

# SDP Capital Works

## Project Summary



<b>Project Title / Asset</b>	Ongoing RO Membrane Replacement
<b>Project Driver</b>	Reliability / Availability

### Purpose

The purpose of this document is to provide a high-level overview for the ongoing replacement of Reverse Osmosis (RO) membranes, further detailed information is available on request.

Information/justification on other elements of the proposed capex program (e.g. refurbishments and replacements of existing assets) are also available on request.

### Project Background

One significant part of the Sydney Desalination Plant (the Plant) operation and maintenance is the RO membrane element maintenance strategy. Thin-film composite (TFC) RO membrane elements typically have a life expectancy of 3 to 5 years. Even if not operated, most RO membrane suppliers indicate a maximum life of 5 years. However, the in-service life can be extended, in some cases to over 10 years with good pre-treatment of feedwater, conservative design, and experienced trained operators, all attributes of the Plant. Eventually though, the RO membrane elements will need to be replaced.

The RO membrane elements currently in-service at the Plant are over 3 years old and were last replaced during the 2019 Restart when dam levels dropped below 60%. There is limited experience globally on large-scale desalination RO membrane operation in the context of the Plant's operating experience since 2010 – including relatively short periods of operation at full capacity, an extended period of mothball, restart again to full capacity, and then operation at low flow interspersed with regular ramp-ups to full capacity at short notice.

It is essential to have an RO membrane element replacement strategy to ensure the Plant remains available and serves as a critical piece of drinking water supply infrastructure. It is essential that a prudent RO membrane replacement program strategy is developed and sufficient funding approved to ensure replacement occurs in a timely manner and the Plant is always available to produce drinking water of required quality and quantity.

### Asset Details

<b>Asset</b>	Seawater RO membranes elements
<b>Asset durability/ design intent/ asset management Strategy</b>	Membrane assets: 8 years. Design Average Membrane Life (AML) of 3.5 years for 1st pass RO membranes and 5 years for the 2nd pass RO membranes. Regular cleaning and preservation as required, ongoing replacement to maintain AML.
<b>Asset Function/ Subsystem/ System</b>	There are twelve first pass trains and six second pass trains running when the whole plant is in operation (there is one standby train in each pass allowing cleaning or maintenance on one train in each pass while at the same time maintaining maximum capacity operation). There are a total of 36,736

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	<p>membranes at the Plant installed in groups of eight per individual pressure vessel.</p> <p>Using a high-pressure pump, feed water is continuously pumped at elevated pressure to the membrane system. Within the membrane system, the feed water will be split into a low-saline and/or purified product, called permeate, and a high saline or concentrated brine, called concentrate or reject. A flow regulating valve controls the percentage of feedwater that is going to the concentrate stream and the permeate which will be obtained from the feed.</p>
<b>Asset Failure and its consequence</b>	<p>Failure of RO membranes can impact the manufacturing cost and quality of the product water. Once numerous or individually significant enough production volume of the Plant may be decreased.</p> <p>If a catastrophic failure (effecting a large quantity of RO membranes – such as introducing an oxidising agent like chlorine into the RO feed water) were to occur, production would be significantly impacted and membranes will need to be replaced.</p>

### Justification

RO membrane elements deteriorate with time and need to be replaced periodically. The parameters to trigger when the RO membranes should be replaced vary from plant to plant and are typically based on one or more of the following:

- Energy consumption – the largest operating cost of any continuously running seawater desalination plant is energy consumption. As the membranes age, they foul and the feed pressure required to maintain performance increases, thus increasing energy consumption.
- Permeate water quality – permeate is the water that has passed through the RO membrane with the majority of dissolved salts removed from it by the RO membrane. Permeate water quality is affected by the feed salinity, flux rate, temperature, recovery, fouling, RO membrane age, salt rejection and many other factors. Changes in one of these variables can often lead to increased or decreased permeate water quality.
- Feed pressure limitations – as RO membrane elements age and they progressively foul, the feed pressure on the RO system will rise. In some cases, the feed pressure required by the high pressure pump becomes too high to maintain the designed permeate flow.

The main driver for RO membrane replacement at the Plant is to maintain optimum energy consumption. That is, the trigger for membrane replacement is to maintain the AML in a manner such that the cost of membrane replacement is offset by the projected energy savings associated with the RO system, however the RO membrane replacement to maintain AML will also enable the Plant to:

1. Maintain water quality in accordance with the drinking water specifications,
2. Ensure the Plant remains available to respond as required under the proposed new operating environment,
3. Manage risk of asset failure that could jeopardise the ability to respond to flow requests at all times as per the requirements of the proposed new operating environment, and
4. Manage these performance risks considering the long lead times between order and delivery of membranes to the Plant.

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### Options Considered

There are numerous aspects that need to be considered when replacing the RO membrane elements. These include:

- What RO membrane elements to select and from which supplier?
- The best procurement method.
- Delivery to site and how the RO membranes are stored prior to installation
- What spare parts and consumables are required?
- The best approach to installing the RO membrane elements.
- Disposal/beneficial reuse of the old RO membranes elements.

Each of these aspects and the various options within each aspect needs to consider both technical and financial factors to allow the selection of the preferred option.

Options for all the relevant components relating to the RO membrane element replacement have been considered, including:

- RO membrane element selection & procurement
  - RO membranes are technically compatible with the design of the Plant
  - If an alternate supplier is selected, technical and commercial factors preclude mixing and matching membranes from different suppliers in a single RO train. Thus replacement methodology is restricted to Train-by-Train replacement.
  - Supplier capability (large enough, reliable, suitable quality assurance and proven)
  - A market review was conducted to assess the current competitiveness of selected suppliers (technology, warranties, pricing and capacity)
  - RO membrane shelf life
  - RO membrane buy back
  - Procurement lead times
  - Parts and consumables
- Transportation, import and storage
  - International shipping
  - Import duties
  - Local storage
  - Local transport costs
- Installation costs
  - A significant cost associated with the replacement of RO membrane elements is the labour costs to physically remove and dispose of the old elements and install the new RO membrane elements. The manner in which the RO membrane loading is conducted can significantly vary the installation cost. Three loading methods were assessed, namely:
    - Full Train replacement
    - 1 element per vessel replacement
    - 2 elements per vessel replacement
  - Note 1 and 2 elements per vessel replacement may be advantageous from a system performance point of view (i.e. the first and last membranes in a vessel are most likely to require replacement) but installation cost will be higher than replacing all eight elements in a vessel or all elements in a train. This is because the time and cost

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to open and then close the vessel is spread over just one or two membranes rather than over all eight.

- Installation strategy
  - The RO membrane element replacement program can be implemented in numerous ways, ranging from “Do Nothing” through to replace all RO membranes. RO membrane elements can be replaced on a Train-by-Train basis or Element-by-Element basis. The options considered are:
    - Do nothing
    - Full replacement every 8 years
    - Membrane replacement to achieve design AML
    - Membrane replacement to achieve contracted AML
  - The replacement program options considered the ongoing replacement over the next 25 years. The 25 year replacement program for each option allows calculation of the 25 year net present value (NPV) for each option to assess the economics of each option over most of the remaining life of the Plant.
- Old RO membrane element reuse, recycle or disposal options
  - Direct reuse
  - Convert the RO membrane element into Ultra Filtration (UF) membranes
  - Disassemble the element into its components and recycle as much as possible
  - On sell used membranes
  - Landfill for any membranes if other options are not available.

### Proposed Scope

The proposed scope has been selected primarily on a risk based process to ensure the Plant remains available to supply drinking water of quality and quantity whilst being mindful of providing efficiency in the cost of water so as to provide the best value for customers. The replacement program has been selected to ensure risk to Plant availability is minimised. The technical risk minimised by the preferred RO membrane supplier and installation method. The financial costs minimised by maximising the RO membrane life through deferral of RO membrane replacement based on actual performance versus design and the installation methodology.

The proposal is based on the replacement of RO membranes to maintain an AML of 4 years on 1st pass RO trains and 6 years on 2nd pass RO trains consistent with required performance projections, and to ensure a ready supply of membranes should there be any failures or major deterioration in performance in the near term.

The membrane performance will continue to be monitored and the replacement program adjusted to suit, to provide the most efficient replacement program.

The scope of the RO membrane replacement is the:

- Procurement of new RO membrane elements in line with the preferred replacement program
- Deliver the new RO membrane elements to site including all associated components such as:
  - Delivery of empty container to the Membrane Supplier’s factory
  - Loading of RO membrane elements into the containers
  - Transport ex-factory to port of export

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- All export port charges
- Sea freight to Sydney port
- Sydney port charge
- Customs Declaration Fees
- Customs Clearance Agency & Attendance
- Delivery of containers to the local storage facility
- Delivery by side loader transport to site,
- Pick up of empty container after unpack and un-hire container/s.
- Remove existing RO membranes and install the new RO membrane elements into the RO Trains with minimal impact on the Plant's availability
- Commission and test the new RO membranes
- Disposal or reuse of all packaging material
- Beneficial reuse of the old RO membrane elements
- Continue to monitor the old RO membrane element condition and recommend any modifications to the replacement program

### Cost Estimate

A detailed budget estimate has been prepared based on efficient negotiated rates with productivity assumptions aligned with our experience from the 2019 RO membrane installation and Veolia's recent experience replacing RO membranes at the Gold Coast Desalination Plant.

The budget estimate is shown in 2023 Australian Dollars and does not include any allowances (contingency) for changes in site conditions, assumptions or movements in foreign exchange rates.

A summary of the budget estimate for the ongoing RO membrane replacement over the next five years is presented below:

	FY23	FY24	FY25	FY26	FY27
Total Cost: RO Membrane Replacement	\$2,281,972	\$8,469,017	\$10,351,576	\$9,340,888	\$7,805,012