

# WATER QUALITY ASSESSMENT REPORT

*Groundwater Quality Assessment  
for Laamu Atoll Isdhoo, Kalaidhoo, Gan and Dhanbidhoo*



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# 1. Executive Summary

The Water Quality Assessment Report is a deliverable under the ENDhERI Project to undertake “Ground Water Quality Assessment for Laamu Atoll Isdhoo, Kalaidhoo, Gan and Dhanbidhoo” as per the Terms of Requirements (TOR) (IUL)438-ENV/438/2023/234.

This report includes the literature review of other baseline assessment reports conducted in Laamu Atoll and the Maldives. It also showcased studies related to groundwater and environmental impact reports in Laamu Atoll. Moreover, a few regulations and guidelines for water quality were outlined.

The sampling methodology that was followed was described, which includes the parameters that was tested, the procedure to collect groundwater samples from taps and wells, the procedures followed to properly label and document the samples and the storage requirements for samples.

Groundwater sampling was carried out in L. Gan, L. Isdhoo, L. Kalaidhoo and L. Dhanbidhoo from 5 – 7<sup>th</sup> February 2024, and results from each island were presented in this report. Additionally, the physiochemical and microbiological aspects of the samples from each island were discussed with comparison to previous groundwater monitoring data. This report also provided recommendations for future water quality assessments.

This report concluded that the physiochemical parameters from all islands were at an acceptable range. However, the microbiological contamination from all samples were high which indicates that groundwater should be disinfected before use. This is a majorly significant finding for mosques where control samples were taken, and where groundwater is used for ablution purposes. The major limitation of this project was that pesticides were not tested.

It was recommended that for future groundwater assessments it is crucial to include pesticides, E. Coli testing and dictate the number of samples to be tested, based on the size of the island. It is also important to inform relevant stakeholders regarding water regulations to enforce continuous monitoring of the freshwater lens.

## 2. Introduction

The Maldives, a small island nation, faces challenges in protecting its fragile environment and balancing food security. Agriculture contributes only minimally to the economy but plays a crucial role in livelihoods. Increased food demand and nutrient-poor soil leads to heavy use of imported agrochemicals, raising concerns about human health and environmental pollution.

In response to this challenge among other environmental challenges, the Enhancing National Development through Environmentally Resilient Islands (ENDHERI) project has been established under the Ministry of Climate Change, Environment and Energy (MoCCEE). This project has a duration of four years, starting from December 2020, and aiming for completion by September 2024. This project has objectives of enhancing reef protection, resilience and ecosystem recovery by reducing development impacts in a selected project site of the Maldives, enabled for replication nationally through public awareness and integrating the values of marine biodiversity and other natural capital in national accounting. This project has outcomes of supporting sustainable, environment-friendly agricultural practices, building local capacity and awareness on impacts of agrochemicals on environment and human health, and supporting transformation of local agricultural practices to more environmentally sustainable and health-conscious methods.

In line with these objectives and outcomes, MoCCEE has contracted Epoch Associates for the assignment "Ground Water Quality Assessment for Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo". This assignment aims to assess the impact of agrochemical usage on groundwater and build a groundwater baseline in four highly impacted islands of Laamu Atoll and provide groundwater sampling training to project island councils and ministry officials. This water sampling works report is a deliverable under the assignment and will detail the works carried out on site and the sampling methods that were used.

The water sampling and training was carried out through 5<sup>th</sup>-7<sup>th</sup> February 2024, and it was conducted by Epoch Associates Private Limited. The 4 selected inhabited islands were recognized as the most highly impacted agricultural islands within Laamu Atoll.

This report includes other studies and publications such as certain literatures which provide relevance to the groundwater monitoring and assessment within the Maldives. The sampling methodology that was followed will be described. This report will discuss the results of groundwater sampling from each island. The results will be compared with values from previous groundwater monitoring within these islands.

## 3. Literature Review and Desk Study

A careful review of all available literature was made to gather critical information pertaining to the study area and to determine whether any of the historical studies overlap with the intended work.

Literature review covered existing studies undertaken for all of the islands with respect to agricultural activities and practices, groundwater quality, and groundwater contamination. The literature review included published reports and documents by the government, Environmental Impact Assessment (EIA) reports published for the study islands, government policies and masterplans, published studies, and review of institutional framework. The literature reviewed for this study, which was also presented in the Inception phase, is updated and presented below:

### 3.1. Baseline Assessment Reports

- **Baseline Report on Agricultural Practices in Laamu Atoll (Ministry of Environment Climate Change and Technology, 2023)**

The ENDHERI project's baseline assessment aimed to understand the status of agricultural practices in Laamu Atoll, establishing a reference point to identify needs for supporting the local community's agriculture under the project. The study examined 11 inhabited Laamu islands using quantitative data, literature and stakeholder consultations. Agriculture is the main economic activity and livelihood source on the larger islands of Gan, Isdhoo and Kalaidhoo.

The report detailed the farming population, land resources, practices, crops and agrochemical use, while outlining key challenges. Greatest number of farmers are within Gan (33%), Isdhoo (30%), Kalaidhoo (19%) and Dhanbidhoo (6%).

The data revealed that the predominant agricultural activity on the inhabited islands of Laamu Atoll is home gardening, followed by homestead farming and commercial inorganic and organic farming practices.

The report indicates that key challenges include unsustainable practices like unregulated fertilizers and pesticides, impacting health and the environment. Fertilizers and Pesticides commonly used in Laamu Atoll are shown in Figure 3.1. Invasive species are also a reported concern for Laamu and other atoll farmers. Financial constraints and high investment costs also inhibit the expansion of sustainable farming practices on islands in Laamu atoll.

The report indicates that soils found on the Maldivian islands are notably deficient in the essential nutrients required for optimal agricultural crop growth. This necessitates significant use of agrochemicals to enrich the soil and achieve better yields. The soil exhibits very high infiltration rates, resulting in low water-holding capacity. Due to excessive calcium content, the soil pH ranges from 8.0 to 8.8, with an average of 8.5. The soils are generally lacking in nitrogen and potassium due to excessive leaching, as well as deficient in several micronutrients such as iron, manganese, copper, boron, and zinc as a consequence of the high pH levels.



Pesticides and Insecticides			
Name	Main use	Volume	Market Price
Cypermethrin	Used to spray to worms	250ml	170
Senora		100ml	350
Senora	Insecticide	175ml	435
Prodhon Insecticide	Insecticide	250ml	230
Prodhon Insecticide	Insecticide	500ml	320
Starkle-G	Insecticide	1kg	295
Prefenos (C-Cron)	Insecticide		525
Fungrang (copper hydroxide)	Helps leaves to gain protein and growth	500g	235
N+Mancozeb (Maaka)	Contact fungicide	50g	180
Besilas Thrinjiensis (BT)	Control worms	100g	185
Neemaxe	Insecticide	1ltr	
Mapa Diazinon 60	Insecticide	100ml	80
Mapa Diazinon 60	Insecticide	1 ltr	420
Clipper 20SL	Insecticide	1 ltr	350
Asgurd	Insecticide	1 ltr	520
Abamectin (Rihakuru beys)	Insecticide	100ml	85
Abamectin (Rihakuru beys)	Insecticide	1 ltr	440
Acetamiprid	Insecticide	1 ltr	490
Folicur Tebuconazole	Lack of iron in leaves, nutrient deficiency	250ml	275
Imidiclopreed	Used for pesticides and plant growth deficiency	100ml	400
Dhan Preet	Koodi beys	100g	115
Dhan Preet	Koodi beys	500g	600
Pager	Koodi beys	250g	430
Thiram	Used for fungus	100g	135
Thiram	Used for fungus	500g	465
Cyperguard 25 EC	Insecticide	1 ltr	520
Antracol	Contact fungicide	100g	90

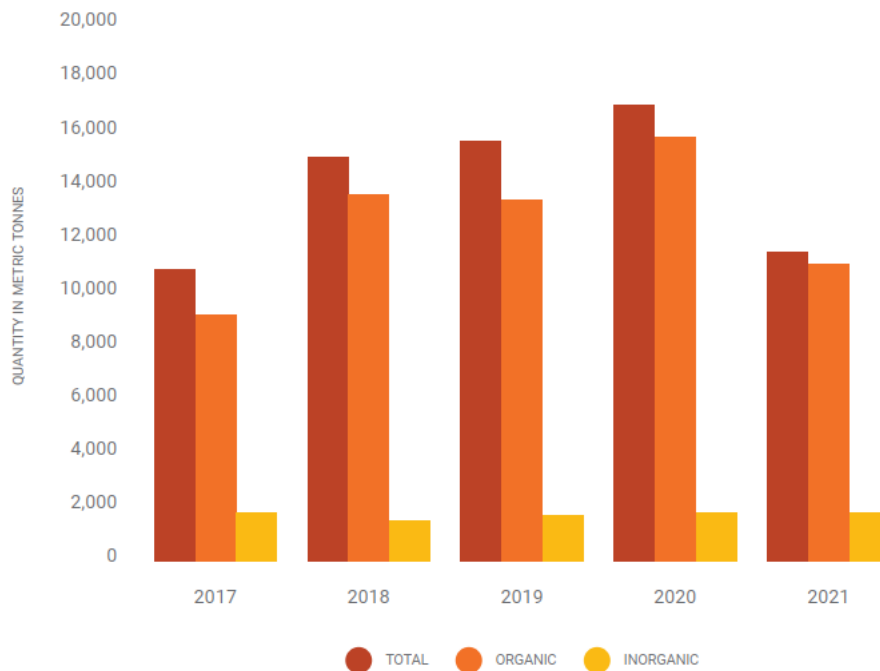
Fertilizers			
Name	Main use	Volume	Market Price
Sulphur	Helps plant growth and greenery	1kg	225
Sulphur (BK)	Helps plant growth and greenery	1kg	170
Sulphur	Helps plant growth and greenery	500g	145
Maxicrop	Foliar Nutrient	400ml	170
Floral 20-20-20	Plant growth at all stages	2.5kg	300
Greenleaf 12.48.8	Foliar fertiliser promoting of flowering		135
Yaara Mila 8.24.24	Plant fertilizer (oh kaana)	1kg	45
NPK 12.12.36 (Florin)	Plant fertilizer (oh kaana)	1kg	75
Yaara Mila 12.11.18	Plant fertilizer (oh kaana)	1kg	55
NPK 27.6.6	Plant fertilizer (oh kaana)	1kg	35
Neu NPK 12.11.18	Plant fertilizer (oh kaana)	1kg	30
Ammonium	Plant fertilizer	1kg	35
Potasium	Plant fertilizer	1kg	35
Neu NPK 12.12.17	Plant fertilizer (oh kaana)	1kg	30
TSP	Plant fertilizer	1kg	55

Figure 3.1: Fertilizers and Pesticides used in Laamu Atoll. Source: (Ministry of Environment Climate Change and Technology, 2023)

- **Baseline Assessment on National Use of Chemicals and Associated Risks 2022** (Ministry of Environment Climate Change and Technology, 2022)

This assessment states that fertilizers and pesticides are the primary chemical applications in agriculture. Both organic and inorganic fertilizers are extensively used in the agricultural sector of the Maldives. Illustrated in

Figure 3.2 is the quantity of organic and inorganic fertilizer groups, alongside the total imported fertilizer quantity. This assessment recorded that over a five-year span, there was a consistent increase in the import of organic fertilizers, surpassing the import of inorganic ones until 2020. The overall import of inorganic fertilizers remained steady throughout this period. In 2021, India emerged as the primary fertilizer supplier, contributing to 57% of the total imports.



**Figure 3.2: Quantity of organic and inorganic fertilizers imported to the Maldives from 2017 to 2021 (Ministry of Environment Climate Change and Technology, 2022)**

As per this report, during 2021, the predominant chemical fertilizers imported comprised nitrogenous fertilizers and NPK fertilizers which are nitrogen (N), phosphorus (P), and potassium (K), enriched with microelements. The cumulative total weight of chemical fertilizers imported summed up to 1,393.70 tonnes.

This report documents that between 2017 and 2021, a range of pesticides falling into categories like fungicides, herbicides, anti-sprouting agents, plant-growth regulators, rodenticides, insecticides, and disinfectants were brought into the country in varying amounts. Most imported pesticides in the Maldives were insecticides, displaying a steady increase from 229.63 tonnes to 1,292.54 tonnes over the five-year span.

- Baseline Assessment Report for Groundwater Resource Management and Aquifer Protection in Maldives (Ministry of Environment, 2020)**

The Baseline Assessment for Groundwater Resource Management and Aquifer Protection in Maldives was conducted in 13 islands in 2019, and report was published by Ministry of Environment (2020). This report presented the results of a robust assessment on the impacts on the freshwater lens based on geo-physical, hydrological, and social investigations. The data and methodologies published in this report were taken as a reference to plan the groundwater sampling surveys. A summary of groundwater quality from the baseline assessment is shown in Table 3-1 and Table 3-2. High Electrical Conductivity (EC in  $\mu\text{S}/\text{cm}$ ) and Salinity (PPT) were recorded mostly in shoreline samples presumably due to pumping induced seawater intrusion with centrally located wells recording lower Electrical Conductivity (EC in  $\mu\text{S}/\text{cm}$ ) and Salinity (PPT).

The results of this study indicate that the freshwater aquifers in islands with high population densities were found to be highly stressed and overexploited, although no deterioration of the freshwater lens specifically from highly agricultural islands such as HDh. Nolvharanfaru was observed. The microbiological investigations of this study indicated that groundwater aquifers in all 13 islands are exposed to faecal contamination, which is caused by effluent from septic tanks.

*Table 3-1: Summary of average concentration or value of groundwater quality from the baseline assessment (1/2)*

	EC ( $\mu\text{S/cm}$ )	Salinity (PSU)	TDS (mg/L)	pH	Turbidity (NTU)
HA. Utheem	1744 $\pm$ 2545	0.812 $\pm$ 1.29	1014 $\pm$ 1503	7.54 $\pm$ 0.261	0.05 $\pm$ 0.0514
HDh. Nolvharanfaru	2240 $\pm$ 3342	1.27 $\pm$ 2.01	1332 $\pm$ 1947	7.61 $\pm$ 0.3	0.683 $\pm$ 1.29
Sh. Funadhoo	7548 $\pm$ 9332	3.84 $\pm$ 5.15	4371 $\pm$ 5400	7.47 $\pm$ 0.192	0.234 $\pm$ 0.411
N. Henbadhoo	4240 $\pm$ 1576	1.99 $\pm$ 0.757	2468 $\pm$ 887	7.31 $\pm$ 0.295	0.213 $\pm$ 0.247
R. Maduvvari	3690 $\pm$ 4060	1.77 $\pm$ 2.11	2152 $\pm$ 2341	7.47 $\pm$ 0.281	0.366 $\pm$ 0.343
B. Dharavandhoo	1009 $\pm$ 384	0.442 $\pm$ 0.179	589 $\pm$ 224	7.45 $\pm$ 0.272	1.01 $\pm$ 1.13
AA. Bodufulhadhoo	6183 $\pm$ 3556	3 $\pm$ 1.82	3594 $\pm$ 2077	7.43 $\pm$ 0.158	3.11 $\pm$ 2.63
ADh. Dhigurah	2726 $\pm$ 4237	2.58 $\pm$ 6.12	1565 $\pm$ 2444	7.5 $\pm$ 0.2	1.37 $\pm$ 2.61
M. Raimandhoo	5039 $\pm$ 7990	2.7 $\pm$ 4.66	3072 $\pm$ 4931	7.69 $\pm$ 0.384	1.02 $\pm$ 0.705
Th. Kinbidhoo	939 $\pm$ 257	0.418 $\pm$ 0.123	559 $\pm$ 157	7.45 $\pm$ 0.14	524 $\pm$ 1355
Dh. Meedhoo	888 $\pm$ 484	0.399 $\pm$ 0.225	530 $\pm$ 288	7.76 $\pm$ 0.36	27.7 $\pm$ 68.5
GA. Kon'dey	637 $\pm$ 115	0.278 $\pm$ 0.0525	377 $\pm$ 70.5	7.56 $\pm$ 0.368	2.78 $\pm$ 6.37
GDh. Fiyoari	998 $\pm$ 388	0.439 $\pm$ 0.176	587 $\pm$ 226	7.49 $\pm$ 0.332	1.8 $\pm$ 2.52

*Table 3-2: Summary of average concentration or value of groundwater quality from the baseline assessment (2/2)*

	DO (mg/L)	Nitrates (mg/L-NO <sub>3</sub> )	Ammonia (mg/L)	Phosphates (mg/L)
HA. Utheem	5.52 $\pm$ 1.79	33.9 $\pm$ 25.4	2.93 $\pm$ 4.01	0.166 $\pm$ 0.118
HDh. Nolvharanfaru	4.434 $\pm$ 2.61	39.2 $\pm$ 34.3	6.72 $\pm$ 7.98	0.244 $\pm$ 0.2
Sh. Funadhoo	6.72 $\pm$ 0.551	41.4 $\pm$ 28.7	7.49 $\pm$ 9.61	0.207 $\pm$ 0.17
N. Henbadhoo	2.21 $\pm$ 1.18	34.3 $\pm$ 10.1	12.9 $\pm$ 7.89	0.359 $\pm$ 0.271
R. Maduvvari	3.07 $\pm$ 1.16	49.1 $\pm$ 33.1	6.16 $\pm$ 12.5	0.338 $\pm$ 0.22
B. Dharavandhoo	2.67 $\pm$ 1.54	25.1 $\pm$ 20.1	1.43 $\pm$ 1.19	0.263 $\pm$ 0.34
AA. Bodufulhadhoo	3.35 $\pm$ 1.71	18.4 $\pm$ 8.8	0.31 $\pm$ 0.303	0.269 $\pm$ 0.201
ADh. Dhigurah	2.55 $\pm$ 1.47	59 $\pm$ 53.6	0.537 $\pm$ 1.44	0.236 $\pm$ 0.173
M. Raimandhoo	2.58 $\pm$ 1.57	25.5 $\pm$ 30.7	5.14 $\pm$ 9.24	0.237 $\pm$ 0.212
Th. Kinbidhoo	3.42 $\pm$ 1.17	10.7 $\pm$ 6.21	1.18 $\pm$ 1.1	0.452 $\pm$ 0.606
Dh. Meedhoo	3.6 $\pm$ 2.11	8.53 $\pm$ 6.42	1.07 $\pm$ 1.39	0.311 $\pm$ 0.273
GA. Kon'dey	4.23 $\pm$ 5.44	13.5 $\pm$ 13.1	0.993 $\pm$ 2.22	0.218 $\pm$ 0.0853
GDh. Fiyoari	3.19 $\pm$ 2.02	12 $\pm$ 14.5	3.62 $\pm$ 7.33	0.345 $\pm$ 0.331

Note: EC=Electrical Conductivity, TDS=Total Dissolved Solids, DO=Dissolved Oxygen

- **Baseline Assessment Report for Assessing Groundwater Resources and Design of Aquifer Recharge Systems in Selected Islands of Maldives – Lot 02 (Ministry of Environment, 2023)**

The Baseline Assessment for Assessing Groundwater Resources and Design of Aquifer Recharge Systems in Selected Islands of Maldives was conducted in 6 islands in 2021, and report published by Ministry of Environment, Climate Change and Technology (2022). This report presented the results of a robust assessment on the impacts on the freshwater lens based on geo-physical, hydrological, and social investigations. The data and methodologies published in this report were taken as a reference to plan the groundwater sampling surveys. A summary of groundwater quality from the baseline assessment is shown in Table 3-3.

From these six (06) islands, Th. Vandhoo shows the highest average of Electrical Conductivity (EC) ( $\mu\text{S}/\text{cm}$ ) of 1,039  $\mu\text{S}/\text{cm}$  which is still within the acceptable limit for potable water of 1,500  $\mu\text{S}/\text{cm}$ . Th. Omadhoo and Th. Gaadhiffushi Islands had EC values within the acceptable range for all the samples. Average Ammonia concentration of the tested samples remained within the acceptable limit of 1.5 mg/L.

It was recorded in this report that each island shows individual characteristics compared to water quality parameters and hydraulic conductivity parameters. This report identified that the main reasons for the critical variation on EC, Ammonia, Nitrate and Phosphates are higher extraction of groundwater, leaching on nitrate based fertilizers, coral stockpiling within the island area, sea water flooding, and contaminants from anthropogenic activities. Agricultural areas in Sh. Foakaidhoo, Th. Vandhoo, and Th. Kandoodhoo islands were recorded with an increase of EC, Ammonia, and Nitrate, which could be due to higher extraction of groundwater, leaching of nitrate-based fertilizers, etc.

*Table 3-3: Summary of groundwater quality from the baseline assessment*

	Th. Kandoodhoo	Th. Vandhoo	Th. Omadhoo	Th. Gaadhiffushi	Sh. Foakaidhoo	Th. Dhiyamigili
<b>EC (<math>\mu\text{S}/\text{cm}</math>)</b>	791 $\pm$ 668	1039 $\pm$ 800	524 $\pm$ 172	641 $\pm$ 294	896 $\pm$ 366	966 $\pm$ 723
<b>pH</b>	7.69 $\pm$ 0.223	7.65 $\pm$ 0.244	7.58 $\pm$ 0.342	7.56 $\pm$ 0.308	7.44 $\pm$ 0.336	7.63 $\pm$ 0.265
<b>Turbidity (NTU)</b>	7.7 $\pm$ 38.3	96.2 $\pm$ 511	0.426 $\pm$ 1.12	1.65 $\pm$ 4.54	0.291 $\pm$ 0.347	32.8 $\pm$ 156
<b>DO (ppm)</b>	4.09 $\pm$ 1.76	4.38 $\pm$ 1.41	3.57 $\pm$ 2.03	4.15 $\pm$ 9.54	3.27 $\pm$ 1.5	2.77 $\pm$ 1.8
<b>Salinity (PSU)</b>	0.424 $\pm$ 0.375	2.44 $\pm$ 7.05	0.00252 $\pm$ 0.0843	0.302 $\pm$ 0.153	0.843 $\pm$ 2.62	0.746 $\pm$ 1.85
<b>Nitrates (mg/L)</b>	8.94 $\pm$ 15.1	3.05 $\pm$ 5.55	4.65 $\pm$ 7.95	19.4 $\pm$ 34.3	14.4 $\pm$ 21.9	4.8 $\pm$ 7.96
<b>Ammonia (mg/L)</b>	0.0578 $\pm$ 0.178	0.263 $\pm$ 0.405	0.406 $\pm$ 1.282	0.289 $\pm$ 0.842	0.23 $\pm$ 0.88	0.78 $\pm$ 1.23
<b>Phosphates (mg/L)</b>	0.474 $\pm$ 0.807	0.228 $\pm$ 0.303	0.248 $\pm$ 0.197	0.258 $\pm$ 0.368	0.366 $\pm$ 0.344	0.53 $\pm$ 0.575

Note: EC=Electrical Conductivity, DO=Dissolved Oxygen



### 3.2. Environmental Impact Reports (EIAs)

From the Environmental Protection Authority (EPA) Public drive available online, all the Environmental Impact Assessment (EIA) reports published for the four project islands were shortlisted and reviewed. EIA reports containing information about groundwater environment were shortlisted. EIA reports from 2015 to 2023 were available on the public domain. Six EIA reports were shortlisted as follows:

- EIA for Proposed Road Development in Gan, Laamu Atoll (2023)
- EIA for the proposed Causeway Development between Kalaidhoo and Dhanbidhoo, Laamu Atoll (2023)
- EIA for the Proposed Establishment of water network in L. Gan, L. Isdhoo, L. Kalaidhoo, L. Maamendhoo (2021)
- EIA for the Proposed Constructions of water Supply Facility at L. Dhanbidhoo (2021)
- EIA for the Proposed Sea Cucumber Development Project at L. Gan (2017)
- EIA for the Proposed Construction of Island Waste Management Centre at Dhanbidhoo, Laamu Atoll (2017)

A total list of all the groundwater parameters tested with sampling dates and results are presented in Annex 1 – Groundwater quality testing results from review of EIA Reports (2015 – 2023). This annex also contains annual averages of relevant tested parameters for all the years available. The results from this review are summarized and presented in Table 3-4 and Table 3-5, in the form of average values and concentration.

**Table 3-4: Summary of average concentration or value of groundwater parameters tested in reviewed EIA reports (1/2)**

	pH	Electrical Conductivity (µS/cm)	Salinity (ppt)	Total Dissolved Solids (mg/L)	Dissolved Oxygen (mg/L)
<b>Dhanbidhoo</b>	7.71	634	0.309	313	4.1
<b>Gan</b>	7.46	906	0.449	454	5.47
<b>Isdhoo</b>	7.33	601	0.295	301	-
<b>Kalaidhoo</b>	7.51	831	0.408	415	-

**Table 3-5: Summary of average concentration or value of groundwater parameters tested in reviewed EIA reports (2/2)**

	Nitrate (mg/L)	Sulfate (mg/L)	Phosphate (mg/L)	BOD (mg/L)	COD (mg/L)
<b>Dhanbidhoo</b>	0.6	-	-	-	-
<b>Gan</b>	8.08	31.6	0.228	5.8	19.9
<b>Isdhoo</b>	-	-	-	-	-
<b>Kalaidhoo</b>	-	-	-	-	-

Note: BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand

### 3.3. Published Studies

- **Effects of Fertilization to Groundwater Contamination (Muian & Kuan, 2022)**

This study focused on the impact of fertilization on groundwater contamination in a paddy field on Langkawi Island in Malaysia. Agricultural activities, particularly the discharge of agrochemicals into water bodies, are a major source of groundwater pollution. Nitrate, a common contaminant from agricultural areas, was specifically examined. The researchers developed a numerical model to simulate nutrient transport, mimicking fertilization in different seasonal conditions.

The study found that in short-term simulations (less than a year), the extent and transport of the nutrient plume were not notably significant. However, the concentration of the nutrient took around 5 years to decrease to less than 10% of its initial concentration at the release site. Even after 30 years, the relative concentration of the dispersed nutrient plume remained at around 16.7% under low flow conditions and 8.6% under high flow conditions.

The results emphasized the importance of aligning fertilizer usage with crop requirements to minimize nitrate leaching and subsequent groundwater contamination. Matching fertilization practices to actual crop needs can significantly reduce the cumulative impact of nitrate leaching into groundwater systems associated with agricultural activities.

- **Sanitary Hazards and Microbial Quality of Open Dug Wells in the Maldives Islands (Barthiban et al., 2012)**

Following the 2004 tsunami, concerns about saline and microbial groundwater quality prompted a surveillance study investigating the sanitary hazards contributing to fecal contamination. Th. Vilufushi, Th. Thimarafushi, Th. Veymandoo, Th. Burunee, ADh. Fenfushi, AA. Thoddoo and B. Dharavandhoo, were chosen for the study. Across the seven islands, two surveys with duplicate sample sets revealed that **only 6.4% of 173 well water samples met the WHO guideline for thermo-tolerant coliform indicator values**. A combined risk analysis considering Sanitary Hazard Scores (SHS) and coliform counts classified **over 57.7% of wells as posing a very high microbial health risk**.

Modifications were made to the WHO's generic sanitary inspection method for better suitability in the vulnerable hydrogeological setting of the Maldives. However, the primary hazard contributing to fecal contamination was the inadequate separation distance between latrine seepage points and wells. Given the hydrogeological conditions and the density of wells and sanitation systems, achieving a safe separation distance was not feasible. Therefore, **improving septic tank effluent quality emerged as crucial for addressing and mitigating fecal contamination in the region**.

- **Assessment of Health Risk and Detailed Evaluation of Causative Factors Associated with Use of Contaminated Groundwater in the Remote Atolls (Hajare et al., 2021a)**

This study addresses water availability challenges on coral islands, where reliance on groundwater of unknown quality poses infection risks due to pathogens. It emphasizes the importance of integrating water quality data with risk prioritization and quantifying the impact of measures like implementing sewer networks for sustainable water management strategies.

The research collected and analyzed 104 water samples for Escherichia coli from 11 islands in Laamu Atoll. Table 3-6 shows descriptive summary statistics. Simultaneously, an 11-point sanitary survey, incorporating sewer network presence, was conducted at each sampling location to assess the risk of contamination (RoC). **Around 87% of samples showed the presence of E. coli.**

Statistical tools, including multivariable linear regression and propensity score matching, identified significant sanitary factors influencing E. coli presence in water. **The analysis suggested a 9–11.1% reduction in E. coli counts with the existence of sewer networks on islands.**

The study underscores the necessity of an effective Water Safety Plan that assesses the entire water system, identifies hazards, assesses associated risks, and establishes monitoring and mitigation plans at the island level. This comprehensive approach aims to safeguard communities from waterborne diseases by proactively managing water quality and mitigating contamination risks.

*Table 3-6: Descriptive statistics to monitor variability in E. coli count among islands of Laamu Atoll. Source: (Hajare et al., 2021)*

Islands	No. of samples	Arithmetic mean (95% CI) CFU/100ml	Semi-quantitative risk Level
<b>L. Gan</b>	<b>18</b>	<b>1171.3 (337.5–2005.3)</b>	<b>Very high risk</b>
L. Fonadhoo	15	198.4 (31.1–365.6)	Intermediate risk
L. Mundoo	3	434.3 (278–1000.2)	High risk
<b>L. Dhanbidhoo</b>	<b>6</b>	<b>17.0 (4.1–45.2)</b>	<b>Low risk</b>
<b>L. Isdhoo</b>	<b>9</b>	<b>108.2 (15.6–201.3)</b>	<b>Intermediate risk</b>
L. Maabaidhoo	7	1588.3 (673.7–2871.6)	Very high risk
<b>L. Kalaidhoo</b>	<b>8</b>	<b>636.7 (736.8–2010.3)</b>	<b>High risk</b>
L. Hithadhoo	10	878.8 (188.1–1944.1)	High risk
L. Kunahandhoo	6	815.5 (121.4–1821.2)	High risk
L. Maavah	13	1483.2 (452.8–3134.1)	Very high risk
L. Maamendhoo	9	1287.3 (215.4–2789.3)	Very high risk
All Samples	104		

- **A modeling approach for assessing groundwater resources of a large coral island under future climate and population conditions: Gan Island, Maldives (Deng & Bailey, 2019)**

The study focuses on forecasting future groundwater supply on Gan Island, Maldives, considering rainfall patterns, sea level rise, and population growth. The method devised for estimating Gan's future groundwater supply can be adapted for other coral islands.

Gan, the largest inhabited island in the Maldives, was assessed using a three-dimensional, density-dependent groundwater and solute transport model called SUTRA. The model was validated against observed groundwater salinity and then projected from 2012 to 2050 to evaluate various scenarios involving future rainfall (based on General Circulation Models), population growth rates (reflecting groundwater pumping), and sea level rise.

The results indicate a 20% increase in total fresh groundwater volume when considering future rainfall patterns alone. However, when moderate pumping (2% annual population growth rate) is factored in, the increase drops to 13%. Aggressive pumping scenarios (9% annual population growth rate) result in a 24% decrease in volume. Additionally, sea level rise and associated shoreline recession lead to a further 15–20% decrease in lens thickness and volume.

These findings provide valuable insights for water resource management on Gan Island and other large coral islands in the Indian and Pacific Oceans. The methodology employed in this study can serve as a template for exploring future groundwater security in any coral island setting.

- **Impact of Agricultural Chemical Inputs on Human Health and Environment in Maldives (Ajila, 2021)**

This study states that the reckless utilization of agrochemicals carries significant consequences for both our delicate environment and human well-being. Issues such as excessive use, unauthorized application, and improper disposal stand out as pivotal problems associated with irresponsible agrochemical usage. Generally, these substances are recognized for their ability to induce neurotoxicity, disrupt endocrine functions, and even pose carcinogenic risks to human health. However, in the Maldives, there's a lack of well-established monitoring and reporting systems to assess the impacts of agrochemicals.

In the Maldives, farmers surpass the recommended technical guidance for pesticide and fertilizer usage. This excessive application of agrochemicals can result in chemical residues remaining on harvested crops or leaching into the groundwater system. Numerous significant issues arise from agrochemical use, including environmental pollution, reduced efficacy, lower food quality, the development of resistance, soil degradation, micronutrient deficiency, toxicity, and diminished income from production. Moreover, there have been observations of pest resistance in many key pests and diseases affecting cultivated crops.

Due to the young geological nature of Maldives' soils—characterized by high porosity and rapid infiltration rates—the extensive application of agrochemicals can easily result in these substances seeping into water bodies. Additionally, mismanaged chemical waste has the potential to permeate into the groundwater system and eventually reach the sea. Seagrass meadows cover the lagoons of many agricultural islands, potentially linked to the heavy use of fertilizers by farmers. An important implication of excessive fertilizer usage is water eutrophication (impacts of chemical fertilizer), raising concerns about its likelihood in Maldivian water systems.

- **Assessment of groundwater quality and human health risk from nitrate contamination using a multivariate statistical analysis (Raheja et al., 2024)**

The study, carried out in the Rohtak district in Haryana, India, examines the suitability of groundwater for drinking and assesses non-carcinogenic health risks for different demographic groups. 47 groundwater samples were



analyzed for various parameters, notably **nitrate** concentration, which ranged from **15 to 85 mg/L**. Nearly half of the samples exceeded the safe limit set by the Bureau of Indian Standards. Spatial mapping showed significant pollution across the study area. Principal component analysis identified five key components explaining 77.36% of the variance. Non-carcinogenic risk rates were found to be elevated, especially for children, with around 80% of the population facing high health risks. Children were identified as particularly vulnerable. The study underscores the urgent need for water treatment before consumption due to the deteriorating groundwater quality in the region.

- **The burden of water insecurity: a review of the challenges to water resource management and connected health risks associated with water stress in small island developing states (Parker et al., 2023)**

Water resources, whether surpassing per capita abundance thresholds or falling below scarcity thresholds, are critical factors influencing health outcomes in small island developing states (SIDS). While thresholds help identify water stress vulnerability in SIDS, they fail to fully capture the tangible impacts of water scarcity.

This study aimed to highlight the primary challenges in consistently meeting water demand in SIDS and to examine how they intersect with certain health conditions such as dengue fever, gastrointestinal disorders, dehydration, and malnutrition.

Utilizing archival evidence, this review categorized challenges undermining water availability in SIDS and their implications for health outcomes. Seasonal variations in rainfall (73%), inadequate distribution infrastructure (64%), saltwater intrusion (61%), contamination (58%), human-induced changes in watersheds (19%), and sea level rise (17%) were identified as key challenges affecting water demand across 59 SIDS, based on 108 country-specific sources.

Groundwater extraction serves as the main water source in Barbados, Kiribati, Maldives, and Tuvalu, where saltwater intrusion results from both excessive extraction and rising sea levels, the problem is exacerbated by groundwater pollution due to improper waste disposal.

It's important to recognize that any water stress indicator is intricately linked to its human impact. These challenges not only impact food security through agricultural drought and soil salinization but also contribute to the spread of vector-borne and sanitation-related diseases across SIDS.

- **A holistic assessment of groundwater quality for drinking and irrigation purposes (Raheja et al., 2023)**

This study examines the suitability of groundwater for drinking and irrigation purposes in the Rohtak district of Haryana, India. Various water quality parameters such as the entropy water quality index (EWQI), sodium absorption ratio (SAR), permeability index (PI), Sodium percentage (Na%), Kelly ratio (KR), magnesium adsorption ratio (MAR), US salinity, and Gibbs diagram were analyzed. Spatial mapping indicates that groundwater quality in the central to southwestern parts of the area is generally poor.

The predominant ions were found to be in the following order:  $Mg^{2+} > Ca^{2+} > Na^+ > K^+$  and  $Cl^- > SO_4^{2-} > NO_3^- > HCO_3^- > F^- > CO_3^{2-}$  respectively. Furthermore, the results show that most groundwater samples exceeded desirable limits for drinking water. The EWQI assessment revealed that 23.4% and 38.4% of groundwater samples were of extremely poor quality during the pre-monsoon and post-monsoon periods, respectively. Additionally, other indices indicated that several parameters surpassed their standard limits, rendering most samples unsuitable for irrigation. The Gibbs diagram and other bivariate plots suggest that various ions in groundwater are attributed to silicate and carbonate weathering, which occur through water-rock interactions and ion exchange

phenomena. Moreover, the US Salinity diagram confirms that many groundwater samples pose significant salinity risks, particularly due to high sodium levels.

- **Evaluating groundwater quality using health risk assessment and irrigation indexes: Saveh Aquifer, Iran (Shahmirnoori et al., 2023)**

The objective of the study was to evaluate the water quality within the Saveh aquifer for its suitability for drinking, public health, and agricultural purposes. Various parameters including the heavy metal pollution index (HPI), hazard index (HI) for non-carcinogenic health risks, sodium percentage, sodium adsorption ratio (SAR), irrigation water quality index (IWQI), and a Piper diagram were utilized. The HPI surpassed 3,300, significantly exceeding the WHO's critical value of 100, indicating severe heavy metal contamination rendering the aquifer unfit for drinking. Heavy metal concentrations also led to cumulative HI exceeding 1 in 54 and 77% of sampling wells for adults and children, respectively. In terms of agriculture, both %NA and IWQI criteria were stricter than SAR. While most of the aquifer met SAR criteria for irrigation suitability, %Na indicated unreliability in many areas, and IWQI suggested unsuitability across almost all regions. The Piper diagram revealed that the prevailing water type was N-Cl, followed by Na-HCO<sub>3</sub> and Ca-HCO<sub>3</sub>, indicating high salinity within the aquifer. Overall, the Saveh aquifer exhibits high salinity and significant heavy metal pollution, posing considerable risks for drinking and/or irrigation purposes.

- **Irrigation water quality standards for indirect wastewater reuse in agriculture: A contribution toward sustainable wastewater reuse in South Korea (Jeong et al., 2016)**

Climate change impacts agricultural water usage vulnerability. Wastewater reuse globally emerges as an alternative amidst changing agricultural conditions. Urbanization accelerates indirect wastewater reuse in agriculture, posing unplanned reuse challenges. Establishing water quality standards is crucial for safe and sustainable implementation. This study proposes preliminary criteria for indirect wastewater reuse in South Korea, integrating practical considerations and categorizing irrigation water usage. It covers parameters such as E. coli, EC, turbidity, Suspended Solids, BOD, pH, odor, and trace elements, aiming to blend conservative and liberal approaches for sustainable practices.

Table 3-7 and Table 3-8 show microbiological indicators for water used for irrigation in the US, recommended by the US EPA and World Health Organisation (WHO).

**Table 3-7: Water quality standards of bacterial indicators for food and non-food crop irrigation in United States (Epa et al., 2004; Jeong et al., 2016)**

Classification	California	Florida <sup>1</sup>	New Jersey	North Carolina	Texas <sup>1</sup>	Virginia <sup>2</sup>
Food <sup>(a)</sup>	Bacterial indicators (cfu/100 mL) Total coliform: -2.2 (7 days median) -23 (not more than one sample exceeds this value in 30 days) -240 (max)	Fecal coliform: -75% of samples below detection -25 (max)	Fecal coliform: -2.2 (weak median) -14 (max)	Fecal coliform or <i>E. coli</i> : -3 (monthly mean) -25 (monthly mean)	Fecal coliform or <i>E. coli</i> : -20 (30-day geom) -75 (max)	Fecal coliform: -14 (monthly geom), CAT > 49 <i>E. coli</i> : -11 (monthly geom), CAT > 35
	Treatment requirements Oxidized, coagulated, filtered, disinfected	Secondary treatment, filtration, high-level disinfection	Filtration, high-level disinfection	Filtration, dual UV/chlorination (or equivalent)	NS	Secondary treatment, filtration, high-level disinfection
Non-food <sup>(b)</sup>	Bacterial indicators (cfu/100 mL) NS	Fecal coliform: -200 (avg) -800 (max)	Fecal coliform: -200 (monthly geom) -400 (weak geom)	Fecal coliform or <i>E. coli</i> : -14 (monthly mean) -25 (daily max)	Fecal coliform or <i>E. coli</i> : -200 (30-day geom) -800 (max)	Fecal coliform: -200 (monthly geom), CAT > 800 <i>E. coli</i> : -126 (monthly geom), CAT > 235
	Treatment requirements Oxidized	Secondary treatment, basic disinfection	Case-by-case	Filtration (or equivalent)	NS	Secondary treatment, disinfection

NS = not specified by the state's reuse regulation; NP = not permitted by the state; CAT = corrective action threshold; geom = geometric mean. <sup>1</sup> In Florida and Texas, spray irrigation (*i.e.*, direct contact) is not permitted on foods that may be consumed raw, and only irrigation types that avoid reclaimed water contact with edible portions of food crops. <sup>2</sup> The requirements presented for Virginia are for food crops eaten raw. <sup>(a)</sup> Food crops: The use of reclaimed water to irrigate food crops that are intended for human consumption. <sup>(b)</sup> Non-food crops and processed food crops: The use of reclaimed water to irrigate crops that are either processed before human consumption or not consumed by humans.

**Table 3-8: Recommended minimum verification monitoring of microbial performance targets for wastewater use in agriculture (Jeong et al., 2016; World Health Organization., 2006)**

Type of Irrigation	<i>E. coli</i> (cfu/100 mL) (Arithmetic Mean)	Helminth Eggs (No./L) (Arithmetic Mean)
	Unrestricted <sup>1</sup>	
Root crops <sup>(a)</sup>	≤10 <sup>3</sup>	
Leaf crops <sup>(b)</sup>	≤10 <sup>4</sup>	≤1
Drip irrigation, low-growing crops	≤10 <sup>3</sup>	
Drip irrigation, high-growing crops <sup>(c)</sup>	≤10 <sup>5</sup>	- <sup>(d)</sup>
	Restricted <sup>2</sup>	
Labor-intensive, high-contact agriculture	≤10 <sup>4</sup>	≤1
Highly mechanized agriculture	≤10 <sup>5</sup>	≤1
Pathogen removal in a septic tank	≤10 <sup>6</sup>	≤1

<sup>1</sup> Use of treated wastewater to grow crops that are normally eaten raw. <sup>2</sup> Use of treated wastewater to grow crops that are not eaten raw by human. <sup>(a)</sup> Crops that may be eaten uncooked. <sup>(b)</sup> Vegetables eaten uncooked such as lettuce and cabbage. <sup>(c)</sup> Crops such as fruit trees and olives. <sup>(d)</sup> No recommendation.

### 3.4. Regulations and guidelines

- **Water Resources Protection and Management Regulation (Regulation No: 2021/R-22)**

Water Resources Protection and Management Regulation (Regulation No: 2021/R-22) published under the Water and Sewerage Act (8/2020) has objectives to establish and implement a mechanism and to establish regulatory framework for the sustainable usage of the available water resources by preservation, protection and development of the resources in order to achieve its benefits to the fullest.

Under this regulation, clause 14 details prevention of contamination of ground water lens due to agriculture. This clause indicates that when agriculture is carried out in uninhabited islands and areas of land of 10,000 (ten thousand) square meters or more within the jurisdiction of the inhabited islands, the Authority has the right to order water testing to determine the effects of it, on the ground or ground water layer. This regulation indicates that every 6 months in minimum, the following parameters shall be analyzed and submitted to the Utility Regulatory Authority (URA):

- (1) pH
- (2) Electrical Conductivity ( $\mu\text{S}/\text{cm}$ )
- (3) Nitrate ( $\text{NO}_3^-$ , mg/l)
- (4) Phosphate ( $\text{PO}_4^{3-}$ , mg/l)
- (5) Ammonium ( $\text{NH}_4^+$ , mg/l)
- (6) Sulphate ( $\text{SO}_4^{2-}$ , mg/l)
- (7) Pesticides (ppm)
- (8) Faecal Coliform (Faecal Coliform CFU/100ml)

In the case where cultivation takes place on agricultural lands less than 10,000 (ten thousand) acres within the jurisdiction of inhabited islands, the Authority shall have the power to designate and direct the island council to establish sampling points for groundwater testing with reference to the size of the agricultural land and the type of agriculture carried out on the land. The regulation indicates that the tests shall be conducted for the same parameters as mentioned previously and has to be submitted to URA before the end of March of each calendar year.

- **Guidelines for water reuse (Epa et al., 2004)**

The U.S. Environmental Protection Agency (EPA) has formulated extensive and current water reuse guidelines to complement regulations and directives established by states, tribes, and other governing bodies. Oversight of water reclamation and reuse standards within the United States primarily falls under the purview of state and local agencies, with no federal regulations specifically dedicated to reuse.

Chapter 3.2 of this guideline provides data for water reuse for irrigation purposes, with Table 3-9 and Table 3-10 providing guideline values for physiochemical parameters of water.



Table 3-9: Guidelines for interpretation of water quality for irrigation (Epa et al., 2004)

Potential Irrigation Problem	Units	Degree of Restriction on Irrigation			
		None	Slight to Moderate	Severe	
<b>Salinity</b> (affects crop water availability) <sup>2</sup>					
EC <sub>w</sub>	dS/m	< 0.7	0.7 – 3.0	> 3.0	
TDS	mg/L	< 450	450 – 2000	> 2000	
<b>Infiltration</b> (affects infiltration rate of water into the soil; evaluate using EC <sub>w</sub> and SAR together) <sup>3</sup>					
SAR	0 – 3	and EC <sub>w</sub> =	> 0.7	0.7 – 0.2	< 0.2
	3 – 6		> 1.2	1.2 – 0.3	< 0.3
	6 – 12		> 1.9	1.9 – 0.5	< 0.5
	12 – 20		> 2.9	2.9 – 1.3	< 1.3
	20 – 40		> 5.0	5.0 – 2.9	< 2.9
<b>Specific Ion Toxicity</b> (affects sensitive crops)					
<b>Sodium (Na)</b> <sup>4</sup>					
surface irrigation	SAR	< 3	3 – 9	> 9	
sprinkler irrigation	meq/l	< 3	> 3		
<b>Chloride (Cl)</b> <sup>4</sup>					
surface irrigation	meq/l	< 4	4 – 10	> 10	
sprinkler irrigation	meq/l	< 3	> 3		
<b>Boron (B)</b>					
	mg/L	< 0.7	0.7 – 3.0	> 3.0	
<b>Miscellaneous Effects</b> (affects susceptible crops)					
<b>Nitrate (NO<sub>3</sub>-N)</b>					
	mg/L	< 5	5 – 30	> 30	
<b>Bicarbonate (HCO<sub>3</sub>)</b>					
	meq/L	< 1.5	1.5 – 8.5	> 8.5	
pH			Normal Range 6.5 – 8.4		

Table 3-10: Recommended water quality criteria for irrigation (Epa et al., 2004)

Constituent	Maximum Concentrations for Irrigation (mg/L)	Remarks
Aluminum	5.0	Can cause nonproductiveness in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity
Arsenic	0.10	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice
Beryllium	0.10	Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans
Boron	0.75	Essential to plant growth; sufficient quantities in reclaimed water to correct soil deficiencies. Optimum yields obtained at few-tenths mg/L; toxic to sensitive plants (e.g., citrus) at 1 mg/L. Most grasses are tolerant at 2.0 - 10 mg/L
Cadmium	0.01	Toxic to beans, beets, and turnips at concentrations as low as 0.1 mg/L; conservative limits are recommended
Chromium	0.1	Not generally recognized as an essential element; due to lack of toxicity data, conservative limits are recommended
Cobalt	0.05	Toxic to tomatoes at 0.1 mg/L; tends to be inactivated by neutral and alkaline soils
Copper	0.2	Toxic to a number of plants at 0.1 to 1.0 mg/L
Fluoride	1.0	Inactivated by neutral and alkaline soils
Iron	5.0	Not toxic in aerated soils, but can contribute to soil acidification and loss of phosphorus and molybdenum
Lead	5.0	Can inhibit plant cell growth at very high concentrations
Lithium	2.5	Tolerated by most crops up to 5 mg/L; mobile in soil. Toxic to citrus at low doses—recommended limit is 0.075 mg/L
Manganese	0.2	Toxic to a number of crops at few-tenths to few mg/L in acidic soils
Molybdenum	0.01	Nontoxic to plants; can be toxic to livestock if forage is grown in soils with high molybdenum
Nickel	0.2	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH
Selenium	0.02	Toxic to plants at low concentrations and to livestock if forage is grown in soils with low levels of selenium
Tin, Tungsten, and Titanium	-	Excluded by plants; specific tolerance levels unknown
Vanadium	0.1	Toxic to many plants at relatively low concentrations
Zinc	2.0	Toxic to many plants at widely varying concentrations; reduced toxicity at increased pH (6 or above) and in fine-textured or organic soils

## 4. Technical Approach and Methodology

The methodology for water sampling was presented in the Inception Report which was approved by MoCCEE on 25<sup>th</sup> January 2024. The presented methodology was used in the water sampling works as it embodied sound engineering practices in the field of groundwater sampling. The team adopted a well-planned approach to achieve the project objectives within the expected quality, cost, and time. The field investigations and their methodologies are detailed in the following sections.

### 4.1. Sampling methodology – Physiochemical surveys

From each island, 9 locations were chosen from agricultural areas and 1 location from a mosque was chosen, comprising a total of 10 samples for each island. This method was used as it is important to have comparison points to determine the extent of agrochemical contamination, and the effect it would have on the groundwater utilized by the general population, compared to groundwater used for irrigation. Sampling locations were evenly distributed throughout the island. The geographical coordinates of the sampling location were marked using GPS.

The water samples were collected in sterile plastic containers provided by the laboratory, following standard sampling procedures. Appropriately sized containers were used and proper filling and sealing procedures were followed.

Additionally, a YSI ProDSS water quality meter was used for the on-site measurement of parameters temperature, pH and Dissolved Oxygen. The YSI ProDSS is a portable, handheld multi-parameter probe/meter with a digital sampling system.



*Figure 4.1. Groundwater sampling by dipping YSI ProDSS probes directly into the well*

All groundwater sampling and water quality testing was conducted following US EPA LSASDPROC-301-R6 Procedures for Groundwater Sampling in the Laboratory Services and Applied Science Division (United States Environmental Protection Agency, 2023)) and ASTM D4448: Standard Guide for Sampling Ground-Water Monitoring Wells (ASTM, 2019).

The parameters that were measured for each island are indicated below:

1. Turbidity
2. Water Temperature

3. Color
4. Odor
5. Conductivity
6. pH
7. Acidity
8. Alkalinity
9. Total Dissolved Solids (TDS)
10. Dissolved Oxygen (DO)
11. Biological Oxygen Demands (BOD)
12. Chemical Oxygen Demand (COD)
13. Total Phosphorous
14. Total Nitrogen
15. Chloride
16. Nitrate
17. Nitrite
18. Sulphate
19. Sodium
20. Magnesium
21. Calcium
22. Iron
23. Potassium
24. Ammonium
25. Total Coliform
26. Faecal Coliform
27. Phosphate
28. Salinity

#### 4.1.1. Collecting Groundwater Samples from a pump/tap

When water samples were taken from a tap, the following procedures were used:

- **Cleaning the Tap Outlet:** An industrial-grade disposable cleaning paper soaked in disinfectant was used to thoroughly clean the tap, focusing particularly on the outlet to eliminate any dirt, debris, or residue that may have accumulated. This step is essential to prevent any external contaminants present in the tap from entering the water sample.
- **Flushing the Tap:** The tap was turned on, adjusted to the maximum flow rate, and water was allowed to run for at least one minute at this high flow rate. This procedure is known as Flushing. Flushing the tap helped remove any stagnant water in the pipes and cleared the line of any impurities or residues that might affect the sample's integrity. It ensured that the water was collected from the source (the freshwater lens) and not the piping or tap.
- **Preparing the Sampling Bottle:** The cap was removed from the sampling bottle and the bottle was rinsed three times with the water intended for testing. This rinsing process ensures that any residual substances or contaminants in the bottle are eliminated, minimizing the risk of sample contamination.
- **Collecting the Water Sample:** While maintaining the cap and protective cover of the bottle facing downwards, the bottle was filled with the water from the tap. This positioning prevented any dust or particles from the cap or cover from contaminating the sample as it was filled.
- **Filling and Air Space:** If the bottle is completely full, some water was discarded to create an air space within the bottle, ensuring proper closure without spillage.
- **Sealing the Bottle Securely:** After collecting the desired amount of water in the sampling bottle, the bottle was sealed securely with cap. This step ensured that the sample remained uncontaminated and preserved its integrity during transportation to the laboratory for analysis. Proper sealing was ensured by flipping the container and checking for any leakages.
- **Labeling the bottle:** The outside of the bottle was wiped and then labelled.

#### 4.1.2. Collecting Groundwater Samples from a well

When water samples were taken from a well, a custom-made portable bailer ("Dhaani" in Dhivehi) was used as shown in Figure 4.2. This bailer was made to ensure that the bottles provided from the laboratory fit securely within the bailer.

The following procedures were used during sampling:

- a) **Preparation of Sampling Bottle:** Prepare the sampling bottle by opening the bottle and attaching it to the bailer.
- b) **Use of bailer for Lowering the Bottle:** The bailer was lowered slowly into the well. It was crucial to prevent the bottle from touching the sides of the well to avoid any contamination from the well walls.
- c) **Submerging the Bottle:** Once the bottle was fully submerged, it was immersed completely in the water and ensured that it went well below the surface without touching the bottom or disturbing any sediment. This step aimed to collect a representative water sample from the main body of the water.
- d) **Removing the bailer and bottle:** Once bottle was completely filled with water, the bailer was removed from the well and bottle was removed from the bailer.
- e) **Filling and Air Space:** If the bottle is completely full, some water was discarded to create an air space within the bottle, ensuring proper closure without spillage.
- f) **Sealing the bottle:** The bottle was capped tightly to prevent any spillage or contamination during transportation to the laboratory for analysis.
- g) **Labeling the bottle:** The outside of the bottle was wiped and then labelled.





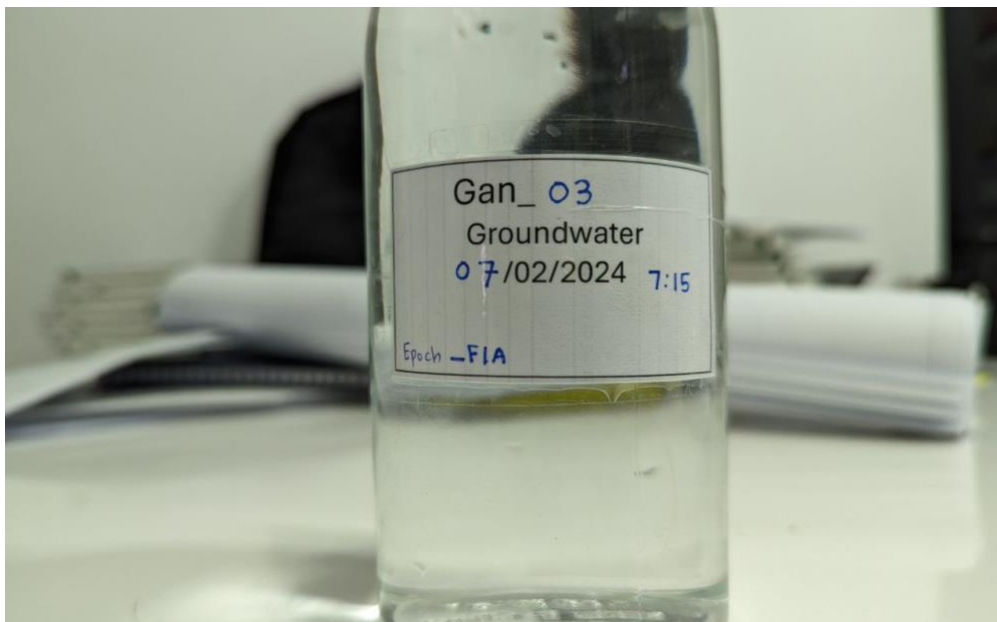
*Figure 4.2: Collecting groundwater samples directly from well using custom-made bailer*

#### 4.1.3. Sample labelling and documentation

The water samples were labeled with the following parameters:

1. **Sampled Date and Time:** The precise date and time when the sample was collected was recorded. This information is essential for tracking any changes or variations in water quality over different periods.
2. **Specific Location Details:** The specific location from which the sample was taken was clearly indicated using site identification numbers.
3. **Type of Sample:** The type of sample collected (groundwater) was specified. This classification is essential for laboratory technicians to identify which reagents to use in the calibration of equipment used for analysis.
4. **Name of the Collector:** The name of the person who collected the sample was also documented. This information is vital for accountability, allowing for traceability and contact in case of any queries or discrepancies.

Pre-printed labels were used to clearly mark the sampling bottle, as can be seen from Figure 4.3. These labels were ensured to be durable and resistant to water to ensure they remained intact throughout handling and transportation. Water resistance was increased by taping over the label after completing it using a transparent tape. Waterproof markers were used to ensure legibility and resistance to smudging or fading.



*Figure 4.3: Labelled sampling bottle*

The physical parameters of groundwater were also recorded at each location. The appearance and smell of each sample was noted. As part of documentation, detailed records of the sampling process including date, time, well characteristics, and all observations were recorded. These observations were recorded manually on pen and paper on the field, and then converted to digital records once the fieldwork was finished. The water sampling log sheets are attached in Annex 1.

#### **4.1.4. Water Sample Storage**

To preserve the representative water samples, all samples were held with freezer blocks in cool boxes, to maintain sample integrity until analysis. It was ensured that samples were not stored below freezing temperatures to prevent solidification of samples. The sample storage boxes, which can be seen in Figure 4.4, were sealed well and protected from light.



*Figure 4.4: Sample storage cool boxes*

## **4.2. Sampling methodology – Microbiological surveys**

Microbiological surveys were conducted on all 4 islands. Samples were collected for total coliform and faecal coliform analysis. Same sampling locations were used for both microbiological and physiochemical surveys.

The water samples were collected using Whirl-Pak® Thio-Bags® which contain 25 mg of active sodium thiosulfate to neutralize chlorine at the time of collection. To ensure the integrity of the water samples, they were kept with freezer blocks inside cool boxes to maintain temperatures between 0 and 6 degree Celsius. These samples were transported to an accredited laboratory within 24 hours for faecal coliform testing. The following Table 4-1 shows the details of the microbiological testing that was carried out.

*Table 4-1: Microbiological Test Details*

<b>Parameter</b>	<b>Test Method</b>	<b>Unit</b>
<b>Faecal coliform</b>	Laboratory	MPN/100 mL
<b>Total coliform</b>	Laboratory	MPN/100 mL

Quality assurance (QA) and quality control (QC) procedures are integral to ensure representativeness and integrity of water samples and resulting data to be used in review, analysis and concept and detailed design. The following QA/QC measures were followed to minimize errors and provide accurate results for the microbiological survey:

- The person collecting the sample washed hands thoroughly with soap and water before collecting samples. Alternatively, disposable nitrile gloves were used to decrease contamination when collecting samples. New gloves were used at every new sampling location.
- If wells are sampled, care was taken to ensure the sterility of all sampling equipment and all other equipment entering the well.
- There was no flushing of Whirl-Pak® Thio-Bags® with sample water to prevent removal or disintegration of the preservatives in the bag.
- The bags were handled with care and were only opened at the time of collecting the sample and filling the bag.
- To avoid contamination of sample, it was ensured that the water filling the bag wasn't touched by anybody and nobody touched the inside or on the lip of the sampling bag.
- The bag was sealed tightly immediately after collecting sufficient amount of water and labelled.

The bags were kept with freezer blocks inside cool boxes at temperatures between 0 and 6 degree Celsius to ensure integrity of samples.



## 5. Groundwater Quality Results

### 5.1. Physiochemical survey results

#### 5.1.1. L. Gan

Groundwater quality measurements were made at 10 selected locations in L. Gan and Table 5-1, Table 5-2 and Table 5-3 show the statistical summary of the water quality results. Individual results for physiochemical parameters are shown in Table 5-4. Map of locations where groundwater quality points were taken for physiochemical analysis is attached to Annex I.

For the following parameters, statistical summary could not be provided for the described reasons:

- **Odor** - Sampling procedure used a threshold odor test (APHA-2150-B), which provides qualitative description of odour as either “agreeable” or “not agreeable”. All samples tested except one sample had an agreeable result for odour.
- **Acidity, nitrite, ammonia, total phosphorous, total nitrogen, and phosphate** - All results showed concentrations less than 0.1 mg/L.

Table 5-1: Statistical summary of groundwater physiochemical parameters in L. Gan (1/3)

	Temp (°C)	Color (Hazen)
<b>Mean</b>	29.4	3.80
<b>Median</b>	28.9	3.75
<b>SD</b>	2.01	0.49
<b>Min</b>	27.7	3.20
<b>Max</b>	34.6	5.10
<b>CV</b>	0.068	0.129

Table 5-2: Statistical summary of groundwater physiochemical parameters in L. Gan (2/3)

	Turbidity (FNU)	TDS (mg/L)	EC (µS/cm)	Sal (ppt)	pH	Alkalinity (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
<b>Standards</b>	<1 Source <sup>2</sup>	150 – 350, <500 Source <sup>2</sup>	<1500 Potable purposes Source <sup>1</sup>  <2500 Non-potable purposes Source <sup>1</sup>  300 – 700, <1000 Source <sup>2</sup>		6.5-8.5 Source <sup>2</sup>		>3 Source <sup>3</sup>	<12 Source <sup>3</sup>	
<b>Mean</b>	0.36	328	490	0.28	7.73	31.2	3.80	5.25	15.80
<b>Median</b>	0.20	307	460	0.26	7.80	31.5	3.71	5.00	15.50
<b>SD</b>	0.31	82.1	124	0.07	0.41	7.57	2.27	0.43	2.48
<b>Min</b>	0.10	254	378	0.23	6.75	20.0	0.97	5.0	13.0
<b>Max</b>	1.20	545	818	0.48	8.29	42.0	9.39	6.0	21.0
<b>CV</b>	0.862	0.251	0.253	0.253	0.053	0.243	0.597	0.0825	0.157

Table 5-3: Statistical summary of groundwater physiochemical parameters in L. Gan (3/3)

	Chlorides (mg/L)	Nitrates (mg/L)	Sulphate (mg/L)	Magnesium as Mg (mg/L)	Calcium as Ca (mg/L)	Iron (mg/L)	Sodium as Na (mg/L)	Potassium as K (mg/L)
<b>Standards</b>	<200 Source <sup>2</sup>  <600 Source <sup>3</sup>	<50 Source <sup>1,2</sup>	<250 Source <sup>1,2</sup>			<0.3 Source <sup>2</sup>	<200 Source <sup>2</sup>	0-50 Source <sup>2</sup>
<b>Mean</b>	78.10	3.49	9.31	17.6	44.6	0.03	17.4	4.65
<b>Median</b>	75.50	2.20	7.95	17.0	43.0	0.02	18.3	4.75
<b>SD</b>	9.49	4.19	3.23	1.91	5.24	0.03	3.21	0.72
<b>Min</b>	71.00	1.50	7.50	15.0	39.0	0.01	13.0	3.70
<b>Max</b>	105.00	16.00	18.60	21.0	58.0	0.08	22.9	5.80
<b>CV</b>	0.122	1.201	0.347	0.108	0.117	0.853	0.184	0.155

Note: SD=Standard Deviation, Min=Minimum, Max=Maximum, CV=Coefficient of Variation  
 Temp=Temperature,  
 TDS=Total Dissolved Solids, EC=Electrical Conductivity, Sal=Salinity, DO=Dissolved Oxygen, BOD=Biological Oxygen Demand, COD=Chemical Oxygen Demand  
 Cl<sup>-</sup>=Chloride, NO<sub>3</sub><sup>-</sup>=Nitrate, SO<sub>4</sub><sup>2-</sup>=Sulfate, Mg=Magnesium as Mg, Ca=Calcium as Ca, Fe=Iron, Na=Sodium, K=Potassium as K  
 Source<sup>1</sup> = WHO Drinking Water Guidelines, 2017. Source<sup>2</sup> = URA Supply Water Quality Standard, 2022, Source<sup>3</sup> = water suitable for irrigation and agricultural activities, under the Sri Lankan National Environmental (Ambient Water Quality) Regulations, 2019.

Table 5-4: Physiochemical water parameters in L. Gan

Sample No	Gan_01	Gan_02	Gan_03	Gan_04	Gan_05	Gan_06	Gan_07	Gan_08	Gan_09	Gan_10
Temperature (°C)	29.5	34.6	28.3	28.2	27.7	29.4	27.8	27.8	30.8	30.3
Color (Hazen)	3.4	3.8	3.5	3.2	3.9	3.7	5.1	3.6	4	3.8
Odour	A*	A*	A*	Not A*	A*	A*	A*	A*	A*	A*
Turbidity (NTU)	0.4	0.2	0.2	0.6	0.2	0.3	1.2	0.2	0.1	0.2
TDS (mg/L)	378	277	296	545	324	254	353	258	272	318
EC (µs/cm)	567	414	443	817.5	483	378	529.5	384	406	477
Salinity (ppt)	0.31	0.25	0.26	0.48	0.26	0.23	0.27	0.23	0.24	0.26
pH	6.8	7.7	7.5	7.5	7.7	8.0	8.1	7.9	8.3	8.0
Alkalinity (mg/L)	21	31	36	20	31	41	32	22	36	42
Acidity (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DO (mg/L)	4.46	3.13	2.01	0.97	4.42	4.87	3.30	1.32	9.39	4.11
BOD (mg/L)	5	<5	5	6	<5	<5	<5	<5	<5	5
COD (mg/L)	19	14	15	21	16	13	17	13	14	16
Chlorides (mg/L)	81	73	75	105	77	71	79	71	73	76
Nitrates (mg/L)	2.5	1.8	2.1	2.9	16	1.5	2.5	1.6	1.7	2.3
Nitrite (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphate (mg/L)	10.2	7.8	7.9	18.6	8	7.5	9.9	7.5	7.7	8
Magnesium as Mg (mg/L)	21	17	17	21	18	16	18	15	16	17
Calcium as Ca (mg/L)	45	41	43	58	48	40	43	39	42	47
Iron (mg/L)	0.08	0.01	0.02	0.02	0.02	<0.005	0.08	<0.005	0.01	0.02
Ammonia (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total-Phosphorous (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Nitrogen (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium as Na (mg/L)	20.8	15.2	18	22.9	18.5	13	20	13	14.5	18.5
Potassium as K (mg/L)	5.6	4.1	4.7	5.8	4.8	3.7	5.3	3.7	4	4.8
Phosphate (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Note: A\* = Agreeable

TDS = Total Dissolved Solids, EC = Electrical Conductivity, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand

### 5.1.2. L. Isdhoo

Groundwater quality measurements were made at 10 selected locations in L. Isdhoo and Table 5-5, Table 5-6 and Table 5-7 show the statistical summary of the water quality results. Individual results for physiochemical parameters are shown in Table 5-8. Map of locations where groundwater quality points were taken for physiochemical analysis is attached to Annex I.

For the following parameters, statistical summary could not be provided for the described reasons:

- **Odor** - Sampling procedure used a threshold odor test (APHA-2150-B), which provides qualitative description of odour as either “agreeable” or “not agreeable”. All samples tested except one sample had an agreeable result for odour.
- **Acidity, nitrite, ammonia, total phosphorous, total nitrogen, and phosphate** - All results showed concentrations less than 0.1 mg/L.

For the parameter Iron, it should be noted that 5 samples had concentration less than 0.005 mg/L and therefore the iron concentration of these 5 samples could not be quantified through the lab testing procedure. Statistical summary is provided for 5 remaining samples, which had concentrations greater than 0.005 mg/L.

*Table 5-5: Statistical summary of groundwater physiochemical parameters in L. Isdhoo (1/3)*

	Temp (°C)	Color (Hazen)
<b>Mean</b>	27.98	4.61
<b>Median</b>	27.95	3.95
<b>SD</b>	0.67	1.49
<b>Min</b>	27.0	3.70
<b>Max</b>	29.2	8.20
<b>CV</b>	0.024	0.322

*Table 5-6: Statistical summary of groundwater physiochemical parameters in L. Isdhoo (2/3)*

	Turbidity (FNU)	TDS (mg/L)	EC (µS/cm)	Sal (ppt)	pH	Alkalinity (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
<b>Standards</b>	<1 Source <sup>2</sup>	150 – 350, <500 Source <sup>2</sup>	<1500 Potable purposes Source <sup>1</sup>  <2500 Non-potable purposes Source <sup>1</sup>  300 – 700, <1000 Source <sup>2</sup>		6.5-8.5 Source <sup>2</sup>		>3 Source <sup>3</sup>	<12 Source <sup>3</sup>	
<b>Mean</b>	0.74	321	480	0.29	7.85	7.86	120	5.25	15.3
<b>Median</b>	0.20	285	427	0.25	7.88	7.85	39.4	5.00	14.5
<b>SD</b>	1.11	122.1	182	0.09	0.16	0.12	175	0.43	4.03
<b>Min</b>	0.10	197	296	0.22	7.52	7.70	1.49	5.00	10
<b>Max</b>	3.60	621	926	0.52	8.10	8.10	501	6.00	25
<b>CV</b>	1.50	0.380	0.379	0.318	0.021	0.015	1.45	0.082	0.263

*Table 5-7: Statistical summary of groundwater physiochemical parameters in L. Isdhoo (3/3)*

Chlorides (mg/L)	Nitrates (mg/L)	Sulphate (mg/L)	Magnesium as Mg (mg/L)	Calcium as Ca (mg/L)	Iron (mg/L)	Sodium as Na (mg/L)	Potassium as K (mg/L)

<b>Standards</b>	<200 Source <sup>2</sup>	<50 Source <sup>1,2</sup>	<250 Source <sup>1,2</sup>			<0.3 Source <sup>2</sup>	<200 Source <sup>2</sup>	0-50 Source <sup>2</sup>
	<600 Source <sup>3</sup>							
<b>Mean</b>	93.3	4.19	9.43	18.3	43.4	0.0240	16.8	4.44
<b>Median</b>	73.5	1.85	7.85	18.0	40.0	0.02	16.1	4.30
<b>SD</b>	60.8	6.95	3.97	3.52	8.10	0.01	4.87	1.10
<b>Min</b>	62.0	1.40	7.20	13.0	33.0	0.01	11.1	3.00
<b>Max</b>	275	25.00	20.50	26.0	64.0	0.05	28.5	7.20
<b>CV</b>	0.652	1.658	0.421	0.193	0.187	0.565	0.290	0.249

Note: SD=Standard Deviation, Min=Minimum, Max=Maximum, CV=Coefficient of Variation  
Temp=Temperature, TDS=Total Dissolved Solids, EC=Electrical Conductivity, Sal=Salinity, DO=Dissolved Oxygen, BOD=Biological Oxygen Demand, COD=Chemical Oxygen Demand  
Source<sup>1</sup> = WHO Drinking Water Guidelines, 2017. Source<sup>2</sup> = URA Supply Water Quality Standard, 2022, Source<sup>3</sup> = water suitable for irrigation and agricultural activities, under the Sri Lankan National Environmental (Ambient Water Quality) Regulations, 2019.

Table 5-8: Physiochemical water parameters in L. Isdhoo

Sample No	Isd_01	Isd_02	Isd_03	Isd_04	Isd_05	Isd_06	Isd_07	Isd_08	Isd_09	Isd_10
Temperature (°C)	28.9	27.5	27.1	27	28	28.1	27.8	28.3	27.9	29.2
Color (Hazen)	3.8	4.2	4	8.2	3.9	3.8	6.8	3.7	3.7	4
Odour	A*	Not A*	A*	A*	A*	A*	A*	A*	A*	A*
Turbidity (NTU)	0.2	0.1	0.1	3.6	0.2	0.4	2.1	0.3	0.2	0.2
TDS (mg/L)	289	295	240	621	256	197	479	259	294	281
EC (µs/cm)	433	441	359	926	381	295.5	714	386	440	420
Salinity (ppt)	0.25	0.26	0.23	0.52	0.23	0.22	0.39	0.24	0.26	0.25
pH	7.5	7.8	7.9	7.7	7.9	8.1	7.7	7.9	8.0	8.0
Alkalinity (mg/L)	32	35	32	25	25	41	30	35	36	42
Acidity (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DO (mg/L)	2.01	3.36	1.49	49.1	29.6	25.1	501	64.8	101	426
BOD (mg/L)	<5	5	<5	6	<5	<5	5	<5	5	<5
COD (mg/L)	15	15	13	25	13	10	20	13	15	14
Chlorides (mg/L)	74	75	70	275	71	62	86	72	75	73
Nitrates (mg/L)	1.9	2	1.4	25	1.6	1.7	2.9	1.6	2	1.8
Nitrite (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphate (mg/L)	7.9	7.9	7.5	20.5	7.5	7.2	12.5	7.6	7.8	7.9
Magnesium as Mg (mg/L)	18	19	14	22	18	13	26	17	19	17
Calcium as Ca (mg/L)	40	43	39	51	40	33	64	40	44	40
Iron (mg/L)	0.02	0.02	<0.005	<0.005	<0.005	<0.005	0.05	<0.005	0.02	0.01
Ammonia (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total-Phosphorous (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Nitrogen (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium as Na (mg/L)	16.3	17.9	12.8	28.5	13	11.1	21.4	13.2	17.9	15.9
Potassium as K (mg/L)	4.4	4.6	3.6	7.2	3.7	3	5.3	3.8	4.6	4.2
Phosphate (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Note: A\* = Agreeable

TDS = Total Dissolved Solids, EC = Electrical Conductivity, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand

### 5.1.3.L. Kalaidhoo

Groundwater quality measurements were made at 10 selected locations in L. Kalaidhoo and Table 5-9, Table 5-10 and Table 5-11 show the statistical summary of the water quality results. Individual results for physiochemical parameters are shown in Table 5-12. Map of locations where groundwater quality points were taken for physiochemical analysis is attached to Annex I.

For the following parameters, statistical summary could not be provided for the described reasons:

- **Odor** - Sampling procedure used a threshold odor test (APHA-2150-B), which provides qualitative description of odour as either “agreeable” or “not agreeable”. All samples tested except one sample had an agreeable result for odour.
- **Acidity, nitrite, ammonia, total phosphorous, total nitrogen, and phosphate** - All results showed concentrations less than 0.1 mg/L.

For the parameter Iron, it should be noted that 5 samples had concentration less than 0.005 mg/L and therefore the iron concentration of these 5 samples could not be quantified through the lab testing procedure. Statistical summary is provided for 5 remaining samples, which had concentrations greater than 0.005 mg/L.

*Table 5-9: Statistical summary of groundwater physiochemical parameters in L. Kalaidhoo (1/3)*

	Temp (°C)	Color (Hazen)
<b>Mean</b>	28.4	5.28
<b>Median</b>	28.4	4.65
<b>SD</b>	0.9	1.61
<b>Min</b>	27.3	3.30
<b>Max</b>	30.3	7.60
<b>CV</b>	0.030	0.305

*Table 5-10: Statistical summary of groundwater physiochemical parameters in L. Kalaidhoo (2/3)*

	Turbidity (FNU)	TDS (mg/L)	EC (µS/cm)	Sal (ppt)	pH	Alkalinity (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
<b>Standards</b>	<1 Source <sup>2</sup>	150 – 350, <500 Source <sup>2</sup>	<1500 Potable purposes Source <sup>1</sup>  <2500 Non-potable purposes Source <sup>1</sup>  300 – 700, <1000 Source <sup>2</sup>		6.5-8.5 Source <sup>2</sup>		>3 Source <sup>3</sup>	<12 Source <sup>3</sup>	
<b>Mean</b>	1.39	273.2	409	0.25	8.07	7.93	52.8	5.50	14.4
<b>Median</b>	0.85	263	394	0.25	8.07	7.85	37.3	5.50	14.5
<b>SD</b>	1.34	63.5	95	0.04	0.26	0.30	42.1	0.50	3.2
<b>Min</b>	0.20	188	282	0.20	7.70	7.50	5.62	5.00	9.0
<b>Max</b>	3.70	394	591	0.32	8.60	8.60	120	6.00	21.0
<b>CV</b>	0.964	0.233	0.233	0.163	0.032	0.038	0.797	0.091	0.222

*Table 5-11: Statistical summary of groundwater physiochemical parameters in L. Kalaidhoo (3/3)*

Chlorides (mg/L)	Nitrates (mg/L)	Sulphate (mg/L)	Magnesium as Mg (mg/L)	Calcium as Ca (mg/L)	Iron (mg/L)	Sodium as Na (mg/L)	Potassium as K (mg/L)
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<b>Standards</b>	<200 Source <sup>2</sup>	<50 Source <sup>1,2</sup>	<250 Source <sup>1,2</sup>			<0.3 Source <sup>2</sup>	<200 Source <sup>2</sup>	0-50 Source <sup>2</sup>
	<600 Source <sup>3</sup>							
<b>Mean</b>	72.1	2.01	8.09	15.9	39.6	0.0380	15.2	4.04
<b>Median</b>	73.0	1.90	7.75	16.0	40.0	0.02	15.3	3.85
<b>SD</b>	6.1	0.36	1.08	2.66	4.15	0.03	3.41	0.92
<b>Min</b>	62.0	1.60	7.10	12.0	33.0	0.01	10.8	2.90
<b>Max</b>	83.0	2.80	10.60	21.0	46.0	0.07	20.5	5.80
<b>CV</b>	0.085	0.179	0.134	0.167	0.105	0.694	0.225	0.227

Note: SD=Standard Deviation, Min=Minimum, Max=Maximum, CV=Coefficient of Variation

Temp=Temperature,

TDS=Total Dissolved Solids, EC=Electrical Conductivity, Sal=Salinity, DO=Dissolved Oxygen, BOD=Biological Oxygen Demand, COD=Chemical Oxygen Demand

Source<sup>1</sup> = WHO Drinking Water Guidelines, 2017. Source<sup>2</sup> = URA Supply Water Quality Standard, 2022, Source<sup>3</sup> = water suitable for irrigation and agricultural activities, under the Sri Lankan National Environmental (Ambient Water Quality) Regulations, 2019.

Table 5-12: Physiochemical water parameters in L. Kalaidhoo

Sample No	Kal_01	Kal_02	Kal_03	Kal_04	Kal_05	Kal_06	Kal_07	Kal_08	Kal_09	Kal_10
Temperature (°C)	28.5	30.3	29.2	28.3	28.4	27.7	27.9	27.6	27.3	29.2
Color (Hazen)	7.6	3.8	7.2	7.1	4	3.9	3.9	3.3	5.3	6.7
Odour	A*	A*	A*	Not A*	A*	A*	A*	A*	A*	A*
Turbidity (NTU)	3.7	0.2	2.6	3.5	0.2	0.2	0.2	0.4	1.3	1.6
TDS (mg/L)	364	243	188	239	289	302	283	394	204	226
EC (µs/cm)	546	364.5	282	356	432	450	424	591	306	339
Salinity (ppt)	0.31	0.3	0.2	0.23	0.25	0.26	0.25	0.32	0.21	0.21
pH	8.33	7.94	8.60	8.15	7.89	7.99	7.74	7.70	8.20	8.19
Alkalinity (mg/L)	26	26	51	20	36	35	31	31	42	43
Acidity (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DO (mg/L)	97.4	120	114	17.5	72.2	36.8	37.8	20.4	5.62	6.64
BOD (mg/L)	5	<5	<5	<5	<5	<5	<5	6	<5	<5
COD (mg/L)	18	15	9	13	15	15	14	21	11	13
Chlorides (mg/L)	78	73	62	70	75	76	73	83	65	66
Nitrates (mg/L)	2.5	1.8	1.6	1.9	1.9	2.2	1.9	2.8	1.7	1.8
Nitrite (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphate (mg/L)	9.7	7.8	7.1	7.5	7.7	8	7.9	10.6	7.3	7.3
Magnesium as Mg (mg/L)	19	17	12	16	17	15	16	21	13	13
Calcium as Ca (mg/L)	46	42	33	40	42	38	40	45	34	36
Iron (mg/L)	0.07	<0.005	<0.005	<0.005	0.02	0.02	0.01	0.07	<0.005	<0.005
Ammonia (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total-Phosphorous (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Nitrogen (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium as Na (mg/L)	20	14.6	10.8	12	16.3	18.1	16	20.5	11.5	11.8
Potassium as K (mg/L)	5.2	3.5	2.9	3.5	4.3	4.7	4.2	5.8	3.1	3.2
Phosphate (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Note: A\* = Agreeable

TDS = Total Dissolved Solids, EC = Electrical Conductivity, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand

#### 5.1.4.L. Dhanbidhoo

Groundwater quality measurements were made at 10 selected locations in L. Dhanbidhoo and Table 5-13, Table 5-14 and Table 5-15 show the statistical summary of the water quality results. Individual results for

physiochemical parameters are shown in Table 5-16. Map of locations where groundwater quality points were taken for physiochemical analysis is attached to Annex I.

For the following parameters, statistical summary could not be provided for the described reasons:

- **Odor** - Sampling procedure used a threshold odor test (APHA-2150-B), which provides qualitative description of odour as either “agreeable” or “not agreeable”. All samples tested except one sample had an agreeable result for odour.
- **Acidity** - All results showed concentrations less than 0.1 mg/L.
- **Nitrite, ammonia, total phosphorous, total nitrogen, and phosphate** - Only one sample showed concentration greater than 0.1 mg/L

For the parameter Iron, it should be noted that 3 samples had concentration less than 0.005 mg/L and therefore the iron concentration of these 3 samples could not be quantified through the lab testing procedure. Statistical summary is provided for 8 remaining samples, which had concentrations greater than 0.005 mg/L.

**Table 5-13: Statistical summary of groundwater physiochemical parameters in L. Dhanbidhoo (1/3)**

	Temp (°C)	Color (Hazen)
<b>Mean</b>	28.8	4
<b>Median</b>	27.6	3.3
<b>SD</b>	27.4	4.2
<b>Min</b>	27.4	3.1
<b>Max</b>	30.1	6.2
<b>CV</b>	28	3.8

**Table 5-14: Statistical summary of groundwater physiochemical parameters in L. Dhanbidhoo (2/3)**

	Turbidity (FNU)	TDS (mg/L)	EC (µS/cm)	Sal (ppt)	pH	Alkalinity (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
<b>Standards</b>	<1 Source <sup>2</sup>	150 – 350, <500 Source <sup>2</sup>	<1500 Potable purposes Source <sup>1</sup>  <2500 Non-potable purposes Source <sup>1</sup>  300 – 700, <1000 Source <sup>2</sup>		6.5-8.5 Source <sup>2</sup>		>3 Source <sup>3</sup>	<12 Source <sup>3</sup>	
<b>Mean</b>	0.64	498	666	0.43	8.05	8.04	4.66	7.00	22.1
<b>Median</b>	0.30	411	425	0.34	8.07	8.05	3.36	6.00	17.5
<b>SD</b>	0.94	312	482	0.26	0.27	0.20	3.14	2.45	11.6
<b>Min</b>	0.20	188	281	0.23	7.65	7.70	1.29	5.00	10.0
<b>Max</b>	3.40	1255	1873	1.12	8.59	8.40	10.75	12.00	49.0
<b>CV</b>	1.463	0.627	0.724	0.611	0.033	0.024	0.675	0.350	0.526

**Table 5-15: Statistical summary of groundwater physiochemical parameters in L. Dhanbidhoo (3/3)**

	Chlorides (mg/L)	Nitrates (mg/L)	Sulphate (mg/L)	Magnesium as Mg (mg/L)	Calcium as Ca (mg/L)	Iron (mg/L)	Sodium as Na (mg/L)	Potassium as K (mg/L)
<b>Standards</b>	<200 Source <sup>2</sup>	<50 Source <sup>1,2</sup>	<250 Source <sup>1,2</sup>			<0.3 Source <sup>2</sup>	<200 Source <sup>2</sup>	0-50 Source <sup>2</sup>

	<600 Source <sup>3</sup>							
<b>Mean</b>	144.1	8.35	15.2	19.6	54.1	0.0671	24.4	5.26
<b>Median</b>	81.0	2.70	10.3	20.5	54.5	0.03	20.6	4.85
<b>SD</b>	135.8	12.14	9.68	4.15	15.3	0.05	15.3	2.78
<b>Min</b>	64	1.60	7.30	13.0	34.0	0.02	10.8	2.00
<b>Max</b>	515	35.0	38.0	25.0	87.0	0.15	65.2	11.30
<b>CV</b>	0.943	1.454	0.635	0.212	0.283	0.754	0.629	0.529

Note: SD=Standard Deviation, Min=Minimum, Max=Maximum, CV=Coefficient of Variation  
Temp=Temperature,  
TDS=Total Dissolved Solids, EC=Electrical Conductivity, Sal=Salinity, DO=Dissolved Oxygen, BOD=Biological Oxygen Demand, COD=Chemical Oxygen Demand  
Source<sup>1</sup> = WHO Drinking Water Guidelines, 2017. Source<sup>2</sup> = URA Supply Water Quality Standard, 2022, Source<sup>3</sup> = water suitable for irrigation and agricultural activities, under the Sri Lankan National Environmental (Ambient Water Quality) Regulations, 2019.

Table 5-16: Physiochemical water parameters in L. Dhanbidhoo

Sample No	Dhab_0 1	Dhab_0 2	Dhab_0 3	Dhab_0 4	Dhab_0 5	Dhab_0 6	Dhab_0 7	Dhab_0 8	Dhab_0 9	Dhab_1 0
Temperature (°C)	28.8	27.6	27.4	28.5	27.8	28	29.9	30.1	28.1	29.7
Color (Hazen)	6.2	3.3	4.2	5.4	3.5	3.8	3.3	3.2	4	3.1
Odour	A*	A*	A*	A*	A*	A*	A*	Not A*	A*	A*
Turbidity (NTU)	3.4	0.3	0.2	0.8	0.4	0.2	0.3	0.4	0.2	0.2
TDS (mg/L)	780	591	1255	349	473	308	188	588	261	189
EC (µs/cm)	1164	339	1873	521	359	461	281	882	389	386
Salinity (ppt)	0.66	0.45	1.12	0.31	0.36	0.26	0.23	0.45	0.24	0.23
pH	8.6	8.3	7.7	8.1	7.8	7.7	8.1	8.2	8.0	8.1
Alkalinity (mg/L)	48	45	39	41	37	26	42	43	31	43
Acidity (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DO (mg/L)	8.51	3.29	1.29	3.42	2.49	1.81	2.19	10.75	4.52	8.28
BOD (mg/L)	8	6	12	6	<5	<5	<5	5	<5	5
COD (mg/L)	35	28	49	17	18	15	10	24	13	12
Chlorides (mg/L)	265	108	515	79	83	76	64	110	72	69
Nitrates (mg/L)	30	3	35	2.5	2.9	2.2	1.6	3.1	1.6	1.6
Nitrite (mg/L)	<0.1	<0.1	0.14	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphate (mg/L)	25	19.3	38	8.6	12	8	7.3	19.3	7.6	7.3
Magnesium as Mg (mg/L)	20	25	25	21	22	16	14	23	17	13
Calcium as Ca (mg/L)	55	65	87	54	63	44	34	62	41	36
Iron (mg/L)	0.15	0.03	0.12	0.02	0.1	0.02	<0.005	0.03	<0.005	<0.005
Ammonia (mg/L)	<0.1	<0.1	0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total-Phosphorous (mg/L)	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Nitrogen (mg/L)	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium as Na (mg/L)	35.4	24.5	65.2	19.7	21.4	18.2	10.8	24.6	13.2	10.8
Potassium as K (mg/L)	9.2	5.9	11.3	5	2	4.7	2.7	5	3.8	3
Phosphate (mg/L)	<0.1	<0.1	0.37	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Note: A\* = Agreeable

TDS = Total Dissolved Solids, EC = Electrical Conductivity, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand

## 5.2. Microbiological survey results

### 5.2.1. L. Gan

Groundwater microbiological quality sampling was conducted at the same 10 selected locations in L. Gan as physiochemical sampling was conducted. The following Table 5-17 shows the results.

*Table 5-17: Groundwater microbiological parameters in L. Gan*

Sample No.	Faecal Coliform (MPN/ 100mL)	Total Coliform (MPN/ 100mL)	Notes
Gan_01	12	12	
Gan_02	124	326	
Gan_03		2420	
Gan_04	>2420	>2420	
Gan_05	378	>2420	
Gan_06		>2420	
Gan_07	>2420	>2420	
Gan_08	>2420	>2420	
Gan_09	>2420	>2420	
Gan_10	>2420	>2420	Control Location (mosque)

### 5.2.2. L. Isdhoo

Groundwater microbiological quality sampling was conducted at the same 10 selected locations in L. Isdhoo as physiochemical sampling was conducted. The following Table 5-18 shows the results.

*Table 5-18: Groundwater microbiological parameters in L. Isdhoo*

Sample No.	Faecal Coliform (MPN/ 100mL)	Total Coliform (MPN/ 100mL)	Notes
Isd_01	138	>2420	Control Location (mosque)
Isd_02	>2420	>2420	
Isd_03	>2420	>2420	
Isd_04	866	>2420	
Isd_05	921	>2420	
Isd_06	>2420	>2420	
Isd_07	>2420	>2420	
Isd_08	173	>2420	
Isd_09	>2420	>2420	
Isd_10	>2420	>2420	

### 5.2.3. L. Kalaidhoo

Groundwater microbiological quality sampling was conducted at the same 10 selected locations in L. Kalaidhoo as physiochemical sampling was conducted. The following Table 5-19 shows the results.

*Table 5-19: Groundwater microbiological parameters in L. Kalaidhoo*

Sample No.	Faecal Coliform (MPN/ 100mL)	Total Coliform (MPN/ 100mL)	Notes
Kal_01	1300	>2420	
Kal_02	436	>2420	
Kal_03	>2420	>2420	
Kal_04	77	>2420	
Kal_05	91	>2420	
Kal_06	437	>2420	
Kal_07	183	>2420	
Kal_08	>2420	>2420	
Kal_09	94	>2420	
Kal_10	>2420	>2420	Control Location (mosque)

### 5.2.4. L. Dhanbidhoo

Groundwater microbiological quality sampling was conducted at the same 10 selected locations in L. Dhanbidhoo as physiochemical sampling was conducted. The following Table 5-20 shows the results.

*Table 5-20: Groundwater microbiological parameters in L. Dhanbidhoo*

Sample No.	Faecal Coliform (MPN/ 100mL)	Total Coliform (MPN/ 100mL)	Notes
Dhab_01	178	1553	
Dhab_02	1553	>2420	
Dhab_03	96	>2420	
Dhab_04	1553	>2420	
Dhab_05	10	238	
Dhab_06	105	300	
Dhab_07	78	261	Control Location (mosque)
Dhab_08	111	1986	
Dhab_09	548	>2420	
Dhab_10	>2420	>2420	



## 6. Discussion

### 6.1. L. Gan

#### 6.1.1. Physiochemical analysis

Overall, the physiochemical results fall within permissible limits when measured against both national and international standards outlined in Table 5-1, Table 5-2 and Table 5-3, with one exception. The sample labeled Gan\_04 exhibits an excessively high level of TDS that surpasses the acceptable threshold specified in the URA Supply Water Quality Standard (URA, 2022). High levels of TDS can have a slight to moderate effect on usage for irrigation (Epa et al., 2004). Additionally, this sample also has a not agreeable odour present.

Despite the chloride concentrations being within acceptable limits specified in national and international standards, the level of chloride in all 10 samples renders them highly unsuitable for use with sensitive crops with specific ion toxicity towards chloride, as outlined by (Epa et al., 2004).

Gan\_07 had colour of 5.1 Hazens, which is higher than other locations. However, there were no available standards that provided color measurements specifically in Hazen units, making it difficult to draw comparisons.

The results of groundwater quality results for 11 of the 13 pump stations in L. Gan, which were taken in November 2022 by Fenaka Corporation for groundwater monitoring purposes, are shown below in Table 6-1. The locations of pump stations and sewerage treatment plants are shown in Figure 6.1, as per data received from Fenaka (2023). Most parameters are within acceptable limits, except for high conductivity and TDS in PS 1, PS 8 and PS 9. Gan\_04, which is close to PS8 also has high TDS. The Nitrate levels of PS 3 and PS 5 are also higher than the rest of the pump stations and are moderately unsuitable for irrigation use for crops susceptible to Nitrate (Epa et al., 2004).

Table 6-1: Groundwater quality results for samples taken close to pump stations in L. Gan taken in November 2022 (Fenaka, 2023)

Sample Location	PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	PS 7	PS 8	PS 9	PS 10	PS 11
Physical Appearance	Clear with particles										
Conductivity (µS/cm)	1038	647	877	138.1	778	420	974	1507	1455	438	486
pH	7.3	7.2	7.1	9.5	7.3	7.7	7.6	7.3	7.2	7.7	7.6
Salinity (‰)	0.51	0.32	0.43	0.07	0.39	0.21	0.49	0.76	0.72	0.22	0.24
Temperature (°C)	22.4	22.1	21.9	21.8	21.9	22.5	22.3	22.3	22.2	22.2	22.6
Total Dissolved Solids (mg/L)	519	324	439	69	389	210	487	754	727	219	243
Nitrate (mg/L)	4.0	3.1	7.8	1.9	10.1	2.5	2.6	1.2	1.3	0.7	0.4
Sulphide (µg/L)	<5 (LoQ 5 µg/L)										
Phosphate (mg/L)	0.38	0.16	0.19	0.16	0.59	0.17	0.32	0.13	0.18	0.17	0.09

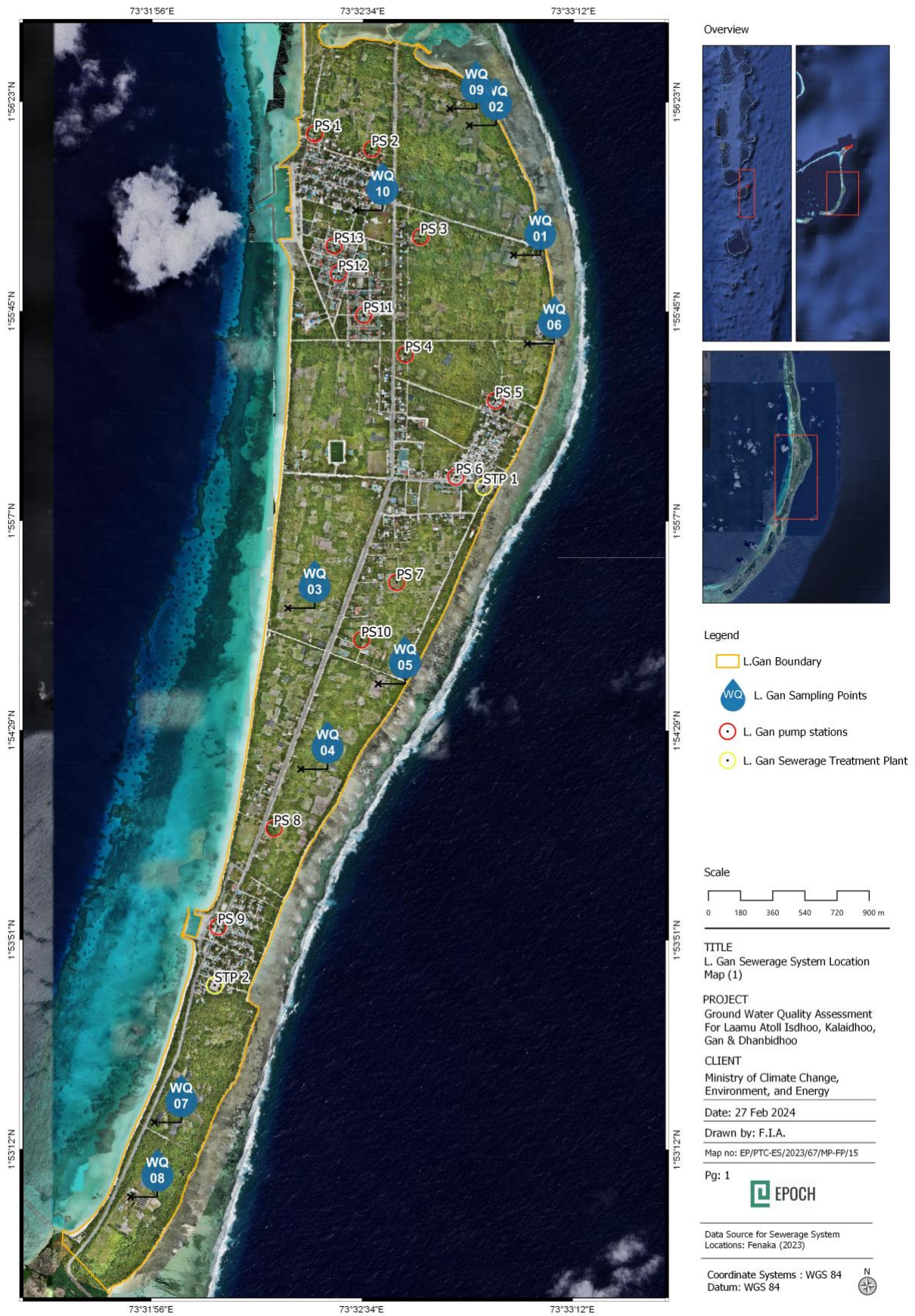


Figure 6.1: Gan Sewerage System Locations Map (Fenaka, 2023)

### 6.1.2. Microbiological analysis

Overall, L. Gan has extremely poor microbiological water quality at all 10 locations sampled. Total coliform levels were too numerous to count and exceed measurable levels at 8 of the 10 locations sampled. Faecal coliform levels exceed measurable levels at 5 of the 8 locations sampled. The remaining locations also have high levels of both total and fecal coliform, except for Gan\_01. The results concur with the very high-risk levels of E. Coli detected by (Hajare et al., 2021b) as shown in Table 3-6. As a result, the groundwater in L. Gan has deteriorated to wastewater quality levels. This could be in part due to untreated disposal of sewage into the freshwater lens from septic tanks or damaged pipelines. Although there are 2 sewerage treatment plants in L. Gan, neither of them is currently operated regularly.

The total and fecal coliform levels in all 10 locations exceed the limits by the US EPA shown in Table 3-7 for crops used for food. As E. Coli is the major component of fecal coliform, and the fecal coliform results are higher than 1000 MPN/100 mL for 4 locations (Gan\_04, Gan\_07, Gan\_08, Gan\_09 and Gan\_10), it can be interpreted from Table 3-8 that these locations are unsuitable for root crop irrigation and low growing crops. They are also potentially unsuitable for leaf crops and high-growing crops. Consequently, none of the sampled L. Gan locations have water suitable for drinking or irrigation. It is not recommended to use this water directly for these purposes without disinfection. WHO Standards (citation) indicate that faecal coliform must not be detectable in any 100ml sample of water

It is also important to note that the control location (Gan\_10) which is a mosque located in the island has both total and fecal coliform levels greater than 2420 MPN/100mL. As the water is used for ablution, it is recommended to discontinue use until the water can be disinfected prior to use. Alternatively, desalinated water supplied by the newly commissioned water treatment plant should be used for all purposes in the mosque. The microbiological testing at L. Gan is recommended to be conducted regularly to confirm the level of contamination. E. Coli testing should be conducted along with total and fecal coliform.

## 6.2. L. Isdhoo

### 6.2.1. Physiochemical analysis

Overall, the physiochemical results fall within permissible limits when measured against both national and international standards outlined in Table 5-5, Table 5-6 and Table 5-7, with one sample having two exceptions. The sample Isd\_04 exhibits an excessively high level of TDS (621 mg/L) that surpasses the acceptable threshold specified in the URA Supply Water Quality Standard (URA, 2022). High levels of TDS can have a slight to moderate effect on usage for irrigation (Epa et al., 2004).

Sample Isd\_04 also has an excessively high level of Chloride (275 mg/L) that surpasses the acceptable threshold specified in the URA Supply Water Quality Standard (URA, 2022). Despite the chloride concentrations being within acceptable limits specified in national and international standards for all samples except Isd\_04, the level of chloride in all 10 samples renders them highly unsuitable for use with sensitive crops with specific ion toxicity towards chloride, as outlined by (Epa et al., 2004).

The samples Isd\_04 and Isd\_07 exhibited higher color levels measured in Hazen units (8.2 and 6.8 Hazens respectively) compared to the other samples. However, there were no available standards that provided color measurements specifically in Hazen units, making it difficult to draw comparisons.

The results of groundwater quality results for 2 reed beds in L. Isdhoo, which were taken in November 2022 by Fenaka Corporation for groundwater monitoring purposes, are shown below in Table 6-2. The locations of pump stations and reed beds are shown in Figure 6.2, as per data received from Fenaka (2023). The pump stations are located close to Isd\_01 and Isd\_03. The conductivity and TDS levels at reed beds are quite high, in addition to phosphate levels, with both samples being yellow with particles. The reed beds installed in 2006 infiltrate treated wastewater directly into the ground, which could potentially cause deterioration in groundwater quality due to poor treatment and lack of maintenance of the treatment system.

*Table 6-2: Groundwater quality results for samples taken close to pump stations in L. Isdhoo taken in November 2022 (Fenaka, 2023)*

Sample Location	Reed bed 1	Reed bed 2
Physical Appearance	Yellow with particles	Yellow with particles
Conductivity (µS/cm)	<b>1400</b>	<b>1410</b>
pH	7.0	7.1
Salinity (‰)	0.7	0.7
Temperature (°C)	23.1	23.8
Total Dissolved Solids (mg/L)	<b>701</b>	<b>705</b>
Nitrate (mg/L)	2.7	2.7
Sulphide (µg/L)	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)
Phosphate (mg/L)	<b>24.8</b>	<b>1820</b>





Figure 6.2. Isdhoo Sewerage System Locations

### 6.2.2. Microbiological analysis

Overall, L. Isdhoo has extremely poor microbiological water quality at all 10 locations sampled. Total coliform levels were too numerous to count and exceed measurable levels at 8 of the 10 locations sampled, and fecal coliform levels exceed measurable levels at 5 of the 8 locations sampled.

Overall, L. Isdhoo has extremely poor microbiological water quality at all 10 locations sampled. Total coliform levels were too numerous to count and exceed measurable levels at 6 of the 10 locations sampled. Faecal coliform levels exceed measurable levels at all the locations sampled. The results concur with the intermediate risk levels of E. Coli detected by (Hajare et al., 2021b) shown in Table 3–6. As a result, the groundwater in L. Isdhoo has deteriorated to wastewater quality levels. This could partly be due to poor and incomplete treatment of wastewater from an aging reed bed sewerage treatment mechanism, which discharges effluent into the ground.

The total and fecal coliform levels in all 10 locations exceed the limits by the US EPA shown in Table 3–7 for crops used for food. As E. Coli is the major component of fecal coliform, and the fecal coliform results are higher than 1000 MPN/100 mL for 6 locations (Isd\_02, Isd\_03, Isd\_06, Isd\_07, Isd\_09 and Isd\_10), it can be interpreted from Table 3–8 that these locations are unsuitable for root crop irrigation and low growing crops. They are also potentially unsuitable for leaf crops and high-growing crops. Consequently, none of the sampled L. Isdhoo locations have water suitable for drinking or irrigation. It is not recommended to use this water directly for these purposes without disinfection.

It is also important to note that the control location (Isd\_01) which is a mosque located in the island has total coliform level greater than 2420 MPN/100 mL, and fecal coliform levels of 138 MPN/100mL. As the water is used for ablution, it is recommended to discontinue use until the water can be disinfected prior to use.

The microbiological testing at L. Isdhoo is recommended to be conducted regularly to confirm the level of contamination. E. Coli testing should be conducted along with total and fecal coliform.

## 6.3. L. Kalaidhoo

### 6.3.1. Physiochemical analysis

Overall, the physiochemical results fall within permissible limits when measured against both national and international standards outlined in Table 5-10 and Table 5-11 with one exception. The sample Kal\_03 exhibits a slightly high pH of 8.6 that does not fall within the acceptable threshold specified in the URA Supply Water Quality Standard (URA, 2022).

Despite the chloride concentrations being within acceptable limits specified in national and international standards for all samples, the level of chloride in all 10 samples renders them highly unsuitable for use with sensitive crops with specific ion toxicity towards chloride, as outlined by (Epa et al., 2004).

The samples Kal\_01, Kal\_03, Kal\_04, Kal\_09, and Kal\_10 exhibited higher color levels measured in Hazen units compared to the other samples. However, there were no available standards that provided color measurements specifically in Hazen units, making it difficult to draw comparisons. Additionally, Kal\_04 had a not agreeable odour.

The results of groundwater quality results for 3 reed beds in L. Kalaidhoo, which were taken in November 2022 by Fenaka Corporation for groundwater monitoring purposes, are shown below in Table 6-3. The locations of pump stations and reed beds are shown in Figure 6.3, as per data received from Fenaka (2023). The pump stations are located close to Kal\_05 and Kal\_10. The conductivity and TDS levels are high in Reed Bed 3, with abnormally high nitrate levels in all 3 reed beds. The reed beds installed in 2006 infiltrate treated wastewater directly into the ground, which could potentially cause deterioration in groundwater quality due to improper treatment and lack of maintenance of the treatment system.

*Table 6-3: Groundwater quality results for samples taken close to pump stations in L. Kalaidhoo taken in November 2022 (Fenaka, 2023)*

Sample Location	Reed bed 1	Reed bed 2	Reed bed 3
Physical Appearance	Cloudy with particles	Pale yellow with particles	Pale yellow with particles
Conductivity ( $\mu\text{S}/\text{cm}$ )	606	903	<b>1137</b>
pH	7.4	7.4	7.3
Salinity (‰)	0.29	0.44	0.56
Temperature ( $^{\circ}\text{C}$ )	25.1	25.2	25.2
Total Dissolved Solids (mg/L)	303	452	<b>568</b>
Nitrate (mg/L)	<b>17.1</b>	<b>41.9</b>	<b>83.6</b>
Sulphide ( $\mu\text{g}/\text{L}$ )	<5 (LoQ 5 $\mu\text{g}/\text{L}$ )	6	8
Phosphate (mg/L)	0.28	2.7	2.04





Figure 6.3: L. Kalaidhoo Sewerage System Locations

### 6.3.2. Microbiological analysis

Overall, L. Kalaidhoo has extremely poor microbiological water quality at all 10 locations sampled. Total coliform levels were too numerous to count and exceed measurable levels at all 10 locations sampled. Faecal coliform levels exceed measurable levels at 3 of the 10 locations sampled, and the remaining 7 locations have high fecal coliform levels greater than 75 MPN/100mL. The results concur with the high-risk levels of E. Coli detected by (Hajare et al., 2021b) shown in Table 3-6. As a result, the groundwater in L. Kalaidhoo has deteriorated to wastewater quality levels. This could be in part due to poor treatment of wastewater from an aging reed bed sewerage treatment mechanism, which discharges wastewater into the ground.

The total and fecal coliform levels in all 10 locations exceed the limits by the US EPA shown in Table 3-7 for crops used for food. As E. Coli is the major component of fecal coliform, and the fecal coliform results are higher than 1000 MPN/100 mL for 4 locations (Kal\_01, Kal\_03, Kal\_08, and Kal\_10), it can be interpreted from

Table 3-8 that these locations are unsuitable for root crop irrigation and low growing crops. They are also potentially unsuitable for leaf crops and high-growing crops. Consequently, none of the sampled locations in L. Kalaidhoo have water suitable for drinking or irrigation. It is not recommended to use this water directly for these purposes without disinfection.

It is also important to note that the control location (Kal\_10) which is a mosque located in the island has both total and fecal coliform levels greater than 2420 MPN/100mL. As the water is used for ablution, it is recommended to discontinue use until the water can be disinfected prior to use.

The microbiological testing at L. Kalaidhoo is recommended to be conducted regularly to confirm the level of contamination. E. Coli testing should be conducted along with total and fecal coliform.

## 6.4. L. Dhanbidhoo

### 6.4.1. Physiochemical analysis

Overall, most of the physiochemical results fall within permissible limits when measured against both national and international standards outlined in Table 5-5, Table 5-6 and Table 5-7, with four samples having 10 exceptions. The samples Dhab\_01, Dhab\_02, Dhab\_03, and Dhab\_08 exhibits high levels of TDS (780mg/L, 591 mg/L, 1255 mg/L, and 588 mg/L respectively) that surpass the acceptable threshold specified in the URA Supply Water Quality Standard (URA, 2022). High levels of TDS can have a slight to moderate effect on usage for irrigation (Epa et al., 2004).

The samples Dhab\_01 and Dhab\_03 exhibits high levels of Electrical Conductivity (1164  $\mu\text{S}/\text{cm}$  and 1873  $\mu\text{S}/\text{cm}$  respectively) that surpass the acceptable threshold specified in the URA Supply Water Quality Standard (URA, 2022). Samples Dhab\_01 and Dhab\_03 also have excessively high levels of Chloride (265 mg/L and 515 mg/L) that surpasses the acceptable threshold specified in the URA Supply Water Quality Standard (URA, 2022). Despite the chloride concentrations being within acceptable limits specified in national and international standards for all samples except Dhab\_01 and Dhab\_03, the level of chloride in all 10 samples renders them highly unsuitable for use with sensitive crops with specific ion toxicity towards chloride, as outlined by (Epa et al., 2004).

The samples Dhab\_01 and Dhab\_04 exhibited higher color levels measured in Hazen units (6.2 and 5.4 Hazens respectively) compared to the other samples. However, there were no available standards that provided color measurements specifically in Hazen units, making it difficult to draw comparisons.

The results of groundwater quality results for 4 pump stations in L. Dhanbidhoo which were taken in November 2022 by Fenaka Corporation for groundwater monitoring purposes, are shown below in Table 6-4. The locations of pump stations and reed beds are shown in Figure 6.4, as per data received from Fenaka (2023). The pump stations are located close to Dhab\_07, Dhab\_08 and Dhab\_09. The conductivity and TDS levels are high in PS 2. The locations contain reed beds installed in 2006 which previously used to infiltrate treated wastewater directly into the ground, which could potentially cause deterioration in groundwater quality due to improper treatment and lack of maintenance of the treatment system. Currently, wastewater is discharged into the open lagoon.

*Table 6-4: Groundwater quality results for samples taken close to pump stations in L. Dhanbidhoo taken in November 2022*

Sample Location	PS 1	PS 2	PS 3	PS 4
Physical Appearance	Clear with particles	Clear with particles	Clear with particles	Clear with particles
Conductivity ( $\mu\text{S}/\text{cm}$ )	517	<b>1101</b>	177.7	821
pH	7.2	7.4	7.4	7.4
Salinity (‰)	0.25	0.55	0.09	0.4
Temperature ( $^{\circ}\text{C}$ )	23.4	23.1	23.3	23.1
Total Dissolved Solids (mg/L)	258	<b>550</b>	88.9	411
Nitrate (mg/L)	2.7	1.1	1.5	2.1
Sulphide ( $\mu\text{g}/\text{L}$ )	<5 (LoQ 5 $\mu\text{g}/\text{L}$ )	<5 (LoQ 5 $\mu\text{g}/\text{L}$ )	<5 (LoQ 5 $\mu\text{g}/\text{L}$ )	<5 (LoQ 5 $\mu\text{g}/\text{L}$ )
Phosphate (mg/L)	0.13	0.21	0.26	0.29



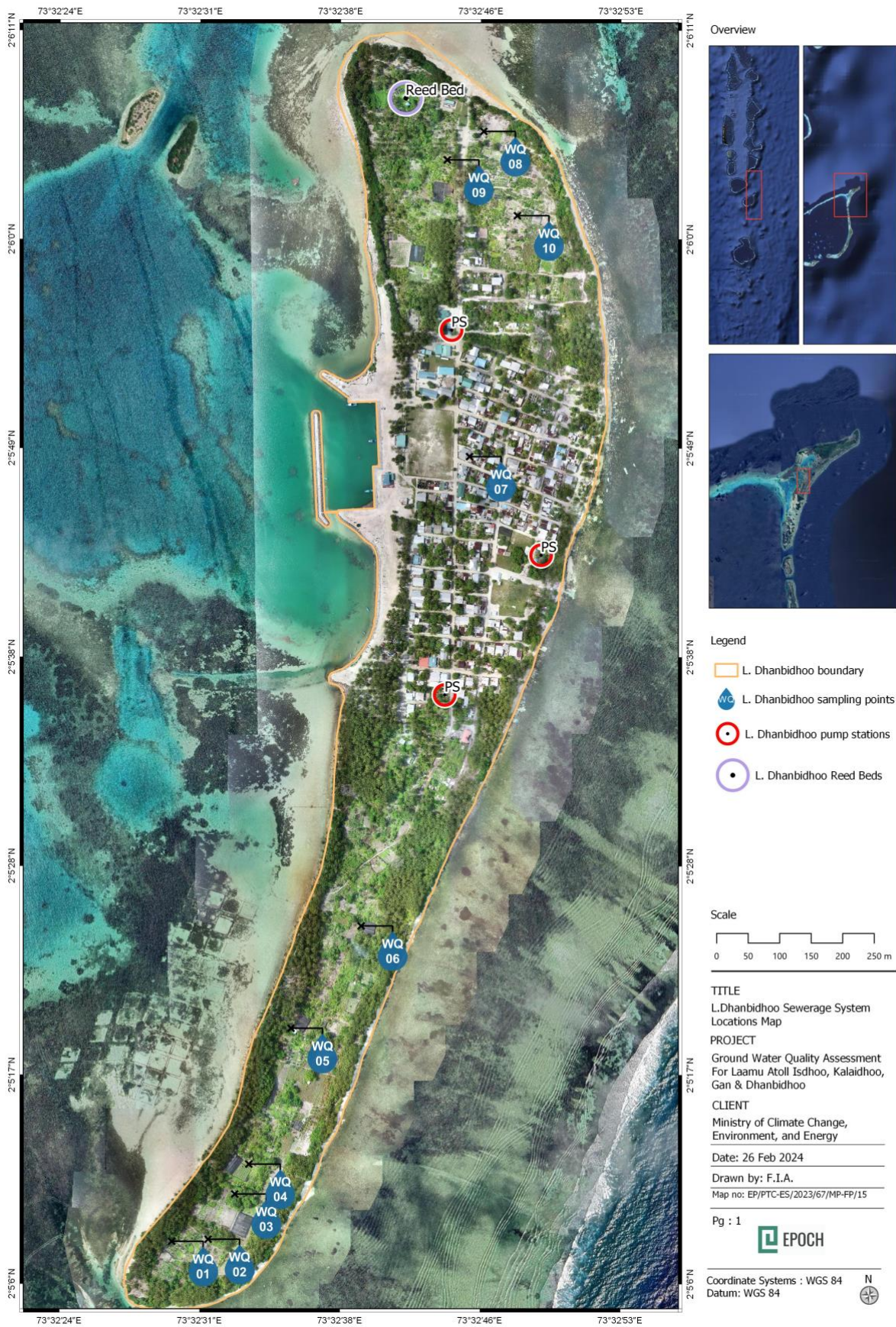


Figure 6.4: Dhanbidhoo Sewerage System Locations

#### 6.4.2. Microbiological analysis

Overall, L. Dhanbidhoo has better microbiological water quality compared to the other 3 islands. Total coliform levels are too numerous to count and exceed measurable levels at 5 of the 10 locations sampled. Fecal coliform levels exceed measurable levels at 1 of the 10 locations sampled, and the remaining locations have varying levels of fecal coliform. The results concur with the low-risk levels of E. Coli detected by (Hajare et al., 2021b) as shown in Table 3-6. The groundwater in Dhab\_10 has deteriorated to wastewater quality levels, while Dhab\_02, Dhab\_04, and Dhab\_09 also have highly contaminated water levels.

The total and fecal coliform levels in all 10 locations exceed the limits by the US EPA shown in Table 3-7 for crops used for food. As E. Coli is the major component of fecal coliform, and the fecal coliform results are higher than 1000 MPN/100 mL for 3 locations (Dhab\_02, Dhab\_04, and Dhab\_10), it can be interpreted from Table 3-8 that these locations are unsuitable for root crop irrigation and low growing crops. They are also potentially unsuitable for leaf crops and high-growing crops. Consequently, none of the sampled L. Dhanbidhoo locations have water suitable for drinking or irrigation. It is not recommended to use this water directly for these purposes without disinfection.

It is also important to note that the control location (Dhab\_07) which is a mosque located in the island has total coliform level at 261 MPN/100mL and fecal coliform levels at 78 MPN/100mL. As the water is used for ablution, it is recommended to discontinue use until the water can be disinfected prior to use.

The microbiological testing at L. Dhanbidhoo is recommended to be conducted regularly to confirm the level of contamination. E. Coli testing should be conducted along with total and fecal coliform.

## 7. Conclusion and Recommendations

Water Sampling was carried out on four islands from 5-7<sup>th</sup> February 2024. Methodologies approved in the inception stage were followed, in line with relevant international groundwater sampling standards. Logistical arrangements were made to ensure that water samples reached the laboratory within the stipulated maximum allowable water storage period. Stringent sample labeling and documentation procedures were followed, as well as appropriate water storage conditions.

The results indicated all 4 islands had generally acceptable physiochemical parameter ranges. However, certain samples had high TDS, color levels, and an unpleasant odor. Samples from all islands had varying chloride levels which can be potentially harmful to chloride-sensitive crops. Microbiological components were high in all samples. Importantly, the sample size was the same regardless of island size, making deriving definitive conclusions difficult, especially for larger islands. Therefore, it is crucial to determine sample numbers based on island size and continuously monitor groundwater conditions.

As all 40 locations tested had varying levels of total and fecal coliform, it is important to retest these two parameters, and include E. Coli testing for future groundwater assessments. Additionally, groundwater in these locations should not be used for irrigation, unless they are disinfected prior to use to confirm the absence of fecal coliform and E. Coli. Furthermore, positive total and fecal coliform results beyond measurable limits were found for the control site (mosque) in L. Gan and L. Dhanbidhoo, and high levels in both L. Isdhoo and L. Kalaidhoo as well. As water in mosques are used for ablution, it is imperative that groundwater be discontinued for further use until it can be disinfected for all 4 mosques.

A major limitation of this study is that pesticides were not tested. For future groundwater monitoring studies, it is highly recommended to include pesticide testing. This is because pollution due to contamination from sewerage systems, or agrochemicals can only be differentiated through pesticide testing based on the findings of this report.

Relevant stakeholders, such as local councils should be informed about The Water Resources Protection and Management Regulation (Regulation No: 2021/R-22), which includes a framework for continuously monitoring groundwater conditions, which is recommended to be followed across all islands.

### 7.1. Recommendations

For future groundwater studies the following measures are recommended:-

- Determine sample size based on island size, and number of agricultural plots
- Include E. Coli testing for future groundwater assessments
- Include pesticide testing as a groundwater testing parameter
- Assess the volume and stress level of freshwater lens through hydrogeologic assessments
- Assess the level of pesticide residue on produce using techniques such as gas chromatography coupled with mass spectrometry.
- Conduct soil testing to assess the infiltration of pesticides. Certain parameters include nitrogen, phosphorous, potassium, calcium, sulfur, magnesium, iron, manganese, boron and molybdenum.

The following general measures are recommended: -

- Discontinue groundwater usage in mosques until water can be disinfected
- Inform relevant stakeholders (local councils, atoll councils, etc..) about The Water Resources Protection and Management Regulation



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## **9. ANNEXES**

**Annex 1 – Groundwater quality testing results from review of EIA Reports (2015 – 2023)**

**Annex 2 – Water Quality Sampling Locations**

**Annex 3 – Laboratory Results**

**Annex 4 – Water Quality Result Graphs**

**Annex 5 – Correlation Matrices**

**Annex 6 – Framework for groundwater quality monitoring for agrochemical contamination**

All groundwater quality parameters from review of EIA Reports (2015 – 2023)



Island	Sample	Physical Appearance	Conductivity (µS/cm)	pH	Salinity (ppt)	Temperature (°C)	Total Dissolved Solids (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Sulphide (mg/L)	Phosphate (mg/L)	Dissolved Oxygen (mg/L)	Chemical Oxygen Demand (mg/L)	Biological Oxygen Demand (mg/L)	Total Petroleum Hydrocarbon (mg/L)	Total Coliform (MPN/100ml)	Faecal Coliform (MPN/100ml)	Sampled Date
<b>EIA for Proposed Road Development in Gan, Laamu Atoll (2023)</b>																		
Gan	G1	Clear With Particles	745	7.9	0.36	24	372	1	31	<5 (LoQ 5 µg/L)	-	7.46	-	-	<0.036 (LoQ 0.036 mg/L)	411 (13/04/2023 15:00)	-	11-04-2023 3:00 AM
Gan	G2	Clear With Particles	981	7.4	0.48	23.9	490	5.5	42	<5 (LoQ 5 µg/L)	-	5.54	-	-	<0.036 (LoQ 0.036 mg/L)	>2420 (13/04/2023 15:00)	-	11-04-2023 3:00:00 AM
Gan	G3	Clear With Particles	762	7.4	0.38	23.9	381	11.1	29	<5 (LoQ 5 µg/L)	-	5.84	-	-	<0.036 (LoQ 0.036 mg/L)	30 (13/04/2023 15:00)	-	11-04-2023 3:00:00 AM
Gan	G4	Clear With Particles	688	7.1	0.34	24	344	0.8	29	<5 (LoQ 5 µg/L)	-	2.02	-	-	<0.036 (LoQ 0.036 mg/L)	308 (13/04/2023 15:00)	-	11-04-2023 3:00:00 AM
Gan	G5	Clear With Particles	924	7.5	0.46	23.8	462	6.9	27	<5 (LoQ 5 µg/L)	-	6.48	-	-	0.552	980 (13/04/2023 15:00)	-	11-04-2023 3:00:00 AM
<b>EIA for the proposed Causeway Development between Kalaidhoo and Dhanbidhoo, Laamu Atoll (2023)</b>																		
Not Stated	KDGW1	Clear With Particles	-	7.21	0.64	21.5	655	-	-	-	-	-	-	-	-	-	-	11-05-2023 2:30:00 AM
Not Stated	KDGW2	Clear With Particles	-	7.43	0.94	21.7	929	-	-	-	-	-	-	-	-	-	-	11-05-2023 2:42:00 AM
Not Stated	KDGW3	Clear With Particles	-	7.22	0.45	21.8	395	-	-	-	-	-	-	-	-	-	-	11-05-2023 2:59:00 AM
Not Stated	KDGW4	Clear With Particles	-	7.88	0.39	21.6	413	-	-	-	-	-	-	-	-	-	-	11-05-2023 3:20:00 AM
<b>EIA for the Proposed Establishment of water network in L.Gan, L.Isdhoo, L.Kalaidhoo, L.Maamendhoo (2021)</b>																		
Kalaidhoo	G1, G2	Clear With Particles	858	8.09	0.42	23.9	429	-	-	-	-	-	-	-	-	>2420 (15/04/2021 13:00)	78 (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Kalaidhoo	G3	Pale Yellow with Particles	1036	7.38	0.51	24	518	-	-	-	-	-	-	-	-	22 (15/04/2021 13:00)	Not Detected (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Kalaidhoo	G4	Clear With Particles	673	7.37	0.33	24	336	-	-	-	-	-	-	-	-	131 (15/04/2021 13:00)	Not Detected (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Kalaidhoo	G5	Clear With Particles	755	7.21	0.37	24	377	-	-	-	-	-	-	-	-	155 (15/04/2021 13:00)	1 (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Isdhoo	G1, G2	Clear With Particles	536	7.45	0.26	23.9	268	-	-	-	-	-	-	-	-	33 (15/04/2021 13:00)	1 (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Isdhoo	G3	Clear With Particles	549	7.22	0.27	24	275	-	-	-	-	-	-	-	-	27 (15/04/2021 13:00)	Not Detected (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Isdhoo	G4	Clear With Particles	591	7.38	0.29	24	296	-	-	-	-	-	-	-	-	243 (15/04/2021 13:00)	8 (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Isdhoo	G5	Clear With Particles	729	7.28	0.36	24.1	364	-	-	-	-	-	-	-	-	44 (15/04/2021 13:00)	1 (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Gan	G1	Clear With Particles	1972	7.6	1	24.1	986	-	-	-	-	-	-	-	-	113 (15/04/2021 13:00)	54 (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Gan	G2	Pale Yellow with Particles	761	7.41	0.37	24	381	-	-	-	-	-	-	-	-	1120 (15/04/2021 13:00)	3 (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Gan	G3	Clear With Particles	601	7.34	0.29	24	301	-	-	-	-	-	-	-	-	40 (15/04/2021 13:00)	Not Detected (15/04/2021 13:00)	14-04-2021 11:00:00 AM
Gan	G4	Clear With Particles	635	7.44	0.31	23.8	318	-	-	-	-	-	-	-	-	122 (15/04/2021 13:00)	57 (15/04/2021 13:00)	14-04-2021 11:00:00 AM



## Average annual Groundwater quality parameters from review of EIA Reports (2015 – 2023)

Average pH				
year	Dhanbidhoo	Gan	Isdhoo	Kalaidhoo
2017	7.72	-	-	-
2021	7.69	7.45	7.33	7.51
2023	-	7.46	-	-

Average Electrical Conductivity ( $\mu\text{S}/\text{cm}$ )				
year	Dhanbidhoo	Gan	Isdhoo	Kalaidhoo
2017	634	-	-	-
2021	-	992	601	831
2023	-	820	-	-

Average Salinity (ppt)				
year	Dhanbidhoo	Gan	Isdhoo	Kalaidhoo
2017	0.31	-	-	-
2021	0.307	0.493	0.295	0.408
2023	-	0.404	-	-

Average Total Dissolved Solids (mg/L)				
year	Dhanbidhoo	Gan	Isdhoo	Kalaidhoo
2021	313	497	301	415
2023	-	410	-	-

Average Dissolved Oxygen (mg/L)				
year	Dhanbidhoo	Gan	Isdhoo	Kalaidhoo
2021	4.10	-	-	-
2023	-	5.47	-	-

Average Nitrate concentration (mg/L)				
year	Dhanbidhoo	Gan	Isdhoo	Kalaidhoo
2016	-	11.1	-	-
2017	0.6	-	-	-
2023	-	5.06	-	-

<b>Average Sulfate concentration (mg/L)</b>				
<b>year</b>	<b>Dhanbidhoo</b>	<b>Gan</b>	<b>Isdhoo</b>	<b>Kalaidhoo</b>
2023	-	31.6	-	-

<b>Average Phosphate concentration (mg/L)</b>				
<b>year</b>	<b>Dhanbidhoo</b>	<b>Gan</b>	<b>Isdhoo</b>	<b>Kalaidhoo</b>
2016	-	0.228	-	-

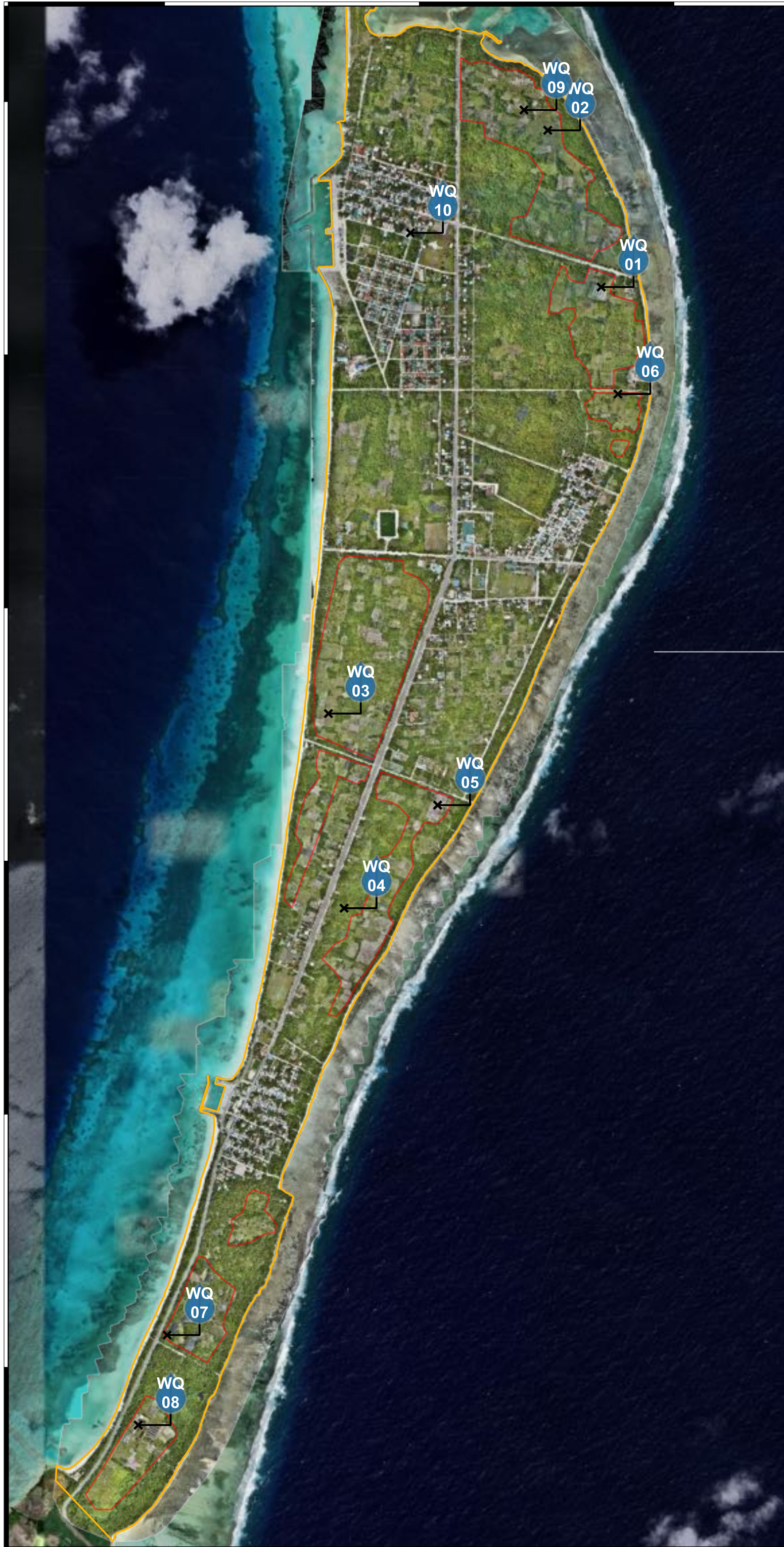
<b>Average Biological Oxygen Demand (mg/L)</b>				
<b>year</b>	<b>Dhanbidhoo</b>	<b>Gan</b>	<b>Isdhoo</b>	<b>Kalaidhoo</b>
2016	-	5.80	-	-

<b>Average Chemical Oxygen Demand (mg/L)</b>				
<b>year</b>	<b>Dhanbidhoo</b>	<b>Gan</b>	<b>Isdhoo</b>	<b>Kalaidhoo</b>
2016	-	19.9	-	-

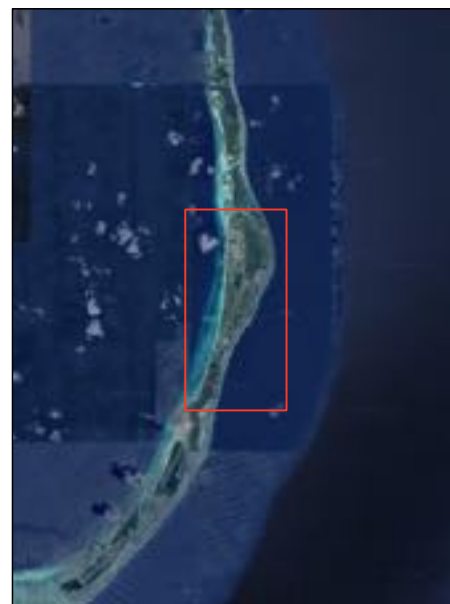
<b>Average Total Coliform (MPN/ 100mL)</b>				
<b>year</b>	<b>Dhanbidhoo</b>	<b>Gan</b>	<b>Isdhoo</b>	<b>Kalaidhoo</b>
2016	-	1075	-	-
2021	1211	349	86.8	682
2023	-	830	-	-

<b>Average Faecal Coliform (MPN/ 100mL)</b>				
<b>year</b>	<b>Dhanbidhoo</b>	<b>Gan</b>	<b>Isdhoo</b>	<b>Kalaidhoo</b>
2016	-	823	-	-
2021	867	28.5	2.5	19.75





Overview



Legend

- L. Gan Boundary
- L. Gan Agriculture Zones
- × L. Gan Sampling Points

Scale



TITLE

L. Gan Sampling Points Map (1)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/11

Pg : 1



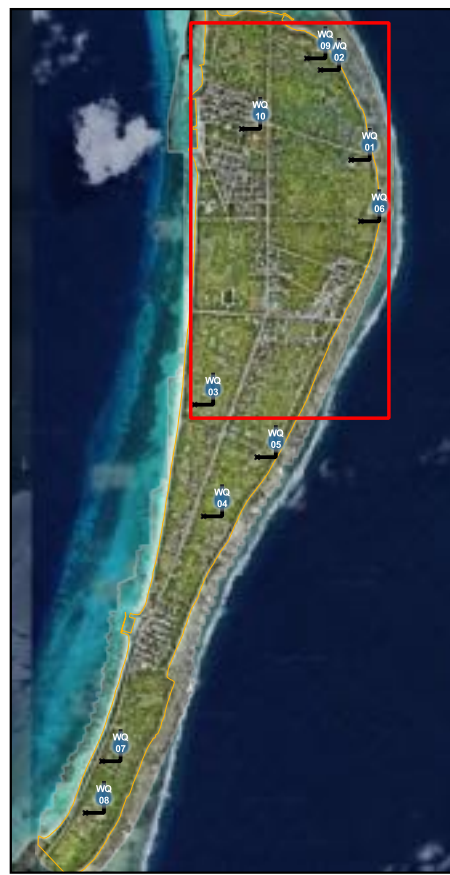
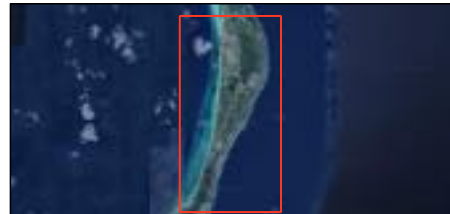
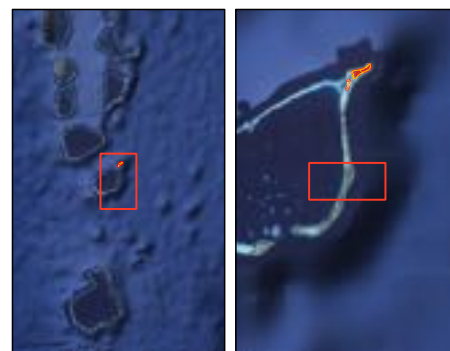
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Datum: WGS 84







Overview



DATA ID	Longitude	Latitude
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wq02	73.54815	1.93862
wq03	73.53904	1.91419
wq06	73.55108	1.92758
wq09	73.54716	1.93947
wq10	73.54244	1.93432

Legend

- L.Gan Boundary
- L. Gan Agriculture Zones
- L. Gan Sampling Points

Scale



TITLE

L. Gan Sampling Points Map (2)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/11

Pg : 2



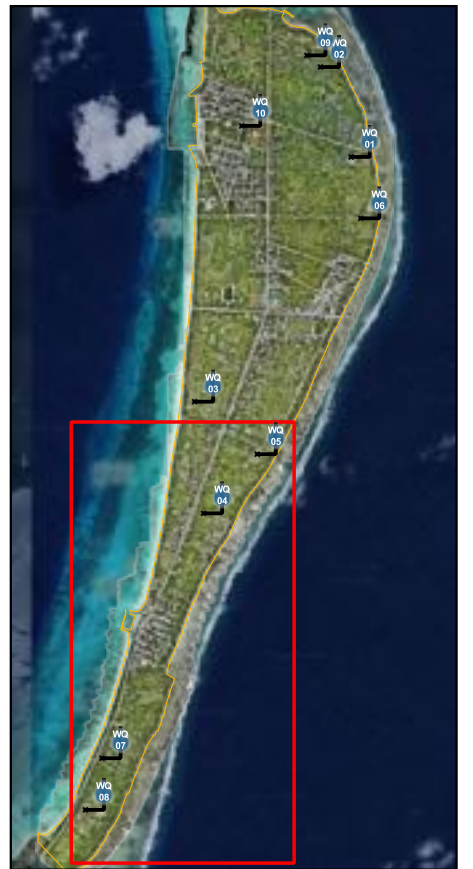
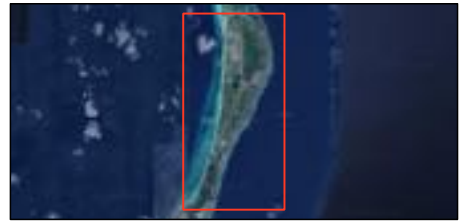
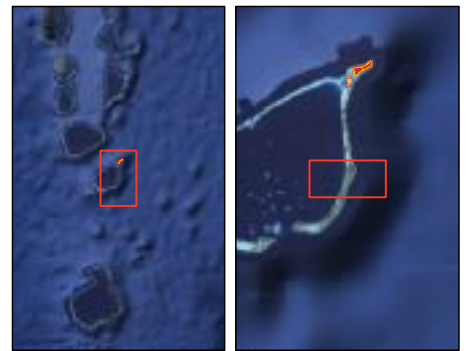
Coordinate Systems : WGS 84  
Datum: WGS 84










Overview

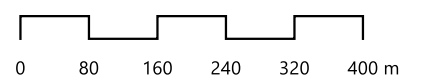


DATA ID	Longitude	Latitude
wq04	73.5397	1.90604
wq05	73.54359	1.91036
wq07	73.53235	1.88816
wq08	73.53115	1.88439

Legend

-  L.Gan Boundary
-  L. Gan Agriculture Zones
-  L. Gan Sampling Points

Scale



TITLE

L. Gan Sampling Points Map (3)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/11

Pg : 3



Coordinate Systems : WGS 84  
Datum: WGS 84





73°34'2"E

73°34'17"E

73°34'32"E

73°34'47"E

73°35'2"E

2°7'58"N

2°7'58"N

2°7'43"N

2°7'43"N

2°7'27"N

2°7'27"N

2°7'12"N

2°7'12"N

73°34'2"E

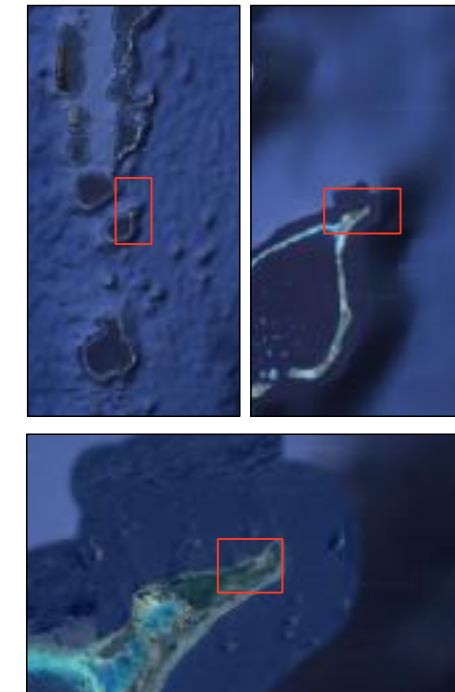
73°34'17"E

73°34'32"E

73°34'47"E

73°35'2"E

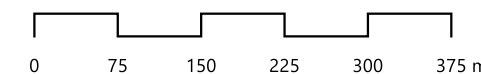
Overview



Legend

- L.Isdhoo Boundary
- ✕ L.Isdhoo Sampling Points
- L. Isdhoo Agriculture Zones

Scale



TITLE

L.Isdhoo Sampling Locations Map (1)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/13

Pg : 1

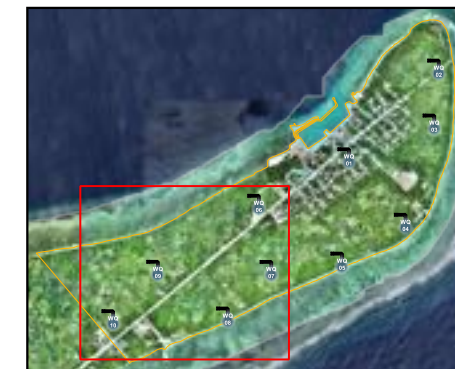


Coordinate Systems : WGS 84  
Datum: WGS 84





Overview

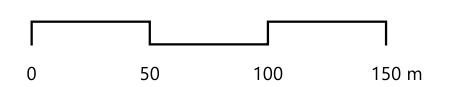


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wq07	73.57688	2.12152
wq08	73.57486	2.11934
wq09	73.57161	2.12152
wq10	73.56953	2.11921

Legend

- L.Isdhoo Boundary
- L.Isdhoo Sampling Points
- L. Isdhoo Agriculture Zones

Scale



TITLE

L.Isdhoo Sampling Locations Map (2)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/13

Pg : 2



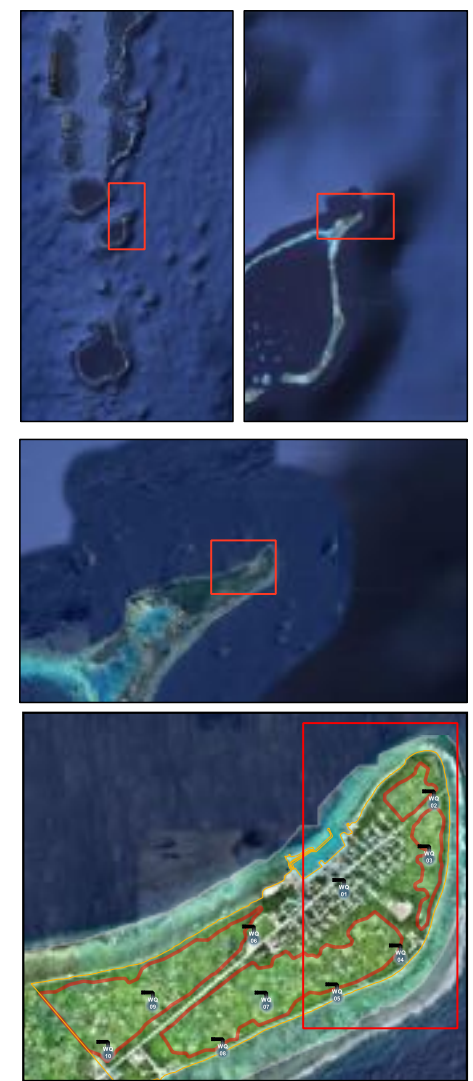
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Datum: WGS 84







Overview

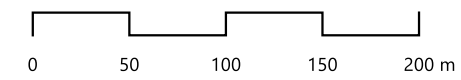


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wq02	73.58466	2.13094
wq03	73.58445	2.12837
wq04	73.58312	2.12373
wq05	73.58017	2.12191

Legend

- L.Isdhoo Boundary
- L.Isdhoo Sampling Points
- L. Isdhoo Agriculture Zones

Scale



TITLE

L. Isdhoo Sampling Points Map (3)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/13

Pg : 3



Coordinate Systems : WGS 84  
Datum: WGS 84





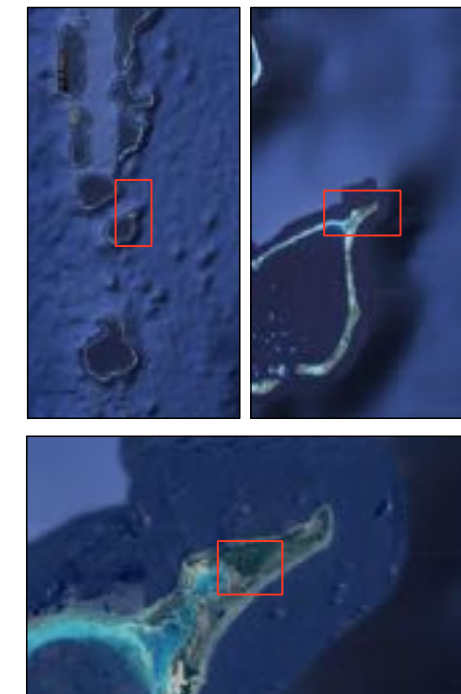
73°33'17"E

73°33'32"E




73°33'47"E

73°34'2"E

Overview



Legend

-  L. Kalaidhoo Boundary
-  L. Kalaidhoo Agriculture Zones
-  L. Kalaidhoo Sampling Points

Scale



TITLE

L. Kalaidhoo Sampling Map (1)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/12

Pg : 1



Coordinate Systems : WGS 84  
Datum: WGS 84



2°7'12"N

2°7'12"N

2°6'56"N

2°6'56"N

2°6'41"N

2°6'41"N

2°6'25"N

2°6'25"N

73°33'17"E

73°33'32"E

73°33'47"E

73°34'2"E






Overview

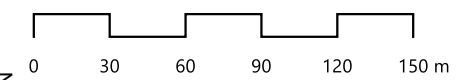


DATA ID	Longitude	Latitude
wq01	73.56722	2.11708
wq02	73.56818	2.11662
wq03	73.56825	2.11985
wq04	73.56522	2.11406

Legend

-  L. Kalaidhoo Boundary
-  L. Kalaidhoo Agriculture Zones
-  L. Kalaidhoo Sampling Points

Scale



TITLE

L. Kalaidhoo Sampling Map (2)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/12

Pg : 2



Coordinate Systems : WGS 84  
Datum: WGS 84



2°7'12"N

2°7'12"N

2°6'56"N

2°6'56"N



2°7'12"N

2°7'12"N



2°6'34"N




2°6'34"N

Overview

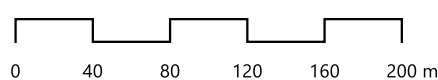


DATA ID	Longitude	Latitude
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wq06	73.55643	2.11765
wq07	73.55786	2.11906
wq08	73.561	2.11927
wq09	73.55859	2.11461
wq10	73.55787	2.10822

Legend

-  L. Kalaidhoo Boundary
-  L. Kalaidhoo Agriculture Zones
-  L. Kalaidhoo Sampling Points

Scale



TITLE

L. Kalaidhoo Sampling Points Map (3)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/12

Pg : 3



Coordinate Systems : WGS 84  
Datum: WGS 84







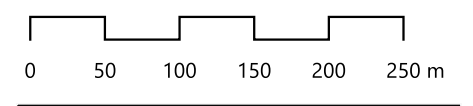
Overview



Legend

- L.Dhanbidhoo Boundary
- x L.Dhanbidhoo sampling points
- Dhanbidhoo Agriculture Zones

Scale



TITLE

L.Dhanbidhoo Sampling Points Map (1)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/14

Pg : 1



Coordinate Systems : WGS 84  
Datum: WGS 84








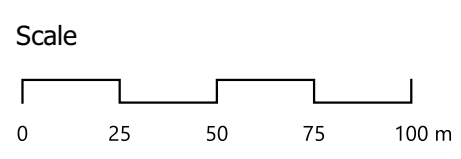


Overview



DATA ID	Longitude	Latitude
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wq02	73.54212	2.08564
wq03	73.5425	2.08629
wq04	73.5427	2.08672
wq05	73.5433	2.08867
wq06	73.5443	2.09014

- Legend
-  L.Dhanbidhoo Boundary
  -  L.Dhanbidhoo sampling points
  -  Dhanbidhoo Agriculture Zones



**TITLE**  
L.Dhanbidhoo Sampling Points Map (2)

**PROJECT**  
Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

**CLIENT**  
Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/14








Overview

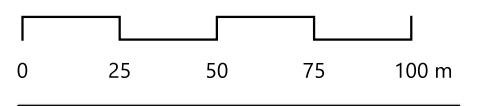


DATA ID	Longitude	Latitude
wq07	73.54584	2.09688
wq08	73.54604	2.10155
wq09	73.54552	2.10114
wq10	73.54652	2.10034

Legend

-  L.Dhanbidhoo Boundary
-  L.Dhanbidhoo sampling points
-  Dhanbidhoo Agriculture Zones

Scale



TITLE

L.Dhanbidhoo Sampling Points Map (3)

PROJECT

Ground Water Quality Assessment For Laamu Atoll Isdhoo, Kalaidhoo, Gan & Dhanbidhoo

CLIENT

Ministry of Climate Change, Environment, and Energy

Date: 25 Feb 2024

Drawn by: F.I.A.

Map no: EP/PTC-ES/2023/67/MP-FP/14

Pg : 3



Coordinate Systems : WGS 84  
Datum: WGS 84





**ISSUED TO**

**Epoch Associates Private Limited**  
G. Rosary West, 3rd Floor, Husnuheena Magu,  
Male' 20101,  
Republic of Maldives

**Sub Contracted by NSURE Private Limited**

**Issue Date: 16.02.2024**

**Sample Collection Date: 06.02.2024**

**Sample Registration Date: 09.02.2024**

**TEST RESULTS**

SAMPLE NAME	TEST PARAMETER	UNITS	RESULTS	**ACCEPTABLE LIMITS	SATISFACTORY / UNSATISFACTORY
Kalai - Ground Water 01	Turbidity	NTU	3.7	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	7.6	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	546	Max 1000	Satisfactory
	pH	--	7.7	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	26	--	--
	Total Dissolved Solids	mg/L	364	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	05	40	--
	Chemical Oxygen Demand	mg/L	18	50	--
	Chloride	mg/L	78	Max 200	Satisfactory
	Nitrates	mg/L	2.5	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	9.7	Max 250	Satisfactory
	Magnesium as Mg	mg/L	19	30	Satisfactory
	Calcium as Ca	mg/L	46	75	Satisfactory
	Iron as Fe	mg/L	0.07	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory	
Total Nitrogen	mg/L	<0.1	100	Satisfactory	
Sodium as Na	mg/L	20	<200	Satisfactory	
Potassium as K	mg/L	5.2	0 – 50	Satisfactory	

Reviewed by  
*[Signature]*  
(Samhitha)



Authorized Signatory  
*[Signature]*  
R. Sekurthala (Microbiology)

<b>Kalai - Ground Water 01 Cont.</b>	Salinity	ppt	0.31	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>Kalai - Ground Water 02</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	3.8	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	364.5	Max 1000	Satisfactory
	pH	--	7.7	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	26	--	--
	Total Dissolved Solids	mg/L	243	500	Satisfactory
	Dissolved Oxygen	mg/L	6.2	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	15	50	--
	Chloride	mg/L	73	Max 200	Satisfactory
	Nitrates	mg/L	1.8	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.8	Max 250	Satisfactory
	Magnesium as Mg	mg/L	17	30	Satisfactory
	Calcium as Ca	mg/L	42	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	14.6	<200	Satisfactory
Potassium as K	mg/L	3.5	0 – 50	Satisfactory	
Salinity	ppt	0.30	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>Kalai - Ground Water 03</b>	Turbidity	NTU	2.6	--	--
	Temperature	°C	25.2	--	--
	Colour	Hazen	7.2	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	282	Max 1000	Satisfactory
	pH	--	8.6	6.5-8.5	Unsatisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	51	--	--
	Total Dissolved Solids	mg/L	188	500	Satisfactory

<b>Kalai - Ground Water 03 Cont.</b>	Dissolved Oxygen	mg/L	6.4	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	09	50	--
	Chloride	mg/L	62	Max 200	Satisfactory
	Nitrates	mg/L	1.6	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.1	Max 250	Satisfactory
	Magnesium as Mg	mg/L	12	30	Satisfactory
	Calcium as Ca	mg/L	33	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	10.8	<200	Satisfactory
	Potassium as K	mg/L	2.9	0 – 50	Satisfactory
Salinity	ppt	0.2	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>Kalai - Ground Water 04</b>	Turbidity	NTU	3.5	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	7.1	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	356	Max 1000	Satisfactory
	pH	--	7.5	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	20	--	--
	Total Dissolved Solids	mg/L	239	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	13	50	--
	Chloride	mg/L	70	Max 200	Satisfactory
	Nitrates	mg/L	1.9	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.5	Max 250	Satisfactory
Magnesium as Mg	mg/L	16	30	Satisfactory	
Calcium as Ca	mg/L	40	75	Satisfactory	



<b>Kalai - Ground Water 04 Cont.</b>	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Not Agreeable	Agreeable	Unsatisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	12	<200	Satisfactory
	Potassium as K	mg/L	3.5	0 – 50	Satisfactory
	Salinity	ppt	0.23	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>Kalai - Ground Water 05</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	4.0	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	432	Max 1000	Satisfactory
	pH	--	7.9	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	36	--	--
	Total Dissolved Solids	mg/L	289	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	15	50	--
	Chloride	mg/L	75	Max 200	Satisfactory
	Nitrates	mg/L	1.9	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.7	Max 250	Satisfactory
	Magnesium as Mg	mg/L	17	30	Satisfactory
	Calcium as Ca	mg/L	42	75	Satisfactory
	Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	16.3	<200	Satisfactory
	Potassium as K	mg/L	4.3	0 – 50	Satisfactory
	Salinity	ppt	0.25	--	--

<b>Kalai - Ground Water 05</b>	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	3.9	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	450	Max 1000	Satisfactory
	pH	--	7.9	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	35	--	--
	Total Dissolved Solids	mg/L	302	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	15	50	--
	Chloride	mg/L	76	Max 200	Satisfactory
	<b>Kalai - Ground Water 06</b>	Nitrates	mg/L	2.2	Max 50
Nitrite		mg/L	<0.1	--	--
Sulphate		mg/L	8	Max 250	Satisfactory
Magnesium as Mg		mg/L	15	30	Satisfactory
Calcium as Ca		mg/L	38	75	Satisfactory
Iron as Fe		mg/L	0.02	Max 0.3	Satisfactory
Ammonia		mg/L	<0.1	Max 0.5	Satisfactory
Odour		--	Agreeable	Agreeable	Satisfactory
Acidity		mg/L	<0.1	--	--
Total-Phosphorous		mg/L	<0.1	5.0	Satisfactory
Total Nitrogen		mg/L	<0.1	100	Satisfactory
Sodium as Na		mg/L	18.1	<200	Satisfactory
Potassium as K		mg/L	4.7	0 – 50	Satisfactory
<b>Kalai - Ground Water 07</b>	Salinity	ppt	0.26	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	3.9	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	424	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	31	--	--
Total Dissolved Solids	mg/L	283	500	Satisfactory	
Dissolved Oxygen	mg/L	6.3	--	--	

<b>Kalai - Ground Water 07 Cont.</b>	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	14	50	--
	Chloride	mg/L	73	Max 200	Satisfactory
	Nitrates	mg/L	1.9	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.9	Max 250	Satisfactory
	Magnesium as Mg	mg/L	16	30	Satisfactory
	Calcium as Ca	mg/L	40	75	Satisfactory
	Iron as Fe	mg/L	0.01	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	16	<200	Satisfactory
	Potassium as K	mg/L	4.2	0 – 50	Satisfactory
	Salinity	ppt	0.25	--	--
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>Kalai - Ground Water 08</b>	Turbidity	NTU	0.4	--	--
	Temperature	°C	25.2	--	--
	Colour	Hazen	3.3	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	591	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	31	--	--
	Total Dissolved Solids	mg/L	394	500	Satisfactory
	Dissolved Oxygen	mg/L	6.2	--	--
	Biological Oxygen Demand	mg/L	06	40	--
	Chemical Oxygen Demand	mg/L	21	50	--
	Chloride	mg/L	83	Max 200	Satisfactory
	Nitrates	mg/L	2.8	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	10.6	Max 250	Satisfactory
	Magnesium as Mg	mg/L	21	30	Satisfactory
Calcium as Ca	mg/L	45	75	Satisfactory	
Iron as Fe	mg/L	0.07	Max 0.3	Satisfactory	

<b>Kalai - Ground Water 08 Cont.</b>	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	20.5	<200	Satisfactory
	Potassium as K	mg/L	5.8	0 – 50	Satisfactory
	Salinity	ppt	0.32	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>Kalai - Ground Water 09</b>	Turbidity	NTU	1.3	--	--
	Temperature	°C	25.2	--	--
	Colour	Hazen	5.3	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	306	Max 1000	Satisfactory
	pH	--	8.2	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	42	--	--
	Total Dissolved Solids	mg/L	204	500	Satisfactory
	Dissolved Oxygen	mg/L	6.2	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	11	50	--
	Chloride	mg/L	65	Max 200	Satisfactory
	Nitrates	mg/L	1.7	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.3	Max 250	Satisfactory
	Magnesium as Mg	mg/L	13	30	Satisfactory
	Calcium as Ca	mg/L	34	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	11.5	<200	Satisfactory
	Potassium as K	mg/L	3.1	0 – 50	Satisfactory
	Salinity	ppt	0.21	--	--
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	



<b>Kalai - Ground Water 10</b>	Turbidity	NTU	1.6	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	6.7	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	339	Max 1000	Satisfactory
	pH	--	8.2	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	43	--	--
	Total Dissolved Solids	mg/L	226	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	13	50	--
	Chloride	mg/L	66	Max 200	Satisfactory
	Nitrates	mg/L	1.8	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.3	Max 250	Satisfactory
	Magnesium as Mg	mg/L	13	30	Satisfactory
	Calcium as Ca	mg/L	36	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory	
Total Nitrogen	mg/L	<0.1	100	Satisfactory	
Sodium as Na	mg/L	11.8	<200	Satisfactory	
Potassium as K	mg/L	3.2	0 – 50	Satisfactory	
Salinity	ppt	0.21	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>ISDH - Ground Water 01</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.4	--	--
	Colour	Hazen	3.8	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	433	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	32	--	--
	Total Dissolved Solids	mg/L	289	500	Satisfactory
	Dissolved Oxygen	mg/L	6.4	--	--
Biological Oxygen Demand	mg/L	<05	40	--	

<b>ISDH - Ground Water 01 Cont.</b>	Chemical Oxygen Demand	mg/L	15	50	--
	Chloride	mg/L	74	Max 200	Satisfactory
	Nitrates	mg/L	1.9	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.9	Max 250	Satisfactory
	Magnesium as Mg	mg/L	18	30	Satisfactory
	Calcium as Ca	mg/L	40	75	Satisfactory
	Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	16.3	<200	Satisfactory
	Potassium as K	mg/L	4.4	0 – 50	Satisfactory
	<b>ISDH - Ground Water 02</b>	Salinity	ppt	0.25	--
Phosphate as PO <sub>4</sub>		mg/L	<0.1	<5	Satisfactory
Turbidity		NTU	0.1	--	--
Temperature		°C	25.4	--	--
Colour		Hazen	4.2	Max. 5.0	Satisfactory
Electric Conductivity		µs/cm	441	Max 1000	Satisfactory
pH		--	7.9	6.5-8.5	Satisfactory
Alkalinity as CaCO <sub>3</sub>		mg/L	35	--	--
Total Dissolved Solids		mg/L	295	500	Satisfactory
Dissolved Oxygen		mg/L	6.1	--	--
Biological Oxygen Demand		mg/L	05	40	--
Chemical Oxygen Demand		mg/L	15	50	--
Chloride		mg/L	75	Max 200	Satisfactory
Nitrates		mg/L	2	Max 50	Satisfactory
Nitrite		mg/L	<0.1	--	--
Sulphate		mg/L	7.9	Max 250	Satisfactory
Magnesium as Mg	mg/L	19	30	Satisfactory	
Calcium as Ca	mg/L	43	75	Satisfactory	
Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory	
Ammonia	mg/L	<0.1	Max 0.5	Satisfactory	

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<b>ISDH - Ground Water 02 Cont.</b>	Odour	--	Not Agreeable	Agreeable	Unsatisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	17.9	<200	Satisfactory
	Potassium as K	mg/L	4.6	0 – 50	Satisfactory
	Salinity	ppt	0.26	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>ISDH - Ground Water 03</b>	Turbidity	NTU	0.1	--	--
	Temperature	°C	25.2	--	--
	Colour	Hazen	4.0	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	359	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	32	--	--
	Total Dissolved Solids	mg/L	240	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	13	50	--
	Chloride	mg/L	70	Max 200	Satisfactory
	Nitrates	mg/L	1.4	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.5	Max 250	Satisfactory
	Magnesium as Mg	mg/L	14	30	Satisfactory
	Calcium as Ca	mg/L	39	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	12.8	<200	Satisfactory
	Potassium as K	mg/L	3.6	0 – 50	Satisfactory
Salinity	ppt	0.23	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>ISDH - Ground Water 04</b>	Turbidity	NTU	3.6	--	--

<b>ISDH - Ground Water 04 Cont.</b>	Temperature	°C	25.2	--	--
	Colour	Hazen	8.2	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	926	Max 1000	Satisfactory
	pH	--	7.7	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	25	--	--
	Total Dissolved Solids	mg/L	621	500	Unsatisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	06	40	--
	Chemical Oxygen Demand	mg/L	25	50	--
	Chloride	mg/L	275	Max 200	Satisfactory
	Nitrates	mg/L	25	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	20.5	Max 250	Satisfactory
	Magnesium as Mg	mg/L	22	30	Satisfactory
	Calcium as Ca	mg/L	51	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	28.5	<200	Satisfactory
	Potassium as K	mg/L	7.2	0 – 50	Satisfactory
Salinity	ppt	0.52	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>ISDH - Ground Water 05</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	3.9	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	381	Max 1000	Satisfactory
	pH	--	7.7	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	25	--	--
	Total Dissolved Solids	mg/L	256	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
Chemical Oxygen Demand	mg/L	13	50	--	

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<b>ISDH - Ground Water 05 Cont.</b>	Chloride	mg/L	71	Max 200	Satisfactory
	Nitrates	mg/L	1.6	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.5	Max 250	Satisfactory
	Magnesium as Mg	mg/L	18	30	Satisfactory
	Calcium as Ca	mg/L	40	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	13	<200	Satisfactory
	Potassium as K	mg/L	3.7	0 – 50	Satisfactory
	<b>ISDH - Ground Water 06</b>	Salinity	ppt	0.23	--
Phosphate as PO <sub>4</sub>		mg/L	<0.1	<5	Satisfactory
Turbidity		NTU	0.4	--	--
Temperature		°C	25.3	--	--
Colour		Hazen	3.8	Max. 5.0	Satisfactory
Electric Conductivity		µs/cm	295.5	Max 1000	Satisfactory
pH		--	8.1	6.5-8.5	Satisfactory
Alkalinity as CaCO <sub>3</sub>		mg/L	41	--	--
Total Dissolved Solids		mg/L	197	500	Satisfactory
Dissolved Oxygen		mg/L	6.2	--	--
Biological Oxygen Demand		mg/L	<05	40	--
Chemical Oxygen Demand		mg/L	10	50	--
Chloride		mg/L	62	Max 200	Satisfactory
Nitrates		mg/L	1.7	Max 50	Satisfactory
Nitrite		mg/L	<0.1	--	--
Sulphate	mg/L	7.2	Max 250	Satisfactory	
Magnesium as Mg	mg/L	13	30	Satisfactory	
Calcium as Ca	mg/L	33	75	Satisfactory	
Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory	
Ammonia	mg/L	<0.1	Max 0.5	Satisfactory	
Odour	--	Agreeable	Agreeable	Satisfactory	

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<b>ISDH - Ground Water 06 Cont.</b>	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	11.1	<200	Satisfactory
	Potassium as K	mg/L	3	0 – 50	Satisfactory
	Salinity	ppt	0.22	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>ISDH - Ground Water 07</b>	Turbidity	NTU	2.1	--	--
	Temperature	°C	25.4	--	--
	Colour	Hazen	6.8	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	714	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	30	--	--
	Total Dissolved Solids	mg/L	479	500	Satisfactory
	Dissolved Oxygen	mg/L	6	--	--
	Biological Oxygen Demand	mg/L	05	40	--
	Chemical Oxygen Demand	mg/L	20	50	--
	Chloride	mg/L	86	Max 200	Satisfactory
	Nitrates	mg/L	2.9	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	12.5	Max 250	Satisfactory
	Magnesium as Mg	mg/L	26	30	Satisfactory
	Calcium as Ca	mg/L	64	75	Satisfactory
	Iron as Fe	mg/L	0.05	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	21.4	<200	Satisfactory
	Potassium as K	mg/L	5.3	0 – 50	Satisfactory
Salinity	ppt	0.39	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>ISDH - Ground Water 08</b>	Turbidity	NTU	0.3	--	--
	Temperature	°C	25.1	--	--



<b>ISDH - Ground Water 08 Cont.</b>	Colour	Hazen	3.7	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	386	Max 1000	Satisfactory
	pH	--	7.9	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	35	--	--
	Total Dissolved Solids	mg/L	259	500	Satisfactory
	Dissolved Oxygen	mg/L	6.2	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	13	50	--
	Chloride	mg/L	72	Max 200	Satisfactory
	Nitrates	mg/L	1.6	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.6	Max 250	Satisfactory
	Magnesium as Mg	mg/L	17	30	Satisfactory
	Calcium as Ca	mg/L	40	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	13.2	<200	Satisfactory
Potassium as K	mg/L	3.8	0 – 50	Satisfactory	
Salinity	ppt	0.24	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>ISDH - Ground Water 09</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	3.7	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	440	Max 1000	Satisfactory
	pH	--	7.9	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	36	--	--
	Total Dissolved Solids	mg/L	294	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	05	40	--
	Chemical Oxygen Demand	mg/L	15	50	--
Chloride	mg/L	75	Max 200	Satisfactory	

<b>ISDH - Ground Water 09 Cont.</b>	Nitrates	mg/L	2	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.8	Max 250	Satisfactory
	Magnesium as Mg	mg/L	19	30	Satisfactory
	Calcium as Ca	mg/L	44	75	Satisfactory
	Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	17.9	<200	Satisfactory
	Potassium as K	mg/L	4.6	0 – 50	Satisfactory
	Salinity	ppt	0.26	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>ISDH - Ground Water 10</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	4.0	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	420	Max 1000	Satisfactory
	pH	--	8.0	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	42	--	--
	Total Dissolved Solids	mg/L	281	500	Satisfactory
	Dissolved Oxygen	mg/L	6.4	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	14	50	--
	Chloride	mg/L	73	Max 200	Satisfactory
	Nitrates	mg/L	1.8	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.9	Max 250	Satisfactory
	Magnesium as Mg	mg/L	17	30	Satisfactory
	Calcium as Ca	mg/L	40	75	Satisfactory
	Iron as Fe	mg/L	0.01	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
Odour	--	Agreeable	Agreeable	Satisfactory	
Acidity	mg/L	<0.1	--	--	

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<b>ISDH - Ground Water 10 Cont.</b>	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	15.9	<200	Satisfactory
	Potassium as K	mg/L	4.2	0 – 50	Satisfactory
	Salinity	ppt	0.25	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>GAN - Ground Water - 01</b>	Turbidity	NTU	0.4	--	--
	Temperature	°C	25.2	--	--
	Colour	Hazen	3.4	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	567	Max 1000	Satisfactory
	pH	--	7.5	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	21	--	--
	Total Dissolved Solids	mg/L	378	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	05	40	--
	Chemical Oxygen Demand	mg/L	19	50	--
	Chloride	mg/L	81	Max 200	Satisfactory
	Nitrates	mg/L	2.5	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	10.2	Max 250	Satisfactory
	Magnesium as Mg	mg/L	21	30	Satisfactory
	Calcium as Ca	mg/L	45	75	Satisfactory
	Iron as Fe	mg/L	0.08	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	20.8	<200	Satisfactory
	Potassium as K	mg/L	5.6	0 – 50	Satisfactory
Salinity	ppt	0.31	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>GAN - Ground Water - 02</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	3.8	Max. 5.0	Satisfactory

<b>GAN - Ground Water – 02 Cont.</b>	Electric Conductivity	µs/cm	414	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	31	--	--
	Total Dissolved Solids	mg/L	277	500	Satisfactory
	Dissolved Oxygen	mg/L	6.4	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	14	50	--
	Chloride	mg/L	73	Max 200	Satisfactory
	Nitrates	mg/L	1.8	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.8	Max 250	Satisfactory
	Magnesium as Mg	mg/L	17	30	Satisfactory
	Calcium as Ca	mg/L	41	75	Satisfactory
	Iron as Fe	mg/L	0.01	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	15.2	<200	Satisfactory
Potassium as K	mg/L	4.1	0 – 50	Satisfactory	
Salinity	ppt	0.25	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	

\*\* As per Utility Regulatory Authority (Male: Republic of Maldives).

Reviewed by  
  
(Samhitha)



Authorized Signatory  
  
R. Sekunthala (Microbiology)

**ISSUED TO**

**Epoch Associates Private Limited**  
G. Rosary West, 3rd Floor, Husnuheena Magu,  
Male' 20101,  
Republic of Maldives

**Sub Contracted by NSURE Private Limited**

**Issue Date: 16.02.2024**

**Sample Collection Date: 07.02.2024**

**Sample Registration Date: 09.02.2024**

**TEST RESULTS**

SAMPLE NAME	TEST PARAMETER	UNITS	RESULTS	**ACCEPTABLE LIMITS	SATISFACTORY / UNSATISFACTORY
GAN - Ground Water - 03	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.2	--	--
	Colour	Hazen	3.5	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	443	Max 1000	Satisfactory
	pH	--	7.9	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	36	--	--
	Total Dissolved Solids	mg/L	296	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	05	40	--
	Chemical Oxygen Demand	mg/L	15	50	--
	Chloride	mg/L	75	Max 200	Satisfactory
	Nitrates	mg/L	2.1	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.9	Max 250	Satisfactory
	Magnesium as Mg	mg/L	17	30	Satisfactory
	Calcium as Ca	mg/L	43	75	Satisfactory
	Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory	
Total Nitrogen	mg/L	<0.1	100	Satisfactory	
Sodium as Na	mg/L	18	<200	Satisfactory	
Potassium as K	mg/L	4.7	0 – 50	Satisfactory	

Reviewed by  
*[Signature]*  
(Samhitha)



Authorized Signatory  
*[Signature]*  
R. Sekurthala (Microbiology)

<b>GAN - Ground Water - 03 Cont.</b>	Salinity	ppt	0.26	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>GAN - Ground Water - 04</b>	Turbidity	NTU	0.6	--	--
	Temperature	°C	25.2	--	--
	Colour	Hazen	3.2	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	817.5	Max 1000	Satisfactory
	pH	--	7.5	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	20	--	--
	Total Dissolved Solids	mg/L	545	500	Unsatisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	06	40	--
	Chemical Oxygen Demand	mg/L	21	50	--
	Chloride	mg/L	105	Max 200	Satisfactory
	Nitrates	mg/L	2.9	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	18.6	Max 250	Satisfactory
	Magnesium as Mg	mg/L	21	30	Satisfactory
	Calcium as Ca	mg/L	58	75	Satisfactory
	Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Not Agreeable	Agreeable	Unsatisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	22.9	<200	Satisfactory
Potassium as K	mg/L	5.8	0 – 50	Satisfactory	
Salinity	ppt	0.48	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>GAN - Ground Water - 05</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	3.9	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	483	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	31	--	--
	Total Dissolved Solids	mg/L	324	500	Satisfactory

<b>GAN - Ground Water - 05 Cont.</b>	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	16	50	--
	Chloride	mg/L	77	Max 200	Satisfactory
	Nitrates	mg/L	16	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	8	Max 250	Satisfactory
	Magnesium as Mg	mg/L	18	30	Satisfactory
	Calcium as Ca	mg/L	48	75	Satisfactory
	Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	18.5	<200	Satisfactory
	Potassium as K	mg/L	4.8	0 – 50	Satisfactory
Salinity	ppt	0.26	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>GAN - Ground Water - 06</b>	Turbidity	NTU	0.3	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	3.7	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	378	Max 1000	Satisfactory
	pH	--	8.0	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	41	--	--
	Total Dissolved Solids	mg/L	254	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	13	50	--
	Chloride	mg/L	71	Max 200	Satisfactory
	Nitrates	mg/L	1.5	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.5	Max 250	Satisfactory
Magnesium as Mg	mg/L	16	30	Satisfactory	
Calcium as Ca	mg/L	40	75	Satisfactory	



GAN - Ground Water - 06 Cont.	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	13	<200	Satisfactory
	Potassium as K	mg/L	3.7	0 – 50	Satisfactory
	Salinity	ppt	0.23	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
GAN - Ground Water - 07	Turbidity	NTU	1.2	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	5.1	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	529.5	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	32	--	--
	Total Dissolved Solids	mg/L	353	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	17	50	--
	Chloride	mg/L	79	Max 200	Satisfactory
	Nitrates	mg/L	2.5	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	9.9	Max 250	Satisfactory
	Magnesium as Mg	mg/L	18	30	Satisfactory
	Calcium as Ca	mg/L	43	75	Satisfactory
	Iron as Fe	mg/L	0.08	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	20	<200	Satisfactory
Potassium as K	mg/L	5.3	0 – 50	Satisfactory	
Salinity	ppt	0.27	--	--	

GAN - Ground Water - 07	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	3.6	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	384	Max 1000	Satisfactory
	pH	--	7.5	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	22	--	--
	Total Dissolved Solids	mg/L	258	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	13	50	--
	Chloride	mg/L	71	Max 200	Satisfactory
	GAN - Ground Water - 08	Nitrates	mg/L	1.6	Max 50
Nitrite		mg/L	<0.1	--	--
Sulphate		mg/L	7.5	Max 250	Satisfactory
Magnesium as Mg		mg/L	15	30	Satisfactory
Calcium as Ca		mg/L	39	75	Satisfactory
Iron as Fe		mg/L	<0.005	Max 0.3	Satisfactory
Ammonia		mg/L	<0.1	Max 0.5	Satisfactory
Odour		--	Agreeable	Agreeable	Satisfactory
Acidity		mg/L	<0.1	--	--
Total-Phosphorous		mg/L	<0.1	5.0	Satisfactory
Total Nitrogen		mg/L	<0.1	100	Satisfactory
Sodium as Na		mg/L	13	<200	Satisfactory
Potassium as K		mg/L	3.7	0 – 50	Satisfactory
GAN - Ground Water - 09	Salinity	ppt	0.23	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
	Turbidity	NTU	0.1	--	--
	Temperature	°C	25.4	--	--
	Colour	Hazen	4.0	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	406	Max 1000	Satisfactory
	pH	--	7.9	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	36	--	--
Total Dissolved Solids	mg/L	272	500	Satisfactory	
Dissolved Oxygen	mg/L	6.4	--	--	



<b>GAN - Ground Water - 09 Cont.</b>	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	14	50	--
	Chloride	mg/L	73	Max 200	Satisfactory
	Nitrates	mg/L	1.7	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.7	Max 250	Satisfactory
	Magnesium as Mg	mg/L	16	30	Satisfactory
	Calcium as Ca	mg/L	42	75	Satisfactory
	Iron as Fe	mg/L	0.01	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	14.5	<200	Satisfactory
	Potassium as K	mg/L	4	0 – 50	Satisfactory
	Salinity	ppt	0.24	--	--
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>GAN - Ground Water - 10</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	24.9	--	--
	Colour	Hazen	3.8	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	477	Max 1000	Satisfactory
	pH	--	8.0	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	42	--	--
	Total Dissolved Solids	mg/L	318	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	05	40	--
	Chemical Oxygen Demand	mg/L	16	50	--
	Chloride	mg/L	76	Max 200	Satisfactory
	Nitrates	mg/L	2.3	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	8	Max 250	Satisfactory
	Magnesium as Mg	mg/L	17	30	Satisfactory
Calcium as Ca	mg/L	47	75	Satisfactory	
Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory	

<b>GAN - Ground Water - 10 Cont.</b>	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	18.5	<200	Satisfactory
	Potassium as K	mg/L	4.8	0 – 50	Satisfactory
	Salinity	ppt	0.26	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>DHAB - Ground Water 01</b>	Turbidity	NTU	3.4	--	--
	Temperature	°C	25.2	--	--
	Colour	Hazen	6.2	Max. 5.0	Unsatisfactory
	Electric Conductivity	µs/cm	1164	Max 1000	Unsatisfactory
	pH	--	8.4	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	48	--	--
	Total Dissolved Solids	mg/L	780	500	Unsatisfactory
	Dissolved Oxygen	mg/L	6.2	--	--
	Biological Oxygen Demand	mg/L	08	40	--
	Chemical Oxygen Demand	mg/L	35	50	--
	Chloride	mg/L	265	Max 200	Unsatisfactory
	Nitrates	mg/L	30	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	25	Max 250	Satisfactory
	Magnesium as Mg	mg/L	20	30	Satisfactory
	Calcium as Ca	mg/L	55	75	Satisfactory
	Iron as Fe	mg/L	0.15	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	35.4	<200	Satisfactory
	Potassium as K	mg/L	9.2	0 – 50	Satisfactory
Salinity	ppt	0.66	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	



<b>DHAB - Ground Water 02</b>	Turbidity	NTU	0.3	--	--
	Temperature	°C	25.3	--	--
	Colour	Hazen	3.3	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	339	Max 1000	Satisfactory
	pH	--	8.2	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	45	--	--
	Total Dissolved Solids	mg/L	591	500	Satisfactory
	Dissolved Oxygen	mg/L	6.2	--	--
	Biological Oxygen Demand	mg/L	06	40	--
	Chemical Oxygen Demand	mg/L	28	50	--
	Chloride	mg/L	108	Max 200	Satisfactory
	Nitrates	mg/L	3	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	19.3	Max 250	Satisfactory
	Magnesium as Mg	mg/L	25	30	Satisfactory
	Calcium as Ca	mg/L	65	75	Satisfactory
	Iron as Fe	mg/L	0.03	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory	
Total Nitrogen	mg/L	<0.1	100	Satisfactory	
Sodium as Na	mg/L	24.5	<200	Satisfactory	
Potassium as K	mg/L	5.9	0 – 50	Satisfactory	
Salinity	ppt	0.45	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>DHAB - Ground Water 03</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	4.2	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	1873	Max 1000	Unsatisfactory
	pH	--	8.0	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	39	--	--
	Total Dissolved Solids	mg/L	1255	500	Unsatisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
Biological Oxygen Demand	mg/L	12	40	--	

<b>DHAB - Ground Water 03 Cont.</b>	Chemical Oxygen Demand	mg/L	49	50	--
	Chloride	mg/L	515	Max 200	Unsatisfactory
	Nitrates	mg/L	35	Max 50	Satisfactory
	Nitrite	mg/L	0.14	--	--
	Sulphate	mg/L	38	Max 250	Satisfactory
	Magnesium as Mg	mg/L	25	30	Satisfactory
	Calcium as Ca	mg/L	87	75	Unsatisfactory
	Iron as Fe	mg/L	0.12	Max 0.3	Satisfactory
	Ammonia	mg/L	0.25	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	0.12	5.0	Satisfactory
	Total Nitrogen	mg/L	0.12	100	Satisfactory
	Sodium as Na	mg/L	65.2	<200	Satisfactory
	<b>DHAB - Ground Water 04</b>	Potassium as K	mg/L	11.3	0 – 50
Salinity		ppt	1.12	--	--
Phosphate as PO <sub>4</sub>		mg/L	0.37	<5	Satisfactory
Turbidity		NTU	0.8	--	--
Temperature		°C	25.1	--	--
Colour		Hazen	5.4	Max. 5.0	Unsatisfactory
Electric Conductivity		µs/cm	521	Max 1000	Satisfactory
pH		--	8.0	6.5-8.5	Satisfactory
Alkalinity as CaCO <sub>3</sub>		mg/L	41	--	--
Total Dissolved Solids		mg/L	349	500	Satisfactory
Dissolved Oxygen		mg/L	6.4	--	--
Biological Oxygen Demand		mg/L	06	40	--
Chemical Oxygen Demand		mg/L	17	50	--
Chloride		mg/L	79	Max 200	Satisfactory
Nitrates		mg/L	2.5	Max 50	Satisfactory
Nitrite	mg/L	<0.1	--	--	
Sulphate	mg/L	8.6	Max 250	Satisfactory	
Magnesium as Mg	mg/L	21	30	Satisfactory	
Calcium as Ca	mg/L	54	75	Satisfactory	
Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory	
Ammonia	mg/L	<0.1	Max 0.5	Satisfactory	



<b>DHAB - Ground Water 04 Cont.</b>	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	19.7	<200	Satisfactory
	Potassium as K	mg/L	5	0 – 50	Satisfactory
	Salinity	ppt	0.31	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>DHAB - Ground Water 05</b>	Turbidity	NTU	0.4	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	3.5	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	359	Max 1000	Satisfactory
	pH	--	7.9	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	37	--	--
	Total Dissolved Solids	mg/L	473	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	18	50	--
	Chloride	mg/L	83	Max 200	Satisfactory
	Nitrates	mg/L	2.9	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	12	Max 250	Satisfactory
	Magnesium as Mg	mg/L	22	30	Satisfactory
	Calcium as Ca	mg/L	63	75	Satisfactory
	Iron as Fe	mg/L	0.1	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	21.4	<200	Satisfactory
	Potassium as K	mg/L	2	0 – 50	Satisfactory
Salinity	ppt	0.36	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>DHAB - Ground Water 06</b>	Turbidity	NTU	0.2	--	--

<b>DHAB - Ground Water 06 Cont.</b>	Temperature	°C	24.9	--	--
	Colour	Hazen	3.8	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	461	Max 1000	Satisfactory
	pH	--	7.7	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	26	--	--
	Total Dissolved Solids	mg/L	308	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	15	50	--
	Chloride	mg/L	76	Max 200	Satisfactory
	Nitrates	mg/L	2.2	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	8	Max 250	Satisfactory
	Magnesium as Mg	mg/L	16	30	Satisfactory
	Calcium as Ca	mg/L	44	75	Satisfactory
	Iron as Fe	mg/L	0.02	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	18.2	<200	Satisfactory
	Potassium as K	mg/L	4.7	0 – 50	Satisfactory
Salinity	ppt	0.26	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>DHAB - Ground Water 07</b>	Turbidity	NTU	0.3	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	3.3	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	281	Max 1000	Satisfactory
	pH	--	8.1	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	42	--	--
	Total Dissolved Solids	mg/L	188	500	Satisfactory
	Dissolved Oxygen	mg/L	6.3	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
Chemical Oxygen Demand	mg/L	10	50	--	



<b>DHAB - Ground Water 07 Cont.</b>	Chloride	mg/L	64	Max 200	Satisfactory
	Nitrates	mg/L	1.6	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.3	Max 250	Satisfactory
	Magnesium as Mg	mg/L	14	30	Satisfactory
	Calcium as Ca	mg/L	34	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	10.8	<200	Satisfactory
	Potassium as K	mg/L	2.7	0 – 50	Satisfactory
	<b>DHAB - Ground Water 08</b>	Salinity	ppt	0.23	--
Phosphate as PO <sub>4</sub>		mg/L	<0.1	<5	Satisfactory
Turbidity		NTU	0.4	--	--
Temperature		°C	25.1	--	--
Colour		Hazen	3.2	Max. 5.0	Satisfactory
Electric Conductivity		µs/cm	882	Max 1000	Satisfactory
pH		--	8.1	6.5-8.5	Satisfactory
Alkalinity as CaCO <sub>3</sub>		mg/L	43	--	--
Total Dissolved Solids		mg/L	588	500	Unsatisfactory
Dissolved Oxygen		mg/L	6.2	--	--
Biological Oxygen Demand		mg/L	05	40	--
Chemical Oxygen Demand		mg/L	24	50	--
Chloride		mg/L	110	Max 200	Satisfactory
Nitrates		mg/L	3.1	Max 50	Satisfactory
Nitrite		mg/L	<0.1	--	--
Sulphate	mg/L	19.3	Max 250	Satisfactory	
Magnesium as Mg	mg/L	23	30	Satisfactory	
Calcium as Ca	mg/L	62	75	Satisfactory	
Iron as Fe	mg/L	0.03	Max 0.3	Satisfactory	
Ammonia	mg/L	<0.1	Max 0.5	Satisfactory	
Odour	--	Not Agreeable	Agreeable	Unsatisfactory	

<b>DHAB - Ground Water 08 Cont.</b>	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	24.6	<200	Satisfactory
	Potassium as K	mg/L	5	0 – 50	Satisfactory
	Salinity	ppt	0.45	--	--
	Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory
<b>DHAB - Ground Water 09</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.1	--	--
	Colour	Hazen	4.0	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	389	Max 1000	Satisfactory
	pH	--	7.8	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	31	--	--
	Total Dissolved Solids	mg/L	261	500	Satisfactory
	Dissolved Oxygen	mg/L	6.2	--	--
	Biological Oxygen Demand	mg/L	<05	40	--
	Chemical Oxygen Demand	mg/L	13	50	--
	Chloride	mg/L	72	Max 200	Satisfactory
	Nitrates	mg/L	1.6	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.6	Max 250	Satisfactory
	Magnesium as Mg	mg/L	17	30	Satisfactory
	Calcium as Ca	mg/L	41	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
	Sodium as Na	mg/L	13.2	<200	Satisfactory
Potassium as K	mg/L	3.8	0 – 50	Satisfactory	
Salinity	ppt	0.24	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	
<b>DHAB - Ground Water 10</b>	Turbidity	NTU	0.2	--	--
	Temperature	°C	25.2	--	--



<b>DHAB - Ground Water 10 Cont.</b>	Colour	Hazen	3.1	Max. 5.0	Satisfactory
	Electric Conductivity	µs/cm	386	Max 1000	Satisfactory
	pH	--	8.2	6.5-8.5	Satisfactory
	Alkalinity as CaCO <sub>3</sub>	mg/L	43	--	--
	Total Dissolved Solids	mg/L	189	500	Satisfactory
	Dissolved Oxygen	mg/L	6.1	--	--
	Biological Oxygen Demand	mg/L	05	40	--
	Chemical Oxygen Demand	mg/L	12	50	--
	Chloride	mg/L	69	Max 200	Satisfactory
	Nitrates	mg/L	1.6	Max 50	Satisfactory
	Nitrite	mg/L	<0.1	--	--
	Sulphate	mg/L	7.3	Max 250	Satisfactory
	Magnesium as Mg	mg/L	13	30	Satisfactory
	Calcium as Ca	mg/L	36	75	Satisfactory
	Iron as Fe	mg/L	<0.005	Max 0.3	Satisfactory
	Ammonia	mg/L	<0.1	Max 0.5	Satisfactory
	Odour	--	Agreeable	Agreeable	Satisfactory
	Acidity	mg/L	<0.1	--	--
	Total-Phosphorous	mg/L	<0.1	5.0	Satisfactory
	Total Nitrogen	mg/L	<0.1	100	Satisfactory
Sodium as Na	mg/L	10.8	<200	Satisfactory	
Potassium as K	mg/L	3	0 – 50	Satisfactory	
Salinity	ppt	0.23	--	--	
Phosphate as PO <sub>4</sub>	mg/L	<0.1	<5	Satisfactory	

\*\* As per Utility Regulatory Authority (Male: Republic of Maldives).

Reviewed by  
  
(Samhitha)



Authorized Signatory  
  
R. Sekunthala (Microbiology)

**WATER QUALITY TEST REPORT**  
 Report No: 500199468

**Customer Information:**  
 Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: **07/02/2024**  
 Test Requisition Form No: **900199812**  
 Sample(s) Recieved Date: **06/02/2024**  
 Date of Analysis: **06/02/2024 - 07/02/2024**

Sample Description ~	Gan_01	Gan_02	TEST METHOD	UNIT		
Sample Type ~	Ground Water	Ground Water				
Sample No	83246661	83246662				
Sampled Date ~	05/02/2024 03:55 PM	05/02/2024 03:55 PM				
Physical Appearance	Clear with particles	Clear with particles				
PARAMETER	ANALYSIS RESULT					
Total Coliforms	12 (06/02/2024 03:00 PM)	326 (06/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml		
Faecal Coliforms	12 (06/02/2024 03:00 PM)	124 (06/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml		

Keys: **MPN/100ml** : Most Probable Number

Checked by



Aminath Shahidha  
 Laboratory Executive

Approved by



Nihaz A. Zahir  
 Assistant Quality Manager

**Notes:**

Sampling Authority: Sampling was not done by MWSC Laboratory.  
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 ~ Information provided by the customer. This information may affect the validity of the test results.  
 \*Parameters accredited by Eiac under ISO/IEC 17025:2017

\*\*\*\*\* END OF REPORT \*\*\*\*\*





**WATER QUALITY TEST REPORT**  
 Report No: 500199503

Report date: 12/02/2024  
 Test Requisition Form No: 900199829  
 Sample(s) Recieved Date: 08/02/2024  
 Date of Analysis: 08/02/2024 - 09/02/2024

**Customer Information:**  
 Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Sample Description ~	Isd_01	Isd_02	Isd_03	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246733	83246734	83246735		
Sampled Date ~	06/02/2024 09:50 AM	06/02/2024 10:05 AM	06/02/2024 10:18 AM		
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>				
Total Coliforms	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	138 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

**Keys: MPN/100ml** : Most Probable Number

**Checked by**

Aminath Shahidha  
 Laboratory Executive

**Approved by**

Nihaz A. Zahir  
 Assistant Quality Manager

**Notes:**

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**Male' Water & Sewerage Company Pvt Ltd**  
**Water Quality Assurance Laboratory**

Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives  
 Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv



**WATER QUALITY TEST REPORT**  
 Report No: 500199503

**Customer Information:**

Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: **12/02/2024**  
 Test Requisition Form No: **900199829**  
 Sample(s) Recieved Date: **08/02/2024**  
 Date of Analysis: **08/02/2024 - 09/02/2024**

Sample Description ~	Isd_04	Isd_05	Isd_06	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246736	83246737	83246738		
Sampled Date ~	06/02/2024 10:40 AM	06/02/2024 11:00 AM	06/02/2024 11:15 AM		
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>				
Total Coliforms	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	866 (08/02/2024 03:00 PM)	921 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

Keys: **MPN/100ml** : Most Probable Number

Checked by

Aminath Shahidha  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

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 Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv



**WATER QUALITY TEST REPORT**  
 Report No: 500199503

**Customer Information:**

Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: **12/02/2024**  
 Test Requisition Form No: **900199829**  
 Sample(s) Recieved Date: **08/02/2024**  
 Date of Analysis: **08/02/2024 - 09/02/2024**

Sample Description ~	Isd_07	TEST METHOD		UNIT
Sample Type ~	Ground Water			
Sample No	83246739			
Sampled Date ~	06/02/2024 11:25 AM			
Physical Appearance	Clear with particles			
PARAMETER	ANALYSIS RESULT			
Total Coliforms	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000		MPN/100ml
Faecal Coliforms	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000		MPN/100ml

Keys: **MPN/100ml** : Most Probable Number

Checked by

Aminath Shahidha  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

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**WATER QUALITY TEST REPORT**  
 Report No: 500199504

Report date: 12/02/2024  
 Test Requisition Form No: 900199830  
 Sample(s) Recieved Date: 08/02/2024  
 Date of Analysis: 08/02/2024 - 09/02/2024

**Customer Information:**  
 Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Sample Description ~	Kal_05	Kal_06	Kal_07	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246740	83246741	83246742		
Sampled Date ~	06/02/2024 02:30 PM	06/02/2024 02:45 PM	06/02/2024 03:03 PM		
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>				
Total Coliforms	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	91 (08/02/2024 03:00 PM)	437 (08/02/2024 03:00 PM)	183 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

**Keys: MPN/100ml** : Most Probable Number

Checked by

Aminath Shahidha  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

**Notes:**

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**Male' Water & Sewerage Company Pvt Ltd**  
**Water Quality Assurance Laboratory**

Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives  
 Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv



**WATER QUALITY TEST REPORT**  
 Report No: 500199504

**Customer Information:**

Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: **12/02/2024**  
 Test Requisition Form No: **900199830**  
 Sample(s) Recieved Date: **08/02/2024**  
 Date of Analysis: **08/02/2024 - 09/02/2024**

Sample Description ~	Kal_08	Kal_09	Kal_10	TEST METHOD	UNIT		
Sample Type ~	Ground Water	Ground Water	Ground Water				
Sample No	83246743	83246744	83246745				
Sampled Date ~	06/02/2024 03:19 PM	06/02/2024 03:35 PM	06/02/2024 03:55 PM				
Physical Appearance	Clear with particles	Clear with particles	Clear with particles				
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>						
Total Coliforms	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml		
Faecal Coliforms	>2420 (08/02/2024 03:00 PM)	94 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml		

Keys: **MPN/100ml** : Most Probable Number

Checked by

Aminath Shahidha  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

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**WATER QUALITY TEST REPORT**  
 Report No: 500199513

Report date: 12/02/2024  
 Test Requisition Form No: 900199832  
 Sample(s) Recieved Date: 08/02/2024  
 Date of Analysis: 08/02/2024 - 09/02/2024

**Customer Information:**  
 Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Sample Description ~	Kal_01	Kal_02	Kal_03	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246749	83246750	83246751		
Sampled Date ~	06/02/2024 01:40 PM	06/02/2024 01:50 PM	06/02/2024 02:05 PM		
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>				
Total Coliforms	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	1300 (08/02/2024 03:00 PM)	436 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

**Keys: MPN/100ml** : Most Probable Number

Checked by

Aminath Shahidha  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

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**Male' Water & Sewerage Company Pvt Ltd**  
**Water Quality Assurance Laboratory**

Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives  
 Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv



**WATER QUALITY TEST REPORT**  
 Report No: 500199513

**Customer Information:**

Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: 12/02/2024  
 Test Requisition Form No: 900199832  
 Sample(s) Recieved Date: 08/02/2024  
 Date of Analysis: 08/02/2024 - 09/02/2024

Sample Description ~	Kal_04	TEST METHOD		UNIT
Sample Type ~	Ground Water			
Sample No	83246752			
Sampled Date ~	06/02/2024 02:20 PM			
Physical Appearance	Clear with particles			
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>			
Total Coliforms	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000		MPN/100ml
Faecal Coliforms	77 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000		MPN/100ml

Keys: MPN/100ml : Most Probable Number

Checked by

Aminath Shahidha  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

**Notes:**

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\*\*\*\*\* END OF REPORT \*\*\*\*\*



**WATER QUALITY TEST REPORT**  
 Report No: 500199517

Report date: 12/02/2024  
 Test Requisition Form No: 900199838  
 Sample(s) Recieved Date: 08/02/2024  
 Date of Analysis: 08/02/2024 - 09/02/2024

**Customer Information:**  
 Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Sample Description ~	Gan_03	Gan_06	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water		
Sample No	83246762	83246765		
Sampled Date ~	07/02/2024 07:15 AM	07/02/2024 08:25 AM		
Physical Appearance	Pale yellow with particles	Clear with particles		
PARAMETER	ANALYSIS RESULT			
Total Coliforms	2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

Keys: MPN/100ml : Most Probable Number

Checked by

Nashath Ali  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

**Notes:**

Sampling Authority: Sampling was not done by MWSC Laboratory.  
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\*\*\*\*\* END OF REPORT \*\*\*\*\*





**WATER QUALITY TEST REPORT**  
 Report No: 500199518

Report date: **12/02/2024**  
 Test Requisition Form No: **900199838**  
 Sample(s) Recieved Date: **08/02/2024**  
 Date of Analysis: **08/02/2024 - 09/02/2024**

**Customer Information:**  
 Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Sample Description ~	Gan_04	Gan_05	Gan_07	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246763	83246764	83246766		
Sampled Date ~	07/02/2024 08:00 AM	07/02/2024 08:10 AM	07/02/2024 10:15 AM		
Physical Appearance	Pale yellow with particles	Pale yellow with particles	Pale yellow with particles		
PARAMETER	ANALYSIS RESULT				
Total Coliforms	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	>2420 (08/02/2024 03:00 PM)	378 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

Keys: **MPN/100ml** : Most Probable Number

Checked by

Nashath Ali  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

**Notes:**

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**Male' Water & Sewerage Company Pvt Ltd**  
**Water Quality Assurance Laboratory**

Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives  
 Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv



**WATER QUALITY TEST REPORT**  
 Report No: 500199518

**Customer Information:**

Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: 12/02/2024  
 Test Requisition Form No: 900199838  
 Sample(s) Recieved Date: 08/02/2024  
 Date of Analysis: 08/02/2024 - 09/02/2024

Sample Description ~	Gan_08	Gan_09	Gan_10	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246767	83246768	83246769		
Sampled Date ~	07/02/2024 10:30 AM	07/02/2024 11:59 AM	07/02/2024 12:00 PM		
Physical Appearance	Pale yellow with particles	Pale yellow with particles	Pale yellow with particles		
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>				
Total Coliforms	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

Keys: MPN/100ml : Most Probable Number

Checked by

Nashath Ali  
 Laboratory Executive

Approved by

Nihaz A. Zahir  
 Assistant Quality Manager

**Notes:**

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**WATER QUALITY TEST REPORT**  
 Report No: 500199497

Report date: **12/02/2024**  
 Test Requisition Form No: **900199839**  
 Sample(s) Recieved Date: **08/02/2024**  
 Date of Analysis: **08/02/2024 - 09/02/2024**

**Customer Information:**  
 Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Sample Description ~	DBD_01	DBD_02	DBD_03	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246770	83246771	83246772		
Sampled Date ~	07/02/2024 02:40 PM	07/02/2024 02:50 PM	07/02/2024 02:55 PM		
Physical Appearance	Pale yellow with particles	Pale yellow with particles	Pale yellow with particles		
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>				
Total Coliforms	1553 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	178 (08/02/2024 03:00 PM)	1553 (08/02/2024 03:00 PM)	96 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

**Keys: MPN/100ml** : Most Probable Number

**Checked by**

Aminath Shahidha  
 Laboratory Executive

**Approved by**

Nihaz A. Zahir  
 Assistant Quality Manager

**Notes:**

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**WATER QUALITY TEST REPORT**  
 Report No: 500199497

**Customer Information:**

Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: **12/02/2024**  
 Test Requisition Form No: **900199839**  
 Sample(s) Recieved Date: **08/02/2024**  
 Date of Analysis: **08/02/2024 - 09/02/2024**

Sample Description ~	DBD_04	DBD_05	DBD_06	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246773	83246774	83246775		
Sampled Date ~	07/02/2024 03:00 PM	07/02/2024 03:05 PM	07/02/2024 03:10 PM		
Physical Appearance	Clear with particles	Clear with particles	Pale yellow with particles		
PARAMETER	ANALYSIS RESULT				
Total Coliforms	>2420 (08/02/2024 03:00 PM)	238 (08/02/2024 03:00 PM)	300 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	1553 (08/02/2024 03:00 PM)	10 (08/02/2024 03:00 PM)	105 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

Keys: **MPN/100ml** : Most Probable Number

Checked by

Aminath Shahidha  
 Laboratory Executive

Approved by

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 Assistant Quality Manager

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**WATER QUALITY TEST REPORT**  
 Report No: 500199497

**Customer Information:**  
 Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: **12/02/2024**  
 Test Requisition Form No: **900199839**  
 Sample(s) Recieved Date: **08/02/2024**  
 Date of Analysis: **08/02/2024 - 09/02/2024**

Sample Description ~	DBD_07	DBD_08	DBD_09	TEST METHOD	UNIT
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83246776	83246777	83246778		
Sampled Date ~	07/02/2024 03:30 PM	07/02/2024 03:35 PM	07/02/2024 03:40 PM		
Physical Appearance	Clear with particles	Pale yellow with particles	Pale yellow with particles		
<b>PARAMETER</b>	<b>ANALYSIS RESULT</b>				
Total Coliforms	261 (08/02/2024 03:00 PM)	1986 (08/02/2024 03:00 PM)	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	78 (08/02/2024 03:00 PM)	111 (08/02/2024 03:00 PM)	548 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

**Keys: MPN/100ml** : Most Probable Number

**Checked by**

Aminath Shahidha  
 Laboratory Executive

**Approved by**

Nihaz A. Zahir  
 Assistant Quality Manager

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 Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv



**WATER QUALITY TEST REPORT**  
 Report No: 500199497

**Customer Information:**

Epoch Associates Pvt Ltd  
 G.Rosary West, 3rd Floor  
 Husnuheena Magu  
 k MALE'

Report date: 12/02/2024  
 Test Requisition Form No: 900199839  
 Sample(s) Recieved Date: 08/02/2024  
 Date of Analysis: 08/02/2024 - 09/02/2024

Sample Description ~	DBD_10	TEST METHOD	UNIT
Sample Type ~	Ground Water		
Sample No	83246779		
Sampled Date ~	07/02/2024 03:50 PM		
Physical Appearance	Pale yellow with particles		
PARAMETER	ANALYSIS RESULT		
Total Coliforms	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml
Faecal Coliforms	>2420 (08/02/2024 03:00 PM)	Colilert®-18/Quanti-Tray®2000	MPN/100ml

Keys: MPN/100ml : Most Probable Number

Checked by

Aminath Shahidha  
 Laboratory Executive

Approved by

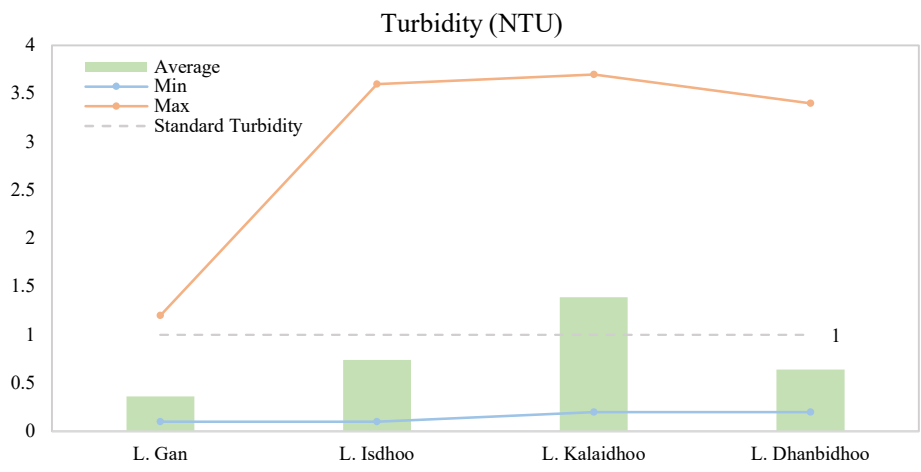
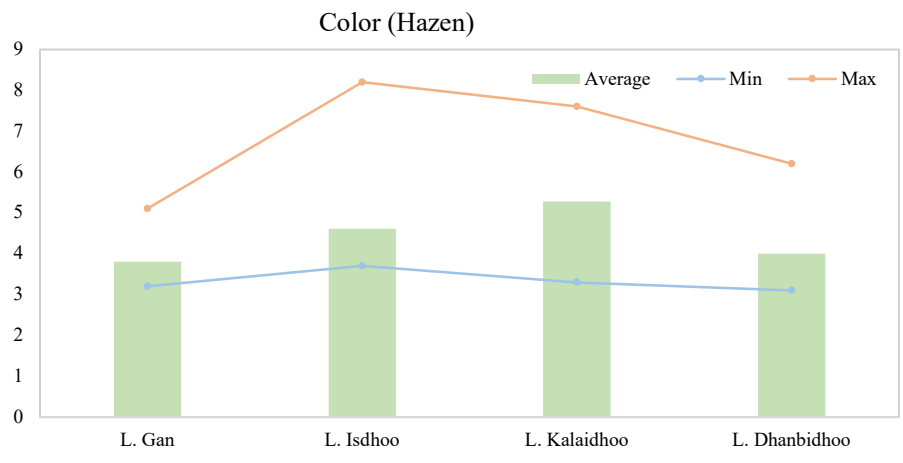
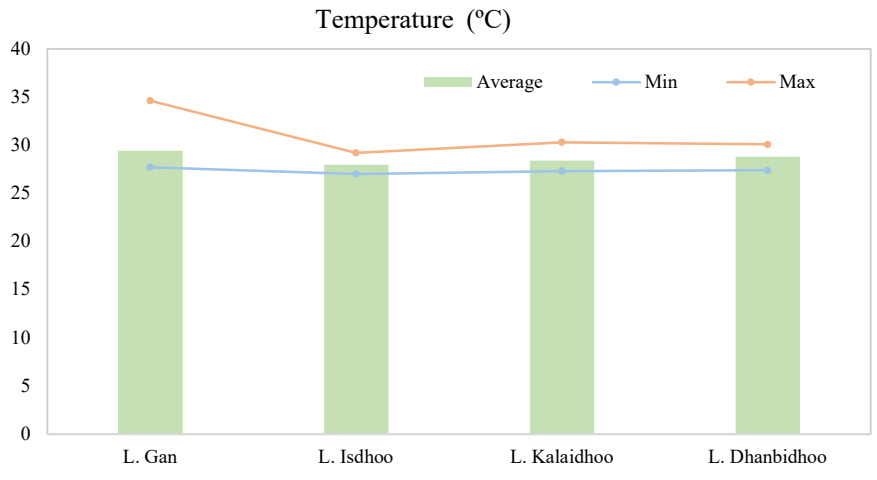
Nihaz A. Zahir  
 Assistant Quality Manager

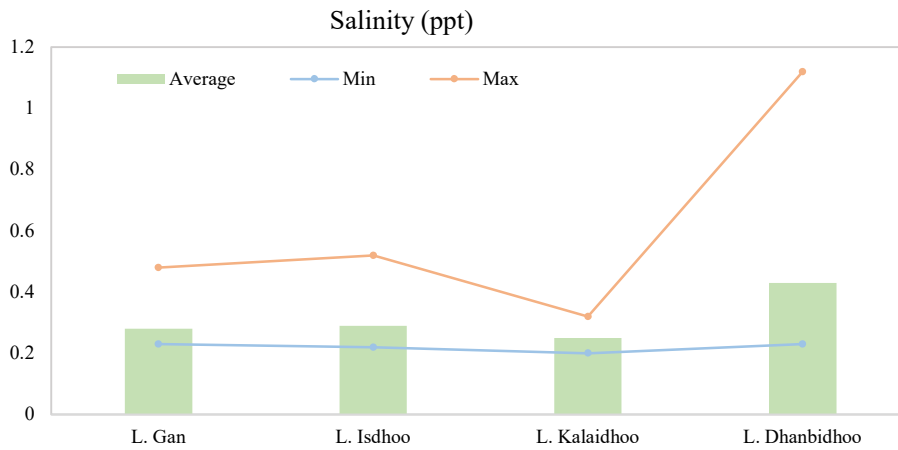
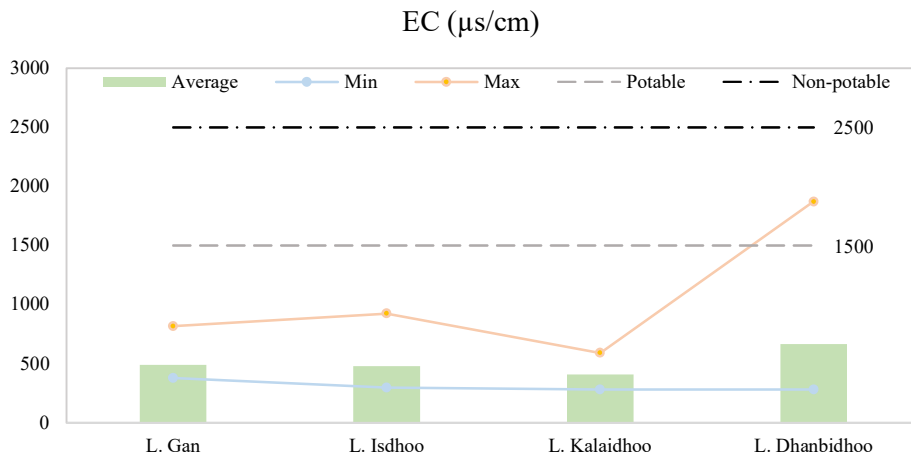
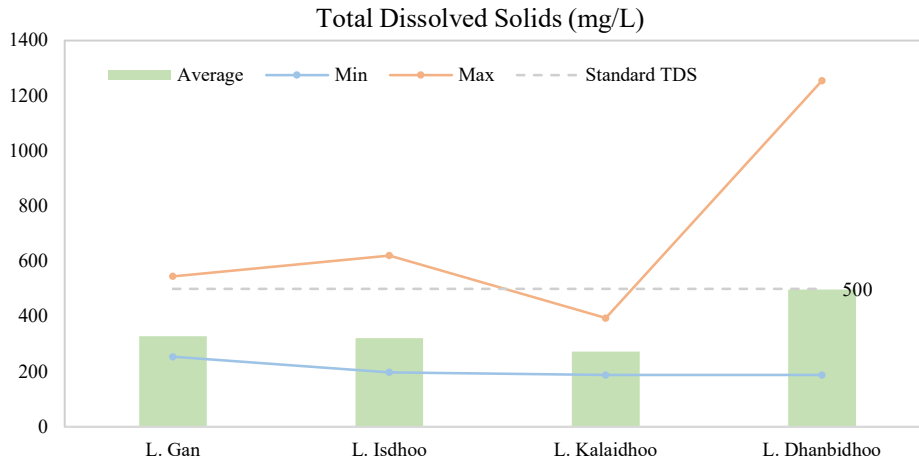
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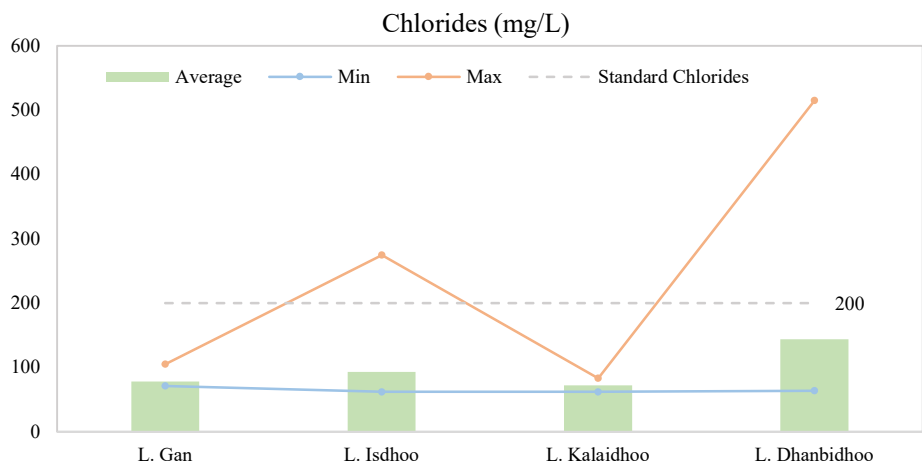
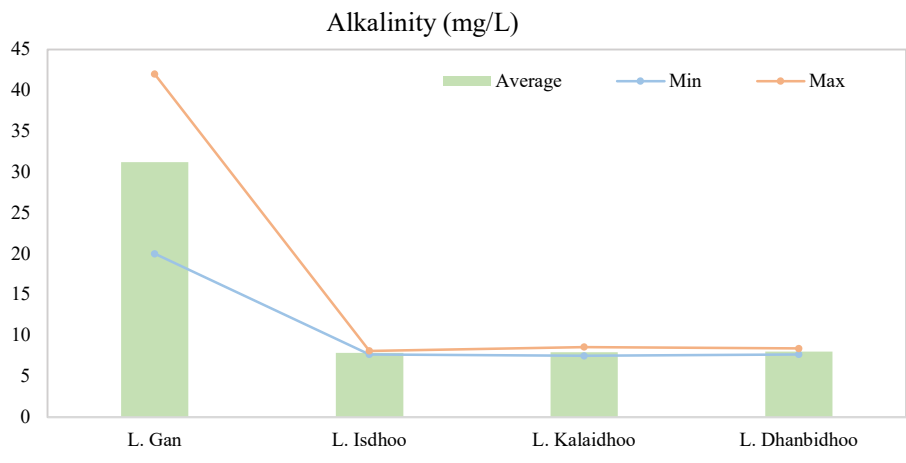
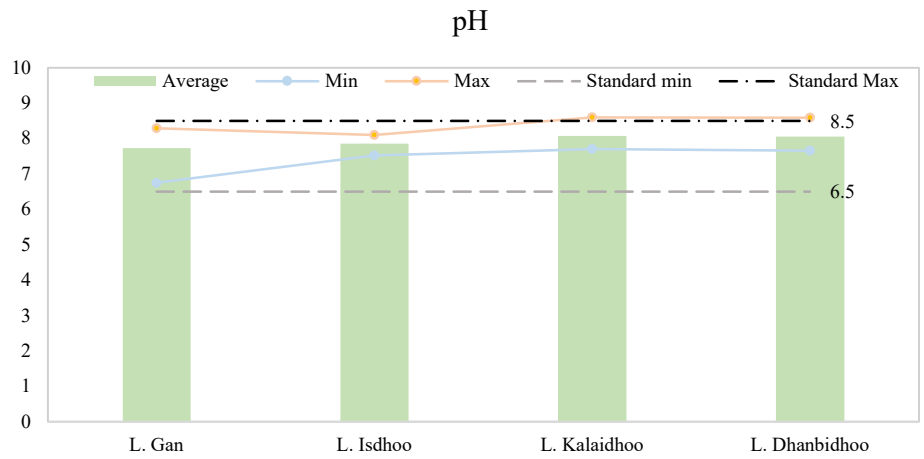
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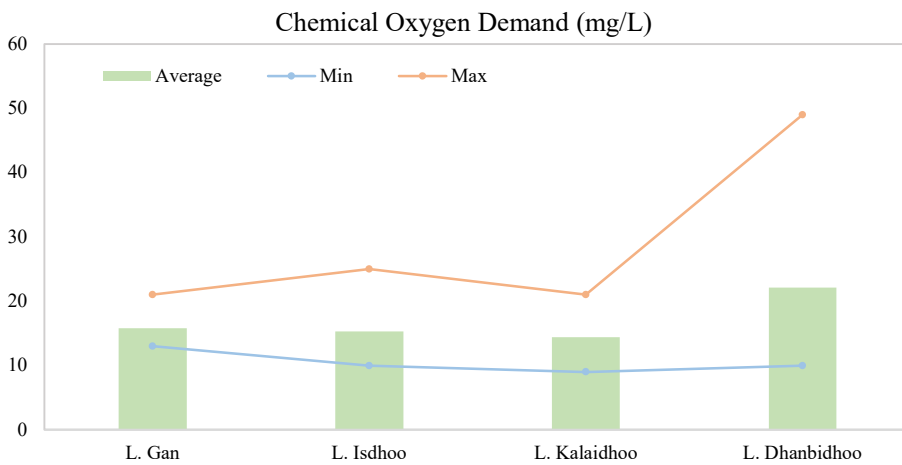
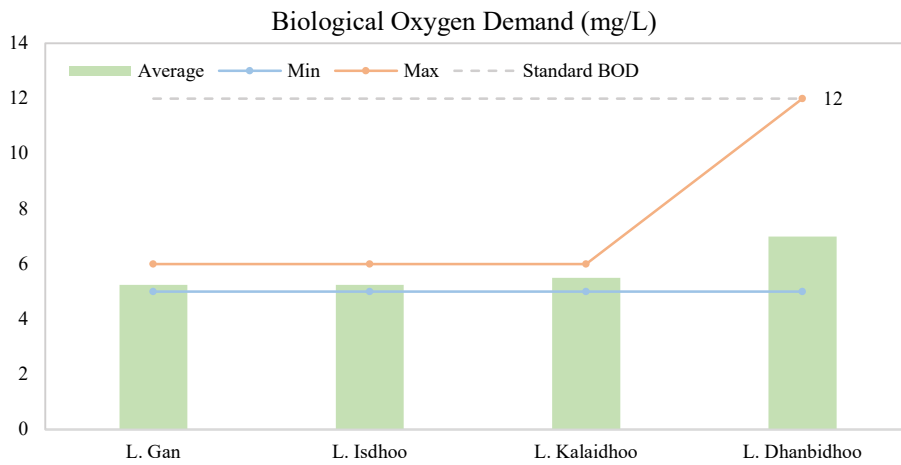
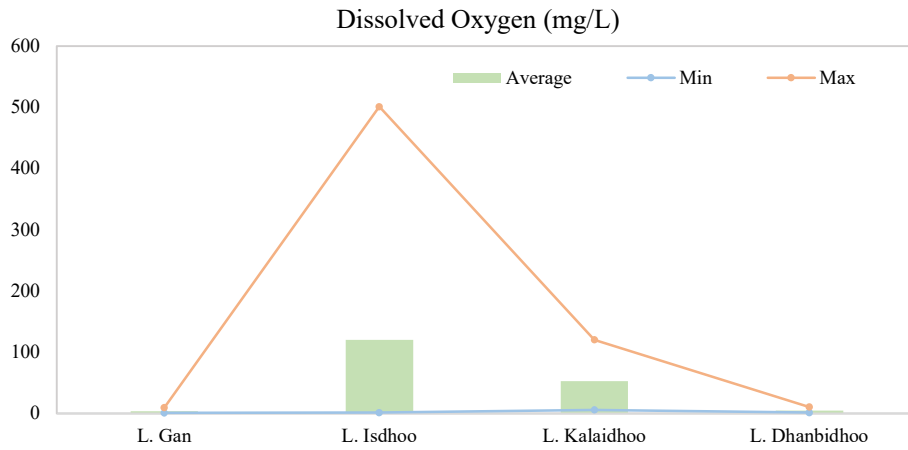


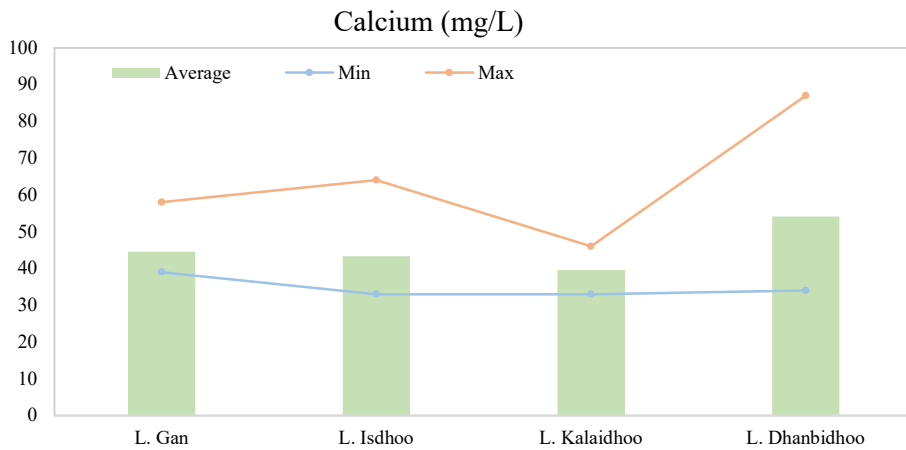
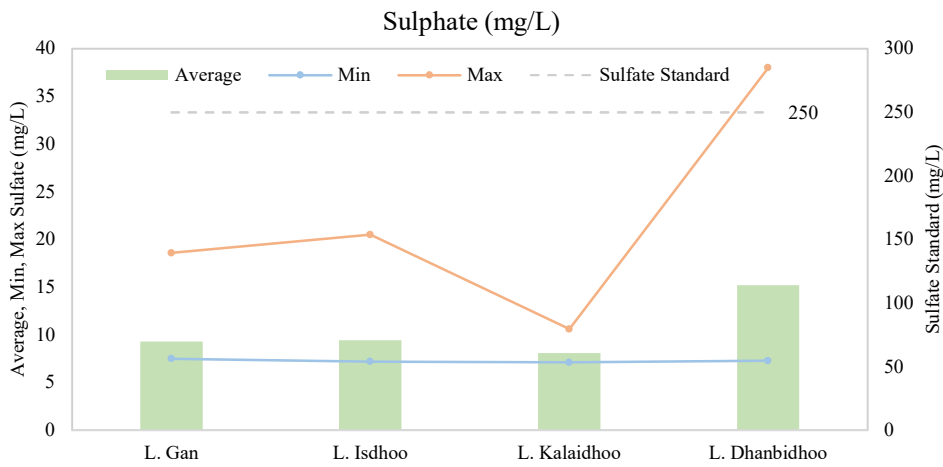
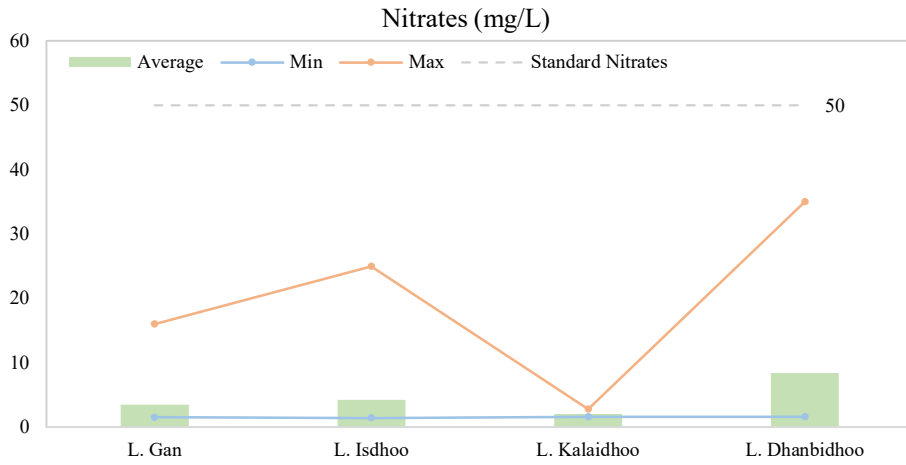


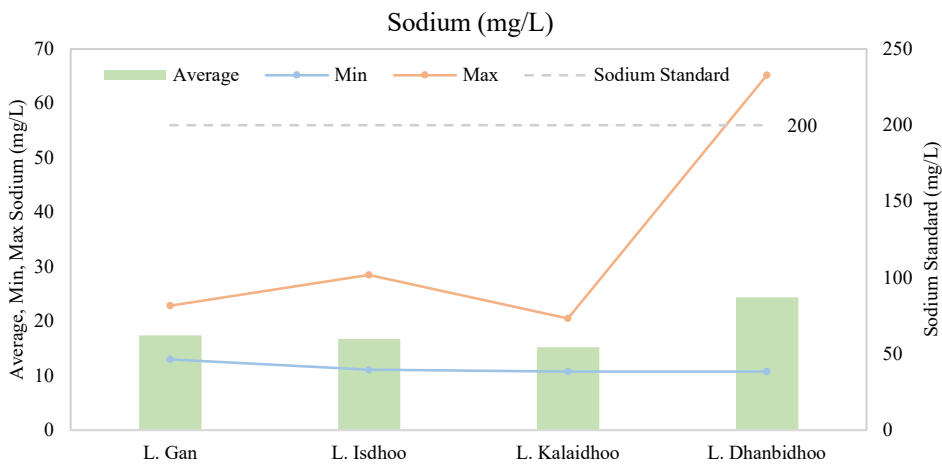
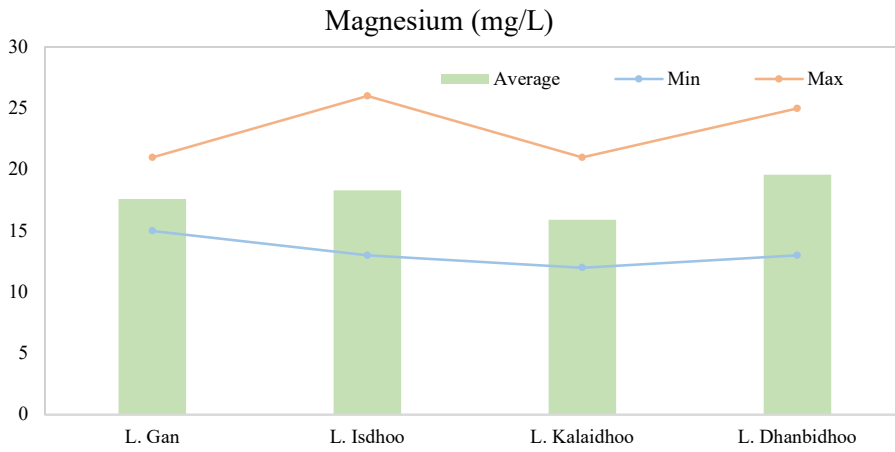
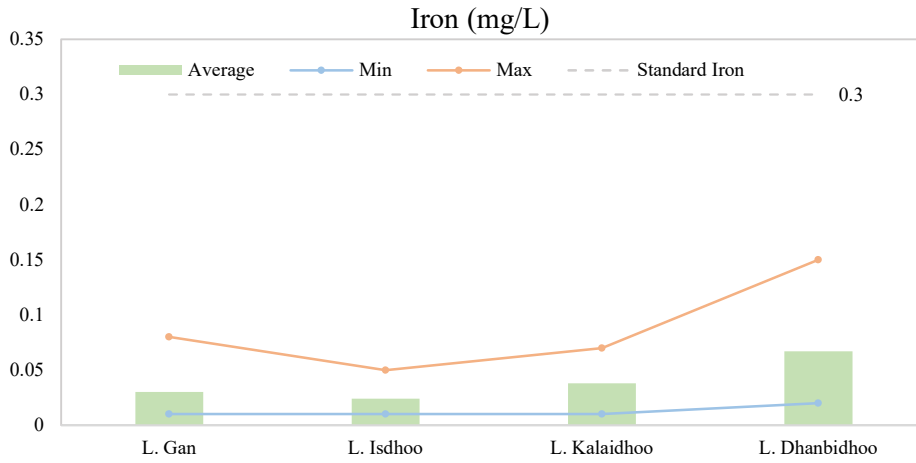




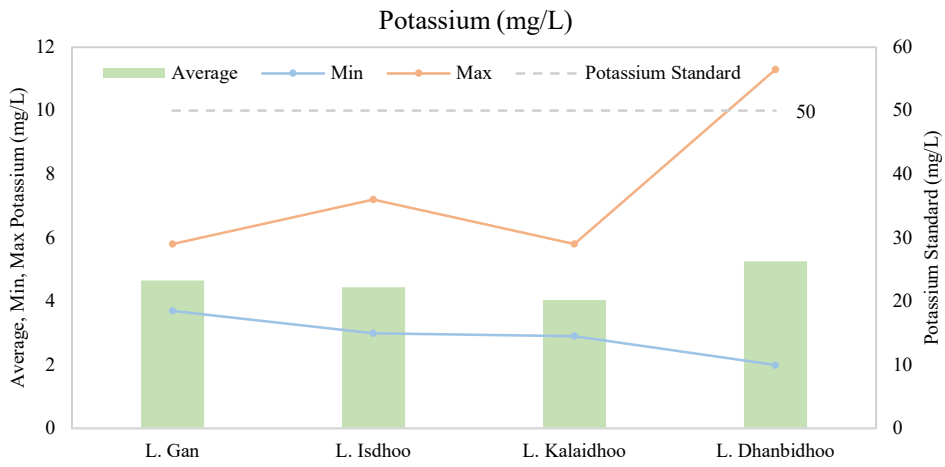








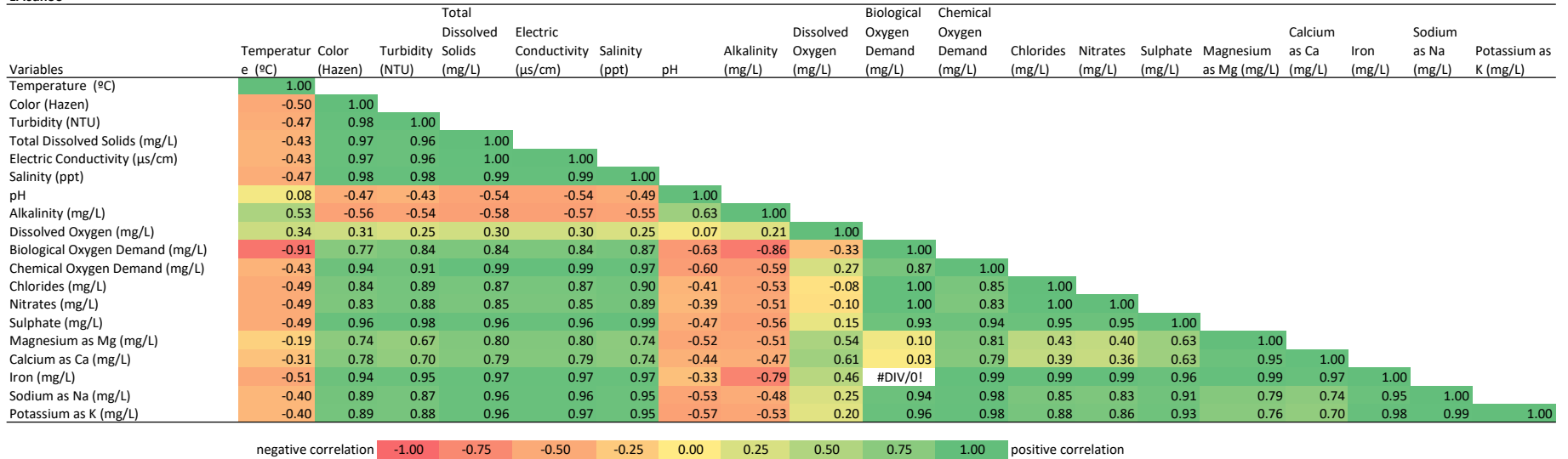




**L. Gan**



**L. Isdhoo**



**L. Kalaidhoo**



**L. Dhanbidhoo**





## Annex 6 – Framework for groundwater quality monitoring for agrochemical contamination

Prior to conducting fieldwork for water sampling, clear objectives should be set, and scope defined with study areas defined and confirmed. In the inception phase, stakeholder consultation and literature review should be carried out.

*The recommended parameters to test for agrochemical contamination, and their sampling and storage requirements are given in Table 1: Recommended parameters to test for agrochemical contamination.*

Parameter	Container*	Minimum Sample Size (mL)**	Preservation	Maximum storage recommended**	US EPA maximum allowed storage
<b>pH</b>	P, G	50	Analyze immediately, determine on site	<b>0.25 h</b>	<b>0.25 h</b>
<b>Phosphate</b>	G	100	Cool to $\leq 6^{\circ}\text{C}$ ,	48 h	48 h
<b>Nitrate</b>	P, G	100	Cool to $\leq 6^{\circ}\text{C}$	48 h	48 h
<b>Sulphate</b>	P, G	100	Cool to $\leq 6^{\circ}\text{C}$	28 d	28 d
<b>Pesticides</b>	G	1000	Cool to $\leq 6^{\circ}\text{C}$	7 d	7 d
<b>Potassium</b>	P, G	50	-	14 d	14 d
<b>Ammonia</b>	P, G	500	Cool to $\leq 6^{\circ}\text{C}$	7 d	28 d
<b>Electrical Conductivity</b>	P, G	100	Cool to $\leq 6^{\circ}\text{C}$	24 h	24 h
<b>Faecal Coliform</b>	S	100	Cool to $\leq 10^{\circ}\text{C}$ , do not allow samples to freeze	24 h	24 h
<b>Total Coliform</b>	S	100	Cool to $\leq 10^{\circ}\text{C}$ , do not allow samples to freeze	24 h	24 h
<b>E. coli</b>	S	100	Cool to $\leq 10^{\circ}\text{C}$ , do not allow samples to freeze	24 h	24 h

\* P = Plastic, G = Glass, S = Sterile

\*\* Sampling container, minimum sampling size and storage recommendations can differ for different laboratories based on testing method, as one parameter can have multiple methods of analyzing in the laboratory. To confirm, consult the laboratory where samples are sent to. Information sheets are available from local MWSC and MFDA laboratories.

Description of the parameters are given in Table 2.

*Table 1: Recommended parameters to test for agrochemical contamination.*

<b>Parameter</b>	<b>Container*</b>	<b>Minimum Sample Size (mL)**</b>	<b>Preservation</b>	<b>Maximum storage recommended**</b>	<b>US EPA maximum allowed storage</b>
<b>pH</b>	P, G	50	Analyze immediately, determine on site	<b>0.25 h</b>	<b>0.25 h</b>
<b>Phosphate</b>	G	100	Cool to $\leq 6^{\circ}\text{C}$ ,	48 h	48 h
<b>Nitrate</b>	P, G	100	Cool to $\leq 6^{\circ}\text{C}$	48 h	48 h
<b>Sulphate</b>	P, G	100	Cool to $\leq 6^{\circ}\text{C}$	28 d	28 d
<b>Pesticides</b>	G	1000	Cool to $\leq 6^{\circ}\text{C}$	7 d	7 d
<b>Potassium</b>	P, G	50	-	14 d	14 d
<b>Ammonia</b>	P, G	500	Cool to $\leq 6^{\circ}\text{C}$	7 d	28 d
<b>Electrical Conductivity</b>	P, G	100	Cool to $\leq 6^{\circ}\text{C}$	24 h	24 h
<b>Faecal Coliform</b>	S	100	Cool to $\leq 10^{\circ}\text{C}$ , do not allow samples to freeze	24 h	24 h
<b>Total Coliform</b>	S	100	Cool to $\leq 10^{\circ}\text{C}$ , do not allow samples to freeze	24 h	24 h
<b>E. coli</b>	S	100	Cool to $\leq 10^{\circ}\text{C}$ , do not allow samples to freeze	24 h	24 h

\* P = Plastic, G = Glass, S = Sterile

\*\* Sampling container, minimum sampling size and storage recommendations can differ for different laboratories based on testing method, as one parameter can have multiple methods of analyzing in the laboratory. To confirm, consult the laboratory where samples are sent to. Information sheets are available from local MWSC and MFDA laboratories.

Table 2: Description of recommended parameters

Parameter	Description
<b>Electrical Conductivity</b>	Electrical conductivity (EC) refers to the measure of a solution's ability to conduct an electrical current. It's a critical parameter used to assess the salinity or total dissolved salt concentration in soil or irrigation water. EC is measured in units of millisiemens per centimeter (mS/cm) or microsiemens per centimeter ( $\mu$ S/cm)
<b>pH</b>	In the context of agriculture, pH refers to the measurement of the acidity or alkalinity of soil or water. It's a crucial factor influencing the availability of nutrients to plants and the overall health of crops. The pH scale ranges from 0 to 14, with 7 considered neutral. Values below 7 indicate acidity, while values above 7 indicate alkalinity. Different plants thrive in varying pH ranges, and maintaining the appropriate pH level in soil and water is essential for optimal plant growth.
<b>Nitrate</b>	Nitrate is a chemical compound composed of nitrogen and oxygen ( $\text{NO}_3^-$ ). It's a form of nitrogen essential for plant growth, serving as a vital nutrient required for the synthesis of amino acids, proteins, and chlorophyll. Nitrate is a primary source of nitrogen for plants, playing a critical role in their development and productivity. However, excessive nitrate levels in soil or water can lead to various agricultural and environmental issues.
<b>Fecal Coliform</b>	Fecal coliforms are bacteria found in the intestinal tracts of warm-blooded animals, including humans, and are commonly used as indicators of water and soil contamination.
<b>Total Coliform</b>	Total coliforms are a broad group of bacteria that inhabit various environments, including soil, water, and the intestines of warm-blooded animals. Total coliforms can be naturally occurring in the environment.
<b>E. Coli</b>	Escherichia coli (E. coli) is a bacterium commonly found in the intestines of warm-blooded animals, including humans. Its presence in water suggests that the water may be contaminated with pathogens (disease-causing organisms) from human or animal waste.
<b>Phosphate</b>	Phosphate is a crucial nutrient in agriculture that plays a fundamental role in plant growth and development. Phosphorus runoff from agricultural lands can contribute to water pollution in surface water bodies. When excess phosphorus enters these water sources, it can promote algal growth and eutrophication, causing harmful algal blooms.
<b>Sulphate</b>	Sulphate is a natural component found in water bodies, originating from the weathering of rocks and minerals. It's commonly present in groundwater and surface water sources. Sulfate in the soil contributes to overall soil fertility. Sulfur helps maintain soil pH and aids in the breakdown of organic matter, releasing other nutrients that plants require for growth. Insufficient sulfur levels can limit crop yields and quality.
<b>Pesticides</b>	There are three types of pesticide testing that is generally conducted in water samples, organophosphate pesticides, carbamate pesticides and organochlorine pesticides. Organophosphates can be measured through testing of phosphates in water. Carbamate pesticides serve as insecticides, nematocides, and arachnidocides employed for pest management in agricultural crops, as well as for controlling insects in lawns and gardens. Their toxic nature stems from their capacity to function as enzyme cholinesterase inhibitors. Organochlorine pesticides are frequently found in waters impacted by agricultural runoff. These pesticides are known for their ability to accumulate in organisms over time and remain relatively stable. They also possess toxicity or carcinogenic properties.  Specific pesticides that are recommended to be tested: <b>Cypermethrin, Profenofos, Diazinon, Tebuconazole, Imidacloprid, Acetamiprid, Novaluron, Dinotefuran, Mancozeb, Azadirachtin, Copperoxychloride, Zabamec, Diafenthiuron, Propineb</b>



Parameter	Description
<b>Potassium</b>	Potassium is an essential macronutrient for plant growth and agricultural productivity. Elevated levels of potassium in water sources are generally not a concern for human health. However, excessive potassium levels can contribute to increased water conductivity, affecting water quality indicators, especially in areas with intensive agricultural activities or excessive fertilizer application.
<b>Ammonia</b>	Ammonia (NH <sub>3</sub> ) is a compound composed of nitrogen and hydrogen. Ammonia is used in the production of nitrogen-based fertilizers like ammonium nitrate and urea. These fertilizers provide a readily available nitrogen source for plants, aiding in their growth and development. Excessive ammonia in water bodies can negatively impact aquatic ecosystems, leading to toxicity for aquatic organisms like fish and altering the balance of the aquatic environment.

The specific pesticides that are recommended to be tested are shortlisted after checking the specific active ingredients in commonly used pesticide brands in Laamu Atoll as per the Baseline Report on Agricultural Practices in Laamu Atoll published by Ministry of Environment, Climate Change and Technology in 2023. However, it is recommended to do a broader range of pesticide testing for at least a few samples to ensure that no crucial specific pesticides are missed out on the shortlist of pesticides specified here.

Groundwater testing should be carried out **quarterly**, and ensure seasonal variations are recorded. The sample size should be determined based on island size, and number of agricultural plots. As a reference, from an area of 20,000 square meter of agricultural plots, at least 1 sample must be taken.

Sampling locations should be evenly distributed through the study area, and sampling points should be georeferenced. It is important to include a control sample to compare contamination levels between agricultural areas and other areas.

The sampling methodology should follow the quality control and quality assurance requirements set in Water Sampling Training Materials Report for sample collection, labelling, documentation, storage and transportation. Proper equipment for sample collection, handling, storage and transportation should be ensured, and personnel should be trained in proper sampling techniques to minimize contamination risks and maintain data integrity.

An accredited laboratory, laboratories with expertise in water quality testing and experience analyzing samples from similar environments, should be utilized for sample analysis.

All field data and analytical results should be compiled into a centralized database, and results compared to relevant national and international water quality standards. Tools such as Geographic Information Systems (GIS) should be utilized to map spatial variations in groundwater quality. Statistical analysis software such as SPSS or Microsoft Excel should be used to analyze data over time to identify trends or emerging issues.

In terms of reporting, comprehensive reports should be produced which include objectives, methodology, results, discussion, recommendations and conclusions. Data should be clearly presented in the form of tables, figures and maps. Report should be disseminated to relevant stakeholders, including government agencies, and atoll and island councils, and it should also be made accessible to the general public.