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DESIGN CRITERIA AND TECHNICAL  
SPECIFICATIONS - DESIGN AND  
CONSTRUCTION OF WATER TREATMENT  
AND SUPPLY SYSTEM

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**Environmental Protection Agency**

Ministry of Environment and Energy

-Water and Sanitation Unit-

# CONTENTS

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1. Description of Work .....	1
2 General Design Parameters .....	2
2.1 Fire Hydrants.....	3
2.2 Water storage .....	3
3 Water Supply Distribution System .....	4
3.1 Household Connections .....	5
3.2 Water Meters.....	5
3.3 Level Indicators .....	5
3.4 Sampling taps.....	5
3.5 Disinfection .....	5
3.6 Pumps .....	5
3.6.1 Control System.....	6
3.6.2 Pump controllers.....	6
3.6.3 Raw water intake .....	6
3.8 Dewatering.....	6
3.9 Reverse Osmosis Plant.....	6
3.10 Brine Disposal.....	6
4 Administration Building .....	7
5 Roads and hardstand .....	7
6 Stand-by Diesel Generator Set.....	7
7 Trial runs and commissioning .....	7
8 Record Drawings (As Built Drawings).....	8
9 Training of Personnel and Others .....	8
10 Manuals.....	8
11 Operation and Maintenance and spare parts.....	10
12 TECHNICAL REQUIREMENTS .....	10
12.1 General Requirements .....	10
12.1 Materials not others specified .....	10
12.2 Substitutions .....	11
12.3 Standard Specifications.....	11
12.4 Access to the private property.....	11
12.5 Water and Power Supply .....	11

12.6 Public Utilities and Other Services .....	11
12.7 Pre commencement photographs .....	12
12.8 Vegetation management .....	12
12.9 Setting out of Works .....	12
12.10 Cooperation at Site .....	12
12.11 Protection of Work and Public.....	12
12.12 Environmental Protection.....	13
12.13 Final Clearance of Site.....	13
13 Excavation .....	13
13.1 Backfilling .....	13
13.1.1 Topsoil.....	14
13.2 Pipe laying.....	14
13.2.1 Handling and Transportation of Pipes on Site .....	14
13.2.2 Pipeline Laying and Installation .....	14
13.2.3 Testing of Pipelines .....	14
13.3.4 Identification.....	14
13.3.5 Cleaning and Disinfection of Pipelines.....	14
14 Product Delivery, Storage and Handling.....	15
15 Concrete Works .....	15
15.1 Drainage .....	15
15.2 Footpaths .....	15
16 Electro Mechanical and Electrical Equipment .....	15
16.1 Electrical and Control Equipment .....	15
16.1.1 Workmanship, Materials and Standards .....	16
16.1.2 Indicator instruments .....	16
16.1.3 Indicators .....	16
16.1.4 Clocks .....	16
17 Inspection and Testing .....	17
18 INSTRUMENTATION, CONTROL, DATA MONITORING .....	17
19 Electrical Commissioning .....	17
19.1 General.....	17
19.1.1 Flow Rates.....	17
19.1.2 Level Switches .....	18
19.1.3 Overload Protection.....	18
19.1.4 Alarms .....	18

## 1. DESCRIPTION OF WORK

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The description of work which may be required under this Specification includes the following:

- (i) Initial/layout design of a water distribution network, collection and storage facilities, boreholes, reverse osmosis (RO) plant, sea outfall for brine disposal, administration and laboratory buildings, fencing and gate works, landscaping works, area lighting, hard standings etc. and any other associated works including but not necessary limited to soil testing, topographic survey, and surveying of ground invert levels, high and tide level dimensions and lagoon bathymetry.
- (ii) Final engineering design, procurement, and construction management, inclusive of, surveying, set out, shop testing of equipment and supplies, inspections, testing, trial runs and commissioning of all necessary mechanical, electrical, instrumentation, telemetry and control systems necessary for the successful, safe and efficient operation of the RO plant, preparation and submission of "As Built Drawings", and Operation Maintenance (O&M) and Health and Safety manuals.
- (iii) Supply and installation of all mechanical and electrical plant, water meters, house connections, equipment and spare parts in accordance with the approved design and these specifications including all pipe work, valves, cabling, laboratory equipment, office furniture and lockers etc., collection and storage facilities, water supply wells, pumps, back-up power generator, electrical instrumentation, control panels, switchgear, telemetry, fencing and gates etc. as necessary for the successful construction and safe and efficient operation of the water supply system.
- (iv) Construction of all civil engineering works and associated works in accordance with the approved design and these specifications including but not necessarily limited to site clearance, trenching, dewatering, grading and/or filling to the formation level, formwork, reinforcement, concreting, block-work, painting, roofing, installation of pre formed structures and closures, electrification, and access ladders and platforms, mobilization, temporary works, reinstatement of access, transportation and storage of materials as necessary for the successful construction and safe and efficient operation of the water supply system and RO plant.
- (v) Operator training of local personnel for operation and maintenance, and community training for those indirectly involved in the operations and maintenance of the water supply system.
- (vi) Operations and maintenance support.

## 2 GENERAL DESIGN PARAMETERS

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The projected population shall be estimated for a 35 year period. The population shall be estimated with reference to the relevant national census data and island population data. Transient and seasonal population will be estimated using the methodology recommended by the American Society for Civil Engineers

The contractor shall assess the projected population as mentioned. Based on projected population and EPA guidelines, required demand for water shall be calculated. Water demand for other sources such as hotels, schools etc. plus unaccounted for shall be taken into account.

The Water Supply Distribution Network shall be designed, considering appropriate peak factor (typically which shall be 1.5 times the maximum day demand or 2.25 times the average day demand). Adequate fire Fighting facilities shall be established in the island. The numbers of fire hydrant shall be calculated considering either about 10 numbers of hydrants per square kilometer or distance between two fire hydrants shall be typically 300 m.

RO Plant, Pumping Machinery and water supply wells shall be designed for Maximum Day Demand i.e. 1.5 times the Average day Demand. This peak factor figure may vary depending on the growth potential and development on the island.

The RO plants shall be designed for a minimum water consumption rate of 20liters per capita per day. This water consumption rate is primarily for drinking and cooking purposes only.

Additional demands for institutions shall be assessed separately as per actual. However, additional demand for industrial, commercial, institutional and parks and other uses shall be taken from following table. Unaccounted for provisions to be taken as 5-10 % of the Average Daily Demand. The water supply shall be continuous throughout the day.

<b>Source/ Development</b>	<b>Average Daily Flow L/unit</b>	<b>Unit</b>
Auditorium/theater	10-15 L/day	Seat
Automobile repair garage	300 L/day	Garage
Carwash – garage	1000 L/day	Garage
Bakery	1000 L/day	Bakery
Cafeteria	100 L/day	Seat
Mosque	20 L/day	Person

Community centre	10-15 L/day	Person
Health facility		Bed
Hospital	300 L/day	Bed
Laboratory	200 L/day	Laboratory
Manufacturing - industry	As per assessment	
Office building	500 L/day	1000 square feet
Dormitory – college or residential	150 L/day	Student
Residential – boarding house	150 L/day	Bed
Residential – 1 bedroom apartment	150 L/day	Per person
Residential – 2 -3 bedrooms apartment	150 L/day	Per person
Residential – guest house with kitchen	150 L/day	Per person
Restaurant – fixed seat	800 L/day	1000 square feet
School – day care center	20 L/day	Child
School - kindergarten	20 L/day	Child
School – elementary / junior high	20 L/day	Student
School – high school	25 L/day	Student

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### 2.1 Fire Hydrants

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The minimum pressure at the point of installation of fire hydrants shall not be less than 7 bars .The fire hydrant location and pressure shall be consistent with the fire hydrant regulation

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### 2.2 Water storage

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A minimum of 7 days of water demand shall be provided as water storage in the island. The water being supplied should not stay for more than 7 days in the storage tank.

For the purpose of the water distribution network system and storage facilities design a maximum depth of excavation shall not exceed 1.5 m

The design horizon for the water distribution network shall be for period of 35 years. The design horizon for all associated hardware included RO plant, pumps, generators etc. shall be for period of 15 years

Except where otherwise pipes, fittings, equipments, cables and all other materials used for the successful completion of the water supply systems shall conform to BS-EU standards or equivalent.

The supplier shall make available copies of standards together with their English translations for use during inspection and testing.

### 3 WATER SUPPLY DISTRIBUTION SYSTEM

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Fresh water to the island residents shall be fed through a pressurized network. Elevated reservoir or delivery pump or combination of both may be used to feed the pressurized network. The network consists of PE/HDPE pipe. All the pipe mains in the distribution network shall be of HDPE material and laterals shall be of PE. Pipes and fittings should conform to PN6 for working pressure and PN9 for test pressure.

Hazen William's equation may be applied for the design. Typically Hazen William Co-efficient of 120 shall be used.

The minimum size of the pipe in the water distribution system shall be 63mm. The water distribution network shall be designed typically for net minimum water pressure of 20 to 25 meters at the far end of the water distribution network. However, depending on the development and population growth on the island this figure can vary. The maximum pressure in the water distribution network shall not exceed 60-65 meters. The recommended average velocity is 1.2 m/s.

The cover over pipe in the water distribution network shall not be less than 0.6 meter, in some special cases where pipes having cover less than 0.6 meter shall be encased in concrete. Suitable bedding material preferably sand shall be provided for the water supply pipe.

The pipes, valves and specials if it is to be used on the road, shall withstand a live load of 25 tonnes.

There shall be horizontal and vertical separation between the water pipe and the sewer as per international standard to safeguard the drinking water from contamination.

Thrust blocks shall be installed on all bends and branches where pipes do not possess adequate tensile strength. Sluice valves shall be installed on all branch connections and on the delivery side of the main line tees. Line valves on pressure pipelines shall be flanged Ductile Iron for the line pressure and maximum different pressures across them.

The control valves shall be provided in the water distribution system for repair purposes. Provisions for Washout valves, Air valves shall also be made in the water distribution system. Valves on underground pipe work shall be in chambers. Valve spacing shall suit operational requirements for draining the main and disposing its contents.

Wash out valves shall be installed appropriately. The outlet shall be above any possible flood level to prevent contamination of the main. To comply with environmental requirements, wash outs may not be permitted to have a direct discharge to a water course.

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### **3.1 Household Connections**

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The pipe to be used for house connection shall be of PE/HDPE material and shall meet the pressure rating requirements. Single house will be fed with a minimum pipe size 18 mm. High rise buildings or multi-story buildings can be provided with 75-90mm as manifold for local booster system.

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### **3.2 Water Meters**

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All house connection shall be metered. Meters shall be placed at the interface between the public and private water system. Meters are located typically within the house premises 450-750mm from the boundary wall.

Bulk water meters shall be installed at entry of main reservoir, and outlet into the delivery main as a minimum. Production equipments shall also have bulk water meters installed.

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### **3.3 Level Indicators**

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All storage tanks shall be provided with external level indicators to prevent overflows during filling. Elevated and ground storage measurements shall be made by either external mechanical float switch level indicators or ultrasonic sensors/switches.

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### **3.4 Sampling taps**

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Sampling taps shall be provided at the entry and outlet of the water reservoir and at the reject line. Additional sampling taps minimum 2 nos for each square kilometers shall be provided to collect representative samples of water for monitoring purposes..

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### **3.5 Disinfection**

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Water and water storage facilities, associated piping, and ancillary equipment must be disinfected before use.

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### **3.6 Pumps**

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Two pumps minimum shall be installed which will operate alternatively as duty and stand-by. It is the intention that all pumps supplied and installed should be of the same make and type in order to simplify maintenance and spare part requirements.

Normal pump operation shall be controlled through an ultrasonic sensor or 'float-switches for low and high water levels alarms. The pumps are to be fitted with overload protection devices and thermal protection. A relay will automatically switch from duty to standby after each cycle.



Fittings typically used are PE.

All pumps shall have the followings as minimum:-

- 2 No. isolation valve of same diameter as inlet main shall be located on the water main in the pump station (incoming). The valve is to be a gate valve.
- 2 No. non return valves of swing check type with cast iron casing and bronze disc.
- 2 No gate valves as rising main isolation valves with cast iron casing and bronze wedge, anti-clockwise closure with non-rising spindles and terminate with a key operated stem cap (outgoing),

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### **3.6.1 Control System**

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Normal pump operation shall be controlled through an ultrasonic sensor or 'float-switches'.

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### **3.6.2 Pump controllers**

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Pump controllers shall be microprocessor or microcontroller based and designed to meet pumping station requirements

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### **3.6.3 Raw water intake**

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Raw water for the RO plant may be drawn from either sea or ground. Adequate raw water intake shall be designed and constructed following the Regulations for Installing and Operating Desalination plants in the Maldives and any other relevant EPA guidelines.

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### **3.8 Dewatering**

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All water removed during excavation for trenching and construction shall be disposed of inland from the excavation for re-percolation back into the water table as outlined in the EPA guidelines. Care shall be taken to avoid excessive de-watering that would cause damage or draw down of the fresh groundwater used for household use.

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### **3.9 Reverse Osmosis Plant**

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The RO plants minimum 2 nos, each having capacity of half of the maximum day demand, shall be fully assembled with all the necessary equipment and all the civil, electrical and mechanical works related to the same to ensure a fully functioning Plant.

Regulations for Installing and Operating Desalination plant in the Maldives, EPA shall be followed.

The quality of water produced and distributed shall conform to EPA water quality guidelines and standards.

Adequate protection and security for the machinery and equipments shall be provided through proper fencing or other means.

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### **3.10 Brine Disposal**

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Reject water from desalination process shall be disposed in accordance to the Desalination plant Regulation of EPA in the Maldives.

Outfall pipelines shall be High Density Polyethylene (HDPE) minimum class PN16 (nominal working pressure 1.6MPa or 160m head). A t-head diffuser shall be installed at the termination point of the outfall

The Contractor shall minimise all impacts on the coastal and marine environment as stated in the EPA guidelines.

## 4 ADMINISTRATION BUILDING

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An administration building shall be located at the site of the RO plant and should have a minimum covered 1500 square meters. The administrative building must have the following facilities:

1. An office space
2. laboratory
3. Generator room
4. Equipment storage
5. Vehicle parking space
6. Electrical mechanical instruments repair workshop

## 5 ROADS AND HARDSTAND

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Roads and hardstand shall be designed for a minimum twenty five (25) tons loading.

## 6 STAND-BY DIESEL GENERATOR SET

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A fixed back-up electric power generator unit, make of international repute shall be supplied to provide stand-by electric power in case of island power network failure and shall be equipped with a 3m water proof cable and socket for power transfer. Generator shall be sound attenuated.

The generator shall be capable of providing energy sufficient to operate RO plant and distribution pumps in case of power failure or during emergency.

Reasonable spare parts and replaceable fittings for the stand-by generator and associated equipment shall be provided by the supplier to ensure proper and trouble free operation and maintenance for a period of at least 1 year.

## 7 TRIAL RUNS AND COMMISSIONING

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After execution of works a trial run of borehole pumps, RO plant, collection and storage tanks, water supply distribution network shall be undertaken to demonstrate satisfactory performance of the system. In the event that the plant or any of the facilities do not satisfactorily achieve the required performance standards during this period, the trial run period shall be extended until all deficiencies are satisfactorily rectified.

Completion of the successful trial run of raw water intake, RO plant, collection and storage tanks, water supply distribution network, reject water disposal and the physical completion of all other Works shall be achieved before commissioning. Commissioning shall be undertaken of the entire works inclusive of all necessary mechanical, electrical, instrumentation, and control systems. The commissioning shall be undertaken by operating the system 24 hours continuously as a fully integrated system. The trial run period shall be extended until all deficiencies are satisfactorily rectified. Commissioning of the plant will be deemed to be completed after the plant has been operated trouble free.

## **8 RECORD DRAWINGS (AS BUILT DRAWINGS)**

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Reproducible drawings of the whole works "as constructed" (As-Built) shall be provided. The drawings shall be produced to a standard similar to that of the Construction Drawings and shall be provided to the relevant authority with 3 months of the physical completion of works.

Record drawings shall include the positions and extent of all support construction left in any excavations and exact locations of all services encountered during construction. Record drawings shall be prepared and approved by an engineer as the work proceeds and shall be handed to the relevant authority on completion.

## **9 TRAINING OF PERSONNEL AND OTHERS**

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A 3 months comprehensive training program facilitated by a skilled operator will be provided for local operations and maintenance personnel following the signing of handing over Certificates. The training shall include practical training on all aspects of the operation, maintenance and routine repair of the whole water supply system, equipment and facilities under normal and special operating conditions. The training shall include but is not limited to training related to process, mechanical, electro-mechanical, electrical, instrumentation and control equipment supplied and installed.

For the purpose of training to maintain the said facilities and equipment, proper training manuals based on operation and maintenance manual and checklists shall be provided.

An awareness and training program for the Island community, Island Office staff, utility company staffs and other personnel that may be directly involved with the maintenance of water supply system shall be provided. The awareness program should include aspects related to community participation during the construction since most of the work will be executed within or close to the houses and properties to be connected.

## **10 MANUALS**

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The Contractor has to submit an operation manual after the physical completion of the Work. This manual will be submitted as draft at the date of physical completion and as final version 1(one) month after commissioning, including all the experiences made during the tests and the training given to the operators during the commissioning period. This manual will be established by the Contractor in cooperation with his suppliers and subcontractors and after consultation with the Project Manager for the detailed contents. It will contain at least:

- a) General description of the plant and its functioning
- b) Step-by step procedures for all operation requirements and adjustments
- c) Mechanical, electrical, instrumentation, piping drawings, sections, details, charts
- d) Nomenclature and nomenclature schedule of all the equipment (mechanical, electrical, instrumentation, power and signal cables, electrical and sanitary fixtures)
- e) For each item of the equipment:
  - drawing, section, exploded drawing
  - operation instructions
  - calibration charts (if required)
  - fault identification and location guides and charts
  - repair instructions (if repair by operators is possible)
  - maintenance instructions including type and quantity of lubricants
  - spare parts list with addresses and procedures for ordering
- f) Preventive maintenance schedules for all the equipment, showing the type and frequency of maintenance of different items.
- g) Type and quantity of the recommended consumables (lubricants, fuels, etc.)
- h) Emergency management for specimen emergency situations which might occur due to external or internal factors
- i) Logs for the operators of the system
- j) operating hours
- k) salient indicators of the operation
- l) maintenance operations
- m) faults and actions taken
- n) other events
- o) Address and telephone number (Hotline) to contact in case of operation problems

It is emphasized that a collection of standard literature of a general nature, unaccompanied by specific drawings and descriptive matter relating to the Work as commissioned, shall not be acceptable.

The operation manual shall be bound in one or several loose leaf binders designed to prevent loss and damage of the contents. The binders shall be titled, numbered and have a table of contents of all information contained.

## 11 OPERATION AND MAINTENANCE AND SPARE PARTS

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Operation and maintenance of the constructed, hydraulically tested and successfully commissioned water supply systems along with electrical and mechanical equipment and instrumentation shall be provided for a period of one year from the date of final completion during which period all chemicals and consumables operating and maintenance staff shall be provided.

Reasonable spare parts, replaceable fittings and chemicals for the RO plant and the standby power generator provided by the supplier(s) to ensure proper and trouble free operation and maintenance for a period of 1 year.

Any accessories and spare parts and consumables which are not specifically mentioned in these specifications, but which are usual or necessary for the successful performance of the system shall be provided over the defects liability period.

To the maximum extent practical and feasible, supply of plant and equipment shall be standardized on the manufacture so as to minimize the operation and maintenance requirements.

All plant and equipment which require routine and periodic maintenance shall be and installed in a manner which will facilitate such operations.

If at any time during testing, commissioning or defects liability period, any of the quality and process parameters cannot be reached, all necessary modifications to the civil structures, the mechanical, hydraulic, electrical and other components of the plant, or modify the operation procedures and the chemical dosing parameters in order to achieve the required performance of the plant.

The defects liability period shall typically be one year from the date of final completion.

Provide operational procedures with relevant log sheets and preventive maintenance schedules. Details of where the spare parts can be purchased including manufacturer address and contact details.

## 12 TECHNICAL REQUIREMENTS

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### 12.1 General Requirements

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Where this specification refers to approval for acceptance of materials, supplies, workmanship, execution of works, and tests it has to be approved by an engineer or such a person who is suitably qualified, experienced and employed for the purpose of giving such approvals.

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#### 12.1 Materials not others specified.

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Unless otherwise specified, all materials and plant incorporated in the permanent work shall be new. Materials not otherwise designated by detailed specifications shall be of the best commercial quality and suitable for the purpose intended.

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### **12.2 Substitutions**

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Substitution of materials other than those specified will only be approved by if the material proposed for substitution is equal or superior to the material specified; or that the material specified cannot be delivered to the work site in time to complete the work. To receive consideration, request for substitution shall be accompanied by documentary proof of quality in the form of certified quotations and guaranteed date of delivery from suppliers of both the specified and the proposed substituted materials.

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### **12.3 Standard Specifications**

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Except as otherwise indicated in these Technical Specifications, the all Works undertaken shall comply with the latest adopted edition of the Standard Specifications as used by the Ministry of Housing and Environment (MHE) or other relevant authorities.

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### **12.4 Access to the private property**

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Written permission of the property owner and the Island Office must be obtained for entry on to private property and to obtain the rights of way for the laying of house laterals.

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### **12.5 Water and Power Supply**

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Water required for general use may be drawn from groundwater wells such that it should not cause an intrusion of saline water from below or adverse effects on adjacent property wells. Where ground water is not suitable for concreting work allowance shall be made for acquiring sufficient quantities for use in concreting work either from rain harvesting or desalination.

All water pumped or drained from the works shall be directed through settlement tanks of adequate capacity to remove silt before being disposed of in an approved manner and location. Groundwater will not be discharged to the sea unless if disposed of into the groundwater water table its salinity would be detrimental to that groundwater.

Where pumped or drained groundwater is suspected of being saline its electrical conductivity should be tested before determining the manner and location of disposal.

Arrangements may be made with the island office for the supply of temporary electricity services during construction. Where connection from local mains is not possible allowance shall be made for a suitable generating plant.

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### **12.6 Public Utilities and Other Services**

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All utility and service providers (i.e. electricity, telephones, cable TV, etc.) shall be consulted with prior to commencing any excavations, have utility lines located and marked in the field, and have all rights-of-way cleared through the Island Office.

Arrangements for diversion or removal of services may be required because of the proposed method of working.

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### **12.7 Pre commencement photographs**

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Colour photographs at locations of the works should be taken prior to commencement of works to demonstrate conditions of the site before work commences progress, during the construction period and after completion of the works.

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### **12.8 Vegetation management**

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All works should avoid un-necessary disturbance or removal of garden plants and trees. Only the removal of plants and trees totally necessary for the construction of the works shall be permitted.

Only the approved working area required for laying of pipelines and construction of collection and storage facilities and treatment facilities shall be cleared of shrubs, plants, bushes, large roots, rubbish and other surface materials. All such materials required to be removed shall be disposed of in an approved manner. All trees and shrubbery that are to remain shall be adequately protected and preserved in an approved manner.

Approval may be required from the Island Office for the rights of way, for which a provisional sum may be allocated for replacement or compensation.

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### **12.9 Setting out of Works**

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Working or construction lines and grades shall be established as required. Stakes and other such materials shall be provided and maintained. All points, stakes, grade marks and bench marks made or established on the work, shall be safeguarded. Any work done beyond the lines, levels and limits shown on the drawings shall be rectified.

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### **12.10 Cooperation at Site**

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All work shall be carried out in such a way as to allow access and afford all reasonable facilities to persons including others who may be employed in the execution and/or operation at or near the site of any work in connection or otherwise.

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### **12.11 Protection of Work and Public**

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Precautions shall at all times be exercised for the protection of labor employed and public life and property at and around the sites of work. The safety provisions of applicable laws, building and construction codes shall be observed. Machinery, equipment and all hazards shall be guarded against or eliminated.

During the execution of the work, and maintain during the night time barriers and lights shall be erected so as to effectively prevent accidents. Barricades, red light "Danger" or "Caution" signs and watchmen shall be placed at all places where the work causes obstructions to the normal traffic or constitutes in any way a hazard to the public.

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### **12.12 Environmental Protection**

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All necessary actions shall be taken to ensure that the local environment is protected and that groundwater, soil and air are kept free from pollution (including noise) due to the works being undertaken.

An Environmental Management Plan based on the monitoring requirements of the approved Environmental Impact Assessment report shall be implemented for both construction and operations phases.

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### **12.13 Final Clearance of Site**

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On completion of work, all constructional plant, surplus materials, rubbish, scaffoldings and temporary works of every kind shall be clear away and removed from the site leaving whole of the site and works in a clean condition.

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## **13 EXCAVATION**

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During excavation material suitable for backfilling shall be stockpiled in an orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent sides from caving in.

Topsoil shall be stockpiled separately, for subsequent reuse as necessary. All excavated material unsuitable or not required for backfilling shall be removed to an approved location.

Excavation in the streets shall be carried in such a manner that street passage is not blocked by excavated material. Measures should be taken to warn the traffic and people using the stretch of the road where the pipes are being laid. Special care shall be taken with existing subsurface services likely to be encountered during the execution of work which require special precaution for their protection, such as sewers, drain pipes, water mains, electric cables, telephone cables and the foundations of adjacent structures.

Unsound material or soft spots naturally occurring in the bottom of any excavation shall be removed and disposed of and the resulting void shall be filled with a suitable material or concrete.

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### **13.1 Backfilling**

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Backfill material for structures and trenches shall consist of excavated soil which is free from stones and clay lumps larger than 75mm in any dimension and also free from timber, rubbish and other debris. It shall exclude clay of liquid limit greater than 80 and/or plastic limit greater than 55 or materials of



excessively high moisture content. Backfill material shall have enough moisture for proper compaction, and shall be compacted in an approved manner.

For pipes bedded on the trench bottom, or on a sand or granular bed, selected backfill material free from vegetable matter, building rubbish, stones, etc. shall be placed in unconsolidated layers of 150 mm thickness, and then uniformly compacted. Compacted backfilling will be required for the full depth of the trenches. Well compacted back filling should reach at least 95% of Maximum Dry Density.

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### **13.1.1 Topsoil**

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Topsoil which has been stockpiled during excavation may be required for the top 150mm of backfill. In such circumstances the topsoil shall be saturated with fresh groundwater and after it has dried, shall be spread to the required final grade.

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## **13.2 Pipelaying**

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### **13.2.1 Handling and Transportation of Pipes on Site**

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Plastic pipes shall be handled with care at all times, while transporting to the site of work, and while installing. The pipes should be kept stored in a cool place free from sunlight. No cracked, broken or defective pipe shall be used in the work.

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### **13.2.2 Pipeline Laying and Installation**

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All pipe laying shall be carried out according to the standard code of practice. The pipe shall be laid directly on the selected bedding materials properly compacted.

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### **13.2.3 Testing of Pipelines**

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Pipelines shall be tested on in-situ to ensure:

- water tightness

Should the pipeline fail to meet the relevant performance standard, defects or leaks shall be remedied. In certain cases excavation and replacement of the sections concerned may be required.

Testing will be repeated as soon as the repair works have been completed.

The water used for the above test shall be obtained from an approved source.

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### **13.3.4 Identification**

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Continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping shall be installed. Equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel shall be attached permanently.

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### **13.3.5 Cleaning and Disinfection of Pipelines**

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Upon completion of laying and jointing the interior of the pipes shall be thoroughly flushed to remove remaining traces of foreign matter and thereafter maintained in such condition. Disinfection shall be done following standard code of practice using any suitable disinfectant chemical. The distribution pipe network shall be flushed prior to disinfection with clean potable water until dirty water does not appear at points of outlet.

## **14 Product Delivery, Storage and Handling**

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Transportation of any material shall be by suitable vehicles which when loaded does not cause spillage and all loads shall be suitably secured. All vehicles must comply with this requirement or any local traffic regulations and laws.

All materials and equipment when delivered shall be stacked and stored in a manner suitable to protect them against slippage, damage, breakage, pilferage etc.

The following must be observed:

A. Delivery of Materials: Piping materials shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.

B. Storage: Piping materials shall be carefully stored in a manner that will prevent damage and in an area that is protected from sunlight and other harmful elements.

## **15 Concrete Works**

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All concrete works shall be done following standard code of practice. Only materials of appropriate quality shall be used in concrete works.

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### **15.1 Drainage**

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Adequate drainage system shall be constructed at RO plant and administrative building sites to minimize the risk of water logging.

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### **15.2 Footpaths**

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The formation and sub-grade for footpaths shall be prepared as specified for roads, except that profile rolling will not be required. Edging to footpaths shall be of pre-cast concrete or any suitable alternative materials.

## **16 ELECTRO MECHANICAL AND ELECTRICAL EQUIPMENT**

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Where appropriate pump/ heavy equipment lifting device should be provided to enable lifting and maintenance activities.

### **16.1 Electrical and Control Equipment**

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### **16.1.1 Workmanship, Materials and Standards**

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Generally all materials and standards shall comply with the relevant requirements of the appropriate local electrical regulations for the Maldives. When no such specification is available, the relevant ISO Standard shall apply. Materials and workmanship throughout shall be in accordance with the generally accepted best practice for projects of this type and scope.

Compliance certification, documentation, testing and metering is required.

Connections shall be made to the point of supply and power supply cables run to the main electrical control panel in accordance with the requirements of the power authority. All cables and necessary fittings and accessories shall be selected in accordance with the relevant regulations.

All electrical and mechanical equipment shall be earthed and bonded in accordance with the requirements of the Electrical Wiring Regulations.

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### **16.1.2 Indicator instruments**

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All indication instruments shall have performances in accordance with relevant ISO standards.

Level indicators shall be scaled vertically, alarm levels being indicated by red areas.

Motor current ammeters shall have red lines or movable pointers to indicate motor full load current.

Ranges shall be arranged so that the normal working point is between 50% and 75% of full-scale deflection.

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### **16.1.3 Indicators**

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Digital indicators shall be colour LCD /LED / FLUOROSCENT. Input shall be 4-20 ma dc or pulse input/potential free contact. The indicator must read zero at zero (process) input readings shall be direct without using conversion factors other than multiples of ten, which shall be clearly indicated. Figures shall be 14mm gauge visible up to 12 metres.

At least two Programmable alarm contacts shall be provided for high or low alarms. Steadiness of readout is more important than high speed accuracy and updating of figures is not required more than once in three seconds. Each alarm condition shall be indicated on an alarm annunciator. The flashing of more than one annunciator shall be synchronous to minimise confusion between fast and slow flashing of multiple alarms.

All instruments shall wherever possible be hermetically sealed. If this is not possible they shall be enclosed in moisture and dust proof casing.

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### **16.1.4 Clocks**

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A digital 24 hr. synchronous clock having numerals no less than 100mm high shall be fitted at the top center of the Main Instrument Panel.

## 17 INSPECTION AND TESTING

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Tests shall be carried out on all equipment in accordance with the appropriate ISO unless otherwise specified.

## 18 INSTRUMENTATION, CONTROL, DATA MONITORING

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The complete ICDM shall have system uniformity, subsystem compatibility and co-ordination of all system interfaces. Provide all necessary equipment components and interconnections and the services of the manufacturers, engineering representatives for the engineering, implementation, installation, calibration, validation commissioning operation and instruction to ensure that the end user receives a completely integrated and operational ICDM as herein specified. All equipment shall operate with 240 V +10%, -15% 50 HZ ac. The design and quality of all instruments sensors and controllers and other equipment shall be fully suited to the conditions, which will be met in service.

All voltage circuits to instruments shall be protected by MCB's in each unearthed phase of the circuit placed as close as practicable to the main connection. Metal oxide varistors and surge arrestors shall be provided to protect against abnormal voltages. Control voltages used shall be selected to suit the particular application of the instrumentation equipment.

Indicating instruments shall be designed to measure and indicate the quantities using the following units:

- Flow l/s Litres per second
- Level m Metres
- Pressure head of water m.hdMetres, Temperature °C Degree Celsius, Concentration p.p.m Parts per million, Current A Amperes
- Voltage V Volts
- Power W Watts
- Electrical Energy Whr Watt-hours Frequency Hz Hertz
- Speed r.p.m Revolutions per minute

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the scheme in order to facilitate maintenance and the stocking of spare parts. Instruments of the same type and range shall have identical scales.

## 19 ELECTRICAL COMMISSIONING

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### 19.1 General

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The pumps, controls, electrical system and pressure discharge pipes shall be proven to perform satisfactorily.

#### 19.1.1 Flow Rates

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Testing shall include confirmation of the flow rates and the measured delivery heads of all the pumps. This test may be carried out with clean water for measurement purposes. The pumps shall also be demonstrated to show satisfactory operation.

The pump testing shall include:

- a) carrying out three draw down tests on each pump, recording:
- b) carry out three closed head tests on each pump recording:

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#### **19.1.2 Level Switches**

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Demonstrate the correct operation of all level switches.

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#### **19.1.3 Overload Protection**

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Demonstrate the correct operation of motor protection devices.

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#### **19.1.4 Alarms**

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Demonstrate the correct operation of all alarms.

*NOTE: Also please refer to the cable standards and the MEA regulations attached with this document*