

8 Marine Factors - Operational Impacts

8.1 Background

This chapter describes the operation of the proposed seawater intake and brine discharge pipelines and diffusers for the SSDP and evaluates the impacts of the operation of these facilities.

8.1.1 Overview of Intake and Discharge

The first stage of the plant will have a nominal production of 50GL/yr of potable water. This will require approximately 120GL/yr of seawater to be brought into the desalination plant and 70GL/yr of brine discharge to be returned to the ocean. These flows will double when the second stage of the plant is completed. The actual production rate varies somewhat from season to season, with higher production on days with higher seawater temperatures and clear water, and lower production in winter when the seawater is cooler and more turbid.

To allow for annual maintenance of the facilities, the nominal production period is 330 days per year. The design intake and brine discharge flow rates to produce between 50 GL and 100 GL of potable water during 330 days are shown in Table 8.1. Peak flow rates may be as much as 15% higher than the design flow rates. Typical flow rates will be between half the design flow rate and the peak flow rate. The salinity, pH, and temperature characteristics of the discharge are shown in Table 8.2.

Table 8.1: Flow Rates of the Desalination Plant

Case	Intake (ML/d)	Brine Discharge (ML/d)
Stage 1 – 50 GL/yr potable production		
Design	360	210
Peak	415	240
Stage 2 – 100 GL/yr potable production		
Design	720	420
Peak	830	480

Table 8.2: Typical Discharge Characteristics of the Desalination Plant

Parameter	Discharge Characteristics
Salinity (ppt)	Up to 65
pH	6-8
Temperature (°C)	Increase of less than 2 degrees above ambient

8.1.2 Commissioning

It will take about 6 months to commission the new desalination plant. During commissioning, seawater will be brought into the plant at up to peak production rates. Any fresh water produced will be combined with the brine and discharged, resulting in the discharge not having an environmental impact as its salinity will be that of normal seawater.

8.1.3 Control of Seawater Growth

Chlorine (sodium hypochlorite) will be added to the seawater at the intake to control marine growth on the inside of the intake pipeline. Any residual chlorine will be neutralised to ensure excess chlorine is not discharged to marine waters.

8.1.4 Operation of Seawater Intakes

The seawater intakes and pipelines will operate under gravity, using the low pressure created at the intake of the seawater pumping station.

Periodically, the screens at the seawater intakes will be cleaned of marine growth by divers using a high pressure water jet.

8.1.5 Removal and Disposal of Solids

The pre-treatment of the seawater will involve fine screening and flocculation of the solids in the incoming seawater. The solids will be taken to a landfill (as discussed in Chapter 6).

8.1.6 Discharge Area (LEPA)

Marine areas are typically classified as low, medium or high ecological protection. A Low Ecological Protection Area (LEPA) will be required as a mixing zone for the brine. This ensures that the discharged concentrations meet requirements of a High Ecological Protection Area (HEPA) at the boundary of the LEPA.

A LEPA is defined in the State Environmental (Cockburn Sound) Policy 2005 (Government of Western Australia, 2005) as “an area in which large changes are allowed to the quality of water, sediment or biota (i.e. large changes in contaminant concentrations that could cause large changes beyond natural variation in the natural diversity of species and biological communities, rates of ecosystem processes and abundance/biomass of marine life, but which do not result in bioaccumulation or biomagnification in near-by high ecological protection areas)”.

A HEPA is defined in the State Environmental (Cockburn Sound) Policy 2005 (Government of Western Australia, 2005) as “an area afforded high protection in which small changes are allowed to the quality of water, sediment or biota (i.e. small changes in contaminant concentrations with no resultant detectable changes beyond natural variation in the diversity of species and biological communities, ecosystem processes and abundance/biomass of marine life)”.

Based on measurements of the PSDP diffuser discharge (CWR 2007a), the near field (i.e. the mixing zone) extends around 100m either side of the diffuser. For this reason the LEPA is proposed to be a rectangular zone that extends 100m from the SSDP diffuser(s) in all directions (see Figure 8.1).

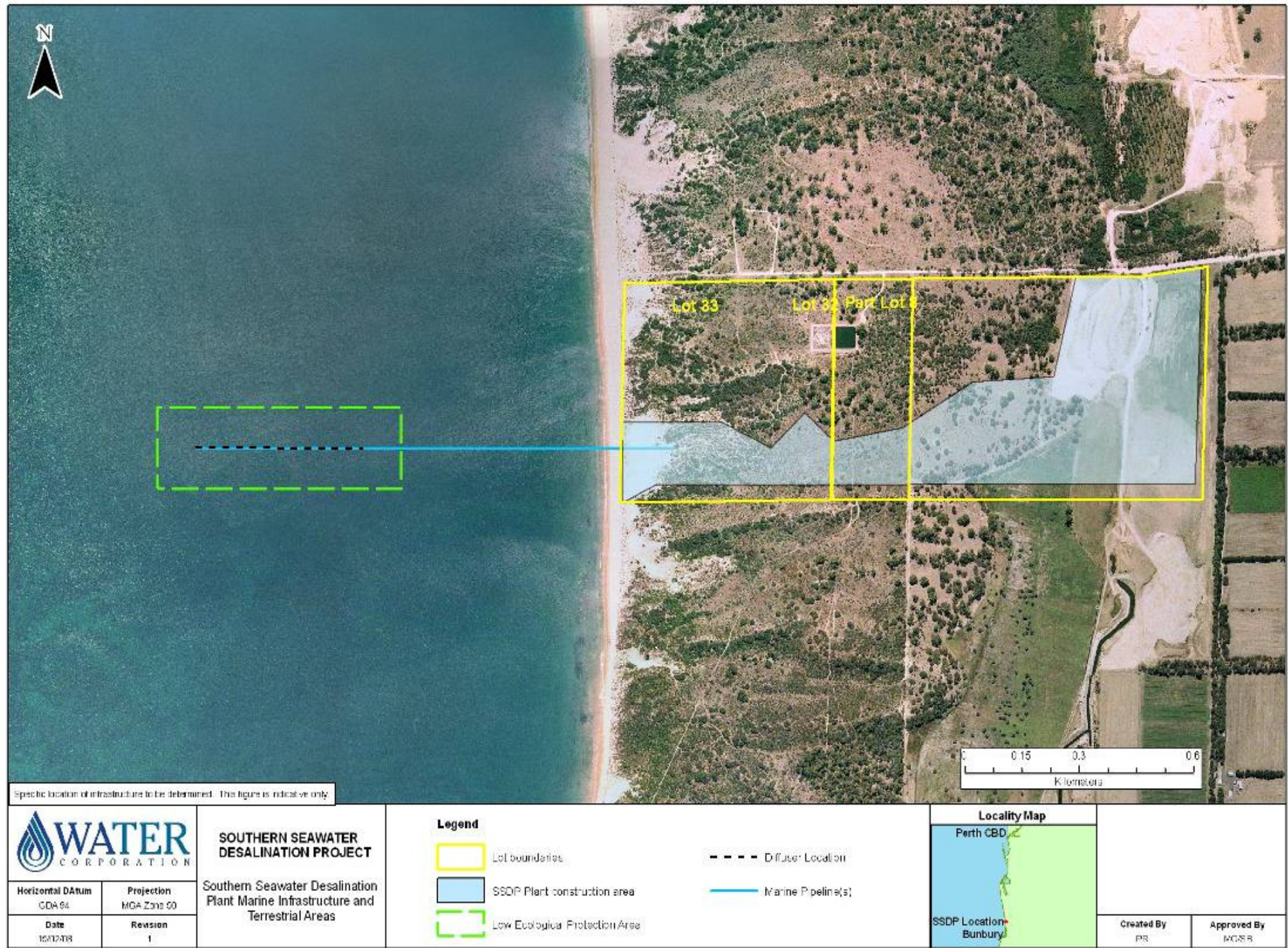


Figure 8.1 Schematic showing the diffuser(s) and the LEPA for the SSDP

8.1.7 Operation of Discharge Pipelines and Diffuser

During operation the Seawater Desalination Plant will discharge brine through the ocean outfall diffuser(s) located between 600m and 1100m offshore with a total diffuser length of up to 450m. The brine is discharged at relatively high velocity and mixes relatively rapidly with the surrounding seawater (see Figure 8.2).



Figure 8.2 Desalination brine being ejected from a port on the Perth Seawater desalination Plant Diffuser (source: WA Newspapers). The brine was temporarily dyed red to show mixing with surrounding seawater.

The brine is heavier than the surrounding seawater due to its increased salinity. The region where the brine settles to the seafloor (see Figure 8.3) is termed the near field and is fully contained within the Low Ecological Protection Area. Once the diluted brine reaches the seabed it continues to dilute due to natural mixing processes. It is also moved by currents and moves down slope (i.e. offshore) due to being slightly heavier than the surrounding seawater.

**ILLUSTRATIVE CROSS-SECTION OF PLUME CHARACTERISTICS FOR ONE PORT
NOT TO SCALE**

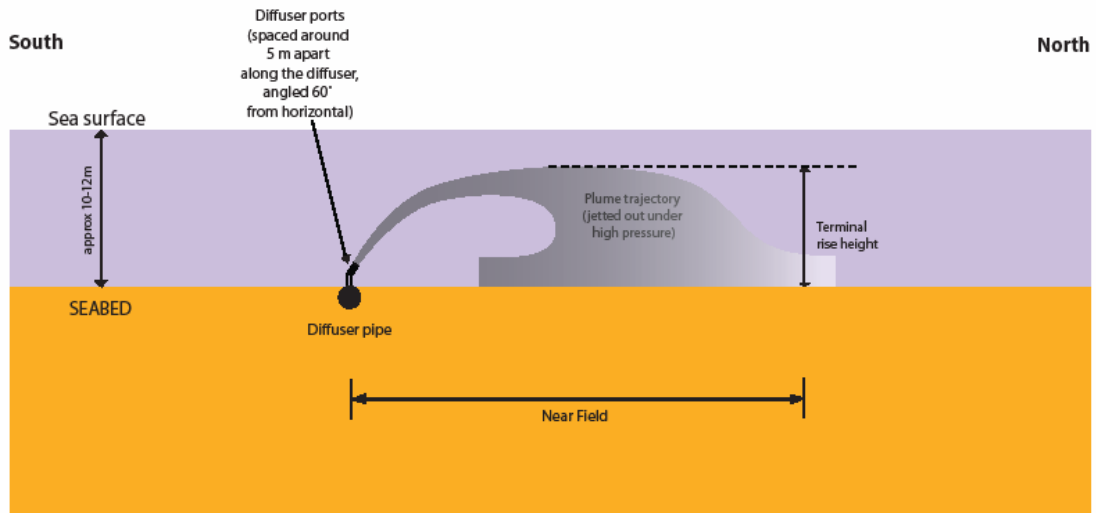


Figure 8.3 Schematic of brine discharged from the diffuser

8.1.8 Nominal Diffuser Design

The Water Corporation has committed to the brine not causing an increase in salinity at the boundary of the Low Ecological Protection Area (LEPA):

1. Greater than 1 part per thousand (ppt) 95% of the time; and
2. Greater than 1.3 ppt at any time.

The basis of this commitment is explained in Chapter 8.2.7.

KBR (2008b) determined a nominal diffuser design to achieve a salinity increase of no greater than 1 ppt outside of the LEPA. This design is conservative because it is based upon:

- Empirical relationships which underestimate dilution;
- Desalination discharge flow rates up to 15% higher than design;
- Discharge salinities almost 4% higher than design; and
- Not including currents which would increase dilution.

The KBR (2008b) diffuser design meets the commitment for salinity increase – the lowest dilution being around 28 fold. At low discharge flow rates, seawater will be added to the brine prior to discharge to ensure that this minimum dilution or higher is achieved. The maximum required rate of seawater addition is less than 60 MLD. The salinity increase at the edge of the near field (i.e. LEPA boundary) and the dilution based upon the nominal design are shown in Figure 8.4. For stage 1, the brine will be discharged through either:

- A single diffuser of around 440 m length with half of the discharge ports blocked off, or

- One of 2 diffusers (each of nominal length 220 m).

The dilution and salinity increase is shown for Stage 1 and Stage 2 in Figure 8.4.

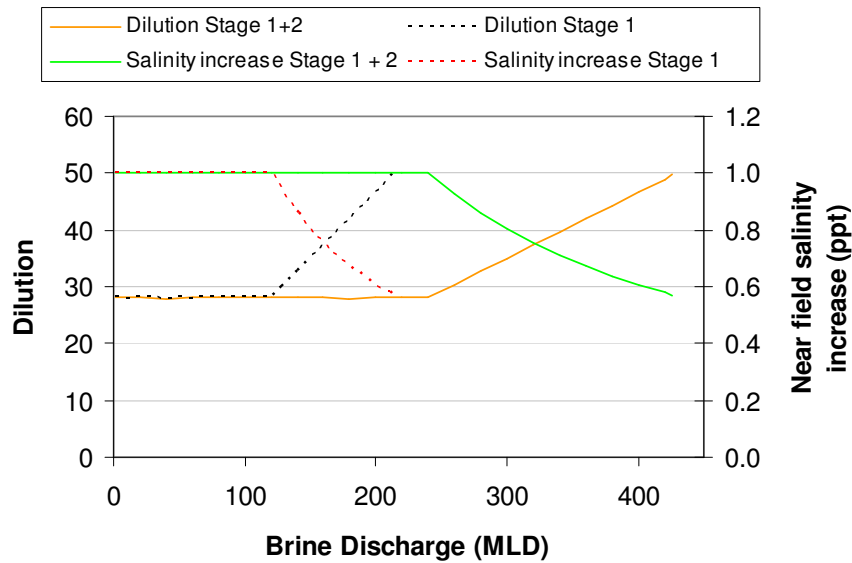


Figure 8.4 The predicted salinity increase and dilution at the LEPA for Stage 1 and Stage 2 based upon the KBR (2008a) nominal diffuser design.

The diffuser is designed to ensure that there is no visible disturbance to the ocean surface (i.e. the maximum or terminal rise height shown in Figure 8.3 is less than the water depth).

It should be noted that if the diluted brine was not able to disperse or spread away from the LEPA, it is possible that the brine being discharged from the diffuser could be partially mixing with previously discharged brine. This means that the performance of the diffuser may be reduced leading to a higher salinity increase within and outside of the LEPA. For this reason, three-dimensional modelling was undertaken. This modelling (KBR 2008a) verified that the diluted brine disperses and moves away from the LEPA due to the prevailing currents, mixing, and down slope movement of the diluted brine.

8.1.9 Subsequent Movement and Effect of Diluted Brine Discharge

Based on the conservative diffuser design of KBR (2008a), at normal (design) production, the brine discharge will be diluted 43 times, resulting in a salinity increase above background of less than 0.65 ppt at the LEPA boundary (see Figure 8.4). At two-thirds of normal (design) production the dilution will be around 28 times with the salinity increase at the LEPA being approximately 1 ppt. Further dilution of the brine occurs beyond the LEPA due to background or natural mixing as shown in Figure 8.5. There is no potential for long term build up of salinity due to the discharge being sited on an open coastline.

The brine discharge is predicted to increase the average density stratification by no more than 0.1 kg/m³ at 0.5 km from the diffuser (KBR 2008a). This stratification reduces with distance away from the diffuser and there is only a minor change to the duration of stratification 2 km and more from the diffuser (KBR 2008a).

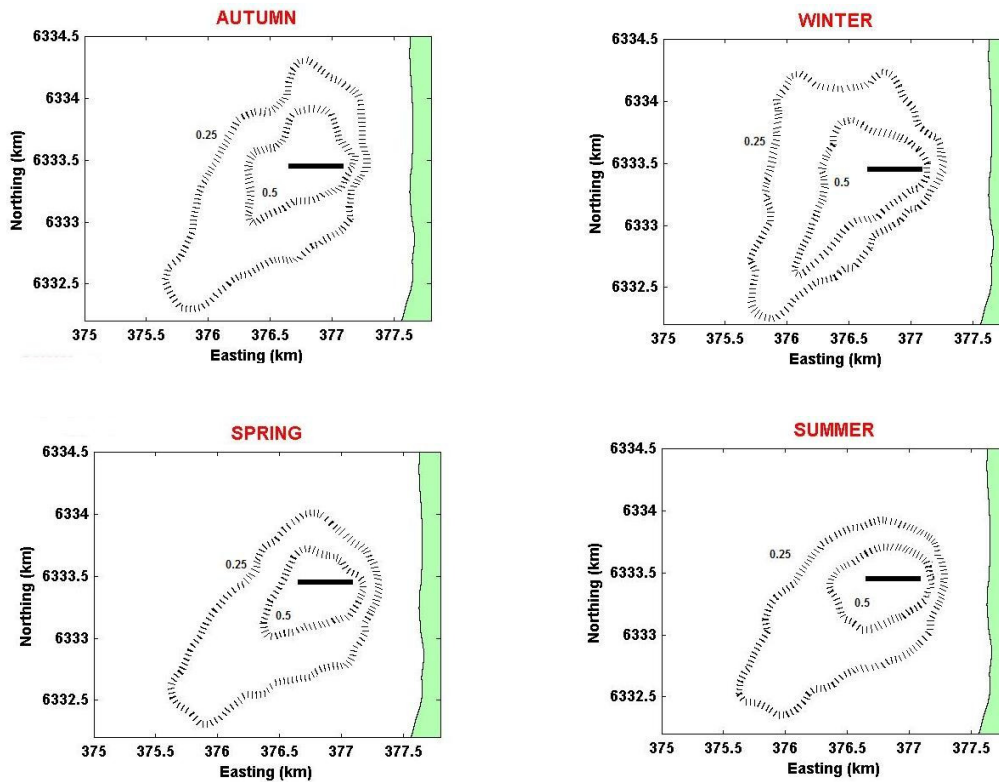


Figure 8.5 Modelled salinity increase due to brine discharge of 247 ML/d for Stages 1 and 2 (from KBR 2008a). The salinity increase at the LEPA boundary is 1 ppt.

8.1.10 Chemicals in the Brine Discharge

A number of chemicals are required for the efficient and effective operation of the desalination plant. These may include chemicals listed in Table 8.3. The actual chemical dosing regimes will be determined following pilot testing and will be refined during commissioning. The possible impacts of these chemicals, which may be present in the discharge, are described in detail in Chapter 8.2.

Table 8.3: Dosing Rates of chemicals

Substance	Dosing Frequency	Concentration
Sulfuric acid (H ₂ SO ₄ 100%)	continuous	10 mg/L
Ferric sulphate/chloride (FeCl ₃ or FeSO ₄ 100%)	continuous	≤ 4 mg/L
Polyelectrolyte (100%)	continuous	≤ 1 mg/L
Antiscalant	continuous	≤ 1.5 mg/L
Sodium hypochlorite (NaOCl 100%)	intermittent, 0.5h/weekly	4 mg/L
Sodium bisulphite (NaHSO ₃ 100 %)	intermittent, 0.5h/weekly	12 mg/L

8.2 Marine Flora (Benthic Habitat) and Fauna

8.2.1 EPA Objectives

- To maintain the ecological function, abundance, species diversity and geographic distribution of benthic habitat in order to protect ecosystem health; and to protect marine flora consistent with the *Wildlife Conservation Act 1950*; and
- To maintain the ecological function, abundance, species diversity and geographic distribution of marine fauna in order to protect ecosystem health, in accordance with the values and objectives identified in Perth Coastal Waters Environmental Values and Objectives; and to protect marine fauna consistent with the *Wildlife Conservation Act 1950*.

8.2.2 Potential Impact

Potential impacts to the benthic habitat environment from the operation of the desalination plant can be grouped into two broad areas:

- Removal of marine organisms via intake of seawater; and
- Brine discharge.

The typical characteristics of the discharged brine are shown in Table 8.1 and Table 8.2. The chemicals shown in Table 8.3 may be present in the brine.

The potential impacts on the marine environment associated with the brine discharge are:

- Reduction in light,
- Reduction in pH;
- Increase in nutrients causing eutrophication,
- Increase in salinity affecting flora and fauna,
- Chemicals in the brine affecting flora and fauna, and
- Lower dissolved oxygen levels affecting flora and fauna.

Each of these is discussed separately in following sections. Toxicity effects associated with salinity and chemicals are also addressed in the discussion on brine toxicity (Chapter 8.2.9).

Whilst there is no specific information on the toxicity effects of desalination brine on marine mammals (such as whales and dolphins), Western Whale Research (2008) considered it unlikely that there would be any effects from highly diluted brine. Furthermore, based upon reviewing more than 70 papers and reports associated with RO plants, Water Consultants International (2006) did not report any findings of adverse impacts on marine mammals.

8.2.3 Intake of Feed Water (Entrapment and Entrainment)

Entrapment is when organisms are trapped in the marine intake infrastructure. Entrainment is when organisms, usually tiny marine plankton and larvae, are drawn in through the intake and into the desalination plant.

Two velocities are of importance in the environmental design of seawater intake structures:

1. The approach velocity, measured just in front of the face of the intake screen; and
2. The through-screen velocity (between the bars in the screen).

The approach velocity determines whether marine organisms are trapped by the flow through the screen. The US EPA has determined that an intake velocity of 0.15 m/s provides an adequate safety factor for 96% of fish species (US Federal Register 2001). Ideally, the approach velocity should be less than the higher velocities that naturally occur in the Binningup marine waters and to which 'swimming' organisms such as fish have adapted. UWA (2008d) measured velocities of up to 0.3 m/s, however, velocities only exceed 0.15 m/s around 5% of the time.

To minimise the impact to marine organisms (and to enable safe underwater inspection) the design of the seawater intake will:

- Comprise a large cylinder or similar with a perimeter screen to prevent medium to large fish, seaweed, marine mammals, penguins and divers from being drawn into the intake; and
- Utilise wedge screens (to limit the risk of capturing fish and debris) with horizontal inflow velocities not exceeding 0.15 m/s in the screen slots and 0.1 m/s based on the gross screen area.

It is also possible that sub-surface (buried) intake structures may be the preferred design. If this is the case then there is no possibility of entrainment nor entrapment of any marine fauna.

Small scale marine life such as phytoplankton and larvae which are drawn into the intake will be returned to the ocean via the desalination discharge or will end up in the filter backwash cake (sludge) which is taken to landfill if a coagulating process is used and iron salts are added (if an alternate process is used the resulting product is returned to the ocean via the marine diffuser). Survival rates for organisms return via the desalination discharge are unknown. With regard to the marine waters in the vicinity of the diffuser, UWA (2008a) stated:

The area had similar reef and seagrass communities to those reported to the north and south although the diversity and abundance of organisms in this region appeared to be poorer.

Maunsell (2008) noted the widespread occurrence of the habitats found at the Binningup site and noted that "there is no evidence to suggest endemicity [localisation] of larval stages of species at or around the proposed Binningup Site" and concluded that, although there will be a local impact due to entrainment, the operation of the SSDP was unlikely to have an overall impact upon regional fish populations and other marine fauna in the region. Larger marine animals, such as whales and dolphins will not be drawn into the intake.

8.2.4 Light

The water entering the Seawater Desalination Plant will be filtered through dual media filters prior to the RO process, thereby removing suspended marine material such as silt, sand and algae. It is this suspended material that reduces light penetration into water. As a result, the discharge of the desalination discharge will not reduce light penetration into marine waters (DAL 2005).

8.2.5 pH

pH is a measure of alkalinity (or acidity). pH values of 7 are considered 'neutral' with values below 7 being 'acidic' and those above 7 being 'alkaline'. Typical seawater (such as occurs naturally at Binningup) has a pH of approximately 8 (KBR 2008b). The discharge will range from pH 6 to 8. The buffering capacity (the ability to neutralise pH) of seawater coupled with the high level of dilution of the desalination discharge means that pH of any desalination discharge will be rapidly converted to background pH levels.

8.2.6 Nutrients

Nitrogen is the nutrient of concern in marine environments with regard to stimulating primary productivity. A number of process chemicals contain nitrogen (polyelectrolytes, biocides and acid detergents). Of these chemicals, the greatest amount of nitrogen is contained in the polyelectrolytes used in the desalination pre-treatment process. GCD Alliance (2006) estimated that the Gold Coast reverse osmosis plant (200 MLD discharge) would add approximately 2.5 tonnes/year of nitrogen from polyelectrolytes to the marine environment. For the Perth Seawater Desalination Plant (PSDP) (180 ML/d discharge) it was originally estimated in 2004 that at most 5.8 tonnes/year of nitrogen could be added to Cockburn Sound (Water Corporation 2004). However, subsequent measurements on the PSDP show that any nitrogen added in the RO process is equal to that removed in the filter backwash cake (i.e. sludge that is taken away to landfill) with the net result being no nitrogen added to Cockburn Sound.

It can be concluded that the operation of the SSDP Plant is unlikely to increase nitrogen levels in marine waters.

8.2.7 Salinity

The ANZECC/ARMCANZ (2000) national water quality guidelines provide the following advice on deriving trigger values for physical and chemical stressors in marine waters (Paper No. 4, Volume 1, Chapter 3, pages 3.1-5):

'For physical and chemical stressors and toxicants in water and sediment, the preferred approach to deriving trigger values follows the order: use of biological effects data, then local reference data (mainly physical and chemical stressors), and finally (least preferred) the tables of default values provided in the Guidelines...'

It is this first approach which is followed for determining acceptable salinity increases for the SSDP.

The United States EPA specifies a threshold criterion of 10% above ambient salinity (around a 3.6 ppt increase) as an acceptable salinity increase for desalination discharge discharges (Water Consultants International 2006). Marine benthic invertebrates have generally been found to be tolerant of slight (up to 5 ppt) increases in seawater salinity both at adult and larval stages (DAL, 2005). GCD Alliance (2006) state that:

Review of literature demonstrates that most aquatic organisms can readily tolerate salinities above 40 ppt... However, the most sensitive fauna were noted to tolerate only about 38 ppt before physical impacts began to occur (e.g. fish pro-larvae [Californian grunion] and sea urchin egg development).

The 'normal' salinity of seawater in the general Binningup region is between 34.7-36.7 ppt (Oceanica 2008a). With the highest measured salinity at Binningup being 36.5 during 2007 (see Water Corporation 2008). Hence, 38 ppt represents an increase of 1.3 ppt for the most sensitive salinity effect that can be found in published literature worldwide.

As stated in Chapter 8.1.8, the Water Corporation has committed to the SSDP desalination discharge not causing an increase in salinity at the boundary of LEPA that is:

1. Greater than 1 part per thousand (ppt) 95% of the time; and
2. Greater than 1.3 ppt at any time.

Marine mammals such as whales and dolphins are unlikely to be affected by the saline discharge as they are able to sense changes in salinity and avoid if necessary (Western Whale Research 2008).

Subject to the implementation of the preceding salinity commitment, It can be concluded that the operation of the SSDP Plant is unlikely to increase salinity to a level that will affect flora and fauna residing outside of the LEPA.

8.2.8 Chemical Discharge

Discharge of chemicals used in the RO process and maintenance of plant may potentially adversely affect water quality and contaminate nearby sediments if not managed properly, which could in turn affect marine flora and fauna. These chemicals are discussed here based upon assessments in Water Corporation (2004) and Water Consultants International (2006). The discussion of brine toxicity (see Chapter 8.2.9) covers any possible synergistic (combined) effects.

Ferric Sulphate/Chloride

Ferric sulphate or ferric chloride may be used as a coagulant in the pre-treatment process, although other pre-treatment processes may not use these iron salts. The majority of ferric (iron) will be captured in the pre treatment process and wastewater treatment system, which will then be removed from site as solid filter backwash cake (sludge) if this coagulant process is used. The final concentration of iron hydroxide in the brine discharge will be heavily diluted with no detectable discolouration or impact upon the seawater, sediments or organisms.

Polyelectrolyte

Polyelectrolyte (if used) will be dosed in the pre-treatment to enhance coagulation. Polyelectrolytes are organic substances with very high molecular masses that flocculate colloids. Polyelectrolytes are completely miscible in water and, therefore some of it will pass through the media filters into the RO modules. The remaining polyelectrolyte will be discharged with the backwash water. No toxic effects are known for these organic substances.

Antiscalant

Antiscalants are dosed in the incoming seawater at a very diluted concentration. The active ingredient in the product used at the PSDP (Nalco product 'PC 1020') is phosphinocarboxylic acid and does not contain heavy metals or known hazardous substances nor does it have the potential to bioaccumulate. This product ultimately degrades into the harmless natural by-products (carbon dioxide and phosphorus oxides). Antiscalants are commonly approved for RO systems around the world and are "comparable to naturally occurring humic materials in terms of chemical composition and fate" and are considered "comparatively safe for aquatic life" (Lattemann & Höpner 2003).

The use of antiscalants is not expected to impact upon the marine flora, water quality and ecological function of the Binningup marine environment.

Sodium Hypochlorite

Sodium hypochlorite is used for shock dose chlorination of the intake structures on a weekly basis to reduce marine growth on internal surfaces. The sodium hypochlorite is neutralised before entering the RO process and as such chlorine will be undetectable in the waters surrounding the outfall. The components that make up sodium hypochlorite are naturally found in seawater and as such it is not expected to have any impact upon marine flora and fauna.

Sodium Metabisulphite

As the RO membrane elements are very sensitive to chlorine, residual free chlorine in the feedwater will be removed prior to the RO system by dosing with sodium metabisulfite. This neutralisation process ultimately produces chloride and bromide ions which are common in seawater and sodium bisulfate which is non-hazardous to marine flora and fauna.

Biocide

Biocide may be used on the RO membranes in order to kill bacteria, fungi, yeast, and algae. Substances such as Occtech "OE-BIO-2000" are often used for this purpose and are added at approximately annual or bi-annual intervals. The product is non-oxidising, broad-spectrum, and fast-acting and contains the active ingredient 2,2-dibromo-3-nirilopropion amide (DBNPA). The product contains no heavy metals and, under normal plant operating temperatures and pH, will decompose in less than one day into the harmless natural by-products (carbon dioxide, ammonium and bromide).

The use of biocides is not expected to impact upon the marine biota, water quality and ecological function of the Binningup marine environment.

Other RO cleaning chemicals

Citric Acid or Caustic acid are examples of other RO membrane cleaning chemicals that may be used from time to time. The concentrations of chemicals will be extremely dilute and all wastewater will be neutralised before entering the brine outflow, hence no impact to marine flora is anticipated.

Metals in the Discharge

Unlike thermal desalination plants, reverse osmosis desalination plants do measurably add metals to the brine. However, the seawater drawn into the seawater plant naturally contains metals (see KBR 2008b) whose concentrations will be approximately doubled in concentration before being discharged in the brine stream. Dilutions of 28 to 50 within the LEPA would result in these substances being around 4% to 2% higher in concentration at the LEPA boundary compared to background seawater. Additional dilution beyond the LEPA will reduce this increase in concentration even further. Hence, it is only if a substance is added during the treatment process, as opposed to being present in the seawater intake stream, that there is the potential for any measurable environmental impact.

However, given the potential toxicity of some metals, monitoring of the desalination discharge stream for metals will be carried out as part of the Discharge Water Quality Monitoring Management Plan (see – Appendix D).

8.2.9 Brine Toxicity

The use of living test organisms (i.e. Whole Effluent Toxicity (WET) testing) is a reliable way to measure the potential biological impacts of the desalination discharge on the surrounding environment. In particular, it has the advantage that all substances in the desalination discharge are tested for synergistic (combined) effects. Local organisms (flora and fauna) are chosen to maximise the relevance of the test results for the system under consideration. The use of a range of species in the tests means that the tests can be considered to be representative of the organisms that occur in the marine waters.

A WET testing methodology was developed for the PSDP to compare the discharge with the specifications in the Cockburn Sound Environmental Protection Policy (Government of Western Australia, 2005) and the Manual of Standard Operating Procedures (Cockburn Sound) (EPA 2005b). This methodology has been adopted (with minor modifications based on accumulated learning from the testing of the PSDP desalination discharge) for the SSDP (see the Whole Effluent Toxicity Management Plan in the Operational Environmental Management Framework in Appendix D).

Some issues were identified with the 2006 PSDP WET testing method (Geotechnical Services 2008; Warne 2008). As a result, the methodology was modified for the 2007 reporting and is now the preferred ecotoxicity testing protocol. Relevant toxicity testing undertaken by others is discussed in Water Corporation (2004).

The 2007 PSDP WET testing (see Geotechnical Services, 2008) showed that a dilution of 12 (based upon IC/EC10 values) was required to meet the specifications for a High Ecological Protection Area in the Revised Environmental Quality Criteria Reference Document (Cockburn Sound) (EPA 2005c). Given that the actual dilution will be 28 or more (see KBR, 2008b) and the processes and chemicals used for the PSDP and SSDP Plant are similar, significant toxicity impacts on flora and fauna are unlikely. This is supported by the fact that marine life is growing directly on and around the PSDP diffuser (see Figure 8.6).



Figure 8.6 Marine life on and around a PSDP diffuser riser

8.2.10 Dissolved Oxygen

Dissolved oxygen is required for marine ecosystems to survive and function. Generally, dissolved oxygen levels of 5-6 mg/L (around 65 to 80% sat) are considered to be sufficient for most aquatic species while concentrations of 3-5 mg/L (around 40 to 65% sat) are considered stressful for many aquatic species, especially for prolonged periods (Oceanica, 2005). This is consistent with published data collated by Travers (2006). Hypoxia in aquatic systems is generally considered to be less than 2–3 mg/L (around 25 to 40% saturation) oxygen concentration. Many species possess behavioural and physiological mechanisms that enable survival of shorter-term aperiodic or periodic low dissolved oxygen concentration events.

The relationship between dissolved oxygen in mg/L and % saturation is shown in Figure 8.7.

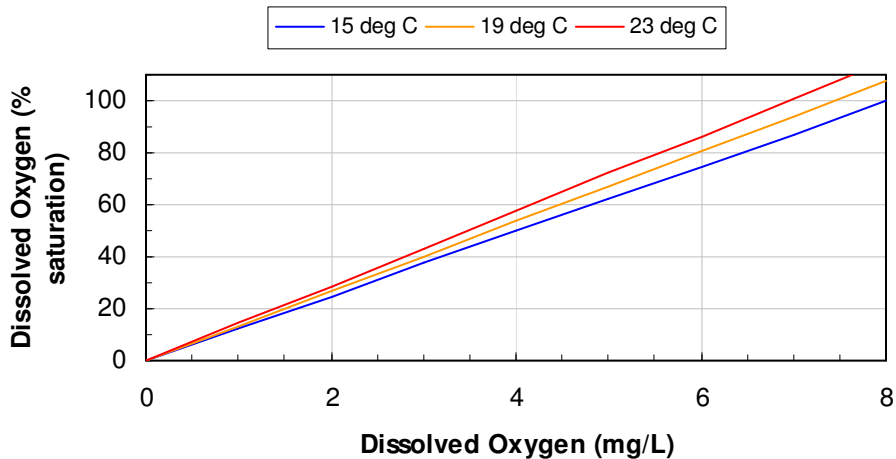


Figure 8.7 Relationship between dissolved oxygen in mg/L and % saturation

The Effect of the PSDP Desalination Discharge on Dissolved Oxygen in Cockburn Sound

During the environmental impact assessment for the PSDP, it was publicly hypothesised that the plant discharge could extend the duration of naturally-occurring stratification events (density layering) in the deep basin of Cockburn Sound. It was postulated that this increased stratification may cause additional oxygen depletion of oxygen compared to conditions with the PSDP operating. As a result conservative dissolved oxygen criteria were applied and the Water Corporation commissioned a series of reports from experts around Australia to assess impacts on dissolved oxygen. The most recent work, undertaken by the Centre for Water Research (CWR) at the University of Western Australia builds upon the earlier reports and makes use of:

- The results from two intensive field experiments (August 2006 and April 2007);
- Laboratory investigations;
- A detailed monitoring programme;
- Sophisticated three-dimensional modelling; and
- Real-time continuous dissolved oxygen measurements.

The key findings (see CWR 2006a and b; CWR 2007b and c) are:

- There is no possibility of the discharge sufficiently prolonging stratification in the deep basin such that dissolved oxygen levels are measurably affected;
- The 'stratification-dissolved oxygen lowering hypothesis' does not and will not occur due to the desalination plant discharge; and
- There is not likely to be any significant change, beyond natural variation, in any ecological or biological indicators that are affected by poorly oxygenated water in deeper waters.

The Effect of the Proposed Desalination Plant Discharge on Dissolved Oxygen Levels

GCD Alliance (2006) noted that oxygen becomes less soluble in seawater with increased temperature and salinity (the SSDP brine will be up to 2°C warmer and up to around 30 ppt saltier than seawater). The use of sodium bisulphite to remove any residual chlorine can also lower dissolved oxygen. GCD Alliance (2006) estimated that, as a worst case, the brine from an RO plant could be up to 2 to 2.5 mg/L lower in dissolved oxygen than the ambient seawater. Following dilution with seawater, the largest decreases in dissolved oxygen that could occur are 0.09 mg/L (1.3 % sat) and 0.14 mg/L (2 % sat) at the LEPA boundary and within the LEPA respectively. Such

changes, if they were to occur, would not be discernable against background variations in dissolved oxygen concentrations.

The level of dissolved oxygen near the seabed in open shallow marine waters depends on the balance between supply of oxygen (mixed downwards from the atmosphere) and consumption of oxygen by microbial processes in the sediments (known as Sediment Oxygen Demand or SOD). Mixing, and hence the supply of oxygen, is lowest when there are light winds and/or density stratification.

CWR (2007c) noted that the desalination plant discharge can only affect dissolved oxygen levels if the discharge prolongs stratification events. Such prolonged stratification events are more likely to occur in poorly flushed seabed depressions or embayments which can potentially trap the saline discharge water. A detailed bathymetric and seabed feature survey was conducted (Fugro 2008a) in the immediate vicinity of the proposed seawater desalination plant site. The beach at the plant site does not form an embayment. The water depth gradually increases towards the west (offshore) without any significant depressions in the seabed.

For the period from late August 2007 to February 2008, UWA (2008c) concluded that there was no stratification for 75 to 80% of the time at Binningup. A more detailed assessment of stratification as measured at Binningup is given in Water Corporation (2008) (see Appendix E). It appears that significant density stratification occurs due to freshwater inflows with stratification persisting up to around 5 days. This compares with stratification persisting for up to around 11 days in Cockburn Sound. These durations can be used with the measured Sediment Oxygen Demand (SOD) coefficients to predict the maximum DO lowering that can occur near the bed when a density stratified layer prevents vertical transport of oxygen to the bed and there are no currents (to transport oxygen laterally). Based upon such predictions (Water Corporation 2008), it can be concluded that:

- The marine waters at Binningup will, under natural conditions, are no more susceptible to dissolved oxygen lowering than those of Cockburn during long stratification events; and
- As discussed in Chapter 2.8.4, dissolved oxygen levels at Binningup are generally in the range of 6.5 to 8.5 mg/L (around 80 to 100 %sat) with some isolated instantaneous measurements showing localised dissolved oxygen levels as low as around 5 mg/L. These dissolved oxygen levels indicate that the marine environment is not oxygen stressed.

The modelling of KBR (2008a) shows that, apart from a localised increase in stratification in the vicinity of the diffuser, stratification will not be enhanced by the brine discharge. In turn, dissolved oxygen levels should not be affected. Further, based upon reviewing more than 70 papers and reports associated with RO plants, Water Consultants International (2006) concluded that:

It has been considered that dissolved oxygen may be reduced in zones below a density or thermally induced stratification. Theoretically this could result from the normal action of aerobic biota in a water volume that was not mixing or interacting with the full water body because of the stratification. No evidence of this was found in any literature reviewed, even when salinity strata were identified in areas up to 20 m away from the discharge.

In summary, there is no evidence worldwide of desalination plant discharge measurably reducing near bed oxygen levels. More specifically, the marine waters at Binningup:

- Are no more susceptible to dissolved oxygen lowering than those of Cockburn Sound (in which the PSDP discharge has not affected dissolved oxygen levels);
- Are generally well oxygenated;

- Will not experience longer stratification events due to the discharge of brine, and
- As such, discharge of brine from the SSDP Plant will not measurably affect dissolved oxygen in the marine waters.

Although there is little risk of impacts due to dissolved oxygen lowering, monitoring of dissolved oxygen will be conducted each two months during the first twelve months of operation as specified in the Diffuser Performance Monitoring Plan (see Appendix D).

8.2.11 Policy and Standards

- EPA Guidance 29: Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment.
- Perth Coastal Water Environmental Values and Objectives.
- National Water Quality Management Strategy for Australia and New Zealand (ANZECC & ARMCANZ 2000)

8.2.12 Management of Impacts

The SSDP diffuser:

- Has been located to avoid sensitive and/or uncommon benthic communities;
- Is sited where local oceanographic conditions and bathymetry enhance mixing and dispersion of the brine discharge; and
- Is designed to dilute the brine at least 28 fold – resulting in levels of salinity and chemical concentrations that are unlikely to impact marine flora and fauna.

Monitoring will be conducted to verify these natural dilution and dispersion processes and to measure performance based on the salinity targets. The Operational Environmental Management Framework (see Appendix D) contains management plans for:

- Whole effluent toxicity testing;
- Diffuser performance monitoring; and
- Discharge water quality monitoring.

Diffuser performance monitoring will involve profile measurements of salinity, temperature and dissolved oxygen which will be used to determine the change in salinity due to the discharge and the dilution factor. The discharge water quality monitoring will measure the plant discharge and seawater intake twice each year for the life of operation to determine concentrations of nutrients and toxicants.

8.2.13 Predicted Outcome

The EPA objective of maintaining the ecological function, abundance, species diversity and geographic distribution of benthic habitat and marine fauna outside of the LEPA will be met.

8.3 Marine Water Quality and Sediment Quality

8.3.1 EPA Objective

- Maintain the overall marine water and sediment quality.

- Protect objectives defined in ANZECC water and sediment quality guidelines

8.3.2 Potential Impact

The potential impacts on the water quality and sediments of the marine environment are associated with the brine discharge. These are:

- Reduction in pH;
- Increase in nutrients causing eutrophication;
- Increase in salinity;
- Lowering of dissolved oxygen; and
- Chemicals in the brine.

Nutrients, pH, salinity and dissolved oxygen and their management have already been discussed in Chapter 8.2. Chemicals in the brine have been discussed in Chapters 8.2.8 and 8.2.9 and it is only their potential to bioaccumulate that is discussed here. Accidental spills of chemicals can potentially impact on marine water quality – this is managed under the Chemical and Dangerous Goods Management Plan (see appendix D).

8.3.3 Bioaccumulation of Treatment Chemicals in Sediments

As demonstrated in Chapters 8.2.8 and 8.2.9, all of the treatment chemicals used are either non-hazardous, form harmless byproducts or biodegrade relatively rapidly. Furthermore, no metals are added during the treatment process. Accordingly, it is unlikely that there will be any bioaccumulation of substances associated with the desalination process within marine sediments.

8.3.4 Policy and Standards

- Perth Coastal Water Environmental Values and Objectives.
- National Water Quality Management Strategy for Australia and New Zealand (ANZECC & ARMCANZ 2000)

8.3.5 Management of Impacts

The desalination discharge will be monitored for levels of nutrients, toxicants and process additive chemicals as part of the Discharge Water Quality Monitoring Plan (see Appendix D)

8.3.6 Predicted Outcome

It is expected the EPA's objectives for marine water quality and sediment quality will be met.

8.4 Coastal Processes

8.4.1 EPA Objective

- To maintain seascape and landform integrity, ecological functions and environmental values and to ensure that the development does not significantly impact upon coastal processes.

8.4.2 Potential Impact

If the marine intake and outlet infrastructure is not correctly designed and constructed, it could alter sediment transport processes and consequently alter the seabed and coastline shape. In turn, this could affect benthic flora and fauna.

8.4.3 Erosion and Accretion

Measurement of beach profiles indicated that the beaches around Binningup are regularly eroded by winter storms and rebuilt during summer (UWA 2008b) while UWA (2008a) noted that “sediment sheets and megaripples were observed midshore suggesting sediment was highly mobile”.

As discussed in Chapter 7, all marine infrastructure will be buried beneath the beach and offshore to around the 6 m depth contour. The pipes will be buried to a depth that is unlikely to be uncovered in a 1 in 100 year storm and will therefore not affect natural beach erosion and accretion processes once constructed.

Apart from the intake towers, no infrastructure offshore of the 6 m depth contour will protrude more than 1 m or 10% of the water depth (whichever is the lesser) above the seabed. Turbidity data (GHD 2007; GHD 2008a; KBR 2008b and ADCP data) demonstrate that sediment is regularly suspended in the bottom few metres of the water column. This means that the pipes on the seabed are unlikely to interrupt longshore sediment movement. There is no potential for the pipes to affect onshore-offshore sediment movement as the pipes are oriented perpendicular to the shore.

8.4.4 Policy and Standards

- EPA Guidance 29: Benthic Primary Producer Habitat Protection for Western Australia’s Marine Environment.
- EPA Perth Coastal Waters Environmental Values and Objectives.
- WA Planning Commission Statement of Planning Policy No. 2.6
- EPA Guidance 33: Draft environmental guidance for planning and development.
- WAPC Development Control Policy 6:1 Country Coastal Planning Policy

8.4.5 Management of Impacts

Any impacts on erosion and accretion will be managed by burying pipes in the beach and surf zones (to approximately the 6 m depth contour. Offshore of the 6 m contour, the amount that the pipes can protrude above the seabed will be restricted as discussed earlier.

8.4.6 Predicted Outcome

Seascape and landform integrity will be maintained. Ecological functions and environmental values that depend upon these will also be maintained. There will not be any significantly impact upon coastal processes.

8.5 Wastes

8.5.1 EPA Objective

- To maintain the integrity, ecological function and values of the environment and to ensure that emissions do not adversely affect health, welfare and amenity of people and land uses; and to manage wastes in accordance with the Waste Hierarchy; and to take all reasonable and practical measures to minimise the generation of wastes and discharge into the environment.

8.5.2 Potential Impact

Wastes to the marine environment potentially include:

- Solid wastes (rubbish, office consumables, replaced components etc);
- Brine discharge (discussed in chapter 8.2); and
- Filter backwash cake (sludge) which only returned to the marine environment if iron salts are not used in the coagulant process as discussed in chapter 6.4.

8.5.3 Policy and Standards

- Environmental Protection (Controlled Waste) Regulations 2004 (WA).
- Country Sewerage Policy (Health Department of Western Australia et al. 1999).
- *Health Act 1911*.

8.5.4 Management of Impacts

Impacts will be managed by the implementation of the Waste Management Plan (see Appendix D). Requirements in this plan include:

- All solid wastes will be recycled or taken to landfill.

8.5.5 Predicted Outcome

The ecological function and values of the Binningup marine environment will be maintained and the health, welfare and amenity of people and land uses will not be impacted through wastes generated by the operation of the desalination plant.