DESIGN CRITERIA AND TECHNICAL SPECIFICATIONS FOR CONVENTIONAL GRAVITY SEWERAGE SYSTEMS

Environmental Protection Agency

CONTENTS

1. DESCRIPTION OF WORK

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

(i) Initial/layout design of a sewerage collection network, pump stations, pumping main, waste water treatment plant, marine outfall, sludge drying beds, 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 and control systems necessary for the successful, safe and efficient operation of the treatment 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, equipment and spare parts in accordance with the approved design and these specifications including all pipe work, valves, penstocks, cabling, laboratory equipment, office furniture and lockers etc., air-blowers, lift pumps, sludge pumps, filter feed pumps and effluent delivery pumps, back-up power generator, vehicle mounted sewer jetting machine, electrical instrumentation, control panels, switchgear, fencing and gates etc. as necessary for the successful construction and safe and efficient operation of the conventional gravity sewerage system and wastewater treatment plant.

(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 conventional gravity sewerage system and wastewater treatment 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 conventional gravity sewerage system.

(vi) Operations and maintenance support.

2. GENERAL DESIGN PARAMETERS

The projected population shall be estimated for a 30-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 (Gravity sanitary sewer design and construction).

For the purpose of estimating Average Dry Weather Flow (ADWF) the following waste water flow rates shall be used:

Source/ Development	**Average Daily Flow L/unit**	**Unit**
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 center	10-15 L/day	Person
Health facility	200 L/day	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

Note: 70 to 80 percent of the water consumption rates mentioned in the above table shall be used in calculating the sewage flows.

For the purpose of estimating Average Wet Weather Flows (AWWF) infiltration shall be 10% of ADWF.

For the purpose of estimating Peak Wet Weather Flow (PWWF) the Average dry Weather Flow shall be multiplied using a peak flow factor given by Babbits formula and plus infiltration.

$$Peak\ wet\ weather\ flow\ (design\ flow) = Avg\ dry\ weather\ flow \times peak\ factor + infiltration$$

For the purpose of laying of sewer pipes the maximum depth of trench should not exceed 2.5m and for the purpose of construction of lifting stations /pumping stations, the depth of excavation should not exceed 3.5m from the ground level.

The design horizon for the sewerage collection network shall be for period of 35 years. The design horizon for all associated hardware included pumps, generators blowers etc. shall be for period of 15 years (pump replacement may be for a lesser period). The design ***concept for*** the sewage treatment plant shall be based on two modular configurations to serve up to 35 years.

Typical Raw Sewage quality is taken as:

$BOD_5$20°C	250-350mg/l
COD	200-400 mg/l
SS (suspended solids)	250-300 mg/l
Fecal Coliforms	10^5-10^7/100ml

Note: for details on the sewage quality parameters (influent/effluent), refer to General Guidelines for Domestic wastewater Disposal by MWSA
Telemetry is not typically installed on conventional gravity sewerage systems on islands outside of Male', however, there may be circumstances where some or all sewerage pump stations will require such equipment. In such cases a general specification has been provided in Appendix X to provide guidance to the design engineer on the type of telemetry system and configuration of such which may be appropriate.

2.1 Velocity

The conventional gravity sewerage system design shall be based on a velocity of at least 0.60m/sec, for all depth of flows in the sewer.

Manhole / Access Chamber spacing of not more than 60m and shall be provided at street crossings, change of slope, change of size/direction of street sewer. The manhole shall be of plastic material like uPVC or HDPE. The main sewer pipes shall be manufactured of uPVC minimum of 160mm.The lateral sewer pipes shall be manufactured of uPVC minimum of 110mm

Pipe Sewer and fittings
The pipe sewer and fittings shall be of uPVC or HDPE material.
Pipes for gravity sewers and drains shall have a wall thickness and stiffness to satisfy SDR 35/41 classification.

The color of PVC pipes used for gravity main shall be brown. Blue color pipes shall not be accepted for use in conventional gravity sewerage systems.

Household Connections
The house connection pipe shall be manufactured of uPVC and the minimum size shall be110mm, pipes greater than this size should be justified through calculations for multi-story buildings, schools, hospitals etc.

Inspection Chambers
Pre-fabricated street access chambers shall be manufactured from material that is non-biodegradable and resistant to salt and acidic substances typically PP, PE. Or uPVC. The minimum size of the inspection chamber shall be 450mm.

Manhole Openings, Covers and Frames
Street manhole and manhole covers and frames shall have minimum clear openings of 600 mm diameter: Covers located in roads shall be made for heavy duty use only. preferably be double triangular loosely coupled with bolts. Covers located in the road verge, protected from heavy vehicle wheel loading shall be made for medium duty use.

All street manholes and manhole covers' and frames shall incorporate a suitably secured gas tight GRP and ABS sealing plate. A heavy grease seal is to be formed between the cover and frame to prevent the ingress of sand and water.

- Manhole covers shall be closed.
- Manhole covers shall have cast into the surface: - "Sanitary Sewer".

2.2 Sewage Lifting Station (SLS)

Each sewerage basin catchment typically requires one lifting station. The individual lifting station will discharge the wastewater through the sewage pumping main either to the sump of another SPS or to the inlet of the Wastewater Treatment Plant as necessary to avoid the emergency wastewater outflows. All catchments shall be interlinked via a catchment overflow link laid at a flat grade at the closest point between two catchments. The pump station shall be designed operate from an alternative on site power supply via one standard connection in case of mains power failure.

Inlet chamber, Pump well and valve pit
The Inlet chamber shall receive all incoming pipework prior to entering the pump well. The discharge pipe from the inlet chamber shall be of sufficient diameter to cater for outflow to the pumping well. The inlet chamber must be fitted with a diversion pipe to direct incoming flow from the inlet chamber to the valve pit without entering the pumping well in times of maintenance. The diversion pipe shall be manufactured of PE and of sufficient diameter to cater for out flow. The inlet chamber shall be fitted with 2 Nos. sluice valves with a cast iron casing and bronze wedge, anti-clockwise closure with non-rising spindles and terminate with a stem cap and shall be key operated. 1 No. shall be located on the incoming flow side and 1 No. on the outgoing flow side.

The minimum size of pump well shall typically be 1.5-2.0 m diameter and no more than 3.5m in depth. The working depth of the pump should not be less than 1.25m. The pump well must be capable of accommodating three submersible pumps, associated pipe work, electrical wiring and access equipment and personnel access. The design shall require pumps and personnel can pass through the pump well opening.

The pump well floor is to be shaped to avoid retention of waste water and material entering the pump well. Where this is achieved through placement of mass concrete, the concrete is to be sloped towards the well pump sump.

There shall be an external valve pit adjacent to the pump well structure. A 75 mm uPVC pipe shall be provided to discharge wastewater from the valve pit into the pump well. The floor of the valve pit is to be sloped towards the discharge pipe.

Polyethylene pipework will be accepted for use in both the inlet chamber, the pump well and valve pit. PE discharge pipes shall be supported at not less than 1.0 m intervals in any direction. The discharge pipe work shall be taken as typically 150mm below the sewer invert. Fittings installed in both the valve pit and pump well shall be cast or ductile iron or ductile iron.

The following valve types are to be supplied and installed to the pump well and associated works:

- 2 No. gate valve of same diameter as sewer main (incoming flow side) with non-rising stem, Grade 316 S.S. Component and Grade 316 S.S. extension spindle extension spindle and with valve key cover boxes;
- 2 No. gate valves of the same diameter as rising main (outgoing flow side) with non-rising stem, Grade 316 S.S. Component and Grade 316 S.S. extension spindle extension spindle and with valve key cover boxes;
- 2 No. non return valves of swing check type with cast iron casing and bronze disc. 1 No. located on incoming and 1 No. located on outgoing.
- 1 No. flap valve to be installed at the 75mm discharge from valve pit to pump well.

All Ductile Iron fittings are to be to be Epoxy lined so as to protect against corrosion. Application of Epoxy lining is to be carried out by manufacture of pipe and fittings at their factory. An approved epoxy material supply and application system is to be used, such as Dulon 'Armourcote' 412 applied by accredited applicator and have dry film thickness of 500 micrometers applied through two coats in accordance with manufacturer's instructions, or similar two pack epoxy protective coating.

Pumps

The capacity of the pumps shall be based on the Peak wet weather flow (Peak dry weather flow + infiltration) for the catchment served by the SPS. The number of pumps in each pumping station shall be three (two working each having half the peak wet weather flow capacity + one Stand-by). One working pump will be operating for low flows and the second working pump will be operating when the capacity exceeds one working pump. All pumps shall be fitted with overload protection devices and thermal protection and shall be of the same make and type. The pumps shall be connected to fixed wiring by means of a suitably rated 5-pole IP56 switch socket unit.

The typical pumps specifications shall be as follows. Other composition may be provided if accompanied with sufficient documents and proofs.

One working pump capacity:	Q= 1/2x peak wet weather flow
Second working pump capacity:	Q= 1/2 x peak wet weather flow
Standby pump capacity:	Q = max peak wet weather flow

Pump type:	Submersible grinder capable of handling solids up to 75mm
Impeller:	SS ASTM A743 CF 8 M
Shaft:	SS BS 970 Gr 304 S11
Casing:	IS 210 Gr.FG 260 with 1.5-2% Ni
Start/Stops:	restricted to 6 per hour
Motor:	[as per engineering design], IP 68 protection with Class F insulation
Guiderail pipe & Chain:	SS BS 970 Gr 304 S11

Control Cabinet(s) and Panels

Typically control panels shall be provided with single-phase power supply to adequately operate pumps, pump controls, and other equipment and instrumentation. A fuse switch, distribution board for Single phase, 3 pole, switched socket outlets, and appropriate pump protection system shall be provided. The cable to these outlets shall be installed in minimum 2.5 square mm cable from 16 Amp fuses in the Distribution Board. For SPS with larger flow 3 Phase power supply may be required for soft start of pumps in which case the necessary component specifications will be matched to meet the requirements of 3 phase supply.

The cabinets shall be freestanding cubicle pattern type - Himel cabinets or equivalent complying with standard industry practice for the Maldives sited adjacent to the source chamber. The cabinets will house all push buttons, indicator lights, switches, timers, and controllers. A switched water proof connection plug for receiving power from a stand-by generator in case of mains power failure shall be provided and a protected warning (alarm) light and exterior alarm horn shall be mounted on top of the cabinet. They shall stand alone on a concrete plinth so that the indicators and buttons are between 1 and 1.5m above the ground. The cabinets shall be adequate ventilated and shall be provided with weatherproof closures and lockable handles. Doors should be removable to allow easy access for servicing.

Control voltages used shall be selected to suit the particular application of the instrumentation equipment. Typically control and instrumentation supply voltages shall not exceed 24 volts d.c.

Electrical single line diagram/circuit diagram should be designed for each of the electrical panel and provided along with the panel.

Conductors*

The conductor insulation shall be color coded to the following schedule:

230 VAC controls	red	(P)	black or Blue	(N)
24 VAC controls-	purple	(P)	black	(N)
24 VDC controls-	white	(+)	black	(-)
12 VDC controls-	gray	(+)	black	(-)
Analogs	brown	(+)	black	(-)

conductors should comply with MEA standards

All earth conductors shall be colored green/yellow or green. The use of yellow control wires is prohibited. Due allowance shall be taken of voltage drops particularly with low voltage control circuits. The minimum size of power feeds to control modules (PLC I/O modules etc.) shall be 1.0 mm^2. All conductors shall be stranded.

Control cables

All control cables shall be fitted with bootlace ferrules where practical and identified by means of a numbered plastic ferrule fitted at each end of the conductor. The numbering of the control cables may differ from terminal numbers but all numbering must be clearly identified on the schematics.

Instrument protection*

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.

All instruments shall be capable of carrying their full load currents without undue heating. They shall not be damaged by the passage of fault currents within the rating of the associated MCB or through the primaries of their corresponding instrument transformers and shall be provided with protection against power supply transients, disturbances, lightning surges and radio frequency interferences. All instruments shall be back connected and the metallic cases shall be earthed. A means shall be provided for zero adjustment, span or range and configuring of instruments without dismantling.

Moving parts and contacts shall be adequately protected from the ingress of dust, and all instruments shall be protected by moisture and dustproof cases including those mounted in panels. All equipment shall be suitable for its environment. Panel mounted receiving instruments shall be of the electrically operated miniature flush mounting type.

Instrument protection should comply with MEA standards

Indicator Meters

The following meters shall be provided:

- Motor current ammeters;
- Voltmeter (0 – 600 v) and selector switch;
- 5-digit hours run meter.

Switches and lights

The panel shall include Run/Off/Auto selector switches, Running and Fault lights for each pump, and Running and Alarm Reset Pushbutton switches. The control switches for Run /Off/ Auto can be internal to the Control Panel. All contactors shall be Sprecher&Schuh CA3 or Telemecanique series or equivalent with matching overload units. Within the starter switch the required contactor size shall be based on a service life of one million operations at the full name plate load of the controlled motor and selected duty rating. Typical ratings shall be based on a minimum of AC3 duty or AC 4 for severe duty applications. Contactors selected for control of resistive heating loads shall be rated for AC2 duty.

Pushbuttons for operational circuits shall be provided with a shroud, guard or other suitable means to prevent inadvertent operation. Illuminated (LED type recommended) pushbuttons where used shall be of a design that allows easy replacement of the lamps from the front of the panel. If legends are engraved on the pushbuttons, they shall be clear. Pushbuttons and indicator lights shall be similar to Allen Bradley type 800 H RositeNema Type 4X, water tight, corrosion resistant stations with Nema Type 4/4X bootless operators or the equivalent. All pushbuttons provided for control start functions shall be provided with a flush type operator. All indicator lamp and pushbutton operators shall conform to the following color coding:

	Pushbuttons*	**Indicator Lamps**
Red	Command Stop	Fault
Green	Command Start (preparation)	Ready/Run
Blue	Any other function	Other function

Pushbuttons contact blocks shall be suitable for direct control of 220 VAC contactors as required and should comply with MEA standards

Control System
Normal pump operation shall be controlled through an ultrasonic sensor or 'float-switches'. The pump control system shall consist of the following components:

1) Ultrasonic sensor/ switch for start / stop control of the pump(s) and maximum level override and alarm; or
2) Float switches for low level to signal pump OFF, high level to signal pump ON; maximum level alarm and override.

The switches shall be set at a level recommended by the pump manufacturer to ensure that the pumps do not run dry. Switch shall activate the standby pump if the maximum effluent level is reached. If both pumps are operational the two pumps will pump at a higher rate. A common alarm output shall drive flashing amber light and an audible alarm horn.

Ultrasonic Sensors/Switches
Ultra-sonic level measurement shall be by the use of non-contact, echo-time measuring equipment operating at ultrasonic frequency. The equipment shall transmit pulses, which are reflected back to the sensor from the surface of the liquid whose level is being measured.

The equipment shall consist of a sensor incorporating both transmitter and receiver, together with a separate control unit. The equipment shall be provided with automatic temperature compensation and shall be suitable for operation in the designated application under the climatic conditions. The overall accuracy of the level measurements shall be within ±1.0% of the instrument span. The connection between the sensor and control unit shall be via commercially available twisted and screened cable, of sufficient cable length to enable removal of pump well equipment. The sensor shall be suitable for mounting in the open, or within an enclosed tank, and shall be totally enclosed and hose proof with environmental protection to IP67.

The sensor shall be installed on a robust and rigid structure provided for the purpose. The structure shall include a means of leveling the sensor so that the transmitted beam is perpendicular to the liquid surface and a safe and easy access to the sensor for servicing and maintenance.

The control units shall incorporate:

- Facilities for independently adjusting dead band zero and span, and shall have an output of 4-20mA proportional to level.
- A 4-digit read out in meters to indicate liquid level.
- An entry for operating parameters without the need to physically measure the distance to water level or to remove the sensor head.
- Potential free changeover contacts to provide a minimum of 5 control points.
- Secure access for parameters via a removable /fixed keypad.
- A common potential free alarm signal for system faults, echo loss and memory failure.
- A LED display to the level control unit shall illuminate on receipt of acceptable echoes and extinguish when echoes are not received.
- A LED for indication for dc power availability shall also be provided.
- A level control unit that shall be automatically checked for availability and any faults signaled back to the control panel.

The equipment shall be suitable for the application, particularly with regard to the blocking distance, transmitted beam angle or cone.

Float switches
The float shall be impact and corrosion resistant and of robust construction and supplied with a non-mercury switch, sealed neoprene jacketed cable, and ABS shell with changeover contacts tether method of tie wrap nylon.

Contacts shall remain open when the tilting action changes over between opening of one contact and closing. This "dead band" shall operate over an arc of approximately 20 degrees on either side of horizontal. Means for preventing the float from movement due to draft or liquid turbulence should be provided as also a means for raising the units for maintenance and repair.

Float switches shall be supplied with full-length flexes of equal length to run from pump well to junction box or socket unit. Cabling shall be run back to the control panel cabinet. Excess lengths shall be neatly coiled. The float switch cable shall be installed in a manner that is clear from interference. A protective cover shall be placed in front of the float cables so as to protect against turbulence during pumping causing cable tangling which may interfere with the float operation.

Pump controllers
Pump controllers shall be microprocessor or microcontroller based and designed to meet pumping station requirements having the following features:

- Automatic pump sequencing which determined by the specified level detection system.
- Monitoring and protection from over voltage, under voltage and phase imbalance, pump motor over current etc.
- LCD readout screen which shall show the system status i.e. pump running, level, line voltage, pump motor current and pump starting sequence.
- Operating Log which displays number of starts and total running hours for each pump.
- Fault log which displays all active alarms e.g. all parameters detailed.
- System Configuration. This screen shall be pass-word protected to prohibit unauthorized changes to the system.
- Indicator lights for power ON, AUTO, OFF and processor fault.
- A membrane key pad to set system configuration and operating set points. It shall be provided with contacts of suitable rating to interface with the relevant pump motor to operate in auto mode. It shall accept potential free contact from the MCC to activate the auto mode from Pump auto/manual selector switch.

2.3 Sewage pumping main

The pumping main shall be manufactured of HDPE of minimum 80mm ID to cater the peak discharge from pumping stations.

Polyethylene pipes
Polyethylene pipes, PE 100, shall be black in color, flexible, minimum pressure rating PN 6 and supplied in compliance with latest version of internationally recognized standard. Pipes shall be produced by manufacturers who operate under ISO 9002 series quality assurance scheme.

2.4 Dewatering

Due to the extremely high-water tables which on average are between 0.5 and 1.5m below ground level extensive dewatering is typically required during construction and installation of pipe networks which increases in intensity as depth increases.

Given the instability of the sand/soil conditions, trench shoring shall be used to maintain the vertical integrity of the sidewalls of all excavations. 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 ***Design Criteria for Conventional gravity sewerage systems, 2007***.

2.5 Wastewater Treatment Plant (When required)

The centralized Wastewater Treatment Plant (WWTP) will comprise full pre-treatment and secondary treatment utilizing a diffuse air aerobic process. The treatment process shall consist of inlet structure/primary sedimentation, contact aeration, secondary sedimentation and an outfall pump station. The effluent from the treatment works shall be discharged to sea via a marine outfall. The sludge treatment will be by drying beds. The design shall include adequate provision for odor control for emissions from the WWTP.
Each WWTP module will be designed for the estimated Average Wet Weather Flow (AWWF) over its 30-year design horizon for civil structures and 15 years for mechanical components of sewerage treatment plant.

The treatment process shall not rely on overly sophisticated treatment techniques and controls that require very specialist operation and maintenance.

The treatment process shall treat sewage to the standard as given in the table pertaining to disposal of treated sewage into deep sea.

BOD_5 20°C	20mg/l
Suspended Solids	30mg/l

The point of compliance shall be at the inflow to the outfall pump station. Under normal operating conditions compliance shall be taken as a 90^{th} percentile (9 in every 10 samples) calculated on a rolling average.
The construction of the WWTP shall be careful coordinated with the construction of the conventional gravity sewerage system and the marine outfall to confirm interfaces and for the timely completion, commissioning and testing of these elements.
The treatment plant must always operate in a failsafe mode. Overflows or spillages to the site surface and subsequently to the groundwater must not occur. Process units shall be provided with bypasses and in emergency situations, a bypass shall be made available to pump directly to the ocean outfall.
The WWTP will be designed and sized to the design parameters and all components divided into two equally sized compartments which are hydraulically isolated from one another for the provision of maintenance. The WWTP shall consist of the following functional components:

2.5.1 Inlet Structure/Preliminary Treatment

The cumulative influent sewage shall enter the WWTP by means of interlinked pumping mains to the Primary Headworks of the WWTP.

The inlet structure should be located on top of the Aeration Tank and provide flow dividing chamber, preliminary screening of floating material, grit, grease and oil and mass solids from the wastewater stream. There shall be channel with an emergency manually raked screen, walk way, railings and a tap for wash water to clean the screen and the channel. There shall be a mechanism for dewatering of the screenings and an arrangement by which the screenings can be removed after dewatering and deposited in a receptacle for disposal elsewhere. Suitable oil and grease separator to be considered

in primary treatment plant unit if oil and grease is identified as a major input source to the wastewater stream which may adversely impact on the operation of the plant over its design life. All the preliminary/inlet structures shall be designed as per international design practices.
Equal quantities of flow from the primary treatment works shall be distributed into the two compartments of the aeration tank.

2.5.2 Diffused Aeration Tank

The wastewater from the primary treatment works is pumped to the diffused aeration tank. Typically, the aeration tank should be designed to provide approximately 18 to 20 hours of retention time at Average Wet Weather Flow (AWWF). The Aeration Tank should be designed in two equal compartments.
The Aeration Tank shall be provided with High Surface Area Fill Media.

- Material of Construction: EPDM
- Make: Reputed
- MOC: Vacuum formed thermoplastic
- Frames Construction: Stainless Steel

The Diffused Aeration System shall comprise of 100 cm long, on-clog, and fine bubble membrane diffusers, installed at the base of the aeration tank with PVC pipes (or better), fittings, fastener etc. The diffusers shall be designed to ensure uniform permeability and to produce a flow of fine air bubbles.

Oxygen shall be supplied to diffused aeration system via Air Blowers. The air blowers shall be Twin Lobe design coupled with Motor, Pulleys, Filter, Silencer, base plate etc. Typically, the air blowers should be designed for the provision of $3m^3(O^2)$/hour/m^3 of wastewater.

2.5.3 Sedimentation/secondary clarifier

The Secondary Sedimentation Tank should typically allow for 4 hours retention of Average Wet Weather Flow (AWWF). The Secondary Sedimentation Tank should be designed with a similar configuration as the Aeration Tank in two equal Compartments. The design of each vessel must allow for the accumulation of sludge to concentrate at a collection zone for ease of de-sludging. The clarifier shall be provided with the facility of periphery weir to control the overflow rate.

2.5.4 Pumps

The following pumps shall be provided:

Feed Pump No(s):	2 [1 working & 1 standby]
Type:	Surface mounted, centrifugal, self-priming, non-clogging
Make:	Grundfos or Flyt or equivalent
Specification:	[*as per engineering design*]
Sludge Pump No(s):	2[1 working & 1 standby]
Type:	Surface mounted, centrifugal, self-priming, non-clogging, semi open impeller
Make:	Grundfos o r Flyt or equivalent
Specification:	[as per engineering design]

2.5.5 Ocean Outfall Pump Station

The Ocean Outfall Pump Station, located after the Secondary Sedimentation Tank should have sufficient volume for 1 to 2 hours retention of Peak Wet Weather Flow (PWWF). The outfall pump

station shall be equipped with similar pipe work, fittings, pluming electro – mechanical arrangements as the SPS's.

A magnetic flowmeter with 4-20 mAmp output is to be installed immediately downstream of the valve pit. Typically, the flow meter shall be as follows:

1. Each flow metering system shall consist of the primary transducer (sealed to IP68), earthling rings, the necessary signal converter and power supply unit and all cabling between the primary transducer and signal converter and power supply unit.
2. Each of the signal converters/power supply units shall be supplied for remote mounting and sealed to IP65, unless otherwise specified.
3. The signal converters/power supply units shall be provided with a 4-20 mA output signal, linear with flow and suitable for retransmission to remote instrumentation. The outputs shall be capable of supplying a load of 1000 ohms under all conditions. The supply voltage may vary by ±15% and frequency between 48 and 52 Hz.

The flow element of magnetic flow meter shall be Pulsed dc electromagnetic type with a linear output and should have inherent (zero) stability. The metering tube of the flow meter shall be of carbon steel unless otherwise indicated Flow meter flanges shall be ANSI 150-pound carbon steel unless indicated otherwise the liner shall be polyurethane or fusion bonded epoxy. Flow meter shall be housed in below grade vaults and shall be designed to withstand accidental submergence in 10 m of water for 24 hours. Sufficient cable shall be supplied to allow for the primary transducers to be situated up to 25 metres from their signal converters, unless a longer length is specified.

The flow meter accuracy shall be Â±0.2% or reading in the velocity range of 10 metres/sec down to 0.5 m/s and Â±0.05% of reading down to 0.2 m/s orbiter. The repeatability of the flow meter shall be Â±0.05% down to 0.5 m/s velocity increasing progressively to Â±1% at 0.25 m/s or better and calibrated on NEMAS accredited flow calibration rigs and calibration certificates shall be required.

2.6 Sludge drying beds

The sludge generated from the waste water treatment process will be transferred to the sludge drying beds which shall consist of coarse sand bed, supported on coarse gravel / crushed stone aggregate, underlain with perforated collection pipes. Open jointed PVC pipes shall be used. The pipes should be covered with fine nylon net to prevent access of fine sand and other filter media into the effluent. The liquid element of the sludge will percolate through the coarse sand substrate and be collected in the perforated pipes for distribution back into the liquid waste water stream through the plant inlet. The sludge shall be air dried to a minimum of 30 % dry solids.

The base of the beds shall be covered with a water proof membrane to prevent leakage to the groundwater, and a thin wire mesh will cover the entire facility to prevent access from birds, vermin etc. The beds shall be covered by a sloping roof in order to protect the beds from rains.

The sludge cakes should be removed and stored in a covered hard standing area at a vacant, easily accessible place within the WWTP compound before being removed for disposal or reuse.

2.7 Ocean Outfall

The Ocean outfall pipeline will be constructed of PE 100typically 160mm OD or greater. The color of HDPE pipes used for Sea outfall shall be black. The pipeline shall typically be buried to a depth of 0.6m on land and place on the sea bed concrete ballast blocks of a mass sufficient to prevent the movement

of the pipeline during heavy wave activity. Sea outfall shall extend beyond the house reef of the Island. The discharge point shall be a minimum depth of 5m from the low tide level.

Following the emergence of the pipeline at depth, it shall be secured. The pipeline will be fixed to the ballast blocks with stainless steel straps and secured with bolts of similar material cast into the blocks. The pipes may be anchored with two halves to encase the pipe in a concrete collar, with through bolts securing the two halves together for ease of bolt replacement. Ballast blocks shall be placed at intervals of a minimum of 6m to center. A "T" head diffuser will be fixed to the discharge end of the ocean outfall pipeline to increase dilution performance and dispersion of effluent.

2.8 Administration Building

An administration building will be located at the site of the WWTP. An office space and laboratory will be included for operators and WWTP administration. The administration Building will also serve as a storage facility with sufficient covered vehicle parking space for a standby generator set and service vehicle. In addition, sufficient space will be available for the purpose of maintenance of electrical equipment and pumps/blowers associated with the sewerage collection network and WWTP. Where appropriate lifting devices should be provided to enable lifting for overhaul and maintenance activities of pump/ heavy plant and equipment. Adequate toilets and wash facility shall be provided to cater for both administration staff and plant operators.

2.9 Fencing and landscaping

The Administration Building shall be fenced inside a lockable compound. The fencing shall be plastic coated wire mesh and adequate provision shall be made for landscaping, and where possible vegetative buffering.

2.10 Roads and hardstand

Roads and hardstand shall be designed for a minimum twenty (20) tons loading.

2.11 Pumping Station Stand-by Diesel Generator Set (for lifting station and sewerage treatment plant)

A mobile electric power generator unit, make of international repute shall be supplied to provide stand-by electric power to the sewage pumping stations 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.

A fixed back- up generator should be provided for the operations of the electro mechanical equipment at the WWTP in case of mains power failure.

The generator shall be self-contained and be trailer mounted with a minimum operational 3-phase output of required capacity for each SPS (minimum 10 KVA- or as appropriate to start and operate 2 pumps-duty and stand-by both). The generator shall be powered by diesel electric start engine and have a fuel tank of sufficient capacity for 12 hours continuous operation.

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.

2.12 Sewer Jetting Machine / Jetting Vehicle

The Contractor / Supplier should choose the Jetting Machine / Jetting Vehicle based on the following 3 options. The Contractor / Supplier can propose a Jetting Machine / Jetting Vehicle with a better specification than the below mentioned options with a proper justification and approval from the Client / Proponent. Any proposed changes to Jetting Machine / Jetting Vehicle product specification from Contractor / Supplier should be submitted to EPA for final approval.

2.12.1 Option 1: Trailer Mounted

- This is the best option for smaller islands (700 – 3000 population) with a gravity system without septic tanks.
- Adequate for sewerage systems with 5 to 10 pump stations.
- Easy to handle and less Operation and Maintenance cost

Type	Trailer Mounted
Pressure and Flow	Up to 275 bar / Up to 55 litres per minute (4000 psi / 12 gpm) Up to 350 bar / Up to 41 litres per minute (5000 psi / 9 gpm) Up to 415 bar / Up to 32 litres per minute (6000 psi / 7 gpm)
Pump	'P' type radial piston diaphragm
Engine	45 hp water cooled diesel
Water Tank	Four interconnected water storage tanks with a total capacity ranging from 500 litres to 1000 litres with a minimum of 15 minutes of water storage at full pressure
Frame	Box section steel shot blasted and powder coated
Hose Reel	Variable-speed hydraulic-rewind hose reel with 100m high pressure hose capacity
*Dimensions	3525 mm long x 1890 mm wide x 1470 mm high (minimum dimensions)
Suggested Accessories	- 1/2" Standard jetting hose – 90m (300 ft) - 3 x 1/2" Standard drain jets (3r, 3r1f & 6r) - 1/2" Safety leader hose – 3m (10 ft) - 1/2" Drain jet extension – 9"
Safety Equipment (must)	- Jetting helmet set - Jetting safety boots (Sizes 6 -12) - Water proof suits (sizes S – XL) including safety goggles - Gauntlet Gloves - Safety Burst Discs (White 4000 psi) Safety Burst Discs (Black 5000 psi)
Hoses (optional – based on the requirement)	- Lightweight Hose – 90 m - Hose – 90 m, Hose, 30 m - Safety Leader Hose – 3 m * Maximum Hose pipe length can be decided based on the location of the trailer mounted to the farthest house in an inaccessible road (for the trailer mounted).

2.12.2 Option 2: Van Pack type (portable)

- Portable, can be carried in a van or a pickup.
- Capacity is limited.
- Easy to handle and less Operation and Maintenance cost
- Viable for small islands (<1000 population)

Type	Trailer Mounted
Pressure and Flow	Up to 275 bar / Up to 60 litres per minute (4000 psi / 13 gpm)
Pump	Triplex plunger pump (capable of running dry)
Engine	45 hp water cooled diesel (max) Can go for a lower hp engine if required
Water Tank	Single – 400 liters / 500 liters Twin – 800 liters / 900 liters Minimum of 15 minutes of water storage at full pressure
Frame	Light weight folded steel, shot blasted and powder coated
Hose Reel	Variable – speed hydraulic – rewind hose reel with 100m high pressure hose capacity
Radio Remote (optional)	Supplied with a mains charger and 12v in-car charger. The remote can operate at a distance of 90m and allows the unit to be operated by a single operative.
*Dimensions	1700 mm long x 1000 mm wide x 1470 mm high (reference dimensions)
Suggested Accessories	- 1/2” Standard jetting hose – 90m (300 ft) - 3 x 1/2” Standard drain jets (3r, 3r1f & 6r) - 1/2” Safety leader hose – 3m (10ft) - 1/2” Drain jet extension - 9”
Optional	* a van or a pickup should be provided if not available.
Safety Equipment (must)	- Jetting helmet set - Jetting safety boots (Sizes 6 -12) - Water proof suits (sizes S – XL) including safety goggles - Gauntlet Gloves - Safety Burst Discs (White 4000 psi) Safety Burst Discs (Black 5000 psi)

2.12.3 Option 3: Combined Jet Suction Truck

- This is the best option for bigger islands (3000 – 10,000 population) and Cities (>10,000 population) with a gravity system, septic tanks and STPs.
- Adequate for sewerage systems with > 10 pump stations and long-distance travelling.
- High Operation and Maintenance cost – if vehicle is damaged cannot be used.

General	Vehicle brand	Supplier's choice (should be durable and long lasting)	
	Chassis Brand	Supplier's choice (should be durable and long lasting)	
	Overall Dimension	Mounting length (advised loading platform length) 3.45m Overall length max. 3.75 Width = 1.600mm Height = 1.650mm	
	GVW/Kerb Weight	6000 kg – 10000 kg	
Cab	Cab Capacity	3 persons seats (minimum)	
Engine	Fuel Type	Diesel	
	Drive	Electronic starting system	
	Engine Brand	Supplier's choice (should be well known and regionally available brand)	
	Power	33KW/44 hp	
	Displacement (L)	1.498	
	Combustion system	IDI	
	Max speed (rpm)	3000	
	Emission Standard	Interim Tier A / Stage III A	
Chassis	Drive Type	4x2, right hand drive	
	Transmission	6-speed forward, 1 reverse	
	Wheelbase	3815 mm	
	Number of axles	2	
	Tyre Specification	235/75R17.5	
	Tyre Number	6 tyres and 1 spare tyre	
	Max speed	105 km/h	
	Paint	Metallic paint	
Super Structure	Water Tank	Tank Capacity	1600/1400 litres (water sludge division) Minimum of 15 minutes of water storage at full pressure
		Tank Material	Carbon steel + Tank entirely hot-dip galvanized both inside and out
		High Pressure Pump	3 plunger high pressure pump capable of running dry

		Flow Speed	125 l/min (max) 50 l/min (min)
		Cleaning Pressure	200 bar (max) 100 bar (min)
		Water Filling hose	Optional, water filling hose reel 50m 3/4” water hose (ND 20)
		Suction head	8m
	Sewer Tank	Tank capacity	1600/1400 litres (water/sludge division)
		Tank material	Carbon steel + Tank entirely hot-dip galvanized both inside and out
		Vacuum system	Thrust jetter / vacuum pump Adequate for 80% vacuum
		Free air displacement	8.33 l/min (max)
		Flow speed	Thrust jetter, 7500 l/min (max) Vacuum pump, 6150 l/min (max)
		Vacuum pressure	0.85 bar
		High pressure hose	80m 1/2” (ND13) / 80m 5/8” (ND16)
		High pressure hose material	Durable, flexible PVC material
	HP Reel Drive	270o rotating hydraulically driven HP reel, mounted on swiveling frame (with extendable hose guiding system	
	Pressure relief valve for safety and a float valve to prevent overflow is recommended. Vacuum gauge should also be visible.		
Optional	*Automatic opening and closing of rear cover with 4 actuated locks and 2 open/ close actuator		
Safety Equipment (must)	- Jetting helmet - Jetting safety boots (Sizes 6 -12) - Water proof suits (sizes S – XL) including safety goggles - Gauntlet Gloves - Safety Burst Discs (White 4000 psi) Safety Burst Discs (Black 5000 psi)		

Note: *Contractor / Supplier can propose a jetting machine or vehicle similar or better than the above specification but, in that case, it should be approved by the Client / Proponent*
Any changes to the product specification should be proposed with justification based on the island requirement and the design
Any changes or upgrades to the options and the requirements will be made by the regulator and endorsed by the policy maker (Ministry of Environment)

3. TECHNICAL REQUIREMENTS

3.1 General Requirements

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

Where this specification refers to the undertaking, carrying out, execution, or remedy of works it is typically referring to the relevant trade contractor who is suitably qualified, experienced and employed for the purpose of undertaking, carrying out, execution, or remedy of such work.

3.1.1 Materials not others specified.

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.

3.1.2 Substitutions

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.

3.1.3 Standard Specifications

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

3.1.4 Access to the private property

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.

3.1.5 Water and Power Supply

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.

3.1.6 Public Utilities and Other Services

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.

3.1.7 Pre commencement photographs

Color 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.

3.1.8 Vegetation management

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 pumping stations 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.

3.1.9 Setting out of Works

Working or construction lines and grades shall be established as required. Stake sand 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.

3.1.10 Cooperation at Site

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.

3.1.11 Protection of Work and Public

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.

3.1.12 Environmental Protection

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.

3.1.13 Final Clearance of Site

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.

4. TECHNICAL SPECIFICATIONS

4.1 Excavation - General

All excavation of whatever substance encountered shall be performed to the depths and widths indicated or as otherwise specified. 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. Grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations.

Adequate precautions must be in place to prevent 'boiling' of the sub-soil that would make the formation for pipelines or structures unsound.

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.

The term "earth" shall include all materials which does not require blasting, barring or wedging for removal from its original bed.

Material that requires blasting, barring or wedging for removal from its original bed will be classed as "rock".

4.1.1 Excavation of Trenches for Pipes

Unless otherwise approved, not more than 30 metres of any trench in advance of the end of the pipeline already laid shall be opened at any time. The width and depth of pipeline trenches will be as indicated in the drawings.

Depressions for joints shall be dug after the trench bottom has been graded. The pipe, except for joints shall rest on the prepared bottom for its full length. Large stones shall be removed to avoid point bearing. Whenever wet or otherwise unsuitable material that is incapable of properly supporting the pipe, as determined by the Engineer, is encountered in the bottom of the trench, such material shall be removed to the depth required and the trench backfilled to the proper grade with coarse sand, or other suitable approved granular material.

4.1.2 Excavation for Structures

When foundation level is reached, exposed ground shall be inspected. Further excavation may be required. Where excavation is to be covered by a permanent structure construction on that foundation shall commence.
If the foundation excavation deteriorates due to exposure, it shall be made good prior to construction on that foundation.

4.1.3 Shoring of Buildings

As part of the work under the excavation all buildings, walls and other structures, the stability of which is liable to be endangered by the execution of the work shall be shored up.

Should any such property, structures, installations or services be endangered or damaged as a result of the works any such danger or damage shall be reported and approved remedial measures undertaken.

4.1.4 Shoring of Excavations

If ordinary open cut excavation is not possible or advisable, sheeting and bracing shall be furnished and installed in excavations to prevent damage and delay to the work and to provide working conditions which are necessary for the safety of the work, the general public and adjacent property.

Sheeting and bracing shall be removed as the work progresses and in such a manner as to prevent damage to finished work and adjacent structures and property. As soon as it is withdrawn, all voids left by the sheeting and bracing shall be carefully filled with selected material and compacted.

4.1.5 Maintenance of Excavations

All excavations shall be properly maintained, while they are open and exposed, both during day and night. Sufficient suitable barricades, warning lights, signs, and similar items shall be provided.

4.1.6 Dewatering of Excavations

As part of the work under the excavation drains and ditching, pumping, bailing and other necessary works shall be carried out to keep the excavation clear of sewage and extraneous water during the progress of the work and until the finished work is safe. Necessary precautions against flooding and floatation of structures, such as septic tanks and sewage pumping stations shall be taken.

Care shall be taken to avoid excessive de-watering that would cause damage or draw down of the fresh groundwater used for household use.

4.1.7 Shoring and Sheeting Left in Place

Shoring and sheeting piling may be left in place for purpose of preventing injury to the structures, other property or persons, whether such sheeting was shown on drawings or placed at direction, or otherwise. If left in place, such sheeting shall be cut off at approved elevation. The sheeting remaining in place shall be driven in tight.

4.1.8 Protection of Existing Services

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.

4.1.9 Backfilling of Material

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.

4.1.10 Backfilling for Trenches

Trenches for sewers, drain pipes, water lines, etc., shall be backfilled to the ground surface with selected excavated material or other material that is suitable for proper compaction. Trenches improperly backfilled shall be reopened to the depth required for proper compaction, then refilled and compacted to the specified density.

Normal backfilling operations in trenches shall be carried out as follows:

1. In the lower portion of the trench the backfill material, up to a level of at least 300mm over the top of the pipe line, shall be deposited in layers not more than 200mm thick and compacted with approved type tampers to the density specified. The backfill material in this portion of trench shall consist of excavated materials of approved quality, free from stones and hard pieces larger than 40mm in any dimension, and also free from timber, rubbish and other debris.

2. The remainder of the trench shall be backfilled with excavated material free from a stones and hard pieces larger than 75mm in any dimension and also free from timber, rubbish and other debris, deposited in layers not more than 300mm thick and compacted with approved tampers to the density specified.

Required compaction for normal trench backfilling, as specified above, shall be 85 per cent of maximum density.

After the completion of the backfilling and satisfactory compaction, finished grading of the site to such grades and elevations as may be shown on the drawings or required for proper drainage of the site shall be undertaken.

4.1.11 Disposal of Surplus Excavated Material

All surplus material excavated shall be disposed of at approved locations. When it is necessary to haul earth material over streets or pavements, such material shall be prevented from falling on the streets or pavements.
Contaminated demolition waste from the removal of old septic tanks will be sterilized with lime powder, or other approved method, and disposed of at an approved location.

4.1.12 Topsoil

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.

4.1.13 Earth Borrow (brought from outside)

Where satisfactory materials for trench backfill and filling of depressions to the required level are not available in sufficient quantities from the on-site excavations, satisfactory materials shall be obtained from other approved sources.

4.2 Pipe laying

4.2.1 Handling and Transportation of Pipes on Site

Plastic sewer pipes shall be handled with care at all times, while transporting to the site of work, and while installing. The pipes should not be kept exposed to direct sunlight for lengthy periods during transportation and installation process. They shall be stored in a cool place free from sunlight until needed. Each pipe shall be carefully inspected according to standard specification requirements upon delivery and before being laid. No cracked, broken or defective pipe shall be used in the work. Chipping of the tongue and groove or bell and spigot pipe ends may be sufficient cause for the rejection of any pipe.

4.2.2 Trench Bedding and Pipe Protection

The applicable bedding material as per schedule given on the drawings should be placed as soon as the trench conditions allow. Three types of bedding may be used:

i.	Granular Bedding	Class A
ii.	Concrete Haunching	Class B
iii.	Concrete Encasement	Class C

Granular Bedding: This is designated as Class A bedding. It will be a composed of clean fine/coarse sand free of stone. If any trench bottom is excavated below the grade shown on the drawings, it shall be refilled to the required level with bedding material and thoroughly compacted into place.

Concrete Haunching: This is designated as Class B bedding. The trench shall be filled and compacted up to half of the pipe's diameter with granular material as specified for Class A bedding and the upper part will be encased in concrete. Concrete shall be un-reinforced of the Class shown on the drawings.

Concrete Encasement: This is designated as Class C bedding. The concrete shall be of the Class shown on the drawings. Each pipe to be encased shall be supported on at least two points with pre-cast concrete wedge blocks. The wedge blocks should be located at a distance L/4 from the joint. To avoid movement of the pipe during concreting the concrete shall be carefully placed and tamped beneath the pipe, followed by pouring of concrete on both side of the pipe.

4.2.3 Laying of Sewers

All sewers shall be constructed and laid with a true grade and in straight lines between manholes. The sewers shall be laid with the aid of suitable boning rods and sight rails at intervals not exceeding 10 metres. The use of laser instruments for setting the sewer pipes to line and grade may be used. With both methods, the pipes will also be checked by accurate leveling along the invert line of the sewer by means of leveling instruments.

No sewer pipe or bedding shall be laid or placed until the trench condition and the alignment of the sewer and its levels and gradients have been carefully checked and found correct.

Each pipe shall be placed carefully to line and grade. The work shall be rejected if the sewer invert varies by as much as ±2 to ±3 mm of the pipe internal diameter from the proper elevation as shown on the drawings.

When laying is not in progress, open pipes shall be sealed to prevent the entry of unwanted material into the pipeline.

4.2.4 Pipe Jointing

All pipe joints shall be made strictly in accordance with the manufacturer's recommendations. Joint rings and gaskets shall be stored until needed in a cool place free from direct sunlight. Before making any joint the interior of each pipe or fitting shall be clean.

Special care shall be taken to see that the axis of the pipe to be laid forms one straight line with the axis of the previously laid pipe. Spigot and socket ends shall be central with regard to each other.

The following measures shall be taken for joints made with the "sliding method". The rubber ring, the edge as well as the internal slide surface of the pipe socket shall be coated with a non-acid lubricant which satisfies the pipe and rubber ring manufacturers.

For joints executed by "rolling" of the rubber ring, the spigot and socket ends and the rubber ring shall be completely dry and clean before insertion of the joint. The positioning of the rubber ring shall be such that twisting is prevented while the circumferential stress is applied before each joint is made.

Flexible joints on pipes shall have the angular space between the pipe and the socket or coupling ring protected to prevent the ingress of loose material or concrete by a Hessian band or ring or other approved method.

The jointing of uPVC pipes with solvent cement shall not be permitted.

4.2.5 Pipes and Joints Adjacent to Structures

A flexible joint shall be provided as close as is feasible to the outside face of any structure into which the pipe is built, compatible with the satisfactory completion and subsequent movement of the joint.

The first pipe (rocker pipe) that is clear of the external face of a concrete wall or structure shall be a short length of either spigot and socket or double spigot to suit the flow direction and pipe material. The effective length of this pipe shall be 2 times the nominal bore or 600 millimetres whichever is the greater.

A pipeline may, where practicable, be laid through a manhole and the crown cut out to the half diameter, provided flexible joints are situated on each side, no further than 600 mm from the inner face of the manhole wall, and that adjacent pipes comply with requirements specified.

Any over-excavation adjacent to a structure and beneath the formation level of a pipe trench or excavation to make a connection to a plugged or capped pipe laid shall be backfilled to the formation level of the pipe trench with compacted granular backfill material. This compacted material shall extend to the limit of the over-excavation along the line of the pipe trench and across the full width of the pipe trench or to the limit of the excavation whichever is the lesser.

4.2.6 Connecting of Existing pipes

Where a connection of any kind is to be made into an existing pipe, such as connecting to household wastewater pipes, the connection shall be inspected and verified at the start of the work.

The period of interruptions of the existing service pipeline shall be kept to the minimum and in coordination with the Island Office and property occupier/owner.

4.2.7 Cleaning Pipelines

During installation the interior must be kept clean of pipes clean and free from water, dirt, stones, rubbish and other foreign matter. 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.

4.3 Pipe Manufacture and Supply Quality Assurance

4.3.1 Materials standard

Except where otherwise specified all materials shall comply with the standards of the International Organization for Standardization (ISO). Materials may be supplied to a different international code or specification only if it can be shown that the product offered is of equal standard

The supplier may be requested to present copies of standards together with their English translations for use during inspection and testing.

4.3.2 Test Certificates

Certificates in triplicate shall be provided by the Supplier for each diameter of pipe and fittings supplied giving the process of manufacture and the results of the specified tests.

Similar certificates in triplicate shall be provided by the Supplier in respect of materials to be used in the manufacture of the pipes and fittings giving the process of manufacture, chemical analysis (where relevant) and the results of specified tests. The materials shall be suitably marked to enable them to be identified from references on the certificates.

4.3.3 Independent and Local Tests

Independent or local tests on the pipes and fittings may be undertaken. Any pipes and fittings which are shown by such independent tests not to be in accordance with the specifications shall be rejected notwithstanding any previous certificates, which may have been provided.

4.3.4 Quality Assurance Certificates

Quality Assurance Certificate established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent shall be provided.

The certificate shall be valid for a period covering the manufacture of pipes and fittings. If the suppliers are not the manufacturer, the suppliers will provide the Quality Assurance Certificates of the original manufacturer.

4.4 Pipe and Manufacturers Markings

Each pipe, fitting and special appurtenance shall be marked with permanent identification which should include but not necessarily limited to the following:

1. Serial number

2. Class of pipe, pressure rating in compliance with referenced standards
3. Nominal diameter
4. Name or trade mark of manufacturer (ISO)
5. Date of manufacture
6. Type of service
7. Full details on fittings such as angles of change and reduction.

4.5 Product Delivery, Storage and Handling

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.

4.6 Joints Rings and Lubricants

Rubber rings for jointing pipes shall comply with BS 2494 or equivalent and shall be Type 2.

Rubber rings shall be manufactured from synthetic rubber and shall be suitable for the environmental conditions in service and for the pipe life expectancy. Subject to the aforementioned conditions rubber rings shall be manufactured from EPDM, SBR or nitrile rubber (NBR).

Rubber joint rings shall be obtained from the manufacturers of the pipes to be jointed.

Joint lubricants for sliding joints shall have no deleterious effects on either the joint rings or pipes and shall be unaffected by the liquid to be conveyed.

4.7 Concrete Works

4.7.1 Certificates

A minimum of 2weeks prior to starting concrete work material test data and certification shall be provided by a qualified independent inspection and testing laboratory to certify that mix proportions selected will produce concrete of quality, yield and strength and will comply with BSEN 206-1 or equivalent for:

1. Portland cement, sulphate resistant cement
2. Supplementary cementing materials.
3. Admixtures.
4. Aggregates.
5. Water.

4.7.2 Type of Cement

Unless otherwise approved cement shall be:

- Ordinary Portland cement complying with BS 12 or equivalent;
- Sulfate resisting cement complying with BS 4027 or equivalent.

The cement shall either be delivered in sealed bags marked with the manufacturer's name or in bulk consignments in an approved manner. High alumina cement shall not be used in any circumstance.

4.7.3 Tests of Cement

Test certificates relating to each consignment of cement shall be provided. Each certificate shall show that a sample of the consignment has been tested by the manufacture or by an approved laboratory and that it complies in all respects to the relevant Standard.

Samples of cement may be taken on delivery to Site, during storage or on the Site for testing at a nominated laboratory.

No cement from any consignment shall be used without the approval and a record shall maintain of the locations of the concrete made from each consignment.

If cement has been stored on the site for more than 40 days new tests may be required to check whether the cement is still conforming to the requirements.

4.7.4 Delivery and Storage of Cement

All cement shall be delivered to the Site in properly and permanently marked, sound and sealed paper bags or other approved containers. Cement from abroad shall be packed in sealed plastic bags and placed inside paper bags.

Cement shall be delivered in quantities sufficient to ensure the proper progress of the Works.

Cement when being conveyed to the island on landing craft or a ship, and to the worksite in lorries or other vehicles, shall be adequately protected from the weather and from contamination by dust, sand or any Organic materials. Any Cement which shall prove to have been exposed to damage by water will be rejected upon delivery.

All cement shall be stored in a weatherproof, waterproof and reasonably airtight condition provided solely to that purpose. The base of cement storage facility shall be raised at least 300 mm above the ground level to prevent the absorption of moisture.

4.7.5 Rejection of Cement

Notwithstanding the receipt of a test certificate cement may be rejected as a result of further tests. Cement which has deteriorated owing to inadequate protection or other causes may be rejected. Rejected cement shall be removed from the Site without delay.

4.7.6 Mixes

Proportion normal density concrete shall be in accordance with BSEN 206-1 or equivalent, Alternative 1, to give the following properties for all concrete:

1. Portland Cement, sulphate resistant.
2. Minimum compressive strength at 28 days for concrete structures not in contact with water: 25MPa, unless indicate otherwise.
3. Minimum compressive strength at 28 days for concrete structures in contact with water unless indicated otherwise.
4. Minimum compressive strength at 28 days for lean concrete unless indicate otherwise.
5. Class of exposure: severe salt water.
6. Nominal size of coarse aggregate: 20mm.
7. Slump at point of discharge: 80mm ± 30mm.
8. Chemical admixtures: in accordance with ASTM C494 or equivalent.

4.8 Execution

4.8.1 Formwork

1. Verify lines levels and centers before proceeding with formwork/false work and ensure dimensions agree with drawings.
2. Fabricate and erect formwork to produce finished concrete conforming to shape, dimensions, locations and levels indicated within tolerances required by CSA– A23.1.
3. Align form joints and make watertight. Keep form joints to minimum.
4. Build in anchors, sleeves, and other inserts required to accommodate work specified in other sections.
5. Leave formwork in place until concrete has attained sufficient strength to sustain all loadings.
6. Provide all necessary reshoring of members where early removal of forms may be required or where members may be subjected to additional loads during construction as required.
7. Re-use formwork subject to requirements of international standards.
8. Coat forms with approved water-based form release agent.

4.8.2 Placing Reinforcement

1. Clean reinforcing of rust build-up, mill scale or other coating that prevent or reduce bond.
2. Place reinforcing steel as indicated on reviewed placing drawings and in accordance with CSA– A23.1.
3. Protect epoxy coated portions of bars with covering during transportation and handling.
4. Touch – up damaged and cut ends of epoxy coated or galvanized reinforcing steel with compatible finish to provide continuous coating.
5. Prior to placing concrete, obtain Engineer's approval of reinforcing material and placement.

4.8.3 Preparation

1. Pumping of concrete is permitted only after approval of equipment and mix. All constructional plant and materials required, or which may be required during the concrete work and for curing shall be on site.

2. Prior to placing of concrete obtain approval of proposed method for protection of concrete during placing and curing.
3. Ensure reinforcement and inserts are not disturbed during concrete placement.
4. Cool any shuttering that has become overheated or exceptionally dry through prolonged exposure to the sun. All shuttering shall retain a sufficient amount of humidity and shall not become shrunk or warped. All soaking or spraying of shuttering shall be done with potable water.
5. No Placement of concrete in any shuttering which become too hot and/or dry and the condition of which could harm the quality and strength of concrete.
6. Maintain accurate records of poured concrete items to indicate date, location of pour, quality, and air temperature and test samples taken.
7. Do not place load upon new concrete until concrete has attained sufficient strength to sustain loads without damage.
8. In locations where new concrete is dowelled to existing work, drill holes in existing concrete. Place steel dowels and pack solidly with shrinkage compensating grout to anchor and hold dowels in positions as indicated.

4.8.4 Construction

1. Do cast – in – place concrete work in accordance with BSEN 206.1 or equivalent.
2. Set sleeves, ties, and other inserts and openings as indicated or specified. Sleeves and openings greater than 100×100 mm not indicated must be approved.
3. Do not eliminate or displace reinforcement to accommodate hardware. If inserts cannot be located as specified, obtain approval of modifications before placing concrete.
4. Check locations and sizes of sleeves and openings shown on drawing.
5. Place anchor bolts to templates under supervision of trade supplying anchors prior to placing concrete.
6. Use only tools and handling equipment that are clear of rust or other harmful and foreign material to avoid efflorescence and staining of slabs or hardened concrete.
7. Use concrete pumps to place concrete only with approval of methods, equipment and mix design.
8. Provide continuous supervision during placement of concrete including concrete grout to ensure reinforcing steel is maintained in correct position.
9. When ambient temperature exceeds 27ºC, measures shall be placed in affect to minimize concrete temperature to less than 35 ºC for sections less than 0.3m thick to include shading of aggregate piles.

4.8.5 Placing Grout

Grout where indicated using procedures in accordance with manufacturer's recommendation which results in 100% contact over grouted area

4.8.6 Joint Fillers

Furnish filler for each joint in single piece for depth and width required for joint, unless otherwise authorized by Engineer. When more than one piece is required for a joint, fasten abutting ends and hold securely to shape by stapling or other positive fastening.

4.8.7 Tolerance

Concrete tolerance in accordance with CSA -A23.1, straight edge method.

4.8.8 Finishing

1. Finish concrete in accordance with CSA -A23.1.
2. Use smooth form finish for all concrete surfaces. Use form facing material that will produce a smooth, hard, uniform texture on the concrete. Do not use material with raised grain, torn surfaces, worn edges, patches, dents or other defects that will impair the texture of the concrete surface. Patch the holes and the defects. Remove fins exceeding 5mm in height.
3. Rub exposed sharp edges of concrete with carborundum to produce 3mm radius edges unless otherwise indicated.
4. Use curing compounds compatible with applied finish on concrete surfaces. Provide written declaration that compounds used are compatible.

4.8.9 Protection

When rate of surface moisture evaporation for concrete surfaces exceeds 0.75kg/m²/hr, measures shall be taken to prevent rapid loss of moisture consisting of one or more of the following:

1. Dampening forms prior to placing concrete.
2. Erecting sun shades over concrete.
3. Lowering concrete temperature.
4. Covering concrete with white polyethylene sheeting.
5. Applying fog spray.
6. Beginning the concrete curing immediately after finishing.
7. Placing and finishing at night.

Material must be available on site to protect the surface of plastic at contact from rain.

4.8.10 Curing

1. Approved fabric mats or burlap covers.
2. Keep surface continuously wet.
3. Leave form in place for five (5) days.

4.9 Roadwork

4.9.1 General

The roads and pedestrian access pavements to be reinstated may include the following types of surfacing:

- sand-gravel roads and foot paths
- concrete accesses and pavements

Roadways within the project Sites shall be constructed with coral sand-gravel pavements unless shown otherwise.

4.10 Granular Materials

Granular sub-base material shall be natural sands, gravels, crushed rock or crushed concrete. The material shall be well graded and lie within the following grading limits:

BS 410 Test Sieve	Percentage by Mass Passing	
	Type 1	Type 2
75 mm	100	100
37.5 mm	85-100	85-100
10 mm	40-70	45-100
5 mm	25-45	25-85
600 mm	8-22	8-45
75 mm	0-10	0-10

Where granular sub-base material is to be used within 450 mm of the surface of any road, a certificate confirming that the material has a heave not greater than 15 mm when subjected to the frost test as specified in BS 812: Part 124 or equivalent shall be provided

Natural sands and gravels shall only be permitted in Type 2 material.

The particle size shall be determined by the washing and sieving method of BS 812: Part 103 or equivalent. The material passing a 425μm BS sieve, when tested in accordance with BS 1377: Part 2 or equivalent, shall be non-plastic for Type 1 and have a Plasticity Index of less than 6 for Type 2.

With the exception of well burnt shale, the material shall have a 'ten per cent fines' value of 50 kN or more when tested in accordance with BS 812: Part 111 or equivalent.

4.11 Earthworks for Roads

4.11.1 General

Where the dry density of the natural ground within 500 mm depth of the formation level is below 95% of the maximum dry density as determined in accordance with BS 1377 or equivalent, the subgrade material shall be reworked and compacted. During wet weather conditions, particular attention shall be paid to the requirement that fill shall be compacted with a slight outward slope to ensure good run-off of surface water. Material excavated out of the road bed which is suitable for use in fill, shall be used for filling as far as this is practicable.

4.11.2 Filling of Excavations beneath Site Roads

Excavations for pipelines laid under site roads shall be back filled with sand to BS 882: Grade C Sand or equivalent.

Filling shall be built up evenly over the full width and compacted in layers not exceeding 300 mm in depth at the optimum moisture content. The moisture content of the sand may require adjustment to that required to attain maximum density. Sand which contains insufficient moisture to obtain the

desired compaction will require the incorporation of additional water by the use of approved sprinklers and mixing.

Layers more than 300 mm below road formation shall be compacted to 90% of the maximum dry density determined according to BS 1377 Test 12 or 14 or equivalent. Layers less than 300 mm below road formation level shall be compacted to 95 % of the maximum dry density determined according to the aforementioned standard method.

Sand laid immediately adjacent to a structure concrete wall or thrust; block shall be well compacted. Hand operated vibrating plate compactors vibro-tampers or power rammers shall be used. In other cases, compaction shall be carried out by vibrating compactors smooth wheel or pneumatic tyre rollers of types approved by the Engineer.

Excavations for pipelines laid otherwise and for all other structures beneath the carriageways shall be back filled with lean mix concrete. This concrete shall comprise proportions by weight of 1 part of cement: 3 parts of sand: 6 parts of aggregate with a maximum size of 40 mm.

4.11.3 Finish and Protection of Subgrade

When the sub-grade has been compacted to the required degree, the surface shall have a formation parallel to the finished surface of the carriageway and to the correct levels and cross-section.

The finished surface of the sub-grade shall be approved before any sub-base material is placed. The sub- grade, once it has been finally compacted, shaped and approved, shall be protected and kept well drained.

Plant and materials shall not be stored or stockpiled on the formation. Traffic shall not be permitted to pass over the completed sub-grade unless otherwise approved.

4.11.4 Material and Construction of Sub-Grade

All material shall be placed, spread evenly and compacted, spreading shall be undertaken concurrently with placing. The material shall be spread in one or more layers so that after compaction the total thickness is as required. Compaction of the sub-base shall be to 98% of the maximum dry density as determined in accordance with BS 1377 or equivalent and shall be completed as soon as possible after material has been spread. Where compacting plant is of insufficient capacity, the sub-base shall be laid in two or more layers. During the construction period the sub-base shall be maintained in such a condition that it will be drained at all times. The outflow shall be diverted away from the construction at all times. The outflow shall be diverted away from the construction in order to prevent erosion.

4.11.5 Requirements for Compaction

Vibratory compacting plant may be used. The number of passes to be made will be determined having regard to the characteristics of the plant to be employed and the material to be used.

If necessary, test specimens shall be taken to determine the optimum method of compaction. The surface of any layer of material shall, on completion of compaction, be well closed, free from movement under compaction plant and free from compaction planes.

All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

4.11.6 Drainage

Surface water drainage to site roads hard-standings and access roads consists of a cross-fall on the surface of the roads or paved areas draining to the adjoining ground.

Where surface water drainage is provided for roads it shall consist of piped drainage. Where practicable drainage work shall be completed before road works are commenced.

Trenches for piped drainage shall be excavated to the minimum dimensions necessary for the proper construction of the work, and after pipes have been laid, tested and, where specified, surrounded with gravel or concrete, the trenches shall be back-filled with excavated material and compacted to a dry density equal to that of the adjacent ground. Surplus excavated material shall be disposed of site.

Pipes shall be laid to the required lines and levels. Pipes shall be haunched or surrounded with concrete as necessary.

Porous pipes shall be laid dry jointed and shall be Surrounded with gravel. Brickwork manholes and gullies shall be constructed complete with cast iron covers or gully gratings.

4.11.7 Footpaths

The formation and sub-grade for footpaths shall be prepared as specified for roads, except that pro of rolling will not be required.

Edging to footpaths shall be of pre-cast concrete. It shall be bedded in concrete foundation shaped up as necessary.

No sub-base will be required for footpaths. The base shall be as specified for road base, laid and compacted to a minimum thickness of 75 mm using a roller of not less than 2.5 tonne mass or other approved equipment giving equivalent compaction.

Where a flexible final surface is specified the base course shall be sealed with a coat of cut-back bitumen, 100 seconds grade sprayed on at the rate of 1.4 litres/m2 and shall be covered by a surfacing of 6 mm nominal size medium textured wearing course macadam not less than 25 mm thick made and laid in accordance with BS 4987.

Where concrete flags are specified as the final surface, they shall be bedded on a layer of sand approximately 50 mm thick, laid on to the base course. Joints shall be made 3 :1 sand-cement mortar. Paths surfaced with concrete flags will not normally have pre-cast concrete edgings.

4.12 Electrical and Instruments and Control Equipment

4.12.1 Workmanship and Materials

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 British 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 by Maldives regulations.

4.12.2 Reference Standards

All the components of the system shall satisfy BS EN60654 or equivalent, Operating conditions for industrial process measurement and control and quality procedures as per BS5750 or equivalent, and the requirements of ingress protection as laid down in BS EN 60529 or equivalent. Protection from Radio frequency interferences as brought out in the various British standards shall also be ensured. Instrumentation cables shall satisfy BS 5308 or equivalent requirements and in respect of symbolic representation of process control functions and instruments BS1646 or equivalent shall be applicable.

All equipment shall operate with 240 V +10%, -15% 50 HZ ac. The design and quality of all instrument's sensors and controllers and other equipment shall be fully suited to the conditions, which will be met in service.

Analogue signals shall be 4-20 mA DC to BS 5863: Part 1:1986 or equivalent. They shall operate over two wires and be isolated from earth. 1 -5V DC signals shall only be permitted within the main instrument enclosure.

Analogue signals shall be so connected that the failure of a remotely transmitted signal to another panel will not affect other readings on instruments operated by the same signal. Instrumentation cables shall satisfy the requirements of BS 5308 Part1 and part2 or equivalent and shall be armored and shielded with twisted pair for noise immunity.

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 m.hd Metres head of water
- 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.

Where applicable each instrument chassis shall be easily removable from its housing for maintenance without interrupting its signal.

All instrument bezels shall be finished to an approved British Standard color.

Scales shall be clearly marked with black lettering and graduations on a white background. Instruments of the same type and range shall have identical scales.

4.12.3 Electrical Works

Connection 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.

4.12.4 Cabling

All unspecified cables shall be selected in according to the relevant regulations, and to the recommendation of manufacturer.

All electrical cabling shall be supplied and installed from the point of supply to the electrical control cabinet. From the electrical control cabinet cabling shall be supplied and installed to motors and single-phase sockets. Cables runs shall be as approved. The minimum sized cable to any motor shall be 2.5mm^2.

Control cabling shall be carried out in PVC/PVC multi-core cables or similar screened cables where appropriate rated for a minimum of 600 volts. TPS cables shall not be used as control cabling.

All cores of multi-core cables are to be terminated. Terminals shall be DIN rail mounted. All terminals shall be clearly labeled. Unused cables shall be labeled spare. All cables shall be glanded.

Unscreened tails shall be kept as short as practical. Separate 24 VDC power supplies shall be provided for separate cabling shall be provided for instrumentation, discrete control and power cabling. Under no circumstances shall Low Voltage (230V) and Extra Low Voltage (typically 24V or instrumentation signals) utilize a common multi-core control cable.

Termination of cables shall be by way of compression tools. Indent crimp tools are not to be used.

4.12.5 Cable Ladders, Trunking and Conduits

All cables shall be installed in cable ducting. Where a cabling is run outside, including underground cabling, shall be run in in high impact PVC conduit colored orange. Where it is not buried, it shall be encased in timber, VHT conduit or approved alternative.

All cable ladders shall be manufactured from high-grade aluminum and shall be of the extra heavy-duty pattern. In corrosive atmospheres, cable ladder shall be of rigid fiber-glass construction. All changes in direction shall be made using purpose made slow radii bends and cranks as manufactured for this purpose. An adequate support system shall be installed to support this cable ladder and the ladder rack throughout the installation.

All cable support systems shall be adequately sized. All cable ladder, conduit and trucking is to be sized such that with all cables/wires installed, the ladder/trucking is to be no greater than 70% full on completion of installation.

4.12.6 Earthing

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

Earth continuity conductors shall be provided with all cables and securely bonded to the item of equipment being supplied by the phase conductors.

All cable ladders are to be earth bonded throughout its length and bonded to the main earth at each end. The cable ladder is not to be used for bonding of equipment.

Earthling conductors shall be run with all phase conductors and shall be saddled system. Under no circumstances shall earthling conductors take a different route from the phase conductors.

The use of cable armoring as earth continuity conductors is not approved. Such armoring, however, shall always be earth bonded.

Jointing of earth conductors is to be similar to Cadweld brand, self-amalgamating tap over the joint, completed with a cover of green insulating tape.

Multi-core cables shall use the last core number as the earth conductor.

4.12.7 Junction Boxes

All junction boxes shall be manufactured from GRP. Junction boxes shall be rated to IP65.

4.12.8 Socket Outlets and Switches

Socket outlets complying with BS4343 shall be used. All outlets shall be protected by RCD units or earth leakage breakers and be weather proof, suitable for use outdoors.

Earth leakage protection devices, where installed, shall be of the residual current core balance type with a minimum of 3KA rating.

4.12.9 Indicator instruments

All indication instruments shall have performances in accordance with BS 89, dimensions to DIN 43700 and scale markings to DIN 43802. Class index shall be between 1.0 and 5.0 depending on the scale length.

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.

4.12.10 Digital Indicators

Digital indicators shall be panel mounted type with dimensions of 96x48 mm, 41/2 Digit electronic digital display type color 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.

Precaution shall be taken such as the use of snubbers or other means to ensure that fluctuations in the signal, however caused, does not cause the last figure to flicker and become unreadable during normal running.

4.12.11 Field Mounted Instruments

Field mounted instruments shall, where possible, be hermetically sealed. If this is not possible, they shall be of weatherproof construction with heavy cast cases. Transmitters and similar equipment shall be further enclosed in weather-proof, glass reinforced fire-retardant polyester resin cabinets. Particular regard shall be paid to the ease of access to all instruments. Serial number/calibration plates shall be visible when the instrument is in its cabinet.

Locally mounted indicating instruments shall be mounted in viewable positions. Field mounted instruments shall be complete with all mounting brackets, pillars, fittings and fixings to complete the installation.

4.12.12 Panel Mounted Instruments

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

4.12.13 Alarm Annunciator

Each alarm condition shall be indicated on an alarm annunciator having the following basic features:

An audible alarm shall sound upon the initiation of any alarm condition. The audible signal shall be muted upon depression of "ALARM MUTE" pushbutton, automatically after an adjustable delay of 1-5 minutes, or upon the depression of the "ALARM ACCEPT" pushbutton.

The appropriate annunciator shall flash with an equal mark/space ratio at approximately 230 flashes per minute (fast flash) upon the initiation of any alarm condition.

Upon depression of the “ALARM ACCEPT" pushbutton the alarm annunciator shall change to steady indication.

Upon the clearing of the initiating alarm contact, the appropriate annunciator shall flash with an equal mark/space ratio approximately 70 flashes per minute (slow flash).

Upon the depression of the "ALARM RESET" pushbutton, any annunciator whose initiating contacts have cleared, the appropriate annunciator shall be reset and the lamp shall be extinguished.

Depression of the "ALARM RESET" pushbutton shall not reset any alarms which have not been accepted and shall only reset alarms whose initiating contacts have cleared.

Any subsequent alarm that occurs after the "ALARM ACCEPT" pushbutton has been depressed shall be considered as a new alarm condition, irrespective of the state of other alarm legends.

Depression of the "ALARM TEST" pushbutton shall simulate the effect of an alarm condition occurring on all channels into audible alarm and fast flash mode. After a preset adjustable period of between 1-10 seconds, the test facility shall simulate the clearing of the initiating condition to allow resetting of the annunciators.
All annunciators shall be sized to permit an adequate unambiguous description to be engraved in letters no smaller than 3.5mm high. The legends shall be black on an amber background and shall not be visible unless illuminated.

The flashing of more than one annunciator shall be synchronous to minimize confusion between fast and slow flashing of multiple alarms.

For each annunciator provided under the project the Contractor must provide spare parts for two years operation. These spare parts must as a minimum include one module or PCB of every type used in the annunciator including the CPU.

4.13 Steel Protective Coating System

4.13.1 General

Steelwork associated with this specification will be exposed to an atmosphere that can be corrosive as a result of hydrogen sulphide generation and release of other compounds from the septic tank effluent.

Generally, all materials used shall be resistant to corrosion or they shall be protected from being exposed to such corrosion. This applies to materials used in electrical equipment and cabling as well as for other purposes.

All necessary precautions shall be taken to prevent electrolytic corrosion, particularly with stainless steel and aluminum.

Ferrous Steel Work

All steelwork including bolts, pipes, supports and fittings shall be hot dip galvanized, and the electrical control cabinet shall be subsequently painted with an approved protective coating system as specified below. Details of the specific protective coating system to be used together with details of how structural steelwork that cannot be galvanized is to be protected shall be provided at the time of tender. No paint shall be applied until the system and topcoat colors have been approved.

Surface Preparation

All ferrous steel surfaces shall be ground to remove all weld dags and splatters; all sheared and other excessively sharp edges shall be slightly rounded by grinding. All ferrous steelwork shall be pickled in accordance with CP3012: 1972, Code of Practice for Cleaning and Preparation of Metal Surfaces. After cleaning, the surface shall be kept free of oil, grease, dirt and moisture.

Galvanizing

All ferrous steelwork shall be galvanized in accordance with BS 729, Specification for Hot Dipped Galvanized Coatings on iron and steel articles.

Painting

An approved three coat painting system(s) shall be applied to the electrical control cabinet. Application shall be in strict accordance with the manufacturer's instructions, as they may pertain to the site environment.

The three-coat system shall comprise:

- prime coat as an adhesion coating on galvanized metal and compatible with first coat
- first coat of epoxy paint or equivalent
- final coat of epoxy paint or equivalent

Stainless Steel

All stainless sections and anchors shall remain unpainted.

ANNEXX: INSPECTION, TESTING &COMMISSIONING

A1 Inspection and Testing General

Tests shall be carried out on all equipment in accordance with the appropriate BS unless otherwise specified. All tests will be witnessed by the Engineer.

A1.1 Works tests

Tests shall be carried out during manufacture and/or on completion of equipment at the Contractor's or manufacturer's works.

Test procedures shall be submitted to the Engineer for agreement and approval sufficiently in advance to allow for any required changes to the proposed procedures to be discussed and agreed beforehand.

The Engineer may require to witness complete functional and assimilated tests at the Manufacturer's Works to prove the correct operation of all instruments, indicators, recorders, controllers, control loops, programs, alarms, interlock circuits, indications etc.

The equipment shall be tested together using the multi-core cable(s) with correctly tagged ends which will be used in the final installation.

All control, interlock and alarm circuits shall be checked with simulated loads or links as necessary. Milliamp input signals shall be applied as necessary to check the operation of recorders, control loops etc.

All indicating instruments shall be checked for correct operation.

High voltage and insulation resistance tests shall be carried out using applicable voltages.

Calibration tests shall be carried out on all flow, level, pressure, and other instruments and controllers, at the Manufacturer's works, and all such shall be witnessed by the Engineer.

A1.2 Site Tests

The Contractor shall be responsible for the submission to the Engineer of details of all plant in his supply for site inspection and testing as required by the Engineer.

During the course of erection, the Engineer shall have full access for inspecting the progress of the work and checking its accuracy or witnessing such checks as may be deemed necessary by him.

At least 24 hours' notice shall be given to the Engineer of the time at which such inspections and testing is to be carried out.

Three months prior to pre-commissioning tests being commenced the Contractor shall supply test sheets for the Engineer's approval. These sheets shall provide for the following information to be set out in a tabular form:

- Name and number of items of plant or equipment
- Actual test or checks to be carried out and details of standards Test results or data obtained during checks

- Date of test and names of persons conducting and witnessing tests Space for remarks

On completion of erection, running tests on all plant shall be carried out by the Contractor and witnessed by the Engineer to demonstrate adequately that the equipment as erected on site is entirely suitable for commercial operation.

Four copies of all test results and calculations shall be provided by the Contractor to the Engineer for his approval.

The Contractor shall provide all the necessary certified standard Instruments and gauges and any other equipment necessary for checking the installation as and when required and shall operate the plant and carry out the tests to the satisfaction of the Engineer.

Tests and checks shall include functional checks and tests on all instruments, controllers control loops, programs, alarms and protective devices. Wiring shall be tested for polarity, continuity and insulation resistance.

All primary / transmitting / receiving / indicating / recording / totalizing instruments shall be re-calibrated at Site before starting up the Plant and before, during or after the Final Acceptance Tests - as directed by the Engineer.

The Engineer shall witness all such calibration tests, which shall be carried out entirely at the Contractor's own expense.

A1.3 Tests on Completion

The Contractor shall carry out the Plant performance tests on completion before taking over as stipulated.

1. Test for non-monsoon conditions
2. Test for monsoon conditions

Failure to Pass Tests after Completion

The performance criteria, as specified in this section, are the minimum acceptable criteria, below which the works failing to pass tests after completion shall be rejected.

A1.4 Submittals

The following documents have to be submitted by the contractor

1. Overall general arrangement of Instrumentation panels and devices and Process Instrumentation diagram
2. Interconnection drawings showing interconnections between MCC and Central control room and instruments
3. Shop drawings, product data and detailed manuals
4. Complete description, specifications schematic drawings and descriptive literature
5. Conduit routing/lay out and wire pulling schedules

6. Grounding schemes
7. Panel supports
8. Enclosures and junction boxes
9. List of spare parts to be provided for one-year operation
10. Details of training to be imparted to plant personnel for successful Operation and maintenance of the plant

The submittals are subject to approval by the engineer. Final Documentation shall be submitted based on the Engineers' comments.

Electrical Testing

A 2 Electrical General

The pumps, controls, electrical system and pressure discharge pipes shall be proven to perform satisfactorily to the Engineer's discretion. A written record of the following should be maintained:

- dates and times of testing
- those present during the testing
- tests undertaken and results.

A 2.1 Flow Rates

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:
   - volume of water pumped
   - time of pumping
   - start and stop water levels
   - current drawn

b) carry out three closed head tests on each pump recording:
   - current drawn

A 2.2 Level Switches

Demonstrate the correct operation of all level switches.

A 2.3 Overload Protection

Demonstrate the correct operation of motor protection devices.

A 2.4 Alarms

Demonstrate the correct operation of all alarms.

A 3 Testing of Pipelines

Pipelines shall be tested on in-situ to ensure:

- horizontal and vertical alignment
- 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. Pipelines shall be tested in lengths between manholes or in shorter lengths.

Fittings required for temporarily closing the openings in pipelines to be tested shall be properly designed for this purpose and shall be adequately strutted to withstand the test pressure specified.

The arrangements for testing a pipeline shall include provision for the purging of air from the pipeline prior to a water test.

A record of all tests in a book. A copy of each page shall be handed over to the Engineer. A space shall be provided on each page for the Engineer to sign when he has witnessed the testing recorded thereon.

The sections to be tested shall be tightly closed or plugged. Each pump to be used for testing shall be provided with a recording water-gauge, a recording manometer, including a facility for an extra connection for a control-manometer and dead weight tester. Pumps and manometers shall be of a make and type suitable for the work to be executed, in a good state of repair and well adjusted.

Pipelines shall be tested in the shade with air or water when they have been bedded and jointed and before any concrete surround or backfill is placed. A further test shall be carried out when any concrete surround has been completed and when backfill has been placed and compacted to a depth of 300 millimetres above the crown of the pipeline.

a) *Air Test*

Pipelines to be air tested shall have air pumped into the length under test until a pressure equivalent to 100 millimetres of water as indicated on a graduated glass U tube gauge. After a period of five minutes without any further pumping this pressure shall not have fallen below 75 millimetres water gauge. The method of pumping shall be by an approved method and shall be such as to avoid significant changes in the temperature or humidity of the air pumped into the pipeline.

b) *Water Test*

Pipelines to be water tested shall be filled with water under a pressure head of not less than 1.2 metres above the crown of the pipe at the high end. Unless otherwise agreed by the Engineer the test shall commence one hour after filling the test section at which time the level of the water at the vertical feed pipe shall be made up to produce the required 1.2- metre minimum test head. The loss of water over a 30-minute period shall be measured by adding water at regular intervals to maintain the original water level and recording the amounts of water added. Each section of the pipeline would have passed the test is the volume of water added does not exceed 0.12 litres per hour per 100 metres of pipeline per millimetre of nominal Internal diameter of the pipe. The water used for the above test shall be obtained from an approved source.

c) *Infiltration Test*

For non-pressure pipelines the total infiltration shall not exceed 6 litres per day per millimetre of nominal bore per kilometer of pipeline and no pipe or joint shall show visible infiltration flow during an internal inspection. The infiltration shall be measured after backfilling has been completed and the ground water has returned to its pre-construction level (a minimum of 7 days shall be left after back filling) and after all pressure testing has been completed.

A 4 Testing of concrete

Tests may be carried out at appropriate intervals to demonstrate that the materials achieve the specified density.

Each area of layer shall be inspected and tested for compliance with surface level-accuracy.

Waste Water Treatment Plant Testing

A 5 Initial Performance Testing

Performance testing shall comprise 10 days periods. The first of such test is to commence 1 month after plant commissioning, and the second test would be 4 months later.

Daily 24-hour composite samples shall be taken, stored and analyzed in a manner approved in advance by the Engineer. Detailed daily records shall be kept by the contractor of all flows and sludge quantities, weather conditions, staff activities, and electrical power and chemical consumptions during the testing periods.

Detailed performance test reports shall be submitted by the contractor within 20 days following the end of each test. In order to pass a performance, test a minimum of 90% of the results for any individual analysis shall comply with the specified effluent quality for secondary effluent and similarly for the final effluent for recharge. The plant shall also operate within the power and chemical requirements defined by the contractor in his tender.

If any of the up to 10% of samples failing the test requirements exceed the specified limits by more than 100% or if the plant does not operate within the contractor's defined power and chemical consumptions, the overall test shall be deemed a failure. Should the plant fail the second performance test, the test shall be repeated at 2 months intervals until a successful second test is achieved and approved by the Engineer.

The Engineers' approval or rejection of Performance Testing Reports shall be given within 15 days of receipt of the report.

APPENDIX X - LIST OF STANDARDS

B1 Abbreviations for standards

The following abbreviations where used in the Specification refer to Standards, Codes of Practice and other publications published by the organizations listed below:

ACI	American Concrete Institute
AWWA	American Water Works Association
BS	British Standards Institution
CIRIA	Construction Industry Research and Information Association
CP	British Standards Institution (Code of Practice)
ICE	Institution of Civil Engineers, UK
SI	International System of Units

B2 Earth works

BS 1377	Methods of test for soils for civil Engineering purposes.
BS 5930	Code of practice for site investigations
BS 6031	Code of practice for earthworks
BS 8004	Code of practice for foundations

B3 Sewer Pipe laying

BS 497	Specification for manhole covers, road gully ratings and frames for drainage
BS 3416	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 4147	Specification for bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required
BS 4315	Methods of test for resistance to air and water penetration
BS 4483	Specification for steel fabric for the reinforcement of concrete
BS 4504	Circular flanges for pipes, valves and fittings (PN designated)
BS 5911	Precast concrete pipes, fittings and ancillary products
BS 7263	precast concrete flags, kerbs, channels, edgings and quadrants
BS 8005	Sewerage
BS 8010	Code of practice for pipelines

B4 Sewerage Materials

BS 534	Specification for steel pipes, joints and specials for water and sewage
BS 2569	Specification for sprayed metal coatings
BS 3416	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 4147	Specification for bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required
BS 4346	Joints and fittings for use with un-plasticised PVC pressure pipes
BS 451 4	Specification for unplasticised PVC soil and ventilating pipes, fittings and accessories
BS 4576	Unplasticised polyvinyl chloride (PVC-U) rainwater goods and accessories
BS 4660	Specification for unplasticised polyvinyl chloride (PVC-l1) pipes and plastics fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage
ES 4865	Dimensions of gaskets for flanges to BS 4504
BS 5255	Specification for thermoplastics waste pipe and fittings
BS 5481	Specification for unplasticised PVC pipe and fittings for gravity sewers
BS 5556	Specification for general requirements for dimensions and pressure ratings for pipe of thermoplastics materials (metric series)
BS 5911	Precast concrete pipes, fittings and ancillary products
BS 6209	Specification for solvent cement for non-pressure thermoplastics pipe systems
BS EN 295	Vitrified clay pipes and fittings and pipe joints for drains and sewers
BS EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods
BS EN 598	Ductile iron pipes, fittings, accessories and their joints for sewerage applications. Requirements and test methods
BS EN 1401-1	PVC-U Underground Drainage System
WIS 4-31-05	Specification for solid wall concentric external rib-reinforced uPVC sewer pipe
WIS 4-31-07	Specification for unplasticised PVC pressure fittings and assemblies for cold potable water (underground use)
WIS 4-52-01	Specification for polymeric anti-corrosion (barrier) coatings

B5 Concrete Works

BSEN 206-1 Concrete- part 1: Specification Performance, Production and Conformity (BS8500-1 Concrete and BS8500-2).

BS4027:1996 Specification for Sulphate Resisting Portland Cement

BSEN 12504 Testing Concrete

BSEN 12620 Aggregates for Concrete. (ASTM):

1. American Society for Testing and Materials
2. ASTM Book of Standards Vol 1.04:02 Concrete and Aggregates.
3. ASTM A615/A615M-05a, Standard Specification for Deformed and Plain Carbon- steel Bars for Concrete Reinforcement.
4. ASTM C 109/C 109M-05, Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-in. or 50-mm Cube Specimens).
5. ASTM C 150-05, Portland Cement Sulphate Resistant Type.
6. ASTM C309-03, Specification for liquid Membrane- Forming Compound for Curing Concrete.
7. ASTM C494/C 494M-05, Specification for Chemical Admixtures for Concrete. ASTM A775/A775M-04a, Standard Specification for Epoxy- Coated Steel Reinforcing Bars.
8. ASTM C827-01a (2005), Test Method for Change in Height at Early Ages of Cylindrical Specimen from Cementitious Mixtures.
9. ASTM C 939-02, Test Method for Flow of Grout for Preplaced- Aggregate Concrete (Flow Cone Method).

B6 Road Works

BS 410 Specification for test sieves

BS 812 Testing aggregates

BS 882 Specification for aggregates from natural sources for concrete

BS 1377 Methods of test for soils for civil Employers Representating purposes

APPENDIX X – ENVIRONMENTAL PROTECTION

The following table provides a list of probable impacts related to the construction of the works. The list is not exhaustive and a full-scale EIA must be prepared and approved prior to any construction activities taking place. The resultant environmental management plan shall be adhered to at all times during construction.

Condition of work site

- Problems posed by dust during excavation, noise, fuel spillage and discharge of exhaust fumes from machineries and plants, uncontrolled dumping of depleted spares, conditions at temporary living quarters, and construction of site sanitation.
- Road blocking during construction of sewerage and facilities.
- Damage to the location of work such as soil displacement, tearing of roots, possible rupture of underground service.
- Disturbance to existing sanitation pipes.
- Possible damage to gravity and force-main pipes, and to septic tanks due to accidental vertical loading from vehicles and other construction activities

Trench excavations and Public Safety

- Excavations near property lines and buildings causing problems with stability of walls and adjacent properties.
- Open trenches across public access.
- Lack of adequate working space in narrow lanes between house plots for safe operation of plant and machinery.
- Pooling of undrained water from trench dewatering.

Disturbance to garden plots and vegetation

- Disturbance or loss of top soil inside the household garden plots.
- Damage to island vegetation due to excavation and construction works.

Accumulation of waste material

- Waste generated during construction activity stockpiled on site for long periods.
- Lack of mechanisms to dispose of wastes on islands.

Damage to underground services

- Disruption of underground services during trenching.
- Damage to services at shallow depth within the pressure zone of moving loads such as wheels of vehicles used by contractor.

Dewatering

- Dewatering should be done in accordance with the dewatering guidelines of EPA
- Possibility of contamination by saline intrusion into the soil
- Loss of freshwater if freshwater discharged to sea.
- Loss of fines in the soil that contribute to differential settlement of existing structures, and the effects on the growth of plants.

Impact on Groundwater

- Spillage of oil and other construction chemicals.
- Backflow of salt water through pipes at high tides.
- Dewatering impacts on water take level causing saline infiltration

Impacts on Marine environment

- Turbidity during anchoring pipe to reef edge
- Damage the reef or lagoon environment during pipe installation.
- If a barge or a boat is required during work, improper waste fuel and garbage disposal.
- Anchor damage/ collision damage to reef.
- Blasting of reef during trenching work.

APPENDIX X: OPERATIONS AND MAINTENANCE, TRAINING, MANUALS AND AS BUILTS

C 1 Training, Operation and Maintenance Manual

The operations and maintenance manual shall include:

- manufacturer's information about each pump;
- maintenance requirements for each pump;
- manufacturer's operations instructions for each pump;
- as-built wiring drawings;
- as-built drawings;
- copy of commissioning test results and all other records;
- contact names, addresses and phone numbers of suppliers of and service agents for the pumps and control system.

C 2 Trial runs and commissioning

1. After execution of works a trial run the sewerage collection 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.
2. Completion of the successful trial run of the collection network 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. The entire Works, as designed and constructed, must operate as a fully integrated system which is capable of achieving the required output and that each individual component performs in a manner which is complimentary to that of all other components. In the event that the system does not satisfactorily achieve the required performance standards during this period, 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.

C 3 Record Drawings (As Built Drawings)

1. 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.
2. 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.

C 4 Training of Personnel and Others

1. 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 sewerage collection and pumping network, sewage pumping stations, WWTP, 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.
2. 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.
3. An awareness and training program for the Island community, Island Office staff, utility company staffs and other personnel that may be in-directly involved with the maintenance of the household sanitation and public sewers 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.

C 5 Manuals

All the manuals related to operation and maintenance shall be provided in both English and Dhivehi language.

C 6 Operation and Maintenance and spare parts

1. Operation and maintenance of the constructed, hydraulically tested and successfully commissioned plant 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.
2. Reasonable spare parts and replaceable fittings for the sewer jetting equipment 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.
3. 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.
4. 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.
5. All plant and equipment which require routine and periodic maintenance shall be and installed in a manner which will facilitate such operations.
6. 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.
7. The defects liability period shall typically be one year from the date of final completion.

5. Operation and Maintenance

The treatment plant shall be designed and built and subsequently efficiently operated and properly maintained by the contractor for a period of one (1) year. During the operation and maintenance (O&M) period the contractor shall undertake formal training of the client's O&M staff and details of the training plan shall be included in the tender submission.

Reporting formats as given are to be developed and implemented during this period. The contractor shall design the plant allowing for it only to be attended 16 hours a day 7 days a week, with appropriate controls automation and alarm raising provided to operate and monitor the plant outside the manned periods.

Spares for blowers

1.	1 set of Bearings	8Nos- 6203 (make Tata /NRB)
2.	1 set of Oil seal	
3.	2 set of V-belts/Spares for Diffuser	
Mechanical components		
1.	E. P. D. M Membrane Diffuser	4 No.
2.	Float Switch	3No-Spares for Electrical Control Panel
Electrical components		
1.	Contactor MN16	1 No
2.	Contactor MN12	1 No
3.	230 –V-AC Coil for Contactors	2 No
4.	Overload Relay MN2	2 No
5.	1-0-2 Change Over switch 16 Amps	2 No
6.	Panel Board indicator	5 No
7.	Single phase preventer	1 No

Spare Parts and Tools

Spare parts and tools for the Wastewater treatment plant must be provided by the contractor for the operation period of 1 year. Spare parts and tools shall be handed over to the appointed individual by the Employer and Island Officials.

6. SCHEDULE OF EQUIPMENT & QUANTITIES FOR PUMP STATIONS

Ultrasonic level sensors along with unit Quantity Location level transmitter and microprocessor-based controller with configuration facility with 5 sets of relay contacts each per equipment for auto operation set three Pump stations of pumps at sewage pumping station along with high alarm at pumping stations with necessary fixing hardware, Power supply, accessories interconnecting cables and connectors for each of the three pumping stations

1. Magnetic flow sensor, transmitter and set ten Pump stations Flow indicator, Totalizer, with necessary fixing hardware power supply, accessories interconnection cables for indication of flow in discharge side of each of the three pumping stations
2. Necessary tools and spares of instrumentation One set - for two years operation
3. List of alarm points and controls in central control room

7. TRAINING REQUIREMENTS

7.1 General

The Contractor shall provide comprehensive training for the different categories of the Employers operation and maintenance staff. Training shall fall into two main types which are 'off the job' and 'on the job'. Off the job training shall take place in the class room, on the job training shall be carried out on the running plant.

7.2 Off the Job Training

The Contractor shall prepare formal training documentation for distribution to the trainees. Visual aids shall be used where possible to illustrate the points being made and to make the training programme as interesting and enjoyable as possible for the participants.

The off the job training shall comprise the following: Off the Job Training Programme for all Trainees

a) To provide training:
b) on the simple chemistry and process principles involved in the operation of the Works;
c) health and safety;
d) plant safety procedures;
e) on the use of the local and central MMI s

Off the Job Process Training Programme for Operators

To provide training:

a) on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure;
b) on the day to day operation of the Works and procedures;
c) on a comprehensive list of 'what if' scenarios dealing with the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc.;
d) on first line mechanical maintenance;
e) safe methods of work general;
f) on safety procedures to be followed in operating, maintaining and cleaning the plant;

Off the Job Training Programme for Electrical Maintenance Staff

To provide training:

a) on the configuration, construction and operation of the electrical Plant;
b) on the electrical maintenance requirements of the Works;
c) on the switching and safety procedures to be followed;
d) safe methods of working;
e) on fault finding and repair procedures

Off the Job Training Programme for Control and Instrumentation Maintenance Staff

To provide training:

a) on the configuration, construction and operation of the Plant;
b) on the control and instrumentation maintenance requirements of the Works;
c) on fault finding and repair procedures;
d) safe methods of working;

Off the Job Training Programme for Mechanical Maintenance Staff

To provide training:

a) on the routine mechanical maintenance requirements of the Works;
b) on lubrication requirements of the Works;
c) on fault finding, repair and overhaul procedures;
d) safe methods of working.

Off the Job Training Programme for Water Treatment Management Staff

To provide training:

a) Wastewater treatment process management techniques;
b) Wastewater treatment plant cost management;
c) Wastewater treatment plant laboratory management;
d) safe methods of work general;
e) on safety procedures to be followed in operating, maintaining and cleaning the plant

7.3 On the Job Training

The Contractor shall utilize the Operations and Maintenance Manuals as the primary training aid in carrying out the on the job training. Short comings, omissions and errors identified in the O & M Manuals during the training shall be rectified prior to final acceptance of the O & M Manuals.
On the Job Training Programme for all Trainees

To provide training:

a) plant familiarization tour;
b) health and safety;
c) identify areas where special safety precautions are necessary

On the Job Process Training Programme for Operators

To provide training:

a) under operational conditions on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure;
b) illustrate by example the day to day operation of the Works and procedures;
c) illustrate by example the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc. (as identified in the 'what if' scenario off the job training);
d) illustrate by example the first line mechanical maintenance;
e) illustrate by example safety procedures to be followed in operation, maintenance and cleaning of the Works.

On the Job Training Programme for Electrical Maintenance Staff

To provide training:

a) carry out detail tour of the electrical plant;
b) illustrate by example the operation of the electrical Plant;
c) illustrate by example the electrical isolation and maintenance procedures;
d) illustrate by example fault finding and repair procedures;
e) illustrate by example switching and safety procedures to be followed;
f) illustrate by example safe systems of work.

On the Job Training Programme for Control and Instrumentation Maintenance Staff

To provide training:

a) illustrate by example the operation of the Works;
b) illustrate by example the control and instrumentation maintenance requirements of the Works;
c) illustrate by example fault finding and repair procedures
d) illustrate by example safe systems of work

On the Job Training Programme for Mechanical Maintenance Staff

To provide training:

a) illustrate by example the routine mechanical maintenance requirements of the Works;
b) illustrate by example lubrication procedures;
c) illustrate by example fault finding, repair and overhaul procedures.
d) illustrate by example safe systems of work.

7.4 Training Program

Off the job training shall be carried out prior to Taking Over of the Works or any section of the Works.

On the job training shall be carried out primarily after Taking Over of the Works or any section of the Works. However, where it is possible to do so without reducing the effectiveness of the training and with the permission of the Engineer and the Employer on the job training may be carried out prior to Taking Over. On the job training shall be completed as a condition for acceptance of the Works following completion of the Tests after Completion.

The Contractor shall provide a training plan for each category of staff. The training plan shall detail the content and duration of each course. The training plan shall be submitted for the approval of the Engineer at least 60 days prior to the commencement of the Tests on Completion.

7.5 Training Personnel

The Contractor shall provide suitably qualified trainers to carry out the off the job and on the job training.

The trainers are to be experienced in treatment plant and pumping station management, operation and maintenance in their relevant discipline and in the training of skilled and unskilled staff.

The training expert shall be fluent in English or the Contractor shall provide the services of an interpreter in Dhivehi during the training periods.

8. OPERATION MANUAL AND AS-BUILT DRAWINGS

The submission of the as-built drawings and the final operation manual for the facilities is the precondition for the final payment.

8.1 Operation Manual

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) Architectural, 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.

8.2 As-Built Drawings

The Contractor shall submit to the Project Manager within one month of actual completion, "Completion" Drawings as specials below. These Drawings shall be accurate and correct in all respects and shall be shown to and approved by the Project Manager.

Completion Drawings as below on two prints and one polyester film shall be supplied by the contractor, along with a soft copy in CD. These drawings shall be developed in latest version of Auto CAD. Drawings shall be of standard size for below.

I. Site plan showing all features existing and as constructed under this contract with all external dimensions, dimensions of clear spaces among those, diameter and materials of pipeline etc. complete.
II. Architectural, Civil and Structural details of all components of the plant including plans at different levels, elevations from all sides as well as sectional etc. complete with all dimensions including structural Thickness, concrete grade, reinforcement details, finishing details, schedules of doors and windows, details of associated fittings and features complete.
III. All piping, plumbing and electrical details with dimensions, diameters etc. complete at specific cases isometric views of piping may be necessary.
IV. Dimensioned details of all electrical, mechanical and instrumentation equipment including accessories along with arrangement inside the buildings or enclosures, connected piping and cabling layout etc. all complete.

V. Dimensioned details of all control and measuring devices lined weirs, V-notches, probes, valves, gates, consoles, panels, switch boards, cable layouts etc. for the complete proposed plant. Fine diagrams/ Circuit diagrams shall be used wherever applicable.
VI. L-sections for pipelines laid externally, showing pipe profile, ground profile, soil condition, bedding, location of specials, valves and other accessories complete.
VII. Dimensioned details of all site development works such as roads, drainage, cables pipelines, landscaping etc. complete with layout, cross-sections, levels etc. complete.

All drawings shall be prepared in appropriate scale and with adequate notes, legends, titles etc. for clarity.

9. GENERAL REQUIREMENTS FOR OPERATION AND MAINTENANCE

The Contractor shall maintain the entire plant within his contract during the operation and maintenance period of one (1) year including defect liability period from commissioning of existing plant. The operation and maintenance period shall include the defect liability period. All necessary repairs shall be made to maintain the plant at the status at handing over. The tasks of the Contractor shall be:

- Operating the plant up to design capacity as directed by Project Manager from time to time by maintaining the required output quality;
- Keeping the down time of any equipment as low as possible but at least below the desired level as required:
- Maintaining all the plants, equipment and tools installed by him and making necessary repairs;
- Technical and administrative monitoring of the plant and reporting to EMPLOYER;
- Communication and co-ordination with the adjacent plants and related agencies.

The operation, maintenance and repair service shall be performed according to the following principles/specifications:

Operation of the plant as per O&M Manual

The plant shall be operated according to the rules and procedures laid down in the O&M manual as required by the system.

Awareness & Cleanliness

The contractor and his staff shall maintain a high degree of awareness in operation and maintenance of the plant. At all times the plant, its equipment and surroundings shall be kept clean and in order.

I. Frequency of Preventive Maintenance: The preventive maintenance will be done according to the preventive maintenance schedule of the plant. The regular staff may be reinforced by short term specialists by the Contractor for special maintenance tasks.
II. The operation, maintenance and repairs shall be made with the help of the equipment and tools available at the plant, backed up and completed with the facilities of the Contractor or brought to the plant by him temporarily for special maintenance.

Repairs

Repairs shall be made as and when needed very promptly on the spot or at the contractor's workshop; the need of repair on the spot or at the Contractor's workshop has to be defined in co-ordination with the Project Manager and according to the status of the spare parts availability.

Spare parts

I. The Contractor has to keep a reasonable stock of spare parts so that the down time of equipment can be kept in the limits. The contents of the stock have to be approved by Project Manager.
II. Transportation All necessary transports shall be arranged and made by the Contractor at his own costs.

Consumables

The Contractor has to ensure that always there is a sufficient stock of 15 days of the treatment chemicals and other consumables in the plant.

9.1 General Obligation

The Contractor shall operate and maintain the entire plant under this contract for the period specified in the Contract.

Contractor will submit a detailed operation and maintenance plan for approval of Project Manager. All operation and maintenance activities by contractor shall be carried out strictly in accordance with the approved plan.

a) Services shall include but not limited to:
b) Operation and maintenance of all the facilities including WWTP,
c) Operation and maintenance of all mechanical, electrical equipment and all the Instruments of the facilities;
d) Training of O&M staff of EMPLOYER.
e) Maintenance of all civil works under the contract.
f) Contractor shall submit periodic reports as per schedule and formats approved by Project Manager.

9.2 Operation

Operational Services

The Contractor shall operate the complete conventional gravity sewerage system including Wastewater Treatment plant, treated wastewater pumping station and sea Outfall.

The Contractor shall operate and utilize all the control and monitoring systems provided in treatment system and if found to be necessary and if approved by the Project Manager, shall make adjustments within the operating range of the control system and equipment so that the plat operation matches the treatment process requirement.

If it is determined that the facility is not capable of meeting the design parameters for any reason, the Contractor shall determine the specific cause of failure and report to the Project Manager on action to correct the deficiency.

Electricity

Employer shall directly pay all the electricity bills. Contractor will be required to furnish the details of Electricity Consumption in the format prescribed by the Project Manager.

Chemicals

Employer shall provide the chemicals if necessary, to operate the plant. The Contractor will be required to furnish Chemical's consumption, in the format prescribed by the Project Manager. However, laboratory chemical shall be provided by the contractor.

Miscellaneous and other consumables

All other consumable and spares required to operate and maintain the plant in good condition shall be provided by the Contractor at his expense.

General Maintenance and Facilities

All example tools, cleaning & housekeeping equipment, security and safety equipment, etc. shall be provided by the Contractor at his own expense.

Laboratory Services

a) The Contractor shall perform all tests, sampling and analyses as and when required as per the O & M Standards.
b) The Contractor will submit in his offer a complete list of laboratory equipment and materials in accordance with the analysis program required.
c) Without limiting the above obligations, the Contractor shall perform all tests, sampling and analyses required in order to obtain the following information:
d) The daily totals and hourly variations during the day of:
    - *Flow entering at inlet of treatment plant (m^3/d and m^3/h)*

Manpower

The Contractor shall provide experienced managerial, technical, supervisory, laboratory, administrative and non-technical personnel and labor necessary to operate and maintain the Wastewater Treatment plant & works properly, safely and efficiently for the full term of the O&M Period.

The qualifications and capability of the Contractor's personnel shall be appropriate for the task they are assigned to perform. The staff provided shall be fully trained in the operation of the Works before being given responsibility for operation of the works. If, in the opinion of the Project Manager, a member of the Contractors staff is considered to be in sufficiently skilled or otherwise inappropriate for the task he is required to perform, he shall be replaced by the Contractor with a person with the appropriate skills and experience for the task, to the approval of the Project Manager.

The Contractor shall propose in his tender a staff management structure for the operation and maintenance of the Works. This structure shall be expected to include but not necessarily be limited to the following personnel:

- Plant Operator 1 No. Full time
- Electrician/ Mechanic 1 No. Part time
- Helper 2 No. Full time

To this end, the Contractor will be required to complete the Prescribed Schedule.

The Contractor shall provide all secretarial support, printing and publishing services, office furniture and office supplies as necessary for entire O & M period.

The O&M personnel shall be dedicated 100 % of their time for the specified duties and responsibilities and shall not be diverted to perform Contractor's administrative duties, construction arrangement, office management, or other non-project activities. Adequate support staff shall be provided by the Contractor in order to avoid any such diversion.

Safety

The Contractor shall be responsible for safety of his staff on Site during the O&M of the plant by the Contractor.

The Contractor's duties with respect to Safety shall include the following:

Utilize safety awareness procedures in every element of operation and maintenance. Give emphasis to site safety including:

a) Safe working procedures.
b) Cleanliness and care of Plant as a whole.
c) Accident and hazardous conditions reporting.
d) Safe practice in water and chemical handling.

Hold informal safety discussions among all members at least weekly at various points throughout the plant. Formal discussions shall be held with all concerned agencies at least once a month.

The Contractor shall cooperate with other off-site authorities preparing the "Off-Site Emergency Plan" on request.

The Contractor shall provide Notice Boards/Display Boards at appropriate location detailing precautions to be taken by operation and maintenance personnel in work in conformity to regulation and procedures.

The Contractor shall notify the Project Manager immediately if any accident occurs whether on-Site or off- Site in which the Contractor is directly involved which results in any injury to any person whether directly concerned with the Site or a third party. Such initial notification may be verbal and shall be followed by a written comprehensive report within 24 hours of the accident.

Reporting

Contractor shall prepare reports daily and monthly and submit to the Project Manager. The Daily reports are to be submitted within 1st working hour of the next day. The monthly reports shall be submitted on the first day of the next month and within first two working hours.

The reports shall generally contain information as enclosed formats along with brief write-up on specific matters needing attention of concerned agencies.

Overall reporting formats will be approved by Project Manager and may have to be modified from time to time as required and approved by Project Manager. Contractor may have to prepare and submit additional reports on particular matter and incidents as and when required by the Project Manager

9.3 Maintenance

Maintenance of Installed Facilities

The Contractor shall ensure the continuous operation of the Plant and that the breakdown or the deterioration in performance of the plant, under normal operating conditions, of any items of the Plant and equipment and component parts thereof is kept to a minimum.

The classes of maintenance provided shall comprise:

- Full Operational Maintenance.
- Standby Maintenance.

Full Operational Maintenance comprises the planned and regular maintenance carried out by the Contractor on a day-to-day basis, including cleaning, lubricating, minor adjustment, together with preventive and corrective maintenance plan, for those items of plant and equipment within the treatment works, which have been commissioned and made operational.

Standby maintenance comprises the planned and regular maintenance carried out by the Contractor including cleaning, lubricating, periodic operation and minor adjustments of all items of plant and equipment within the treatment works which have been installed but have not yet been made operational.

The Contractor shall carry out the Maintenance of the plant installations in accordance with the requirements of the O&M Manual and to the approved Maintenance Plan.

The Contractor shall strictly adhere to the manufacturers' recommendations with respect to equipment maintenance, the types and grades of lubricants to be used, frequency of lubrication, adjustments to be made regularly and recommended spares to be held in store.

9.4 Pumping Stations

Operation of plants as required, including provision of required manpower for routine operation of pumping station.

I. Periodic site calibration of all measuring /metering equipment at every 6 months minimum or as recommended by the manufacturer. The calibration at the manufacturer's works/independent laboratory shall be carried out only in case of major failure of the instrument.
II. Repair or replacement, as required, of damaged electrical equipment / parts for proper functioning of electrical system.
III. Maintenance of the cooling and lubricating systems.
IV. Routine maintenance of the pumps / motors as per recommendation of the manufacturer.
V. Replacement of bearings, impellers and other damaged parts so that the operation of pumps ensures the guaranteed efficiencies with desired noise and vibration levels.
VI. Re-painting of the exposed mild steel components of pipe line, ladders, railings etc. in the pump house.
VII. Maintaining the surrounding areas of the pumping station free from shrubs, weeds, grass and other unplanted vegetation.
VIII. Routine monitoring of substation equipment's and taking preventive measures as required.
IX. Keeping the hourly records of:

- Status of pumps
- Current
- Voltage
- Frequency
- Active and reactive power
- Water level
- Delivery gauge readings
- Rate of flow
- Pump head

X. Keeping daily records of:

- Total number of hours of operation
- Total quantity pumped
- Total energy (kWh) consumption

Contractor will prepare the maintenance schedule for Pumping Stations as required.

9.5 Spare parts

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labeled on the outside of it's packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

10. SITE MAINTENANCE

The Contractor shall be responsible for:

a) The full maintenance of building electrical, ventilation, plumbing and drainage installations.
b) Building and housekeeping maintenance.
c) Full maintenance of the site water and wastewater services, cabling and earthling system, together with the site road lighting system.
d) Site maintenance including the upkeep of landscaped areas.
e) The building services and housekeeping maintenance shall be undertaken on all buildings and services installations.

Routine housekeeping maintenance shall be carried out in accordance with the procedures specified in the Operation and Maintenance Manual.

10.1 Preventive Maintenance

The Contractor shall prepare a planning of the day-to-day maintenance and the preventive maintenance. This planning must include for each equipment for estimating necessary hours in preventive maintenance and curative maintenance with in each case the qualification of the foreseen maintenance personnel.

The Contractor shall provide the yearly requirement of spare parts and consumable needed for the maintenance of each equipment's. These correspond only to the day-to-day maintenance, preventive maintenance and foreseen curative maintenance if any. The contractor shall get the plan approved from Project Manager.

11. OPERATION AND MAINTENANCE MANUAL

The Contractor, before commencement of the Tests on Completion, shall submit 4 (Four) copies of the operation and maintenance manual, in English language, containing descriptions, illustrations, sketches, drawings, sectional drawings, sectional arrangement view and manufacturer's parts numbers to enable the connections, functions, operation and maintenance of all components of the complete plant to be easily followed and for all parts to be easily identified to facilitate ordering of the replacement parts. Exploded views of the items/ works where appropriate shall be used for clarity. The Contractor shall provide the contact address and telephone number (Hotline) in the manual.

The operation manual shall also include the following:

- Technical data of each equipment and their performance.
- Instructions for servicing and overhauling.
- Particulars of lubricating oil and grease to be used, also alternative indigenous commercial lubricating oils suitable for use.
- Performance curves for all units regarding efficiency loading and output.
- Performance curves for the motors.
- List of tools mounted on wall panels.
- List of spares provided in the spare box.
- Spare parts list, with manufacturer's part numbers.
- Operator's Log.
- List of the photographs of the plant and machinery as fabricated by the manufacturer.
- Safety procedures/guidelines

The maintenance manual shall also include the following:

- Procedures for maintenance.
- Preventive maintenance procedures for all the equipment.
- Emergency maintenance management of the plant and equipment

APPENDIX X: SCHEDULE OF MAKES (ELECTRO – MECHANICAL ITEMS)

A Schedule of popular makes of Electro-Mechanical items is furnished below; the list is not exhaustive and contractors may consider other equivalent products as well.

Submersible Pumps
Kishore/Grundfos/KSB/Johnson/Equivalent Vertical Turbine Pumps:
Kirloskar/Jyoti/M&P/Worthington/Fair Bank Morse
Motors:
Kirloskar/NGEF/Jyoti/BHEL/Crompton Greaves Valves (sluice valves and non-return valves):
Kirloskar/Four ESS
HOT crane: W.H. Brady & Co. Hercules Hoists Ltd. (INDEF)/Sharp Engineering Pvt. Ltd.

Exhaust fans / Ceiling Fans
Bajaj Electricals/Crompton Greaves/Jay Engineering Works (USHA)

Power Transformers
NGEF Bharat Bij lee Ltd./Kirloskar/Crompton Greaves/BHEL

11 KV / 6.6 KV switch gear
Jyoti Siemens/Crompton Greaves/Kirloskar/MEI

415 V Switch Gear and Control Gear
L&T Siemens/Control and Switchgear/BhartiaCuttler Hammer/HH Elecon/ELPAN/English Electric/Crompton Greaves

Cables &C Cables
CCI Incab/Universal/Tropodur/Equivalent

Lighting Fixtures
Philips/Crompton Greaves/Bajaj/Equivalent

Instruments and Controls
Automatic Electric Universal Electric/MECO Instruments Pvt. Ltd./Industrial Motors (P) Ltd.

415V CBs
English Electric/Larsen & Toubro/Siemens/Kirloskar/Crompton Greaves

Relays Control and Relay Panels
English Electric/Jyoti Universal Electricals Ltd./EasunReyrolles Relays/Hindustan Brown Bowery/MEI

Pressure Gauges
Manometers India Ltd./H Guru Instruments Pvt. Ltd./A.N.Instruments/General Instrument Pvt. Ltd.

Fire Extinguisher
KooverjiDevshi& Co. Pvt. Ltd./Vijay Fire Protection Systems Pvt. Ltd./Steelage Industries

Gear Reducers
Essen Pro/Radicon/Eleco

CTs & PTs
MEI/Automatic Electric Pvt. Ltd./Kappa Electricals/Hindustan Brown Boveri

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

12. ELECTRICAL WIRING STANDARD BY MALDIVES ENERGY AUTHORITY

MALDIVES ENERGY AUTHORITY
GOVERNMENT OF MALDIVES

Electrical wiring

Electrical wiring should be done by a person recommended by Maldives Energy Authority.

When wiring, in single phase wiring, the live wire should be red, the neutral wire should be black, the earth should be green or green wire with yellow stripes.

In three phase wiring, the first phase should be a red wire, the second phase should be yellow, the third phase should be blue, neutral should be black and earth wire should be green or green wire with yellow stripes.

A green wire or green wire with yellow stripes can only be used to connect the earth wire. Black wire should only be used to represent neutral connection.

In three phase wiring if the appropriate three colors of wire cannot be obtained for each phase, the end of the wires used should be color coded to show the color of the wire that is represented.

In three phase wiring, all the three phases should receive equal amount of the output load.

The main earth wire of a certain building should have the appropriate diameter that is optimized for the size of the building. The main earth should be earthed after it passes through the d-board or through the input located for the earth wire in the main switch. The earth wire should be connected to the earth rod using a cable lug. An earth rod could also be used instead of an earth pipe. The earth wire should be earthed inside an 8" x 8" pit.

In wiring, even if the installation is small, a D-board, Main Switch and ELCB should be connected. The ELCB should be connected after it is tested and approved by the Maldives Energy Authority or by a party recommended by the Authority. In single phase wiring there should be a minimum of one socket and two lights. In three phase wiring there should be a minimum of three sockets and six lights.

For houses and buildings the ELCB rating is: for single phase tripping current should be 30mA, 240V rated electricity 30 – 63 A, 2 poles and current operated ELCB. For three phase ELCB tripping current should be 30mA, 440V/380V, 40-63A, 4 poles and current operated. A lower rated ELCB could also be used. But the tripping current should not exceed 30mA.

A Live Neutral and Earth wire should originate from each circuit from the D-board. An appropriate MCB should be connected to each circuit. A high rated MCB should not be connected.

A (bas-bar) connection should be used in the d-board. A wire loop should not be used instead of this. When installing the (bas-bar) in three phase d-board, the separate phases should not be kept close to each phase.

If the size of the wire used is 3/029 or 1.5 mm^2, than the circuit could support 5 lights. A fan could be included too. The load in the circuit should not exceed 500 watts. For socket circuits, the size of the wire should not be greater than 7/029 or 2.5 mm^2. The circuit could support 2 sockets if 7/029 or 2.5 mm^2 wire was used

If two or more gang switches are used in the same box when wiring, only one phase should be connected to the switches

In single phase wiring a MCB exceeding 2 pole 40A should not be used instead of 30A main switch. In three phase wiring a MCB exceeding 3 or 4 pole 63A shouldn't be used instead of 60A main switch. If the main switch is installed on the d-board it should be installed at a height of 5 to 6 feet and should be reachable from ground level.

Wires should be inserted into a conduit or PVC pipe when wiring. If such pipes are not used in wiring, then the wires should be held in place using cable clips or another method such as that.

A separate circuit should be used for machines that utilizes high loads such as air-conditions and deep freezers.

Wiring for machineries should utilize a wire that originates from the starter or main switch. The starter and main switch should be easily reachable from where the machine is located and should be easy to operate.

The d-board should be installed such that the lower edge of the d-board is not higher than 6 feet.

A water proof switch should be connected in a place where water is accessible such as in a toilet. If another type of switch is used than it should be installed in a location where water is not reachable.

If a socket without a switch is used, than it should be operated with a separate switch. Normally, sockets without switch would not be allowed.

In large buildings the phase neutral, phase earth and neutral earth shouldn't be less than 1 mega ohms. Even so, if the wire is less than 5 points, than 1 mega ohms is not enough. Under such circumstances the wires should have 10 mega ohms.

In emergency situations another generator could be used to supply electricity if there is a change over switch. The change over switch should be able to cut of the live and neutral wire and should be able to cope with the load.

After wiring and testing by Maldives Energy Authority or by a party recommended by the Authority, if additional circuits need to be connected to the d-board, than the wiring has to be again tested by Maldives Energy Authority or by a party recommended by the Authority. Wirings that are not tested and approved by Maldives Energy Authority or by a party recommended by the Authority should not be installed.

If the wiring is incorrect than responsibility of the faulty wiring will fall on the person that signed the test form identifying him as the person who did the wiring.

MALDIVES ENERGY AUTHORITY
GOVERNMENT OF MALDIVES

SUBJECT: Cables and Wires used in the electrical installations in Maldives

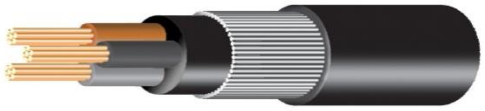
This is to bring to your attention that cables and wires used in the electrical installations in Maldives should comply with the following standards:

PVC INSULATED NON-ARMOURED CABLES WITH COPPER CONDUCTOR FOR VOLTAGES UPTO AND INCLUDING 450/750V, FOR ELECTRIC POWER, LIGHTING AND INTERNAL WIRING.
Has to comply with BS 6004 OR BS 6360 (class 2 stranded) standard.
[BS 6004 is equivalent to IEC 60 227-3]

ELECTRIC CABLES. THERMOSETTING INSULATED, ARMOURED CABLES FOR VOLTAGES 600/1000 V AND 1900/3300 V.
Has to comply with BS 5467 OR BS 6360 (class 2 stranded) standard.
[BS 5467 is equivalent to IEC 60502]

13. CABLE STANDARDS

HARMONISED CABLE COLOURS
IEE Wiring Regulations
BS 7671: AMENDMENT No. 2 (MARCH 2004)



A huge change for industry

The harmonisation of cable core colours which the UK has to implement by April 2006 represents the biggest change that the electrical industry has had to accommodate.

Harmonised cable colours

- Why change?
- What are the changes?
- How do we best implement the change?

Harmonised core colours

Three-phase interface marking