3 PROJECT DESCRIPTION

As briefly mentioned in the introduction, in view of the current water situation in Mauritius, Constance Group intends to preventively install a desalination plant at Constance Belle Mare Plage.

A seawater reverse osmosis desalination plant is proposed at Constance Belle Mare Plage.

3.1 PRINCIPLES OF SEA WATER REVERSE OSMOSIS

Reverse osmosis (RO) is a membrane separation process in which water in a pressurized saline solution is separated from the solutes (the dissolved material) by a membrane. No heating or phase change is necessary for this separation, and the major energy requirement is for pressurizing the feed water. In practice, the saline feed water is pumped into a closed vessel where it is pressurized against the membrane. As a portion of the water passes through the membrane, the salt content of the remaining feed water increases since there is less water containing the same total amount of dissolved salts. At the same time, a portion of this saltier feed water is discharged without passing through the membrane.

Two improvements have helped reduce the operating costs of RO plants during the past decade, namely

- the development of membranes that can operate efficiently at lower pressures, and
- the use of energy recovery devices.

The flow diagram of a RO system is shown in Figure 1 below.

![Figure 1: Flow Diagram of a Reverse Osmosis System](image)

Constance Belle Mare Plage - Proposed Installation of a Seawater RO Desalination Plant  
April 2012
Feed pre-treatment for the removal of suspended material, bacteria and organics is carried out in modern plants with Ultra-Filtration and Micro-Filtration modules. If residual chlorine is present, it is removed by active carbon filters. The high-pressure pump used to feed the membrane module is connected on a single shaft with the motor and a turbine or other means, in order to recover the energy content of the pressurized concentrate.

3.2 DESIGN BASIS

3.2.1 Design Components

The project will consist of the following components:

(v) The construction of the RC plant room;

(vi) The supply, installation and commissioning of a seawater RO (SWRO) desalination plant to meet the parameters for drinking water standard as defined in the Schedule of the Environmental Protection (Drinking Water Standards) Regulations 1996, Government Notice No 55 of 1996

(vii) The transfer of the potable water from the SWRO desalination plant to the existing potable water storage tank of the hotel

(viii) The ancillary facilities for sea water intake and brine rejection through inland boreholes structures with necessary piping to and from the SWRO desalination plant

A location plan highlighting the various components is shown in Figure 1 below and further more shown in larger format in the Drawing section of the EIA report.

Architectural drawings of the RC plant room are attached in the Drawing section of the EIA report as follows:

- 1204/BMP/02: Desalination Plant – Floor Plan
- 1204/BMP/03: Desalination Plant – Roof Plan
- 1204/BMP/04: Desalination Plant – Sections 1-1 & 2-2
- 1204/BMP/05: Desalination Plant – Sections 3-3 & 4-4
- 1204/BMP/06: Desalination Plant – Elevations
Figure 2: SWRO Desalination Plant Components

LEGEND

BH1 - Raw seawater supply borehole
BH2 - Diluted brine discharge borehole
HWM - High water mark
P.W.T - Potable water tank
I.W.T - Irrigation water tank
3.2.2 Feed Water

3.2.2.1 Feed Water Intake Borehole

The feed seawater will be abstracted from an inland borehole – BH1 - drilled to the saline aquifer.

The use of an inland borehole not only precludes impingement, i.e. trapping of marine organisms on the grills or screening of an intake structure, but also ensures that, the seawater abstracted undergoes some initial filtration through the natural layers of sand/rocks and is therefore normally very clean, thereby reducing unnecessary investments in pre-treatment facilities, and to extend the lifetime of the membranes of the seawater reverse osmosis (SWRO) system.

The relevant characteristics of the intake borehole BH1 are as follows:

- location: 185m from High Water Mark, 10m from the plant room
- diameter: 250mm
- drilled depth: 26m below ground level
- water strikes marks during boring: 2.00m, 6.00m, 8.00m and 22.0m
- Static water level: 0.72m
- Dynamic water level: 1.00m
- Change in drawdown during pumping test: 0.28m
- Final yield during pumping test: 108m³/h @21.0m

Refer to Water Research report attached at Appendix B for further geotechnical details

The pumping depth is likely to be between 20.0 to 25.0m

3.2.2.2 Feed Water Parameters

A complete seawater analysis of the intake seawater at 25m deep in BH1 has been carried out by P.I. Eco Srl (Italy) Laboratory as shown in Table 2 below.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>7.56</td>
</tr>
<tr>
<td>Conductivity</td>
<td>µS/cm</td>
<td>49700</td>
</tr>
<tr>
<td>Alkalinity P</td>
<td>°F</td>
<td>0</td>
</tr>
<tr>
<td>Alkalinity M</td>
<td>°F</td>
<td>13</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>20.8</td>
</tr>
<tr>
<td>Colour</td>
<td></td>
<td>Not perceptible with dilution 1:20</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>1.2</td>
</tr>
<tr>
<td>Odour</td>
<td></td>
<td>Odourless</td>
</tr>
<tr>
<td>C.O.D.(as O₂)</td>
<td>mg/l</td>
<td>10</td>
</tr>
<tr>
<td>Total Dissolves Solids</td>
<td>mg/l</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Calcium</td>
<td>mg/l</td>
<td>260.8</td>
</tr>
<tr>
<td>Potassium</td>
<td>mg/l</td>
<td>513.6</td>
</tr>
<tr>
<td>Magnesium</td>
<td>mg/l</td>
<td>997.8</td>
</tr>
</tbody>
</table>
### Parameter | Unit | Result | Drinking water Standards
--- | --- | --- | ---
Silica | mg/l | < 0.02 | |
Sodium | mg/l | 10800 | |
Ammonia (as NH₄) | mg/l | < 2 | |
Nitrite (as N) | mg/l | 1.80 | |
Nitrous Nitrogen (as N) | Mg/l | < 0.015 | |
Sulphate (as SO₄) | mg/l | 4700 | |
Fluoride | mg/l | < 0.1 | |
Bromine | mg/l | < 0.1 | |
Total phosphorous (as P) | mg/l | 0.70 | |
Chloride | mg/l | 16600 | |
Bicarbonate (as HCO₃) | mg/l | 137.2 | |
Total Salinity | mg/l | 33700 | |
TOC | mg/l | 3.41 | |
DDT | mg/l | <0.001 | |
Hexachlorobenzene | mg/l | <0.001 | |
methoxychlor | mg/l | <0.001 | |
heptachlor | mg/l | <0.001 | |
Total pesticides excludes | mg/l | <0.001 | |
Phosphorus of which: | | | |
Aldrin | mg/l | <0.001 | |
Dieldrin | mg/l | <0.001 | |

Table 2: Complete Seawater Analysis for Intake Borehole BH1

### 3.2.3 Product Water

The product water i.e. the permeate obtained from a single pass reverse osmosis process will conform to WHO drinking water guideline and standards (2002) as well as meet the standards for drinking water as defined in the Schedule of the Environmental Protection (Drinking Water Standards) Regulations 1996, Government Notice No 55 of 1996 (refer Appendix C).

Based on the feed water and RO plant characteristics, the water quality of the permeate has been computerised and is provided in Table 3 below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Result</th>
<th>Drinking water Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>-</td>
<td>5.39</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Calcium</td>
<td>mg/l</td>
<td>0.29</td>
<td>-</td>
</tr>
<tr>
<td>Potassium</td>
<td>mg/l</td>
<td>2.95</td>
<td>-</td>
</tr>
<tr>
<td>Magnesium</td>
<td>mg/l</td>
<td>1.10</td>
<td>-</td>
</tr>
<tr>
<td>Silica</td>
<td>mg/l</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/l</td>
<td>44.47</td>
<td>-</td>
</tr>
<tr>
<td>Ammonia (as NH₄)</td>
<td>mg/l</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>Parameter</td>
<td>Unit</td>
<td>Result</td>
<td>Drinking water Standards</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------</td>
<td>--------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Nitrite (as N)</td>
<td>mg/l</td>
<td>0.01</td>
<td>3.0</td>
</tr>
<tr>
<td>Sulphate (as SO₄)</td>
<td>mg/l</td>
<td>6.21</td>
<td>250</td>
</tr>
<tr>
<td>Fluoride</td>
<td>mg/l</td>
<td>0.00</td>
<td>1.5</td>
</tr>
<tr>
<td>Bromine</td>
<td>mg/l</td>
<td>0.00</td>
<td>--</td>
</tr>
<tr>
<td>Total phosphorous (as P)</td>
<td>mg/l</td>
<td>0.00</td>
<td>--</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/l</td>
<td>70.0</td>
<td>250</td>
</tr>
<tr>
<td>Bicarbonate (as HCO₃)</td>
<td>mg/l</td>
<td>0.64</td>
<td>--</td>
</tr>
<tr>
<td><strong>Total Salinity</strong></td>
<td>mg/l</td>
<td>126.09</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 3: Computerised Permeate Water Quality

The permeate will be chlorinated prior to being mixed with potable water provided by the CWA where a self-stabilisation will occur.

### 3.2.4 By-product

#### 3.2.4.1 Water Quality in Rejection Borehole

The rejected water will be injected down an inland borehole – BH2 - drilled to the saline aquifer.

The use of an inland deep borehole to reject the by-product of the desalinated plant is recognised as having no impact on the living environment as opposed to rejection in the ocean through a sea outfall.

Since the brine is heavier than seawater, best engineering practices require that the rejection borehole is deeper than the intake borehole and located minimum 30m away one from the other.

The relevant characteristics of the rejection borehole BH2 are as follows:

- location: 235m from High Water Mark, 85m from BH1
- diameter: 250mm
- drilled depth: 40m below ground level
- water strikes marks during boring: 12.0 and 35.0m
- airlift yield: 75m³/h for 1 hour

Refer to Water Research report attached at Appendix B for further geotechnical details

The rejection depth is likely to be around 35.0m based on the water strike which will assist further in the dilution.

The water quality of the rejection borehole is similar to the one of the intake borehole as shown in Table 2.
The conductivity and the salinity have been specifically tested and results are provided below:

- Conductivity in BH2: 50600 µS/cm
- Total Salinity: 33900 mg/l

### 3.2.4.2 The Brine

The brine is primarily composed of concentrated seawater and in a lesser manner of any chemicals used in the process (refer to section 3.3.1.).

Based on the feed water and RO plant characteristics, the water quality of the brine has been computerised and is provided in Table 4 below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>-</td>
<td>7.66</td>
</tr>
<tr>
<td>Calcium</td>
<td>mg/l</td>
<td>401.08</td>
</tr>
<tr>
<td>Potassium</td>
<td>mg/l</td>
<td>788.56</td>
</tr>
<tr>
<td>Magnesium</td>
<td>mg/l</td>
<td>1534.49</td>
</tr>
<tr>
<td>Silica</td>
<td>mg/l</td>
<td>0.00</td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/l</td>
<td>16591.44</td>
</tr>
<tr>
<td>Ammonia (as NH₄)</td>
<td>mg/l</td>
<td>0.00</td>
</tr>
<tr>
<td>Nitrite (as N)</td>
<td>mg/l</td>
<td>2.76</td>
</tr>
<tr>
<td>Sulphate (as SO₄)</td>
<td>mg/l</td>
<td>7227.42</td>
</tr>
<tr>
<td>Fluoride</td>
<td>mg/l</td>
<td>0.00</td>
</tr>
<tr>
<td>Bromine</td>
<td>mg/l</td>
<td>0.00</td>
</tr>
<tr>
<td>Total phosphorous (as P)</td>
<td>mg/l</td>
<td>1.08</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/l</td>
<td>25500.77</td>
</tr>
<tr>
<td>Bicarbonate (as HCO₃)</td>
<td>mg/l</td>
<td>208.97</td>
</tr>
<tr>
<td>Total Salinity</td>
<td>mg/l</td>
<td>52273.83</td>
</tr>
</tbody>
</table>

**Table 4: Computerised Brine Water Quality**

The brine will be diluted as a mitigation measure prior to rejection to the borehole (refer section 5.2.4)

### 3.3 RO PROCESS DESCRIPTION

The Layout Plan of Desalination Plant is shown on Drawing No. 1204/BMP/02 attached in the Drawing section of the EA report.

The complete Process description is attached at Appendix D together with the Material Safety Data Sheets of chemicals to be used.
3.3.1 Raw Water Intake

The raw water is pumped from the intake borehole via a submersible pump located in BH1 and directed to a two compartment raw water tank of 48m³, namely:

- Compartment 1 (24m³) is used as a settling tank and could be the flocculation tank should the water quality require a flocculation process
- Compartment 2 (24m³) is used as buffer tank

3.3.2 Pre-treatment

The pre-treatment stage consists in the following steps:

- 1 set of multi-media sand filters (to remove the suspended solids above 50 µm)
- 1 set of 5 microns cartridge filters (to remove the finer particles above 5 µm)
- 1 anti-scalant injection system (RPI-3000A - phosphonate based product at an injection rate of 3mg/l)
- 1 UV irradiation system (to sterilize the feed water before entering the membranes)

The cleaning of the multimedia filters is an operation that does not require any chemicals; only the borehole sea water is used. The operation has to be done manually whenever the differential pressure between the inlet and outlet of the filters reaches 10 PSI (0.7 Bars). The frequency of the backwashes cannot be defined by a fixed timing interval since the usage of the RO unit will be variable. However, in regard of the quality of the raw water, it is estimated that the filters should be cleaned every 2,500 linear meter of filtration, which represents around 250 hours of RO operation.

3.3.3 Treatment: Reverse Osmosis

A 35% RO plant recovery means that 35% of the water (as H₂O) will pass through the membranes (being the Permeate) while the remaining 65% containing the salts and other undesired elements will be rejected (being the Brine).

To exceed the osmotic pressure in order to produce the 350 m³/day of fresh water, a centrifugal high pressure pump is used; the brine discharge flow is re-used to power back an energy recovery turbine coupled with high pressure pump. The nominal pressure of the system is 54 Bars in total (19.3 Bars being provided by energy recovery system).

The RO plant is equipped with 24 membranes, distributed in 4 series of 6 membranes. Each series of 6 membranes is housed in 2 vessels containing 3 membranes each.

The cleaning of membranes is required only when a permeate flow rate decreases and the performance of the machine drops, i.e. when fouling occurs. Different chemicals can be used for the cleaning, depending on the type of fouling. Generally the cleaning process includes

- an alkaline cleaner, e.g. EB-Cleaner B2, potassium hydroxide based membrane washing product (to remove organic deposits), followed by
- an acid cleaner, e.g. EB-Cleaner A1, sulphamic acid based membrane washing product to remove inorganic deposits.)
The typical concentration of membrane washing product EB-Cleaner B2 and EB-Cleaner A1 will be of 1% v/v.

In any case the cleaning is always performed on the external part (brine side) and the cleaning is done under very low pressure far below the osmotic pressure. There is therefore no risk of chemical passage to the permeate side during this operation. The cleaning operation is always ended by a rinse with fresh water.

### 3.3.4 Mode of Operation

As previously said, the desalination plant to be installed at Constance Belle Mare Plage is a back-up source of potable water supply in the event of water shortages. Accordingly, the mode of operation will depend totally on the hotel's water requirements and availability of potable water supply from the CWA. It can however be safely said at this stage that the plant would primarily run a few hours during the day if required.

### 3.3.5 Process Flowchart

The Sea water reverse osmosis flowchart for Belle Mare Plage desalination plant shown in Figure 3 below is computerised based on the sea water analysis et other design criteria provide by the operator.
Figure 3: SWRO Process Flowchart