# Environmental Impact Assessment

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

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

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

## CPS CONDITIONS OF SERVICE

The party that submits a completed service request form to Company or signs a quotation issued by the Company for its performance of services ("**Services**") is the "**Client**" under these Conditions of Service. The entity within the Bureau Veritas Consumer Products Services division accepting the service request form and issuing the Report documenting the results of those Services is the "**Company**" under these Conditions of Service. Company and Client are, together, the "**Parties**" and each is a "**Party**". A request for Services constitutes a legally binding agreement on both Parties when such a request is accepted by the Company ("**Agreement**") under the following terms and conditions (collectively, "**Conditions**"):

**1. Services. (a)** The completion of the Services shall be evidenced by the Company's issuing to Client a written report setting forth the results of the Services based upon the properly accepted request, applicable protocols, written information, and where applicable, the product sample provided by Client to Company ("**Report**"). Company may delegate/assign the performance of all or a portion of the Services to an affiliate of Company or to an agent or subcontractor. Client shall provide to Company on a timely basis, all documents and information necessary to enable Company to properly perform the Services. Company may, in its sole discretion, dispose of product samples furnished to Company for the Services that were not destroyed in the course of performance of the Services. **(b)** Client represents and warrants to Company that (i) each product sample is not submitted in violation of a third party's intellectual property rights; (ii) Client will not use and rely upon Company's Report for any product whose properties differ from the sample(s) upon which the Report is based; and (iii) any goods subject to inspection will be completely prepared for the type of inspection booked for the specified date, and **(c)** Client accepts sole responsibility and liability for the accuracy of documents submitted to government or other regulatory bodies, including certificates of compliance required under the US Consumer Product Safety Improvement Act and EU requirements under REACH regulations. Client's responsibility and liability for accuracy shall apply even where Company has provided assistance to Client in preparation of such documentation.

**2. Report. (a)** The Report shall (i) constitute the sole deliverable for the Services, (ii) relate solely to the facts and circumstances as observed and recorded by Company at the time of performance of the Services within the limits of written information and instructions received from Client; Company shall have no obligation to update the Report after its issuance. Where the Services include testing or inspection: (i) the Report will set forth the findings of Company solely with respect to the product samples identified therein and (ii) the results set forth in the Report are not to be construed as indicative or representative of the quality or characteristics of the lot from which a product sample was taken for Company's performance of Services. **(b)** The Report is issued solely by Company, is intended for the exclusive use of Client and its affiliates and, except as required by a regulatory body, shall not be published, used for advertising purposes, copied or replicated for distribution or publicly disclosed without Company's prior written consent. Company is not responsible for any third party's interpretation of the Report. **(c)** Client shall not request a Report for purposes of litigation, nor shall it list Company, its affiliates or employees as an expert in any proceeding without Company's prior written consent. If Client anticipates producing or otherwise using the Report in any legal proceedings, it shall so notify Company prior to submitting the Report in such proceeding.

**3. Representations and Warranties. (a)** Company undertakes due care and ordinary skill in the performance of its Services. **(b)** Client agrees that Company is neither an insurer nor a guarantor and does not take the place of Client or the third parties that it retains, including designers, manufacturers, agents, buyers, distributors, and transportation or shipping companies; Company disclaims all liability in such capacities. Client understands that, if it seeks to protect itself from claims of loss, damage or injury, it should obtain appropriate insurance. **(c)** Company does not warrant or guarantee Client's products, and Company's Report does not represent a warranty of merchantability, a warranty of fitness for a particular purpose, or any other warranty or guarantee.

**4. Payment.** Payment in full shall be due 30 days after the date of invoice, failing which Company may revoke any credit extended to Client. Client shall reimburse Company for (i) interest on overdue amounts from the due date until paid at an interest rate of 1.5% per month and (ii) any other costs Company incurs in collecting past due amounts, including court, attorneys and collection agencies' fees.

**5. Intellectual Property.** The names, service marks, trademarks and copyrights of Company and its affiliates (collectively, the "**Marks**") are and remain the sole property of Company and shall not be used by Client. Client shall not contest the validity of the Marks or take any action that might impair the value or goodwill associated with the Marks or the image or reputation of Company or its affiliates. Client understands that any information or samples submitted to Company is a license for Company to use the same in the performance of Services.

**6. Relationship. (a)** Nothing herein creates a partnership, agency or joint venture between the Parties. **(b)** The failure to require strict observance or performance of any provision of these Conditions shall not be construed to be a waiver of a Party's right to later require strict observance and performance of the same. If any provision of these Conditions is held to be invalid or unenforceable, such invalidity shall not invalidate the remainder of the Conditions. **(c)** For a period of two years after the commencement of this Agreement, Client shall not directly or indirectly try to solicit for employment any of Company's employees.

**7. INDEMNITY.** CLIENT SHALL HOLD HARMLESS AND INDEMNIFY COMPANY, ITS AFFILIATES, AND THEIR RESPECTIVE DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND SUBCONTRACTORS AGAINST ALL THIRD-PARTY CLAIMS FOR LOSS, DAMAGE, INJURY, DEATH, OR EXPENSE OF WHATEVER NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS ARISING FROM OR RELATING TO (I) THE PERFORMANCE OF ANY SERVICES BY COMPANY, (II) THE SALE, RESALE, MANUFACTURE, DISTRIBUTION OR USE OF ANY OF CLIENT'S GOODS OR (III) BREACH OF CLIENT'S OBLIGATIONS OR WARRANTIES HEREIN.

**8. LIMITATIONS OF LIABILITY. (A)** COMPANY SHALL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL OR SPECIAL LOSS IN CONNECTION WITH THE REPORT, THE PRODUCT FOR WHICH SERVICES WERE PERFORMED, OR THE SERVICES PROVIDED BY COMPANY HEREUNDE' COMPANY SHALL NOT BE LIABLE FOR ANY LOSS OR DAMAGE WHATSOEVER RESULTING FROM ANY DELAY IN THE PERFORMANCE OF ITS OBLIGATIONS HEREUNDER OR FROM THE FAILURE OF COMPANY TO PROVIDE ITS SERVICES WITHIN ANY TIME PERIOD FOR COMPLETION ESTIMATED BY COMPANY, REGARDLESS OF THE CAUSE OF THE DELAY OR FAILURE. **(B)** THE ENTIRE FINANCIAL AND LEGAL LIABILITY OF COMPANY IN RESPECT OF ANY CLAIM FOR LOSS, INDEMNITY, CONTRIBUTION OR DAMAGE OF WHATEVER NATURE OR HOWSOEVER ARISING, SHALL NOT EXCEED AN AMOUNT EQUAL TO FIVE (5) TIMES THE AMOUNT OF FEES PAID TO COMPANY FOR THE SPECIFIC SERVICES WHICH GAVE RISE TO SUCH CLAIM.

**9. Force Majeure.** If any event of force majeure or any event outside the control of Company occurs, Company may immediately cancel or suspend its performance hereunder without incurring any liability whatsoever to Client.

**10. Governing Law.** These Conditions shall be governed by the laws of the country as follows: for Services performed in (i) the Americas: the laws of New York, (ii) Asia Pacific, South Asia, Middle East and Africa: the laws of Hong Kong (except for China where PRC laws govern), and (iii) Europe: the laws of England.

**11. Dispute Resolution. (a)** If Client desires to assert a claim relating to the Services, it must submit the same to Company in writing setting forth with particularity the basis for such claim within 90 days from discovery of the claim and not more than six months after the date of issuance of the Report. Client waives any and all claims without limitation that it does not submit within such time periods. **(b)** If a dispute arises under this Agreement, the Parties shall first attempt good faith negotiations, failing which, the Parties (i) agree that the courts of the country of governing law shall have exclusive jurisdiction to settle any such dispute related to this Agreement and (ii) irrevocably waive their right to trial by jury in any such action or proceeding.

**12.** These Conditions, the applicable order form and/or quotation and the Report represent the entire understanding of the Parties on the subject matter hereof, and no modification is binding unless in writing. Any of Client's terms and conditions attached to, enclosed with or referred to in any order form, purchase order or other document shall not apply.

Gen v.1 copyright 2015 Bureau Veritas

# TEST REPORT

**Report No:** **(7418)144-0214D(SL)** Jul 14, 2018



## TEST RESULTS

| No. | Parameters | Results | LOQ | Unit | Test Method |
|---|---|---|---|---|---|
| 1 | Temperature at Receiving | 24.2 | - | °C | APHA 20th Edition – 2550B |
| 2 | Turbidity | 0.2 | - | NTU | APHA 2130 B |
| 3 | pH at 24°C* | 8.4 | - | - | FD-MTHD-007:2013 Reference to APHA 4500H+ |
| 4 | Nitrate (as $NO_3^-$) | 0.4 | - | mg/l | APHA 4500 -$NO_3$– E |
| 5 | Oil & Grease* | <2.0 | 2.0 | mg/l | FD-MTHD-032:2013 Reference to APHA 5520B |
| 6 | Free Ammonia (as $NH_3$) | <0.02 | 0.02 | mg/l | SLS 614 Appendix A: 2013 |
| 7 | Salinity | 37 | - | ppt | APHA 2520 |
| | **Heavy Metals** | | | | |
| 8 | Arsenic (as As)* | ND | 0.001 | mg/l | CPSD-AN-00581-MTHD with ICP-MS |
| 9 | Cadmium (as Cd)* | ND | 0.0001 | mg/l | |
| 10 | Lead (as Pb)* | ND | 0.001 | mg/l | |
| 11 | Mercury (as Hg)* | ND | 0.00005 | mg/l | |
| 12 | Nickel (as Ni)* | ND | 0.001 | mg/l | |
| 13 | Copper (as Cu)* | ND | 0.001 | mg/l | |
| 14 | Zinc (as Zn)* | ND | 0.001 | mg/l | |
| 15 | Chromium (as Cr) | ND | 0.001 | mg/l | |

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

# TEST REPORT

**Report No:** **(7418)144-0214D(SL)** Jul 14, 2018



**Remark –**

***ISO 17025 :2005 ACCREDITED TEST BY SRI LANKA ACCREDITATION BOARD FOR CONFORMITY ASSESSMENT (SLAB)**

**NOTE:**

mg/l: milligrams per liter, ppt: parts per thousand,
APHA: American Public Health Association
ND: Not Detected, LOQ: Limit of Quantification,
NTU: Nephelometric Turbidity Units, °C : Celcius,
ICP-MS: Inductively Coupled Plasma – Mass Spectroscopy.

**Contact information for this report (Technical and General Inquiries and Feedback)**

| | | |
|---|---|---|
| **GENERAL INQUIRIES:** | | |
| IROSHA UDUGAMPALA | TEL: +94 768 229 528 | E-MAIL: Irosha.Udugampala@lk.bureauveritas.com |
| **TECHNICAL INQUIRIES:** | | |
| INDRAJITH HATHURUSINGHA | TEL: + 94 769 603 814 | E-MAIL: Indrajith.hs@lk.bureauveritas.com |
| **FEED BACK:** | | |
| DHANUKA PERERA –EXECUTIVE QHSE | TEL: +94 768 229 479 | E-MAIL: dhanuka.perera@lk.bureauveritas.com |

REVIEWED BY: SHYAMIKA WICKRAMASINGHE

BUREAU VERITAS CONSUMER PRODUCTS SERVICES LANKA (PVT) LTD.

AUTHORIZED SIGNATORY

APPROVED BY: for
INDRAJITH HATHURUSINGHA
MANAGER-
FOOD LABORATORY

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

**CPS CONDITIONS OF SERVICE**

The party that submits a completed service request form to Company or signs a quotation issued by the Company for its performance of services ("Services") is the "Client" under these Conditions of Service. The entity within the Bureau Veritas Consumer Products Services division accepting the service request form and issuing the Report documenting the results of those Services is the "Company" under these Conditions of Service. Company and Client are, together, the "Parties" and each is a "Party". A request for Services constitutes a legally binding agreement on both Parties when such a request is accepted by the Company ("Agreement") under the following terms and conditions (collectively, "Conditions").

1. **Services.** (a) The completion of the Services shall be evidenced by the Company's issuing to Client a written report setting forth the results of the Services based upon the properly accepted request, applicable protocols, written information, and where applicable, the product sample provided by Client to Company ("Report"). Company may delegate/assign the performance of all or a portion of the Services to an affiliate of Company or to an agent or subcontractor. Client shall provide to Company on a timely basis, all documents and information necessary to enable Company to properly perform the Services. Company may, in its sole discretion, dispose of product samples furnished to Company for the Services that were not destroyed in the course of performance of the Services. (b) Client represents and warrants to Company that (i) each product sample is not submitted in violation of a third party's intellectual property rights, (ii) Client will not use and rely upon Company's Report for any product whose properties differ from the sample(s) upon which the Report is based, and (iii) any goods subject to inspection will be completely prepared for the type of inspection booked for the specified date, and (c) Client accepts sole responsibility and liability for the accuracy of documents submitted to government or other regulatory bodies, including certificates of compliance required under the US Consumer Product Safety Improvement Act and EU requirements under REACH regulations. Client's responsibility and liability for accuracy shall apply even where Company has provided assistance to Client in preparation of such documentation.

2. **Report.** (a) The Report shall (i) constitute the sole deliverable for the Services, (ii) relate solely to the facts and circumstances as observed and recorded by Company at the time of performance of the Services within the limits of written information and instructions received from Client. Company shall have no obligation to update the Report after its issuance. Where the Services include testing or inspection, (i) the Report will set forth the findings of Company solely with respect to the product samples identified therein and (ii) the results set forth in the Report are not to be construed as indicative or representative of the quality or characteristics of the lot from which a product sample was taken for Company's performance of Services. (b) The Report is issued solely by Company, is intended for the exclusive use of Client and its affiliates and, except as required by a regulatory body, shall not be published, used for advertising purposes, copied or replicated for distribution or publicly disclosed without Company's prior written consent. Company is not responsible for any third party's interpretation of the Report. (c) Client shall not request a Report for purposes of litigation, nor shall it list Company, its affiliates or employees as an expert in any proceeding without Company's prior written consent. If Client anticipates producing or otherwise using the Report in any legal proceedings, it shall so notify Company prior to submitting the Report in such proceeding.

3. **Representations and Warranties.** (a) Company undertakes due care and ordinary skill in the performance of its Services. (b) Client agrees that Company is neither an insurer nor a guarantor and does not take the place of Client or the third parties that it retains, including designers, manufacturers, agents, buyers, distributors, and transportation or shipping companies. Company disclaims all liability in such capacities. Client understands that, if it seeks to protect itself from claims of loss, damage or injury, it should obtain appropriate insurance. (c) Company does not warrant or guarantee Client's products, and Company's Report does not represent a warranty of merchantability, a warranty of fitness for a particular purpose, or any other warranty or guarantee.

4. **Payment.** Payment in full shall be due 30 days after the date of invoice, failing which Company may revoke any credit extended to Client. Client shall reimburse Company for (i) interest on overdue amounts from the due date until paid at an interest rate of 1.5% per month and (ii) any other costs Company incurs in collecting past due amounts, including court, attorneys and collection agencies' fees.

5. **Intellectual Property.** The names, service marks, trademarks and copyrights of Company and its affiliates (collectively, the "Marks") are and remain the sole property of Company and shall not be used by Client. Client shall not contest the validity of the Marks or take any action that might impair the value or goodwill associated with the Marks or the image or reputation of Company or its affiliates. Client understands that any information or samples submitted to Company is a license for Company to use the same in the performance of Services.

6. **Relationship.** (a) Nothing herein creates a partnership, agency or joint venture between the Parties. (b) The failure to require strict observance or performance of any provision of these Conditions shall not be construed to be a waiver of a Party's right to later require strict observance and performance of the same. If any provision of these Conditions is held to be invalid or unenforceable, such invalidity shall not invalidate the remainder of the Conditions. (c) For a period of two years after the commencement of this Agreement, Client shall not directly or indirectly try to solicit for employment any of Company's employees.

7. **INDEMNITY.** CLIENT SHALL HOLD HARMLESS AND INDEMNIFY COMPANY, ITS AFFILIATES AND THEIR RESPECTIVE DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND SUBCONTRACTORS AGAINST ALL THIRD-PARTY CLAIMS FOR LOSS, DAMAGE, INJURY, DEATH, OR EXPENSE OF WHATEVER NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS ARISING FROM OR RELATING TO (i) THE PERFORMANCE OF ANY SERVICES BY COMPANY, (ii) THE SALE, RESALE, MANUFACTURE, DISTRIBUTION OR USE OF ANY OF CLIENT'S GOODS, OR (iii) BREACH OF CLIENT'S OBLIGATIONS OR WARRANTIES HEREIN.

8. **LIMITATIONS OF LIABILITY.** (A) COMPANY SHALL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL OR SPECIAL LOSS IN CONNECTION WITH THE REPORT, THE PRODUCT FOR WHICH SERVICES WERE PERFORMED, OR THE SERVICES PROVIDED BY COMPANY HEREUNDER. COMPANY SHALL NOT BE LIABLE FOR ANY LOSS OR DAMAGE WHATSOEVER RESULTING FROM ANY DELAY IN THE PERFORMANCE OF ITS OBLIGATIONS HEREUNDER OR FROM THE FAILURE OF COMPANY TO PROVIDE ITS SERVICES WITHIN ANY TIME PERIOD FOR COMPLETION ESTIMATED BY COMPANY, REGARDLESS OF THE CAUSE OF THE DELAY OR FAILURE. (B) THE ENTIRE FINANCIAL AND LEGAL LIABILITY OF COMPANY IN RESPECT OF ANY CLAIM FOR LOSS, INDEMNITY, CONTRIBUTION OR DAMAGE OF WHATEVER NATURE OR HOWSOEVER ARISING, SHALL NOT EXCEED AN AMOUNT EQUAL TO FIVE (5) TIMES THE AMOUNT OF FEES PAID TO COMPANY FOR THE SPECIFIC SERVICES WHICH GAVE RISE TO SUCH CLAIM.

9. **Force Majeure.** If any event of force majeure or any event outside the control of Company occurs, Company may immediately cancel or suspend its performance hereunder without incurring any liability whatsoever to Client.

10. **Governing Law.** These Conditions shall be governed by the laws of the country as follows: for Services performed in (i) the Americas, the laws of New York; (ii) Asia Pacific, South Asia, Middle East and Africa, the laws of Hong Kong (except for China where PRC laws govern); and (iii) Europe, the laws of England.

11. **Dispute Resolution.** (a) If Client desires to assert a claim relating to the Services, it must submit the same to Company in writing setting forth with particularity the basis for such claim within 90 days from discovery of the claim and not more than six months after the date of issuance of the Report. Client waives any and all claims without limitation that it does not submit within such time periods. (b) If a dispute arises under this Agreement, the Parties shall first attempt good faith negotiations, failing which the Parties (i) agree that the courts of the country of governing law shall have exclusive jurisdiction to settle any such dispute related to this Agreement and (ii) irrevocably waive their right to trial by jury in any such action or proceeding.

12. These Conditions, the applicable order form and/or quotation and the Report represent the entire understanding of the Parties on the subject matter hereof, and no modification is binding unless in writing. Any of Client's terms and conditions attached to, enclosed with or referred to in any order form, purchase order or other document shall not apply.

Gen v 1 copyright 2015 Bureau Veritas

END OF THE REPORT.

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

# TEST REPORT

**Report No:** **(7418)144-0214E(SL)** Jul 14, 2018



**Applicant:** Water Solutions (Pvt) Ltd.

**Address :** Ma Fas Eri, 1st Floor,
Ameenee Magu,
Male,
Maldives.

**Attn: Mr. Aslam Mohamed/ Mr. Abdulla Fazeel**

| | |
|---|---|
| **Sample Received as:** | 500ml x 2 No.s of water sample contained in sealed plastic bottles submitted by the client. |
| **Sample Described by the Client as:** | Thilafushi SW5<br>Date & time Sampled : 03/07/2018 at 08.30 a.m |
| **Date of Sample Received:** | Jul 06, 2018 |
| **Date of Testing Started:** | Jul 06, 2018 |
| **Date of Testing Completed:** | Jul 13, 2018 |
| **Date of Report Issued:** | Jul 14, 2018 |

**Photo of the Submitted Sample**

**(7418)144-0214E(SL)**

**The content of this PDF file is in accordance with the original issued reports for reference only.**
**This Test Report cannot be reproduced, except in full, without prior written permission of the company.**

**Bureau Veritas Consumer Products Services Lanka (Pvt) Ltd.**
No. 570, Galle Road, Katubedda, Sri Lanka.
Tel : (9411) 2350111 Fax : (9411) 2622198 / 9
E-mail : bvcps.lanka@lk.bureauveritas.com

This report is governed by, and incorporates by reference, the Conditions of Testing as posted at the date of issuance of this report at http://www.mll-acts.com and is intended for your exclusive use. Any copying or replication of this report to or for any other person or entity, or use of our name or trademark, is permitted only with our prior written permission. This report sets forth our findings solely with respect to the test samples identified herein. The results set forth in this report are not indicative or representative of the quality or characteristics of the lot from which a test sample was taken or any similar or identical product unless specifically and expressly noted. Our report includes all of the tests requested by you and the results thereof based upon the information that you provided to us. You have 60 days from date of issuance of this report to notify us of any material error or omission caused by our negligence, provided, however, that such notice shall be in writing and shall specifically address the issue you wish to raise. A failure to raise such issue within the prescribed time shall constitute your unqualified acceptance of the completeness of this report, the tests conducted and the correctness of the report contents.

## CPS CONDITIONS OF SERVICE

The party that submits a completed service request form to Company or signs a quotation issued by the Company for its performance of services ("**Services**") is the "**Client**" under these Conditions of Service. The entity within the Bureau Veritas Consumer Products Services division accepting the service request form and issuing the Report documenting the results of those Services is the "**Company**" under these Conditions of Service. Company and Client are, together, the "**Parties**" and each is a "**Party**". A request for Services constitutes a legally binding agreement on both Parties when such a request is accepted by the Company ("**Agreement**") under the following terms and conditions (collectively, "**Conditions**"):

**1. Services. (a)** The completion of the Services shall be evidenced by the Company's issuing to Client a written report setting forth the results of the Services based upon the properly accepted request, applicable protocols, written information, and where applicable, the product sample provided by Client to Company ("**Report**"). Company may delegate/assign the performance of all or a portion of the Services to an affiliate of Company or to an agent or subcontractor. Client shall provide to Company on a timely basis, all documents and information necessary to enable Company to properly perform the Services. Company may, in its sole discretion, dispose of product samples furnished to Company for the Services that were not destroyed in the course of performance of the Services. **(b)** Client represents and warrants to Company that (i) each product sample is not submitted in violation of a third party's intellectual property rights; (ii) Client will not use and rely upon Company's Report for any product whose properties differ from the sample(s) upon which the Report is based; and (iii) any goods subject to inspection will be completely prepared for the type of inspection booked for the specified date, and **(c)** Client accepts sole responsibility and liability for the accuracy of documents submitted to government or other regulatory bodies, including certificates of compliance required under the US Consumer Product Safety Improvement Act and EU requirements under REACH regulations. Client's responsibility and liability for accuracy shall apply even where Company has provided assistance to Client in preparation of such documentation.

**2. Report. (a)** The Report shall (i) constitute the sole deliverable for the Services, (ii) relate solely to the facts and circumstances as observed and recorded by Company at the time of performance of the Services within the limits of written information and instructions received from Client; Company shall have no obligation to update the Report after its issuance. Where the Services include testing or inspection: (i) the Report will set forth the findings of Company solely with respect to the product samples identified therein and (ii) the results set forth in the Report are not to be construed as indicative or representative of the quality or characteristics of the lot from which a product sample was taken for Company's performance of Services. **(b)** The Report is issued solely by Company, is intended for the exclusive use of Client and its affiliates and, except as required by a regulatory body, shall not be published, used for advertising purposes, copied or replicated for distribution or publicly disclosed without Company's prior written consent. Company is not responsible for any third party's interpretation of the Report. **(c)** Client shall not request a Report for purposes of litigation, nor shall it list Company, its affiliates or employees as an expert in any proceeding without Company's prior written consent. If Client anticipates producing or otherwise using the Report in any legal proceedings, it shall so notify Company prior to submitting the Report in such proceeding.

**3. Representations and Warranties. (a)** Company undertakes due care and ordinary skill in the performance of its Services. **(b)** Client agrees that Company is neither an insurer nor a guarantor and does not take the place of Client or the third parties that it retains, including designers, manufacturers, agents, buyers, distributors, and transportation or shipping companies; Company disclaims all liability in such capacities. Client understands that, if it seeks to protect itself from claims of loss, damage or injury, it should obtain appropriate insurance. **(c)** Company does not warrant or guarantee Client's products, and Company's Report does not represent a warranty of merchantability, a warranty of fitness for a particular purpose, or any other warranty or guarantee.

**4. Payment.** Payment in full shall be due 30 days after the date of invoice, failing which Company may revoke any credit extended to Client. Client shall reimburse Company for (i) interest on overdue amounts from the due date until paid at an interest rate of 1.5% per month and (ii) any other costs Company incurs in collecting past due amounts, including court, attorneys and collection agencies' fees.

**5. Intellectual Property.** The names, service marks, trademarks and copyrights of Company and its affiliates (collectively, the "**Marks**") are and remain the sole property of Company and shall not be used by Client. Client shall not contest the validity of the Marks or take any action that might impair the value or goodwill associated with the Marks or the image or reputation of Company or its affiliates. Client understands that any information or samples submitted to Company is a license for Company to use the same in the performance of Services.

**6. Relationship. (a)** Nothing herein creates a partnership, agency or joint venture between the Parties. **(b)** The failure to require strict observance or performance of any provision of these Conditions shall not be construed to be a waiver of a Party's right to later require strict observance and performance of the same. If any provision of these Conditions is held to be invalid or unenforceable, such invalidity shall not invalidate the remainder of the Conditions. **(c)** For a period of two years after the commencement of this Agreement, Client shall not directly or indirectly try to solicit for employment any of Company's employees.

**7. INDEMNITY.** CLIENT SHALL HOLD HARMLESS AND INDEMNIFY COMPANY, ITS AFFILIATES, AND THEIR RESPECTIVE DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND SUBCONTRACTORS AGAINST ALL THIRD-PARTY CLAIMS FOR LOSS, DAMAGE, INJURY, DEATH, OR EXPENSE OF WHATEVER NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS ARISING FROM OR RELATING TO (I) THE PERFORMANCE OF ANY SERVICES BY COMPANY, (II) THE SALE, RESALE, MANUFACTURE, DISTRIBUTION OR USE OF ANY OF CLIENT'S GOODS OR (III) BREACH OF CLIENT'S OBLIGATIONS OR WARRANTIES HEREIN.

**8. LIMITATIONS OF LIABILITY. (A)** COMPANY SHALL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL OR SPECIAL LOSS IN CONNECTION WITH THE REPORT, THE PRODUCT FOR WHICH SERVICES WERE PERFORMED, OR THE SERVICES PROVIDED BY COMPANY HEREUNDER. COMPANY SHALL NOT BE LIABLE FOR ANY LOSS OR DAMAGE WHATSOEVER RESULTING FROM ANY DELAY IN THE PERFORMANCE OF ITS OBLIGATIONS HEREUNDER OR FROM THE FAILURE OF COMPANY TO PROVIDE ITS SERVICES WITHIN ANY TIME PERIOD FOR COMPLETION ESTIMATED BY COMPANY, REGARDLESS OF THE CAUSE OF THE DELAY OR FAILURE. **(B)** THE ENTIRE FINANCIAL AND LEGAL LIABILITY OF COMPANY IN RESPECT OF ANY CLAIM FOR LOSS, INDEMNITY, CONTRIBUTION OR DAMAGE OF WHATEVER NATURE OR HOWSOEVER ARISING, SHALL NOT EXCEED AN AMOUNT EQUAL TO FIVE (5) TIMES THE AMOUNT OF FEES PAID TO COMPANY FOR THE SPECIFIC SERVICES WHICH GAVE RISE TO SUCH CLAIM.

**9. Force Majeure.** If any event of force majeure or any event outside the control of Company occurs, Company may immediately cancel or suspend its performance hereunder without incurring any liability whatsoever to Client.

**10. Governing Law.** These Conditions shall be governed by the laws of the country as follows: for Services performed in (i) the Americas: the laws of New York, (ii) Asia Pacific, South Asia, Middle East and Africa: the laws of Hong Kong (except for China where PRC laws govern), and (iii) Europe: the laws of England.

**11. Dispute Resolution. (a)** If Client desires to assert a claim relating to the Services, it must submit the same to Company in writing setting forth with particularity the basis for such claim within 90 days from discovery of the claim and not more than six months after the date of issuance of the Report. Client waives any and all claims without limitation that it does not submit within such time periods. **(b)** If a dispute arises under this Agreement, the Parties shall first attempt good faith negotiations, failing which, the Parties (i) agree that the courts of the country of governing law shall have exclusive jurisdiction to settle any such dispute related to this Agreement and (ii) irrevocably waive their right to trial by jury in any such action or proceeding.

**12.** These Conditions, the applicable order form and/or quotation and the Report represent the entire understanding of the Parties on the subject matter hereof, and no modification is binding unless in writing. Any of Client's terms and conditions attached to, enclosed with or referred to in any order form, purchase order or other document shall not apply.

Gen v.1 copyright 2015 Bureau Veritas

# TEST REPORT

**Report No:** **(7418)144-0214E(SL)** Jul 14, 2018



## TEST RESULTS

| No. | Parameters | Results | LOQ | Unit | Test Method |
|---|---|---|---|---|---|
| 1 | Temperature at Receiving | 24.2 | - | °C | APHA 20th Edition – 2550B |
| 2 | Turbidity | 0.3 | - | NTU | APHA 2130 B |
| 3 | pH at 24°C* | 8.4 | - | - | FD-MTHD-007:2013 Reference to APHA 4500H+ |
| 4 | Nitrate (as $NO_3^-$) | 0.5 | - | mg/l | APHA 4500 -$NO_3$– E |
| 5 | Oil & Grease* | <2.0 | 2.0 | mg/l | FD-MTHD-032:2013 Reference to APHA 5520B |
| 6 | Free Ammonia (as $NH_3$) | 0.05 | - | mg/l | SLS 614 Appendix A: 2013 |
| 7 | Salinity | 36 | - | ppt | APHA 2520 |
| | **Heavy Metals** | | | | |
| 8 | Arsenic (as As)* | ND | 0.001 | mg/l | CPSD-AN-00581-MTHD with ICP-MS |
| 9 | Cadmium (as Cd)* | ND | 0.0001 | mg/l | |
| 10 | Lead (as Pb)* | ND | 0.001 | mg/l | |
| 11 | Mercury (as Hg)* | ND | 0.00005 | mg/l | |
| 12 | Nickel (as Ni)* | ND | 0.001 | mg/l | |
| 13 | Copper (as Cu)* | ND | 0.001 | mg/l | |
| 14 | Zinc (as Zn)* | ND | 0.001 | mg/l | |
| 15 | Chromium (as Cr) | ND | 0.001 | mg/l | |

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

# TEST REPORT

**Report No:** **(7418)144-0214E(SL)** Jul 14, 2018



**Remark –**
***ISO 17025 :2005 ACCREDITED TEST BY SRI LANKA ACCREDITATION BOARD FOR CONFORMITY ASSESSMENT (SLAB)**

**NOTE:**
mg/l: milligrams per liter, ppt: parts per thousand,
APHA: American Public Health Association
ND: Not Detected, LOQ: Limit of Quantification,
NTU: Nephelometric Turbidity Units, °C : Celcius,
ICP-MS: Inductively Coupled Plasma – Mass Spectroscopy.

**Contact information for this report (Technical and General Inquiries and Feedback)**

| | | |
|---|---|---|
| **GENERAL INQUIRIES:** | | |
| IROSHA UDUGAMPALA | TEL: +94 768 229 528 | E-MAIL: Irosha.Udugampala@lk.bureauveritas.com |
| **TECHNICAL INQUIRIES:** | | |
| INDRAJITH HATHURUSINGHA | TEL: + 94 769 603 814 | E-MAIL: Indrajith.hs@lk.bureauveritas.com |
| **FEED BACK:** | | |
| DHANUKA PERERA –EXECUTIVE QHSE | TEL: +94 768 229 479 | E-MAIL: dhanuka.perera@lk.bureauveritas.com |

REVIEWED BY: SHYAMIKA WICKRAMASINGHE

BUREAU VERITAS CONSUMER PRODUCTS SERVICES LANKA (PVT) LTD.

AUTHORIZED SIGNATORY

APPROVED BY: INDRAJITH HATHURUSINGHA
MANAGER-
FOOD LABORATORY

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

**CPS CONDITIONS OF SERVICE**

The party that submits a completed service request form to Company or signs a quotation issued by the Company for its performance of services ("**Services**") is the "**Client**" under these Conditions of Service. The entity within the Bureau Veritas Consumer Products Services division accepting the service request form and issuing the Report documenting the results of those Services is the "**Company**" under these Conditions of Service. Company and Client are, together, the "**Parties**" and each is a "**Party**". A request for Services constitutes a legally binding agreement on both Parties when such a request is accepted by the Company ("**Agreement**") under the following terms and conditions (collectively, "**Conditions**").

1. **Services.** (a) The completion of the Services shall be evidenced by the Company's issuing to Client a written report setting forth the results of the Services based upon the properly accepted request, applicable protocols, written information, and where applicable, the product sample provided by Client to Company ("**Report**"). Company may delegate/assign the performance of all or a portion of the Services to an affiliate of Company or to an agent or subcontractor. Client shall provide to Company on a timely basis, all documents and information necessary to enable Company to properly perform the Services. Company may, in its sole discretion, dispose of product samples furnished to Company for the Services that were not destroyed in the course of performance of the Services. (b) Client represents and warrants to Company that (i) each product sample is not submitted in violation of a third party's intellectual property rights; (ii) Client will not use and rely upon Company's Report for any product whose properties differ from the sample(s) upon which the Report is based; and (iii) any goods subject to inspection will be completely prepared for the type of inspection booked for the specified date; and (c) Client accepts sole responsibility and liability for the accuracy of documents submitted to government or other regulatory bodies, including certificates of compliance required under the US Consumer Product Safety Improvement Act and EU requirements under REACH regulations. Client's responsibility and liability for accuracy shall apply even where Company has provided assistance to Client in preparation of such documentation.

2. **Report.** (a) The Report shall (i) constitute the sole deliverable for the Services; (ii) relate solely to the facts and circumstances as observed and recorded by Company at the time of performance of the Services within the limits of written information and instructions received from Client. Company shall have no obligation to update the Report after its issuance. Where the Services include testing or inspection: (i) the Report will set forth the findings of Company solely with respect to the product samples identified therein; and (ii) the results set forth in the Report are not to be construed as indicative or representative of the quality or characteristics of the lot from which a product sample was taken for Company's performance of Services. (b) The Report is issued solely by Company, is intended for the exclusive use of Client and its affiliates and, except as required by a regulatory body, shall not be published, used for advertising purposes, copied or replicated for distribution or publicly disclosed without Company's prior written consent. Company is not responsible for any third party's interpretation of the Report. (c) Client shall not request a Report for purposes of litigation, nor shall it list Company, its affiliates or employees as an expert in any proceeding without Company's prior written consent. If Client anticipates producing or otherwise using the Report in any legal proceedings, it shall so notify Company prior to submitting the Report in such proceeding.

3. **Representations and Warranties.** (a) Company undertakes due care and ordinary skill in the performance of its Services. (b) Client agrees that Company is neither an insurer nor a guarantor and does not take the place of Client or the third parties that it retains, including designers, manufacturers, agents, buyers, distributors, and transportation or shipping companies. Company disclaims all liability in such capacities. Client understands that, if it seeks to protect itself from claims of loss, damage or injury, it should obtain appropriate insurance. (c) Company does not warrant or guarantee Client's products, and Company's Report does not represent a warranty of merchantability, a warranty of fitness for a particular purpose, or any other warranty or guarantee.

4. **Payment.** Payment in full shall be due 30 days after the date of invoice, failing which Company may revoke any credit extended to Client. Client shall reimburse Company for (i) interest on overdue amounts from the due date until paid at an interest rate of 1.5% per month and (ii) any other costs Company incurs in collecting past due amounts, including court, attorneys and collection agencies' fees.

5. **Intellectual Property.** The names, service marks, trademarks and copyrights of Company and its affiliates (collectively, the "**Marks**") are and remain the sole property of Company and shall not be used by Client. Client shall not contest the validity of the Marks or take any action that might impair the value or goodwill associated with the Marks or the image or reputation of Company or its affiliates. Client understands that any information or samples submitted to Company is a license for Company to use the same in the performance of Services.

6. **Relationship.** (a) Nothing herein creates a partnership, agency or joint venture between the Parties. (b) The failure to require strict observance or performance of any provision of these Conditions shall not be construed to be a waiver of a Party's right to later require strict observance and performance of the same. If any provision of these Conditions is held to be invalid or unenforceable, such invalidity shall not invalidate the remainder of the Conditions. (c) For a period of two years after the commencement of this Agreement, Client shall not directly or indirectly try to solicit for employment any of Company's employees.

7. **INDEMNITY.** CLIENT SHALL HOLD HARMLESS AND INDEMNIFY COMPANY, ITS AFFILIATES, AND THEIR RESPECTIVE DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND SUBCONTRACTORS AGAINST ALL THIRD-PARTY CLAIMS FOR LOSS, DAMAGE, INJURY, DEATH, OR EXPENSE OF WHATEVER NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS ARISING FROM OR RELATING TO (i) THE PERFORMANCE OF ANY SERVICES BY COMPANY, (ii) THE SALE, RESALE, MANUFACTURE, DISTRIBUTION OR USE OF ANY OF CLIENT'S GOODS, OR (iii) BREACH OF CLIENT'S OBLIGATIONS OR WARRANTIES HEREIN.

8. **LIMITATIONS OF LIABILITY.** (A) COMPANY SHALL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL OR SPECIAL LOSS IN CONNECTION WITH THE REPORT, THE PRODUCT FOR WHICH SERVICES WERE PERFORMED, OR THE SERVICES PROVIDED BY COMPANY HEREUNDER. COMPANY SHALL NOT BE LIABLE FOR ANY LOSS OR DAMAGE WHATSOEVER RESULTING FROM ANY DELAY IN THE PERFORMANCE OF ITS OBLIGATIONS HEREUNDER OR FROM THE FAILURE OF COMPANY TO PROVIDE ITS SERVICES WITHIN ANY TIME PERIOD FOR COMPLETION ESTIMATED BY COMPANY, REGARDLESS OF THE CAUSE OF THE DELAY OR FAILURE. (B) THE ENTIRE FINANCIAL AND LEGAL LIABILITY OF COMPANY IN RESPECT OF ANY CLAIM FOR LOSS, INDEMNITY, CONTRIBUTION OR DAMAGE OF WHATEVER NATURE OR HOWSOEVER ARISING, SHALL NOT EXCEED AN AMOUNT EQUAL TO FIVE (5) TIMES THE AMOUNT OF FEES PAID TO COMPANY FOR THE SPECIFIC SERVICES WHICH GAVE RISE TO SUCH CLAIM.

9. **Force Majeure.** In any event of force majeure or any event outside the control of Company occurs, Company may immediately cancel or suspend its performance hereunder without incurring any liability whatsoever to Client.

10. **Governing Law.** These Conditions shall be governed by the laws of the country as follows: for Services performed in (i) the Americas, the laws of New York; (ii) Asia Pacific, South Asia, Middle East and Africa, the laws of Hong Kong (except for China where PRC laws govern); and (iii) Europe, the laws of England.

11. **Dispute Resolution.** (a) If Client desires to assert a claim relating to the Services, it must submit the same to Company in writing setting forth with particularity the basis for such claim within 90 days from discovery of the claim and not more than six months after the date of issuance of the Report. Client waives any and all claims without limitation that it does not submit within such time periods. (b) If a dispute arises under this Agreement, the Parties shall first attempt good faith negotiations, failing which, the Parties (i) agree that the courts of the country of governing law shall have exclusive jurisdiction to settle any such dispute related to this Agreement and (ii) irrevocably waive their right to trial by jury in any such action or proceeding.

12. These Conditions, the applicable order form and/or quotation and the Report represent the entire understanding of the Parties on the subject matter hereof and no modification is binding unless in writing. Any of Client's terms and conditions attached to, enclosed with or referred to in any order form, purchase order or other document shall not apply.

Gen v 1 copyright 2015 Bureau Veritas

END OF THE REPORT.

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

# TEST REPORT

**Report No:** **(7418)144-0214F(SL)** Jul 14, 2018



**Applicant**: Water Solutions (Pvt) Ltd.

**Address** : Ma Fas Eri, 1st Floor,
Ameenee Magu,
Male,
Maldives.

**Attn: Mr. Aslam Mohamed/ Mr. Abdulla Fazeel**

**Sample Received as:** 500ml x 2 No.s of water sample contained in sealed plastic bottles submitted by the client.

**Sample Described by the Client as:** Thilafushi SW6
Date & time Sampled : 03/07/2018 at 07.15 a.m

**Date of Sample Received:** Jul 06, 2018
**Date of Testing Started:** Jul 06, 2018
**Date of Testing Completed:** Jul 13, 2018
**Date of Report Issued:** Jul 14, 2018

**Photo of the Submitted Sample**

**(7418)144-0214F(SL)**

**The content of this PDF file is in accordance with the original issued reports for reference only.**
**This Test Report cannot be reproduced, except in full, without prior written permission of the company.**

**Bureau Veritas Consumer Products Services Lanka (Pvt) Ltd.**
No. 570, Galle Road, Katubedda, Sri Lanka.
Tel : (9411) 2350111 Fax : (9411) 2622198 / 9
E-mail : bvcps.lanka@lk.bureauveritas.com

This report is governed by, and incorporates by reference, the Conditions of Testing as posted at the date of issuance of this report at http://www.mtl-acts.com and is intended for your exclusive use. Any copying or replication of this report to or for any other person or entity, or use of our name or trademark, is permitted only with our prior written permission. This report sets forth our findings solely with respect to the test samples identified herein. The results set forth in this report are not indicative or representative of the quality or characteristics of the lot from which a test sample was taken or any similar or identical product unless specifically and expressly noted. Our report includes all of the tests requested by you and the results thereof based upon the information that you provided to us. You have 60 days from date of issuance of this report to notify us of any material error or omission caused by our negligence, provided, however, that such notice shall be in writing and shall specifically address the issue you wish to raise. A failure to raise such issue within the prescribed time shall constitute your unqualified acceptance of the completeness of this report, the tests conducted and the correctness of the report contents.

## CPS CONDITIONS OF SERVICE

The party that submits a completed service request form to Company or signs a quotation issued by the Company for its performance of services ("**Services**") is the "**Client**" under these Conditions of Service. The entity within the Bureau Veritas Consumer Products Services division accepting the service request form and issuing the Report documenting the results of those Services is the "**Company**" under these Conditions of Service. Company and Client are, together, the "**Parties**" and each is a "**Party**". A request for Services constitutes a legally binding agreement on both Parties when such a request is accepted by the Company ("**Agreement**") under the following terms and conditions (collectively, "**Conditions**"):

**1. Services. (a)** The completion of the Services shall be evidenced by the Company's issuing to Client a written report setting forth the results of the Services based upon the properly accepted request, applicable protocols, written information, and where applicable, the product sample provided by Client to Company ("**Report**"). Company may delegate/assign the performance of all or a portion of the Services to an affiliate of Company or to an agent or subcontractor. Client shall provide to Company on a timely basis, all documents and information necessary to enable Company to properly perform the Services. Company may, in its sole discretion, dispose of product samples furnished to Company for the Services that were not destroyed in the course of performance of the Services. **(b)** Client represents and warrants to Company that (i) each product sample is not submitted in violation of a third party's intellectual property rights; (ii) Client will not use and rely upon Company's Report for any product whose properties differ from the sample(s) upon which the Report is based; and (iii) any goods subject to inspection will be completely prepared for the type of inspection booked for the specified date, and **(c)** Client accepts sole responsibility and liability for the accuracy of documents submitted to government or other regulatory bodies, including certificates of compliance required under the US Consumer Product Safety Improvement Act and EU requirements under REACH regulations. Client's responsibility and liability for accuracy shall apply even where Company has provided assistance to Client in preparation of such documentation.

**2. Report. (a)** The Report shall (i) constitute the sole deliverable for the Services, (ii) relate solely to the facts and circumstances as observed and recorded by Company at the time of performance of the Services within the limits of written information and instructions received from Client; Company shall have no obligation to update the Report after its issuance. Where the Services include testing or inspection: (i) the Report will set forth the findings of Company solely with respect to the product samples identified therein and (ii) the results set forth in the Report are not to be construed as indicative or representative of the quality or characteristics of the lot from which a product sample was taken for Company's performance of Services. **(b)** The Report is issued solely by Company, is intended for the exclusive use of Client and its affiliates and, except as required by a regulatory body, shall not be published, used for advertising purposes, copied or replicated for distribution or publicly disclosed without Company's prior written consent. Company is not responsible for any third party's interpretation of the Report. **(c)** Client shall not request a Report for purposes of litigation, nor shall it list Company, its affiliates or employees as an expert in any proceeding without Company's prior written consent. If Client anticipates producing or otherwise using the Report in any legal proceedings, it shall so notify Company prior to submitting the Report in such proceeding.

**3. Representations and Warranties. (a)** Company undertakes due care and ordinary skill in the performance of its Services. **(b)** Client agrees that Company is neither an insurer nor a guarantor and does not take the place of Client or the third parties that it retains, including designers, manufacturers, agents, buyers, distributors, and transportation or shipping companies; Company disclaims all liability in such capacities. Client understands that, if it seeks to protect itself from claims of loss, damage or injury, it should obtain appropriate insurance. **(c)** Company does not warrant or guarantee Client's products, and Company's Report does not represent a warranty of merchantability, a warranty of fitness for a particular purpose, or any other warranty or guarantee.

**4. Payment.** Payment in full shall be due 30 days after the date of invoice, failing which Company may revoke any credit extended to Client. Client shall reimburse Company for (i) interest on overdue amounts from the due date until paid at an interest rate of 1.5% per month and (ii) any other costs Company incurs in collecting past due amounts, including court, attorneys and collection agencies' fees.

**5. Intellectual Property**. The names, service marks, trademarks and copyrights of Company and its affiliates (collectively, the "**Marks**") are and remain the sole property of Company and shall not be used by Client. Client shall not contest the validity of the Marks or take any action that might impair the value or goodwill associated with the Marks or the image or reputation of Company or its affiliates. Client understands that any information or samples submitted to Company is a license for Company to use the same in the performance of Services.

**6. Relationship. (a)** Nothing herein creates a partnership, agency or joint venture between the Parties. **(b)** The failure to require strict observance or performance of any provision of these Conditions shall not be construed to be a waiver of a Party's right to later require strict observance and performance of the same. If any provision of these Conditions is held to be invalid or unenforceable, such invalidity shall not invalidate the remainder of the Conditions. **(c)** For a period of two years after the commencement of this Agreement, Client shall not directly or indirectly try to solicit for employment any of Company's employees.

**7. INDEMNITY**. CLIENT SHALL HOLD HARMLESS AND INDEMNIFY COMPANY, ITS AFFILIATES, AND THEIR RESPECTIVE DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND SUBCONTRACTORS AGAINST ALL THIRD-PARTY CLAIMS FOR LOSS, DAMAGE, INJURY, DEATH, OR EXPENSE OF WHATEVER NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS ARISING FROM OR RELATING TO (I) THE PERFORMANCE OF ANY SERVICES BY COMPANY, (II) THE SALE, RESALE, MANUFACTURE, DISTRIBUTION OR USE OF ANY OF CLIENT'S GOODS OR (III) BREACH OF CLIENT'S OBLIGATIONS OR WARRANTIES HEREIN.

**8. LIMITATIONS OF LIABILITY. (A)** COMPANY SHALL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL OR SPECIAL LOSS IN CONNECTION WITH THE REPORT, THE PRODUCT FOR WHICH SERVICES WERE PERFORMED, OR THE SERVICES PROVIDED BY COMPANY HEREUNDER. COMPANY SHALL NOT BE LIABLE FOR ANY LOSS OR DAMAGE WHATSOEVER RESULTING FROM ANY DELAY IN THE PERFORMANCE OF ITS OBLIGATIONS HEREUNDER OR FROM THE FAILURE OF COMPANY TO PROVIDE ITS SERVICES WITHIN ANY TIME PERIOD FOR COMPLETION ESTIMATED BY COMPANY, REGARDLESS OF THE CAUSE OF THE DELAY OR FAILURE. **(B)** THE ENTIRE FINANCIAL AND LEGAL LIABILITY OF COMPANY IN RESPECT OF ANY CLAIM FOR LOSS, INDEMNITY, CONTRIBUTION OR DAMAGE OF WHATEVER NATURE OR HOWSOEVER ARISING, SHALL NOT EXCEED AN AMOUNT EQUAL TO FIVE (5) TIMES THE AMOUNT OF FEES PAID TO COMPANY FOR THE SPECIFIC SERVICES WHICH GAVE RISE TO SUCH CLAIM.

**9. Force Majeure.** If any event of force majeure or any event outside the control of Company occurs, Company may immediately cancel or suspend its performance hereunder without incurring any liability whatsoever to Client.

**10. Governing Law.** These Conditions shall be governed by the laws of the country as follows: for Services performed in (i) the Americas: the laws of New York, (ii) Asia Pacific, South Asia, Middle East and Africa: the laws of Hong Kong (except for China where PRC laws govern), and (iii) Europe: the laws of England.

**11. Dispute Resolution. (a)** If Client desires to assert a claim relating to the Services, it must submit the same to Company in writing setting forth with particularity the basis for such claim within 90 days from discovery of the claim and not more than six months after the date of issuance of the Report. Client waives any and all claims without limitation that it does not submit within such time periods. **(b)** If a dispute arises under this Agreement, the Parties shall first attempt good faith negotiations, failing which, the Parties (i) agree that the courts of the country of governing law shall have exclusive jurisdiction to settle any such dispute related to this Agreement and (ii) irrevocably waive their right to trial by jury in any such action or proceeding.

**12.** These Conditions, the applicable order form and/or quotation and the Report represent the entire understanding of the Parties on the subject matter hereof, and no modification is binding unless in writing. Any of Client's terms and conditions attached to, enclosed with or referred to in any order form, purchase order or other document shall not apply.

Gen v.1 copyright 2015 Bureau Veritas

# TEST REPORT

**Report No:** **(7418)144-0214F(SL)** Jul 14, 2018



## TEST RESULTS

| No. | Parameters | Results | LOQ | Unit | Test Method |
|---|---|---|---|---|---|
| 1 | Temperature at Receiving | 24.2 | - | °C | APHA 20th Edition – 2550B |
| 2 | Turbidity | 0.2 | - | NTU | APHA 2130 B |
| 3 | pH at 24°C* | 8.4 | - | - | FD-MTHD-007:2013 Reference to APHA 4500H+ |
| 4 | Nitrate (as $NO_3^-$) | 0.3 | - | mg/l | APHA 4500 -$NO_3$– E |
| 5 | Oil & Grease* | <2.0 | 2.0 | mg/l | FD-MTHD-032:2013 Reference to APHA 5520B |
| 6 | Free Ammonia (as $NH_3$) | 0.05 | - | mg/l | SLS 614: Appendix A: 2013 |
| 7 | Salinity | 37 | - | ppt | APHA 2520 |
| | **Heavy Metals** | | | | |
| 8 | Arsenic (as As)* | ND | 0.001 | mg/l | CPSD-AN-00581-MTHD with ICP-MS |
| 9 | Cadmium (as Cd)* | ND | 0.0001 | mg/l | |
| 10 | Lead (as Pb)* | ND | 0.001 | mg/l | |
| 11 | Mercury (as Hg)* | ND | 0.00005 | mg/l | |
| 12 | Nickel (as Ni)* | ND | 0.001 | mg/l | |
| 13 | Copper (as Cu)* | ND | 0.001 | mg/l | |
| 14 | Zinc (as Zn)* | 0.003 | - | mg/l | |
| 15 | Chromium (as Cr) | ND | 0.001 | mg/l | |

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

# TEST REPORT

**Report No:** **(7418)144-0214F(SL)** Jul 14, 2018



**Remark –**

***ISO 17025 :2005 ACCREDITED TEST BY SRI LANKA ACCREDITATION BOARD FOR CONFORMITY ASSESSMENT (SLAB)**

**NOTE:**

mg/l: milligrams per liter, ppt: parts per thousand,
APHA: American Public Health Association
ND: Not Detected, LOQ: Limit of Quantification,
NTU: Nephelometric Turbidity Units, °C : Celcius,
ICP-MS: Inductively Coupled Plasma – Mass Spectroscopy.

**Contact information for this report (Technical and General Inquiries and Feedback)**

| | | |
|---|---|---|
| **GENERAL INQUIRIES:** | | |
| IROSHA UDUGAMPALA | TEL: +94 768 229 528 | E-MAIL: Irosha.Udugampala@lk.bureauveritas.com |
| **TECHNICAL INQUIRIES:** | | |
| INDRAJITH HATHURUSINGHA | TEL: + 94 769 603 814 | E-MAIL: Indrajith.hs@lk.bureauveritas.com |
| **FEED BACK:** | | |
| DHANUKA PERERA –EXECUTIVE QHSE | TEL: +94 768 229 479 | E-MAIL: dhanuka.perera@lk.bureauveritas.com |

REVIEWED BY: SHYAMIKA WICKRAMASINGHE

BUREAU VERITAS CONSUMER PRODUCTS SERVICES LANKA (PVT) LTD.

AUTHORIZED SIGNATORY

APPROVED BY: for
INDRAJITH HATHURUSINGHA
MANAGER-
FOOD LABORATORY

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

**CPS CONDITIONS OF SERVICE**

The party that submits a completed service request form to Company or signs a quotation issued by the Company for its performance of services ("Services") is the "Client" under these Conditions of Service. The entity within the Bureau Veritas Consumer Products Services division accepting the service request form and issuing the Report documenting the results of those Services is the "Company" under these Conditions of Service. Company and Client are, together, the "Parties" and each is a "Party". A request for Services constitutes a legally binding agreement on both Parties when such a request is accepted by the Company ("Agreement") under the following terms and conditions (collectively, "Conditions").

1. **Services.** (a) The completion of the Services shall be evidenced by the Company's issuing to Client a written report setting forth the results of the Services based upon the property accepted request, applicable protocols, written information, and where applicable, the product sample provided by Client to Company ("Report"). Company may delegate/assign the performance of all or a portion of the Services to an affiliate of Company or to an agent or subcontractor. Client shall provide to Company on a timely basis, all documents and information necessary to enable Company to properly perform the Services. Company may, in its sole discretion, dispose of product samples furnished to Company for the Services that were not destroyed in the course of performance of the Services. (b) Client represents and warrants to Company that (i) each product sample is not submitted in violation of a third party's intellectual property rights, (ii) Client will not use and rely upon Company's Report for any product whose properties differ from the sample(s) upon which the Report is based; and (iii) any goods subject to inspection will be completely prepared for the type of inspection booked for the specified date, and (c) Client accepts sole responsibility and liability for the accuracy of documents submitted to government or other regulatory bodies, including certificates of compliance required under the US Consumer Product Safety Improvement Act and EU requirements under REACH regulations. Client's responsibility and liability for accuracy shall apply even where Company has provided assistance to Client in preparation of such documentation.

2. **Report.** (a) The Report shall (i) constitute the sole deliverable for the Services, (ii) relate solely to the facts and circumstances as observed and recorded by Company at the time of performance of the Services within the limits of written information and instructions received from Client. Company shall have no obligation to update the Report after its issuance. Where the Services include testing or inspection, (iii) the Report will set forth the findings of Company solely with respect to the product samples identified therein and (iv) the results set forth in the Report are not to be construed as indicative or representative of the quality or characteristics of the lot from which a product sample was taken for Company's performance of Services. (b) The Report is issued solely by Company, is intended for the exclusive use of Client and its affiliates and, except as required by a regulatory body, shall not be published, used for advertising purposes, copied or replicated for distribution or publicly disclosed without Company's prior written consent. Company is not responsible for any third party's interpretation of the Report. (c) Client shall not request a Report for purposes of litigation, nor shall it list Company, its affiliates or employees as an expert in any proceeding without Company's prior written consent. If Client anticipates producing or otherwise using the Report in any legal proceedings, it shall so notify Company prior to submitting the Report in such proceeding.

3. **Representations and Warranties.** (a) Company undertakes due care and ordinary skill in the performance of its Services. (b) Client agrees that Company is neither an insurer nor a guarantor and does not take the place of Client or the third parties that it retains, including designers, manufacturers, agents, buyers, distributors, and transportation or shipping companies. Company disclaims all liability in such capacities. Client understands that, if it seeks to protect itself from claims of loss, damage or injury, it should obtain appropriate insurance. (c) Company does not warrant or guarantee Client's products, and Company's Report does not represent a warranty of merchantability, a warranty of fitness for a particular purpose, or any other warranty or guarantee.

4. **Payment.** Payment in full shall be due 30 days after the date of invoice, failing which Company may revoke any credit extended to Client. Client shall reimburse Company for (i) interest on overdue amounts from the due date until paid at an interest rate of 1.5% per month and (ii) any other costs Company incurs in collecting past due amounts, including court, attorneys and collection agencies' fees.

5. **Intellectual Property.** The names, service marks, trademarks and copyrights of Company and its affiliates (collectively, the "Marks") are and remain the sole property of Company and shall not be used by Client. Client shall not contest the validity of the Marks or take any action that might impair the value or goodwill associated with the Marks or the image or reputation of Company or its affiliates. Client understands that any information or samples submitted to Company is a license for Company to use the same in the performance of Services.

6. **Relationship.** (a) Nothing herein creates a partnership, agency or joint venture between the Parties. (b) The failure to require strict observance or performance of any provision of these Conditions shall not be construed to be a waiver of a Party's right to later require strict observance and performance of the same. If any provision of these Conditions is held to be invalid or unenforceable, such invalidity shall not invalidate the remainder of the Conditions. (c) For a period of two years after the commencement of this Agreement, Client shall not directly or indirectly try to solicit for employment any of Company's employees.

7. **INDEMNITY.** CLIENT SHALL HOLD HARMLESS AND INDEMNIFY COMPANY, ITS AFFILIATES AND THEIR RESPECTIVE DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND SUBCONTRACTORS AGAINST ALL THIRD-PARTY CLAIMS FOR LOSS, DAMAGE, INJURY, DEATH, OR EXPENSE OF WHATEVER NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS ARISING FROM OR RELATING TO (i) THE PERFORMANCE OF ANY SERVICES BY COMPANY, (ii) THE SALE, RESALE, MANUFACTURE, DISTRIBUTION OR USE OF ANY OF CLIENT'S GOODS OR (iii) BREACH OF CLIENT'S OBLIGATIONS OR WARRANTIES HEREIN.

8. **LIMITATIONS OF LIABILITY.** (A) COMPANY SHALL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL OR SPECIAL LOSS IN CONNECTION WITH THE REPORT, THE PRODUCT FOR WHICH SERVICES WERE PERFORMED, OR THE SERVICES PROVIDED BY COMPANY HEREUNDER. COMPANY SHALL NOT BE LIABLE FOR ANY LOSS OR DAMAGE WHATSOEVER RESULTING FROM ANY DELAY IN THE PERFORMANCE OF ITS OBLIGATIONS HEREUNDER OR FROM THE FAILURE OF COMPANY TO PROVIDE ITS SERVICES WITHIN ANY TIME PERIOD FOR COMPLETION ESTIMATED BY COMPANY, REGARDLESS OF THE CAUSE OF THE DELAY OR FAILURE. (B) THE ENTIRE FINANCIAL AND LEGAL LIABILITY OF COMPANY IN RESPECT OF ANY CLAIM FOR LOSS, INDEMNITY, CONTRIBUTION OR DAMAGE OF WHATEVER NATURE OR HOWSOEVER ARISING, SHALL NOT EXCEED AN AMOUNT EQUAL TO FIVE (5) TIMES THE AMOUNT OF FEES PAID TO COMPANY FOR THE SPECIFIC SERVICES WHICH GAVE RISE TO SUCH CLAIM.

9. **Force Majeure.** If any event of force majeure or any event outside the control of Company occurs, Company may immediately cancel or suspend its performance hereunder without incurring any liability whatsoever to Client.

10. **Governing Law.** These Conditions shall be governed by the laws of the country as follows: for Services performed in (i) the Americas: the laws of New York; (ii) Asia Pacific, South Asia, Middle East and Africa: the laws of Hong Kong (except for China where PRC laws govern); and (iii) Europe: the laws of England.

11. **Dispute Resolution.** (a) If Client desires to assert a claim relating to the Services, it must submit the same to Company in writing setting forth with particularity the basis for such claim within 90 days from discovery of the claim and not more than six months after the date of issuance of the Report. Client waives any and all claims without limitation that it does not submit within such time periods. (b) If a dispute arises under this Agreement, the Parties shall first attempt good faith negotiations, failing which, the Parties (i) agree that the courts of the country of governing law shall have exclusive jurisdiction to settle any such dispute related to this Agreement and (ii) irrevocably waive their right to trial by jury in any such action or proceeding.

12. These Conditions, the applicable order form and/or quotation and the Report represent the entire understanding of the Parties on the subject matter hereof, and no modification is binding unless in writing. Any of Client's terms and conditions attached to, enclosed with or referred to in any order form, purchase order or other document shall not apply.

Gen v 1 copyright 2015 Bureau Veritas

END OF THE REPORT.

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

# TEST REPORT

**Report No:** **(7418)144-0214G(SL)** Jul 14, 2018



**Applicant**: Water Solutions (Pvt) Ltd.

**Address** : Ma Fas Eri, 1st Floor,
Ameenee Magu,
Male,
Maldives.

**Attn: Mr. Aslam Mohamed/ Mr. Abdulla Fazeel**

| | |
|---|---|
| **Sample Received as:** | 500ml x 2 No.s of water sample contained in sealed plastic bottles submitted by the client. |
| **Sample Described by the Client as:** | Thilafushi SW7<br>Date & time Sampled : 03/07/2018 at 08.45 a.m |
| **Date of Sample Received:** | Jul 06, 2018 |
| **Date of Testing Started:** | Jul 06, 2018 |
| **Date of Testing Completed:** | Jul 13, 2018 |
| **Date of Report Issued:** | Jul 14, 2018 |

**Photo of the Submitted Sample**

**(7418)144-0214G(SL)**

**The content of this PDF file is in accordance with the original issued reports for reference only.**
**This Test Report cannot be reproduced, except in full, without prior written permission of the company.**

**Bureau Veritas Consumer Products Services Lanka (Pvt) Ltd.**
No. 570, Galle Road, Katubedda, Sri Lanka.
Tel : (9411) 2350111 Fax : (9411) 2622198 / 9
E-mail : bvcps.lanka@lk.bureauveritas.com

This report is governed by, and incorporates by reference, the Conditions of Testing as posted at the date of issuance of this report at http://www.mit-acts.com and is intended for your exclusive use. Any copying or replication of this report to or for any other person or entity, or use of our name or trademark, is permitted only with our prior written permission. This report sets forth our findings solely with respect to the test samples identified herein. The results set forth in this report are not indicative or representative of the quality or characteristics of the lot from which a test sample was taken or any similar or identical product unless specifically and expressly noted. Our report includes all of the tests requested by you and the results thereof based upon the information that you provided to us. You have 60 days from date of issuance of this report to notify us of any material error or omission caused by our negligence, provided, however, that such notice shall be in writing and shall specifically address the issue you wish to raise. A failure to raise such issue within the prescribed time shall constitute your unqualified acceptance of the completeness of this report, the tests conducted and the correctness of the report contents.

## CPS CONDITIONS OF SERVICE

The party that submits a completed service request form to Company or signs a quotation issued by the Company for its performance of services ("**Services**") is the "**Client**" under these Conditions of Service. The entity within the Bureau Veritas Consumer Products Services division accepting the service request form and issuing the Report documenting the results of those Services is the "**Company**" under these Conditions of Service. Company and Client are, together, the "**Parties**" and each is a "**Party**". A request for Services constitutes a legally binding agreement on both Parties when such a request is accepted by the Company ("**Agreement**") under the following terms and conditions (collectively, "**Conditions**"):

**1. Services. (a)** The completion of the Services shall be evidenced by the Company's issuing to Client a written report setting forth the results of the Services based upon the properly accepted request, applicable protocols, written information, and where applicable, the product sample provided by Client to Company ("**Report**"). Company may delegate/assign the performance of all or a portion of the Services to an affiliate of Company or to an agent or subcontractor. Client shall provide to Company on a timely basis, all documents and information necessary to enable Company to properly perform the Services. Company may, in its sole discretion, dispose of product samples furnished to Company for the Services that were not destroyed in the course of performance of the Services. **(b)** Client represents and warrants to Company that (i) each product sample is not submitted in violation of a third party's intellectual property rights; (ii) Client will not use and rely upon Company's Report for any product whose properties differ from the sample(s) upon which the Report is based; and (iii) any goods subject to inspection will be completely prepared for the type of inspection booked for the specified date, and **(c)** Client accepts sole responsibility and liability for the accuracy of documents submitted to government or other regulatory bodies, including certificates of compliance required under the US Consumer Product Safety Improvement Act and EU requirements under REACH regulations. Client's responsibility and liability for accuracy shall apply even where Company has provided assistance to Client in preparation of such documentation.

**2. Report. (a)** The Report shall (i) constitute the sole deliverable for the Services, (ii) relate solely to the facts and circumstances as observed and recorded by Company at the time of performance of the Services within the limits of written information and instructions received from Client; Company shall have no obligation to update the Report after its issuance. Where the Services include testing or inspection: (i) the Report will set forth the findings of Company solely with respect to the product samples identified therein and (ii) the results set forth in the Report are not to be construed as indicative or representative of the quality or characteristics of the lot from which a product sample was taken for Company's performance of Services. **(b)** The Report is issued solely by Company, is intended for the exclusive use of Client and its affiliates and, except as required by a regulatory body, shall not be published, used for advertising purposes, copied or replicated for distribution or publicly disclosed without Company's prior written consent. Company is not responsible for any third party's interpretation of the Report. **(c)** Client shall not request a Report for purposes of litigation, nor shall it list Company, its affiliates or employees as an expert in any proceeding without Company's prior written consent. If Client anticipates producing or otherwise using the Report in any legal proceedings, it shall so notify Company prior to submitting the Report in such proceeding.

**3. Representations and Warranties. (a)** Company undertakes due care and ordinary skill in the performance of its Services. **(b)** Client agrees that Company is neither an insurer nor a guarantor and does not take the place of Client or the third parties that it retains, including designers, manufacturers, agents, buyers, distributors, and transportation or shipping companies; Company disclaims all liability in such capacities. Client understands that, if it seeks to protect itself from claims of loss, damage or injury, it should obtain appropriate insurance. **(c)** Company does not warrant or guarantee Client's products, and Company's Report does not represent a warranty of merchantability, a warranty of fitness for a particular purpose, or any other warranty or guarantee.

**4. Payment.** Payment in full shall be due 30 days after the date of invoice, failing which Company may revoke any credit extended to Client. Client shall reimburse Company for (i) interest on overdue amounts from the due date until paid at an interest rate of 1.5% per month and (ii) any other costs Company incurs in collecting past due amounts, including court, attorneys and collection agencies' fees.

**5. Intellectual Property.** The names, service marks, trademarks and copyrights of Company and its affiliates (collectively, the "**Marks**") are and remain the sole property of Company and shall not be used by Client. Client shall not contest the validity of the Marks or take any action that might impair the value or goodwill associated with the Marks or the image or reputation of Company or its affiliates. Client understands that any information or samples submitted to Company is a license for Company to use the same in the performance of Services.

**6. Relationship. (a)** Nothing herein creates a partnership, agency or joint venture between the Parties. **(b)** The failure to require strict observance or performance of any provision of these Conditions shall not be construed to be a waiver of a Party's right to later require strict observance and performance of the same. If any provision of these Conditions is held to be invalid or unenforceable, such invalidity shall not invalidate the remainder of the Conditions. **(c)** For a period of two years after the commencement of this Agreement, Client shall not directly or indirectly try to solicit for employment any of Company's employees.

**7. INDEMNITY.** CLIENT SHALL HOLD HARMLESS AND INDEMNIFY COMPANY, ITS AFFILIATES, AND THEIR RESPECTIVE DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND SUBCONTRACTORS AGAINST ALL THIRD-PARTY CLAIMS FOR LOSS, DAMAGE, INJURY, DEATH, OR EXPENSE OF WHATEVER NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS ARISING FROM OR RELATING TO (I) THE PERFORMANCE OF ANY SERVICES BY COMPANY, (II) THE SALE, RESALE, MANUFACTURE, DISTRIBUTION OR USE OF ANY OF CLIENT'S GOODS OR (III) BREACH OF CLIENT'S OBLIGATIONS OR WARRANTIES HEREIN.

**8. LIMITATIONS OF LIABILITY. (A)** COMPANY SHALL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL OR SPECIAL LOSS IN CONNECTION WITH THE REPORT, THE PRODUCT FOR WHICH SERVICES WERE PERFORMED, OR THE SERVICES PROVIDED BY COMPANY HEREUNDER. COMPANY SHALL NOT BE LIABLE FOR ANY LOSS OR DAMAGE WHATSOEVER RESULTING FROM ANY DELAY IN THE PERFORMANCE OF ITS OBLIGATIONS HEREUNDER OR FROM THE FAILURE OF COMPANY TO PROVIDE ITS SERVICES WITHIN ANY TIME PERIOD FOR COMPLETION ESTIMATED BY COMPANY, REGARDLESS OF THE CAUSE OF THE DELAY OR FAILURE. **(B)** THE ENTIRE FINANCIAL AND LEGAL LIABILITY OF COMPANY IN RESPECT OF ANY CLAIM FOR LOSS, INDEMNITY, CONTRIBUTION OR DAMAGE OF WHATEVER NATURE OR HOWSOEVER ARISING, SHALL NOT EXCEED AN AMOUNT EQUAL TO FIVE (5) TIMES THE AMOUNT OF FEES PAID TO COMPANY FOR THE SPECIFIC SERVICES WHICH GAVE RISE TO SUCH CLAIM.

**9. Force Majeure.** If any event of force majeure or any event outside the control of Company occurs, Company may immediately cancel or suspend its performance hereunder without incurring any liability whatsoever to Client.

**10. Governing Law.** These Conditions shall be governed by the laws of the country as follows: for Services performed in (i) the Americas: the laws of New York, (ii) Asia Pacific, South Asia, Middle East and Africa: the laws of Hong Kong (except for China where PRC laws govern), and (iii) Europe: the laws of England.

**11. Dispute Resolution. (a)** If Client desires to assert a claim relating to the Services, it must submit the same to Company in writing setting forth with particularity the basis for such claim within 90 days from discovery of the claim and not more than six months after the date of issuance of the Report. Client waives any and all claims without limitation that it does not submit within such time periods. **(b)** If a dispute arises under this Agreement, the Parties shall first attempt good faith negotiations, failing which, the Parties (i) agree that the courts of the country of governing law shall have exclusive jurisdiction to settle any such dispute related to this Agreement and (ii) irrevocably waive their right to trial by jury in any such action or proceeding.

**12.** These Conditions, the applicable order form and/or quotation and the Report represent the entire understanding of the Parties on the subject matter hereof, and no modification is binding unless in writing. Any of Client's terms and conditions attached to, enclosed with or referred to in any order form, purchase order or other document shall not apply.

Gen v.1 copyright 2015 Bureau Veritas

# TEST REPORT

**Report No:** **(7418)144-0214G(SL)** Jul 14, 2018



## TEST RESULTS

| No. | Parameters | Results | LOQ | Unit | Test Method |
|---|---|---|---|---|---|
| 1 | Temperature at Receiving | 24.2 | - | °C | APHA 20th Edition – 2550B |
| 2 | Turbidity | 0.2 | - | NTU | APHA 2130 B |
| 3 | pH at 24°C* | 8.2 | - | - | FD-MTHD-007:2013 Reference to APHA 4500H+ |
| 4 | Nitrate (as $NO_3^-$) | 0.5 | - | mg/l | APHA 4500 -$NO_3$– E |
| 5 | Oil & Grease* | <2.0 | 2.0 | mg/l | FD-MTHD-032:2013 Reference to APHA 5520B |
| 6 | Free Ammonia (as $NH_3$) | <0.02 | 0.02 | mg/l | SLS 614 Appendix A: 2013 |
| 7 | Salinity | 36 | - | ppt | APHA 2520 |
| | **Heavy Metals** | | | | |
| 8 | Arsenic (as As)* | ND | 0.001 | mg/l | CPSD-AN-00581-MTHD with ICP-MS |
| 9 | Cadmium (as Cd)* | ND | 0.0001 | mg/l | |
| 10 | Lead (as Pb)* | ND | 0.001 | mg/l | |
| 11 | Mercury (as Hg)* | ND | 0.00005 | mg/l | |
| 12 | Nickel (as Ni)* | ND | 0.001 | mg/l | |
| 13 | Copper (as Cu)* | ND | 0.001 | mg/l | |
| 14 | Zinc (as Zn)* | 0.008 | - | mg/l | |
| 15 | Chromium (as Cr) | ND | 0.001 | mg/l | |

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

# TEST REPORT

**Report No:** **(7418)144-0214G(SL)** Jul 14, 2018



**Remark –**
***ISO 17025 :2005 ACCREDITED TEST BY SRI LANKA ACCREDITATION BOARD FOR CONFORMITY ASSESSMENT (SLAB)**

**NOTE:**
mg/l: milligrams per liter, ppt: parts per thousand,
APHA: American Public Health Association
ND: Not Detected, LOQ: Limit of Quantification,
NTU: Nephelometric Turbidity Units, °C : Celcius,
ICP-MS: Inductively Coupled Plasma – Mass Spectroscopy.

**Contact information for this report (Technical and General Inquiries and Feedback)**

| | | |
|---|---|---|
| **GENERAL INQUIRIES:** | | |
| IROSHA UDUGAMPALA | TEL: +94 768 229 528 | E-MAIL: Irosha.Udugampala@lk.bureauveritas.com |
| **TECHNICAL INQUIRIES:** | | |
| INDRAJITH HATHURUSINGHA | TEL: + 94 769 603 814 | E-MAIL: Indrajith.hs@lk.bureauveritas.com |
| **FEED BACK:** | | |
| DHANUKA PERERA –EXECUTIVE QHSE | TEL: +94 768 229 479 | E-MAIL: dhanuka.perera@lk.bureauveritas.com |

REVIEWED BY: SHYAMIKA WICKRAMASINGHE

BUREAU VERITAS CONSUMER PRODUCTS SERVICES LANKA (PVT) LTD.

AUTHORIZED SIGNATORY

APPROVED BY: for
INDRAJITH HATHURUSINGHA
MANAGER-
FOOD LABORATORY

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

**CPS CONDITIONS OF SERVICE**

The party that submits a completed service request form to Company or signs a quotation issued by the Company for its performance of services ("Services") is the "**Client**" under these Conditions of Service. The entity within the Bureau Veritas Consumer Products Services division accepting the service request form and issuing the Report documenting the results of those Services is the "**Company**" under these Conditions of Service. Company and Client are, together, the "**Parties**" and each is a "**Party**". A request for Services constitutes a legally binding agreement on both Parties when such a request is accepted by the Company ("**Agreement**") under the following terms and conditions (collectively "**Conditions**").

1. **Services.** (a) The completion of the Services shall be evidenced by the Company's issuing to Client a written report setting forth the results of the Services based upon the properly accepted request, applicable protocols, written information, and where applicable, the product sample provided by Client to Company ("**Report**"). Company may delegate/assign the performance of all or a portion of the Services to an affiliate of Company or to an agent or subcontractor. Client shall provide to Company on a timely basis, all documents and information necessary to enable Company to properly perform the Services. Company may, in its sole discretion, dispose of product samples furnished to Company for the Services that were not destroyed in the course of performance of the Services. (b) Client represents and warrants to Company that (i) each product sample is not submitted in violation of a third party's intellectual property rights, (ii) Client will not use and rely upon Company's Report for any product whose properties differ from the sample(s) upon which the Report is based, and (iii) any goods subject to inspection will be completely prepared for the type of inspection booked for the specified date, and (c) Client accepts sole responsibility and liability for the accuracy of documents submitted to government or other regulatory bodies, including certificates of compliance required under the US Consumer Product Safety Improvement Act and EU requirements under REACH regulations. Client's responsibility and liability for accuracy shall apply even where Company has provided assistance to Client in preparation of such documentation.

2. **Report.** (a) The Report shall (i) constitute the sole deliverable for the Services, (ii) relate solely to the facts and circumstances as observed and recorded by Company at the time of performance of the Services within the limits of written information and instructions received from Client, Company shall have no obligation to update the Report after its issuance. Where the Services include testing or inspection, (ii) the Report will set forth the findings of Company solely with respect to the product samples identified therein and (iii) the results set forth in the Report are not to be construed as indicative or representative of the quality or characteristics of the lot from which a product sample was taken for Company's performance of Services. (b) The Report is issued solely by Company, is intended for the exclusive use of Client and its affiliates and, except as required by a regulatory body, shall not be published, used for advertising purposes, copied or replicated for distribution or publicly disclosed without Company's prior written consent. Company is not responsible for any third party's interpretation of the Report. (c) Client shall not request a Report for purposes of litigation, nor shall a list Company, its affiliates or employees as an expert in any proceeding without Company's prior written consent. If Client anticipates producing or otherwise using the Report in any legal proceedings, it shall so notify Company prior to submitting the Report in such proceeding.

3. **Representations and Warranties.** (a) Company undertakes due care and ordinary skill in the performance of its Services. (b) Client agrees that Company is neither an insurer nor a guarantor and does not take the place of Client or the third parties that it retains, including designers, manufacturers, agents, buyers, distributors, and transportation or shipping companies. Company disclaims all liability in such capacities. Client understands that, if it seeks to protect itself from claims of loss, damage or injury, it should obtain appropriate insurance. (c) Company does not warrant or guarantee Client's products, and Company's Report does not represent a warranty of merchantability, a warranty of fitness for a particular purpose, or any other warranty or guarantee.

4. **Payment.** Payment in full shall be due 30 days after the date of invoice, failing which Company may revoke any credit extended to Client. Client shall reimburse Company for (i) interest on overdue amounts from the due date until paid at an interest rate of 1.5% per month and (ii) any other costs Company incurs in collecting past due amounts, including court, attorneys and collection agencies' fees.

5. **Intellectual Property.** The names, service marks, trademarks and copyrights of Company and its affiliates (collectively, the "**Marks**") are and remain the sole property of Company and shall not be used by Client. Client shall not contest the validity of the Marks or take any action that might impair the value or goodwill associated with the Marks or the image or reputation of Company or its affiliates. Client understands that any information or samples submitted to Company is a license for Company to use the same in the performance of Services.

6. **Relationship.** (a) Nothing herein creates a partnership, agency or joint venture between the Parties. (b) The failure to require strict observance or performance of any provision of these Conditions shall not be construed to be a waiver of a Party's right to later require strict observance and performance of the same. If any provision of these Conditions is held to be invalid or unenforceable, such invalidity shall not invalidate the remainder of the Conditions. (c) For a period of two years after the commencement of this Agreement, Client shall not directly or indirectly try to solicit for employment any of Company's employees.

7. **INDEMNITY.** CLIENT SHALL HOLD HARMLESS AND INDEMNIFY COMPANY, ITS AFFILIATES, AND THEIR RESPECTIVE DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND SUBCONTRACTORS AGAINST ALL THIRD-PARTY CLAIMS FOR LOSS, DAMAGE, INJURY, DEATH, OR EXPENSE OF WHATEVER NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS ARISING FROM OR RELATING TO (I) THE PERFORMANCE OF ANY SERVICES BY COMPANY, (II) THE SALE, RESALE, MANUFACTURE, DISTRIBUTION OR USE OF ANY OF CLIENT'S GOODS, OR (III) BREACH OF CLIENT'S OBLIGATIONS OR WARRANTIES HEREIN.

8. **LIMITATIONS OF LIABILITY.** (A) COMPANY SHALL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL OR SPECIAL LOSS IN CONJUNCTION WITH THE REPORT, THE PRODUCT FOR WHICH SERVICES WERE PERFORMED, OR THE SERVICES PROVIDED BY COMPANY HEREUNDER. COMPANY SHALL NOT BE LIABLE FOR ANY LOSS OR DAMAGE WHATSOEVER RESULTING FROM ANY DELAY IN THE PERFORMANCE OF ITS OBLIGATIONS HEREUNDER OR FROM THE FAILURE OF COMPANY TO PROVIDE ITS SERVICES WITHIN ANY TIME PERIOD FOR COMPLETION ESTIMATED BY COMPANY, REGARDLESS OF THE CAUSE OF THE DELAY OR FAILURE. (B) THE ENTIRE FINANCIAL AND LEGAL LIABILITY OF COMPANY IN RESPECT OF ANY CLAIM FOR LOSS, INDEMNITY, CONTRIBUTION OR DAMAGE OF WHATEVER NATURE OR HOWSOEVER ARISING, SHALL NOT EXCEED AN AMOUNT EQUAL TO FIVE (5) TIMES THE AMOUNT OF FEES PAID TO COMPANY FOR THE SPECIFIC SERVICES WHICH GAVE RISE TO SUCH CLAIM.

9. **Force Majeure.** If any event of force majeure or any event outside the control of Company occurs, Company may immediately cancel or suspend its performance hereunder without incurring any liability whatsoever to Client.

10. **Governing Law.** These Conditions shall be governed by the laws of the country as follows: for Services performed in (i) the Americas: the laws of New York; (ii) Asia Pacific, South Asia, Middle East and Africa: the laws of Hong Kong (except for China where PRC laws govern); and (iii) Europe: the laws of England.

11. **Dispute Resolution.** (a) If Client desires to assert a claim relating to the Services, it must submit the same to Company in writing setting forth with particularity the basis for such claim within 90 days from discovery of the claim and not more than six months after the date of issuance of the Report. Client waives any and all claims without limitation that it does not submit within such time periods. (b) If a dispute arises under this Agreement, the Parties shall first attempt good faith negotiations, failing which the Parties (i) agree that the courts of the country of governing law shall have exclusive jurisdiction to settle any such dispute related to this Agreement and (ii) irrevocably waive their right to trial by jury in any such action or proceeding.

12. These Conditions, the applicable order form and/or quotation and the Report represent the entire understanding of the Parties on the subject matter hereof, and no modification is binding unless in writing. Any of Client's terms and conditions attached to, enclosed with or referred to in any order form, purchase order or other document shall not apply.

Gen v 1 copyright 2015 Bureau Veritas

**END OF THE REPORT.**

The content of this PDF file is in accordance with the original issued reports for reference only.
This Test Report cannot be reproduced, except in full, without prior written permission of the company.

Environmental Impact Assessment for the Waste-to-Energy Plant Project in Thilafushi

# Biodiversity and Critical Habitat Assessment

**Prepared by**: Aleef Naseem and Abdul Aleem (EIA P03/2019)

25th November 2019

## Contents


I. Introduction ..... 3

II. Definition of Critical Habitat ..... 3

III. Areas of analysis ..... 4

IV. Thresholds of Critical Habitat ..... 5

V. Critical Habitat Screening and Assessment ..... 5

VI. Criteria 1 – 3: Critically Endangered or Endangered Species, Endemic and/or Restricted-range species Migratory or Congregatory Species ..... 5

VII. Criterion 4: Unique assemblages of species that are associated with key evolutionary processes ..... 12

VIII. Criterion 5: Areas having biodiversity of significant social, economic, or cultural importance to local communities (including ecosystem services) ..... 12

IX. Legally protected areas and international recognized areas ..... 13

X. Conclusion and Recommendations ..... 13

## I. Introduction

1. The ADB Safeguard Policy Statement (ADB 2009) requires assessment of whether the project is planned in an area that may qualify as Critical Habitat or Natural Habitat. This assessment followed more detailed guidance in International Finance Corporation Performance Standard 6 and its recently updated accompanying guidance note (IFC 2012, 2019).

2. ADB SPS requires that any projects financed by ADB shall not implement project activities and components in area of critical habitat/s, 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, ADB requires that the project 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. ADB SPS further requires the use of precautionary approach in the use, development, and management of renewable natural resources.

3. In order to assess whether the Greater Malé Waste-to-Energy Project (WTE project) is located in a critical habitat, an initial screening was undertaken using the Integrated Biodiversity Assessment Tool (IBAT).[1] Results show that the location of the WTE project is likely a critical habitat. Therefore, a critical habitat assessment is needed to confirm the results.

4. This biodiversity and critical habitat assessment is applicable to the WTE project. Apart from the information from the IBAT screening, this report is also based on the baseline information provided in the EIA for the WTE project, which was supported with literature review and field data collection.

## II. Definition of Critical Habitat

5. Critical habitat is defined in ADB SPS (2009) as a subset of both natural and modified habitat that deserves particular attention. Critical habitat includes areas with high biodiversity value, including (i) habitat required for the survival of critically endangered or endangered species; (ii) areas having special significance for endemic or restricted-range species; (iii) sites that are critical for the survival of migratory species; (iv) areas supporting globally significant concentrations or numbers of individuals of congregatory species; (v) areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and (vi) areas having biodiversity of significant social, economic, or cultural importance to local communities.

[1] The Integrated Biodiversity Assessment Tool (IBAT) is a multi-institutional programme of work involving BirdLife International, Conservation International, IUCN, and UNEP-WCMC. IBAT provides a basic risk screening on biodiversity. It draws together information on globally recognised biodiversity information drawn from a number of IUCN's Knowledge Products: IUCN Red List of Threatened Species, Key Biodiversity Areas (priority sites for conservation) and Protected Planet/The World Database on Protected Areas (covering nationally and internationally recognised sites, including IUCN management categories I–VI, Ramsar Wetlands of International Importance and World Heritage sites).

## III. Areas of analysis

6. Critical Habitat and Natural Habitat assessment ideally takes place across sensible ecological or political units that are sufficiently large to encompass all direct and indirect impacts from the project. These areas of analysis (AoAs) are thus often much broader than the direct project footprint. AoAs may be separate or combined, depending on the ecology of the biodiversity concerned.

7. Considering the extent of potential impacts on aquatic biodiversity from the Project an aquatic AoA was identified as the 50-km study area to make consistent with the default range in the IBAT Screening. This area is approximately within the Zone 3 of Maldives, within which common biological communities and/or management issues exist (Figure 1).

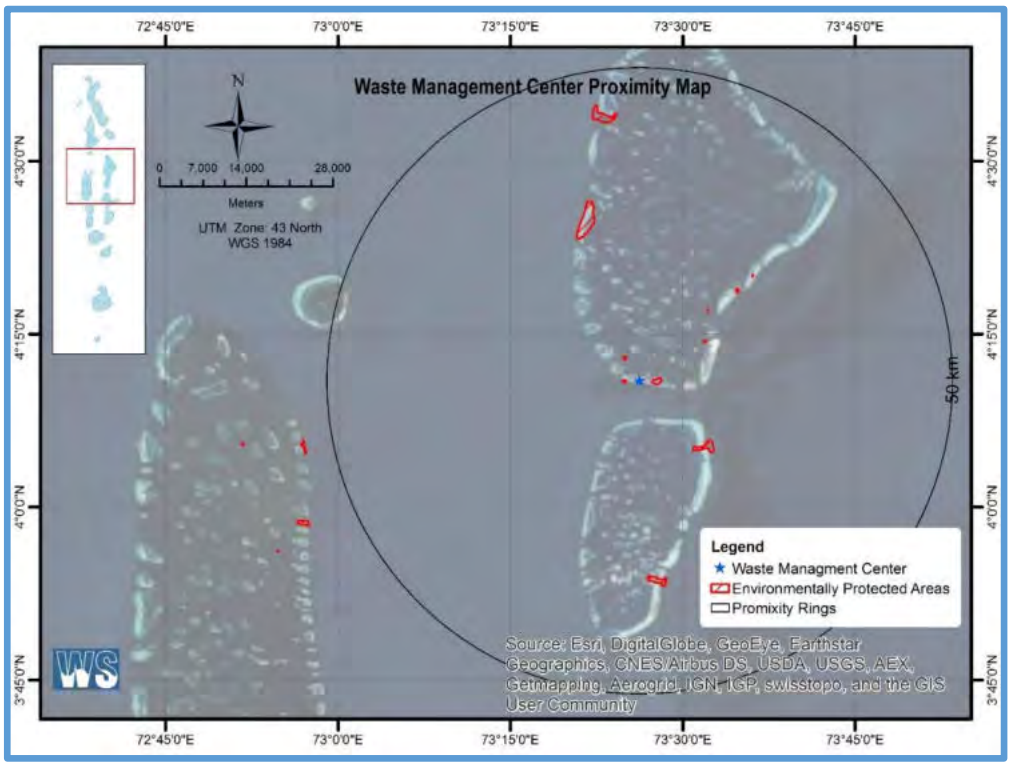



Figure 1: 50km buffer zone from project site at Thilafushi

8. Identification of AoAs does not mean that the project has any obligations across them. The aim of this Critical Habitat Assessment is to identify whether the broad units qualify as Critical Habitat and, if so, for which biodiversity features. This information helps to prioritize impact assessment and to focus mitigation efforts.

## IV. Thresholds of Critical Habitat

1. To identify if a certain species can qualify the project AoA as Critical Habitat, the IFC Guidance Note 6 (2019)[2] has been used.

## V. Critical Habitat Screening and Assessment

2. Critical habitat screening considered critical habitat-qualifying biodiversity candidates identified within the EIA as actually or potentially present. In each case, reasons are identified for each biodiversity feature likely meeting or not meeting Critical Habitat. IBAT was used as the initial screening for critical habitat values. Performance Standard 6 (PS6) defines these values for critical habitat (PS6: para. 16) and legally protected and internationally recognized areas (PS6: para. 20). The IBAT was used to screen for known risks within a standard 50km buffer of the project area at Thilafushi (see **Error! Reference source not found.**).

## VI. Criteria 1 – 3: Critically Endangered or Endangered Species, Endemic and/or Restricted-range species Migratory or Congregatory Species

3. Habitat of significant importance to priority species can trigger critical habitat status. IBAT was used to create a preliminary list of priority species that could occur within the AoA. This list is drawn from the IUCN Red List of Threatened Species (IUCN RL). Due to the uncertainty surrounding the assessment at this preliminary stage, the list of species for which Critical Habitat may be triggered is still provisional and will require further analysis as reiterated in the conclusion.

4. The justification for the assessment has been provided in Table 1.

5. It should be noted that this list is preliminary and other species not currently included or poorly represented such as birds, fish, and invertebrates may come to light and require inclusion following monitoring and field surveys, continued desk study, and stakeholder engagement during project implementation.

[2] https://www.ifc.org/wps/wcm/connect/5e0f3c0c-0aa4-4290-a0f8-4490b61de245/GN6_English_June-27-2019.pdf?MOD=AJPERES&CVID=mRQjZva

Table 1: Critical Habitat Screening Assessment

| Species Name | Criteria 1 CR or EN Species | Criteria 2 Endemic / Restricted Range Species | Criteria 3 Migratory / Congregatory Species | Rationale |
|---|---|---|---|---|
| **Mammals** | | | | |
| Blue Whale *Balaenoptera musculus* | EN | - | M | About 5,000 individuals of this species survive today in three populations: North Atlantic, North Pacific, and the Southern Hemisphere. According to interviews with local people, there has been only few sightings of Blue Whales in Maldives waters and is regarded as an uncommon visitor to the Maldives. There is no recorded information that can confirm the regular occurrence of this species in the AoA. It is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs, at least seasonally. *Balaenoptera musculus* does not appear to qualify the Project area as Critical Habitat. |
| **Birds** | | | | |
| Matsudaira's Storm-petrel *Oceanodroma matsudairae* | - | RS | M | Population is only known to breed on the Volcano Islands in southern Japan. After breeding the species move south across equatorial belt and then winters in the equatorial belt. Only recorded in Ha. Atoll (Anderson & Baldock 2001), which is not within the AoA. There is a possibility that the species could occur near the coast in the Project AoA. This is, however, unlikely given degradation and development in that area. Based on the available information, <10% of the species' range overlap the terrestrial AoA, and there is low likelihood that suitable habitat exists in the Project area. *Oceanodroma matsudairae* does not appear to qualify the Project area as Critical Habitat. |

| Species Name | Criteria 1 CR or EN Species | Criteria 2 Endemic / Restricted Range Species | Criteria 3 Migratory / Congregatory Species | Rationale |
|---|---|---|---|---|
| **Odonata** | | | | |
| *Enallagma maldivense* | CR | RS | - | *Enallagma maldivensis* is a species of damselfly. There is insufficient data available for this species. No data is available on its population size in the AoA nor population size for the entire country. Dragonflies normally are found in freshwater habitats. No information is available on the presence of freshwater habitats (e.g. ponds) in the AoA. On a precautionary basis, it is possible that the terrestrial AoA holds more than 0.5% of the global population of this globally Critically Endangered damselfly. As such, *Enallagma maldivense* qualifies the project AoA as Critical Habitat. |
| **Fishes** | | | | |
| Pondicherry Shark *Carcharhinus hemiodon* | CR | - | - | The Pondicherry Shark is a rare shark found on the continental and insular shelves of the eastern Indian Ocean and the western Pacific, from India to New Guinea. Thought to be extinct, recently found near a seasonal fishing village in Sri Lanka. There have been no recorded sightings in Maldives. It is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Carcharhinus hemiodon* does not appear to qualify the Project area as Critical Habitat. |
| Bowmouth Guitar shark *Rhina ancylostoma* | VU* | - | - | Although this shark is found throughout coastal areas across the Indian Ocean, sightings of this species in Maldives is rare. There is no recorded information that can confirm the regular occurrence of this species in the AoA. There is no reason to suspect that the AoA holds disproportionately high or low populations. The Project only occupies a small percentage of the AoA and is not predicted to have broad-scale impacts. Without further information, it thus seems unlikely that the Project could have impacts on this shark that would impact it to a level that it would become Endangered. As such, *Rhina ancylostoma* does not qualify the Project area as Critical Habitat. |

| Species Name | Criteria 1 CR or EN Species | Criteria 2 Endemic / Restricted Range Species | Criteria 3 Migratory / Congregatory Species | Rationale |
|---|---|---|---|---|
| Bottlenose Wedge shark *Rhynchobatus australiae* | CR | - | - | The Bottlenose Wedgefish inhabits inshore waters on the continental shelves, specifically enclosed bays, estuaries, and coral reefs. It is found in South-East Asia and Australia.<br>Although this shark is also found throughout coastal areas across the Indian Ocean, sightings of this species in Maldives is rare. There is no recorded information that can confirm the regular occurrence of this species in the AoA. It is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Rhynchobatus australiae* does not appear to qualify the Project area as Critical Habitat. |
| Whale Shark *Rhincodon typus* | EN | - | - | Whale sharks are commonly found within Maldives. A possible resident population exists in ADh. Atoll which is outside the AoA. Sightings are rare within the AoA. It is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Rhincodon typus* does not appear to qualify the Project area as Critical Habitat. |
| Shortfin Mako Shark *Isurus oxyrinchus* | EN | - | M | The Shortfin Mako is an offshore littoral and epipelagic species found occurring in tropical and warm-temperate waters of all oceans. It is a highly migratory species making extensive journeys of over 3,000 kilometers. This species is found throughout Maldives. However, occurrence close to the atolls is very rare. There is no recorded information that can confirm the regular occurrence of this species in the AoA, It is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Isurus oxyrinchus* does not appear to qualify the Project area as Critical Habitat. |

| Species Name | Criteria 1 CR or EN Species | Criteria 2 Endemic / Restricted Range Species | Criteria 3 Migratory / Congregatory Species | Rationale |
|---|---|---|---|---|
| Great Hammerhead *Sphyrna mokarran* | EN | - | - | *Sphyrna mokarran* is a coastal-pelagic and semi-oceanic tropical hammerhead occurring close inshore and well offshore, over the continental shelves, island terraces, and in passes and lagoons of coral atolls, as well as over deep water near land. Sightings are seasonal during the start of North-east Monsoon. According to diver community, southern atolls have the most likelihood of sightings which fall outside the AoA. The great hammerhead ranges widely throughout the tropical waters of the world. For this reason, it is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Sphyrna mokarran* does not appear to qualify the Project area as Critical Habitat. |
| Ornate Eagle Ray *Aetomylaeus vespertilio* | EN | - | - | The Ornate Eagle Ray has a sporadic distribution in the Indo-West Pacific, including Maldives. It occurs on the inner continental shelf to depths of 110 m over soft sandy substrate. Rarely seen and one sighting at Landaa Giraavaru, Baa Atoll, Maldives was recorded on February 2018. This area is outside the AoA. It is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Aetomylaeus vespertilio* does not appear to qualify the Project area as Critical Habitat. |
| Longfin Mako *Isurus paucus* | EN | - | - | The Longfin Mako is widespread in tropical and warm temperate waters, and likely occurs in all oceans, although its distribution is poorly recorded.<br>Sightings of this species in Maldives is rare. It is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Isurus paucus* does not appear to qualify the Project area as Critical Habitat. |

| Species Name | Criteria 1 CR or EN Species | Criteria 2 Endemic / Restricted Range Species | Criteria 3 Migratory / Congregatory Species | Rationale |
|---|---|---|---|---|
| Sky Emperor *Lethrinus mahsena* | EN | - | - | This species is found in coral reef habitats and adjacent sandy and seagrass areas. Commercially fished in most of its habitat, but there are no evidences that it happens in the Maldives as well. It is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Lethrinus mahsena* does not appear to qualify the Project area as Critical Habitat. |
| **Echinoderms** | | | | |
| Golden Sandfish *Holothuria scabra;* Golden Sandfish *Holothuria lesson;* Black Teatfish *Holothuria nobilis* | EN | - | - | All these holothurian species are fished commercially, with some local populations in sharp decline due to overexploitation. All three species have a wide range across Indo-Pacific tropical seas. No information is available about the presence and abundance of these species in the project AoA; however, it is very unlikely that the Project AoA holds >0.5% of the global population of this species, and >5 pairs. *Holothuria spp.* do not appear to qualify the Project area as Critical Habitat. |
| **Corals** | | | | |
| *Acropora rudis* | EN | - | - | This species is found in the northern Indian Ocean and the central Indo-Pacific. Found also in the Maldives, however, data lacks on population size. The AoA is already impacted and not all the reefs are in pristine conditions, and this species was also not found during the underwater surveys. It is extremely unlikely the Project AoA holds >0.5% of the global population of this species. *Acropora rudis* does not appear to qualify the Project area as Critical Habitat. |

CR – Critically Endangered under IUCN Red List; EN – Endangered under the IUCN Red List; RS – Restricted Range Species under IUCN; M – migratory.
*- Recently changed to vulnerable status in IUCN Red List

## VII. Criterion 4: Unique assemblages of species that are associated with key evolutionary processes

6. As is the case for the majority of Indo-Pacific islands, the Maldives Archipelago has been subject to long and extreme isolation that has allowed evolutionary processes to generate unique, endemic flora and fauna. Beyond this general context, however, there is no reason to believe that the terrestrial or aquatic AoA host particularly unusual or key evolutionary processes. Unique assemblages of species associated with key evolutionary processes thus do not qualify the Project area as Critical Habitat.

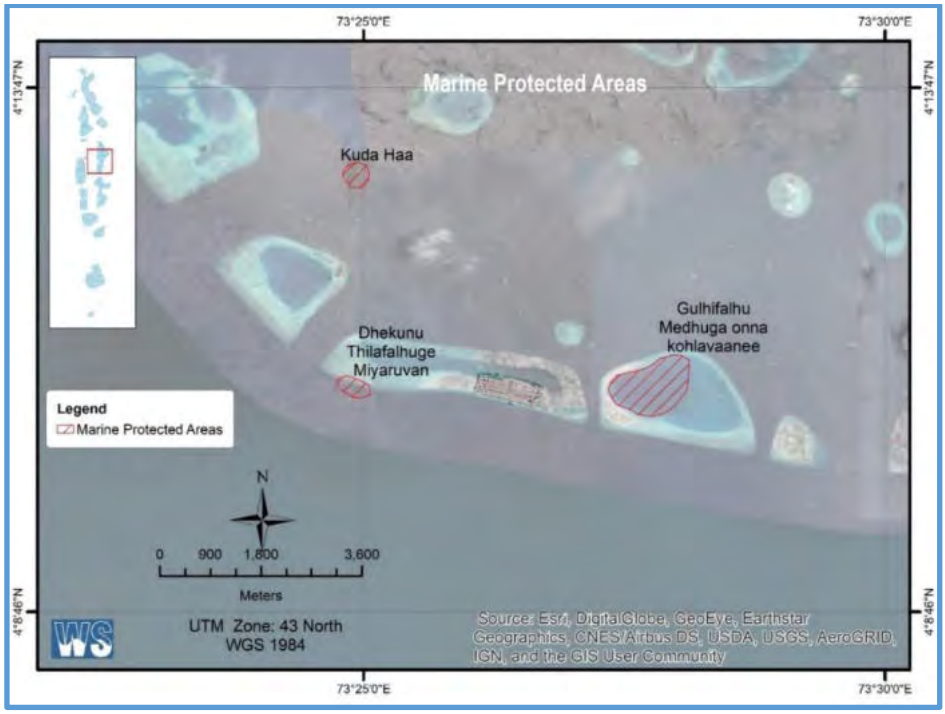
## VIII. Criterion 5: Areas having biodiversity of significant social, economic, or cultural importance to local communities (including ecosystem services)

7. This additional assessment considers the ecosystem services from biodiversity in general. The assessment of significance of ecosystem services to local communities is assessed retrospectively in line with the consultation with local dive communities.

8. Ecosystem services affected by the project are prioritized when all three of the following criteria are met: (i) the project might affect the ability of others to benefit from the service; (ii) the affected service is important to beneficiaries' well-being; and (iii) beneficiaries do not have viable alternatives for that service.

9. The limited information presented does not give reason to believe that the Project terrestrial or aquatic AoA are sufficiently important to local people that they represent Critical Habitat under this criterion. However, it is beyond the scope of this assessment to collect additional information on ecosystem services, and then to assess which may qualify the project area as Critical Habitat.

**Figure 2. 5km buffer zone from project site at Thilafushi**



## IX. Legally protected areas and internationally recognized areas

10. There are some areas near to the Project. The nearest MPA to the WTE project site is the "*Lions Head*" (Dhekunu Thilafalhuge Miyaruvani), around 1 km from the proposed plant. Additionally, as a precautionary approach, a more focused habitat assessment was conducted for this MPA. Results show that none of the IUCN species categorized as critically endangered species, endangered species or vulnerable species is found within this MPA. Results also show that none of nationally protected species is found within this MPA either. A complete assessment of the Lions Head is attached as Annex 2.

24. Following IFC (2019), none of the protected areas found in the Project AoA meets the thresholds for Critical Habitat for some species for which it was designated. For this reason, none of the protected areas found in the AoA qualify the Project area as Critical Habitat.

## X. Conclusion and Recommendations

25. The WTE project will be established in Maldives, a country rich in biodiversity. Based on the initial screening using IBAT, the project site is likely to be a critical habitat at least for a terrestrial insect.

11. In the course of project implementation, it is highly recommended that continuous marine underwater monitoring be undertaken around Thilfushi island to confirm the extent of biodiversity in various seasons of the year, including assessment of features pertinent to critical habitats. In cases when future information determines the existence of critical habitat within the study area, the WTE project should be able to demonstrate that:

(i) It does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values;
(ii) It does not lead to a net reduction in the global and/or national/regional population of any Critically Endangered or Endangered species over a reasonable period of time; and
(iii) It has integrated into its management program a robust, appropriately designed, and long-term biodiversity monitoring and evaluation program.

## REFERENCES


Aeby, G., Lovell, E., Richards, Z., Delbeek, J.C., Reboton, C. & Bass, D. 2008. Acropora rudis. The IUCN Red List of Threatened Species 2008: e.T132913A3490569. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T132913A3490569.en. Downloaded on 27 November 2019.

Al Abdali, F.S.H., Al Buwaiqi, B., Al Kindi, A.S.M., Ambuali, A., Borsa, P., Govender, A. & Russell, B. 2019. Lethrinus mahsena. The IUCN Red List of Threatened Species 2019: e.T16720057A16722325. http://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T16720057A16722325.en. Downloaded on 27 November 2019.

Anderson, C. and Bladock, M. (2001). New records of birds from the Maldives, with notes on other species. Forktail, 17, pp.67–73.

BirdLife International (2019) Species factsheet: Hydrobates matsudairae. Downloaded from http://www.birdlife.org on 27/11/2019

Compagno, L.J.V., White, W. & Fowler, S. (SSG Australia & Oceania Regional Workshop, March 2003) 2003. Carcharhinus hemiodon. The IUCN Red List of Threatened Species 2003: e.T39369A10185838. http://dx.doi.org/10.2305/IUCN.UK.2003.RLTS.T39369A10185838.en. Downloaded on 27 November 2019.

Conand, C., Purcell, S. & Gamboa, R. 2013. Holothuria lessoni. The IUCN Red List of Threatened Species 2013: e.T180275A1609567. http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T180275A1609567.en. Downloaded on 27 November 2019.

Dow, R.A. 2009. Enallagma maldivensis. The IUCN Red List of Threatened Species 2009: e.T59716A11994224. http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T59716A11994224.en. Downloaded on 27 November 2019.

Denham, J., Stevens, J.D., Simpfendorfer, C., Heupel, M.R., Cliff, G., Morgan, A., Graham, R., Ducrocq, M., Dulvy, N.K., Seisay, M., Asber, M., Valenti, S.V., Litvinov, F., Martins, P., Lemine Ould Sidi, M., Tous, P. & Bucal, D. 2007. Sphyrna mokarran. The IUCN Red List of Threatened Species 2007: e.T39386A10191938. http://dx.doi.org/10.2305/IUCN.UK.2007.RLTS.T39386A10191938.en. Downloaded on 27 November 2019.

Khadheeja Ali & Hussain Sinan, 2015. National Plan of Action for the Conservation and Management of Sharks. Ministry of Fisheries and agriculture.

Kyne, P.M., Rigby, C.L., Dharmadi & Jabado, R.W. 2019. Rhynchobatus australiae. The IUCN Red List of Threatened Species 2019: e.T41853A68643043. http://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T41853A68643043.en. Downloaded on 27 November 2019.

McAuley, R.B., Compagno, L.J.V. & Chin, A. 2016. Rhina ancylostoma. The IUCN Red List of Threatened Species 2016: e.T41848A68641634. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41848A68641634.en. Downloaded on 27 November 2019.

Nyawira Muthiga, 2018. Field observations of sea cucumbers at North Male Atoll in the Maldives. SPC Beche de Mer Information Bulletin #27 – March 2008

Pierce, S.J. & Norman, B. 2016. Rhincodon typus. The IUCN Red List of Threatened Species 2016: e.T19488A2365291. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T19488A2365291.en. Downloaded on 27 November 2019.

Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Jabado, R.W., Liu, K.M., Marshall, A., Pacoureau, N., Romanov, E., Sherley, R.B. & Winker, H. 2019. Isurus

oxyrinchus. The IUCN Red List of Threatened Species 2019: e.T39341A2903170. http://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T39341A2903170.en. Downloaded on 27 November 2019.

Riley, M., Hale, M., Harman, A. and Rees, R. (2010). Analysis of whale shark Rhincodon typus aggregations near South Ari Atoll, Maldives Archipelago. Aquatic Biology, 8, pp.145-150.

## Annex 1: IBAT assessment report

IBAT

**Integrated Biodiversity Assessment Tool**

# WORLD BANK GROUP BIODIVERSITY RISK SCREEN

Report generated on 20/11/2019 by Francesco Ricciardi under the license number 2780-5415 held by ADB. www.ibat-alliance.org

**Project Name:** Thilafushi WTE

**Location:** [ 4.2, 73.4 ]

**Overlaps with:**

| | |
|---|---|
| Protected Areas | 11 |
| Key Biodiversity Areas | 0 |
| IUCN Red List | 15 |
| Critical Habitat | Likely |

Displaying project location and buffers: 10.0 km, 50.0 km

WORLD BANK GROUP

This report is based on IFC Performance Standard 6 (PS6) but applies to World Bank Environmental and Social Standard 6 (ESS6)

KNOW YOUR ENVIRONMENT | UN

Thilafushi WTE | Page 1 of 10

IBAT

## About this report

IBAT provides initial screening for critical habitat values. Performance Standard 6 (PS6) defines these values for critical habitat (PS6: para. 16) and legally protected and internationally recognized areas (PS6: para. 20). PS6 will be triggered when IFC client activities are located in modified habitats containing "significant biodiversity value," natural habitats, critical habitats, legally protected areas, or areas that are internationally recognized for biodiversity. References to PS6 and Guidance Note 6 (GN6) are provided to guide further assessment and detailed definitions where necessary. Please see https://www.ifc.org/ps6 for full details on PS6 and GN6.

The report screens for known risks within a standard 50km buffer of the coordinates used for analysis. This buffer is not intended to indicate the area of impact. The report can be used to:

- Scope risks to include within an assessment of risks and impacts
- Identify gaps within an existing assessment of risks and impacts
- Prioritize between sites in a portfolio for further assessment of risks and impacts
- Inform a preliminary determination of critical habitat
- Assess the need for engaging a biodiversity specialist
- Identify additional conservation experts or organizations to inform further assessment or planning

WARNING: IBAT aims to provide the most up-to-date and accurate information available at the time of analysis. There is however a possibility of incomplete, incorrect or out-of-date information. All findings in this report must be supported by further desktop review, consultation with experts and/or on-the-ground field assessment as described in PS6 and GN6. Please consult IBAT for any additional disclaimers or recommendations applicable to the information used to generate this report.

## Legal disclaimer

The Integrated Biodiversity Assessment Tool (IBAT) and IBAT products, which include the IBAT Portal, reports, and data, are owned by IBAT Alliance and accessible by paid subscription.

The IBAT and IBAT products may contain reference to or include content owned and provided by the International Bank for Reconstruction and Development ("IBRD"), the International Development Association ("IDA"), the International Finance Corporation ("IFC"), the Multilateral Investment Guarantee Agency ("MIGA"), and the International Center for Settlement of Investment Disputes ("ICSID") (collectively, the "World Bank Group" or "WBG", individually, the "WBG Member"). The content owned and provided by the WBG Members (the "Member Content") is the respective property of the WBG Member and is protected under general principles of copyright.

The use of Member Content in IBAT and IBAT products is under license and intended for informational purposes only. Such use is not intended to constitute legal, securities, or investment advice, an opinion regarding the appropriateness of any investment, or a solicitation of any type. Additionally, the information is provided on a strictly "as-is" basis, without any assurance or representation of any kind.

KNOW YOUR ENVIRONMENT | UN

IBAT

The WBG Member does not guarantee the accuracy, reliability or completeness of any Member Content included in IBAT or IBAT products or for the conclusions or judgments described therein. The WBG Member accepts no responsibility or liability for any omissions or errors (including, without limitation, typographical errors and technical errors) in any Member Content whatsoever or for reliance thereon. The boundaries, colors, denominations, and other information shown on any map in IBAT do not imply any judgment on the part of WBG Member concerning the legal status of any territory or the endorsement or acceptance of such boundaries. The findings, interpretations, and conclusions expressed in the IBAT and the IBAT products do not necessarily reflect the views of the WBG Member, its member countries, Executive Directors, or the governments it represents.

The WBG Members are international organizations established under their respective constituent agreement among their member countries. IBRD owns the WBG logos and trademark. The logos and other trademarks, service marks, graphics of a WBG Member are the tradenames, trademarks or registered trademarks of that WBG Member (the "WBG Member Mark"). The WBG logo and trademark and WBG Member Marks may not be copied, imitated, or used, in whole or in part, without the prior written permission of WBG or its Members, as appropriate. All other queries on rights and licenses, including subsidiary rights, should be addressed as follows. If to IFC, to IFC's Corporate Relations Department, 2121 Pennsylvania Avenue, N.W., Washington, D.C. 20433. If to MIGA, to MIGA's Legal Affairs and Claims Group (Attn: Chief Counsel, Operations & Policy), 1818 H Street N.W., U12-1204, Washington, D.C. 20433. If to IBRD and/or IDA, to the Office of the Publisher, The World Bank, 1818 H Street N.W., Washington, D.C. 20433; Email: pubrights@worldbank.org.

KNOW YOUR ENVIRONMENT

IBAT

## Priority Species

Habitat of significant importance to priority species will trigger critical habitat status (See PS6: para 16). IBAT provides a preliminary list of priority species that could occur within the 50km buffer. This list is drawn from the IUCN Red List of Threatened Species (IUCN RL). This list should be used to guide any further assessment, with the aim of confirming knownor likely occurrence of these species within the project area. It is also possible that further assessment may confirm occurrence of additional priority species not listed here. It is strongly encouraged that any new species information collected by the project be shared with species experts and/or IUCN wherever possible in order to improve IUCN datasets.

## IUCN Red List of Threatened Species - CR & EN

The following species are potentially found within 50km of the area of interest.
For the full IUCN Red List please refer to the associated csv in the report folder.

| Species name | Common name | IUCN Category | Group |
|---|---|---|---|
| Carcharhinus hemiodon | Pondicherry Shark | CR | CHONDRICHTHYES |
| Rhina ancylostoma | Bowmouth Guitarfish | CR | CHONDRICHTHYES |
| Rhynchobatus australiae | Bottlenose Wedgefish | CR | CHONDRICHTHYES |
| Enallagma maldivense | | CR | INSECTA |
| Balaenoptera musculus | Blue Whale | EN | MAMMALIA |
| Rhincodon typus | Whale Shark | EN | CHONDRICHTHYES |
| Isurus oxyrinchus | Shortfin Mako | EN | CHONDRICHTHYES |
| Sphyrna mokarran | Great Hammerhead | EN | CHONDRICHTHYES |
| Aetomylaeus vespertilio | Ornate Eagle Ray | EN | CHONDRICHTHYES |
| Isurus paucus | Longfin Mako | EN | CHONDRICHTHYES |
| Acropora rudis | | EN | ANTHOZOA |

KNOW YOUR ENVIRONMENT | BirdLife UN WCMC

Thilafushi WTE | Page 4 of 10

IBAT

## Biodiversity features which are likely to trigger Critical Habitat

### Protected Areas

The following protected areas are found within 10.0 km and 50.0 km of the area of interest.
For further details please refer to the associated csv file in the report folder.

| Area name | Distance | Recommendation |
|---|---|---|
| Giravaru Kuda Haa | 10.0 km | Assess for biodiversity risk |
| Hans Hass Plave (Gulhi Falhu) | 10.0 km | Assess for biodiversity risk |
| Lions Head (Thilafalhu Miyaruvani) | 10.0 km | Assess for biodiversity risk |
| Banana reef (Gaathu Giri) | 50.0 km | Assess for biodiversity risk |
| Embudhoo Kanduolhi | 50.0 km | Assess for biodiversity risk |
| Gursidhoo Kandu | 50.0 km | Assess for biodiversity risk |
| Huraa Mangrove | 50.0 km | Assess for biodiversity risk |
| Makunudhoo Kandu | 50.0 km | Assess for biodiversity risk |
| Nassimo Thila (Lankan Thila) | 50.0 km | Assess for biodiversity risk |
| Rasfari | 50.0 km | Assess for biodiversity risk |
| Thanburudhoo Thila (HP Reef) | 50.0 km | Assess for biodiversity risk |

### Key Biodiversity Areas

KNOW YOUR ENVIRONMENT | BirdLife UN

Thilafushi WTE | Page 6 of 10

IBAT

The following key biodiversity areas are found within 10.0 km and 50.0 km of the area of interest.
For further details please refer to the associated csv file in the report folder.

| Area name | Distance | Recommendation |
|---|---|---|

## Species with potential to occur

| Area Taxonomic group | Total assessed species | Total (CR, EN & VU) | CR | EN | VU | NT | LC | DD |
|---|---|---|---|---|---|---|---|---|
| CHONDRICHTHYES | 28 | 19 | 3 | 5 | 11 | 2 | 4 | 3 |
| INSECTA | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| MAMMALIA | 10 | 1 | 0 | 1 | 0 | 0 | 7 | 2 |
| ANTHOZOA | 124 | 23 | 0 | 1 | 22 | 40 | 53 | 8 |
| HOLOTHUROIDEA | 31 | 5 | 0 | 3 | 2 | 0 | 15 | 11 |
| ACTINOPTERYGII | 656 | 3 | 0 | 1 | 2 | 3 | 628 | 22 |
| REPTILIA | 2 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| AVES | 36 | 2 | 0 | 0 | 2 | 4 | 30 | 0 |
| MAGNOLIOPSIDA | 5 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| AMPHIBIA | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| HYDROZOA | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| MALACOSTRACA | 8 | 0 | 0 | 0 | 0 | 0 | 7 | 1 |
| LILIOPSIDA | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |

KNOW YOUR ENVIRONMENT | BirdLife UN WCMC

Thilafushi WTE | Page 7 of 10

| Area Taxonomic group | Total assessed species | Total (CR, EN & VU) | CR | EN | VU | NT | LC | DD |
|---|---|---|---|---|---|---|---|---|
| POLYPODIOPSIDA | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| GASTROPODA | 66 | 0 | 0 | 0 | 0 | 0 | 65 | 1 |
| BIVALVIA | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

IBAT

## Country-level summary

Coming soon

IBAT

## Recommended Experts and Organizations

For projects located in critical habitat, clients must ensure that external experts with regional expertise are involved in further assessment (GN6: GN22). Clients are encouraged to develop partnerships with recognized and credible conservation organizations and/or academic institutes, especially with respect to potential developments in natural or critical habitat (GN6: GN23). Where critical habitats are triggered by priority species, species specialists must be involved. IBAT provides data originally collected by a large network of national partners, while species information is sourced via the IUCN Red List and affiliated Species Specialist Groups. These experts and organizations are listed below. **Please note that this is not intended as a comprehensive list of organizations and experts. These organizations and experts are under no obligation to support any further assessment and do so entirely at their discretion and under their terms. Any views expressed or recommendations made by these stakeholders should not be attributed to the IFC or IBAT for IFC partners.**

## Relevant national or regional organizations

IBAT integrates information developed by a global network of conservation agencies, organizations and experts. These efforts are coordinated by the IBAT Alliance (BirdLife International, Conservation International, IUCN and UNEP-WCMC) who compile and maintain this information as globally standardized databases. The local partners most relevant to the area of analysis are:

**Wild Bird Society of Japan Address:** Maruwa Building, 3-9-23 Nishi-Gotanda, Shinagawa-ku, Tokyo 141-0031, JapanWeb: http://www.wbsj.org/

**BirdLife Asia Regional Office Address:** 354 Tanglin Road, #01-16/17, Tanglin International Centre, Singapore 247672 Email: singapore.office@birdlife.org Web: http://www.birdlife.org/asia

## Directory for Species Survival Commission (SSC) Specialist Groups and Red List Authorities

URL: http://www.iucn.org/about/work/programmes/species/who_we_are/ssc_specialist_groups_and_red_list_authorities_directory/

## Annex 2: Critical Habitat Assessment for Lions Head MPA

LIVE&LEARN
MALDIVES

**FINAL REPORT**

Baseline Socio Economic Survey in
Thilafushi and Gulhifalhu

TA 9327 - Greater Male' Environmental Improvement and Waste Management Project

**August – September2019**

# Table of Contents

1. Introduction ..... 2
2. Methodology ..... 2
2.1 Objectives ..... 2
2.2 Approach ..... 2
2.3 The Sampling Frame and Sampling Strategy ..... 3
2.4 Data Collection ..... 4
2.4.1 Questionnaire ..... 4
2.5 Data Analysis ..... 4
2.5.1 Data entry, analysis, synthesis and interpretation ..... 4
2.5.2 Integration of Different Information Gathering Processes ..... 4
3. Key Findings ..... 5
3.1 General Information ..... 5
3.2 Income, Expenditure and Savings ..... 5
3.4 Health Condition and Healthcare Services ..... 7
3.5 Solid Waste Management ..... 8
3.6 Other Issues ..... 9
4. Limitations ..... 10
5. Recommendations ..... 10
APPENDICES ..... 11
APPENDIX A: List of Tenants Located in Thilafushi ..... 11
APPENDIX B: Maps of Thilafushi and Gulhifalhu with the surveyed individuals and companies located ..... 22
APPENDIX C: Questionnaires for Individual and Company Surveys ..... 23
APPENDIX D: Graphical representation of data obtained from individual survey ..... 24
APPENDIX E: Graphical representation of data obtained from company survey ..... 44

# 1. Introduction

Asian Development Bank (ADB) requested and received assistance through the Ministry of Environment and Energy (MEE) for the services of Live and Learn Environment Education to carry out the baseline socio-economic survey of the residents of Thilafushi and Gulhifalhu which was a requirement of the Greater Male' Environmental Improvement and Waste Management Project.

The overall objective of this consultancy was to ascertain baseline socio economic profile of the residents in Thilafushi and Gulhifalhu islands. The survey also aimed to determine the current waste disposal practices, the needs and willingness of the companies operating in the islands to pay for waste management services. The results of the survey will be used for evidence-based planning and designing needs based socially inclusive strategies to maximize project benefits.

This document reports a summary of the purpose, methodology, sampling frame and strategy, data collection and analysis process, key findings of the study, limitations of the study and general recommendations.

# 2. Methodology

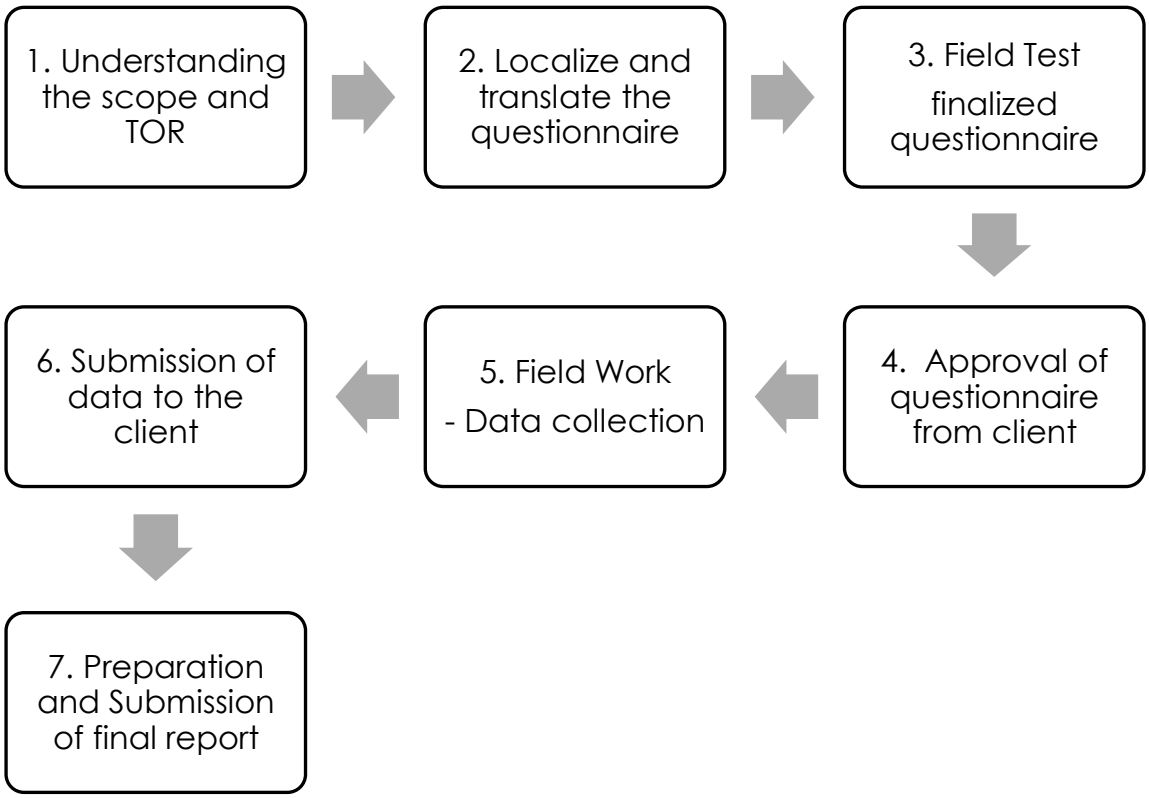
## 2.1 Objectives

The aim of this study was to ascertain baselines with regards to poverty and development indicators that included a set of socio- economic variables such as, education, occupation, economic status, access to basic services- including access to healthcare, accommodation, clean drinking water and food, and waste management. The survey targeted residents living and/or working in all areas in Thilafushi and Gulhifalhu islands.

## 2.2 Approach

The following schematic diagram summarizes the key steps of the approach that was followed to carry out the assignment.

**Figure 1: Schematic diagram showing the work methodology**




## 2.3 The Sampling Frame and Sampling Strategy

The survey was carried out in Thilafushi and Gulhifalhu islands. The survey was based on a core sets of information, an updated list of tenants obtained from Greater Male' Industrial Zone Limited (GMIZL) and estimated number of workers on site. The survey sample represented a cross-section of the individuals working and/or residing in Thilafushi and Gulhifalhu Islands and the companies based in these two islands.

During the inception phase, Live and Learn identified the survey locations, sampling methodology and sample size. The sample size was based on instructions provided by the client. Specific instructions were provided to survey about 200 individuals living/ and or working in areas or sites that are close in proximity to the waste management site in Thilafushi. Survey locations were finalized with guidance from Thilafushi and Gulhifalhu management office, the Greater Male' Industrial Zone Limited (GMIZL). According to the information received, not many companies were in areas close to the waste management site in Thilafushi. GMIZL highlighted that there are discrepancies in utility services available in the different zones of the island, that the "old Thilafushi" identified in the map as "silver plots" did not have water and sanitation services available. They also guided the survey team to identify the size and type of tenants in the different zones of the islands. Care was taken to ensure that the sample represented residents living/ and working in sites near all areas/ zones in the islands. To maximize on the quality, a comprehensive list of tenants was obtained from GMIZL. See *Appendix A* for the list of tenants located in Thilafushi, obtained from GMIZL and *Appendix B* for maps of Thilafushi and Gulhifalhu with the surveyed companies located.

## 2.4 Data Collection

### 2.4.1 Questionnaire

The survey was carried out using two questionnaires based on socio economic variables - one for individuals working and/ or residing in Thilafushi and Gulhifalhu and the other for companies based in Thilafushi and Gulhifalhu Islands. The sample covered 430 individuals (Thilafushi 374; Gulhifalhu 56) and 35 companies (Thilafushi 32; Gulhifalhu 3).

The questionnaires were developed to elicit the most important quantifiable data for this assessment. The questionnaires included various research questions that intended to get information for the research areas, specifically,

a. Provision and accessibility to basic services including;
   - Accommodation
   - Food
   - Healthcare

b. Expenses on basic needs and savings
c. Waste management
d. Factors influencing waste management practices
e. Readiness to use improved waste management services

The questionnaires were modified in line with the societal norms, adapted to the local context and was translated in Dhivehi. The questionnaires were field-tested and refined based on the experience gained by the field test. The modified questionnaires are included in *Appendix C.*

## 2.5 Data Analysis

### 2.5.1 Data entry, analysis, synthesis and interpretation

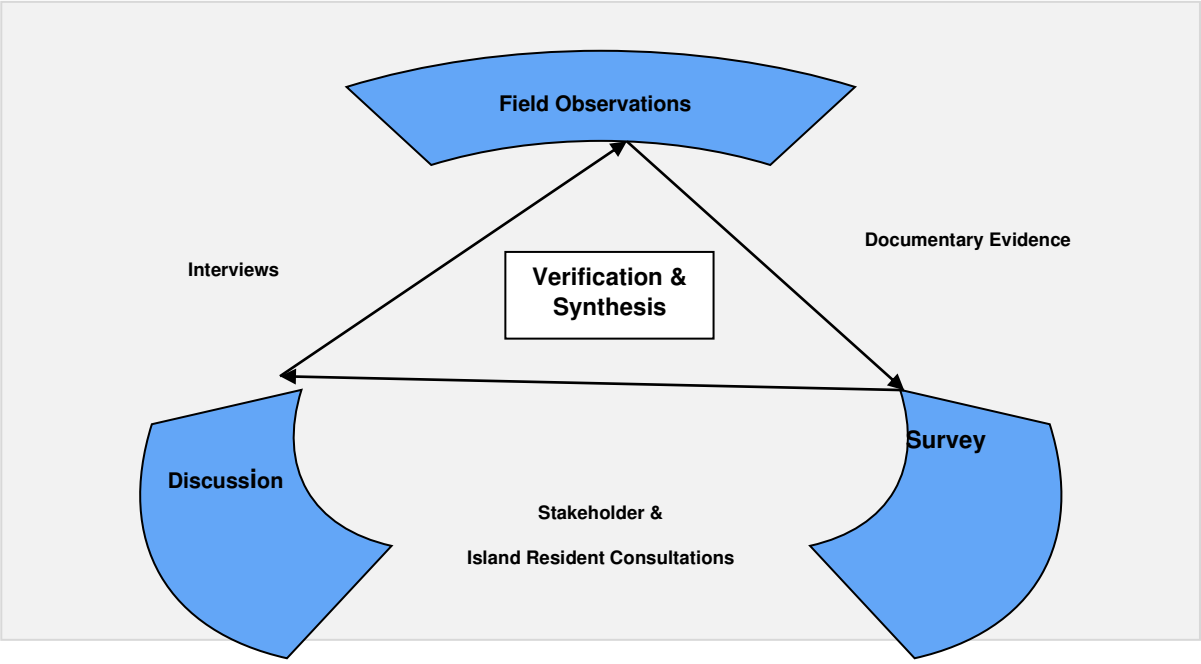
The questionnaires were filled by trained enumerators using tablet computers or smart phones in order to ensure efficiency and accuracy. The data were automatically entered, coded and fed into a central data base.

Data analysis and tabulation were carried out using a set of tables prepared by the Consultant's Team and shared with the client for feedback and comments.

### 2.5.2 Integration of Different Information Gathering Processes

Findings of field research were triangulated and documented to ensure their credibility and validity. Information gathered from the different sources were checked through comparisons and verification discussions. For example, information from surveys was cross checked with information gathered from discussions with client, project documents and observations. Consultant compared data mainly from these three sources prior to making conclusions and reporting. Evidence from secondary sources including stakeholder consultation and interviews were used as supplementary sources of information to support the findings gathered from the above three key sources. Following figure illustrates the triangulation process of data that was gathered from various methods under this study.

**Figure 2: Triangulation of raw data collected from different methods**




# 3. Key Findings

## 3.1 General Information

The survey respondents comprised of 1 female and 429 males. The respondents' ages ranged from 18 to 67 and are mostly Muslims (81%) and from Bangladesh (66%). The length of stay of the respondents in Maldives ranged from less than one year to more than 35 years. 78 percent of the respondents stated that they had a work visa or permit, 18 percent did not have a work visa or work permit and 3 percent did not want to respond to the question. Note that Maldivians (15%) do not need a permit to work in Thilafushi and Gulhifalhu. Hence, out of the 85 percent of foreign respondents, approximately 66 percent had a work visa or permit.

The education level of the respondents' showed that 9 percent did not have any education, 12 percent had basic literacy skills, 25 percent completed primary and 39 percent completed secondary education (secondary school and O'level), 7 percent have completed A'level and 4 percent have completed degree and above.

The education level was reflected in the job titles that the respondents hold as 54 percent of the respondents were unskilled labourers, 35 percent skilled workers, 7 percent at supervisor level, 1 percent at managerial level and 3 percent of the respondents' held jobs that were not categorized in any of the above mentioned categories.

The key points that emerged from the study are;

## 3.2 Income, Expenditure and Savings

- The self-assessed economic status showed that 24 percent respondents perceived themselves to be poor. The proportion of respondent who felt that they were in the lower middle-income level to middle income level constituted approximately 70 percent. Two percent respondents believed that they are rich.

- The highest expenditure for the respondents was estimated to be on communication (phone and internet) and the average monthly spent monthly ranged from MVR 500 to MVR 1500. The monthly expenditure on accommodation and basic needs such as utilities, food and drinks, and health care were borne by the employers and respondents had to spend minimal amount on these (Refer Table 1 below).

**Table 1: Summary of expenditure**

| Expenditure (MVR) | Number of people who spent on: | | | | | | |
|---|---|---|---|---|---|---|---|
| | B2.Food & Drinks | B3. House Rent | B4. House Maintenance | B5. Healthcare | B6. Electricity | B7. Water | B8. Communication |
| 0-499 | 253 | 395 | 404 | 396 | 402 | 403 | 149 |
| 500-999 | 40 | 1 | 7 | 14 | 9 | 13 | 205 |
| 1000-1499 | 47 | 3 | 3 | 10 | 5 | 2 | 45 |
| 1500-1999 | 36 | 3 | 2 | 1 | 3 | 1 | 14 |
| 2000-2499 | 15 | 1 | 3 | 4 | 5 | 6 | 11 |
| 2500-2999 | 1 | 1 | 2 | 0 | 1 | 0 | 0 |
| 3000-3499 | 13 | 2 | 2 | 1 | 0 | 1 | 2 |
| 3500-3999 | 2 | 1 | 1 | 0 | 0 | 2 | 0 |
| 4000-4499 | 5 | 1 | 1 | 0 | 1 | 1 | 2 |
| Above 5000 | 18 | 22 | 5 | 4 | 4 | 1 | 2 |

- The respondents stated that their average savings would be about 60 to 80 percent of the monthly income and 78 percent of the respondents send their savings to their families in respective countries.

**Table 2: Summary of Income**

| | No. of respondents' – Summary of Income (MVR) | | | |
|---|---|---|---|---|
| **Place of Residence** | **Below poverty line (<2000 MVR)** | **2001-4000** | **4001-6000** | **>6000** |
| Male' | 2 | 7 | 3 | 40 |
| Thilafushi | 19 | 46 | 140 | 119 |
| Gulhifalhu | 5 | 14 | 19 | 14 |
| Boat | 0 | 0 | 2 | 1 |
| Other | 1 | 0 | | 2 |
| **Total** | **27** | **67** | **164** | **176** |

- Note: As indicated in the initial communications with the client, it was anticipated that a lot of people would hesitate to provide accurate data for income and expenditure, since the state is preparing to decree income tax. It appears that the data on expenditure and savings have errors and inconsistencies due to this. The main observation is that the lowest incomes estimated from the data received range from MVR200 to MVR500, some of whom are local and foreign nationals serving as technical/skilled employees. No local would work on a full-time job for a salary that is less than MVR5000, specifically in this job category. Additionally, the lowest income for foreign laborers will not be less than USD200, i.e., approximately 3000 per month.

### 3.3 Housing, Infrastructure and Basic Services

- Majority of the respondents lived in Thilafushi (74%) and the rest of the respondents lived in Male' (12%), Gulhifalhu (12%) and in a boat or a dhoni (1%).

- 46 percent of the respondents lived in shared rooms, 37 percent in living quarters, 14 percent in single rooms and 3 percent at the project worksite.

- In the majority of the accommodation that respondents lived, the walls are built with concrete blocks plastered with cement (60%) and the rest corrugated iron (25%), wood (12%) and stone (2%); and the roofs are mostly built with corrugated iron (87%).

- 58 percent of the respondents had a separate kitchen in their living premises and out of that 50% use cooking gas for cooking.

- Main sources of drinking water were house/building service connection (34%), public tap water from treated source (30%), bottled water (28%) and rainwater (4%). Similarly the source of water used for washing and bathing include house/building service connection (53%), public tap water from treated source (41%), and rainwater (2%)

- On average it was reported that respondents shared a toilet among 5 to 10 people and 96 percent of the toilets they used were flush latrine connected to piped sewer system. 15 respondents stated that they use alternated toilets and out of which 3 respondents used public toilets.

- For the question on whether respondents were aware of their rights, 39 percent said "Yes" and 61 percent said "No". In terms of respondents perception on what their basic rights were, majority said right to accommodation (33%) and the rest said right to food (30%), salary (29%), healthcare (29%), leave (26%), safe water and sanitation (26%) and number of working hours (23%).

## 3.4 Health Condition and Healthcare Services

- 68 percent of the respondents surveyed had a health insurance and 46 percent had a health issue past six months. The common issues reported were fever (65%) and cold (9%). Other issues reported include asthma, breathing problems, throat pain and other body aches and pains.

- 94 percent of those who reported sick saw a doctor and 96 percent went to a health facility in Male'. This could be because a health facility was opened in Thilafushi only recently (July 2019) and with limited facilities and services.

**Table 3: Disease Incidence Summary**

| | No. of respondents' | | | |
|---|---|---|---|---|
| **Place of Residence** | **Asthma/Lung related/Allergies/Cold, cough, fever** | **Water-borne diseases** | **Vector-borne diseases** | **Skin diseases** |
| Male' | 16 | 0 | 2 | 0 |
| Thilafushi | 125 | 0 | 6 | 5 |
| Gulhifalhu | 5 | 0 | 0 | 0 |
| Boat | 0 | 0 | 0 | 0 |
| Other (Villimale and Hulhumale) | 0 | 0 | 0 | 0 |
| **Total** | **146** | **0** | **8** | **5** |

Note: Records of water and air borne diseases are not available.

## 3.5 Solid Waste Management

- Majority of the respondents (66%) and companies (76%) highlighted that they are aware of the health issues related to garbage while 32 percent of the respondents' 24 percent of the companies said that they are not aware of such issues.

- 46 percent of the respondents believed that garbage is a huge problem in their locality, 19 percent of the respondents believed that it is a problem while 8 percent of the respondents reported that they rarely have issues and 25 percent respondents said not an issue at all. Similarly, 46 percent of the companies believed that garbage is a huge problem in their locality, 43 percent believed that it is a problem while 3 percent reported that they rarely have issues and 6 percent said not an issue at all.

- 67 of the respondents and 83 percent of the companies reported that the present practice of waste disposal in Thilafushi, including burning caused health issues and majority of the respondents said main problem was health problems due to air pollution and smoke (59%). Other problems stated include problems due to flies (4%) and problems due to contamination of lagoon (1%).

Solid waste management survey was mostly focused on to the companies based in Thilafushi and Gulheefalhu Islands and hence the key findings stated below in this section are based on the company responses.

- 69 percent reported that they segregate waste while 29 percent said that they do not. The companies who segregate waste reported that they segregate waste into plastics (31%), organics (32%), paper (14%) and metal (51%).

- 6 percent of the companies have received training on waste management while the majority 94 percent reported that they have not received any training in this area.

However, 71 percent companies stated that training on solid waste management will be beneficial.

- 37 percent companies said that they sell recyclable materials, while the majority 63 percent said that they do not sell recyclable waste materials.

- 29 percent of companies had door to door waste collection service and 71 percent opted for private arrangement. The frequency of waste collection or disposal services include: daily (9%), weekly (12%), monthly (3%) and irregular (6%).

- 9 percent of the companies reported that they use WAMCO's services for waste disposal. 91 percent said that they made private arrangements. This was evident from the responses as 71 percent of the companies stated that they were poorly satisfied with the present waste collection mechanism.

- 62 percent of the companies said they pay for waste collection and 38 percent said that they did not pay. The amount, companies who were paying for waste disposal, range from MVR 500 – MVR 40,000.

- From the companies currently not using the services of WAMCO for waste disposal, 85 percent stated that they will shift to WAMCO if services were improved and 9 percent said they did not want. In addition, 91 percent companies are willing to pay a reasonable amount to WAMCO if waste disposal practices were improved.

- Most companies (65%) were not aware about Government's program on Solid Waste Management (SWM) improvement through Ministry of environment and WAMCO.

## 3.6 Other Issues

Other socioeconomic issues, problems and concerns raised by the individual respondents and companies during the survey included:

- No electricity and water services available in some parts of Thilafushi
- No regulations on road safety and parking.
- No regular ferry services were available, hence, the residents had to hire speedboats if there was an emergency medical issue.
- Smoke inhalation is the main problem. Some days smoke becomes so thick that you will not be able to see the person standing next to you.
- No banks and other facilities available on the Islands and therefore, have to go to Male' to send money home.
- Currently, government charging a very high amount for waste disposal.
- Waste management is a hazard. Hope the government solves this problem soon

See *Appendix D* and *Appendix E* for graphical representation of data obtained from individual survey and company survey respectively.

# 4. Limitations

- Time constraints – Since the timeframe for data collection was about 4 days, data collection process was rushed and enumerators may have missed some information given by the respondents. In addition, had to seek permission from the companies to conduct the survey and since most of the companies' heads were based in Male, it was difficult to contact them within the time frame and hence, was not able to get some data such as number of employees from all the companies surveyed.
- Communication – The translators were briefed about the survey. However, even translators were not able to comprehend some questions such as "Are you aware of your rights?" and explain to respondents. One reason for this could be that translators competency in formal Dhivehi language may be limited.
- Reluctant or refused to give information on certain questions such as salary and company assets.

# 5. Recommendations

- Conduct regular assessments of the risk factors involved for residents of Thilafushi and Gulheefalhu and establish mechanisms to reduce risk factors including health hazards.
- Enhance health facility at Thilafushi with improved services to deal with emergency at all times.
- Have schedule ferries at night.
- Develop and improve the current waste management system used
  - Regular collection of waste
  - Create awareness and provide training on proper waste management and individual responsibility
  - Establish a system to collect payment based on the amount of garbage
  - Enact laws and regulations. Penalize those do not abide by the regulations
  - Train WAMCO staff on customer care and establish a grievance procedure and an efficient complaints system
  - Manage waste and abolish burning of waste to minimize health hazards.

# APPENDICES

## APPENDIX A: List of Tenants Located in Thilafushi

**TENANT REGISTRY SHEET| GREATER MALE' INDUSTRIAL ZONE LIMITED**

| # | TENANT NAME | ZONE | LOCATION | TYPE OF WORK |
|---|---|---|---|---|
| 1 | Aasandha Company Limited | Silver | Thilafushi 01 | File Storage |
| 2 | Waste Management Corporation Limited | - | - | Waste management |
| 3 | Villa Hakatha Pvt Ltd | Platinum Plot | Thilafushi 02 | LPG storage and refilling plant, bulk cement station, cement packing plant, cement storage, diesel petrol kerosene storage tank, LPG and oxygen, sale of cement and oil, warehousing and All works allowed in Thilafushi |
| 4 | Heavy Load Maldives Pvt Ltd | | | Loading and unloading harbor, warehousing and labor accomodation |
| 5 | MTCC | Platinum Plot | Thilafushi 02 | Warehousing and slipway |
| 6 | MTCC | Gold Plot | Thilafushi 02 | Boat building and boat repair |
| 7 | Silver Sands Pvt Ltd | Gold Plot | Thilafushi 01 | Boat repair and slipway |
| 8 | Yacht Tours Maldives | - | - | Slipway work |
| 9 | Nalahiya Tradings Pvt Ltd | Platinum Plot | Thilafushi 02 | Warehouse of construction materials<br>Shop (by letter no: TCL-PRJ/PRIV/2018/005) |
| 10 | State Trading Organization Plc Ltd | Gold Plot | Thilafushi 02 | Warehousing |
| 11 | Fuel Express Maldves Pvt Ltd | Platinum Plot | Thilafushi 01 | Vessel building and servicing fiber glass work |
| 12 | Fuel Express Maldves Pvt Ltd | Platinum Plot | Thilafushi 01 | Vessel building and servicing fiber glass work |
| 13 | Maldives Ports Limited | Platinum Plot | Thilafushi 01 | Boat building and boat repair |
| 14 | Maldive Gas Pvt Ltd | Platinum Plot | Thilafushi 01 | LPG refilling |
| 15 | Villa Shipping & Trading Co. Pvt Ltd | Gold Plot | Thilafushi 02 | Cooking gas, cement, oxygen tank, diesel, petrol, kerosene storage and sale ,warehousing<br>, boat building and repair ,slipway, engine repair and maintenance workshop for land and sea vessel and labor accommodation |
| 16 | Apollo Holdings Pvt Ltd | Platinum Plot | Thilafushi 02 | All Works allowed in Thilafushi |
| 17 | Sun Transport Pvt Ltd | TIZ | TIZ | Boat Yard |
| 18 | Maldive Gas Pvt Ltd | Platinum Plot | Thilafushi 01 | LPG |
| 19 | Gulf Craft Service Centre Maldives Pvt Ltd | Gold Plot | Thilafushi 02 | Speed boat building and repair |

| | | | | |
|---|---|---|---|---|
| 20 | Gulf Craft Service Centre Maldives Pvt Ltd | Gold Plot | Thilafushi 02 | Vessel work |
| 21 | Nalahiya Tradings Pvt Ltd | Gold Plot | Thilafushi 02 | Warehouse of construction materials |
| 22 | Universal Enterprises Pvt Ltd | Platinum Plot | Thilafushi 01 | Boat repair |
| 23 | Ahmed Luthfee | Platinum Plot | Thilafushi 01 | Fiber glass speed boat & fishing boat building and boat repair |
| 24 | R.K.L Group Pvt Ltd | Platinum Plot | Thilafushi 01 | Warehousing and related works, Cement brick and related works, heavy vehicle parking and repairing related works, land and sea vessel building and repairing and related works |
| 25 | Coastline Investments Pvt Ltd | Platinum Plot | Thilafushi 01 | Warehousing |
| 26 | Al Shaali Marine Maldives Pvt Ltd | Platinum Plot | Thilafushi 01 | Vessel repair |
| 27 | Coastline Investments Pvt Ltd | Platinum Plot | Thilafushi 01 | Vessel repair, all works allowed in Thilafushi, diesel storage tank and warehousing |
| 28 | VA Pvt Ltd | Platinum Plot | Thilafushi 02 | Warehousing |
| 29 | Nalahiya Construction Material | platinum Plot | Thilafushi 02 | Warehousing |
| 30 | Agas Maldives Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing & land and sea vessel building |
| 31 | Uniforce Investment Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing and land and sea vessel building |
| 32 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Vessel repair |
| 33 | Fuel Supplies Maldives Pvt Ltd | Platinum Plot | Thilafushi 01 | Vessel building and repair, workshop, labor accommodation and warehousing |
| 34 | State Trading Organization Plc Ltd | - | - | N/A |
| 35 | Maldives Structural Products Pvt Ltd | Gold Plot | Thilafushi 02 | Production of metal sheet |
| 36 | Static Company Pvt Ltd | Gold Plot | Thilafushi 01 | RO plant workshop (diselination plant manafuacturing), workshop (welding, lathing, engineering and repair works, pannel making), fiber works, warehousing and labor accommodation |
| 37 | Villa Hakatha Pvt Ltd | Gold Plot | Thilafushi 02 | All works allowed in Thilafushi |
| 38 | Waste Management Corporation Limited | - | - | warehousing, accommodation block, parking, garage, recycle facility and office building |
| 39 | Tommy Engineering Pvt Ltd | | | Boat Yard |
| 40 | Ministry of Defence and National Security | - | - | MNDF works |

| | | | | |
|---|---|---|---|---|
| 41 | State Electric Company Ltd | Silver Plot | Thilafushi 02 | Electricity sevices to Thilafushi |
| 42 | Apollo Holdings Pvt Ltd | Gold Plot | Thilafushi 02 | All Works allowed in Thilafushi |
| 43 | Apollo Holdings Pvt Ltd | Gold Plot | Thilafushi 02 | All Works allowed in Thilafushi |
| 44 | Timber House Pvt Ltd | Silver Plot | TIZ | Wood storage and other works |
| 45 | The Hawks Pvt Ltd | Platinum Plot | Thilafushi 01 | Retail shop, oil supply, brick work, café and boat building |
| 46 | Secure Bag (Maldives) Pvt Ltd | Gold Plot | Thilafushi 01 | - |
| 47 | Muni Enterprises Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 48 | A.H. Brothers Pvt Ltd | Silver | Thilafushi 01 | Warehousing |
| 49 | Alia Investments Pvt Ltd | TIZ | TIZ | Auto Mobile/ Motor Vehicle |
| 50 | Amin Construction Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and Carpentry work |
| 51 | Apollo Holdings Pvt Ltd | Gold Plot | Thilafushi 02 | All Works allowed in Thilafushi |
| 52 | Ego Maldives Pvt Ltd | TIZ | TIZ | Warehousing and Carpentry work |
| 53 | Marine Export & Trading Company Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and vehicle repair |
| 54 | Rainbow Aluminum Pvt Ltd | Gold Plot | Thilafushi 02 | Construction work and aluminum works |
| 55 | Rainbow Enterprises | Gold Plot | Thilafushi 02 | Warehousing, Furniture production and related works |
| 56 | Vimla Construction and Trade Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing, carpentry and labor accommodation |
| 57 | Alia Investments Pvt Ltd | TIZ | TIZ | Industrial Equipments/ Marine Power Generation |
| 58 | Moosa Kaleem | Silver Plot | - | Warehousing of construction materials, hardware materials GI pipe and structural beam |
| 59 | Heavy Dockyard Maldives Pvt Ltd | Platinum Plot | Thilafushi 01 | All Works allowed in Thilafushi |
| 60 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 61 | Universal Enterprises Pvt Ltd | Platinum Plot | Thilafushi 01 | Warehousing |
| 62 | Mild Steel Maldives Pvt Ltd | Gold Plot | Thilafushi 01 | Boat yard |
| 63 | Sonee Hardware Pvt Ltd | TIZ | TIZ | General harware and Warehousing |
| 64 | Sonee Hardware Pvt Ltd | TIZ | TIZ | General harware and Warehousing |
| 65 | Sonee Hardware Pvt Ltd | TIZ | TIZ | General harware and Warehousing |
| 66 | Mafhaa Private Limited | Gold Plot | Thilafushi 01 | Boat building and boat repair |
| 67 | Coastline Investments Pvt Ltd | Platinum Plot | Thilafushi 01 | Warehousing |
| 68 | Heavy Dockyard Maldives Pvt Ltd | Platinum Plot | Thilafushi 01 | All Works allowed in Thilafushi |
| 69 | Aima Construction Pvt Ltd | TIZ | TIZ | brick works |

| | | | | |
|---|---|---|---|---|
| 70 | Umet Construction Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and construction work |
| 71 | Mohamed Manik | Gold Plot | Thilafushi 01 | Warehousing |
| 72 | Sunfront Pvt Ltd | - | - | Warehousing |
| 73 | MWSC | TIZ | TIZ | Water production and distribution system |
| 74 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 75 | Apollo Holdings Pvt Ltd | Platinum Plot | Thilafushi 02 | All Works allowed in Thilafushi |
| 76 | Maldive Gas Pvt Ltd | Platinum Plot | Thilafushi 01 | Buffer zone |
| 77 | Sunfront Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing |
| 78 | Far Horizon Pvt Ltd | Silver Plot | Thilafushi 01 | Fish processing plant, ice plant, aquaponics, fiber tub construction, boat construction and boat repair |
| 79 | Maziya Service Pvt Ltd | TIZ | TIZ | fabrication and wood work |
| 80 | Maldives Ports Limited | - | - | Vehicle storage |
| 81 | Sun Transport Pvt Ltd | TIZ | TIZ | Godown ,carpentary , fiber glass works and workshop |
| 82 | Abdul Latheef | TIZ | TIZ | Alluminium Workshop |
| 83 | Maldives Petroleum Link Pvt Ltd | Platinum Plot | Thilafushi 01 | Warehousing and oil works |
| 84 | Vermillion International Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing, boat building, machanicale engineering and brick production |
| 85 | Simdi Company Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing |
| 86 | Nazaki Aluminium Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and aluminum workshop |
| 87 | Heavy Load Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | All works allowed in Thilafushi |
| 88 | Marine Export & Trading Company Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 89 | Leo Trading Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing, parking , vehicle repair and temporary labor accommodation |
| 90 | Beach Marine Pvt ltd | TIZ | TIZ | Workshop |
| 91 | Aaru Pvt Ltd | Silver | Thilafushi 01 | Warehousing |
| 92 | Abbas Abdulla | Gold | Thilafushi 02 | Warehousing of Construction Materials |
| 93 | Agas Maldives Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing |
| 94 | Ahmed Mujah | Silver Plot | Thilafushi 01 | Warehousing, Work shop and live fish |
| 95 | Aima Construction Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing & Carpentry |
| 96 | Ali Abdulla | Gold Plot | Thilafuhsi 2 | Warehousing/Construction Materials |
| 97 | Ali Muththalib | TIZ | TIZ | Warehousing, fiber works & workshop |
| 98 | Al Shaali Marine Maldives Pvt Ltd | Platinum Plot | Thilafushi 01 | Vessel repair |
| 99 | Apollo Holdings Pvt Ltd | Platinum Plot | Thilafushi 02 | All Works allowed in Thilafushi |
| 100 | Aries Enterprises Pvt Ltd | TIZ | TIZ | Warehousing |

| | | | | |
|---|---|---|---|---|
| 101 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 102 | FW Construction Company Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and workshop |
| 103 | Fuel Supplies Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Oil works |
| 104 | Maldives Petroleum Link Pvt Ltd | Platinum Plot | Thilafushi 01 | Workshop and oil works |
| 105 | Heavy Force Pvt Ltd | Gold Plot | Thilafushi 01 | Vehicle repair |
| 106 | Ibrahim Abdul Latheef | - | - | Workshop |
| 107 | Ismail Shafeeu | Silver Plot | Thilafushi 01 | Warehousing |
| 108 | M.T Hojgaard Pvt Ltd | TIZ | TIZ | Concrete work, carpentry, welding and boat repair |
| 109 | Nakachafushi Island Resort | Silver Plot | Thilafushi 01 | Warehousing |
| 110 | Nalahiya Tradings Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 111 | Olhahali Investment Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing |
| 112 | Reollo Enterprise Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 113 | Sunfront Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing |
| 114 | Sunfront Pvt Ltd | Gold Plot | Thilafushi 01 | Warehousing |
| 115 | Sunland Trading Company Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 116 | Tep Construction Pvt Ltd | TIZ | TIZ | Warehousing of Construction Materials |
| 117 | Vista Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and construction work |
| 118 | Amin Construction Pvt Ltd | TIZ | TIZ | Warehousing |
| 119 | Ahmed Luthfee | Silver Plot | Thilafushi 01 | Fiber glass speed boat & fishing boat building and boat repair |
| 120 | Moosa Kaleem | Silver Plot | Thilafushi 01 | Warehousing |
| 121 | Adam Ibrahim | Silver | Thilafushi 01 | Warehousing |
| 122 | Alia Construction Pvt Ltd | TIZ | TIZ | Warehousing, workshop, carpentry, labor quarter,vessel building, garage and parking zone |
| 123 | Umar Zahir | Silver Plot | Thilafushi 01 | Warehousing |
| 124 | Sandcays Pvt Ltd | TIZ | TIZ | Warehousing and labor accommodation |
| 125 | Mohamed Ahmed Abdulla | Silver Plot | Thilafushi 01 | Warehousing |
| 126 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Vessel repair and vessel building |
| 127 | Hussain Mohamed Fulhu | Silver Plot | Thilafushi 01 | All works allowed in Thilafushi |
| 128 | Marine Coral Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 129 | Mohamed Moosa | Silver Plot | Thilafushi 01 | Warehousing |
| 130 | Ibrahim Rasheed Ali | Silver Plot | Thilafushi 01 | Wood warehousing and wood works |
| 131 | Waste Management Corporation Limited | - | - | warehousing, accommodation block, parking, garage, recycle facility and office building |

| | | | | |
|---|---|---|---|---|
| 132 | Mass Enterprises Pvt Ltd | Silver Plot | Thilafushi 01 | Wood warehousing and wood works |
| 133 | Aima Construction Pvt Ltd | TIZ | TIZ | Vehicle and Barge repair |
| 134 | Ali Naashid | Silver Plot | Thilafushi 01 | Wood warehousing & wood works |
| 135 | Alia Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Wood warehousing and wood works |
| 136 | FW Construction Company Pvt Ltd | Silver Plot | Thilafushi 01 | Wood warehousing and wood works |
| 137 | Far Horizon Pvt Ltd | Silver Plot | Thilafushi 01 | Wood warehousing and wood works |
| 138 | Ibrahim Hassan | Silver Plot | Thilafushi 01 | Wood warehousing and wood works |
| 139 | Onus Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 140 | Sunfront Pvt Ltd | - | - | Warehousing and Carpentry work |
| 141 | Timber House Pvt Ltd | Silver Plot | Thilafushi 01 | Wood storage and other works |
| 142 | Timber Trade Pvt Ltd | Silver Plot | Thilafushi 01 | Wood storage and other works |
| 143 | Ali Shareef | Silver Plot | Thilafushi 01 | Warehousing |
| 144 | Ahmed Sinah | Platinum Plot | Thilafushi 01 | Dockyard |
| 145 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | All works allowed in Thilafushi |
| 146 | Maldives Petroleum Link Pvt Ltd | Platinum Plot | Thilafushi 01 | Warehousing |
| 147 | Heavy Load Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | All works allowed in Thilafushi, except works stated in clause 12 of the agreement. |
| 148 | Aaru Pvt Ltd | Silver | Thilafushi 01 | Warehousing |
| 149 | Hello Maldives Pvt Ltd | Gold Plot | Thilafushi 01 | Fish processing plant, ice plant, aquaponics, fiber tub construction, boat construction and boat repair |
| 150 | Silver Sands Pvt Ltd | Gold Plot | Thilafushi 01 | All works allowed in Thilafushi |
| 151 | Bio Diversity Education and Awareness Maldives (BEAM) | - | - | Collecting, segregating and bailing ocean plastic |
| 152 | Marine Coral Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and brick works |
| 153 | Damas Company Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and workshop |
| 154 | Leo Trading Pvt Ltd | Gold Plot | - | Warehousing and workshop (Heavy vehicle maintenance and services) |
| 155 | Mild Steel Maldives Pvt Ltd | - | - | Warehousing |
| 156 | Maldives Structural Products Pvt Ltd | Gold Plot | Thilafushi 02 | Warehousing |
| 157 | Island Engineering Services and Supplies Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 158 | Static Company Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 159 | Damas Company Pvt Ltd | Silver Plot | Thilafushi 01 | Vehicle repair and vehicle storage |

| | | | | |
|---|---|---|---|---|
| 160 | The Hawks Pvt Ltd | Silver Plot | Thilafushi 01 | Bric work, fiber work and carpentry |
| 161 | Hussain Khalid | Silver Plot | Thilafushi 01 | Warehousing, hotel, shop and labor accommodation |
| 162 | Ismail Adil | Silver Plot | Thilafushi 01 | Warehousing |
| 163 | Hassan Haleem | Silver Plot | Thilafushi 01 | Brick work |
| 164 | Mohamed Sameer | Silver Plot | Thilafushi 01 | Brick work |
| 165 | Tep Construction Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing of Construction Materials |
| 166 | Monaza Contracting Company Pvt Ltd | Silver Plot | Thilafushi 01 | Carpentry, staff accommodation, café, workshop and saloon |
| 167 | Mohamed Majid | Silver Plot | Thilafushi 01 | Warehousing and Tailor work |
| 168 | Saroof Naazim | TIZ | TIZ | Non Flammable works |
| 169 | Aaru Pvt Ltd | Silver | Thilafushi 01 | Labor Accommodation |
| 170 | Agas Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 171 | Ahmed Sameeru | Silver Plot | Thilafushi 01 | Warehousing |
| 172 | Ahmed Sinah | TIZ | TIZ | Warehousing |
| 173 | Ahmed Zareer | TIZ | TIZ | Warehousing |
| 174 | Aima Construction Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 175 | Aima Construction Pvt Ltd | Silver Plot | Thilafushi 01 | All works allowed in Thilafushi |
| 176 | Ali Ibrahim Rashid | TIZ | TIZ | Warehousing |
| 177 | Apollo Holdings Pvt Ltd | Platinum Plot | Thilafushi 02 | All Works allowed in Thilafushi |
| 178 | Asian Power Investment Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 179 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and vehicle repair |
| 180 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 181 | Dhivehi Meysthiri Pvt Ltd | Silver Plot | Thilafushi 01 | All Works allowed in Thilafushi |
| 182 | Dhivehi Meysthiri Pvt Ltd | Silver Plot | Thilafushi 01 | Carpentry |
| 183 | Dynamic Construction and Trading Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and brick works |
| 184 | Farifeyran Pvt Ltd | Silver Plot | Thilafushi 01 | Brick work, warehousing, cement works, carpentry, workshop, metal works, fiber works, sale of wood and hardware construction work |
| 185 | Faunu Enterprises Pvt Ltd | Gold Plot | Thilafushi 01 | Vessel repair Shop (by letter no: TCL-LEGAL/PRIV/2018/025) |
| 186 | Haajaraa Workshop | Silver Plot | Thilafushi 01 | Warehousing and machinery repair |
| 187 | Maldives Petroleum Link Pvt Ltd | TIZ | TIZ | Warehousing, labor accommodation and maintences work |
| 188 | Maldives Petroleum Link Pvt Ltd | TIZ | TIZ | Warehousing, labor accommodation and maintences work |

| | | | | |
|---|---|---|---|---|
| 189 | Ibrahim Majid | TIZ | TIZ | Warehousing and Compact works of steel and plastic |
| 190 | Ilyas | Silver Plot | Thilafushi 01 | Workshop |
| 191 | Ismail Hilmy | Silver Plot | Thilafushi 01 | Warehousing |
| 192 | Ismail Zahir | TIZ | TIZ | Vessel repair |
| 193 | Ives Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 194 | Jausa Holdings Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 195 | LuckyHiya Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and Carpentry work |
| 196 | Maldives Road Development Corporation Limited | Silver Plot | Thilafushi 01 | Brick works site office |
| 197 | Mohamed Moosa | Silver Plot | Thilafushi 01 | Brick work, warehousing, cement works, carpentry, workshop, metal works, fiber works, sale of wood and hardware construction work |
| 198 | Mohamed Naasih | Silver Plot | Thilafushi 01 | Vehicle repair |
| 199 | Mohamed Shareef | TIZ | TIZ | Warehousing and services |
| 200 | Muaz Mohamed | TIZ | TIZ | Warehousing |
| 201 | Muni Enterprises Pvt Ltd | TIZ | TIZ | Carpentry |
| 202 | MWSC | Platinum Plot | Thilafushi 01 | Water plant and other water related works |
| 203 | MWSC | Platinum Plot | Thilafushi 01 | Water supply for Thilafushi |
| 204 | Ocean Brilliant Sea Food International Pvt Ltd | TIZ | TIZ | Fish processing |
| 205 | Prop Pvt Ltd | - | - | N/A |
| 206 | Rasheed Carpentry & Construction Pvt Ltd | Silver Plot | Thilafushi 01 | Carpentry |
| 207 | Rasheed Carpentry & Construction Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and Carpentry work |
| 208 | The Hawks Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing, vehicle repair, brick work, oil storage, retail business, boat building and café |
| 209 | Universal Enterprises Pvt Ltd | Silver Plot | Thilafushi 01 | Labor Acommodation |
| 210 | Vantha Pvt Ltd | TIZ | TIZ | Warehousing, labor accommodation and boat building and repair |
| 211 | Villa Hakatha Pvt Ltd | Platinum Plot | Thilafushi 02 | Warehousing |
| 212 | Villa Hakatha Pvt Ltd | Gold Plot | Thilafushi 02 | All works allowed in Thilafushi |
| 213 | Damas Company Pvt Ltd | Silver Plot | Thilafushi 01 | All Works allowed in Thilafushi |
| 214 | Maziya Service Pvt Ltd | TIZ | TIZ | Warehousing |
| 215 | Hassan Jawhary | Silver Plot | Thilafushi 01 | Warehousing |
| 216 | Damas Company Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 217 | Sirius Enterprises Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 218 | Ahmed Lilal | | | building material storage |
| 219 | Sirius Enterprises Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 220 | Eye Care Pvt Ltd | TIZ | TIZ | Warehousing, workshop and café |

| | | | | |
|---|---|---|---|---|
| 221 | Ahmed Sameeru | Silver Plot | Thilafushi 01 | Warehousing and Vessels/Vehicle repair |
| 222 | Thoha Mohamed | TIZ | TIZ | Warehousing and Carpentry work |
| 223 | Abdul Muhsin Hussain | Gold | - | Warehousing |
| 224 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | N/A |
| 225 | Marine Coral Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 226 | Marine Coral Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 227 | Meridium Services Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and oil works |
| 228 | Tennssor Holdings Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 229 | Wheel Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and workshop |
| 230 | Asian Power Investment Pvt Ltd | TIZ | TIZ | Vessel repair and production of machine |
| 231 | Mario Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Construction work |
| 232 | Haneefa Exzim Investment | Silver Plot | Thilafushi 01 | Warehousing |
| 233 | Ahmed Sameeru | Silver Plot | Thilafushi 01 | Warehousing and Workshop |
| 234 | Asir Nizar | Silver Plot | Thilafushi 01 | Workshop |
| 235 | The Wiz Company Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing |
| 236 | Mohamed Yoosuf | TIZ | TIZ | Warehousing and brick works |
| 237 | Ali Ahmed | TIZ | TIZ | Warehousing, Café, Shop & Workshop |
| 238 | The Hawks Pvt Ltd | Silver Plot | Thilafushi 01 | Retail shop, oil supply, brick work, café and boat building |
| 239 | Ahmed Luthfee | Silver Plot | Thilafushi 01 | Fiber glass speed boat & fishing boat building and boat repair |
| 240 | LoneStar Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing, workshop and labor accommodation |
| 241 | Maldives Petroleum Link Pvt Ltd | TIZ | TIZ | Warehousing, labor accommodation and maintences work |
| 242 | Mohamed Waheed Hassan | TIZ | TIZ | Warehousing, shop, café and workshop |
| 243 | Rayline Services Pvt Ltd | TIZ | TIZ | Warehousing |
| 244 | Mario Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Construction work |
| 245 | The Hawks Pvt Ltd | Silver Plot | Thilafushi 01 | Retail shop, oil supply, brick work, café and boat building |
| 246 | Denicon Construction & Trading Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and construction work |
| 247 | Ahmed Naseer | TIZ | TIZ | Warehousing |
| 248 | Rishtha Company Pvt Ltd | TIZ | TIZ | Warehousing and brick works |
| 249 | Tennssor Holdings Pvt Ltd | TIZ | TIZ | Heavy machinery storage and services |
| 250 | Abdulla Abdul Sattar | Silver | Thilafushi 01 | Workshop |
| 251 | Abdulla Salih | TIZ | TIZ | Warehousing & Workshop |
| 252 | Afeef Mohamed | TIZ | TIZ | Labor Accommodation & Café<br>Fiber Glass Work (Allowed through letter) |

| | | | | |
|---|---|---|---|---|
| 253 | Ahmed Amir | Silver | Thilafushi 01 | All Works allowed in Thilafushi |
| 254 | Ahmed Mujah | TIZ | TIZ | Warehousing |
| 255 | Ali Abdulla | Silver Plot | Thilafushi 01 | Workshop |
| 256 | Ali Ahmed | TIZ | TIZ | Warehousing, Café, Shop & Workshop |
| 257 | Ali Rasheed | Silver Plot | Thilafushi 01 | Warehousing |
| 258 | Alia Investments Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 259 | Alia Investments Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 260 | Alia Investments Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 261 | Bric Construction | TIZ | TIZ | Workshop and warehouse |
| 262 | Coastline Investments Pvt Ltd | Silver Plot | Thilafushi 01 | Warehouse |
| 263 | Denicon Construction & Trading Pvt Ltd | Silver Plot | Thilafushi 01 | Labor Accommodation and shop |
| 264 | Dhiraagu | Silver Plot | Thilafushi 01 | Mobile antenna |
| 265 | Gasim Mahmood | TIZ | TIZ | Workshop |
| 266 | Heavy Force Pvt Ltd | Gold Plot | Thilafushi 01 | Engineering works |
| 267 | Hussain Khalid | TIZ | TIZ | Warehousing & labor accommodation |
| 268 | Hussain Nazeeh | Silver Plot | Thilafushi 01 | Warehousing |
| 269 | Hussain Rasheed | TIZ | TIZ | Warehousing |
| 270 | Hussain Shiyam | TIZ | TIZ | Warehousing |
| 271 | Hussain Waheed | TIZ | TIZ | Workshop |
| 272 | Ibrahim Ali | TIZ | TIZ | Carpentry |
| 273 | Jiaz Maldives Pvt Ltd | Silver Plot | TIZ | Warehousing and labor accommodation |
| 274 | Meridium Services Pvt Ltd | Silver Plot | Thilafushi 01 | Oil works |
| 275 | Misraab Trading Co Pvt Ltd | TIZ | TIZ | Warehousing |
| 276 | Mohamed Abdul Sattar | Silver Plot | TIZ | Warehousing |
| 277 | Mohamed Haleel | Silver Plot | - | Warehousing and workshop |
| 278 | Mohamed Musthag | TIZ | TIZ | Warehousing and workshop |
| 279 | Mohamed Naasih | - | - | Warehousing |
| 280 | Mohamed Rasheed Ahmed | Silver Plot | TIZ | Warehousing, café, workshop and shop |
| 281 | Mohamed Rasheed Hussain | TIZ | TIZ | Warehousing, workshop, brick work and machine production |
| 282 | Mohamed Shakir | Silver Plot | Thilafushi 01 | Vehicle and engine repair |
| 283 | Mohamed Shareef | TIZ | TIZ | Metal sheet storage |
| 284 | Musthafa Fareed | TIZ | TIZ | Warehousing |
| 285 | Naadira Jameel | TIZ | TIZ | Show room and workshop |
| 286 | Nasrullah Abdul Waahid | TIZ | TIZ | Warehousing |
| 287 | Ocean Logistics Pvt Ltd | TIZ | TIZ | Warehousing of Construction Materials |
| 288 | Ooredhoo Maldives Pvt Ltd | Silver Plot | Thilafushi 01 | Antenna |
| 289 | Pool Chemicals and Services Maldives Pvt Ltd | TIZ | TIZ | Radio station |
| 290 | Prestige Group Maldives Pvt Ltd | TIZ | TIZ | Warehousing |

| | | | | |
|---|---|---|---|---|
| 291 | Relax Maldives Pvt Ltd | TIZ | TIZ | Warehousing, brick work and café |
| 292 | Relax Maldives Pvt Ltd | TIZ | TIZ | Warehousing, brick work and café |
| 293 | Relax Maldives Pvt Ltd | TIZ | TIZ | Brick work and workshop |
| 294 | Riffathulla Ali | TIZ | TIZ | Warehousing, café, workshop and shop |
| 295 | Riznee Mohamed | TIZ | TIZ | Warehousing, labor accommodation and hydroponics agriculture |
| 296 | Shen Maldives Raufa Construction Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing and labor accommodation |
| 297 | Standard and Origin Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 298 | Standard and Origin Pvt Ltd | TIZ | TIZ | Warehousing and workshop |
| 299 | Tennssor Holdings Pvt Ltd | TIZ | TIZ | Heavy machinery storage and services |
| 300 | Tennssor Holdings Pvt Ltd | TIZ | TIZ | Heavy machinery storage and services |
| 301 | Try On Maldives Pvt Ltd | TIZ | TIZ | Marine engineering workshop |
| 302 | Umar Zahir | Silver Plot | Thilafushi 01 | Clinic |
| 303 | Urban Investment Pvt Ltd | TIZ | TIZ | Warehousing |
| 304 | Well Land Investment Pvt Ltd | TIZ | TIZ | Warehousing and making of name board |
| 305 | Ahmed Nizar | Silver Plot | Thilafushi 01 | Garage |
| 306 | B Company Pvt Ltd | TIZ | TIZ | Godown |
| 307 | Hussain Musthaq | Silver Plot | Thilafushi 01 | Warehousing |
| 308 | Sunfront Pvt Ltd | Silver Plot | Thilafushi 01 | Warehousing of Construction Materials |
| 309 | Wheel Pvt Ltd | Silver Plot | Thilafushi 01 | Workshop |
| 310 | Equalise Investment Pvt Ltd | TIZ | TIZ | Auto Repair and maintenance services |
| 311 | Aboobakuru Jauhary | TIZ | TIZ | Vehicles Paintings and cleaning works |
| 312 | Moosa Ali | TIZ | TIZ | metal fabrication |
| 313 | Aujaz Hassan | TIZ | TIZ | Workshop and brick work |
| 314 | Department of Public Health | Silver Plot | Thilafushi 01 | Warehousing |
| 315 | Department of Public Health | Silver Plot | Thilafushi 01 | Warehousing |
| 316 | State Electric Company Ltd | Silver Plot | Thilafushi 02 | Electricity sevices to Thilafushi |
| 317 | State Electric Company Ltd | Silver Plot | Thilafushi 02 | Electricity sevices to Thilafushi |
| 318 | State Electric Company Ltd | Silver Plot | Thilafushi 02 | Electricity sevices to Thilafushi |
| 319 | State Electric Company Ltd | Silver Plot | Thilafushi 02 | Electricity sevices to Thilafushi |
| 320 | Greater Male' Industrial Zone Limited | | Thilafushi | Overall administration and management of Thilafushi and Gulhifalhu |

## APPENDIX B: Maps of Thilafushi and Gulhifalhu with the surveyed individuals and companies located

INDIVIDUALS LOCATIONS

COMPANIES LOCATIONS

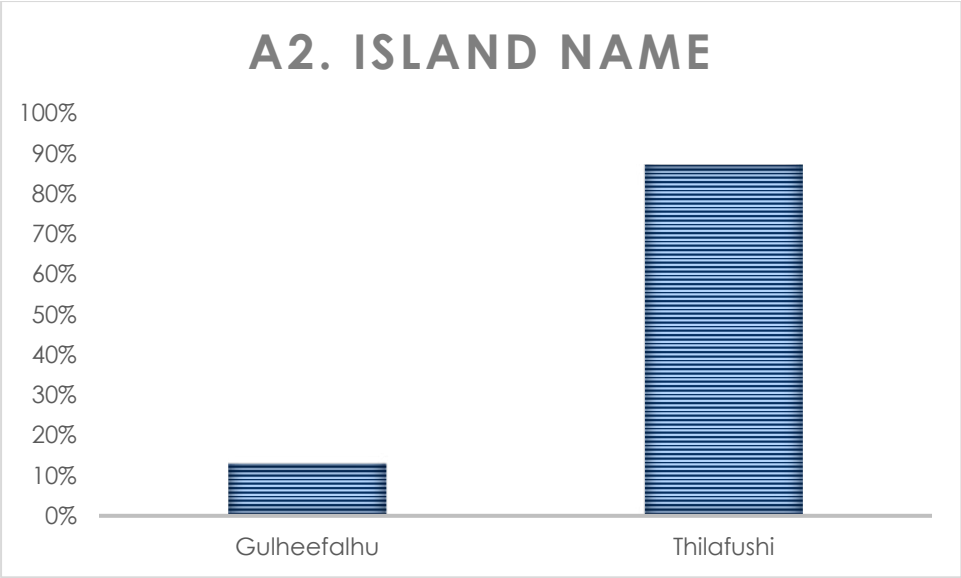
## APPENDIX C: Questionnaires for Individual and Company Surveys

**(Attached as a separate file)**

## APPENDIX D: Graphical representation of data obtained from individual survey

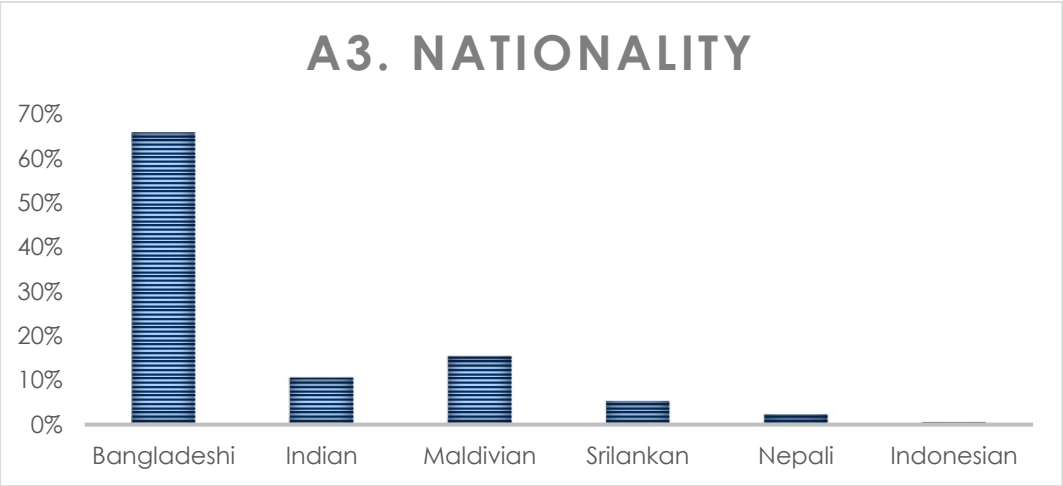
### A. GENERAL INFORMATION: RESPONDENT

**A2. Island Name**



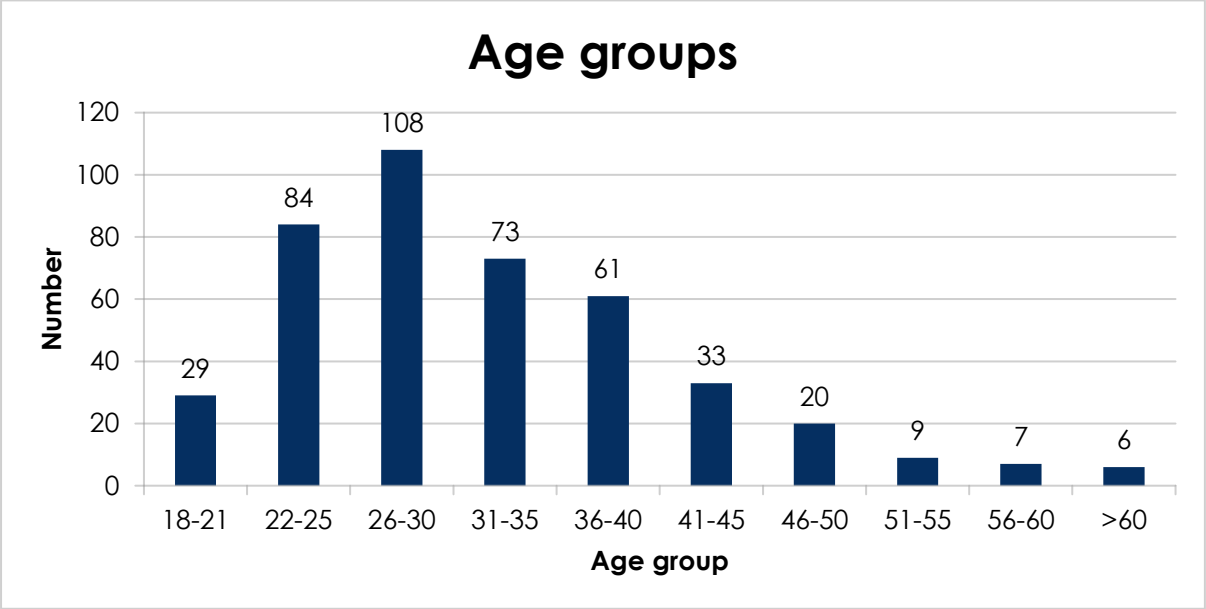

| | | |
|---|---|---|
| Gulheefalhu | 56 | 13% |
| Thilafushi | 378 | 87% |

**A3/A4. Nationality**



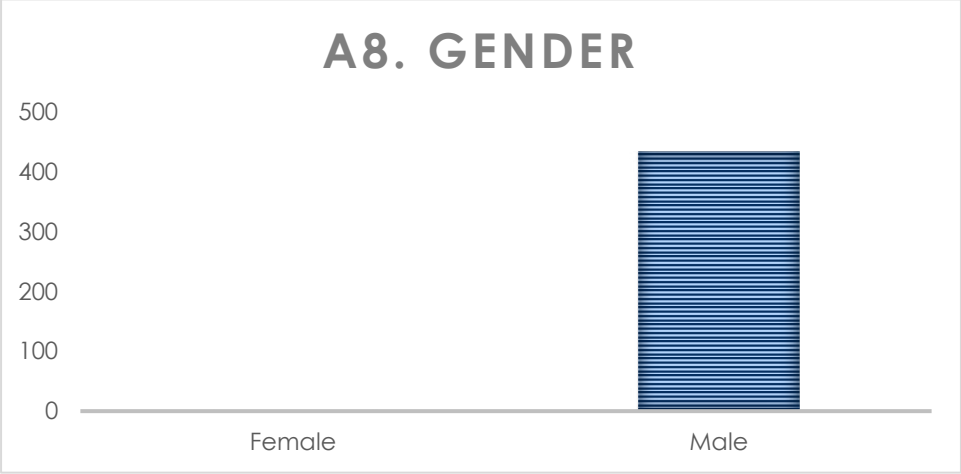

| | | |
|---|---|---|
| Bangladeshi | 286 | 66% |
| Indian | 46 | 11% |
| Maldivian | 67 | 15% |
| Srilankan | 23 | 5% |
| Nepali | 10 | 2% |
| Indonesian | 2 | 0% |

**A7. Age group**




| Age group | Count |
|---|---|
| 18-21 | 29 |
| 22-25 | 84 |
| 26-30 | 108 |
| 31-35 | 73 |
| 36-40 | 61 |
| 41-45 | 33 |
| 46-50 | 20 |
| 51-55 | 9 |
| 56-60 | 7 |
| >60 | 6 |
| | **430** |

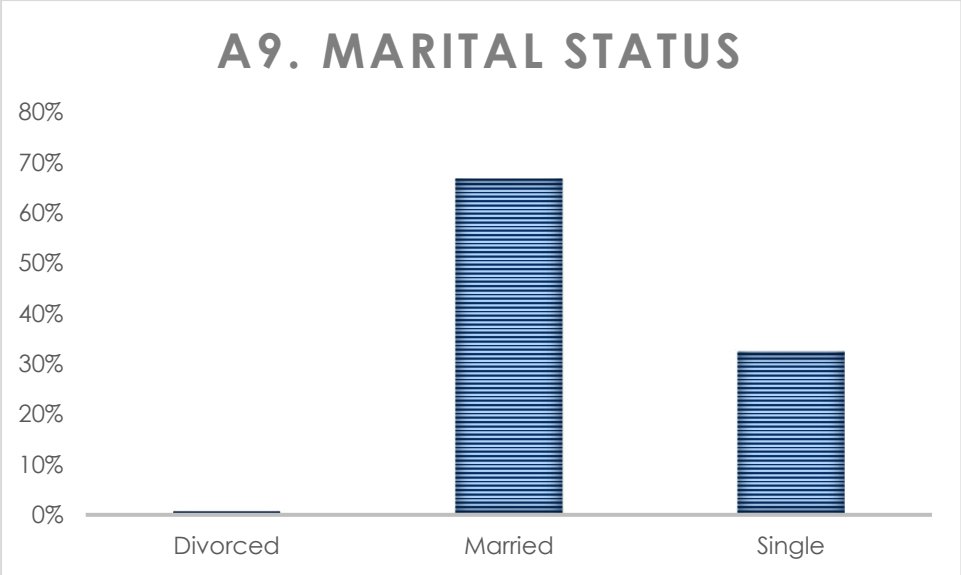
**A8. Gender**




| | |
|---|---|
| Female | 1 |

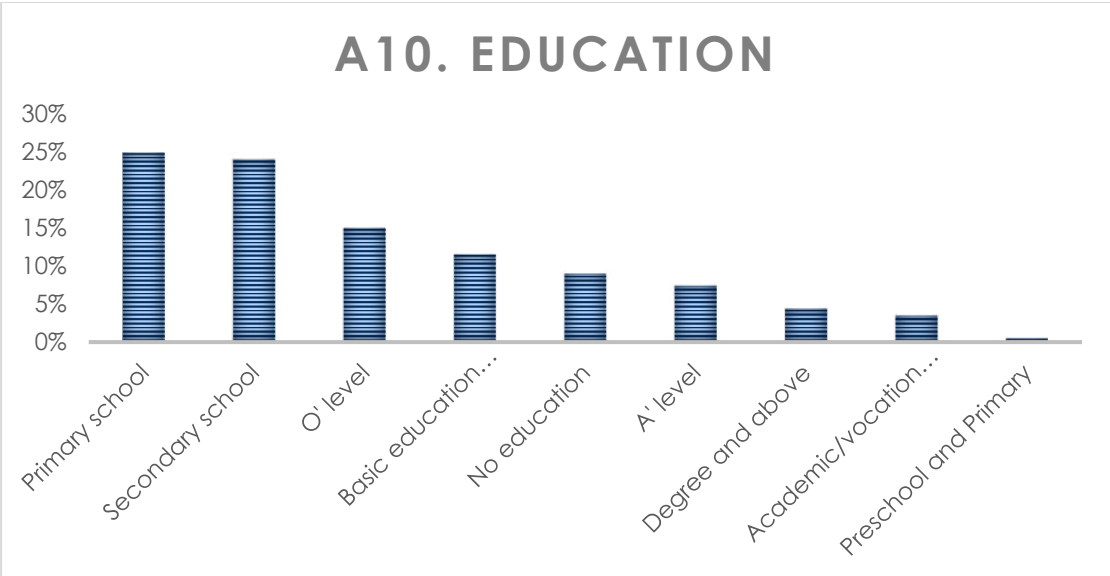
| | |
|---|---|
| Male | 429 |

**A9. Marital Status**




| | | |
|---|---|---|
| Divorced | 3 | 1% |
| Married | 290 | 67% |
| Single | 141 | 32% |

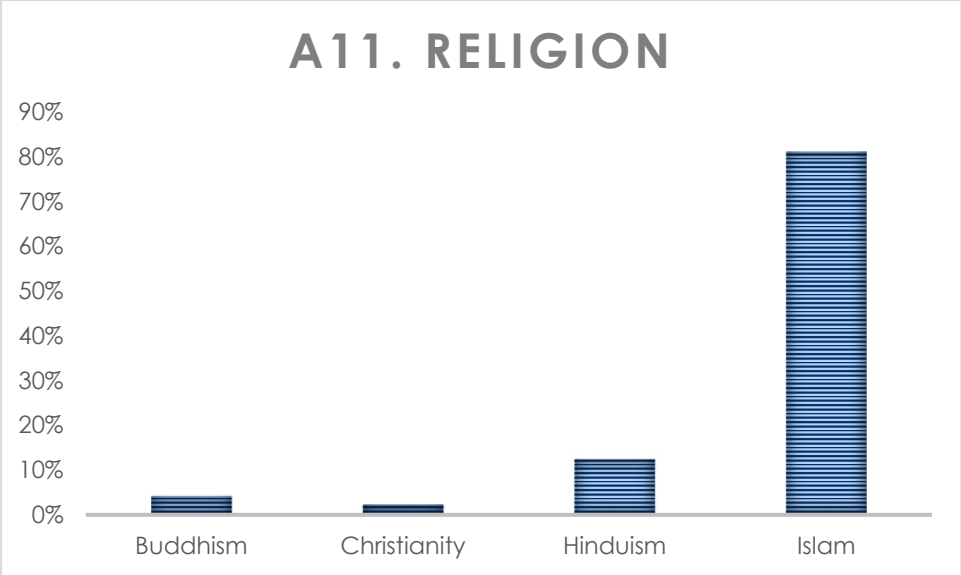
**A10. Education**




| | | |
|---|---|---|
| Primary school | 108 | 25% |
| Secondary school | 104 | 24% |
| O' level | 65 | 15% |
| Basic education (basic literacy) | 50 | 12% |
| No education | 39 | 9% |
| A' level | 32 | 7% |

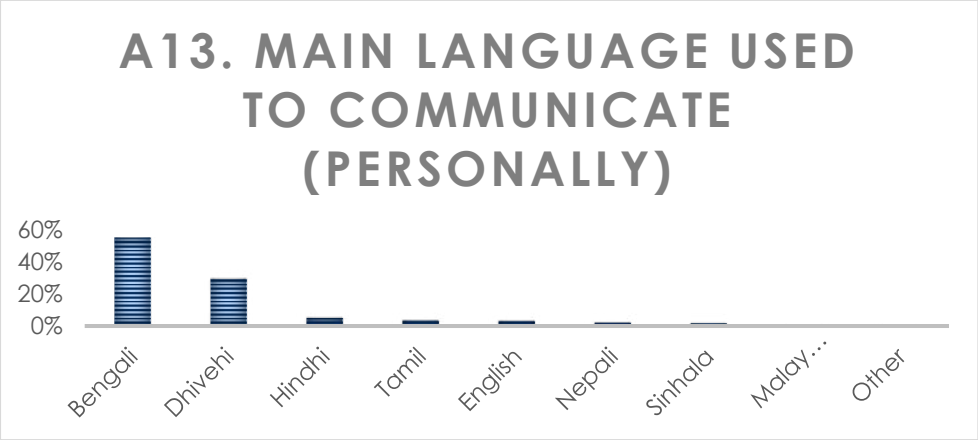
| | | |
|---|---|---|
| Degree and above | 19 | 4% |

**A11/A12. Religion**



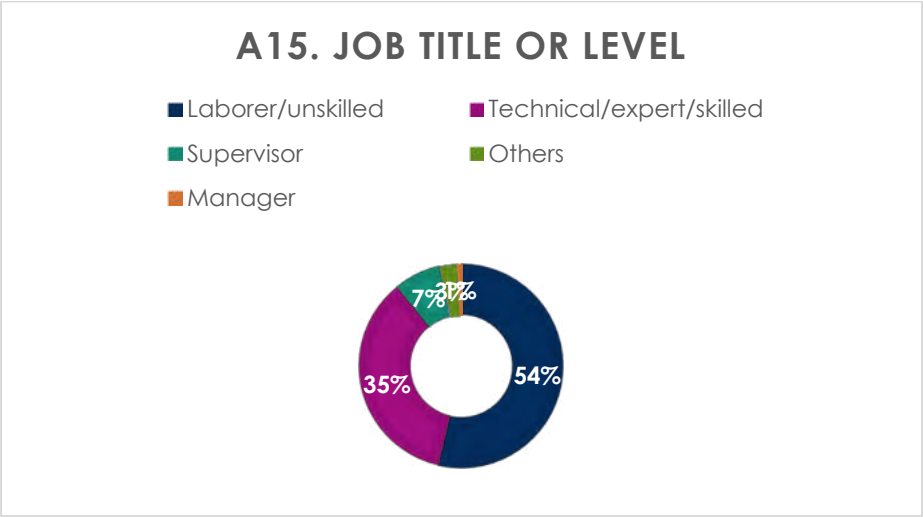

| | | |
|---|---|---|
| Buddhism | 18 | 4% |
| Christianity | 10 | 2% |
| Hinduism | 54 | 12% |
| Islam | 352 | 81% |

**A13/A14. Main Language used to communicate**



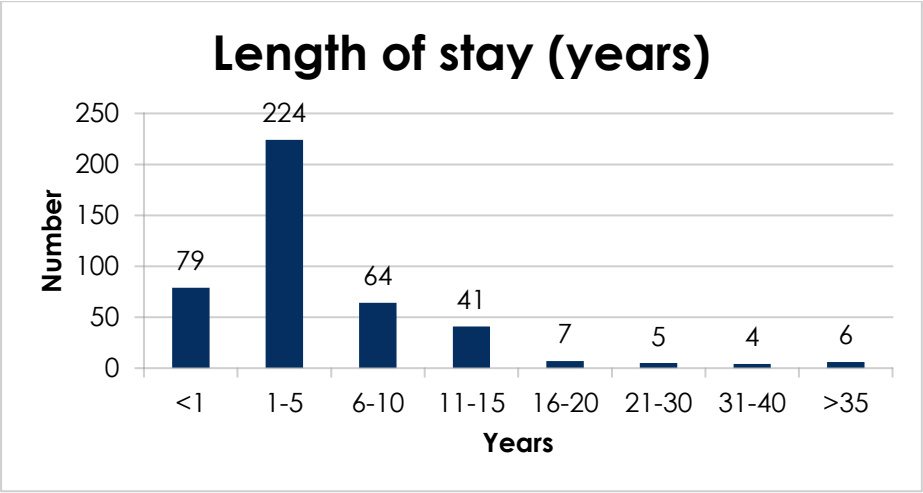

| | | |
|---|---|---|
| Bengali | 239 | 55% |
| Dhivehi | 127 | 29% |
| Hindhi | 22 | 5% |
| Tamil | 15 | 3% |
| English | 13 | 3% |
| Nepali | 9 | 2% |
| Sinhala | 7 | 2% |
| Malayalam | 1 | 0% |

**A15. Job Title/ or Level**




| | | |
|---|---|---|
| Laborer/unskilled | 233 | 54% |
| Technical/expert/skilled | 154 | 35% |
| Supervisor | 32 | 7% |
| Others | 12 | 3% |
| Manager | 3 | 1% |

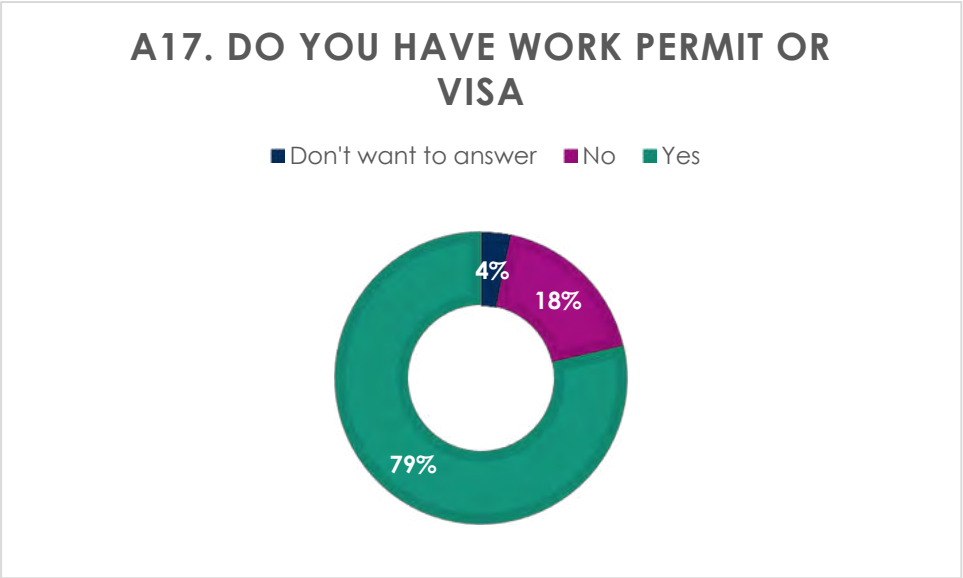
**A16. Length of Stay**




| Length of stay (years) | Count |
|---|---|
| <1 | 79 |
| 1-5 | 224 |
| 6-10 | 64 |
| 11-15 | 41 |
| 16-20 | 7 |
| 21-30 | 5 |
| 31-40 | 4 |

| | |
|---|---|
| >35 | 6 |
| | **430** |

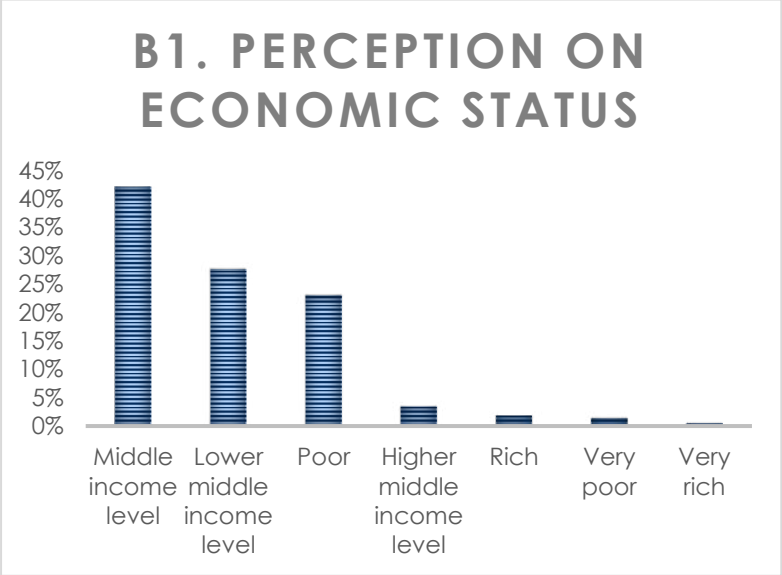
**A17. Do you have a work permit?**




| | | |
|---|---|---|
| Don't want to answer | 15 | 4% |
| No | 78 | 18% |
| Yes | 337 | 78% |

## B. INCOME, EXPENDITURE AND SAVINGS

**B1. Perception on Economic status**

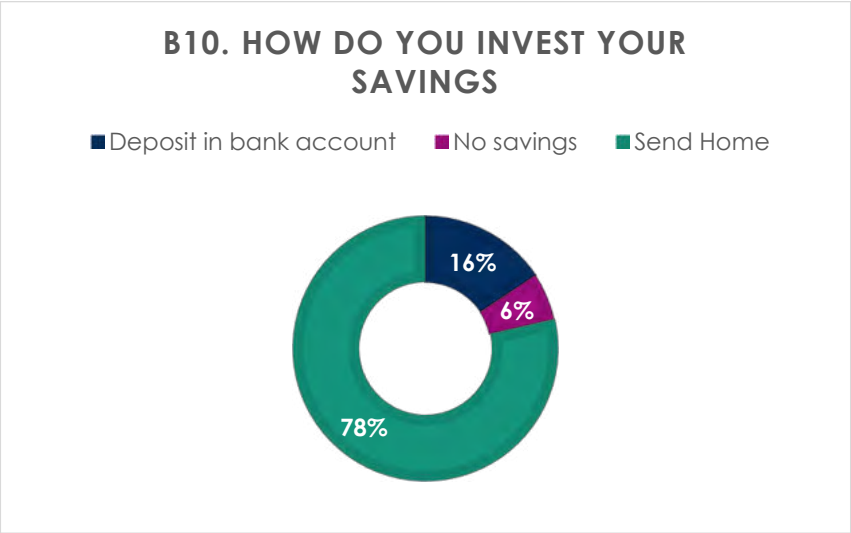



| | | |
|---|---|---|
| Middle income level | 183 | 42% |
| Lower middle income level | 120 | 28% |
| Poor | 100 | 23% |
| Higher middle income level | 15 | 3% |
| Rich | 8 | 2% |
| Very poor | 6 | 1% |
| Very rich | 2 | 0% |

**B2/B3/B4/B4/B6/B7/B8. Estimated monthly expenditure**

| Expenditure (MVR) | Number of people who spent on: | | | | | | |
|---|---|---|---|---|---|---|---|
| | B2.Food & Drinks | B3. House Rent | B4. House Maintenance | B5. Healthcare | B6. Electricity | B7. Water | B8. Communication |
| 0-499 | 253 | 395 | 404 | 396 | 402 | 403 | 149 |
| 500-999 | 40 | 1 | 7 | 14 | 9 | 13 | 205 |
| 1000-1499 | 47 | 3 | 3 | 10 | 5 | 2 | 45 |
| 1500-1999 | 36 | 3 | 2 | 1 | 3 | 1 | 14 |
| 2000-2499 | 15 | 1 | 3 | 4 | 5 | 6 | 11 |
| 2500-2999 | 1 | 1 | 2 | 0 | 1 | 0 | 0 |
| 3000-3499 | 13 | 2 | 2 | 1 | 0 | 1 | 2 |
| 3500-3999 | 2 | 1 | 1 | 0 | 0 | 2 | 0 |
| 4000-4499 | 5 | 1 | 1 | 0 | 1 | 1 | 2 |
| Above 5000 | 18 | 22 | 5 | 4 | 4 | 1 | 2 |

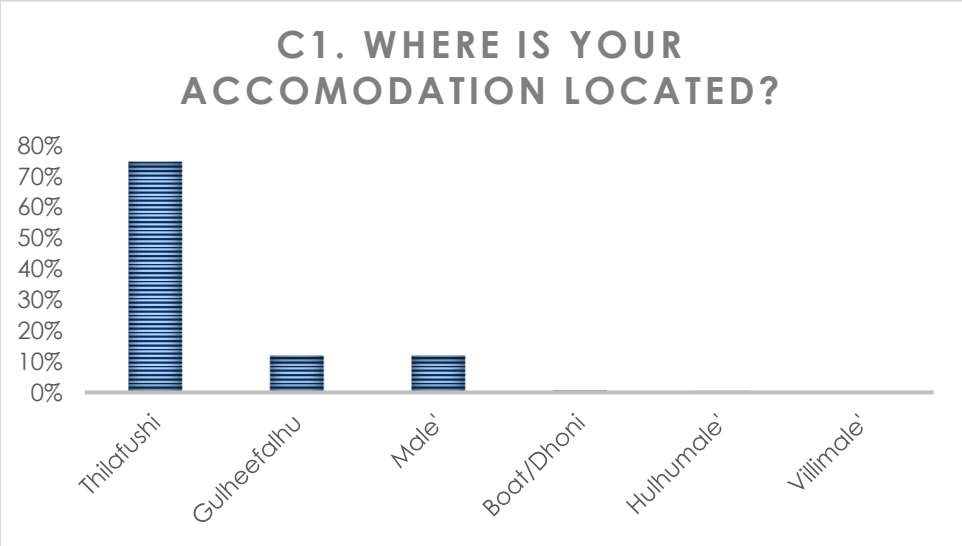
**B10. How do you invest your savings?**




| | | |
|---|---|---|
| Deposit in bank account | 68 | 16% |
| No savings | 25 | 6% |
| Send Home | 341 | 78% |

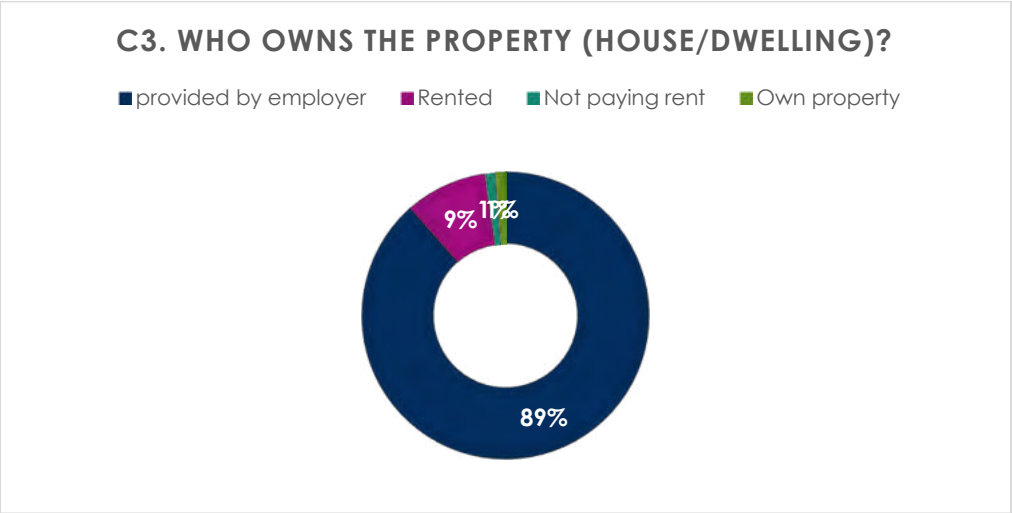
## C. HOUSING, INFRASTRUCTURE AND BASIC SERVICES

**C1/C2. Where (which island) is your accommodation located?**



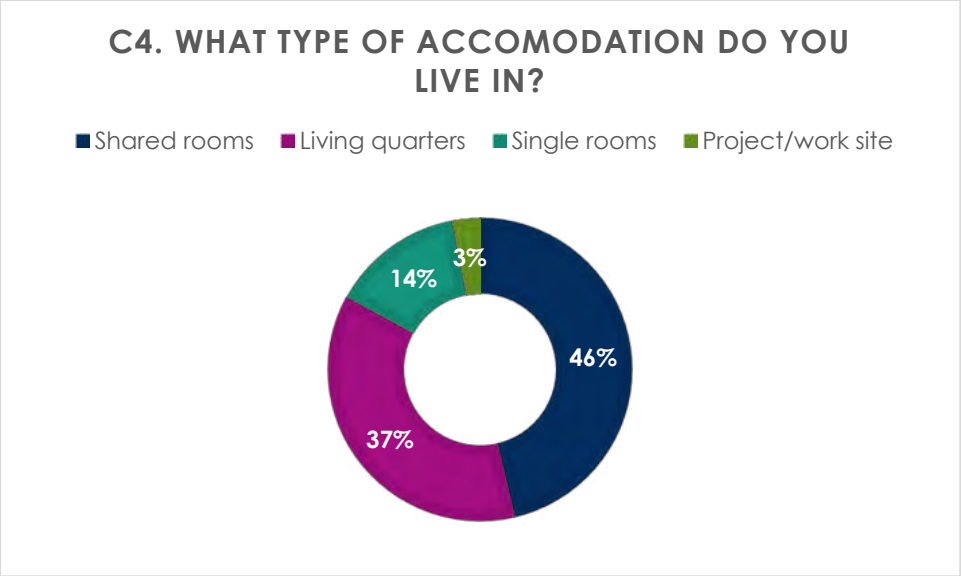

| | | |
|---|---|---|
| Thilafushi | 320 | 74% |
| Gulheefalhu | 52 | 12% |
| Male' | 52 | 12% |
| Boat/Dhoni | 3 | 1% |
| Hulhumale' | 2 | 0.47% |
| Villimale' | 1 | 0.23% |

**C3. Who owns the property (House/dwelling)?**



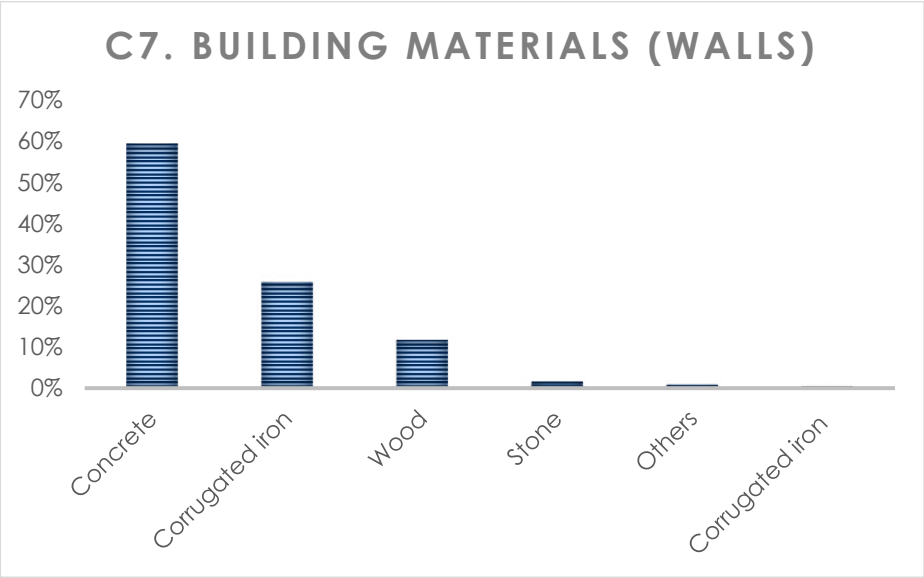

| | | |
|---|---|---|
| provided by employer | 384 | 88% |
| Rented | 40 | 9% |
| Not paying rent | 5 | 1% |
| Own property | 5 | 1% |

**C4. What type of accommodation do you live in?**



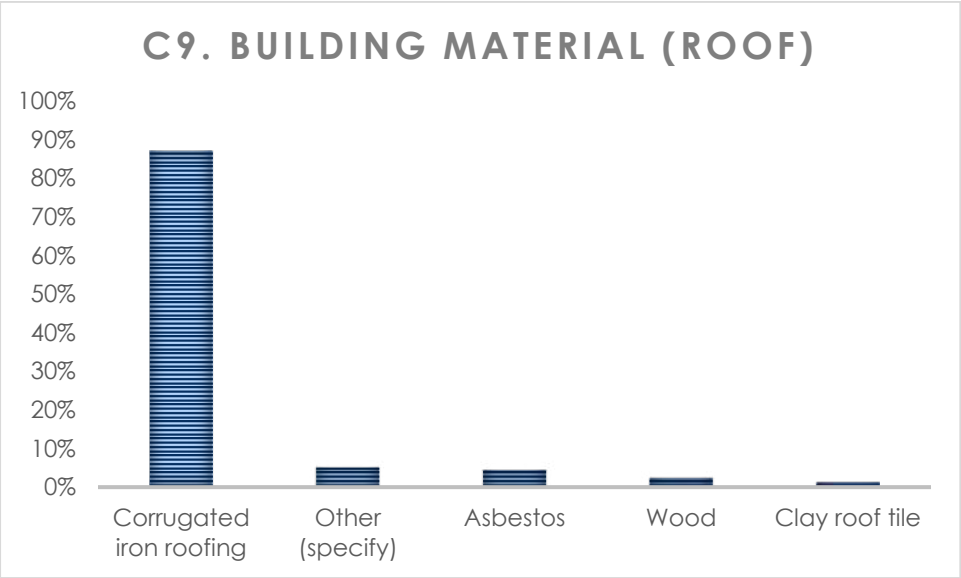

| | | |
|---|---|---|
| Shared rooms | 201 | 46% |
| Living quarters | 159 | 37% |
| Single rooms | 61 | 14% |
| Project/work site | 13 | 3% |

**C7/C8. Building material (Walls)**



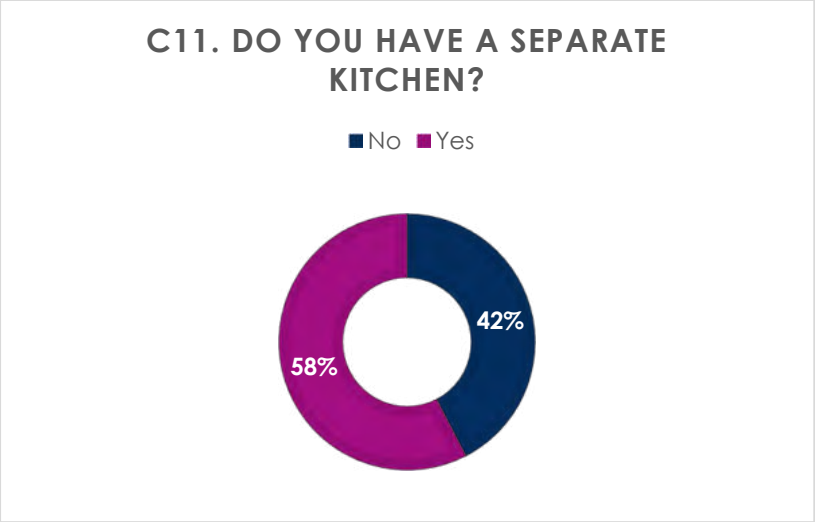

| | | |
|---|---|---|
| Concrete | 258 | 60% |
| Corrugated iron | 108 | 25% |
| Wood | 51 | 12% |
| Stone | 7 | 2% |
| Others | 4 | 1% |
| Corrugated iron | 2 | 0% |

**C9/C10. Building material (Roof)**



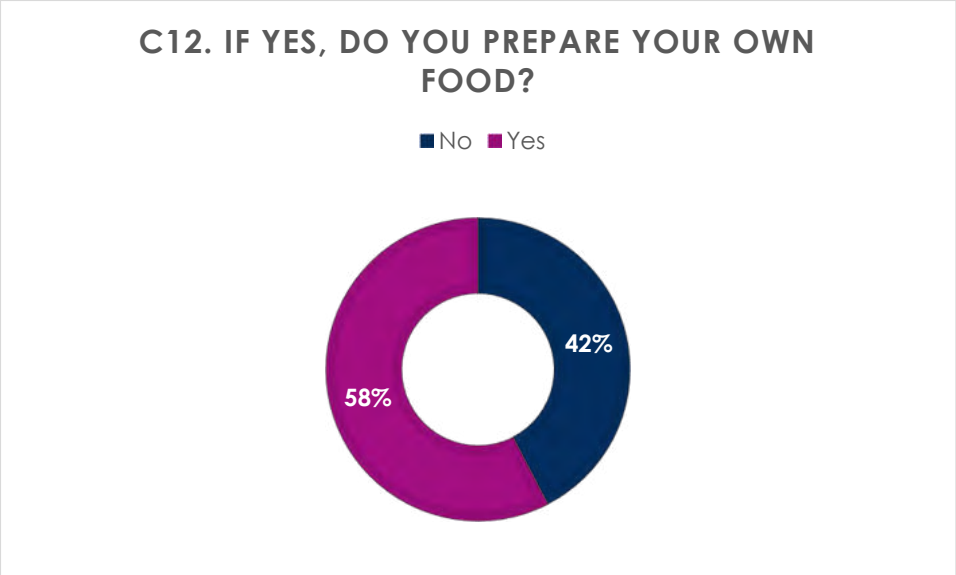

| | | |
|---|---|---|
| Corrugated iron roofing | 378 | 87% |
| Other (specify) | 22 | 5% |
| Asbestos | 19 | 4% |
| Wood | 10 | 2% |
| Clay roof tile | 5 | 1% |

**C11. Do you have a Separate kitchen?**



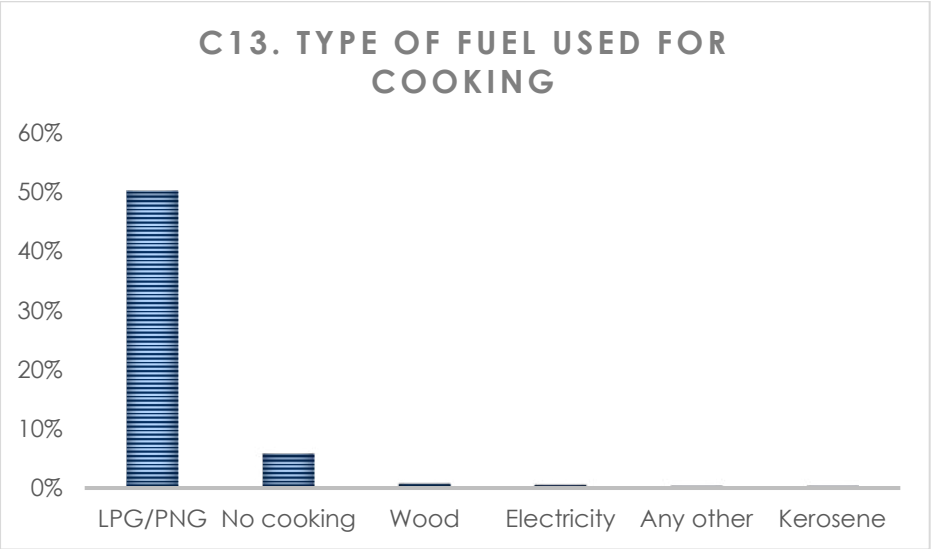

| | | |
|---|---|---|
| No | 184 | 42% |
| Yes | 250 | 58% |

**C12. If yes, do you prepare your own food?**



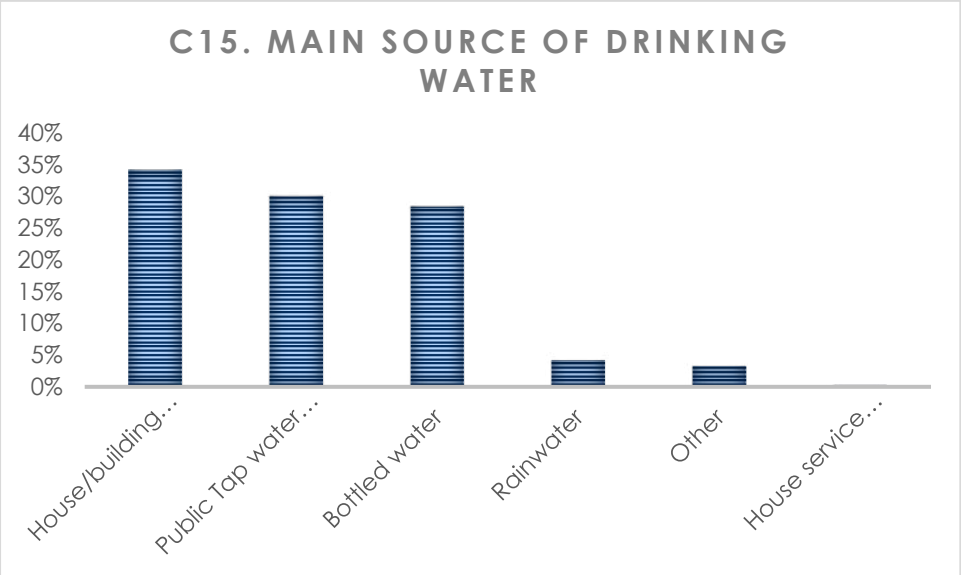

| | | |
|---|---|---|
| No | 106 | 42 |
| Yes | 144 | 58 |

**C13/C14. What type of fuel is used for cooking?**



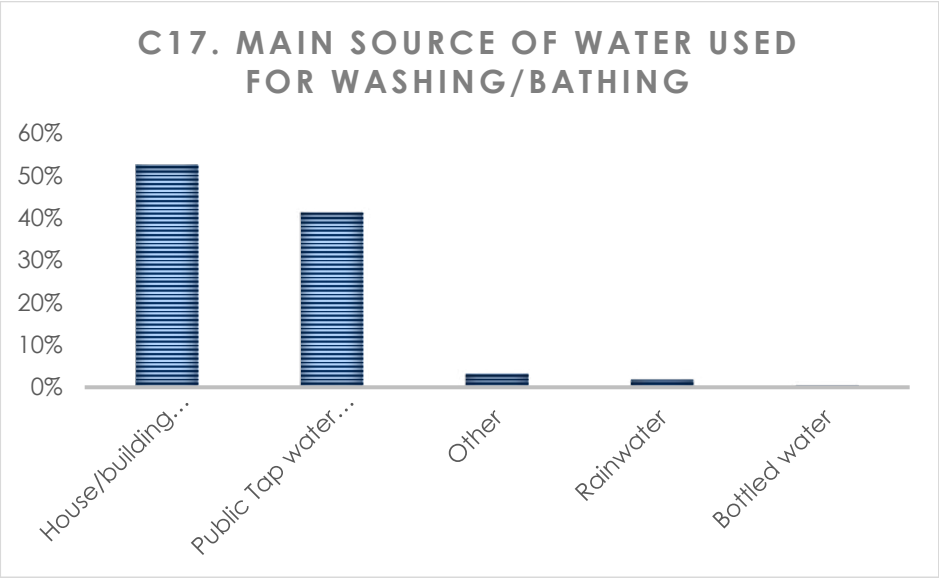

| | | |
|---|---|---|
| LPG/PNG | 218 | 50% |
| No cooking | 25 | 6% |
| Wood | 3 | 1% |
| Electricity | 2 | 0% |
| Any other | 1 | 0% |
| Kerosene | 1 | 0% |

**C15/C16. Main source of drinking water**



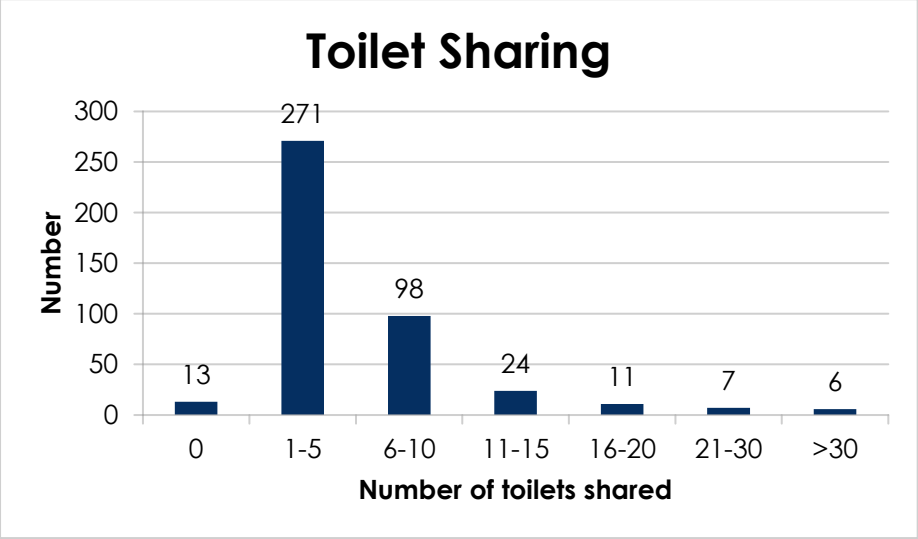

| | | |
|---|---|---|
| House/building service Connection | 148 | 34% |
| Public Tap water from treated source | 130 | 30% |
| Bottled water | 123 | 28% |
| Rainwater | 18 | 4% |
| Other | 14 | 3% |
| House service Connection | 1 | 0% |

**C17/C18. Main source of water used for washing/ bathing**



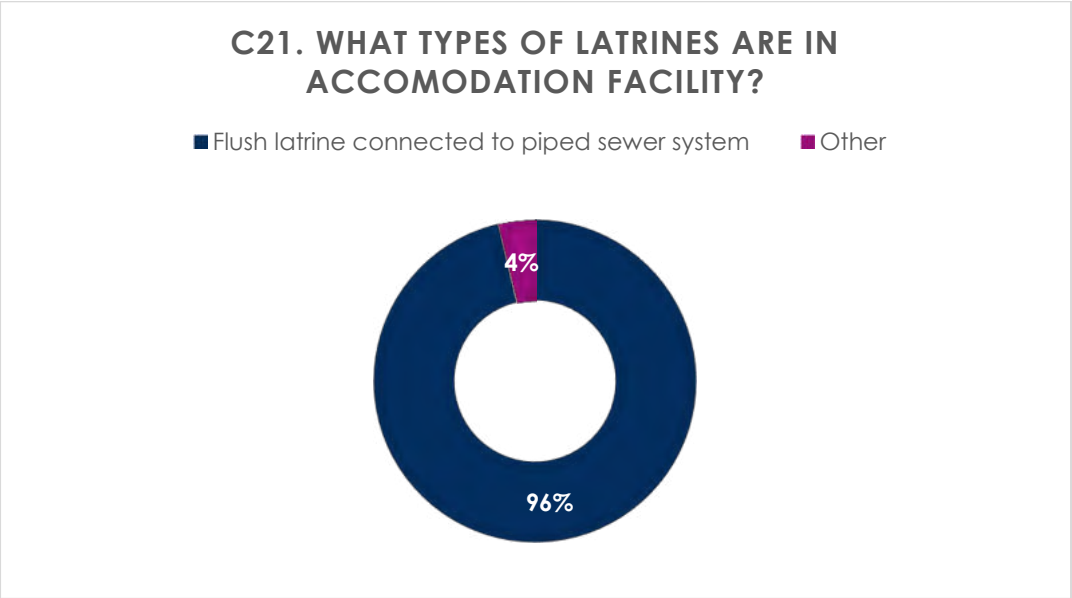

| | | |
|---|---|---|
| House/building service Connection | 228 | 53% |
| Public Tap water from treated source | 179 | 41% |
| Other | 14 | 3% |
| Rainwater | 8 | 2% |
| Bottled water | 2 | 0% |

**C20. Number of toilets shared**



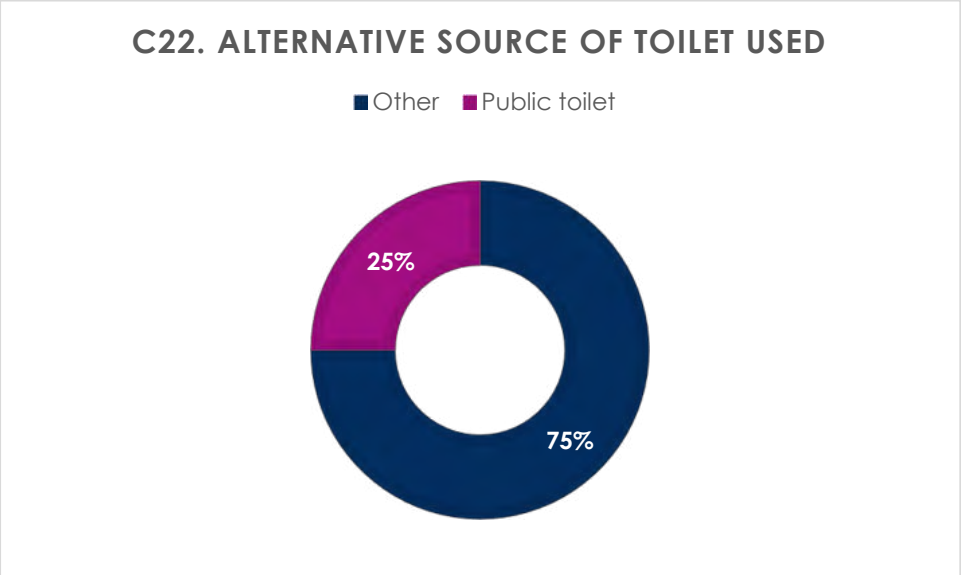

| Number of toilets shared | Count |
|---|---|
| 0 | 13 |
| 1-5 | 271 |
| 6-10 | 98 |
| 11-15 | 24 |
| 16-20 | 11 |
| 21-30 | 7 |
| >30 | 6 |
| | **430** |

**C21. What Types of Latrines are in the accommodation facility?**



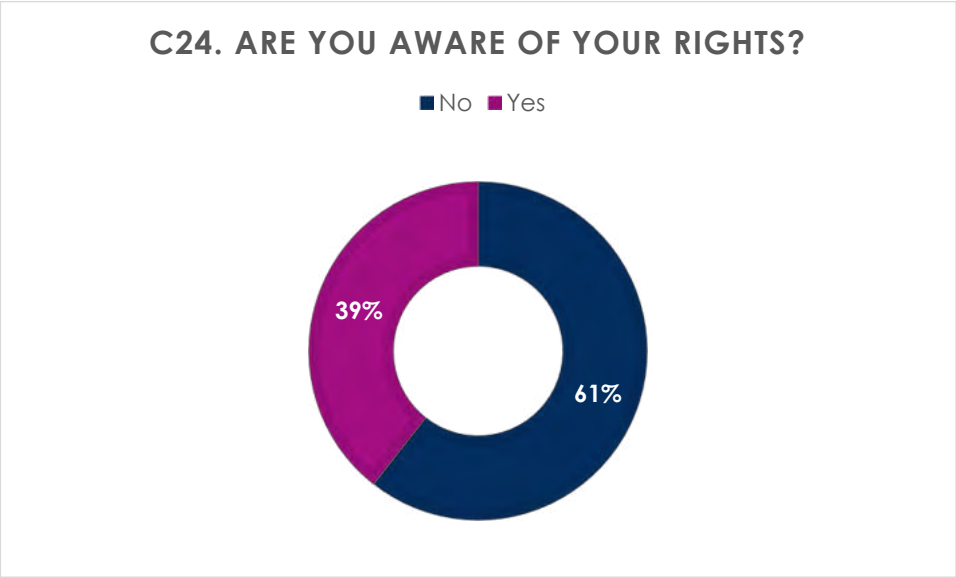

| | | |
|---|---|---|
| Flush latrine connected to piped sewer system | 414 | 96% |
| Other | 16 | 4% |

**C22/C23. Alternate source of toilet used**



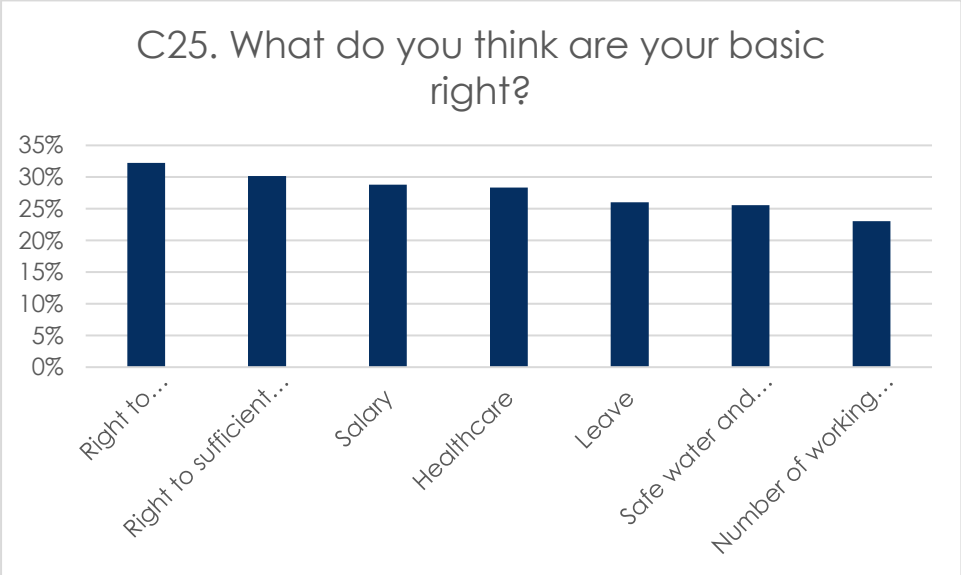

| | | |
|---|---|---|
| Other | 15 | 83% |
| Public toilet | 3 | 17% |

**C24. Are you aware of your rights?**




| | | |
|---|---|---|
| No | 263 | 61% |
| Yes | 167 | 39% |

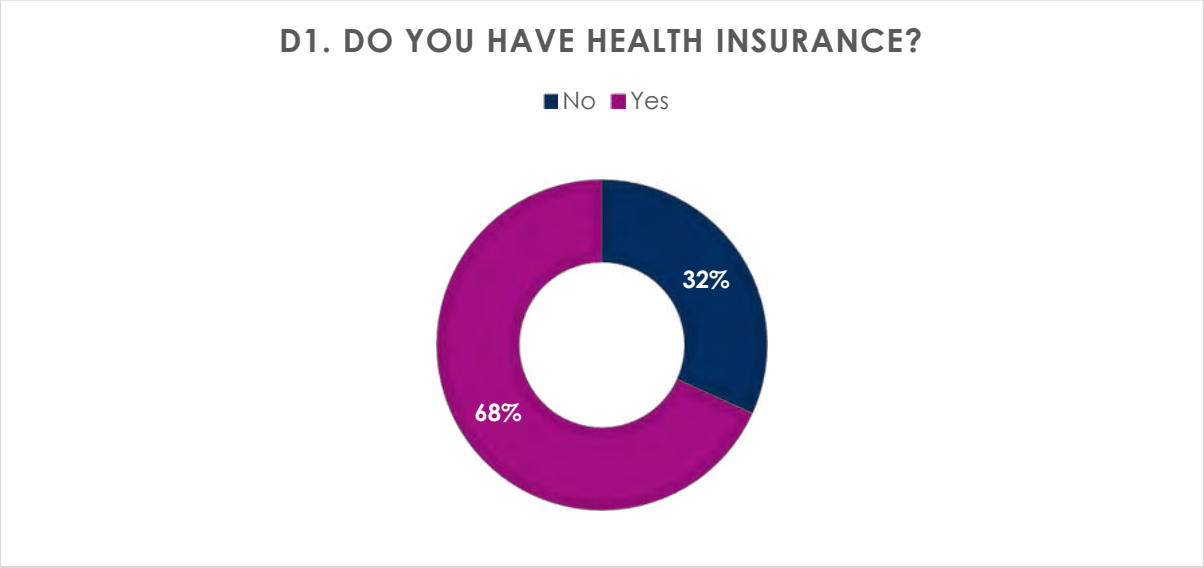
**C25.What do you think are your basic rights?**




| | | |
|---|---|---|
| Right to accommodation | 140 | 32% |
| Right to sufficient foods/meals | 131 | 30% |
| Salary | 125 | 29% |
| Healthcare | 123 | 28% |
| Leave | 113 | 26% |
| Safe water and sanitation | 111 | 26% |
| Number of working hours | 100 | 23% |

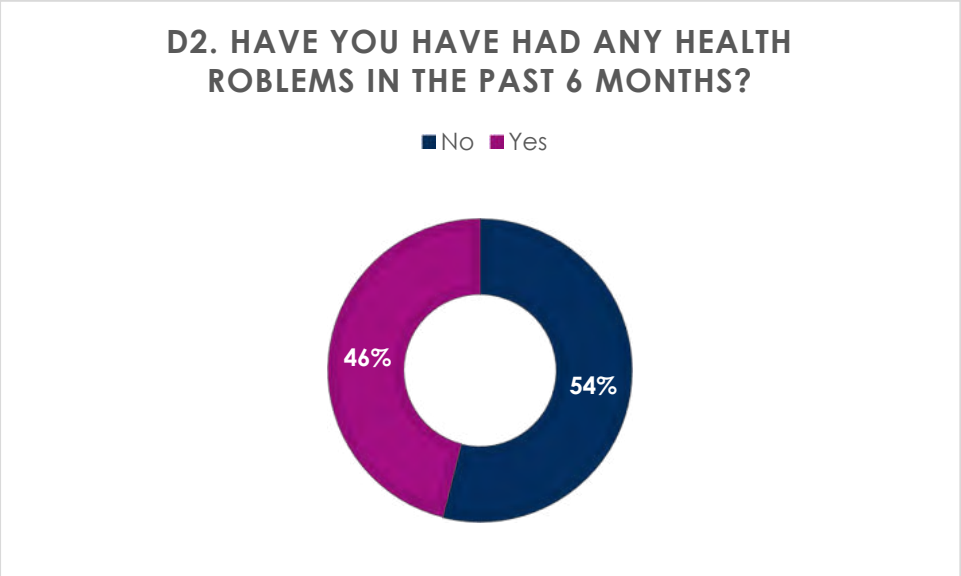
## D. HEALTH CONDITION AND HEALTH CARE SERVICES

**D1. Do you have health insurance?**



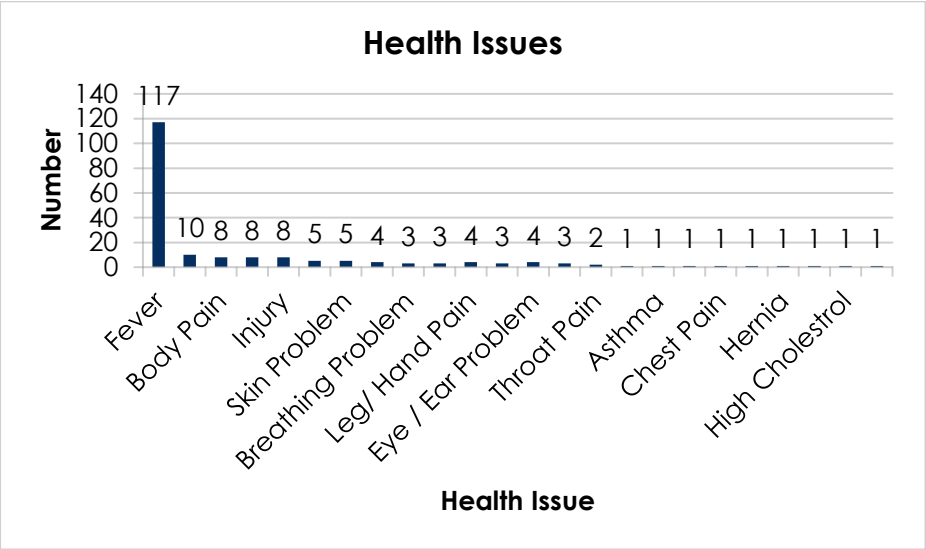

| | | |
|---|---|---|
| No | 138 | 32% |
| Yes | 296 | 68% |

**D2. Have you have had any health problems in the past 6 months?**



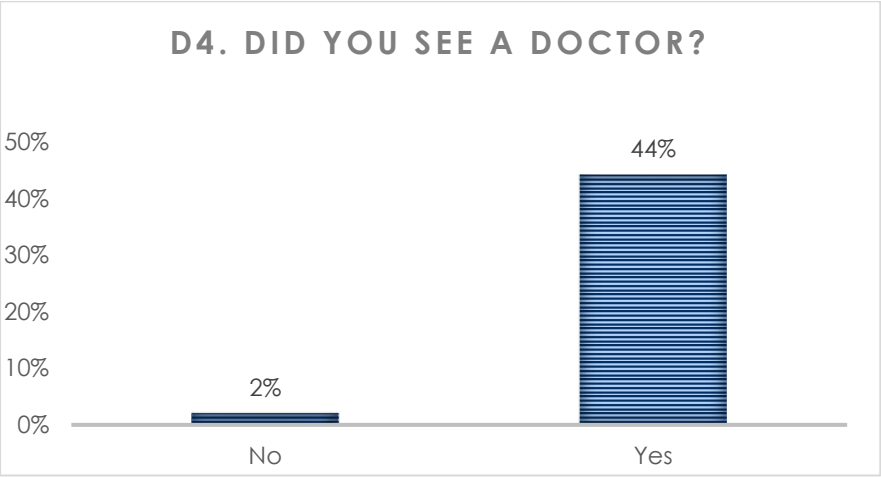

| | | |
|---|---|---|
| No | 234 | 54% |
| Yes | 200 | 46% |

**D3. Health Issues**



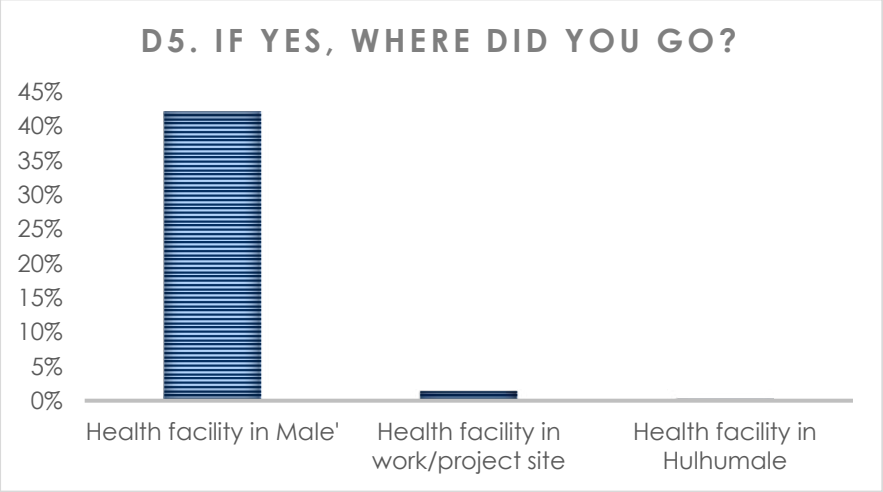

| Health Issue | Count |
|---|---|
| Fever | 117 |
| Fever & Cold | 10 |
| Body Pain | 8 |
| Cold | 8 |
| Injury | 8 |
| Chikungunya | 5 |
| Skin Problem | 5 |
| Dengue | 4 |
| Breathing Problem | 3 |
| Headache | 3 |
| Leg/ Hand Pain | 4 |
| Tooth Pain | 3 |
| Eye / Ear Problem | 4 |
| Stomach Pain | 3 |
| Throat Pain | 2 |
| Allergy | 1 |
| Asthma | 1 |
| Back Pain | 1 |
| Chest Pain | 1 |
| Diabetics | 1 |
| Hernia | 1 |
| High Blood Pressure | 1 |
| High Cholestrol | 1 |
| Other | 1 |
| | 196 |

D4. **Did you see a doctor?**




| | | |
|---|---|---|
| No | 9 | 2% |
| Yes | 192 | 44% |

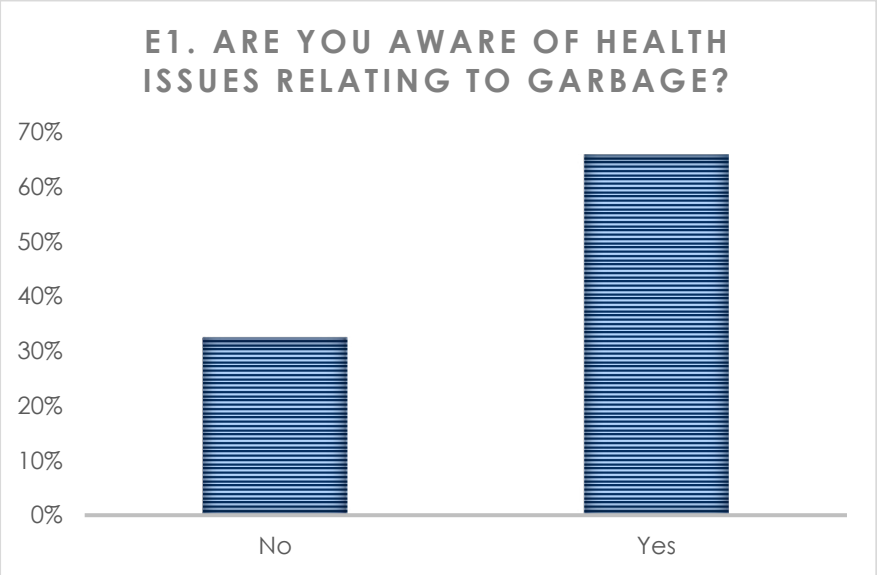
**D5. If yes, where did you go?**




| | | |
|---|---|---|
| Health facility in Male' | 183 | 42% |
| Health facility in work/project site | 6 | 1% |
| Health facility in Hulhumale | 1 | 0% |

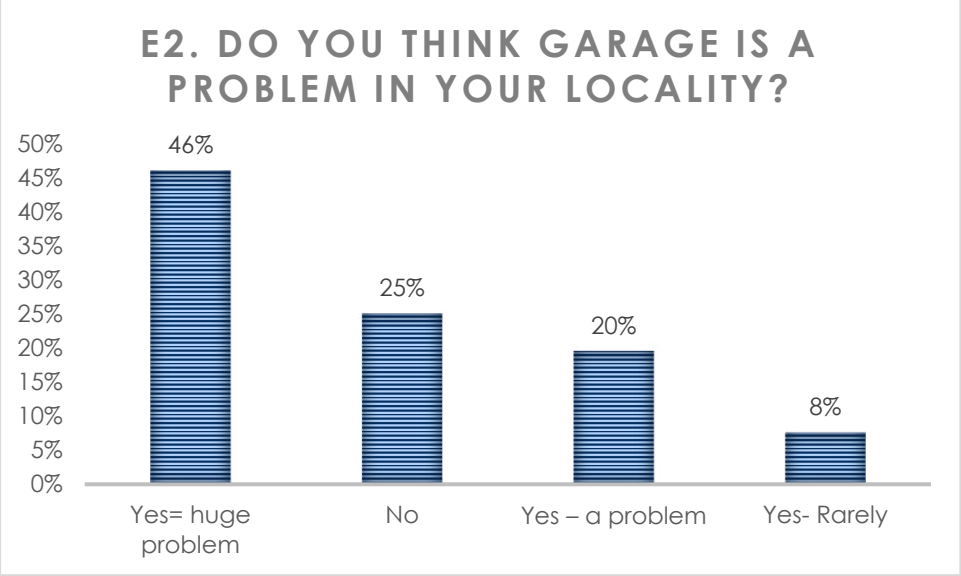
## E. SOLID WASTE MANAGEMENT

**E1. Are you aware of any health issues relating to garbage/ waste management?**



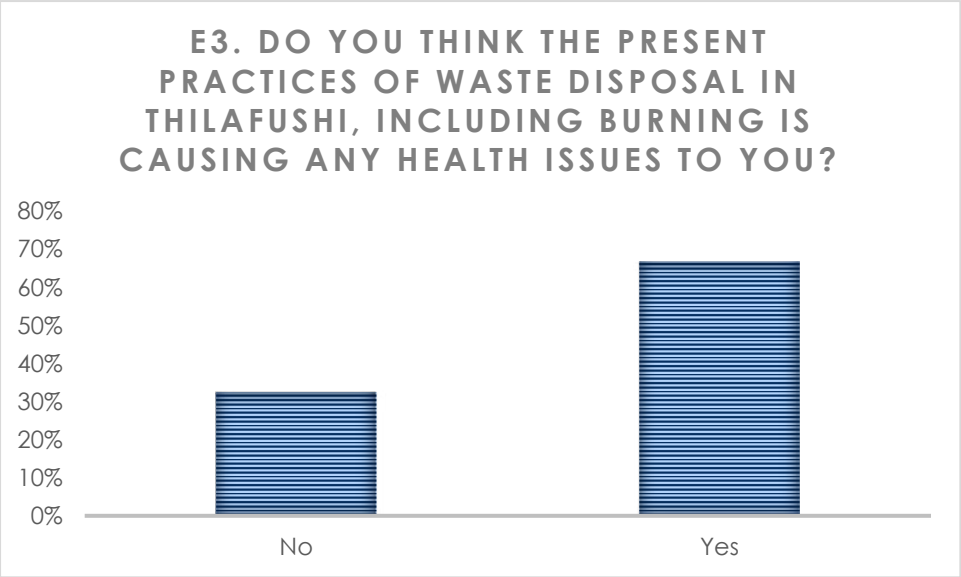

| | | |
|---|---|---|
| No | 141 | 32% |
| Yes | 286 | 66% |
| (blank) | 7 | 2% |

**E2. Do you think garbage is a problem in your locality?**



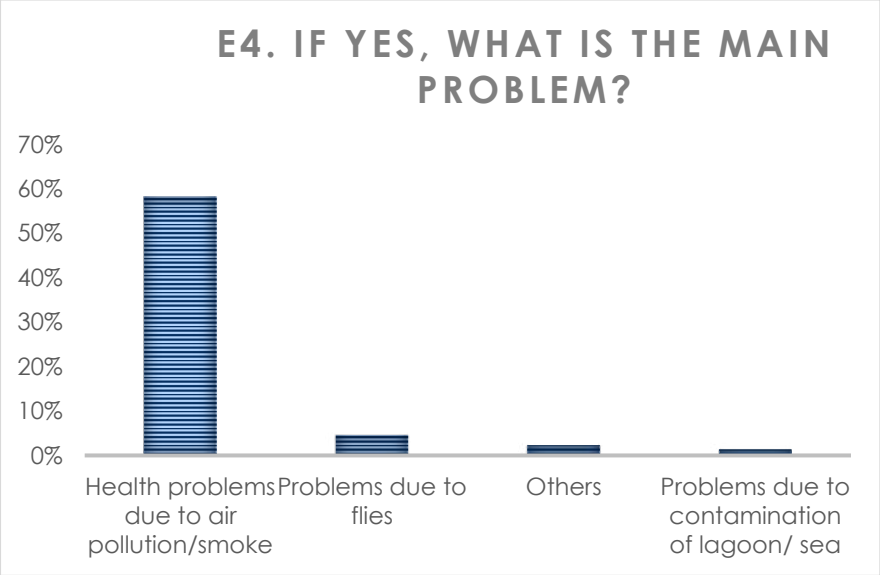

| | | |
|---|---|---|
| Yes= huge problem | 200 | 46% |
| No | 109 | 25% |
| Yes – a problem | 85 | 20% |
| Yes- Rarely | 33 | 8% |
| (blank) | 7 | 2% |

**E3. Do you think the present practices of waste disposal in Thilafushi, including burning is causing any health issues to you?**




| | | |
|---|---|---|
| No | 141 | 32% |
| Yes | 290 | 67% |
| (blank) | 3 | 1% |

**E4/E5. If yes, what are the problems?**



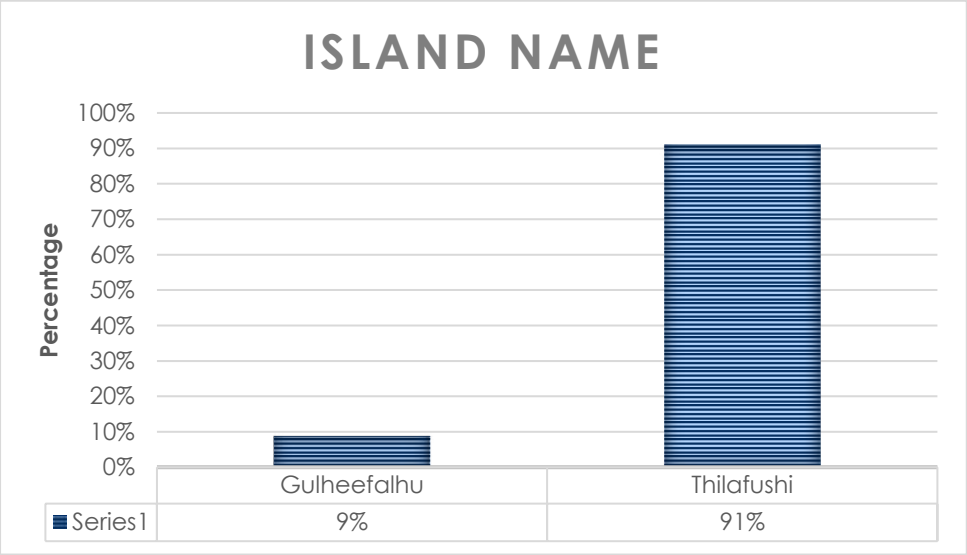

| | | |
|---|---|---|
| Health problems due to air pollution/smoke | 253 | 58% |
| Problems due to flies | 20 | 5% |
| Others | 10 | 2% |
| Problems due to contamination of lagoon/ sea | 6 | 1% |
| (blank) | 145 | 33% |

## APPENDIX E: Graphical representation of data obtained from company survey

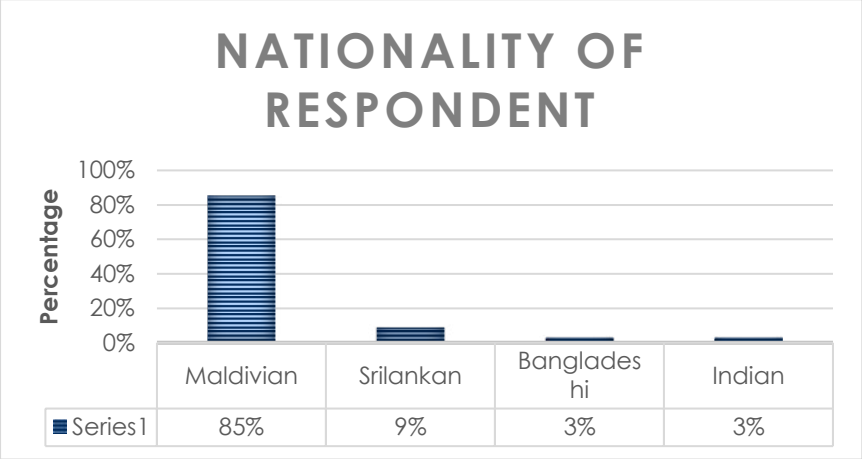
### DATA AND GRAPHS – COMPANY SURVEY

### A. GENERAL INFORMATION

**A2. Island Name**



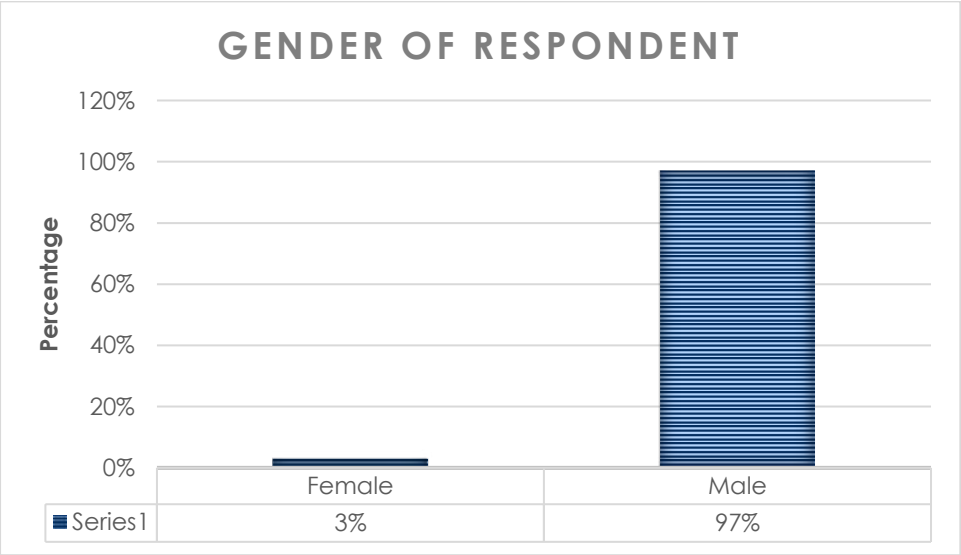

**A3 & A4 Nationality (of respondent)**




**A5. Name of Respondent**

(Data not to be disclosed)

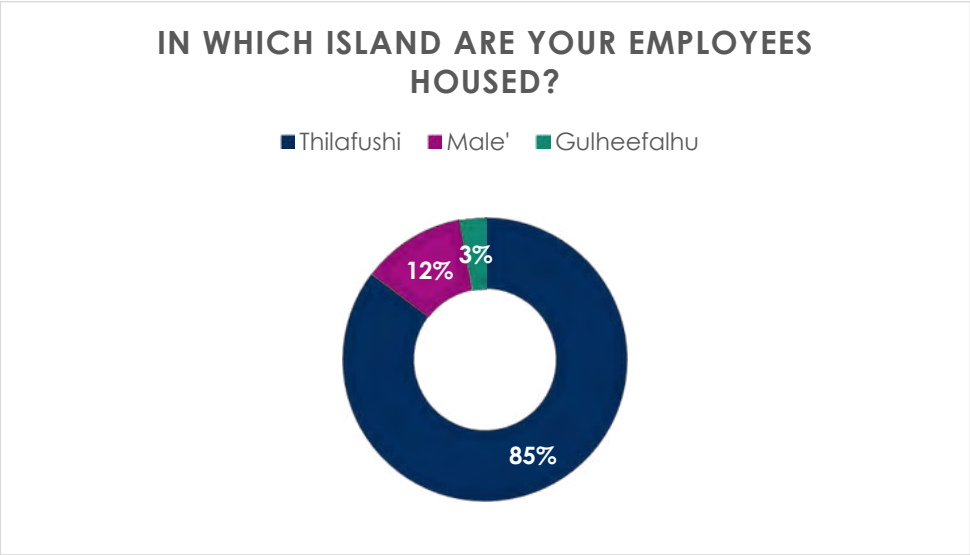
**A6. Gender (of respondent)**



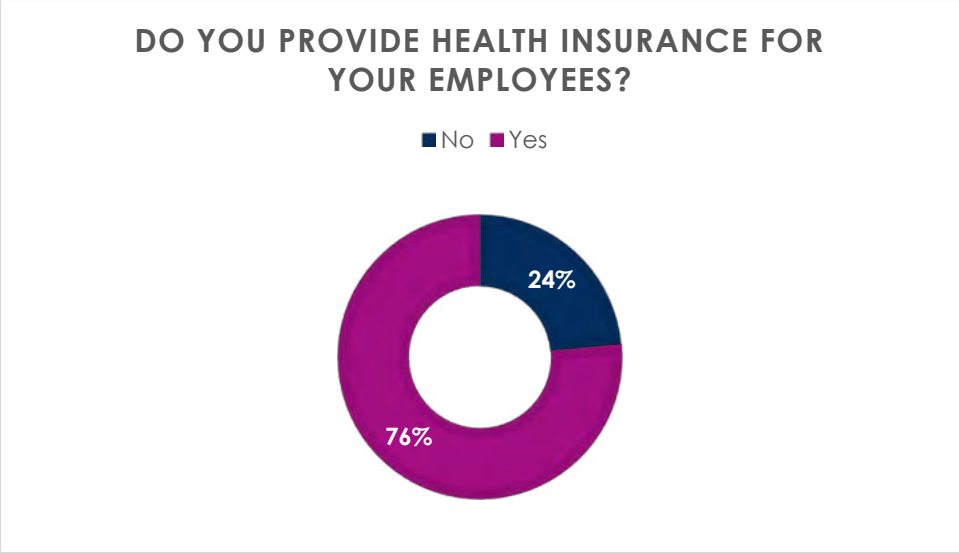
## A7, A8 and A9. Company Name, Key Activities and Total Number of Employees

| # | A2. Island Name | A7. Company Name | A8. What are the key Activities conducted by the company? | A9. Number of employees? | Gender |
|---|---|---|---|---|---|
| 1 | Thilafushi | Villa Hakatha | Delivery, gas, cement petrol and diesel | 130 | men |
| 2 | Thilafushi | Villa Hakatha F n B | Food and Beverage services, restaurant services | 24 | men |
| 3 | Thilafushi | Batch construction PVT LTD | Warehouse, storing metal, wood and electrical supplies | 15 | men |
| 4 | Thilafushi | Wheel pvt ltd | Leasing tugboats, excavators etc., Repairing and maintenance of vehicles and vessels, Taking projects such as land reclamation | 10 | men |
| 5 | Thilafushi | Mtcc | Warehouse and slipway, boat building and boat repair | 180 | men |
| 6 | Thilafushi | IZ | Workshop | No information | |
| 7 | Thilafushi | Eve garment | All works allowed in Thilafushi | No information | |
| 8 | Thilafushi | Leo trading | In Thilafushi they have mechanical and technical staff as the main work done there is the maintenance of assets such as landing craft, excavators etc. | 47 | men |
| 9 | Thilafushi | Sony hardware | Warehouse, storing and packaging | 200 | men |
| 10 | Thilafushi | Lafarge Maldives | Cement Factory | No information | |
| 11 | Thilafushi | MALDIVE GAS | LPG filling | 29 | men |
| 12 | Thilafushi | WAMCO | Solid waste management services, conduct clean up programs | 150 | men |
| 13 | Thilafushi | Mpl thilafushi | Boat building and boat repair, vehicle garage | 35 | men |
| 14 | Thilafushi | Dhamas | warehouse and workshop, vehicle repair and garage, warehouse | No information | |
| 15 | Thilafushi | Nalahiya trahiya trading pvt ltd | Warehouse for constuction materials | 200 | men |
| 16 | Thilafushi | Maldives Structural Product MSP | manufacturing roofing products, corrugated iron sheets | 15 | men |
| 17 | Thilafushi | Raajje logistics pvt ltd | Logistics Work, Transportaion sea and land | 33 | men |
| 18 | Thilafushi | Leo Trade | Logistics work | 33 | men |
| 19 | Thilafushi | Sunfront | Repairing boats and logistics | 25 | men |
| 20 | Thilafushi | Static company (aqua reef) | Water plant and electrical work | 19 | men |
| 21 | Thilafushi | The Hawks | Oil supplier; boatyard for loading, unloading and repair; port harbour; workshop, | 120 | men |
| 22 | Thilafushi | Metco | Garage | 5 | men |
| 23 | Thilafushi | Thilafalhu cafe | Tea shop | 7 | men |
| 24 | Thilafushi | Heavy Force | Repair n maintenance of heavy vehicles, Precast Yard. | 35 | men |
| 25 | Thilafushi | Antrac (maldives petroleum | Heavy vehicles are rented out, sell diesel oil, have 3 landing crafts | 28 | men |
| 26 | Thilafushi | Gulf craft | Boat building n repair | 130 | 1 woman |
| 27 | Thilafushi | Maldives police services | Serve and protect | 25 | men |
| 28 | Thilafushi | Best dives ptv ltd | Boat yard, engine repair | 12 | men |
| 29 | Thilafushi | Build Maldives Company | Ship Repair and maintenance | 24 | men |
| 30 | Gulheefalhu | Stelco | Provide electricity | 6 | men |
| 31 | Gulheefalhu | GMIZ | Manage all services related to tenants including municipal services such as road maintenance, land lease, and conflict resolution. Tree plantation to make the island green | 35 | men |
| 32 | Gulheefalhu | Litus | Storage and workshop | 15 | men |
| 33 | Thilafushi | Apollo | Loading and unloading cargo | 230 | men |
| 34 | Thilafushi | GMIZ | Tenants related all municipal service including road works; Conflict resolution; land leasing and monitoring | 155 | men |

**A10. In which island are your employees housed?**




**A11. Do you provide health insurance for your employees?**

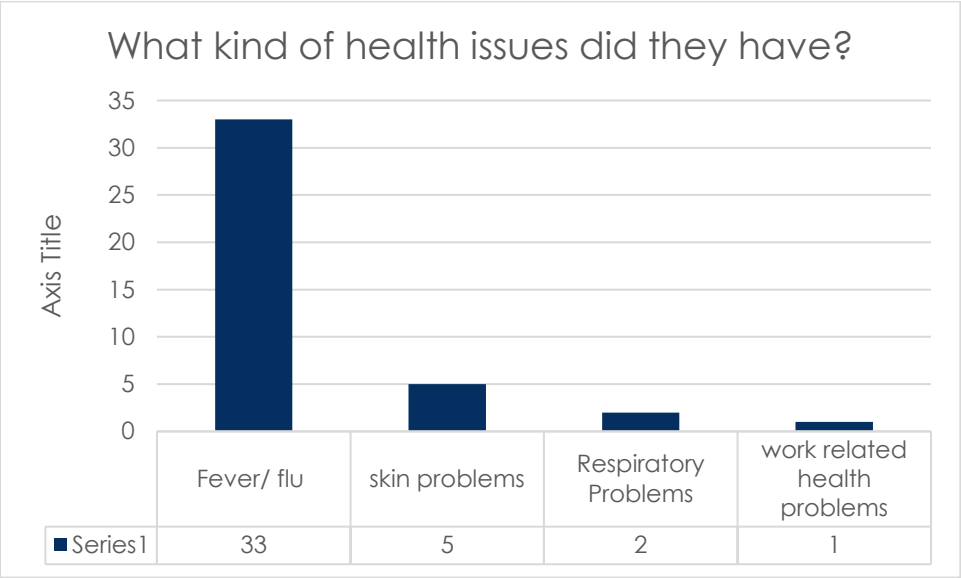



Note: Maldivian Nationals have access to the Government Health Insurance Scheme – Aasandha.

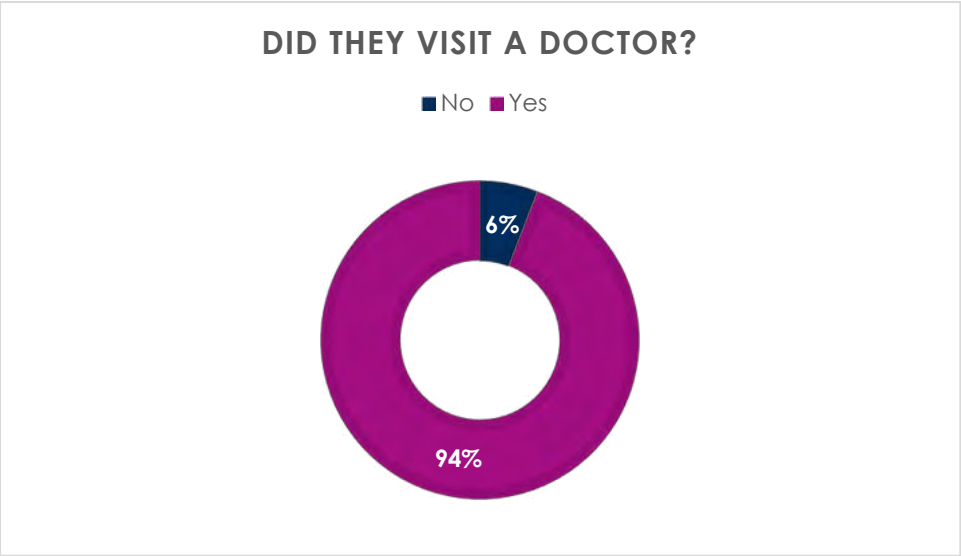
## A12. How many of your employees have reported sick in the past year?

| | A2. Island Name | A7. Company Name | A9. Total number of employees? | A12. How many of your employees have reported sick in the past year? |
|---|---|---|---|---|
| 1 | Thilafushi | Villa Hakatha | 130 | 60 |
| 2 | Thilafushi | Villa Hakatha F n B | 24 | 10 |
| 3 | Thilafushi | Batch construction PVT LTD | 15 | 1 |
| 4 | Thilafushi | Wheel pvt ltd | 10 | 25 |
| 5 | Thilafushi | Mtcc | 180 | 6 |
| 6 | Thilafushi | IZ | no information provided | 2 |
| 7 | Thilafushi | Eve garment | no information provided | 20 |
| 8 | Thilafushi | Leo trading | 47 | 10 |
| 9 | Thilafushi | Sony hardware | 200 | 60 |
| 10 | Thilafushi | Lafarge Maldives | no information provided | 2 |
| 11 | Thilafushi | MALDIVE GAS | 29 | 3 |
| 12 | Thilafushi | WAMCO | 150 | 25 |
| 13 | Thilafushi | Mpl thilafushi | 35 | 3 |
| 14 | Thilafushi | Dhamas | no information provided | 11 |
| 15 | Thilafushi | Nalahiya trahiya trading pvt ltd | 200 | 4 |
| 16 | Thilafushi | Maldives Structural Product MSP | 15 | 5 |
| 17 | Thilafushi | Raajje logistics pvt ltd | 33 | 5 |
| 18 | Thilafushi | Leo Trade | 33 | 25 |
| 19 | Thilafushi | Sunfront | 25 | 25 |
| 20 | Thilafushi | Static company (aqua reef) | 19 | 16 |
| 21 | Thilafushi | The Hawks | 120 | 36 |
| 22 | Thilafushi | Metco | 5 | 25 |
| 23 | Thilafushi | Thilafalhu cafe | 7 | 5 |
| 24 | Thilafushi | Heavy Force | 35 | 10 |
| 25 | Thilafushi | Antrac (maldives petroleum | 28 | 4 |
| 26 | Thilafushi | Gulf craft | 130 | 80 |
| 27 | Thilafushi | Maldives police services | 25 | 24 |
| 28 | Thilafushi | Best dives ptv ltd | 12 | 4 |
| 29 | Thilafushi | Build Maldives Company | 24 | 20 |
| 30 | Gulheefalhu | Stelco | 6 | 6 |
| 31 | Gulheefalhu | GMIZ | 35 | 10 |
| 32 | Gulheefalhu | Litus | 15 | 2 |
| 33 | Thilafushi | Apollo | 230 | 90 |
| 34 | Thilafushi | GMIZ | 155 | 60 |

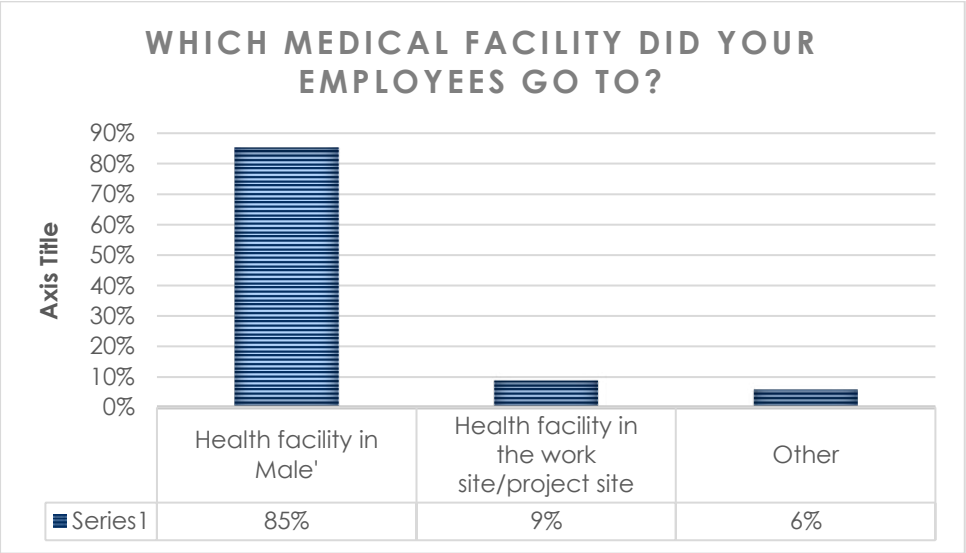
**A13. What kind of health issues did they have? (please provide a list if you have one)**




**A14. Did they visit a doctor?**



**A15. If yes to A14, Where did they go?**




**A16. What is the average annual cost for healthcare services for your employees? (in MVR)**

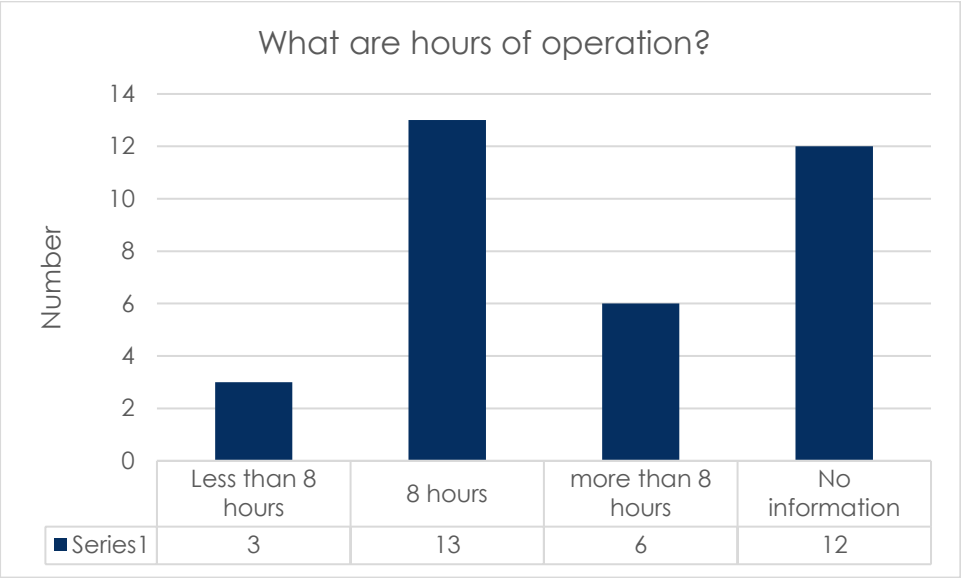
This information was provided by 8 companies.

| | Island Name | Company Name | Annual cost for healthcare |
|---|---|---|---|
| 1 | Thilafushi | Wheel pvt ltd | 45000 |
| 2 | Thilafushi | Leo trading | 300000 to 400000 |
| 3 | Thilafushi | Sony hardware | 400000 |
| 4 | Thilafushi | MALDIVE GAS | 66700 |
| 5 | Thilafushi | Nalahiya trahiya trading pvt ltd | 8400 |
| 6 | Thilafushi | Maldives Structural Product MSP | 8250 |
| 7 | Thilafushi | Heavy Force | 350000 |
| 8 | Thilafushi | Antrac (maldives petroleum | 28000 (company pays MVR1000 per person) employee pays MVR1000 (annually) |

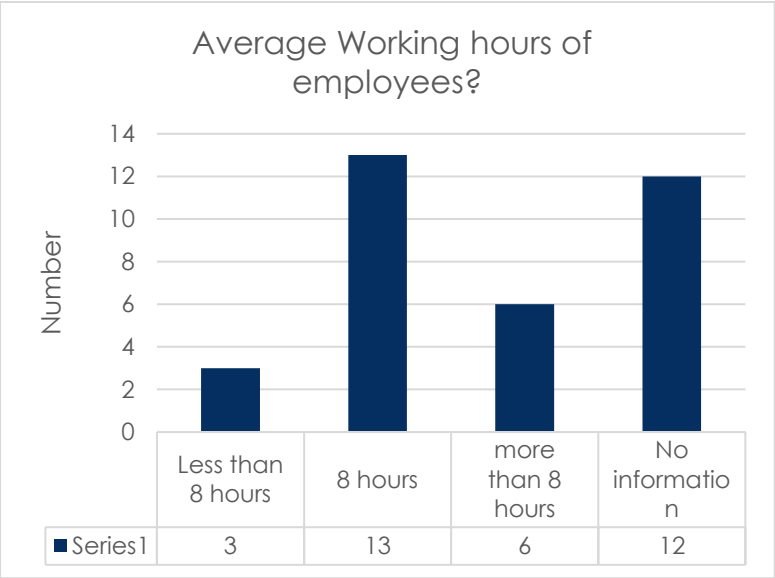
**A17. What are the range of salaries of your employees?**

None of the companies provided this information

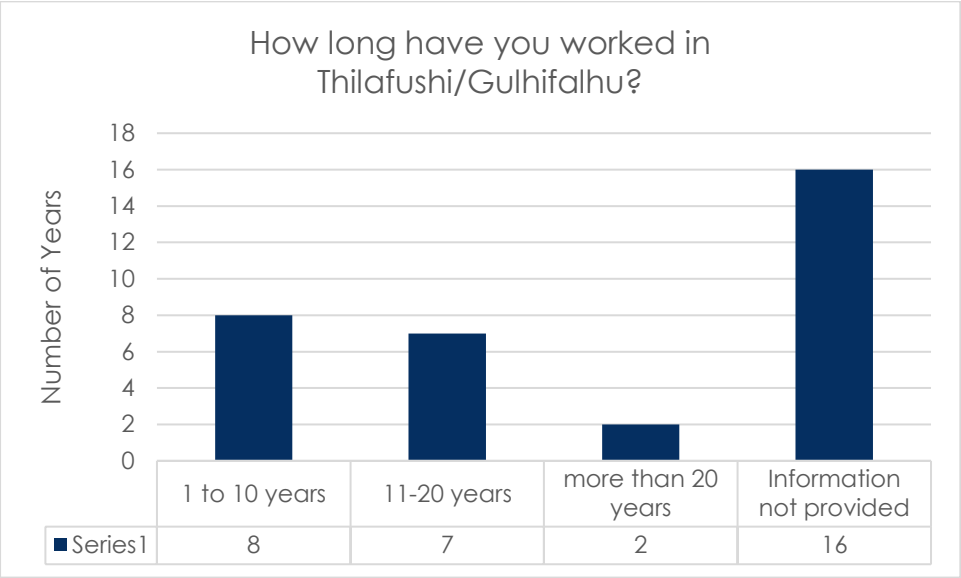
**A18. What are the hours of operation?**



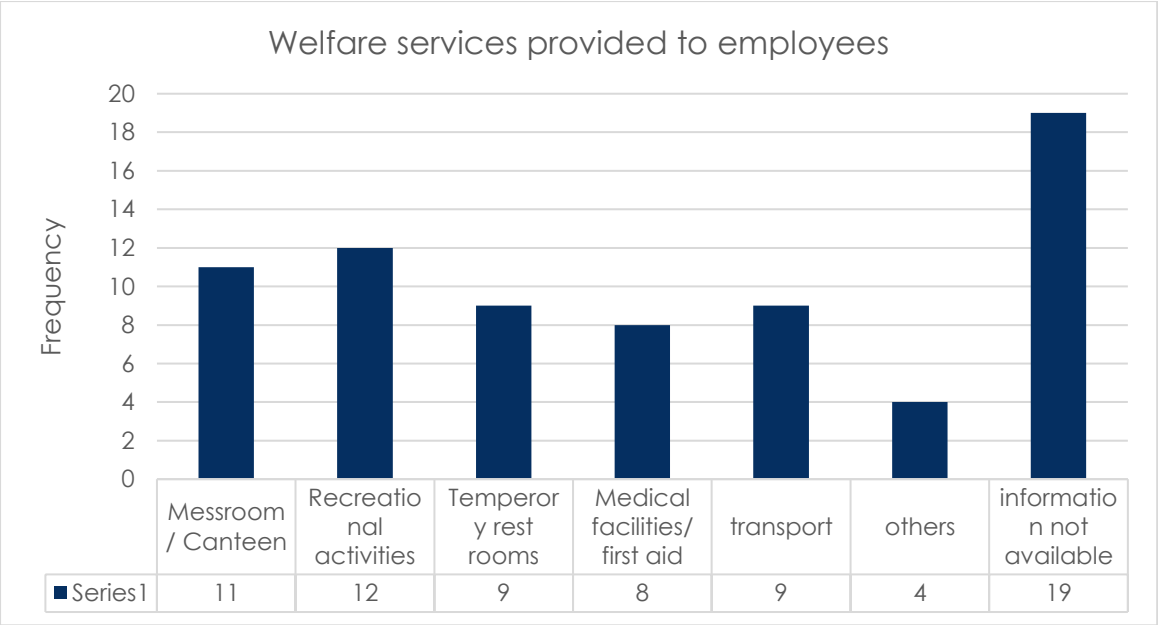

**A19. What are the average working hours of your employees?**



**A20. When did you start operations in Thilafushi/ Gulhifalhu?**




**A21. Specify the types of employee welfare facilities provided by your company**




**A22. Do you provide your employees with life insurance?**

None of the companies provide life insurance to their employees

**A23. Do you provide your employees with disability insurance?**

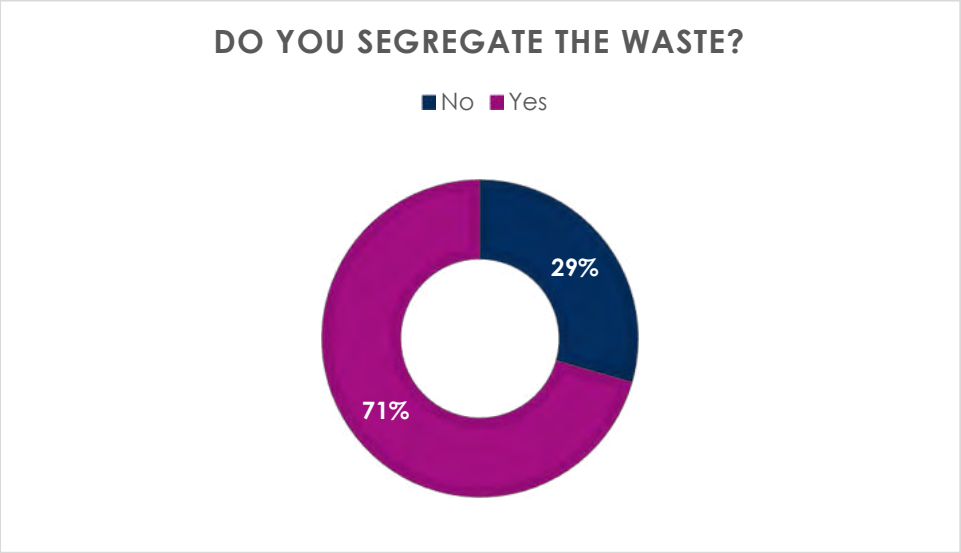
None of the companies provide disability insurance to their employees

**A24. What are the company's main assets? Can you provide details?**

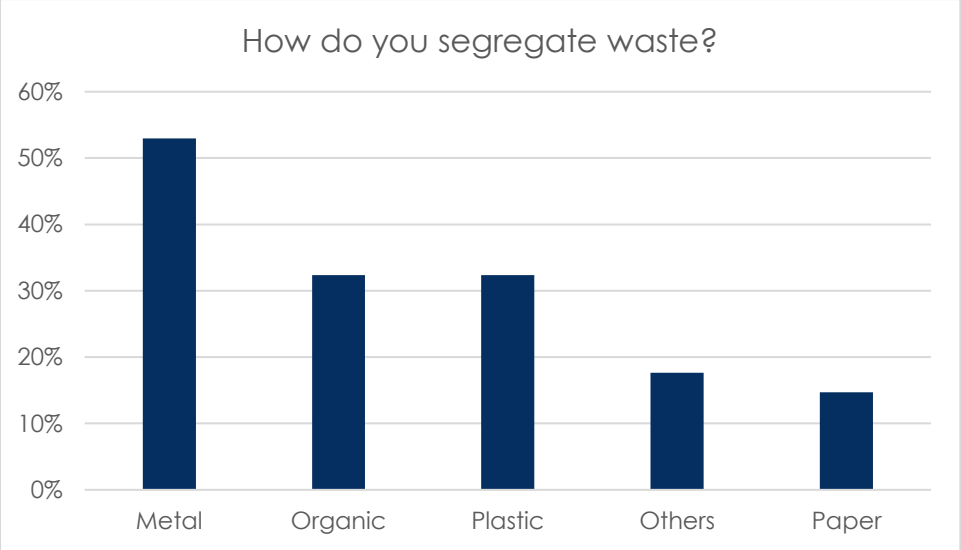
Only two companies provided details

## F. SOLID WASTE MANAGEMENT

**B1. Do you segregate the waste?**



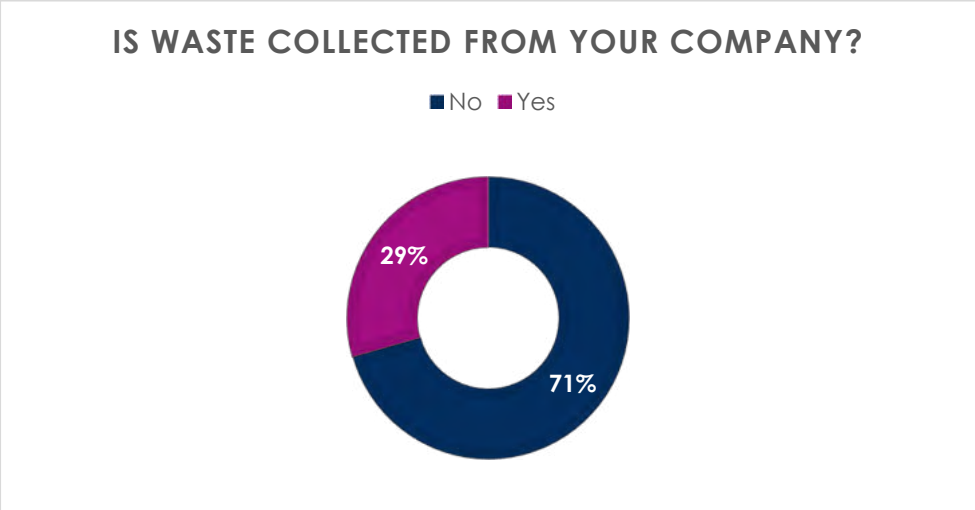

**B2 and B3 How do you segregate waste?**



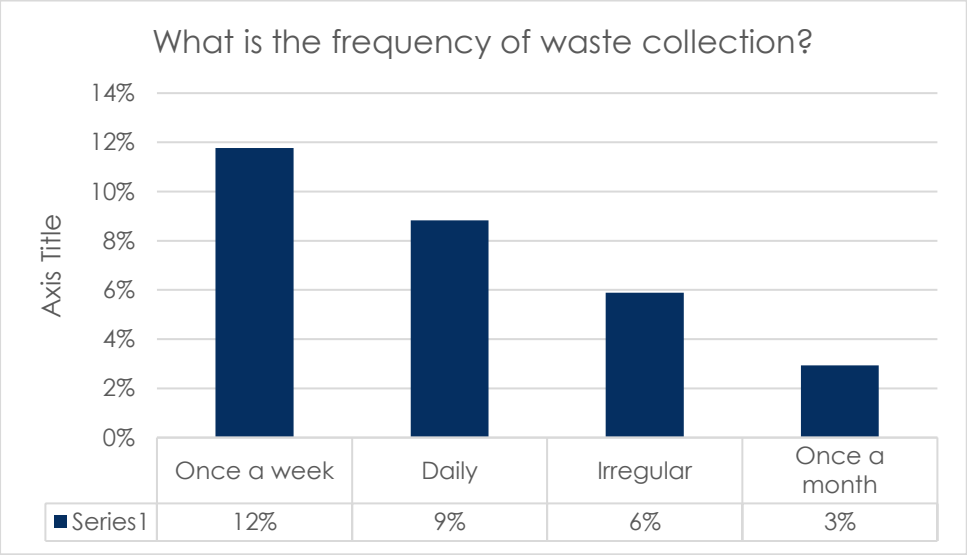
**B4. Have you received any training and assistance in waste segregation?**

**B6. Do you sell recyclable waste?**

**B7. Is waste collection door to door/ from the company premises?**



**B8. If yes to B7, what is the frequency of waste collection?**



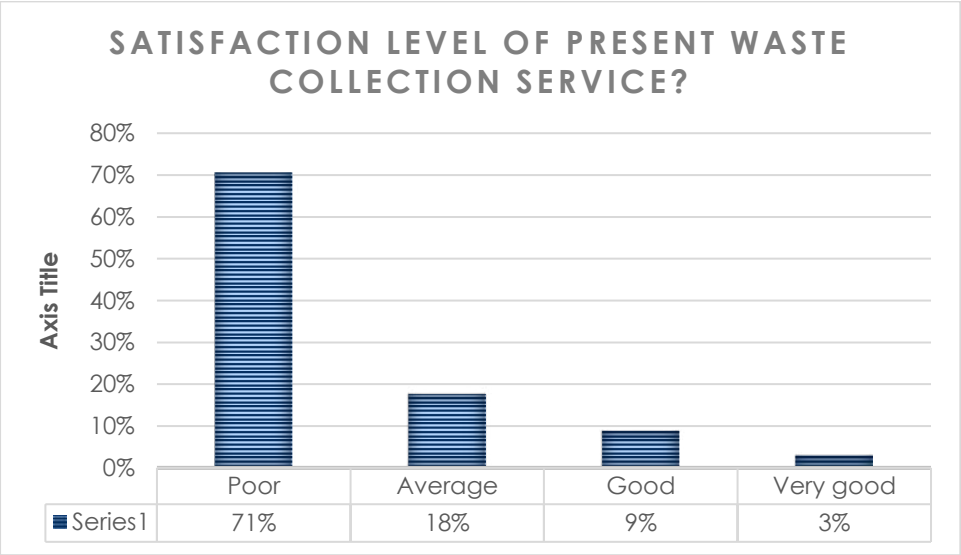

**B9 and B10. Who is responsible for waste collection?**

**B11. Do you pay for waste collection/ disposal service?**

**B12. How much do you pay for monthly waste collection (in MVR)**

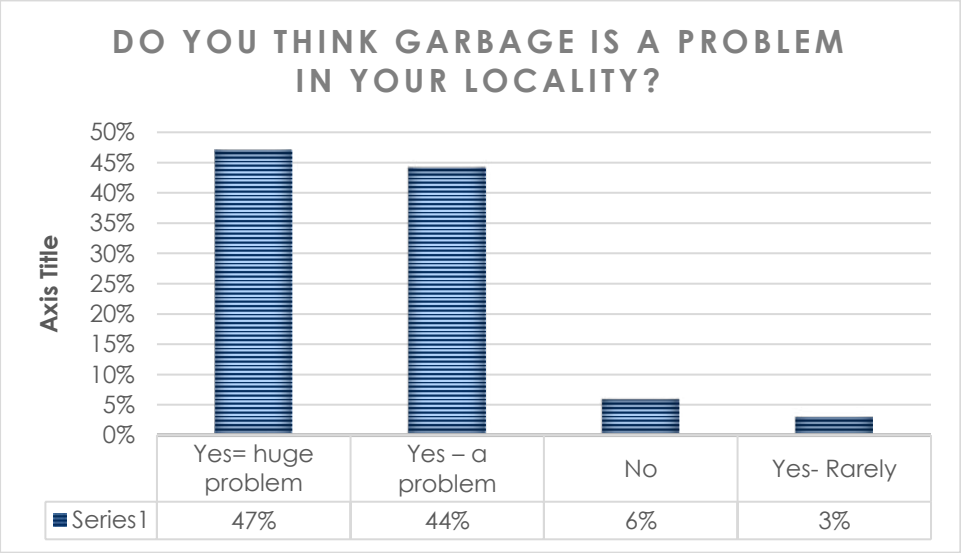
| Amount in MVR | Sum of Count |
|---|---|
| (blank) | 1 |
| 0-499 | 14 |
| 500-999 | 2 |
| 1000-1499 | 1 |
| 1500-1999 | 4 |
| 2000-2499 | 5 |
| 2500-2999 | 2 |
| 4000-4499 | 1 |
| 6000-6499 | 1 |
| 7000-7499 | 1 |
| 14000-14499 | 1 |
| 19000-19499 | 1 |
| 19500-20000 | 1 |
| | 35 |

**B13. Satisfaction level of present waste collection/ management service?**

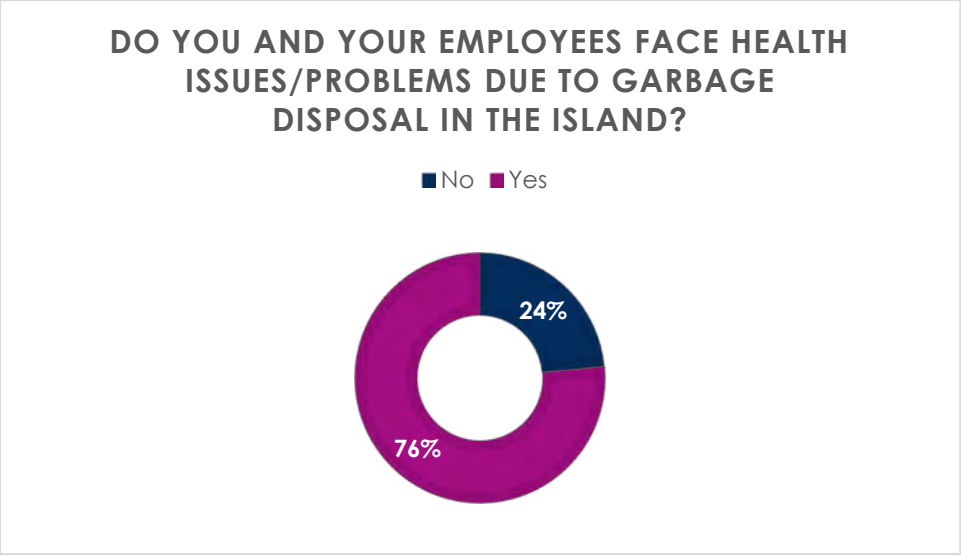



**B14. Do you feel the present monthly charge for waste collection is:**

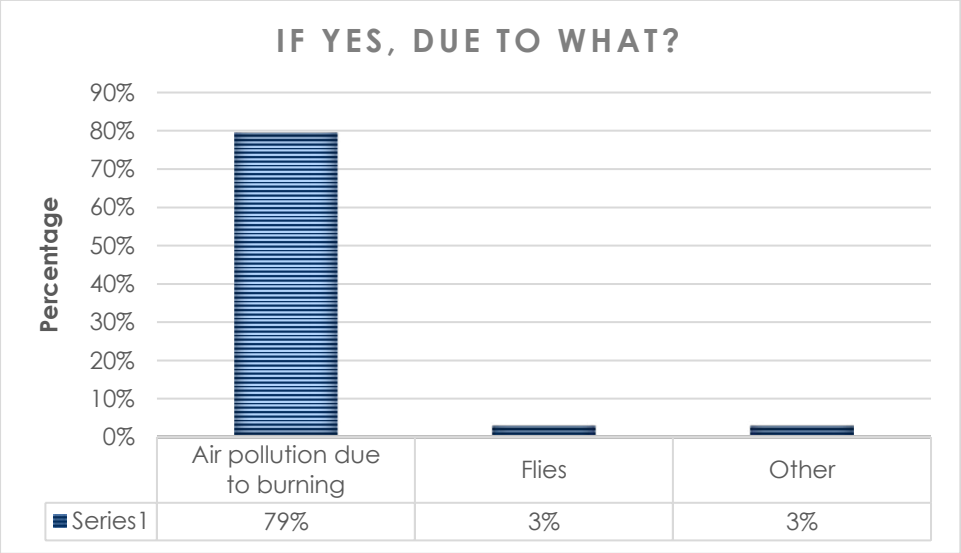
**B15. Do you think garbage is a problem in your locality?**



**B16 and B17. Do you and your employees face health problems/ issues due to the present practices of waste disposal in Thilafushi, including burning?**

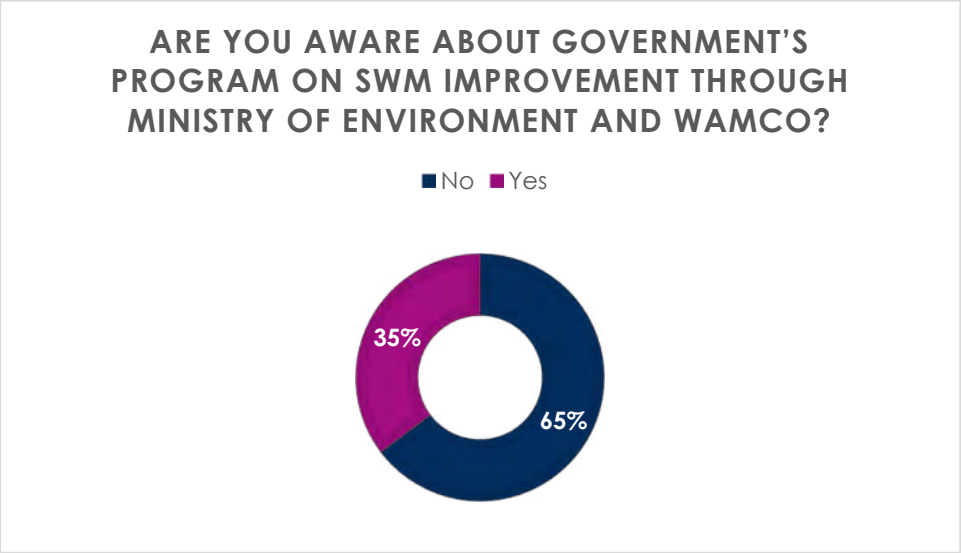



**If yes to B16, due to what?**

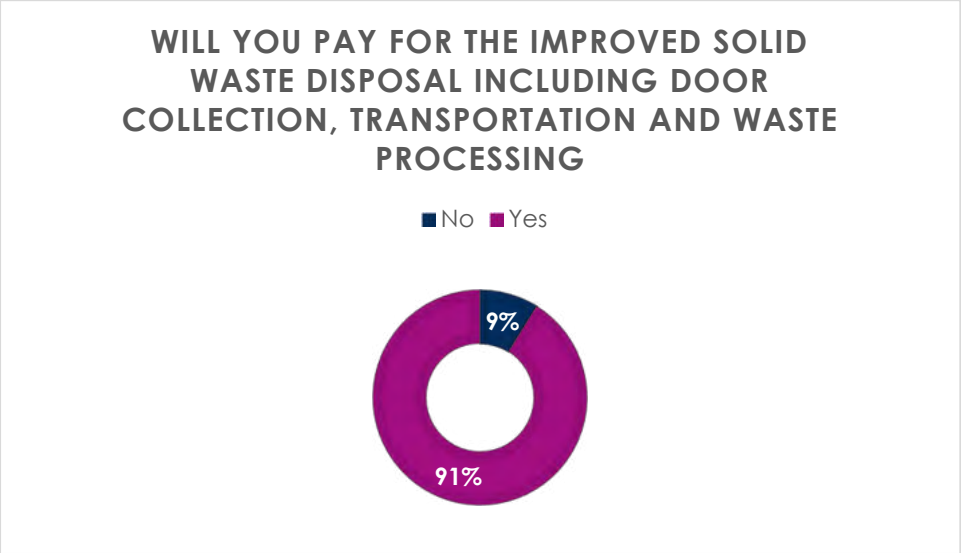


**B18. Do you think community level trainings in solid waste management will be beneficial?**

**B19. Are you aware about Government's program on SWM improvement through Ministry of environment and WAMCO?**



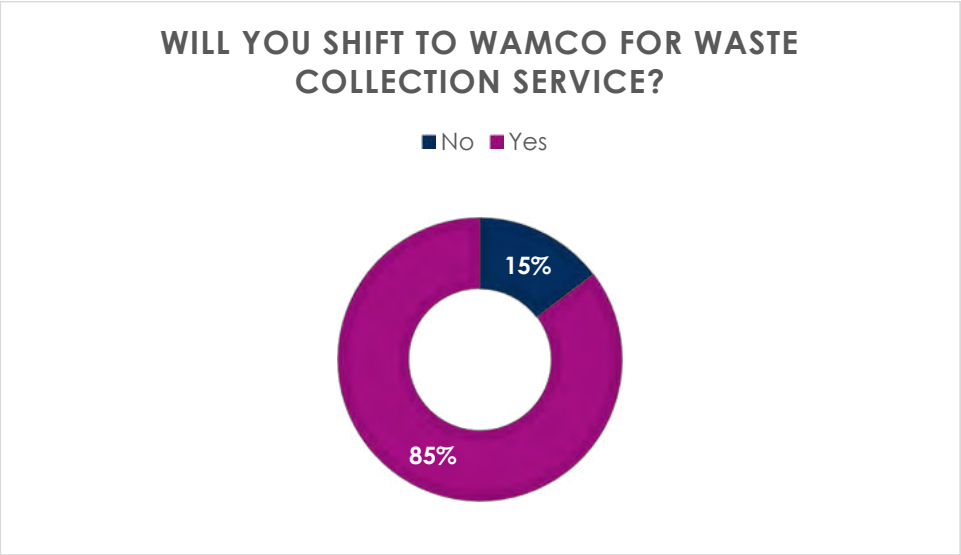
**B20. Will you pay for improved solid waste disposal including door collection, transportation and waste processing?**




**B21. If yes to B20, how much would you be willing to pay for improved waste collection and waste management services?**

| Amount in MVR | Sum of Count |
|---|---|
| <0 or (blank) | 19 |
| 0-499 | 3 |
| 500-999 | 3 |
| 1000-1499 | 4 |
| 1500-1999 | 1 |
| 2000-2499 | 2 |
| 5000-5499 | 2 |
| 39500-40000 | 1 |
| **Grand Total** | **35** |

**B22 and B23. Will you shift to WAMCO for waste collection service?**



## B24. What are the socio-economic problems face by your employees? Any other suggestions/ comments?

| | Island Name | Company Name | What are the socio-economic problems faced by your employees? Any other suggestions or comments? |
|---|---|---|---|
| 1 | Thilafushi | Villa Hakatha | No comments |
| 2 | Thilafushi | Villa Hakatha F n B | Conduct surveys annually to assess |
| 3 | Thilafushi | Batch construction PVT LTD | Health issues |
| 4 | Thilafushi | Wheel pvt ltd | No comments |
| 5 | Thilafushi | Mtcc | No comments |
| 6 | Thilafushi | IZ | No water and electricity |
| 7 | Thilafushi | Eve garment | No comments |
| 8 | Thilafushi | Leo trading | No comments |
| 9 | Thilafushi | Sony hardware | Yes. Food services are not so good, no regulations on road safety, parking |
| 10 | Thilafushi | Lafarge Maldives | No comments |
| 11 | Thilafushi | MALDIVE GAS | No comments |
| 12 | Thilafushi | WAMCO | No comments |
| 13 | Thilafushi | Mpl thilafushi | Heard about possible other issues. But no choice. Need to work here |
| 14 | Thilafushi | Dhamas | Infrastructure, roads, no lights at night. No security fo vehicles, parking space, abandoned vehicles, rule of law and order. |
| 15 | Thilafushi | Nalahiya trahiya trading pvt ltd | Healh services only recently established, road conditions |
| 16 | Thilafushi | Maldives Structural Product MSP | Ferry schedule regularly; taxi services; garbage per tonne of the lorry |
| 17 | Thilafushi | Raajje logistics pvt ltd | Waste disposal while transferring loads |
| 18 | Thilafushi | Leo Trade | Smoke I inhalation is their main problem, no proper sewage, poor road conditions during rainy season |
| 19 | Thilafushi | Sunfront | Waste disposal into the sea can be quite problematic as difficult for boats to come near the jetty for loading n unloading goods |
| 20 | Thilafushi | Static company (aqua reef) | Mainly smoke inhalation is their main concern |
| 21 | Thilafushi | The Hawks | Fighting;Illegal ppl; drinking; Banking problem; emergency ferry/boat system;;emergency med |
| 22 | Thilafushi | Metco | No comments |
| 23 | Thilafushi | Thilafalhu cafe | No comments |
| 24 | Thilafushi | Heavy Force | Smoke, roads, emergency transport |
| 25 | Thilafushi | Antrac (maldives petroleum | No electricity no water or sewage system at the present moment, the road conditions are bad, staff live in newly reclaimed land area and no electricity from main grid is not available, company provides generators and water is carried to site for staff to use. Smoke from burning waste is the main issue. |
| 26 | Thilafushi | Gulf craft | Waste gets washed from the ocean into our facility. Seasonal problems are there, during one season flies would be a hazard. During some days smoke is so thick the person standing next to you is not visible. |
| 27 | Thilafushi | Maldives police services | Nil |
| 28 | Thilafushi | Best dives ptv ltd | Nil |
| 29 | Thilafushi | Build Maldives Company | No infrastructure, road lights, road building not provided |
| 30 | Gulheefalhu | Stelco | Ferry timing a d the transportation is quite difficult |
| 31 | Gulheefalhu | GMIZ | Wamco to pick garbage twice monthly |
| 32 | Gulheefalhu | Litus | No comments |
| 33 | Thilafushi | Apollo | Waste management is a hazard! The governemnt should solve it as soon as possible |
| 34 | Thilafushi | GMIZ | Waste management is a hazard; WAMCO should not charge government for waste management as they have been allocated a plot of land; maybe a nominal fee; drug and prostitution was a problem but not that we have Police and they are patrolling 24/7 problems are minimised; should be given risk allowance for people working here |

| |
|---|
| Republic of Maldives |
| Ministry of Environment and Energy |
| Consultancy Services for Feasibility Study for an Integrated Solid Waste Management System for Zone III (including Greater Male') and Preparation of Engineering Design of the Regional Waste Management Facility at Thilafushi |
| |
| Saafu Raaje Zone III Integrated Waste Management System |
| Environmental and Social Impact Assessment for the Regional Solid Waste Management Facility (RSWMF) Thilafushi |
| Chapter on Air quality (2nd revision of 18.09.2019) |

| | |
|---|---|
| Date: | 18/09/2019 |
| Prepared by: | Ahmed Jameel |
| Checked by: | Chakir Kasdarli |

Revision History

| Revision | Details | Date | Initial |
|---|---|---|---|
| 01 | Completion of section 7.4 and 9 | 12/09/2019 | AJ |
| 02 | Revised version after ADB comments of 16.09.2019 | 18/09/2019 | AJ |
| | | | |
| | | | |
| | | | |
| | | | |

Disclaimer:

This report has been prepared by Water solutions and Kocks Consult GmbH with all reasonable skill, care and diligence within the terms of the Contract with the client. Water solutions and Kocks Consult GmbH disclaims any responsibility to the client and others in respect of any matters outside the scope of the above.

This report is confidential to the client and the Consultant accepts no responsibility of whatsoever nature to third parties whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.

# TABLE OF CONTENT


1 Introduction ..... 1
2 Scope of work ..... 2
2.1 ToR for air modelling consultant 2
3 Policy and Guidance ..... 3
3.1 National legislation 3
3.2 European legislation 6
3.3 German legislation (as basis for the ADM) 7
3.4 Guidance note 8
4 Methodology ..... 11
4.1 Ambiant air quality/Existing conditions 12
4.2 Air dispersion modelling (ADM) 17
4.2.1 Rationale ..... 17
4.2.2 Comparaison AUSTAL2000 vs AERMOD ..... 17
4.2.3 Comparaison AUSTAL2000 vs CALPUFF ..... 18
4.2.4 Conclusion ..... 18
4.2.5 Grid ..... 19
4.2.6 Potential sensitive locations/Assessment points ..... 19
4.2.7 Level of uncertainity ..... 19
4.2.8 Meteorology ..... 19
4.2.9 Topography ..... 26
4.2.10 Building effects ..... 27
4.2.11 Emissions ..... 28
5 Assessment criteria ..... 29
5.1 Criteria to protect human health 29
5.2 Criteria to protect ecological sites 30
6 Determination of significance of effects ..... 31
7 Baseline conditions ..... 31
7.1 Project location (Macrolocation) 31
7.2 Project location (Microlocation) 36
7.3 Component of the WtE facility 38
7.3.1 Stack height ..... 40
7.3.2 Coolling system ..... 41
7.3.3 Bottom ash treatment ..... 41
7.3.4 Residual waste landfill ..... 41
7.3.5 Electricity generation ..... 42
7.3.6 Layout arrangement ..... 43
7.4 Ambiant Air quality/Baseline survey 43

7.4.1 Air Quality baseline survey AQ 1 (Thilafushi workers camp).....45
7.4.2 Air Quality baseline survey AQ 2 (Thilafushi 2, new reclaimed area) 46
7.4.3 Air Quality baseline survey AQ 3 (Thilafushi 3, Opposite of dumpsite).....47
7.4.4 Air Quality baseline survey AQ 4 (Vilingili).....50
7.4.5 Interpretations of the results.....50
8 Identification and assessment on potential effects.....51
8.1 General emission 51
8.1.1 Emission mass flow.....51
8.1.2 Control of the necessity of the dispersion calculation .....52
8.2 Air dispersion modelling for relevant parameter 54
8.3 Maximum ground level/Additional load 59
8.4 Interpretation of the results with respect to baseline conditions 70
9 Conclusions .....72
References .....74

# List of Figures

Figure 1: Air Quality monitoring station with two Aeroqual Series 500 monitors ..... 13

Figure 2: Location of Ambiant air quality monitoring station (Source Google earth) ..... 16

Figure 3: Long term average rainfall for the central atolls (Source: Maldives Meteorological Service, 2016) ..... 20

Figure 4: Spatial distribution of wind speed and directions from 1986-2016 (Source: LHI, 2018) ..... 23

Figure 5: Directional Distribution of Wind Statistics (% Occurrence for Wind Speed vs. Wind Direction) ..... 24

Figure 6: average Wind rose over project location ..... 25

Figure 7: areal picture of reclaimed area for WtE Facility ..... 27

Figure 8: tentative Location of the WtE, the stack (square) and the genset (circle) ..... 28

Figure 9: Project location (macro-location) [Source Google Earth] ..... 32

Figure 10: Project location (Meso-location, distances from tentative stack location of the WtE) [Source google Earth] ..... 33

Figure 11: land use plan [developed by given land use plan and Google Earth Image] ..... 35

Figure 12: Project location (micro-location) ..... 37

Figure 13: schematic layout of the WtE Facility ..... 39

Figure 14: View around AQ4 (Villingil) on 3rd March 2019 ..... 43

Figure 15: Air quality monitoring at location AQ1 on 19rd March 2019 ..... 44

Figure 16: Air quality monitoring at location AQ3 on 20th August 2019 ..... 44

Figure 17: View around AQ2 (Thilhafushi) on 25th August 2019 ..... 45

Figure 18: graphical presentation of survey results for $SO_2$ at AQ3 ..... 49

Figure 19: graphical presentation of survey results for $PM_{2,5}$ and $PM_{10}$ at AQ3 ..... 49

Figure 19: Location of the emission points where maximum load was calculated and examined ..... 57

Figure 20: additional load Mercury-Deposit from the dispersion model. ..... 61

Figure 21: PM-Deposit from the dispersion model. ..... 62

Figure 22: F-Deposit from the dispersion model. ..... 63

Figure 23: $SO_2$-Deposit from the dispersion model. ..... 64

Figure 24: NOx-Deposit from the dispersion model. ..... 65

Figure 25: Pb-Deposit from the dispersion model. ..... 66

Figure 26: Ni-Deposit from the dispersion model. ..... 67

Figure 27: Tl-Deposit from the dispersion model. ..... 68

Figure 28: Cd-Deposit from the dispersion model. ..... 69

Figure 29: As-Deposit from the dispersion model. ..... 70

# List of Tables

Table 1: Locations for ambient air quality monitoring ..... 13

Table 2: Immission rate/ambient air concentration values and irrelevant values according Nr. 4.2 of the TA Luft ..... 30

Table 3: Immison rate/ambient air concentration values and irrelevant values according Nr. 4.3 - 4.5 of the TA Luft ..... 30

Table 4: Summary of Thilafushi project location (macro-location ..... 36

Table 5: Summary of project location (Micro-location WtE plant) ..... 38

Table 6: Design parameters for Bottom ash treatment plant ..... 41

Table 7: Maximum mass concentration ..... 51

Table 8: Emission mass flow (for R = 115 713 m³/h, T = 180 °C, Ø = 2.12 m) ..... 51

Table 9: Minor mass flow according 4.6.1.1 TA Luft and WtE mass flow ..... 52

Table 10: Minor mass flow according to Section 4.6.1.1 TA Luft - system mass flow ..... 54

Table 11: Emissions Stack WtE ..... 56

Table 9: Ambient air quality points ..... 59

Table 10: Ambient air quality additional charge (IZ) (including statistical uncertainty) ..... 59

## List of Annexes

| | |
|---|---|
| ANNEX 1 | |
| ANNEX 2 | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

# List of units, abbreviations and acronyms

| Abbreviations and acronyms | |
|---|---|
| ADB | Asian Development Bank |
| ADM | Air dispersion modelling |
| AQMA | Air Quality Management Area |
| AQO | Air Quality Objective |
| As | arsenic |
| Cd | cadmium; |
| CO | carbon monoxide |
| Cr | chromium |
| CrVI | chromium VI |
| Cu | copper |
| DBO | Design-Build-Operate |
| GOM | Government of Maldives |
| GM | Greater Male’ |
| EAL | Environmental Assessment Level |
| ELV | Emissions Limit Value |
| EU | European Union |
| HCl | hydrogen chloride |
| HF | hydrogen fluoride |
| Hg | mercury |
| HSE | Health, Safety, Environment |
| IED | Industrial Emissions Directive |
| IFC | International Finance Corporation |
| IWM | Integrated waste management |
| MOE | Ministry of Environment |
| MSL | Mean Sea Level |
| MSW | Municipal Solid waste |
| NH3 | ammonia |
| Ni | nickel |
| NO2 | nitrogen dioxide |

| | |
|---|---|
| NOx | nitrogen oxides |
| Pb | lead |
| $PM_{10}$ | fine airborne particulate matter with an aerodynamic diameter of less than 10 micrometers |
| $PM_{2.5}$ | fine airborne particulate matter with an aerodynamic diameter of less than 2.5 micrometers |
| RSWMF | Regional Solid Waste Management Facility |
| Sb | antimony |
| SBD | Standard Bidding documents |
| SO2 | sulphur dioxide |
| SWM | Solid Waste Management |
| TA Luft | First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control in the following document as *"TA Luft"* |
| TOC | Total Organic Carbon |
| TPD | Tonnes Per Day |
| V | vanadium |
| VDI | Verein Deutscher Ingenieure (German Engineer Association) |
| VOCs | Volatile Organic Compounds; |
| WHO | World Health Organisation |
| WTE | Waste to Energy |
| Units | |
| µm | micrometre: 1 µm = 0.001 mm |
| mm | millimetre: 1 mm = 0.001 m |
| m | metre: 1 m = 0.001 km |
| km | kilometre |
| $m^2$ | square metre |
| ha | hectare: 1 ha = 10,000 $m^2$ |
| l | litre: 1 l = 0.001 $m^3$ |
| $m^3$ | cubic metre |
| ng | nanogram: 1 ng = 0.001 µg |
| µg | microgram: 1 µg = 0.001 mg |
| mg | milligram: 1 mg = 0.001 g |

| | |
|---|---|
| g | gram: 1 g = 0.001 kg |
| kg | kilogram: 1 kg = 0.001 Mg (t) |
| Mg | megagram (same as t: tonne) |
| s | second |
| h | hour |
| d | day (calendar day) |
| a | year |
| °C | degrees Celsius |
| K | Kelvin |
| Pa | pascal: 1 Pa = 0.01 mbar (millibar) |
| kPa | kilopascal: 1 kPa = 1,000 Pa |
| MPa | megapascal: 1 MPa = 1,000,000 Pa |
| kJ | kilojoule |
| kWh | kilowatt hour: 1 kWh = 3,600 kJ |
| MW | megawatt |
| OU | odour unit |
| OU/m3 | odorous substances concentration |
| LU | livestock unit (1 livestock unit equals an animal live weight of 500 kg) |

# Glossary

| | |
|---|---|
| Immissions | Immissions shall be air pollutants affecting humans, animals, plants, soil, water, the atmosphere, cultural assets and any other property.<br>Immissions shall be indicated as follows:<br>a) Mass concentration, as mass of air pollutant per unit volume of polluted air; for gaseous substances, mass concentrations are to be referenced to 293.15 K and 101.3 kPa.<br>b) Deposition, as mass of pollutant per unit area of ground per unit time.<br>Synonym of immission : Ambient air quality |
| Immission Indicators, | Immission indicators describe the initial load, the additional load or the total load of the respective air pollutant. The initial load shall describe the pre-existing load of a pollutant. The additional load shall characterise the concentrations, which can be expected to be caused (for planned installations) or which are actually caused (for existing installations) by the planned project. With respect to planned installations, the indicator for the total load shall be calculated on the basis of the initial load plus the additional load indicators. With respect to existing installations, this indicator equals the initial load. |
| Assessment Points, | Assessment points shall be those points in the vicinity of an installation for which immission indicators, indicative of the total load, are determined. |
| Grid Points | Grid points shall be those points in the vicinity of an installation for which the additional load is calculated (immission projection). |
| Immission Values also known as immission rate or ambient air values | The annual immission value shall be the concentration or deposition value of a substance averaged over one year.<br>The daily immission value shall be the concentration value of a substance averaged over one calendar day, taking into account the respective frequency limit for excess values (number of days) over one year.<br>The hourly immission value shall be the concentration value of a substance, averaged over a whole hour (e.g., from 8 a.m. to 9 a.m.), taking into account the respective frequency limit for excess values (number of hours) over one year. |
| Waste Gas Volume and Waste Gas Volumetric Flow Rate | Waste gases shall be carrier gases with solid, liquid or gaseous emissions. any data regarding the waste gas volume and the waste gas volumetric flow rate are referenced to standard conditions (273.15 K and 101.3 kPa) after subtraction of the water vapour content unless explicitly indicated otherwise |
| Emissions | Emissions shall be air pollutants originating from an installation.<br>Emissions shall be indicated as follows:<br>a) mass of substances or groups of substances emitted as related to the volume (mass concentration)<br>aa) of waste gas under standard conditions (273.15 K and 101.3 kPa) after subtraction of the water vapour content,<br>bb) of waste gas (wet) under standard conditions (273.15 K and 101.3 kPa) before subtraction of the water vapour content,<br>b) mass of substances or groups of substances emitted per unit time as a mass flow (emitted mass flow); the mass flow is the total emission occurring in one hour of normal operation of an installation under operating conditions which are most unfavourable to the maintenance of air quality; |

| | |
|---|---|
| | c) quantity of fibres emitted (fibre dust concentration), as related to the volume of waste gas under standard conditions (273.15 K and 101.3 kPa) after subtraction of the water vapour content;<br>d) ratio of the mass of emitted substances or groups of substances to the mass of products generated or processed or to stocking density (emission factor); the mass ratio shall take into account the total emissions from the installation occurring over one day of normal operation of such installation under operating conditions most unfavourable to the maintenance of air quality;<br>e) amount of Odour Units of odorous substances emitted, as related to the volume (odorous substances concentration) of waste gas at 293.15 K and 101.3 kPa before subtraction of the water vapour content; the odorous substances concentration is the olfactometrically-measured ratio of volume flows when diluting a waste gas sample with neutral air down to the odour threshold, indicated as a multiple to the odour threshold. |
| Emission Ratio | The emission ratio shall be the ratio of the mass of an air pollutant emitted in waste gas to the mass of supplied fuels or input materials; it shall be provided as a percentage. |
| Emission Reduction Ratio | The emission reduction ratio shall be the ratio of the mass of an air pollutant emitted in waste gas to its mass supplied in crude gas; it shall be provided as a percentage. The odour reduction ratio is an emission reduction ratio. |
| Emission Standards and Emission Limits | Emission standards shall provide the basis for emission limits. The emission limits shall be established in the letter of permit or in a subsequent<br>order as<br>a) permissible fibre dust, odorous substances or mass concentrations of air pollutants in waste gas provided that<br>aa) any daily mean values do not exceed the established concentration level and<br>bb) any half-hourly mean values do not exceed twice the established concentration level,<br>b) permissible mass flows, as related to one hour of operation,<br>c) permissible mass ratios, as related to one day (daily mean values),<br>d) permissible emission ratios, as related to one day (daily mean values),<br>e) permissible emission reduction ratios, as related to one day (daily mean values), or<br>f) any other requirements to provide precaution against harmful effects of air pollutants on the environment. |

## Consultation/Comments & answers matrix

Following the ADB mission held in Male' between the 04-08.08.2019 the following questions and comments have been addressed to the consultant:

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| AQ1 | Need for robust baseline data to inform air quality modelling and to confirm airshed status | (new comments) | Update: Further air quality monitoring is reported as being currently in progress ('Air quality and air dispersion modelling report 190828' page 41), which is welcomed. The measurements made during this period should be analysed and assessed against the relevant limit values to determine background conditions and whether the location should be treated as a degraded airshed. | Please see updated Chapter 7.4. It could not be clearly determined whether the location should be treated as a degraded airshed or not. The site is clearly influenced by the adjacent dumpsite and its open burning. (see Chapter 7.4) |
| AQ2 | Impact of the proposed facility on air quality | (new comments) | Update: AQ2 comments remain valid. The new report 'Air quality and air dispersion modelling report 190828' is unfinished, but does not refer to the EHS requirement for the contribution from a facility to account for less than 25% of the air quality standard/guideline. When baseline air quality data are available, the assessment results should be reinterpreted in the light of these requirements. | Please see Chapter 8.4. It is obvious that new facilities emissions are far below the EHS requirements. The main problematic is the ambient baseline condition which is mainly influenced by the dumpsite and which contributes to a temporary degraded airshed. |
| AQ3 | Required assessment of average emission limit values for heavy metals | (new comments) | Update: these substances are now all listed in Table 6 (p44). These substances have been considered in the assessment, at least at the preliminary screening stage. The assessment states (p51) that "In the calculation, the heavy metal nickel was considered representative of the group of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel". The reason for limiting the assessment to nickel is not explained. The assessment for all substances listed above should be clearly set out.<br><br>The new report also states that: 'For ammonia and hydrogen chloride (5.2.4 Class III TA Luft), for carbon | For the calculation at the assessment point the emission value for Nickel was considered as 0,5 mg/m³ which is the emission threshold value for all heavy metals (Antimony, chromium, copper, margan, vanadium, tin, lead, cobalt and nickel) which means we are considering a worst case. |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| | | | monoxide, for organic substances (expressed as total C) as well as dioxins and furans no minor mass flow are set in the regulations therefore there is no need to undertake a detailed dispersion modelling for these parameters either.' These substances should in principle be included in the assessment. It is likely that no significant impacts would be identified for ammonia or hydrogen chloride. However, emissions of dioxins and furans should be modelled and, as a screening approach, evaluated against the WHO guideline of Air concentrations of 0.3 pgTEQ/m3 which is used to identify local emission sources that need to be identified and controlled | |
| AQ4 | Confirmation of stack height | (new comments) | The revised assessment confirms the proposed stack height of 50 metres, which would be adjacent to a building of height 43 metres. This appears to be relatively low for a facility of this nature. AQ4 remains valid. | This comment is wrong. The building height is 30 m (and not 43 m). There is no reference in the report that the building is 43 m high. The statement relatively low is not clear enough. If ADB experts has another formula how to calculate the stack height than please do it and provide us with a clear height |
| AQ5 | Reliability of model results | (new comments) | The new report 'Air quality and air dispersion modelling report 190828' states: 'The results have been checked again and are considered as right and robust. The model used is a state of the art, accepted model by the German Ministry of Environment. It reaches it best performances in flat environment and poor database which is the case in the Maldives. The comparison with plants in the UK which has provenly different ambient and environmental conditions could not be considered as appropriate.' The consultant is correct: the situation in the Maldives is different to the UK, and different dispersion characteristics would be expected. However, our experience is based on the use of ADMS | The Consultant is unable to run another model as the one presented in this report. As far as there is no mandatory requirement to use AERMOD or ADMS in the national ToR as well in the EHS guidelines, the consultant estimate to use an internationally recognized ADM. Rationale for using this model has been presented. |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| | | | and AERMOD for modelling assessments worldwide, not just in the UK. This comment remains valid.<br><br>In the context of assessing mercury, the report states "[As] pre-pollution with air pollutants at the site is not known (baseline), so it is assumed that the calculated values represent the total load." This seems to imply that the assessment has been carried out by assuming that there is no baseline contribution due to mercury. This is not a conservative approach to the assessment, and the assessment should take account of baseline levels of air pollutants. | This text has been changed. The additional represents the "process contribution" from the WtE. Considering this source as a single standing source, the results from the calculations shows that increase of pollutants in the atmosphere is far below the requirements of IFC. The combination of process contribution and baseline unfortunately not (for the parameter PM, $SO_2$, $NO_2$). This is mainly related to the influence of the dumpsite. |
| AQ6 | Calculation of emission mass flows for nitrogen oxides (nitrogen monoxide and nitrogen dioxide), specified as nitrogen dioxide | (new comments) | Further clarification has been provided which indicates that there may be a further factor of 90% involved in calculating nitrogen dioxide concentrations. This is not clearly explained, and does not account for the discrepancy, but the difference is small and not likely to significantly affect the study conclusions. | OK |
| AQ7 | Responses provided to questions from ADB Experts | | | |
| 1 | Air quality assessment to be undertaken following international good practice, for which ADB would usually refer to IFC EHS Guidelines. Since German approach has been utilized and ADB is not familiar with this, it needs to be demonstrated how this is consistent with international good practice, notably in stack height calculation, scoping out potential air quality impacts, and in terms of the dispersion model used, the EIA should also include the justification for using the German approach | See Chapter 4 "Methodology" | The report explains the background to the German method, but does not relate this to the IFC EHS methodology which is specified for use in the ADB Safeguard Policy Statement (2009). See AQ1 and AQ2 above. | It is not very clear for the consultant, what the ADB experts wants more. Concerning AQ1 and AQ2 we completed the report accordingly. The German approach does not differs from other approaches which is :<br><br>• Considering Regulatory requirements (in this case due to non availability of Maldivian regulation, we used German regulations and International standards |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| | | | | • Significance of the source (detailed description of WtE facility was provided in the document<br>• Location of the emitting facility relative to other sources (Macro, Meso and Microlocation presented)<br>• Location of sensitive receptors (done)<br>• Existing ambient air quality, and potential for degradation of the airshed from a proposed project (The airshed is allready temporary degraded due to the dumpsite and is tending to be better after the dumpsite closure)<br>• Technical feasibility and cost effectiveness of the available options for prevention, control, and release of emissions (part of the complete EIA) |
| 2 | in any case, as ADB is used to seeing assessments undertaken against terminology of IFC EHS Guidelines, the results of German approach should be presented in that context in EIA and avoid using German specific terminologies. | Whether it was possibly terminology has been harmonized additional glossary was presented on page 1-2 | The glossary is useful, but terminology has not been harmonized. E.g. sections 8.1.2 and 8.2.1.2 use the German terminology throughout. | Terminology has been harmonized. Whether it was not possible to use another terminology the glossary can be used. |
| 3 | Specifically German approach ambient air quality standards are based on WHO interim targets, rather than the WHO | For baseline assessment table 1.1.1 of IFC HSE guidelines (WHO guidelines was used) for emission values German | The WHO guidelines or EU standards should be used throughout the assessment (not just for baseline assessment) rather than using the approach based on | The German standards are mainly similar to EU standards, for certain parameters even more stringent. |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| | guidelines; the EIA is to also discuss results in context of latter. | standards have been used which are more stringent than EU IED standards presented in the IFC EHS sector guidelines for MSW treatment facilities (see Chapter 4 "metjodology) | German standards. See also AQ2 Reference to emission standards is not relevant | |
| 4 | The status of the airshed does need to be reported, for this baseline ambient air quality monitoring at Thilafushi is required | Thilafushi Island airshed is actually highly influenced by the uncontrolled burning of the illegal dumpsite. Once the dumpsite fires have been stopped (latest with the operation of the WtE), there is no further emission source like the dumpsite. The fires and smokes are temporary and with actual basline aire monitoring no significant pollution has been detected. If there was a similar source (after extinguishing the fires on Thilafushi) the concerns about the degraded air-shed would be reasonable. Actually on Thilafushi the dispersion of any potential pollutant that yet may be produced is unrestricted. | Report is incomplete.<br><br>The issue of open burning can be addressed when considering the results of baseline air quality monitoring.<br><br>The report could explain why baseline levels are considered likely to be negligible: this would need to take account of existing industrial and other activity in the local area. | Based on the updated baseline chapter and its results we did an assessement of the airshed. Baseline monitoring have been done on 4 locations at 3 different periods:<br>• June 2018<br>• March 2019<br>• August 2019<br><br>Covering main parameters as per ToR with a monitoring and recording frequency which able to develop baseline parameters comparable to WHO guidelines for ambient air quality.<br><br>See chapter 7.4 |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| 5 | Monitoring should include $NO_2$, $SO_2$, $PM_{10}$ and $PM_{2.5}$ as well as all parameters listed in national TOR including $CH_4$, CO, Cd, Pb, Hg, HC which do not yet appear to have been monitored (or it needs to be explained why the cannot be, but if mercury has more than negligible impact it should have baseline). | | | $NO_2$, $SO_2$; $PM_{10}$; $PM_{2,5}$ done at all survey points. $CH_4$, CO done at selected survey points. Pb, Cd, Hg and HC could not be done due to the non-availability of adequate equipment. Additional paramaters done : $CO_2$, $H_2S$<br>See Chapter 7.4 |
| 6 | Monitoring should enable the ambient air quality to be clearly established by reference to WHO guidelines: 1 hour averages for $NO_2$, 10 minute and 24 averages for $SO_2$, and 24 hour averages for $PM_{10}$ and $PM_{2.5}$. Monitoring program should be done over a period of two weeks, i.e. not just a one off and undertaken in different seasons (second season can be added to EIA at later date) to reflect changes in wind direction etc. | Done see page 42. | Report incomplete | Done see Chapter 4 methodology and Chapter 7.4 Baseline |
| 7 | The ambient air quality data already collected needs to be adequately presented with averaging period, units etc.They also need to be compared to the WHO guidelines to determine if the airshed is degraded. | Done see page p 42 | Report incomplete | Done see Chapter 7.4 Baseline |
| 9 | The assessment to include consideration of all the parameters in the EU IED even if it is just to scope out they have a negligible impact | Done | All pollutants now included. Assessment of metals needs to be further explained; assessment of dioxins & furans is required. See AQ3. | |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| 10 | Under German approach, mercury is reported to have more than a negligible impact. It needs to be clarified why in terms of input data used, ideally to support that WtE is clean technology preferable if mercury levels were negligible. It may raise concerns why mercury is flagged, as perhaps it relates to burning of unsegregated hazardous waste? | The 17th ordinance for the implementation of the Federal Immission control Act (Ordinance on Incineration Plants for municipal waste and similar combustible cubstances) has defined an maximum emission value of 0,03 mg/m³. This value is monitored and controlled at the stack To respect this value active carbon is used in the flue gas cleaning in order to deposit the mercury. The problematic with mercury is that it is difficult to identify the source in the waste. Therefore it is a venture that the mercury is provided by hazardous waste. With the maximum flue gas volume flow and maximum allowed mercury concentration we have a mass flow which is over the threshold value. Therefore an air dispersion model is needed (made with Astral200). This was made an the expert (sub-contractor) came to the conclusion that there is | Provided issues with the air quality assessment can be addressed (AQ1, AQ2, AQ4, AQ5), the evaluation of mercury is acceptable. | OK |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| | | no critical additional pollution | | |
| 11 | Consultant has modelled the parameters in Table 10, whilst not required under German legislation it is important to ADB the EIA clearly demonstrates the air quality impacts of the WtE plant on a spatial basis and, given what is currently degraded airshed, that maximum project contribution impact is not significant. Thus dispersion plots for all the modelled parameters should be provided, | Done | The assessment does not clearly demonstrate the air quality impacts of all pollutants: see comments AQ1 to AQ6 above.<br><br>Dispersion plots were provided for some parameters: these are a mix of airborne concentration and deposition plots. | Please precise what ADB experts understand under "clearly". The assessment is saying that parameters below minor mass flow have a negligible impact, for those over the minor mass flow an ADM has to be conducted to see "the dispersion effect" of this parameter and consequently its impact. Dispersion plots have been provided upon request of the ADB expert after on site mission. Most of the plots show clearly that the impacts are low at the receiving sensitive points |
| 12 | Also confirm the maximum ground level concentration (additional load in German terms) that the model has predicted. Note the maximum ground level concentration may not be at the same location as ANP1 receptor point included in the model by consultant. The dispersion modelling is required by the national TOR. | Ambiant air quality baseline measures have not been done actually for Mercury.<br><br>ADB is right that maximum ground level concentration may not be at the same location as ANP 1. On the ANP1 we have factories with people working 8-10 h permanetly exposed to hazards.<br><br>On our experts opinion it makes less sense to undertake an extensive Mercury baseline survey:<br><br>Actually Mercury is released in a diffuse form | This comment refers to model outputs, not to ambient air quality measurements. The consultant's response does not address the question. | We confirm these figures as it was mentioned in the report received from our sub-consultant. If ADB experts identified a mistake then please advice then we could check with the data set. But a first cross check does not show any discrepancies |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| | | from the old dumpsite on fire. This releasing will be stopped as soon as the dumpsite is closed and rehabilitated.<br><br>Mercury baseline surveys are complex and costly because of the surveying of vaporous gaz and of particle-bound mercury. In order to meet the requirements of ADB it is necessary to have a narrow mesh of measurement points. Also the analytics is very expensive. | | |
| 13 | Confirm the basis for 8,000 hours operation, as 8,200 hours availability is also mentioned. Is it possible it could operate for more hours? Though WtE plant will not operate all the time, dispersion modelling is usually done for 8,760 hours since it is not known exactly which days of the year (under what met conditions) will be operational or not. | We confirm that ADM was made on the communicated operation hours of 8,000 hrs. There are mandatory yearly revisions imposed to the contractor so it is not expected that it could be operated longer | The response addresses the question, and confirms that the assessment is not conservative in respect of operating hours. This should be taken into account when interpreting the results. | The WtE facility needs mandatory yearly revision and maintenance time where the facility is shut down or working partially. These are mandatory requirements to the DBO contractor. So it is almost impossible that the WtE facility will operate at all thime and therefore a realistic operation time of 8,000 is considered as realistic for the conclusion of the outcome of this report |
| 14 | The consultant needs to check the results of the model, as per our technical advisor the emissions of $NO_2$, $SO_2$ and $PM_{10}$ appear to be relatively low for a WtE plant of this scale. At the minute the impacts are not significant, but this raises a concern they have been underestimated. Need to confirm the | The results have been checked again and are considered as right and robust. The model used is a state of the art, accepted model by the German Ministry of Environment. It reaches | The consultant is correct: the situation in the Maldives is different to the UK, and different dispersion characteristics would be expected. Our experience is based on the use of ADMS and AERMOD for modelling assessments worldwide, not just in the UK. Our comment AQ5 remains valid. | There are more than 140 models developed and accepted only in Europe.<br><br>As per National ToR and also as per IFC performance standard it is not mandatory to use a specific ADMS or AERMOD. As a German consultants we have used Austal 2000 which is the |

| N° | ADB experts Comments | Answer/Reference after 1st draft comments | Comments of ADB expert team (Ricardo) from 16.09.2019 | Consultant's answers |
|---|---|---|---|---|
| | model inputs are appropriate and were correctly inputted and why model concentrations can be considered as robust. This issue may relate to either input data or the type of model used which does not follow same principles as more frequently used ADMS or AERMOD. | it best performances in flat environment and poor database which is the case in the Maldives. The comparaison with plants in the UK which has provenly different ambient and environmental conditions could not be considered as appropriate | | official reference model of the German Regulation on Air Quality Control, listed as an accepted model by the European Environment agency and the 11th International Conference on Harmonization within Atmospheric Dispersion Modeling for Regulatory Purposes, held in Cambridge, England.<br><br>The model is considered as robust and has been runned two times.The model running (including additional parameters) costs 8,000 EUR. The consultant cannot afford to use a second model for consistency check anymore. If ADB experts are not convinced about the results we suggest to engage a special consultant for consistency check with AERMOD or other ADM model |

# AIR QUALITY REPORT WtE THILAFUSHI

# 1 Introduction

The ambient air quality status of Maldives is currently unknown due to the lack of monitoring data. It is generally considered good as the sea breezes flush the air masses over the small the islands. However rapid urbanization and economic growth in the recent years has shown noticeable changes in the air quality, particularly in the Male' region. Aside from the increased land and sea vessels, diesel power generation, and construction, open burning in Thilafushi is also a significant source of air pollution in the region.

The proposed WtE Facility will treat approximately 500 TPD of municipal waste (Household waste and similar to Household waste) based on the estimated throughput at design point, generating as a "by-product", electricity. This air quality repor for the proposed facility was carried out as follows:

a) Outline review of the policy context for air quality.
b) Assessment of baseline air quality
c) Identification of potentially sensitive locations
d) Calculation of the minimum stack height
e) Identification of potential parameters which needs a more detailed dispersion modelling
f) Evaluation of forecast levels of released substances against relevant standards, guidelines, critical levels and critical loads
g) Dispersion modelling study of emissions to forecast air concentrations and deposition rates at potentially sensitive locations
h) Conclusions

The main focus of the air quality assessment was the evaluation of modelled levels against relevant standards and guidelines. Levels of relevant substances were forecast at sensitive receptors to enable an assessment of the effects on air quality with regard to human health risks and environment to be evaluated.

As the Maldives did not have a wide range of air quality survey network, therefore baseline assessment have been done through temporary field measures.

The proposed development is forecast to have no significant effects on air quality during abnormal operating conditions or due to road traffic emissions, and no significant cumulative effects are forecast to occur. No amenity issues such as odours or dusts would be expected to arise outside the site boundary, and emissions to air from the proposed facility are forecast to have no significant effects on the local environment.

The proposed facility will have no significant adverse effects on air quality. Consequently, it was concluded that no further mitigation is necessary, other than the extensive mitigation and control measures already built into the proposed facility.

# 2 Scope of work

## 2.1 ToR for air modelling consultant

For this special purposes of establishing a detailed and reliable air quality report (as part of a complete EIA), Water solutions and Kocks Consult GmbH hired The Engineer Company Ulbricht GmbH from Germany a specialised consultant in the field of environmental consultancy, permitting procedures and noise abatement.

The scope of work was to undertake:

- the stack height calculation
- The calculation and assessment of air pollutants emission

According First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control – TA Luft).

For the purpose of this work Water Solutions and Kocks Consult GmbH have submitted the following documentation to the consultant

[1] The emission values according Industrial Emissions Directive (IED) (2010/ 75/ EU, 2010) and 17th Ordinance for the implementation of the Federal Immission control Act (Ordinance on Incineration Plants for municipal waste and similar combustible cubstances (the more stringent had to be used, dioxins and furans according IED)

[2] The data set for Thilafushi from the National Maldives meteoroligcal service

[3] The dimensioning parameter for WtE, particularly the flue gas cleaning

# 3 Policy and Guidance

## 3.1 National legislation

The proposed SWM project will be governed by the laws of the Government of Maldives and the implementing regulations promulgated in accordance with such laws. As summarized below, the legal and regulatory framework for the protection and preservation of the environment of the Maldives with respect to solid waste management is currently evolving to conform to international standards within the unique context of the Maldivian natural environment. In light of the development of a comprehensive national solid waste management program including establishment of facilities to provide state of the art solid waste disposal, recycling and resource recovery, it is expected that certain existing proposed laws, draft regulations and temporary guidelines concerning solid waste management will be significantly revised and promulgated in binding final form during the course of the project. To the extent that Maldivian laws and regulations become final they shall be binding upon the project proponents superseding analogous standards referenced herein.

At present, Maldives does not have a national air quality policy or a national ambient air quality standard. However there are legislations and programmes to prevent air pollution such as Environmental Protection and Preservation Act (4/93), Draft Waste Incineration Guideline, Concrete Batch Plant Guideline and the Vehicular Emission Standard (MEE, 2017).

### The Environmental Protection and Preservation Act (eppa) 1993

The Environmental Protection and Preservation Act (EPPA) of the Maldives (Law No. 4/93) is an umbrella law that provides statutory powers regarding environmental regulation and enforcement.

The relevant components of the EPP Act 1993 are:

Environmental Guidance

Article (2) The concerned government authorities shall provide the necessary guidelines and advise on environmental protection in accordance with the prevailing conditions and needs of the country. All concerned parties shall take due considerations of the guidelines provided by the government authorities.

Environmental Protection and Conservation

Article (3) The Ministry of Environment shall be responsible for formulating policies, rules and regulations for protection and conservation of the environment in areas that do not already have a designated government authority already carrying out such functions.

Protected Areas and Natural Reserves

Article (4) The Environment Ministry shall be responsible for identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation.

Environmental Impact Assessment

Article (5) (a) An EIA shall be submitted to the Environment Ministry before implementing any developing project that may have a potential impact on the environment.

The EIA process in the Maldives is coordinated by the Environment Protection Agency (EPA) in consultation with relevant government agencies and National Commission for the Protection of the Environment (NCPE). The first step in environmental assessment process involves screening of the project to be classified as one that requires an Initial Environmental Examination (IEE) or one that requires a full Environmental Impact Assessment (EIA). Based on this decision, the Ministry then decides the scope of the EIA which is discussed with the proponent and the EIA consultants in a "scoping meeting". The consultants then undertake the EIA starting with baseline studies, impact prediction and finally reporting the findings with impact mitigation and monitoring plan. The EIA report is reviewed by EPA following which an EIA Decision Note is given to the proponent who will have to implement the Decision Note accordingly. As a condition of approval, appropriate environmental monitoring may be required and the proponent will have to report monitoring data at required intervals to the Ministry.

### Environmental Impact Assessment regulation, 2007

The Environment Ministry issued the EIA Regulation in May 2007, which guides the process of undertaking the Environmental Impact Assessment in the Maldives. This Regulation provides a comprehensive outline of the EIA process, including the application to undertake an EIA, details on the contents, format of the IEE/EIA report, the roles and responsibilities of the consultants and the proponents as well as minimum requirements for consultants undertaking the EIA.

The objective of the Maldivian Environmental Impact Regulations, 2007 is to serve as a decision making tool for stakeholders in assessing the potential significant environmental impacts of a development proposal at the same time providing required guidance in obtaining environmental approval for such projects in the form of Environmental Decision Statement.

The Table of Contents for Initial Environmental Examination or EIA as specified in Schedule E of the EIA Regulations requires the proponent to furnish a detailed description of the natural, economic and human environment. This includes

- description of site characteristics including soil type, relief, landforms, present land use and drainage system
- type of flora and fauna, rare or endangered species, sensitive habitats of ecological importance including wetlands and mangroves
- marine environment including rocky bottom, coral reefs and sea grass beds
- beach systems; composition; stability; current; tide and wave dynamics
- description of surrounding infrastructure including utilities
- socio-economic characteristics including demographic profile, economic activities, housing and utilities, employment statistics and available skills, labour availability, unique cultural characteristics
- other attributes of the locality e.g. amenities and recreational values

The proposed WtE and landfill project is categorized under "Schedule D" list of projects requiring an EIA study.

### Post EIA monitoring, auditing and evaluation

The EIA Regulations 2007 provides a guideline of the environmental monitoring programme that should be included in EIA reports as monitoring is a crucial aspect of the EIA process.

Accordingly, the monitoring programme shall outline the objectives of monitoring, the specific information to be collected, the data collection program and managing the monitoring programme. Managing the monitoring programme requires assigning institutional responsibility, enforcement capability, requirements for reporting and ensuring that adequate resources are provided in terms of funds, skilled staff and the like.

### Solid waste management regulation

The main objective of the regulation is to implement the National Solid Waste Management Policy and through that protect the environment by;

- minimizing the impact of waste on the environment including, in particular, the impact of waste so far as it directly affects human health;
- Establishing an integrated framework for minimizing and managing waste in a sustainable manner; and putting in place uniform measures to seek to reduce the amount of waste that is generated, and where waste is generated, to ensure that waste is reused, recycled and recovered in an environmentally sound manner before being safely treated and disposed.

The regulation also takes note in detail accounts of the following fields in its enactment.

Waste management measures - Waste Management Standards, Plans, Protocols of declaration of priority wastes, Extended producer responsibilities, Prohibition of unauthorized disposal of waste, Littering, Container standards for collection of waste in public places, Waste Collection standards in sea vessels, Waste collection facilities standards in ports, Protocols in Reduction, re-use recycling and recovery of waste, Waste Management activities list and Protocols of restrictions on provision of waste management services.

Waste Management Licenses – Basic requirements for licensing, key standards, the validity period of the license, transfer protocols of a license, protocols for surrendering a license, license fees and governance of a license register.

Transportation of Waste - Duties of personnel transporting the waste, protocols of exporting and transboundary transfer of hazardous wastes, protocols of transportation of waste from one island to another, duties of receivers of waste and accidentals protocols at sea

Monitoring, Inspection , Auditing and Enforcement - Duty to furnish information, duty to reporting, Notice from the Administering Authority requiring a review of activities carried out under a license, Revocation of a license, Defrayal of Administering Authority costs, Register of fines and administrative actions, Inspectors, Establishment of national waste information system, National Waste Management Status Reports.

Clause 18 of this regulation restricts provision of waste management services without obtaining a licence for the following activities:

- Operate a waste management facility
- Operate waste collection and transportation services
- Waste recycling services
- Operation of landfills

### Waste management policy

Former MHTE (Now MoE) has published a National Solid Waste Management Policy for the Maldives. The aim of the waste management policy is to formulate

and implement guidelines and means for solid waste management in order to maintain a healthy environment. The developer shall follow any guidelines /regulations on waste management that the government may introduce.

Waste management during construction and operation of the proposed project will be guided by the relevant laws, regulations and policies related to waste in Maldives.

Review of the Maldivian regulatory framework during the course of the baseline monitoring exercise revealed that there exists limited regulations/standards which are appropriate to the present study and can be referred for compliance to the environmental components being monitored. Hence an attempt has been made in accordance with IFC PS requirements to identify the internationally recognized standards viz. WHO which has been referred to review conformance with the baseline values of the various environmental parameters being monitored. The list of such international standards has been provided below.

#### WHO air quality guidelines, 2005

the WHO Air quality guidelines as revised in 2005 (Refer Annex 3.7) represent the most widely agreed and up- to-date assessment of health effects of air pollution, recommending standards for air pollutants viz. PM10, PM2.5, SO2, NOx and Ozone at which the public health risks are significantly reduced. Necessary efforts has therefore been made by the proponent to compare the baseline air pollutant values monitored with the WHO air quality standards to establish any possible deterioration in ambient air quality and subsequent impact on worker health due to emissions that are resulting from open burning of solid wastes. Significant improvement in ambient air quality, if any due to implementation of the proposed waste management facility will also be verified based on the WHO standards.

#### Male' declaration on control and prevention of air pollution and its likely transboundary effects for South Asia

The objectives of Male' Declaration includes:

Assessing and analyzing the origin and causes, nature, extent and effects of local and regional air pollution,

Developing and/or adopting strategies to prevent and minimize air pollution

Setting up monitoring arrangements beginning with the study of sulphur and nitrogen and volatile organic compounds emissions, concentrations and deposition.

The proposed project will minimize the air pollution caused by the existing waste management practices of open burning of mixed waste in Thilafushi.

## 3.2 European legislation

The Industrial Emissions Directive (IED) (2010/ 75/ EU, 2010) brings together seven existing directives, including the Waste Incineration Directive, into one piece of legislation. The IED outlines total emission limit values (ELVs) for a number of pollutants typically emitted during waste incineration. These are NOx, CO, total dust, HCl, HF, SO2, organic substances, trace metals, and dioxins and furans. The design and operation of all new waste incinerations facilities must ensure compliance with the ELVs.

## 3.3 German legislation (as basis for the ADM)

*First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control – TA Luft) published in the Joint Ministerial Gazette from 30 July 2002 (English translation)*

At the national level in Germany, the Act on the Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration and Similar Phenomena (Federal Immission Control Act - BImSchG) is at the core of the body of statutory instruments that makes up immission control legislation. It has in the meantime received significant reinforcement in the form of numerous statutory instruments and two significant administrative provisions – Technical Instructions on Air Quality Control (TA Luft) and Technical Instructions on Noise Abatement (TA Lärm). The TA Luft is a comprehensive air pollution control regulation that includes:

- A discussion of the scope of the TA Luft application, which is to review applications for licenses to construct and operate new industrial facilities (or altered existing facilities) and to determine whether the proposed new or altered facilities will comply with the requirements of the TA Luft and the requirements of other air pollutant emission regulations promulgated under the Federal Pollution Control Act.
- Air pollutant emission limits for dust, sulfur dioxide, nitrogen oxides, hydrofluoric acid and other gaseous inorganic fluorine compounds, arsenic and inorganic arsenic compounds, lead and inorganic lead compounds, cadmium and inorganic cadmium compounds, nickel and inorganic nickel compounds, mercury and inorganic mercury compounds, thallium and inorganic thallium compounds, ammonia from farming and livestock breeding operations, inorganic gases and particulates, organic substances and others.
- Emission limits may also be set for hazardous, toxic, carcinogenic or mutagenic substances as part of the TA Luft review procedures.
- Other limits or requirements related to stack heights (for flue gases or other process vents) and for storing, loading or working with liquid or solid substances.
- Various requirements for sampling measuring and monitoring emissions.
- Listing of the industries subject to the requirements of the TA Luft, such as mining, electric power generation, glass and ceramics, steel, aluminum and other metals, chemical plants, oil refining, plastics, food, and others.

Annex 3 is devoted to guidelines on: how the atmospheric dispersion modeling required during the TA Luft review is to be performed, and the acceptable type of dispersion model to be used. In essence, the modeling must be in accordance with the VDI Guidelines 3782 Parts 1 and 2, 3783 Part 8, 3784 Part 2, and 3945 Part 3.

*17th Ordinance for the implementation of the Federal Immission control Act (Ordinance on Incineration Plants for municipal waste and similar combustible cubstances*

The 17th Ordinance for the implementation sets the regulatory framework for the special case of the municipal waste incinerators based on the general requirement of the Federal immission control Act and the TA Luft. The Air emissions standards which have been set as the basis for the project (DBO) are *similar to the EU-IED and in some cases more stringent*

*VDI (German Engineer Association) Guideline 3945 part 3 "Environmental meteorology/Atmospheric dispersion models –Particle model" of September 2000*

The Commission on Air Pollution Prevention of the VDI and DIN – Standards Committee, which includes experts from science, industry and administration, acting independently, establish VDI guidelines and DIN standards in the field of environmental protection. These describe the state of the art in science and technology in the Federal Republic of Germany and serve as a decision-making aid in the preparatory stages of legislation and the application of legal regulations and ordinances. KRdL's working results are also considered as the common German point of view in the establishment of technical rules at the European level by CEN (the European Committee for Standardization) and at the international level by ISO (the International Organization for Standardization). This guideline describes a numerical model for simulating the dispersion and calculating the concentrations of trace species in the atmosphere. Data required for the model include the mean wind field, turbulence parameters, emission data and, depending on the specific case, further application-specific input data.

## 3.4 Guidance note

*Latest IFC General EHS Guideline, page 3-17 "Air emission and ambient air quality"*

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). These General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Page 3-17 applies to facilities or projects that generate emissions to air at any stage of the project life-cycle. It complements the industry-specific emissions guidance presented in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines by providing information about common techniques for emissions management that may be applied to a range of industry sectors. This guideline provides an approach to the management of significant sources of emissions, including specific guidance for assessment and monitoring of impacts. It is also intended to provide additional information on approaches to emissions management in projects located in areas of poor air quality, where it may be necessary to establish project-specific emissions standards.

*Latest IFC EHS Guideline for Waste management facilities page 8-10 and 29-30*

The proposed WtE will involve a state of the art management of MSW generated from the Zone III waste catchement area (GM and other atolls and resorts) through waste incineration and sanitary landfill disposal of residual waste and is likely to be driven by IFC Sector EHS Guidelines on Waste Management Facilities. The guideline outlines significant EHS issues associated with waste management facilities during operations and decommissioning phases along with recommendations for mitigating the identified impacts. The applicability of these guidelines with respect to specific waste management operation including the current waste management practices has been discussed in details below.

Presently waste received at the Thilafushi is dumped in an uncontrolled manner with intentionally or non-intentionally burning leading to emission of pollutants (VOCs, dioxins & furans, particulate matter, acid fumes, SOx, NOx, etc.) which are expected to result in the deterioration of ambient air quality and occupational health. Hence in line with IFC Sectoral EHS requirements the ambient air quality needs to be periodically monitored by the proponent to check conformance with WHO Ambient Air Quality Guidelines, 2005.

Air pollutant emissions are also envisaged during the operation of waste incineration to be commissioned as an integral part of the proposed Thilafushi WtE.Carbon dioxide, Sulfure dioxide, particulate matter etc. have been identified as the key air pollutants that are likely to be released by waste incineration. High temperature maintained within the combustion furnace of the plant generally limits/restricts the formation of toxic substances viz. dioxins/furans, NOx, SOx and CO. Hence in accordance to the provision of the IFC EHS Guidelines it is necessary to undertake periodic monitoring of such emissions to review the performance of these proposed waste management systems against national & internationally recognized standards. However in absence of specific standards catering to emissions from Incineration plants in Maldives, project will be designed and operated in accordance with the substantive provisions of the following guidelines:"Air Emission Standards for MSW Incinerators in the EU & US" (Refer Appendix 4.1) and respective EU and german legislation. These regulations establish the minimum standards that must be met by facilities; specifically, emission levels for various pollutant materials: organics (dioxins, furans), metals (cadmium, lead and mercury), particulate matter (opacity), acid gases (hydrogen chloride, sulfur dioxide, nitrogen dioxide) and fugitive gas emissions.

### *IFC Performance standard*

This section specifies the environmental monitoring requirements and assesses the compliance to the applicable national and international EHS guidelines/standards with respect to the current waste management practices and proposed Thilafushi RWMF as defined under relevant provisions of the applicable IFC Performance Standards.

### *PS3: pollution prevention & abatement*

PS3 identifies the contribution of industrial activity and urbanization towards increased levels of pollution to air, water, and land that may threaten people and the environment at the local, regional, and global level. This performance standard therefore aims towards avoidance and minimization of the adverse impacts on human health and environment by addressing the pollution from project activities.

Paragraph 9 of the PS requires the proponent to undertake periodic monitoring of pollutants appropriate to the nature and scale of the potential impacts to demonstrate compliance with applicable national regulations and evaluate project environmental performance to determine corrective actions, if any. For project involving pollutant emissions Paragraph 26 and 27 of the PS requires the proponent to evaluate whether the existing background ambient levels are in compliance with the relevant national or internationally recognized ambient quality guidelines and/or standards so that adequate control measures can be put in place to prevent significant deterioration of environment quality and demonstrate continual improvement.

As the proposed Thilafushi Waste Management Project will involve emissions of air pollutants (CO2, CO, NOX, SOx, PM, VOCs, dioxins/furans, etc.) and noise from operation of the plant and vehicles involved in waste handling and

transportation, generation of leachate landfill facilities there may exist potential risks on ambient environment, occupational and community health from such operations if not properly managed. Hence it is imperative that a monitoring framework is developed and implemented during the project operations stage to periodically assess and evaluate the performance of key HSE indicators to regularly check conformance with applicable national and international standards/guidelines *(WHO Ambient Air Quality Standards*, IFC Waste Management Facility EHS Guidelines, etc.) for necessary corrective action, if any.

Further in line with provisions of PS1, primary monitoring has been undertaken for physical components (ambient air) to establish the baseline environment and check for any possible deterioration in ambient environment.

# 4 Methodology

This air quality report was carried out in accordance with the TA Luft and established good practice for air quality modelling and assessment. The study considered emissions from the WtE stack and the Diesel Genset controlled under the 17th Ordonance of the German Federal Imission Control act and the Industrial Emissions Directive (2010/75/EU). In summary, the substances to be assessed are set out in the table below. For the sake of clarity a comparaison table with Table 1 of the IFC HES sector guideline for MSW facilities (standard guideline for ADB) has been developed. The values in blue are the values used for this project.

| Table 1 Air emission standards for MSW Incinerators in the EU and US as per IFC EHS sector guideline Waste management Facilities page 29 | | | 17. Ordinance for the Implementation of the Federal Immission Control Act (Germany) |
|---|---|---|---|
| Parameter | EU | USA[a] | |
| Total Suspended particulates ($PM_{10}$) | 10 mg/m³ [24 hr average] | 20 mg/dscm | 5 mg/m³ [24 hr average] 20 mg/m³ [0,5 hr average] |
| Total Carbon (C) | | | 10 mg/m³ [24 hr average] 20 mg/m³ [0,5 hr average] |
| Sulfur Dioxide ($SO_2$) | 50 mg/m³ [24 hr average] | 30 ppmv (or 80% reduction) | 50 mg/m³ [24 hr average] 200 mg/m³ [0,5 hr average] |
| Oxides of Nitrogen ($NO_x$) | 200-400 mg/m³ [24 hr average] | 150 ppmv [24 hr average] | 150 mg/m³ [24 hr average] 400 mg/m³ [0,5 hr average] |
| Opacity | n/a | 10% | n/a |
| Hydrochlorid Acid (HCl) | 10 mg/m³ | 25 ppmv (or 95% reduction) | 10 mg/m³ [24 hr average] 60 mg/m³ [0,5 hr average] |
| Dioxins and furans | 0,1 ng TEQ/m³ [6-8 hr average] | 13 ng/dscm (total mass) | n/a |
| Cadmium* | 0,05-0,1 mg/m³ [0,5-8 hr average] | 0,010 mg/dscm | n/a |
| Carbon Monoxide (CO) | 50-150 mg/m³ | 50-150 ppmv[c] | 50 mg/m³ [24 hr average] 100 mg/m³ [0,5 hr average] |

| Table 1 Air emission standards for MSW Incinerators in the EU and US as per IFC EHS sector guideline Waste management Facilities page 29 | | | 17. Ordinance for the Implementation of the Federal Immission Control Act (Germany) |
|---|---|---|---|
| Parameter | EU | USA[a] | |
| Lead (Pb)* | See total metals below | 0,140 mg/dscm | n/a |
| Mercury (Hg) | 0,05-0,1 mg/m³ [0,5-8 hr average] | 0,050 mg/dscm (or 85% reduction)[b] | 0,03 mg/m³ [24 hr average] 0,05 mg/m³ [0,5 hr average] |
| Total metals* | 0,5-1 mg/m³ [0,5-8 hr average] | n/a | n/a |
| Hydrogen Fluoride (HF) | 1 mg/m³ | n/a | 1 mg/m³ [24 hr average] 4 mg/m³ [0,5 hr average] |
| Ammonia ($NH_3$) | n/a | n/a | 10 mg/m³ [24 hr average] 15 mg/m³ [0,5 hr average] |

[a] All values corrected to 7% oxygen [b] Whichever is less stringent

*Actually as there were no requirements for heavy metals (including lead) and cadmium this was not considered. The Consultant has contacted his sub-contractor due undertake additional assessment of these pollutants

It could be seen that values considered in this report for $PM_{10}$, $NO_x$, Mercury (Hg) are more stringent than EU-IED values. Additional parameters like Ammonia ($NH_3$), Total Carbon (C) *(in the TA luft but not in the IED)* and dioxin and furans *(in the IED but not in the TA Luft)* have been considered.

## 4.1 Ambiant air quality/Existing conditions

Actually the Maldives does not have an Air quality monitoring surveying network. Therefore ambient air quality has been assessed through a temporary field survey.

Baseline Air quality monitoring was conducted at four locations: 3 locations at Thilafushi (AQ1, AQ2, and AQ3) and one location at Villingili (AQ4) by Water Solutions. In 2018, air quality monitoring was carried out at AQ3 at Thilafushi from 20th to 26th June 2018. In 2019, air quality monitoring was carried out at AQ4 at Villingili from 3rd to 9th March 2019, at AQ1 from 19th to 25th March 2015. Additional air quality monitoring was carried at AQ2 from 20th to 25th August 2019 and at AQ3 from 25th to 31st August 2019.

One station was selected in the downwind direction of the WtE stack emission plume while another station was placed at the cross wind direction of the plume. One station was selected in the cross wind direction of the smoke plume from the existing dump site at Thilafushi. The additional station at Vilingili was selected as a control site.

The instrument used for taking air quality for baseline is the Aeroqual series 500 monitors and sensors. Aeroqual is a portable monitor suited for surveying common indoor and outdoor pollutants compatible with over 30 different sensors. The Series 500 can be deployed for short term fixed monitoring by

adding an optional outdoor enclosure. The Aeroqual Series 500 is also highlighted as the leading instrument for measuring ozone, nitrogen dioxide and carbon monoxide by the United States Environmental Protection Agency (US EPA).

**Figure 1:** Air Quality monitoring station with two Aeroqual Series 500 monitors

Predominant wind direction is an important criteria in selection of the air quality sampling stations as gaseous and particulate emissions from the project activities have a greater chance of dispersal along the predominant wind direction and affect the downwind human habitations. The monitoring network for ambient air quality was developed based on the following key criteria;

- Regional meteorology (primarily wind speed and direction)
- Important receptor locations (e.g. nearby inhabitation);
- Proposed project activities
- Logistics for operating the air monitoring equipment

The predominant wind directions in Maldives are dependent on the NE and SW monsoons. The wind directions for all seasons recorded at the National Meteorological Centre, Maldives reveal that apart from the winter months (when winds primarily blow from NW-NE), winds predominantly blow from the west.

The ambient air quality monitoring locations are shown in and rationale for selection of the locations is presented in Table 1.

**Table 1:** Locations for ambient air quality monitoring

| Station Name | Station Coordinates | Monitoring rationale |
|---|---|---|
| *Thilafushi* Downwind (AQ1) | 4°10'56.6 N<br>73°26'53.3 E | This downwind station with respect to the proposed facility has been selected to establish the baseline that could be compared with the monitoring to be undertaken during the construction and operational phases of the project to detect actual project imprints to the air quality of the nearest receptor. |
| *Thilafushi* crosswind (AQ2) | 4°10'57.3 N<br>73°25'59.4 E | The cross wind station with respect to the proposed facility has been selected to establish the general baseline of the island, for comparison with the downwind station at the time of project activities |

| Station Name | Station Coordinates | Monitoring rationale |
|---|---|---|
| *Thilafushi* crosswind (AQ3) | 4°11'07.6 N<br>73°26'37.4 E | The cross wind station with respect to the existing dumpsite at the Thilhafushi has been selected to establish the general baseline of the island |
| *Viligili Island* (AQ4) | 4°10'26.4 N<br>73°28'59.9 E | The cross wind station with respect to Thilhafushi has been selected as a control site and to detect project imprints to air quality of the nearest receptor due to trans-island transportation of pollutants |

The exact location of the ambient air stations were selected by WS/Kocks on site personnel to ensure the stations experience free air flow and are established at height between 1.5-5 meters and comply with the rationale of the monitoring program.

Selection of the sampling stations was based on the general climatological data obtained from the National Meteorological Center, Maldives. Also, data for the predominant wind directions for the sampling period was obtained from the National Meteorological Centre Maldives. As the direction of flow of exhaust air will be affected with changing wind directions, predominant exhaust air directions were noted down several times during the sampling program.

Because of the location of the island, strong gusts and variations of wind directions were noted which have the potential to influence the dispersion and in turn affect the air sampling. As a result it was thought pertinent to systematically record wind direction and strong gust.

Summary of the parameters measured:

| Station | Parameters | Date | Frequency of recording |
|---|---|---|---|
| AQ 1 | $PM_{10}$ | 19.03.2019-20.03.2019 | Minutely (24 hrs) |
| | $PM_{2,5}$ | 19.03.2019-20.03.2019 | Minutely (24 hrs) |
| | $NO_2$ | 20.03.2019-21.03.2019 | Minutely (24 hrs) |
| | CO | 22.03.2019-23.03.2019 | Minutely (24 hrs) |
| | $CH_4$ | 21.03.2019-22.03.2019 | Minutely (24 hrs) |
| | $CO_2$ | 19.03.2019-20.03.2019 | Minutely (24 hrs) |
| | $H_2S$ | 20.03.2019-21.03.2019 | Minutely (24 hrs) |
| | $SO_2$ | 22.03.2019-23.03.2019 | Minutely (24 hrs) |
| | VOC | 21.03.2019-22.03.2019 | Minutely (24 hrs) |
| AQ2 | $CO_2$ | 25.08.2019-26.08.2019 | Every 15 min (24 hrs) |
| | CO | 26.08.2019-27.08.2019 | Every 15 min (24 hrs) |
| | $NO_2$ | 27.08.2019-29.08.2019 | Every 15 min (24 hrs) |
| | $PM_{2,5}$ | 25.08.2019-26.08.2019 | Every 15 min (24 hrs) |
| | $PM_{10}$ | 25.08.2019-26.08.2019 | Every 15 min (24 hrs) |

| Station | Parameters | Date | Frequency of recording |
|---|---|---|---|
| AQ 3 | $PM_{10}$ | 20.06.2018-24.06.2018 | Every 10 min (96 hrs) |
| | $PM_{2,5}$ | 20.06.2018-24.06.2018 | Every 10 min (96 hrs) |
| | $SO_2$ | 20.06.2018-24.06.2018 | Every 10 min (96 hrs) |
| | $CO_2$ | 25.08.2019-26.08.2019 | Every 15 min (24 hrs) |
| | CO | 26.08.2019-27.08.2019 | Every 15 min (24 hrs) |
| | $NO_2$ | 28.08.2019-29.08.2019 | Every 15 min (24 hrs) |
| | $PM_{10}$ | 25.08.2019-26.08.2019 | Every 15 min (24 hrs) |
| | $PM_{2,5}$ | 25.08.2019-26.08.2019 | Every 15 min (24 hrs) |
| AQ 4 | $SO_2$ | 06.03.2019-10.03.2019 | Minutely (96 hrs) |
| | $NO_2$ | 06.03.2019-10.03.2019 | Minutely (96 hrs) |
| | $PM_{10}$ | 06.03.2019-10.03.2019 | Minutely (96 hrs) |
| | $Pm_{2,5}$ | 06.03.2019-10.03.2019 | Minutely (96 hrs) |
| | $CH_4$ | 06.03.2019-10.03.2019 | Minutely (96 hrs) |
| | CO | 06.03.2019-10.03.2019 | Minutely (96 hrs) |

Figure 2: Location of Ambiant air quality monitoring station (Source Google earth)

## 4.2 Air dispersion modelling (ADM)

### 4.2.1 Rationale

The dispersion modelling for the pollutants was carried out using the dispersion model AUSTAL2000. The computer program AUSTAL2000 is a reference implementation developed on behalf of the *German Federal Environmental Agency.* (Available as a free download at https://www.umweltbundesamt.de/themen/luft/regelungen-strategien/ausbreitungsmodelle-fuer-anlagenbezogene/austal2000n-download)

AUSTAL2000 is a steady-state dispersion model that is designed for long-term sources and continuous buoyant plumes. AUSTAL2000 is also capable of using multiple point, area, volume, and line sources. This model includes dry deposition algorithms and considers the conversion of nitric oxide (NO) to nitrogen dioxide (NO2). It is also able to make predictions about the frequency of odour nuisance.

It also available in English version as it is used by *other EU-member states*

The program system AUSTAL2000 calculates the spread of pollutants and odours in the atmosphere. It is an extended implementation of Annex 3 of the German regulation TA Luft (Technical Instruction on Air Quality Control) demands for dispersion calculations a Lagrangian particle model in compliance with the German guideline VDI 3945 Part 3. The modelling work was carried out by Ulbricht Consulting (Germany). The dispersion modelling report is attached as an Annex to this report.

Steady-state Gaussian plume models assess pollutant concentrations and/or deposition fluxes from a variety of sources associated with an industrial source complex. *Unlike the Gaussian models* commonly used, this flexible modelling procedure used in AUSTAL2000 *provides realistic results even when buildings and uneven terrain influence flue gas dispersion*. The model calculates the contribution of specified air pollutants from a given point source to the background concentrations present in the ambient air at ground level in the area surrounding the source.

### 4.2.2 Comparaison AUSTAL2000 vs AERMOD[1]

Unlike the Gaussian dispersion model AERMOD, AUSTAL2000 is a Lagrangian dispersion model that simulates the dispersion of air pollutants by utilizing a random walk process. According to Sawford[2] a Lagrangian simulation *has greater potential for application* as it mimics the behaviour of particles. The direction and velocity of dispersion are estimated by wind field vectors. Additionally, the vector of the turbulent velocity is randomly varied for every particle by using a Markov process. The random element varies with the intensity of turbulence. The concentration is determined by counting the particles in a given volume[3]

[1] Christian Langner & Otto Klemm (2011) A Comparison of Model Performance between AERMOD and AUSTAL2000, Journal of the Air & Waste Management Association, 61:6,640-646, DOI: 10.3155/1047-3289.61.6.640

[2] Sawford, B.L. Lagrangian Statistical Simulation of Concentration Mean and Fluctuation Fields; J. Climate Appl. Meteorol. 1985, 24, 1152-1166.

[3] Guideline 3945, Part 1. Environmental Meteorology—Atmospheric Dispersion Models—Particle Model; Verein Deutscher Ingenieure: Düsseldorf, Germany, 2000.

Like AERMOD, AUSTAL2000 is capable of calculating terrain and contains its own algorithm to assess the effects of building downwash[4]. AUSTAL2000 does not differentiate between rural or urban areas. AUSTAL2000 requires *less meteorological* information than AERMOD: z0, wind measurement height, wind direction, wind speed, and the stability classes according to Klug–Manier. The Klug–Manier classes represent the German standard stability classification for the atmosphere, similar to the Pasquill stability classes[5] in the United States. All of these meteorological data come from ground-based measurements and no information from upper air soundings is utilized. The wind measurement height and z0 are provided in the input file. If z0 is not provided by the user, AUSTAL2000 will calculate it using an internal database of roughness lengths and the coordinates of the area.AUSTAL2000 uses the register of roughness lengths and the integrated wind field component TALdia, which creates wind field libraries for complex terrain and for cases with buildings.

AERMOD generally predicted concentrations closer to the field observations. AERMOD and AUSTAL2000 performed considerably better when they included the emitting power plant building, indicating that the downwash effect near a source is an important factor. Both models performed acceptable for a no buoyant volume source. AUSTAL2000 had difficulties in stable conditions, resulting in severe underpredictions. This analysis indicates that AERMOD is the stronger model compared with AUSTAL2000 in cases with complex and urban terrain.

Generally speaking, the analysis indicates that AERMOD is the stronger model compared with AUSTAL2000 in complex and urban terrain. *In cases with simple terrain*, both models lead to acceptable results. Given the specific conditions and scope of the investigation, a model user has to evaluate whether he/she can get the meteorological data required to operate AERMOD. *For cases of poor meteorological data coverage, AUSTAL2000 could be an alternative*

### 4.2.3 Comparaison AUSTAL2000 vs CALPUFF[6]

Given the same quality of meteorological data, the performance of AUSTAL is similar to that of CALPUFF when using the Kincaid data set. The AUSTAL predictions tend to be conservative, usually overestimating the Kincaid GLC by roughly a factor two. AUSTAL performance is strongly affected by the choice of "quality factor" parameter, which controls the stochastic variability through the number of particles released. AUSTAL also tends to underestimate the wind speed at elevated levels, but AUSTAL predictions *are greatly improved when wind data at an elevated level* (close to the elevated source) is provided. AUSTAL predictions are improved when the thermal properties of exhausted gas from a power plant are described by the *VDI thermal flux equation*.

### 4.2.4 Conclusion

The computer program AUSTAL2000 is a reference implementation developed on behalf of the German Federal Environmental Agency. It is also used by other EU-state members and is a state of the art model following international good practice. AUSTAL2000 is is a Lagrangian dispersion model that simulates the

[4] AUSTAL2000—Program Documentation of Version 2.4; Janicke Consulting: Dunum, Germany, 2009.
[5] Pasquill, F. The Estimation of the Dispersion of Windborne Material; Meteor. Mag. 1961, 90, 33-49
[6] Ka-Hing Yau, Robert W. Macdonald & Jesse L. Thé (2011), inter-comparison of the austal2000 and calpuff dispersion models against the kincaid data set, 9th Int. Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

dispersion of air pollutants by utilizing a random walk process, with a particular strong performance in simple terrain and with poor meteorological data coverage. The model requires less meteorological information than similar models (AERMOD, etc.) which, given the circumstances and the environment in Maldives, makes it probably more suitable to generate a reliable output.

### 4.2.5 Grid

The stack height of has been set for the ADM to min 46 m (Worst case/see stack height calculation). Therefore the ADM area has a radius of at least 2,300 m (50 times the stack height). The grid for the calculation of concentration and deposition shall be selected in accordance with Chapter 7 (2) of Annex 3 of the Technical Instruction "Air" so that the location and contribution of the maximum emission can be determined with sufficient certainty. This is usually the case when the horizontal mesh size does not exceed the stack height. At source distances greater than 10 times the height of the stack, the horizontal mesh size can be selected proportionally larger. The calculations and assessments were carried out in an area of 3.2 x 2.6 km and a grid with mesh sizes of 5 to 20 m.

### 4.2.6 Potential sensitive locations/Assessment points

In the examination area, two asessement points were determined for the calculations. The location of these points can be found in Annex 3. BUP 1 (west) is the point with the maximum load. ANP 1 (East) has been considered for additional mercury load dispersion calculation. These points are also nearby the baseline ambient air survey points.

### 4.2.7 Level of uncertainity

The resulting statistical uncertainty (in %) was taken into account in the evaluation. The calculation was performed with the quality level "2". To assess the emissions, the calculated value is increased by the statistical uncertainty.

### 4.2.8 Meteorology

#### 4.2.8.1 *Rainfall, Temperature, atmospheric pressure*

The rainfall over the Maldives varies during the two monsoon periods with more rainfall during the southwest monsoon. These seasonal characteristics can be seen from *Figure 3*, which shows the mean monthly rainfall observed for central atolls.

The average annual rainfall for the archipelago is 2,124 mm. There are regional variations in average annual rainfall: southern atolls receive approximately 2,280 mm, and northern atolls receive approximately 1,790 mm annually (MEE, 2015). Mean monthly rainfall also varies substantially throughout the year with the dry season getting considerably less rainfall. This pattern is less prominent in the southern half, however. The proportions of flood and drought years are relatively small throughout the archipelago, and the southern half is less prone to drought (UNDP, 2006).

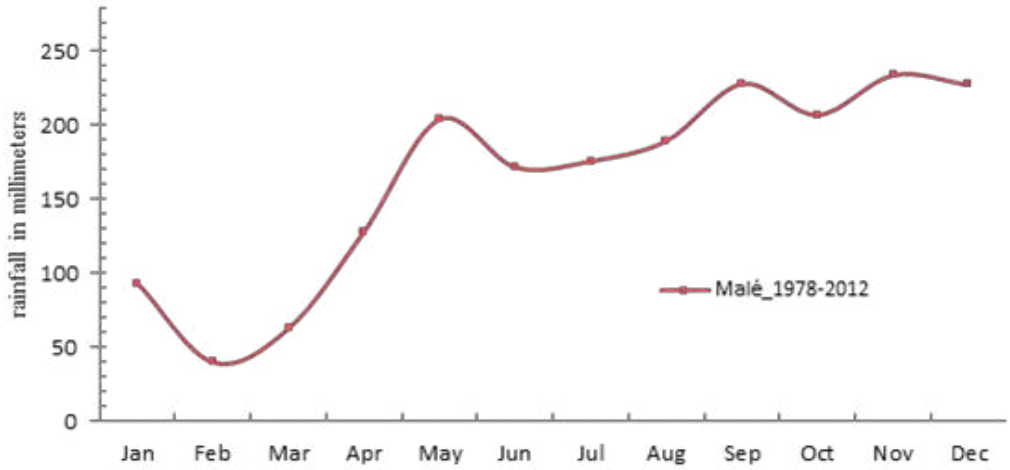



Figure 3: Long term average rainfall for the central atolls (Source: Maldives Meteorological Service, 2016)

For the ADM the following meteorological data have been acquired and used

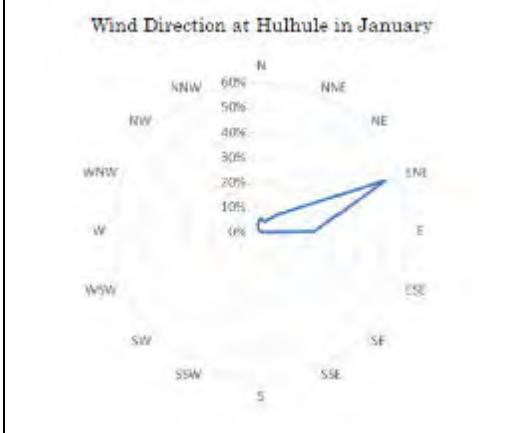
| | |
|---|---|
| Rainfall data set (daily) | Source : Maldives Meteorological service<br>Location : Weather station Hulhule' (Airport) at 10 km East of Thilafushi<br>Data set: from 08.1974-12.2017 |
| Temperature data set (daily) | Source : Maldives Meteorological service<br>Location : Weather station Hulhule' (Airport) at 10 km East of Thilafushi<br>Data set: from 01.-12.2017 |
| Atmospheric pressure data set (daily) | Source : Maldives Meteorological service<br>Location : Weather station Hulhule' (Airport) at 10 km East of Thilafushi<br>Data set: from 01.-12.2017 |

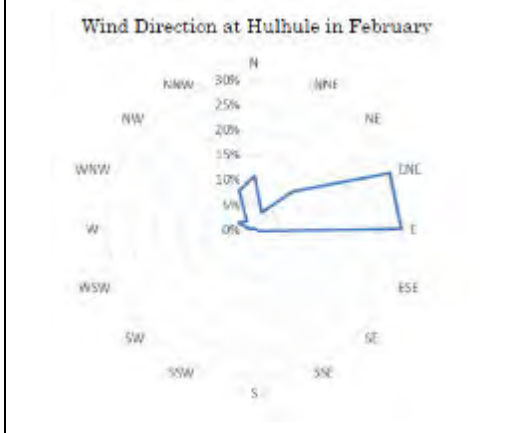
The data set have bee provided in Excel format and have been computed for the purpose of the model in AKterm format.

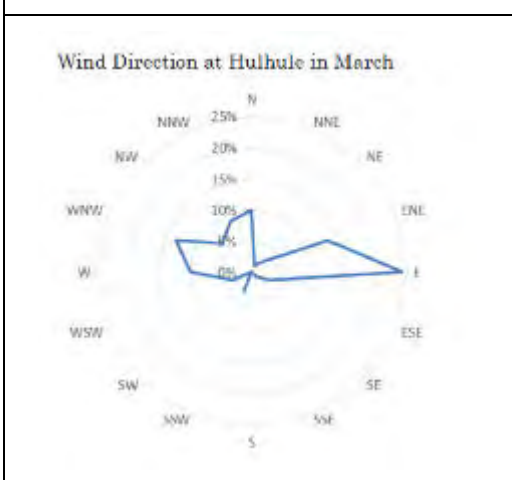
#### 4.2.8.2 *Wind*

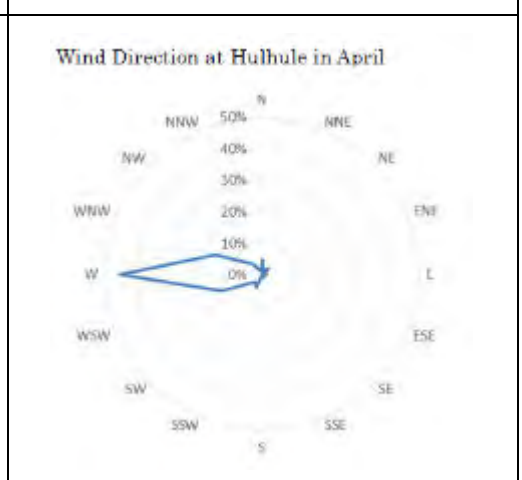
The prevailing wind over the Maldives represents typical Asian monsoonal characteristics. It follows the traditional definition of monsoon as seasonal reversal of wind direction by more than 120° between the months January and July. Looking at annual variations, westerly winds are predominant throughout the country, varying between west-southwest and west-northwest *Figure 4*.

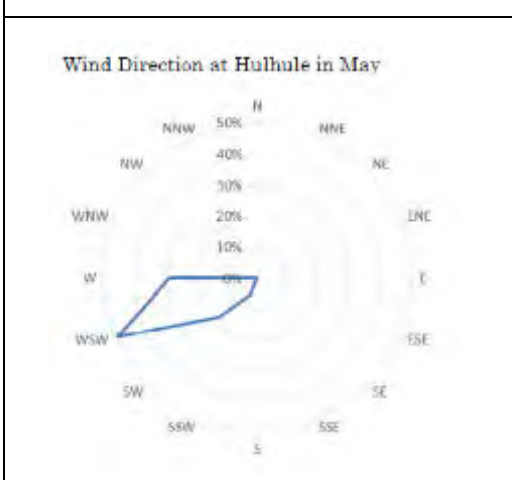
The southwest monsoon, with winds predominantly between SW and NW, lasts from May to October. In May and June, winds are mainly from WSW to WNW, and in July to October, winds between W and NW predominate. The northeast monsoon, with winds predominantly from NE to E, lasts from December to February. During March and April, winds are variable. During November, winds are primarily from the west, becoming variable and can occasionally exceed 30 knots from the NE sector. However, yearly wind speed in the northeast and southwest monsoons are observed to be between 9-13 knots.

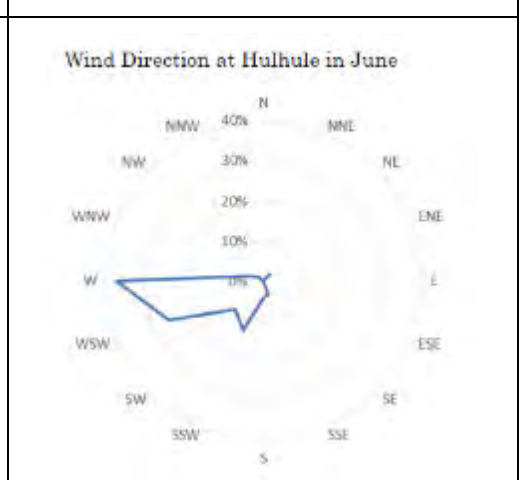

Wind Direction at Hulhule in January
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
60%
50%
40%
30%
20%
10%
0%

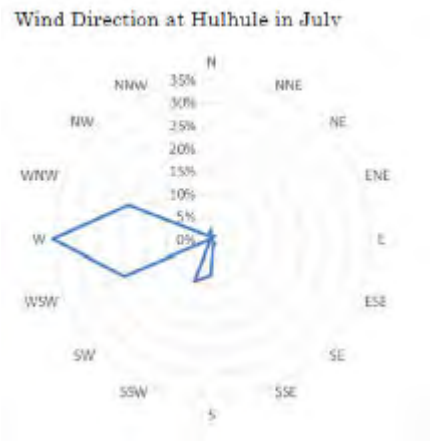

Wind Direction at Hulhule in February
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
30%
25%
20%
15%
10%
5%
0%

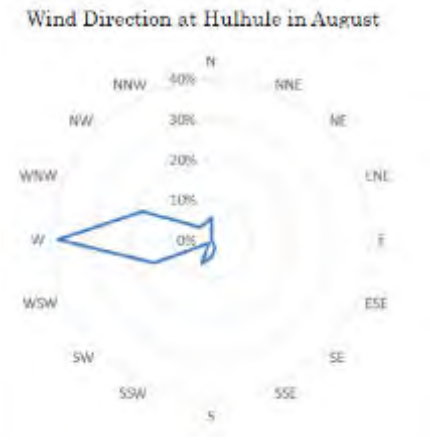

Wind Direction at Hulhule in March
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
25%
20%
15%
10%
5%
0%


Wind Direction at Hulhule in April
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
50%
40%
30%
20%
10%
0%

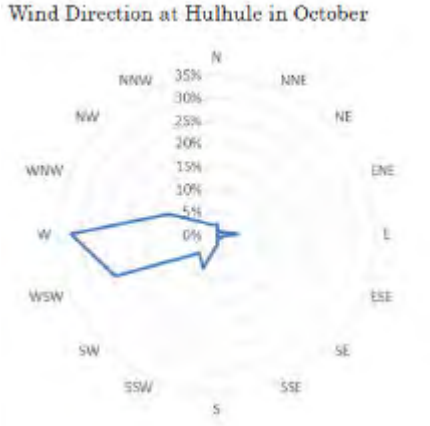

Wind Direction at Hulhule in May
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
50%
40%
30%
20%
10%
0%

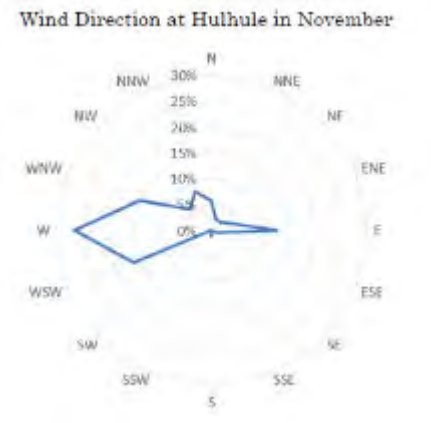

Wind Direction at Hulhule in June
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
40%
30%
20%
10%
0%

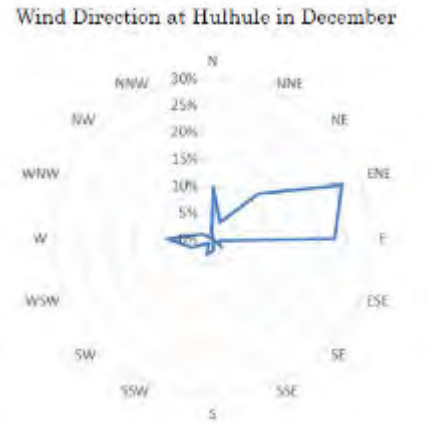

Wind Direction at Hulhule in July
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
35%
30%
25%
20%
15%
10%
5%
0%


Wind Direction at Hulhule in August
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
40%
30%
20%
10%
0%

Wind Direction at Hulhule in September
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
35%
30%
25%
20%
15%
10%
5%
0%


Wind Direction at Hulhule in October
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
35%
30%
25%
20%
15%
10%
5%
0%


Wind Direction at Hulhule in November
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
30%
25%
20%
15%
10%
0%


Wind Direction at Hulhule in December
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
30%
25%
20%
15%
10%
5%

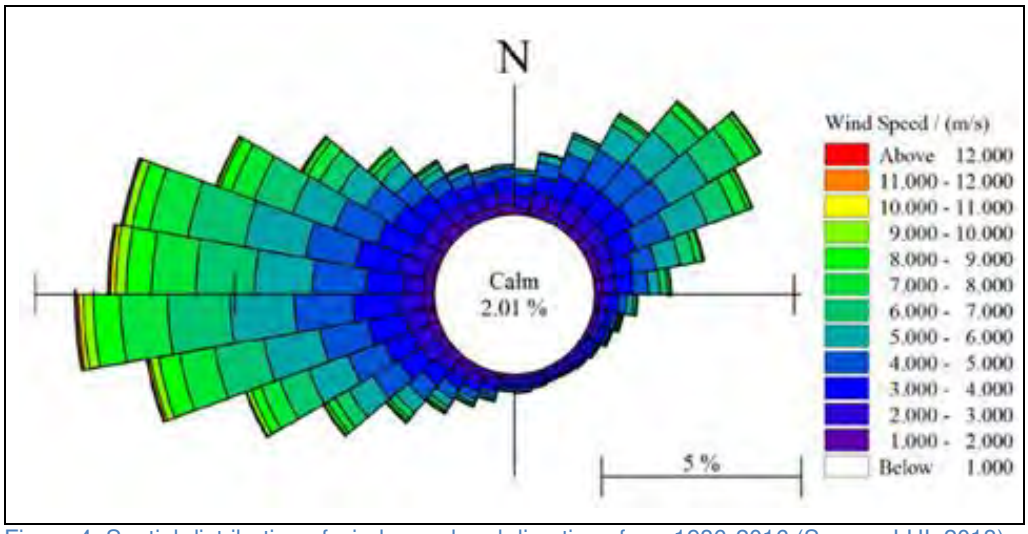



Figure 4: Spatial distribution of wind speed and directions from 1986-2016 (Source: LHI, 2018)

*Figure 5* illustrates clearly wind the distribution pattern in terms of direction and frequency. The length of the "slices" represents the percentage of occurrence while the colour code illustrates wind speed. Furthermore, Table 15 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 from the South-East quadrant is negligible. Significantly, calm conditions are rare, occurring 2.01% of the time.

| Dir (Deg N) / Speed (m/s) | 0 – 10 | 10 – 20 | 20 – 30 | 30 – 40 | 40 – 50 | 50 – 60 | 60 – 70 | 70 – 80 | 80 – 90 | 90 – 100 | 100 – 110 | 110 – 120 | 120 – 130 | 130 – 140 | 140 – 150 | 150 – 160 | 160 – 170 | 170 – 180 | 180 – 190 | 190 – 200 | 200 – 210 | 210 – 220 | 220 – 230 | 230 – 240 | 240 – 250 | 250 – 260 | 260 – 270 | 270 – 280 | 280 – 290 | 290 – 300 | 300 – 310 | 310 – 320 | 320 – 330 | 330 – 340 | 340 – 350 | 350 – 360 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 – 1 | 0.03 | 0.06 | 0.06 | 0.05 | 0.06 | 0.07 | 0.06 | 0.04 | 0.09 | 0.03 | 0.03 | 0.05 | 0.04 | 0.06 | 0.05 | 0.04 | 0.05 | 0.08 | 0.03 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.11 | 0.03 | 0.06 | 0.07 | 0.08 | 0.06 | 0.07 | 0.06 | 0.06 | 0.03 | 2.07 |
| 1 – 2 | 0.17 | 0.24 | 0.20 | 0.21 | 0.24 | 0.26 | 0.21 | 0.19 | 0.20 | 0.14 | 0.14 | 0.14 | 0.10 | 0.12 | 0.10 | 0.10 | 0.11 | 0.12 | 0.11 | 0.16 | 0.19 | 0.10 | 0.24 | 0.21 | 0.23 | 0.24 | 0.30 | 0.23 | 0.30 | 0.23 | 0.27 | 0.29 | 0.27 | 0.24 | 0.23 | 0.10 | 7.07 |
| 2 – 3 | 0.29 | 0.38 | 0.43 | 0.48 | 0.44 | 0.45 | 0.43 | 0.35 | 0.34 | 0.23 | 0.19 | 0.16 | 0.15 | 0.14 | 0.13 | 0.11 | 0.11 | 0.13 | 0.12 | 0.17 | 0.19 | 0.28 | 0.32 | 0.49 | 0.51 | 0.53 | 0.64 | 0.53 | 0.64 | 0.54 | 0.48 | 0.45 | 0.39 | 0.34 | 0.31 | 0.29 | 12.16 |
| 3 – 4 | 0.31 | 0.40 | 0.57 | 0.67 | 0.67 | 0.72 | 0.60 | 0.49 | 0.42 | 0.24 | 0.19 | 0.16 | 0.13 | 0.10 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.18 | 0.22 | 0.27 | 0.44 | 0.65 | 0.73 | 0.98 | 1.10 | 0.95 | 1.13 | 0.92 | 0.77 | 0.58 | 0.41 | 0.38 | 0.35 | 0.28 | 16.39 |
| 4 – 5 | 0.26 | 0.38 | 0.58 | 0.86 | 1.03 | 1.05 | 0.90 | 0.61 | 0.37 | 0.20 | 0.10 | 0.08 | 0.07 | 0.03 | 0.04 | 0.04 | 0.05 | 0.09 | 0.08 | 0.13 | 0.20 | 0.31 | 0.48 | 0.75 | 0.97 | 1.28 | 1.48 | 1.26 | 1.31 | 1.11 | 0.82 | 0.55 | 0.38 | 0.29 | 0.21 | 0.19 | 18.62 |
| 5 – 6 | 0.10 | 0.19 | 0.42 | 0.68 | 0.89 | 1.13 | 1.00 | 0.59 | 0.30 | 0.16 | 0.06 | 0.05 | 0.03 | 0.03 | 0.03 | 0.01 | 0.04 | 0.05 | 0.04 | 0.07 | 0.11 | 0.21 | 0.41 | 0.70 | 1.07 | 1.40 | 1.63 | 1.45 | 1.51 | 1.15 | 0.75 | 0.48 | 0.23 | 0.14 | 0.09 | 0.08 | 17.39 |
| 6 – 7 | 0.02 | 0.04 | 0.09 | 0.26 | 0.69 | 0.90 | 0.72 | 0.39 | 0.19 | 0.08 | 0.05 | 0.03 | 0.02 | 0.01 | 0.00 | 0.01 | 0.02 | 0.01 | 0.03 | 0.04 | 0.08 | 0.11 | 0.20 | 0.40 | 0.76 | 1.24 | 1.58 | 1.19 | 1.13 | 0.96 | 0.57 | 0.25 | 0.12 | 0.07 | 0.03 | 0.02 | 12.89 |
| 7 – 8 | 0.00 | 0.01 | 0.03 | 0.08 | 0.23 | 0.47 | 0.35 | 0.18 | 0.08 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | | | | 0.01 | 0.02 | 0.02 | 0.02 | 0.06 | 0.09 | 0.21 | 0.50 | 0.50 | 1.18 | 1.07 | 0.98 | 0.62 | 0.33 | 0.15 | 0.05 | 0.03 | 0.00 | 0.01 | 7.78 |
| 8 – 9 | | 0.00 | 0.03 | 0.02 | 0.05 | 0.12 | 0.11 | 0.04 | 0.01 | 0.01 | 0.02 | 0.00 | | | | | | | 0.01 | 0.00 | 0.01 | 0.02 | 0.04 | 0.09 | 0.25 | 0.57 | 0.65 | 0.62 | 0.43 | 0.30 | 0.14 | 0.04 | 0.03 | 0.02 | | | 3.60 |
| 9 – 10 | | | | 0.02 | 0.04 | 0.05 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | 0.00 | 0.01 | 0.01 | 0.02 | 0.12 | 0.21 | 0.24 | 0.28 | 0.21 | 0.08 | 0.04 | 0.01 | 0.00 | | | | 1.39 |
| 10 – 11 | | | | | | 0.00 | 0.01 | | | | | | | | | | | | | | | 0.01 | 0.00 | 0.01 | 0.03 | 0.06 | 0.13 | 0.12 | 0.06 | 0.02 | 0.02 | 0.00 | | | | | 0.47 |
| 11 – 12 | | | | | | | | | | | | | | | | | | | | | | | | | 0.01 | 0.02 | 0.08 | 0.04 | 0.02 | 0.01 | 0.00 | 0.01 | | | | | 0.18 |
| 12 – 13 | | | | | | | | | | | | | | | | | | | | | | | | | 0.01 | 0.01 | 0.04 | 0.01 | 0.01 | 0.01 | 0.00 | | | | | | 0.09 |
| 13 – 14 | | | | | | | | | | | | | | | | | | | | | | | | 0.00 | | | 0.01 | 0.01 | | | | | | | | | 0.02 |
| 14 – 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.00 | | | | | | | | | | 0.00 |
| 15 – 16 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.00 | | | | | | | | | 0.00 |
| Total | 1.18 | 1.70 | 2.42 | 3.33 | 4.44 | 5.22 | 4.42 | 2.86 | 2.00 | 1.12 | 0.81 | 0.69 | 0.54 | 0.51 | 0.44 | 0.41 | 0.47 | 0.58 | 0.51 | 0.81 | 1.08 | 1.53 | 2.28 | 3.60 | 5.26 | 7.42 | 9.13 | 8.22 | 8.09 | 6.03 | 4.27 | 2.89 | 1.95 | 1.56 | 1.28 | 1.06 | 100 |

Figure 5: Directional Distribution of Wind Statistics (% Occurrence for Wind Speed vs. Wind Direction)

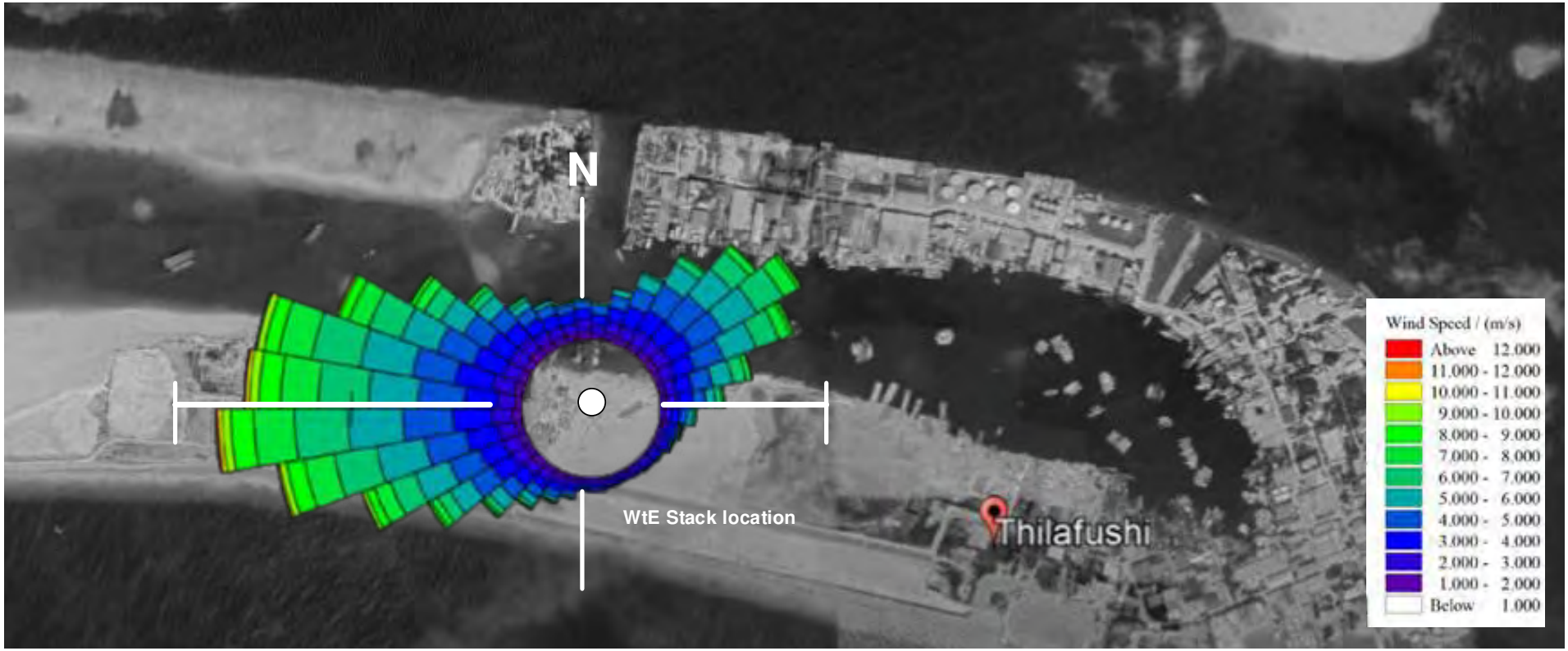



Figure 6: average Wind rose over project location

Besides the annual monsoonal wind variations, there are occasional tropical storms in the central region of the Maldives which increases wind speeds up to 110 km/h, precipitation to 30 to 40 cm over a 24 hour period and storm surges up to 3 m in the open ocean (UNDP, 2006).

For the ADM the following hourly wind data set have been acquired and used

| | |
|---|---|
| Wind data set (hourly) | Source : Maldives Meteorological service<br>Location : Weather station Hulhule' (Airport) at 10 km East of Thilafushi<br>Data set: from 01.-12.2017 (24 hrs/day)<br>Wind measurement height $z_o$ : 11,5 m over ground level |
| Dispersion class time series | The wind direction distribution and the wind speeds were modelled with a dispersion class time series for the year 2017[7]. |

The data set have bee provided in Excel format and have been computed for the purpose of the model in AKterm format.

### 4.2.9 Topography

All islands of the Maldives are very low lying; more than 80% of the land area is less than 1 m above mean high tide level (MEEW, 2005). Combined with the small size of the islands, this means that accelerated sea level rise will have devastating effects on the islands and threatens the very existence of all the islands of the Maldives.

The proposed site for the establishment of the WtE was reclaimed in 2018. 15 hectares of land was reclaimed from the shallow lagoon which was located on either side of the link road that was constructed at Thilafushi. The materials for the reclamation was borrowed from North Male' Atoll with a radius of 10 km from Thilafushi using a Trailing Suction Hopper Dredger (TSHD). The dredger borrowed the material for the reclamation from borrow sites were within a depth range of 40-50m. The material from the dredger was discharged to the reclamation area via a floating pipe line which ran from the sea floor to the reclamation area, which was bunded with sand bunds, from southern side of the reclamation area.

The site has been reclaimed to a height of +1.5 m from MSL from an average depth of -1.5 m above the sea floor. The sand grains are angular to sub-angular in shape with gravel size varies from 20 – 30 mm in diameter and fairly uniformly graded. It can be described as loosely packed, silty, coral sand with pieces of corals and shells. Since the area had been recently reclaimed, the site does not have humus topsoil which is found on typical tropical islands. The soils have very high permeability for water. Much of the rainfall occurs as intense storms but no signs of erosion is observed, confirming high infiltration capacity.

The entire Island and the project location are mainly on the main level over MSL and don't present any substantial elevation (only the actual dumpsite is culminating at approx. 15 m over MSL). The following figure present the actual site configuration

[7] Wind data provided by Maldives Meteorological Services

Figure 7: areal picture of reclaimed area for WtE Facility

| | |
|---|---|
| Ground roughness | The ground roughness of the terrain is described by an average roughness length z0. It is determined according to the land use classes of the CORINE Cadastre. The roughness length was chosen within the calculation to be z0 = 0.2. This value should be considered as representative for the area of calculation. |
| Terrain and slope | It is a flat terrain. In the computing area, no gradients of more than 1:20 or even more than 1: 5 occur. |

### 4.2.10 Building effects

Influence of buildings have been also considered in the model. The following building dimension and location (stack and Diesel genset) have been considered for the WtE facility.

WtE dimensions: Approx. Length x width x height [m]: 100 x 70 x 30

Sourrounded buildings location have been considered according land use plan, topographical survey and google earth maps. The height of the buildings have been considered to maximum 10 m.

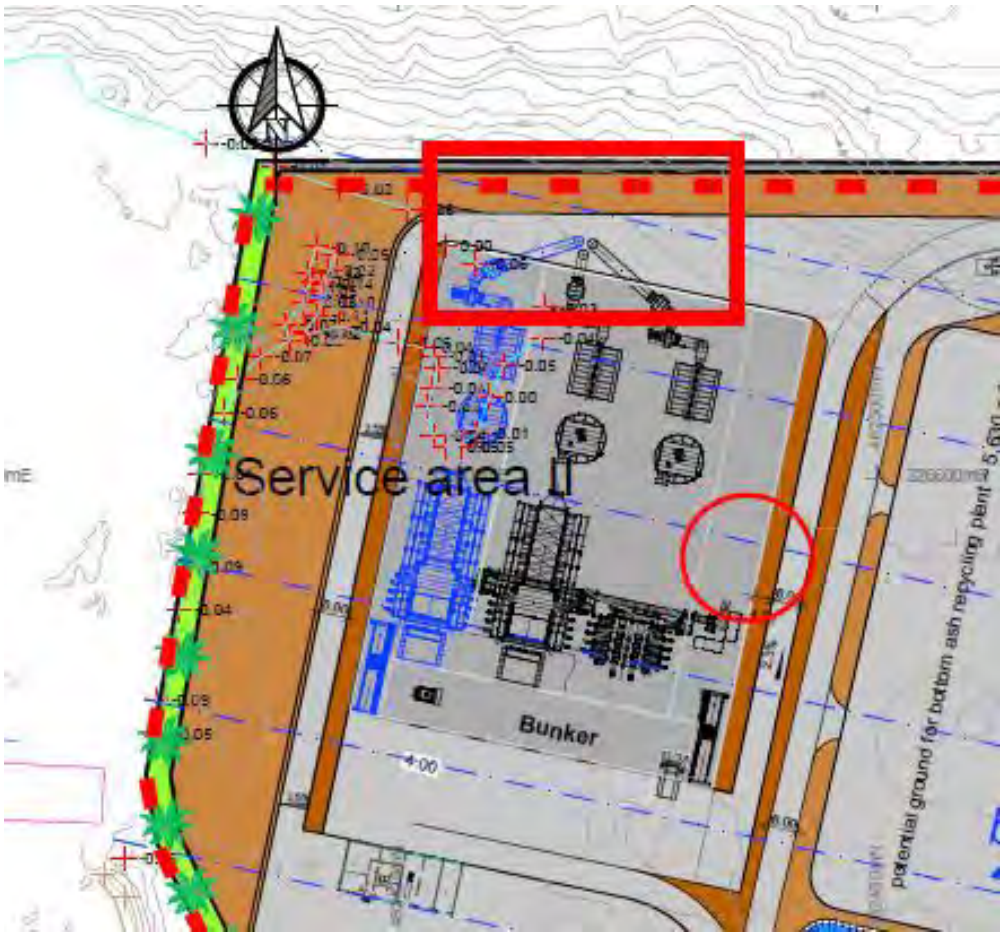



Figure 8: tentative Location of the WtE, the stack (square) and the genset (circle)

### 4.2.11 Emissions

The following parameter have been provided to the consultant for the ADM

| | | |
|---|---|---|
| Location of the stack | 4.183004 N; 73.437155 E | |
| Number of stacks | 2 | |
| Stack height above ground level | 46 m for ADM (Stack height will be fixed to 50 m for DBO) | |
| Distance between stacks | 7 m (to be considered as 1 single source) | |
| Equivalent diameter | 2.12 m | |
| Operation hrs WtE/Stack | 8,000 hrs/year | |
| Flue gas volume flow | Stack 1 | Stack 2 |
| | 57,856 m³/h | 57,856 m³/h |
| Flue gas temperature | 180°C | |
| Location of Genset | 4.182394 N; 73.437370 E | |
| Number of Genset | 1 | |

| | |
|---|---|
| Distance between Genset and stack | Approx. 150 m |
| Operation hours Genset | 760 h/year (only emergency/Island mode) |
| Flue gas volume flow Genset | 12.470 Nm³ |
| Emissions (based on 11% $O_2$ in the flue gas) | |
| Total dust | 5 mg/Nm³ |
| $PM_{10}$ | 0,5 mg/Nm³ |
| Total carbon | 10 mg/Nm³ |
| HCl | 10 mg/Nm³ |
| Hf | 1 mg/Nm³ |
| $SO_2$ | 50 mg/Nm³ |
| $NO_x$ | 150 mg/Nm³ |
| Hg | 0,03 mg/Nm³ |
| CO | 50 mg/Nm³ |
| $NH_3$ | 10 mg/Nm³ |
| Dioxin/furan | 0,1 ng/Nm³ |

# 5 Assessment criteria

## 5.1 Criteria to protect human health

The Technical Instruction provides Immison rate/ambient air concentration values for the concentration of substances above which risks to human health are expected (paragraph 4.2) or they cause considerable nuisance or considerable disadvantages (Section 4.3). significant drawbacks, in particular protection of vegetation and ecosystems (Section 4.4) and harmful environmental effects by pollutant depositions (section 4.5) as well as irrelevant additional burdens, the compliance of which, according to Number 4.1 the TA Luft, can eliminate the determination of the total load, if the threshold are not respected

The following tables show the Immison rate/ambient air concentration values specified in the TA Luft as well as the irrelevant additional loads for the WtE plant relevant pollutants.

Table 2: Immission rate/ambient air concentration values and irrelevant values according Nr. 4.2 of the TA Luft

| Substance/group of substances | Immison rate/ambient air concentration values | Average period | Allowed exceeding frequency per year | Irrelevant additional load |
|---|---|---|---|---|
| Protection of human health - Emission values according N° 4.2 TA Luft | | | | |
| Aerosol ($PM_{10}$) | 40 µg/m³ | year | - | 1.2 µg/m³ |
| | 50 µg/m³ | 24 hours | 35 | - |
| Sulfur dioxide ($SO_2$) | 50 µg/m³ | year | - | 1.5 µg/m³ |
| | 125 µg/m³ | 24 hrs | 3 | - |
| | 350 µg/m³ | 1 hr | 24 | - |
| Nitrogen dioxide ($NO_X$) | 40 µg/m³ | year | - 18 | 1.2 µg/m³ |
| | 200 µg/m³ | 1 hr | | - |

## 5.2 Criteria to protect ecological sites

Table 3: Immison rate/ambient air concentration values and irrelevant values according Nr. 4.3 - 4.5 of the TA Luft

| Substance | Ambient air quality value | Averaging period | Irrelevant additional load |
|---|---|---|---|
| Protection against considerable nuisance or major drawbacks due to dust precipitation - Ambient air quality values according to number 4.3 TA Luft | | | |
| Dust precipitation (non-hazardous dust) | 0.35 g / (m² · d) | year | 0.0105 g / (m² d) |
| Protection against nuisances, in particular protection of vegetation and ecosystems - Ambient air quality values according to 4.4 TA Luft | | | |
| Ammonia | Whether the protection against nuisances and drawbacks by damage of sensitive plants (eg nurseries, crop plants) and ecosystems by the effect of ammonia is guaranteed, is to be examined according to number 4.8 TA Luft. | | |
| Protection against harmful environmental effects through pollutant deposition - Ambient air quality values according to number 4.5 TA Luft or protection against considerable disadvantages according to number 4.4 TA Luft | | | |
| Mercury and its inorganic compounds, expressed as mercury | 1 µg / (m² · d) | year | 0.05 µg / (m² · d) |
| Hydrogen fluoride and gaseous inorganic fluorine compounds, indicated as fluorine | 0.4 µg / m³ | year | 0.04 µg / m³ |
| Arsenic and its inorganic compounds, expressed as arsenic | 4 µg / (m² · d) | year | 0.2 µg / (m² · d) |

| Substance | Ambient air quality value | Averaging period | Irrelevant additional load |
|---|---|---|---|
| Lead and its inorganic compounds, indicated as lead | 100 µg / (m² · d) | year | 5 µg / (m² · d) |
| Cadmium and its inorganic compounds, expressed as cadmium | 2 µg / (m² · d) | year | 0.1 µg / (m² · d) |
| Nickel and its inorganic compounds, expressed as nickel | 15 µg / (m² · d) | year | 0.75 µg / (m² · d) |
| Thallium and its inorganic compounds, reported as thallium | 2 µg / (m² · d) | year | 0.1 µg / (m² · d) |

# 6 Determination of significance of effects

According to the TA Luft calculated emission loads were assessed against the relevant critical loads fixed in the regulation. Only for the loads which are over the critical load (minimum mass flow) an detailed air dispersion model is required. For the purpose of the determination of the signfificance of effects and the need of a detailed ADM the following parameters have been considered:

- Total suspended material/dust expressed as PM10
- Sulphur oxide and dioxide expressed as Sulphur dioxide ($SO_2$)
- Nitrogen oxide ($NO_x$)
- Ammonia ($NH_3$)
- And mercury (Hg).

In the present case, the emissions are calculated with the calculation program for all relevant pollutants, insofar as emission values are specified for these substances in the TA Luft

For the other relevant pollutants: total C, carbon monoxide (CO), hydrogen chloride, dioxins and furans, no emission values are specified in the TA Luft.

# 7 Baseline conditions

## 7.1 Project location (Macrolocation)

The development of the proposed project takes place at Thilafushi. Thilafushi is located in North Male' atoll, 9.5km from Male'. In terms of geographic coordinates, it is located at 04° 11' 00" N and 73° 26' 44" E. The nearest inhabited island is Villingili, approximately 7.1 km east of Thilafushi. The reef system is approximately 4.65 km long, 0.94 km wide (width of ring reef, including the lagoon area). A newly reclaimed Industrial Island (Gulhi Fahlu) is approximatevly at 650 m from the eastern tip of the Thilafushi and the nearest resort (Centar Ras Fushi) at more than 3,2 km on the North-West of the Island.

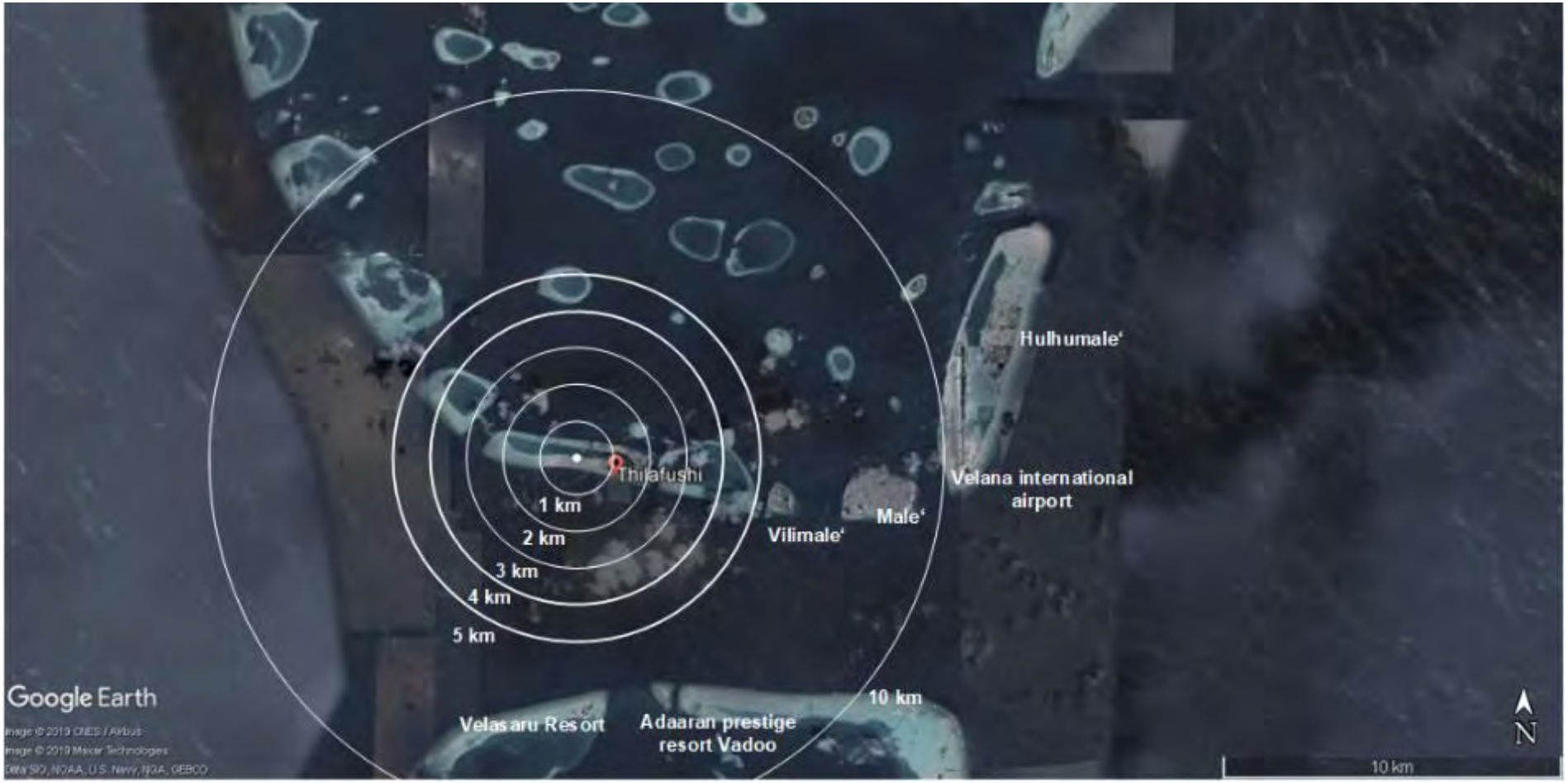



Figure 9: Project location (macro-location) [Source Google Earth]

Figure 10: Project location (Meso-location, distances from tentative stack location of the WtE) [Source google Earth]

Thilafushi Island has been developed as a solid waste land fill since December 1992. The island was initially developed as a sand bank using dredged material from the Thilafushi Reef. Since then, land has been reclaimed by placing solid waste in dredged holes on the reef flat and later topping it up with fresh lagoon sand. The island referred to as Thilafushi-1 was and is being reclaimed using this method.

A second island, zoned as Thilafushi-2, was reclaimed from lagoon sand to meet the demand. Subsequently a third island, Thilafushi-3, was initiated to reclaim 167 Ha of land from the remaining reef areas of Thilafushi.

Figure 11: land use plan [developed by given land use plan and Google Earth Image]

| | |
|---|---|
| Name | Thilafushi Island |
| History | 1992 lagoon became dumpsite by filling with waste and sand. Development of the site by land reclamation through waste and sand dumping |
| Coordinates | 4°11′N<br>73°26′E |
| Dimensions | Length : approx. 3.50 km<br>Width: approx. 0.20 km |
| Vocation | Industrial Island |
| Population | Registred people (workers)<br>Approx. 2,052 workers 2,048 male, 04 female, no children, 69 % Foreigners (international migrants)<br>Approx. 1,500 residents (one base camp)<br>Others relocated in Guli Fahlu |
| Borders/Boundaries | Island surrounded by seawater |
| Nearest Island | Guli Fahlu at 2,081 km from WtE stack (650 m from edge of Thilafushi), Industrial Island and workers camp |
| Nearest Resort or inhabited Island | Centar Ras fushi resort at 3,20 km (from WtE stack) |
| Vegetation | Basic vegetation, after landscaping measure, no rare or endangered species, no high vegetation |
| Tourism | None |
| Industry | Boat building<br>Cement conditioning<br>Construction companies' base/storage sites<br>Methane gas bottling<br>Storage of goods<br>Water bottling<br>Small industry (RO plants, etc.) |
| Facilities | Customs<br>Small police and fire station<br>Ferry station |

Table 4: Summary of Thilafushi project location (macro-location

## 7.2 Project location (Microlocation)

The coordinates of the project location are 4°10'54.49"N 73°26'24.38"E. The establishment of RWMF for Zone 3 at Thilafushi requires 15 hectares which have been reclaimed from the adjacent shallow lagoon. Figure 12 illustrates the location of the project.

**Figure 12:** Project location (micro-location)

| | |
|---|---|
| Name | Waste to Energy facility Thilafushi |
| Description of the components | Waste acceptance area with weighbridge<br>Waste bunker with crane<br>Waste incineration (grate technology) with 3 combustion chambers<br>Boiler<br>Flue gas cleaning and stack<br>Residual waste treatment : bottom ash treatment plant<br>Residual waste disposal: residual waste (fly ash conditioned in big bags) state of the art landfill<br>Buildings and facilities (admin, storage, maintenance, water supply, sewerage, electricity, firewater, stormwater, etc..) |
| Coordinates | North West: 4°10'58.73"N, 73°26'11.51"E<br>North East: 4°10'58.87"N, 73°26'22.20"E<br>South West: 4°10'50.71"N, 73°26'9.74"E<br>South East: 4°10'48.09"N, 73°26'20.87"E |
| Borders/boundaries | North: Lagoon<br>East: Old dumpsite<br>West: New reclaimed industrial area<br>South: Open sea |
| Contract | Design-Build Operate Contract for 20 years |
| Actual stage | Preliminary design and Tender documents for DBO contractor |
| Project site | Newly reclaimed area (no waste) with compacted coarse sand<br>North side (lagoon) closed by a concrete quay wall with a height of 1,5 m over MSL<br>South side is closed by a coastal shore protection of rock boulders and a separation liner of a geotextile with an average height of 2,0 over MSL |
| Vegetation | No vegetation actually, landscaping measures foresee in the DBO |
| Activity | None (WtE later stage) |
| Ambient air quality | No activities/negligible |
| Surface water | Lagoon seawater on the north of the site<br>Open seawater at the Southside |
| Groundwater | Brackish seawater (after land reclamation) |

Table 5: Summary of project location (Micro-location WtE plant)

## 7.3 Component of the WtE facility

The WtE facility shall be designed and built as a conventional state-of-the-art grate type incinerator of two lines of 250 Mg/d each (total of 500 Mg/d), that shall consist of the following main set of process units and plant components:

a) Waste reception, storage and feeding consisting of a weigh bridge incl. guard house, tipping hall and waste bunker, a shredder and waste cranes;
b) Thermal treatment consisting of combustion system; boiler and heat recovery system and boiler feed water and make-up water system;
c) Air pollution control system and ID fan and stack and continuous emission monitoring system (CEMS)
d) Turbine with generator and condenser, cooling water pre-treatment system and cooling water pumps,
e) Other balance of plant components incl. fuel and chemicals supply and storage; fire-fighting water supply system; waste water treatment plant for sewerage, water supply system;
f) Bottom ash treatment plant incl. bottom ash bunker and conveying system;
g) Residue sanitary landfill and leachate collection, management and treatment system;
h) Electric system incl. connection to public network

All process units and the balance of plant components are to be equipped with the necessary electrical and control components, with valves, fittings, piping, utility mains etc. and shall be combined to a fully functional system that is fit for purpose and that is operated and controlled by a DCS which shall facilitate monitoring and recording of operational data.

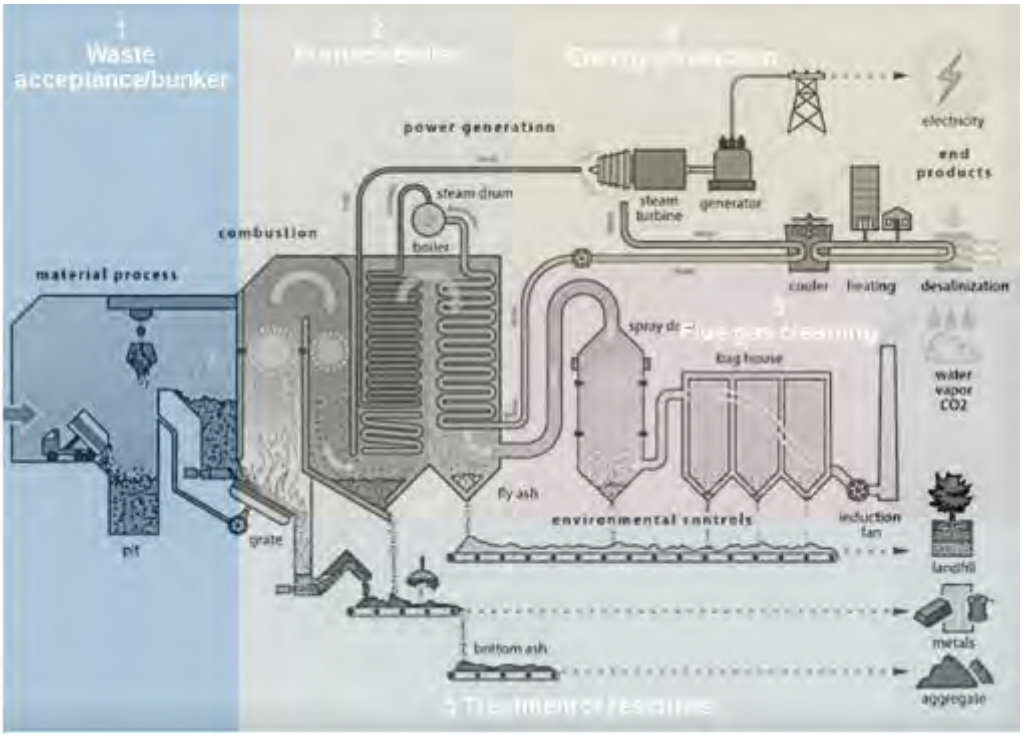



Figure 13: schematic layout of the WtE Facility

These process units are accomodated by the following buildings, housings and civil constructions:

a) Waste reception/guard house
b) Tipping hall
c) Waste bunker
d) Machinery hall and steam turbine housing
e) Housing for the bottom ash processing plant
f) Administration block incl. control room and visitors' center
g) Workshop

h) Housing of the leachate treatment plant

The WtE facility shall be designed and built to allow the extension of the plant by a third line of 250 Mg/d (to reach a total of 750 Mg/d)

To operate the facility the following infrastructure needs also to be realised:

- Water supply, electricity supply (emergency Genset), sewerage system
- Roads, carriageways and sidewalks
- Cooling water inlet and outlet structure
- Storm water drainage system
- Landscaping
- Fencing

All infrastructural elements shall be incorporated into the buildings and process units to allow an easy operation and maintenance of all facilities.

The residual waste from the waste incineration is 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: as covering material for landfill, as a ballast layer or reinforcement layer in road construction or as a filler/aggregate for construction blocks. A bottom ash processing plant is also part of the facility

The residues from the flue gas cleaning (fly ash) are hazardous and need to be dumped in a controlled way on a sanitary landfill after being conditioned safely in sealed big bag.

### 7.3.1 Stack height

The stack height has been established through the use of modelling services engaged for the EIA. The assessment was done with reference to standards applied for air quality control in Germany, as set out in an instruction document with legal standing in Germany,TA Luft. The stack height required to comply with the technical instruction was determined, following which predictions of concentrations of pollutants in the emissions from the WtE were predicted, and dispersion modelling undertaken for those exceeding a designated minimum level.

Determination of the requisite stack height was undertaken using a nomogram and calculation steps provided in the German TA Luft. The input values for this process are the inside diameter of the stack, the temperature of the waste gas at the mouth of the stack, the volume of flow of the waste gas in standard conditions after subtraction of the water vapour content, and the rate of emission mass flow of the air pollutants from the plant. In determining these parameters, a feed of 500 tons of household waste per day was assumed. The final stack height is determined based on the dimensions of adjoining buildings.

A stack height of minimum 45.7m would have sufficient dilution of the exhaust gases and an undisturbed transport with the free air flow is ensured.

With a view to alleviate the potential air quality impacts at critical air sensitive receivers (ASRs) but at the same time to minimize potential visual impact associated with a tall stack, 50m is selected as the stack height for the RWMF at Thilafushi. It has considered the air quality benefit and visual impact due to a relatively tall stack in a small island geographic setting. The cleaned and cooled gases from the gas cleaning system are discharged into a stack. The gases are discharged by means of an induced drafted fan.

### 7.3.2 Coolling system

The heat energy of the exhaust air from the furnace is transmitted to water, converting the water to high pressure steam. The high pressure steam is used to rotate a steam turbine and generate electricity. After the electricity generation process, steam pressure is reduced and the steam is further cooled down by a cooling system. The proposed cooling system uses a seawater cooled condenser and involves exchange of the heat of the low pressure steam to sea water, which is then discharged to the sea from south side of Thilafushi.

### 7.3.3 Bottom ash treatment

The DBO-Contractor shall be responsible for designing and building the bottom ash processing plant including bottom ash storage to satisfy the requirements of the envisaged bottom ash reuse. Subject to the design considerations of the DBO Contractor an intermediate bottom ash storage shall be provided. The floor of the bottom ash storage hall shall allow run-off from the wet bottom ash via a drainage system. The drained run-off from the bottom ash storage area shall be forwarded after either mechanical or gravity cleaning to buffer tanks prior to the leachate treatment system. The intermediate bottom ash storage area shall be sized to accommodate short term stoppages in the conveying system (e.g. the overhead cranes and belt conveyors.

Table 6: Design parameters for Bottom ash treatment plant

| **Bottom ash Handling System (design parameter)** | |
|---|---|
| Ash content in SW (dry ash/wet) | Max. 35% |
| Water content in bottom ash downstream extractor | Max. 15% |
| Capacity | Min. 160% of the maximum bottom ash flow |
| **Boiler & Fly ash transport system** | |
| Boiler hopper ash and air pollution control system fly ash shall be collected from each boiler, economizer, and air pollution control system hopper with drag conveyors, screw conveyors, or a pneumatic conveying system to conditioning the fly ash into big bags. After conditioning the fly ash shall be deposed into the landfill cell. Provisions will be made to prevent dusting during transfer to a disposal truck. The big bags shall be fully enclosed and dustproof and located in the residue building before transport<br><br>Boiler ash and fly ash drag conveyors, screw conveyors, or pneumatic system shall be completely dust-tight to prevent leakage of fly ash. | |

### 7.3.4 Residual waste landfill

The DBO Contractor's shall design the residual waste landfill complying with the following criteria:

- The landfill arrangement shall be designed to maximise the useable landfill volume of the Site;
- The landfill cell arrangements shall be designed to allow for the progressive closure of individual landfill cells on completion and thereby to minimise the amount of leachate requiring treatment over the lifetime of the landfill;

- The design shall allow for the development of individual cells in a coherent and logical sequence and in a manner which ensures the stability of all working faces and of the waste mound as a whole.
- The design shall incorporate appropriate back-up systems in the event of failure of any component of the environmental control and management systems;
- The landfill concept shall be designed to minimise the lateral and vertical extent of the working face and thereby the amount of deposited waste that is exposed to the environment;
- The design shall ensure that waste can be deposited in a manner that prevents damage to the engineered barrier or liner, the leachate control system, and the collection and transfer system.
- The landfill design shall incorporate an internal access corridor to allow for safe traffic movement and to accommodate site services and monitoring devices;
- Measures shall be provided for controlling unauthorised access to the landfill including, as appropriate, the provision of ditches, berms, planting and fencing;
- Slopes shall be graded to ensure long term slope stability. Graded slopes shall be a maximum of 25%;
- Soil erosion and dust generation shall be minimised;
- All landfill construction materials shall be free of organic matter and debris;
- Measures shall be provided to monitor and manage groundwater beneath and adjacent to the landfill area;

The Contractor's design shall include surface water and storm water collection and diversion systems in order to protect the landfill area and minimise the generation of leachate. Sedimentation ponds shall be established to contain polluted drainage and runoff containing soil and sediment.

The Contractor's design shall include an engineered barrier to prevent leachate contamination of surface water and groundwater. The barrier shall comply with the following:

- The hydraulic conductivity of the barrier shall be no greater than the equivalent of 1 x $10^{-9}$ metres per second.
- The level of the engineered barrier shall be no deeper than 1.5 metres above mean sea level and in accordance with the applicable environmental standards;

All components of the leachate collection, extraction, transfer and treatment system shall be capable of being maintained in a clean condition to ensure effective operation. Concentrate shall be re-injected in the flue gas treatment process of the WtE. The Contractor shall design and build or organise a system for the safe collection, transport and re-injection of the LTP concentrate.

### 7.3.5 Electricity generation

The heat produced during the incineration process will be recovered and used for electricity generation. The electricity generated from the incineration process will be used to support the normal operation of the facilities within the RWMF. Surplus energy will be exported to other users via the existing electricity grids maintained by the State Electric Company (STELCO). The supply of process steam and electrical energy for the side shall take place via combined heat and power.

### 7.3.6 Layout arrangement

The RWMF has been designed to provide long term environmentally sustainable solution for waste management in Zone 3 of the Maldives. Limitations and scarcity of land and the requirement to protect the fragile eco-system have also been considered during the design of RWMF. With a view to minimize the land use and the associated environmental impacts, the preferred location for the RWMF was the area around the old dumpsite of Thilafushi. This has the advantage to reduce environmental risks on another location and islands, and to conduct the dumpsite rehabilitation in parallel. The vocation of Thilafushi as an industrial island plays also in favour of a site location of the facility on this island.

The layout for the RWMF is considered appropriate, taking into consideration the functional need for operation of the RWMF, reasonable flexibility in design for the DBO contractor and allowance of suitable size of land for provision for the future. The design of the RWMF has been done considering factors such as waste composition, quantity reaching RWMF, applicability in the local condition and regulatory compliance.

## 7.4 Ambiant Air quality/Baseline survey

Air quality monitoring for baseline was conducted by Water Solutions at Thilafushi (and Villingili). Three locations were selected at Thilafushi and one location at Villingili for baseline Air quality monitoring in 2018 and 2019 (see chapter methodology). The Principal objective of the ambient air quality monitoring is to access background environment status and to check the conformity to the applicable standards of ambient air quality. Despite rapid increase in sources of air pollutants and associated diseases there is no national standard for air quality or regulations to control air emission in the Maldives (MEE, 2017). In the absence of any National Ambient Air Quality Standards, the WHO guidelines were considered to assess the air quality.

**Figure 14:** View around AQ4 (Villingil) on 3rd March 2019

On each sampling day, 1 set of 24-hour average samples were collected continuously. $PM_{10}$, $PM_{2.5}$, Sulphur dioxide ($SO_2$) and Oxides of nitrogen (NO2) were measured by sampling continuously during the sampling period.

**Figure 15:** Air quality monitoring at location AQ1 on 19rd March 2019

As per ToR additional survey for the parameter $CH_4$, VOC, $CO_2$, CO, $H_2S$ has been undertaken at selected locations (see Methodology).

**Figure 16:** Air quality monitoring at location AQ3 on 20th August 2019

**Figure 17:** View around AQ2 (Thilhafushi) on 25th August 2019

### 7.4.1 Air Quality baseline survey AQ 1 (Thilafushi workers camp)

| Weather/climate | Clouds | Wind direction | Wind speed | Dumpsite |
|---|---|---|---|---|
| Sunny 33°C | No | North-East | Low-moderate | Open burning |

| Parameter | Date | µg/m³ | WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in µg/m³ |
|---|---|---|---|
| $PM_{10}$ | 19.03.-20.03.2019 | 26,5 [24 hr] | 50 [24 hr] |
| $PM_{2,5}$ | 19.03.-20.03.2019 | **26,9 [24 hr]** | 25 [24 hr] |
| $SO_2$ | 22.03.-23.03.2019 | **214 [24 hr]** | 20 [24 hr] |
| | | **866 [10 min max]** | 500 [10 min] |

| | | | |
|---|---|---|---|
| $NO_2$ | 19.03.-20.03.2019 | 67,5 [1 hr max.] | 200 [hr] |

Additional parameters according ToR

| Parameter | Date | µg/m³ | WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in µg/m³ |
|---|---|---|---|
| $CH_4$ | 19.03.-20.03.2019 | 11.745 [24 hr] | N/a |
| CO | 19.03.-20.03.2019 | 126 [24 hr] | N/a |
| VOC | 21.03.2019 | 4.889 [24 hr] | N/a |

### 7.4.2 Air Quality baseline survey AQ 2 (Thilafushi 2, new reclaimed area)

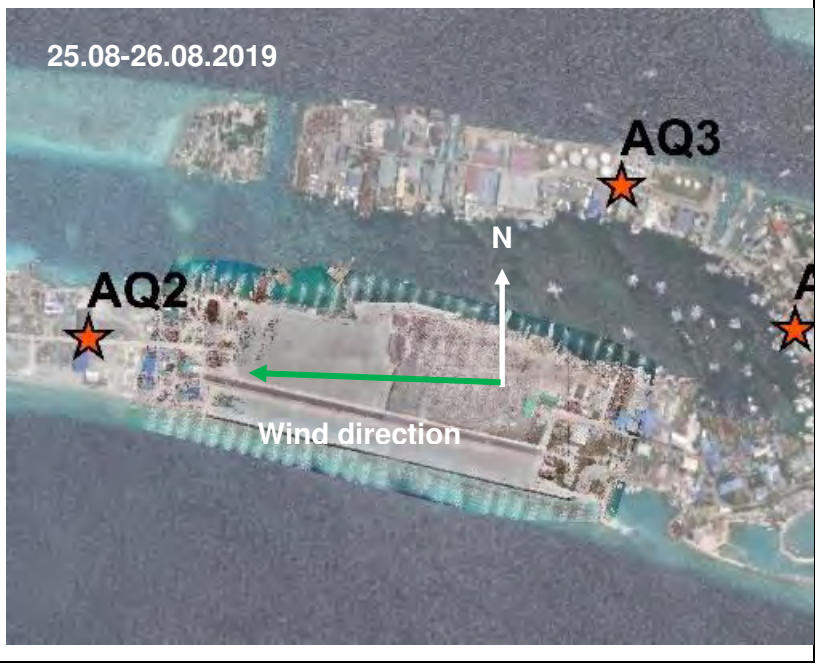
| Weather/climate | Clouds | Wind direction | Wind speed | Dumpsite |
|---|---|---|---|---|
| Sunny 32°C | yes | North-East | moderate | Open burning |

| Parameter | Date | µg/m³ | WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in µg/m³ |
|---|---|---|---|
| $PM_{10}$ | 25.08.-26.08.2019 | **538,93 [24 hr]** | 50 [24 hr] |
| $PM_{2,5}$ | 25.08.-26.08.2019 | **387,45 [24 hr]** | 25 [24 hr] |
| $SO_2$ | - | N/a | 20 [24 hr] |
| | | N/a | 500 [10 min] |
| $NO_2$ | 28.08.-29.08.2019 | 72,8 [1 hr max] | 200 [hr] |

### 7.4.3 Air Quality baseline survey AQ 3 (Thilafushi 3, Opposite of dumpsite)

| Weather/climate | Clouds | Wind direction | Wind speed | Dumpsite |
|---|---|---|---|---|
| Sunny 31°C | yes | North-East | Moderate-high | Open burning |

| Weather/climate | Clouds | Wind direction | Wind speed | Dumpsite |
|---|---|---|---|---|
| Sunny 33°C | yes | West | moderate | Open burning |



| Parameter | Date | µg/m³ | WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in µg/m³ |
|---|---|---|---|
| $PM_{10}$ | 20.06.-21.06.2018 | **359,7 [24 hr]** | 50 [24 hr] |
| | 21.06-22.06.2018 | **96,50 [24 hr]** | |
| | 22.06-23.06.2018 | **86,29 [24 hr]** | |
| | 23.06-24.06.2018 | **291,47 [24 hr]** | |
| | 25.08.-26.08.2019 | **88,46 [24 hr]** | |
| $PM_{2,5}$ | 20.06.-21.06.2018 | **233,33 [24 hr]** | 25 [24 hr] |
| | 21.06-22.06.2018 | **61,38 [24 hr]** | |
| | 22.06-23.06.2018 | **51,38 [24 hr]** | |
| | 23.06-24.06.2018 | **184,70 [24 hr]** | |
| | 25.08.-26.08.2019 | **42,81 [24 hr]** | |
| $SO_2$ | 22.06-24.06.2018 | **291 24 [hr]** | 20 [24 hr] |
| | | **970 [10 min max]** | 500 [10 min] |
| $NO_2$ | 28.08.-29.08.2019 | 72,8 [1 hr max] | 200 [hr] |

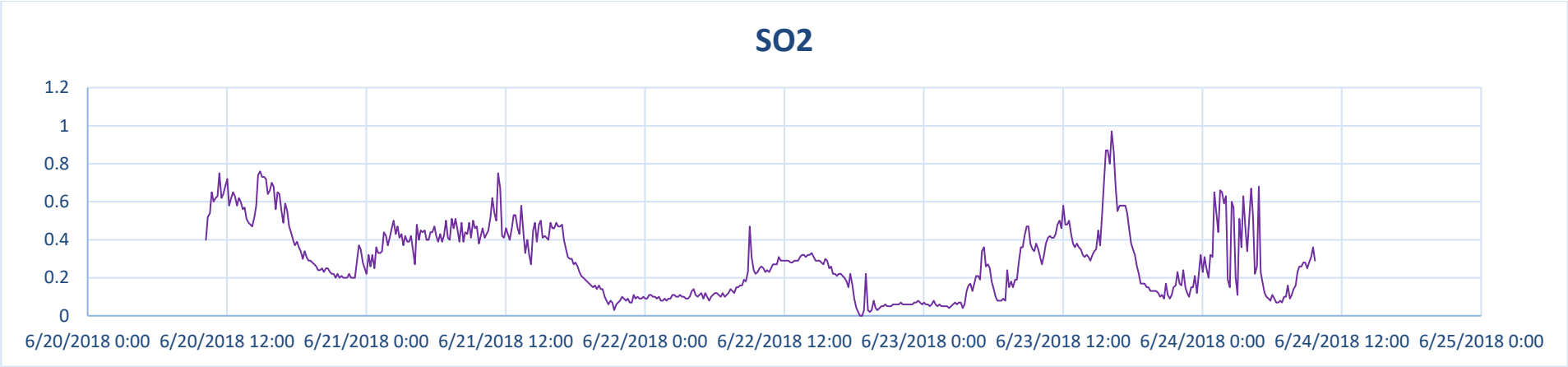



**Figure 18:** graphical presentation of survey results for $SO_2$ at AQ3 (PPT)

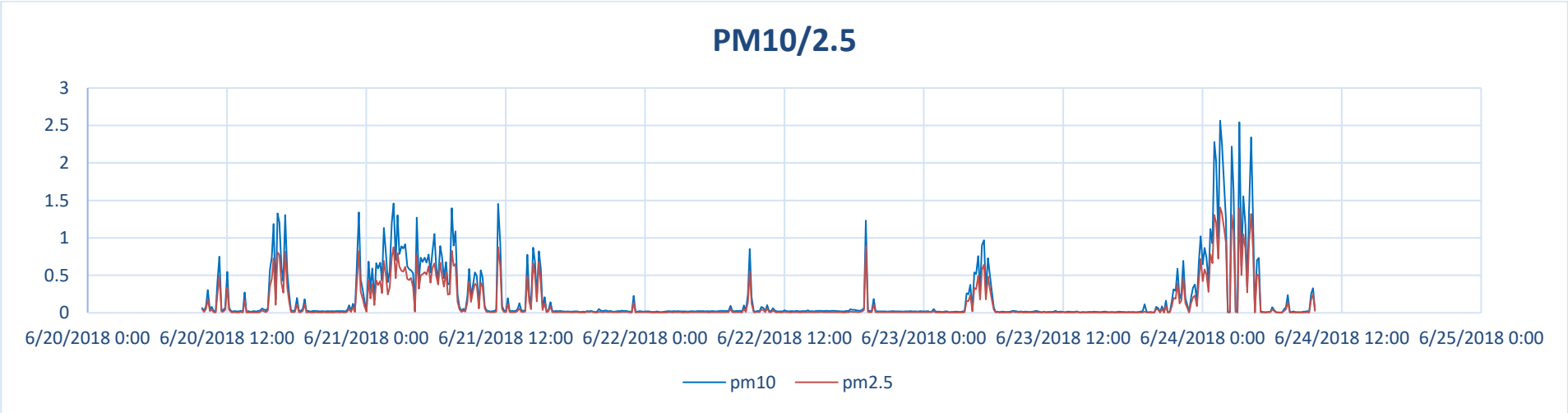



**Figure 19:** graphical presentation of survey results for $PM_{2,5}$ and $PM_{10}$ at AQ3 (PPT)

### 7.4.4 Air Quality baseline survey AQ 4 (Vilingili)

| Parameter | Date | µg/m³ | WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in µg/m³ |
|---|---|---|---|
| $PM_{10}$ | 06.03.-08.03.2019 | 22,7 [24 hr] | 50 [24 hr] |
| $PM_{2,5}$ | 06.03.-08.03.2019 | 22,7 [24 hr] | 25 [24 hr] |
| $SO_2$ | 06.03.-08.03.2019 | 7,6 [24 hr] | 20 [24 hr] |
| | | 190 [10 min max] | 500 [10 min] |
| $NO_2$ | 06.03.-08.03.2019 | 87 [1 hr] | 200 [hr] |

Additional parameters according ToR

| Parameter | Date | µg/m³ | WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in µg/m³ |
|---|---|---|---|
| $CH_4$ | 06.03.-08.03.2019 | 0,175 [24 hr] | N/a |
| CO | 06.03.-08.03.2019 | 124 [24 hr] | N/a |

### 7.4.5 Interpretations of the results

The ambient air quality results obtained from the monitoring undertaken at Thilafushi indicate that only some parameters were within the WHO guidelines for ambient air quality.

As it could be seen one main influencing factor is the dumpsite at Thilafushi and its illegal burning

Particular manners usually varies between 27-540 µg/m³ (daily average) with a min around 4 µg/m³ and a maximum peak reaching more than 2.000 µg/m³.

$NO_2$ (hourly maximum) are below WHO guidelines at all places

$SO_2$ is in the rage of 214-290 µg/m³ (24 hr average) and 800-866 µg/m³ and over the WHO values.

It must be noted that at each period of surveying the dumpsite was burning and that unfortunetaly the wind direction and the wind speed (velocity) were during the survey period exactly in the direction of the survey points. It can be seen that when the velocity is low (AQ 1 end of March 2019) or the wind direction is not in the direction of the survey point (AQ3 August 2019) the parameters are closer to the WHO guidelines.

For Vilingili as the main inhabitated islands close to Thilafushi all the parameters are below the WHO guidelines.

# 8 Identification and assessment on potential effects

## 8.1 General emission

The following maximum mass concentrations should be achieved by the flue gas cleaning.

Table 7: Maximum mass concentration

| Substance | Mass concentration [1] |
|---|---|
| Total dust, including particulate matter (No 5.2.1 TA Luft) | 5 mg /m³ |
| Fluorine and its compounds, indicated as hydrogen fluoride (5.2.4 Class II TA Luft) | 1 mg /m³ |
| gaseous inorganic chlorine compounds, indicated as hydrogen chloride (5.2.4 class III TA Luft) | 10 mg/m³ |
| Ammonia (5.2.4 class III TA Luft) | 10 mg/m³ |
| Sulphur oxides (sulphur dioxide and sulphur trioxide), expressed as sulphur dioxide (5.2.4 Class IV TA Luft) | 50 mg/m³ |
| Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), expressed as nitrogen dioxide (5.2.4 (2), 2nd sentence TA Luft) | 150 mg/m³ |
| Carbon monoxide (5.2.4 para. 2 sentence 1 TA Luft) | 50 mg/m³ |
| organic substances (expressed as total C) (TA Luft 5.4.10.20) | 10 mg/m³ |
| Mercury and its compounds, reported as Hg (No 5.2.2 Class I TA Luft) | 0.03 mg/m³ |
| Dioxins and furans | 0.1 ng/m³ |
| Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III) | as total 0.5 mg/m³ |
| Thallium and its compounds (5.2.2 TA Luft class I) cadmium | as total of 0.05 mg/m³ |
| 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) (5.2.7.1.1 TA Luft Class I ) | as total 0.05 mg / m³ |

### 8.1.1 Emission mass flow

Table 8: Emission mass flow (for R = 115 713 m³/h, T = 180 °C, Ø = 2.12 m)

| Substance | Masses concentration | Mass flow Q in kg/h | Factor S | Q/S in kg/h ** |
|---|---|---|---|---|
| Total dust, including particulate matter (No 5.2.1 TA Luft) | 5 mg/m³ | 0.579 | 0.08 | 7.2 |
| Fluorine and its compounds, indicated as hydrogen fluoride (5.2.4 Class II TA Luft) | 1 mg/m³ | 0.116 | 0.0018 | 64.3 |

| Substance | Masses concentration | Mass flow Q in kg/h | Factor S | Q/S in kg/h ** |
|---|---|---|---|---|
| Gaseous inorganic chlorine compounds, indicated as hydrogen chloride (5.2.4 class III TA Luft) | 10 mg/m³ | 1,157 | 0.1 | 11.6 |
| Ammonia (5.2.4 class III TA Luft) | 10 mg/m³ | 1,157 | - | - |
| Sulphur oxides (sulphur dioxide and sulphur trioxide), expressed as sulphur dioxide (5.2.4 Class IV TA Luft) | 50 mg/m³ | 5,786 | 0.1 4 | 41.3 |
| Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), expressed as nitrogen dioxide (5.2.4 (2), 2nd sentence TA Luft) | 150 mg/m³ | 11,108 * | 0.1 | 111.08 * |
| Carbon monoxide (5.2.4 para. 2 sentence 1 TA Luft) | 50 mg/m³ | 5,786 | 7.5 | 0.77 |
| Organic substances (expressed as total C) (TA Luft 5.4.10.20) | 10 mg/m³ | 1,157 | 0.1 | 11.6 |
| Mercury and its compounds, reported as Hg (No 5.2.2 Class I TA Luft) | 0.03 mg/m³ | 0.003 47 | 0.00 013 | 26.7 |
| Dioxins and furans | 0.1 ng/m³ | $1.16 \times 10^{-8}$ | - | - |
| Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III) | 0.5 mg / m³ | 0.057 86 | 0.05<br>0.1 | 1.157<br>0.579 |
| Thallium and its compounds (5.2.2 TA Luft class I) cadmium | 0.05 mg / m³ | 0.005 79 | 0.005 | 1.16 |
| 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) (5.2.7.1.1 TA Luft Class I ) | 0.05 mg / m³ | 0.00579 | 0.00005 | **115.7** |

* According to point 5.5.3 TA Luft, the emission of nitrogen monoxide is based on a conversion rate of 60% to nitrogen dioxide, and is based on a ratio of $NO/NO_2$ = 90%/10%, cf. Annex 1.1

### 8.1.2 Control of the necessity of the dispersion calculation

The determination of the ambient air quality characteristics is not required if the emissions of the air pollutants do not exceed the following minor mass flows:

Table 9: Minor mass flow according 4.6.1.1 TA Luft and WtE mass flow

| Pollutants | Minor mass flow | Plant mass flow (Annex 2) |
|---|---|---|
| | in kg / h | |
| Emissions derived from stacks | | |
| Dust (without consideration of dust contents) | 1 | 0.579 |
| Fluorine and its compounds, indicated as hydrogen fluoride (5.2.4 Class II TA Luft) | 0.15 | 0.116 |
| Gaseous inorganic chlorine compounds, indicated as hydrogen chloride (5.2.4 class III TA Luft) | - | 1,157 |
| Ammonia (5.2.4 class III TA Luft) | - | 1,157 |
| Sulphur oxides (sulphur dioxide and sulphur trioxide), expressed as sulphur dioxide (5.2.4 Class IV TA Luft) | 20 | 5,786 |
| Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), expressed as nitrogen dioxide (5.2.4 (2), 2nd sentence TA Luft) | 20 | 11.108 |
| Carbon monoxide (5.2.4 para. 2 sentence 1 TA Luft) | - | 5,786 |
| Organic substances (expressed as total C) (TA Luft 5.4.10.20) | - | 1,157 |
| Mercury and its compounds, reported as Hg (No 5.2.2 Class I TA Luft) | 0.0025 | 0.00347 |
| Dioxins and furans | - | $1,16x\ 10^{-8}$ |
| Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III) | 0.025 lead, nickel (class II) | 0.05786 |
| Thallium and its compounds (5.2.2 TA Luft Class I) | 0.0025 | 0.00579 |
| 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) (5.2.7.1.1 TA Luft Class I) | 0.0025 | 0.00579 |

For most of substances the values are below the minor mass flows. For mercury as well as heavy metals and their components (referred to thallium and arsenic/cadmium and lead/nickel) the values are over the minor flows, therefore there is a need to perform the **dispersion modelling** for these substances.

For ammonia and hydrogen chloride (5.2.4 Class III TA Luft), for carbon monoxide, for organic substances (expressed as total C) as well as dioxins and furans no minor mass flow are set in the regulations therefore there is no need to undertake a detailed dispersion modelling for these parameters either.

### Emergency Gen-set

For the emissions mass flow calculation of the air pollutants of the emergency Gen-set, data of the client have been made available [1].

The following pollutants have to be considered. The exhaust gas volume flow was given as $V_n$ = 12 470 $mN^3/h$ and the exhaust gas temperature to T=180° C.

Table 10: Minor mass flow according to Section 4.6.1.1 TA Luft - system mass flow

| Substance | Minor mass flow | Plant mass flow in kg/h |
|---|---|---|
| | in kg / h | |
| Dust (without consideration of dust contents) | 1 | 0.9976 |
| Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), expressed as nitrogen dioxide (5.2.4 (2), 2nd sentence TA Luft) | 20 | 3.99 |
| Carbon monoxide (5.2.4 (2) sentence 1 TA Luft) | - | 3,741 |
| Formaldehyde - HCHO | - | 0,748 |

The minor mass flows have also been not exceeded by the Gen-set emission values, so that no dispersion calculation has to be carried out for these substances.

For carbon monoxide and formaldehyde no minor mass flow has been set in the regulation. For these substances, so that for this substance group also no dispersion calculation is to be carried out.

No indications were found which requires a special case test according to section 4.8 TA Luft.

## 8.2 Air dispersion modelling for relevant parameter

In order to estimate exposures to airborne pollutants from the incineration and emergency electricity generation, dispersion modelling was carried out. Modelling was done for the pollutants: dust, nitrogen monoxide and nitrogen dioxide), carbon monoxide and formaldehyde from the emergency electricity generation sets. Modelling was done for the pollutants: total dust including fine dust, fluoride and its compound specified as hydrogen fluoride, ammonia, sulphur (sulphur dioxide and sulphur trioxide), specified as sulphur dioxide, nitrogen oxide (nitrogen monoxide and nitrogen dioxide) specified as nitrogen dioxide and mercury and its compound specified as mercury from the waste to energy plant. The study zone was defined as a 5000 m radius of influence from incinerator stack at Thilafushi. The figure below shows the area around the proposed waste to energy plant at Thilafushi Island.

The dispersion modelling for the pollutants was carried out using the dispersion model AUSTAL2000. The computer program AUSTAL2000 is a reference implementation developed on behalf of the German Federal Environmental Agency

The program system AUSTAL2000 calculates the spread of pollutants and odours in the atmosphere. It is an extended implementation of Annex 3 of the German regulation TA Luft (Technical Instruction on Air Quality Control) demands for dispersion calculations a Lagrangian particle model in compliance with the German guideline VDI 3945 Part 3. The modelling work was carried out by Ulbricht Consulting (Germany). The dispersion modelling report is attached as an Annex 1 to this report.

Steady-state Gaussian plume models assess pollutant concentrations and/or deposition fluxes from a variety of sources associated with an industrial source complex. Unlike the Gaussian models commonly used, this flexible modelling procedure used in AUSTAL2000 provides realistic results even when buildings and uneven terrain influence flue gas dispersion. The model calculates the contribution of specified air pollutants from a given point source to the background concentrations present in the ambient air at ground level in the area surrounding the source.

Parameter for additional load, the parameter for the emission year-additional load (IJZ) is the average of all calculated individual contributions at each reference point.

#### 8.2.1.1 *Emission from installations*

The following emission sources have been considered:

Exhaust stack: WtE

The following operation time has been considered: 8,000 h/a

#### 8.2.1.2 *Emissions from guided sources*

For the emissions of the air pollutants of the incinerator WtE data are available from the client [1]. For the incineration plant, the following pollutants have been taken into account in the dispersion calculation. The exhaust gas volume flow was given as Vn = 115713 $mN^3/h$ and the exhaust gas temperature as T = 180° C.

The air dispersion calculation was made with a stack height of 46,0 m.

In chapter 6 (Employer's requirement) of the DBO a minmum height of 50,0 m has been fixed.

Therefore the calculated emsissions are presenting the worst case. With the extension of the stack, the ambient air concentration value will be reduced at the reception point.

Table 11: Emissions Stack WtE

| Substance | mg / m³ | Total flow $V_N$ m³/h | Emission mass flow in kg/h |
|---|---|---|---|
| Total dust, including particulate matter | 5 | 115713 | 0.579 |
| Fluorine and its compounds, indicated as hydrogen fluoride | 1 | | 0.1 16 |
| Ammonia | 10 | | 1,157 |
| Sulphur oxides (sulphur dioxide and sulphur trioxide), expressed as sulphur dioxide | 50 | | 5,786 |
| Nitrogen oxides (nitric oxide and nitrogen dioxide), expressed as nitrogen dioxide | 150 | | 11.108 |
| Mercury and its compounds, indicated as Hg | 0.03 | | 0.0035 |
| Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III) | 0.5 mg / m³ | | 0.05786 |
| Thallium and its compounds (5.2.2 TA Luft class I) | 0.05 mg / m³ | | 0.00579 |
| 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) (5.2.7.1.1 TA Luft Class I) | 0.05 mg / m³ | | 0.00579 |

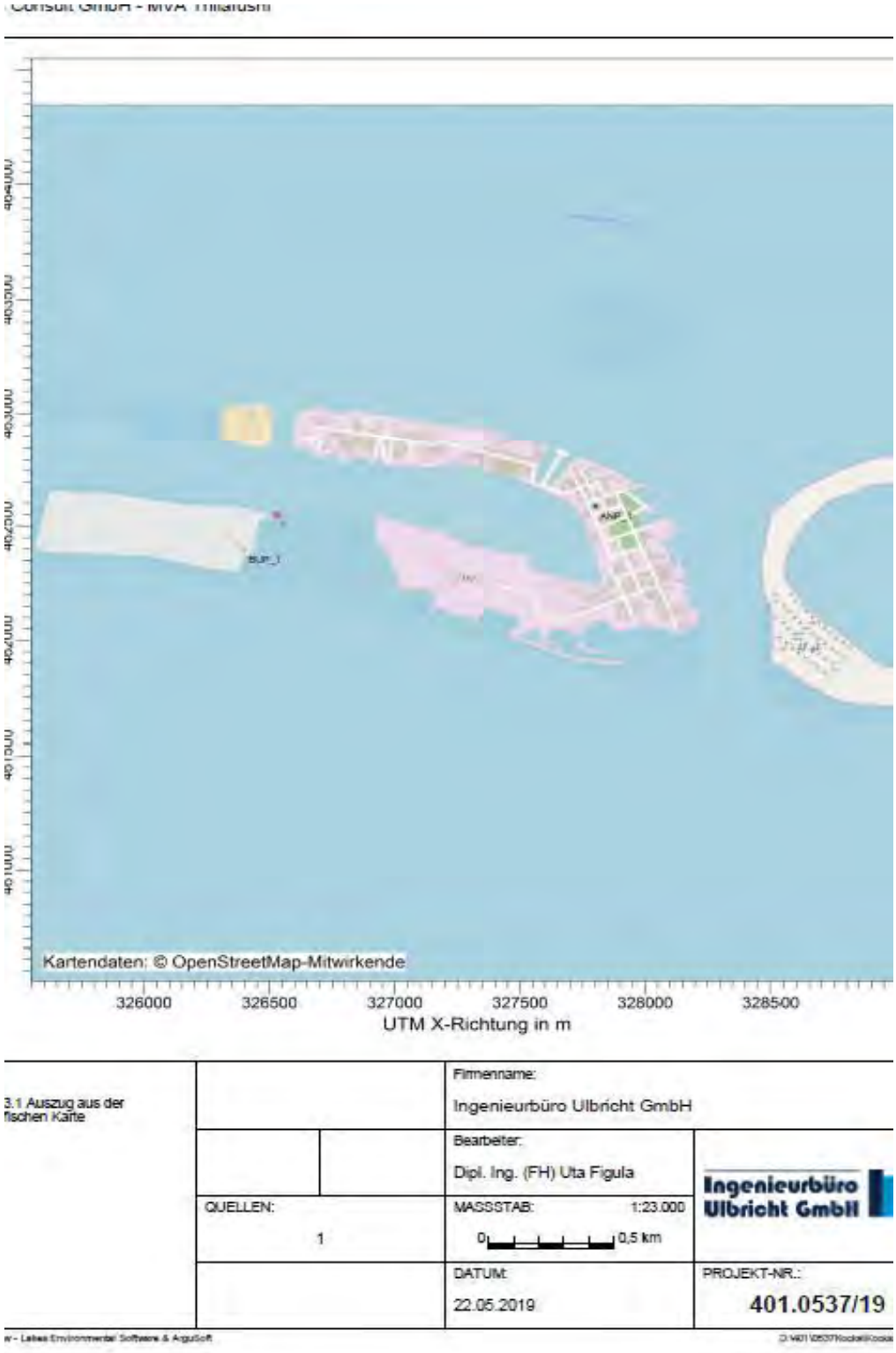



Figure 20: Location of the emission points where maximum load was calculated and examined

## Computer model

For the calculation the dispersion model AUSTAL2000, version 2.6.11-WI-x, of the company Janicke Consulting was used, which is implemented in the program AustalView TG of the company Argusoft. The program system AUSTAL2000 calculates the spread of pollutants and odours in the atmosphere. It is an extended implementation of Annex 3 of the TA Luft. The model underlying the program is described in guideline VDI 3945 Part 3.

Computational domain

Due to the stack height of 46 m the calculation area has a radius of at least 2300 m (50 times the height). The grid for the calculation of concentration and deposition shall be selected in accordance with Chapter 7 (2) of Annex 3 of the TA Luft so that the location and contribution of the maximum ambient air quality can be determined with sufficient certainty. This is usually the case when the horizontal mesh size does not exceed the stack height. At source distances greater than 10 times the height of the stack, the horizontal mesh size can be selected proportionally larger. The calculations and assessments were carried out in an area of 3.2 x 2.6 km and a grid with mesh sizes of 5 to 20 m.

Ground roughness

The ground roughness of the terrain is described by an average roughness length $z_0$ .It is in accordance with the land use classes in the CORINE cadastre. The roughness length was chosen to be $z_0 = 0{,}2$ in the calculation. This value should be considered representative for the area of calculation

Sources

In the calculation program emission source can be differentiated into different source types. Exhaust stacks are defined as point sources.

The source calculated on the basis of the emission behaviour described in Appendix 3, in accordance with Appendix 3, was entered using the parameters described. The parameters and emission data are given in Appendix 3. An emission source plan is also included in Appendix 3.

Pollutants

As per Table 4 in section 6 the dispersion modelling is required for mercury and heavy metals and their components (represented by lead/nickel, thallium and arsenic/cadmium). For all other pollutants, the minor mass flows according to Table 7 of No. 4.6.1.1 of the TA Luft have not been exceeded. For these substances, it can be assumed that harmful environmental effects from the plant cannot be caused.

The following pollutants relevant to the plant could be calculated according to TA Luft: dusts (dust precipitation, PM10), sulphur dioxide, nitrogen oxide, ammonia, mercury, arsenic, cadmium, nickel, lead, thallium. In the present case, for all relevant pollutants, insofar as emission limits are defined for these substances in TA Luft, the air dispersion modelling has been run.

For the other relevant pollutants: total C, carbon monoxide (CO), hydrogen chloride, dioxins and furans , no emission values are specified in the TA Luft.

Dispersion class time series

The wind direction and wind speeds were modelled with a dispersion class time series for the year 2017 [8].

Terrain and slope

It is a flat terrain. In the computing area, no gradients of more than 1:20 or more than 1:5 occur.

Statistics

The resulting statistical uncertainty (in %) was taken into account in the evaluation. The calculation was performed with the quality level "2". To assess the ambient air quality limits, the calculated value have been increased by the statistical uncertainty.

Receiver points

In the examination area two ambient air quality points have been determined for the calculations. The BUP 1 was chosen as the point of presumed highest load due to the shortest distance to the emission source. The ANP 1 (nearby a food place), due to which in comparison with the BUP 1 gives the higher additional load of pollutant deposition, was to be considered in more detail. The location of the ambient air quality points can be found in Annex 3.

**Table 12: Ambient air quality points**

| Ambient air quality points |
|---|
| BU P 1 West |
| ANP 1 east |

## 8.3 Maximum ground level/Additional load

The following results apply exclusively taking into account the characteristics of the emission sources mentioned in Chapter 7. The dispersion calculation is required for the substances mentioned in chapter 6.1. All other results in Table 10 are presented for information only. As a guide, a comparison is made with the irrelevance values and the ambient air quality values of TA Luft.

The detailed analysis results are given in Appendix 3 and the grid diagram representation of the substances (except for ammonia and suspended particulate $PM_{10}$) could be found in Annex 4 .

**Table 13: Ambient air quality Maximum ground level/additional load (IZ) (including statistical uncertainty)**

| Ambient air quality points | Irrel. IZ | IW | BUP 1 | ANP 1 |
|---|---|---|---|---|
| Substance | | | | |
| Mercury g/(m² d) | *0.05* | 1 | 0,007 | 1.0 |
| $PM_{DEP}$ g/(m² d) | *0.0105* | 0.35 | 0,0001 | 0,0001 |
| PM10 µg/m³ | *1.2* | 40 | 0 | 0 |
| Hydrofluoric µg/m³ | *0.04* | 0.4 | 0 | 0.005 |
| Sulphur dioxide µg/m³ | *1.5* | 50 | 0 | 0.2 |
| Nitrogen oxides µg/m³ | *1.2* | 40 | 0 | 0.4 |
| Ammonia µg/m³ | - | | 0 | 0.04 |
| Lead µg/(m² d) | *5* | 100 | 0,2 | 17,0 |
| Nickel µg/(m² d) | *0.75* | 15 | 0,122 | 17,1 |
| Thallium µg/(m²d) | *0.1* | 2 | 0,01 | 1,7 |
| Cadmium µg /(m² d) | *0.1* | 2 | 0.01 | 1, 7 |
| Arsenic µg/(m² d) | *0.2* | 4 | 0.02 | 1,7 |

A pre-pollution with air pollutants at the site is not known (baseline), so it is assumed that the calculated values represent the total load.

*Evaluation point BUP 1*

At assessment point BUP 1, the values are below the “irrelevance thresholds” of TA Luft for the substances.

*Analysis point ANP 1*

At the ANP 1 analysis point, the air pollutants PM10, dust precipitation, sulphur dioxide, nitrogen oxides, hydrogen fluoride fall below the irrelevance values according to TA Luft.

If an orienting comparison is made with the air quality values of TA Luft, the following can be stated:

- For lead, thallium, cadmium, arsenic, the ambient air quality value of TA Luft is below. For mercury, the ambient air quality value of TA Luft is reached (not exceeded).
- The specified ambient air quality value in the TA Luft for nickel is exceeded. In the calculation, the heavy metal nickel was considered representative of the group of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III).

Taking into account the volumetric flow and the desired mass concentration (corresponding to the emission limit value (class II according to 5.2.2 TA Luft) for the group of heavy metals, the emission mass flow for the group of heavy metals was assigned to the substance nickel. Fom a technical perspective it is not expected that none of the further elements of the heavy metal group occur in the exhaust gas, so that the exceeding of the ambient air quality value for nickel is likewise not expected.

<u>Ammonia</u>

No ambient air quality value is specified for ammonia. The desired mass concentrations by means of flue gas cleaning are below the values specified in the TA Luft (limit values). A negative impact on the environment is therefore not expected.

<u>Hydrogen chloride, total C, carbon monoxide (CO), dioxins and furans</u>

No ambient air quality values are specified for these substances. The mass concentrations aimed at by means of flue gas cleaning are below the values stated in the TA Luft (limit values). A negative impact is therefore not to be feared.

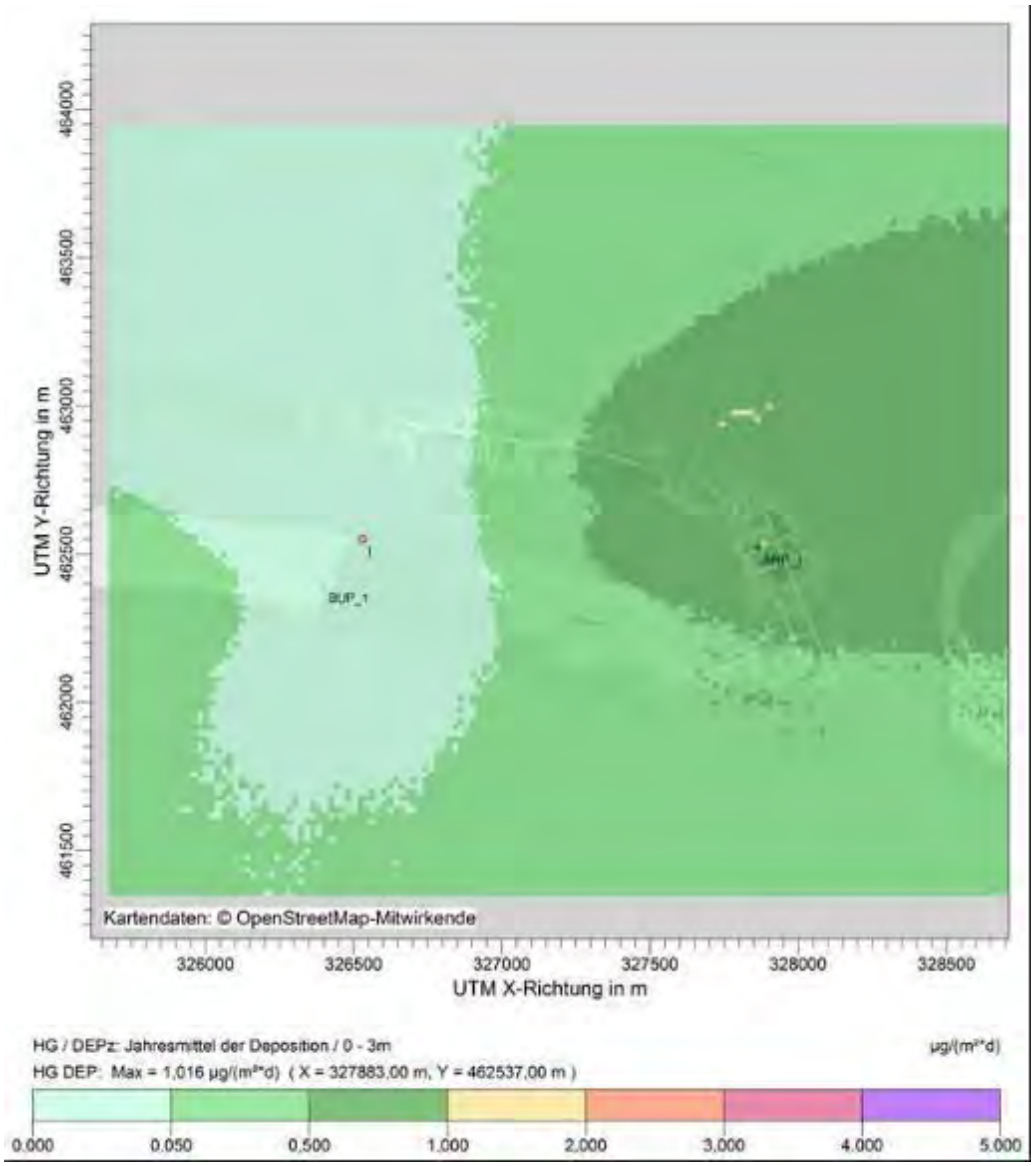



Figure 21: additional load Mercury-Deposit from the dispersion model.

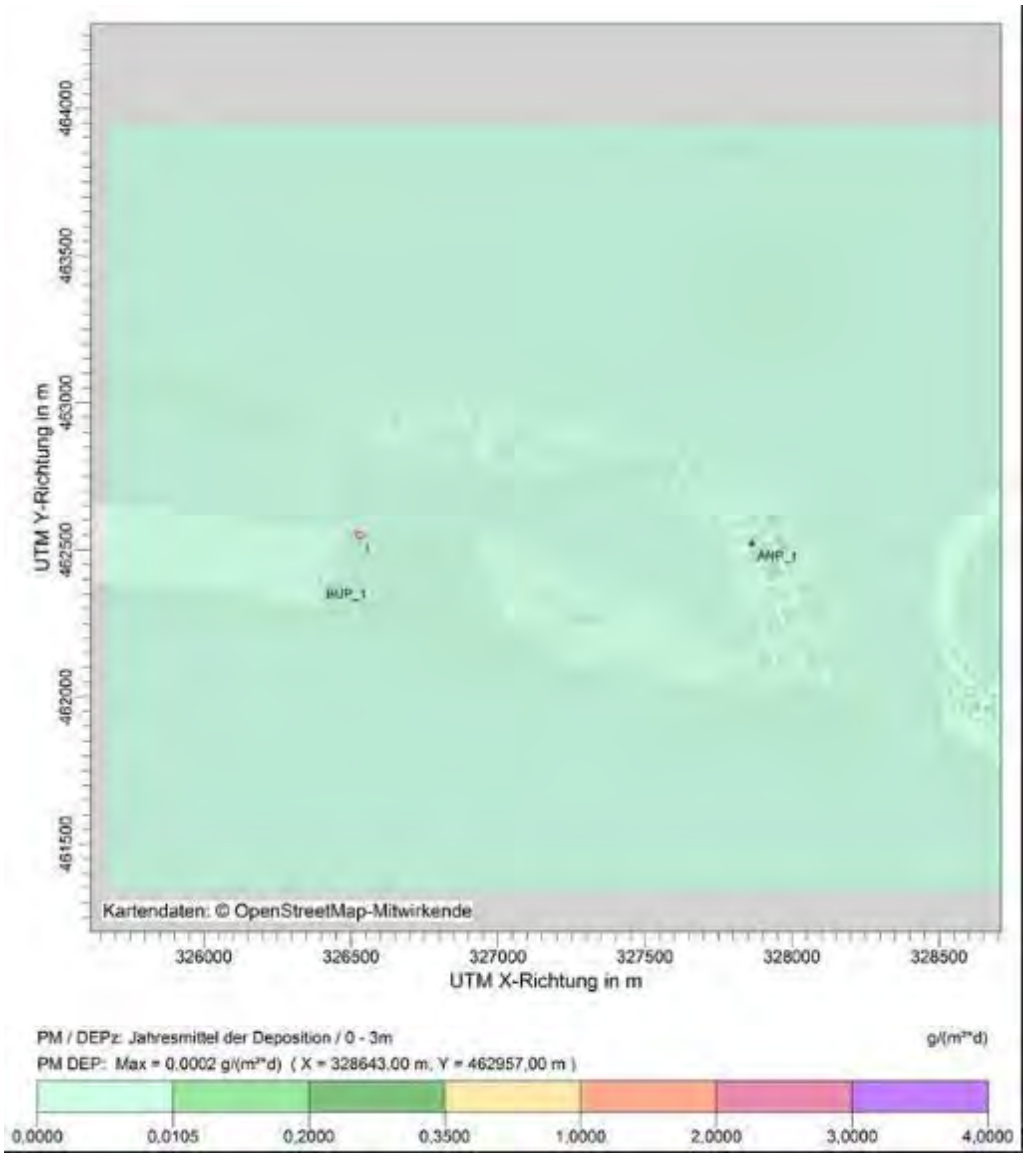



Figure 22: PM-Deposit from the dispersion model.

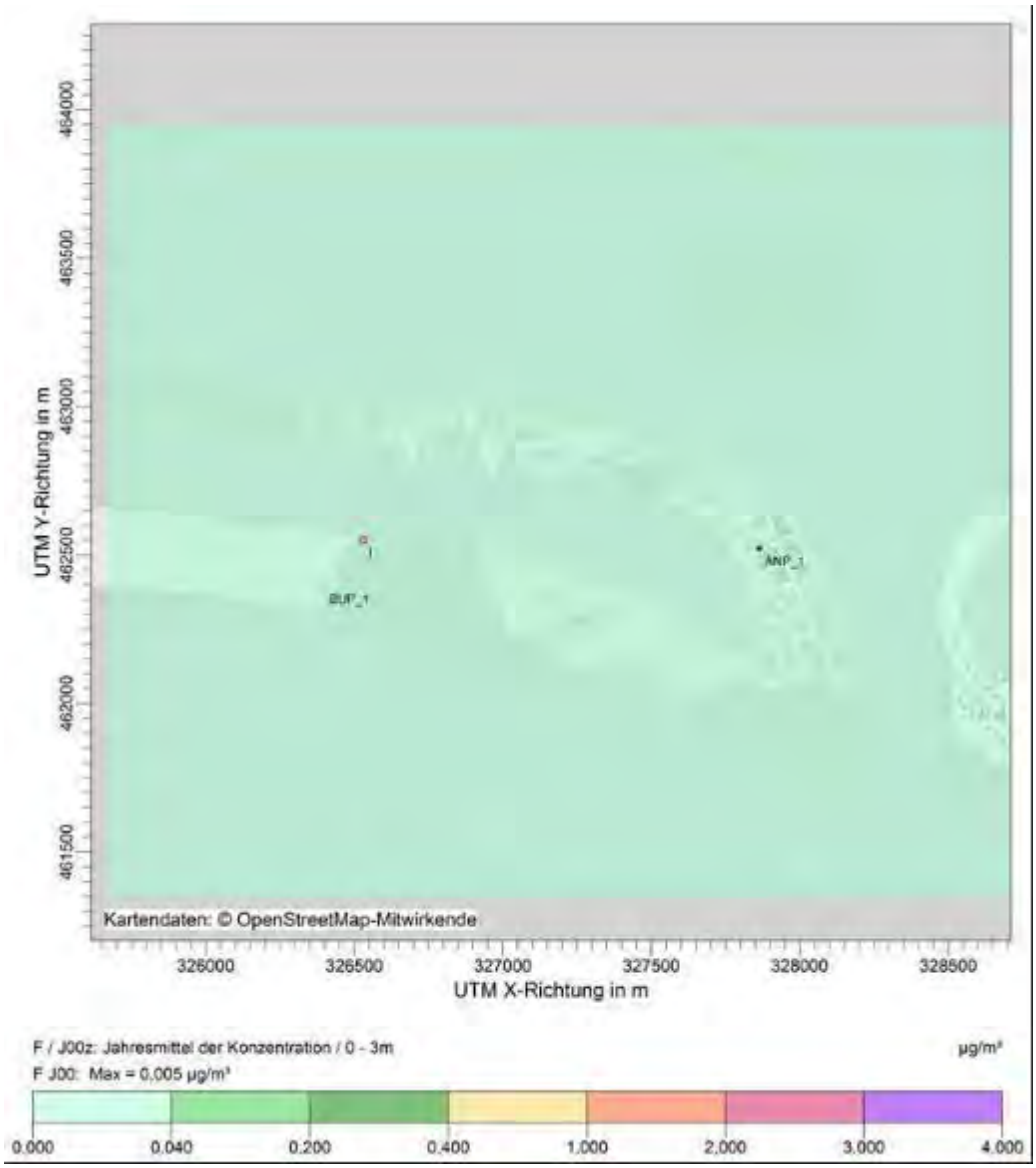



Figure 23: F-Deposit from the dispersion model.

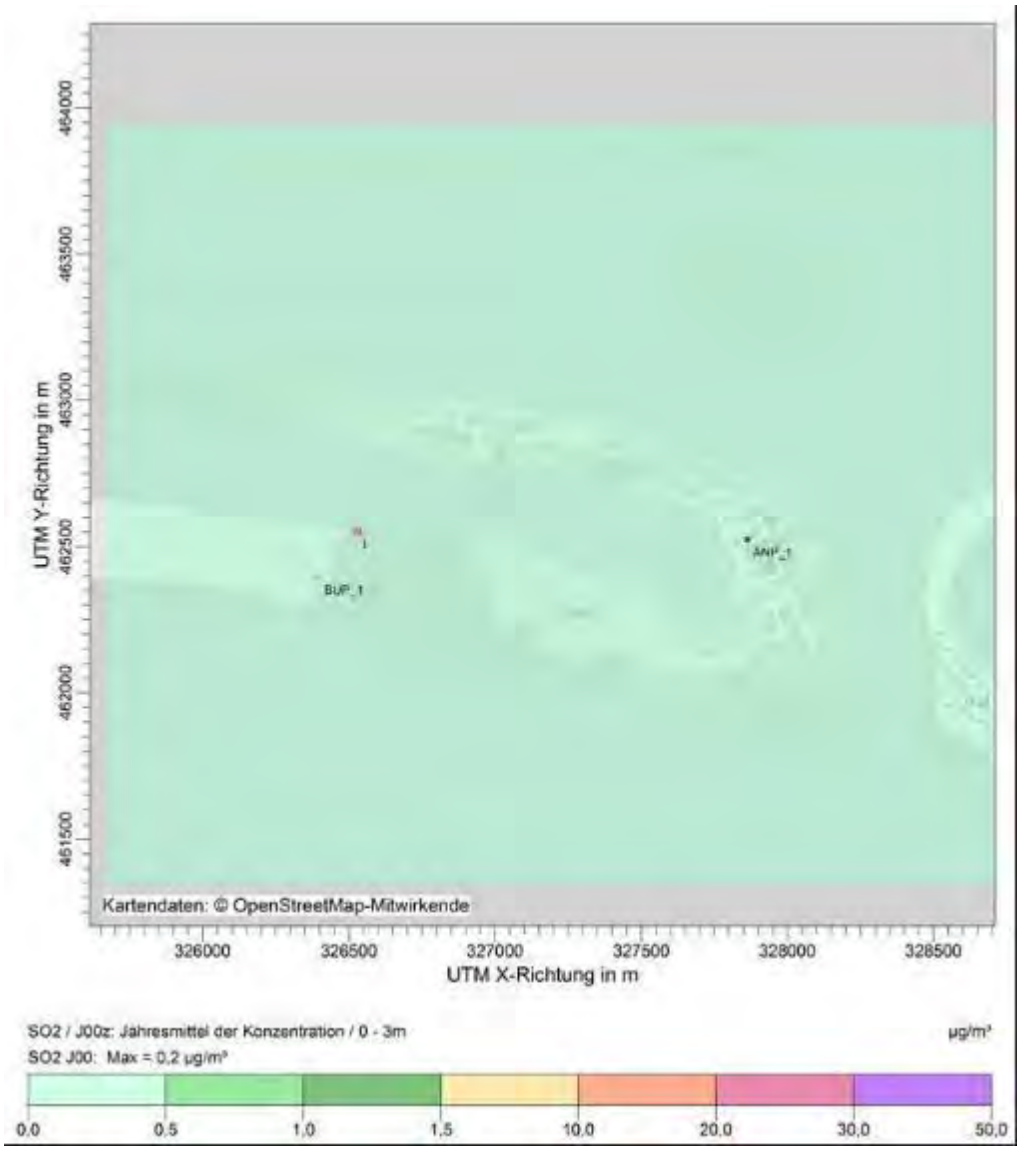



Figure 24: $SO_2$-Deposit from the dispersion model.

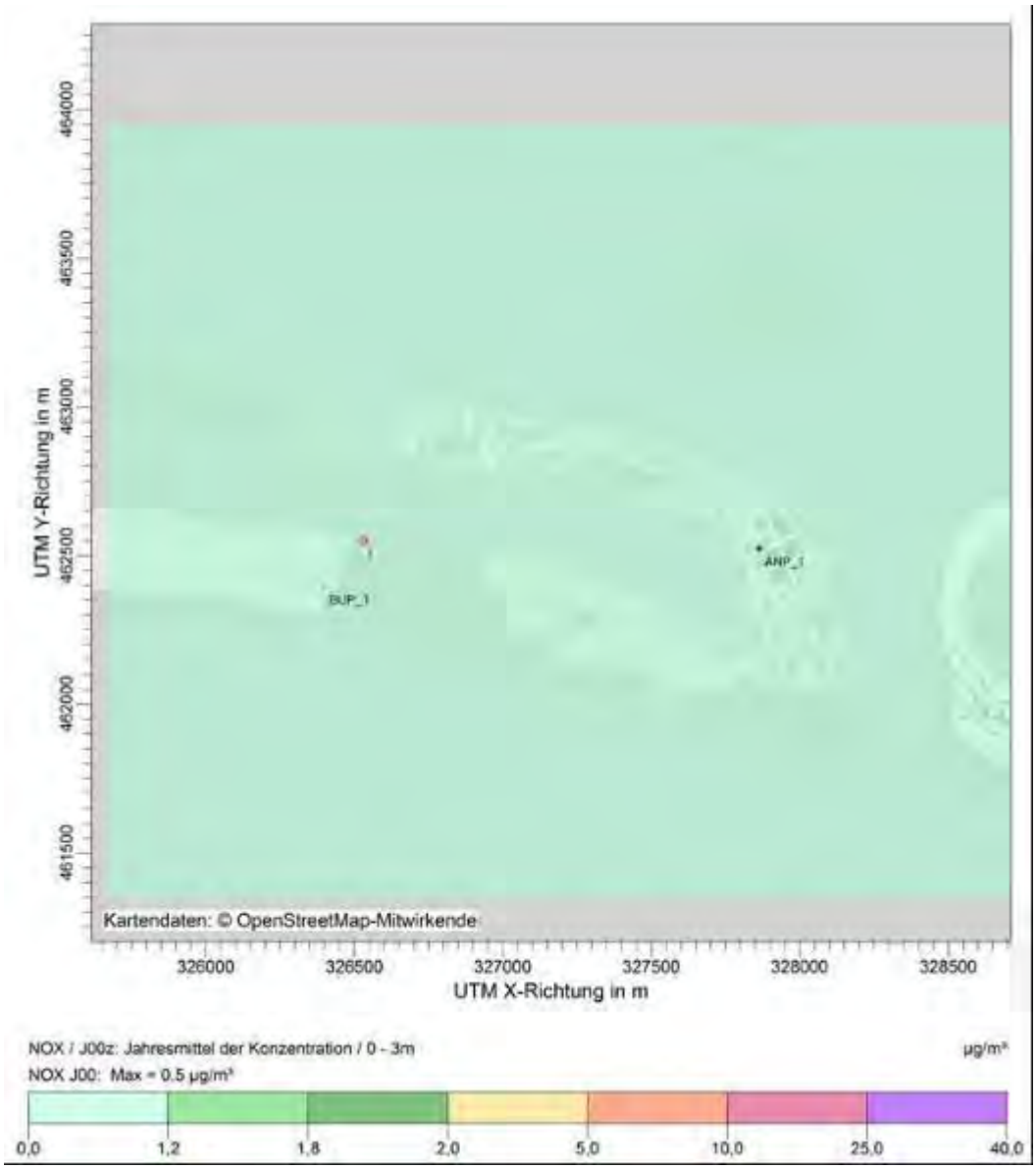



Figure 25: NOx-Deposit from the dispersion model.

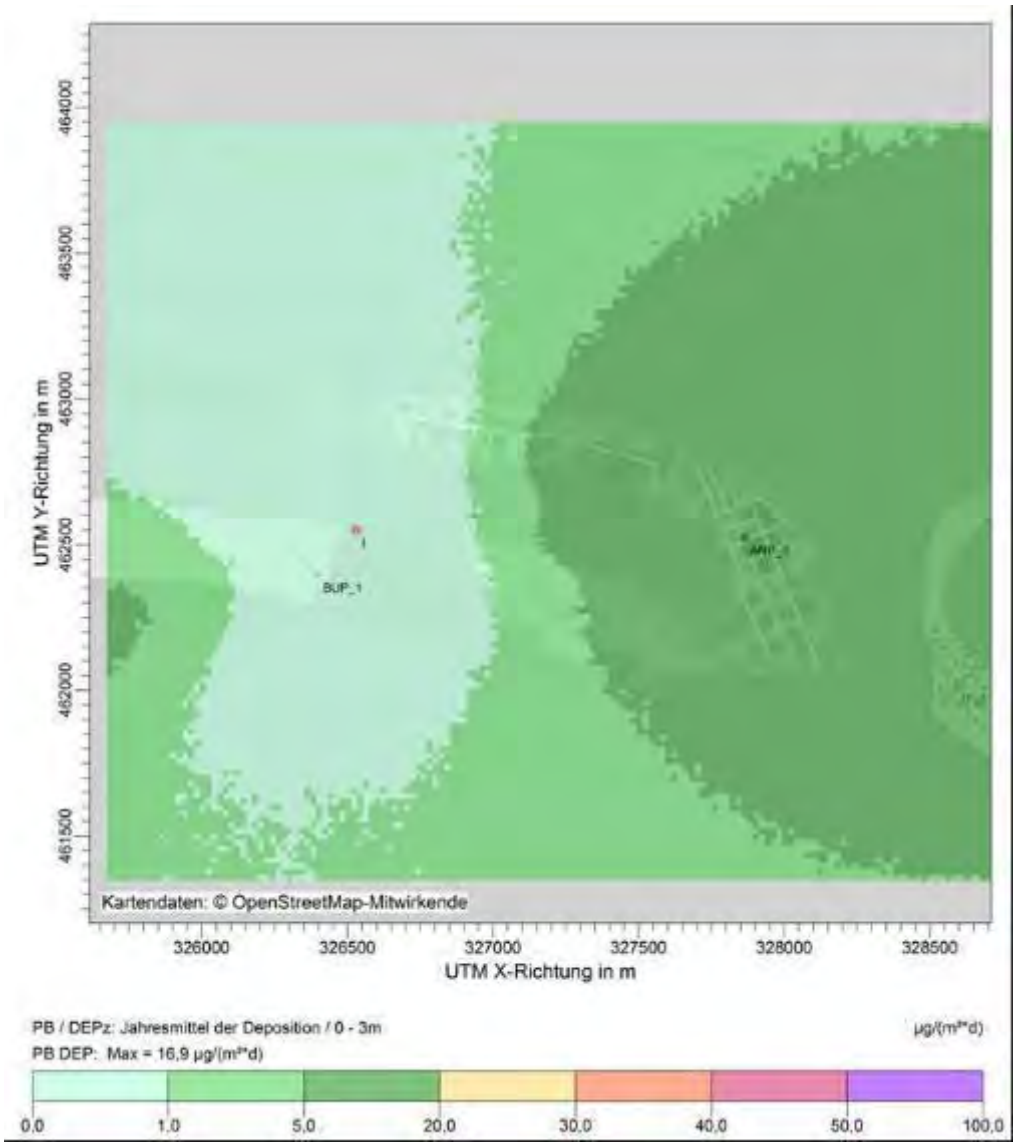



Figure 26: Pb-Deposit from the dispersion model.

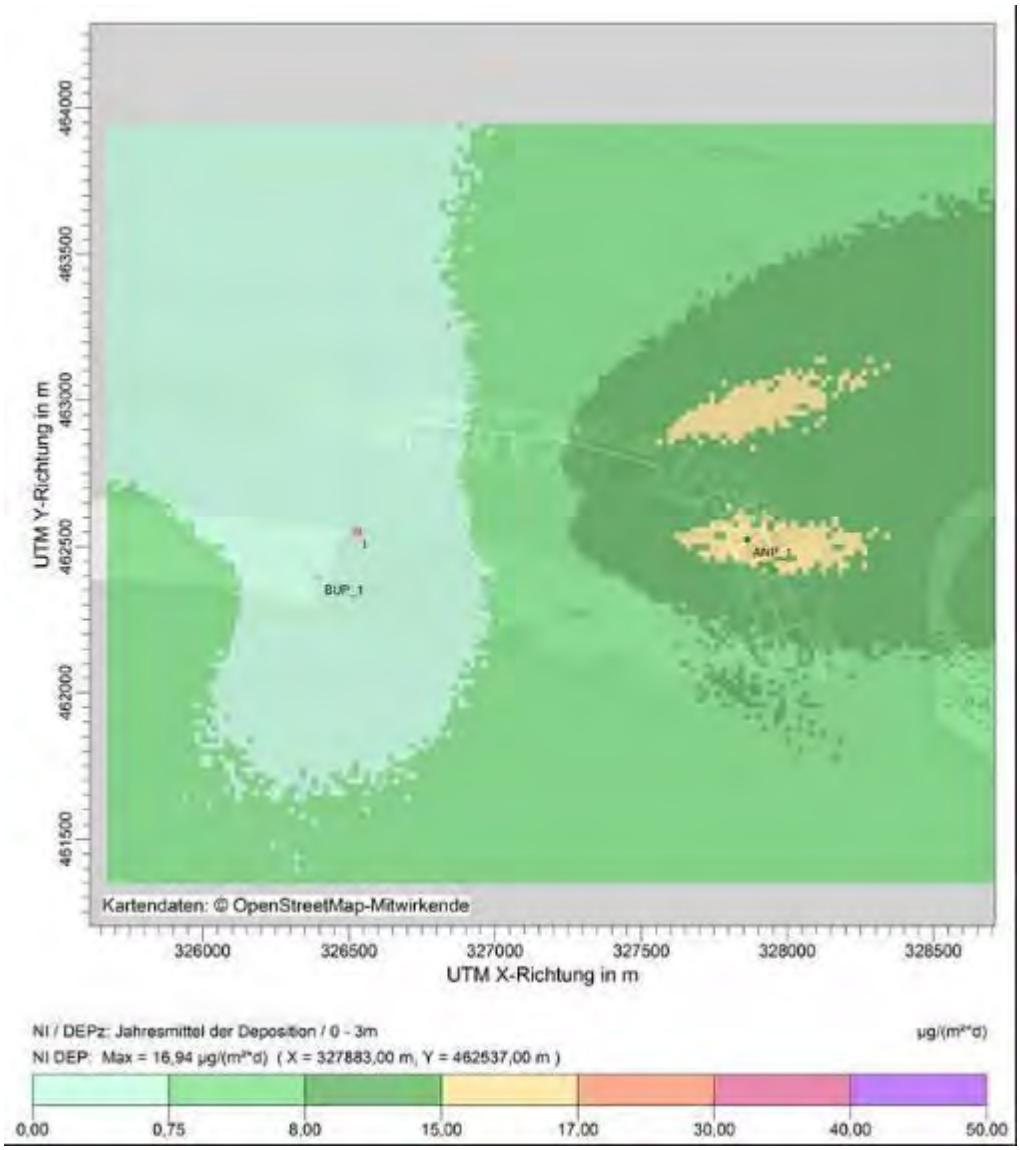



Figure 27: Ni-Deposit from the dispersion model.

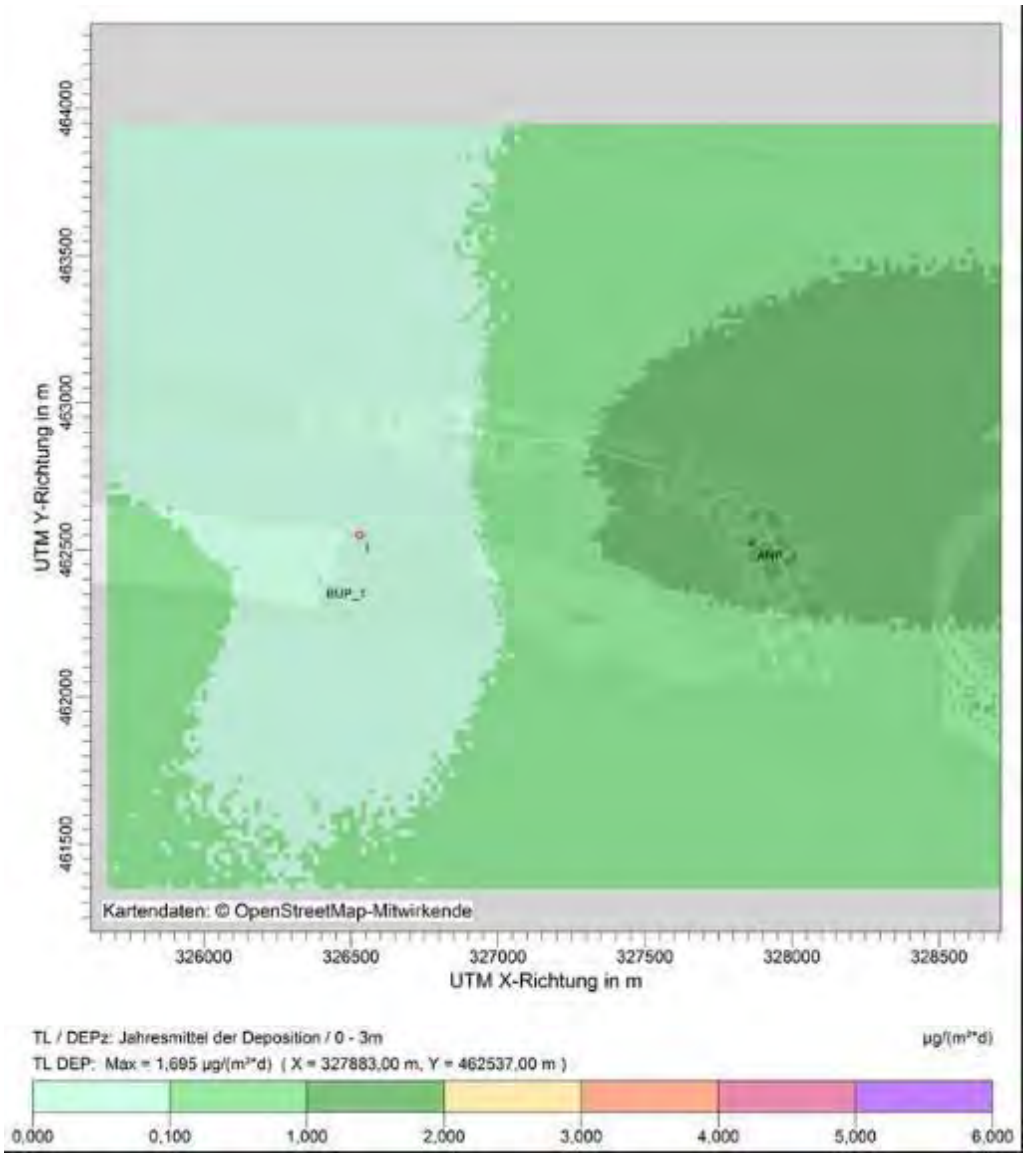



Figure 28: Tl-Deposit from the dispersion model.

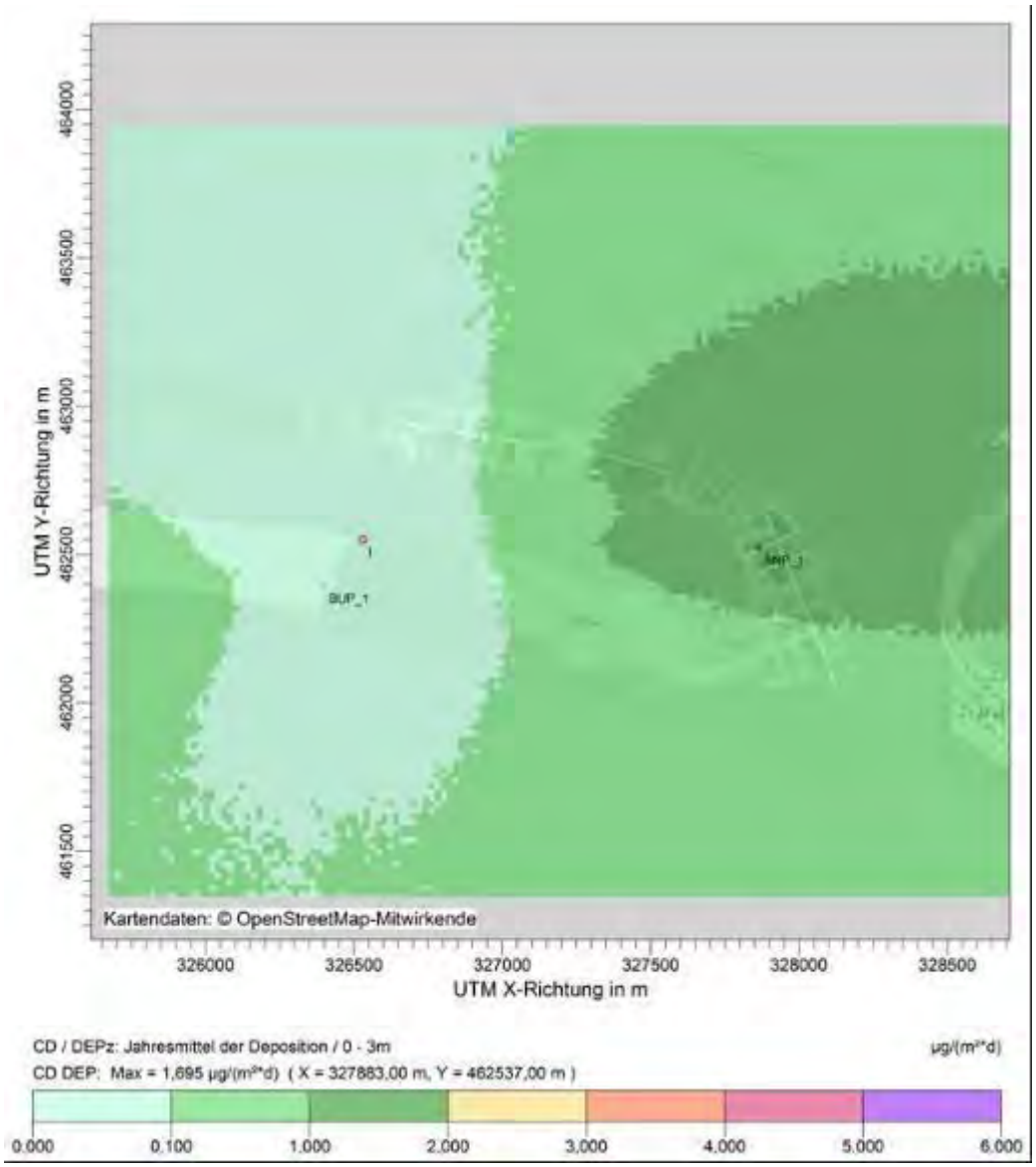



Figure 29: Cd-Deposit from the dispersion model.

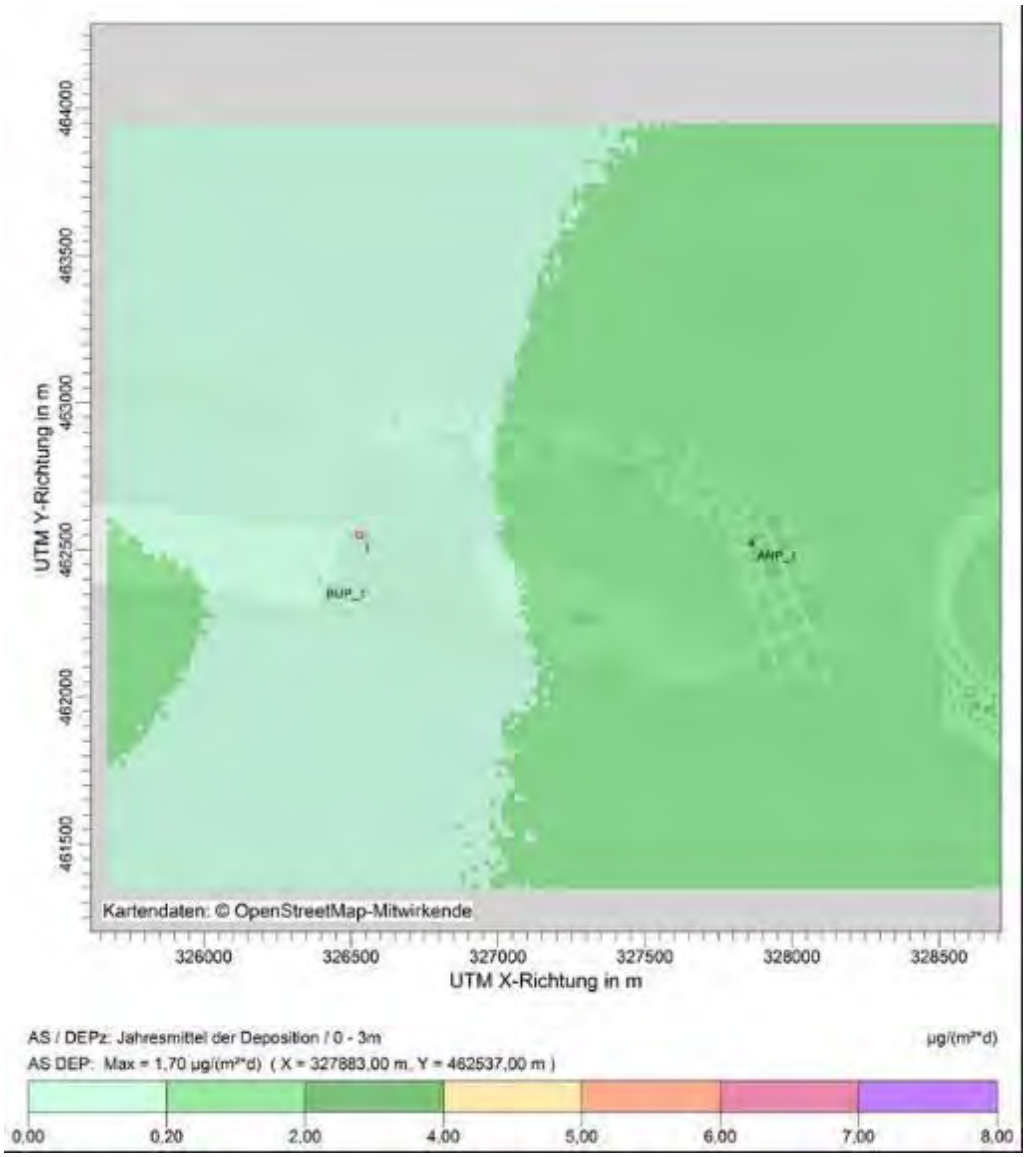



Figure 30: As-Deposit from the dispersion model.

The overall air quality of the project site is expected to increase with time. More significantly when the existing dumpsite is closed. Therefore, a long term, positive, and significant impact is expected with the operation of this project.

## 8.4 Interpretation of the results with respect to baseline conditions

Considering only the additional from process contribution it is clear that no harmful pollution is to be expected from the installation. Actually the baseline situation is mainly characterized by the dumpsite of Thilafushi which is set to be closed at the start of the operation of the new facility. Therefore the following results needs to be considered with care

| Substance | Averaging time | AQ Standard/ Guideline (µg/m³) | Baseline (µg/m3) | Process contribution (µg/m3) | PC/ AQSG | Combined process + baseline (µg/m3) | Combined/ AQSG |
|---|---|---|---|---|---|---|---|
| Particulate matter ($PM_{10}$) | 24 hr average | 50 | **538,94** | 0,100 | 0,20% | 539,04 | **1078,08%** |
| Particulate matter (PM10) | 1 year | 20 | | 0,000 | 0,00% | | |
| Particulate matter (PM2,5) | 24 hr average | 25 | **387,57** | 0,100 | 0,40% | 387,67 | **1550,68%** |
| Particulate matter (PM 2,5) | 1 year | 10 | | 0,000 | 0,00% | | |
| Sulfur dioxide SO2 | 24 hr average | 20 | **291,24** | 0,200 | 1,00% | | |
| Sulfur dioxide SO2 | 10 minutes | 500 | **970,00** | 1,333 | 0,27% | 971,33 | **194,27%** |
| Nitrogen dioxide (NO2) | 1 year | 40 | | 0,000 | 0,00% | | |
| Nitrogen dioxide (NO2) | 1 hr | 200 | 72,80 | 0,017 | 0,01% | 72,82 | 36,41% |

# 9 Conclusions

The ambient air quality status of Maldives had been unknown due to the lack of air quality monitoring data. The air quality is generally considered good as the sea breezes flush the air masses over the small the islands. However rapid urbanization and economic growth in the recent years has shown noticeable changes in the air quality, particularly in the Male' region. Thilafushi Island is being used to dump huge volume of wastes from the neighbouring inhabited islands (Malé, Villingili and Hulhumalé) and nearby resort islands. Open burning of mixed wastes is being practiced at the island to reduce the volume of the waste. The smoke generated from burning increases the air pollutant load in the local air shed and also affects the air quality of the island.

The air quality at the Thilafushi Island is expected to be polluted i.e. the values for the pollutants such as $PM_{2.5}$, $PM_{10}$, $SO_2$ and NOx are expected to be higher in the region downwind of Thilafushi as the smoke plume generated from the open burning of waste frequently passes through this region. The numbers of stations and their locations for baseline air quality monitoring was selected to collect ambient air quality data that is representative of the baseline air quality of the Thilafushi Island and its surrounding areas.

Air quality monitoring for baseline was conducted at four locations. One station was selected in the downwind direction of the WtE stack emission plume while another station was placed at the cross wind direction of the plume. One station was selected in the cross wind direction of the smoke plume from the existing dump site at Thilafushi. Additional station was selected at Vilingili as a control site.

The ambient air quality results obtained from the monitoring at Villingili undertaken indicate that all parameters were within the WHO guidelines for ambient air quality at station AQ-4 (Villingili Island). The stations at AQ-1 AQ-2 and AQ-3 had all parameters that were beyond the WHO guidelines for ambient air quality. The monitoring results showed that the air quality of Thilfushi which are on downwind wind direction of the existing waste dump site is degradaded with the smoke from the dumpsite.

In order to estimate exposures to airborne pollutants from the incineration and emergency electricity generation, air pollutant dispersion modelling was carried out. Modelling was done for the pollutants: total dust including fine dust, fluoride and its compound specified as hydrogen fluoride, ammonia, sulphur (sulphur dioxide and sulphur trioxide), specified as sulphur dioxide, nitrogen oxide (nitrogen monoxide and nitrogen dioxide) specified as nitrogen dioxide and mercury and its compound specified as mercury from the waste to energy plant.

The dispersion modelling for the pollutants was carried out using the dispersion model AUSTAL2000. The computer program AUSTAL2000 is a reference implementation developed on behalf of the German Federal Environmental Agency. AUSTAL2000 is a steady-state dispersion model that is designed for long-term sources and continuous buoyant plumes. Given that poor meteorological data coverage near the proposed project site, the dispersion model AUSTAL2000 was preferred to a popular dispersion model AERMOD, which requires high quality meteorological data to run the AERMOD.

The proposed site for the establishment of the WtE was reclaimed in 2018. The entire Island and the project location are mainly on the main level over MSL and do not present any substantial elevation.

The stack emission dispersion modelling showed, except for mercury as well as heavy metals and their components (referred to thallium and arsenic/cadmium and lead/nickel), maximum mass concentrations was achieved by the flue gas cleaning and will be mass concentration of the emission from the stack. Hence emission characteristics was not required as the emissions of the air pollutants do not exceed the minor mass flows. For mercury as well as other heavy metals and their components the values were over the minor flows, therefore dispersion modelling was carred out for these substances.

Dispersion modelling showed that the level of lead, thallium, cadmium, arsenic, would be below the ambient air quality value and for mercury, level in the the ambient air quality would be reached but not exceeded. It is not expected that heavy metal group occur in the exhaust gas, so that the exceeding of the ambient air quality value for nickel is not expected. The desired mass concentrations by means of flue gas cleaning are below the limit values for ammonia and a negative impact on the environment is therefore not expected. Similar is with hydrogen chloride, total carbon, carbon monoxide, dioxins and furans as desired mass concentrations by means of flue gas cleaning would achieve below the emission value limits.

Based on the predicted concentrations and the post project concentrations of concerned pollutants, it can be inferred that the ambient air quality of the area is unlikely to be affected significantly due to proposed project. The overall air quality of the project site is expected to increase with time. More significantly when the existing dumpsite is closed. Therefore, a long term, positive, and significant impact is expected with the operation of this project.

## References

German Engineer Association (2000) Guideline 3945 part 3 “Environmental meteorology/Atmospheric dispersion models –Particle model”

German Federal Environmental Agency (2000) AUSTAL2000

German Federal Environmental Agency (2002) First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control – TA Luft)

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 and Energy.

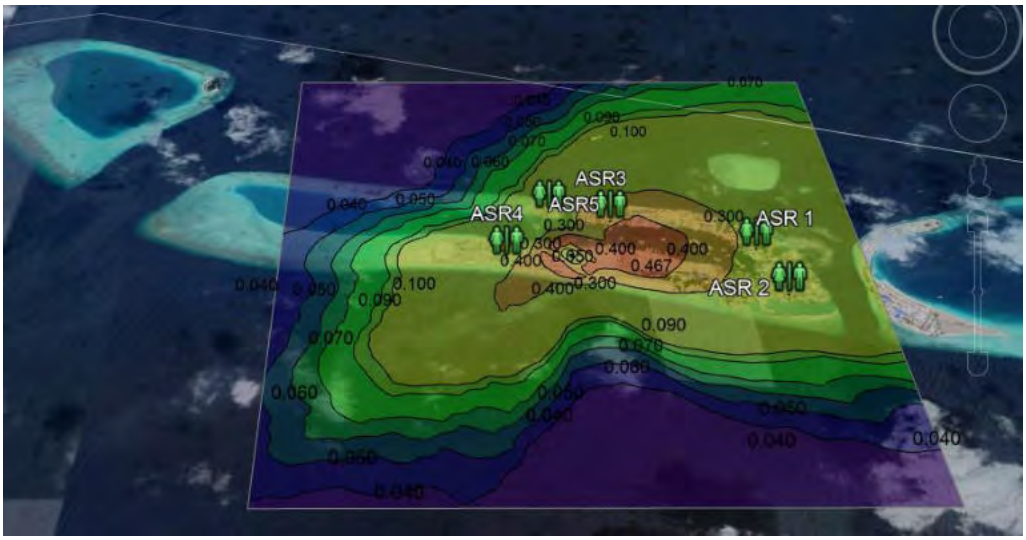
MEE (2017) EIA for the Proposed Reclamation of Thilafalhu for the establishment of the Regional Waste Management Facility for Zone 3, Kaafu Atoll, Ministry of Environment and Energy and Energy, Malé.

Ulbricht GmbH (2019) Revision and addition of the Stack height calculation and the determination of the emission of air pollutants for a waste incineration plant on Thilafushi / Maldives.

WHO (2005) Ambient Air Quality Guidelines

**DISPERSION MODEL REPORT**
**AERMOD VALIDATION PROJECT**

2 UNITS X 250 TON/DAY WTE GRATE TYPE INCINERATOR AND
0.8 MW DIESEL GENRATORSET ENGINE




Greater Male' Waste to Energy Project
Environmental Impact Assessment Waste to Energy

Draft as of 11 OCTOBER 2019

TABLE OF CONTENTS

**EXECUTIVE SUMMARY** ..... **5**
**1. BACKGROUND INFORMATION** ..... **13**
**OBJECTIVES OF THIS STUDY** ..... **13**
**COMPONENT OF THE WTE PLANT** ..... **13**
**2. THE STUDY AREA** ..... **14**
**3. AIR POLLUTANTS OF CONCERN** ..... **14**
PARTICULATE MATTER EMISSIONS (PM) ..... 14
CARBON MONOXIDE EMISSIONS (CO) ..... 15
NITROGEN OXIDES EMISSIONS (NOX) ..... 15
SULFUR OXIDES EMISSIONS (SOX) ..... 16
METALS EMISSIONS AND ACID GASES ..... 16
GREENHOUSE GASES ..... 16
**THE AIR DISPERSION MODEL** ..... **17**
**METEOROLOGY IN THE STUDY AREA - WIND ROSE** ..... **19**
GEP STACK HEIGHT = H + 1.5L ..... 32
DISTANCE FROM STACK-BLDG <= 5L ..... 32
8.4 INPUT DATA IN THE DISPERSION MODEL (SOURCE PATHWAY) ..... 36
9. RESULTS OF DISPERSION MODEL RUN ..... 37
**10. DISCUSSION OF RESULTS** ..... **74**
**10.1 AERMOD VER.9.1 MODEL RUN USING TIER 3 MET DATA (MALDIVES METEOROLOGY)** ..... **74**
**10.2 TOTAL DUST (TD)** ..... **75**
**10.3 PARTICULATE MATTER 10 (PM-10)** ..... **75**
**10.4 SULFUR DIOXIDE (SO2)** ..... **75**
**10.5 NITROGEN OXIDES (NOX)** ..... **76**
**10.6 MERCURY (HG)** ..... **76**
**10.7 AMMONIA (NH3)** ..... **76**
**10.8 HYDROGEN CHLORIDE (HCL)** ..... **76**
**10.9 HYDROGEN FLOURIDE (HFL)** ..... **76**
**10.11 DIOXINS AND FURANS (D/F)** ..... **77**
**10.12 OVERALL RESULTS** ..... **78**
**10.13 AERMOD VER.9.1 MODEL MAXIMUM GROUND LEVEL CONCENTRATIONS IN AREA SENSITIVE RECEPTORS (ASR-GLCMAX)** ..... **79**
**11. RECOMMENDATIONS** ..... **80**
**12. RECOMMENDED AMBIENT AIR QUALITY MONITORING STATIONS** ..... **81**
ANNEX 3: MALDIVES MM5 2018 METEROLOGICAL DATA SCREENSHOT PROFILE MET DATA ..... 84
ANNEX 4: MALDIVES MM5 2018 METEROLOGICAL DATA SCREENSHOT SURFACE MET DATA) 85
ANNEX 5: AERMOD VER. 9.7 SAMPLE PLOT FILES ..... 86
**REFERENCES** ..... **186**

## LIST OF TABLES

Table 1: Wind direction frequency diagram for Maldives, 2018……..….19
Table 2: UTM Coordinates of Location of Area Sensitive Receptors (ASRs)……..…28
Table 3: AERMOD BPIP…….…….32
Table 4: Input Data for AERMOD Model Run 2 X 250 T/YR MW WTE Boiler and 0.8 MW Diesel Generator set……34
Table 5: Design emission concentration……..….34
Table 6: Design emission strength……..…….…..34
Table 7: Summary Maximum Ground Level Concentration - AERMOD……..…..……36
TABLE 8: TABLE OF NOTEABLE PEAK VALUES IN AREA SENSITIVE RECEPTORS AREAS (ASRS)……..…..…….…..6
5

**LIST OF FIGURES**

Figure 1: Schematic Diagram of the WTE Plant Boiler (per line) ……11
Figure 2: Principle for the Gaussian Plume Model……14
Figure 3: Gaussian Dispersion Equation……15
Figure 4: Data flow in AERMOD Modeling System……16
Figure 5: MM5 Frequency Distribution of Wind Speed and Direction 2018 Maldives……18
Figure 6: MM5 Annual Wind Rose Wind Speed and Direction Windrose, 2018 Maldives……19
Figure 7: MM5 Surface Meteorology (SFC)……20
Figure 8: MM5 Surface Meteorological Data MM5……20
Figure 9: MM5 Profile Meteorology (PFL)……21
Figure 10: MM5 Profile Meteorological Data (PFL)……21
Figure 11: AERMOD Treatment of Boundary Parameters……22
Figure 12: Domain of AERMOD Dispersion Modeling……23
Figure 13: 4 km X 4 km Model Domain (100 x 100 meters grid) ……24
Figure 14: 4km X 4km Domain (100m X 100m Grid) Google Earth Overlay……24
Figure 15: Terrain effects in AERMOD SYSTEM……25
Figure 16: SRMT Terrain Elevation……26
Figure 17: SRMT Terrain Elevation Google Earth Overlay……26
Figure 18: Location of the ASRs and SRMT Terrain……27
Figure 19: Building Coordinates……28
Figure 20: Building Perimeter of WTE Plant……28
Figure 21: Building Area of WTE Plant……29
Figure 22: AERMOD Source Influence Zones of buildings to plume dispersion……30
Figure 23: Building Source Influence Zones of buildings to plume dispersion……30
Figure 24: Location of Maximum Predicted Ground Level Concentration……36
Figure 25: Total Dust (TD) (1 HR) (Isopleth in microgram/m3) ……37
Figure 26: TD (24 HR) ( 1-HR RUN) (Isopleth in microgram/m3)……38
Figure 27: Total Dust 1YR (Isopleth in microgram/m3) ……39
Figure 28: Total Dust 1YR Deposition (Isopleth in microgram/m3……40
Figure 29: PM10 1 HR (Isopleth in microgram/m3)……41
Figure 30: PM10 24 HR (Isopleth in microgram/m3)……42
Figure 31: PM10 1 YR DEPOSITION (Isopleth in microgram/m3)……43
Figure 32: SO2 1 HR (Isopleth in microgram/m3)……44
Figure 33: SO2 24 HR (Isopleth in microgram/m3)……45
Figure 34: SO2 1 YR (Isopleth in microgram/m3)……46
Figure 35: NO2 1 HR (Isopleth in microgram/m3)……47
Figure 36: NO2 24 HR (Isopleth in microgram/m3)……48
Figure 37: NO2 1 YR (Isopleth in microgram/m3)……49
Figure 38: Hg 1 HR (Isopleth in microgram/m3)……50
Figure 39: Hg 24 HR (Isopleth in microgram/m3)……51
Figure 40: Hg 1 year (Isopleth in microgram/m3)……52
Figure 41: $NH_3$ 1 HR (Isopleth in microgram/m3)……53
Figure 42: 5.19 $NH_3$ 24 HR (Isopleth in microgram/m3)……54
Figure 43: HF 1 HR (Isopleth in microgram/m3)……55
Figure 44: HF 24 HR (Isopleth in microgram/m3)……56
Figure 45: Dioxin and Furans 1 HR (Isopleth in microgram/m3)……57
Figure 46: Dioxin and Furans 24 HR (Isopleth in microgram/m3)……58
Figure 47: HCl 1 HR (Isopleth in microgram/m3)……59

Figure 48: HCl 24 HR (Isopleth in microgram/m3)…….60
Figure 49: SB 1 HR (Isopleth in microgram/m3)…….66
Figure 50: SB 24 HR (Isopleth in microgram/m3)…… …….…….67
Figure 51: SB 1 YR (Isopleth in microgram/m3)…… …….…….68
Figure 52: AS 1 HR (Isopleth in microgram/m3)…….69
Figure 53: AS 24 HR (Isopleth in microgram/m3)……..…….70
Figure 54: AS 1 YR (Isopleth in microgram/m3)…….71
Figure 55: TL 1 HR (Isopleth in microgram/m3)…….72
Figure 56: TL 24 HR (Isopleth in microgram/m3)……..…….73
Figure 57: TL 1 YR (Isopleth in microgram/m3)…….…….74
Figure 58: Recommended monitoring sites…….81

## EXECUTIVE SUMMARY

AERMOD validation modeling was conducted in comparison with the Austal2000 German Lagrangian model. In said report, it was highly acknowledged that AERMOD is a “Stronger model” compared to Austal2000 in complex and urban terrain. It was also noted that Austal2000 was used as an alternative only because of the complexity of the meteorological data requirement of AERMOD. For the AERMOD validation run, the meteorological (metdata) provides a strong advantage because it accounts land use data, surface and upper air and its influence mechanical and convective mixing among other Planetary Boundary Layer (PBL) Parameters included met data set.

AERMOD meteorological data utilize surface characteristics in the form of albedo, surface roughness and Bowen ratio, plus standard meteorological observations such as wind speed, wind direction, temperature, and cloud cover. Using the AERMOD metdata processor AERMET, it calculates the PBL parameters such as: friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height, and surface heat flux . These parameters are then passed to the Interface within AERMOD where similarity expressions in conjunction with measurements are used to calculate vertical profiles of wind speed, lateral and vertical turbulent fluctuations, potential temperature gradient, and potential temperature. The AERMOD processes the MM5 formatted data to generate *.SFC and *.PFL met data files. See snapshot of the generated *.SFC met data file and *PFL met data file. Figure below also shows the AERMOD treatment of boundaries parameters.

In the same way as the Austal2000 model, AERMOD validation run has considered the effects of building downwash. Waste to Energy (WTE) dimensions: Approx. Length x width x height [m]: 100 x 70 x 30. Surrounding building location have been considered according to land use plan, topographical survey and Google Earth maps. The height of the buildings has been considered to maximum 10m. This is another strong feature in AERMOD that the aerodynamic turbulence induced by nearby buildings cause a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level concentrations.

Terrain effects, such as elevations, were also incorporated which have impact on the air dispersion, deposition modeling results and potential risk to human health and the environment. Terrain elevation is the elevation relative to the facility base elevation. Complex Terrain are those elevations defined as anywhere within 50 km from the stack, are above the top of the stack being evaluated in the air modelling analysis. Terrain consideration was determined using SRTM3 terrain data processed by AERMAP terrain processor and has noted that highest elevations in the project area is at 7 meters only above sea level. Nevertheless, this AERMOD validated executed terrain situations using SRTM3 terrain data processed by AERMAP terrain processor where model considers terrain height exceeds stack base elevation, model receptors are also assumed on elevated terrain. Terrain elevations for receptors in the receptor Pathway are also considered.

Output of model run includes: one (1) hour, twenty-four (24) hour, and one (1) year averaging time plot files, isopleths diagrams, and table of worst-case scenarios. Meteorological data used is based on TIER 4 meteorological data, NCAR MM5 (5th-generation Mesoscale Model) prognostic meteorological model was the basis for meteorological background of the areas. Prognostic MM5 meteorological model are specified location and site domain. Once the MM5 preprocessing has been completed, the MM5 output file is converted into a format recognized by the **AERMET model** (meteorological preprocessor for the AERMOD model). The final output is generated by creating a pseudo met-station at the specified site location.

## AREA SENSITIVE RECEPTORS (ASRs)

Area Sensitive Receptors (ASRs) include, but are not limited to residential areas, hospitals, schools, daycare facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to air pollutants. Extra monitoring and abatement efforts must be taken when dealing with contaminants and pollutants in close proximity to areas recognized as ASRs. For the WTE project and for the purpose of assessing potential impacts, Thillafushi islands' industrial areas are considered as ASRs as there are identified facilities with workers quarters. ASRs are located in the following area and details are provided in the main text of this report: (1.) ASR1-ENE; (2.) ASR2-SSE; (3.) ASR3-NNE; (4.) ASR4- SSW; (5) ASR5-NNW 474 to 1273 meters upwind and downwind directions from the center of the domain at UTM coordinates Easting 326540 and Northing 462472. This AERMOD Report includes results of the dispersion model showing the highest predicted ground level concentrations (GLC) in the ASRs.

The results and outputs of the models are compared with TA Luft Standards as specified in the Austal2000 Report and applicable United States Environmental Protection Agency (USEPA) standards and World Health Organization (WHO) Air Quality Guidelines.

## TOTAL DUST (TD)

Predicted short term (1 hour) for controlled[1] total dust (TD) maximum ground level concentrations is 7.60 ug/m3 located 280 meters ENE from the center of the domain. The 24 hour controlled total dust (TD) maximum ground level concentrations is 3.188 ug/m3 located 608 meters ENE from the center of the domain. Simulated concentrations for maximum ground level concentration for 1 hour total dust (TD) are generally very low. There is no available the Ambient Air Quality Standards for total dust in the Austal2000 Report. For the total dust (TD) deposition, AERMOD results shows 0.00754 g/m2 for 1 hour, 0.038505 g/m2 for 24 hr, and 0.43394 g/m2 for 1 year deposition. Deposition simulations are all below the TALuft precipitation limit of 0.35 g/m2-d. There are no applicable USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at Universal Transverse Mercator (UTM) coordinates Easting 326540 and Northing 462472.

**Summary Maximum Ground Level Concentration using AERMOD**

| Parameters | Ave.Time | Results | **German Standard (TA Luft)** | | **USEPA** | **WHO Air Quality Guidelines** | **% of the Applicable Standards** |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| Total Dust | 1 hour | 7.60628 | - | - | - | - | - |
| Total Dust | 24 hour | 3.18863 | - | - | - | - | - |
| Total Dust | 1 year | 0.34134 | - | 0.35 | - | - | - |

## PARTICULATE MATTER 10 (PM10)

Predicted short term (1 hour) for controlled particulate matter 10 (PM-10) maximum ground level concentrations is 0.102 ug/m3 located 100 meters E from the center of the domain. The 24-hour controlled PM-10 maximum ground level concentrations is 0.02844 ug/m3 located

[1] Controlled emission parameters refer to post-air pollution control devices. For the WtE, each stack will include baghouse and electostatic precipitators.

100 meters E from the center of the domain. Simulated concentration for maximum ground level concentration for 24 hour PM10 is below the 35 ug/m3 TA Luft standards. There is no available Ambient Air Quality Standards for PM-10 in the Austal2000 report. For the PM-10 deposition, AERMOD results shows 0.00037 g/m2 for 1 hour, 0.0007g/m2 for 24 hour and 0.025 g/m2 for 1 year deposition. There is no TALuft limit for PM10 for 1-hour in the Austal2000 report. Results are below TA Luft and WHO Air Quality Guideline Values. There are no USEPA standards in ug/Nm3 unit, the values used are converted from parts per billion by volume (ppbv). The results show insignificant increase of 0.51% for 1-hour, 0.06% for 24-hour, and 0.01% for 1-year. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

**Summary Maximum Ground Level Concentration using AERMOD**

| Parameters | Ave.Time | Results | **German Standard (TA Luft)** | | **USEPA** | **WHO Air Quality Guidelines** | **% of the Applicable Standards** |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| PM10 | 1 hour | 0.10288 | - | - | - | 20 | 0.51 |
| PM10 | 24 hour | 0.02844 | 50 | - | 150 | 50 | 0.06 |
| PM10 | 1 year | 0.0025 | 40 | - | 50 | 20 | 0.01 |

## SULFUR DIOXIDE ($SO_2$)

Predicted short term (1 hour) for controlled sulfur dioxide ($SO_2$) maximum ground level concentrations is 10.34 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled $SO_2$ maximum ground level concentrations is 2.85 ug/m3 located 100 meters E from the center of the domain. For 1-year averaging time, results of maximum concentration is 0.25302 ug/m3. Results for maximum ground level concentration for 1 hour, 24 hour and 1 year $SO_2$ are all below the TA Luft standards of 350 ug/m3 for 1 hour, 125 ug/m3 for 24 hr and 50 ug/m3 for 1 year respectively. There are no USEPA standards in ug/Nm3 unit, the values used are converted from parts per billion by volume (ppbv). The results show insignificant increase of 4.88% for 1-hour, 14.29% for 24-hour, and 0.32% for 1-year. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

**Summary Maximum Ground Level Concentration using AERMOD**

| Parameters | Ave.Time | Results | **German Standard (TA Luft)** | | **USEPA** | **WHO Air Quality Guidelines** | **% of the Applicable Standards** |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| SO2 | 1 hour | 10.33980 | 350 | - | 212 | - | 4.88 |
| SO2 | 24 hour | 2.85793 | 125 | - | 365 | 20 | 14.29 |
| SO2 | 1 year | 0.25302 | 50 | - | 79 | - | 0.32 |

## NITROGEN OXIDES (NOX)

Predicted short term (1 hour) for controlled $NO_2$ maximum ground level concentrations is 48.91 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled $NO_2$ maximum ground level concentrations is 14.16 ug/m3 located 100 meters E from the center of the domain. For 1 year averaging time, results of maximum $NO_2$ concentration is 2.1 ug/m3. Simulated concentration for maximum $NO_2$ ground level concentration for 1 year is below the TA

Luft standards of 40 ug/m3. There are no USEPA standards in parts per billion by volume (ppbv) therefore cannot be converted to ug/Nm3 unit. The results show increase of 24.46% for 1-hour, and 5.25% for 1-year if compared to WHO Air Quality Guidelines. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

**Summary Maximum Ground Level Concentration using AERMOD**

| Parameters | Ave. Time | Results | German Standard (TA Luft) | | USEPA | WHO Air Quality Guidelines | % of the Applicable Standards |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| NO2(Nox) | 1 hour | 48.91013 | 200 | - | 100 ppb | 200 | 24.46 |
| NO2(Nox) | 24 hour | 14.16085 | - | - | - | | - |
| NO2(Nox) | 1 year | 2.10000 | 40 | - | 53 ppb | 40 | 5.25 |

## MERCURY (HG)

Predicted short term (1 hour) for controlled mercury (Hg) maximum ground level concentrations is 0.00643 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled Hg maximum ground level concentrations is 0.00178 ug/m3 located 100 meters E from the center of the domain. For 1 year averaging time, results of maximum concentration is 0.0057 ug/m3. There are no TA Luft, USEPA standards and WHO Air Quality Guideline Values. The results show insignificant increase of 0.18% for 24-hour and 3.14% for 1-year using TA Luft standards. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

**Summary Maximum Ground Level Concentration using AERMOD**

| Parameters | Ave. Time | Results | German Standard (TA Luft) | | USEPA | WHO Air Quality Guidelines | % of the Applicable Standards |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| Hg | 1 hour | 0.00643 | - | - | - | - | |
| Hg | 24 hour | 0.00178 | - | 1 | - | - | 0.18 |
| Hg | 1 year | 0.00157 | - | 0.05 | - | - | 3.14 |

## AMMONIA ($NH_3$)

Predicted short term (1 hour) for controlled ammonia ($NH_3$) maximum ground level concentrations is 2.066 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled $NH_3$ maximum ground level concentrations is 0.57123 ug/m3 located 100 meters E from the center of the domain. There are no $NH_3$ TA Luft standards in the Austal2000 report. There are no USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

**Summary Maximum Ground Level Concentration using AERMOD**

| Parameters | Ave. Time | Results | German Standard (TA Luft) | | USEPA | WHO Air Quality Guidelines | % of the Applicable Standards |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NH3 | 1 hour | 2.06667 | - | - | - | - | - |
| NH3 | 24 hour | 0.57123 | - | - | - | - | - |
| NH3 | 1 year | 0.00147 | - | - | - | - | - |

## HYDROGEN CHLORIDE (HCL)

Predicted short term (1 hour) for controlled hydrogen chloride (HCl) maximum ground level concentrations is 2.066 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled $NH_3$ maximum ground level concentrations is 0.57123 ug/m3 located 100 meters E from the center of the domain. There are no HCl TA Luft standards in the Austal2000 report. There are no USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

| **Parameters** | **Ave. Time** | **Results** | **German Standard (TA Luft)** | | **USEPA** | **WHO Air Quality Guidelines** | **% of the Applicable Standards** |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| HCl | 1 hour | 2.06667 | - | - | - | - | - |
| HCl | 24 hour | 0.57123 | - | - | - | - | - |
| HCl | 1 year | 0.00147 | - | - | - | - | - |

## HYDROGEN FLOURIDE (HF)

Predicted short term (1 hour) for controlled hydrogen fluoride (HFl) maximum ground level concentrations is 2.066 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled HFl maximum ground level concentrations is 0.57123 ug/m3 located 100 meters E from the center of the domain. There are no HFl TA Luft standards in the Austal2000 report. There are no USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

| **Parameters** | **Ave. Time** | **Results** | **German Standard (TA Luft)** | | **USEPA** | **WHO Air Quality Guidelines** | **% of the Applicable Standards** |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| Hf | 1 hour | 0.20705 | - | - | - | - | - |
| Hf | 24 hour | 0.05723 | - | - | - | - | - |
| Hf | 1 year | 0.00015 | - | - | - | - | - |

## DIOXINS AND FURANS (D/F)

Predicted short term (1 hour) for controlled Dioxins and Furans maximum ground level concentrations is 0.0258 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled Dioxins and Furans maximum ground level concentrations is 0.00569 ug/m3 located 100 meters E from the center of the domain. There are no Dioxins and Furans TA Luft standards in the Austal2000 report. There are no USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

| Parameters | Ave.Time | Results | German Standard (TA Luft) | | USEPA | WHO Air Quality Guidelines | % of the Applicable Standards |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| D/F | 1 hour | 0.02058 | - | - | - | - | - |
| D/F | 24 hour | 0.00569 | - | - | - | - | - |
| D/F | 1 year | 0.00002 | - | - | - | - | - |

**SUM OF HEAVY METALS AND THEIR COMPONENTS: ANTIMONY, CHROMIUM,COPPER, MANGANESE, VANADIUM, TIN, LEAD, COBALT, NICKEL ( TA LUFT CLASS II AND III)**

Predicted short term (1 hour) for the Sum of heavy metals and their components: antimony, chromium,copper, manganese, vanadium, tin, lead, cobalt, nickel ( TA Luft class II and III) ground level concentrations is 1.3161 ug/m3 located 316 meters NorthNorthEast (NNE) from the center of the domain. The 24 hour controlled total sum of metals maximum ground level concentrations is 0.4954 ug/m3 located 141 meters NorthWest (NW) from the center of the domain. For 1 year averaging time, results of maximum concentration is 0.0982 ug/m3. Simulated concentrations for maximum ground level concentration for both 1, 24 hours & 1 Year averaging which are generally very low. Results are generally lower than US RSLs for combined 24 hr averaging for Cu, Vn,Cr and Mn of 0.152 ug/m3 and the 3 month NAAQS for Lead of 0.15 ug/m3. There is no available the Ambient Air Quality Standards for said metals in the Austal2000 Report. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

| Parameters | Ave.Time | Results | German Standard (TA Luft) | | USEPA | WHO Air Quality Guidelines | % of the Applicable Standards |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| Sum of Metals (Sb)[1] | 1 hour | 1.31607 | - | - | - | - | - |
| Sum of Metals (Sb)[1] | 24 hour | 0.49540 | - | - | - | - | - |
| Sum of Metals (Sb)[1] | 1 year | 0.09818 | - | - | - | - | - |

[1]Sum of metals: Antimony, Chromium, Copper, Manganese, Vanadium, in, Lead, Cobalt, Nickel

**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) (TA LUFT CLASS I )**

Predicted short term (1 hour) for the Sum of heavy metals and their components: 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) (TA Luft Class I ) ground level concentrations is 0.13161 ug/m3 located 316 meters NorthNorthEast (NNE) from the center of the domain. The 24 hour controlled total sum of metals maximum ground level concentrations is 0.049 ug/m3 located 141 meters NorthWest (NW) from the center of the domain. For 1 year averaging time, results of maximum concentration is 0.00982 ug/m3. Simulated

concentrations for maximum ground level concentration for both 1, 24 hours & 1 Year averaging which are generally very low. Results are generally lower than the available ESL for Arsenic of 3 ug/m3 and 0.067 ug/m3 for 1 year. There is no available the Ambient Air Quality Standards for said metals in the Austal2000 Report. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

| **Parameters** | **Ave.Time** | **Results** | **German Standard (TA Luft)** | | **USEPA** | **WHO Air Quality Guidelines** | **% of the Applicable Standards** |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| Sum of Metals (As)[1] | 1 hour | 0.13161 | - | - | - | - | - |
| Sum of Metals (As)[1] | 24 hour | 0.04954 | - | - | - | - | - |
| Sum of Metals (As)[1] | 1 year | 0.00982 | - | - | - | - | - |

[1]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)

## THALLIUM AND ITS COMPOUNDS ( TA LUFT CLASS I) CADMIUM

Predicted short term (1 hour) for the Sum of heavy metals and their components: Thallium and its compounds ( TA Luft class I) cadmium ground level concentrations is 0.13161 ug/m3 located 316 meters NorthNorthEast (NNE) from the center of the domain. The 24 hour controlled total sum of metals maximum ground level concentrations is 0.049 ug/m3 located 141 meters NorthWest (NW) from the center of the domain. For 1 year averaging time, results of maximum concentration is 0.00982 ug/m3. Simulated concentrations for maximum ground level concentration for both 1, 24 hours & 1 Year averaging which are generally very low. There is no available the Ambient Air Quality Standards for said metals in the Austal2000 Report and in the USEPA NAAAQS, ESLs and RSLs. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

| **Parameters** | **Ave.Time** | **Results** | **German Standard (TA Luft)** | | **USEPA** | **WHO Air Quality Guidelines** | **% of the Applicable Standards** |
|---|---|---|---|---|---|---|---|
| | | Conc (ug/Nm3) | Conc (ug/Nm$^3$) | Deposition (g/m2) | Conc (ug/Nm$^3$) | Conc (ug/Nm$^3$) | % |
| Sum of Metals (Tl)[1] | 1 hour | 0.13161 | - | - | - | | |
| Sum of Metals (Tl)[1] | 24 hour | 0.04954 | - | - | - | | |
| Sum of Metals (Tl)[1] | 1 year | 0.00982 | - | - | - | | |

[1]Sum of metals: Thallium and its compounds and cadmium

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.

## 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. Toxic heavy metal parameters such Ni, Ti, As,Cd, and Pb was excluded in the validation model due to absence of design emission data.

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.

## RECOMMENDATIONS

It recommended to (i) retain the four (4) ambient monitoring stations used in conducting ambient air quality in Thillafushi island for the EIA study; and (ii) put up additional ambient monitoring stations in ASR 2, ASR 3 and ASR 5 areas due to industrial facilities with workers quarters.

Background ambient air quality was not accounted in the modeling run. However given there are no potential significant sources of air pollution (such as mobile, area, line sources, community and other air-pollutant emitting industries) near the WTE plant, the results of both the Austal2000 and AERMOD models are generally acceptable and can be seen as below TA Luft and USEPA Standards. However, it is highly recommended to conduct a validation run after 1 to 3 months during operations stage using actual CEMS, stack testing, and ambient air monitoring results.

# 1. BACKGROUND INFORMATION

Atmospheric dispersion modeling is the mathematical simulation of how air pollutants disperse in the ambient atmosphere. The dispersion models are used to estimate the downwind ambient concentration of air pollutants emitted from sources. They can also be used to predict future concentrations under specific scenarios (i.e. changes in emission sources) and are most useful for pollutants that are dispersed over large distances and that may react in the atmosphere. advanced dispersion modeling programs include a pre-processor module for the input of meteorological and other data, and many also include a post-processor module for graphing the output data and/or plotting the area impacted by the air pollutants on maps. The plots of areas impacted may also include isopleths showing areas of minimal to high concentrations that define areas of the highest health risk. The isopleths plots are useful in determining protective actions for the public and responders.

## Objectives of This Study[2]

The objectives of this validation studies are: (i) evaluation of Austal2000 model conducted as part of the EIA study; (ii) compare results with relevant TA Luft and USEPA standards and guidelines; and (iii) identify and forecast levels of relevant pollutants at different area sensitive receptors (ASRs) in Thillafushi to assess effects of air quality with regards to human health, risks and environment.

## Component of the WTE Plant[3]

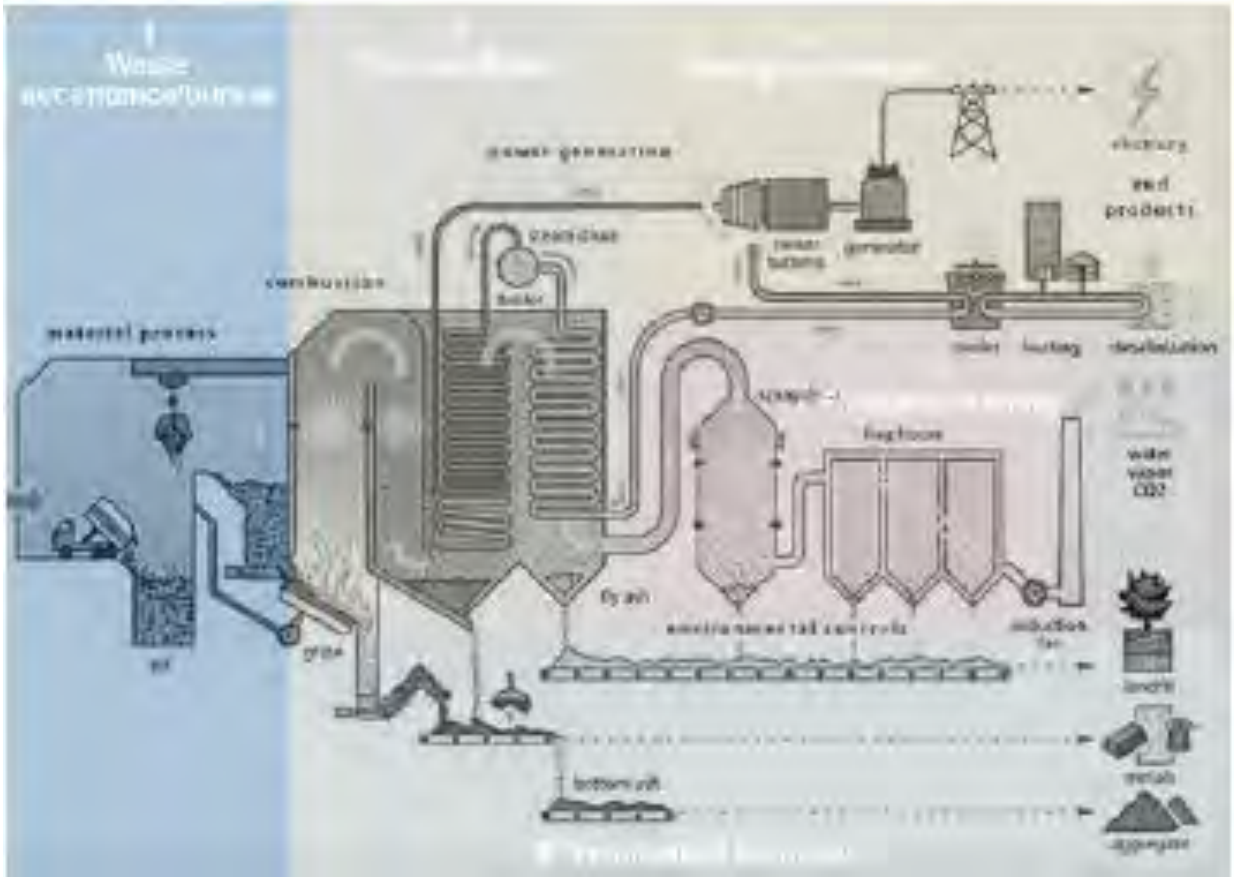
The WTE plant shall be designed and built as a conventional state-of-the-art grate type incinerator of two lines of 250 Mg/d each (total of 500 Mg/d), that shall consist of the following main set of process units and plant components:

a) Waste reception, storage and feeding consisting of a weigh bridge incl. guard house, tipping hall and waste bunker, a shredder and waste cranes;
b) Thermal treatment consisting of combustion system; boiler and heat recovery system and boiler feed water and make-up water system;
c) Air pollution control (APC) system and ID fan and stack and continuous emission monitoring system (CEMS);
d) Turbine with generator and condenser, cooling water pre-treatment system and cooling water pumps;
e) Other balance of plant components incl. fuel and chemicals supply and storage; fire-fighting water supply system; wastewater treatment plant for sewerage, water supply system;
f) Bottom ash treatment plant incl. bottom ash bunker and conveying system;
g) Residue sanitary landfill and leachate collection, management and treatment system;
h) Electric system incl. connection to public network

All process units and the balance of plant components are to be equipped with necessary electrical and control components, with valves, fittings, piping, utility mains etc. and shall be combined to a fully functional system that is fit for purpose and that is operated and controlled by a DCS which shall facilitate monitoring and recording of operational data.

[2] Greater Male' Waste to Energy Project Environmental (EIA) Waste to Energy Facility in Thilafushi
[3]Greater Male' Waste to Energy Project Environmental (EIA) Waste to Energy Facility in Thilafushi

**Figure 1: Schematic Diagram of the WTE Plant Boiler (per line)**




## 2. The Study Area

The WTE plant will be located on a 27 hectares government-owned land, of which 15 hectares have been reclaimed from shallow lagoon in Thilafushi island. It is on the southern rim of North Malé atoll, and on the eastern line of atolls within the archipelago. Thilafushi is located 9.5 km from Malé. In terms of geographic coordinates, it is located at 04° 11' 00" N and 73° 26' 44" E. The nearest inhabited island is Villingili, approximately 7.1 km east of Thilafushi.

## 3. Air Pollutants of Concern

### Particulate Matter Emissions (PM)

Particulate matter (PM) can vary greatly in size with diameters ranging from less than 1 micrometer to hundreds of micrometers (µm). Fine particulates, having diameters less than 10µm (known as PM-10), are of increased concern because a greater potential for inhalation and passage into the pulmonary region exists. Further, acid gases, metals, and toxic organics may preferentially adsorb onto particulates in this size range. Particulate emissions may be categorized as either filterable or condensable. Filterable emissions are generally considered to be the particles that are trapped by the glass fiber filter in the front half of USEPA Reference Method 5 or Method 17. Vapors and particles less than 0.3 microns pass through the filter. Condensable particulate matter is material that is emitted in the vapor state which later condenses

to form homogeneous and/or heterogeneous aerosol particles. The condensable particulate emitted from boilers is primarily inorganic in nature.

The level of PM at the inlet of the APC SYSTEM will vary according the combustor design, air distribution, waste characteristics, and the combustor's operation. Under normal combustion conditions, solid fly ash particulates formed from inorganic, noncombustible constituents in MSW are released into the flue gas. Most of this particulate is captured by the facility's APC system and are not emitted to the atmosphere.

**Carbon Monoxide Emissions (CO)**

The presence of carbon monoxide (CO) in the exhaust gases of combustion systems results principally from incomplete fuel combustion. High levels of CO indicate that the combustion gases were not held at a sufficiently temperature in the presence of oxygen (O2) for a long enough time to convert CO to carbon dioxide ($CO_2$). Several conditions can lead to incomplete combustion, including insufficient oxygen ($O_2$) availability; poor fuel/air mixing; cold-wall flame quenching; reduced combustion temperature; decreased combustion gas residence time; and load reduction (i.e., reduced combustion intensity).

By controlling the combustion process carefully, CO emissions can be minimized. Thus, if a unit is operated improperly or not well maintained, the resulting concentrations of CO (as well as organic compounds) may increase by several orders of magnitude. Smaller boilers, heaters, and furnaces tend to emit more of these pollutants than larger combustors. This is because smaller units usually have a higher ratio of heat transfer surface area to flame volume than larger combustors have; this leads to reduced flame temperature and combustion intensity and, therefore, lower combustion efficiency.

Since various combustion modifications for NOx reduction can produce one or more of the mentioned conditions, the possibility of increased CO emissions is a concern for environmental, energy efficiency, and operational reasons.

**Nitrogen Oxides Emissions (NOX)**

Oxides of nitrogen (NOx) formed in combustion processes are due either to thermal fixation of atmospheric nitrogen in the combustion air ("thermal NOx"), or to the conversion of chemically-bound nitrogen in the fuel ("fuel NOx"). The term NOx refers to the composite of nitric oxide (NO) and nitrogen dioxide ($NO_2$). Test data have shown that for most external fossil fuel combustion systems, over 95 percent of the emitted NOx is in the form of nitric oxide (NO). Nitrous oxide ($N_2O$) is not included in NOx but has recently received increased interest because of atmospheric effects. The formation of thermal NOx is affected by four factors: (1) peak temperature, (2) fuel nitrogen concentration, (3) oxygen concentration, and (4) time of exposure at peak temperature. The emission trends due to changes in these factors are generally consistent for all types of boilers: an increase in flame temperature, oxygen availability, and/or residence time at high temperatures leads to an increase in NOx production.

Conversion of nitrogen in the waste occurs at relatively low temperatures (less than 109 $^0$C), while fixation of atmospheric nitrogen occurs at higher temperatures. Because of the relatively low temperatures at which WTE plants operate, 70 to 80% of NO formed is associated with nitrogen in the waste.[4]

[4] USEPA AP 42- Chapter 2.1 Refuse Combustion

### Sulfur Oxides Emissions (SOX)

Sulfur oxides (SOx) emissions are generated during combustion from the oxidation of sulfur contained in the fuel. The emissions of SOx are predominantly in the form of $SO_2$. Uncontrolled SOx emissions are almost entirely dependent on the sulfur content of the fuel and are not affected by boiler size, burner design, or grade of fuel being fired. On average, more than 95% of the sulfur content in the municipal solid waste is converted to $SO_2$, about 1% to 5% is further oxidized to sulfur trioxide ($SO_3$), and 1% to 3% is emitted as sulfate particulate. $SO_3$ readily reacts with water vapor (both in the atmosphere and in flue gases) to form a sulfuric acid mist.

### Metals Emissions and Acid Gases

Metals are present in a variety of municipal solid waste streams are emitted from WTE plant in association with PM (e.g., arsenic [As], Cd, chromium [Cr], and Pb) and as vapors, such as Hg. Due to the variability in municipal solid waste composition, metal concentrations are highly variable and are essentially independent of combustor type. If the vapor pressure of a metal is such that condensation onto particulates in the flue gas is possible, the metal can be effectively removed by the PM control device. Except for mercury (Hg), most metals have sufficiently low vapor pressures which result in almost all of the metals being condensed. Therefore, removal in the PM control device for these metals is generally greater than 98%. Hg, on the other hand, has a high vapor pressure, but the level of carbon in the fly ash appears to affect the level of Hg control. A high level of carbon in the fly ash can enhance Hg adsorption onto particles. Hg can be removed in a typical APC system controlling the operating temperature and by the PM control device.[5]

The chief acid gases of concern from WTE plants are hydrochloric acid (HCl) and sulfuric acid ($H_2SO_4$) from $SO_2$. Hydrogen fluoride (HF), hydrogen bromide (HBr), and sulfur trioxide ($SO_3$) are also generally present, but at much lower concentrations. Concentrations of HCl and $H_2SO_4$ in flue gases directly relate to the chlorine and sulfur content in the municipal solid waste the availability of alkali materials in combustion-generated fly ash that act as sorbents, and the type of APC system used. Acid gas concentrations are considered to be independent of combustion conditions.

### Greenhouse Gases

WTE plants involve generation of climate-relevant emissions such as $CO_2$ (carbon dioxide) as well as N2O (nitrous oxide), $N_2O$, ammonia ($NH_3$) and organic carbon, measured as total carbon. Methane ($CH_4$) is not generated in a WTE plant during normal operation. It only arises, in exceptional cases and to a small extent (from waste remaining in the waste bunker), therefore that in quantitative terms $CH_4$ is not to be regarded as climate relevant.

$CO_2$ constitutes the chief climate-relevant emission of WTE plant. A WTE plant of 1 Mg of municipal solid waste is associated with the production/release of about 0.7 to 1.2 Mg of $CO_2$ output. The proportion of carbon of biogenic origin is usually in the range of 33% to 50%. The climate-relevant $CO_2$ emissions from WTE plants are determined by the proportion of waste whose carbon compounds are assumed to be of fossil origin. The allocation to fossil or biogenic carbon has a crucial influence on the calculated amounts of climate-relevant $CO_2$ emissions. An energy transformation efficiency equal to or greater than about 25% results in an allowable

[5] USEPA AP 42- Chapter 2.1 Refuse Combustion

average substituted net energy potential that renders the emission of WTE plants (calculated as $CO_2$ equivalents) climate-neutral due to the emission credits from the power plant mix.[6]

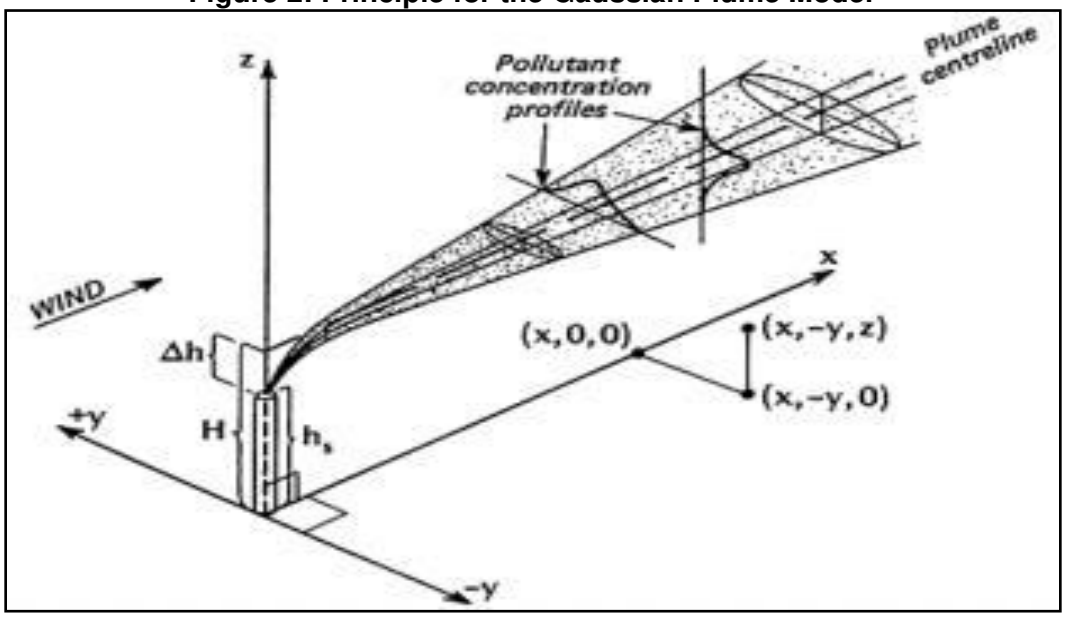
## The Air Dispersion Model

### Gaussian plume model

Gaussian plume model uses a realistic description of dispersion, where it represents an analytical solution to the diffusion equation for idealized circumstances. The model assumes that the atmospheric turbulence is both stationary and homogeneous. The model is the method of choice for many, especially for the prediction of yearly averaged concentration. It is the most widely used plume model and is the basis for most of the computer models distributed by the USEPA.

In the Gaussian plume dispersion model the concentration of pollution downwind from a source is treated as spreading outward from the centerline of the plume following a normal statistical distribution. The plume spreads in both the horizontal and vertical directions (Figure 2).

**Figure 2: Principle for the Gaussian Plume Model**




In the model, determining the pollutant concentrations at ground-level beneath an elevated plume involves two main steps:

(i) first, the height to which the plume rises at a given downwind distance from the plume source is calculated. The calculated plume rise is added to the height of the plume's source point to obtain the so-called "effective stack height"

(ii) second, the ground-level pollutant concentration beneath the plume at the given downwind distance is predicted using the Gaussian dispersion equation.

The Gaussian dispersion equation can be written as Figure 3:

[6] Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, paper was written by Mr. Bernt Johnke (Germany) and reviewed by Robert Hoppaus (IPCC/OECD/IEA), Eugene Lee (US), Bill Irving (USEPA), T. Martinsen (IPCC/OECD/IEA), and K. Mareckova (IPCC/OECD/IEA).

**Figure 3: Gaussian Dispersion Equation**

$$C(x,y,z) = \frac{Q}{2\pi\pi_y\sigma_z u}\exp\left(-\frac{y^2}{2\sigma_y^2}\right)\times$$
$$\left\{\exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right)+\exp\left(-\frac{(z+H)^2}{2\sigma_z^2}\right)\right\}$$

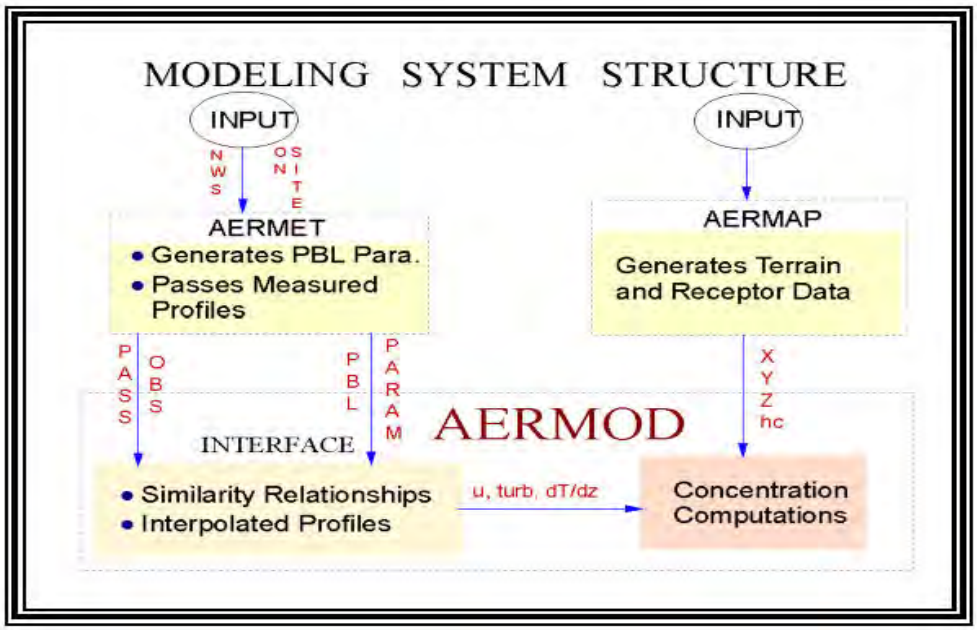
| | | | |
|---|---|---|---|
| Where | C | = | concentration |
| | Q | = | emission rate of the pollutant from the source |
| | u | = | wind speed which defines the direction |
| | x, y | = | horizontal distance perpendicular to the wind direction |
| | z | = | vertical direction |
| | $h_s$ | = | Height of the source |
| | H | = | effective height of the plume (considering the additional height Δh to which the hot gases rise above the physical height of the source, $h_s$); i.e., $H = h_s + \Delta h$ |
| | σy, σz | | parameters of the normal distributions in y and z directions, usually called the dispersion coefficients in y and z directions respectively |

**AERMOD Modeling System**

The American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) was formed to introduce state-of-the-art modeling concepts into the USEPA's air quality models. Through AERMIC, a modeling system, AERMOD, was introduced that incorporated air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

There are two input data processors that are regulatory components of the AERMOD modeling system: AERMET, a meteorological data pre-processor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data pre-processor that incorporates complex terrain using United States Geological Survey (USGS) Digital Elevation Data.

**Figure 4: Data flow in AERMOD Modeling System**




AERMOD is a steady-state plume model. In the stable boundary layer (SBL), it assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf). This behavior of the concentration distributions in the CBL was demonstrated by Willis and Deardorff (1981) and Briggs (1993). Additionally, in the CBL, AERMOD treats "plume lofting," whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL.

AERMOD also tracks any plume mass that penetrates the elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate. Using a relatively simple approach, AERMOD incorporates current concepts about flow and dispersion in complex terrain. Where appropriate the plume is modeled as either impacting and/or following the terrain. This approach has been designed to be physically realistic and simple to implement while avoiding the need to distinguish among simple, intermediate and complex terrain, as required by other regulatory models. As a result, AERMOD removes the need for defining complex terrain regimes. All terrain is handled in a consistent and continuous manner while considering the dividing streamline concept (Snyder et al. 1985) in stably stratified conditions.

**Meteorology in the Study Area - Wind Rose**

The prevailing wind over the Maldives represents typical Asian monsoonal characteristics. It follows the traditional definition of monsoon as seasonal reversal of wind direction by more than 120° between the months January and July. Looking at annual variations, westerly winds are predominant throughout the country, varying between west-southwest and west-northwest.[7]

[7] Consultancy Services for Feasibility Study for an Integrated Solid Waste Management System for Zone III and Prepare Engineering Design of the Regional Waste Management Facility at Thilafushi

The southwest monsoon, with winds predominantly between SW and NW, lasts from May to October. In May and June, winds are mainly from WSW to WNW, and in July to October, winds between W and NW predominate. The northeast monsoon, with winds predominantly from NE to E, lasts from December to February. During March and April, winds are variable. During November, winds are primarily from the west, becoming variable and can occasionally exceed 30 knots from the NE sector. However, yearly wind speed in the northeast and southwest monsoons are observed to be between 9-13 knots.

As part of the recent update to the USEPA Guideline on Air Quality Models (EPA,2017), the use of prognostic data is allowed for regulatory applications of AERMOD where it is cost-prohibitive or not feasible to collect site-specific data and there is no representative weather data or comparable station nearby. EPA developed the Mesoscale Model Interface Program, or MMIF for processing prognostic meteorological data for AERMOD (Environ, 2014).

For the study area, meteorological data was obtained from Lakes Environmental https://www.weblakes.com/services/met_data.html which employs the Weather Research and Forecasting (WRF) model[8] to compute accurate wind fields and provide modeled meteorological data. The data is obtained by running the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5)[9] prognostic meteorological model for a specified location and site domain. Once the MM5 pre-processing has been completed, the MM5 output file is converted into a format recognized by the AERMET model. The final output is generated by creating a pseudo met-station at the specified site location.

Below is the frequency distribution and wind rose of Maldives for 2018 based on MM5 AERMET processed prognostic meteorological data.

[8] Weather Research and Forecasting (WRF) model is a numerical weather prediction (NWP) system designed to serve both atmospheric research and operational forecasting needs. NWP refers to the simulation and prediction of the atmosphere with a computer model, and WRF is a set of software for this. WRF features two dynamical (computational) cores (or solvers), a data assimilation system, and a software architecture allowing for parallel computation and system extensibility. The model serves a wide range of meteorological applications across scales ranging from meters to thousands of kilometres. WRF can produce simulations based on actual atmospheric conditions (i.e., from observations and analyses) or idealized conditions.

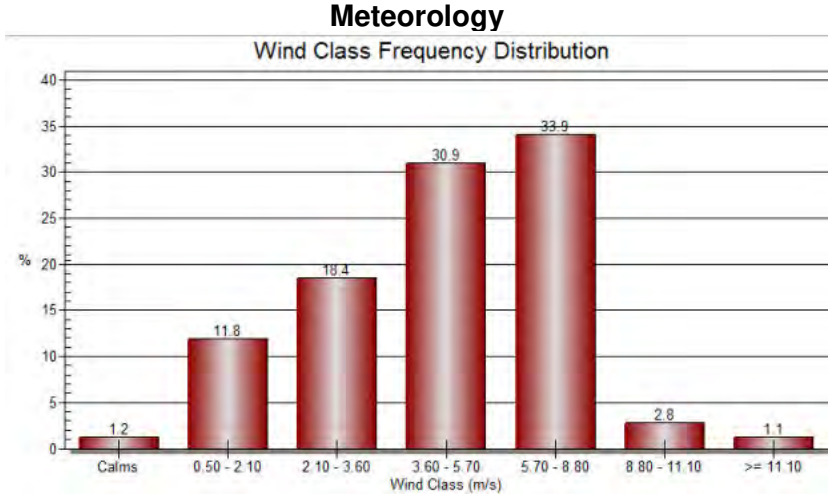
[9] It is a community model maintained by Penn State University and the National Center for Atmospheric Research. The MM5 is a limited-area, terrain-following sigma coordinate model that is used to replicate or forecast mesoscale and regional scale atmospheric circulation.

**Table 1: Wind Direction Frequency Diagram for Maldives, 2018**

| | Directions / Wind Classes (m/s) | 0.50 - 2.10 | 2.10 - 3.60 | 3.60 - 5.70 | 5.70 - 8.80 | 8.80 - 11.10 | >= 11.10 | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | 348.75 - 11.25 | 0.00502 | 0.00400 | 0.00731 | 0.00342 | 0.00000 | 0.00000 | 0.01975 |
| 2 | 11.25 - 33.75 | 0.00662 | 0.00628 | 0.01370 | 0.01199 | 0.00000 | 0.00000 | 0.03858 |
| 3 | 33.75 - 56.25 | 0.00765 | 0.01267 | 0.02500 | 0.01450 | 0.00137 | 0.00000 | 0.06119 |
| 4 | 56.25 - 78.75 | 0.00947 | 0.01267 | 0.02078 | 0.00970 | 0.00000 | 0.00000 | 0.05263 |
| 5 | 78.75 - 101.25 | 0.00811 | 0.01370 | 0.01290 | 0.00571 | 0.00000 | 0.00000 | 0.04041 |
| 6 | 101.25 - 123.75 | 0.00788 | 0.00993 | 0.00422 | 0.00285 | 0.00000 | 0.00011 | 0.02500 |
| 7 | 123.75 - 146.25 | 0.00639 | 0.00868 | 0.00685 | 0.00126 | 0.00000 | 0.00000 | 0.02317 |
| 8 | 146.25 - 168.75 | 0.00377 | 0.00742 | 0.01016 | 0.00354 | 0.00000 | 0.00000 | 0.02489 |
| 9 | 168.75 - 191.25 | 0.00491 | 0.00856 | 0.01587 | 0.00537 | 0.00000 | 0.00000 | 0.03470 |
| 10 | 191.25 - 213.75 | 0.00514 | 0.01438 | 0.02078 | 0.01769 | 0.00000 | 0.00000 | 0.05799 |
| 11 | 213.75 - 236.25 | 0.00913 | 0.01781 | 0.03185 | 0.05342 | 0.00148 | 0.00000 | 0.11370 |
| 12 | 236.25 - 258.75 | 0.00856 | 0.01747 | 0.04075 | 0.08950 | 0.01005 | 0.00616 | 0.17249 |
| 13 | 258.75 - 281.25 | 0.01005 | 0.01564 | 0.04669 | 0.06815 | 0.01107 | 0.00457 | 0.15616 |
| 14 | 281.25 - 303.75 | 0.00902 | 0.01450 | 0.02443 | 0.03779 | 0.00342 | 0.00034 | 0.08950 |
| 15 | 303.75 - 326.25 | 0.00970 | 0.01221 | 0.01975 | 0.00936 | 0.00011 | 0.00000 | 0.05114 |
| 16 | 326.25 - 348.75 | 0.00628 | 0.00788 | 0.00753 | 0.00502 | 0.00000 | 0.00000 | 0.02671 |
| | Sub-Total | 0.11769 | 0.18379 | 0.30856 | 0.33927 | 0.02751 | 0.01119 | 0.98801 |
| | Calms | | | | | | | 0.01199 |
| | Missing/Incomplete | | | | | | | 0.00000 |
| | Total | | | | | | | 1.00 |

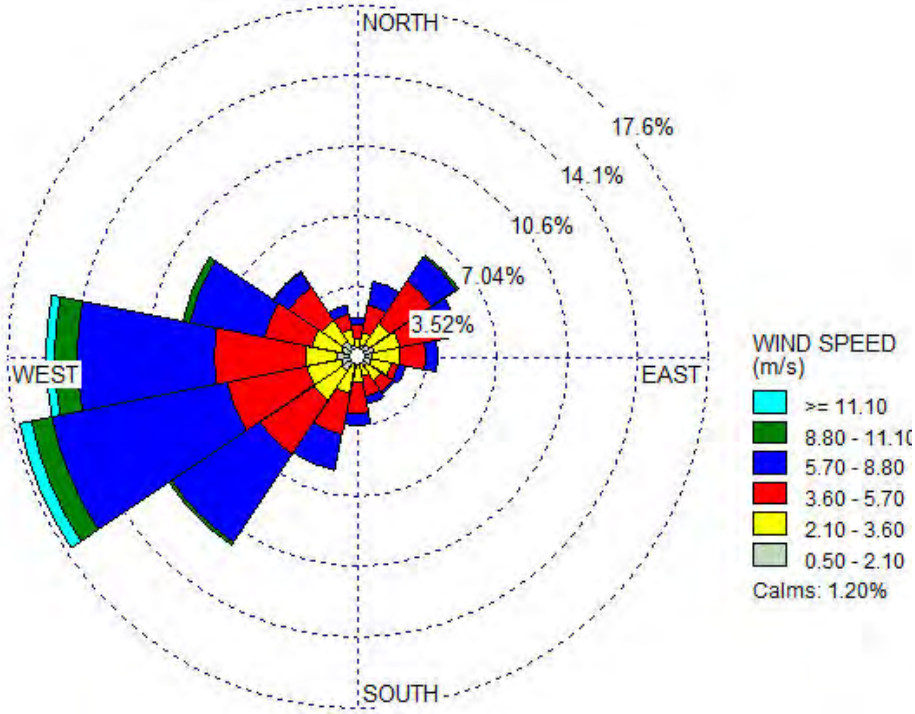
** Reference bearing CW 90$^0$*

**Figure 5: MM5 Frequency Distribution of Wind Speed and Direction 2018 Maldives Meteorology**




Windrose diagram generated using WRPlot view Version 5.8 software which utilizes SCRAM (.DAT) files. Wind direction was oriented in "Blowing from" configuration. Figure 6 presents the annual wind rose diagram at Maldives Synoptic Station.

**Figure 6: MM5 Annual Wind Rose Wind Speed and Direction Windrose, 2018 Maldives**




Meteorological data such as stability classes and wind speeds, mixing height, cloud cover among other are considered this model run. TIER 3 meteorological data was used.

AERMET meteorological processor (EPA, 2018a) was applied to prepare the meteorological data for the AERMOD model (EPA, 2018b). Values for three surface characteristics: surface roughness length {zo},[10] albedo {r},[11] and Bowen ratio {Bo}[12] were determined.

[10] The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer.
[11] The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption.
[12] The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

## Figure 7: MM5 Surface Meteorology (SFC)

File Header Data

Surface File Name: AER_NAZZ2_DAGUP.SFC
Station Latitude: 16.000N
Station Longitude: 0.000W
Upper Air Station ID: 1
Surface Station ID: 1
Onsite Station ID: N/A
Version: 14134 CCVR_SUB TEMP_SUB

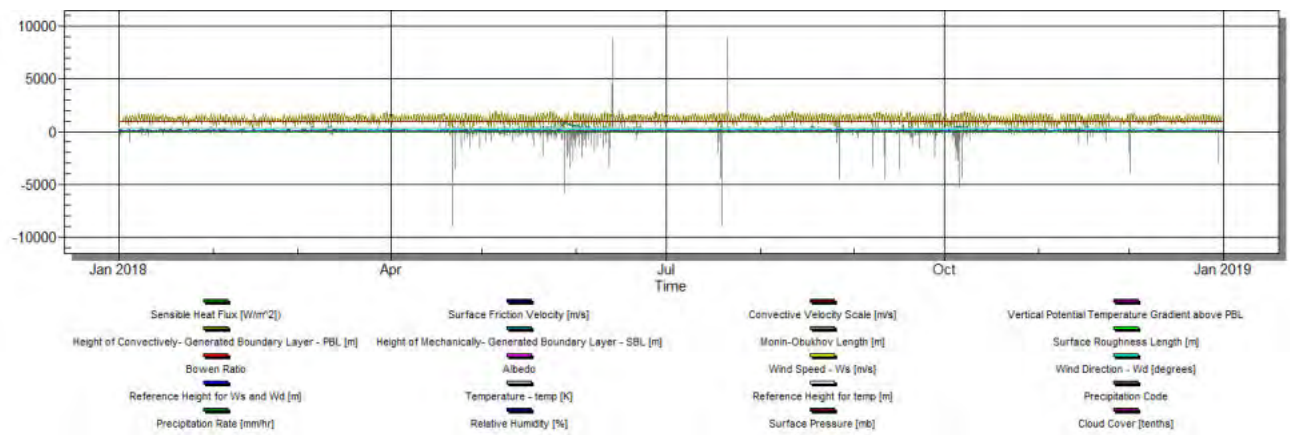
Filter
Year: 2004 Month: All Day: All Julian Day: All
Show All

Data Quality
Calms: 730 [hours] 8.31 [%]
Missing: 24 [hours] 0.27 [%]

Table Graph

| | Year | Month | Day | Julian Day | Hour | Sensible Heat Flux [W/m^2]) | Surface Friction Velocity [m/s] | Convective Velocity Scale [m/s] | Vertical Potential Temperature Gradient above PBL | Height of Convectively-Generated Boundary Layer - PBL [m] | Height of Mechanically-Generated Boundary Layer - SBL [m] | Monin-Obukhov Length [m] | Surface Roughness Length [m] | Bowen Ratio | Albedo | Wind Speed - Ws [m/s] | Wind Direction - Wd [degrees] | Reference Height for Ws and Wd [m] | Temperature - temp [K] | Reference Height for temp [m] | Precipitation Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min. | 2004 | Jan | 1 | 1 | 1 | -999.0 | -9.000 | -9.000 | -9.000 | -999.0 | -999.0 | -99999.0 | -9.000 | -9.00 | -9.00 | 0.00 | 0.0 | -9.0 | 295.1 | -9.0 | 0 |
| Max. | 2004 | Dec | 31 | 366 | 24 | 397.6 | 0.866 | 2.809 | 0.005 | 4000.0 | 1934.0 | 8888.0 | 1.000 | 2.00 | 1.00 | 999.00 | 999.0 | 10.0 | 999.0 | 2.0 | 0 |
| Graph | | | | | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ |
| 1 | 2004 | Jan | 1 | 1 | 1 | -999.0 | -9.000 | -9.000 | -9.000 | -999.0 | -999.0 | -99999.0 | 1.000 | 2.00 | 1.00 | 0.00 | 0.0 | 10.0 | 301.1 | 2.0 | 0 |
| 2 | 2004 | Jan | 1 | 1 | 2 | -999.0 | -9.000 | -9.000 | -9.000 | -999.0 | -999.0 | -99999.0 | 1.000 | 2.00 | 1.00 | 0.00 | 0.0 | 10.0 | 301.1 | 2.0 | 0 |
| 3 | 2004 | Jan | 1 | 1 | 3 | -25.5 | 0.294 | -9.000 | -9.000 | -999.0 | 362.0 | 89.8 | 1.000 | 2.00 | 1.00 | 2.10 | 144.0 | 10.0 | 301.1 | 2.0 | 0 |
| 4 | 2004 | Jan | 1 | 1 | 4 | -45.7 | 0.493 | -9.000 | -9.000 | -999.0 | 832.0 | 237.3 | 1.000 | 2.00 | 1.00 | 3.10 | 143.0 | 10.0 | 301.1 | 2.0 | 0 |
| 5 | 2004 | Jan | 1 | 1 | 5 | -36.3 | 0.504 | -9.000 | -9.000 | -999.0 | 859.0 | 318.9 | 1.000 | 2.00 | 1.00 | 3.10 | 143.0 | 10.0 | 301.1 | 2.0 | 0 |
| 6 | 2004 | Jan | 1 | 1 | 6 | -36.3 | 0.504 | -9.000 | -9.000 | -999.0 | 859.0 | 318.9 | 1.000 | 2.00 | 1.00 | 3.10 | 142.0 | 10.0 | 301.1 | 2.0 | 0 |
| 7 | 2004 | Jan | 1 | 1 | 7 | -39.9 | 0.500 | -9.000 | -9.000 | -999.0 | 849.0 | 282.6 | 1.000 | 2.00 | 1.00 | 3.10 | 145.0 | 10.0 | 301.1 | 2.0 | 0 |
| 8 | 2004 | Jan | 1 | 1 | 8 | 39.4 | 0.558 | 0.380 | 0.005 | 50.0 | 999.0 | -397.9 | 1.000 | 2.00 | 0.33 | 3.10 | 163.0 | 10.0 | 301.1 | 2.0 | 0 |
| 9 | 2004 | Jan | 1 | 1 | 9 | 129.1 | 0.587 | 1.272 | 0.005 | 576.0 | 1078.0 | -141.2 | 1.000 | 2.00 | 0.21 | 3.10 | 157.0 | 10.0 | 301.1 | 2.0 | 0 |
| 10 | 2004 | Jan | 1 | 1 | 10 | 202.1 | 0.603 | 1.676 | 0.005 | 840.0 | 1124.0 | -97.9 | 1.000 | 2.00 | 0.18 | 3.10 | 161.0 | 10.0 | 301.1 | 2.0 | 0 |
| 11 | 2004 | Jan | 1 | 1 | 11 | 214.2 | 0.606 | 1.861 | 0.005 | 1087.0 | 1131.0 | -93.6 | 1.000 | 2.00 | 0.17 | 3.10 | 184.0 | 10.0 | 301.1 | 2.0 | 0 |
| 12 | 2004 | Jan | 1 | 1 | 12 | 197.8 | 0.603 | 1.935 | 0.005 | 1324.0 | 1123.0 | -99.8 | 1.000 | 2.00 | 0.16 | 3.10 | 176.0 | 10.0 | 301.1 | 2.0 | 0 |
| 13 | 2004 | Jan | 1 | 1 | 13 | 237.2 | 0.611 | 2.162 | 0.005 | 1541.0 | 1145.0 | -86.6 | 1.000 | 2.00 | 0.16 | 3.10 | 183.0 | 10.0 | 301.1 | 2.0 | 0 |

## Figure 8: MM5 Surface Meteorological Data MM5



## Figure 9: MM5 Profile Meteorology (PFL)

Filter
Year: All  Month: All  Day: All

Table | Graph

| | Year | Month | Day | Hour | Measurement Height [m] | 1, if this is the last (highest) level for this hour, or 0 otherwise | Direction the wind is blowing from for the current level [degrees] | Wind Speed for the current level [m/s] | Temperature at the current level [C] | Standard deviation of the wind direction fluctuations [degrees] | Standard deviation of the vertical wind speed fluctuations [m/s] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Min. | 2004 | Jan | 1 | 1 | 10.0 | 1 | 0.0 | 0.00 | 22.0 | 99.0 | 99.00 |
| Max. | 2004 | Dec | 31 | 24 | 10.0 | 1 | 999.0 | 999.00 | 99.9 | 99.0 | 99.00 |
| Graph | | | | | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ |
| 1 | 2004 | Jan | 1 | 1 | 10.0 | 1 | 0.0 | 0.00 | 28.0 | 99.0 | 99.00 |
| 2 | 2004 | Jan | 1 | 2 | 10.0 | 1 | 0.0 | 0.00 | 28.0 | 99.0 | 99.00 |
| 3 | 2004 | Jan | 1 | 3 | 10.0 | 1 | 144.0 | 2.10 | 28.0 | 99.0 | 99.00 |
| 4 | 2004 | Jan | 1 | 4 | 10.0 | 1 | 143.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 5 | 2004 | Jan | 1 | 5 | 10.0 | 1 | 143.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 6 | 2004 | Jan | 1 | 6 | 10.0 | 1 | 142.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 7 | 2004 | Jan | 1 | 7 | 10.0 | 1 | 145.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 8 | 2004 | Jan | 1 | 8 | 10.0 | 1 | 163.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 9 | 2004 | Jan | 1 | 9 | 10.0 | 1 | 157.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 10 | 2004 | Jan | 1 | 10 | 10.0 | 1 | 161.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 11 | 2004 | Jan | 1 | 11 | 10.0 | 1 | 184.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 12 | 2004 | Jan | 1 | 12 | 10.0 | 1 | 176.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 13 | 2004 | Jan | 1 | 13 | 10.0 | 1 | 183.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 14 | 2004 | Jan | 1 | 14 | 10.0 | 1 | 179.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 15 | 2004 | Jan | 1 | 15 | 10.0 | 1 | 322.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 16 | 2004 | Jan | 1 | 16 | 10.0 | 1 | 324.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 17 | 2004 | Jan | 1 | 17 | 10.0 | 1 | 321.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 18 | 2004 | Jan | 1 | 18 | 10.0 | 1 | 357.0 | 3.10 | 28.0 | 99.0 | 99.00 |
| 19 | 2004 | Jan | 1 | 19 | 10.0 | 1 | 4.0 | 3.10 | 28.0 | 99.0 | 99.00 |

## Figure 10: MM5 Profile Meteorological Data (PFL)

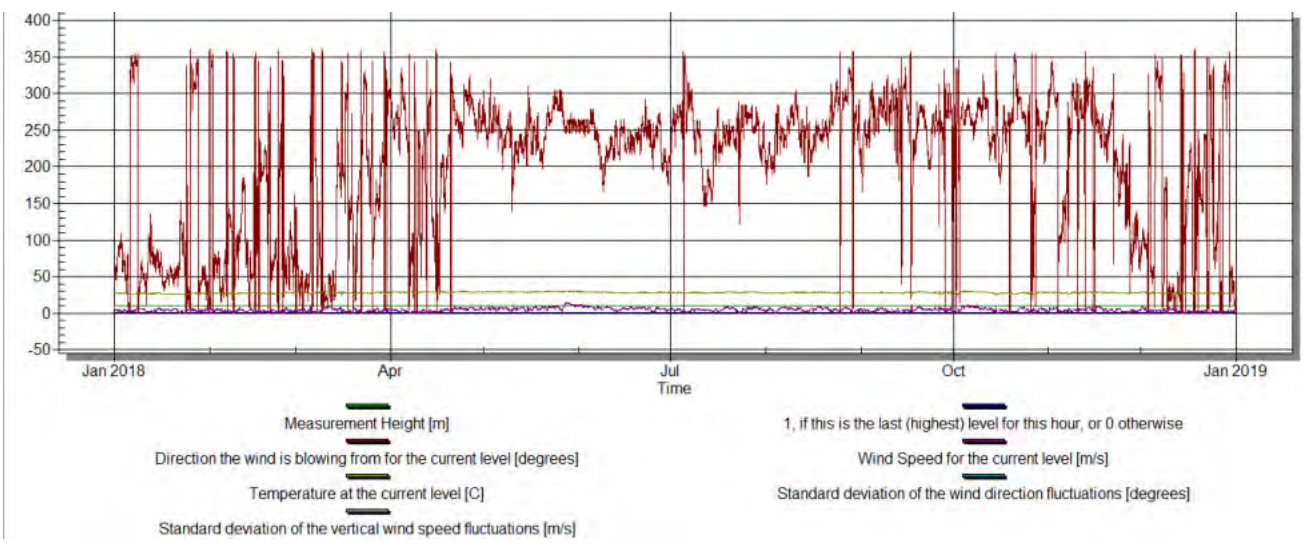
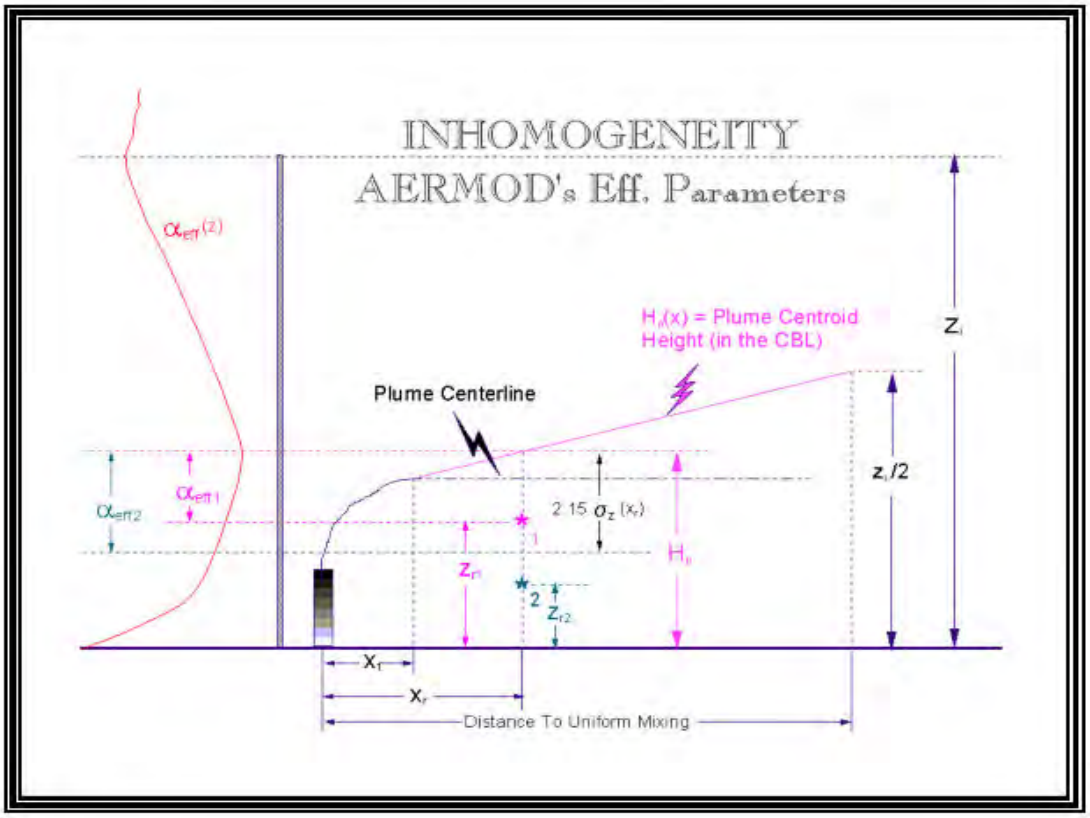


**Figure 11: AERMOD Treatment of Boundary Parameters**




**Model Receptor Grid (Model Domain) and Grid Coordinates**

The extent of the grid was chosen to include any regions of sensitive or important receptors such as residential areas and should also be sufficiently large to capture peak downwind pollutant predictions. For sources emitting pollutants close to ground level, the maximum ground-level concentration will be close to the source. However, for stack sources, the maximum ground-level concentration can be some distance away, and the model may have to be run more than once with increasing grid ranges to make sure the peak is captured.

The WTE plan stack 1 (designated as origin) is assigned with coordinates 0,0 m and all site measurements can relate to this benchmark. All facility buildings and sources could then be related spatially to this origin.

Model domain covers 4,000 meters by 4,000 meters with 100 meter grid spacing. This is to cover area sensitive receptors (ASRs) near the WTE plant site and in Thilafushi. Center of the model domain is based on the location of the WTE plant's of 250 TPD boilers (2 units) and 0.8 mW diesel generator set. Figures 12 to 14 show the model domain.

**Figure 12: Domain of AERMOD Dispersion Modeling**

**Figure 13: 4 km X 4 km Model Domain (100 x 100 meters grid)**

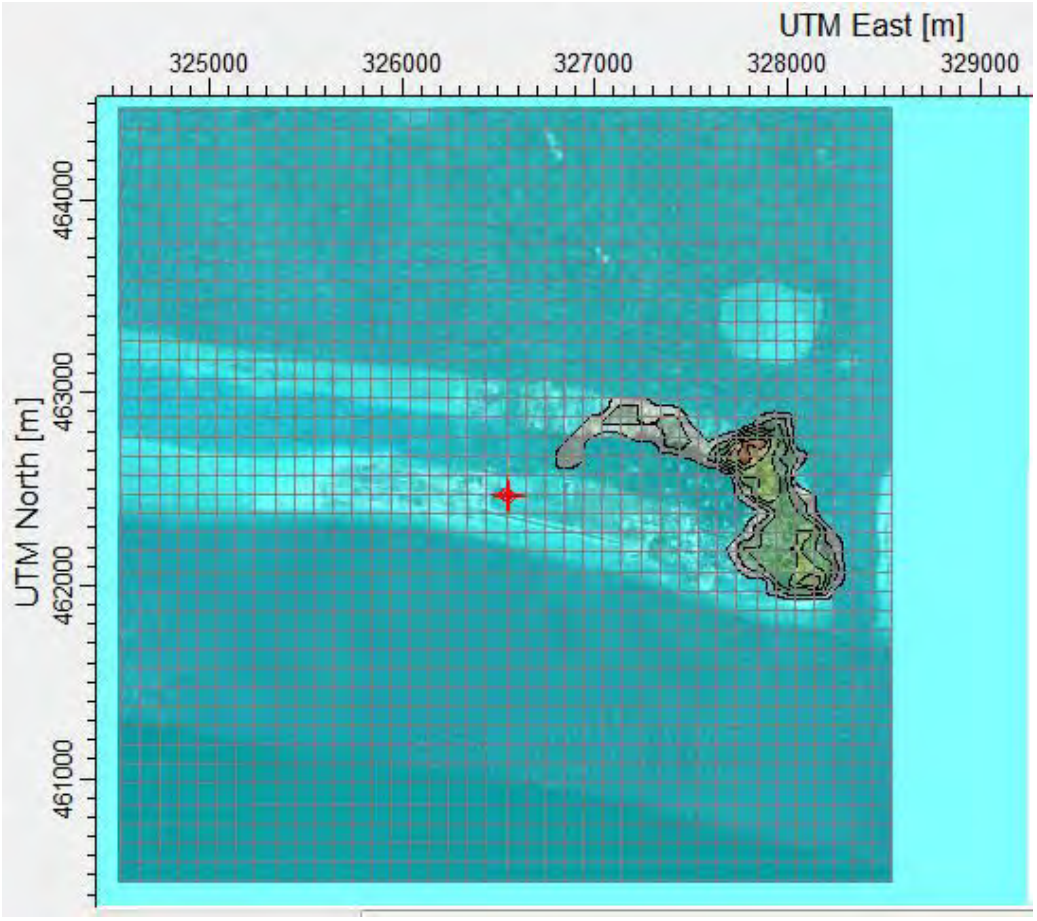
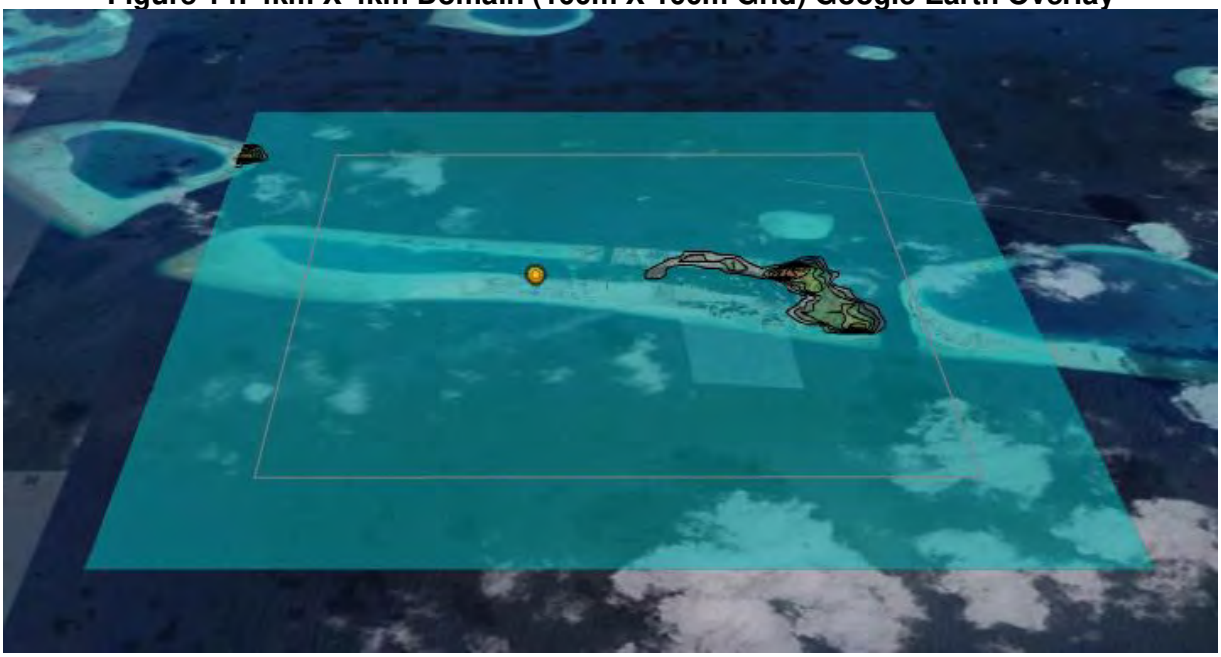


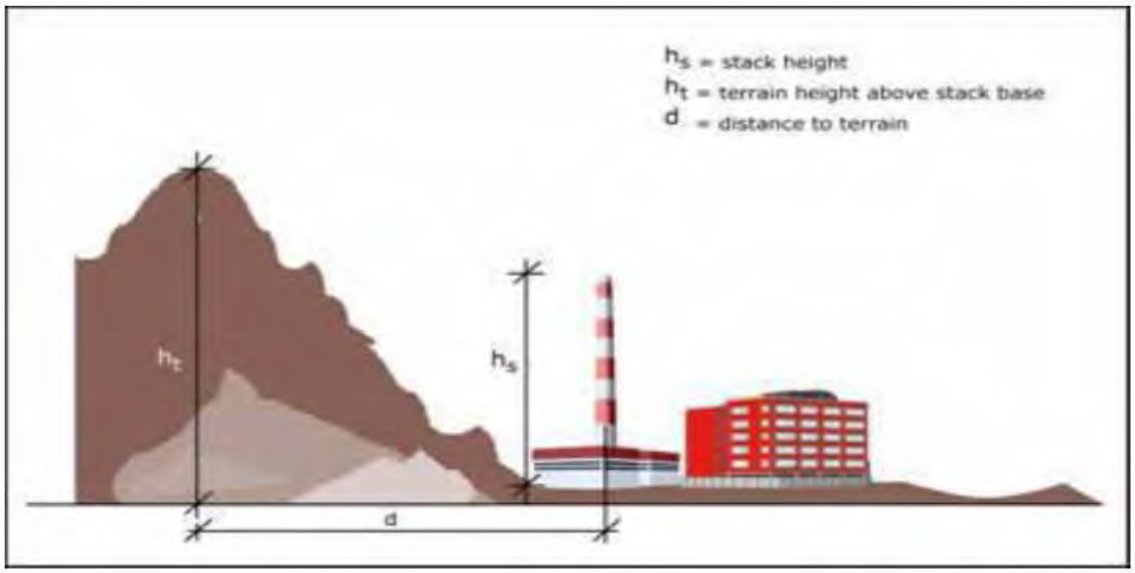

**Figure 14: 4km X 4km Domain (100m X 100m Grid) Google Earth Overlay**



### Terrain Effects

Terrain elevations have a large impact on the air dispersion and deposition modelling results. Terrain elevation is the elevation relative to the facility base elevation (Figure XXX).

**Figure 15: Terrain effects in AERMOD SYSTEM**




The AERMOD model utilized elected terrain using Shuttle Radar Topography Mission (SRTM3) terrain data processed by AEMAP terrain processor. This option assumes terrain height exceeds stack base elevation; model receptors are also assumed on elevated terrain. Terrain elevations for receptors in the receptor pathway are also considered. Elevated terrain is selected, and receptor heights are not specified, then it is assumed to have a value of 0.0 meters. Figures 16 to 17 provides the SRMT terrain elevation used in the modelling. Complex terrain illustrated in figures are those elevations defined as anywhere within 50 km from the stack, are above the top of the stack being evaluated in the air modelling analysis.

Surface characteristics at the measurement site influence boundary layer parameter estimates. These influences are quantified through the albedo, Bowen ratio, and surface roughness length. The surface roughness length is the height at which the mean horizontal wind speed approaches zero and is related to the surface roughness characteristics of the terrain. It is not equal to the physical dimensions of the obstacles to the wind flow but is generally proportional to them. The surface roughness length dialog provides empirically determined surface roughness length values (from Sheih et al., 1979) for various land use types for each season. In order to better quantify these characteristics, frequency that these characteristics change (annual, seasonal, or monthly) and the number of different sectors have been specified in the modelling.

**Figure 16: SRMT Terrain Elevation**

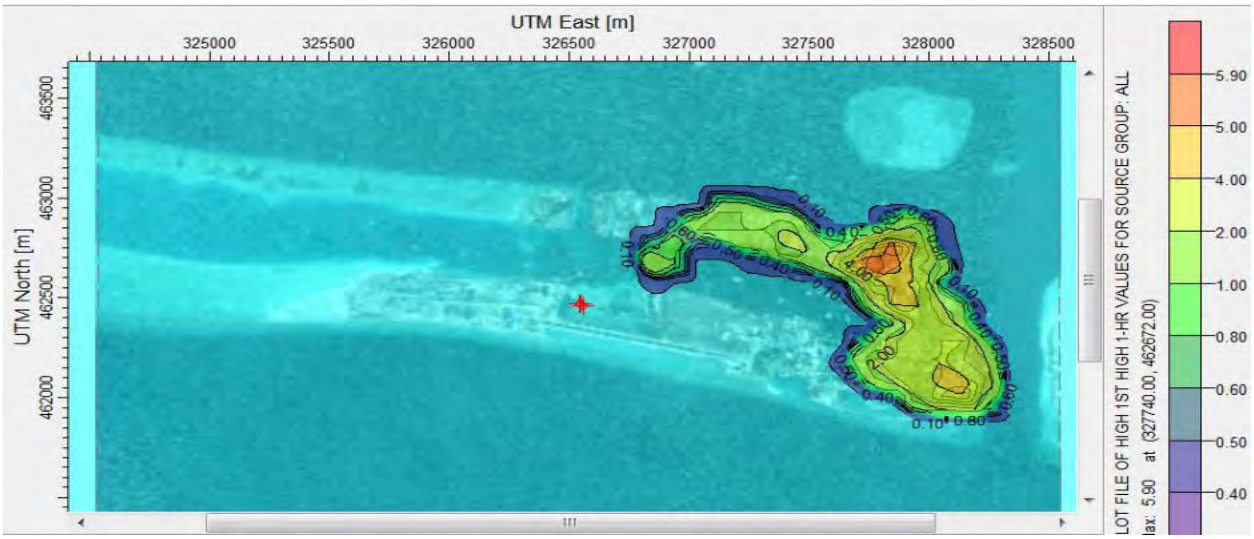



**Figure 17: SRMT Terrain Elevation Google Earth Overlay**

**Area Sensitive Receptors (ASRs)**

Area Sensitive Receptors (ASRs) include, but are not limited to residential areas, hospitals, schools, daycare facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to air pollutants. Extra monitoring and abatement efforts must be taken when dealing with contaminants and pollutants in close proximity to areas recognized as ASRs.

For the WTE plant and for the purpose of assessing potential impacts, Thillafushi islands' industrial areas are considered as ASRs as there are identified facilities with workers quarters. ASRs are located in the following area and details are provided in the figure and table below: (1.) ASR1-ENE; (2.) ASR2-SSE; (3.) ASR3-NNE; (4.) ASR4- SSW; (5) ASR5-NNW 474 to 1273 meters upwind and downwind directions from the center of the domain at Universal Transverse

Mercator (UTM) coordinates Easting 326540 and Northing 462472. This AERMOD Report includes results of the dispersion model showing the highest predicted ground level concentrations (GLC) in the ASRs.

**Figure 18: Location of the ASRs and SRMT Terrain**

**Table 2: UTM Coordinates of Location of Area Sensitive Receptors (ASRs)**

| | Long | Lat |
|---|---|---|
| ASR1 | 327811.66 | 462535.58 |
| ASR2 | 327938.27 | 462105.3 |
| ASR3 | 326838.73 | 462821.63 |
| ASR4 | 326087.04 | 462454.99 |
| ASR5 | 326415.56 | 462929 |

### Building Downwash

Building downwash occurs when the aerodynamic turbulence induced by nearby buildings cause a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level concentrations. Influence of buildings have been also considered in the model. The following building dimension and location (stack and Diesel genset) have been considered for the WTE plant. WTE dimensions: Approx. Length x width x height [m]: 100 x 70 x 30 Surrounded buildings location have been considered according land use plan, topographical survey and google earth maps. The height of the buildings have been considered to maximum 10 m[13].

[13] Environmental and Social Impact Assessment (ESIA) Waste to Energy Facility Thilafushi