NAMIBIA WATER CORPORATION Ltd

CENTRAL NAMIB DESALINATION WSS

TENDER No: NW 020/2007/O

THE DESIGN, CONSTRUCTION, AND TWO YEAR OPERATION AND MAINTENANCE OF A DESALINATION PLANT ON THE CENTRAL COAST OF THE REPUBLIC OF NAMIBIA

SECTION 600:

EMPLOYER'S REQUIREMENTS

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SCOPE

This Employer's Requirements is set out in two portions.

PORTION 1 contains a general description of the project, site circumstances, temporary facilities required on site, aspects requiring specific attention, and the detailed specification of the Permanent Works.

PORTION 2 contains variations and additions to the applicable standardised specifications for Civil Works applicable to the contract.

PORTION 3 contains the particular specifications for Civil Works that are applicable to the contract.

PORTION 4 contains the particular specifications for Motors and Switchgear that are applicable to the contract.

PORTION 5 contains the particular specifications for Electrical and Electronic Installation for Buildings that are applicable to the contract.

PORTION 6 contains general guidelines for Citect SCADA Installations for the tenderers information.

STATUS

Portion 2 of the Employer's Requirements supplements the Standardized Specifications and both Portions 1 and 2 form an integral part of the contract.

Should any provisions of the Employer's Requirements conflict with any requirement of the standardised specifications listed in Paragraph PS 12 of Portion 1, the provisions of the Employer's Requirements shall prevail.

In case of discrepancy or conflict between the various specifications and drawings, the order of preference shall be as follows:-

1. The Detail Specifications contained in Portion 1 of the Employer's Requirements
2. Tender Drawings
3. Particular Specifications
4. The variations and additions to the Standardised Specifications
5. Standardised Specifications

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SECTION 600:

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PORTION 1

THE WORKS

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PORTION 1:

THE WORKS

PS 1 GENERAL DESCRIPTION OF THE WORKS

PS 1.1 Background

The Namibia Water Corporation (hereinafter referred to as "NamWater" or "the Employer") is currently challenged by a situation where, due to an unprecedented growth in the Uranium Mining Industry adjacent to Namibia's central coastal area, large volumes of potable water will be required in the medium term to provide in the growing demand of NamWater's existing and prospective new Mining Clients, which can no longer be supplied from the current groundwater sources in the area. To enable NamWater to do so the NamWater Board of Directors approved the development of a desalination plant on Namibia's central coast North of the town of Swakopmund.

PS 1.2 Plant technical description, including design basis

The scope of this project is to design and construct a 15 Mm^3/annum seawater reverse osmosis (SWRO) plant located on a site on the central Namibian coast. The contract between the Contractor and the Employer will include a 2-year period of operation and maintenance.

In order to ensure the required annual production and to allow for stoppages, maintenance and anticipated power load-shedding outages, the plant shall be designed to initially deliver 50 Ml/day on a 24hr basis and the design shall allow for future expansion to 80 Ml/day. For this purpose all civil works and buildings shall be designed and constructed for the final capacity of 80ML/day.

The plant shall be designed, and the process equipment selected, for continuous operation 24 hours per day, 365 days per year. Scheduled complete plant shutdowns will be allowed for not more than a total of 15 days per year, with no single shutdown exceeding 48 hours without the express consent of the Employer.

The plant is to be constructed in the vicinity of another SWRO plant currently under construction by UraMin Namibia (Pty) Ltd. The two facilities will share a common seawater intake structure, twin seabed pipelines to a common onshore pump station, and common brine discharge pipeline. An electrical substation will also be constructed as part of the UraMin project.

The seawater pump station will supply untreated seawater to both the UraMin and the NamWater SWRO plants by means of separate pump sets and supply pipelines. The supply pumps for the NamWater SWRO plant will be separately controllable by means of variable speed drives to supply the required flow rates to the plant. The Tenderer shall consult with the Employer's electrical engineers to ensure the functionality of the control interface between the seawater pump station and the plant.

The off-shore intake structure will be fitted with the necessary means to provide continuous chlorination to the intake structure, and the off-shore pipelines. The Tenderer should consider this in his design by incorporating a means by which the presence of chlorine in the incoming seawater can be detected, and dechlorination can be accomplished prior to the water entering the RO membranes.

The NamWater SWRO plant will consist of the following key facilities:

- Pretreatment facilities and buildings
- SWRO system, with energy recovery equipment and building
- Post-treatment facilities and building
- Primary electrical building, to be connected by the Contractor to a new 11KV electrical service to be provided by NamPower
- Administration, stores, maintenance and workshop building
- Liquid and sludge waste handling facilities
- Chemical bulk storage, dry stores and chemical feed equipment.
- A 2 meter high security wall encircling the site with a controlled entrance and guard house.

The Tenderer shall consult with the Employer's engineers to ensure the functionality of the interface at the NamWater/UraMin brine commingling point.

The Contractor will be responsible for the design, procurement, delivery, equipment and materials storage, construction, installation, commissioning, start-up, and acceptance testing of all facilities listed above. The post-treated product water will be delivered to a storage tank and pump station to be constructed by the Employer on an adjacent site under separate contract. Upon the completion of the Acceptance Test, the Contractor will be responsible for two years operation and maintenance of the facilities.

The Contractor will also be responsible for providing a full complement of spare parts and special tools needed for proper dismantling, maintenance and repair of the treatment equipment.

The design, construction and commissioning of the SWRO facilities shall be completed in accordance with all relevant standards, codes and regulatory requirements and sound engineering and construction practices. The SWRO process design will recognize current practice in the global desalination industry, using materials which are customarily used in similar facilities for the fabrication and construction of key desalination components.

The SWRO pretreatment shall utilize single or two stage granular media filtration followed by membrane filtration, either pressure driven or submerged. The combination of pretreatment technologies shall produce a high quality pretreated water that is suitable for reliable operation of the SWRO water treatment plant, while maintaining the lowest possible operating and maintenance cost. Alternate technologies for pre-treatment may be offered and will be considered by the Employer, however, membrane filtration is required prior to the SWRO.

It is required that the initial SWRO installation consist of 5 trains, each with a rated permeate production capacity of 10 Ml/day. The space reserved for expansion shall be sized to accept three additional 10 Ml/day trains. It is preferred that each train is a stand alone system, including pump(s), energy recovery devices, and controls. However, the pressure center concept will be considered if the economic benefits can be demonstrated by the Tenderer.

Post treatment of the SWRO permeate shall be designed to condition the permeate for potable use. It is anticipated that calcite beds will be utilized to re-harden and re-carbonate the permeate, and raise the pH. Carbon dioxide or acid will provide the acidity in the water necessary for dissolution of the calcium media and the formation of calcium bicarbonate. Caustic soda will be used for trimming the pH, and chlorine gas will be used for disinfection.

PS 1.3 **Use of the product water**

The product water will primarily be used for bulk water supply to a number of NamWater's existing and prospective new uranium mining clients. The product water will however be transported via a common pipeline to Swakopmund that will also carry groundwater supplied from NamWater's well fields near Hentiesbay for residential and industrial consumption in the Town of Swakopmund. Therefore the finished water must comply in all respects with the Employers requirements for potable water.

PS 2 DESCRIPTION OF SITE AND ACCESS

PS 2.1 **Project Location**

The proposed site for the NamWater desalination plant is located on the central coast line of Namibia, approximately 4 km to the North of the Wlotzkasbaken settlement and 36 km to the North of Swakopmund on the right hand side of the road traveling in a Northern direction along the C34. The Southern most corner peg of the site has the following geographical coordinates:
Lat 22 22 33.1947 South
Long 14 26 34.7271 East

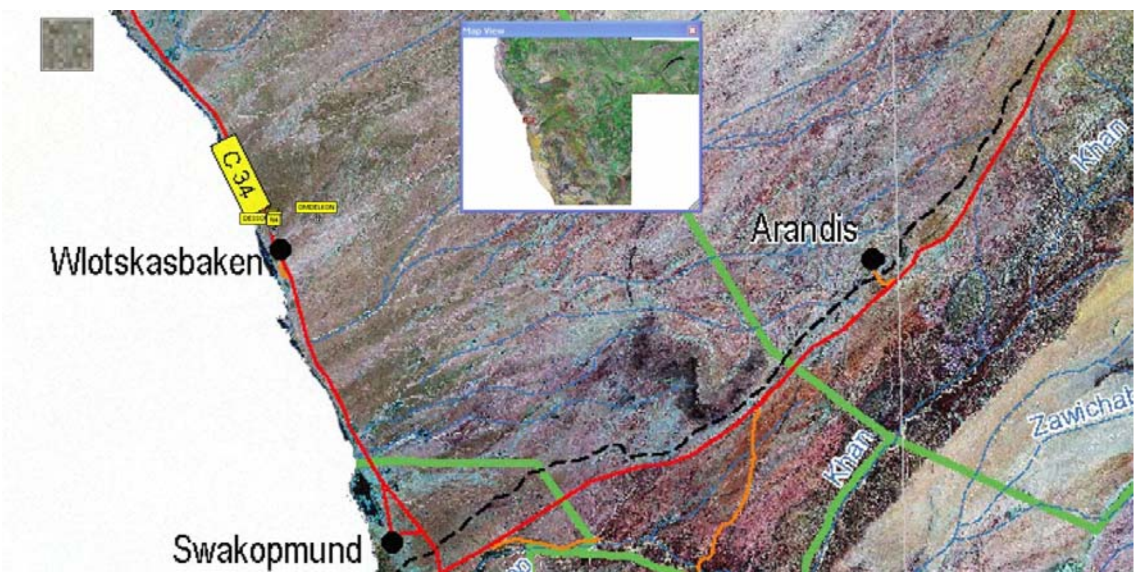

Figure indicating the approximate location of the site in relation to Swakopmund

PS 2.2 **Climate**

There is no detailed data on climate for the site of the desalination plant. The following is information is obtained from the *Atlas of Namibia 2002*.

The average number of days of frost per year is less than 1.

The average maximum temperature for the hottest month is between 20 and 22 Deg C.

The average minimum temperature for the coldest month is between 10 and 12 Deg C.

At Walvis Bay 60 km south of the desalination plant the lowest ever recorded temperature is minus 4 Deg C and the highest ever recorded temperature is 40 Deg C.
Mean annual rainfall is less than 50 mm. When rainfall events do occur they may be very intense and 50 mm may fall within a few hours.

The prevailing wind is from the south. Strong winds carrying large quantities of sand and dust are common.

On average there are between 100 and 125 days with fog each year.

During the winter months from May to August, hot berg winds (>40 deg C) carrying high contents of sand and dust tend to blow frequently.

Climatic conditions are amongst the most aggressive in the world with respect to corrosivity of the soils and atmosphere and as such special precautions need to be taken regarding the protection of steel and concrete.

PS 2.3 **Roads and rail availability**

The C34 main road running from Swakopmund North is a salt road (similar to gravel) usually in a good condition. During heavy foggy conditions, light rain, the road tends to become extremely slippery.

Before heavy equipment or trucks can be off-loaded at the site, a platform will have to be created.

The nearest railway station is located in the town of Swakopmund, 36 km to the South of the site.

PS 2.4 **Port facilities**

The nearest well developed port facilities are located in the town of Walvisbay some 65 km to the South of the site.

PS 2.5 **Construction interfaces**

The following battery limits has been fixed (co-ordinates in the Namibian Gauss conform Lo 22/15 system as per the Schwarzeck datum) for the works, a graphical representation of these limits can be seen on drawings 01 R0 and 02 R0:

The Employer will arrange to receive the product water from the plant as follows:
(1) Product water limit Y = +57218.7359; X = +41426.9889; Z = +/-10m above mean sea level. The tenderer will provide for a rational site layout, pumping, piping and costing resulting in a 1000mm flange to table 1000/3 of SABS 1123 with an available head of 20m at the flange for the discharge of the water to the transfer pump station or into the primary storage reservoir on site.

(2) Raw water limit Y = +57429.8150; X = +41519.8541; Z =+/-8m above mean sea level. The tenderer will provide for receiving the raw water from the intake pump station from two 900mm diameter flanges rated as table 1000/3 as per SABS1123. For design purposes the tenderer will assume that a 10m head will be available at the receiving point of the raw water with which to possibly drive his pre-treatment process.

(3) Brine discharge limit: Y = +57437.3275; X = +41496.0095; Z=+/- 8m above mean sea level. The tenderer will provide for a rational site layout, pumping, piping and costing resulting in a 1000mm flange to table 1000/3 of SABS 1123 with an available head of 10m (to be confirmed) at the flange for the discharge of the concentrate.

PS 2.6 Nature of ground and subsoil conditions

PS 2.6.1 Soils, topography and geology

The general site layout, drawing no. 01 R0 in Volume 3 of this tender may be referenced to note that the intake pump station is estimated to be positioned at a level of 3m above mean sea level. The desalination site is located about 1.1 km to the eastern side of the intake at an average level of 10m above mean sea level.

The prevailing geological condition is that a relatively thin layer of sand covers a layer of residual gneiss which is underlain by gneiss rock. Drawing no. 02 R0 can be referenced to find the location of 38 (marked D1 to D30 and R1 to R8) Dynamic Cone Penetration test conducted on site at the end of January 2008. A summarizing table of the results of the tests appears as follows:

ID	max mm per blow	lowest UCS in kPa	mm of loose material (UCS < 100kPa)	mm to very dense material (UCS > 500kPa)
D1	37.2	56	507	731
D2	31	69	186	565
D3	39.4	53	500	630
D4	10.4	226	66	71
D5	25.8	84	240	259
D6	6.2	397	1	42
D7	23.8	92	170	211
D8	5	502	25	25
D9	29.2	73	458	654
D10	29.6	72	596	880
D11	38	55	232	495
D12	27.6	78	779	434
D13	4.8	525	14	62
D14	17	132	6	160
D15	19.6	113	2	160
D16	14.6	156	104	123
D17	19.2	116	20	533
D18	0	0	0	0
D19	12.6	183	45	130
D20	47.8	43	580	604
D21	20	111	30	486
D22	14	163	0	87
D23	5	502	15	40
D24	14	163	10	94
D25	2.6	1023	38	51
D26	30	71	205	835
D27	18.2	123	40	260
D28	30	71	160	181
D29	24.6	88	143	300
D30	16.4	137	5	404
R1	33.2	64	190	260
R2	38.8	54	855	910
R3	44	47	230	280

R4	36	58	312	415
R5	26	83	140	255
R6	19	117	0	183
R7	25	87	135	228
R8	26.2	82	24	455

The results indicate that rock appears on the surface at test position D18. The level of this rock above mean sea level is 10m. The table further reflects that founding a structure at a depth of 1m, a recommended bearing capacity of 500kPa appears realistic. Patches of loose overlying soil however must be removed up to very dense material before founding any structure on the position.

Soil is expected to contain high levels of chlorides and sulphates.

PS 2.6.2. Water table (to determine need for dewatering foundation excavations)

Tests pit digging done for the purposes of constructing the intake pump station indicate that the water level close to the sea (on the beach) is at 1.5m below the surface. Provided that the Contractor does not require to blast beyond 10m below surface on the desalination site, no problems with ground water table are foreseen.

PS 3 TEMPORARY SITE FACILITIES

PS 3.1 **Contractor's Facilities and Utilities**

The Contractor will shall make his own arrangements for his offices, workshops and construction yard at the site. The extent of the Contractor's yard and offices shall be restricted to the area agreed upon and the area shall be fenced in.

The Contractor shall keep the yard neat and tidy at all times and on completion of the works, shall restore same to its original condition at his own expense and to the Engineer's satisfaction. No pollution or littering of any kind will be tolerated and the camp terrain shall be to the approval of the health authority.

Potable water and electrical power supply are not available at the site. The Contractor shall make his own arrangements for the supply of these services and for laying on the water and the power distribution systems for his yard and to the construction site. A water supply point can be made available by the Employer on its current water supply pipeline to Swakopmund approximately 5 kilometres from the site. The current tariff for water supplied by NamWater is N$ 5.40/m^3.

The Contractor shall make his own arrangements for the disposal of wastewater and sewerage effluent. Under no circumstances will the discharge of wastewater (including seawater) to the land surface be permitted.

PS 3.2 **Site Offices for the Engineer**

The Contractor shall provide a site office for the use of the Engineer and his assistants with two rooms as specified in Clause 3.2 of SABS 1200AB.

The first room, which shall have a floor area of at least 15m^2 shall be furnished with the following:

- One desk table 2m long x 1m wide by 0.9m high, with a smooth top and a high back swivel and tilting chair.
- One lockable upright steel filing cabinet with four drawers.
- One air conditioner with a minimum capacity of 9000 BTU's/h, 2.5kW, cool/heat.
- Waste basket

- Internet and telephone access

The second room, which shall have a floor area of at least 30m^2 shall be furnished with the following:

- One desk table 1.6m long x 0.8m wide by 0.9m high, with a smooth top and a high back swivel and tilting chair.
- One desk table 1.6m long x 0.8m wide by 0.9m high, with a smooth top as work station for drawings.
- One conference table capable of seating 12 people and 12 chairs.
- One lockable upright steel filing cabinet with four drawers.
- One air conditioner with a minimum capacity of 9000 BTU's/h, 2.5kW, cool/heat.
- A fax and photocopier
- Two waste baskets
- Internet and telephone access

It shall be the Contractor's responsibility to keep the offices clean at all times with free access being provided to the Engineer and his staff.

PS 3.3 **Temporary Latrines**

The Contractor shall provide sufficient latrine facilities at site for the use of his employees and the Engineer's personnel and he shall be entirely responsible for maintaining of such latrines in a clean, orderly and sanitary condition to the satisfaction of the Engineer and Health Authorities.

Latrines shall provide protection against the weather, and shall be properly screened from the public. Latrines shall be provided at the rate of one latrine for every 10 persons working on the Site.

PS 3.4 **Materials Laboratory Facilities**

The Contractor shall make use of an approved independent materials laboratory to do all the required materials tests or provide a fully equipped laboratory on site, staffed with qualified personnel carrying out the tests specified in terms of the contract. The Engineer and his site staff shall have unrestricted access to the laboratory at all times for the purpose of controlling testing procedures and/or carrying out their own tests should the need arise. The laboratory shall be equipped with the equipment to carry out the following tests:

- Sieve analysis of gravel, sand and soil samples.
- Determination of Atterberg Limits (Liquid Limit, Plastic Limit, Plasticity Index, Linear Shrinkage).
- Determination of maximum dry density and optimum moisture content of gravel, soil and sand.
- The determination of in-situ dry density of soil and or gravel by the sand replacement method.
- Determination of in-situ density and moisture content of soils and gravels by nuclear methods.
- Determination of the California Bearing Ratio (CBR)
- Determination of the fineness modulus of fine aggregate.
- Making and curing and compressive strength determination of concrete test cubes.
- Determination of the slump of freshly made concrete.

Notwithstanding the equipment requirements for the above tests, the Contractor shall ensure that the following equipment is kept on site:

- Sufficient concrete cube moulds (150 mm x 150 mm) to comply with the minimum frequency of sampling specified in Clause 7.1.2 of SABS 1200 G and the requirements of the number of cubes per test as set out in Clause PSG 7.1.2.2 of Portion 2 of the Project Specifications.
- Cube curing baths capable of holding the number of cubes accumulated over 28 days.
- An adequate number of 50 kg sample bags.
- Adequate equipment to carry out density tests on the stabilisation of the foundation materials.

The Contractor shall provide for the proper maintenance and cleaning of the equipment during the contract period.

PS 3.5 Accommodation of Employees:

No housing is available for the Contractor's employees and the Contractor shall make his own arrangements to house his employees. With the exception of a night watchman, employees may not be housed or accommodated on the Site of the Works. The Contractor will be responsible for the provision of water and electricity, ablution facilities, the handling of sewage, the fencing of the accommodation erected and the supply of transport to Site. The supply and maintenance of accommodation for his employees will be for the Contractor's account. It is also the responsibility of the Contractor to comply with any restrictions or employment regulations applicable, The Contractor shall negotiate with the local authority to finalise the actual position of the site for the erection of this accommodation.

PS 3.6 Dump Site:

The Contractor shall make his own arrangement with the local authority and the Ministry of Environment and Tourism regarding the disposal of rubbish, surplus excavated materials, building rubble and other surplus building materials. The Employer however reserves the right to object to the Contractors method of disposal of these materials and to instruct the Contractor otherwise.

PS 3.7 Project Name Board

A project name board as per the attached drawing is required for this Contract. The project name board shall be supplied by the Contractor and erected in a position as directed by the Engineer.

PS 4 REQUIREMENTS FOR THE PERMANENT WORKS

PS4.1 Intake and Discharge Facilities

Raw seawater will be delivered to the site from a pump station designed and constructed by others. It is anticipated that a head of approximately 10 meters will be available at the tie-in point at the property line of the Employer’s SWRO treatment facility. Tenderer shall connect to the raw water delivery piping at the tie-in point by a flanged connection. Should the pretreatment design offered by the Tenderer require additional head, it must be provided on site by the Tenderer. Provision has been made for continuous chlorination of the seawater feed at the offshore intake structure. Tenderer shall take note of this, and provide the necessary de-chlorination facilities to protect the SWRO membranes.

Provision shall be made onsite for a pipeline pigging recovery station. This facility shall be designed and constructed as part of this contract on the section of raw water piping connecting to the pre-treatment system.

RO concentrate, backwash water, and other wastewaters shall be disposed of through a pipeline connecting the SWRO facility to a headbox located between the NamWater and UraMin facilities. The headbox and the connection from the headbox to the off-shore disposal pipeline/diffuser system will be provided by others. The wastewater disposal system has been designed to accept only liquid waste. No suspended solids will be permitted to be discharged into the headbox, therefore the proposed backwash handling system must be capable of total removal of solids prior to liquid discharge.

PS 4.2 Pretreatment System

PS 4.2.1. Raw feed water quality,

The long clear reach seawards from the Namibian coast make it a high energy system and there is a strong north flowing current. “Red tides” associated with algal blooms and sulphur eruptions are common occurrences all along the coast. The seawater is therefore both nutrient rich and of very variable quality. Pre treatment processes to provide water suitable as feed to RO membranes must be designed to accommodate the full range of physical and biological quality expected, while retaining the capability of producing consistent high quality feedwater to the seawater RO system. The pretreatment systems therefore need to be reliable and robust.

As discussed above, the intake system includes provision for continuous chlorination of the incoming seawater. While it is anticipated that this process will be activated and operated in a co-operative manner, the Tenderer is advised to consider providing the ability to provide supplemental disinfection capability, to support and supplement the off-shore system.

PS 4.2.2. Raw water analysis

The feed water quality to the facility is contained in the following table. This data summarizes existing water quality data collected by NamWater at the pilot facility during 1998 and 2006 to 2007

	Minimum (mg/L, unless otherwise stated)	Average (mg/L, unless otherwise stated)	Maximum (mg/L, unless otherwise stated)
Calcium	750 as CaCO3	991 as CaCO3	1085 as CaCO3
Magnesium	1292 as CaCO3 *	4648 as CaCO3	5667 as CaCO3
Sodium	7000	10221	11 100
Potassium	340	359	400
Strontium	4.09	4.6	4.74
Barium	0.01	0.01	0.01
Iron	0.015	0.028	0.043
Total Alkalinity	106 as CaCO3	118 as CaCO3	122 as CaCO3
Chloride	11 500 *	17 549	21 066
Sulphate	1750	3084	9480
Fluoride	0.8	0.9	1.0
Silica as SiO2	1	2.1	3
Boron	4.3	4.8	5.3
pH	7.27	7.69	8.33

TSS	113	301	396
TOC	1.1	2.3	3.8
Temperature, ^{O}C	13.90	17.18	23.50
TDS	32 428	34 173.7	35 711

*Singular anomalies both associated with high sulphates.

In October 2006 small scale pre-treatment facilities were developed to allow some assessment of water quality and a review of alternative approaches to pre-treatment to be evaluated. The pilot plant is located at the Ministry of Fisheries and Marine Resources in Swakopmund, Namibia. Intake to the system is approximately 0.5 km away off-shore near the end of a jetty constructed in the late 1880's. Since October 2006 the primary objective of testing with the current equipment is documentation of the highly variable water quality and observing the operation and performance of various components of pretreatment. Available water quality results gathered during the operation of the pilot indicate the TOC concentration ranges from 1.1 to 3.8 mg/L.

The Tenderer will incorporate the range of raw water quality conditions in the design of the treatment processes as shown below.

Parameter	Low	Average	High
Temperature, C	13.90	17.20	23.50
TDS, mg/l	32,000	34,200	36,000
TOC, mg/l	1.1	2.3	3.8
TSS, mg/l	113	301	396
Turbidity , NTU	1.56	8.48	34.50

PS 4.2.3. <u>Seasonal variation</u>

There is inadequate information available on seasonal variations in seawater quality to draw a valid conclusion. From a qualitative perspective it is suspected that suspended solids will be higher during berg wind conditions that occur from time to time in winter; and organic and biomass content of the feed water could be greater during periods of red tide and sulphur eruptions.

PS 4.2.4. <u>Requirements for pretreated feedwater</u>

Filtered water quality shall meet the minimum requirements contained in table below.

Parameter	<u>Media Filtration</u>	<u>Membrane Filtration</u>
15-minute Silt Density Index, SDI_{15}	<5.0	3.5 maximum ≤3.0 (95% confidence)
TSS, mg/L	<1.0	<0.5
Turbidity, NTU	≤1.0	0.15 maximum ≤0.10 (95% confidence)
System Recovery, %	>95%	≥90%

PS 4.2.5. Acceptable treatment processes

Pretreatment facilities shall be provided ahead of the RO system to protect the integrity, customary length of the useful life and the consistent performance of the downstream processes and reverse osmosis membrane system. The base line pretreatment system design shall be single or two-stage media filtration followed by membrane filtration.

The Tenderer may utilize coagulants, filter aids, acid, base, oxidants and oxidant-scavengers to improve the performance of the pretreatment system. All process pumping and chemical feed systems shall be designed to include at least one standby pump per system. Adequate chemical mixing and flocculation upstream of the pretreatment components shall be incorporated into the design, if chemical addition is proposed.

The Tenderer shall design and provide description and layout of the proposed pretreatment system and all system service and auxiliary facilities.

PS 4.2.6. Plant requirements (Specifications)

The basic pretreatment system shall utilize granular media filtration followed by membrane filtration technology. Alternative, proven pretreatment technologies of similar or better performance will be considered in order to achieve minimum filter effluent quality requirements listed in section 4.2.4. However the final pretreatment step shall be membrane filtration.

PS 4.2.6.1 *Media Filtration*

The key minimum pretreatment system design criteria for granular media filtration system are summarized below.

- Use of non alum-based coagulants, flocculants, oxidants, and acid is acceptable;
- Other Chemicals – as needed for normal operation of the media filters.
- Proven filtration technology (conventional filter cell configuration or alternative configuration with a track record for similar applications);
- Filter design loading Rate = 4 $l/s/m^2$. For a two stage system, loading rates shall be proposed by the Tenderer.
- Minimum of 12 filter cells for the full 80Ml/day treated water capacity, of which 8 cells shall be equipped for the initial 50Ml/day operation. (maximum loss of 1/8 of filtration area during backwash for the initial installation);
- Air scour + water backwash provisions;
- Rinse to waste provisions;
- Covered filter cells and effluent wet well.

The filter size, type and size of filter media and configuration shall be determined by the Tenderer and fully described in the proposal.

Constant rate gravity filters shall be used for this application. Declining rate filters are not acceptable. Filter cells shall be covered to prevent algae growth and to protect against dust entry as a result of sandstorm events.

Filters shall be equipped with electronic flow meters, distribution boxes, wash troughs, crosswalks, wash headers, filtered water weirs, underdrains, automatic backwash controls, backwash waste piping and valves, cell isolation piping and valves, filter-to-waste valves and piping, air wash blower, electric or pneumatic actuated valves, and overflow lines.

The prefiltration flocculation system shall be equipped with permanent screening devices to minimize the entry of large particles and biomass sloughed off of the raw water piping system.

An overflow system shall be provided at each filter cell. When water level inside a filter cell reaches a preset high level, water will flow over an overflow weir and will be conveyed to the backwash handling system.

The filters shall be provided with air scour-water backwash system. Filters shall be backwashed automatically. Backwash water source may be RO concentrate, filtered water, or reclaimed backwash water.

In-line turbidity meters shall monitor individual cell filtrate. If the in-line monitors indicate that the filter effluent turbidity reading is above the maximum design criterion, the filtered water shall either be conveyed to the plant discharge line for disposal or recycled ahead of the pretreatment filters for reprocessing. An alternate approach may be offered by the Tenderer.

Filtered water shall be collected in a wet well. The wet well shall be sized to store backwash water for at least two filter cell backwash cycles, if filtered water is to be used. Alternatively, if concentrate or reclaimed backwash is proposed as a source for backwash water, provisions shall be made to store this water for at least two filter cell backwash cycles at all times. An in-line turbidity meter and automatic SDI testing system shall monitor the wet well filtrate water quality prior to the downstream membrane filtration system.

A detailed filtration system layout and a typical cross-section view of filter cell configuration shall be provided in the proposal. The cross-section view drawing shall illustrate the arrangement of the rapid mix and screened flocculation structures, inlet flume; center distribution column; cell inlet, isolation backwash and waste valves; underdrains; filter media; wash troughs; gullets; backwash control weir, and hydraulic gradeline.

PS 4.2.6.2 *Membrane Pretreatment Filtration Process*

a. The key minimum system design criteria for the membrane filtration process are summarized below.

- Membrane filtration system may be either microfiltration or ultrafiltration. Although outside-in configuration is preferred, an inside-out configuration may be proposed with supporting justification.
- Use of non alum-based coagulants and/or polymers is acceptable.
- Other chemicals as needed for normal operation of the system, including chemical enhanced backwashes (CEB), and cleaning.
- Proven track record on similar applications.
- The duration between cleanings should not be less than of 30 days per unit.
- Tenderer shall select the instantaneous and average flux rates for membrane filtration system. The values selected must be supported and justified in the proposal by documented experience in similar seawater applications.
- Minimum 350 days per year of filtrate online availability.
- Backwashing protocol shall be selected so as not to interrupt the feed water flow rate required by the SWRO system. As a minimum, the

number of units proposed shall match the number of RO trains proposed.

- Operating mode shall be dead end with cross flow capability
- On-line membrane integrity testing capability.
- Chemical / Enhanced Backwash with Air Assist Provisions.
- Provision for filtrate diversion to waste.

The membrane filtration system may be pressure or vacuum driven, selected by the Tenderer and fully described in the proposal.

The membrane filtration system shall be provided with electronic flow meters, distribution manifolds, cleaning headers, automatic flow and pressure regulators, automatic backwash and clean in-place piping and controls, backwash waste piping and valves, module and rack isolation piping and valves, off-spec filter-to-waste valves and piping, air compressor systems and electric actuated valves, and overflow lines. The membrane filtration system shall be independently controlled by its own PLC-based control system. It is the responsibility of the Tenderer to ensure that the membrane filtration system manufacturer's control system is based on PLC system and software from KOYO Electronics, the preference of the Employer, which will be fully compatible with and integrated into the balance of plant control and SCADA system.

If vacuum-driven membrane technology is used, an overflow system shall be provided in the immersion tank. If the level control system fails to keep the operating level below a preset high water level, water will flow over an overflow weir and will be returned to the media filter wet well.

Membrane modules shall be assembled in racks of equal capacity. Each rack shall be capable of independent operation for its process sequences upon initiation. It is not acceptable to share valves and instrumentation that perform similar internal functions between membrane racks or require that all membrane units be removed from normal filtration and backwashing in order to perform a function or sequence. It is permissible to share control panels, CIP systems, backpulse/backwash/reverse flush pump systems, air scour systems, and compressed air systems.

The membrane filtration system shall include provisions for the use of an automated "maintenance" chemical backwash (CEB) cycle using chemical solutions made up with RO permeate. The volume of permeate used for this process shall be in addition to the permeate produced to meet the rated plant capacity. The chemical washing sequences shall be initiated using time or volume throughput. The Tenderer shall provide design criteria for the solution mixing equipment and controls to batch the solution that is used for chemical cleaning of the modules.

Each membrane rack shall be configured such that it is possible to perform cleaning of the rack with a heated clean in-place solution (CIP), rinsed, and then immediately followed with another cleaning solution. CIP solutions shall be made up with SWRO permeate.

Each rack shall be equipped with an on-line membrane integrity test system to verify the integrity of membrane fibres using air pressure. The integrity test system shall verify the integrity of the filter fibres and upon successful completion of the integrity verification, return the module or rack to service. Membrane modules shall be provided with isolation capability for removal from service in the event of an integrity failure. If a module or rack does not pass the integrity verification, it shall be removed from service, while maintaining facility design capacity at all times. The integrity test system shall be manually or automatically initiated and automatically sequenced by the PLC system. The Tenderer shall provide a description of the procedure used for the integrity test in the proposal.

Backwash/backpulse water shall be membrane filtered water. It is proposed that this water be stored in a filtered water storage tank which will be sized to provide for the feedwater to the SWRO system and for backwashing/backpulsing of the membrane filtration system. To ensure that this tank is always full, it is recommended that it be designed as a continuous overflow tank, with the overflowing water being returned to the media filter wet well. The Tenderer is at liberty to propose alternative means to guarantee that filtered water will always be available for both purposes, without running the risk of having insufficient feedwater for the SWRO.

Backwash waste streams from the membrane filters shall flow in a controlled manner to the backwash handling system. The CEB waste, and the clean in-place waste shall be collected in a dedicated chemical waste system, and treated as described later.

In-line turbidimeters and particle counters shall monitor individual membrane rack filtrate water quality. If the in-line monitors indicate that the filter filtrate turbidity and/or particle count reading is above the maximum design criterion, the off-spec water shall be recycled to the media filter wet well. The Tenderer shall establish the criterion to be used for the particle counter function. This shall be selected based on research and field experience of the membrane filtration system manufacturer proposed for this project. The basis for this parameter shall be included and discussed in detail in the proposal.

In addition to the particle counter and in-line turbidimeter, an automatic SDI testing system shall be provided to monitor the filtrate water quality leading to the SWRO system. The output from this device will be displayed on the central control system monitor, and locally at the membrane filtration building. A continuous out of specification SDI reading will cause the SWRO system to go into a controlled shutdown, and divert the filtrate to the media filter wetwell. The elapsed time between alarm and SWRO shutdown will be selected by the Tenderer.

A detailed membrane filtration system layout and a typical cross-section view of the membrane filtration configuration shall be provided in the proposal. The cross-section view drawing shall illustrate the arrangement of the modules, racks, feed, filtrate and cleaning manifolds, isolation and waste valves, and hydraulic gradeline.

b. Pretreatment Membrane Flux

It is well established in the literature that excessive membrane flux can lead to accelerated fouling of UF/MF membranes. Tenderers shall design the MF/UF system to maintain a sustainable flux below 55 $l/m^2/hr$. Alternative flux values may be proposed so long as the results are consistent with the desire for the Employer to maintain the optimum balance between energy use and capital cost.

c. Instrument Panel, Block (or Rack)-Mounted

A locally mounted instrument panel will be provided for each MF/UF block. The panels shall be fabricated from rigid GRP, PVC or passivated 316 stainless steel sheets, with machine cut openings for instruments indicators, gauges, and interconnecting tubing. The mounting stands/brackets shall be fabricated from GRP, aluminum, or 316 stainless steel. All fasteners shall be 316 stainless steel. The panels shall be mounted in a location convenient for the operating staff immediately adjacent to the train.

Piping and tubing used to connect instruments to the process piping shall be selected so that the material and pressure rating is consistent with the corresponding process piping. Train operating data shall be displayed on a touch screen panel. The manufacturer shall be Siemens, an Employer preference.

The panel shall be equipped with the minimum instrumentation described below:

- MF/UF feed pressure
- Filtrate pressure
- Block (Unit) differential pressure
- Feed/vacuum pressure transmitter
- Filtrate/permeate pressure transmitter
- Differential pressure indicating transmitter
- Filtrate/permeate flow indicating transmitter
- Filtrate/permeate turbidity indicating-transmitter
- Filtrate/permeate residual chlorine indicating transmitter
- Filtrate/permeate particle count

PS 4.2.6.3 *Membrane Filtration Cleaning System*

A membrane cleaning (CIP) system shall be provided. The membrane filtration system shall include provisions for the use of an automated “maintenance” chemical backwash (CEB) cycle using chemical solutions made up with RO permeate. The volume of permeate used for this process shall be in addition to the permeate produced to meet the rated plant capacity. The chemical washing sequences shall be initiated using time or volume throughput. The Tenderer shall provide design criteria for the solution mixing equipment and controls to batch the solution that is used for chemical cleaning of the modules.

Each membrane rack shall be configured such that it is possible to perform cleaning of the rack with a heated CIP solution, rinsed, and then immediately followed with another cleaning solution. CIP solutions shall be generated with SWRO permeate.

The cleaning system will consist of the following components:

- Two (2) non-metallic cleaning solution storage tanks, each equipped with a heater, fabricated from material suitable for the range of pH expected for the cleaning solutions, and able to withstand temperatures up to the maximum cleaning temperature recommended by the membrane manufacturer. One tank will be used for cleaning solution, and the other for rinse, while the spent solution is being pumped out to treatment and disposal.
- One (1) smaller tank for dissolving and mixing cleaning chemicals.
- One (1) service, and one (1) standby pump to transfer concentrated cleaning solution to the cleaning solution storage tank.
- One (1) service, and one (1) standby cleaning pump.

- One (1) horizontal cleaning solution cartridge filter fabricated from 316 stainless steel.
- All necessary instrumentation, control and monitoring equipment.

Cleaning operations shall be initiated and stopped locally to the cleaning system, but remote monitoring in the control room will be made available.

The cleaning system shall be connected to the membrane pretreatment system blocks by PVC or GRP piping. RO permeate shall be used to prepare the cleaning solutions.

The cleaning solution tanks shall be sized to provide storage for the volume of solution required for all the modules in one MF/UF train to be cleaned at one time, the volume contained in the delivery and return piping, and a residual volume in the tanks to prevent loss of suction to the cleaning pump. The tank heater heating rate shall be selected raise the temperature of the cleaning solution over an 8-hour period. The return inlet to the tank shall be submerged to minimize splashing and foaming. The tank bottom shall be sloped to allow for the complete pump out and draining of the spent cleaning solution.

The cleaning piping shall be connected to each MF/UF rack with duplex stainless steel butterfly valves. Provision shall be made in the piping design to allow for the complete drain down of cleaning solution after the completion of cleaning. An isolated return shall be provided on the permeate header of each train to return filtrate/permeate created during cleaning to the cleaning solution storage tank.

PS 4.2.6.3 *Process and Equipment Design Criteria*

Technical data sheets for the major pretreatment equipment shall be prepared by the Tenderer and shall be submitted with the proposal. Basic guidance and datasheets are included in the Tender Document, and the Tenderer shall provide key process performance and sizing criteria for all pretreatment facilities and equipment, including pumps, piping, valves, vessels, mixing systems, chemical delivery and storage systems, filter media, and control systems. Additional design information will be provided by the Tenderer as needed to describe the key features and benefits of their proposed pretreatment system.

The material for all piping in contact with seawater or chemical solutions shall be either thin wall duplex stainless steel, or non-metallic such as GRP or HDPE for large diameter piping, and nominal pressure PN20 uPVC for piping for chemical systems, and process piping up to 250 mm.

Buried piping shall follow the Employer’s specifications shown in Section 600 of the Tender Document.

Valves shall follow the following schedule:

- Non-modulating valves for general pipeline service shall be flanged butterfly type, with duplex stainless steel disc and shaft. The disc shall seal on a non-metallic seat. Manual valves shall be equipped with gear reduction boxes, and hand wheels, as per the NamWater specification in Section 600. For actuated valves, the actuator shall be selected for operation in a harsh environment, and equipped with position switches to indicate fully open and fully closed. The electric actuators shall be manufactured by Rotork, an Employer preference

- Valves for use in the pretreatment processes shall be as supplied by the equipment suppliers, who shall supply the valves with all exposed wetted metal surfaces and shafts fabricated from duplex stainless steel, or as metal bodied valves protected by a full elastomeric liner. Electric actuators shall be manufactured by Rotork, an Employer preference.

- Valves used in chemical service shall be non-metallic uPVC valves. Valves 150mm and smaller shall be true union ball valves, with seats and seals manufactured from elastomeric material suitable for exposure to the chemical being handled. Larger valves shall be wafer style uPVC butterfly valves. If actuators are required, they shall be three phase electric actuators standard to the valve manufacturer.

PS 4.2.6.4 *Process and Equipment Control Strategy*

The Tenderer shall illustrate the operation and control philosophy for the pretreatment system on separate piping and instrumentation diagrams (P&ID's) developed for this system. A description of the proposed pretreatment system equipment control strategy shall be included in the proposal.

The Tenderer shall incorporate as a minimum the following control strategy guidance and capabilities (HMI = human-machine interface):

- HMI plant flow control setpoint capabilities based on the number of UF/MF and RO trains in service;
- Chemical pump speed and stroke control setpoint capabilities, and flow measurement capabilities at HMI, (Tenderer shall describe the dose control loops);
- Automatic process pump control and operation to maintain uninterrupted facility production;
- Alarmed setpoint values for high turbidity, high particle count, high SDI, high or low flow, high or low pH, high or low pressure; high or low level
- Method to monitor normalized membrane pretreatment performance;
- Method to automatically divert media filter and membrane filter system filtrate during startup and in case the water quality specifications are not met during normal operation.
- Provisions for operation on Automatic, Semi-automatic and Manual modes.

PS 4.2.7. <u>Proposal requirements</u>

- Process flow diagram of proposed pre treatment processes, including material balance, pipe sizes and flow rates.
- Chemical use chart, in the form shown below:

PRE- TREATMENT CHEMICAL USAGE			
Chemical	Form	Units	Quantity
Primary Chlorine	gas	kg/day	
Ferric salt(give name)	liquid	kg/day	
Polymer (give name)	liquid	Kg/day	
Acid (give type)*	liquid	kg/day	
MF/UF CEB 1 (give name)		kg/day	
MF/UF CEB 2 (give name)		kg/day	
MF/UF CIP 1 (give name)		kg/day	
MF/UF CIP 2 (give name)		kg/day	
MF/UF CIP 3 (give name)		kg/day	
Other chemicals (add rows)		kg/day	

- A detailed filtration system layout and elevations of vacuum filter cell configuration or pressure system racks shall be provided in the proposal. Typical cross-section view of the membrane filtration configuration shall be provided in the proposal. The cross-section view drawing shall illustrate the arrangement of the modules, racks, feed, filtrate and cleaning manifolds, isolation and waste valves.
- Discussion of the effect of red tide blooms and sulphur eruptions on the performance of the pretreatment system, and means taken in the design to mitigate these impacts.
- Design criteria for the solution mixing equipment and controls to batch the solution that is used for chemical cleaning of the membrane modules.
- Technical specification sheets for all major equipment proposed.
- Preliminary P&IDs for the media filtration and membrane filtration steps
- Technical discussion of the membrane filter flux selection.
- Discussion of proposed process control strategy, including a detail description of the specific control strategy for the media filtration and the membrane filtration system.
- Membrane filtration system manufacturers guarantees.
- Hydraulic gradeline

PS 4.3 Seawater Reverse Osmosis System

PS 4.3.1. <u>Plant requirements (Specifications)</u>

The SWRO plant includes the following:

- Membrane Assemblies, including support frame, pressure vessels, and membranes, instrument panels and sample panels.
- RO feed pump
- Energy Recovery Device (ERD) including booster pump, if included.
- High pressure piping and valves
- Low pressure piping and valves
- Cartridge filters
- Chemical feed system(s)
- Flush system
- Cleaning system
- Instrumentation components.

The Reverse Osmosis plant is to be designed to desalinate Atlantic Ocean seawater. The table following represents the Employer's conceptual design. Tenderers are free to offer an alternative process design, if there are demonstrated economic and operational benefits to the Employer.

Plant firm capacity, initial	50 Ml/day
Plant firm capacity, expanded	80 Ml/day
Permeate capacity/train	10 Ml/day
Number of trains, initial	5
Number of trains, expanded	8
Recovery minimum	45%
Membrane diameter	8-inch
Membrane length	40-inch
Pressure vessel length	7 element
Maximum# of vessel positions vertically	10
Maximum Average Flux	14-17 l/m^2/hour

PS 4.3.1.1 *Projected Feed Water Quality*.

The product water quality required is based on NamWater standards. Of particular importance is the boron concentration in the finished product water. The proposed acceptable Namibian standard, consistent with the World Health Organisation ,is <0.5 mg/l, with a, Namibian ideal guideline of <0.3 mg/l. It is recognized that in a single pass seawater RO system, the boron concentration in the permeate will in all probability be greater than 0.5 mg/l. It is the Employer's intent to achieve the best possible potable water quality while minimizing plant capital and operating cost. Therefore the Tenderer should provide a basic design to achieve the lowest possible boron concentration in the finished water without the use of a partial second RO pass, or other boron reduction technology.

An alternate proposal shall be submitted which is based on a Boron concentration in the finished water of <0.5 mg/l. The Tenderer may select a partial second pass RO, or other technology to achieve this. If RO is proposed, a guideline specification is included in this section. If alternate technology is offered, the proposal must contain a detailed description of the process, and its benefits and drawbacks when compared to a partial second pass RO system.

The table below shows the expected RO feedwater quality after pretreatment, together with a summary of the required finished water quality.

Parameter	Pretreated Seawater mg/l	Required Finished Water Quality mg/l.
Calcium	398	<80
Magnesium	1135	<30
Sodium	10221	<100
Potassium	359	<25
Strontium	4.6	<1
Barium	0.04	<0.01
Iron	0.027	<0.03
Total alkalinity as $CaCO_3$	118	>50
Chloride	17550	<100
Sulphate	3084	<100
Fluoride	1.0	<0.7
Si, as SiO_2	2.1	N/A
Boron	5.0	<0.5
pH	determined by pretreatment	7.5-8.5
Temperature (deg. C)	13-23	N/A
Design temp, deg C	15	N/A
SDI (15 min)	<3.0	N/A
Turbidity, NTU	<0.2	<0.5
TSS, mg/l	<0.5	<1.0
DOC, mg/l	determined by pretreatment	<5.0
CCPP mg/l		4-6
TDS (as sum of ions)	34173	<500

PS 4.3.1.2 *Seawater RO Membrane Assemblies-1st PASS*

a. The pressure vessels shall be supported on a "space frame" structure. The frames may be fabricated from structural shapes made of GRP, powder-coated carbon steel, or marine grade aluminium. GRP and aluminium structures will be coated with a white two part epoxy or poly-urethane finish. The frames shall be designed to be mounted on a concrete housekeeping pad, and shall incorporate 3-point pressure vessel support. The support structures shall be fully engineered for static and dynamic loads that will be imposed upon them during operation, and provide for adequate support and anchoring points for items such as supports for piping, instrumentation, etc. All attachment points shall be prefabricated prior to the application of any protective coating, and field modification will not be permitted without the express consent of the Employer.

b. Support structures must be free of pockets and niches which may not be coated initially, and which will present ongoing maintenance problems for the Employer.

c. All mounting hardware, for pressure vessels, manifolds, instrument panels and sample boards shall be 316 SS. Bolts, washers and other fasteners shall be 316 SS.

d. Support structures shall be anchored to the housekeeping pads. Stainless steel expansion bolts and/or chemical anchoring systems with 316 stainless steel rods shall be used for this purpose. The support structure shall be leveled properly notwithstanding housekeeping pad construction, and a non-expanding machinery grout will be used for any difference in equipment to pad measurement.

e. The membrane elements shall be thin film composite membranes.

The operating characteristics of the membrane elements shall be measured at the following conditions:

Test solution	32000 mg/l NaCl, 5 mg/l Boron
Applied pressure	55 bar
Test temperature	25 degrees C
Element recovery	8%-10%
pH range	6.5-8.0

Performance data taken after 30 minutes of stable operation

Minimum performance standards required, based on the above procedure:

NaCl Rejection	99.75% average
Boron Rejection	> 90%
Permeate Flow	28.5-34 m^3/day

The only allowed membrane manufacturers for this Contract are:

Toray
Hydranautics
Dow Filmtec

f. Pressure vessels shall have a diameter and length designed specifically to contain a quantity of seven (7) standard eight-inch diameter (20cm) by 40 inch long (100cm) spiral-wound membrane elements. The feed and concentrate ports shall be located in the sidewall of the pressure vessel. Vessels shall have a maximum working pressure of not less than 82.7 bar (1200 psi) at a temperature up to 48^{O}C (120^{O}F).

Vessels shall be complete with end closures, hardware, shims, and membrane element end adapters to match the membrane elements to be installed. Vessels shall be designed, constructed, third party inspected and code-stamped in accordance with the latest edition of the ASME Boiler and Pressure Vessel Code - Section X, Fiber-Reinforced Plastic Pressure Vessels. Requirements include, but are not limited to, the following:

- Each vessel will undergo a Hydrostatic Leakage Test, at a pressure of 1.3 x the rated pressure.

- The locking ring groove shall be a 316 stainless steel insert integrally filament wound into the I. D. of the vessel. Cutting or grinding of fibers to form the locking ring groove is not acceptable. The primary means for head retention shall be a single retaining mechanism that provides ASME-required redundancy and is constructed of stainless steel for ease of use and long term reliability.

- The shell of the vessel shall be fabricated of filament-wound fiberglass reinforced plastic using continuous glass roving, impregnated with an elevated temperature cure epoxy resin system. The shell bore shall be fabricated from a resin-rich epoxy barrier. The interior surface of the vessel shall have a mirror-like smooth surface, and shall be free of pits or voids. All wetted components in continuous contact with the pressurized process water or permeate shall be made from plastics or metals that are known to have long-term resistance to corrosion in the service intended. Plastic materials in contact with permeate must have current NSF approval (or equivalent international standard) for use with potable water.

Preferred vessel manufacturers are Beckaert Progressive Composites (Protec) or Pentaire (Codeline).

g. Feed, Concentrate and Permeate Piping

Vertical manifold piping shall be an integral part of the membrane assemblies. Feed and concentrate manifolds shall be fabricated from duplex stainless steel piping, Schedule 40S. Permeate manifold shall be fabricated from 316 stainless steel, Schedule 5S. Assemblies shall be thoroughly cleaned inside and out, and all scale and welding slag removed. Completed assemblies shall be immersion passivated per ASTM standards, and the outside surfaces electropolished to a bright finish. Completed components shall be pressure-tested to 1.5 times working pressure.

Provision shall be made for air release at high points in the RO train piping. Provision shall be made by the use of a permeate standpipe to prevent siphoning of permeate out of the train when it is not operating.

The feed and concentrate manifolds shall be connected to the pressure vessel ports with duplex stainless steel Victaulic-type connectors, with 316 stainless bolts and nuts. Gaskets shall be EPDM.

Connection between permeate manifolds and pressure vessels shall be with reinforced black plastic tubing. The bend radius of the tubing shall be sufficient to avoid leaking or cracking of the tubing. The pressure vessel permeate stub tube which is not attached to the permeate manifold shall be plugged with a threaded PVC plug. Contractor shall supply two probing kits per train.

h. Instrument Panel, Train-Mounted

A train mounted instrument panel will be provided for each RO train. The panels shall be fabricated from rigid GRP, PVC, or passivated 316 stainless steel sheets, with machine cut openings for instruments indicators, gauges, and interconnecting tubing. The mounting stands/brackets shall be fabricated from GRP, aluminum, or 316 stainless steel. All fasteners shall be 316 stainless steel. The panels shall be attached to the support structure of the train, or floor mounted immediately adjacent to the train. The bottom of the panel shall be a minimum 1.5 meters above finished floor.

Piping and tubing used to connect instruments to the process piping shall be selected so that the material and pressure rating is consistent with the corresponding process piping. All train operating readings shall be displayed locally on a touch screen interface. The manufacturer shall be Siemens, an Employer preference.

The panel shall at least be equipped with the instrumentation described below:

i. Train pressure gauge with selector valve for:

- Discharge pressure
- RO feed pressure
- Concentrate pressure
- ERD low pressure discharge pressure
- ERD low pressure inlet pressure
- Permeate pressure
- ERD high pressure

ii. RO feed pressure indicating transmitter

iii. RO concentrate pressure indicating transmitter

iv. RO feed to concentrate differential pressure indicator

v. RO permeate flow indicating transmitter

vi. Concentrate flow indicating transmitter

vii. Permeate conductivity indicating-transmitter.

i. Sample Board

A sample board shall be mounted on each train. The boards will be fabricated from GRP with 316 stainless steel hardware. The board shall be fitted with sample valves. There shall be one (1) sample valve for each vessel‘s permeate, plus valves for feed and concentrate. The sample board shall be equipped with a trough, of the same material as the panel, which will be drained to the pipe trench. Sample valves shall be arranged in horizontal rows Each valve will be fitted with a 316 stainless steel tubing discharge spout, to prevent splashing. Valves shall be 316 stainless steel 1/4 turn plug valves for permeate, and duplex stainless steel valves for feed and concentrate. Each valve will be labeled with an engraved label indicating the source of sample.

Permeate sample tubing shall have a working pressure of 10 bar at operating temperature, and shall be Nylon or other suitable non-metallic material, with 316 stainless steel fittings. Feed water and concentrate tubing shall have a minimum working pressure equal to that of the process piping, and shall be fabricated from duplex stainless steel, with duplex stainless steel fittings.

PS 4.3.1.3 *Cleaning and Flushing Systems*

a. Cleaning System

A membrane cleaning system shall be provided. The cleaning system will consist of the following components:

- Two (2) non-metallic cleaning solution storage tanks with heater, fabricated from material suitable for the range of pH expected for the cleaning solutions, and able to withstand temperatures up to the maximum cleaning temperature recommended by the membrane manufacturer. One tank will be used for cleaning solution, and the other for the permeate rinse, while the spent solution is being pumped out to treatment and disposal.
- One (1) smaller tank for dissolving and mixing cleaning chemicals:
- One (1) service, and one (1) standby pump to transfer concentrated cleaning solution to the cleaning solution storage tank:
- One (1) service, and one (1) standby cleaning pump;
- One (1) horizontal cleaning solution cartridge filter fabricated from 316L stainless steel;
- All necessary instrumentation, control and monitoring equipment.

Cleaning operations shall be initiated and stopped locally to the cleaning system, but remote monitoring in the control room will be made available.

The cleaning system shall be connected to the seawater RO system trains by uPVC or GRP piping. RO permeate shall be used to prepare the cleaning solutions.

The cleaning solution tanks shall be sized to provide storage for the volume of solution required for all the pressure vessels in one RO train to be cleaned at one time, the volume contained in the delivery and return piping, and a residual volume in the tanks to prevent loss of suction to the cleaning pump. A flow of 9-10 m^3/hour/vessel shall be used to calculate the cleaning tank volume. The tank heater heating rate shall be selected raise the temperature of the cleaning solution over an 8-hour period. The return inlet to the tank shall be submerged to minimize splashing and foaming. The tank bottom shall be sloped to allow for the complete pump out and draining of the spent cleaning solution.

The cleaning piping shall be connected to each RO train with duplex stainless steel butterfly valves. Provision shall be made in the piping design to allow for the complete draindown of cleaning solution after the completion of cleaning. An isolated return shall be provided on the permeate header of each train to return permeate created during cleaning to the cleaning solution storage tank.

b. Flushing system.

On shutdown, each seawater RO train shall be flushed with permeate. The flush water shall enter the suction side of the RO feed and ERD booster pump and continue for sufficient time to allow the ERD to rotate, and replace the concentrated seawater throughout the system.

The flush system shall consist of a non-metallic flush water storage tank, sized for the volume of flush water required; two (2) flush pumps, one service and one standby; uPVC or GRP piping and valves; instrumentation and control.

The flush pumps shall be end suction centrifugal pumps fabricated from 316 stainless steel, operating at 1450 rpm. The pumps shall be fitted with single mechanical seal flushed with the pumped fluid.

The flush shall take place upon shutdown of a train, and shall continue for sufficient period of time that the train, RO feed pump, ERD, and ERD boost pump are completely filled with permeate.

PS 4.3.1.4 *RO Feed Pumps*

The RO feed pumps shall be horizontal axial split case or radial split case multistage pumps. All wetted parts shall be fabricated from duplex stainless steel. The pumps shall be selected for highest efficiency, reliability and proven performance in seawater RO plants, when operating at similar heads and capacities. Two pumps will be required for each RO train, the RO feed pump and the energy recovery device boost pump. Both pumps shall be equipped with variable frequency drives, to compensate for variations in feedwater temperature, salinity and the loss of flux due to membrane fouling, while maintaining the design permeate output. Pumps shall be fitted with mechanical seals which are externally flushed. Pump selection should be made to allow for a 15% loss of membrane flux between cleaning events.

PS 4.3.1.5 *Energy Recovery Devices*

Employer’s preference is for the isobaric type of energy recovery device (ERD), due to the potential for higher efficiency in the energy recovery process. However, other competing devices, such as the hydraulic turbocharger and the Pelton wheel devices may be offered, in which case only one RO feed pump will be required per RO train. Since the primary purpose of the ERD is to reliably maximize the recovery of the residual energy available in the RO concentrate stream, the type of system offered should consider operating flexibility, maintenance requirements, and estimated life expectancy of the system. Regardless of the type of ERD offered, the Contractor is required to demonstrate in his proposal prior direct experience with the device offered in a SWRO facility of similar size.

PS 4.3.1.6 *Cartridge Filters*

Cartridge filter vessels shall be of the horizontal type, fabricated from duplex stainless steel. The inlet and outlet connections shall be flanged. The O-ring cover gaskets shall be Buna-N, or EPDM. The cartridge seats shall be specified to accept double O-ring, single open end cartridges, with a nominal separation of 5µ.

Each filter vessel shall have the following connections:

- inlet and outlet process connections shall be flanged connections with a rating of 10 bar.
- one flanged vent connection on the top tangent of the vessel with manual ball valve.
- one flanged pressure gauge/sample connection for each chamber,
- one connection for draining the dirty side chamber,
- one connection for draining the clean side chamber.

Housing materials, design, fabrication, and inspection shall conform to Section VIII of the ASME Boiler and Pressure Vessel Code or the equivalent European Code. Provide the ASME or other relevant code stamp.

Each filter cartridge housing shall come factory equipped with a manual davit lifting device for removing the access cover for the filter housing.

PS 4.3.1.7 *Process Piping*

High pressure piping shall be fabricated from duplex stainless steel. The pressure rating of pipe and flanges shall be selected based on the intended service for the pipe. All high pressure piping shall be shop fabricated. All welding practice shall be in accordance with South African National Standards, and shall be performed by certified alloy welders.

Flexible couplings, fabricated from duplex stainless steel, such as Victaulic, Piedmont Pacific, or equal may be used to connect pipe spools of 250 mm, and smaller. All other piping connections shall be flanged. Bolts washers and nuts shall be 316 stainless steel, installed with a thread lubricant.

Connections for gauges and other hydraulic instrumentation source devices shall be flanged, with isolating ball valve. A female threaded connection shall be provided on the companion flange. Pressure rating for these connections shall be equal to or greater than the pressure rating of the pipe.

High pressure butterfly valves shall be fully lugged wafer type, with duplex stainless steel disc and shaft. The actuator shall be selected for operation in a harsh environment, and equipped with switches, transmitter and indicators to indicate fully open and fully closed. Actuators shall be Rotork, an Employer preference. The actuator shall be selected with a torque at least 20% higher than the maximum torque required to drive the valve from a fully closed to a fully open position.

The check valve shall be of the non-slam double door type. The valves shall be flanged.

Any valves used as flow-control in or around the membrane assemblies or ERD systems should be of characterized seat ball valve (V-Ball or other) construction with wetted parts in duplex stainless steel. Actuators shall be Rotork, an Employer preference. The actuator shall be selected with a torque at least 20% higher than the maximum torque required to drive the valve from a fully closed position.

Flange bolting shall be by 316 stainless steel bolts and nuts, or other corrosion resistant material. A thread lubricant will be used to reduce galling.

Low pressure piping and fittings smaller than 250 mm shall be uPVC, with a pressure rating of at least 10 bar. Pipe shall be Type I, Grade 1 (Class 12454-

B), conforming to ASTM D 1784 and D 1785, or equivalent South African, British or German standard.

Low pressure pipe and fittings greater than 250 mm shall be fabricated from HDPE, or GRP materials. Pressure rating of pipe and fittings shall be at least 10 bar.

Valves for low pressure piping (in non-modulating service) shall be wafer style uPVC butterfly valves up to 200 mm, except for valves 50 mm and smaller, which shall be uPVC full union ball valves. Valves larger than 200 mm shall be wafer style, fully lugged valves with cast iron lined bodies, and Nylon coated or stainless steel disc. If the valve is used in seawater service, the stainless disc shall be duplex material.

PS 4.3.1.8 *Brackish Water RO System-2nd PASS*

a. The Tenderer may offer as an alternate bid, a second pass RO system to reduce Boron concentration to the required standard of <0.5 mg/l, in which case the following will apply:

b. The second pass brackish water RO system shall be a two stage system based on a recovery of 90%, with an average flux not to exceed 34 l/m^2/hour. Concentrate from the second pass shall be returned to the filtered feed water wet well for blending with the first pass RO. Selecting the permeate flow from the second pass will be the responsibility of the Tenderer.

c. The membrane elements shall be thin film composite membranes. The operating characteristics of the membrane elements shall be measured at the following conditions:

Test solution	1500-2000 mg/l NaCl
Applied pressure	10.3 bar
Test temperature	25 degrees C
Element recovery	15%
pH range	6.5-8.0

Performance data taken after 30 minutes of stable operation

Minimum performance standards required, based on the above procedure:

NaCl Rejection	99.3-99.5 % average
Permeate Flow	34-44 m^3/day

d. Membrane manufacturer shall be the same as the manufacturer of the 1st pass membranes.

e. Pressure vessels contain a quantity of seven (7) standard eight-inch diameter (20cm) by 40 inch long (100cm) spiral-wound membrane elements, and be of side ported design. The same manufacturer shall supply the vessels for both passes.

f. Feed, Concentrate and Permeate Piping

Vertical manifold piping shall be an integral part of the membrane assemblies. Feed, concentrate and permeate manifolds shall be fabricated from 316 stainless steel piping, schedule 10S. Permeate manifolds shall be fabricated from 316 stainless steel piping, schedule 5S. Assemblies shall be thoroughly cleaned inside and out, and all scale and welding slag removed. Completed assemblies shall be immersion passivated per ASTM standard, and the outside surfaces electropolished to a bright finish. Completed components shall be pressure-tested to 1.5 times working pressure.

The feed and concentrate manifolds shall be connected to the pressure vessels ports with 316 stainless steel Victaulic-type connectors, with 316 stainless bolts and nuts. Gaskets shall be EPDM.

g. Instrument Panel, Train-Mounted

A train mounted instrument panel will be provided for each RO train. The panels shall be fabricated from rigid GRP, PVC or passivated 316 stainless steel sheets, with machine cut openings for instruments indicators, gauges, and interconnecting tubing. The mounting stands/brackets shall be fabricated from GRP, aluminum, or 316 stainless steel. All fasteners shall be 316 stainless steel. The panels shall be attached to the support structure of the train, or floor mounted immediately adjacent to the train.

Piping and tubing used to connect instruments to the process piping shall be selected so that the material and pressure rating is consistent with the corresponding process piping. Train operating data shall be displayed on a touch screen panel. The manufacturer shall be Siemens, an Employer preference.

The panel shall be equipped with the instrumentation described below:

i. Train pressure gauge with selector valve for:
   - RO feed pressure
   - Interstage pressure
   - Concentrate pressure
   - Permeate pressure

ii. RO feed pressure transmitter

iii. RO Interstage pressure transmitter

iv. RO concentrate pressure transmitter

v. RO differential pressure indicating transmitter-each stage

vi. RO permeate flow indicating transmitter-each stage

vii. Concentrate flow indicating transmitter

viii. Permeate conductivity indicating-transmitter.

h. Sample Board

A sample board matching those on the first pass shall be mounted on each train.

Sample tubing shall have a working pressure of 20 bar at operating temperature, and shall be opaque Nylon or other suitable non-metallic material, with 316 stainless steel fittings.

PS 4.3.2. Need for partial second pass

The permeate from the seawater RO system is expected to be of high quality and meet all required water quality standards with the exception of Boron. It is envisaged that a second pass is required to get the Boron to below 500 µg/l.

Preliminary projections of expected SWRO permeate quality, using membrane types from Dow, Toray and Hydranautics, indicate that the expected Boron concentration in the permeate, at 45% recovery, and assuming 5mg/l of Boron in the feed water, will be between 600µg/l and 900µg/l, at a feed pH of 7.8, which is assumed to be the pH of the feedwater after adjustment with caustic soda prior to SWRO. As discussed in Pretreatment, Section 4.2, the Tenderers are at liberty to propose chemical pretreatment of the raw seawater to enhance the efficiency of the media filtration step. If acid is used to lower pH prior to the addition of a ferric salt, then the filtered feed water pH prior to RO will have to be raised to improve the rejection of Boron. Tenderers therefore should include in the proposal a caustic soda feed system for this purpose.

NamWater fully understands the issues that must be met to produce a product water meeting the Boron standard. Therefore, Tenderers are encouraged to propose a treatment strategy that generates a Boron concentration as close to the acceptable standard as is feasible using a single pass SWRO system as the base offer. NamWater will also consider an alternate proposal in which Boron is reduced to the acceptable standard of <500 µg/l by use of a partial second RO pass, or an alternative treatment, such as selective ion exchange.

PS 4.3.3. Finished water quality

The finished water quality shall meet the requirements as provided in PS 4.3.1 above. The exception to this is Boron, which has been discussed in PS 4.3.2 above.

PS 4.3.4. Recovery, first pass, second pass, overall

As stated in Section 4.3.1, the minimum recovery of the SWRO is to be 45%. Tenderers are at liberty to propose higher recovery, if there is an economic and operational benefit to the Employer. For the alternate proposal for enhanced boron reduction, the minimum recovery of a second pass RO system shall be 90%, with concentrate recycle to the filtered water storage.

The overall recovery will be largely dictated by the efficiency of the pretreatment media filter and membrane filtration processes. Tenderers are encouraged to minimize backwash and forward rinse volumes used in these two processes (Minimum requirements are specified in Section PS 4.2, Pretreatment).

The overall recovery of the treatment system, from intake structure to finished water, shall be a minimum of 40%.

PS 4.3.5. Second pass concentrate recycle

If a partial second pass using brackish water RO membranes is used for Boron reduction, the concentrate from the second pass shall be recycled to the filtered water storage tank, downstream of the membrane filtration system.

PS 4.3.6. First element and average flux

It is well established in the literature that excessive lead (first) element flux can result in accelerated fouling of the membranes in SWRO and other RO systems. While high lead element flux generally occurs in systems dealing with seawater at higher temperatures than expected for this project, Tenderers shall design the SWRO system to maintain a lead element flux below 25l/m^2/hr, or less than 1.6 times the average system flux, whichever is less.

Since the optional second pass uses as its feed water first pass permeate, the fouling potential of this water is minimal. Therefore the Tenderer is at liberty to establish lead element and average flux (up to the maximum stated) values that result in the optimum balance between energy use, and capital cost.

PS 4.3.7. Proposal requirements

- Process flow diagram of proposed SWRO system, including material balance, pipe sizes and flow rates.
- Written description of the proposed design of the SWRO system. This description should include but not be limited to the selected recovery, flux, and the proposed method of minimizing Boron passage, train design, selection of energy recovery device, and operational parameters.
- Proposed approach to the required proposal to reduce Boron to the level of <0.5 mg/l.
- Chemical use chart, in the form shown below:

1st Pass SWRO CHEMICAL USAGE			
Chemical	Form	Units	Quantity
50% Caustic Soda	liquid	kg/day	
Scale Inhibitor	liquid	kg/day	
Cleaning chemical 1 (give name)		Kg/day	
Cleaning chemical 2 (give name)		kg/day	
Cleaning chemical 3 (give name)		kg/day	
Cleaning chemical 4 (give name)		kg/day	

- Pipe and valve schedule
- Technical specifications for pumps, energy recovery device
- Discussion of SWRO control philosophy.
- Membrane specifications, and projections for 0, 1, and 5 year performance
- Discussion of the impact of feedwater temperature variation on SWRO performance.
- Preliminary P&IDs
- Preliminary layout drawings
- Technical specifications for chemical feed systems
- Membrane manufacturers guarantees.

PS 4.4 Post Treatment Requirements

PS 4.4.1. Potable water requirements

The potable water produced by the SWRO Water Treatment plant must meet the required finished water quality as specified in PS 4.3.1. As discussed previously, the Employer reserves the right to waive the standard for Boron, based on the cost-benefit of achieving this standard by additional treatment means. The Tenderer shall however, submit an alternative proposal designed to achieve the acceptable standard for Boron of <500µg/l.

The Employer will not consider any variance of the specified acceptable standards other than Boron.

PS 4.4.2. Other water quality requirements

Permeate from the SWRO system is to be stabilized with calcite contactors. It is required that the permeate be chlorinated prior to entering the calcite beds. A secondary chlorination point downstream of the contactors will be provided for the purpose of adjusting the free chlorine residual prior to storage. The free chlorine residual in the water entering storage shall not be less than 0.5 mg/l and not greater than 1.0 mg/l after 30 minutes of contact time.

PS 4.4.3. Disinfection

Disinfection of the product water shall be accomplished with gaseous chlorine. A chlorination system, manufactured by Alldos, the Employer's preference, using vacuum extraction shall be provided. Chlorine gas in 1 ton containers shall be housed in a chlorine room within the post treatment building. Leak detectors shall be provided. Two chlorinators shall be provided for each application point. The Tenderer is responsible for the sizing of the chlorination equipment. Monitoring and control shall be as described elsewhere in this document.

The chlorine storage area shall be adequate for the storage of 3 weeks consumption and shall be easily accessible by delivery trucks. The storage area shall be equipped with overhead lifting equipment for the offloading of the 1 ton containers and the movement of containers within the storage area. The containers currently in use and one standby shall be resting on load cell scales with a local display and a 4-20 mA output for every scale.

The chlorinators shall be mounted in a separate room immediately adjacent to the storage area, equipped with positive ventilation, and complete with leak detection monitors and safety equipment. The chlorine facilities shall comply in all respects with the current SANS 10298: 2005 edition 1.1 code of practice, and shall meet all applicable national safety regulations.

Chlorination shall take place prior to the water entering the post treatment stabilization step. A secondary chlorination point shall be provided downstream of the stabilization step, to adjust the chlorine residual if required prior to transferring the water to storage.

PS 4.4.4. Chemical Feed Systems

Chemical feed systems for liquid chemicals shall include as a minimum the following components:

1. Day Tank. Day tanks shall be non-metallic, fabricated form a plastic material inert to the contained chemical. The tanks shall be fitted with a cover. Each tank will be equipped with a sight glass, level transmitter, low level switch, and all necessary nozzles for attaching fill, extraction and drain piping.

2. Calibration Tube. A clear Pyrex calibration tube shall be provided and installed between the solution tanks and the metering pump suction manifold, for each chemical system The calibration tube shall be graduated, with engraved calibrations, and shall be valved so that the tube may be filled by gravity flow from the day tank, isolated, and used as a suction chamber for the pumps. The calibration tubes will be firmly mounted on the wall or anchored to the floor. Devices shall have a minimum capacity of 1 liter of chemical.

3. Metering Pumps. Metering pumps shall be Grundfos "Alldos", an Employer preference. At least two pumps shall be supplied for each chemical, one service and one standby. A boxed spare for each type shall be included in the list of

spare parts to be included with the proposal. The pump motors shall be as described in the electrical section of this document. Automatic stroke and speed control shall be provided.

4. Injector Assemblies The injector shall be inserted into connections provided on the static mixers. The injector shall be screwed into a female nipple incorporated into the body of the mixer. The injector shall be fabricated entirely from Teflon or PVDF.

5. External Back Pressure Valve. Back pressure valves shall be located at each injection point. The valve shall be constructed of a plastic material suitable for the chemical service intended, and fitted with a PTFE diaphragm. The valves shall have a minimum pressure rating of 10 bar.

PS 4.4.5. Corrosion control

Corrosion control chemical feed equipment will not be included in the initial project. However, the Employer may elect to utilize a corrosion inhibitor in the future. Therefore, the Contractor shall include in the post treatment building sufficient space to add a corrosion inhibitor feed system in the future. The space provided shall be sufficient for a bulk storage tank; day tank; chemical metering pumps with calibration column; and all necessary piping and valves, controls, electrical service, etc. Conduits for power and control shall be provided in the initial construction. An injection point, plugged, shall be provided on the piping from the transfer pumps to storage.

PS 4.4.6. Hardness and alkalinity

The specified finished water quality requirements provide the minimum limits for hardness and alkalinity in the finished water, from which the hardness and alkalinity to be added to the permeate can be derived. The Tenderer shall pay special attention to NamWater's requirements in PS 4.3.1 for calcium carbonate precipitation potential (CCPP), and the finished water pH range.

The Contractor shall provide all necessary equipment and instrumentation to reliably produce finished water that meets these requirements.

PS 4.4.7. CCPP

The post treatment system provided by the Contractor shall be designed to meet the CCPP range required by NamWater, as discussed above. This range shall be 4-6 mg/l.

PS 4.4.8. Preferred stabilization method

The preferred stabilization method is the use of CaO or $CaCO_3$ beds to add calcium hardness and bicarbonate alkalinity to the RO permeate. The Tenderer may utilize either carbon dioxide or acid to provide the acidity in the water necessary for dissolution of the calcium media and the formation of calcium bicarbonate.

The calcium contactors may be proposed as either down-flow or up-flow mode. The Tenderer shall make provision in his design of the contactors for case of removal of insoluble materials contained in the commercial material.
Water from the contactors shall flow into a clearwell, from where the water will be pumped by vertical turbine pumps to the Employers storage. The wetted surfaces of these pumps shall be 316 stainless steel.

The contactors shall be constructed as part of the post treatment building.

In the design of the stabilization system, the Tenderer shall consider the need for additional pH adjustment downstream of the contactors, so that the finished water is in full compliance with the finished water quality requirements. Additional pH adjustment, if provided, shall utilize sodium hydroxide, 50% strength. The Contractor shall provide all necessary equipment for storing and feeding the caustic soda, including a bulk storage tank located in the central bulk chemical storage area; day tank and metering pumps located in the post treatment building; piping, valves, electric power and control and monitoring equipment, including double containment piping from the bulk storage area to the post treatment building.

PS 4.4.9. Proposal requirements

- Process flow diagram of proposed post treatment processes, including material balance, pipe sizes and flow rates.
- Preliminary P&ID for the post treatment processes.
- Chemical use chart, in the form shown below.
- Preliminary Layout of Post Treatment Building.
- Equipment Specification sheet for transfer pumps, pumping to Employer's storage.
- Calculations pertaining to projected finished water pH, hardness and alkalinity, and CCPP.
- Chemical use chart, in the form shown below:

POST TREATMENT CHEMICAL USAGE			
Chemical	Form	Units	Quantity
Primary Chlorine	gas	kg/day	
Carbon dioxide*	gas	kg/day	
Acid (give type)*	liquid	kg/day	
Secondary Chlorine	gas	kg/day	
Calcite**	solid	kg/day	
Calcium Carbonate**	solid	kg/day	
Caustic Soda (50%)	liquid	kg/day	

* Tenderer will include one or the other
** Tenderer will include one or the other

PS 4.5 Buildings and Structures

PS 4.5.1. General

Buildings and structures shall be so designed to as far as possible blend in with the natural environment and be consistent in appearance with the development by UraMin on the adjacent site and meet the Employer's preferences. The Tenderer is therefore advised to appoint a local architect to liaise with NamWater and UraMin's architect and advise and assist the Tenderer during the design of the buildings and structures.

Buildings and structures shall comply with the Applicable Standards and Particular Specifications for Civil, Building and Structural Steel Works specified in PS 4.9 below.

All buildings and civil works shall be designed and constructed for build-out capacity (80 Ml/day).

PS 4.5.2. RO Process building

The RO system shall be installed in a building specifically designed for that purpose. The building structure itself shall be in compliance with the Employer's specifications for Civil, Building and Structural Steel Works.

The building layout shall be arranged in such a manner as to minimize high pressure piping runs. Large diameter piping shall in general be installed in trenches, or in a basement area. The layout should as much as possible follow the water flow, from cartridge filters to pumps to membrane assemblies. Care should be paid to providing adequate work space around the equipment for ease of access for maintenance personnel and equipment. A minimum clear space of 2 meters, unobstructed by piping or conduit shall be provided at each end of each membrane assembly for loading and unloading membranes. Attention should be paid to providing accessible space close by for placing the membranes in preparation for loading, and a similar space for placing unloaded membranes.

Because of the environmental nature of the site, building height should be kept as low as possible, thus influencing the membrane array footprint. It is required that the SWRO train height be limited to ten (10) pressure vessels.

The building shall include as a minimum the following:

- Cartridge filter vessels;
- Scale inhibitor feed system, including drum or tote storage; day tank; metering pumps. The area designated for the scale inhibitor system shall be as close as possible to the point of injection;
- Caustic soda feed system, if required for Boron control
- SWRO feed pumps and energy recovery devices;
- SWRO trains
- BWRO second pass trains;
- Cleaning and flushing systems, including storage space for cleaning chemicals;
- Electrical room sized for the variable speed drives and MCC's required for 8 trains;
- Control system remote terminal room;
- Traveling electrical bridge crane (Demag or Morris, the Employer's preference) for pump and motor maintenance;
- Mechanical room for building services;
- Janitor's closet and supply space.

In the design of the building, careful attention should be paid to the environmental characteristics of the site location. The Tenderer should propose measures to mitigate the noise generated in the SWRO process, particularly the noise generated by the pumps and energy recovery devices, and also rapid changes in pipeline velocity, such as in valves. It is proposed that the Tenderer consider an acoustically designed enclosure that would isolate this equipment from the membrane hall.

PS 4.5.3. Administration and operations building

The envisaged minimum staff and their job specific needs that the Employer has for control, operation and maintenance of the plant are as follows:

Designation	Job specific need	Shared facility required	Minimum Individual Area required
Plant Manager	Office	Ablution; conference; tea room	5m x 5m
Assistant Plant Manager	Office	Ablution; conference;	5m x 5m

		tea room	
Admin Clerk	Office	Ablution; conference; tea room	4m x 5m
Instrument & Electrical Technician	Office Workshop with office cubicle	Ablution; conference; tea room	7m x 8m
Mechanical Technician & Handyman	Workshop with office cubicle	Ablution; conference; tea room; Shower & locker room	7m x 8m
Lab Technician	Laboratory	Ablution; conference; tea room	6m x 6m
Shift Supervisors	Master control center	Ablution; conference; tea room	8m x 7m
Servers	Server Room	-	3m x 3m
Public / visitors	Lobby	Ablution	4m x 5m
Janitor / labourers	Janitorial space	Ablution; conference; tea room; Shower & locker room	3m x 2m
	Conference/Training/ Tea Room		6m x 6m
	Kitchen		2m x 3m
	Stores		6m x 6m
	Archive		2m x 3m
	Shower & lockers		3m x 4m
	Ablutions		6m x 4m

A minimum area of 429m^2 will be required for the individual / dedicated spaces and the shared facilities as described. The shared facilities will comprise of: 4 ablution units (2 for men, 1 for ladies and 1 for disabled persons these will have a total area of 24m^2), one conference / tea room with an area of 36m^2, one archive with an area of 6m^2 and finally a shower and locker room with a minimum area of 12m^2.

The administration, workshop, laboratory and control building will therefore have a total roof covered area requirement of 429m^2. General building regulations and their application as set out in SABS 0400 will be upheld. Special care will be taken to ensure that the materials of construction are suitable for the environment.

The whole building will be accessible by wheelchair and disabled person friendly. The Tenderer will ensure the design and layout of the laboratory; workshops and control room to suit the expected vehicle and foot traffic on site.

The entrance to the workshops will be accessible by light delivery vehicles. The Tenderer is further requested to ensure the design incorporates the optimum use of natural light.

The percolation test conducted indicate that a French drain adequately sized for 12 persons will suffice for sewerage requirements. A bio-reactor membrane filtration plant will be installed capable of handling the expected sewerage loading on the site with 12 workers.

PS 4.5.4. <u>Electrical building</u>

The building structure itself shall be in compliance with NamWater's specifications for Civil, Building and Structural Steel Works.

Separate rooms will be provided for housing of transformers and MCC required for the control of equipment specified for the different processes per building. The size of the buildings or rooms will be determined by the required electrical equipment to be installed in the building or room. Enough free space, at least 2m, will be provided for easy access to the equipment or MCC installed in the building/room from all sides.

Provision will be made for easy installation and replacement of transformers or MCC's in the rooms or buildings where this equipment is installed. Doors must be sized to enable this.

Provision will be made for the necessary cable entries and exits. Enough free space will be made available at bottom of MCC's for cable connections. Cable trenches and sleeves, designed to meet the bending specifications of the cables, must be provided within the MCC room.

Special designs will be required to ensure that the rooms/buildings for electrical equipment are dust free.

All MCC rooms where variable frequency drives are installed will be fitted with air conditioners. The Tenderer will ensure that the air-conditioning system is adequately sized to handle climatic conditions as described in PS2.2 Spare air-conditioning units will be installed to make provision for temperature control during the breakdown of installed units. The temperature of the rooms will be measured by PT100 sensors connected to the MCC in the room. This temperature will also be displayed numerically and graphically on the SCADA system.

PS 4.5.5. Chemical storage

Bulk chemicals for water treatment will be stored close to the point of use for each chemical in appropriately designed housing with easy truck access. It is anticipated that these chemicals will include but not be limited to ferric salt solution and acid for pretreatment, scale inhibitor and caustic soda for the SWRO, acid or carbon dioxide, chlorine and caustic soda for post treatment.

The chemical bulk storage facilities will be enclosed in a masonry frame structure with open sides and protected from direct sunlight. Provision shall be made for chemical bulk tank delivery, at a point close to the bulk storage tanks. The fill point will be provided with a connection located within the contained area, a local level indicating device so that the transfer may be accomplished without overflowing the tank. Safety shower and eyewash station will also be provided in compliance with the relevant SABS or ISO standard.

It is recommended that the Tenderer contact local bulk chemical suppliers to ascertain the coupling type that is used for each chemical, the size, and whether or not compressed air is required for chemical transfer.

PS 4.5.6. Other Structures

Allowance must be made in the design and site layout for a guard house & wall around premises, paved roads, site lighting, drainage, landscaping, and covered parking facilities for eight vehicles. These facilities must be designed bearing in mind that the NamWater desalination plant must conform to the aesthetic appearance of the UraMin plant while conforming to all rational and functional standards to ensure safety and ease of movement of delivery vehicles and maintenance equipment and people.

The building construction and design of any buildings will be done in accordance with SABS 0400 while ensuring that the structures will be fit for their intended purposes under the harsh environmental conditions of the Namibian coast line.

PS 4.5.7. Proposal requirements

Architectural rendering of the building structures
Elevations from North, South, East and West
Floor plan of each building
Building domestic electrical load, including HVAC.
Interior and exterior lighting plan
General site layout

PS 4.6 Electrical Systems

PS 4.6.1 Power Supply Point. (NamPower)

Namibia's power supply company, NamPower, will provide NamWater with power at a predefined point near the NamWater Site. The supply point is indicated on drawing NO 01 RO

The power from NamPower will be provided by two 40MW transformers that will be installed at the power point. The point will be shared with other users.

The details of the NamWater power off take point:

Voltage	: 11 KV
Frequency	: 50 Hz
Power Capacity	: 20 MW (18 MW)**
Number of feeder points	: Three

** The power of the inlet/raw water pump station is not part of this power point. The power for the clear water pump station (Water supply to Swakopmund) is part of the power point. It is envisaged that this pump station would require 2MW for operation. A total of 18 MW will therefore be available for the NamWater plant.

The Tenderer will responsible for the design of the total power supply systems downstream of this point. This will include the distribution of power to the NamWater Plant from the above mentioned point and on site power for the NamWater Plant.

All the necessary authorization regarding right of way and application for power supply from NamPower will be the responsibility of the Employer.

PS 4.6.2 Power distribution on NamWater Site.

All the power provided by NamPower will be metered at this NamWater central distribution point. The metering instrument will be used as check meter to confirm the NamPower account on maximum demand and power usage.

The distribution of power on the NamWater site will be the responsibility of the tenderer. The Tenderer will be responsible for the design of power distribution systems to ensure that the voltages supplied to all the equipment on the NamWater site is within the equipment supplier's specifications. The tenderer will design the system to allow for direct on line starting of electrical motors when required.

The power distribution will be done by means of underground cables installed in sleeves with regular manholes every 50 meters between the different points and the NamWater central distribution point.

The tenderer will ensure that all the designs for the power distribution systems make provision for surge and lightning protect on the total distribution systems.