DSDP Engineering Design Detail Summary

Dampier Seawater Desalination Plant

RTIO-0213868

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SUMMARY

This memo provides detail on the engineering design and desalination process for the Dampier Seawater Desalination Plant (DSDP). Specifically, it outlines design considerations for the life cycle of the project including construction, commissioning, operations and decommissioning, and the treatment processes to be used for operation of the desalination plant.

This document is intended to support the referral of the DSDP (the Proposal) under Section 38 (Part IV) of the *Environmental Protection Act 1986* (EP Act). It provides further detail on engineering design that is not required for environmental impact assessment.

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1 Construction activities

The below sections describe the likely construction methods; however, these may be modified after further engineering design work is undertaken, whilst still ensuring construction activities remain of low risk to the marine and terrestrial environment.

1.1 Existing intake pond

The existing intake pond at Parker Point has been selected as the proposed location for the seawater intake pond (Figure 1).

Figure 1: Existing intake pond

This site has been chosen to minimise impacts to the marine environment. Use of the existing pond avoids the need to construct an entirely new seawater intake site, which would require significant construction works in the marine environment.

1.2 Intake construction

The initial construction activities around the existing intake pond will involve refurbishment of the artificial pond and culverts which link the pond to the ocean. During construction, a silt curtain will be set up on the ocean side of the culverts to minimise sediment dispersion beyond the existing intake pond during these works. Some sparse (less than 10% cover) turf algae, microalgae and corals are present on the rocks and rubble surrounding the seawater intake, but no significant benthic communities or habitat were identified (MScience, 2021).

Culvert refurbishment

The existing bar screens in front of the culverts (on the ocean side) (Figure 2) will be replaced with new 150 mm aperture screens to prevent items larger than 150 mm from entering the seawater intake. A remotely operated vehicle inspection by the Proponent revealed the existing bar screens are partially buried (Figure 2), so a small volume of material will need to be excavated from in front of the culverts. Any fallen rocks will also be removed. A vessel may be used for culvert refurbishment activities.

Figure 2: Culvert bar screens

The inside of the culverts will then be cleaned to remove any biological and sediment build-up. This work is likely to be done using underwater jetting or vacuuming, with dislodged material directed towards the seawater intake pond.

Removal of existing built-up sediment from the seawater intake pond

The culverts will be completely blocked on the intake side and sediment will then be removed from the base of the seawater intake pond to return it to originally constructed levels. This work will be done by a long-reach excavator or other suitable equipment. A temporary causeway may be built out into the seawater intake pond to provide equipment access to all areas of the pond. The causeway would be constructed using imported material from an existing borrow pit or purchased from local commercial quarries.

A dedicated area will be established adjacent to the seawater intake pond where the excavated material will be temporarily stockpiled. This area will be lined and bunded and include a decant system to dewater the excavated material. Decant water and stormwater runoff will be directed back to the pond and excavated material from the existing intake pond will be transported to a licenced waste management facility.

Construction of the intake structure

The temporary causeway (if required) will remain in place to provide access for the drill-based piling activities which are required to construct the seawater intake structure (Figure 3).

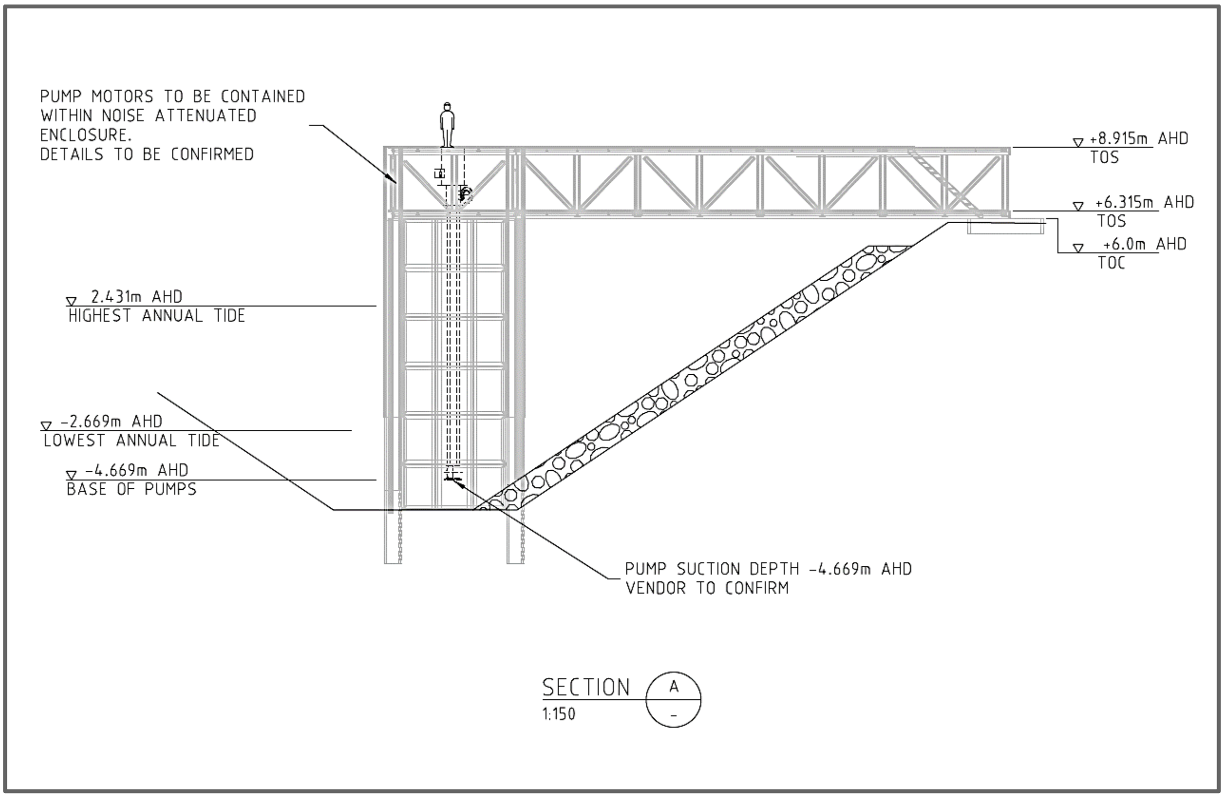

Figure 3: **Indicative cross-section design of seawater intake**

Up to six piles will be installed using drilling methods to minimise noise and vibration associated with the works to both the marine environment and to the community of Dampier. A mesh screen will be installed around the intake pumps to avoid entrapment of debris and marine life.

Material will be reused from the temporary causeway to construct the seawater intake equipment pad, which will be sized for the maximum 8 GL/a capacity. The pad will be raised above the current surface level (about 2.5 m Australian Height Datum (AHD)) to a maximum height of 6.5 m AHD, above storm surge levels. Fill will be sourced offsite from nominated borrow pits or purchased from local commercial quarries. New drainage around the pad and any existing drainage that flows to the seawater intake pond will be diverted towards the ocean (Figure 4).

Figure 4: **Drainage diversion at the seawater intake pond**

1.3 Services corridor

A services corridor will be established within the development envelope between the existing intake pond and the desalination plant for pipelines, power, fibre optic cable and associated access tracks, including:

- land disturbance within a corridor approximately 20 m wide (included within the development envelope)
- earthworks to achieve the required surface levels
- construction of drainage along the corridor, including v-drains and culverts where required
- excavation of open trenches to bury:
    - two seawater intake pipelines
    - two chlorine supply pipelines in double containment arrangement
    - two screen backwash lines in double containment arrangement.
- excavation of open trenches to bury power and fibre optics.

The requirements for trenching will vary depending on the ground conditions. The water table is not expected to be intercepted during trenching. Before excavation begins, an investigation will be conducted to identify potential contaminants, such as asbestos fragments. If found, they would be removed and transported to an appropriate licenced disposal facility.

Trenches will be backfilled either by using the material originally excavated, if suitable, or clean imported material.

Another smaller services corridor will also be established to extend the existing potable water system to the existing intake pond. The construction activities will be the same as those listed above, except for:

- land disturbance within a corridor of approximately 8 m wide
- excavation of open trenches to bury the pipeline.

A number of services corridors will be established between the desalination plant site and tie-in locations to existing services, including potable water, power and fibre optics. This work will comprise:

- land disturbance within a corridor up to approximately 15 m wide (most of the area is already clear of vegetation)
- excavation of open trenches to bury pipelines and power/fibre optics in a separate trench.

The requirements for trenching will vary depending on the ground conditions. The water table is not expected to be intercepted during trenching. Trenches will be backfilled either by using the material originally excavated, if suitable, or clean imported material.

As part of the development for the later stage of the Proposal, another smaller services corridor may need to be established to upgrade the existing ring main power cable between the Dampier Bulk Supply Substation and Western Stockyard Substation. Where feasible, the cable will be installed above-ground in an existing cable tray, but ground disturbance will be required to bury the cable at road crossings. In these instances, excavation of an open trench would be required to bury the cable.

1.4 Plant

The desalination plant site will be constructed on an area of land reclaimed by historic dredge spoil deposition activities (Figure 5).

Figure 5: **Plant site location**

Ground improvement may be required to mitigate the risk of settlement. The type of ground improvement will vary depending on ground conditions, but the preferred method is to remove the existing material and replace it in compacted layers. Where this is not feasible, it is envisaged ground improvement may consist of one of the two potential solutions presented in Table 1.

Table 1: **Potential ground improvement solutions**

Ground improvement solution	Description
Stone columns	Construction of load-bearing columns by introducing gravel or crushed aggregate into the soil using a vibrating poker. This method also densifies soils surrounding each column.
Controlled modulus columns	Construction of unreinforced concrete/grouted loadbearing columns by continuous flight auger type methodology.

Fill will be imported to achieve the required levels for the pad and site access roads. The plant pad will be raised to a minimum level of +6.5m AHD to raise the plant equipment above storm surge levels and any underlying redundant services. Fill will be sourced from nominated existing borrow pits or purchased from existing local commercial quarries.

Site drainage will be directed to the existing open drainage channel along the eastern side of the desalination plant site via a new v-drain around the plant perimeter.

A conceptual visualisation of the desalination plant is shown in Figure 6.

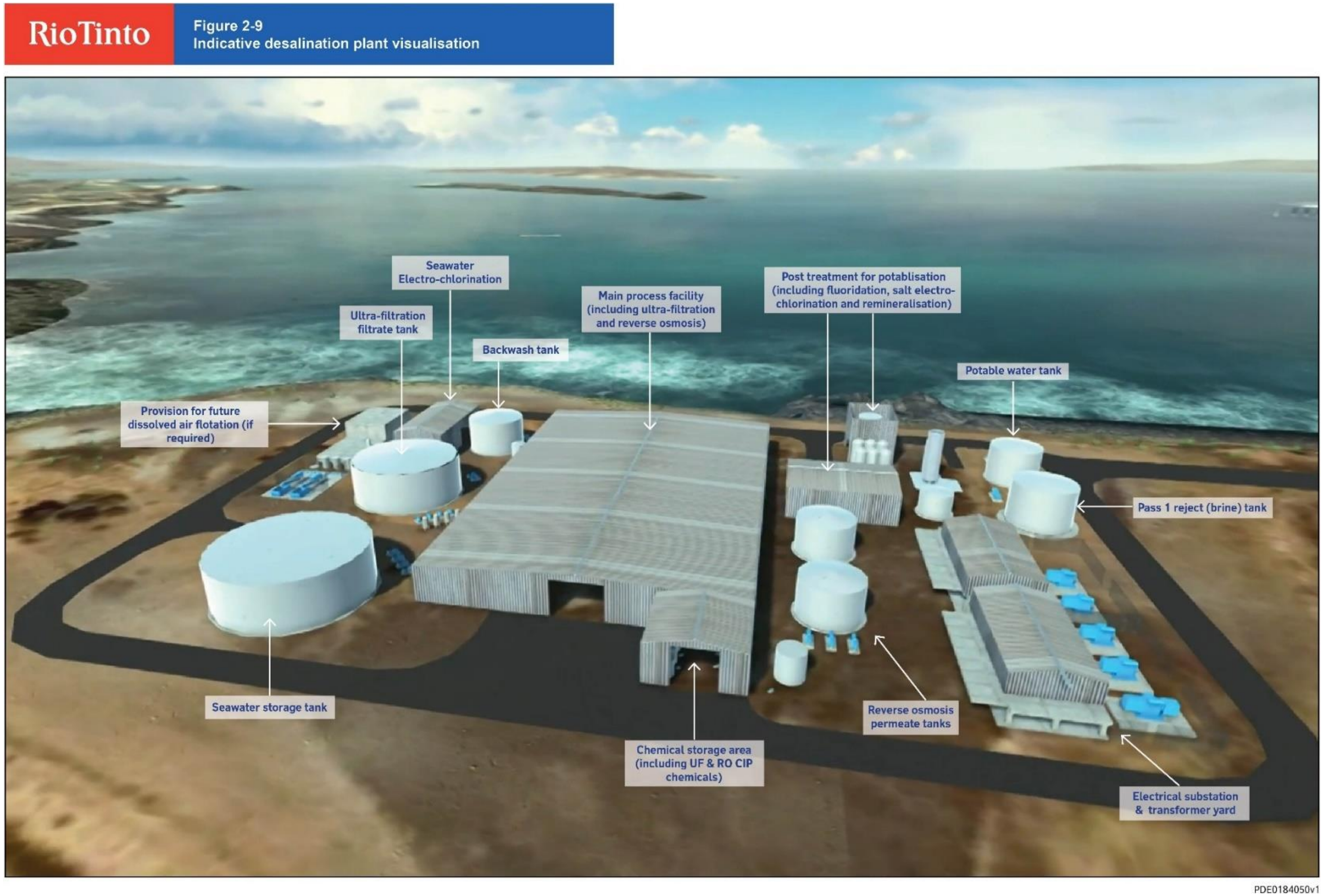

Figure 6: Indicative desalination plant visualisation

1.5 Outfall

Brine, ultra-filtration backwash and treated clean-in-place (CIP) wastewater from the desalination plant will be conveyed via a pipeline to the diffuser location along the Parker Point wharf. The pipeline will be buried overland from the desalination plant to the start of the Parker Point wharf to minimise heat transfer from higher ambient air temperatures. A services corridor between the desalination plant and the start of the wharf will be established for the outfall pipelines, including:

- land disturbance within a corridor no greater than 15 m wide
- excavation of open trenches to bury the services
- backfilling of trenches by using the material originally excavated, if suitable, or imported material.

The pipeline along the wharf will be installed from the shore and/or off the wharf where feasible; however, it is likely construction vessels will be required to support the construction activities. Construction vessels may anchor alongside the wharf.

The diffuser design is expected to comprise a single arrangement fitted to a single wharf pile submerged at approximately 0.2 m above the seabed. A photo of the indicative location on the wharf where the diffuser arrangement will be fitted is shown in Figure 7.

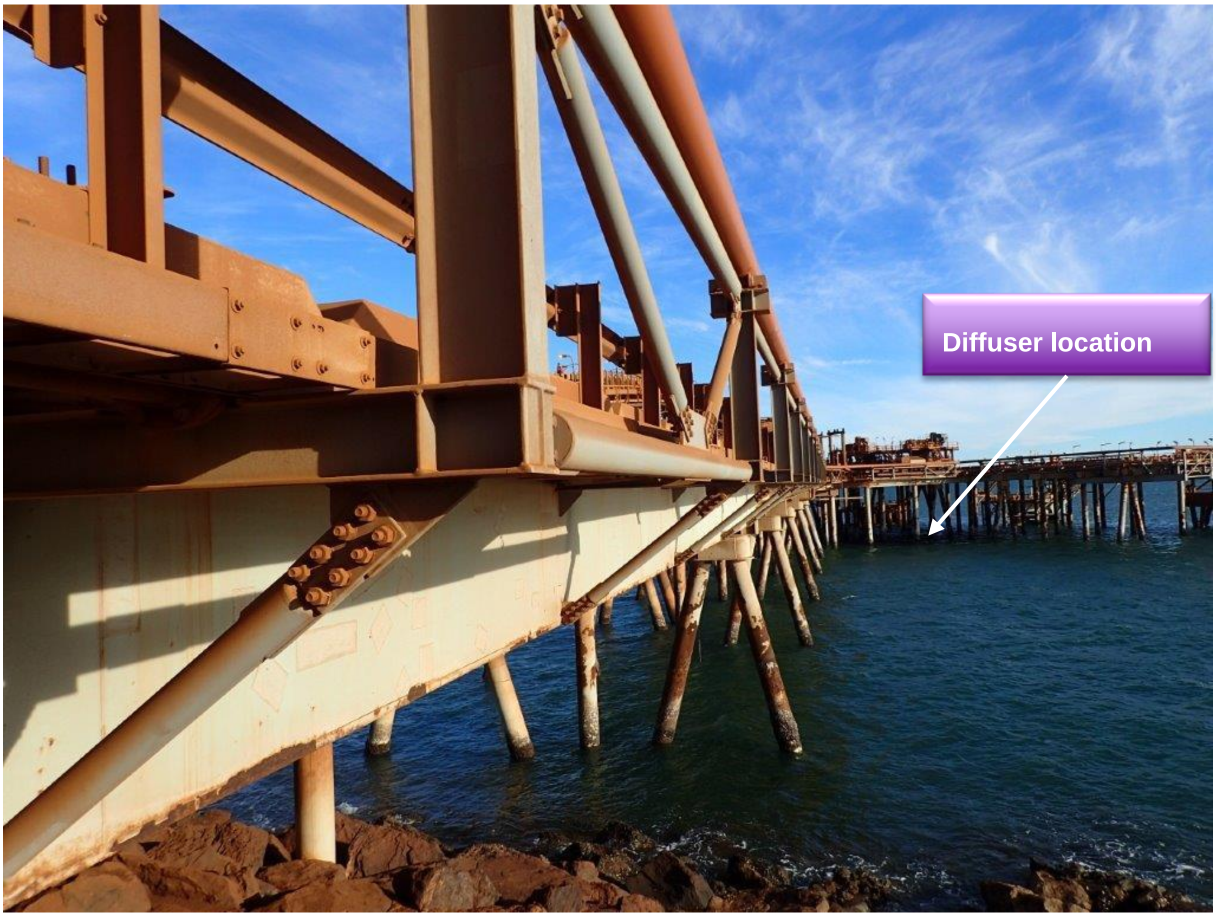

Figure 7: Indicative location of diffuser

One outfall diffuser will be installed initially for Stage 1, with a further diffuser installed to meet the discharge requirements of Stage 2. The diffusers will be sized to achieve an exit velocity of 3 to 6 m/s (**Error! Reference source not found.**). The diffuser pieces will either be lifted in place from the wharf or from a construction barge and fixed to the wharf piles using divers. An example diffuser design arrangement is shown in Figure 8.

Table 1: Outfall specifications

Item	Unit
Number of outlets	Two diffuser arrangements (one for each stage)
Outlet depth	Outlets will be oriented to discharged upwards at an angle of 45 degrees
Outlet diameter	Each outlet 250 mm
Outlet velocity	3 to 6 m/s for each port

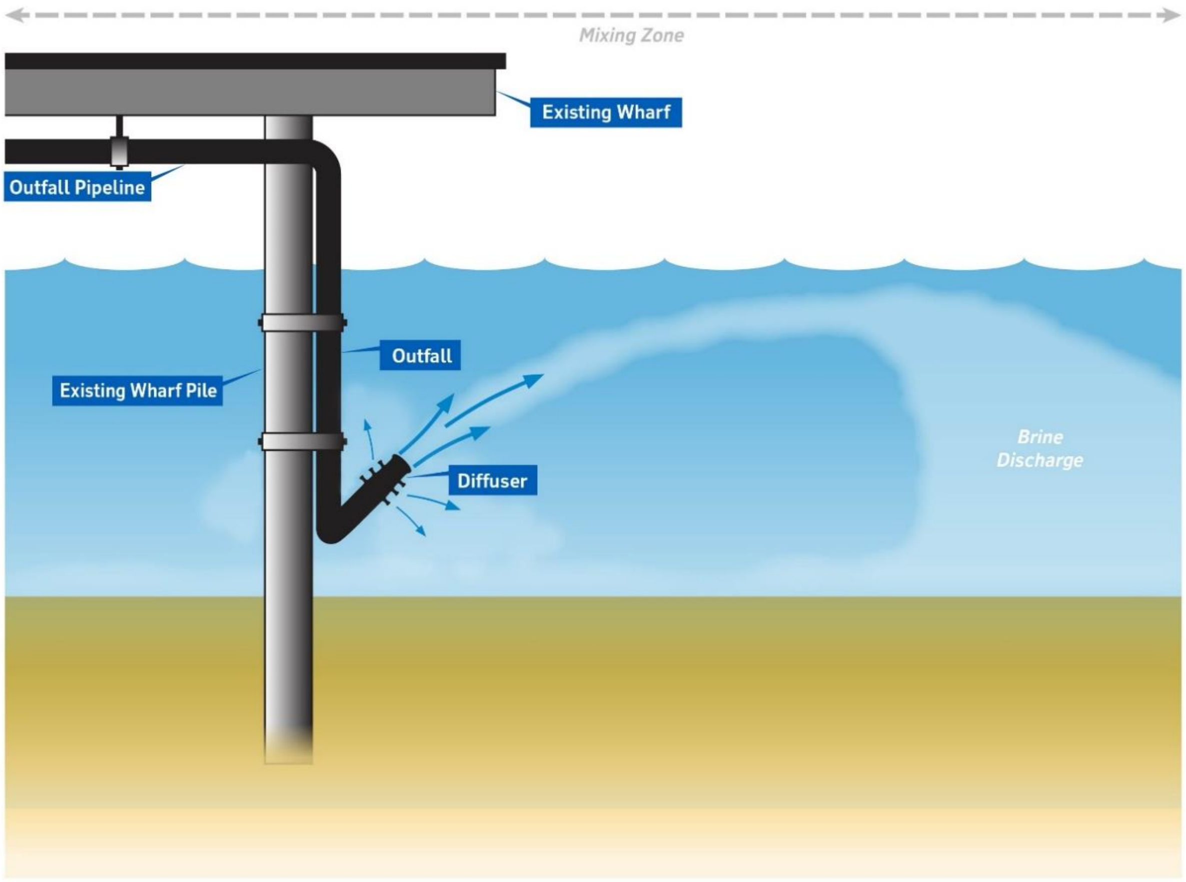

Figure 8: Indicative diffuser arrangement

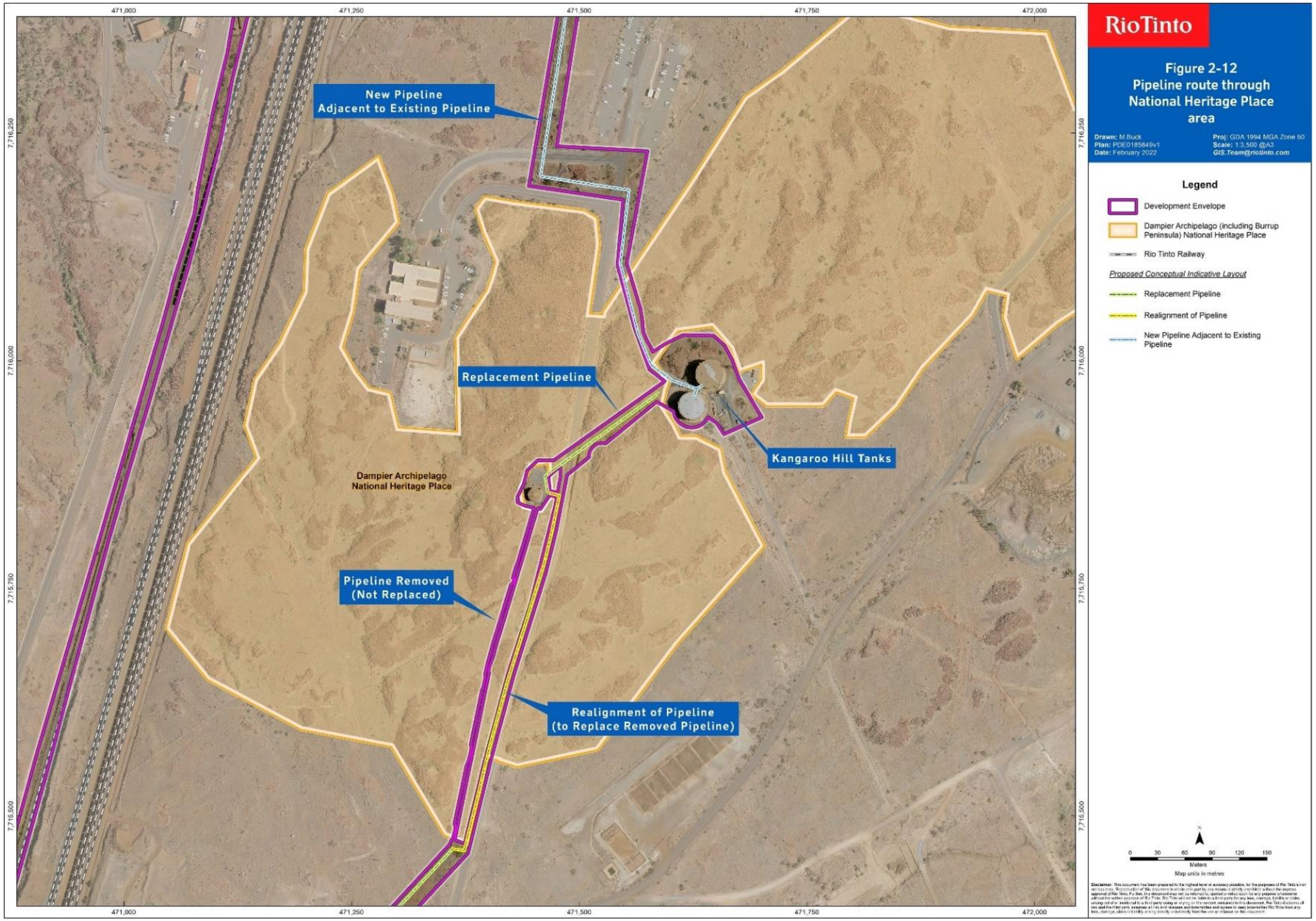

Figure 9: Pipeline route through the National Heritage Place

1.6 Water transfer pipelines

The construction of the water transfer pipelines includes:

- New pipeline:
    - Installed from the desalination plant to connect to the existing pipeline corridor and to the existing Kangaroo Hill tanks. This pipeline will be 350 to 450 mm in diameter, largely above ground, and will follow existing pipelines for the majority of its alignment. In the NHP near the existing Kangaroo Hill tanks, the new pipeline will be constructed immediately adjacent to an existing pipeline and has been designed to have no impact on the national heritage values within the NHP.
    - From the booster pump station to tie in with the existing pipeline to East Intercourse Island.
- Removal of existing pipeline and realignment along the existing road corridor (private road):
    - South of existing Kangaroo Hill tanks within the NHP (approximately 400 m).
- Replacement of existing pipeline:
    - South of the National Heritage Place to the booster pump station.

The existing water pipelines through the NHP are shown in Figure 9.

The water transfer pipelines will generally be constructed above-ground to avoid excavation of hard rock (bedrock) and to allow easy access for maintenance. Above-ground pipelines will be held in place with pipe supports and anchorage where required. Some excavation may be needed to bury the bases of the pipe supports.

Below-ground installation will be adopted where above-ground installation is not feasible, such as road and railway crossings. Most below-ground piping will be installed using open trenching methods. Trenching requirements will vary, depending on specific ground conditions.

Railway crossings will be installed using trenchless methods, which will involve tunnel boring, pipe jacking or horizontal directional drilling.

The water transfer pipelines' construction will involve:

- land disturbance within a corridor up to approximately 15 m wide[1]; where feasible, construction of the pipeline route will be limited to already cleared areas and follow existing roads to minimise disturbance
- excavation of open trenches to bury the services
- backfilling of trenches, as soon as practicable, either by using the material originally excavated, if suitable, or imported material.

The existing water transfer pipelines north and south of the existing Kangaroo Hill tanks intersect the Dampier Archipelago (including Burrup Peninsula) NHP. The existing restricted corridor will be used for installation of the pipeline within and near the boundary of the NHP.

Photos of the existing water pipelines through the NHP are shown in Figure 10. The approximately 400 m section of pipeline south of the existing Kangaroo Hill tanks is close to rocky outcrops; therefore, to

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[1] With the exception of launch and receive pits required at the trenchless crossings beneath railways which may require up to a 20 m x 20 m area

avoid potential impacts to nearby heritage values, the pipeline will not be replaced. Instead, this section of pipeline will be realigned to follow along the existing road corridor (private road) to the east (Figure 9).

Figure 10: Existing environment along pipeline alignment through National Heritage Place

1.7 Additional construction activities

During construction, the following activities will also occur within the development envelope:

- Construction areas will have artificial lighting to provide safe working conditions. Areas will be lit to the minimum extent for safe working conditions and only areas where works are being performed, or which are critical to safe movements around the site, will be lit.
- Construction vehicles will move heavy machinery and equipment. Light vehicles will transport the construction workforce to and around the site. It is expected the construction vehicles will enter the site through one main entrance. However, where required, additional temporary entrances may be needed. These will be closed following construction activities. Where possible, entrances will be limited to avoid multiple interactions with the adjoining public roads.
- Hot works, such as welding, will be required throughout operations. These will be performed in accordance with established Rio Tinto hot works procedures.
- Amenities will be provided onsite for the construction workforce. This will include crib huts, meeting rooms and temporary office spaces with temporary ablution facilities. No accommodation will be provided onsite. Construction workers are expected to travel from Dampier or other nearby towns, such as Karratha, for their shifts.
- Temporary stormwater control will be implemented around the site where required. This will be designed to prevent water egress to construction areas and to minimise sediment runoff outside the development envelope.
- All solid and liquid waste will be managed onsite and collected for disposal at appropriate facilities offsite.
- Chemical storage areas will be established to comply with relevant Australian standards. These will include bunded, lined areas that will be rehabilitated before operations begin.
- Laydown areas will be set up around the site as required. These have been included in the development envelope and will only be established as required. When these areas are no longer required, they will be rehabilitated as soon as practicable, and before operations begin.
- Topsoil and vegetation will be removed from the permanent infrastructure footprint, as well as the areas needed for temporary construction activities. Given the site is predominantly reclaimed land from dredge spoil, most of the site is already cleared and it is unlikely all areas will have topsoil. However, all topsoil and grub will be temporarily stockpiled during construction and be used to rehabilitate temporary construction areas before operations begin. It is not expected that any topsoil will be remaining after the rehabilitation of temporary construction areas.

2 Commissioning

Testing and commissioning is expected to take three to six months. A comprehensive commissioning plan will be developed ahead of such activities, and the process will be managed by a dedicated commissioning manager and team. The commissioning plan will be to work through each process step of the desalination plant and check and prepare the infrastructure ready for start-up, handover and operation.

Flow rates discharged to the marine environment during commissioning may at times be greater than those discharged during normal operations. In instances where larger flow rates need to be discharged, the diffusers will be supplemented with a single pipeline outlet. This outlet is intended for commissioning only and will not be used during normal operations.

Commissioning will begin by initially flushing all components of the desalination plant with either seawater or potable water from the Parker Point network (depending on the area of the desalination plant being flushed). Flush water from the intake, outfall and desalination plant will be released to the outfall via the diffuser after appropriate remediation (e.g., removal of debris with screens, neutralisation of chlorine, etc). Flush water from the transfer pipelines will be discharged to the terrestrial environment. The location of the discharge points will be determined at the time of commissioning (low points allow most effective discharge). The discharge points will be located away from key identified environmental and cultural heritage receptors and not within the NHP. These discharge points will be controlled under the requirements of a Part V licence. All commissioning water will be treated before discharge to the environment. The testing process will involve checking for watertightness, pressure rating, electrical compliance and general functional checks for equipment.

The commissioning process involves disinfection, energisation and performance testing of equipment and sub-systems to validate the operational performance of all process elements, individually at first and then later as an integrated system. Integration testing and commissioning will bring together the operation of all elements, safely discharging reject brine and neutralised backwash water, and producing safe drinking water.

Testing and commissioning water will be sourced either from the ocean or the potable water network. Water used for testing and commissioning will be released to the outfall via the diffuser. The exceptions will be water from:

- water transfer pipelines, which will be discharged to the terrestrial environment (as described above)
- leak testing of tanks, which will be discharged to the existing drainage channel adjacent to the desalination plant.

Any chlorinated water to be released to the environment will first be neutralised with sodium bisulphite (SBS) and tested before discharge.

To minimise water usage and disposal volumes, water will be recycled where possible and used for testing and commissioning steps in other parts of the desalination plant.

The above processes may either occur progressively as the infrastructure is constructed or may occur after construction of the whole desalination plant is complete.

3 Operations

The below sections describe the likely operations methods; however, these may be modified after further engineering design work is undertaken, while still ensuring operational activities remain of low risk to the marine and terrestrial environment.

3.1 Intake

3.1.1 Replacement of culverts (unplanned)

The existing culverts linking the pond to the ocean are more than 50 years old. It is not expected that these will need to be replaced to meet initial Proposal requirements. However, this may become necessary during the operational phase, should the culverts fail or become damaged, preventing sufficient flow to the existing intake pond. Culvert replacement would involve:

- modifying the existing intake pond rock wall to accommodate the heavy equipment needed to complete the works
- removing the area of rock wall from above the existing culverts to stockpile for later reuse
- removing the existing culvert(s) with an excavator, including the concrete encasement surrounding the culvert(s) which may require a rock breaker (30 to 40 tonne rock breaker)
- installing new culvert(s), including pouring underwater concrete to encase the culvert(s)
- providing suitable backfill around the culvert(s)
- rebuilding the rock wall above the culvert(s).

This work would be undertaken using land-based equipment. A silt screen would be placed around the culverts during these replacement activities. The removed culverts would be disposed offsite to a suitable facility.

3.1.2 Intake pump specifications

Up to 22 GL/a of sea water will be extracted from within the intake pond, which fills naturally through tidal inflows and inundation. The intake pipe has been designed to be located at the far side of the pond, approximately 100 m from the screened entrance. The location and meshed screen covering the intake turbine pipes provides an additional barrier to the movement of marine fauna and potential entrapment within the system. The design of the intake pump has provided for three specific mitigation measures to minimise the potential to impact marine fauna, including;

1. screens on the culverts at the entrance of the pond (150 mm),

2. screen mesh of an appropriate size installed on the intake pipe to prevent all but the smallest of marine fauna from being drawn into the system, and

3. the intake velocity designed to maintain a flow rate at the entrance of the pond below 0.15 m/s at all times.

The proposed velocity has been selected to align with best practice management recommended by the US Environmental Protection Agency (2001), as it ensures the protection of 96% of fish species, and is lower than the swim speed of marine turtles (Bell & Richardson, 1978; Bustard & Limpus, 1970; Chung et al., 2009; de Silva, 1995; Frick, 1976; Hirth, 1971; Hughes, 1974; Papi et al., 1995; Prange, 1976; Salmon & Wyneken, 1987; Witherington, 1991, Wyneken 1997). This flow rate has been adopted at a number of seawater intakes in WA and around the world, including Mardie Salts Project, Anketell Port, the Wheatstone Development and Adelaide Desalination Plant.

With the implementation of these three controls the risk of marine fauna entrapment is expected to be lowered to an acceptable level.

Table 2 **Intake specifications**

Item	Unit
Location	~100 m from culverts on adjacent side of the pond to the marine environment.
Culvert screen diameter	150 mm
Velocity at culverts	0.15 m/s at the entrance of the intake pond.

3.1.3 Pond desilting

To enable maintenance of the existing intake pond infrastructure, when sediment has built up over time in the existing intake pond, it will require desilting. This would involve similar activities to the initial intake pond excavation described in Section 1.1, which involves:

- blocking the culverts to isolate them from the ocean
- installing a silt curtain on the ocean side of the culverts
- establishing a lined and bunded area adjacent to the existing intake pond where the excavated material will be temporarily stockpiled with a decant system to dewater the excavated material
- directing water runoff back to the existing intake pond
- transporting excavated material offsite to a licenced waste management facility
- unplugging the culverts (only when water is of a suitable quality).

3.1.4 Chlorination

A 1 to 2% sodium hypochlorite solution will be generated at the main desalination plant site by an electro-chlorination unit using seawater filtrate as its feedstock. This chlorine solution will be pumped from the desalination plant site to a small storage tank at the existing intake pond via a double-skinned buried pipeline. A detection system will be established along the pipeline to identify any leakages. About 1.4 kg/day of hydrogen will be produced as a by-product at the electro-chlorination unit; the hydrogen will be vented to the atmosphere.

A bunded area will be provided adjacent to the existing intake pond for the sodium hypochlorite storage tank and dosing pumps, in compliance with relevant Australian Standards. The bunded area will have a sump with instrumentation to raise an alarm in the unlikely event of a leak or overflow.

Sodium hypochlorite will be routinely dosed in the seawater being transferred to the desalination plant to prevent biofouling of the intake pipeline. The dosing point will be located downstream of the pump discharge check valves to achieve a concentration of 1 to 5 mg/L at the dosing point.

Sodium hypochlorite will also be intermittently dosed to the backwash wastewater tank to achieve a concentration of 10 to 50 mg/L to prevent biofouling of the backwash line.

Provision has been made for annual cleaning of the intake pipeline with stronger concentrations of sodium hypochlorite in case of significant biofouling. This is the last line of defence and is not expected to be done routinely during normal operations so long as the other protections (100 µm and 40 µm screens) succeed. The water used for this clean will be either raw seawater from the seawater storage tank or filtered seawater from the ultra-filtration filtrate tank. A temporary strainer would be used to collect solids, which would be disposed offsite at a licenced waste management facility. Any water passing through the temporary screen would be collected in a temporary tank and the residual chlorine neutralised with SBS prior to discharge at the outfall.

3.2 Plant

The overall desalination process is shown in Figure 11 and is outlined in further detail below.

3.2.1 Pre-Treatment Process

The pre-treatment system will physically filtrate the sea water of suspended solids and organic matter. This includes:

- Physical screens remove coarse particulates and water is dosed with hypochlorite to prevent fouling in the desalination plant prior to reverse osmosis (reverse osmosis).
- Ultra-filtration uses fine membranes to filter off remaining fine particles prior to reverse osmosis.

3.2.2 Screening

Multiple screens are proposed as the first level of pre-treatment for separating coarse suspended solids and micro-organisms before reverse osmosis.

Primary screening will be done with a series of automatic back-washable screens installed immediately downstream of the intake pumps, nominally 2.5 mm, 100 µm and 40 µm aperture (subject to final detailed design).

The screens will be regularly backwashed with chlorinated water to remove built-up sediment. Backwash wastewater from the 2.5 mm screen will be discharged to geotextile bags which allows the solids to be dewatered. The water runoff will be drained to a sump and pumped back into the pipeline system. Once filled, the geotextile bags will be removed offsite to a licenced waste management facility.

Chlorinated backwash wastewater from the 100 µm and 40 µm screens will be directed to a holding tank and pumped to the desalination plant site via a double-skinned buried pipeline. At the desalination plant, the screens' backwash wastewater will be received into the primary backwash tank that also contains the ultra-filtration backwash wastewater. Any chlorine residual that is still present will be neutralised with SBS (discussed in Section 3.1.4). The neutralised screen backwash will be co-disposed with the ultra-filtration backwash to the outfall from the main backwash tank.

3.2.3 Ultra-filtration

Ultra-filtration is proposed as the final level of pre-treatment before reverse osmosis for separation of finer suspended solids and micro-organisms. This technique uses membranes with pore size down to 0.01 µm and comprises:

- multiple parallel racks supplied by feed pumps and protected with guard screens
- fully automated ultra-filtration CIP system (separate to reverse osmosis CIP system)
- flushing system.

Ultra-filtration has been selected over more traditional multi-media filters because it is chemical-free during operations, which means no chemicals will report to the seawater filtrate and then onwards to the reject. The ultra-filtration membranes will be regularly cleaned in offline modes using brief chemical-enhanced backwash (CEB) procedures, and slightly longer CIP procedures. Ultra-filtration CIP and CEB waste will be sent to the neutralisation tank and backwash tank, which will discharge continuously to the ocean.

Both CEB and CIP for ultra-filtration will use commodity chemicals which can be completely neutralised to benign by-products. Chlorine is used to clean the membranes, sometimes with sodium hydroxide. If an acidic clean is required, citric acid (a weak organic acid) is preferred.

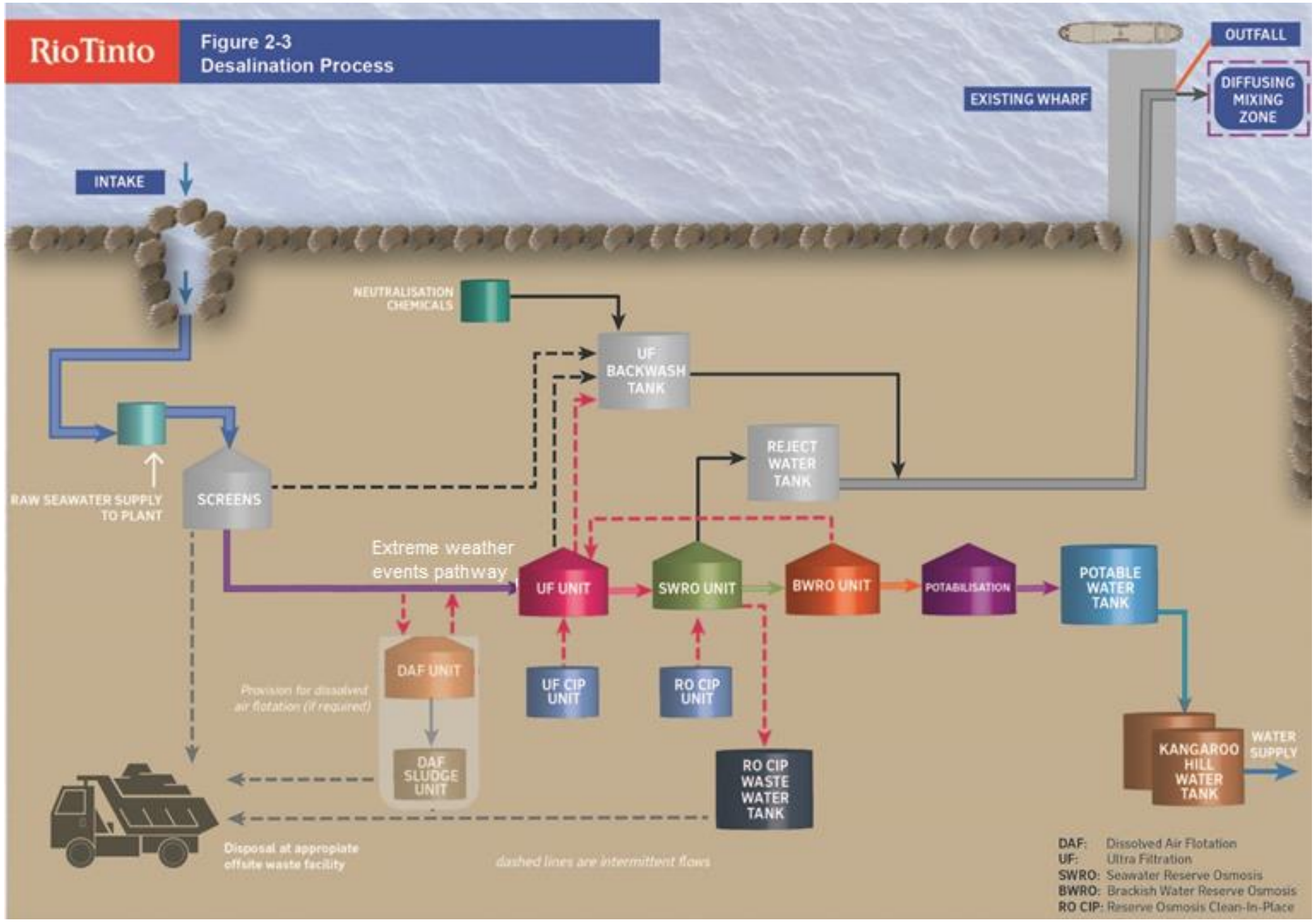

Figure 11: **Seawater reverse osmosis desalination process**

SBS neutralises the chlorine, while sulfuric acid or citric acid neutralise the sodium hydroxide. Chlorine becomes chloride, sodium hydroxide becomes water, and SBS and sulfuric acid become sulfate. Each of these are found naturally in seawater. Citric acid becomes citrate which can readily biodegrade in the ocean.

3.2.4 Seawater reverse osmosis

Reverse osmosis technology is proposed as the method to desalinate the seawater (Figure 11). It requires a high pressure (around 6,500 kPa), as it is primarily a pressure-driven rather than a chemical-driven process.

The reverse osmosis process will remove dissolved salts from the seawater in a two-stage process to achieve the required permeate quality that complies with Water Corporation, Department of Health and Australian Drinking Water Guideline values for potable water. The reverse osmosis unit will comprise:

- first-pass SWRO with energy recovery system supplied by high-pressure pumps
- second-pass BWRO supplied by low-pressure pumps
- semi-automated reverse osmosis CIP system (separate to ultra-filtration CIP system)
- flushing and suck back system.

An energy recovery device will be used on the first-pass SWRO to capture energy from the high-pressure reject stream and transfer energy to the SWRO feed stream. This saves energy consumption by reducing the pressure requirements of the high-pressure pumps (which are the desalination plant’s largest power consumer).

Only two chemicals are dosed online to the reverse osmosis: SBS and anti-scalant. These will be dosed continuously to the SWRO feed stream.

The SBS will be dosed to prevent any residual level of chlorine reaching the reverse osmosis membranes, which have zero tolerance to chlorine. The chlorine residual at the entry point to the reverse osmosis plant is expected to be less than 1 mg/L because it will have depleted in its mode of action en route from its dosing point at the intake. SBS is therefore dosed at a similar level, with the aim of completely neutralising the chlorine to zero and leaving a slight excess of SBS (around 0.5 mg/L) to guarantee chlorine has been removed. SBS dosage is controlled using an oxidation reduction potential meter to result in a ‘reducing’ environment (i.e., not an ‘oxidising’ environment that would be caused by chlorine).

If the SBS is too low or unavailable, the reverse osmosis plant will rapidly shut down to protect the membranes. The brine stream will therefore never have any chlorine in it. SBS itself has no beneficial use in the reverse osmosis process, but once it has reacted with chlorine, it will revert to sodium sulfate. This is already prevalent in the ocean and thus will be rejected by the reverse osmosis membranes to the reject brine stream.

The anti-scalants (proprietary products) will consist of medium molecular-weight organic phosphonate compounds which are completely biodegradable. As is typical with conventional SWRO plants, anti-scalant is dosed as an insurance against scaling of calcium salts (bicarbonate and sulfate) in the reverse osmosis membranes, typically at 2 to 5 mg/L. Its mode of action is to attach to any scaling particles as they are forming a crystal (called scale): This disrupts the crystal shape so they break easily and do not stick to the membranes. As such, anti-scalant deactivates itself before discharge to the ocean.

Within the broad desalination industry, it is known that anti-scalant products are generally formulated with only about 5% active material (the phosphonate). Therefore, a 2 to 5 mg/L dosage ‘as product’ equates to 0.10 to 0.25 mg/L active chemical. In its mode of action, the active level will deplete as the treated seawater progresses through the desalination plant. The expectation is that by the time the reject stream exits the reverse osmosis racks, the anti-scalant active material will be close to 0 mg/L.

The reverse osmosis membranes will also be cleaned using CIP compounds, including one or more proprietary cleaners and a biocide, as well as some commodity chemicals such as citric acid and sodium hydroxide. Cleaning frequencies are typically once per month to once per year per reverse osmosis rack, depending on seawater conditions and membrane operations.

Cleaning volumes per clean are only about 25 to 50 kL. Neutralised reverse osmosis CIP waste will be discharged to a dedicated wastewater tank and transported offsite to a suitable disposal facility. The proprietary cleaner formulations are not available for transparent assessments for ocean discharge.

3.2.5 Dissolved Air Flotation (DAF) (*Provisional* Unit)

Waste products will be generated during the pre-treatment stage of the reverse osmosis process. Solids are naturally present in the intake water, including suspended solids and micro-organisms that have a specific gravity equal or lighter than water (e.g. algae). These suspended solids and organic material are manageable at natural baseline levels, however during rare extreme weather events (i.e. cyclonic activities) become elevated and problematic. To accommodate these periodic short-term spikes in total suspended solids (TSS), a Dissolved Air Flotation (DAF) unit has been designed as a provisional filtration system that may be installed to support the pre-treatment stage. If installed, this would reduce the TSS loading on the downstream ultra-filtration step in the processing stage.

The DAF unit may operate in two modes: one with air-only and another with coagulation and flocculation to enhance flotation and/or settling of particulates for more effective solids removal. The waste stream from the DAF unit in air-only mode will be chemical-free, and therefore may be co-disposed with the screen and ultra-filtration backwash stream to the outfall via the backwash tank. However, when flocculant and coagulant are used, the waste stream containing the material forms a thick sludge that will be pumped to a dewatering/thickening system to produce a ‘spadable cake’. This will be disposed onshore at a licenced waste management facility.

- Should there be an ongoing, unexpected change in influent seawater characteristics, or if a higher plant availability is required, the desalination plant will be staged such that a DAF unit may be retrofitted into the pre-treatment process. The subsequent inclusion of a DAF unit would not impact the outfall design with respect to solids discharge, as all DAF semi-solids material will be disposed of onshore to a licenced waste management facility. The DAF unit is considered in this Proposal to allow for future retrofitting, if required.

3.2.6 Solids handling

Solids are naturally present in the intake water. These solids are collected during the pre-treatment process and require disposal. All waste solids arising from the water treatment process that do not contain any chemicals, or that may contain neutralised chemicals, will be discharged back to the ocean via the backwash tank and brine streamline.

The coagulant-treated DAF sludge and the densified backwash waste from the calcite reactors (which may contain chemicals) will be disposed at a licenced waste management facility. All waste solids arising from the water treatment process that do not contain any chemicals, or that may contain neutralised chemicals, will be discharged back to the ocean via the backwash tank and brine streamline.

If a DAF unit is installed upstream of the ultra-filtration, the waste solids stream will be directed to the outfall when the DAF unit is operated in air-only mode, as treatment chemicals will not be added when operating in this mode. If the DAF unit is operating with coagulant and flocculant, the waste solids will be pumped to a dewatering/thickening system and then disposed via a skip bin and removed to an appropriate waste disposal facility. The clear water from the dewatering/thickening system will be recycled to the head of the desalination plant for reclamation.

3.2.7 Post-treatment (potabilisation)

The post-treatment system will produce water that meets drinking standards. This includes:

- calcite contactors and carbon dioxide gas or sulfuric acid to remineralise the water (replenish magnesium and calcium)
- chlorine for disinfection – sodium hypochlorite will be electro-generated from a solid salt that is dissolved in permeate water
- fluoro silicic acid solution for fluoridation.

Post-treatment will occur downstream of the reverse osmosis into the permeate stream before the potable water storage tank.

The calcite contactor will require occasional backwashing using water sourced from the potable water system. The waste solids from this process will be further treated in a high-rate thickener to densify the solids to a paste or spadable cake: use of flocculant will enhance the dewatering of this sludge. The dewatered sludge will be discharged to a skip bin or geobags that will be removed to a licenced waste management facility, given there may be some residual flocculant material entrained within the sludge.

3.2.8 Chemical use

The chemicals used in the desalination plant treatment and maintenance process are typical of most approved and operating Plants located across the State and Nationally.

A list of potential chemicals used in desalination plant treatment and maintenance is provided in Table 3.

Table 3: **Diluted chemicals used in desalination plant treatment and maintenance**

Chemical	Application
Continual discharge to outfall	
Anti-scalant (proprietary)	SWRO system
SBS	Screen backwash neutralisation and SWRO system
Intermittent discharge to outfall	
Neutralised citric acid	Ultra-filtration CIP neutralisation
Neutralised chlorine	Ultra-filtration CIP neutralisation
Neutralised sodium hydroxide	Ultra-filtration CIP neutralisation
Rare discharge to outfall (e.g., commissioning, equipment failure)	
Coagulant (ferric sulfate/chloride)	Residual from DAF unit in clear water to ultra-filtration
Flocculant (organic)	Residual from DAF unit in clear water to ultra-filtration
Rare discharge to existing drainage channel (e.g., commissioning, equipment failure)	
Coagulant (ferric sulfate/chloride)	DAF unit overflow
Flocculant (organic)	DAF unit overflow
Chlorine	Seawater tank overflows (screened seawater and ultra-filtration filtrate)

Storage

Concentrated chemicals used at the desalination plant will be stored within bunded storage facilities in compliance with all relevant Australian Standards. No concentrated chemicals will be allowed to discharge beyond their designated bunded areas and are therefore not expected to reach sensitive locations, such as the reject brine stream or drainage channels.

Chemicals, including bulk chemicals and post-treatment chemicals, will be stored in two primary areas located inside appropriately designed and secure buildings at the desalination plant.

All dosing lines will be double contained to prevent leakage to ground. Chemicals may be diluted within the chemical storage facility before pumping to the dosing point to minimise the impact of any spillage.

In rare ‘unplanned’ events, some water flows containing chemicals at their designated dosage rates may occasionally be discharged to the existing drainage channel adjacent to the desalination plant.

Heavy Metals

No metals (‘heavy’ or otherwise) other than the coagulants that contain ferric, which will precipitate to form the waste sludge, will be dosed to the main desalination process stream. The metals that are already naturally present in seawater used in the process may be concentrated by the time they reach the reject stage, by a factor of approximately 1.8, and they are not altered in any manner.

Coagulants

The primary cationic coagulant will be inorganic compounds such as ferric sulfate or ferric chloride, both of which are commodity chemicals with good biodegradability profiles.

A secondary cationic coagulant could enhance the effect and reduce the consumption of the inorganic coagulant. The secondary cationic coagulant is typically an organic compound which is also fully biodegradable and non-toxic, such as a polydiallyldimethylammonium chloride.

- *Anti-scalant*

The antiscalant used in the process is proprietary and the exact formulation is 'commercial in confidence' (note: if required, the vendor will provide the environmental data on request). Standard antiscalant products are typically ≥95% water, with concentrated product reaching approximately 90% water. The main active compounds in anti-scalants generally contain phosphonate and polyacrylates. Phosphonates and polyacrlates are entirely synthesized organic compounds with no heavy metals, used widely in common household products. Given the proprietary nature of the anti-scalant chemicals (which prevents a detailed toxicity assessment) they will be discharged to a dedicated wastewater tank and transported offsite to a licenced waste management facility, thereby avoiding impacts to the marine environment associated with discharging the waste to the ocean.

Once these compounds have been dosed, antiscalant activity is mitigated/degraded in two ways:

1. The compound will attach to incipient scale particles as part of their 'mode of action' to prevent calcium carbonate scale in the reject within the RO membrane, and
2. Any 'active' residual left after it leaves the SWRO will readily biodegrade to inorganic compounds meeting the LEPA zonation.

Outlet discharge

The backwash wastewater from the pre-treatment stage will be neutralised prior to discharge back to the marine environment via the outfall blended with the brine stream. Where a chemical cannot be neutralised or its chemical nature verified in documentation from vendors, it will be collected and discharged at an appropriate offsite waste disposal facility.

For the discharge to ocean, there are only six chemicals which need to be considered, and all of these become neutralised to benign products before they reach the marine environment:

- **Antiscalant** – pre-treatment additive that gets injected into the feedwater that flows through the RO membrane, preventing the membrane from scaling.
- **Chlorine -** used on the seawater for disinfection and cleaning the UF membranes. Chlorine is easily neutralised to benign chloride with the sulphite. (note: Seawater contains organic compounds that most chlorine will be consumed.)
- **Sulphite –** Sulphite in the form of "sodium bisulphite" is a "reducing agent" that neutralises oxidising agents such as chlorine and contains no heavy metals or phosphorus. In the neutralisation of chlorine, the sulphite is itself neutralised to benign sulphate. Any residual sulphite (<1 mg/L) is then neutralised back to sulphate once it reaches the ocean.
- **Citric acid** - Citric acid is a weak 'organic' acid commonly found in citrus fruit, and contain no heavy metals or phosphorus. Citric acid is used for intermittent cleaning of the UF membranes and is neutralised by sodium hydroxide. It will neutralise and/or bio-degrade to benign compounds containing oxygen and hydrogen only.
- **Sulphuric Acid and Sodium hydroxide (NaOH) -** These chemicals are only required for neutralisation of other chemicals. NaOH is mainly used to neutralise citric acid. It is itself

neutralised to benign sodium citrate and water. Sulphuric acid is used to neutralise alkaline CIP chemicals and will report to land-side wastewater disposal facility. It is itself neutralised to benign sodium sulphate and water

3.2.9 Unplanned discharges

During operations there may be times when the tanks overflow. Water levels will be monitored in the tanks to prevent overflow. During an overflow event, it is expected that all water will be collected by the site stormwater system and discharged via the existing stormwater network at the port.

3.3 Outfall

The wastewater generated from desalination will consist of brine stream from the reverse osmosis process, as well as neutralised wastewater from pre-treatment backwash and cleaning processes.

Both streams will be blended and discharged continuously via the outfall while the desalination plant is in operation. If a portion of the desalination plant is operating, the flows will be in proportion to the operating unit's rating.

A bypass line has been provided around certain process units to allow them to be redirected to the outfall. This is to maintain the desalination plant's overall reliability and availability in the event of minor process unit upsets. Any discharges would be rare and may include neutralised seawater filtrate, reverse osmosis permeate and neutralised potable water. Table 4 presents the expected discharge characteristics.

Table 4 Expected discharge characteristics

Parameter	Final discharge
Flow rate[1]	Up to 13 GL/a
Salinity	Approximately 65.9ppt (Summer) and 64.4ppt (Winter)
Temperature[2]	<2ºC above ambient seawater temperatures
Dissolved oxygen	At saturation of the prevailing seawater value (i.e., 100%, or about 6 to 8 mg/L)
pH	Same as per seawater at about pH 8.0 to 8.3
Total suspended solids	TSS is based on approximately 1.8 times the prevailing seawater value: if seawater is 10 mg/L, discharge will be around 20 mg/l

[1] Discharge flow rates will be greater if certain process units are required to be bypassed for maintenance. These would be rare discharges and would produce a diluted water quality compared with discharge during normal operations.

[2] Outfall pipelines will mostly be buried up until the wharf to minimise heat transfer in the pipeline from higher ambient air temperatures (the treatment process does not add heat).

3.3.1 Maintenance activities

During maintenance activities, the desalination plant and pipelines may need to be flushed and emptied to allow works to be performed. Where possible, water from the pipelines and desalination plant will be captured and recycled after the maintenance activities. If this is not possible, water from the desalination plant will be directed into the stormwater drainage system for discharge via the existing stormwater network at the port or discharged via the outfall. For onshore pipelines, water will be discharged to land at existing discharge points.

3.3.2 Ancillary activities

The following ancillary activities will also occur during operations:

- Permanent stormwater management will be provided onsite. This will drain to existing licenced drainage systems adjacent to the desalination plant site. Any areas where there is potential for contamination to occur will be bunded and potentially contaminated stormwater will be taken offsite for discharge at appropriately licenced facilities.

- Amenities will be provided onsite for the operations workforce, which will include offices, crib rooms and ablution blocks. Ablution facilities will be designed to treat sewage in accordance with the City of Karratha and Department of Health (WA) requirements.
- Permanent lighting will be established around the buildings at the desalination plant site. This will consist of amber LEDs to the extent required to provide safe working conditions.

4 Decommissioning

4.1 Closure legal obligations

The desalination plant will be approved pursuant to the *Iron Ore (Hamersley Range) Agreement Act 1963* (WA) (**Hamersley Range State Agreement**). Specific closure obligations are specified within the Hamersley Range State Agreement:

> "*the improvements and things erected on the relevant land and provided for in connection therewith other than plant and equipment shall remain or become the absolute property of the State without compensation*".

Based on this, it is expected the Proposal assets will be transferred to the State of Western Australia at closure following relinquishment by Rio Tinto. If any infrastructure is not desired by the State, it will be appropriately decommissioned and all disturbed areas no longer required will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species.

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