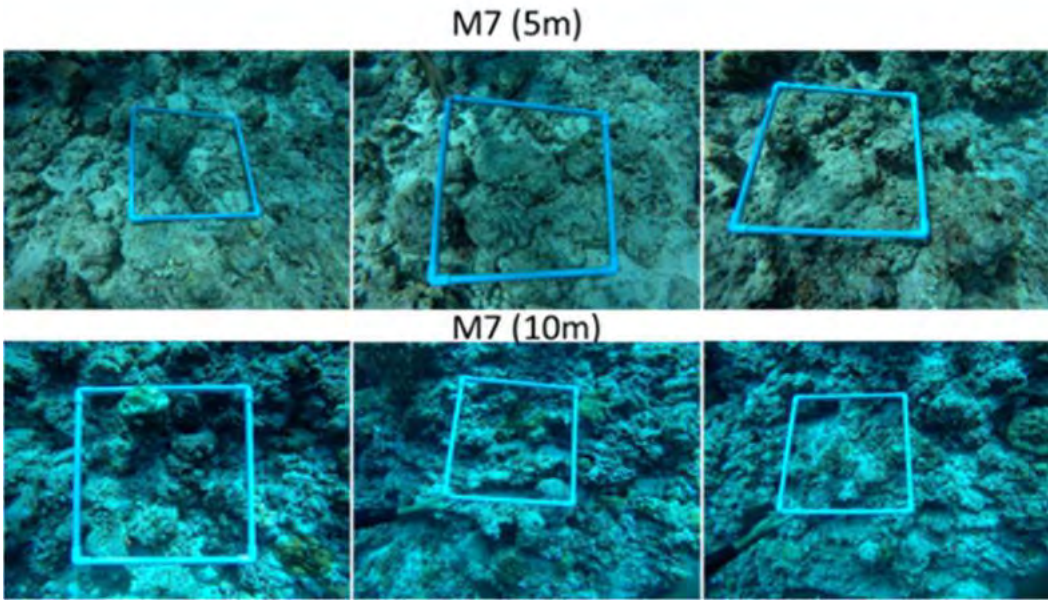


Figure 18: Photos taken from site 7 (M7) (23rd April 2018)

5.8 Observation during the marine survey in 2019

The highest coral cover was observed at the depth of 10 meters in site M2 adjacent to the current waste dumping area. The results are highlighted in the figure below. Therefor there is the possibility the leachate from land fill are not having negative impacts on the reef at site M2.

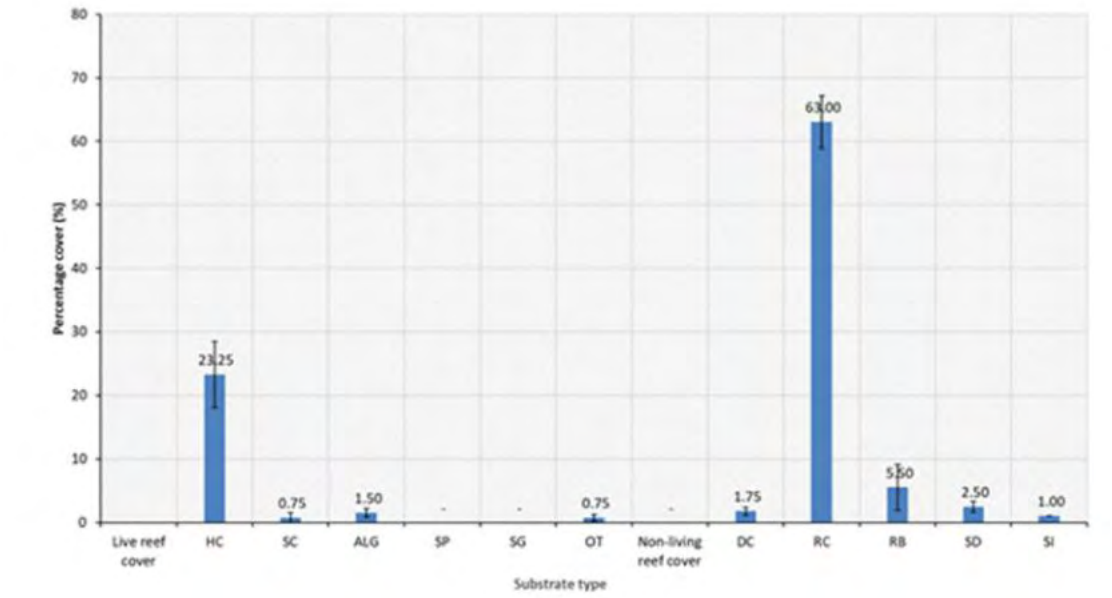


Figure 19: Percentage benthic composition at site 2(M2) at a depth of 10 meter ± standard error (SE).

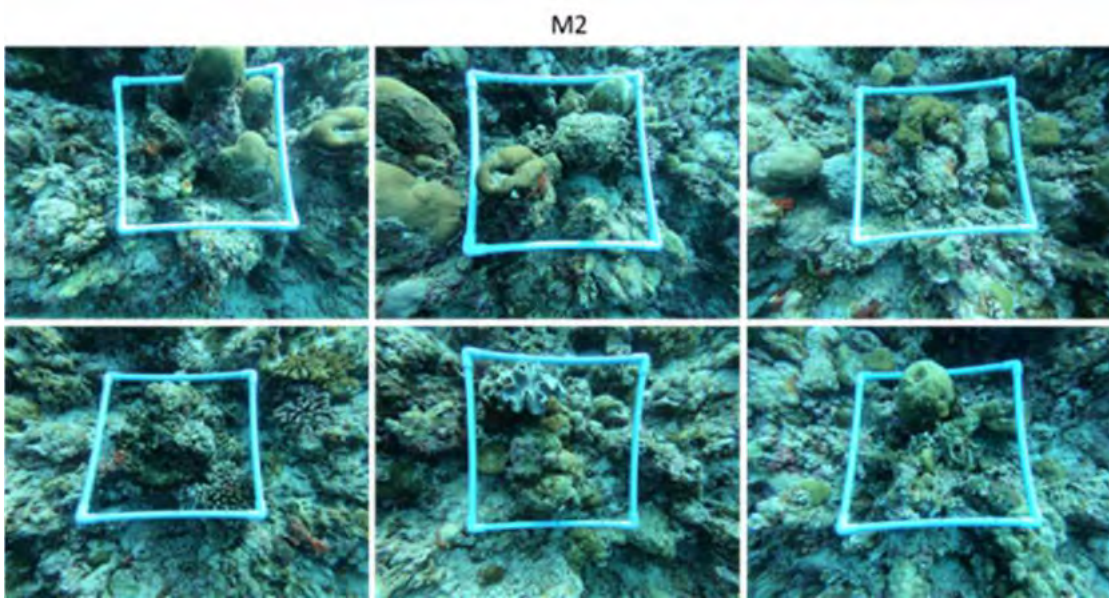


Figure 20: Photos compiled from site 2 (M2) at a depth of 10 meters.

5.9 Status of site M8

Site M8 was selected from the Southern rim of the island reef. The site was chosen as this is the proposed location for the hot water discharge outfall. The substrate at the site is dominated by silt along the entire transect line (43 ± 11.69%). Hard coral cover was observed to be low (8 ± 2.71). Massive porites were the dominating the group of hard coral observed at the site. Fishes observed to be very rare. It is to be noted that just a week prior to the survey, due to the severe weather, this entire stretch of reef has been hit by strong waves causing the sediments on the western side of the Thilafuhi to be spread along most part of the southern side. This has resulted in large areas of the reef being covered with silt. The following image illustrates the reef slope characteristics at site M10.

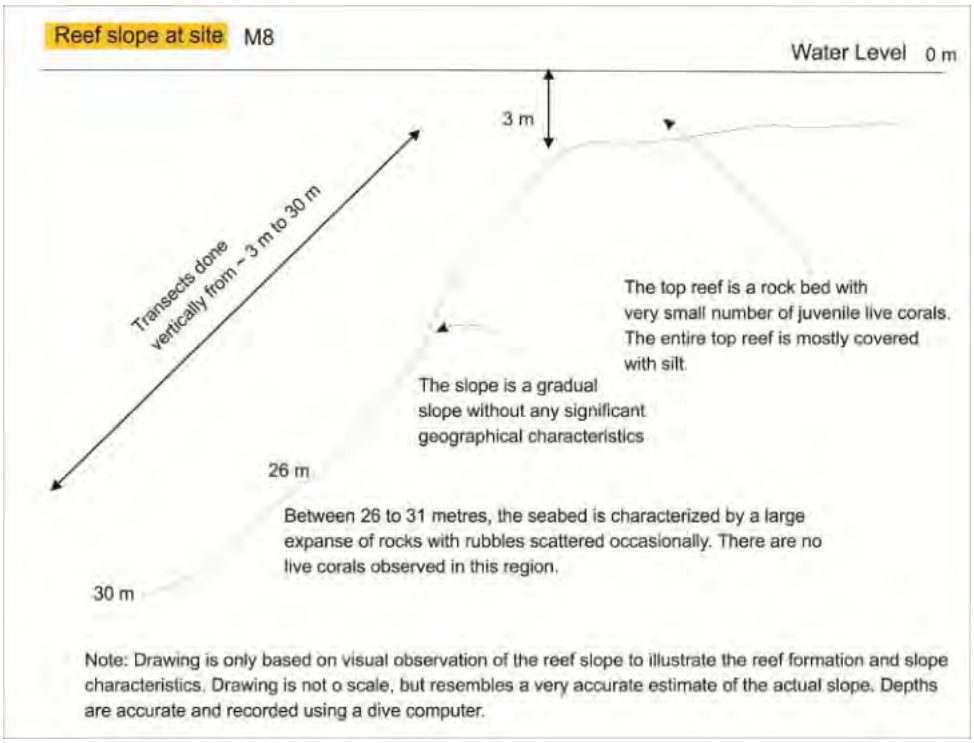


Figure 21: Reef slope characteristics at M8 (1st September 2019).

The following graph outlines the status of site M8.

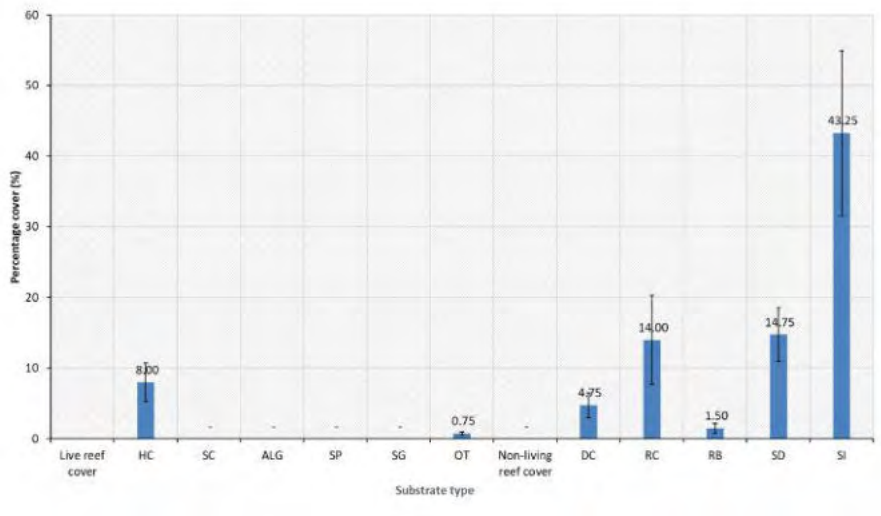


Figure 22: Percentage benthic composition at site M8 at depths from ~ 3 to 30 meters ± Standard Error (SE) (1st September 2019).

5.10 Status of site M9

Site M9 was also selected from the Southern rim of the island reef east of site 1. The substrate at the site is dominated by silt (64.5 ± 3.77%). Hard coral cover was observed to be low along the surveyed depths from approximately 3 to 30 metres (10.75 ± 3.22). Massive porites were the dominating group of hard coral observed at the site. Fishes observed were very low and includes anthias and surgeon fishes (refer to the fish census table for details). The following graph outlines the status of site M9.

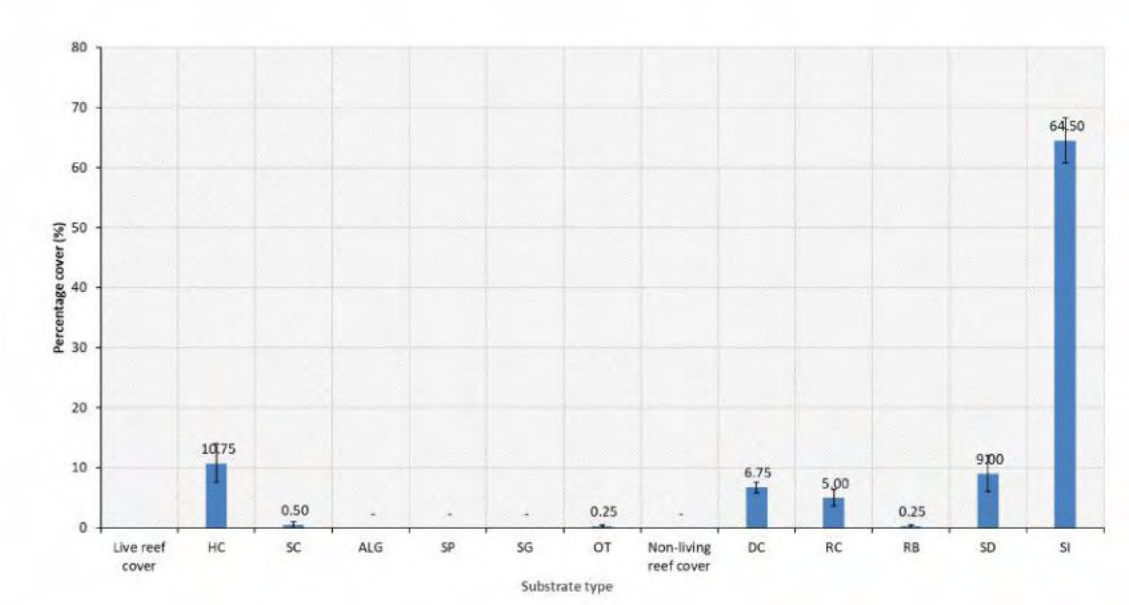


Figure 23: Percentage benthic composition at site M9 at depths from ~ 3 to 30 meters ± SE (1 September 2019).

The following image illustrates the reef slope characteristics at site M9.

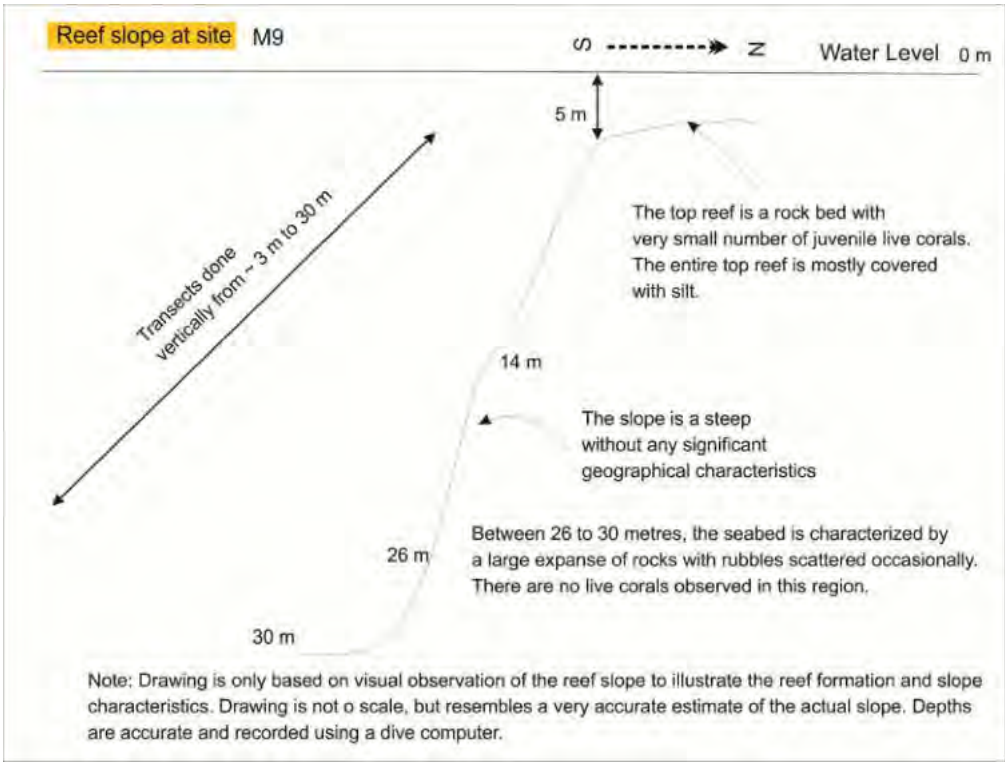


Figure 24: Reef slope characteristics at M9 (1 September 2019).

5.11 Status of site M10

Site M10 was also selected from the Southern side of the island reef. The following image illustrates the reef slope characteristics at site M10.

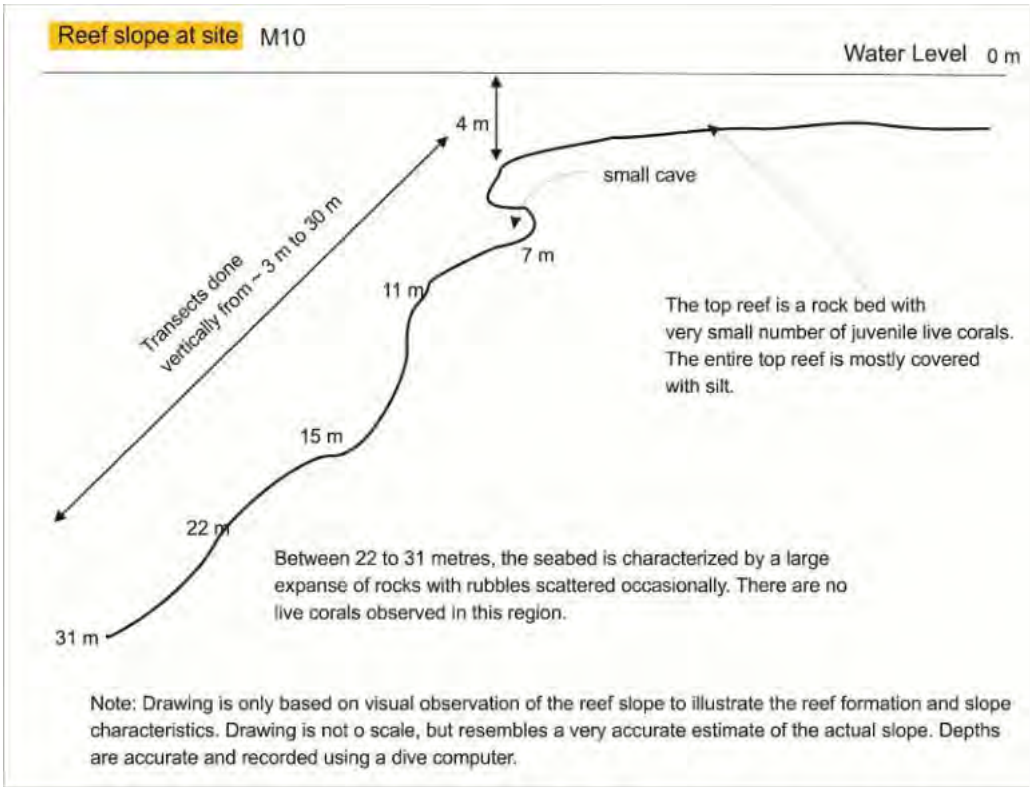


Figure 25: Reef slope characteristics at M10 (1 Sept 2019).

The substrate at the site is dominated by silt (58.50 ± 4.57 %). Hard coral cover was observed to be moderate (23.75 ± 7.43). Massive Porites were the dominating group of hard coral observed at the site. Fishes observed to be very low. The following graph outlines the status of site M10.

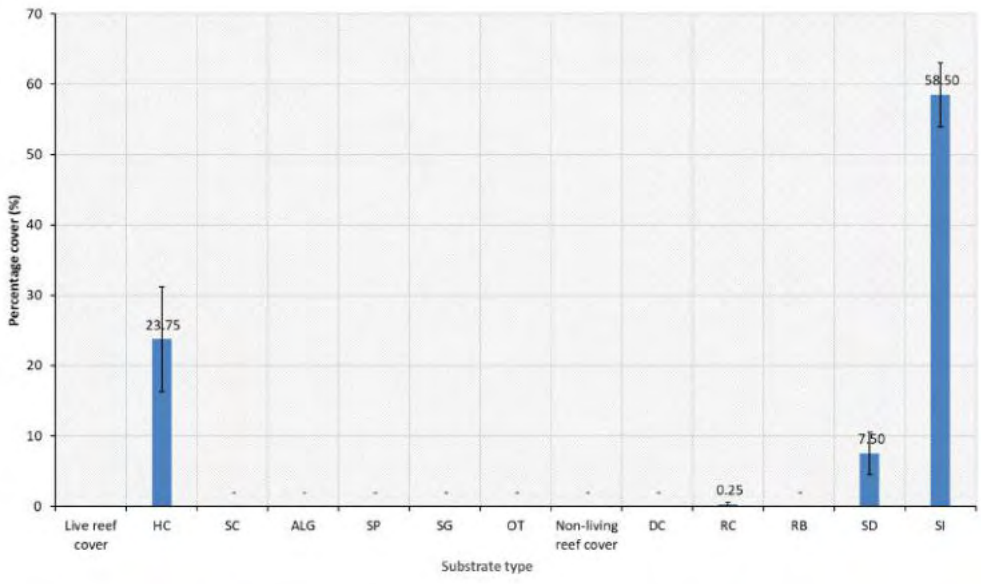


Figure 26: Percentage benthic composition at site M10 ± SE (1 Sept 2019).

5.12 Manta Tow between M9 and M10

The following table outlines the results of the Manta Tow survey that was carried out on 1st September from M9 to M10

Table 1: Manta Tow survey results of approximate substrate cover around the reef edge

	Love Coral cover%	Dead coral cover%	Soft corals cover%	Rock cover %	Rubble cover %	Silt cover %	Benthic diversity	Fish diversity
5 metres								
	5	8	-	15	2	70	low	low
10 metres								
	10	6	-	27	7	50	Low	low

The Manta Tow survey showed that coral reef system along the surveyed stretch is not in very good conditions in term of percentage live coral cover, diversity of corals, benthic and pelagic life. The overall live coral cover of the reef system appeared to be approximately 5% at 5 metres and approximately 10% at 10 metres. The reef substrate at both these depths were dominated by silt. Abundance and diversity of fish was also lower along the stretch. The live coral cover was highest at 10 metres. The corals inmost abundance were massive type coral head belonging to the genus Porites.

5.12.1 Protected marine species

During the Manta tow survey, no protected marine species such as sharks or were observed and recorded.

5.12.2 Reef Aesthetics

This attribute was assessed by visual observations based on the observer's judgment and experience of the relative merits of a reefs in the Maldives. This value judgment incorporated coral cover, diversity of life forms, fish life, reef structure and general appeal. The following categories were used to determine aesthetics of the reef system:

a. Very poor (mostly dead corals, pelagic life not abundant and diversity very low, structure uniform).
b. b. Poor (Lot of dead corals, pelagic life not abundant and diversity low, some differences in structure).
c. c. Average (Live corals about 10%, pelagic life abundant, diversity low, some structural variations exists).
d. d. Good (Live corals about 20% pelagic life abundant, diverse, structural variations exists).
e. e. Very good (Live corals about 30%, pelagic life abundant, diverse, overhangs, and other structures).
f. f. Excellent (Live corals over 40%, pelagic life very abundant, very diverse, lots of different structures, overhangs, caves, gullies, and different habitat types exists.

Reef aesthetics of Thilafushi's coral reef system (along the 500 metres) is regarded as very poor, given that substantial level of the reef is covered in sill and poor diversity of life forms. Fish life and abundance are very poor at the time of surveying and generally this stretch of reef can be considered to be very poor.

5.13 Fish Diversity and Abundance (April 2018)

The amount and type of fish present at a given site can be a good indicator of the marine environment. For example, increased grazers are generally a sign of increased nutrients in the area, thus decreased coral cover and increased algal cover. 15-minute fish counts were done in sites M1-M7 in depths of 5 and 10m. The counts include Mega fauna in addition to fishes. The fishes were identified to family level, however some protected species such as the napoleon wrasse, were identified to species level. The following table outlines the fish count survey at all the sites.

Table 2: Fish abundances observed at sites 1 to 7 at a depth of 5 and 10 meters.

Family/Subfamily	**Site M1**		**Site M2**		**Site M3**		**Site M4**		**Site M5**		**Site M6**		**Site M7**	
Depth	**5m**	**10m**	**5m**	**10m**	**5m**	**10m**	**5m**	**10m**	**5m**	**10m**	**5m**	**10m**	**5m**	**10m**
Anthias (Anthiadinae)	R	A	A	A	R	A	C	-	R	C	C	C	R	-
Surgeonfishes (Acanthuridae)	A	C	A	C	A	C	A	C	A	A	A	A	A	C
Wrasses (Labridae)	C	C	-	C	-	-	C	C	C	C	A	-	C	-
Parrotfishes (Scaridae)	C	C	A	C	R	R	C	R	A	-	C	C	C	-
Triggerfishes (Balistidae)	C	A	A	A	-	A	R	-	C	A	A	A	C	-
Boxfishes (Ostraciidae)	-	-	R	-	-	-	-	-	-	-	-	-		-
Damselfishes (Pomacentridae)	A	A	A	A	-	A	C	-	R	A	A	A	A	-
Groupers (Serranidae)	R	-	R	R	R	-	R	-	R	R	R	R	R	-
Moorish idol (Zanclidae)	R	R	R	R	R	R	R	R	C	R	R	R	R	R
Butterflyfishes (Chaetodontidae)	A	C	A	A	C	C	A	C	R	C	A	A	A	-
Goatfishes (Mullidae)	-	-	R	R	-	-	C	C	R	-	R	-	R	-
Hawkfishes(Cirrhitidae)	-	-	R	R	R	-	-	-	R	-	R	-	-	-
Threadfin and Whiptail breams (Scolopsis)	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Octopus (Octopodidae)	-	-	R	-	-	-	-	-	-	-	-	-	-	-
Fusiliers (Caesionidae)	-	-	-	-	-	-	A	A	-	-	-	-	-	-
Rabbitfishes (Siganidae)	-	-	-	-	-	-	R	-	-	-	R	-	-	-
Gobies (Gobiidae)	-	-	-	-	R	-	-	R	R	-	-	-	-	-
Pipefishes and seahorses (Syngnathinae)	-	-	-	-	-	-	R	-	R	R	-	-	-	-
Puffers (Tetraodontidae)	-	-	-	-	R	-	R	-	C	-	R	-	-	-
Emperors or scavengers (Lethrinidae)	-	-	-	-	-	-	-	-	C	-	R	-	-	-
Jacks and Trevalleys (Carangidae)	-	-	-	-	A	-	-	-	R	-	-	-	-	-

Family/Subfamily	Site M1		Site M2		Site M3		Site M4		Site M5		Site M6		Site M7	
Depth	5m	10m	5m	10m	5m	10m	5m	10m	5m	10m	5m	10m	5m	10m
Angelfishes (Pomacanthidae)	-	-	-	-	-	-	-	-	R	-	R	R	-	-
Lizardfishes (Synodontidae)	-	-	-	-	-	-	-	-	R	-	-	-	-	-
Squirrelfishes, soldierfishes (Holocentridae)	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Grunts and Sweetlips (Haemulidae)	-	-	-	-	-	-	-	-	-	R	R	-	-	-
Eels and Morays (Anguilliformes)	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Napoleon Wrasse (Cheilinus undulatus)	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Sharks & Rays (Elasmobranchii)	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Sea Turtles (Chelonioidea)	-	-	-	-	-	R	-	-	-	-	-	-	-	-

A= Abundant (Meaning that during the 15-minute time swim survey, species counts were recorded more than 50, hence it is difficult to count their numbers). C=Common (Meaning that during the 15-minute time swim survey, they were spotted occasionally and throughout the survey, but their numbers were less than 50). R=Rare (Meaning that during the survey, only few of these species were observed, often 1 or 2

5.14 Fish Diversity and Abundance (September 2019)

The following table outlines the results of the fish counts along the survey points which was conducted from approximately 3 meters up to 30 meters at each site.

Table 3: Fish abundances observed at sites M8, M9 & M10 on 1st September 2019.

Family/Subfamily	Site M8	Site M9	Site M10
Anthias (Anthiadinae)	-	C	R
Surgeonfishes (Acanthuridae)	R	C	R
Wrasses (Labridae)	-	-	-
Parrotfishes (Scaridae)	R	-	R
Triggerfishes (Balistidae)	-	-	-
Boxfishes (Ostraciidae)	-	-	-
Damselfishes (Pomacentridae)	-	-	-
Groupers (Serranidae)	-	-	-
Moorish idol (Zanclidae)	-	-	-
Butterflyfishes (Chaetodontidae)	-	-	-
Goatfishes (Mullidae)	-	-	-
Hawkfishes(Cirrhitidae)	-	-	-
Threadfin and Whiptail breams (Scolopsis)	-	-	-
Octopus (Octopodidae)	-	-	-
Fusiliers (Caesionidae)	R	-	R
Rabbitfishes (Siganidae)	-	-	-
Gobies (Gobiidae)	R	-	R
Pipefishes and seahorses (Syngnathinae)	-	-	-
Puffers (Tetraodontidae)	-	-	-
Emperors or scavengers (Lethrinidae)	-	-	-
Jacks and Trevalleys (Carangidae)	-	-	-

A= Abundant (Meaning that during the 15-minute time swim survey, species counts were recorded more than 50, hence it is difficult to count their numbers). C=Common (Meaning that during the 15-minute time swim survey, they were spotted occasionally and throughout the survey, but their numbers were less than 50). R=Rare (Meaning that during the survey, only few of these species were observed, often 1 or 2.

5.14.1 Plankton tows

Plankton are the base of the marine food chain. The phytoplankton and zoo plankton abundances in the area could possibly be affected by the presence of heavy metals. If the plankton community is thriving in these areas the heavy metals maybe bio accumulating in the food chain. Therefore plankton counts were done around Thilafushi Island in order to establish a baseline. A plankton net of 50µm mesh was built to carry out the survey. The plankton tows were carried out at sites where the marine water samples were collected.

5.14.1.1 Data Collection methodology

A plankton net of opening 0.48 x 0.48 m was tied to a 20m rope and released from a vessel. The net was allowed to drift for 20 meters and then towed towards the boat. Any organisms or particles larger than 50µm gets caught up in the net and collected in the cod end.

5.14.1.2 Data processing methodology

5.14.1.2.1 Zooplankton

Analyses of the samples were done using a microscope using a Sedgewick rafter counting chamber. The chamber has a volume of approximately 1ml. The samples collected from the net were approximately 150 – 250ml in volume. For the zooplankton count, the samples were transferred to a beaker diluted to approximately 500 – 900 ml and the volume recorded. The purpose of dilution is to reduce the number of plankton in the optical view of the microscope for ease of counting. Two sub-samples were counted from each sample. To calculate Total count in the sample, the counts in the subsamples were averaged. Thereafter the average value in the sub samples were multiplied with the total Volume in the diluted sample to obtain the Total count in the Sample. From the Total count in the sample and from the opening area of the net and the distance towed, the abundance of zooplankton per meter cube was calculated using the formula, Abundance = Total Count in the Sample/(Distance towed x Opening area). During the survey the zoo plankton were classified into Rotifera, Protozoa, Chordata, Mollusca, Annelida, Cnidaria, Crustacea and Chaetognatha. Additionally, Copepods were classified into three groups, Calanoida, Cyclopoida and Harpacticoida.

5.14.1.2.2 Phytoplankton

Analyses of the samples were done using a microscope using a Sedgewick rafter counting chamber. The chamber has a volume of approximately 1ml. The samples collected from the net were approximately 150 – 250ml in volume. For the phytoplankton count, the samples were transferred filtered through a 200µm sieve to remove large zooplankton for ease of counting. Thereafter the sample was transferred to a beaker, and diluted to approximately 500 – 900 ml and the volume recorded. The purpose of dilution is to reduce the number of plankton in the optical view of the microscope for ease of counting. Two sub-samples were counted from each sample. To calculate Total count in the sample the counts in the subsamples were averaged. Thereafter the average value in the sub samples was multiplied with the total Volume in the diluted sample to obtain the Total count in the Sample. From the Total count in the sample and from the opening area of the net and the distance towed, abundance of zooplankton per meter cube was calculated using the formula, Abundance = Total Count in the Sample/(Distance towed x Opening area).

5.14.1.3 Limitations of the methodology

The above method gives approximate estimates of abundances for each group/genera of plankton. Using a Sedgewick rafter to count zooplankton limits the subsample volume to 1ml thus, rare groups in plankton would likely not be observed in the counts. The method is reliable to estimate the total abundance of common groups of Zooplankton which are greater than 50µm in size and phytoplankton greater than 50 µm and less than 200µm.

5.14.1.4 Plankton abundance

5.14.1.4.1 Zooplankton

5.14.1.4.1.1 Common Phyla

Crustaceans were observed to be of the highest abundance amongst the zooplankton from all 7 sites. Additionally, the highest abundance of zoo plankton was observed from site 7 (PKT 7). The lowest abundance of zooplankton was observed from site 5. The table and figures below outline the variation in zooplankton abundance between the sites.

Table 4: Abundance of common phyla of zooplankton from sites PKT 1 to PKT 7.

Phyla	Abundance at sites (Individuals/m^3)						
	PKT 1	**PKT 2**	**PKT 3**	**PKT 4**	**PKT 5**	**PKT 6**	**PKT 7**
Rotifera	174	760	1,270	293	195	814	1,519
Protozoa	260	2,170	1,563	1,172	781	1,628	868
Chordata	347	705	1465	977	391	746	217
Mollusca	87	163	391	NA	98	339	217
Annelida	174	54	98	NA	98	68	NA
Cnidaria	217	380	98	488	NA	NA	NA
Crustacea	3,212	7,378	16,113	9,277	1,465	6,782	21,267
Chaetognatha	43	109	488	98	NA	NA	217
Total Zooplankton	7,769	19,151	37,598	21,582	4,492	17,158	45,573

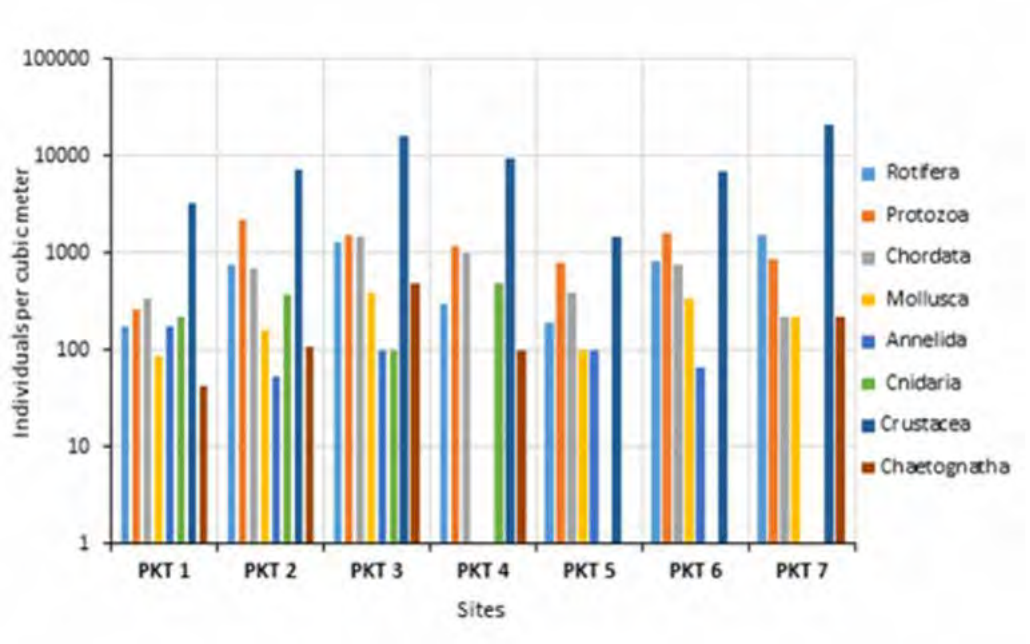


Figure 27: Abundance of common phylum of zooplankton from sites PKT 1 to PKT 7.

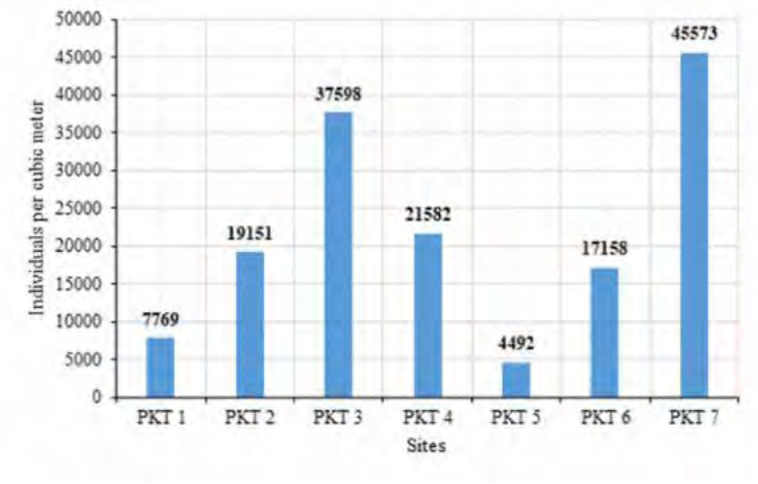


Figure 28: Total abundance of zooplankton from sites PKT 1 to PKT 7.

5.14.1.4.1.2 Copepods

The dominating group of copepods observed in the sites were calanoids. The highest abundance of copepods were observed at site 7 and the lowest abundance of copepods at site 5. The table and figure below outlines the variation in copepod abundance between the sites.

Table 5: Abundance of copepods from sites PKT 1 to PKT 7.

Order	Abundance at Sites (Individuals/m^3)						
	PKT 1	PKT 2	PKT 3	PKT 4	PKT 5	PKT 6	PKT 7
Calanoida	1693	2767	6543	3516	684	2509	11502
Cyclopoida	260	434	1367	391	195	543	1085
Harpacticoida	391	163	195	684	195	407	651

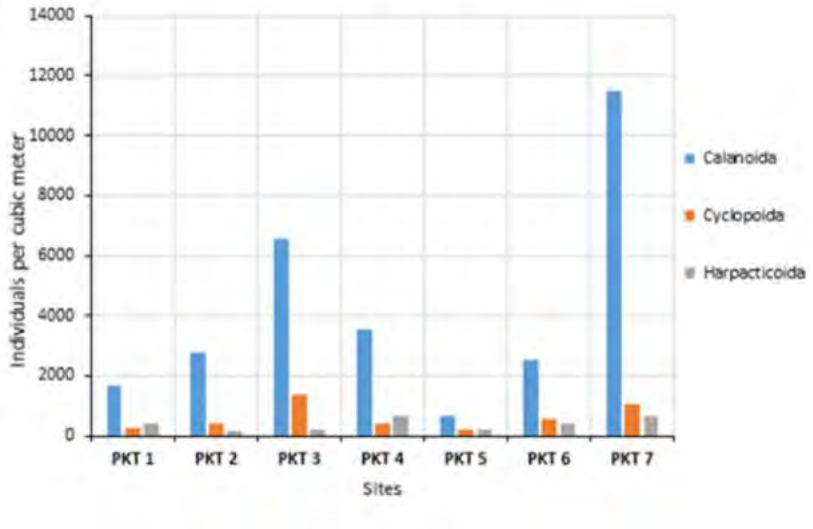


Figure 29: Abundance of copepods from sites PKT 1 to PKT 7.

5.14.1.4.2 Phytoplankton

Diatoms were observed to be of the highest abundance, amongst the phytoplankton from all 7 sites. Additionally, the highest abundance of phytoplankton was observed from site 7 (PKT 7). Additionally,

the lowest abundance of phytoplankton were observed from site 5. The Figures below show the variation in phytoplankton abundance between the sites.

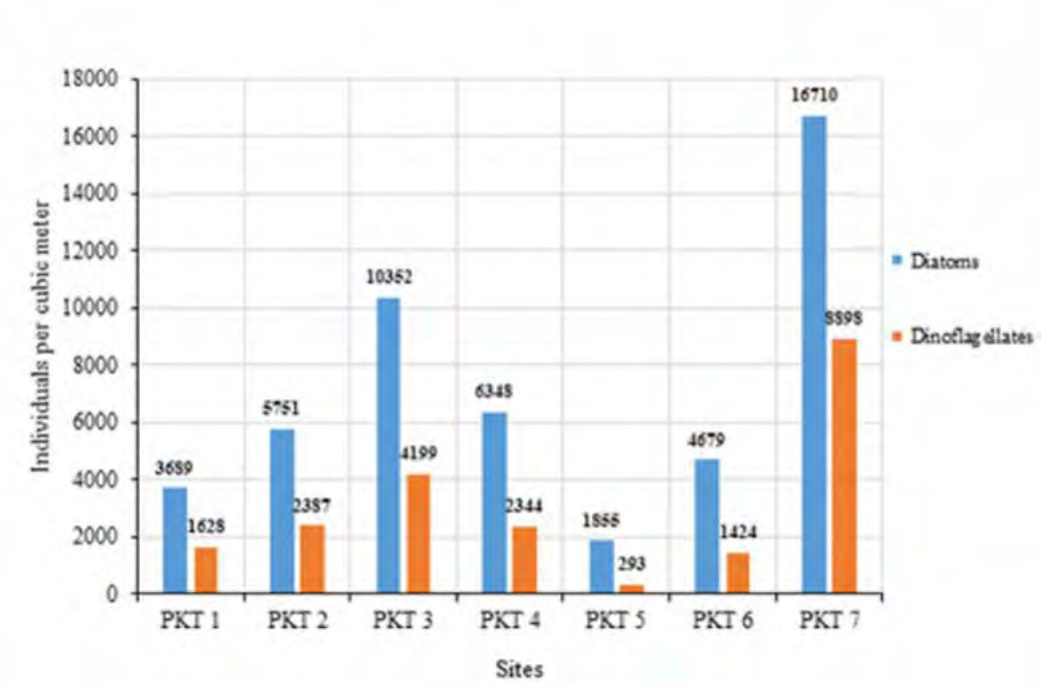


Figure 30: Abundance of diatoms and dinoflagellates from sites PKT 1 to PKT 7.

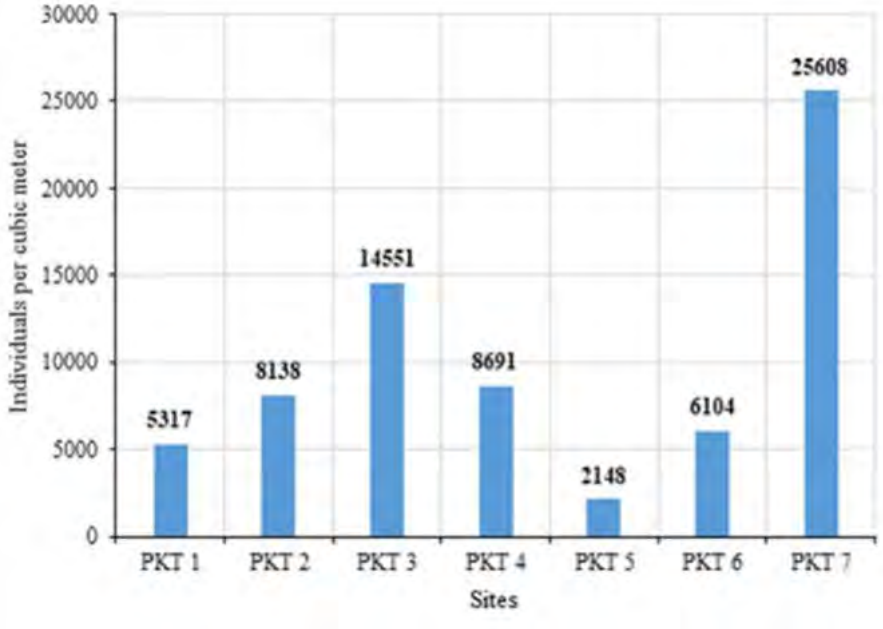


Figure 31: Total abundance of phytoplankton from sites PKT 1 to PKT 7.

6 Conclusion

The coral reef of Thilafushi has been under a lot of stress over the past two decades from the various industrial activities and developments that have occurred on this once barren reef. Over the years, the coral reef has undergone significant direct and indirect impacts resulting from the evolution of this artificial island that has been reclaimed initially from waste and later expanded in a more ecologically sound manner.

Surveys were undertaken in April 2018 and September 2019 to assess the coral reef and its health. The initial surveys were carried out in April 2018 which indicates that the highest coral cover was prevalent at a depth of 10 meters in site M2. This site is adjacent to the current waste dumping area. Therefor based on this results, there is the possibility that one can conclude that the leachate from land fill is not having a significant negative impacts on the reef at site M2 in terms of coral cover. On the overall, the reef around Thilafushi does not indicate a very healthy reef with average coral cover below 20% in most of the surveyed sites (based on the surveys done in April 2018).

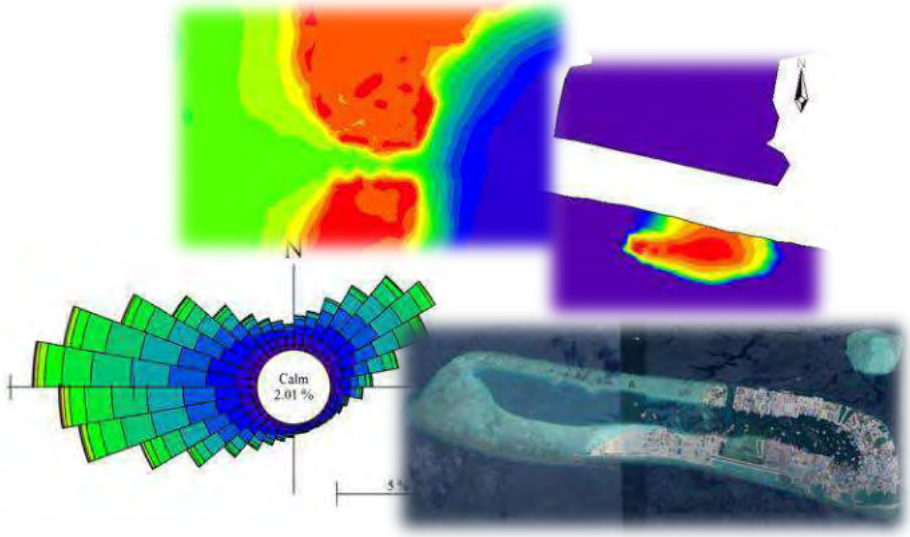
A new set of surveys were conducted in three sites, M8, M9, M10, on 1st September 2019. This detail marine survey was carried out along a 500 m coastal stretch of house reef on southern site of Thilafushi between M9 and M10. The results indicate that very few (or none at all) marine species are found at a depth of less than 10 m along this stretch. The survey also revealed further that no significant marine life such as live corals, fishes or other pelagic organisms was found at greater depths from 10 m to 30 m along this stretch of house reef. The marine survey carried out in September 2019 found that the reef profiles at M8, M9 and M10 are very identical and at any of these sites, an outfall could be laid. Geographically, these three sites does not pose major challenges when it comes to laying an outfall pipe. There were no sensitive corals nor benthic cover recorded in any of these sites nor are any odd slope formations there.

The reef slope at surveyed sites M8, M9 and M10 is characterized by a wall with the majority of the benthic composition being mainly rubble and silt. Along these sites, from a depth of approximately 20 meters and below, there is no live coral cover and the fish life is virtually none existent at the time of the survey on 1st September 2019. The southern side of Thilafushi is also exposed to a lot of sedimentation during south-west monsoon, which causes dispersion of sediments along a large area of the reef. This is the reason why the percentage of silt along M8, M9 and M10 were so high during the surveys undertaken in September 2019.

During the surveys in April 2018, one sea turtle was recorded. Sea turtles are very commonly observed throughout the Maldives due to their protected state. Their numbers have grown significantly since they were declared as a protected species in the 1980's. Since then, turtles are observed in a lot of reefs throughout the Maldives. Thilafushi being an artificial island does not possess the right coastal ecology for turtles to lay their eggs and no reports of turtle nests nor eggs have been reported to have been spotted from Thilafushi beaches. Hence, this single observation of a turtle can be confidently declared as an occasional occurrence.

Water Solutions Pvt. Ltd.

Effluent Dispersion Modelling at Thilafushi Island, Maldives



Final Report

October 2018

Lanka Hydraulic Institute Ltd
Coast and Water

Client Water Solutions Pvt. Ltd	**Client's Representative** Mr. Ahmed Jameel
Project Effluent Dispersion Modelling at Thilafushi Island, Maldives	**Project No.** 1808
Authors Eng. M.S.L. Fernando Eng. (Ms) B.M.V. Basnayake	**Date** October 2018
	Approved by Eng. J.K.P. Kurukulasuriya Eng. Dr. K. Raveenthiran

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Lanka Hydraulic Institute Ltd

Coast and Water

177, John Rodrigo Mawatha, Katubedda, Moratuwa, Sri Lanka.
Tel. Nos. 2650409 / 2650471 / 2650472-3, Fax No. 2650470 - Email: lhi@lhi.lk

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1 INTRODUCTION

Water Solutions Pvt Ltd (WS) is currently assisting Ministry of Environment and Energy (MEE) to undertake an Environmental Impact Assessment (EIA) for Waste Management Project at Thilafushi Island, Maldives. As part of the project, an incinerator is proposed to burn waste material and seawater through an intake will be used to cool condenser. After cooling process, the hot seawater will be re-discharged through an outfall into the sea. As part of the EIA work, the dispersion behaviour of the discharged hot water need to assessed.

Water Solutions Pvt Ltd requested Lanka Hydraulic Institute Ltd (LHI) to submit a proposal for Effluent Dispersion Model study for the proposed cooling system of incinerator, and we, Lanka Hydraulic Institute Ltd (LHI), submitted the proposal in response to the requirements. After reviewing the proposal, LHI was awarded the contract to conduct the Effluent Dispersion Model study for the proposed cooling system of incinerator.

This report includes six chapters. Background of the project and basic methodology used in the study are given in Chapter 1. The details of collected wind data and analysis of it are given in Chapter 2. Wave transformation method and model usage for wave generation are discussed in detail in Chapter 3. In order to assess the water circulation, a set of hydrodynamic models was performed; those methods and results are discussed under Chapter 4. As the main part of study, thermal dispersion modelling system and discussion of its results are presented in Chapter 5. Finally the conclusions are given in Chapter 6.

1.1 Background

The Thilafushi island is located in North Male Atoll, Maldives, and around 7km westwards to Male City (Figure 1.1). Presently, the island is used as the main waste dumping site in the country capital Male and its adjacent inhabited islands and the airport at Hulhule. The Government of the Maldives has identified solid waste disposal as a priority problem and decided to implement a solid waste management plan to minimize the environmental problem.

As a part of the project, an incinerator has been proposed to burn the waste. The cooling system of incinerator will run using sea water as coolant. The dispersion of hot water in marine environment is required to assess with respect to the coastal process of region.

This island is subjected to two monsoon period namely South-West and Nort-East; South West monsoon is considered as from May to November while North East as from December to April. Energy of swell waves approach from southern Indian ocean may reduce due to diffraction and other interaction of other atoll reefs, and mainly sea waves are affected to the island. Sea currents are developed around the island reef mainly wind, wave and tidal effect.

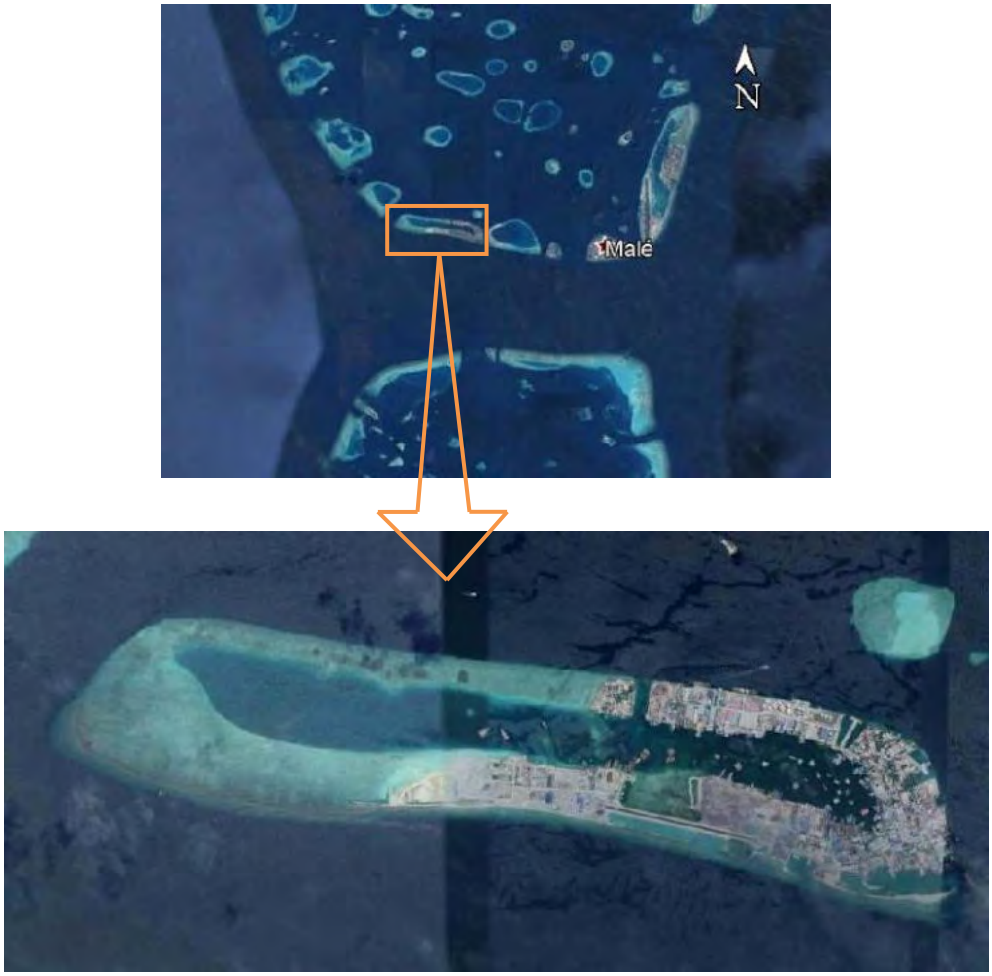

Figure 1.1: Location of Thilafushi Island

1.2 Objective of the Study

The discharge of effluent in the coastal area is a sensitive issue in the context of environmental conservation and therefore dispersion of the effluent requires proper assessment to ensure that nearshore coastal environment will not be subjected to pollution and health risk due to discharged effluent. For this purpose it is extremely essential to ensure that effluent constituent is diluted to acceptable levels within the receiving water in the immediate vicinity of discharge point. Secondly, the advection dispersion of the effluent should be favourable to the environment for every monsoon period.

The objective of this modelling task is to simulate the dynamic behaviour of hot water discharged through the outfall, and to assess the impacts on the surrounding areas of the outfalls, near-shore areas and beaches.

1.3 Basic Methodology of Study

Since the hot water dispersion is to be assessed for different monsoons and tidal conditions, at the first stage, wave conditions and tidal conditions require to be developed at site location. In

order to develop wave conditions for different monsoon periods at site location, long period wind data was used in a Wind-Wave Transformation Model (MIKE 21 SW). In order to find out current conditions, a Hydrodynamic Model (MIKE 21 HD) was utilised with giving wind/wave condition and tidal variation as input parameters. After that thermal dispersion model, CORMIX was used to find out initial dilution in near field and its results were further applied to the Hydrodynamic Model couple with thermal dispersion tool to assess the dilution in 2D plain.

Main activities of study are given below.

1. Obtain and analyze of UK Met Office (UKMO) wind data at site location.
2. Develop model bathymetries using Admiralty Chart Maps and measured data
3. Find out wave condition near the site using Wind-Wave Transformation Model (MIKE 21 SW)
4. Simulate a regional Hydrodynamic Model using known tidal boundaries in order to find out hydrodynamic conditions at local model boundaries.
5. Simulate local Hydrodynamic Model with applying wind, wave and tidal condition and find out current condition at site for different monsoons.
6. Apply current conditions obtained from Hydrodynamic Model in CORMIX model and find out initial dilution in near field.
7. Simulate again Hydrodynamic Model couple with thermal dispersion tool and applying CORMIX model results to assess the dilution in 2D plain.

2 WIND DATA AND WAVE GENERATION

The wind data was obtained based on the hind-cast data from Numerical Weather Prediction Atmospheric Global model of the UK Met Office (UKMO). The available nearest suitable data point (3.984 N, 73.477 E) which located in the South Male Atoll was selected with considering fetch length and open sea area which would be adopted in the wind wave model (Figure 2.1). Real time observational data from satellite wind radar, ship and buoy data were (and are) assimilated into the atmospheric model. This process strives to give the best possible rendition of the 'surface' wind field at analysis or run time, in order to give an optimum forecast. In effect, the atmospheric wind fields represent a hybrid of numerical and real data. It is the analysis time steps of these models of whatever resolution which go to make up the archive on which hind-casts are based.

Wind speed and wind direction for 30 years during January 1986 to June 2016 were utilized for the study. The data set contents 89,112 no of records with the interval of 3 hours. Analyses were carried out to assess the distribution of wind parameters and given in the Figure 2.2 and the Table 2.1.

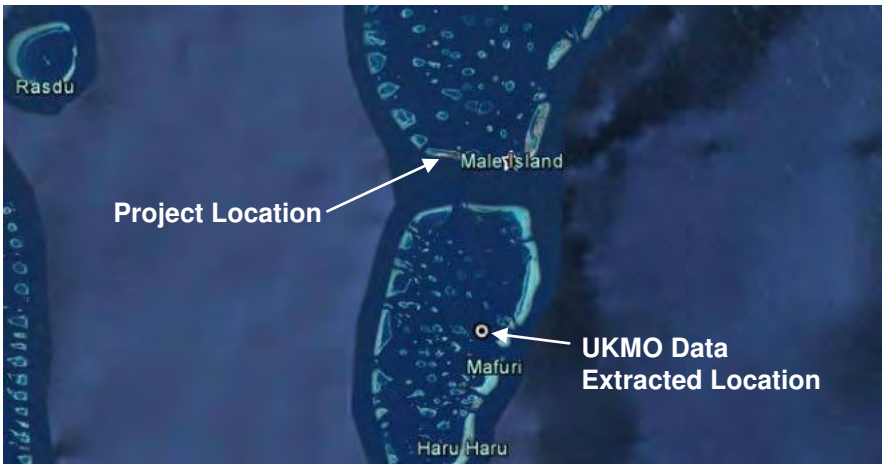

Figure 2.1: Wind Data Extracted Location

2.1 Analysis of UKMO Wind Data

Analysis of raw data before apply it in the model is an essential part in wind - wave transformation numerical modelling process to gain an idea about the wind climates of the region. Therefore analyses for UKMO data were carried out based on wind speed and direction.

Figure 2.2 illustrates clearly wind distribution pattern in 360° angle. The length of slices represents the percentage of occurrence while the colour code for the wind speeds. Furthermore, Table 2.1 shows the occurrence of wind by values in different directions and

various speeds. According to the analysis, two dominant wind directions can be observed; i.e. West and North-East. The wind reached from South- East quadrant is negligible.

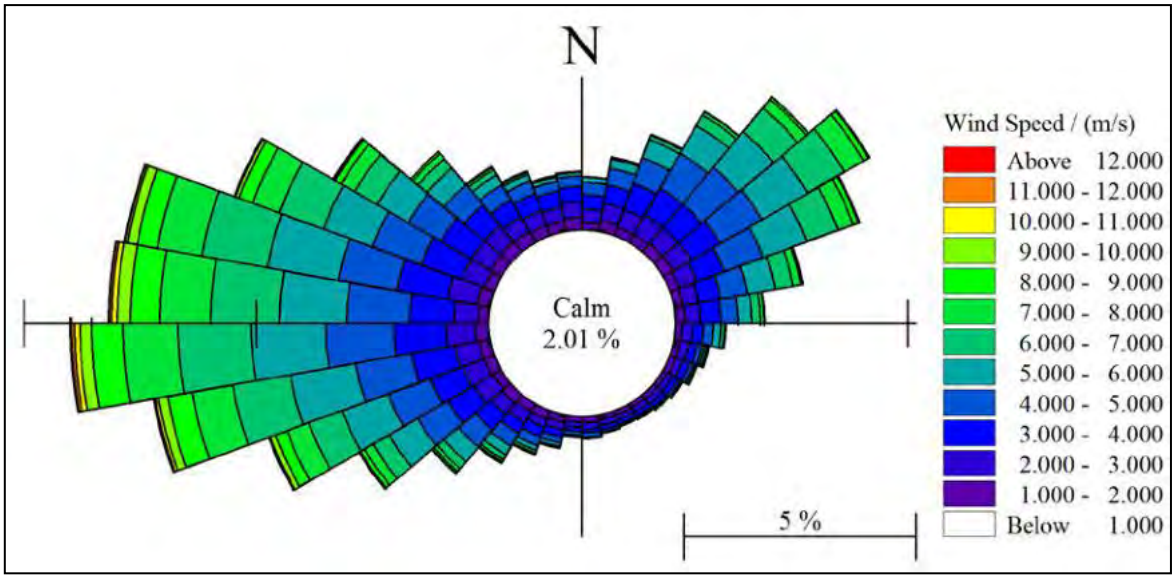

Figure 2.2: Annual Distribution of Wind