Department of
Sustainability and
Environment

EPA Works Approval Application

Victorian Desalination Project

A Victorian Government project

Victoria
The Place To Be

Department of Sustainability and Environment

Victorian Desalination Project

Works Approval Application Supporting Documentation

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Glossary

Terms, Abbreviations and Acronyms

Term	Definition
ABGR	Australian Building Greenhouse Rating
AEP	Annual Exceedence Probability
AHD	Australian Height Datum
AIIA	Australian Information Industry Association
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid sulfate soils
AWS	Automatic weather station
A-weighted	Frequency weighted as specified in Australian Standard 1259-1982 – Sound Level Meters. A-weighting applies certain biases to recorded values so as to make them representative of human hearing response.
BBSC	Baw Baw Shire Council
BCA	Building Code of Australia
BCSC	Bass Coast Shire Council
BEP	Best Efficiency Point
BPEM	Best practice environmental management guidelines
CAPEX	Capital expenditure
CIP	Clean-in-place
Concentrate	Saline waste stream produced as a by-product of the desalination process.
CSIRO	Commonwealth Scientific & Industrial Research Organisation
Cth.	Commonwealth
CWS	Clear Water Storage
DAF	Dissolved air flotation
DAFF	Dissolved air flotation and filtration
dB	Unit of measurement for Sound Pressure Level
dB(A)	Unit used to measure ‘A weighted’ sound pressure levels.
DER	Dust emission rate
DMP	Dust management plan

Term	Definition
DPCD	Department of Planning and Community Development
DSE	Department of Sustainability and Environment
DTA	Direct Toxicity Assessment
EC10	The concentration of a chemical that is estimated to cause a response in 10% of the test organisms or causes the mean response of the organisms to differ from the control by 10%.
EES	Environment Effects Statement
EIP	Environment Improvement Plan
EMF	Environmental Management Framework
EMP	Environmental Management Plan
EMS	Environmental Management System
EOI	Expression of Interest
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Cth.)
EPA	Environment Protection Authority (Victoria)
ERA	Environmentally Relevant Activity
ERD	Energy Recovery Devices
EREP	Environment and Resource Efficiency Plan
ESD	Ecologically sustainable development
FAD	Fish Attracting Device
GCD	Gold Coast Desalination
GHG	Greenhouse gas
GL	Gigalitre
GMA	Groundwater Management Area
GMS	Groundwater Management System
GRWMG	Gippsland Regional Waste Management Group
GW	Gippsland Water
ha	hectare
HEC-RAS	Hydrologic Engineering Centre River Analysis System
HVAC	Heating, ventilation & air conditioning
IBC	Intermediate bulk containers
IWMP	Industrial Waste Management Policy

Term	Definition
IWMP (WASS)	IWMP (Waste Acid Sulfate Soils)
IMS	Invasive Marine Species
km	kilometre
L_{Aeq}	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring. This is considered to represent ambient noise.
L_{A90}	The A-weighted sound pressure level that is exceeded for 90 per cent of the time over which a given sound is measured. This is considered to represent the background noise e.g. $L_{A90\ (15\ min)}$
LCC	Latrobe City Council
m	metre
mm	millimetre
μg	microgram
MAFFRI	Marine and Freshwater Fisheries Research Institute
MF	Microfiltration
MGA	Map Grip of Australia
MHF	Major Hazard Facility
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
MW	Megawatt
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Council (Ambient Air Quality) Measure
NF	Nanofiltration
NGER	National Greenhouse and Energy Reporting
NO_x	Oxides of nitrogen
OCP	Odour control plant
OER	Odour emission rate
OH&S	Occupational health & safety
Options	Options may potentially be of interest to the Project, but which have not been considered further in this WAA for technical or commercial reasons or because they did not appear to offer significant advantage over the Reference Project.
OU	Odour unit
PAC	Polyaluminium chloride
PAR	Photosynthetic Active Radiation

Term	Definition
PASS	Potential acid sulfate soils
PEM	Protocol for Environmental Management
PEMP	Project Environmental Management Plan
Performance Requirements	The Performance Requirements govern the Project for WAA purposes, and will be the basis of any contract with the Project Company. The Performance Requirements set the environmental parameters for the Project.
PIW	Prescribed industrial waste
$PM_{2.5}$	Particles with a diameter of 2.5 micrometres (μm) or less
PM_{10}	Particles with a diameter of 10 micrometres (μm) or less
PMF	Probable Maximum Flood
PPE	Personnel protective equipment
PPP	Public Private Partnership
Project Company	A commercial organisation appointed by the Victorian Government through a competitive tender process to design, construct and operate the Desalination Project.
PSC	Public Sector Comparator
psu	practical salinity unit
PTS	Permanent Threshold Shift
Reference Design	Detailed specifications of an engineering project. It contains the essential elements of the project; however, third parties may enhance or modify the original design.
Reference Project	The Reference Project is an integrated response to the Performance Requirements developed by the State. It is used in this EES to demonstrate the Project's feasibility and ability to achieve acceptable environmental outcomes.
RFP	Request for Proposal
RL	Relative level
RLWT	Reduced level water table
RO	Reverse osmosis
RORB	Runoff routing hydrologic catchment model
SBS	Sodium bisulphite
SDI	Silt density index
SEA	South-Eastern Australia
SEC	Specific Energy Consumption
SEP	Self Elevating Platform

Term	Definition
SEPP	State environment protection policy
SEPP (AQM)	SEPP (Air Quality Management)
SEPP (GoV)	SEPP (Groundwaters of Victoria)
SEPP (WoV)	SEPP (Waters of Victoria)
SEPP N-1	SEPP (Control of Noise from Commerce, Industry and Trade) No. N-1
SGSC	South Gippsland Shire Council
SITA	SITA Environmental
Sound Power Level (SPL)	The capacity of an object or process to produce sound.
Sound Pressure Level (SPL)	20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level of 20 micropascals.
SWL	Standing water level
SWMM	Stormwater Management Model
SWRO	Seawater Reverse Osmosis
TAPM	The Air Pollution Model
TBM	Tunnel boring machine
TDS	Total dissolved solids
TTS	Temporary threshold shift
TUFLOW	Flood and tide simulation software
the Act	Environment Protection Act 1970
UF	ultrafiltration
Variations	Variations contemplate other design and management solutions, outside the Reference Project, which also meet the Performance Requirements and are within the scope of this EES assessment.
VOC	Volatile Organic Compounds
VSD	Variable speed drives
VVVF	Variable voltage variable frequency
WAA	Works Approval Application
WASS	Waste acid sulfate soils
WELS	Water Efficiency Labelling Standards
WGCMA	West Gippsland Catchment Management Authority
WMP	Waste Management Policy

Term	Definition
WSAA	Water Services Association of Australia
WSPA	Water Supply Protection Area
TSP	Total suspended particulates

Executive Summary

Introduction

This document has been prepared in support of a Works Approval Application (WAA) for the proposed construction of a Desalination Plant that will ultimately be capable of delivering up to 200 GL of desalinated water per year. Establishment of a Desalination Plant that has a capacity to process more than 1 megalitre of feed water per day requires a works approval from EPA.

The proposed Site for the Desalination Plant is located near the town of Wonthaggi, on the Bass Coast, within the Bass Coast Shire, and is approximately 90 km to the south-east of Melbourne.

The Government has announced that the Victorian Desalination Project (the Project) will be delivered as a Public Private Partnership (PPP) under the *Partnerships Victoria* policy, and will be operational by the end of 2011.

The delivery of the Project will involve private sector finance, design, construction, commissioning, operation, repair, maintenance and handover of the Desalination Plant and associated infrastructure to facilitate the production and supply of desalinated water. Any works approval obtained by the Proponent is intended to be transferred to the successful bidder (the Project Company) pursuant to the terms of the *Environment Protection Act 1970* (the Act). The Project Company will thereafter be solely responsible for compliance with the works approval and any licence subsequently issued by the EPA.

A detailed Reference Design (a design solution for the Project) has been developed for the Project, though the Reference Design may not be the form in which the Project may necessarily be designed and built by the Project Company. In fact, the Project as bid and built by the Project Company will almost certainly differ in some or many respects from the Reference Design.

The benefit of a PPP approach is that it encourages people to think about outputs and outcomes, rather than inputs, and encourages innovative solutions. To foster this innovation, the State has developed a detailed set of outputs known as Performance Requirements, which are intended to be the basis for any contract with the Project Company. The Performance Requirements focus on the outputs that the Project must meet, but they are not prescriptive about how they must be met, except in areas of particular, significance for instance to the environment, where constraints may apply.

Project Description

For the Environmental Effects Statement (EES) and WAA, a ‘Reference Project’ has been developed as the basis for environmental impact and risk assessment. It is based on but not identical to, the Reference Design. The Reference Project demonstrates a feasible way that the Project could achieve the State’s objectives and environmental Performance Requirements. It provides an appropriate basis for assessing the expected range of economic, social and environmental impacts, while recognising that altered or additional impacts may result from configuring the Project differently. The following components of the Reference Project are relevant to this WAA:

- Marine Structures consisting of the seawater intake and the discharge concentrate outlet structures; and
- Desalination Plant with reverse osmosis desalination technology.

In addition to the design and other concepts presented in the Reference Project, approval is also sought for a range of other concepts that are considered to fall within the scope of the risks and impact assessments undertaken for the Reference Project. These concepts are included in this WAA as Variations to the Reference Project.

Coordination of WAA and EES Processes

The WAA is based on the same proposal that is exhibited and assessed in the EES, but addresses specific requirements of the Act and State Environment Protection Policies (SEPPs), Waste Management Policies (WMPs) and regulations established under the Act. The WAA is advertised jointly with and at the same time as the EES and public submissions may be made on the EES, WAA or both. The EES panel hearing will serve the purpose of a submitters' conference required by Section 20B of the Act. EPA must not issue the WAA until it receives the Minister for Planning's Assessment Report at the end of the EES process.

The following provides a brief description of each of the key components of the WAA.

Best Practice Considerations

Consistent with the requirements as set out by various SEPPs and WMPs, the WAA provides for the adoption and implementation of best practice to facilitate the protection of beneficial uses of the receiving environment from potential risks posed by emissions.

Best practice encompasses consideration of resource usage and emissions to segments of the environment as part of environmental impact. Whilst best practice is a driver for minimisation of environmental impacts, it is accepted that there may be a trade-off in the interests of overall environmental benefit for example, considering the relative benefits of minimising resource use whilst minimising local air emissions.

The WAA sets out best practice design, construction, and operational objectives and evaluation criteria, which have been developed for relevant components of the Project. Reference is made to these criteria in assessing the Reference Project, and its Variations, against best practice.

From a review of the literature, key environmental (and other) considerations associated with desalination become apparent. These include consideration of the siting, design and operation of desalination plants; system reliability and product water quality; energy intensity and process efficiency; and mitigation of potential impacts associated with the Project.

A number of these considerations (including plant siting, system reliability and product water quality, as well as potential impact on the marine environment) have been addressed at a conceptual level in the Feasibility Study for the Project (GHD and Melbourne Water, 2007). Selection of the Desalination Plant location and product water quality are not discussed in the WAA.

The application of best practice in development of the Desalination Project has assumed a 'whole-of-system' engineering approach, giving balance to both technical and environmental constraints. The WAA evaluates the Project against benchmarks for overall Plant efficiency in regards to resource use, such as benchmarking for overall Plant Specific Energy Consumption (SEC).

The WAA summarises outcomes of the environmental impact and risk assessment concluded and where relevant mitigation and management measures have been identified. For each segment of the environment, environmental performance objectives and criteria for the Desalination Project have been developed.

Greenhouse Gas (GHG) Emissions

GHG emissions arising from the construction and operation of the Desalination Plant have been assessed as part of the Project. To reduce energy use and GHG emissions works approval applicants are required to adopt best practice, considering environmental, technical, logistical and financial constraints.

The Government has made the commitment to offset 100% of the electricity used in operating both the Desalination Plant and Transfer Pipeline by the purchase of renewable energy credits from generation sources which are commissioned after 1 January 2007. Other indirect sources of emissions include the transportation of waste offsite, waste decomposition in landfill, delivery of operational chemicals and the embodied emissions in those chemicals. Figures relating to waste decomposition in landfill include the presumption that the lime sludge resulting from the Reverse Osmosis process will be reused offsite.

It is expected that during the 30-year life of the Project a number of significant developments will drive future market outcomes in the National Electricity Market, reducing the emissions factor for purchased electricity. Therefore, the estimate of total emissions associated with electricity sourced from the grid presented in the assessment conservatively overstates the likely GHG emissions. Project emissions are expected to progressively reduce by up to 25% in 2020 compared with emissions based on the current configuration of the network.

Waste Management

Management options for the expected waste streams to be produced during the construction and operation of the Desalination Plant have been considered and evaluated in relation to the waste hierarchy to optimise avoidance, mitigation and management of waste streams, and protect beneficial uses of natural resources. Options were also considered with reference to relevant Industrial Waste Management Policies (IWMPs) and EPA waste classifications. The outcome of this assessment being that many wastes produced by the Project can be avoided, reused or recycled and only a small proportion of the total wastes produced require management on land.

Environment and Resource Efficiency Considerations

It is expected that once operation of the Desalination Plant commences exemption from preparing an EREP (assessment of environmental resource use and waste generation, selection of improvement targets and reporting for the Project) may be possible. This is achieved in the WAA, by demonstrating that resource efficiency has been considered and adopted to the extent practicable in the Reference Project and the identified Variations for each Project component, incorporating best practice design considerations.

Environment Impact Assessments

The WAA provides an assessment of the potential impacts on the receiving environment arising from construction and operation of the Desalination Plant. Impacts investigated correspond to risks assessed as medium or higher from a risk assessment completed for the Project.

Where necessary, appropriate mitigation and management measures have been identified for potential environmental impacts. For each segment of the environment, Project environmental performance objectives and criteria have been developed. The impact assessment of the ‘whole-of-project’ Reference Project demonstrates that the Project can be delivered without significant unacceptable environmental effects.

Air Environment

The air quality assessment undertaken for the Project demonstrates that odour emissions under routine operations can readily meet the EPA odour criterion off-site, so that odour impact due to Site operations are unlikely to occur. The implementation of dust control measures, consistent with EPA Environmental Guidelines for Major Construction Sites, should limit dust emissions during the construction phase so as not to cause adverse impact at the nearest off-site receptors. Air emissions arising from the proposed Desalination Plant should meet the requirements of the SEPP (AQM).

Further, the Reference Design reflects international best practice and thus is consistent with the requirement for minimising emissions to the maximum extent achievable.

Surface Water

The surface water impact assessment indicates that development of the Desalination Plant Site is unlikely to have a significant effect on flow patterns, velocities, depths, and flood behaviour of the Powlett River and its floodplain. Likewise, changes in stormwater drainage conditions around the Plant Site are not expected to lead to significant increases in downstream velocities or erosion. It is expected that there will be negligible impact on pollutant loads in the river system with the proposed treatment train in place.

With appropriate mitigation measures in place, significant surface water related environmental effects are not expected. It is therefore considered unlikely that construction and operation of the proposed Desalination Plant will have an unacceptable impact on beneficial uses as set out in SEPP (WoV).

Groundwater

Preliminary field investigations were undertaken to describe existing conditions in and around the Plant Site. These assessments indicated that Groundwater levels are less than 6 m below the natural surface, but marginally above sea level and local groundwater use is limited. Groundwater quality on the Site is variable, ranging from Segment B through Segment D. Most bores identified in the region indicate Segment B or C range salinity.

In assessing the impact to groundwater, availability (based on groundwater level) and quality were considered the key elements. No significant potential impacts were identified for the operational phase of the Desalination Plant. With appropriate mitigation, no unacceptable potential impacts were identified for the construction phase, in accordance with the requirements of the SEPP (GoV).

Marine Environment

The WAA provides an assessment of the potential impacts on the marine environment arising from construction and operation of the Desalination Plant, specifically, impacts from the intake of seawater, discharge of saline concentrate and construction of Marine Structures.

A multi-disciplinary approach was applied regarding compliance with the SEPP (WoV) and to assess impacts corresponding to risks identified as medium or higher. The approach taken for each specific marine impact is described as follows.

Discharge of saline concentrate:

- assessment of possible alternative disposal options with consideration of the waste hierarchy;
- characterisation of the constituents of the saline concentrate;
- determination of baseline water quality and local water quality trigger values;
- determination of an appropriate dilution to protect beneficial uses of the segment;
- toxicity testing to assess acute and chronic effects on marine life;
- hydrodynamic modelling to determine the discharge configuration and discharge behaviour in the mid-field; and
- ecological impact assessment (based on the aforementioned studies).

Intake of seawater:

- assessment of the marine life in the region most likely to be effected by the intake;
- particle monitoring, comprising hydrodynamic modelling and Lagrangian particle dispersal modelling, to assess percentage reductions due to the intake of particles, representing plankton such as eggs and larvae zooplankton and phytoplankton;
- these model results were then used for an ecological assessment of the consequence of plankton removal at a population scale; and
- assessment of commercial fish species that may be impacted by the inlet.

Construction:

- identification of construction activities with the potential to impact the environment; and
- identification of impact pathways and the expected extent of impacts.

The following measures were devised to mitigate impacts on the marine environment:

- use of the proposed mixing zone (to be licenced by EPA), outside of which beneficial uses would be protected;
- application of an intake design and velocity (including screens) to minimise the ingress of marine life; and
- application of construction environmental management measures to prevent impacts during construction of the Project.

The application of a proposed mixing zone (to be licenced by EPA), intake design considerations and construction mitigation and management measures is intended to protect beneficial uses, in accordance with the SEPP (WoV).

Soils and Land

Based on a non-intrusive review of existing conditions, the potential for significant, widespread land contamination at the Plant Site is considered low. However, historic and current land uses identified in the area may give rise to shallow dispersed or point source contamination associated with agricultural uses, or isolated point source contamination associated with land filling and waste disposal.

Potential acid sulfate soils (PASS) possibly exist in the north east corner of the Site, though these are not expected to be disturbed during the construction or operation of the Desalination Plant.

It is expected that intrusive investigations to be undertaken in the near future as part of geotechnical investigations, will incorporate fieldwork and testing to verify the presence of PASS and contaminated soils. Specific measures have been devised for managing contaminated soils and PASS, should they be encountered, to mitigate potential environmental impact.

Noise

Noise modelling results indicate that operation of the Project would comply with the regulation noise limit at the sensitive receivers under both modelled neutral and adverse weather conditions. Sleep disturbance during the night period is not expected to be an issue due to the continuous nature of noise sources and elevated ambient noise levels that typically occur during the night.

Potential noise exceedances arising from construction are best addressed by the implementation of a range of noise control measures and monitoring adapted to the construction activities occurring simultaneously at a single point in time. Once the Plant has been constructed and is operational, noise and vibration monitoring should be undertaken by a qualified professional and with consideration to the relevant industry standards and guidelines.

Environmental Management Framework

DSE has developed an Environmental Management Framework (EMF) to manage the environmental aspects of the Desalination Project for the design, construction and operation phases of the Project. The purpose of the EMF is to support that activities are planned and carried out so that adverse effects on the environment will be either avoided or kept to an acceptable level and are completed in accordance with statutory requirements.

Implemented through a Project Agreement, the EMF will require the Project Company to comply with the Performance Requirements, comply with conditions as set out by EPA works approval and EPA Waste Discharge Licence, and develop, implement and maintain an overarching project environmental management plan (PEMP) for the Project and discrete environmental management plans (EMPs) for the design, construction, operation and maintenance phases of each of the relevant Project components.

The EMF shall be consistent with DSE's environmental management policies and the AS/NZS/ISO 14000 Environmental Management Systems Standards series. The EMF provides a structure for management of the Project in a way that achieves compliance with environmental legislation, programmed monitoring, auditing, review and reporting of environmental performance, and supports continual improvement in environmental management and performance.

Conclusion

DSE intends to seek a WAA for the construction of the Project, which sets performance-based objectives for the design of the Desalination Plant and its discharges to the environment. These performance objectives form the basis of relevant Performance Requirements for the Project.

A best practice approach will be applied to the development of the Project, which will incorporate a 'whole-of-system' engineering approach, giving balance to both technical and environmental constraints.

The environmental impact assessment process for various segments of the environment has indicated that, in most instances, beneficial uses will not be compromised by the Project. The mitigation and management measures, and corresponding Performance Requirements arising from the impact assessment, combined with the best practice design approach, suggests that the Project can be delivered without unacceptable environmental effects.

1. Introduction

1.1 Project Background

For more than a decade, large parts of Victoria have struggled with rainfall significantly below the long-term average. In 2006, streamflows into Melbourne's major harvesting reservoirs at Thomson, Upper Yarra, O'Shannassy and Maroondah, were the lowest in almost 100 years of recorded history. The ten-year period from 1997 to 2006 saw two other major drought years (the years ended 30 June 1998 and 2006) in which streamflows were lower than the long-term average. Streamflows in the past twelve months have been consistent with the trend observed in the preceding ten years. This has resulted in storage reserves reduced from almost full capacity in 1996 to below 30% of capacity in June 2008.

In 2004, the Victorian Government put in place a long-term plan for water: *Our Water Our Future*. *Chapter 2* of the Environment Effects Statement (EES) document explains the Project rationale and provides further detail of this plan. Implementation of the *Our Water Our Future* plan was the most-successful water saving campaign in Australia, and resulted in a reduction in water usage in Melbourne of 34% per person in 2007 (when compared to the 1990s).

This plan also gave rise to the development of a comprehensive strategy for the sustainable use of water resources in the central region of Victoria. In 2006, the Victorian Government released the *Central Region Sustainable Water Strategy*, which highlighted the importance of being prepared for the possibility that the low inflows to reservoirs experienced over the past ten years may continue. The strategy identified that rainfall-independent sources of water may be necessary to meet the future water needs of Melbourne, and it committed to the completion of a feasibility study for seawater desalination options for Melbourne.

The confirmation of unprecedented low inflows in the calendar year of 2006, shortly after release of the *Central Region Sustainable Water Strategy*, brought forward the need to consider large-scale augmentations for the Melbourne water supply system. Uncertainty regarding climate change and future inflows means that augmentation is an urgent requirement if Melbourne's water supply system is to recover from the reduction of storage reserves and to provide a degree of reliable supply.

In response to the risk that Victoria's worst drought will continue, the Victorian Government released the next stage of its plan to secure Victoria's future water supplies in June 2007, *Our Water Our Future: The Next Stage of the Government's Water Plan,* which details the action the Government is taking to secure Victoria's water supplies, by:

- diversifying and boosting water supplies in Melbourne;
- networking water resources across the State through the Victorian Water Grid; and
- enabling a rapid and flexible response to changing water needs.

The plan provides the biggest boost to Victoria's water supplies in 25 years and includes the development of a new Desalination Plant on the Bass Coast, modernising Victoria's Food Bowl irrigation infrastructure in northern Victoria expanding the Victorian Water Grid and increasing water recycling.

The Government has announced that the Desalination Plant will be delivered as a Public Private Partnership (PPP) under the *Partnerships Victoria* policy, and will be operational by the end of 2011.

1.2 Project Proponent

The Secretary to the Department of Sustainability and Environment (DSE) is the Proponent for the Victorian Desalination Project (the Project), as the ‘facilitating agency’ nominated by Order in Council 18 December 2007 under the *Project Development and Construction Management Act 1995* (Vic). Under this Act, the responsible Minister (the Minister for Water) and the Secretary (as the facilitating agency) have powers to govern, co-ordinate and implement the Project. Under the direction of the Secretary, the Capital Projects Division of DSE is responsible for the development of the Project and the preparation of this Works Approval Application (WAA).

The Government has indicated that a State Owned Enterprise is likely to be established to manage the delivery of the Project.

1.3 Requirement for a Works Approval

Pursuant to the *Environment Protection (Scheduled Premises and Exemptions Regulations) 2007*, water desalination plants having a design capacity to process more than 1 megalitre per day of feed water are defined as a scheduled premises (type number K 04) and are subject to the works approval and licensing provisions of the *Environment Protection Act 1970* (the Act). A WAA is therefore required for the Plant and associated Marine Structures.

1.4 Mode of Delivery of the Project

In September 2007, the Victorian Premier and Minister for Water announced that the Project would be delivered as a PPP in accordance with the Government’s *Partnerships Victoria* policy framework (Victorian Government, June 2000).

The delivery of the Project will involve private sector finance, design, construction, commissioning, operation, repair, maintenance and progressive handover of the Project to facilitate the production and supply of desalinated water to Melbourne, and potentially, parts of Western Port and the South Gippsland regions. In this capacity, the State is seeking to contract with a single purpose privately owned vehicle (Project Company) to deliver the Project over the full Project term.

Any works approval obtained by the Proponent is intended to be transferred to the Project Company pursuant to the terms of the Act. The Project Company will thereafter be solely responsible for compliance with the works approval and any licence subsequently issued by the EPA.

PPP documentation generally uses the language of ‘outputs’ (that is, the performance that the Project must achieve) rather than the detailed design or process used to achieve it. The reason for this is at the heart of PPP procurement. Although PPP delivery may be justified on cost effectiveness alone (‘value for money’ based on an efficient distribution of risk between the private sector and the State), the State is also looking for innovation in design, technology, operations and financial structuring.

A benefit of the PPP approach is that it encourages bidders to think about outputs and outcomes, rather than inputs. This gives recognition that there can be more than one way to achieve an outcome. Being too prescriptive may limit innovation opportunities and scope for delivering solutions. By focusing on desired outcomes, better emphasis can be placed on achieving this goal for the Project.

To foster this innovation, the State develops a detailed set of outputs known as Performance Requirements which form the contractual basis within which bidders must frame their competitive bids. The Performance Requirements focus on the outputs that the Project must meet, but they are not prescriptive about how the Performance Requirements must be met, except in areas of particular significance for instance to the environment, where particular constraints may apply.

The Performance Requirements will ensure that the Project Company' final design, though it may differ in some respects to the Reference Project, will still achieve the level of environmental protection required for each facet if the Project and EES/WAA.

1.5 The Partnerships Victoria Tender Process

The Project represents a significant asset for Victoria and the State seeks to select the most appropriate party to deliver this element of the plan to secure Victoria's long-term water supplies.

The tender process for the Project will run in parallel with the environmental assessment processes. The State environmental assessment and Commonwealth approval under the EPBC Act are anticipated to inform the tender process for the Project.

The tender process involves two phases. An invitation for Expression of Interest (EOI) is this first phase of the tender process. The EOI was released on 4 June 2008 and closed to submissions on 24 July 2008. The second phase of the tender process will involve the release of a Request for Proposal (RFP) to bidders short-listed from the EOI process. The RFP is due to be released in September 2008 and is intended to close in March 2009. Based on responses to the RFP, a bidder would be selected to execute the Project for the State.

1.6 Effect of Mode of Delivery on WAA

As discussed above, Project bidders will be encouraged to propose innovative commercial approaches to delivery of the Desalination Project. With this approach, the specific design of the Plant, including technologies, layout, building materials and construction methods, will not be available until the Project Company is engaged. With this in mind, the WAA focuses on performance based outputs that need to be achieved, rather than a detailed method and design.

It is intended that DSE will obtain a works approval through the coordinated EES/WAA process. The works approval will then be transferred to the Project Company. The coordination of the works approval and EES processes is described in Section 1.7 of this WAA.

DSE intends to seek a works approval, which sets performance-based objectives for the design of the Desalination Plant and its discharges to the environment, and provides flexibility to bidders on specific approaches to design, operation maintenance and monitoring of the Project. These performance objectives form the basis for environmental Performance Requirements for the Project, which will be included as contractual requirements of the Project deed between the State and the Project Company.

A works approval issued to DSE may include provision of further information as a condition of the approval. It is expected that this would occur after the transfer of the works approval, and would be provided by the Project Company.

It is further expected that information provided by the Project Company may include:

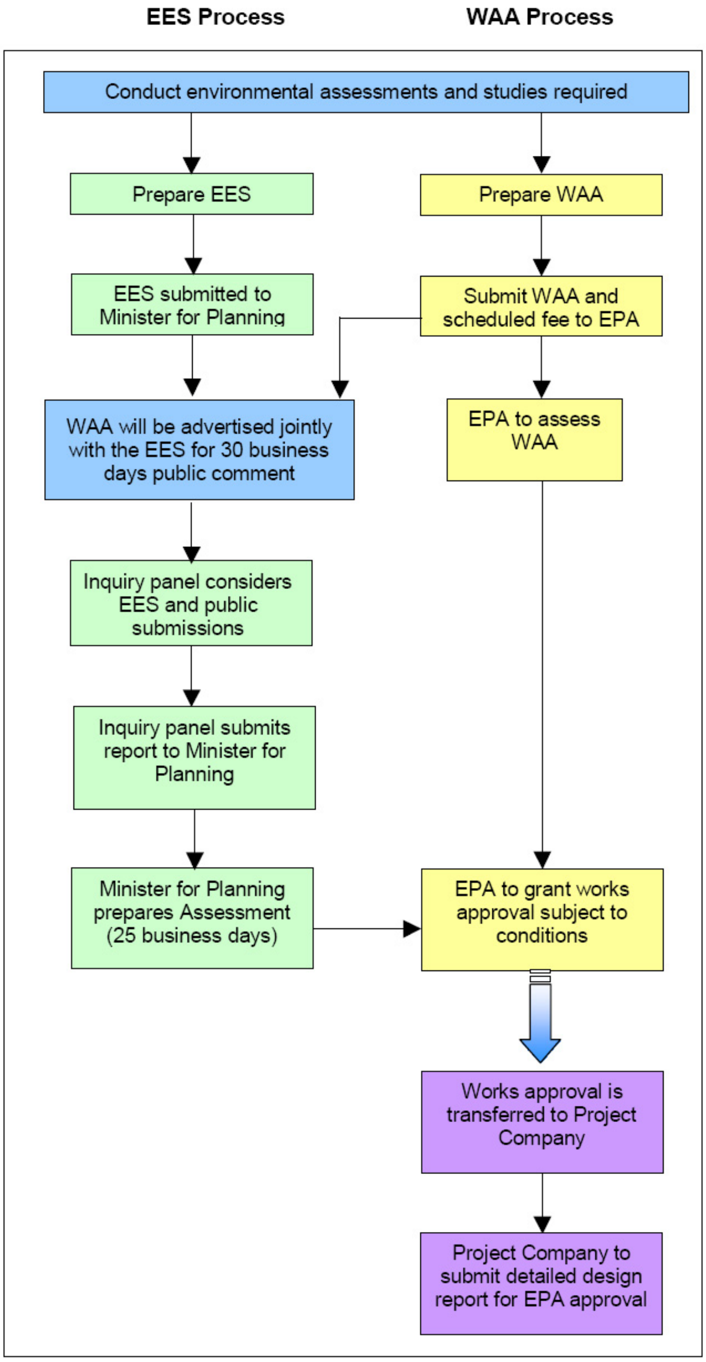
- precise details on the specific design of the plant, including innovation, technologies, layout, building materials and construction methods;
- presentation of test results, modelling or other information to validate that the Project Company's proposal meets the Performance Requirements for the Project, and other requirements of an issued works approval; and
- proposed program or programs for environmental management and monitoring, as required by the Environmental Management Framework (EMF) for the Project, given in Section 17 of this WAA, and discussed further in Section 1.12 of this WAA.

1.7 Coordination of Works Approval and EES Processes

The works approval process is coordinated with the EES process as follows:

- the WAA is based on the same proposal that is exhibited and assessed in the EES, but addresses the specific requirements of the Act and subordinate legislation established under the Act;
- the WAA is advertised jointly with and at the same time as the EES;
- public submissions may be made on the EES or WAA or both;
- the EES panel hearing will serve the purpose of a submitters' conference required by Section 20B of the Act; and
- EPA must not issue the WAA until it receives the Minister for Planning's Assessment Report at the end of the EES process.

The coordinated works approval and EES process is displayed diagrammatically in Figure 1-1.



WAA Process Comments

Evaluate compliance with best practice requirements, in consultation with EPA. Conduct studies including air quality, noise, stormwater, waste, greenhouse and environmental risk assessment.

Document findings of studies undertaken, describe management and mitigation programs and prepare WAA documentation.

Sections of the WAA in draft form submitted to EPA for comment prior to submission of the final application.

The WAA is jointly advertised with the EES under provision of Section 20AA of the Act.

EPA may request further information from the applicant.

The Act requires EPA to finalise its decision on a WAA within 4 months of receival.

EPA must not issue the works approval until it receives the Minister for Planning's Assessment report.

DSE and EPA may need to sign a S67A agreement (under the Act) to allow the time required for the Minister to release an assessment after considering the EES Panel Report.

The works approval will be transferred to the Project Company under Section 25 of the Act.

Upon completion of detailed design of the Project, the Project Company will submit for EPA approval a report containing precise details of the project and a comparison with the proposed design as presented in the WAA.

Figure 1-1 Overview of the works approval process

1.8 Project Description

For the EES and WAA, a 'Reference Project' has been developed as the basis for environmental impact and risk assessment. It is based on but not identical to, the PSC Reference Design. The Reference Project demonstrates a feasible way that the Project could achieve the State's objectives and environmental Performance Requirements. It provides an appropriate basis for assessing the expected range of economic, social and environmental impacts, while recognising that altered or additional impacts may result from configuring the Project differently.

1.8.1 Summary of Evolution of the Reference Project

The evolution of the Reference Project is described in detail in Section 6 of this WAA. In summary, a broad range of concepts were developed for different aspects of the Project; these were then assessed for technical feasibility and subsequently for compliance with the Project Objectives. This process resulted in a 'matrix' of opportunities from which a combination was selected for the Reference Project.

To achieve the flexibility required by the PPP procurement process, concepts that survived 'whole-of-Project' feasibility studies and meet Project Objectives have been included in the scope of the EES and WAA assessment and are described as Variations. They represent other technologies and other configurations than those selected for the Reference Project which a bidder might wish to put forward, and for which there is sufficiently reliable information concerning their environmental impacts to warrant their inclusion in the EES and WAA at a similar level of confidence to the Reference Project. Variations are also considered capable of meeting the Project Objectives and Project Performance Requirements.

The identification and analysis of concepts and development of the Reference Project, as well as Variations, aimed to establish a set of best practice solutions relevant to the Project. The process of establishing best practice solutions is outlined in Section 2.2 and further discussion is provided in Section 7 of this WAA.

In addition, the EES identifies Options that may, potentially, be of interest to the Project however have not been considered further for technical or commercial reasons, or because they did not appear to offer significant advantages over the Reference Project. These Options have not been assessed in the WAA, however they are matters upon which comment is invited by the EES. Any further process for the EES Options will be determined by the Minister for Planning prior to any endorsement by the State for utilisation in the Project.

Approval is sought for the Reference Project and the Variations. No approval is sought for the EES Options.

Additionally, a sensitivity analysis was incorporated into the WAA studies to verify the scope or circumstances:

- within which scientific conclusions reached remain valid; and
- with a view to providing evidence that design variation within certain parameters is unlikely to disrupt estimates of impacts of the Project, or it will do so in limited and quantifiable ways.

The key infrastructure elements of the Reference Project and Variations being contemplated in this WAA, along with EES Options, for the Marine Structures and Desalination Plant are shown in Figure 1-2 and Figure 1-3 respectively.

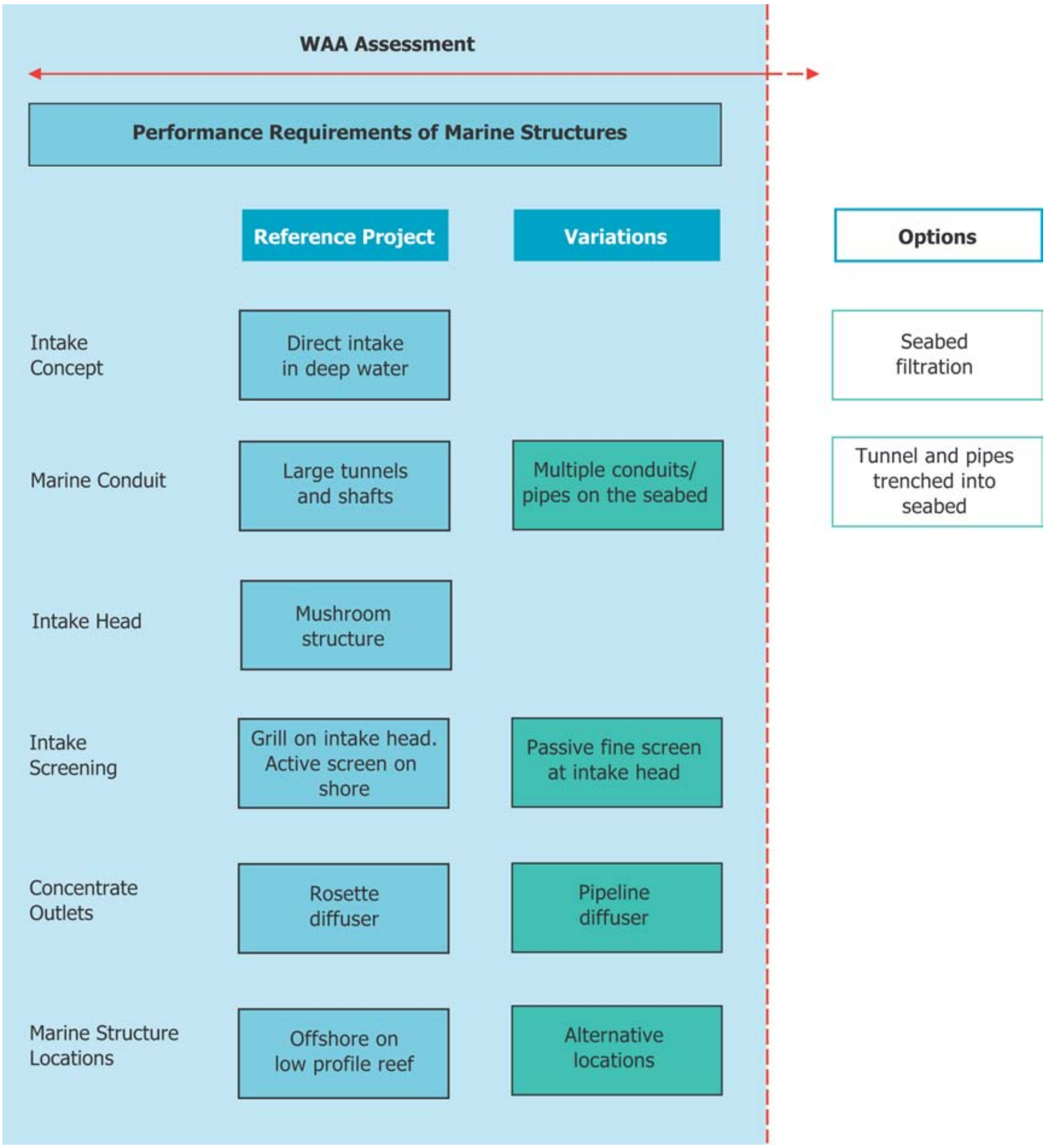


Figure 1-2 Reference Project, Variations and EES Options for the Marine Structures

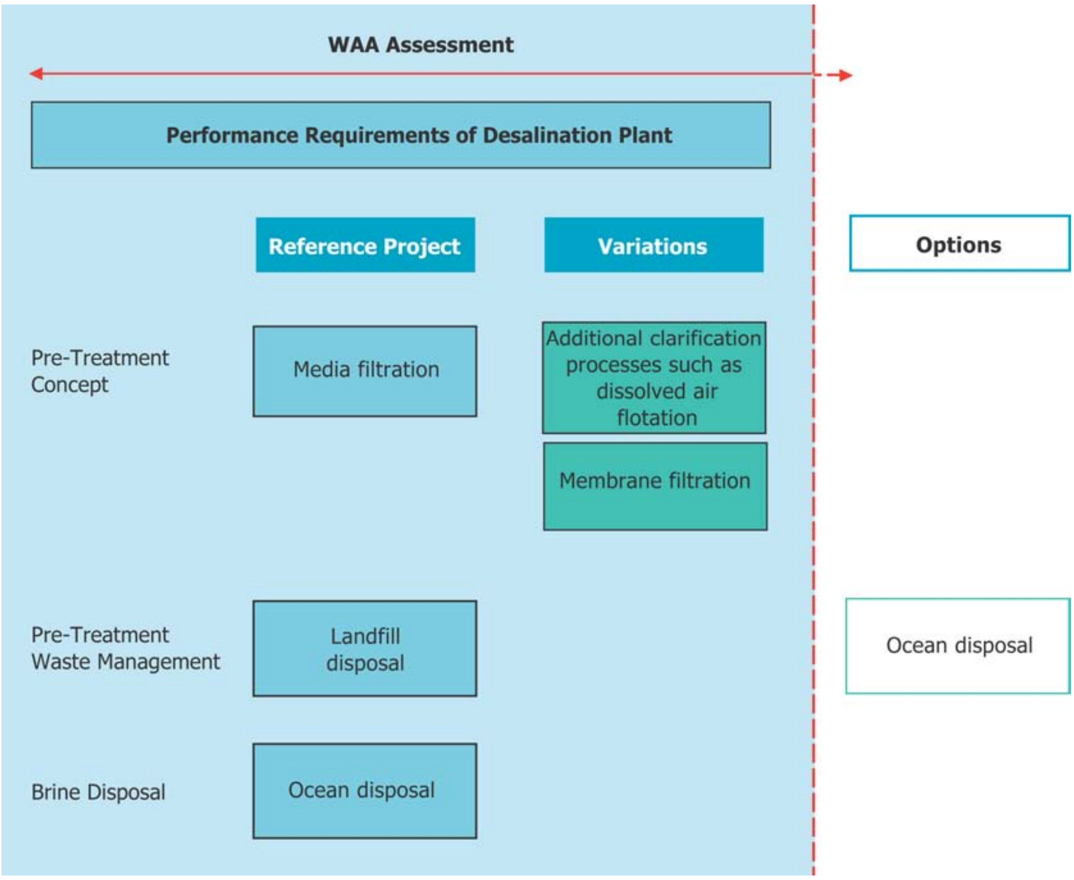


Figure 1-3 Reference Project, Variations and EES Options for the Desalination Plant

1.9 Overview of Environmental Evaluation Framework and Criteria

The environmental evaluation framework adopted for this WAA is based upon Victorian legislation, policies and guidelines applicable to the Project.

Consideration has been given to the objectives of the Desalination Project EES Scoping Requirements.

The environmental evaluation framework for this WAA is outlined in Section 2 of this WAA. This framework was used to:

- guide identification and consideration of best practice technology options for components of the Project;
- assist in the evaluation of potential effects of the Project through investigations undertaken for the WAA, including the environmental impact and risk assessment process; and
- guide the development of Project Performance Requirements and the EMF.

1.10 Overview of Risk Assessment Process

A detailed Environmental Risk and Impact Assessment ('risk assessment') (Maunsell 2008a) was carried out for the Victorian Desalination Project to evaluate potential impacts that the Project could have on a wide range of environmental, social and economic assets and beneficial uses.

The risk assessment is an important component of the integrated approach to environmental impact assessment adopted for the Project. Impact assessment studies were conducted concurrent with the risk assessment process. As the studies progressed, new or additional information identified was fed into the risk assessment process.

The methodology and outcomes of the risk assessment are detailed in Section 4 of this WAA.

1.11 Overview of Environmental Impact Assessment

The environmental impact assessment presented in this WAA addresses key areas relevant to the works approval process, including:

- emissions from the Desalination Plant having potential to impact on any of the policy areas – surface water, groundwater, air, land and noise. This includes the potential impact of discharge of saline concentrate and other chemicals to the ocean;
- potential impacts of the intake of seawater; and
- energy efficiency and greenhouse gas minimisation.

To achieve the investigative depth required by the WAA, detailed studies that support this WAA focus generally on the Reference Project as the base case, and proposed Variations where relevant. However, the scope of the impact assessment is sufficiently broad to provide assurance that any Desalination Plant, if constructed within the parameters defined by the Reference Project and/or Variations and in accordance with the set of environmental Performance Requirements included in the WAA, will:

- comply with the requirements of the Act;
- comply with relevant policy objectives and principles; and
- not have an adverse impact on identified beneficial uses of air, noise, land, surface water and groundwater.

The environmental Performance Requirements provide the objectives, performance criteria and particular performance requirements that the Project Company's final proposal will have to achieve in order to comply with legislation and policy and to avoid, mitigate or manage potential impacts identified in the risk assessment process.

1.12 Overview of Environmental Management Framework

DSE has developed an EMF, given in Section 17 of this WAA, to manage the environmental aspects of the Desalination Project for the design, construction and operation phases of the Project. The purpose of the EMF is to support that activities are planned and performed to meet the environmental Performance Requirements so that adverse effects on the environment will be either avoided or managed to an acceptable level.

The EMF is consistent with DSE's environmental management policies and the AS/NZS/ISO 14 000 series of standards for environmental management systems. The EMF provides a structure for:

- managing the Project in a way that achieves compliance with environmental legislation and encourages continual improvement in environmental performance;
- establishing and assessing performance against the Project's environmental commitments, including the environmental Performance Requirements and any specific conditions of statutory approvals (such as a works approval);
- developing and implementing appropriate plans and procedures for all phases of the Project; and
- monitoring, auditing, reviewing and reporting performance.

More information on the EMF developed for the Project can be found in Section 17 of this WAA.

1.13 WAA Format and Structure

This report and its supporting information comprise the supporting documentation to the Works Approval Application form submitted for the Project.

This WAA is advertised jointly with the EES prepared for this proposal as shown in Figure 1-1. Relevant sections of the EES are referred to throughout this document where further information is offered.

A number of detailed environmental investigations and impact assessments have been relied upon in preparing this document. These reports, in their original form, are appended to the EES document and are listed in each Section of this WAA where they are directly applicable (including their EES Technical Appendix reference number) (also refer Reference List for this document, see Section 18).

A brief overview of this WAA and its content is provided in Table 1-1.

Table 1-1 Overview of WAA Structure and Contents

Section	Title	Content
Section 1	Introduction	Provides context and a general overview of the Project for which works approval is sought, and an overview of the approach adopted in this WAA.
Section 2	Environmental Evaluation Framework and Criteria	Outlines the environmental evaluation framework adopted for the WAA, and highlights key regulatory and best practice requirements / criteria.
Section 3	Other Approval Processes	Discusses other approvals required for the Desalination Project.
Section 4	Identification of Key Risks	Provides a summary of the methodology and findings of the risk assessment process, used to identify issues of significance.
Section 5	Site Description	Describes key features of the Desalination Plant Site.
Section 6	Project Description	Describes relevant components of the Project. It discusses the development of the Reference Project, key elements of the Reference Project and Variations for which approval is sought.

Section	Title	Content
Section 7	Evaluation Against Best Practice Criteria	Provides a discussion of best practice design considerations for relevant components of the Project. An evaluation of the Reference Project, and Variations, against the relevant best practice criteria is made.
Section 8	Greenhouse Gas Emissions	Provides an assessment of expected energy consumption and related greenhouse gas emissions, and offsets associated with the Project. Energy efficiency measures are discussed.
Section 9	Waste Management	Outlines key objectives for the Project with respect to waste management, including implementation of the waste hierarchy. Major waste generating activities are identified and appropriate waste management methods discussed.
Section 10	EREP	Addresses the requirements of an Environment and Resource Efficiency Plan (EREP), so that an exemption from the EREP program may be sought for this Project.
Sections 11 to 16	Detailed Environmental Impact Assessments (air, surface water, groundwater, marine, soils and land and noise)	These Sections summarise the outcomes of detailed environmental impact and risk assessments, including consideration of potential mitigation and management measures. For each policy area, environmental Performance Requirements for the Desalination Project are developed.
Section 17	Environmental Management and Monitoring	This Section describes the EMF developed for the Desalination Project, including a summary of specific environmental management measures and Performance Requirements that will need to be addressed by the Project Company. Monitoring and reporting programs are discussed.

2. Environmental Evaluation Framework and Criteria

2.1 Regulatory Framework

2.1.1 Environment Protection Act

The Act provides the legislative framework for protection of the environment in Victoria, including:

- principles of environment protection;
- a range of tools for control of activities with potential to impact the environment; and
- offences related to pollution and improper handling of waste.

The key principles of environment protection set out in the Act constitute a guiding framework within which EPA's activities and decisions take place. These principles are:

- integration of economic, social, and environmental considerations;
- precautionary principle;
- intergenerational equity;
- conservation of biological diversity and ecological integrity;
- improved valuation, pricing, and incentive mechanisms;
- shared responsibility;
- product stewardship;
- waste hierarchy;
- integrated environmental management;
- enforcement; and
- accountability.

The Act also provides the main statutory framework for licensing and controlling potentially deleterious discharges to land, water, and atmosphere. It contains provisions that:

- require prescribed premises to be licensed;
- prohibit pollution;
- enable notices to be served requiring abatement of pollution and remediation of contaminated land;
- control noise;
- require works approval for certain activities;
- regulate transportation of wastes;
- foster best practice resource efficiency through environmental and resource efficiency plans, regional waste management plans, solid industrial waste management plans, landfill levy and industrial waste reduction agreements;

- regulate accreditation of environmental auditors and the issue of certificates of environmental audit;
- allow accreditation of licensees; and
- require the minimisation of waste.

Pursuant to the Act, a WAA is required for works at scheduled premises that will or are likely to alter or increase the discharge of wastes or air and noise emissions to the environment or to be used for the treatment or storage of prescribed industrial wastes.

A WAA must address all requirements set out in the Act, relevant State Environment Protection Policies (SEPPs) and Waste Management Policies (WMPs). EPA's website provides guidance and specifies additional information that must be addressed in a WAA.

In accordance with the *Environment Protection (Scheduled Premises and Exemptions) Regulations 2007*, seawater desalination plants having a design capacity to process more than 1 megalitre per day (ML/d) of feed water are subject to the works approval and licensing provisions of the Act.

Subsequent to the issue of the works approval, the Project Company would also need to obtain an EPA licence prior to commencement of Site operation. The licence would address operation of the Desalination Plant, set waste discharge parameters, set out environmental monitoring and reporting requirements (including greenhouse gas and EREP requirements) and requirements for continuous environmental improvement.

2.1.2 State Environment Protection Policies

SEPPs are declared under section 16(1) of the Act. These statutory policies identify and protect 'beneficial uses' of the relevant segment of the environment from the effects of pollution and waste. Beneficial uses may include:

- human health and wellbeing;
- ecosystem protection;
- visibility;
- useful life and aesthetic appearance of buildings, property, and materials;
- aesthetic enjoyment; and
- local amenity.

A discharge to the relevant segment of the environment must not compromise the beneficial uses of that segment. Generally, a SEPP will include:

i) identification of the beneficial uses of the environment that are to be protected;

ii) indicators (or measures) of environmental quality;

iii) environmental quality objectives; and

iv) selected measures supporting attainment of the policy's environmental quality objectives.

The SEPPs relevant to this proposal are:

- *SEPP (Air Quality Management) No. S240* (2001) – provides a framework for the management of emissions to the air environment so that the beneficial uses of the air environment are protected, Victoria's air quality goals and objectives are met and continuous improvement in air quality is achieved;
- *SEPP (Ambient Air Quality) No. S19* (1999) – sets Victoria's air quality objectives and goals, based on the requirements of the National Environment Protection Council (Ambient Air Quality) Measure (NEPM);
- *SEPP (Control of Noise from Commerce, Industry and Trade) No. N1* (1989) – sets the maximum allowable noise level in a noise sensitive area, taking into account the time of day, land use zoning, and existing background noise levels;
- *SEPP (Waters of Victoria) No. S210* (1988) – provides the framework to determine beneficial uses and environmental values of surface waters (including the ocean) to achieve sustainable surface water environments and maintain their environmental, social, and economic benefits;
- *SEPP (Groundwaters of Victoria) No. S160* (1997) – provides an integrated framework which aims to maintain and where necessary improve groundwater quality sufficient to protect existing and potential beneficial uses of groundwaters throughout Victoria; and
- *SEPP (Prevention and Management of Contaminated Land) No. S95* (2002) – outlines requirements for the prevention of contamination of land and management/clean-up of contamination, so that the relevant beneficial uses may be protected.

The key environmental criteria associated with each relevant segment of the environment and other key requirements of these SEPPs are summarised in Table 2-1.

2.1.3 Waste Management Policies

The Act was amended by the *Environment Protection (Resource Efficiency) Act 2002* to provide EPA with scope to develop waste management policies (WMPs) to maintain and strengthen control of municipal waste. WMPs declared under section 16A(1) of the Act outline requirements for the generation, storage, reprocessing, treatment, transport, containment, disposal, and general handling of wastes. WMPs also outline procedures to be implemented in the recycling, recovery, reclamation and reuse of wastes.

The principle of waste hierarchy (section 1I of the Act) states that wastes should be managed in accordance with the following order of preference:

(a) avoidance;

(b) re-use;

(c) recycling;

(d) recovery of energy;

(e) treatment;

(f) containment; and

(g) disposal.

The following WMPs are relevant to this proposal:

- *Waste Management Policy (Used Packaging Materials) No. S94* (2006) (Vic) – encourages the reuse and recycling of used packaging materials; and
- *Waste Management Policy (Ships' Ballast Water) No. S 100* (2004) (Vic) – developed to protect Victoria's marine environment by minimising the introduction of marine pests into Victoria from ships' ballast water and to provide information to assist the shipping industry in assessing and managing the risks associated with domestic ballast water discharges.

Industrial waste management policies (IWMPs) were introduced into the Act by the *Environment Protection (Industrial Waste) Act 1985* to improve the management of industrial wastes. Pursuant to section 18E of the Act, the following IWMPs are of relevance to this proposal:

- *Industrial Waste Management Policy (Prescribed Industrial Waste) No. S183* (2000) – provides a framework for the management of prescribed industrial wastes (PIWs), their hazard classification, and requirements for specialised waste storage and/or containment facilities; and
- *Industrial Waste Management Policy (Waste Acid Sulfate Soils) No. S 125* (1999) – provides a framework to guide the management of waste acid sulfate soils (ASS) in Victoria. The stated objective of the policy is "to protect human health and the environment from risks that may be posed by waste acid sulfate soils, by ensuring that they are managed in an environmentally responsible manner".

The key requirements of these WMPs and IWMPs are summarised in Table 2-1.

2.1.4 Other Regulatory Requirements

Other regulatory requirements relevant to this proposal include:

- *Environment Protection (Fees) Regulations 2001*;
- *Environment Protection (Scheduled Premises and Exemptions) Regulations 2007*;
- *National Greenhouse and Energy Reporting Act 2007* (Cth.);
- *Environment Protection (Prescribed Waste) Regulations 1998*; and
- controlling provisions of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) as determined by the Minister for Environment, Heritage and the Arts on 4 February 2008.

2.1.5 Relevant Policy, Codes and Guidelines

The following policies, codes, and guidelines are relevant to this proposal:

- ANZECC, 1992, *Australian Water Quality Guidelines for Fresh and Marine Waters*, Australian and New Zealand Environment and Conservation Council;
- ANZECC and ARMCANZ, 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*;
- DPCD, *Scoping Requirements – Desalination Project Environment Effects Statement*, May 2008 (see Section 2.1.6 for further discussion);
- EPA Publication 275, *Construction Techniques for Sediment Pollution Control*, May 1991;

- EPA Publication 347, *Bunding Guidelines*, December 1992;
- EPA Publication 441, *A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes,* March 2000;
- EPA Publication 441.7, *A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes*, March 2000;
- EPA Publication 448.3, *Classification of Wastes*, May 2007;
- EPA Publication 480, *Environmental Guidelines for Major Construction Sites,* February 1996;
- EPA Publication 609, *Industrial Waste Strategy – Zeroing in on Waste*, July 1998;
- EPA Publication 628, *Environmental Guidelines for the Concrete Batching Industry,* November 1998;
- EPA Publication 655, *Acid Sulfate Soil and Rock*, August 1999;
- EPA Publication 668, *Hydrogeological Assessment (Groundwater Quality) Guidelines*, September 2006;
- EPA Publication 669, *Groundwater Sampling Guidelines*, 2000;
- EPA Publication 788, *Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills*, October 2001;
- EPA Publication 824, *Protocol for Environmental Management: Greenhouse Gas and Energy Efficiency in Industry*, January 2002;
- EPA Publication 840, *The Clean-up and Management of Polluted Groundwater,* April 2002;
- EPA Publication 859, *Prevention and Management of Contamination of Land*, July 2002;
- EPA Publication 862, *Groundwater Quality Restricted Zone*, July 2002;
- EPA Publication 996, *Guidelines for the Hazard Classification of Solid Prescribed Industrial Wastes,* June 2005;
- EPA Publication 1198, *EREP Guidelines: Environment & Resource Efficiency Plans*, February 2008;
- EPA Publication AQ 2/86, *Recommended Buffer Distances for Industrial Residual Air Emissions*, July 1990;
- EPA Publication N3/89, *Interim Guidelines for Control of Noise from Industry in Country Victoria*, April 1989;
- EPA Publication TG 302/92, *Noise Control Guidelines*, July 1992;
- Government of Victoria, *Towards Zero Waste*, 2005;
- NEPC*, National Environment Protection (Assessment of Site Contamination) Measure*, 1999; and
- NEPC, *National Pollutant Inventory*, 1998.

Table 2-1 Summary of SEPP and WMP Key Clauses

Component	Legislation	Key Clause	Description	Where addressed in this WAA
Air Quality	*SEPP (Air Quality Management) No. S 240*	18	Defines what the management of emissions and what a generator of emissions means for the purposes of the policy. Specifies general requirements for generators of emissions to manage their activities and emissions in accordance with the requirements of the policy, apply best practice, and pursue continuous improvement.	Section 8, Section 11
		19	Requires that best practice be applied in the management of a new or substantially modified source of emissions.	
		28	Requires generators of emissions to model their transport and dispersion, in order to demonstrate that predicted emissions meet relevant design criteria and that odours do not adversely affect local amenity.	
		33	Requires generators of greenhouse gases to manage emissions of those gases in accordance with the general requirements for minimising emissions under the policy. In accordance with Clause 19, generators of new sources of greenhouse gas emissions must apply best practice to the management of those emissions. Protocols for environmental management relating to greenhouse gas emissions developed by EPA will be applied to generators of emissions subject to works approvals and licences.	
		Schedule A	Specifies design criteria for Class 1, 2 and 3 indicators and unclassified indicators for the purpose of assessing proposals for new emission sources or modifications to existing emission sources.	
		Schedule B	Establishes intervention levels(2) for Class 1, 2 and 3 indicators.	
	SEPP (Ambient Air Quality) No. S 19	8	Identifies beneficial uses to be protected for the purpose of the policy.	Section 11

Component	Legislation	Key Clause	Description	Where addressed in this WAA
		9	Outlines environmental indicators and quality objectives to ensure beneficial uses are protected.	Section 11
		Schedule 1	Provides environmental indicators.	
		Schedule 2	Provides environmental quality objectives.	
Noise	*SEPP (Control of Noise from Commerce, Industry and Trade) No. N-1*	8	Identifies beneficial uses to be protected for the purpose of the policy.	Section 16
		9	Identifies noise types that are not assessed by this policy. These include construction activities on building sites, intruder/emergency/safety alarms, fire pumps in an emergency, and non-commercial vehicles except where being commercially serviced or repaired.	
		13	Requires that the effective noise level does not exceed the prescribed noise limits (subject to Clause 17G).	
		14	Requires that the effective noise level at a derived point does not exceed the derived noise limit (subject to Clause 17G).	
		16	Requires that proposed new commercial, industrial or trade premises be designed so that noise emissions do not exceed noise limits set out in the policy.	
		19	Requires that, where equipment is to be replaced or new equipment installed, the quietest equipment available be used where a significant reduction of noise in noise sensitive areas can be expected to occur.	
		Schedule A	Determines effective noise levels as environmental quality indicators.	
		Schedule B	Determines noise limits as environmental quality objectives.	
		Schedule D	Determines derived noise limits at a derived point.	
	Interim Guidelines for Control of Noise from Industry in Country	2	Requires that *SEPP (Control of Noise from Commerce, Industry and Trade)* be applied where background noise levels are comparable to Metropolitan Melbourne.	Section 16

Component	Legislation	Key Clause	Description	Where addressed in this WAA
		3	Identifies applicable noise limits (at residential premises) where background noise levels are considered ‘low’.	
	Noise Control Guidelines (TG 302/92)	12	Specifies noise mitigation measures that are to be undertaken during construction activities, including noise limits and normal working hours.	Section 16
Surface Water	*SEPP (Waters of Victoria) No. S 210*	9	Defines segments of the surface water environment for the purpose of the policy.	Section 12, Section 14
		10	Identifies beneficial uses to be protected for each segment of the surface water environment.	
		11	Describes the level of environmental quality required to protect beneficial uses and values identified in Clause 10, and how this is to be assessed. This Clause links to Schedule A of the policy.	
		12	Requires environment management practices and actions to be implemented, including “best practice” where required.	
		27	Requires that any discharge of waste or wastewater to surface waters be managed in accordance with the waste hierarchy, and does not display acute lethality at the discharge point nor cause chronic impacts outside any mixing zone. Outlines how EPA will protect beneficial uses when a wastewater discharge licence is sought.	
		28	Outlines requirements for applicants for licences and works approvals to manage and progressively reduce new wastewater discharges to surface waters in order to minimise threats to beneficial uses. Outlines circumstances where EPA will not approve a wastewater discharge. These include areas where a discharge will pose significant environmental or public health risks, as well as those that pose an environmental risk to beneficial uses. They also include situations where best management practices have not been adopted.	Section 12, Section 14

Component	Legislation	Key Clause	Description	Where addressed in this WAA
		30	Allows for the declaration of a mixing zone as part of a licence issued by EPA if, after all practicable steps are taken, a wastewater discharge will result in the environmental quality objectives being exceeded at point of discharge. This Clause ensures flexibility in policy implementation while still ensuring the protection of beneficial uses. Requires for regular review of mixing zone management, to ensure minimal mixing zone size.	
		31	Supports the re-use and recycling of wastewater which has a range of environmental, social and economic benefits. The Clause requires re-use and recycling activities to be carried out in a sustainable manner in accordance with guidance provided by the EPA.	
		32	Requires that on-site domestic wastewater be managed to prevent the transport of pollutants to surface water and to prevent impacts on groundwater beneficial uses.	
		36	Requires that discharge of saline wastewater be managed in accordance with the waste hierarchy, and in accordance with relevant approved salinity plans and strategies.	
		37	Requires management of chemicals to minimise environmental risks to beneficial uses.	
		38	Requires measures to be undertaken to prevent the spillage of hazardous substances into surface waters.	
		56	Requires that construction managers implement effective environmental management practices that are consistent with EPA guidance.	Section 12, Section 14
		Schedule A	Outlines environmental quality indicators and objectives to ensure the protection of beneficial uses.	
Groundwater	*SEPP (Groundwaters of Victoria) No. S 160*	8	Defines the segments of the groundwater environment, based upon total dissolved solids (TDS) concentration, for the purpose of the policy.	Section 13

Component	Legislation	Key Clause	Description	Where addressed in this WAA
		9	Identifies the beneficial uses to be protected for each segment of the groundwater environment.	Section 13
		10	Specifies groundwater quality indicators and objectives required to protect beneficial uses.	
		11	Outlines EPA's role, as well as powers, duties, and functions, in administration of the policy/	
		12	Requires that '*all practicable measures must be taken to prevent pollution of groundwater*'.	
		16	Provides for EPA to require hydrogeological assessments to determine existing contamination and risk to quality and beneficial uses.	
		20	Requires that direct discharge of waste to an aquifer not be allowed except where the groundwater quality objectives will be met, where there will be no detriment to any beneficial use of groundwater, land or surface water, and for the purpose of: ▪ Aquifer recharge; ▪ Irrigation drainage; ▪ Backfilling of underground mine workings with tailings; ▪ Stormwater disposal; and/or ▪ Groundwater remediation projects involving the injection of uncontaminated water or the re-injection of treated water to the aquifer.	
		22	Requires that any drilling, bore construction and decommissioning of drillholes and bores be consistent with current best practice or with any relevant best practice guidelines adopted by EPA.	
		24	Requires that best practice be adopted for the management of activities which have the potential to be, or to cause, a diffuse source of groundwater pollution.	

Component	Legislation	Key Clause	Description	Where addressed in this WAA
		29	States that, where deemed appropriate, monitoring of ambient groundwater quality may be required to enable assessment of policy compliance.	Section 13
Land	*SEPP (Prevention and Management of Contaminated Land) No. S 95*	9	Specifies land use categories for the purposes of the policy.	Section 15
		10	Identifies beneficial uses to be protected for each land use category.	
		11	Outlines environmental quality indicators and objectives to ensure beneficial uses are protected.	
		12	Outlines EPA's role, as well as powers, duties, and functions, in administration of the policy.	
		16	Outlines the circumstances in which the application of chemical substances and waste to land can be undertaken.	
		17	Outlines the responsibilities of site occupiers and transporters of chemical substances or waste to prevent land contamination and provides for the preparation and implementation by certain occupiers of environment improvement plans to prevent or progressively mitigate contamination.	
		18	Requires that occupiers of land with constituent materials that may adversely affect beneficial uses (eg. acid sulphate soils) to manage such materials appropriately.	
		19	States that EPA may, through a works approval, licence, or notice, require the occupier of a premises to undertake a site contamination assessment.	
		21	Requires that contaminated land be cleaned up.	
		22	Outlines management strategy requirements when contamination occurs.	
		23	Provides clean-up objectives for contaminated land.	
		24	Requires depth of required clean-up be determined through site-specific assessment.	

Component	Legislation	Key Clause	Description	Where addressed in this WAA
		25	Outlines how waste soils or sediments are to be transported and disposed of.	
Waste	*Waste Management Policy (Used Packaging Materials) No. S94*		Requires users of packaged materials to consider sourcing materials from companies that re-use and recycle their used packaging materials and to support the voluntary strategies in the National Packaging Covenant.	Section 9
	Waste Management Policy (Ships' Ballast Water) No. S100	9	Requires that high-risk domestic ballast water not be discharged into Victorian State waters.	Section 14
		10	Sets out ship owners' and masters' responsibilities in ballast water management.	
		16	Outlines the circumstances and conditions for exemption from Clause 9.	
	Industrial Waste Management Policy (Prescribed Industrial Waste) No. S183	9	Outlines the requirements to be met by waste generators in the management of prescribed industrial waste.	Section 9
		11	States that EPA may classify a prescribed industrial waste in accordance with Schedule 1 and Schedule 2 to the policy. A generator may develop a waste classification in accordance with the requirements of Schedule 1, or develop an alternate classification to that provided by EPA, subject to EPA approval.	
		15	Requires prescribed industrial waste generators to prepare and submit an environment improvement plan (EIP) to EPA when applying for a works approval or if required to do so by EPA. Encourages those prescribed industrial waste generators who may not be required to develop an EIP to voluntarily develop an EIP and have it certified by an EPA appointed environmental auditor.	

Component	Legislation	Key Clause	Description	Where addressed in this WAA
		16	Requires that prescribed industrial waste not be reused, recycled, used as a source of energy or otherwise minimised, stored, transported, reprocessed or treated in such a way that contaminants can be transferred to other environmental media unless this results in a “best practicable environmental outcome”. Requires that prescribed industrial waste not be diluted, mixed or otherwise treated where this reduces the potential for the reuse, recycling or recovery of energy of that waste unless reuse, recycling or recovery of energy is not practicable; or the treatment is necessary to obtain a “best practicable environmental outcome”.	
		Schedule 1	Classifies prescribed industrial waste in terms of its potential for reuse, recycling, or recovery of energy its opportunity for treatment and its hazards.	
	Industrial Waste Management Policy (Waste Acid Sulphate Soils) No. S 125	9	Requires the management of waste acid sulfate soils be in accordance with “current best practice” or any best practice environmental management guidelines approved by EPA.	Section 9, Section 15
		10	Sets out requirements for on-site management of waste acid sulfate soil with the introduction of current best practice environmental management for all on-site handing of waste acid sulphate soils in order to ensure that the relevant beneficial uses, as set out by SEPPs, are protected. This Clause also exempts from any requirement to prepare an EPA approved environment management plan for on-site handling of waste acid sulfate soil.	
		13	Prohibits the disposal or reuse of waste acid sulfate soils at any premises, unless the occupier of the premises is either licensed to do so under the Act or has an environment management plan approved under the policy.	

Notes to Table 2-1:

1. An ‘indicator’ is defined in the *SEPP (Air Quality Management)* as a substance which is used as a measure of air quality.
2. An ‘intervention level’ is defined in the *SEPP (Air Quality Management)* as a numerical value for an indicator which, if exceeded, may trigger development of a neighbourhood environment improvement plan.

2.1.6 Desalination Project EES Scoping Requirements

The Desalination Project EES Scoping Requirements (the Scoping Requirements) were issued by the Minister for Planning in May 2008. The purpose of the Scoping Requirements is to provide strong guidance (but not mandatory direction) on the scope of environmental effects and related matters that should be investigated and documented in the Environment Effects Statement (EES) under the *Environment Effects Act 1978* (Vic), which is also accredited for the purpose of assessing environmental impacts under controlling provisions of the EPBC Act.

Although not strictly required for this WAA, the Scoping Requirements have been taken into consideration in the development of the environmental evaluation framework and criteria.

The Scoping Requirements suggest that development of specific evaluation criteria should take into account:

- key requirements or objectives under statutory provisions, including policy;
- best practice techniques and technologies, available within relevant sectors of activity; and
- objectives and principles of ecologically sustainable development and environmental protection.

Relevant objectives presented in the Scoping Requirements are included in Table 2-2.

Table 2-2 Summary of relevant objectives presented in the EES Scoping Requirements

Component	Reference*	Objective	Where addressed in this WAA
Solid and liquid waste	5.6.2	To ensure that performance criteria for construction and operation of project infrastructure will optimise avoidance, mitigation, and management of waste streams, consistent with the waste hierarchy and the protection of beneficial uses.	Section 9
Greenhouse gas emissions and energy efficiency	5.6.3	To ensure optimal energy efficiency and mitigation of greenhouse gas emissions associated with construction and operation of the project, and to minimise overall greenhouse gas emissions consistent with applicable policy.	Section 8, Section 10
Marine and inland waters	5.6.4	To avoid or minimise adverse effects of project construction and operational activities on marine waters and inland waterways, water resources, and floodway function.	Section 12, Section 14
Ecological effects of seawater intake and saline discharge	5.6.5	To avoid or minimise effects on marine (aquatic) ecosystems associated with the intake of seawater or discharge of saline concentrate, including marine construction.	Section 14
Noise, dust and odour	5.6.9	To avoid or minimise adverse effects on residents' and coastal users' amenity due to noise, dust, and related off-site effects during construction and operation of the project.	Section 11, Section 16
Managing environmental effects and risks	5.6.12	To provide a transparent framework, with clear accountability, for managing environmental effects and risks associated with the project to achieve acceptable outcomes.	Section 17

* Indicates reference section of Desalination EES Scoping Requirements

2.2 Best Practice

2.2.1 Best Practice Definition

A consistent requirement of the regulatory framework outlined in Section 2.1 is the implementation of best practice. Various SEPPs and WMPs require adoption or implementation of best practice to facilitate the protection of beneficial uses of the receiving environment from potential risks effects of emissions.

Best practice is defined in SEPP (Waters of Victoria) and SEPP (Air Quality Management) as *"the best combination of (eco-efficient) techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of (a generator of emissions in) that industry sector or activity"*.

The Scoping Requirements for the Desalination Project EES refer explicitly to this definition in the context of its recommendation that the project evaluation criteria take account of "*Best practice techniques and technologies available within relevant sectors of activity*". The EES Scoping Requirements also acknowledge that "*In making decisions in relation to best practice, practicability is a relevant consideration*".[1]

Best practice encompasses consideration of resource usage and emissions to segments of the environment as part of environmental impact. Whilst best practice is a driver for minimisation of environmental impacts, it is accepted that there may be trade-offs between environmental outcomes in the interests of overall environmental benefit. Best practice also gives consideration to what is commercially practicable.

While the use of leading technology is a key element of best practice, there is a need to incorporate other management processes such as systems and procedures to effect best practice and maintain an appropriate level of applied technology robustness, avoiding or minimising process failure.

2.2.2 Current Best Practice for Desalination

The concept of best practice in desalination is explored in the report *Water Management Challenges in the Loreto Region* (Sherwood 2006; page 28). Currently adopted practices and proven technologies are discussed, and it is put forward that "*there are no universal best practices for desalination. Best practices are determined by site-specific conditions. Every proposed desalination facility should be evaluated to understand the existing constraints sensitive environmental resources that may be affected*".

A comprehensive report prepared by the Pacific Institute (Cooley et al., 2006) provides an overview of the history of desalination, advancements in desalination process technology and the status of desalination plants worldwide. This report makes an assessment of the advantages and disadvantages of desalination, giving consideration to factors such as economics, reliability, water quality, energy use, environmental impacts and coastal development/land use.

This report concludes that "*there is no single best method of desalination. Ultimately, the selection of a desalination process depends on site-specific conditions, including the salt content of the water, economics, the quality of water needed by the end user, and local engineering experience and skills*". (Cooley et al., 2006; page 13).

[1] Refer section 5.3 of EES Scoping Requirements

2.2.3 Approach to Best Practice

The approach to best practice adopted for the Victorian Desalination Project acknowledges that there is not a universal fit for best practice in desalination, and that evaluation of best practice must be made within the context of site-specific conditions.

From a review of the literature, key environmental (and other) considerations associated with desalination become apparent. These include consideration of the siting, design and operation of desalination plants; system reliability and product water quality; energy intensity (and process efficiency); and mitigation of potential impacts associated with the marine environment.

A number of these considerations (including plant siting, system reliability and product water quality, as well as potential impact on the marine environment) have been addressed at a conceptual level in the Feasibility Study for the Project (GHD and Melbourne Water, 2007). Selection of the Desalination Plant location and product water quality are not discussed further in this WAA.

The application of best practice in development of the Desalination Project has assumed a 'whole-of-system' engineering approach, giving balance to both technical and environmental constraints, and is explained as follows:

- consideration of technical feasibility (including system reliability) in identifying suitable concepts for the Project;
- evaluation of potentially suitable concepts against the State's environmental and social objectives;
- an iterative approach to the development of the Reference Project, whereby detailed environmental impact assessments have determined specific Project design decisions. This was achieved by completing a risk assessment (refer Section 4) to confirm that Project risks were reduced to levels where no substantial benefit in risk reduction could be achieved by further, practical modification to the Project design; and
- development of an Environmental Management Framework (EMF) to support management of environmental aspects of the Project during design, construction and operation.

Table 2-3 sets out best practice design, construction, and operational objectives and evaluation criteria, which have been developed for relevant components of the Project. Reference is made to these criteria in assessing the Reference Project, and its Variations, against best practice (refer to Section 7).

Table 2-3 Summary of best practice objectives and evaluation criteria

Component and objective	Element	Best practice evaluation criteria	Where addressed in this WAA
Design Design a Desalination Plant that provides a holistic, best practice solution encompassing minimal resource usage and emissions to the receiving environment	Inlet and outlet systems	Criterion 1: Design the seawater intake and concentrate outlet systems to minimise adverse effects on the marine (aquatic) environment.	Section 7, Section 14
	Pre-treatment	Criterion 2: Design the pre-treatment system to minimise adverse effects on the receiving environment from the residual effects of chemicals (biocides, coagulants, flocculants, antiscalants, etc.) used to condition the feedwater prior to pre-treatment.	Section 7, Section 9, Section 10
		Criterion 3: Design a pre-treatment system to achieve an overall balance and net benefit in energy, water use and waste generation, consistent with EREP requirements and the waste hierarchy.	
	Desalination process technology	Criterion 4: Design a Desalination Plant with a process technology to achieve an overall balance and net benefit in minimising energy use and waste generation.	Section 7, Section 10
	Chemical use	Criterion 5: Design of the pre-treatment, desalination and potabilisation systems to minimise chemical usage and to select chemical products that are proven to have minimal adverse effect on the receiving environment.	Section 7, Section 14
	Surface and groundwater management	Criterion 6: Design a Desalination Plant to minimise the risk of adverse impacts on surface and ground waters.	Section 12, Section 13
	Air and noise	Criterion 7: Design a Desalination Plant to minimise the risk of adverse impacts on sensitive receptors' amenity due to noise, vibration, dust, and odour.	Section 11, Section 16

Component and objective	Element	Best practice evaluation criteria	Where addressed in this WAA
Construction Construct a Desalination Plant that provides a holistic, best practice solution for minimising resource usage and emissions to all segments of the environment.		Criterion 8: Minimise the risk of adverse impacts from construction on the environment Criterion 9: Construct the Desalination Plant in such a manner that will achieve an overall balance and net benefit in minimising energy and water use and waste generation, consistent with EREP requirements and the waste hierarchy.	Sections 9 - 17 Section 9, Section 10 and Section 17
Operation Avoid or minimise adverse impacts and associated risks of the site operation on the receiving environment; Monitor the Desalination Plant operation to provide sufficient assurance and prediction of potential adverse impacts and associated risk of the site operation on the receiving environment, and enable implementation of actions necessary to maintain impacts and manage associated risks within an acceptable range.	Management controls	Criterion 10: Develop, implement, and maintain operational environmental management systems and procedures.	Section 17
	Environmental monitoring	Criterion 11: Develop a proactive and responsive environmental monitoring program that assesses conformance with, and the effectiveness of, established environmental controls and processes identified in this WAA and environmental risk assessment.	Section 17
	Environmental auditing	Criterion 12: Undertake regular environmental audits of the Desalination Plant performance.	Section 17
Energy Efficiency Apply optimal energy efficiencies during design, construction and operational phases.		Criterion 13: Design, construct and operate the Desalination Plant to comply with the Protocol for Environmental Management 'Greenhouse Gas Emissions and Energy Efficiency in Industry'. Operate the Desalination Plant to achieve resource efficiencies consistent with EREP requirements.	Section 8, Section 10

Component and objective	Element	Best practice evaluation criteria	Where addressed in this WAA
<u>Waste Management</u> Optimise avoidance, mitigation and management of waste streams, consistent with the waste hierarchy and protecting beneficial uses of the environment; Dispose of or treat wastes that cannot be practically or cost-effectively managed employing options higher up the waste hierarchy at appropriately licensed and managed facilities; Comply with relevant waste management related legislation, regulations, State environment protection polices, Industrial waste management policies and waste management policies.		Criterion 14: Design, construct and operate the Desalination Plant to: ◗ minimise waste generation and to manage waste in accordance with the waste hierarchy; and ◗ comply with relevant waste management related legislation and regulation. considering the overall balance and net benefit of minimising both energy use and waste generation.	Section 9, Section 10

3. Other Approval Processes

3.1 Commonwealth Environmental Assessment & Approval Process

The Victorian Desalination Project was also referred to the Federal Minister for the Environment, Heritage and the Arts to determine whether it is a controlled action requiring approval under the *Environment Protection and Biodiversity Act 1999* (EPBC Act). On 4 February 2008 the Federal Minister for the Environment, Heritage and the Arts determined that the Project was a controlled action subject to Sections 16 and 17 B (wetlands of international importance) and 18 and 18A (listed threatened species and communities) of the EPBC Act. On the same date, the Minister determined to accredit the Victorian EES as the assessment approach.

3.2 Victorian State – EES

The Secretary to DSE submitted a referral to the Minister for Planning in November 2007 to determine whether the Project required assessment under the *Environment Effects Act 1978* (EE Act). The Minister decided on 28 December 2007 that an EES would be required for the permanent works. The EES is an advisory process intended to inform decision-makers responsible under Victorian law for determining the Project's approvals. The EES process provides for assessment of environmental, social and economic impacts of the Project. The EES is prepared by the proponent with the assistance of specialist consultants and feedback from community consultation.

When completed, the EES is exhibited for public comment. Then the Minister for Planning appoints an Inquiry Panel to consider the EES.

3.3 Other

The Project requires other approvals under various parts of Victorian legislation. Decisions made as to whether or not approve the Desalination Project will be informed by the Minister's Assessment under the EE Act. Particular requirements for approval will depend on the final design and siting of Project infrastructure. In this particular case these approvals may include:

- consent under the *Coastal Management Act 1995* (Vic) for use and development of coastal Crown land; and
- relevant authorisation under the *Planning and Environment Act 1987* (Vic) to provide for establishment of Project infrastructure.

4. Identification of Key Risks

4.1 Approach to WAA Investigations

Investigations for the WAA have taken into account:

- legislative and policy obligations as set out in the environmental evaluation framework (refer to Section 2);
- key environmental matters set out in the EES Scoping Requirements (DPCD, 2008);
- matters identified in the initial information gathering and workshop stage of the risk assessment for the EES Referral (GHD, 2007a);
- analysis of the outcomes during the preliminary stages of the risk assessment and impact assessment which highlighted where further investigation and study was required in the specialist investigations;
- discussions with EPA, government agencies and other key stakeholders throughout the preparation of the WAA; and
- peer review undertaken for specific technical investigations.

4.2 Approach to Field Investigations

The PPP character of the Project has also shaped the way the field investigations for the WAA have been conducted, which could potentially be delivered in a variety of forms using different technologies.

Field studies have focussed intensely on the Plant Site and marine area in which the Marine Structures will be located. This focus reflects the certainty of the envelope location, the sensitivity of the marine and coastal environment, the intensity of the proposed construction activity and the longevity of the operational impacts of the Project as a result of the continuous intake of seawater and discharge of saline concentrate to ocean.

4.3 Overview of the Risk Assessment Process

A detailed explanation of the risk assessment process for the Desalination Project is provided in the report *EES Risk Assessment* (Maunsell, 2008a). This report is included as *Technical Appendix 6* of the EES. The risk assessment was conducted as a transparent process, with clear accountabilities, for identifying environmental risks, analysing, evaluating and management of these environmental risks associated with the Desalination Project.

The scope of the risk assessment included construction and operational risks for the Desalination Project in relation to social, environmental and economic values on both a local and regional scale. The risk assessment process:

- addressed risk assessment requirements specified by relevant legislation, policy and guidelines and the EES Scoping Requirements;
- provided confidence and rigour for decision making and planning;
- incorporated knowledge from specialists and team leaders across Project disciplines and informed refinement of the Reference Project;

- enabled prioritisation of risks and interactions, identification of controls, proactive management and mitigation of risks to the extent practicable; and
- followed the Australian/New Zealand Standard: Risk Management (AS/NZS 4360:2004).

The risk assessment adopted the approach of the AS/NZS 4360:2004, although not a mandatory requirement for the WAA, or required under the Scoping Requirements.

Figure 4-1 shows the structured and iterative approach used, as set out in AS/NZS 4360:2004.

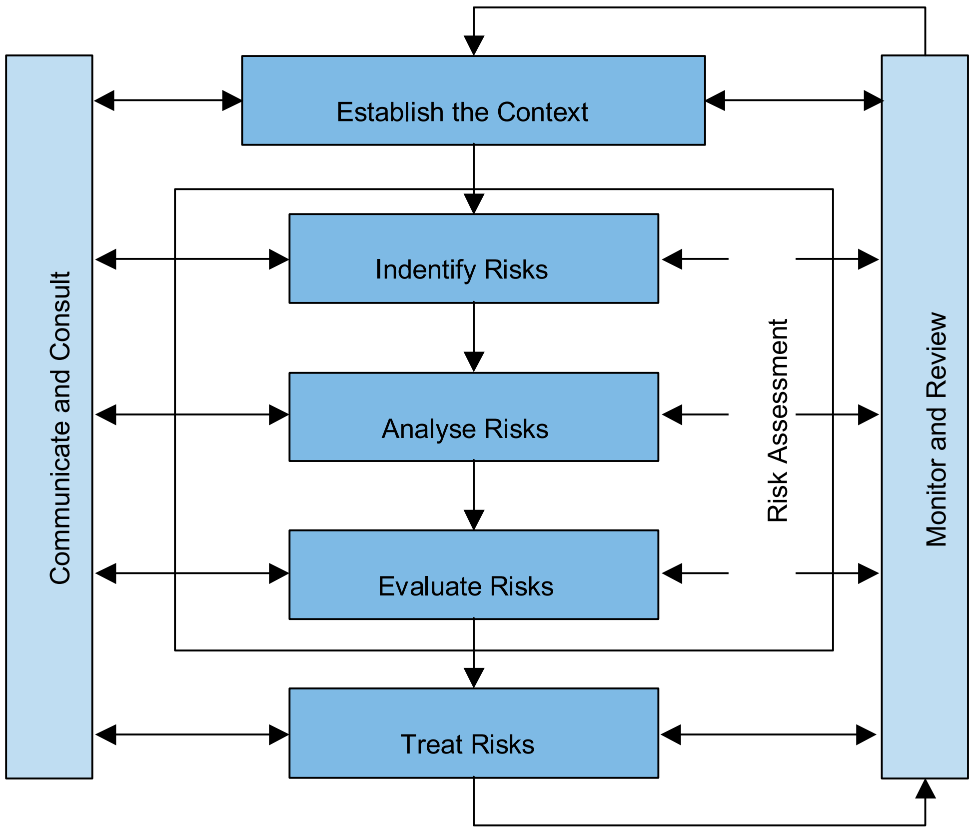


Figure 4-1 Risk assessment process AS/NZS 4360:2004

Table 4-1 shows conformance with AS/NZS 4360:2004 and how the Desalination Project risk assessment process applied specific elements of AS/NZS 4360:2004.

Table 4-1 Conformance with risk assessment standard AS/NZS 4360:2004

Risk Assessment Requirement	Actions during Desalination Project risk assessment
Communicate and consult ▪ consultation with stakeholders at each stage of the process	▪ Identification and engagement of stakeholders ▪ Defining stakeholder values ▪ Consideration of issues and concerns arising from community consultation

Risk Assessment Requirement	Actions during Desalination Project risk assessment
Establish the context ▪ Refine the context in which the analysis will take place, establish evaluation criteria, and define the structure of the risk analysis	▪ Review of relevant legislation, policy and guidelines and EES Scoping Requirements ▪ Development of conceptual ecological models ▪ Defining Project boundaries and scope ▪ Development of consequence and likelihood tables with input to relevant areas from technical specialists ▪ Development of the Reference Project and Variations
Identify, analyse and evaluate risks ▪ Identify and analyse when, where, why and how risk events could occur ▪ Identify existing controls, evaluate consequences and likelihoods to determine levels of risk	▪ Engage with technical specialists to consider and address matters specified in relevant legislation, policy and guidelines and the EES Scoping Requirements ▪ Risk identification through cross-disciplinary approach involving technical and engineering team and technical specialists ▪ Specialist input used in relevant disciplines to assign consequence and likelihood levels and determine ratings for individual risks identified ▪ Establishment of a Risk Register
Treat risks ▪ Develop and implement specific risk reduction mitigation strategies for increasing benefits and reducing potential costs	▪ Technical specialist recommendations to mitigate and reduce the risk of significant adverse effects ▪ Guide design modifications to the Reference Project ▪ Support development of Performance Requirements for the EMF
Monitor and review ▪ Monitor the effectiveness of all the steps in the risk management process and assess changing circumstances	▪ Identification of information gaps leading to further investigation required in WAA and EES development ▪ Cross-discipline review of risk ratings undertaken through Project risk workshops ▪ Use of a multiple peer review process via workshops to interrogate the findings of technical specialists in key subject areas

4.4 Risk Assessment Concepts

4.4.1 Defining Risk

Risk is defined in the standard as the chance of something happening that will have an impact on objectives. A risk can be specified in terms of an event or circumstance and the consequence that may flow from it. Risk is measured in terms of a combination of:

- the magnitude of potential consequence of the event; and
- the likelihood of an event and its associated consequence occurring.

4.4.2 Risk Identification

Importantly, the identification of risks was based on potential interactions between the Desalination Project and assets, values and uses requiring protection.

Project activity and effect pathways were documented, based on the main Project components and associated construction and operations activities.

Risk identification involved the following:

- review of the matters specified by relevant legislation, policy and guidelines and the EES Scoping Requirements;
- review of the risk assessment undertaken for the initial referral prepared for the Desalination Project;
- consideration of issues and concerns raised by stakeholders;
- risk workshops and team meetings involving the Project team leaders, Project teams and technical specialists;
- advice of the technical specialists regarding potential cause and effect pathways arising from the Project components and associated activities; and
- documenting risk pathways in the Risk Register.

4.4.3 Quantifying Likelihood and Consequences

One of the key aims of the risk assessment process was to derive a consistent assessment of consequence and likelihood across the broad range of specialist areas relevant to the Desalination Project. To achieve this, Consequence and Likelihood Tables were developed.

The Consequence Table contains descriptors that guided the technical specialists when assigning consequence levels to a risk event. Three key factors were used to formulate consequence descriptors. These were size (magnitude), area affected (spatial scale) and time (as a recovery period). This is shown in Table 4-2.

Table 4-2 Rationale for consequence descriptors

Consequence level		Negligible	Minor	Moderate	Major	Extreme
Size (magnitude)		Minimal impact	Low impact	Medium impact	High impact	Very high impact
Area scales applicable	Localised area	✓	✓	✓	✓	
	Regional area		✓	✓	✓	✓
Time		Within natural variability	Functional recovery within less than 1 year	Functional recovery within 1 to 5 years	Functional recovery within 5 to 10 years	Functional recovery, if at all, greater than 10 years

For the purposes of the risk assessment the localised area was defined as:

- the terrestrial environment affected by the Project footprint or within the boundary of the property owned by the State; or
- the marine environment within 2 km along the shore from the inlet and outlet points and up to 2 km off the coast.

The regional area is defined as:

- the terrestrial area outside the localised area; or
- the marine environment of the southern coast of Victoria.

The Consequence Table is shown in Table 4-3. It was developed using qualitative descriptions for different consequence types and levels. The Consequence Table is divided into a series of columns of increasing consequence magnitude. Each category was given a qualitative consequence level (negligible, minor, moderate, major and extreme). A generic qualitative description was provided for each level and is shown in Table 4-3.

The generic qualitative descriptions describe not only the level of impact but also a description of how widely the impact could be felt (i.e. number of individuals or communities affected).

It is important to note that the consequence levels were assigned from a localised and regional area perspective and do not necessarily accord with the perception of consequence to an individual. For example, a major impact from the perspective of an individual landowner may be considered to be a moderate consequence in the context of the region.

A consequence level was assigned after taking into account Project controls that would be in place to reduce risk. Project controls are defined as existing processes, policies, devices practices or other actions that are in place to minimise the negative impact of Project activities. For the Desalination Project the controls included the requirements of applicable legislation and policy operating procedures required for equipment and machinery and the design features of the Reference Project. It should be noted that the risks as assessed do not take into account all Performance Requirements as these were developed from the iterative risk and impact assessment process. Accordingly, modified risk outcomes would result with the implementation of all Performance Requirements.

The Consequence Table also facilitates analysis of escalating consequences where, for example, the consequential impacts on ecosystems is rated minor, moderate or major according to the predicted length of time as a Functional Recovery it would take the asset to recover (less than one year, one to five years, or five to ten years). Credible worst-case consequence considers the range of possible outcomes (most common outcome), and conservatively assigns a rating.

Table 4-3 Consequence table

Consequence Level		Negligible	Minor	Moderate	Major	Extreme
Category	**Sub Category**	**Minimal impact in a localised area within natural variability**	**Low impact in a localised or regional area with a functional recovery within less than 1 year**	**Medium impact in a localised or regional area with a functional recover of 1 to 5 years**	**High impact in a localised or regional area with a functional recovery within 5 to 10 years**	**Very in a regional area with functional recovery in greater than 10 years if at all**
Environmental	**Ecosystem Function**	Alteration or disturbance to ecosystem interactions in the localised area, if any, unlikely to be detectable and within expected natural seasonal variation/ occurrence.	Alteration or disturbance to ecosystem interactions in the localised area or regional area, may be detectable but within expected natural annual variation/ occurrence. Functional recovery within less than 1 year.	Alteration or disturbance to ecosystem interactions in the localised area or regional area, detectable but within expected natural short-term variation/ occurrence. Functional recovery within 1 to 5 years.	Alteration or disturbance to ecosystem interactions in the localised area or regional area, detectable and beyond expected natural variation/ occurrence. Functional recovery within 5 to 10 years.	Alteration or disturbance to ecosystem interactions in the regional area, substantially beyond expected natural variation/ occurrence to irreversible. Functional recovery in greater than 10 years if at all.

Consequence Level		Negligible	Minor	Moderate	Major	Extreme
	Fauna and Flora Communities and Species	Loss of individuals not apparent and without reduction in localised population viability (e.g. mortality likely to be no greater than population experiences within natural annual variability).	Loss of small number of individuals without reduction in viability of population in the localised area or regional area (e.g. mortality likely to be no greater than population experiences within natural annual variability). Functional recovery within less than 1 year.	Loss of individuals leads to reduction in viability of population in the localised area or regional area. Functional recovery within 1 to 5 years.	Loss of large number of individuals leads to a high impact on populations in the localised area or regional area. Functional recovery within 5 to 10 years.	Long-term impact on populations in the regional area that may not be recoverable. Functional recovery in greater than 10 years if at all.
Social	**Aboriginal Heritage Sites**	No measurable impact on indigenous heritage sites in the Project area.	Partial removal of one or more indigenous archaeological sites of low significance.	Complete or partial disturbance to between one and five indigenous archaeological sites of low to moderate significance.	Complete or partial disturbance to six or more indigenous archaeological sites of low-moderate significance.	Complete or partial disturbance to one or more indigenous archaeological sites of high significance.
	Historical Heritage Sites	No measurable impact on historical heritage sites.	Detectable impact to state or Commonwealth significant site with heritage values remaining largely intact.	Partial reduction in heritage value intrinsic to state or Commonwealth significant site.	Substantial reduction in heritage value intrinsic to state or Commonwealth significant site.	Complete loss of heritage value intrinsic to state or Commonwealth significant site.
	Maritime Heritage Sites	No measurable impact on maritime heritage sites.	Detectable impact to state or Commonwealth significant site with heritage values remaining largely intact.	Partial reduction in heritage value intrinsic to state or Commonwealth significant site.	Substantial reduction in heritage value intrinsic to state or Commonwealth significant site.	Complete loss of heritage value intrinsic to state or Commonwealth significant site.

Consequence Level		Negligible	Minor	Moderate	Major	Extreme
	Amenity (Physical Factors, e.g. Noise, Air and Water)	Temporary localised impacts on amenity – no lasting effects.	Short term impacts on amenity to the localised area or regional area. Functional recovery within less than 1 year.	Impacts on amenity to the localised area or regional area that negatively alter perceptions of the area. Functional recovery within 1 to 5 years.	Impacts on amenity to the localised area or regional area that significantly negatively alter perceptions of the area. Functional recovery within 5 to 10 years.	Amenity of the regional area permanently negatively altered. Functional recovery in greater than 10 years if at all.
	Recreation	Temporary and localised impacts on recreation – no lasting effects.	Short term impacts on recreational activities within the localised area or regional area. Functional recovery within less than 1 year.	Impacts on recreational activities within the localised area or regional area that negatively impact on access to recreation opportunities and/or participation rates. Functional recovery within 1 to 5 years.	Impacts on recreational activities within the localised area or regional area that significantly negatively impact on access to recreation opportunities and/or participation rates. Functional recovery within 5 to 10 years.	Access to recreational activities within the regional area permanently reduced. Functional recovery in greater than 10 years if at all.
Economic	**Tourism**	Limited & short-term reduction in tourist visitation not outside usual variation. No significant impact on tourism businesses. Region still seen as attractive place to visit. No recovery necessary.	Short-term reduction in tourism use. Recovery within less than 1 year.	Reduction in tourism use. Recovery within 1 to 5 years.	Large reduction of tourism uses. Business viability compromised across wide range of sectors with substantial business failure in both direct and flow-on sectors. Recovery within 5 to 10 years.	Permanent loss of iconic tourism assets of regional significance. Large flow-on effects to supporting businesses. Functional recovery in greater than 10 years if at all.

Consequence Level		Negligible	Minor	Moderate	Major	Extreme
	Commercial Fishing	Limited & short-term reduction in activity within the localised area. No significant impact on businesses. No recovery necessary.	Short-term reduction in commercial activity, in the localised area or regional area. Functional recovery within less than 1 year.	Reduction of 5 - 30% in sustainable yield of the fishery in the localised area or regional area. Functional recovery within 1 to 5 years.	Reduction of 30 - 90% in sustainable yield of the fishery in the localised area or regional area. Functional recovery within 5 to 10 years.	Commercial fishing completely & permanently prohibited or destroyed in the regional area. Functional recovery in greater than 10 years if at all.

The Likelihood Guide in Table 4-4 was applied across all of the technical investigations and event types to derive consistency of likelihood estimates across all kinds of risk, and it was assumed that management and mitigation measures would be implemented.

Where there was substantial uncertainty in an estimate of likelihood, a higher, or more conservative estimate of likelihood was recorded. The nature of the uncertainty was then incorporated in the environmental impact assessments.

Table 4-4 Likelihood guide for risk assessment

Likelihood	Description
Rare	Highly unlikely to occur but theoretically possible.
Unlikely	May occur within the life of the Project.
Likely	Likely to occur more than once during the life of the proposed Development.
Almost Certain	Very likely to occur within a 12 month timeframe. Includes planned activities. Environmental, Social & Economic description includes the period during construction.
Certain	Will occur as a result of the Desalination Project construction and/or operations.

Together the consequence and likelihood were combined consistent with AS/NZS 4360:2004 approach to arrive at a risk rating, using the matrix shown in Table 4-5.

The effect of applying the risk matrix is that a risk that is rare but would have extreme consequence if it did occur is allocated a high risk rating. A risk that is certain and has only a moderate consequence is also allocated a high risk rating. It is therefore necessary to consider the impact pathway both in terms of consequence and its likelihood for the development of potential management and mitigation measures in response to significant risks.

However, the risk matrix automatically designates any risk that is 'likely' as being 'medium' or higher unless its consequence is 'negligible'. While this means that likely risks are given appropriate prominence in the impact assessment and that remote risks with major (or above) consequences are appropriately recognised and managed so that they do not eventuate, the risk ratings should not be confused with the outcomes of the impact assessment, which consider the likely impacts of the Project and focus on consequence.

Table 4-5 Risk Assessment Matrix

Likelihood	Consequences				
	Negligible	**Minor**	**Moderate**	**Major**	**Extreme**
Rare	Low	Low	Low	Medium	High
Unlikely	Low	Low	Medium	Medium	High
Likely	Low	Medium	Medium	High	High
Almost Certain	Medium	Medium	High	High	Critical
Certain	Medium	Medium	High	Critical	Critical

4.4.4 Dealing with Uncertainty

Risk is a concept used to describe events that could occur, and for which the range of potential impacts cannot be accurately predicted. By definition there is always inherent uncertainty associated with the estimation of risk. Uncertainty in estimation of risk may be due to uncertainty around the magnitude of the potential consequences or uncertainty related to the event occurring.

Uncertainty can result from a lack of historical information, uncertainty in scientific knowledge, natural variability, or uncertainty due to assumptions inherent in technical models or calculations. In assessing and measuring uncertainty, the nature and validity of assumptions must be taken into account.

A conservative approach was used to rate the risks associated with the Project activities to address uncertainty in relation to consequence and likelihood levels.

4.5 Relationship Between Risk Assessment and Environmental Impact Assessment

All risks identified in the risk assessment were considered in the impact assessment. As the impact assessment was also used to define or refine the consequence and likelihood components of the risk analysis, some of the conclusions in the technical investigations presented in the Technical Appendices to the EES are expressed in the language of risk. However, this occurs in a minority of cases and, where it does, a conservative approach has been applied to the consequence rating in the risk assessment, which is then taken to be the relevant rating for the impact assessment.

The predominant purpose of the impact assessment is to draw conclusions, on balance, as to the likely impacts of the Project in the context of existing conditions and measures that are available to mitigate its likely impacts. The impact assessment Sections of the WAA focus on the risks with a rating of medium or higher, with some distinction given to the likelihood of the impact pathway occurring. These risks are summarised in the Sections below. A limited discussion of risks with a low rating is also provided in corresponding Sections of the EES.

The risk assessment was used as a means to inform the development of the Reference Project including potential management and mitigation measures in response to significant risks. This iterative approach resulted in a number of updates to the Reference Project during the WAA and EES development.

The risk assessment facilitated an integrated approach to impact assessment by enabling detailed interaction between the technical and engineering and planning and environmental project teams. It also highlighted the overlap or interdependence between technical disciplines.

The risk assessment informed the development of the EMF consistent with the requirements of ISO 14001. Performance Requirements have been established within the EMF to address the key risk issues identified.

A large number of specialist investigations were conducted in relation to the four main Project components. These studies:

- establish whether particular Project hazards could pose a significant risk of adverse environmental effects;
- provide an analysis, supported by relevant scientific and technical information, of the potential consequences and likelihood of adverse effects;
- identify opportunities to either avoid or mitigate particular Project hazards or to manage or offset adverse effects to potentially acceptable levels;
- assess the significance of likely environmental effects in the context of applicable legislation and policy, including the principles of ecologically sustainable development and environment protection; and
- identify, describe and analyse the relevant environmental impacts of the Desalination Project.

By addressing the above steps, the technical investigations enable an overall evaluation of the Desalination Project against the environmental evaluation framework and criteria, outlined in Section 2 of this WAA.

4.6 Risk Assessment of Project Variations

The risk assessment considered other plausible variations outside of the Reference Project.

The Reference Project was only one of a number of combinations that could meet the Performance Requirements for the Project. Accordingly, it was necessary that the risk and impact assessment could accommodate other possible Project combinations within the footprint of the Project area.

Sensitivity analysis was a means of addressing potential Project design variations of the Project Description. These variations departed from the Reference Project but adhere to the Performance Requirements for the Project.

The purpose of sensitivity analysis for the risk assessment was to provide a considered view of alternate solutions in the risk assessment, taking into account uncertainties in the final Project specifications.

The sensitivity analysis was conservative and led to conservative assessment of ratings. Refer to *Section 8.0* of Maunsell (2008a) for the specific examples of sensitivity analysis for the main Project components.

The approach adopted effectively allowed for uncertainty in the likelihood and consequence of risk events through the caution incorporated into an assigned risk level. For this reason, sensitivity analysis was conducted only for those areas of uncertainty where the predicted effects or risk events could plausibly reach an even greater order of magnitude than the already conservative estimates.

4.7 Findings

By application of the risk assessment methodology, conduct of the impact assessment, evaluation against the draft EES Evaluation Objectives, and specification of the Project Requirements, Project investigations have sought to provide and inform this WAA and the EES of a comprehensive account of potential environmental impacts of the Project in the context of the over-riding social and economic objective of securing Victoria's future potable water supply.

5. Site Description

5.1 Site Details

The Desalination Plant is expected to occupy approximately 40 ha along the coast of Bass Strait and east of the Powlett River, with additional land required during construction. The proposed location for the Plant is within the area defined by the Desalination Plant Site Boundary (see Figure 5-1).

The Site address as listed on the Desalination Project Incorporated Document (incorporated into the Bass Coast Planning Scheme under Clause 81), is as follows:

- Lot 1 on Plan of Subdivision 501595, Volume 10907 Folio 010;
- Lot 2 on Plan of Subdivision 501595, Volume 10907 Folio 011;
- Lot 1 on Plan of Subdivision 538458, Volume 10985 Folio 540;
- Lot 2 on Plan of Subdivision 201963G, Volume 09658 Folio 544;
- Lot 1 on Plan of Subdivision 201963G, Volume 09658 Folio 543; and
- Crown Allotment 23A Parish of Wonthaggi, Volume 3798 Folio 500'.

The Site also includes Crown Land on the coastal and marine areas offshore, where the Marine Structures will be constructed.

The closest settlements include the small township of Dalyston to the north-east and the regional centre of Wonthaggi to the east. Vehicular access to the Site is via Mouth of Powlett Road and Lower Powlett Road, both off the Bass Highway.

Located in a rural setting, the Site's south-western perimeter is only a few hundred metres from the Bass Strait. This narrow strip of coastal reserve, characterised by indigenous vegetation and foredunes, separates the Site from Williamsons Beach.

The Powlett River estuary is the immediate area's most dominant natural feature. The Powlett River meets the Bass Strait to the north-west of the Site, creating a floodplain north of the Site.

The area is within the Gippsland Plain Bioregion and South Gippsland drainage basin. A number of dwellings, the Powlett River Caravan Park, and several tourist cottages exist within the vicinity of the Site. There are also scattered rural dwellings to the east and southeast.

Figure 5-1 Aerial view of Desalination Plant Site Boundary

5.2 Surrounding Land Uses

Land use on and surrounding the Site consists of a coastal reserve to the south-west (both on and off-shore) and broad-acre agricultural activities of private landholders on a coastal plain that radiate out in a north-easterly direction. Some rural dwellings lie within 600m of the Site, as well as the Powlett River Caravan Park, as noted in Section 16.3.1 of this WAA. A wind farm, comprising six turbines, is a similar distance to the south. A council-managed recreational "rail trail" is to the north of the Site and runs roughly parallel to and south of the Bass Highway.

5.3 Historical Land Uses

The following description of historical land uses for the Site is based on information provided in *Report for Victorian Desalination Project: Land Contamination Existing Conditions and Impact Assessment – Plant Site* (GHD, 2008a), included in *Technical Appendix 36* of the EES.

A review of historic titles, with selected titles dating back to the late 1800s, indicated that the majority of the land associated with the Site was used for grazing. One parcel of land was historically owned by the Board of Land and Works and is currently temporarily reserved for public purposes (Rail Trail). Two other parcels of land are listed historically as Crown land, believed to have been leased to the Wonthaggi Coal Mine. Treehaven Plantations Pty Ltd is listed as the proprietor of a further allotment in 1983. Based on available aerial photographs, this parcel of land was heavily vegetated from the period 1950 to 1986. In 1989, clearing of vegetation had occurred, indicating a potential land use that may have contributed to land contamination. However, this allotment is outside the Site area.

Vegetation was moderate across most of the Site with no major trees or buildings. It wasn't until the 1950's that some activity occurred on the Site in the form of clearing, roads being established, and dams being built. Photos dating from 1950 to 2006 show that the majority of the Site has been used for farming (typically grazing).

The most notable historical land activity at the Site was the Wonthaggi Coal Mine workings, which were located well below ground with minimal surface disturbance. The Victorian Railways operated the West Dip section of the West Area mine of the State Coal Mine until its closure in 1968. Mining commenced in the area in 1952 and continued until 1964 when mining operations were terminated in the West Dip section. There were two seams that were worked in the study area generally at a depth of 110 m below ground surface with generally 3 m to 6 m vertical spacings. The likely extent of the mine workings is shown in Figure 5-2.

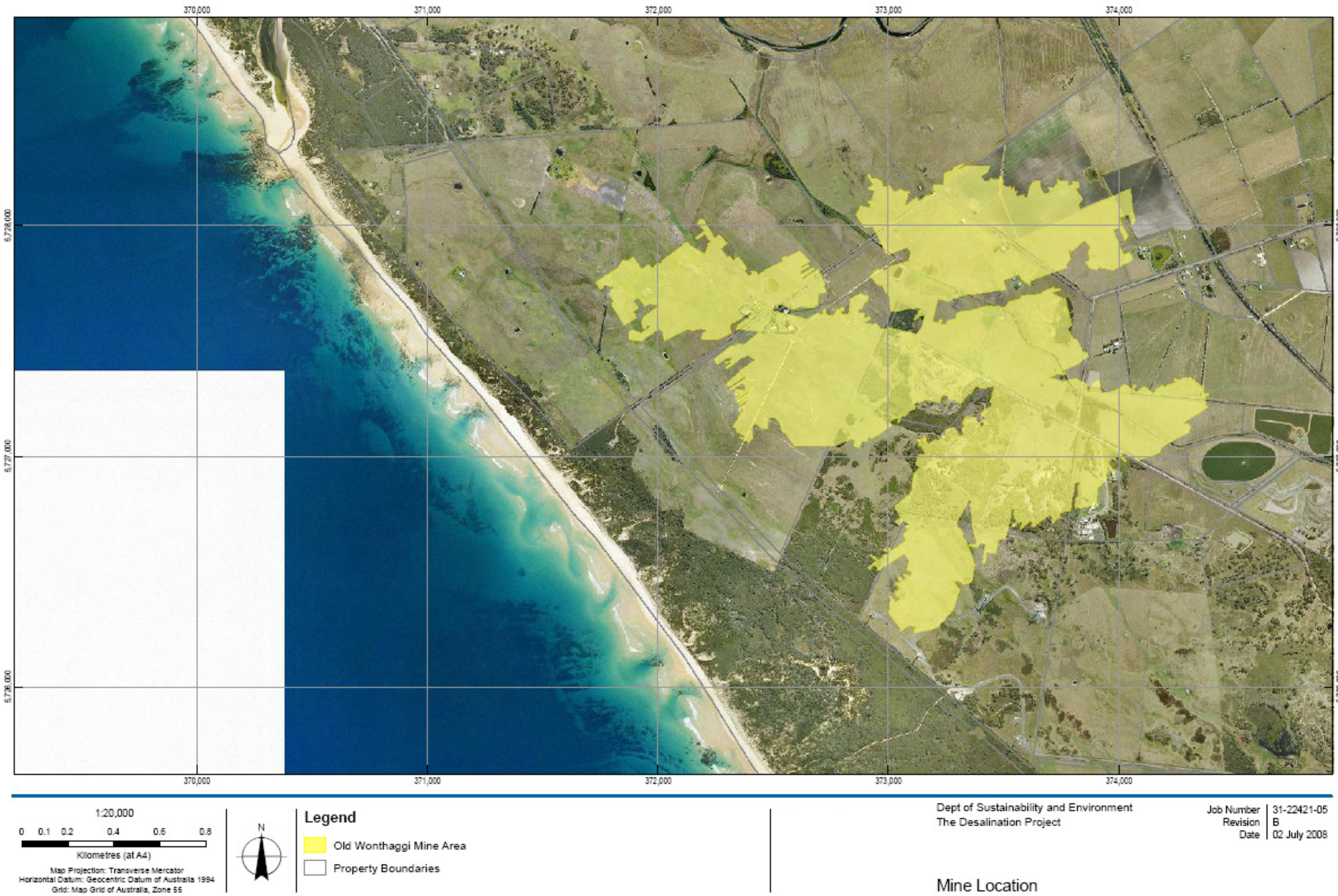


Figure 5-2 Indicative extent of Wonthaggi Coal Mine workings

5.4 Zoning and Planning Controls

The Site is within the Bass Coast Shire and is subject to the Bass Coast Planning Scheme. A site-specific amendment under Clause 52.03 of the Bass Coast Planning Scheme applies to the Site and enables the use of the Site for the proposed Desalination Plant, in accordance with the Desalination Project Incorporated Document.

A *Public Conservation and Recreation Zone* applies to the coastal strip adjacent to the Site, while a *Farming Zone* applies to cleared farmland to the north. Two *Environmental Significance Overlays* apply to the strip of coastal dunes and to the area where there is a hazard of subsidence due to past coal mining operations. A *Land Subject to Inundation Overlay* has been applied to the Powlett River floodplain.

5.5 Meteorology

The following description of meteorology for the Site is based on information provided in *Existing Conditions report: Air Quality – Desalination Plant* (GHD, 2008b), included in *Technical Appendix 47* of the EES.

The Site's meteorological profile has been developed based on data available for Wonthaggi. However, it should be noted that Wonthaggi is situated 4 km from the coast and the Site is within several hundred metres of the coastline. The Site's air quality characteristics are strongly influenced by that of the Bass Strait and its weather conditions.

The local climate is characterised by a hot summer with low rainfall and a cold winter with abundant rainfall. While recent rainfall has been lower than average, the mean annual rainfall for the area is approximately 940 mm.

The area has been given a 'warm summer' definition, due to the following characteristics being displayed:

- the warmest monthly average is above 18 ºC (Wonthaggi is 19ºC);
- the coldest monthly average is above –3 ºC; (Wonthaggi is 10ºC);
- the warmest monthly average not being above 22 ºC (see above).

Wind conditions for the Site are typical of south-eastern Australia, with a windy spring, winter westerlies, and a north-south bias during summer. Data from Wonthaggi and Rhyll indicate that daytime south-south-west and east-north-east winds at night are the predominant summer wind directions, with an average wind speed of 5.15 m/s, while north to north-west winds dominate in the winter. Fog is most likely to occur in autumn during light wind conditions.

The predominant background contributors to local ambient air quality have been identified as airborne dust, ash, and salt particulates, and maritime odours, eg. decomposing seaweed. On occasion, atmospheric plumes of fine particulates may be received from metropolitan Melbourne and the Latrobe Valley.

By extrapolating data from other relevant stations and taking into consideration the exposed nature of the Site, a conservative measure of <20 $\mu g/m^3$ for PM_{10} has been estimated as a background dust level.

5.6 Stratigraphy

The following description of stratigraphy for the Site is based on information provided in *Existing site conditions, Impacts and Risk Assessment Geology, Geomorphology and Acid Sulfate Soils* (Boyd and Rosengren, 2008), included in *Technical Appendix 37* of the EES.

The Site is an area of sand-covered plain, weakly incised by the Powlett River within an alluviated valley. The Site is underlain by Silurian age sedimentary rock while the saprolitic upper layers of a Cretaceous aquifer system are mudstones of lower permeability, with thick-bedded sandstones of higher permeability at depth. Interbedded black coal seams are found at different depths. Across the Plant Site and river floodplain, these indurated sediments are blanketed by undifferentiated Quaternary age water-bearing regolith, comprising of clayey alluvials and swamp deposits, while dune sediments are found along the coastline.

The upper soil horizon comprises leached sandy soils of a low organic content, underlain by a compacted horizon of darker sand, interspersed with tongues of weakly cemented coffee rock, an accumulation of iron, manganese, and humus material washed from the upper horizon.

5.7 Topography

The following description of topography for the Site is based on information provided in *Existing site conditions, Impacts and Risk Assessment Geology, Geomorphology and Acid Sulfate Soils* (Boyd and Rosengren, 2008), included in *Technical Appendix 37* of the EES.

The Site is of low elevation and relief, with a gentle undulation. The highest elevation within the Site is along the inland edge of the coastal foredunes, progressively declining in elevation inland to the lower Powlett Valley. The seaward side of the Site is characterised by coastal sand dunes behind a narrow beach.

Adjoining the dunes to the inland is scrubby and low coastal heathland, which becomes flat to gently undulating cleared farmland, then coastal plain. This plain develops into a floodplain, as it nears the estuary. The Powlett River estuary is the area's most dominant natural feature. In summary, the three terrain types that define the vicinity can be classified as:

- coastline, comprising of shore platforms, beaches, rock cliffs, foredunes, and transgressive dunes;
- gently undulating and terraced sand-covered plain; and
- alluvial floodplain and swamp.

5.8 Hydrogeology

The following description of hydrogeology for the Site is based on information provided in *Report for Desalination Plant Site: Existing Conditions and Impact Assessment – Groundwater* (GHD, 2008c), included in *Technical Appendix 40* of the EES.

The two relevant aquifers are the fractured rock aquifer system of the Lower Cretaceous Strezlecki Group and the porous regolithic media of the Quaternary Aquifer System. The level of confinement of both aquifers is not known. However, the Cretaceous Aquifer and Quaternary alluvials are suspected as being unconfined to possibly semi-confined, whereas saturated Quaternary dune materials are likely to be unconfined.

While the Plant Site does not fall within a defined groundwater management area, groundwater is generally found at less than 6 m below the surface but marginally above sea level, and is used on neighbouring properties for stock and domestic purposes.

Recharge of the Quaternary Aquifer System is via direct infiltration from outcropping dune sands and alluvial sediments. Vertical leakage may contribute to some recharge of the Cretaceous Aquifer, with recharge also occurring at more distant zones.

Due to the area's topography, it is expected that groundwater flows towards the Powlett River and Bass Strait, with discharges from the Quaternary Aquifer System both seaward and landward. Discharge from the Cretaceous Aquifer is expected to be principally seawards.

For further detail, refer to Section 13 of this WAA.

5.9 Surface Water

The following description of surface water for the Site is based on information provided in *Surface Water EES – Plant* (GHD, 2008d), included in *Technical Appendix 43* of the EES.

The Site is within the Powlett River's approximately 500 km^2 catchment which drains the predominant dryland pasture of the South Gippsland Hills' southerly face. The river discharges to the Bass Strait through a dune-controlled swamp system. Waves, tidal processes, and winds shift sand deposits at the river mouth. All contribute to form a sandbar, which periodically closes the river mouth. This can result in the flooding of the river flats on both freehold and public land. The river mouth's sandbar is managed cooperatively by the West Gippsland Catchment Management Authority (WGCMA) and Parks Victoria.

Flood levels are dependent on the complex interaction of a variety of factors that include tidal conditions, wind and wave set-up, storm surges, sandbar conditions, antecedent catchment conditions, seasonal vegetation, rainfall distribution and intensity, and sand bar opening works. Therefore, while the sandbar height and geometry can vary significantly, a height of 3.5 m and a width of 155 m have been found to be the maximum limits at which the Plant Site can remain free of inundation during a 1 in 100 AEP flood event.

Secondary ephemeral channels dissect the coastal plain, including a wide drainage course running north-east to south-west. The floodplain contains a minor seasonal watercourse that drains towards an artificial channel and in turn feeds the Powlett River.

For further detail, refer to Section 12 of this WAA.

6. Project Description

This Section of the WAA describes the relevant components of the Desalination Project. It discusses development of the Reference Project, key elements of the Reference Project and the Variations for which approval is sought. This Section also briefly describes the Options included in the EES (EES Options), which are not included in the scope of this WAA.

6.1 Project Components

The key components of the Project, and their purposes, are set out in Table 6-1. Of particular relevance to this WAA are the Marine Structures and Desalination Plant. Although part of the Reference Project, the Transfer Pipeline and Power Supply are not subject to a works approval.

Table 6-1 Desalination Project components

Project Component	Capacity	Purpose
Marine Structures	200 GL per year	Take in seawater and discharge saline concentrate from the desalination process
Desalination Plant	Plant constructed at 150 GL per year with allowance for expansion to 200 GL per year	Produce fresh water by separating salts and other impurities from seawater using reverse osmosis technology
Transfer Pipeline	200 GL per year	Transfer potable water from the Desalination Plant to the Melbourne water supply system in the vicinity of Cardinia Reservoir
Average Power Demand[2] - Desalination Plant and Transfer pump station - Booster pump station	92 MW – 133 MW 82 MW – 115 MW 10 MW – 18 MW	Provide power supply to the Desalination Plant, transfer pump station and remote booster pump station

6.2 Process for Determining the Project Description

The ‘filtering’ process used to determine the Reference Project and to identify Variations and Options is shown diagrammatically in Figure 6-1.

A wide range of concepts for different aspects of the Project were initially explored. In the first phase of the ‘whole-of-system’ engineering approach to best practice, these concepts were assessed for technical feasibility for the particular Victorian coastal location, geology, water quality, etc. and, if thought unlikely to be feasible, relegated to a ‘no further assessment’ status. The constraints which resulted in these outcomes form part of the Performance Requirements developed for the Project.

[2] Ranges given for 150 GL per year to 200 GL per year Plant capacity

Concepts that survived the 'whole-of-system' feasibility assessment progressed to a second tier for assessment against Project Objectives to determine a short list of concepts that were considered both feasible and environmentally and socially acceptable.

From this short list, choices were made of the component concepts that demonstrated practicality, convenience and cost of delivery in the context of consistency with Project Objectives and ease of integration with other Project components. Best practice considerations were also taken into account in this step. Once properly integrated, through a detailed and lengthy evolutionary process, into a 'whole-of-Project', 'whole-of-life' deliverable, these component concepts became the Reference Project.

A detailed discussion of best practice design considerations is provided in Section 7 of this WAA.

Technically feasible and acceptable concepts other than those adopted in the Reference Project, which also comply with best practice, have continued to receive concept-level analysis and in some instances have been commented upon by the technical and environmental specialists. Where a concept is considered to fall within the scope of the existing risk and impact assessment, it is included as a Variation for which approval is sought in common with the Reference Project. Where a concept falls outside the existing assessment but might be potentially of interest for the Project, it is included as an Option in the EES. No approval is sought for EES Options in this WAA.

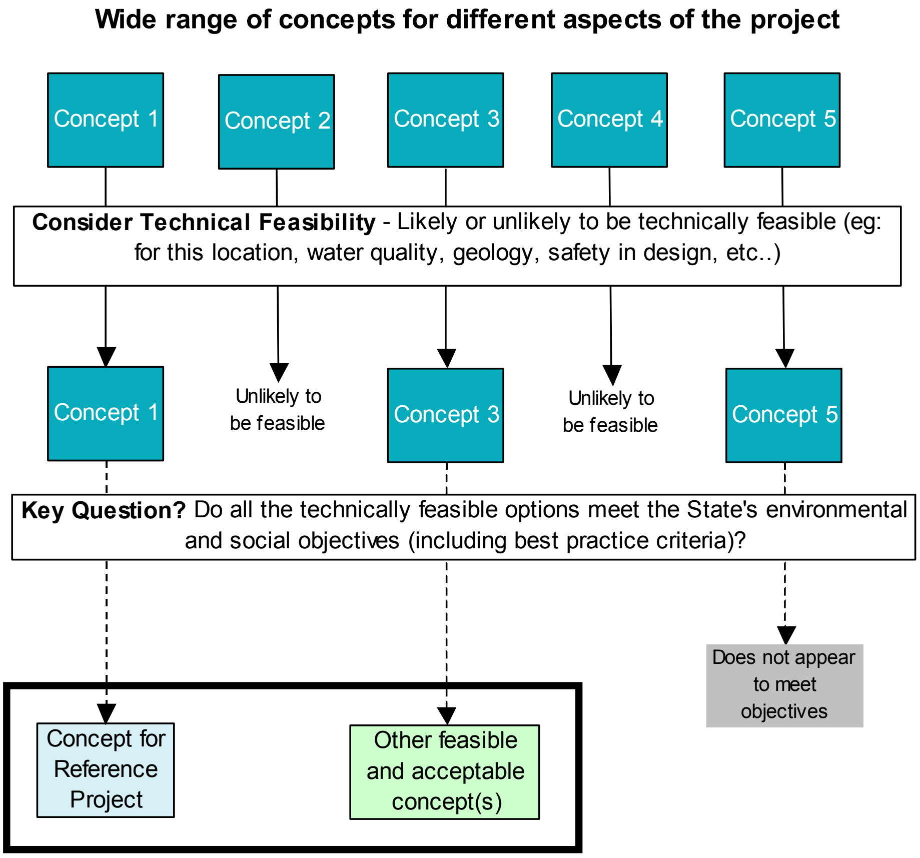


Figure 6-1 Process for considering Options and Variations for the Reference Project

Appendix A outlines the concepts that were considered for Project components relevant to this WAA and indicates which concepts have been adopted for the Reference Project (shown in blue) or as Variations or EES Options (shown in green). Concepts which were perceived not to satisfy feasibility, timing or best practice criteria and did not progress from this process are shown in grey.

Approval is sought for the Reference Project and Variations. Both the Reference Project and Variations will be controlled by the Performance Requirements, to which the Project Company will be bound under the Project Agreement.

6.3 Basis of the Project Description

The subject matter of the WAA, and in effect the Project Description, is based on:

- Performance Requirements (which define the Project);
- Reference Project (which sets out an integrated ‘whole-of-Project’ solution acceptable to the State); and
- Variations (which are within the scope of the impact assessment and this WAA); and

The Performance Requirements, which govern the Project for WAA purposes, are intended to be the basis for any contract with the Project Company, and are discussed further in Section 6.4. The Performance Requirements set the environmental parameters for the Project.

The Reference Project is an integrated response to the Performance Requirements developed by the State. It is used in this WAA to demonstrate the Project's feasibility and ability to achieve acceptable environmental outcomes.

Variations contemplate other design and management solutions which also meet the Performance Requirements and are within the scope of this WAA.

In addition, the EES identifies Options that may, potentially, be of interest to the Project however have not been considered further for technical or commercial reasons, or because they did not appear to offer significant advantages over the Reference Project. These Options have not been assessed in the WAA, however they are matters upon which comment is invited by the EES. Any further process for the Options will be determined by the Minister for Planning prior to any endorsement by the State for utilisation in the Project.

From Section 6.5 onwards, the Reference Project components, including Variations, are described in sufficient detail to convey the nature of the proposed technology, its proposed location and expected footprint and its role within the Project as a whole. Table 6-2 outlines where a description of the Reference Project, and Variations where relevant, can be found for key elements of the Project.

Table 6-2 Guide to description of Reference Project and Variations for key Project elements

Project Component	Key Element	Description of Reference Project	Description of Variations
Marine Structures	Location of Marine Structures	Section 0	Section 6.6.4
	Seawater intake	Section 6.5.4	n/a
	Intake screening	Section 6.5.4	Section 6.6.2
	Marine growth control	Section 6.5.6	n/a
	Concentrate outlet	Section 6.5.5	Section 6.6.3
Desalination Plant	Active onshore screening	Section 6.9.1.3	n/a
	Seawater pump station	Section 6.9.1.4	n/a
	Pre-treatment	Section 6.9.1.5	Section 6.10
	RO process	Section 6.9.1.6	n/a
	Potabilisation	Section 6.9.1.8	n/a
	Waste generation and disposal	Section 6.9.1.14	n/a
	Chlorination facility	Section 6.9.1.12	n/a

Some of the most significant Variations being contemplated relate to the Marine Structures and Desalination Plant and this is shown conceptually in Figure 6-2.

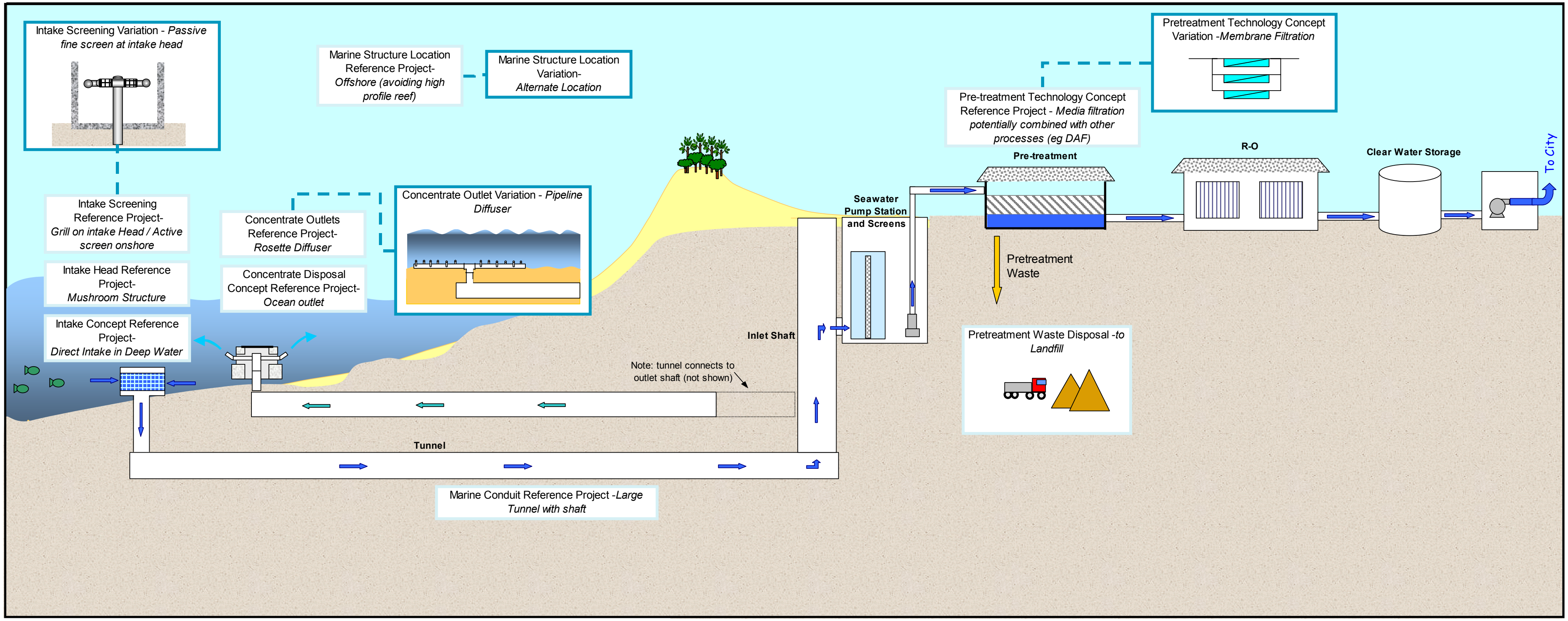


Figure 6-2 Conceptual diagram of the Reference Project (Marine Structures and Plant)

6.4 Performance Requirements

The Performance Requirements in their final form are intended to form the basis of the Government's requirements for Project performance and will be translated into contractual obligations.

The Performance Requirements (as ultimately resolved from the outcomes of the environmental assessment processes) will be used:

- to assess the capacity of a bid project to perform in accordance with the Performance Requirements and the level of that performance; and
- to inform the contractual requirements for performance by the Project Company.

The Performance Requirements are incorporated into the EMF for the Project (refer to Section 17) and embody recommendations for environmental management arising from the environmental impact and risk assessment process.

Conceptually, it is considered that a Project that complies with the Performance Requirements would fall within the WAA assessment and approvals, regardless of the physical configuration of the Project.

The Performance Requirements for each environmental aspect are also presented at the end of each Section of this WAA (where relevant), and a compiled list in provided in Section 17.

6.5 Reference Project for Marine Structures

The Victorian Desalination Project would require structures in the ocean and conduits to deliver seawater to the Desalination Plant and return the saline concentrate (and potentially other waste streams) to the ocean in an environmentally acceptable manner.

In evaluating the different concepts for the Reference Project Marine Structures, the following factors were identified:

- take in seawater from the ocean and deliver it to the Desalination Plant in a way that minimises negative ecological impacts (such as entrainment and impingement of marine biota) supporting the supply of sufficient quality and quantity of seawater;
- dispose of concentrate from the RO process in a way that minimises negative environmental impacts and that the salinity of the feedwater to the plant is not affected by the discharged concentrate;
- limit the biofouling of infrastructure submerged in the marine environment to provide a reliable and consistent supply of seawater to the plant; and
- utilise appropriate technologies that maximise performance of the Marine Structures and freshwater output.

The Marine Structures for the Reference Project are shown conceptually in Figure 6-3.

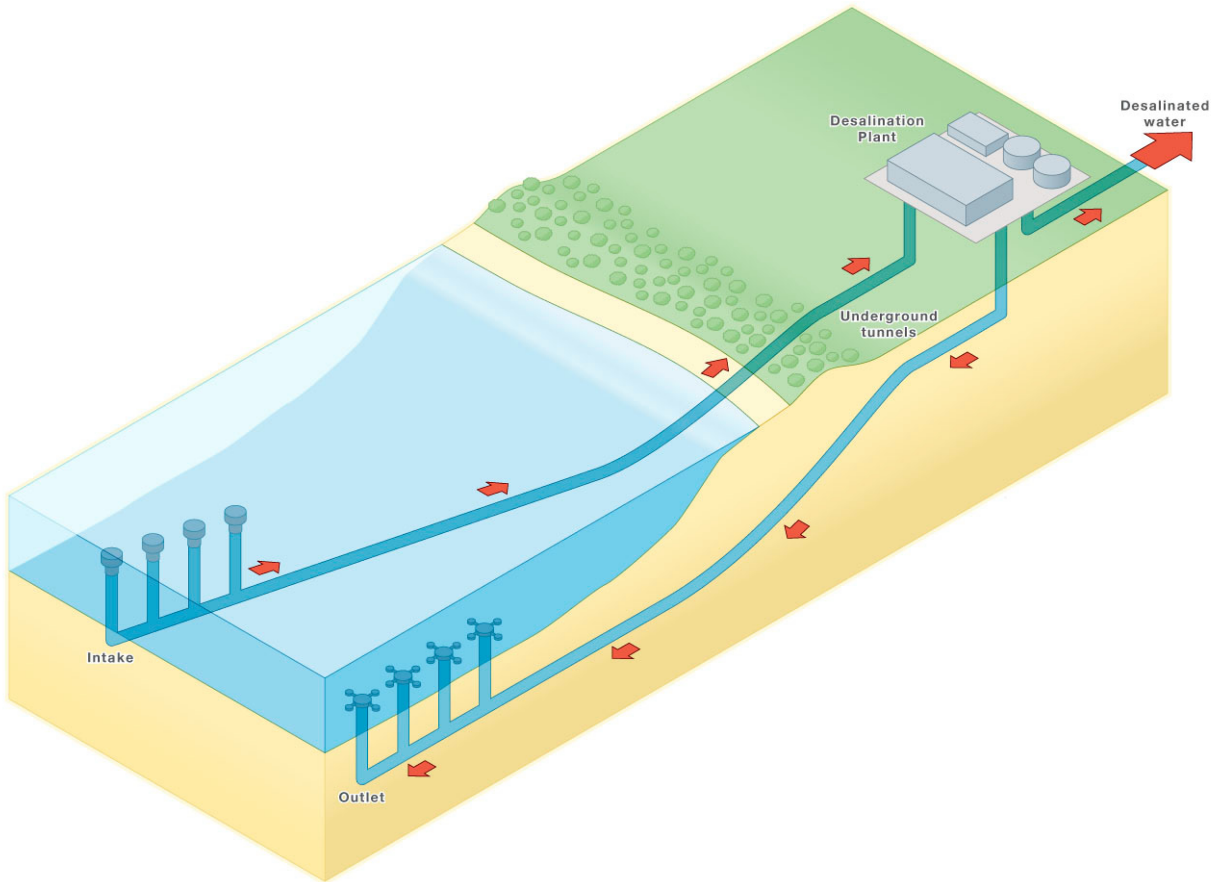


Figure 6-3 Overview of seawater desalination concept

6.5.1 Capacity of Marine Structures

The approximate capacity requirements for the Marine Structures to handle 150 GL to 200 GL of potable water each year and to discharge the saline concentrate created by the RO process, are set out in Table 6-3.

Table 6-3 Approximate capacity of Marine Structures

Indicative volume	Design capacity	
	150 GL per year	200 GL per year
Seawater intake	360 GL per year	480 GL per year
Saline concentrate outlet	210 GL per year	280 GL per year
Potable water	150 GL per year	200 GL per year

6.5.2 Marine Structures Location

The intake and outlet structures may be located anywhere within the marine environment adjacent to the Plant Site, provided that the selected location complies with the relevant Performance Criteria and Requirements (see Section 17). There are certain constraints that limit the available locations. Coastal hydrodynamics, seawater quality, marine ecology, bathymetry, seabed type and other local marine conditions influenced the selection of an appropriate location for the Marine Structures. Siting for the Marine Structures had regard for the risk of entraining marine organisms in the seawater intake and the need to disperse concentrate from the outlet points to avoid impacts of elevated salinity on marine flora and fauna.

These factors have been taken into consideration in the identification of sensitivity areas, where construction of the Marine Structures will not be allowed. The EES and WAA marine studies have identified a suitable area for the location of Marine Structures offshore from the Desalination Plant, such that impacts on areas of high relief reef may be avoided or minimised. The sensitivity areas for construction are illustrated in Figure 6-4. Considerations for the siting of Marine Structures are further discussed in Section of this 7.1 WAA.

The commitment to avoid construction in marine sensitivity areas is enshrined in the environmental Performance Requirements.

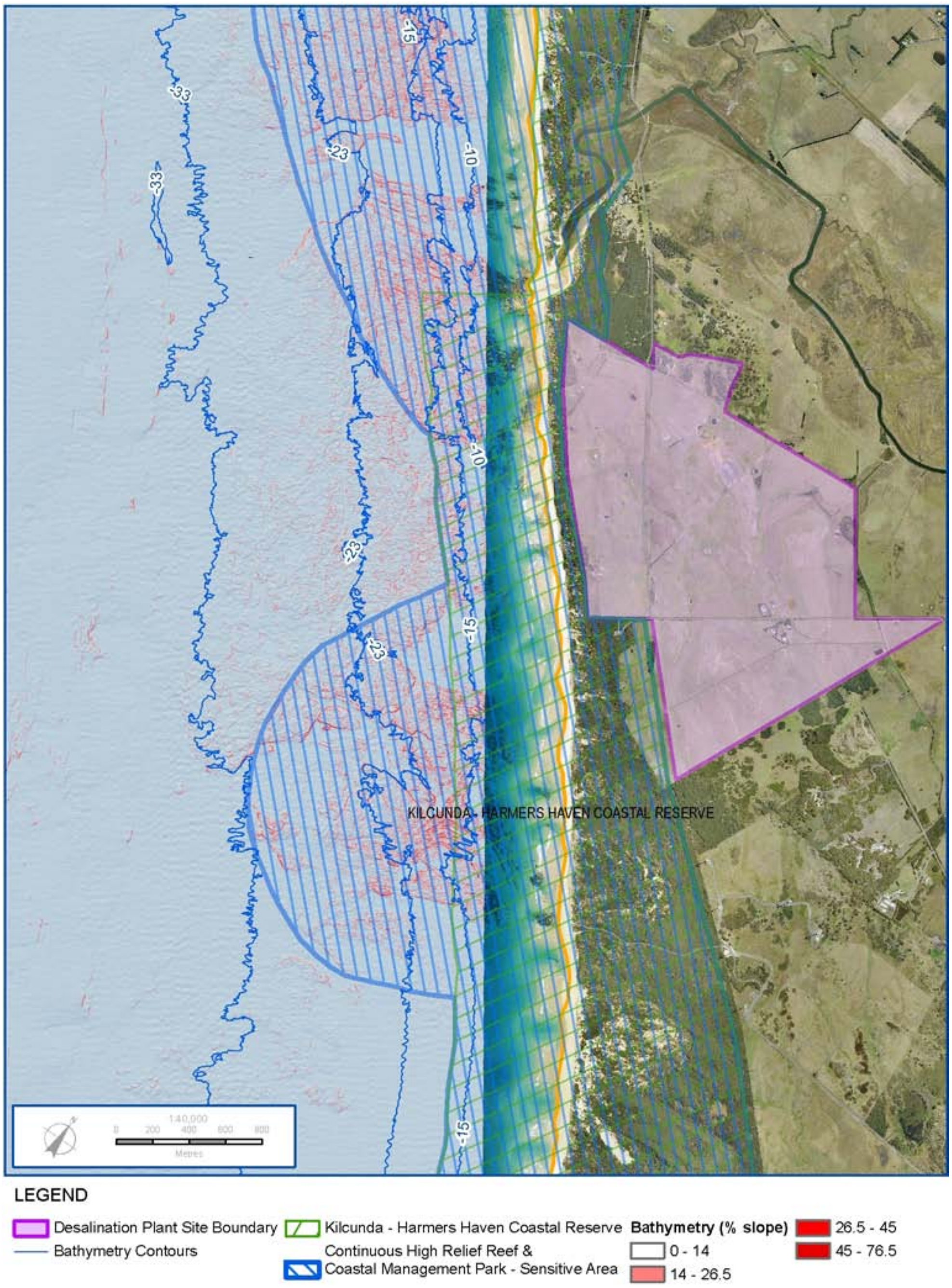


Figure 6-4 Marine Structures sensitivity areas

6.5.3 Underground Structures

The underground structures for the intake and outlet adopted for the Reference Project include:

- onshore shafts;
- launch and backshunt chambers;
- intake and outlet tunnels; and
- stub connection tunnels that link the risers to the tunnel.

These are shown schematically in Figure 6-5 below.

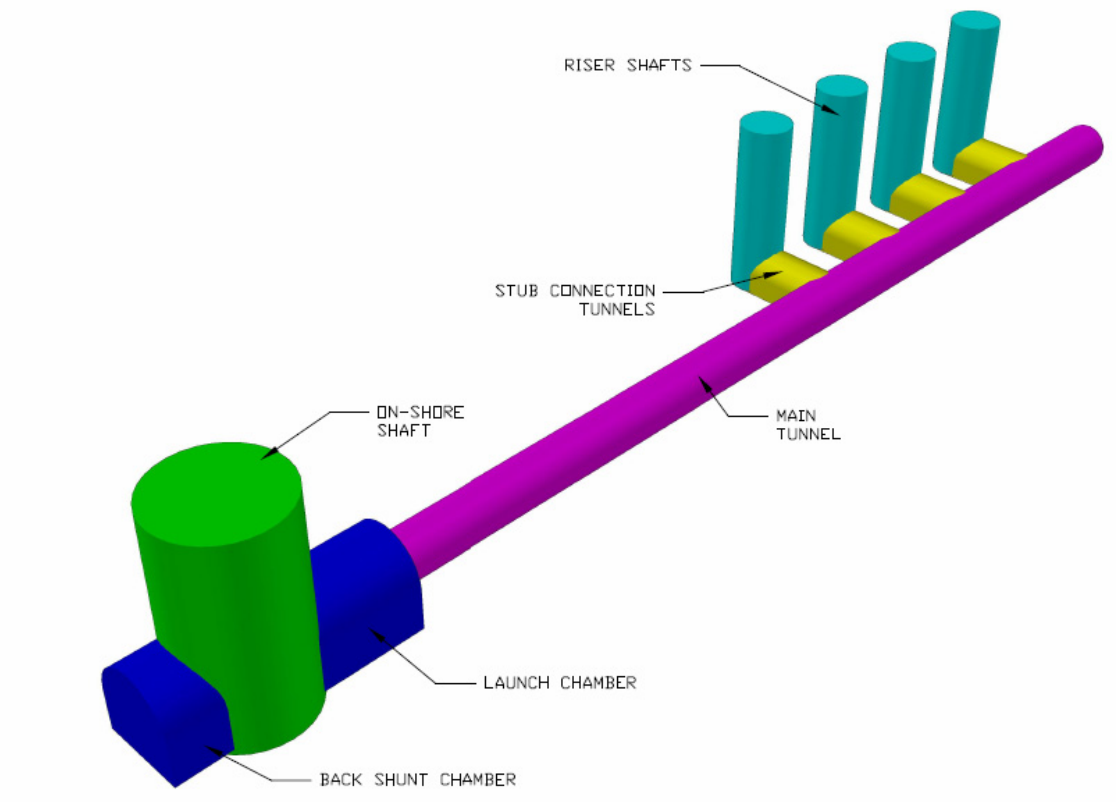


Figure 6-5 Schematic of underground structures adopted for the Reference Project

Onshore shafts

These are land elements that would link the Desalination Plant to the tunnels. The intake shaft would be located near the seawater pumping station. The shafts would be sunk to a depth below ground at the Plant Site (approximately 65 – 70 metres) so that the tunnels, as they extend seawards, would slope gradually upwards but with sufficient clearance below the seafloor to remain in the rock strata.

Launch and backshunt chambers

In the Reference Project, launch and backshunt chambers would be necessary for assembly and launching of the tunnel-boring machine (TBM). The chambers would be constructed from the base of the onshore shafts.

Intake and outlet tunnels

The seawater intake and concentrate outlet tunnels would extend horizontally underneath the coastal reserve and seabed to a distance offshore.

The segmentally lined tunnels would be sloped to enable drainage by pumps in the shaft. Dewatering would be necessary to allow access and maintenance if the need arises. Both inlet and outlet tunnels would be designed to allow periodic inspection and maintenance. Tunnels would be large enough to accommodate the ultimate design capacity for the Desalination Plant of 200 GL per year.

Stub tunnels

The stub tunnels would link the main tunnel to the risers for seawater intake and outlet. The length of the stub tunnels would vary depending on the 'as built' positions of the riser caissons and the main tunnel.

6.5.4 Seawater Intake

In the Reference Project, the intake head structures were designed to begin in water with a depth of approximately 20 metres in order to avoid sediment entrainment, air entrainment and risks to navigation. The intake velocity of the seawater would be controlled by the design and operation of the intake heads and pumps to be lower than natural ocean current velocities, to minimise hydrodynamic effects, and to enable free-swimming marine animals to swim away from the intake stream. The seawater would then be transferred via an underground tunnel to a seawater pump station near the shoreline from where it would be pumped to the Desalination Plant.

The Reference Project intake has been designed with a mushroom-shaped head and with a large cross-sectional flow area at the point of entry, which would narrow as the water progresses towards the riser to the intake tunnel. The effect of this is to make the flow at the intake entrance relatively slow, reducing the tendency for mobile organisms to become entrained and enabling free-swimming marine animals to swim away from the intake stream.

The head would be screened to further reduce impingement of marine biota. A specific grill spacing (100 millimetre horizontal by 100 millimetre vertical or 50 millimetres horizontal by a dimension larger than 100 millimetres should the grill be rectangular) has been adopted in accordance with recommendations made in Section 14.6.13 of this WAA, and this has been captured by relevant Performance Requirements for Marine Structures (refer to Section 14.10). Once past the bar grill, the water flow would accelerate down the narrower riser into the intake tunnel. A schematic of the seawater intake head is shown in Figure 6-6. The Reference Project design of the seawater intake head is shown in Figure 6-7.

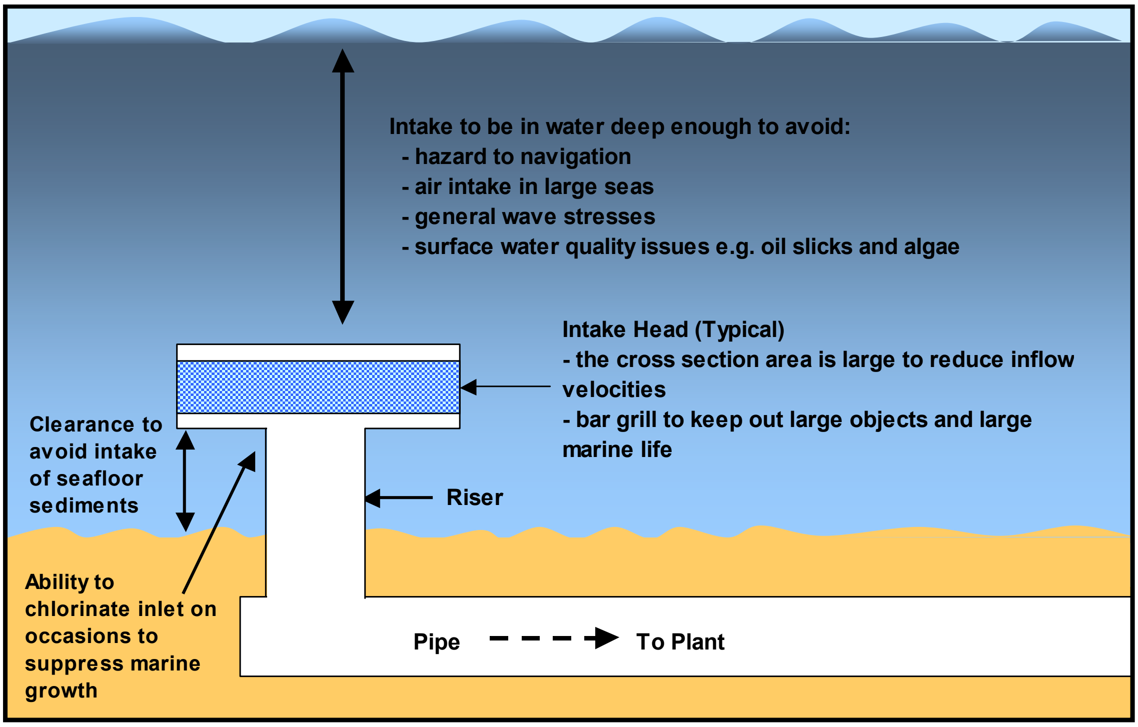


Figure 6-6 Schematic of seawater intake head

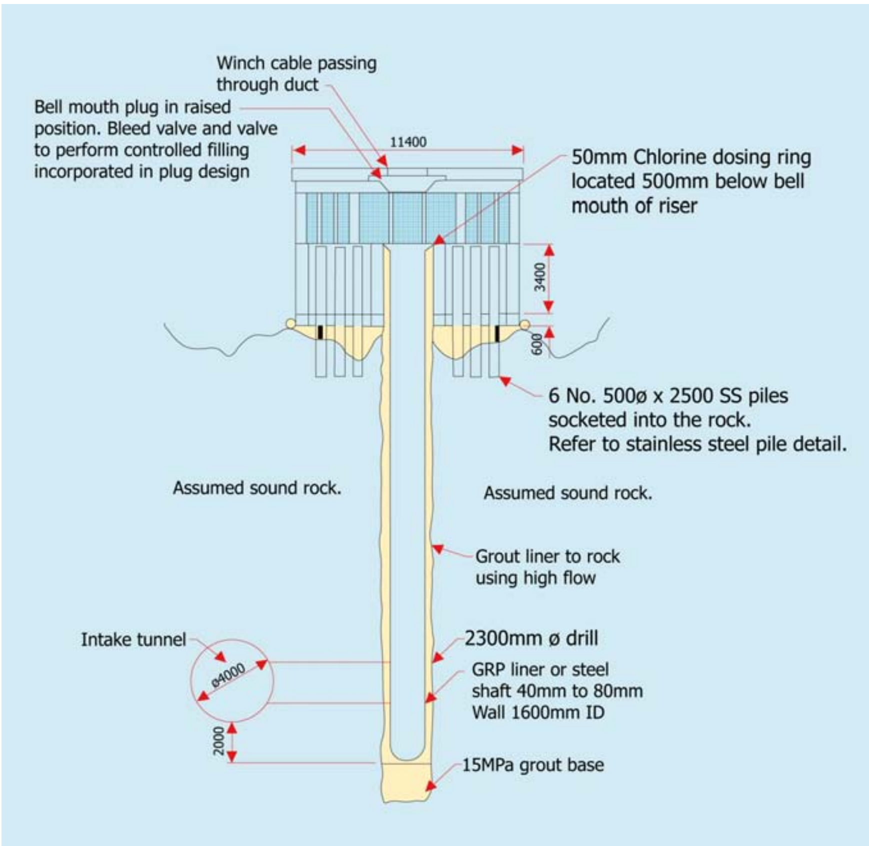


Figure 6-7 Reference Project design for the seawater intake head

6.5.5 Saline Concentrate Outlet

The desalination process generates a saline concentrate stream that is rejected in the reverse osmosis membrane filtration process. The saline concentrate would be approximately double the concentration of seawater but close to the same temperature. It would also contain trace amounts of the chemicals added during the desalination process. For further discussion on the potential constituents of the concentrate stream, refer to the Technical Discussion Paper *DP3 Characterisation of Concentrate*, attached as Appendix C to this WAA.

In the Reference Project, the saline concentrate is discharged to the sea, via gravity, through the outlet tunnel to the outlet diffusers. Rosette-style diffusers have been adopted. The diffuser configuration is designed to maximise the discharge velocity of the concentrate and to allow rapid dispersion mixing of the concentrate with the surrounding seawater.

The Reference Project approach was selected because it minimises the number of structures required to achieve concentrate dispersion. Additionally, this approach has been adopted for other plants of similar scale in Australia.

The Reference Project has adopted the following characteristics:

- diffuser Heads (known as rosettes);
- located to avoid high profile reef
- cross-shore orientation;
- 4 rosettes for 150 GL per year plant and 6 rosettes for 200 GL per year plant
- 4-nozzles per rosette;
- spacing at 50 m centres;
- discharge angle of the nozzles of 50 degrees;
- diameter of the rosette structure of 8 m; and
- diameter of the circle of nozzles of 6 m.

A typical rosette-style outlet structure is shown in Figure 6-8. The concept design for the Reference Project is shown in Figure 6-9.

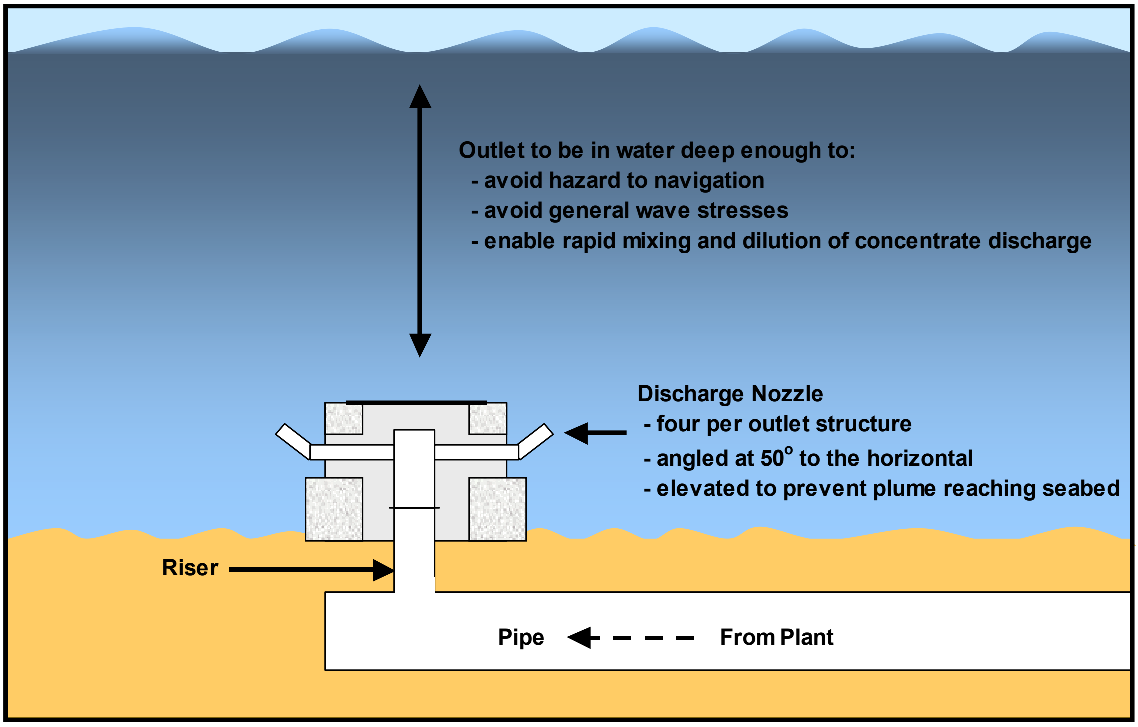


Figure 6-8 Schematic of rosette-style outlet diffuser

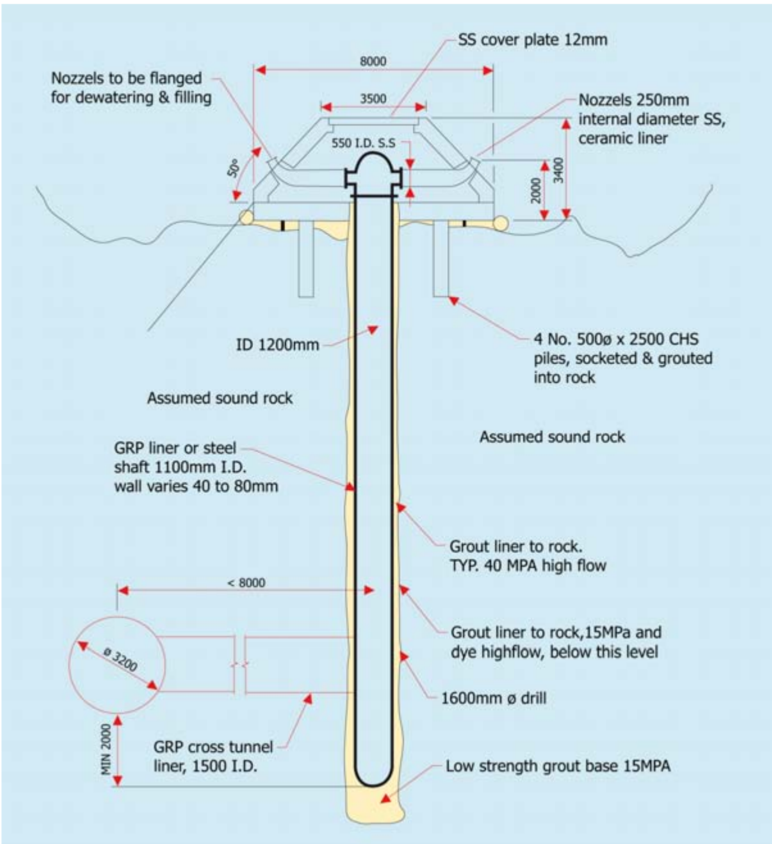


Figure 6-9 Concept design for the Reference Project concentrate outlet

The concentrate would discharge at a velocity driven by the gravity feed from the Desalination Plant. Higher nozzle velocities produce more effective dilution, but there are limitations to ensure the plume is not visible from the surface. If the Plant is not operating at full capacity, a seawater makeup system could be used to 'top-up' the discharge flow volume to maintain the exit velocity required to achieve adequate dilution. Alternatively, diffuser nozzles can be closed off by divers although their access would be limited to infrequent, calm weather.

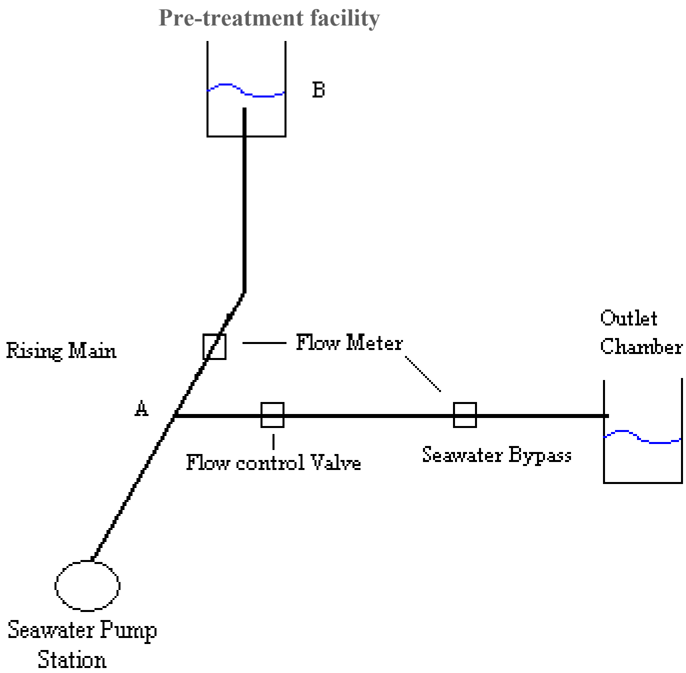


Figure 6-10 Schematic diagram of the seawater bypass system

For each module the seawater bypass would comprise a flow control valve, two flow meters and pipe work from the rising main to outlet chamber. See Figure 6-10 above. The flow control valve would operate according to the required flow at each of the two flow meters.

During normal operation, the module would be at full capacity and there is no need for additional bypass flow to the outlet chamber. The flow meter on the seawater bypass would be required to read zero and the flow control valve would then shut completely to achieve this. The entire flow would travel up the rising main and into the treatment plant.

On occasions where make-up flow is required in the concentrate outlet to maintain outlet diffuser velocity, flow would be directed to the seawater bypass. The flow control valve would open from its normally shut position and allow water to travel down the seawater bypass. The flow control valve would open according to the needs of the seawater bypass system and the pump station would deliver that flow including the flow required at the treatment plant.

Similar to the seawater intake heads, the outlet diffusers would need to be in water deep enough to allow dispersion of the concentrate plume in the water column and to prevent wave damage and avoid risks to navigation.

The dilution achieved by the diffuser design coupled with the location of the concentrate outlet away from the seawater intake means that the feedwater to the Plant is not significantly impacted by the discharge of concentrate.

6.5.6 Marine Growth Control

The concentrate from the outlet structure would typically be concentrated to around twice that of seawater salinity, and is flowing outwards. Therefore biofouling is unlikely to be a problem in the outlet structure.

However, the intake structure — which is dark, relatively free of predators and has a constant flow of seawater — is an ideal environment for the growth of various attaching organisms such as bacteria, bryozoans, sponges, mussels and barnacles. The build-up of this growth, or biofouling, tends to increase the roughness and gradually reduce the diameter of the pipe, restricting the flow of water and increasing the energy required to pump it.

The typical antifouling systems are:

- a direct chlorination[3] dosing system; or
- a combined copper / chlorine dosing system.

These two systems are very similar with regards to project-specific constraints and financial implications. Both systems are used for Australian and international applications for intakes. A detailed review is likely to be conducted on both these techniques by bidders to determine the more viable system for this Project.

The Reference Project includes intermittent dosing of the intake tunnels and risers with chlorine in liquid form (sodium hypochlorite) to minimise marine growth from the primary bacterial layer so as to prevent the formation of secondary and tertiary layers of biofouling. This process is used on many seawater intake systems. The intake water would be de-chlorinated before it is fed through the RO process so that it does not damage the RO membranes. This process means no free chlorine is present in the RO reject stream. An indicative location of chlorine dosing within the intake system is shown in Figure 6-6 and Figure 6-7.

The chlorine dosing ring would be located 500 mm below the bell mouth of the riser. Pilot testing and the final detailed to design would identify the required chlorine dose rate and frequency.

In the long term, it is possible that dry inspection and maintenance of the intake tunnel and outlet would be required. This is a difficult operation and it should be avoided until necessary. The proposed chlorine dosing system and the copper / chlorine dosing system of the intake tunnel is expected to reduce the need for “dry” maintenance.

Chlorine dosing of the inlet pipes is considered unlikely to affect marine communities as dosing occurs to seawater that already passed the slow velocity zone of the inlet structure. Thus, only organisms that have already drawn into the intake are likely to be affected.

[3] Chlorination occurs within the “high velocity” part of the intake pipework.

Alternative marine growth mitigation methods must be considered for the intake head upstream of the dosing location. Options for marine growth mitigation of the intake head upstream of the dosing location include:

- use of non-toxic antifouling coating (Teflon or silicone based) on the inside of the intake head and on the intake grill; and
- minimisation of sharp edges, which minimises eddies hence reducing the opportunity for marine growth. The internal corner of the intake head could be rounded and round bars used for the intake grill.

Note that coatings would be affected by sand scouring and further investigation would need to be undertaken to determine the maintenance of this methodology.

6.5.7 Dimensions and Sizes

The following table (Table 6-4) sets out the dimensions and sizes for the key components of the Marine Structures in the Reference Project. The values provided are consistent with the ultimate Project capacity of 200 GL per year.

Table 6-4 Summary of key dimensions and sizes for Marine Structures in the Reference Project

Marine Structure	Key dimensions and sizes for 200 GL per year Plant capacity
Intake/outlet tunnels	Design life – 100 years Intake tunnel diameter – 4 m Outlet tunnel diameter – 3.2 m Intake tunnel length – approx. 1.25 km Outlet tunnel length – approx. 1.5 km Distance between tunnels – varies, but is approx 500 m at the sea ends Flow velocity in tunnels – approx 1.5 m/s
Intake/outlet shafts	Design life – 100 years Design wave ARI – 1 in 2 000 years Diameter – 10 m Depth of shafts below ground level – 65 m to 70 m
Intake/outlet risers	Intake diameter – approx. 1.6 m internal Outlet diameter – approx. 1.1 m Chlorination of intake – 1 hour per day Chlorination dose – 10 mg/L

Marine Structure	Key dimensions and sizes for 200 GL per year Plant capacity
Intake heads	Design life – 100 years for the main structure (less for some items) Design wave ARI – 1 in 2 000 years Number of heads – 4 Diameter of heads – 6 m Top height of heads above seafloor – approx. 8 m Base height of heads above seafloor– 4 to 5 m Top distance below sea surface – >10 m Seawater depth – approximately 20 m Flow velocity at entrance grill – 0.1 to 0.15 m/s Bar grill spacing 100 mm horizontal by 100 mm vertical or 50 mm horizontal spacing of vertical bars
Outlet diffusers	Design life – 100 years for the main structure (less for some items) Flow velocity from diffuser nozzles – 6-7 m/s for normal operation conditions Rate of discharge – 10.5 m^3/s Seawater depth – approximately 20 m Diffuser height above seafloor – 2 m
Rosette-style diffuser	Number of rosettes – 6 Number of nozzles – 4 per rosette Spacing at 50 m centres Discharge angle of the nozzles - 50 degrees Diameter of the rosette structure - 8 m Diameter of the circle of nozzles – 6 m

6.6 Marine Structure Variations

Four Variations are included within the scope of the WAA in relation to:

- multiple smaller conduits in place of large marine conduits with potential for pipes placed on the seabed;
- passive fine screens at intake head;
- pipeline diffuser; and
- alternate locations for the Marine Structures.

6.6.1 Multiple Smaller Conduits / Pipes on Seabed

A Variation for the Marine Structures would be to construct smaller multiple tunnels to extend from the Plant to the structures. A range of different construction techniques such as horizontal directional drilling, micro-tunnelling, pipe-jacking and other might be used. These techniques all lead to the same result of a smaller diameter hole lined with some form of pipe.

The conduits could extend either to the points where the inlet and outlets would be located, or, alternatively, could connect to pipes running above the seafloor outside of the marine sensitivity area. These pipes could then extend to the location of the inlets and outlets. These Variations are presented schematically in Figure 6-11 and Figure 6-12.

An assessment of potential environmental impacts arising from the construction of marine conduits (including multiple smaller tunnels and shafts) is provided in *Section 16.3* of the report for *The Victorian Desalination Project EES - Marine Biology* (CEE, 2008).

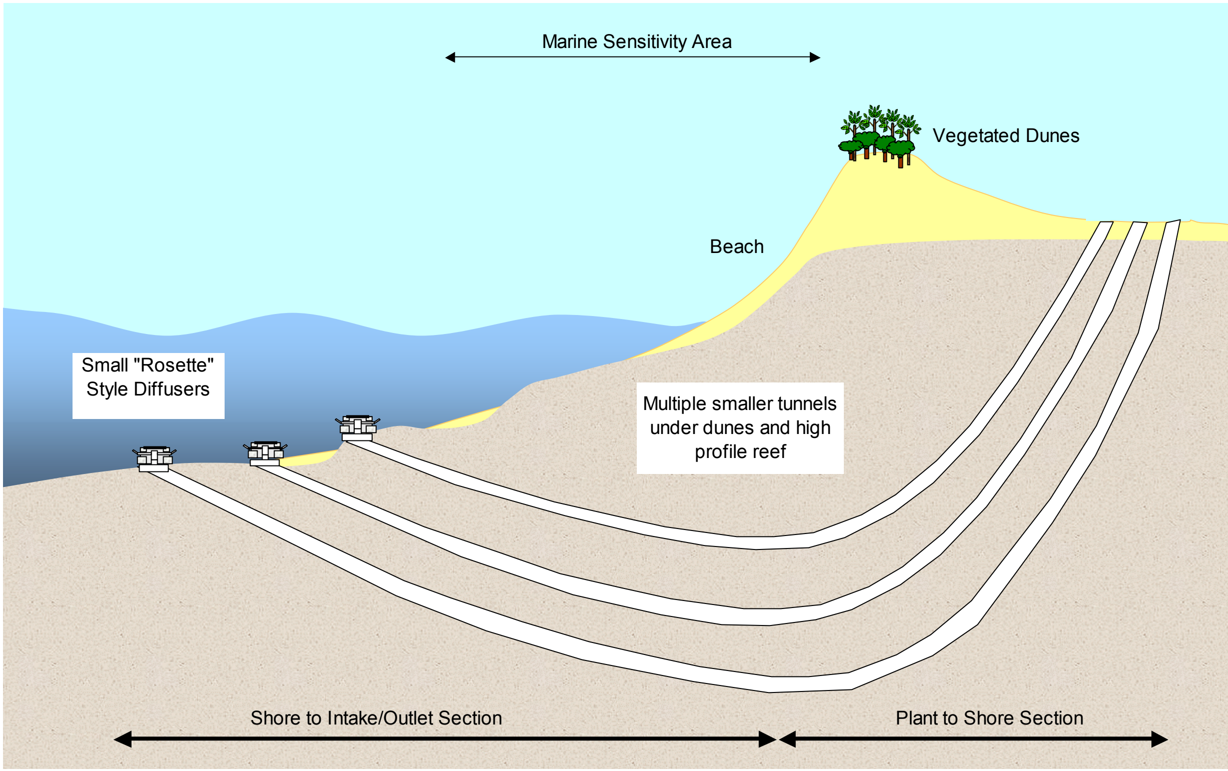


Figure 6-11 Multiple smaller pipes Variation schematic

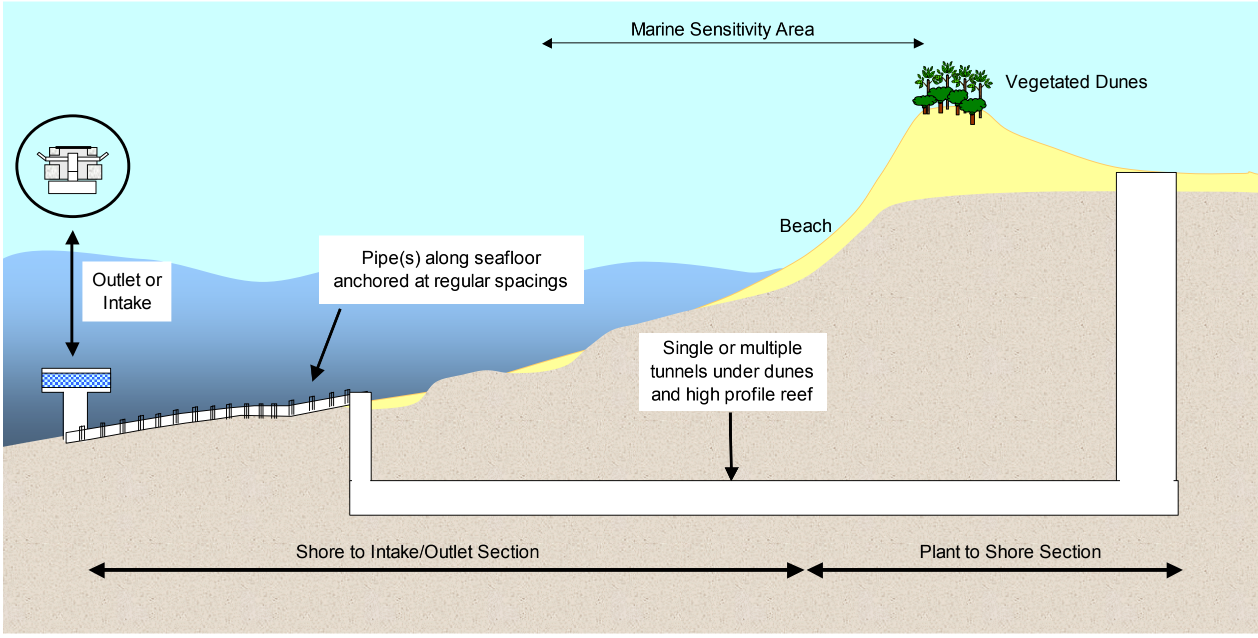


Figure 6-12 Tunnels / conduits with pipes on seabed Variation schematic

6.6.2 Passive Fine Screens on Intake Head

A Variation to the intake system is to construct a passive screening system at the intake head. In this Variation, a fine screen with screen openings of approximately 0.5 to 10 millimetres would be fitted to the intake structure to reduce entrainment in the intake stream. An offshore passive screen at the intake head would filter a higher quantity of marine biota out of feed water and would produce lower level of waste onshore. It would require air backwashing to dislodge marine biota and particles caught in the mesh. In order to accommodate the require intake flow, it is likely that multiple passive screen units would be required if this Variation were adopted.

Fine inlet screens have practical challenges given the marine environment and the scale of the Project. Air backwashing might pose a navigation hazard and the requirements for regular maintenance might prove to be impractical. Given the lack of proven experience of this scale in marine environments like the Project area for passive fine screens, the Reference Project adopted offshore grills and fine onshore screens.

An assessment of potential environmental impacts associated with passive screening at the intake head is provided in *Section 18* of the report for *The Victorian Desalination Project EES - Marine Biology* (CEE, 2008).

6.6.3 Pipeline Diffusers

A Variation considered for the concentrate outlet structure is a pipeline-style diffuser. This diffuser may involve either a series of smaller and/or shorter pipelines or one large pipeline and could be orientated either parallel or perpendicular to the beach at a site further offshore. These pipelines would contain nozzles, usually at an even spacing.

There are several aspects of the pipeline diffuser design including:

- orientation of the pipelines (e.g. longshore or offshore);
- number of pipelines;
- number of nozzles; and
- horizontal angle of the nozzles, i.e. neighbouring nozzles usually 'point' in opposite directions.

Pipeline diffusers are constructed using similar techniques to rosette-style diffusers and provide similar performance. All pipes would require permanent weighting and anchoring which could be achieved by a number of approaches including concrete collars, anchor ties or other methods.

A suitable pipeline-style diffuser based on the above design elements may be selected and is considered a viable Variation to the Reference Project. This concept is shown in Figure 6-13.

This kind of linear arrangement of nozzles could also be engineered with a number of smaller conduits connected to individual heads. Regardless of the construction approach, these methods all use the same functional design of high-velocity nozzles.

The assessment of potential environmental impacts associated with discharge of saline concentrate has been based upon a near-field and mid-field safe dilution requirements. The Reference Project incorporates a rosette style diffuser that achieves these requirements. The ability of a pipeline style diffuser to meet the dilution requirements is discussed in Section 14.5.6.1 of this WAA. The environmental performance of the ultimate outlet design must comply with environmental Performance Requirements (see Section 17).

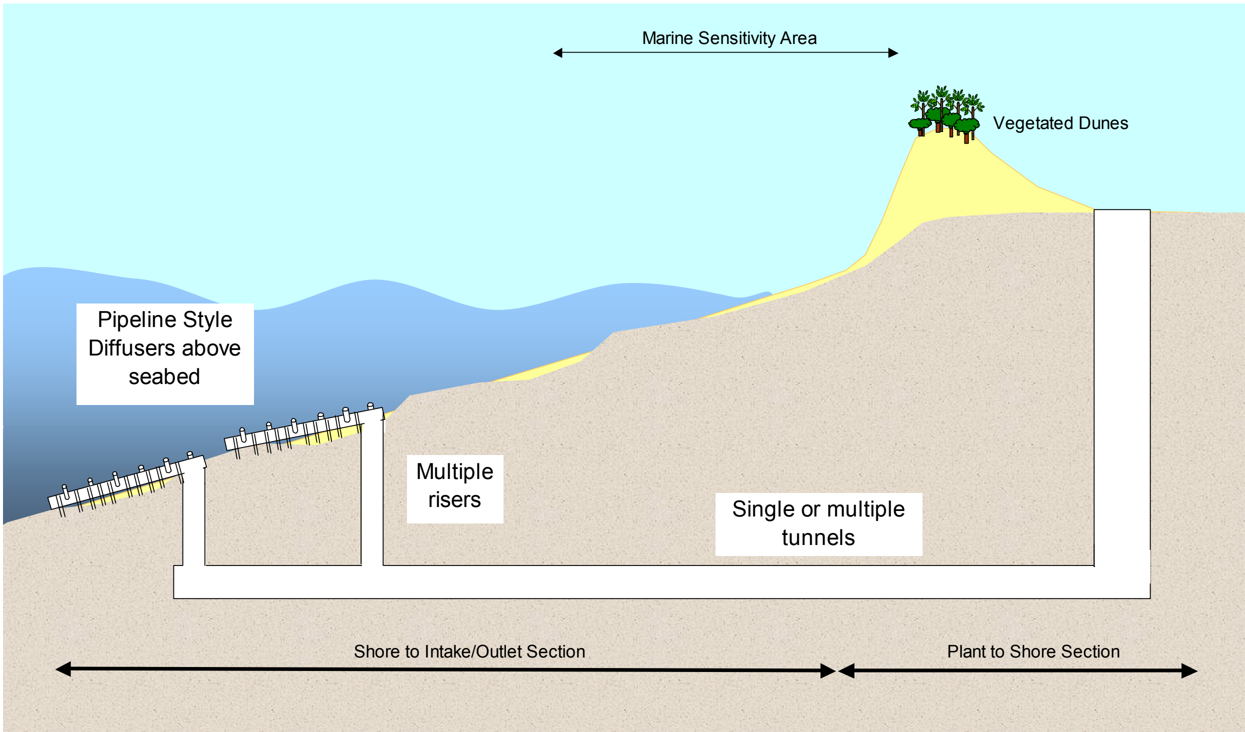


Figure 6-13 Pipeline-style diffuser concept

6.6.4 Marine Structures Locations

Subject to technical feasibility and compliance with the Performance Requirements relating to environmental impacts, alternative locations and alignments of the Marine Structures to those adopted in the Reference Project (including their extension further out to sea) are possible and acceptable. The Marine Structures could be placed at locations other than the Reference Project location, on the low profile reef or sand, such that their impacts during construction and operation fall outside the identified marine sensitivity areas (shown in Figure 6-4). The Performance Requirements contain a requirement for the Project to obtain approval from the EPA for a mixing zone for the discharge of the saline concentrate that avoids the marine sensitivity areas, but could be anywhere else offshore.

6.7 Marine Structure Options for the EES

6.7.1 Indirect Intake – Seabed Filtration

This EES Option involves a sub-surface infiltration gallery intake system consisting of a submerged slow sand media filter constructed on the bottom of the ocean, which is connected with pipelines or tunnels to a series of intake wells located on the shore.

Infiltration intakes would be constructed by excavating the seafloor to avoid low depth to install intake piping of wells and perforated pipes buried at the bottom of the ocean floor. Filter sand would then be filled in above. During operation approximately 25 millimetres of sand would be removed from the surface of the filter bed every 6 to 12 months for a period of several years, after which it would be replaced with new sand to its original depth.

Seawater would be filtered through the engineered sands and gravel, which minimises the potential for entrapment and impingement of marine biota and reduces the need for chemical dosing in the pre-treatment phase, thereby in turn reducing the volume of pre-treatment waste generated.

A subsurface infiltration gallery intake system is used at the 50 ML/day desalination plant at Fukuoka, Japan. The filter has an area of approximately 2.9 hectares and is 11.5 metres deep. A conceptual image of the Fukuoka plant is presented in Figure 6-14.

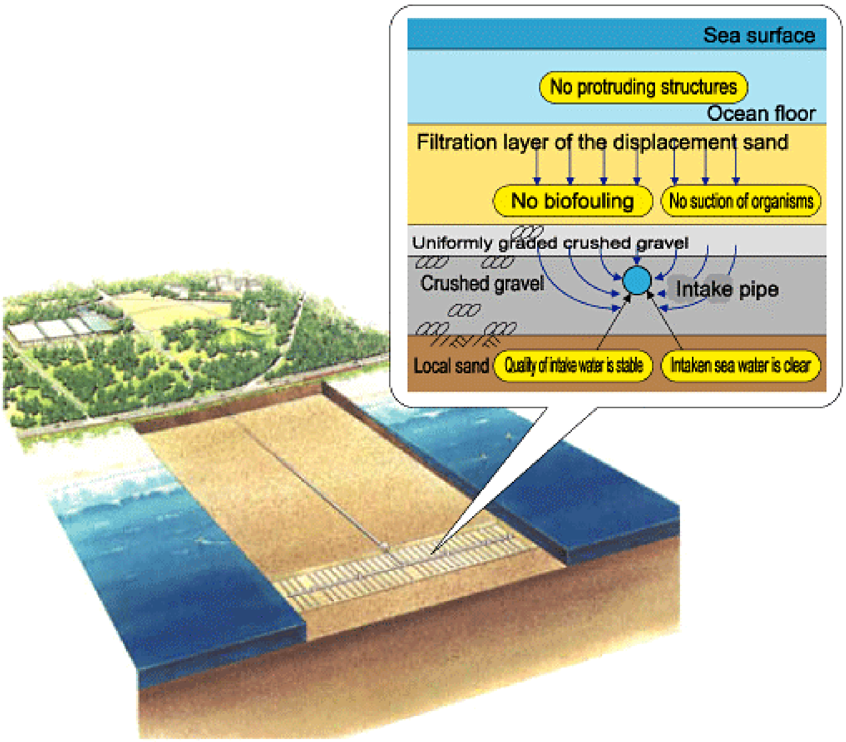


Figure 6-14 Fukuoka seabed infiltration gallery concept[4]

Note: this cross-section from the Fukuoka seabed infiltration system appears to show impacts on the beach. This is not permitted for the Victorian Desalination Project.

Key considerations for the gallery intakes used in the seabed filtration system include:

- Infiltration galleries are typically considered when conventional wells cannot be used due to unfavourable hydrogeological conditions (i.e. low permeability or small beach thickness);
- Seawater is filtered through an engineered media (sand and gravel) as it is being collected thereby reducing pre-treatment requirements;
- Construction requires excavation of large areas of the seabed;
- Viability of engineered sub-surface offshore infiltration intakes is uncertain, as they have only been used in one instance for a large-scale plant (Fukuoka, Japan – 50 ML/d plant capacity);
- Viability for use for large-scale plants has not been proven and may be unlikely due to the large area of constructed filter bed and associated spoil volumes. This would need to be located in an identified low impact marine area such as existing sand beds; and
- Sub-surface intakes may cause entrainment of small marine life (such as plankton and larvae) inside the sand substrate below the bottom of the ocean floor. Unless there is a natural mechanism, such as wave action, to scour and frequently flush the bottom ocean floor substrate and release trapped marine biota, this marine biota would be lost from local ecosystems.

[4] Source: Fukuoka District Waterworks Agency, 2008

6.7.2 Shore to Intake/Outlet Conduits: Tunnel Part Way and Pipes Part Way –Trenched

An EES Option identified for the design of the conduits from the shore to the intake/outlet structure are tunnels part of the distance followed by pipes trenched into the seabed (beyond the marine sensitivity area).

The EES Option envisages tunnelling the intake and outlet pipes from the Desalination Plant to beyond the high relief reef/coastal reserve and then a pipe would be trenched to the seabed surface on the low reef/outside coastal reserve. This is shown schematically in Figure 6-15.

The surface pipe could be laid in a trench constructed along the seafloor. The trench would need to be constructed prior to installation of the pipe. As geotechnical information suggests that the seabed may be unsuitable for dredging, trenching might require drill and blast construction methods or the use of an excavator from a temporary jetty deck or other structure. This would only be possible up to certain water depths.

It is likely this would involve the pipe being either dragged or floated into place and then backfilled with rock or other similar material. While construction of a trench would cause significant short-term impact to the existing seabed, maintenance of the flat seabed profile reduces the risk of interference with coastal processes and rock backfilling may provide colonising opportunities for reef habitat.

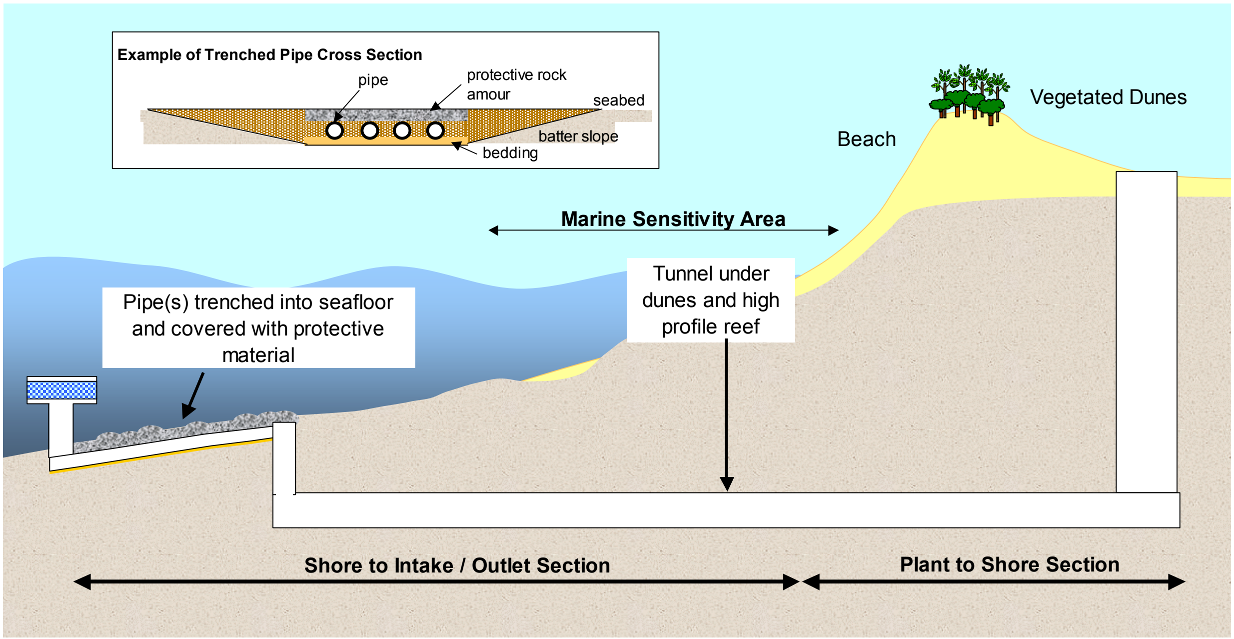


Figure 6-15 Tunnels and pipe Option - Pipe trenched into seafloor

6.8 Summary of Reference Project, Variations and EES Options for the Marine Structures

The key infrastructure elements of the Reference Project and Variations being contemplated in this WAA, along with EES Options for Marine Structures are shown in Figure 6-16 and Table 6-5.

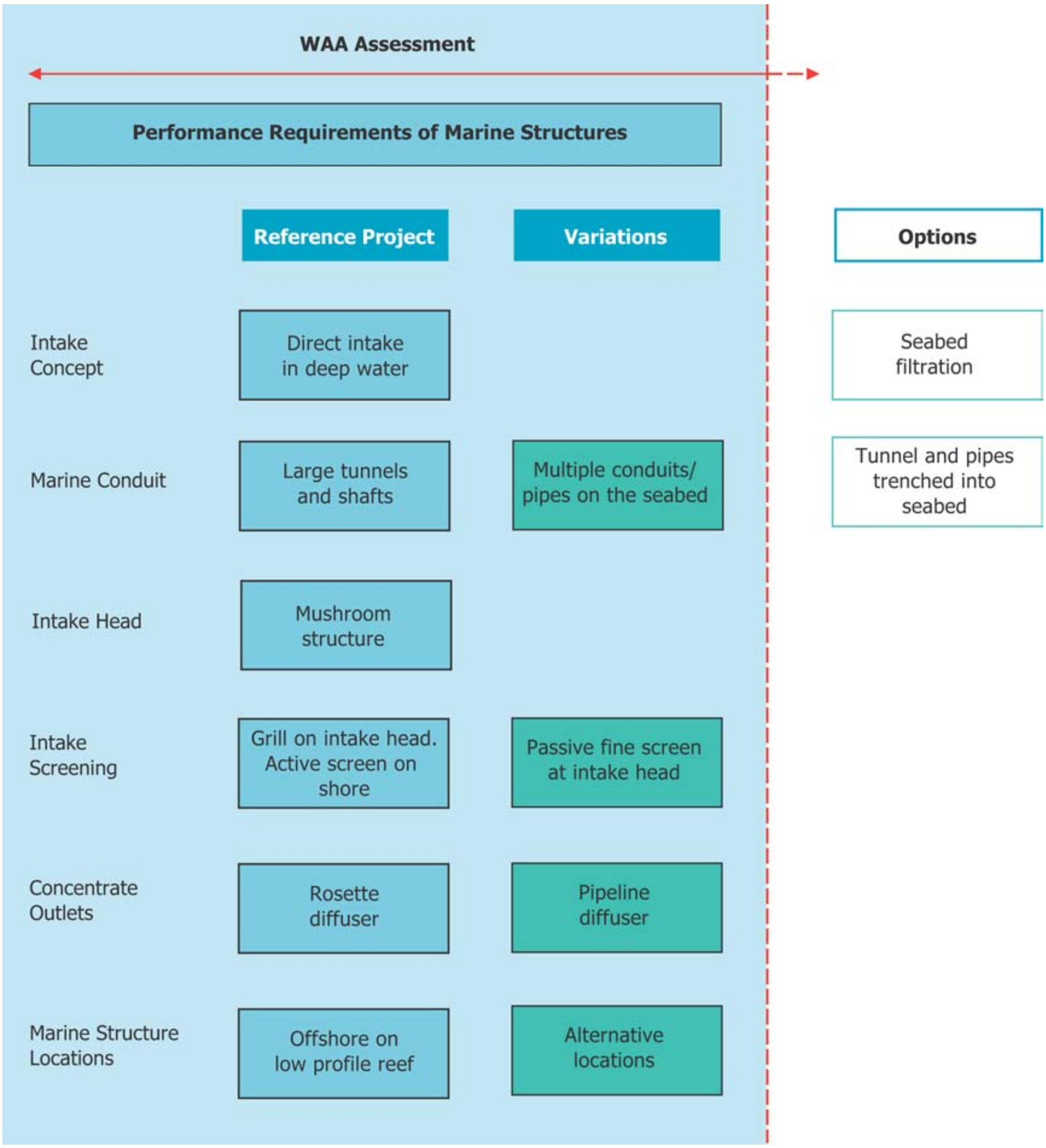


Figure 6-16 Reference Project, Variations and EES Options for the Marine Structures

Table 6-5 Reference Project, Variations and EES Options for the Marine Structures

Key elements	Reference Project	Variation	EES Options
Intake concept	**Direct intake in deep water** Intake concept draws into the plant water from above the seafloor via an intake head structure offshore i.e. outside the wave zone.		**Indirect - seabed filtration** A sub-surface intake constructed in deep water that draws water into the Plant via a filter that is constructed in the seabed.
Marine conduits	**Large tunnels and shafts** Two shafts are constructed onshore (one for each tunnel) which allow the tunnel-boring machine to descend to the required depth of the tunnels, which extend from each shaft.	**Multiple smaller conduits/pipes on seabed** Multiple tunnels or a series of pipes could be constructed rising to intersect with the seabed and through to connect with the intake and outlets. In addition, pipes could then be connected and run along the seabed to connect to intakes or outlets.	**Tunnel and pipes trenched into seabed** Tunnels extend from the Plant Site under the dunes, beach, and wave zone then risers connect the tunnels to a series of pipes that are trenched into the seabed out to the required depth.
Intake head	**Mushroom structure** Intake structure draws in seawater horizontally.		
Intake screening	**Grill on intake head** **Active screen onshore** Intake mushroom head with grill size to reduce entrainment of larger marine biota.	**Passive fine screen at intake head** Passive fine screen on mushroom Intake head to reduce entrainment. Requires air backwashing.	
Concentrate outlets	**Rosette diffuser** A number of diffuser heads are connected to tunnel risers. On each head are a number of nozzles angled to avoid the plume reaching the seafloor. The diffuser heads are evenly spaced along the end section of the tunnel.	**Pipeline diffuser** Connected to a tunnel riser is either a number of small pipes or a large pipe that extend outwards above the seafloor. Each pipeline has a number of nozzles angled to avoid the plume reaching the seafloor.	
Marine Structure locations	**Offshore on low profile reef** Location offshore away from high profile reef.	**Alternative locations** Location offshore in alternative location on low profile reef or on sand in deeper water.	

6.9 Reference Project for the Desalination Plant

The Desalination Plant will produce fresh drinking water from seawater by separating salts and other impurities from the seawater. It is the centrepiece of the Desalination Project and will contribute an initial 150 GL per annum, with potential to expand to 200 GL per annum, of potable water to Melbourne's water supply.

The Reference Project for the Plant embodies both:

- an engineered solution (i.e. it contains a suite of inter-active and compatible technologies); and
- architectural considerations (i.e. it seeks to address the impacts of the infrastructure on landscape and local amenity. However, these considerations are beyond the scope of the WAA).

For this reason, the Reference Project for the Plant is discussed in two parts: the first concentrating on Plant engineering (including waste disposal) and the second concentrating on Plant design. This in turn is followed by an outline of construction and operation methodologies.

6.9.1 Engineering

6.9.1.1 Modular Capacity

The Reference Project is based on three indicative parallel modules with each module producing a third of the initial Plant capacity (50 GL per year). Allowances have been made in the Site layout for a fourth module to be built at a later stage to achieve an ultimate Plant capacity of 200 GL per year. However, the Reference Project is indicative only and other modular solutions may be proposed by the Project Company.

Benefits of this staged module approach include:

- ability to construct the individual modules in parallel thereby reducing construction time;
- ability to maintain some water supply in the event of major failure of one module;
- ability to ramp the Plant up and down by turning on/off individual modules; and
- ability to reduce visual impact as buildings will generally be smaller and more easily blended into the landscape.

6.9.1.2 Process Sequence

Seawater from the ocean intake would be screened and pumped to the Plant RO modules to undergo desalination. The key elements of this process would be:

- screening of influent seawater;
- seawater pump station (to lift screened water to the pre-treatment plant);
- pre-treatment;
- RO desalination;
- potabilisation;
- clear water storage; and

◗ transfer pump station (to transfer clean water to the Transfer Pipeline).

An indicative process flow diagram of the treatment process for the Reference Project is shown in Figure 6-17.

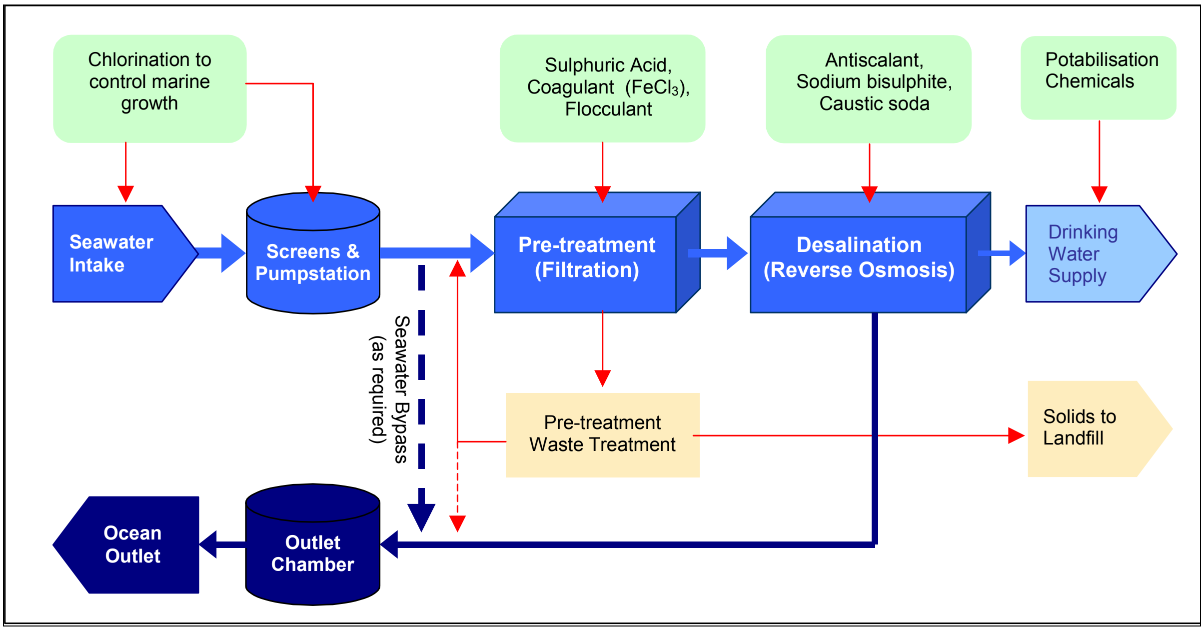


Figure 6-17 Indicative process flow diagram

A description of each of these elements appears below. Disposal of wastes from these processes is discussed separately later in Section 6.9.1.14.

6.9.1.3 Active Onshore Screening

A travelling band dynamic self-cleaning screen would be employed to screen influent seawater. Travelling band and drum screens operate in a similar manner. Examples of travelling band and drum screens are presented in Figure 6-18.

Figure 6-18 Examples of travelling band and drum screens [5]

[5] Source: (left) Perrier Sorem, (accessed June 2008), (right) Beaudry Corporation, (accessed June 2008).

Active travelling band screens have a smaller physical footprint, which makes them easier to accommodate underground in the Reference Project.

More details on the active onshore screening adopted for the Reference Project are provided in Section 11.3.1.

6.9.1.4 Seawater Pump Station

Once screened, the water would be lifted by the seawater pump station from below sea level to a height above sea level, at which the seawater would be able to flow through the pre-treatment plant via gravity.

The seawater pump station would be arranged on a modular basis corresponding to the Plant configuration, i.e. separable portions that service the 50 GL per year plant modules.

6.9.1.5 Pre-treatment Process

The pre-treatment process would:

- remove turbidity and suspended solids;
- manage risks from human activities such as oil leaks from shipping; and
- manage risks to product water quality from naturally occurring events such as algal blooms.

Pre-treatment processes are typically similar to the processes utilised for treating fresh water (in surface water drinking supplies).

The seawater would first be chemically conditioned to coagulate and flocculate suspended matter for removal in pre-treatment filters.

Coagulation is a process where a coagulant (such as ferric chloride) is added to the water to destabilise the small particles suspended in the water. Coagulation is a rapid process and requires rapid mixing to disperse the coagulant in the water. Since the pH of coagulation is critical, an acid is often added prior to coagulation to maintain an optimum pH for coagulation.

The coagulated water would discharge to flocculation tanks with mixers to provide gentle mixing of the coagulated water for the destabilised particles to form clumps, or ‘floc’. At the entry to the flocculation tanks, flocculant (polyelectrolyte) would be added to aid the process.

Coagulated and flocculated material would be removed from the water by passing it through the gravity filters, with a sand, and anthracite (coal) granular medium. It is expected that sand and anthracite would be replaced about every 10 years.

Further discussion of the active onshore screening adopted for the Reference Project can be found in Section 11.3.1.

6.9.1.6 RO Membranes – Treatment Process

Spiral-wound, RO membranes would be used to remove salt from seawater. Membrane elements would be connected in series and placed in a cylindrical pressure vessel. Pressurised seawater would enter the pressure vessel shell and flow through the channels between the spiral windings of the first membrane element. Some of the seawater feed would permeate through the RO membrane and travel a spiral path to the product-water collection tube at the centre of the membrane element. A typical RO membrane is shown schematically in Figure 6-19. An example of a rack of RO pressure vessels is shown in Figure 6-20.

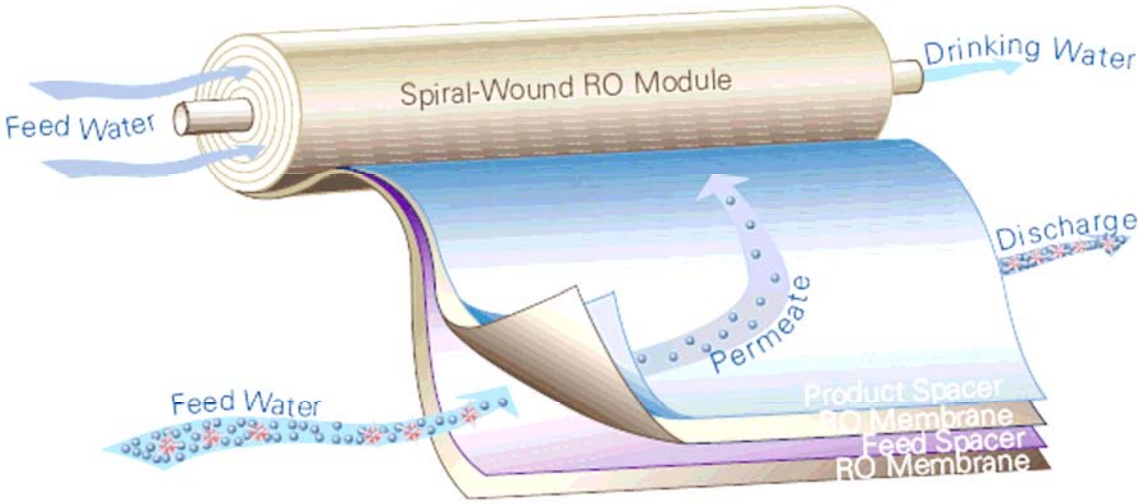


Figure 6-19 Schematic representation of the workings of a spiral wound RO membrane [6]

Figure 6-20 Rack of RO pressure vessels, Perth Desalination Plant [7]

[6] Source: Sydney Water Corporation (2005)

The RO process is pressure driven. Filtered seawater feed would be pressurised to a point at which the osmotic pressure of the solution is overcome and the water molecules in the seawater would be able to pass through the membranes. While most dissolved solids would be rejected by the membranes, a small amount of dissolved solids would pass through into the permeate. To achieve the required final treated water quality for the Reference Project, permeate from the first pass would be treated with a second reverse osmosis system (second pass).

The first pass RO would produce a concentrate discharge stream with a total dissolved solids (TDS) salinity level approximately twice that of seawater. This stream would be discharged to the ocean, including residual contaminant traces from the chemical dosing.

The second-pass RO would produce a waste concentrate stream that is lower in TDS than raw seawater and low in contaminants (as it has already been through the first pass of the RO system). Therefore, the second-pass RO concentrate could be returned to the head of the RO system to improve recovery of the system. Typically, RO membranes have a service life of approximately five years, at which point they need to be replaced. The two-pass RO process is shown schematically in Figure 6-21.

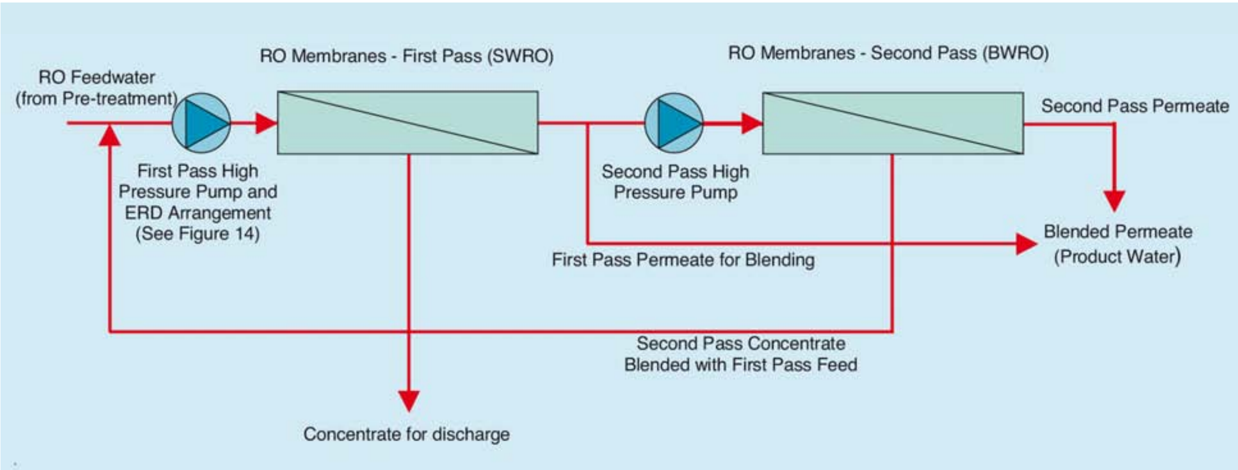


Figure 6-21 Schematic of two-pass RO process

In the Reference Project, the RO system would be configured as a series of process trains that would operate in parallel. Each train consists of the RO pressure vessels, a high-pressure pump, an energy recovery device (discussed below), booster pumps and cartridge filters. These trains could be operated independently of each other, providing scope to ramp the Desalination Plant capacity up and down and to conduct routine maintenance whilst still producing water.

[7] Source: G Crisp (Water Corp)

6.9.1.7 Energy Recovery

The pumps which would be required to pressurise the water feed to the first pass would be responsible for the largest proportion of the Plant's energy consumption. In the Reference Project, an isobaric positive displacement energy recovery device (ERD) would be used to recover some of this pressure energy. ERDs transfer pressure from the concentrate stream to the incoming feed stream, reducing the required pumping energy. Relative energy efficiency is presented for a range of ERDs in Figure 6-22. The configuration of a positive displacement ERD is shown schematically in Figure 6-23. The ERDs installed at the Perth and Barbados Desalination Plants are shown in Figure 6-24 and Figure 6-25 respectively.

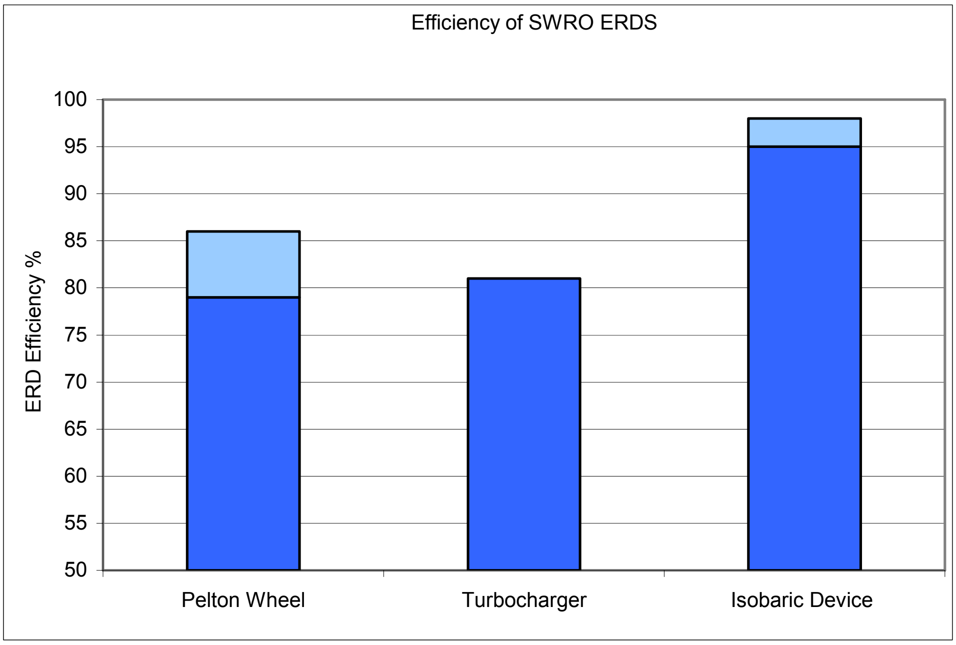


Figure 6-22 Relative energy use from energy for ERD efficiency

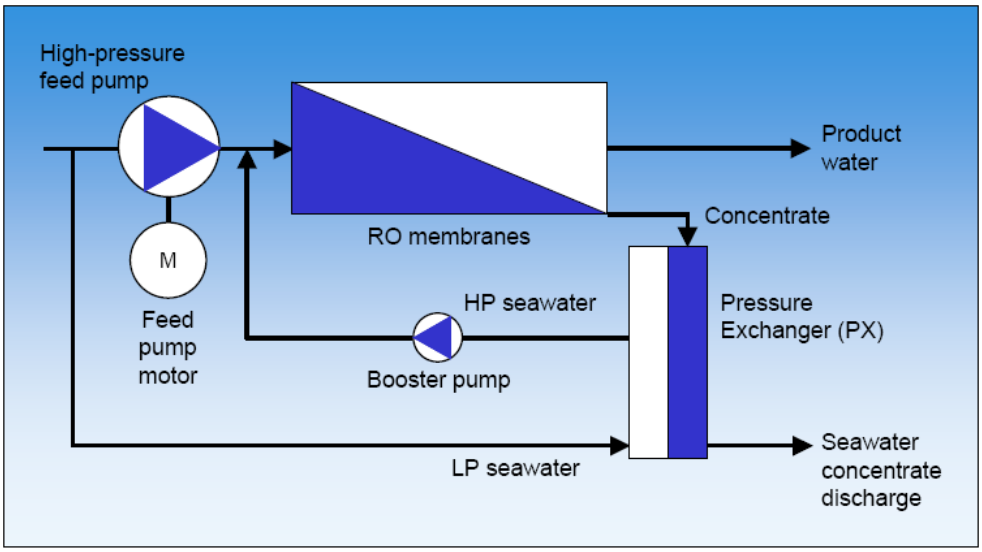


Figure 6-23 Positive displacement ERD

Figure 6-24 ERI PX energy recovery device at Perth's Kwinana SWRO

Figure 6-25 Completed Triple DWEER Energy Recovery systems at the Singapore desalination plant, April 2005 [8]

6.9.1.8 Potabilisation

The treated water quality requirements will include targets for stabilisation, chlorine residual and fluoride to make it suitable for consumption and for delivery into the Melbourne and regional water network. The process through which this would be achieved is also referred to as potabilisation.

Water from the RO process would have very low residual hardness or alkalinity and is therefore considered aggressive to some materials including steel and concrete. Before being supplied to the Melbourne water network, the desalinated seawater would need to be stabilised to prevent corrosion of (new and existing) steel and concrete transfer and storage assets.

[8] Source: Verbeek (2005)

In the Reference Project, water would be stabilised by the addition of carbon dioxide and lime (calcium) to increase its alkalinity. The calcium would then be dosed via limewater, which would be produced by mixing powdered lime with desalinated water in on-site water saturators. The carbon dioxide gas would react with the lime to form calcium bicarbonate, which could buffer the water (increase the resistance to changes in pH), increase hardness and reduce the general corrosiveness of the water. Carbon dioxide and lime are currently in common use in Australia for treating conventional drinking water supplies.

Once stabilised, the water would be chlorinated to disinfect the water and provide disinfection residual in the transfer infrastructure to minimise biofilm growth and mitigate the risk of recontamination. Fluoride would also be added if required.

All chemicals added would be governed by the water quality requirements of the Project, which are linked to the Safe Drinking Water Act (administered by the Department of Human Services). The chemicals used in the Reference Project are, for the most part, chemicals typically used in water treatment plants.

6.9.1.9 Clear Water Storage

Large storages would be required on-site to store the desalinated water prior to distribution. The storages would be sized to provide approximately eight hours of plant production. For the Reference Project, each plant module would have its own clear water storage.

6.9.1.10 Pump Infrastructure

Pumping water from the Desalination Plant to Cardinia Reservoir requires overcoming the following:

- static lift (i.e. the difference in height between the plant and Cardinia Reservoir);
- maintaining pressure requirements of Melbourne Water; and
- friction losses along the Transfer Pipeline.

Most pumping would occur at the transfer pump station located at the Desalination Plant Site. At high flow rates, this would mean high pressures at the start of the pipeline. Therefore, a booster pump would be used along the alignment to split pumping along the route and to reduce the maximum pressure the pipe must handle. The booster pump station along the Transfer Pipeline Route (as well as the Transfer Pipeline) are not part of this WAA.

6.9.1.11 Key Engineering Data

Table 6-6 to Figure 6-11 set out the key engineering data for the Plant Reference Project to illustrate scale and technological parameters. The values provided are consistent with a Project capacity of 150 GL per year. It is stressed that the data presented here refers only to the conceptual Reference Project, and that the technical specifications brought forward by the Project Company may be significantly different.

Table 6-6 Approximate daily flows based on the Reference Project

Plant capacity	ML/day (150 GL per year)	ML/day (50 GL per year)
Seawater feed (ML/day)	1 035	360
Concentrate discharge (ML/day)	600	210
Water production (ML/day)	435	150

Table 6-7 Summary of key data for plant components based on the Reference Project

Plant components	Key data for 150 GL per year Plant capacity
Modules	3 50 GL per year each
Pre-treatment screens	Aperture size 3 mm
Pre-treatment filters	Filter Modules – 3 Filters per module – 14 Filter area – approximately 160 m^2 Building dimensions – 131 m long x 72 m wide x 13 m high (approximately)
Seawater pump station	Water lifted from approximately 5 m below sea level to 10 to 20 m above sea level
Reverse Osmosis Desalination Plant	Number of first pass trains per module – 8 duty and 1 standby Number of second pass trains per module – 4 duty and 1 standby Number of membrane elements in pressure vessel – 7 Membrane element length – approximately 100 cm Membrane element diameter – approximately 20 cm Feed water pressure – up to 68 bar RO Building dimensions: 179m long x 70 m wide x 16m high
Clean water storage	Capacity – 48 ML for each module Height – 19 m (approximately) Diameter – 70 m

Plant components	Key data for 150 GL per year Plant capacity
Transfer pump station	Number of pumps expected – 6 duty and 2 standby (Note: 8 duty and 2 standby required by 200 GL/y plant) Pump delivery flow – 450 ML/day Pump head 225 to 250 m Pump motor – 2.5 MW each Surge protection – 3 No. vertical surge tanks Building dimensions – 95 m long x 13 m wide x 7 m high (approximately) Power supply – 2 transformers at one end that take up 6 m length x 13 m width x 4 m height (approximately)
Area required for construction and operation	Tunnel shafts – 1 to 2 ha Construction area – 20 to 40 ha (any additional area for accommodation would depend on the accommodation and housing strategy employed) Desalination Plant including Transfer pump station – 30 to 40 ha Spoil disposal onsite – 10 to 20 ha Total area required – 60 to 100 ha

Table 6-8 Estimate of Seawater Reverse Osmosis (SWRO) concentrate composition based on Reference Project for 150 GL per year Plant capacity

Parameter	Units	SWRO Concentrate
Flow	ML/day	600 to 1 000
Total dissolved solids (TDS)	mg/L	60 000 – 70 000
Chemicals such as Antiscalant	mg/L	0.1 to 3 (varies)

6.9.1.12 Chlorination Facility

A chlorination facility would be housed on-site at the Desalination Plant site. In the Reference Project, the chlorination building has a floor plan of approximately 30 m by 17 m. Inside the building there would be 4 rooms – chlorine drum storage room (30 m x 12 m), service water pumps and ejector room, chlorinator room and electrical switch room.

The building would be designed for the storage and handling of up to 20 standard chlorine storage drums. Each drum would have a maximum content of 920 kg of liquid chlorine. The facility is expected to consume, at maximum, an equivalent of 7 chlorine drums per week. It is expected that there would be a transfer of 10 drums every 10 days at peak flow and dose conditions. In accordance with WorkSafe requirements, storage and handling of chlorine would be in appropriately designed and located facilities.

The chlorine drums would be connected in a manifold arrangement with two separate manifolds of 10 drums being provided. Each manifold would have two sides (each with banks of 5 drums), one with on-line drums supplying gas for chlorination and the other with off-line drums ready to be brought on-line. At any one time, 10 drums (5 on each manifold) would be supplying gas for chlorination. Automatic valves would be fitted to each manifold to switch between each bank upon depletion of any bank.

Each manifold would be connected to a vacuum regulator, from the vacuum regulator chlorine under a slight vacuum is transported to the injection point in PVC piping. The vacuum regulator would control the flow of chlorine to maintain a set vacuum pressure. When downstream vacuum is lost, as with a chlorinator shut down, or failure of downstream piping, the regulator would close and isolate the chlorine supply.

An automatic shut-off system activated by chlorine detection (ChlorGuard System) would automatically shut the valves attached to the chlorine drums in the event of a chlorine release. This would stop supply of chlorine vapour to the supply manifold. By this method, the magnitude of any chlorine leak from the piping, and other equipment downstream of the drums would be limited to the amount of chlorine in the pipelines.

The chlorination equipment and chlorine drums would be installed in a well-ventilated building in accordance with AS/NZS 2927:2001 - *The Storage and Handling of Liquefied Chlorine Gas*. The chlorine building would have an extraction fan that starts automatically when a low-level chlorine alarm is activated (at a detected concentration of 2.5 ppm chlorine) to allow safe entry into the building for inspection and maintenance.

On activation of the high-level chlorine alarm (at a detected concentration of 10 ppm chlorine), the extraction fan would automatically shut down. The purpose of this shutdown is to attenuate the release of chlorine from the building. The ventilation system would be designed with a high-level air intake duct. This would allow air to enter the building at, or near, floor level for ventilation purposes whilst minimising egress potential for the chlorine in the event of a more significant or sustained leak. It is expected that the outlet from the extraction system would be approximately 6 m above ground level.

The quantity of chlorine expected to be stored onsite would be below the threshold value, listed in the Occupational Health and Safety Regulations, used to classify an organisation as a Major Hazard Facility (MHF). However the inventory would be sufficiently high (greater than 10% of the threshold value) for WorkSafe to deem the facility as an MHF.

The Project Company would be required to design their facility to achieve an equivalent, or improved, level of risk and to obtain MHF consents, if required.

6.9.1.13 Hazardous Substances and Dangerous Goods Storage

Performance Requirements, included in Section 15.6, further support that any other hazardous substances and dangerous goods are managed, stored, handled and disposed of in accordance with relevant policies, regulations and guidelines including:

- Relevant Victorian Workcover Authority guidelines;
- Australian Standard AS 1940-2004 - *Storage and Handling of Flammable and Combustible Liquids*;
- EPA Publication 480*, Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites* (1996); and

- EPA Publication 347, *Bunding Guidelines* (1992).

6.9.1.14 Waste Generation and Disposal

In seawater reverse osmosis, seawater must be pre-treated to minimise fouling of the RO membranes. The pre-treatment processes remove suspended particles and dissolved organic molecules from seawater, and direct these into the waste stream. In the Reference Project the proposed washwater would be seawater and therefore this waste stream would be salty and would contain both particulate contaminants such as sediment and micro-organisms, as well as dissolved metals (from seawater and added chemicals) and organic compounds. This is shown conceptually in Figure 6-26.

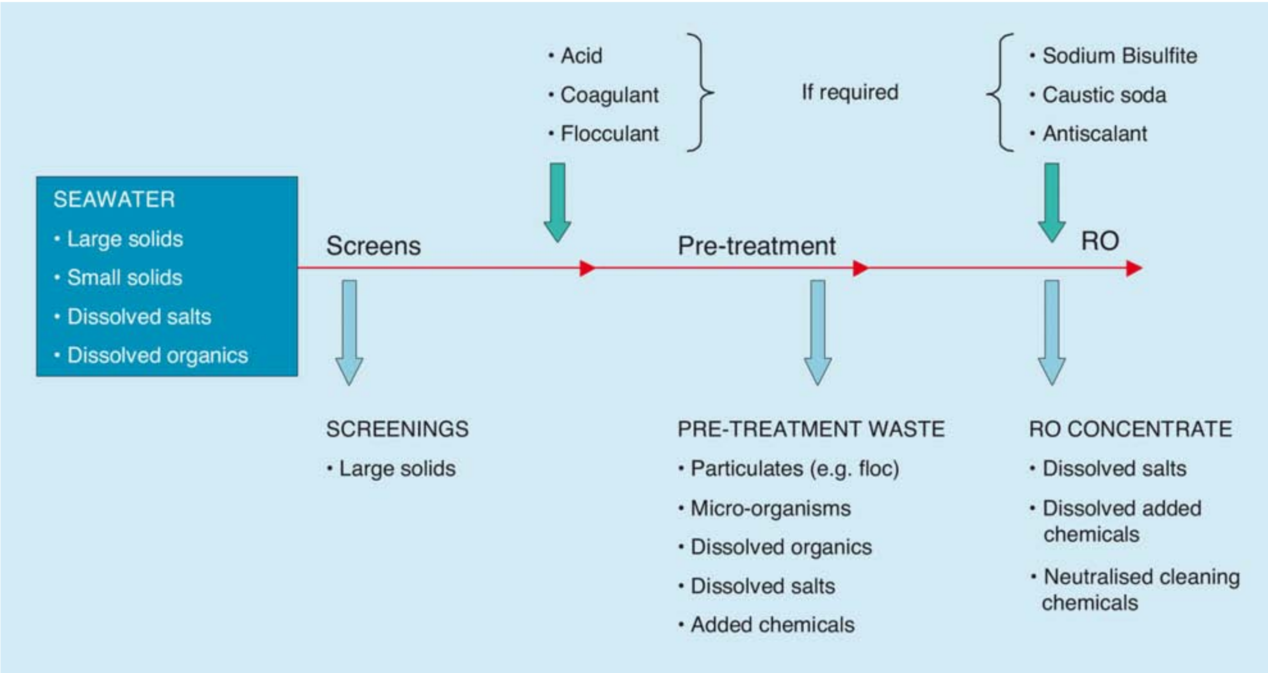


Figure 6-26 Waste streams and their composition

Management measures for operational waste streams have been assessed against the waste hierarchy in Section 9 of this WAA. The following Sections give an overview of the likely waste streams and adopted waste management measures for the Reference Project.

Screenings

'Screenings' is the collective term for the sediment, debris and marine biota that would accumulate on the onshore intake screens. The likely volume of screenings would be determined by a range of variables including the intake location, seabed vegetation, intake velocity and sea conditions e.g. storms.

Based on the Reference Project, it is envisaged that the screenings would be transported by gravity from the top of the travelling band screens via a sluice to the side of a wet well and collected in screenings baskets.

The screenings baskets would be raised from the bottom of the well to surface level using an overhead gantry crane. Given the potential for odours, the screenings would be stored in skips with airtight covers that would be held in screenings rooms until disposal. The air handling system for these rooms would have an activated carbon-filter system. The airtight cover to the skip would only be opened when all doors are closed to reduce any odour escaping to the pump station building. Buffer storage would be required to temporarily store skips with screenings while waiting for a truck to remove them from Site to landfill.

The remainder of the screenings system located within the seawater pump station building, i.e. screens, sluice and screenings baskets would only contain fresh screenings where the potential for odour would be reduced.

Refer to Section 11 for an assessment of potential odour emissions from the Plant.

Pre-treatment Waste

The pre-treatment filters would be periodically cleaned to remove the filtered finer particulates and maintain effective and efficient operation. The approach for the Reference Project was that cleaning would be achieved by backwashing the filters with filtered seawater. Air would also be bubbled through the filter bed with the backwash water to remove solids. These solids would include the naturally occurring suspended matter in the seawater and material from the addition of the coagulant.

The Reference Project proposes to dispose of the backwash wastewater via on-site solids separation and solids disposal. Clarified water would be recycled to the head of the Plant where practicable, otherwise discharged to the ocean with the saline concentrate. The solid waste would be stored for off-site disposal for management to land. This final waste solids are salty and contains iron from the ferric coagulant. It would have a reddish-brown colour from the slightly elevated iron content.

The potential impact of discharging clarified water from pre-treatment waste to ocean (with the saline concentrate) is discussed in Section 14.5.5.

Antiscalants

Antiscalants would typically be used to protect and maintain membrane performance. They would assist in preventing precipitation of dissolved constituents onto the membranes. Antiscalants would be added to the seawater feed stream before processing through the RO membrane. The antiscalants would be rejected by the membranes and therefore become constituents of the seawater concentrate stream with the other dissolved constituents removed from the seawater that would then be discharged to the ocean.

Chemical Cleaning of RO Membranes

Over time, the RO membranes' permeability would be reduced due to fouling and scaling. Fouling and scaling impairs the system performance by reducing the flux of water possible through the membranes at a given pressure, requiring higher pressures for the same water production and hence greater energy use.

The required cleaning frequency for RO membranes can vary from once every two years to four cleaning cycles per year. This frequency would be dependent on the seawater quality, the efficiency of the pre-treatment process and the antiscalants employed.

Possible cleaning and preservation chemicals may include:

- caustic soda;
- sodium bisulfite;
- hydrochloric acid;
- detergents;

- biocides;
- citric acid; and
- ammonia.

Cleaning occurs intermittently and these chemicals would not be used all at the same time. The amount and type of cleaning chemical required would vary depending upon the degree of membrane fouling and the nature of the fouling.

At the completion of each clean, the wastewater is sent to a neutralisation tank. The quantity of cleaning wastewater would depend on cleaning frequency. Once neutralised, the cleaning wastewater would be pumped under controlled conditions for disposal via the concentrate outlet. This approach is consistent with the approach adopted for the Perth and Sydney desalination plants.

6.9.2 Plant Design and Landscaping

Consistent with the modular approach to engineering, the Site layout for the Reference Project would include the major process buildings and storage tanks in three modules. The treatment plant, including some pumps and plant components, would be housed in buildings to protect equipment, to provide a suitable environment for operators and to reduce noise levels at the Plant Site boundary.

An indicative architectural perspective of the Plant layout in Figure 6-27 reflects simple engineering design of buildings for the Reference Project and the built form prior to any visual amenity improvements.

Figure 6-27 Indicative built form architectural rendering

It should be noted that the EES sets out Performance Requirements in relation to enforcing the Plant's architectural and landscape design. Appearance of the Plant is beyond the scope of the WAA. However, some siting and layout features have been incorporated in the Reference Project, because they improve environmental outcomes or process efficiencies, as described in Table 6-9.

Table 6-9 Plant layout – key objectives and approach adopted in Reference Project

Objective	Approach adopted
Allow for rapid and staged construction	Provision of corridors between buildings for equipment access Location of tunnels away from plant to permit concurrent construction
Minimise earthworks	Benching of site with two levels to match existing site contours Selection of RL 8 m minimum bench level to conform to existing site contours and avoid excavation of possible rock at RL 4 - 5 m
Minimise tunnel length	Location of inlet and outlet on western plant boundary (closest to ocean)
Minimise power distribution losses	Location of site switchyard close to major power consumers (treated water pump station and RO buildings) Site switchyard also located away from entrance to minimise visual impact
Minimise settlement	Benching of site, with plant located on cut surface
Minimise pumping	Grouping of assets on two benches to allow gravity flow through the system where possible
Minimise piping	Central pipe corridor to allow common overflow and concentrate from plant modules
Minimise chemical safety risk	Provision of emergency access route Centralisation of potabilisation chemicals in one location Location of chlorine storage at lowest point of plant site away from boundary
Dispose of spoil on-site	Use of spoil to construct earthen wall along northern boundary of plant Earthen wall to act as visual screen and noise barrier for nearby sensitive receptors
Control truck movement	Location of administration building near truck entrance Separation of access routes for trucks and visitors
Minimise noise output	Location of major noise-producing equipment (such as RO pumps and treated water pumps) inside buildings with acoustic control
Maintain access	Maintain emergency access from Mouth of Powlett River Road to Lower Powlett Road. Integrate shared path into facility. Maintain access to Williamsons Beach car park.

6.9.2.1 Power Supply

The Reference Project would include a power terminal station located on-site to step down the transmission voltage from the incoming high voltage supply so that the power is suitable for distribution to load centres around the Site.

6.9.2.2 Lighting

Lighting design at the Plant Site would be required to achieve the minimum task and energy requirement of:

- the Building Code of Australia (BCA);
- Australian Standard AS/NZS 1680.1:2006 - *Interior and Workplace Lighting: General Principals and Recommendations*; and
- Australian Standard AS 2293.1-2005 - *Emergency Escape Lighting and Exit Signs for Buildings – System Design Installation and Operations*.

This is in addition to the functional, environmental and aesthetic objectives of the Project.

The Reference Project proposes limited external lighting outside the Site boundary. However, lighting bollards and low-level external lights in areas of public access would be required, particularly at Site access points.

Shaded streetlights (about one every 30 metres — refer AS 1680) would be provided around the major roads within the Site. These would generally be located on or at a similar level to the architectural wall surrounding the Plant to reduce spot intensity.

If adopted, feature lighting would generally be contained within the internal landscape of the office and administration area. The Reference Project allows for highlights to the Site office and amenities features.

Buildings would have individual internal lighting schemes to achieve high intensity task lighting for Plant operations and emergency lighting to meet BCA Section J and AS 1680.1:2006. Consideration shall be given to the energy usage and maintenance of light fixtures in the design.

Emergency lighting would be provided in compliance with the BCA and AS 2293.1-2005. This would include:

- battery assisted permanent lighting;
- exit and hazard identification; and
- lighting activated for duration of emergency event.

6.9.2.3 On-site Wastewater

Wastewater arising from on-site office buildings, and other facilities and activities, is proposed to be disposed of to the local sewerage system.

6.9.2.4 Stormwater and Rainwater Harvesting

The Desalination Plant in the Reference Project includes roof space and impervious surfaces that would generate significant rainfall runoff during storm events. This does not constitute a water use, but presents an opportunity to capture some of this water for re-use in the Plant as an alternative to desalinated or mains water. There are opportunities to use harvested stormwater in plant operations, site maintenance and fire water supplement. The Reference Project adopts a stormwater treatment train with the following components:

- an in-line trap to remove likely pollutants from the site such as oil, grease and hydrocarbons (a Humes' Humeceptor™ or equivalent);
- a sedimentation basin (or trap) to remove coarser sediments; and

- a wetland system to remove finer sediments and absorbed/dissolved pollutants (i.e. nutrients and metals).

In the Reference Project, as the two sides of the Plant would be virtually identical for the purpose of stormwater management; the system is designed to have two identical treatment trains to improve the quality of runoff from the Site. The treated stormwater would be discharged to the Powlett River through flow channels, constructed with additional channel lining where necessary to prevent erosion of the natural surface.

A ridge at roughly the centre of the south-western Plant edge separates the proposed site drainage paths. Overland flows entering the proposed drainage path north of this ridge would be diverted around the northern edge of the Plant. Similarly, overland flows entering to the south of this ridge would be diverted in a separate drainage path around the southern edge of the Plant.

The Reference Project incorporates stormwater infrastructure as an integrated landscape feature within the overall Site design. The wetland system would play an important role in ensuring that alterations to surface flow paths and absorption resulting from the construction of the Plant and any pollutants arising from operation do not adversely affect the receiving waters of the Powlett River.

6.9.2.5 Water Use

During operation all water used on-site (for the Plant processes and for amenities and offices) would be sourced from the Plant itself. There would be a small connection to the Wonthaggi supply for essential uses (such as offices and amenities supply) that may be utilised in situations of Plant shutdown.

6.9.2.6 Noise

During operation noise would be generated by equipment as well as other standard sources. Most noise generating equipment that would be likely to be used during standard operation is included in Table 6-10.

Table 6-10 Plant equipment for the Reference Project

Plant aspect	Equipment
Seawater pump station	Seawater pump
	Screen drive
	Screen washwater booster pumps
Pre-treatment system	Coagulation basin mixer
	Flocculation basin mixer
	Backwash pump
	Backwash air blower
	Building ventilation
Reverse osmosis system	Feed booster pump RO
	Feed booster pump ERD

Plant aspect	Equipment
	HP pump 1st pass
	ERD booster pump
	Feed pump 2nd pass
	RO building ventilation
	Flushing pumps
	CIP pumps
Potabilisation system	Permeate pump
	Lime screw conveyor
	Lime slurry tank mixer
	Lime slurry pump
	Lime saturator mixer
	Lime water pump
	Lime sludge pump
	Lime sludge holding tank mixer
	Centrifuge decanter feed pump
	Centrifuge decanter
	Centrate pump
Treated water transfer pump station	Treated water transfer pump (Plant Site)
Wastewater treatment system	Feed pump
	Pre-treatment tank mixer
	Lamella clarifier mixer
	Clarified water return pump
	Thickener feed pump
	Thickener mixer
	Thickened sludge transfer
	Sludge holding tank mixer
	Plate press feed pump
	Plate press

6.10 Variations for the Desalination Plant

Two variations to the Reference Project being contemplated are:

- membrane filtration; and
- additional clarification processes (such as Dissolved Air Flotation (DAF)).

6.10.1 Membrane Filtration

Membrane pre-treatment relies on surface removal (straining) of particles whose diameter is larger than the diameter of the membrane pore spaces. Particles within a specified size range would be consistently removed, regardless of seawater quality. Several different membrane filtration alternatives are available, depending upon pore size and operating pressure including:

- Ultrafiltration (UF): 0.02 – 0.2 μm
- Microfiltration (MF): <0. 2 – 4.0 μm (Note that 1 μm = 0.001 mm)

Membrane filtration incorporating ultrafiltration or microfiltration with upstream coagulant dosing could be used in place of conventional filtration to remove solid particles from seawater prior to the RO process. Advances in membrane science have resulted in membrane filtration becoming more technically competitive in recent years. However membrane pre-treatment has generally been limited to small to medium scale plants only.

A comparison of media and membrane filtration technologies is provided in Section 7.2. As discussed in Section 7.2, emissions to the environment associated with both membrane and media filtration are comparable, and as such a separate environmental impact assessment is not considered necessary.

6.10.2 Additional Clarification Processes

Additional stages of clarification, such as Dissolved Air Flotation (DAF), may be required upstream of the filtration process, depending on feed water quality. This clarification may involve the use of a Dissolved Air Flotation (DAF) unit which removes the bulk of the suspended solids by using air to float them to the surface of the backwash water. Alternative clarification processes such as sedimentation are also probable.

Emissions to the environment from additional stages of clarification, such as DAF, are not expected to differ from that of the filtration process to the extent that will require a separate environmental impact assessment.

6.11 Desalination Plant Options for the EES

Ocean disposal of pre-treatment waste is considered as an EES Option, outside of the Reference Project.

This WAA does not address ocean disposal of pre-treatment wastewater. If the Project Company wishes to pursue this waste management option, it would likely need to obtain a separate works approval for the plant and equipment required for this EES Option. Any works approval application would need to consider:

- detailed process design and refinement of water quality characterisation;

- baseline monitoring to confirm trigger values/ranges for relevant physico-chemical and sediment indicators;
- modelling of the behaviours of flocs in the marine discharge to assess dispersion characteristics and potential for settling on the floor;
- site-specific eco-toxicological testing to confirm local and general eco-toxicity of the discharge. Testing may also be undertaken to account for any synergistic effects between different constituents within the concentrate stream. This process will result in final trigger value(s) in accordance with ANZECC Guidelines;
- ongoing monitoring to validate predictions and identify if mitigation actions are required; and
- lifecycle analysis to analyse the benefits and costs.

6.12 Summary of Reference Project, Variations and EES Options for the Desalination Plant

The key infrastructure elements of the Reference Project and Variations being contemplated in this WAA for the Desalination Plant are shown in Figure 6-28 and Table 6-11.

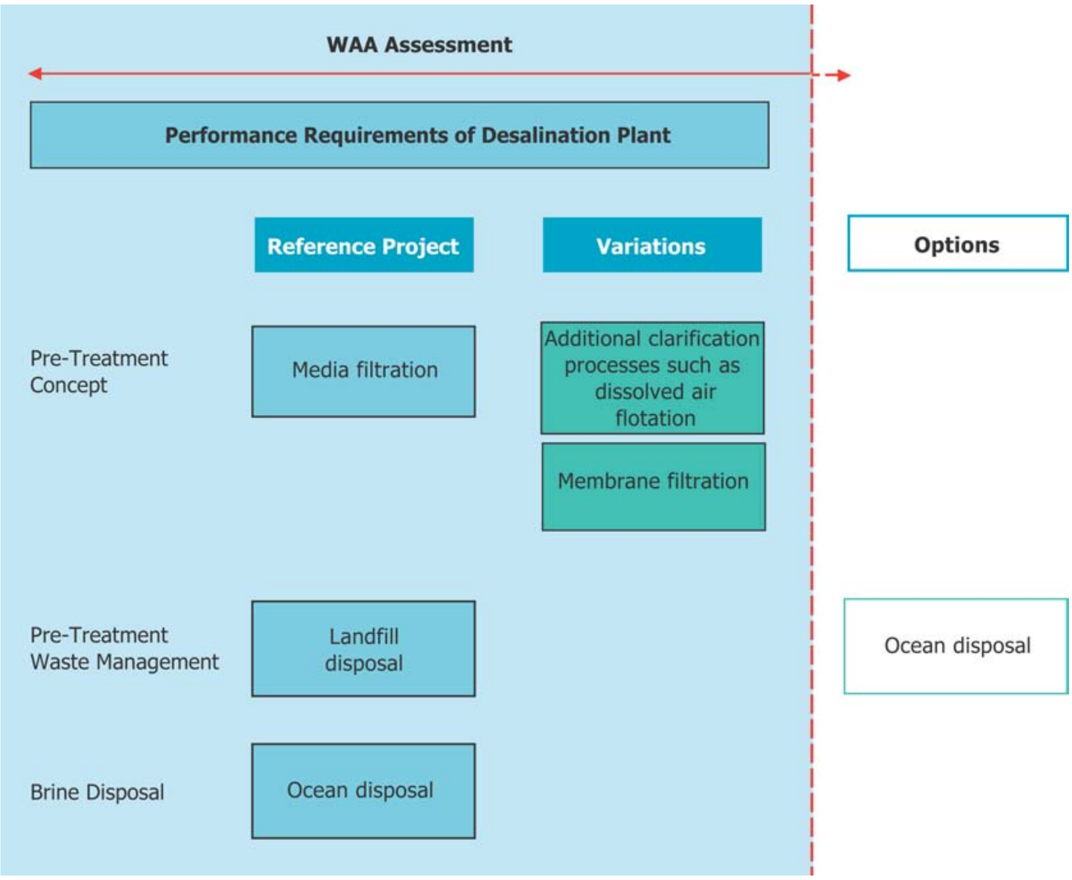


Figure 6-28 Reference Project, Variations and EES Options for the Desalination Plant

Table 6-11 Reference Project, Variations and EES Options for the Desalination Plant

Key elements	Reference Project	Variation	EES Options
Pre-treatment concepts	**Media filtration** Use of granular media to capture particles.	**Additional clarification processes such as Dissolved Air Flotation (DAF)** Additional stages of clarification (including DAF) may be required upstream depending on feed water quality. During clarification in the DAF process dissolved air release creates bubbles which float off contaminants prior to media filtration. **Membrane filtration (MF/UF)** Pre-treatment might employ microfiltration or ultrafiltration in place of granular media filters. This is referred to as MF/UF pre-treatment. Coagulation prior to MF/UF pre-treatment is likely to be needed depending on the water quality and the membrane supplier.	
Pre-treatment Waste Management	**Landfill Disposal** The waste produced during pre-treatment stage is separated and thickened and dewatered prior to taking to landfill. Clarified water would be returned to the head of the plant, where practical and otherwise discharged to the ocean.		**Ocean Disposal** The waste produced during pre-treatment would be blended and discharged in the ocean with the saline concentrate.
Brine disposal	**Brine disposal** Saline concentrate from desalination process is discharged to the ocean.		

6.13 Construction

6.13.1 Marine Structures

6.13.1.1 Shafts

In the Reference Project, shafts at the Plant Site would be sunk to a depth below sea level by excavation, rock hammering, drilling and blasting depending on the ground conditions. These shafts would have a permanent reinforced concrete lining and would be secured with rock bolts where appropriate.

6.13.1.2 Tunnels

A tunnel-boring machine (TBM) would be driven from the bottom of the shaft along the predetermined horizontal path for the intake and outlet structures through the coastal strip, beach and seafloor. It is anticipated that two TBMs would be used on this Project, one for each tunnel. The type of TBM to be used would depend on the expected ground conditions. A typical TBM of the type and diameter that may be used is shown in Figure 6-29.

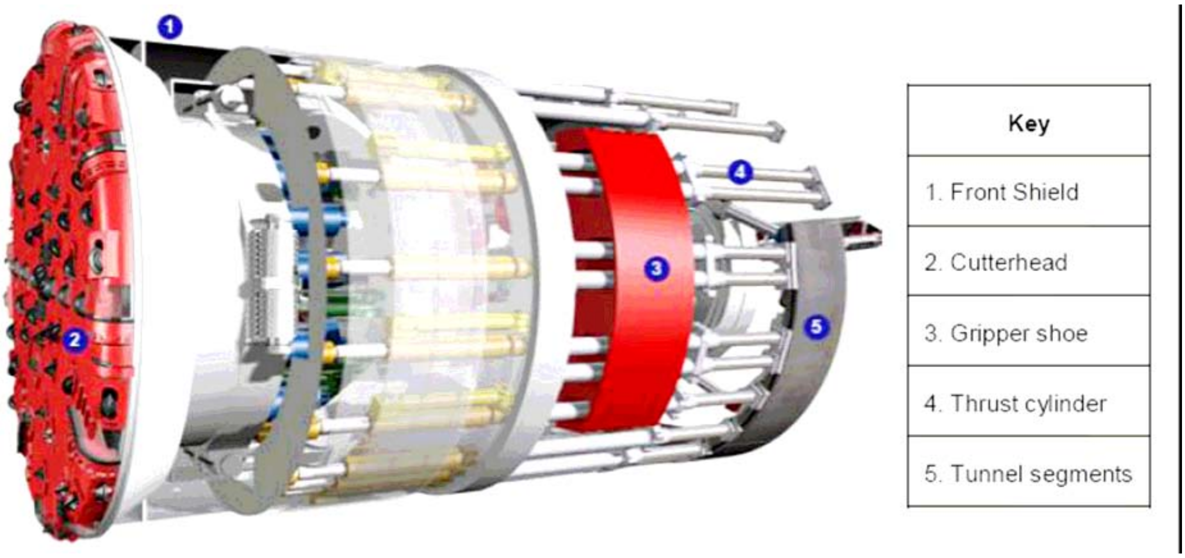


Figure 6-29 Typical tunnel-boring machine (TBM)[9]

Prior to launch, the TBMs would be assembled at the base of each shaft in an assembly chamber (the launch and backshunt chambers described previously). It is expected that these chambers would be excavated using either a roadheader machine or by drill and blast techniques depending on the geological conditions. Extensive cover grouting may be required outside these chambers to minimise the quantity of groundwater entering the excavation. Also, where there are difficult ground conditions consisting of silt or mud the ground may be frozen or injected with grout prior to tunnelling. Bentonite may be used as a drilling fluid to lubricate and cool the cutting head of the TBM.

[9] Source: Herrenknecht (accessed May 2008)

The excavated tunnel diameter for the main tunnels would be slightly larger than the outside diameter of the concrete segment ring that would form the tunnel. On this Project, where hard rock conditions are anticipated, it is expected to be possible to grout this annular gap through the tunnel segments for stability, following the advance of the TBM. This would speed up tunnel excavation and lining cycle times.

Once the TBM has reached the end of the tunnel alignment, it would need to excavate an additional distance beyond the design end point of the tunnel alignment to assist with TBM dismantling. It is proposed that the TBMs would be internally dismantled following completion of each drive and the external shield left in place. The shield and tunnel extension would then be backfilled with mass concrete.

6.13.1.3 Pipe Jacking

Pipe-jacking, a construction method where sections of pipe are pushed into the tunnel for self lining as the TBMs are excavating the tunnel, could also be used for tunnelling. This is another way of constructing a tunnel with a liner which might be considered by the by the Project Company. The amounts of spoil and construction impacts are considered similar to be segmentally lined tunnels.

6.13.1.4 Risers

In the Reference Project it is assumed that a self-elevating platform (SEP or ‘jack-up barge’) would be employed during the construction phase to drill the intake and outlet risers adjacent to the tunnel alignments.

Riser holes would need to be drilled through the grout base and into the rock, to finish deeper than the tunnel invert. The overdrill amount is required to enable grouting of the rock mass prior to commencement of the stub tunnels that connect the risers to their respective tunnels. The risers are sealed to the ocean and the connection between the riser and the tunnel can be excavated and lined from the tunnel side. Clearance between the rock diameter and lining would be provided to allow for installation of chlorine dosing tubes.

It is expected that spoil from excavation of the risers would be collected on the drill barge and later taken to land for management if a suitable marine spoil disposal site cannot be identified. Smaller diameter rock drilling spoil (e.g. from temporary rock bolts) would not be collected. It is not expected that the marine disposal of this spoil would generate significant turbidity during construction.

A number of flat areas around 12 m in diameter would be required surrounding each of the risers for the drilling operation, support of heavy starting ring assembly, and drill and grouting of piles.

6.13.1.5 Construction Exclusion Zone

A temporary construction exclusion zone in the order of two square kilometres would be required to aid protection of public health and safety.

6.13.1.6 Use of Vessels

Vessels that may be required for construction of the Marine Structures are anticipated to include:

- SEPs, most likely with accommodation for the small number of resident crew, helipad etc. and the capability to remain at sea for several months;

- large ocean going tugboats for the SEP;
- offshore supply vessels to supply supplies and fuel to the platforms;
- vessels to take the various Project staff and workers on/off the platform when weather conditions permit;
- barges and small tugboats/workboats to lay anchors for the SEP; and
- support vessels for divers during connection of risers to seawater intake heads and concentrate outlet diffusers.

Some of these craft would arrive from international or interstate locations and would need to undergo appropriate quarantine procedures before operating in Victorian waters.

6.13.1.7 Marine Yard

It is expected that there would need to be an area near an existing wharf for construction of the marine elements of the Project. This is often known as the 'marine yard'. This would potentially include facilities for managing drilling equipment, SEPs, concrete structures and prefabrication of inlet and outlet structures. A suitable marine yard would be identified by the Project Company prior to construction.

6.13.1.8 Major Equipment for Construction and Special Construction Needs

The TBMs require substantial amounts of electrical power, which is likely to be sourced from a combination of the grid and on-site diesel generation. Power supply requirements for construction are discussed in *Volume 5, Chapter 2* of the EES.

6.13.2 Desalination Plant

Construction and commissioning of the Plant would occur over a period from late 2009 (post financial close) to the end of 2011. Major construction activities would include:

- excavation of the shafts and tunnels;
- general earthworks (including topsoil stripping, excavation, filling, topsoil spreading and rehabilitation works);
- building construction;
- drainage installation (including, where required, measures to protect water quality and groundwater flows);
- power connection;
- equipment fabrication and installation; and
- incidental vegetation clearance.

These activities would conclude with commissioning of the Plant, reinstatement of the Site, visual screening and landscaping.

Construction activities are likely to have noise, visual and vibration impacts from welding, building construction, construction machinery, a potential concrete batching plant and the likely presence of multiple large cranes.

One of the benefits of the Plant modular design is that the modules could be constructed in parallel and thus reduce the timeframe; although this may require greater area for construction and an increase in equipment, personnel and noise during construction.

6.13.2.1 Earthworks

Earthworks would include:

- excavation of the shaft and tunnels;
- removal (and replacement) of topsoil over the Plant and construction area; and
- excavation of Plant Site to achieve the required bench levels for each Plant component.

Bench levels would be influenced by several factors including building height and visual impact, geotechnical conditions (including presence of rock), flood level, hydraulic considerations within the Plant and cost of excavation.

The Reference Project assumes that some of the volume of earth moved would be reused once construction is complete to reinstate the site. Management of excess spoil may include trucking this from site to an alternative location or incorporating the spoil in the existing site. Excess spoil could be used to create a vegetated visual and noise barrier.

6.13.2.2 Water Use

During construction, water would be required for a number of uses, including personnel use, dust suppression, concrete batching and other uses. Some of these uses can tolerate lower water quality than other uses, however seawater is unlikely to be suitable for any purpose. The source of construction water is unknown at this stage but would likely be from local supply for processes having occupational health and safety implications. The precise nature of any connection would be subject to approval from the relevant water authority and considerations of local amenity.

6.13.2.3 Power and Lighting

Temporary power supply to the Site for lighting, heating and machinery would be required during construction.

A grid power provider would connect local power to the site, however the existing power supply in the region may not have sufficient capacity during peak periods. An alternative on-site source of construction power would potentially be required. Options for this include the use of commercial diesel generators.

Throughout construction and commissioning, lighting would be provided for safety and task lighting. This may occur 24 hours per day, seven days per week during this time.

6.13.2.4 Construction Workforce and Site Amenities

A variable workforce would attend the site throughout the investigation and construction period, with the maximum amount of people on-site during construction of the main Plant components. Site amenities would be required to support the workforce including offices, meeting rooms, showers and toilets, car parking and catering.

6.13.2.5 Construction Waste

Construction of the Plant would generate waste materials including food wastes, plastics and packaging materials, spoil from earth works, garden wastes, office wastes, vehicle wash water and other wastewater and stormwater.

Waste types and characteristics are further discussed in Section 9.3 of this WAA. Waste management options and relevant Performance Requirements are also discussed in Section 9.

6.14 Commissioning

6.14.1 Marine Structures

The inlet and outlet structures are expected to be commissioned initially by bypassing water directly from one tunnel to the other without running water through the Plant. Water would then be gradually diverted to the Plant to allow slow start up and commissioning of the Plant. Commissioning would take place prior to obtaining an EPA waste discharge licence, and as such an EPA approval would be required for this phase pursuant Section 30A of the Act.

6.14.2 Desalination Plant

Commissioning of the Plant would be dependent on the commissioning of the intake structure to provide a constant seawater flow and the outlet structure to provide for concentrate disposal. The Plant would likely be started and commissioned in separate stages. Commissioning of the Plant would in turn provide water to allow commissioning of the Transfer Pipeline.

During commissioning, the brine composition would vary from that of normal operation.

6.15 Operation

6.15.1 Marine Structures

The intake and outlet are designed to operate at a constant rate 24 hours a day. If the annual production of the Desalination Plant varied from time to time, this could be accommodated by bypassing some inlet flow to the outlet to maintain diffuser velocities over short periods, or by shutting off or opening more diffusers for longer periods.

A small operations exclusion zone would be required to prevent interactions between marine-based activities (e.g. boating) and the Marine Structures. The size of this exclusion zone would be defined in order to support nautical safety and diver safety and to protect intake water quality, while also taking account of the benefits to public access to these waters.

6.15.2 Desalination Plant

In the Reference Project, the Plant was designed to operate at a constant rate, 24 hours per day. This would require 24-hour operator attendance and regular delivery of consumables. The Reference Project would be modular and each module designed to operate independently.

The Project Company may adopt a different approach to operating the Desalination Plant.

6.15.2.1 Operating Regime

The final operating regime is not yet defined. The Reference Project operating regime is based on the following:

- ordering of water on an annual basis, with the ability to order anywhere from 0% to 100% of the Plant's output;
- as Cardinia Reservoir provides storage for the desalinated water, it would be possible for the plant to stop operation on any day without causing supply disruptions. This would reduce the need for redundancy and storage at the Plant;
- the Plant may change production volume from time to time as required to meet overall system demands;
- the plate may be expanded to 200 GL per year in the future;
- minimum and maximum pressure and surge requirements guide design of the transfer pipeline and pumping; and
- treated water quality targets will apply at the connection point to Melbourne's water supply system.

Modern desalination plants have a high degree of automation, with most processes being fully automated. Analysers and sensors throughout the process monitor a range of parameters, feeding signals into the plant control system.

Pre-treatment

In the Reference Project, the pre-treatment process was designed and would be operated to condition the seawater to a suitable quality for downstream desalination through the reverse osmosis plant. Acid, coagulant and flocculant would be dosed automatically to achieve effective coagulation of particulate matter in the seawater before the dosed water would be filtered through dual media filters. Filtered seawater would be collected in the filtered seawater tank ready for desalination through the reverse osmosis plant.

Over time, material would build up on the filters and they require backwashing to removal accumulated material and to maintain the performance of the pre-treatment process. Filters would typically require backwashing every 12-48 hours depending on seawater quality. In the Reference Project, each module would have multiple filters operating in parallel and backwashing of individual filters occurs in a sequential manner to maintain overall flow to the reverse osmosis plant.

Reverse Osmosis (RO) Plant

The Reference Project includes provision for a two-pass RO process to achieve the treated water targets. Each module in the Reference Project would be made up of multiple RO trains operating in parallel. Ramping the plant production up and down could be achieved by bringing individual trains on or offline within each module or changing how many plant modules are online.

Feed water to the RO membranes would be dosed with antiscalants and sodium bisulphite to improve performance and protect the membranes. Caustic soda would also be added prior to the second pass to raise pH for process reasons to meet the treated water quality targets.

RO membranes require cleaning to maintain performance. This can vary from three to 4 cleaning cycles per year, to once every two years, depending on seawater quality and the approach adopted. Typically individual RO trains would be taken offline for cleaning in a sequential manner to maintain overall plant production.

Potabilisation

Potabilisation of the desalinated water is required to stabilise the water and provide a disinfection residual. The Reference Project includes dosing with lime water, carbon dioxide, chlorine and possibly fluorosilicic acid. Each chemical would be dosed on a flow based system to meet the treated water quality targets.

Transfer System

A transfer pump station and booster pump station would pump the treated water along the transfer pipeline to Melbourne's water supply system. The pump stations and pipeline will operate 24 hours per day during plant operation.

Plant Shutdown

From time to time and to meet fluctuations in system demand, the Desalination Plant or individual modules may require short-term shutdown of production or mothballing for more extended periods. In these cases, ongoing maintenance would still be required to:

- maintain equipment;
- preserve reverse osmosis membranes; and
- facilitate recommissioning after shutdown.

6.15.2.2 Expansion of the Project

Expansion of the Project from 150 GL per year to the ultimate capacity of 200 GL per year would require construction of a fourth 50 GL per year module similar to the existing three modules along with additional interconnecting and shared infrastructure. The expansion would include:

- filtration pre-treatment component;
- filtered seawater tank;
- additional pre-treatment wastewater infrastructure;
- cartridge filters and feed booster pump station;
- RO component, including first and second pass RO membranes and intermediate storage;
- additional RO clean in place infrastructure;
- permeate storage tank and pumps within the existing shared pump station;
- additional potabilisation systems for lime, carbon dioxide, chlorine and fluoride dosing;
- clear water storage;
- expansion of the main electrical substation; and
- additional miscellaneous and interconnecting infrastructure such as roads, pipework, chemical dosing, monitoring, control and power distribution systems.

7. Evaluation Against Best Practice Criteria

Project-specific criteria for evaluation of best practice have been developed in Section 2.2 of this WAA, for design, construction and operation of relevant Project components. Table 2-3 in Section 2 of this WAA may be used as a guide to direct the reader to where these best practice evaluation criteria are addressed in this document.

As discussed in Section 2.2, the application of best practice in development of the Desalination Project has assumed a 'whole-of-system' engineering approach. In this Section, a discussion of best practice design considerations for each relevant component of the Reference Project is provided. An evaluation of the Reference Project and Variations against the relevant best practice criteria is then made.

This Section of the WAA aims to provide an overview of best practice design considerations for relevant components of the Project; additional information beyond this is provided elsewhere in this document. In particular, Section 10.3 of this WAA evaluates the Project against benchmarks for overall Plant Specific Energy Consumption (SEC), in kilowatt-hours per kilolitre of water produced (kWh/kL). Additionally, Section 9 of this WAA provides an assessment of likely waste streams associated with construction and operation of the Desalination Plant, which aims to achieve minimisation and management of wastes in accordance with the waste hierarchy.

Best practice in construction and operation is addressed within specific environmental impact assessment Sections (Sections 11-16), as well as an assessment of greenhouse gas (GHG) emissions (Section 8) and through addressing the requirements of EREP (Section 10).

In the impact assessment Sections, demonstration of best practice has been achieved through consideration of protection of beneficial uses, including the use of risk and impact assessment to demonstrate that the protection of beneficial uses can be achieved. Section 17 presents an EMF for the Project, which includes requirements for environmental management, monitoring and auditing.

7.1 Best Practice Considerations for Marine Structures

Criterion 1: Design the seawater intake and concentrate outlet systems to minimise adverse effects on the marine (aquatic) environment.

The following Sections present best practice considerations for the selection and design of Marine Structures as a means of complying with Criterion 1. The information presented is based upon practices in the industry and a review of international literature.

7.1.1 Location of Intake and Outlet Structures

Determining an appropriate location for Marine Structures is site-specific and is influenced by local environmental conditions and systems. It requires consideration of both environmental and engineering requirements and physical aspects of the location.

Potential environmental impacts associated with Marine Structures may be reduced through selection of a suitable location. Aspects that require consideration when locating the individual Marine Structures include areas of high environmental sensitivity, seabed conditions, water depth, hydrodynamic conditions, and water quality. Orientation of the Marine Structures in relation the shoreline and to each other will also influence the location selected.

Areas of Environmental Sensitivity

Environmental investigations undertaken by CEE (2008) in the marine area adjacent to the Project Site have determined a set of guidelines for locating the Marine Structures to protect areas of environmental sensitivity.

Based on the habitat preferences for locating Marine Structures, areas of environmental sensitivity have been determined and are illustrated by Figure 6-3 (refer Section 6 of this WAA).

Seabed Conditions

In the marine area adjacent to the Plant Site there is a gradual change in seabed conditions with increasing distance offshore and thus increasing depth. The seabed between the shoreline and the 10 m depth contour is mobile sand, which is mostly within the surf zone. Construction in the surf zone is often difficult, particularly in high swell areas such as the Bass Coast, therefore location of Marine Structures in deeper water outside the surf zone is preferred for engineering reasons.

Between the 10 and 25 m depth contours the seabed generally appears to comprise of high, medium and low relief reef. The seabed beyond the 25 m depth contour generally appears to be low relief reef, with patches of a thin veneer of sand. Beyond about 2 km offshore (approximately 35 m depth) the seabed appears to be predominantly sand.

Figure 7-1 illustrates a transect of the seabed adjacent to the Plant Site. The topography of the seafloor is variable, so the depths at which different reef types occur will vary for different transects.

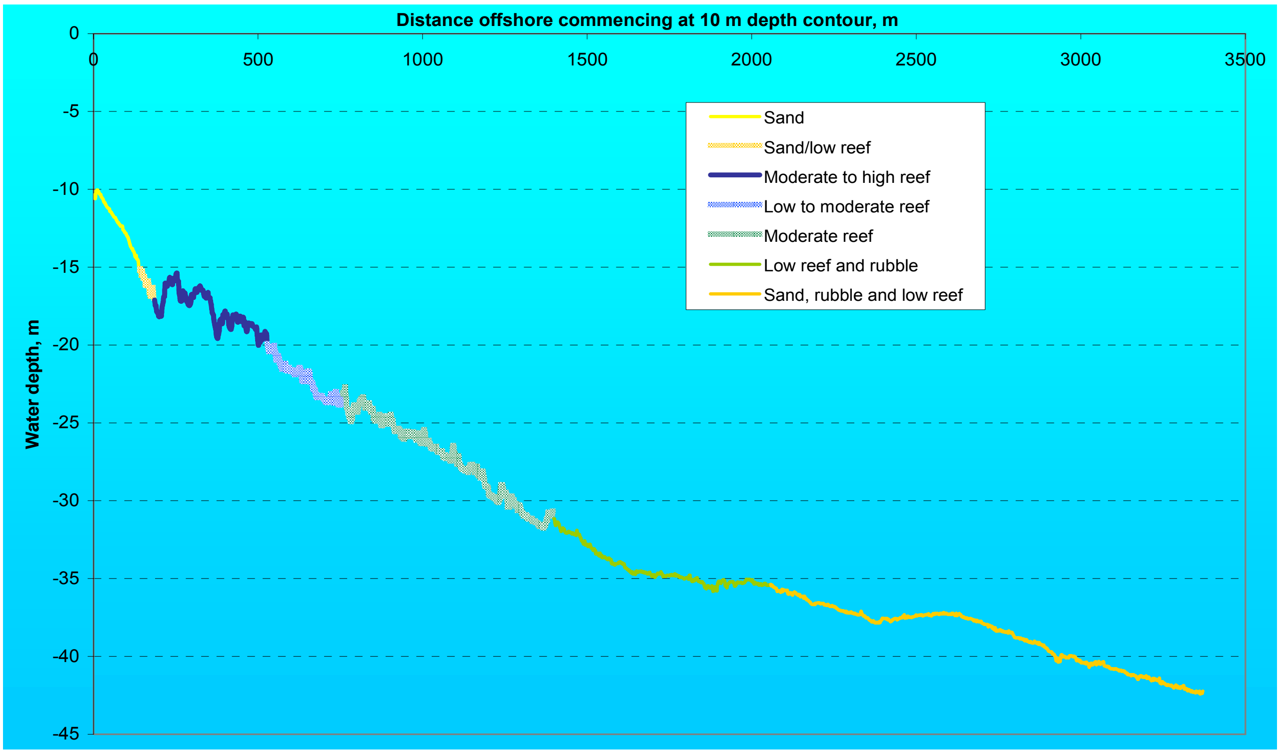


Figure 7-1 Cross section at one transect of the seafloor and seabed habitats (CEE, 2008)

Water Depth

The appropriate water depth for the location of Marine Structures may be different for the seawater intake and concentrate outlet, and will depend on the design adopted for the Marine Structures.

The water depth selected for locating the intake structure should consider the possible entrainment of material, such as sand and marine biota, from the ocean. Locating the concentrate outlet requires consideration of the depth necessary to achieve the relevant dilution target.

Additionally, to avoid navigational hazards, Marine Structures should be located in a sufficient water depth to allow vessels that typically use the area to safely travel near the structures.

The following factors influence the water depth required for location of the seawater inlet:

- *Sand Entrainment:* Sand is stirred up into the water column by wave forces. A higher proportion of sand and sediment is likely to be entrained the closer an intake structure is located to the seafloor. During high wave periods there is an increased chance of sand entrainment due to increased wave forces stirring up sand on the seafloor. Therefore maximising the clearance of an intake structure above the seafloor and location choice will reduce sand entrainment.
- *Marine Life Entrainment:* The water depth where the intake structure is located will influence the proportion of the water column drawn into the intake. A deeper location may typically reduce the amount of marine biota entrained. The environmental constraint applied to the intake structures for the Reference Project is to locate the structure as far above the bottom as practical but preferably in the bottom third of the water column.

The primary factor that influences the water depth required for location of the concentrate outlet is the ability to achieve a suitable defined dilution target.

- *Concentrate Dispersion:* Greater dispersion of the concentrate can be achieved in deeper water, as the concentrate discharge nozzle exit velocity can typically be higher, allowing the concentrate plume to project further into the 'head room' above the diffuser without striking the sea surface. The outlet structures should therefore be located in water that is deep enough to allow the exit velocity to be maximised and for near field, engineering dilution levels to be achieved before the concentrate plume reaches the seafloor.

The water depth selected for Marine Structures should therefore allow the structures to be high enough above the sea floor to reduce the potential impacts and meet the objectives outlined above, whilst maintaining sufficient clearance to avoid navigational hazards (Figure 7-2 and Figure 7-3).

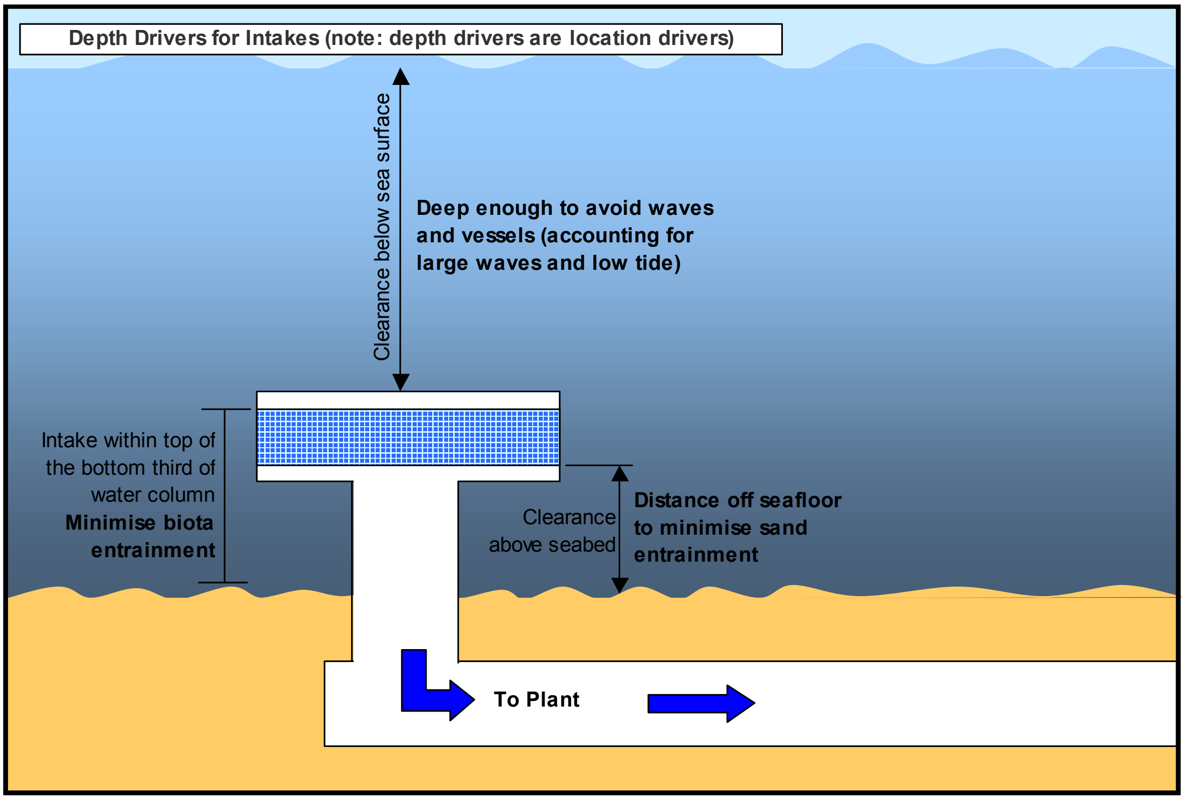


Figure 7-2 Depth Considerations for Intake Structure

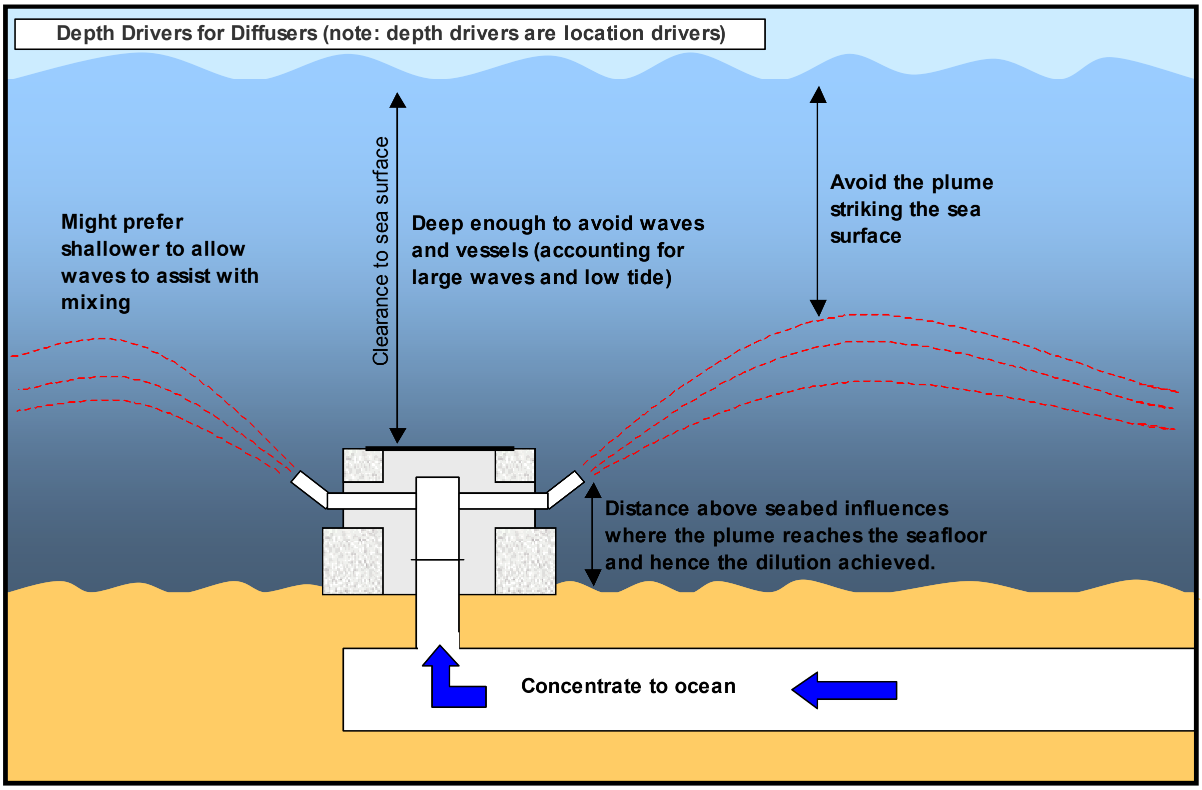


Figure 7-3 Depth Considerations for Outlet Structure

Water Quality

Location of the seawater intake requires additional consideration of the source water quality and potential risks.

For a drinking water supply, it is preferred to draw water from a source that is inherently has low risks. Generally, water drawn from areas further off the coast in deeper water has more consistent and better water quality for desalination. A source water of consistent and good quality may reduce the overall chemical usage, waste generation and operational requirements.

Sources of water quality risks in the ocean include fresh water inputs such as rivers and outfalls. These land-based sources of contamination should be considered when selecting a location for the intake structure. In the area around the Victorian Desalination Plant Site there is the Powlett River that discharges into the coastal waters northwest of the Desalination Plant Site, and the Wonthaggi Wastewater outfall (Baxter's Beach outfall) to the southeast. Therefore, it is preferable to locate the inlet away from the influence of the Powlett River and Wonthaggi outfall.

Orientation of Marine Structures

The positioning of the intake and outlet structures with respect to each other requires consideration of the potential for short-circuiting of concentrate from the outlet to the inlet. Short-circuiting can raise the salinity of the water entering the plant, which may reduce efficiency of the desalination process. Hence where background currents exist, it is preferable to locate the intake upstream of the outlet. Sufficient separation distance needs to be provided to minimise the likelihood of short-circuiting.

The prevailing currents tend to run long shore from Western Port to Cape Patterson for this section of the Bass Coast (Figure 7-4). ASR (2008a) suggests that this occurs approximately 60% of the time with currents in the opposite direction (on the same axis) occurring 20% of the time.

Given prevailing currents tend to run long shore, one design approach could be that the diffusers be orientated perpendicular to the shoreline to enhance wider mixing of the concentrate in time when currents are present. The prevailing currents would therefore predominantly disperse the concentrate offshore and to the southeast if the diffusers were orientated perpendicular to the shoreline. Additionally, since the currents travel predominantly on the same axis for up to 80% for the time (in accordance with modeling results) this suggests that the outlet and inlet should not be located on the same axis i.e.: they should be offset from each other.

The considerations for orientation of Marine Structures are illustrated in Figure 7-4.

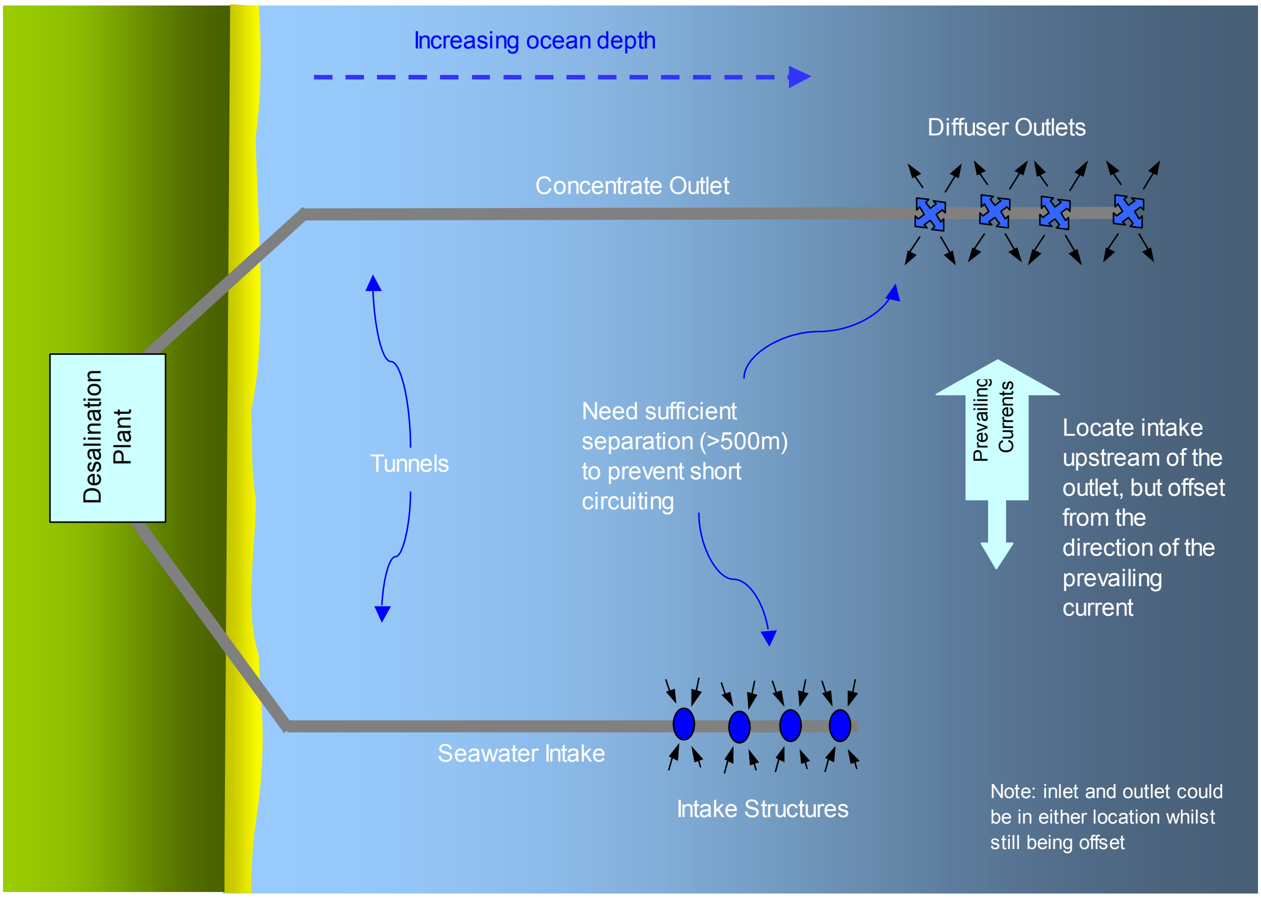


Figure 7-4 Design considerations for location of the intake and outlet (schematic showing key issues, not intended to represent Reference Project)

Best Practice Principles

The best practice principles that apply to locating marine structure for a seawater Desalination Plant can be summarised as follows:

- Avoid locating the Marine Structures and their area of influence on ecologically sensitive areas. For the concentrate, the area of influence prior to sufficient dispersion has been achieved should avoid the sensitive areas;
- Locate the inlet in a depth of water and at a distance off shore so as to provide, as far as practicable, consistent and high quality feed water for the Desalination Plant;
- Locate the outlet in sufficient depth of water to allow efficient diffuser design; and
- Locate the inlet and outlet to minimise the risk of short-circuiting from the outlet back to the inlet.

7.1.1.1 Evaluation Against Relevant Best Practice Criteria

The Reference Project, and Variation, have adopted the following design aspects in relation to the siting of Marine Structures. For a detailed assessment of the Marine Structures location against the environmental evaluation framework and criteria adopted for this WAA, refer to Section 14.

Reference Project

- Intake in water depth approximately 20 m;
- Outlet in water depth approximately 20 m; and
- Marine structures located off-shore to the Plant, on low profile reef, but not within the sensitivity areas as indicated by Figure 6-3 (refer Section 6); and
- Intake located upstream of the outlet, at sufficient separation distance to avoid short-circuiting (refer to Section 14.6.4 for further discussion).

Variation

- Marine structures located off-shore to the Plant, on low profile reef or in deeper water on sand, but not within the sensitivity areas as indicated by Figure 6-3 (refer Section 6).

The Marine Structures location as described in the Reference Project, and Variations, is in agreement with the best practice principles presented in this Section.

Both the Reference Project and Variations will be controlled by the Performance Requirements (refer to Section 17), to which the Project Company will be bound under the Project Agreement. The Performance Requirements control the final selection and optimisation of Marine Structures location such that the final design meets best practice, and other requirements.

7.1.1.2 Seawater Intake

There are two categories of seawater intake systems for desalination plants. These are:

- Open seawater (direct) intake systems; and
- Sub-surface (indirect) intake systems.

While there is not a single best practice solution for intake systems, efforts should be made to avoid entrainment and impingement of marine biota to reduce negative ecological impacts (Sherwood 2006). It is also desirable to reduce entrainment of sediments and marine biota so that RO plant feedwater pre-treatment requirements are reduced (which in turn will act to reduce the amount of pre-treatment waste generated).

Seawater extraction via a sub-surface seabed intake system meets these objectives by filtering seawater through sand (or an engineered media) as it is being collected thereby excluding the majority of organisms and reducing pre-treatment requirements. Experience elsewhere with sub-seabed intake systems is limited to desalination plants having much smaller capacity than the proposed Desalination Plant. For example, the sub-surface infiltration gallery in Fukuoka, Japan (50 Ml/day intake). Large-scale applications of this type of system would require excavation of large areas of the existing seabed during construction, which may have substantially greater effect than direct intake systems resulting in long-term modification of the seabed habitat where the sub-surface system is installed (CEE, 2007).

For this reason, a sub-surface (indirect) intake system is considered as an Option only for the EES, for which approval is not sought in this WAA.

By incorporating appropriate engineering controls, a direct deep water intake system is considered a best practice solution for all large modern desalination plants (Sherwood 2006). They are a proven technology where large volumes of water are required. All seawater intakes for large seawater desalination plants in Australia (either existing or under construction) are of the direct intake type. Seawater intake designs for the Sydney and Gold Coast desalination plants are tunnels with vertical risers and intake heads. The Perth plant consists of a trenched pipe with a single intake head. It is recognised that the use of deep open water intakes is likely to be the dominating approach for large sized desalination plants in locations such as California (Voutchkov, 2007).

Appropriate engineering controls for direct deep water intakes may include:

- Having the intake water stream horizontal to the seabed so that fish can sense the water current. Fish are sensitive to horizontal but not vertical currents and the altering of the direction of the current has been shown to provide large reductions in the entrainment of fish;
- Control of maximum water velocity at the intake to reduce potential entrainment and impingement of marine biota and debris;
- Positioning the intake as far above the bottom as practical (avoid possible seabed boundary aggregations of biota), but in the bottom third of the water column. Locating the intake at this level would minimise intake of fish eggs, larvae, zooplankton in the top part of the water column and minimise intake of benthic zooplankton and small benthic fish species as well as drifting kelp and seaweed (although unlikely to be avoidable at all times);
- Screening at the intake point to prevent entry of larger marine organisms and debris. Screening should not create fouling of the intake point, as this would affect the reliability of the seawater supply. Allowances for control of marine growth can be factored into the design of the intake system, so that the reliability and quality of feedwater supply is not compromised.
  Fine screens (in the order of 0.5 – 10 mm) at the intake could be considered that further reduce the intake of planktonic larvae, zooplankton and small fish species. Fine screens on the offshore intake are subject to practical considerations such as biological fouling growth on offshore screens and the need and ability to regularly clean or change the screens by divers or by remote systems; and

- The location of chemical dosing to prevent undesirable marine growth in the intake structure downstream of the inlet head, so that the potential for chemicals to escape into the ocean is minimised. Alternative marine growth mitigation methods can be employed for the intake head. Intermittent chlorination is typically used to control marine growth in seawater intake conduits, screens, pump station, and rising mains.

Internationally adopted best practice applicable for seawater intake systems is discussed below.

USEPA Clean Water Act

The USEPA Clean Water Act (2001) developed rules *for minimizing adverse environmental impact associated with the use of (cooling water) intake structures*. The regulations cite a range of existing and retrofitted seawater intake systems in USA. USEPA (2001) considered that:

> *Intake velocity is one of the key factors that can affect the impingement of fish and other aquatic biota. In the immediate area of the intake structure, the velocity of water entering a cooling water intake structure exerts a direct physical force against which fish and other organisms must act to avoid impingement or entrainment.*

USEPA concluded that:

> *To develop a threshold that could be applied nationally and is effective at preventing impingement of most species of fish at their different life stages, EPA applied a safety factor of two to the 1.0 ft/s* (0.3 m/s) *threshold to derive a threshold of 0.5 ft/s* (0.15 m/s)*. This safety factor, in part, is meant to ensure protection when screens become partly occluded by debris during operation and velocity increases through portions of the screen that remain open… The data suggest that a 0.5 ft/s* (0.15 m/s) *velocity would protect 96 percent of the tested fish.*

Overall, in relation to impingement and entrainment, USEPA states:

> *Technologies that minimize impingement mortality and entrainment of all life stages of fish and shellfish at a location might include, but are not limited to, intake screens, such as fine mesh screens and aquatic filter barrier systems, that exclude smaller organisms from entering the cooling water intake structure; passive intake systems such as wedgewire screens, perforated pipes, porous dikes, and artificial filter beds; and diversion and/or avoidance systems that guide fish away from the intake before they are impinged or entrained. In some cases, technologies that might be used to achieve the 0.5 ft/s* (0.15 m/s) *velocity standard …, such as passive intake systems, might also minimize impingement mortality and entrainment. Some technologies minimize impingement mortality by maximizing the survival of impinged organisms. These technologies include, but are not limited to, fish-handling systems such as bypass systems, fish buckets, fish baskets, fish troughs, fish elevators, fish pumps, spray wash systems, and fish sills. These technologies either divert organisms away from impingement at the intake structure, or collect impinged organisms and protect them from further damage so that they can be transferred back to the source water at a point removed from the facility intake and discharge points.*

However, USEPA recognised that cooling water intakes were situated in a wide range of environments from lakes and rivers to estuaries, bays and the open ocean. Consequently the design, construction and operational options available to some intake systems were constrained by practicalities related to the specific site conditions. Hence USEPA concluded:

> *Some additional design and construction technologies have feasibility issues limiting their use to certain types of locations. Some have not been used on a widespread basis above certain intake flow rates. The effectiveness of these technologies also may vary depending on factors such as the speed and variability in direction of currents in a waterbody, the degree of debris loading at a location, etc. Because of these issues, EPA has not established a national performance standard for these technologies more specific than to require the applicant to study literature and available physical and biological data on their proposed location, and then to select and install technology(ies) that minimize impingement mortality and entrainment.*

7.1.1.3 Evaluation Against Relevant Best Practice Criteria

The following design aspects to reduce entrainment, impingement and entrapment of marine biota and reduce sediment entrainment have been adopted by the Reference Project, and Variation, for the intake structure. For a detailed assessment of the intake structure against the environmental evaluation framework and criteria adopted for this WAA, refer to Section 14.6 of this WAA.

Reference Project

- Direct deep water intake, with intake head located above the sea floor, outside the wave zone;
- Mushroom type intake head that draws in seawater horizontally;
- Grill on intake head, with grill size in the order of 100 mm x 100 mm, or 50 mm horizontal by 100 mm vertical;
- Intake flow velocity in tunnels in the order of 0.15 m/s; and
- Intermittent dosing within the intake tunnels with chlorine (in liquid form) to minimise marine growth.

Variation

- Passive fine screen at intake head.

The seawater intake design as described in the Reference Project, and Variation, is in agreement with the best practice considerations presented in this Section.

Both the Reference Project and Variations will be controlled by the Performance Requirements (refer to Section 17), to which the Project Company will be bound under the Project Agreement. The Performance Requirements control the final seawater intake design such that the final design meets best practice, and other requirements.

7.1.2 Saline Concentrate Outlet

A reverse osmosis plant requires a reliable way to dispose of seawater concentrate that is produced as a by-product from the plant's operations. Various methods exist for disposal of this saline concentrate, including evaporation, direct discharge to the sea, irrigation, well injection and other methods. For reasons discussed elsewhere in this document (see Appendix A), only direct discharge of concentrate to the sea is considered here.

There is not a single best practice for ocean outlet systems (Sherwood 2006). The most common outlet system for concentrate currently used is a submerged diffuser with velocity nozzles distributed spatially.

Outlet diffusers are typically designed to provide a target dilution of the discharge plume within a mixing zone. A mixing zone (as declared by EPA licence) is an area within the receiving waters where the receiving environmental quality objectives, otherwise applicable under the SEPP (WoV), do not apply to certain indicators within the zone.

The concentrate outlet should be designed to produce the required initial dilution of the concentrate (and other constituents) as close to the point of discharge as practicable.

The Victorian Desalination Plant should achieve engineering nozzle outlet mixing of the concentrate such that 1 unit of the discharge (and its constituents) are diluted with 50 units of the background seawater (with lower concentrations of the same constituents) from the point of discharge.

In addition to the outlet's diffuser design, the depth at the point of discharge is a contributing factor in designing diffuser nozzles and arrays. The greater the depth of the discharge (up to a point), the higher the velocity can be used, and thus mixing can be achieved more rapidly.

Since the diluted concentrate has a higher density than ambient seawater, it may be preferable that the discharge be located in a turbulent area to maximise subsequent mixing into the wider area (where practical). Under calm conditions, the slightly dense plume may tend to form a layer on the seabed and flow downslope due to gravity, so it may be beneficial that the outlets are located where the downslope habitat is predominantly sand, gravel or rubble. Downstream depressions (basins or valleys) should be avoided if possible as they may contribute to a 'pooling' effect in calm conditions.

Key considerations for the location of Marine Structures have been discussed in more detail in Section 7.1.1 and Section 14.

Open ocean outlet systems that meet the following requirements are considered best practice:

- Adequate near field engineered mixing to meet the dilution required to achieve minimum compliance requirements (addressed in Section 14.5.6);
- Selection of the point of discharge with an appropriate water depth (addressed in Section 7.1.1);
- Identification of an optimum geographic location for siting the concentrate outlet, on the basis of coastal hydrodynamics, seawater quality, bathymetry, seabed type, and other local marine conditions, with consideration to the long-term impact of discharging concentrate (addressed in Section 7.1.1);
- Absence of surface strike of the plume; and
- Maintenance of an adequate separation distance between intake and outlet, to minimise risk of 'short-circuiting' of concentrate into intake (addressed in Section 7.1.1).

7.1.2.1 Evaluation Against Relevant Best Practice Criteria

The Reference Project, and Variation, has adopted the following design aspects for the outlet structure. For a detailed assessment of the outlet structure design against the environmental evaluation framework and criteria adopted for this WAA, refer to Section 14.5.

Reference Project

- Target design dilution to achieve compliance requirements; and
- Rosette style diffusers, with diffuser arrangement determined by hydrodynamic modelling.

Variation

- Pipeline style diffuser.

The outlet structure design as presented in the Reference Project, and Variation, is in agreement with the best practice considerations presented in this Section.

Both the Reference Project and Variations will be controlled by the Performance Requirements (refer to Section 17), to which the Project Company will be bound under the Project Agreement. The Performance Requirements control the final design of the concentrate outlet system and design optimisation such that the final design meets best practice, and other requirements.

7.2 Best Practice Considerations for Pre-treatment Plant

Criterion 2: Design the pre-treatment system to minimise adverse effects on the receiving environment from the residual effects of chemicals (biocides, coagulants, flocculants, antiscalants, etc.) used to condition the feedwater prior to pre-treatment.

Criterion 3: Design a pre-treatment system to achieve an overall balance and net benefit in energy, water use and waste generation, consistent with EREP requirements and the waste hierarchy.

The following Sections present best practice considerations for the selection and design of a seawater reverse osmosis (SWRO) pre-treatment system, as a means of complying with the above Criteria 2 and 3. The information presented is based upon practices in the industry and a review of international literature.

7.2.1 Pre-treatment Process Options

'Pre-treatment', in the context of seawater reverse osmosis (SWRO) desalination, refers to those processes that treat seawater prior to the RO membranes.

The purpose of pre-treatment for SWRO is to provide high quality feed water to the RO process. By doing so this improves efficiency of the process by maximising flux rate capabilities, minimising fouling and lowering RO membrane replacement frequencies.

There are multiple pre-treatment processes that can be selected (in isolation and/or combination) that are suitable for seawater reverse osmosis pre-treatment. Two categories of pre-treatment approach are usually considered during the design of a SWRO plant. These are:

- Conventional Pre-treatment – incorporating a granular filtration process and coagulant dosing; and
- Microfiltration (i.e. MF/UF) – incorporating an ultrafiltration or microfiltration process, probably with upstream coagulant dosing.

Traditionally, SWRO plants have used media filters for pre-treatment, with these usually operating as direct filters (not including a clarification stage). However, recent advances in membrane science have made membrane filtration pre-treatment more competitive.

There exist multiple variations within the pre-treatment system that the Project Company may adopt. This is depicted graphically in Figure 7-5.

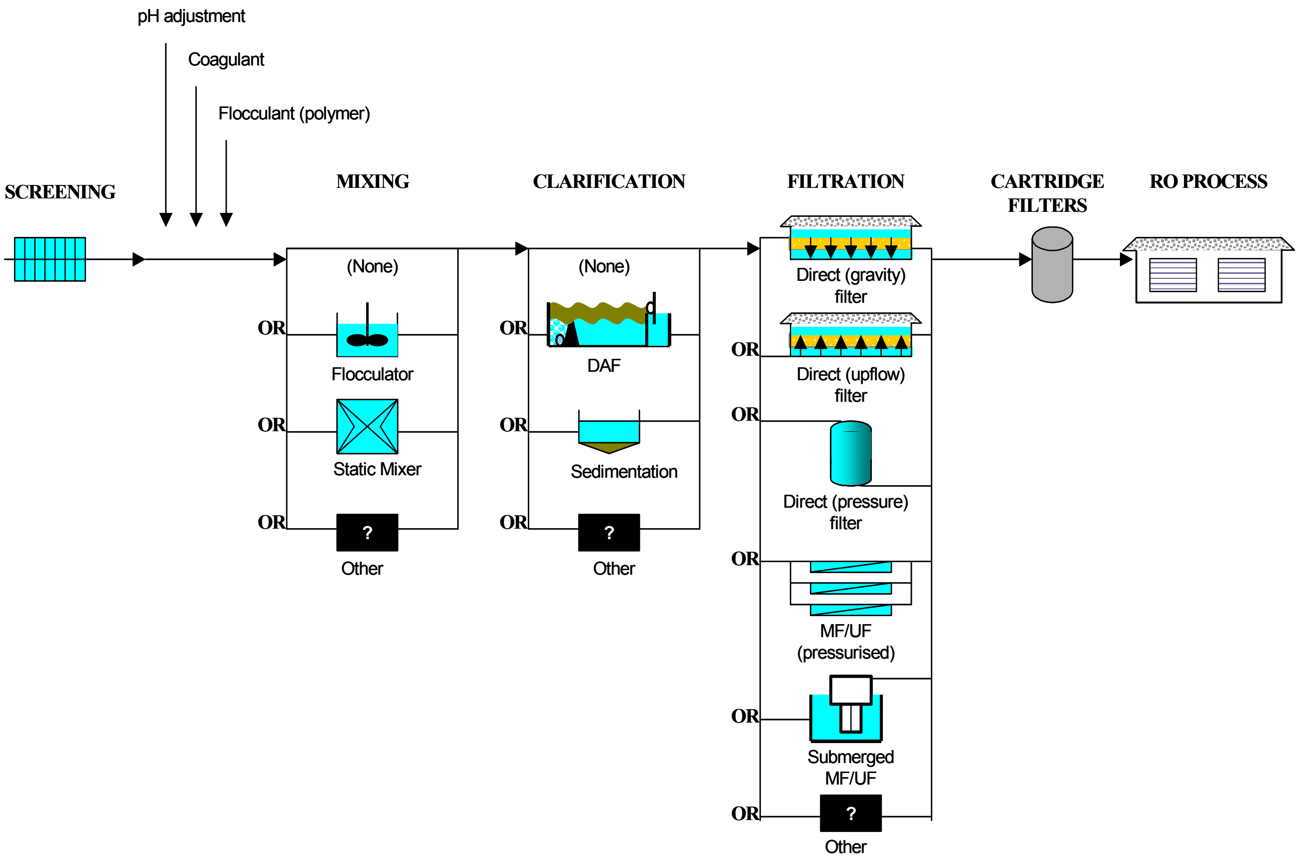


Figure 7-5 Some of the multiple alternatives available for SWRO pre-treatment system

7.2.2 Comparison of Media and Membrane Technologies

Media filtration (i.e. conventional pre-treatment) is the predominant approach for SWRO including all the current large plants in Australia. It has been employed at numerous plants around the world and has a proven track record over the long term, including all large plants currently operating or under construction in Australia, and many of the early SWRO plants located in the Eastern Mediterranean and the Middle East. These older plants have proven that conventional pre-treatment provides a robust pre-treatment solution to cope with a variety of applications and treat a variable feed water quality.

The use of membrane filtration has become more common for surface water, industrial and wastewater applications, but use for SWRO pre-treatment is less common. Advances in membrane science have made membrane filtration pre-treatment more competitive in the last decade and its use for SWRO in small to medium scale applications has become more widespread. However, membrane pretreatment has generally been limited to smaller desalination plants and, if membrane pretreatment were selected for the Victorian plant, it would form a large portion of the globally commissioned pretreatment membranes for SWRO.

There are two aspects of membrane pre-treatment, which are unique, compared to media filtration. The first is that membrane pre-treatment may achieve removal of suspended solids with no or limited pre-treatment, coagulation or chemical dosing. The second is that these levels of removal are achieved at all times, regardless of how the system is operated. While a well operated and designed media filter can achieve removal of suspended solids, including fine colloidal particles, its performance is dependent upon proper and well-maintained chemical dosing.

However, membrane filtration does not remove dissolved substances, and ‘true’ colour[10] which is the result of dissolved material will not be removed unless a coagulant is added. In general, removal of dissolved organics by membrane filtration will require coagulant dosing. This means that pre-treatment waste will likely still contain chemicals. If colour results from colloidal material, then the measured true colour in water may be reduced (but may not be fully removed) using membrane filtration. The degree of removal will be related to the contribution made to colour by particles, which pass at 0.45 μm but not at 0.2 μm.

Published results indicate good performance of membrane filtration at full scale, however, long-term experience at high capacity plants remains limited. *An Environmental Literature Review and Position Paper for Reverse Osmosis Desalination Plant Discharges – Contract No. CN-05-12269- 29 April 2006* (Pankratz & Tonner, 2006) states that largest plants to utilise membrane filtration are approximately 10 ML/day. However, recent publications report a capacity range of between 140 ML/day and 192 ML/day for plants using membrane filtration. This reported capacity is still significantly less than the capacity of the proposed Desalination Plant (of capacity 435-580 ML/day) and being relatively new operations, long-term performance and reliability of membrane filtration at such plants is also unknown.

Conventional pre-treatment usually has a lower capital cost, but requires a larger area than a membrane process. It usually consumes less water during backwashing than membrane pre-treatment and requires less energy to do so.

[10] True colour is colour which passes a 0.45 micron filter and comprises sub 0.45 micron and dissolved material

Conventional pre-treatment will usually require coagulant dosing of a higher concentration at the pre-treatment stage, which may impact the volume and composition of the sludge generated. Conversely, conventional pre-treatment requires less dosing of coagulant and polyelectrolyte at the washwater treatment stage, and it also does not require chemical cleaning in the way that a typical membrane process would. Hence, the benefits of non-conventional treatment (lower dose of coagulant) need to be balanced against the additional backwashing or chemical cleaning required to prevent membrane fouling (i.e. of UF/MF membranes (Lattemann & Höpner, 2003)).

Long-term maintenance is also less costly (financially) for conventional pre-treatment and does not require a commercial commitment to an external supplier for replacement parts, as is the case for MF/UF membranes which are not globally standardised. The selection of membrane pre-treatment can have commercial complications, in that it commits the proponent to a third party supplier of membranes (for 5-10 yearly membrane replacement). This is because encased membrane systems are not of universal, standardised design - in contrast to RO, where individual membrane units are interchangeable.

RO feedwater quality is a key pre-treatment performance indicator, and although greater consistency in RO feed water quality is reported for membrane pre-treatment, conventional pre-treatment meets the RO feed requirements at a majority of plants around the world. An increase in RO flux rate is also reported as an advantage made possible by membrane pre-treatment. The extent of this advantage would need pilot testing to validate, and may not outweigh other factors.

Whether higher RO flux is made possible by membrane pre-treatment will also depend on feed water salinity. At low TDS concentrations, the effect of a consistently low silt density index (SDI) enables greater flux through the RO membranes. An increase in RO flux is reported by Pearce (2007) for feed water TDS <35,000mg/l. However, at elevated TDS concentrations the degree to which SDI consistency is improved by membrane pre-treatment (compared to conventional pre-treatment) is insignificant, given that the TDS inhibits flux.

Additional seawater quality data and pilot trials are required in order to establish whether the benefits of membrane pre-treatment (as discussed above) would apply at the Victorian Desalination Plant. TDS data to date suggests that increased RO flux (as a result of membrane pre-treatment) would probably be limited for the Victorian Desalination Plant.

Preliminary Net Present Cost and life cycle assessment studies indicate that energy consumption is the largest contributing factor to environmental load (carbon footprint) and overall cost. Whether conventional pre-treatment is less energy intensive than membrane pre-treatment, this will depend on the feed water quality and hence process selection under each alternative. Reduced coagulant use (associated with membrane pre-treatment) will potentially result in marginal cost savings in comparison to overall cost and uncertainty associated with these estimates. Furthermore, savings in chemical use incurred via reduced coagulant dosing (for membrane pre-treatment) must be offset against increased use of membrane cleaning chemicals required to prevent fouling under this option. Avoidance of coagulation is rarely reported at full scale SWRO plants, and can cause increased fouling of RO membranes and therefore may not be possible for the Victorian plant, regardless of pre-treatment choice.

Based upon a preliminary analysis and review of the published literature, it is concluded that the differences in 'whole-of-life' cost between conventional and membrane pre-treatment technologies are likely to be 2 – 10 % lower for membrane pre-treatment. However, this value is small enough to be within a typical range of costing uncertainty.

An advantage noted for membrane pre-treatment is that it requires a relatively small land area (or ‘footprint’). Whether reducing the land area required for pre-treatment is considered significant for the Victorian Desalination Plant will depend on the presence of Site constraints. The Site area available (described in Section 5) is considered adequate for both pre-treatment options, however this position could change if spatial constraints become apparent at a later stage.

7.2.3 Requirements and evaluation of options for best practice in pre-treatment

Best practice in pre-treatment can be achieved by:

- Selection of a pre-treatment system suitable to the site-specific requirements by considering emissions to all segments of the environment, arising from the selected option and by acknowledging that there may be trade-offs between resource usage and waste generation;

  Comment: This requirement can be met by both options. The conventional option may have a lower energy usage. The membrane option may have a lower quantity of wastes.

- Design of the pre-treatment system to minimise chemical usage and to select chemical products that are proven to have minimal adverse effect on the receiving environment;

  Comment: This requirement can be met by both options. The membrane options may require a lesser quantity of chemicals, but may require the use of a wider range of chemicals.

- Selection of a pre-treatment process that will achieve the necessary performance at the scale required and avoiding if possible dependence on a single technology provider; and

  Comment: This requirement can probably be met by both options; however, conventional pre-treatment has significantly more operating history at the large scale of the Victorian plant. Membrane pre-treatment is likely to be dependent on a single technology provider.

- Ability to provide a consistent pretreated water quality, with the variability observed in the seawater quality data collected for the Wonthaggi Site;

  Comment: This requirement can also be met by both options, however, based upon its proven track record, conventional pre-treatment is considered a more appropriate solution to accommodate feed water quality observed to date for the Wonthaggi location. Seawater quality data collection is not yet complete, and could alter this process decision. The suitability of either pre-treatment technology will more accurately be determined by pilot trials. Note that, full seasonal-year pilot plant testing is considered important prior to development/implementation of membrane pre-treatment system to establish process requirements to protect against membrane fouling (Burashid *et al.*, 2005).

It can be seen from this comparison that conventional pre-treatment is favoured on the basis of the last two items, although both options represent best practice and are feasible.

7.2.4 Conclusions

Consideration of the above supports adopting the following pre-treatment processes for the Reference Project:

Reference Project

- Media filtration, with coagulant dosing.

Variations

- Membrane filtration.
- Additional clarification processes upstream, such as DAF.

Conventional pre-treatment has been selected for the Reference Project; however, the suitability of pre-treatment technologies will be evaluated by pilot trials conducted by bidders for the Project. Pilot testing could identify which pre-treatment approach is most suitable for the Project location, and would confirm the level of pre-treatment required, in addition to chemical dose rates (including marine growth control dosing). The trial may also confirm whether conventional pre-treatment would require additional stages of clarification (such as DAF).

Both the Reference Project and Variations will be controlled by the Performance Requirements (refer to Section 17), to which the Project Company will be bound under the Project Agreement. The Performance Requirements control the final design of the pre-treatment system such that the final design meets best practice, and other requirements.

7.3 Best Practice Considerations for Desalination Process

Criterion 4: Design a Desalination Plant with a process technology to achieve an overall balance and net benefit in minimising energy use and waste generation.

Criterion 5: Design of the pre-treatment, desalination and potabilisation systems to minimise chemical usage and to select chemical products that are proven to have minimal adverse effect on the receiving environment.

The following Sections present best practice considerations for the selection and design of desalination technology and processes, including chemical use, as a means of complying with the above Criteria 4 and 5. The information presented is based upon practices in the industry and a review of international literature.

7.3.1 Desalination Technology

Seawater desalination is a process that produces fresh water by separating salts and other dissolved minerals from seawater. Reverse osmosis has become the leading technology for desalinating water, and is now used in just over half of all desalination plants around the world.

Seawater desalination to provide drinking water is carried out at many locations throughout the world. In Europe, reverse osmosis plants provide about three quarters of the total desalinated water production. While thermal distillation plants are still being installed in some locations internationally, generally this is occurring in areas where the cost of fuel is low and the desalination plant can be integrated with a heat source (such as in the design and implementation of large new thermal power stations as is occurring in the Middle East). In the Victorian setting, a new heat source (such as a power station) of the capacity necessary is not part of the Desalination Plant proposal.

Recent advances in technology have reduced the costs and energy use of reverse osmosis desalination. In terms of energy use, reverse osmosis is the lowest among all options for seawater desalination. The technical advances and increasing shortages of fresh water have led to increasing numbers of large plants being built. This trend is also evident in Australia, with a plant recently commissioned in Perth, plants under construction on the Gold Coast and in Sydney, and proposed new plants in Perth and Adelaide.

Table 7-1 below outlines the status of the major seawater desalination projects in Australia.

Table 7-1 Seawater desalination projects in Australia

Location	Capacity (ML/day)	Status	Desalination Technology
Perth (1)	135	Commissioned in 2006	Reverse osmosis
Perth (2)	150 to 300	Under tendering phase	Reverse osmosis
Sydney	250 to 500	In construction	Reverse osmosis
Gold Coast	125	In construction	Reverse osmosis
Adelaide (BHP, Olympic dam)	150 or greater	Feasibility study and pilot testing	Reverse osmosis
Adelaide – Port Stanvac	150	Planning and pilot testing	Reverse osmosis
Melbourne	435 to 580	Environmental assessment and Expression of Interest	Reverse osmosis

Best practice considerations for RO plant energy efficiency are discussed in Section 10 of this WAA.

It is considered that best practice in selection and design of desalination technology can be achieved by:

- Using membrane technology, as it provides higher energy efficiencies relative to other currently available technologies; and
- Employing commercially available energy recovery devices.

7.3.1.1 Evaluation Against Relevant Best Practice Criteria

The Reference Project has adopted the following design aspects for the desalination process, which encompass best practice considerations as previously discussed.

Reference Design

- Up to two passes of typical spiral-wound RO membranes.
- Energy recovery devices to transfer pressure from the first pass RO concentrate stream to the incoming feed stream.

7.3.2 Best Practice Considerations for Chemical Use

During operation of the plant, the use of chemicals will be required for three main processes, being pre-treatment (including intake structure marine growth control), desalination and product water potabilisation. Each process requires the aid of various chemicals to maintain the integrity of the equipment and the system as a whole, and to achieve the water quality objectives in the product water. For further discussion refer to Section 14.

An appropriate Performance Requirement is included (see Table 17-3, Section 17) to minimise chemical usage and to select chemical products that are proven to have minimal adverse effect on the receiving environment.

8. GHG Emissions

8.1 Scope of Greenhouse Gas Assessment

8.1.1 Policy Framework

The *SEPP (Air Quality Management) No. S240* (2001) (SEPP (AQM)) establishes a framework for managing emissions to air in Victoria and sets out a program for action to protect the air environment and achieve regional air quality objectives. It also implements a government commitment to promote sustainable business practices by requiring greenhouse gas (GHG) issues to be addressed in the EPA works approval and licensing processes. This is addressed through EPA Publication 824, *Protocol for Environmental Management on Greenhouse Gas Emissions and Energy Efficiency in Industry* (2002) (the PEM), an incorporated document under the SEPP (AQM).

In order to estimate energy consumption and emissions, a boundary for the Project needs to be defined. The PEM requires a works approval applicant to calculate:

- the annual energy consumption by energy type, including use of fuels on-site and consumption of electricity;
- based on that consumption, GHG emissions from the production of the energy whether generated on or off-site; and
- non-energy related GHG emissions.

Given that energy use and GHG emissions of the Desalination Project exceed the threshold levels specified in the PEM (500 GJ/yr, 100 t CO2-e/yr), the PEM requires that best practice measures for energy efficiency and GHG emissions be identified and adopted in the proposal.

8.1.2 Greenhouse Gas Assessment for the EES

In order to assess GHG impacts of the Project for the EES, both construction and operational GHG emissions were estimated based on specific information provided in the Reference Project and assumptions of future Project activities throughout the life of the Project. Direct and indirect emissions were estimated for the construction and operation phases of the Project, addressing all three GHG assessment Scopes, as defined below:

- **Scope 1** includes greenhouse gases emissions created directly by a person or business from sources that are owned or controlled by that person or business;
- **Scope 2** includes greenhouse gas emissions created as a result of the generation of electricity, heating, cooling or steam that is purchased and consumed by a person or business. These are indirect emissions as they arise from sources that are not owned or controlled by the person or business consuming the electricity; and
- **Scope 3** includes greenhouse gas emissions that are generated in the wider economy as a consequence of a person or business's activities. These are indirect emissions as they arise from sources that are not owned or controlled by that person or business but they exclude Scope 2.

The GHG assessment for the EES is broader than that required for the WAA. The scope of the GHG assessment for the WAA is described in the following Section.

8.1.3 Greenhouse Gas Assessment for the WAA

Although a works approval authorises construction of works that will result in discharges or emissions to the environment, the focus of the approval is on the discharges and emissions that will occur when the works are operational. EPA works approval requirements, as per the PEM, do not generally include the construction phase of projects. Therefore, for the purposes of the WAA, only Scope 1, Scope 2 and Scope 3 operational GHG emissions are reported here, drawn from the relevant Sections of the *Victorian Desalination Project Greenhouse Gas Assessment* (Maunsell, 2008b), refer *Technical Appendix 7* of the EES

Table 8-1 defines material Scope 1, Scope 2 and Scope 3 operational emissions, and outlines likely sources of these emissions in the context of the operational phase of the Project relevant to the WAA.

Table 8-1 Description of direct and indirect GHG emissions reporting categories

<table>
<tr><th>Scope and Description</th><th>Reported Project Aspects</th></tr>
<tr><td rowspan="2">Direct Emissions:
Scope 1
Greenhouse gases emissions created directly by the Desalination Project from sources that are owned or controlled by the Project Company.</td><td>Emissions associated with any on-site generation of energy, heat, steam and electricity e.g. from diesel generators.</td></tr>
<tr><td>Emissions associated with fuel consumed by equipment under operational control of the Project Company.</td></tr>
<tr><td>Indirect Emissions: Scope 2
Greenhouse gas emissions created as a direct result of the generation of electricity, heating, cooling or steam that is purchased and consumed by the Project.</td><td>Emissions associated with purchased electricity from the grid for the operation of the Desalination Plant.</td></tr>
<tr><td rowspan="5">Indirect Emissions:
Scope 3
Greenhouse gas emissions that are generated in the wider economy as a consequence of the Desalination Project but arise from sources that are not owned or controlled by the Project Company (other than Scope 2 emissions).</td><td>Emissions associated with off-site disposal of waste to landfill.</td></tr>
<tr><td>Embodied emissions in operational inputs (chemical inputs).</td></tr>
<tr><td>Emissions attributable to the extraction, production and transport of fossil fuels/gas used in the power station that generates electricity for the Project and of fuels used on-site (eg. the diesel used by on-site generators).</td></tr>
<tr><td>Emissions arising during the transmission of electricity to the Desalination Plant.</td></tr>
<tr><td>Emissions associated with fuel consumed in the transport of material to the Desalination Plant.</td></tr>
</table>

8.2 Methodology

8.2.1 Basis of Assessment and Assumptions

A GHG assessment of the Reference Project was undertaken and is presented in this Section of the WAA. In the Reference Project, the Plant and Transfer Pipeline are to be powered by electricity sourced from the grid via the North-South Grid Connection and therefore this Section focuses on GHG emissions associated with a grid connection.

The Reference Project includes the initial construction of a Desalination Plant with a capacity of 150 GL per year and the possible expansion of that capacity in the future to 200 GL per year. In order to cater for the possible expansion of the Plant in the future, the assessment was undertaken by firstly evaluating the GHG emissions associated with the 150 GL per year plant and then assessing the implications of increasing Plant capacity to 200 GL per year. The assessment of GHG emissions associated with the construction of the Marine Structures, Transfer Pipeline and Power Supply is based on the ultimate capacity of 200 GL per year as these components will need to be built to meet the demands of a 200 GL per year plant.

In assessing GHG emissions associated with operation of the Desalination Plant, an annual average power demand was applied. Factors considered when determining this annual average power demand for the Desalination Plant include:

- annual water production;
- fluctuations in seawater quality and temperature; and
- adopted treated water quality targets and operating philosophy.

Where a parameter that was needed for the assessment was not specified in the Reference Project, assumptions were made. The assumptions were derived from consultation with appropriately experienced technicians, product specification sheets and other appropriate sources. Where likely ranges were provided for Project elements, the higher conservative GHG emissions option was used in the assessment. Where no range or any other information was provided for potential elements, such as the type or size of construction machinery to be utilised, the options available on the market for those Project elements were identified and a mid-range selection was used.

The assumptions that were made have been documented on the emissions calculation worksheets that are appended to the Greenhouse Gas Assessment Report (Maunsell, 2008b).

Most assumptions relate to the construction process, which accounts for only 4% of the total Project emissions over a 30-year Project life. The key sources of GHG emissions are associated with the operation of the Desalination Project.

8.2.2 Methods of Calculation

Methodology

The method for calculating the GHG emissions associated with the Project in the Greenhouse Gas Assessment (Maunsell, 2008b) has been adopted from the *National Greenhouse and Energy Reporting Act 2007* (the NGER Act) and associated documents. In particular, Scope 1 and 2 emissions have been calculated in line with the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* and Scope 3 emissions have been calculated using the methodology in the *Technical Guidelines for the Estimation of Greenhouse Emissions and Energy at Facility Level 2007* (discussion paper). The methodology that has been used is consistent with the requirements under ISO14064 and the *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, prepared by the World Resources Institute/World Business Council for Sustainable Development.

Emission Factors

Emission factors enable GHG emissions to be estimated on the basis of specified aspects of an activity, for example the amount of fuel consumed, the weight of waste sent to landfill and the amount of electricity consumed. The emissions factors that were used in the Greenhouse Gas Assessment (Maunsell, 2008b) and the sources for those emission factors are set out in *Appendix B* to the Greenhouse Gas Assessment Report.

The current published Victorian full fuel emissions factor for purchased electricity was applied (1.31 kg CO2-e/kWh). This emissions factor represents the current mix of energy generation sources in Victoria (predominantly brown coal).

Information published by the National Electricity Market Management Company (NEMMCO) suggests that the Victorian system would require additional generating capacity in order to supply the load required by the Project. It is considered that gas-fired power plant(s) (or a greenhouse gas equivalent) will most likely be the form of new capacity added to the grid in Victoria to power the Desalination Plant (if grid supplied). As gas-fired power generation is less emissions intensive than coal-fired power, the greenhouse gas emissions associated with generating the electricity will be significantly lower than what is estimated using the current published Victorian full fuel emissions factor for purchased electricity.

It is expected that during the 30-year life of the Project, a number of significant factors will lead to reducing the emissions factor for purchased electricity. These factors include:

- the introduction of a National Emissions Trading Scheme (from 2010) and its associated impact on supply and demand side investments and retirements of coal-fired generating units;
- future generation fuel costs;
- future electricity load growth;
- obligations/targets for renewable energy;
- timeframe for viable new generation technologies; and
- the timeliness of transmission investments to support new generation technologies.

It is expected that these factors will drive the introduction of lower emissions sources of electricity generation and thus lower the GHG emissions intensity of the Victorian grid. It is likely that these lower emissions sources of electricity will be commissioned to support future electricity load growth and to replace older, coal-fired, higher GHG emitting generating units. Modelling suggests that the full fuel cycle emission factor for the Victorian grid may reduce from its current average published level of 1.31 kg CO_2-e/kWh to 0.96 kg CO_2-e/kWh by 2020.

Therefore, as the current Victorian grid emissions factor has been used in the assessment the estimate of emissions presented in the assessment is conservative and overstates the likely GHG impacts.

8.3 Desalination Project Operations Phase Emissions Estimate

8.3.1 Energy Consumption

As required by the PEM, the first step in calculating GHG emissions is to estimate energy consumption.

The estimated average annual energy requirements for the Project are set out in Table 8-2. These energy requirements were used in the GHG assessment

Table 8-2 Annual electricity use from the Desalination Plant and booster pump station

Activity	Power demand (MW)
Initial 150 GL per year Desalination plant	82
Ultimate 200 GL per year Desalination plant	115
Transfer Pipeline (150 GL per year/ 200 GL per year)	10 / 18

8.3.2 Energy Used for 150 GL per yr operation, for Desalination Plant and Transfer Pipeline

The electricity required to operate the 150 GL per year Desalination Plant and corresponding Transfer Pipeline, assuming average annual energy consumption, is equal to:

- 2,586,000 GJ p.a. for the Desalination Plant; and
- 315,000 GJ p.a. for the Transfer Pipeline.

8.3.3 Energy Used for 200 GL per yr operation, for Desalination Plant and Transfer Pipeline

If the Plant’s capacity is increased to 200 GL per year at some time in the future, the corresponding energy requirement assuming average energy consumption would be increased to:

- 3,627,000 GJ p.a. for the Desalination Plant; and
- 568,000 GJ p.a. for the Transfer Pipeline.

8.3.4 Operational Emissions

The GHG emissions associated with the operation of the Desalination Project are almost entirely from the purchase of electricity to operate the Desalination Plant and the Transfer Pipeline.

The total operational emissions associated with the grid connected power supply are summarised in Table 8-3.

Table 8-3 Emissions arising from operation of the Desalination Project (150 GL per year Plant capacity)

Project component	Activity	Scope 1	Scope 2	Scope 3	Annual operational emissions ($t CO_2$-e) without offsetting commitment	Annual emissions ($t CO_2$-e) with offsetting commitment	Total emissions ($t CO_2$-e) x 30 years without offsetting commitment	Total emissions ($t CO_2$-e) x 30 years with offsetting commitment
Transfer Pipeline	Power purchased (10 MW)	0	106 870	7 010	113 880	0	3 416 400	0
Desalination Plant	Power purchased (82 MW)	0	876 350	57 470	933 820	0	28 014 600	0
	Transportation of waste off-site	0	0	270	270	270	8 100	8 100
	Waste decomposition	0	0	43 330	43 330	43 330	1 299 900	1 299 900
	Chemical deliveries	0	0	850	850	850	25 500	25 500
	Embodied emissions of chemicals	0	0	25 770	25 770	25 770	773 100	773 100
	Transportation of workforce	0	0	30	30	30	900	900
Total		0	983 220	134 730	1 117 950	70 250	33 538 500	2 107 500

The specific activities that have been assessed and included in Table 8-3 are set out as line items in *Appendix A* to the Greenhouse Gas Assessment Report (Maunsell, 2008b). In particular, *Appendix A* to the Greenhouse Gas Assessment Report includes a breakdown of the activities that come within the general activity categories set out in Table 8-3, and details how emissions associated with those activities were calculated and what assumptions were made (Maunsell, 2008b).

8.3.5 Key Findings

The GHG emissions arising from the operational power supply to the Desalination Plant and the Transfer Pipeline are approximately 1 047 700 tCO_2-e per year. The Government has made the commitment to offset 100% of the electricity used in operating the Desalination Plant and transfer Pipeline by the purchase of renewable energy credits from generation sources that are commissioned after 1 January 2007.

The remaining operational emissions of 70 250 tCO_2-e per year relate indirect sources namely the transportation of waste offsite, waste decomposition in landfill, delivery of operational chemicals and the embodied emissions in those chemicals. The figures relating to waste decomposition in landfill include the presumption that the lime sludge resulting from the Reverse Osmosis process will be reused offsite.

As explained in Section 8.2.2 the information published by NEMMCO suggests that even without the extra load required by the Project the Victorian system will reach capacity by 2010. In order to supply the load required by the Project additional generating capacity must be bought on stream. It is considered that gas-fired power plant(s), or a greenhouse gas equivalent, will most likely be the form of new capacity added to the grid in Victoria to power the Desalination Plant (if grid supplied). This greenhouse gas assessment uses an emissions factor based on the current mix of energy generation sources in Victoria (predominantly brown coal) rather than an emissions factor based on gas-fired power generation.

If the additional generating capacity that is needed is provided by new gas-fired power (which is less emissions intensive than coal-fired power) then the greenhouse gas emissions associated with generating that electricity will be significantly lower than the figure estimated in this greenhouse gas assessment.

As explained in Section 8.2.2 above, it is expected that during the 30-year life of the Project a number of significant factors will drive future market outcomes in the National Electricity Market, reducing the emissions factor for purchased electricity. Therefore, the estimate of total emissions associated with electricity sourced from the grid presented in the assessment conservatively overstates the likely GHG impacts. In fact, these emissions are expected to progressively reduce by up to 25% in 2020 compared with emissions based on the current configuration of the network.

8.4 Emissions Summary for a 200 GL per year Plant

The GHG emissions presented in Section 8.3.4, are based on the 150 GL per year Desalination Plant. At some point in the future, the capacity of the Plant may be upgraded to 200 GL per year, which would involve the addition of a fourth 50 GL per year plant module. The Marine Structures, Power Supply infrastructure and Transfer Pipeline have already been assessed for 200 GL per year capacity in this study. Therefore, as shown in Table 8-4, emissions arising from the operation of the additional 50 GL per year module for the Desalination Plant will vary with increasing operational capacity.

Table 8-4 Emissions arising from operation of the Desalination Project (200 GL per year Plant capacity)

Project component	Activity	Scope 1	Scope 2	Scope 3	Annual operational emissions (t CO_2-e) without offsetting commitment	Annual emissions (t CO_2-e) with offsetting commitment	Total emissions (t CO_2-e) x 30 years without offsetting commitment	Total emissions (t CO_2-e) x 30 years with offsetting commitment
Transfer Pipeline	Power purchased (18 MW)	0	192 370	12 610	204 980	0	6 149 400	0
Desalination Plant	Power purchased (115 MW)	0	1 229 030	80 590	1 309 620	0	39 288 600	0
	Transportation of waste off-site	0	0	360	360	360	10 800	10 800
	Waste decomposition	0	0	57 630	57 630	57 630	1 728 900	1 728 900
	Chemical deliveries	0	0	1120	1120	1 120	33 600	33 600
	Embodied emissions of chemicals	0	0	34 270	34 270	34 270	1 028 100	1 028 100
	Transportation of workforce	0	0	50	50	50	1 500	1 500
Total		0	1 421 400	186 630	1 608 030	93 430	48 240 900	2 802 900

Increasing the capacity of the Desalination Plant to 200 GL increases the annual emissions from electricity consumption to 1 514 600 t CO2-e. These emissions will be offset under the Government's commitment resulting in annual operational emissions of 93 430 t CO2-e.

8.5 Energy Efficiency and Best Practice Measures

The PEM requires applicants to adopt best practice, considering environmental, technical, logistical and financial constraints, to reduce energy use and GHG emissions. Energy efficiency measures have been included as detailed in Section 10 of this WAA and also in *Volume 1, Chapter 8* of the EES.

8.6 Environmental Performance Requirements Arising from this Section

As discussed in Sections 1 and 6 of this WAA, the design adopted by the Project Company appointed under the PPP contract is likely to differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Performance Requirements outlined in this Section of the WAA in a manner that would lead to a similar or better GHG emission outcome.

The following environmental Performance Requirements are included in Section 17 of this WAA, and are also to be incorporated into the Performance Requirements for the Project.

Performance Requirements

- Comply with the Performance Criteria set out in Section 17;
- Monitor and report in accordance with the National Greenhouse and Energy Reporting (Measurement) Systems and Technical Guidelines 2008 v1.0 (Department of Water Climate Change, 2008); and
- Demonstrate design, selection of Project components and consumables that minimise Greenhouse Gas Emissions to the extent reasonably practicable.

9. Waste Management

This Section of the WAA provides an assessment of solid and liquid waste streams expected to be generated during construction and operation of the Desalination Project. This Section does not address saline concentrate arising from the desalination process (discussed in Section 14).

A detailed assessment of waste streams and management options has been completed for the Desalination Project and is contained in *Technical Appendix 8* of the EES. The overall objective of this assessment is to support that performance criteria for construction and operation of Project infrastructure associated with the Desalination Project will optimise avoidance, mitigation and management of waste streams, consistent with the waste hierarchy and protecting beneficial uses.

Unlike other Sections of this WAA, risks have not been allocated to waste in the risk assessment process (refer Section 4).

Wastes from construction and operation of the Desalination Plant have not been reviewed in the risk assessment process as these are addressed through traditional waste management pathways consistent with principles of the waste management hierarchy and specific management outcomes for individual waste streams.

9.1 Regulatory and other Requirements

The legislative and policy framework for the management of waste in Victoria is extensive and has undergone change in recent years.

The principles of environment protection, as presented in the *Environment Protection Act 1970* (the Act), of direct relevance to waste management are outlined following.

Principle of Waste Hierarchy

Wastes should be managed in accordance with the following order of preference:

- avoidance;
- reuse;
- recycling;
- recovery of energy;
- treatment;
- containment; and
- disposal.

It should be noted that the components of the waste hierarchy differ slightly in some of the documents reviewed as part of this assessment. For the purposes of this report, the above definition (i.e. as provided in the Act) has been adopted.

Principle of Improved Valuation, Pricing and Incentive Mechanisms

- Persons who generate pollution and waste should bear the cost of containment, avoidance and abatement; and
- Users of goods and services should pay prices based on the full life cycle costs of providing the goods and services, including costs relating to the use of natural resources and the ultimate disposal of wastes.

Principle of Product Stewardship

Producers and users of goods and services have a shared responsibility with Government to manage the environmental impacts throughout the life cycle of the goods and services, including the ultimate disposal of any wastes.

Principle of Integration of Economic, Social and Environmental Considerations

- Sound environmental practices and procedures should be adopted as a basis for ecologically sustainable development for the benefit of all human beings and the environment;
- This requires effective integration of economic, social and environmental considerations in decision making processes with the need to improve community well-being and the benefit of future generations; and
- Measures adopted should be cost-effective and in proportion to the significance of the environmental problems addressed.

In addition to the Act, the following legislation, policies and guidelines are relevant to this Section:

- *Environment Protection (Prescribed Waste) Regulations* (1998) (Vic) - establishes a system of controls over PIW producers, transporters, recyclers, reusers and receivers;
- *Environment Protection (Scheduled Premises and Exemptions) Regulations* (2007) (Vic);
- *Environment Protection (Environment and Resource Efficiency Plans) Regulations* (2007) (Vic);
- EPA Publication 448.3*, Classification of Wastes* (2007) (Vic) - identifies EPA requirements for off-site disposal of different categories of waste and assists in the choice of appropriate management options;
- EPA Publication 996*, Guidelines for the Hazard Classification of Solid Prescribed Industrial Wastes* (2005) (Vic) - establishes a framework to classify solid PIW in accordance with the hazard classification requirements of Industrial waste management policy (Prescribed Industrial Waste) 2000;
- EPA Publication 655, *Acid Sulphate Soil and Rock* (1999) (Vic);
- *Industrial Waste Strategy – Zeroing in on Waste* (1998) - specifically targets potentially hazardous wastes generated by Victorian industries;
- *Industrial waste management policy (Prescribed Industrial Waste)* (2000) (Vic) - provides a framework for the management of prescribed industrial waste (PIW) in Victoria;
- *Industrial waste management policy (Waste Acid Sulfate Soils)* (1999) (Vic) - provides a framework to guide the management of waste acid sulfate soils (ASS) in Victoria;
- *Mineral Resources (Sustainable Development) Act 1990* (Vic);
- *State environment protection policy (Used Packaging Materials)*(2000) (Vic);

- *Towards Zero Waste Strategy 2005* (Vic), provides the direction for Victoria's waste management and resource recovery framework;
- *Waste management policy (Used Packaging Materials)* (2006) (Vic) - encourages the reuse and recycling of used packaging materials by supporting and complementing the voluntary strategies in the National Packaging Covenant; and
- *Waste management policy (Siting, Design and Management of Landfills) 2004* (EPA Victoria).

9.2 Waste Generating Project Activities

Waste generating activities likely to be associated with the construction and operation of the Desalination Plant are summarised below with a brief description of the types of wastes expected for each activity.

9.2.1 Operational Phase

9.2.1.1 Desalination Plant

Waste generating activities likely to be associated with the operation of the Desalination Plant and Marine Structures are likely to include:

Seawater Intake

Seawater intake screening is undertaken after the seawater has passed through the intake head, riser and along the intake tunnels, prior to the pre-treatment phase of the desalination process. The purpose of the seawater intake screens is to filter out macroscopic marine biota, sediments and other entrained materials such as plastics.

Pre-treatment

(a) Pre-treatment backwash wastewater

Seawater must be conditioned to ensure it is of a sufficiently high quality for use in the RO plant. Seawater contains sediments; colloidal material and dissolved constituents that, if not treated or removed, could cause damage to, or reduce longevity of, the RO membranes.

The backwash wastewater is generated from this treatment process, in particular through the addition of coagulants and flocculants to remove colloidal material and dissolved constituents in the seawater feed.

(b) Discarded filter media

In the Reference Project, pre-treatment phase filtration will take the form of a dual media filter, comprising sand (600 mm layer), gravel (200 to 400 mm layer) and anthracite (1,000 mm layer). The pre-treatment filters will be periodically cleaned to remove the filtered solids and maintain effectiveness and efficiency. Despite backwashing enhancing the life span of the filters, periodic replacement of the filter media will be required.

Reverse Osmosis Desalination

(a) RO plant membrane cleaning

The RO membranes must be periodically cleaned to support efficient and effective operation minimising fouling and scaling. The cleaning frequency for the RO plant and type of cleaning chemical required will vary depending upon the specific amount and nature of scaling and fouling. In the Reference Project, it is assumed that the cleaning solutions will be reused multiple times before they would be considered spent, requiring disposal.

(b) Discarded cartridge filter elements

Filter cartridges will form part of the RO Desalination Plant component of the Reference Project and will provide further filtration of the pre-treated water prior to entry to the first pass RO membranes. These elements typically have a service life of approximately three to four months.

(c) Discarded RO membranes

Under the Reference Project, spiral-wound RO membranes will be used to remove the salt from the seawater. Typically these RO membranes have a service life of approximately five years.

Potabilisation – Limewater Production (Lime Sludges)

Water from the RO process has very low residual hardness or alkalinity, and is chemically aggressive to some materials including steel and concrete. Desalinated water is stabilised by the addition of carbon dioxide and limewater to increase alkalinity, which in turn, buffers the water, increases hardness and reduces the general corrosivity of the product water. The limewater production process will result in the generation of a lime sludge stream.

General Operation and Maintenance Activities.

Activities or facilities at the Desalination Plant which are expected to contribute to this waste stream are:

- offices - A broad range of wastes types and classifications are commonly produced by staff working in offices and related facilities such as toilets, lunchrooms and canteens;
- chemical stores - A large quantity and range of chemicals will be required for each of the four components of the Desalination Plant, namely pre-treatment, RO desalination, potabilisation and treated water storage. The storage of such chemicals will invariably result in wastes (e.g. empty containers, and materials used in the temporary containment and clean-up of chemical spills);
- workshop(s) - A broad range of waste types and classifications will arise from scheduled and unscheduled maintenance activities expected to be performed at the Desalination Plant;
- laboratory - It is possible that a laboratory may be developed by the Project Company at the Desalination Plant. The types and quantity of waste produced by the laboratory will depend on the nature and frequency of the tests performed on-site; and
- general gardening or landscaping activities.

9.2.2 Construction Phase

9.2.2.1 Desalination Plant

For the purposes of this study the construction of the Desalination Plant, including the Marine Structures (intake/outlet tunnels), is broadly divided the two phases, being bulk earthworks and infrastructure development.

Bulk Earthworks

Bulk earthworks consist of earthmoving activities associated with the Plant Site preparation and tunnelling of the intake and outlet structures prior to the construction of infrastructure.

Waste generated by these activities is likely to include:

- construction spoil from general earthworks and tunnelling works on-site;
- contaminated soil and wastes that may be encountered during clearing, excavation and/or tunnelling works; and
- spoil arising from earthworks associated with the construction of temporary and/or permanent roads, car parking areas, stormwater drainage works, utilities and lay down areas.

Infrastructure Development

Infrastructure development consists of the building and installation of structures, enclosures, fit-outs, hydraulic installations, electrical installations, mechanical installations and external works.

Wastes generated by these activities are likely to include:

- general construction wastes including material off-cuts, packaging, containers, waste concrete and waste lubricants;
- waste arising from the importation of utilities;
- excess concrete, wastewater, particulate matter and sludge from a concrete batching plant;
- domestic solid waste and wastewater from the construction accommodation and site office;
- workshop and equipment and infrastructure maintenance wastes including used lubricants, solvent and paint residues, chemical containers and triple interceptor trap ‘pump-out’ waste;
- demolition materials from existing structures;
- gardening/landscaping waste; and
- wastes from construction of the Desalination Plant associated building infrastructure.

9.3 Waste Types and Characteristics

The following table contains a summary of the major streams expected to be generated during the construction or operation of the Desalination Plant.

Table 9-1 Summary of waste types/sources for the Desalination Plant

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
Operation			
Seawater intake screenings.	Potentially putrescible or category C(1) PIW depending upon waste characteristics (particularly odour), and proposed handling methods. Waste classification uncertain, to be determined.	Volumes will be dependent on a range of highly variable factors including intake location, seabed vegetation, intake velocity, and seasonal variations in sea conditions.	The intake screenings may comprise materials that are able to pass through the bar grill on the seawater intake heads but not the apertures in the screens, such as marine life, entrained particles, and entrained wastes such as plastic bags and fishing debris.
Pre-treatment backwash wastewater.	Either solid inert waste or PIW. If classified as PIW could potentially be Category C(2). Waste classification uncertain, to be determined.	Approximately 25 to 63 tonnes per day of wet sludge (65 to 85% seawater, 15 to 35% solids), depending on seawater quality and pre-treatment process. This equates to approximately 9,000 – 23,000 tonnes per year (less if the sludge could be further dewatered).	The sludge is expected to contain the suspended solid organics and salt from the intake seawater and possibly other constituents from the seawater, metal oxide flow from the inorganic coagulant aid used in the process (e.g. organic polymer coagulant aid). It is expected there will be a formal assessment of the waste stream characteristics by EPA and determination of the waste classification in accordance with Clause 11(1) of *Industrial waste management policy (Prescribed Industrial Waste) 2000* once the Desalination Plant is operational.

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
Discarded filter media – a mixture of sand and anthracite.	Sand: Likely to be fill material but may be classified as contaminated soil PIW depending upon the total and leachable concentration of residues or depositions present. Anthracite, may be subject to flammability testing, and potentially considered as either solid inert waste or PIW.	Approximately 11,000 t of sand (4,000 m^3) and 10,000 t (7,000 m^3) of anthracite every 10 years.	It is expected there will be a formal assessment of the waste stream characteristics by EPA and determination of the waste classification in accordance with Clause 11(1) of *Industrial Waste Management Policy (Prescribed Industrial Waste) 2000* once the Desalination Plant is operational.
RO plant membrane cleaning wastes.	PIW.	Approximately 8,000 to 16,000 m^3 per annum for each type of cleaning solution, depending on required frequency of membrane cleaning required and chemical reuse.	The RO plant membrane cleaning solutions is expected to contain a low pH solution used to remove salt scale, followed by a high pH solution to remove organic matter. The cleaning solutions could be reused until the cleaning integrity of the membranes can no longer be assured.

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
Discarded cartridge filter elements.	Likely to be solid inert waste but may be classified as PIW depending upon the total and leachable residue concentration or contaminant deposit present.	35,000 to 70,000 elements (up to approximately 420 t) each year.	Provided no liquid is contained in the element and no PIW residues or depositions are contained within, or on the filter elements, it is expected that the waste stream will be classified as solid inert waste (GHD 2007). EPA has advised that PIW Classification No. G24 *Prescribed Industrial Waste – Classification by Hazard for Packaging Waste*, issued by EPA pursuant to Clause 11(1) of the *Industrial waste management policy (Prescribed Industrial Waste) 2000*, could be used as a guide to classifying discarded cartridge filter elements containing PIW residues or depositions.
Discarded RO membranes.	Likely to be solid inert waste but may be classified as PIW depending upon the total and leachable concentration or depositions present.	About 12,000 elements (approximately 170 t) each year.	Information provided by an RO membrane supplier indicates that the elements are commonly manufactured from a variety of plastics. As noted above, EPA will assess the discarded cartridge filter element waste stream and classify it according to Clause 11(1) of *Industrial waste management policy (Prescribed Industrial Waste) 2000*.
Lime sludge.	PIW, likely to be category C(2).	10 to 30 m3 per day (at 20% solids). This volume will vary depending on the amount of lime to be dosed, the quality of the dry lime and the performance of sludge dewatering. This equates to approximately 3,500 to 10,500 m3 per year.	This sludge will not have a high salt content if RO permeate (desalinated water) is used to mix the limewater.

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
General operation and maintenance waste.	Comprises a range of waste classifications, largely solid inert waste, putrescible waste and PIW.	Desalination Plant: ▪ Approximately 8.5 tonnes of waste from office/plant staff per year based on 50 permanent staff. ▪ Waste from chemical storage, workshop waste and on-site laboratory: quantity (and composition) likely to vary significantly on a day-to-day basis.	**(a) Offices and Related Staff Facilities** The waste generated by the office/plant staff is expected to comprise the following broad categories: ▪ paper or cardboard including newspapers, magazines, packaging and stationery; ▪ plastics packaging and other plastic items; ▪ glass containers; ▪ food or beverage aluminium and steel cans; ▪ food scraps; ▪ photocopy toner cartridges and other e-waste; and ▪ prescribed wastes commonly produced in offices including expired batteries, office cleaning chemical containers, fluorescent tubes and clinical waste. **b) Chemical Storage** A significant number of containers and packaging will be generated by the Desalination Plant, possibly comprising a mixture of 1000 L intermediate bulk containers (IBCs) and bulk bags, 200 L steel drums, a mixture of 5 to 50 L plastic containers and a number of bulk polyethylene or natural fibre-blended bags used for transporting chemicals in powder or pellet form. Packaging waste may also include cans, bottles, tins, internal liners and bladders of varying capacity, shape and materials. Related wastes possibly arising from the cleanup of onsite chemical spills include rags, absorbents including booms and pads, disposal bags or similar, discarded personal protective safety equipment (PPE) and contaminated soil.

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
			c) Workshop Discarded material and items typically generated in workshops include: ▪ glass, plastic, paper, steel and aluminium packaging; ▪ timber and plastic off-cuts; ▪ scrap metal; ▪ expired batteries; ▪ vehicle tyres; ▪ lubricants, solvent and paint residues; ▪ discarded air, oil and fuel filters; and ▪ chemical containers. **(d) On-site Laboratory** Wastes typically generated at chemical laboratories include: ▪ small quantities of used laboratory chemicals; ▪ cleaning products; ▪ discarded personal protective safety equipment; ▪ packaging for laboratory equipment, chemical and cleaning products; ▪ plastics (e.g. sample containers); ▪ glass (vials, flasks etc); and ▪ paper.

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
Construction (including temporary/permanent/infrastructure plant etc)			
Construction spoil.	Depending on geological material encountered either fill material, waste ASS or PIW (bentonite slurry).	Tunnels and site: ▪ approximately 1,000,000 to 1,500,000 bulked m^3. Marine construction activities: ▪ approximately 600 m^3. It is not expected that large quantities of ASS would be encountered.	Construction spoil is expected to include: ▪ Excavated material from plant earthworks (topsoil and quaternary sediments); and ▪ Spoil generated by tunnel boring machine (TBM) excavation activities (cretaceous rock and quaternary sediments); and ▪ Other wastes including shoring and other temporary construction materials. The potential for ASS at the Desalination Plant Site is discussed in Section 15 of this WAA.
Contaminated soils.	PIW (either Category A, B or C depending upon total and leachable contaminant concentrations) but may also contain solid inert waste.	Unknown	The potential for land contamination at the Desalination Plant Site has been discussed in Section 15 of this WAA, where it has been concluded that there is limited potential for significant land contamination to exist within the Project area.
Green Waste from vegetation clearance.	Putrescible waste.	Expected to be minor.	The Desalination Plant Site is cleared farmland and therefore little vegetation, apart from pasture grasses, will need to be removed in developing the Site. The clearing of grasses is included in the discussion of topsoil. The management of green waste is therefore not included in this section on waste.

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
Demolition of existing structures (farm houses and associated buildings, fencing).	Likely to be classified as solid inert wastes. Potential asbestos waste would be considered PIW.	Quantities are presently unknown but are not expected to be significant in comparison to construction waste.	Buildings and other existing structures at the Site, including fencing, may be demolished as part of the works program. Wastes likely to be produced during the demolition of these existing structures include concrete, timber, corrugated tin, steel, plasterboard, etc. Asbestos cement materials may be present.
Waste arising from construction and use of temporary infrastructure: ▪ concrete batching plant; ▪ truck wash; and ▪ site amenities.	Comprises a range of waste classifications including fill material, solid inert waste, putrescible waste and PIW. Wastewater from the truck wash facility may be PIW.	Quantities from individual sources may not be significant. Total quantity from all sources is expected to comprise a significant proportion of the total construction waste stream. It is difficult to quantify these individual waste types as they will vary across the construction sites depending upon the precise scale and the nature of the activities. Roads, car parking and lay-down areas will be required during construction work for use by heavy plant equipment. Wastes may also include temporary buildings and fixtures, vehicle maintenance/cleaning, electrical fixtures, packaging, paints etc.	Waste from a concrete batching plant, if one is established on-site, is expected to include excess concrete, wastewater (contaminated stormwater, concrete waste, wash down water, etc.), dust and other particulate matter, and sludge from collection pits. Wastewater generated from a truck wash facility and other pits will contain sediments and hydrocarbons resulting from lubricants, fuel associated with truck and vehicles, and other contaminants (e.g. solvents) from the workshops. Depending on water quality, water from the truck wash facility may be used for on-site dust suppression. The temporary site amenities' waste stream is expected to comprise a diverse range of solid inert, putrescible and prescribed industrial wastes. Where the temporary haul roads, car parking and lay down areas will not be incorporated into the final infrastructure, rehabilitation works will be required. This may consist of removal and disposal (including reuse/recycling) of the pavement material and associated sub-base material. Pavement material will generally consist of crushed rock that will require on-going maintenance; the car park and

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
			some surfaces may be bitumen sealed. If not incorporated within the final design, then material used in the construction of the haul roads, car parking and lay down areas will require management for reuse or disposal off-site. In addition to the permanent service requirements of the Desalination Plant, temporary services will be required for the construction contractor. Generally, services will be installed underground, generating some excess soil wastes that will require management. There will also be waste associated with off-cuts and packaging. Waste quantities are presently unknown but are not expected to be large in comparison to bulk earthwork quantities. In addition to the permanent stormwater system developed at the Desalination Plant Site, temporary stormwater control measures will be required during the construction phase including erosion control. Waste arising from works associated with these measures will include excess spoil from earthworks, sediment from maintenance works and general construction waste.

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
Waste arising from construction of permanent infrastructure.	Comprises a range of waste classifications including fill material, solid inert waste, putrescible waste and PIW.	Quantities from individual sources may not be significant. Total quantity from all sources is expected to comprise a significant proportion of the total construction waste stream. It is difficult to quantify these individual waste types as they will vary across the construction sites depending upon the precise scale and the nature of the activities. Roads, car parking and lay-down areas will be required during construction work for use by heavy plant equipment. Wastes may also include temporary buildings and fixtures, vehicle maintenance/cleaning, electrical fixtures, packaging, paints etc.	The main work items associated with the development of the above infrastructure which are expected to generate waste include the following: ▪ Structures – concrete, structural steel, light steel framing, masonry, woodwork; ▪ Enclosures – roofing, cladding, insulation, windows, glazing, doors, hardware; ▪ Fitouts – suspended ceilings, partitions, lining, plastering, metalwork, fixed furniture, tiling, resilient finishes, carpets, painting, miscellaneous fixtures; ▪ Hydraulic installations – stormwater, sanitary services, water, domestic gas; ▪ Electrical installations – general electrical equipment, wiring and accessories, switchboards, luminaires, communications (including computers), electronic security, fire detection; ▪ Mechanical installations – general mechanical requirements, mechanical equipment, equipment fabrication and installation, ductwork, mechanical pipe work, mechanical insulation; and ▪ External works – paving, roads, car park, fencing, landscape.
Waste arising from landscaping/screen planting works.	Largely solid inert waste.	Unknown but likely to be minor in comparison to total construction waste stream.	Landscaping wastes are expected to be generally limited to packaging. This would include plant pots, trays (polystyrene), stays, plant protectors, ties and containers associated with soil enhancers.

Waste type / source	Waste classification	Estimated quantity for a 150 GL per year Plant capacity	Discussion
Miscellaneous construction waste.	Comprises a range of waste classifications including fill material, solid inert waste, putrescible waste and PIW.	Unknown but likely to be minor in comparison to total construction waste stream.	This is waste which doesn’t necessarily fit into any of the above waste sources or types but which still could comprise a proportion of the total construction waste stream. It is expected to comprise a diverse range of solid inert, putrescible and prescribed wastes including: ▪ empty chemical containers; and ▪ used personnel protective equipment (PPE).

9.4 Assessment of Existing Landfills

An assessment has been made of existing landfills within the general region of the Desalination Project sites to determine:

- present capacity of the landfills to accept wastes for disposal produced during the construction and/or operational phases of the Desalination Project;
- waste types that the sites are presently licensed by EPA to accept for disposal;
- current disposal charges; and
- possible commercial issues or constraints to the landfills receiving wastes for disposal including an initial indication of the willingness of facility owners to accept wastes over the life of the Desalination Project.

Landfills included in this assessment are those generally located closest to the Desalination Plant and includes facilities within the western part of the Gippsland Regional Waste Management Group (GRWMG)[11] and the south eastern fringe of the Melbourne metropolitan area. Both Council and privately operated landfills have been evaluated. The location of these landfills is presented in Table 9-2.

Other landfills presently operating in the GRWMG and the Melbourne metropolitan area are listed in GRWMG's *Regional Waste Infrastructure Study* report (Maunsell, 2007) and *Part 3, Draft Metropolitan Landfill Schedule* to the *Draft Metropolitan Waste and Resource Recovery Strategic Plan* (Victorian Government undated) respectively. Life expectancy estimates for these landfills are presented in these documents. While it may be feasible for these sites to accept waste from the Desalination Project, they have not been included in this assessment.

[11] The GRWMG comprises the municipalities of Bass Coast, Baw Baw, East Gippsland, Latrobe, South Gippsland and Wellington. The Desalination Plant, being located in Bass Coast Shire Council, is therefore located within the GRWMG.

Table 9-2 Summary of Regional Landfill Information

Landfill	Owner	Wastes Presently Licensed to Accept	Remaining Capacity	Estimated Life Based on Present Throughput	Present Disposal Charges ($/t) (7)	Commercial Issues or Constraints to Site Receiving Wastes / Other Comments
Landfills Accepting Putrescible, Solid Inert and/or Prescribed Waste						
Grantville	Bass Coast Shire Council (BCSC)	▪ Putrescible ▪ Solid inert waste ▪ Domestic asbestos ▪ Shredded tyres	Approximately 1.4 million cubic metres	Up to 55 years. Present throughput approximately 24,000 tones per year.	$70/t inclusive of GST and landfill levy for domestic, building, commercial or industrial waste	▪ It is unlikely Council would discount normal gate charges for large waste quantities (i.e. normal gate charges would apply). ▪ Council would consider accepting waste from the Desalination Project on the condition that waste management options higher up the waste hierarchy had been fully explored with the following possible exceptions: – in order to preserve landfill airspace for ratepayers, it is unlikely Council would accept large quantities of construction spoil from the Project; and – due to potential handling issues, it is unlikely Council would accept pre-treatment waste from the Desalination Plant. ▪ While the Site is not presently licensed to accept PIW, Council would consider seeking a licence amendment to permit the disposal of such wastes providing there are no environmental issues and no significant impact on the life of the Site.
Koonwarra	South Gippsland Shire Council (SGSC)	▪ Putrescible ▪ Solid inert waste ▪ Domestic and commercial asbestos ▪ Low level contaminated soils (now Category C PIW)	Approximately 0.73 million cubic metres for Stage 1	Up to 55 years (based on Stages 1 and 2 of which only Stage 1 has been approved by EPA). Present throughput approximately 15,000 tones per	$70/t inclusive of GST and landfill levy for commercial or industrial waste	▪ It is unlikely Council would discount normal gate charges for large waste quantities; in fact, it is possible higher rates would apply to serve as a deterrent;

Landfill	Owner	Wastes Presently Licensed to Accept	Remaining Capacity	Estimated Life Based on Present Throughput	Present Disposal Charges ($/t) [7]	Commercial Issues or Constraints to Site Receiving Wastes / Other Comments
				year.		▪ It is unlikely Council would consider accepting waste from the Desalination Project because of: – the significant impact this would have on the life of the Site; – preference to preserve the remaining landfill capacity for ratepayers; and – the difficulty, including length of time, in obtaining statutory approval for new landfills or major extensions to landfills.
Callignee [1]	Latrobe City Council (LCC)	▪ Putrescible ▪ Solid inert waste ▪ Domestic asbestos ▪ Low level contaminated soils (now Category C PIW)	Approximately 0.9 million cubic metres [2]	Presently estimated to be 18 years but would be reduced if Baw Baw Shire Council uses the Callignee Landfill following closure of its Trafalgar Landfill as per the GRWMG's regional plan.	$85/t inclusive of GST and landfill levy for Morwell Landfill at time of closure. Charges for Callignee Landfill expected to be higher than this rate when it commences operation.	▪ Council may be prepared to accept limited quantities of waste from the Desalination Project. Prepared to consider in detail when waste types and quantities have been firmed up. ▪ Responsibility for the management of waste from the Desalination Project will most likely be considered a regional issue. In this situation landfill options would be expected to be addressed through the GRWMG (3). ▪ There are no direct transportation routes for haulage of waste from the Desalination Plant to the Callignee Landfill. This will increase haulage costs, and environmental impacts through increased vehicular emission, which include greenhouse gases. ▪ Based on the recent experience of LCC, transporting waste to landfills in Melbourne (Werribee) is likely to be a cheaper disposal option than using closer landfill sites in the region given the low disposal rates presently charged by some commercial operators in Melbourne.

Landfill	Owner	Wastes Presently Licensed to Accept	Remaining Capacity	Estimated Life Based on Present Throughput	Present Disposal Charges ($/t) (7)	Commercial Issues or Constraints to Site Receiving Wastes / Other Comments
Trafalgar	Baw Baw Shire Council (BBSC)	▪ Putrescible (6) ▪ Solid inert waste (6) ▪ Domestic asbestos ▪ Low level contaminated soils (now Category C PIW)	Limited capacity, to be confirmed	Limited life, to be confirmed	$85/t inclusive of GST and landfill levy for commercial and industrial waste.	▪ Council is unlikely to accept waste from the Desalination Project given the Trafalgar Landfill presently is the only landfill in Shire, the limited life of the landfill and as of early 2008, it will likely be used for the disposal of municipal, commercial and industrial waste from Latrobe City Council until that municipality's new landfill is established. ▪ Under the GRWMG's regional plan, Council will use the new Latrobe City Council landfill at Callignee following completion of the Trafalgar Landfill.
Taylors Road	SITA Environmental (SITA)	▪ Commercial and industrial (C&I) waste including putrescible and solid inert waste ▪ Category B and Category C PIWs complying with EPA Publication 996 including non-toxic salts, filter cakes and packaging. ▪ Potential ASS		C&I waste: likely closure 2010 (4) (5) PIW: projected closure 2020 (4)	C&I waste: $70 - $80/t + GST + landfill levy PIW: presently $250/t + GST + landfill levy; from 1 July 2008 $360/t + GST + landfill levy Potential ASS: $63.39/t + GST + landfill levy	▪ EPA licence limits PIW disposal to 35% by weight of total waste disposed at the Site – currently 33%. ▪ EPA licence requirement for acceptance of solvent based wastes, cured adhesives or resins, tars and tarry residues arising from refining and any pyrolytic treatment, and Category B contaminated soils - Closed cup flash point of greater than or equal to 610°C. ▪ EPA licence requirement – wastes must not contain any free liquid as determined by method 9095A "Paint Filter Liquids Test" in Test Methods for Evaluating Solid Wastes – Chemical/Physical Methods (USEPA 1997). ▪ Apart from the above licence limits or requirements, no restrictions are expected to apply to the acceptance of waste from the Desalination Project. If a waste was to create an operational or post-closure management issue or a safety issue at the Site, limitations may be placed on the rate at which the waste would be accepted for disposal.

Landfill	Owner	Wastes Presently Licensed to Accept	Remaining Capacity	Estimated Life Based on Present Throughput	Present Disposal Charges ($/t) (7)	Commercial Issues or Constraints to Site Receiving Wastes / Other Comments
Hallam Road	SITA Environmental (SITA)	▪ Commercial and industrial waste including putrescible and solid inert waste		Likely closure 2027 (4)	C&I waste: $70 - $80/t + GST + landfill levy	▪ No restrictions are expected to apply to the acceptance of waste from the Desalination Project. If a waste was to create an operational or post-closure management issue or a safety issue at the Site, limitations may be placed on the rate at which the waste would be accepted for disposal.
Dutson Downs	Gippsland Water (GW)	▪ Limited range of Category C PIWs, namely asbestos, tannery wastes, waste chromium compounds and hydrocarbon contaminated soils (soils shortly to be diverted to a new recovery facility to be established at Dutson Downs)	Not applicable – landfill cells constructed on a needs basis	Not applicable – landfill cells constructed on a needs basis	Tannery waste: $160/t inclusive of GST but excluding landfill levy	▪ GW would be prepared to consider taking PIW from the Desalination Project, however, any decision on the matter would need to take into consideration EPA and community opinion and detailed knowledge of waste characteristics. ▪ This would require an amendment to the Site's EPA licence as it presently allows them to accept a very limited range of PIWs (refer column 3).

Notes to table:

1. Construction of this landfill to commence shortly.
2. Source: *Report for Proposed Callignee South Road Landfill. Documentation Supporting Works Approval Application*. Report prepared by GHD Pty Ltd for Latrobe City Council. January 2007.
3. Potential discussion and considerations required by GRWMG.
4. Source: Appendix I, *Part 3: Draft Metropolitan Landfill Schedule* to *Draft Metropolitan Waste and Resource Recovery Strategic Plan*, Department of Sustainability and Environment, Sustainability Victoria and Metropolitan Waste Management Group.
5. Reducing filling rate may extend life of site.
6. Traditionally, the Trafalgar Landfill has accepted putrescible and solid inert waste from commercial and industrial sources within the municipality only. Since early 2008, this has been extended to include waste from Latrobe City Council.
7. Present landfill levy rates: commercial and industrial waste $13/t for rural areas and $15/t for metro/provincial areas; $50/t for Category C PIW; $130/t for Category B PIW. As of 1 July 2008: $70/t for Category C PIW; $250/t for Category B PIW.

9.5 Waste Management Assessment

Waste management options have been explored for the waste streams identified in Table 9.1. The Project Company will be responsible for determining specific waste management requirements for the Project in accordance with the guiding principles listed below during procurement, design, construction, operation and maintenance of the Plant:

- compliance with all relevant government legislation and regulations;
- application of the following principles of environment protection, set out in the *Environment Protection Act 1970*:
  - Principle of waste hierarchy;
  - Principle of product stewardship;
  - Principle of improved valuation, pricing and incentive mechanisms;
  - Principle of integration of economic, social and environmental considerations; and
- disposal of wastes that cannot be practically or cost-effectively managed employing options higher up the waste hierarchy to appropriately licensed and managed landfills.

The establishment of a dedicated landfill as part of the Desalination Project, either on the Desalination Plant Site or elsewhere has not been considered in this assessment. This in no way precludes a Project Company from evaluating the possibility of this option.

Criteria used to evaluate the waste management options identified include technical, environmental, social, and financial considerations.

9.5.1 Desalination Plant Operation

Intake Screen Washings

The following discussion is provided on the basis that a much greater quantity of washings than is typically recovered at the Perth Seawater Desalination Plant (of the order of 10 kg per day) will be dealt with at the Desalination Plant.

a) Avoidance

There are no options to avoid direct entrainment of seawater organic content in the seawater intake feed.

b) Reuse/Recycling

Innovations made in the Australian seafood industry to reuse fish waste may be applicable in this case. There are alternative waste management options that may use all of the screenings waste or individual components. One such innovation involves the use of hydrolysed fish waste in the production of fertilisers. Seaweed alone is also suitable for reuse as fertiliser, given its high nutrient content.

Fish waste is also readily composted and fish waste produced at aquaculture farms is sometimes composted on-site, which may be an option for the Desalination Project.

A number of commercial composting facilities in metropolitan Melbourne may accept the screenings waste from the Desalination Plant as a feedstock to the composting process.

Another management option involves the use of the seaweed in the manufacture of healthcare products such as general health supplements, skin and hair care.

c) Disposal

While low on the waste hierarchy, the disposal of the screenings to landfill is a possible option. The type of landfill able to accept this waste stream is dependent upon the classification by EPA of the screening wastes from the Desalination Plant.

If the waste is classified as Category C(1) PIW, in accordance with EPA Publication 996 (2005) it can be accepted at a best practice municipal landfill licensed by EPA to accept such waste (i.e. licensed to accept K100 – Animal effluent and residues (poultry and fish processing waste); K101 – Scallop processing residues; and K180 – Abattoir effluent).

Alternatively, if the screenings waste is classified as a putrescible waste it may be disposed of at any landfill licensed by EPA to accept such waste.

Conclusions

A range of reuse options may provide a sustainable alternative to landfilling of this waste stream, the most likely being in the production of compost and organic fertilisers. The technical and commercial viability of these reuse options is presently unclear and further investigation will be required once the waste stream is fully characterised following commissioning of the Desalination Plant. Until the long-term commercial viability of these reuse options has been thoroughly evaluated, landfilling of the waste remains the default option. Many existing landfills, both within the general region of the Desalination Plant and in metropolitan Melbourne, could accept the waste stream, depending on its EPA classification.

Pre-treatment Backwash

Possible waste management alternatives for pre-treatment backwash are discussed below. Note that Section 7 of this WAA provides further discussion regarding application of conventional media pre-treatment filtration or membrane pre-treatment filtration.

a) Avoidance

Possible alternatives to the conventional approach of pre-treating the intake water to remove suspended solids and organics by the addition of a ferrous-based coagulant include:

- Indirect or sub-surface marine intake systems. While there are several variations to this system, including both on-shore and off-shore marine intakes, they essentially involve drawing the plant intake seawater from beneath a sandy seabed - either sand below the beach or below the seabed near the shore. The water is naturally filtered through the seabed thereby reducing the suspended solids content of the intake water and so producing high quality water which requires less pre-treatment processing;
- Use of alternative coagulants and in particular aluminium-based coagulants such as alum (aluminium potassium sulphate), aluminium sulphate or polyaluminium chloride (PACl); and
- The use of microfiltration technologies incorporating an ultrafiltration (UF) or microfiltration (MF) process within the pre-treatment train. Coagulant dosing is usually included upstream but at a reduced rate.

The option of not pre-treating the intake water and allowing all suspended solids to accumulate within the RO membranes has not been considered in this study as it would result in the membrane elements clogging prematurely. This, in turn, would result in increased frequency of RO membrane cleaning and hence increased production of spent cleaning solutions requiring disposal. It would also lead to increased energy consumption and hence greenhouse gas production.

b) Reuse or Recycling

Possible reuse and recycling options for the pre-treatment sludge identified are:

- acid treatment to regenerate a lower grade coagulant for direct recycling to the head of the proposed Desalination Plant to supplement the primary coagulant feed (i.e. recovery of the coagulant);
- use of the sludge as a raw material to manufacture an iron-based catalyst used for off-site applications such as air scrubbing sulphide or arsenic removal from contaminated water;
- blending into cement kiln feed for mineral value;
- direct land application or mixing with soil, compost and/or sewage sludge to produce soil substitutes. Examples include use of the sludge to bind phosphorus and nitrogen contamination, arising from application of fertilisers to agricultural land, to reduce eutrophication of surrounding surface waters;
- use as a cover for landfill replacing other materials (eg. soil), particularly for landfill sites which import cover material;
- production of other useful chemicals from the sludge, examples include:
  - electrolysis of the salt water in the sludge (or following flushing of the sludge to produce a separate salt water stream) to yield chlorine and sodium hydroxide;
  - use of ferric hydroxide for phosphate binding or arsenic removal from drinking water;
- use of ferric salts to reduce arsenic and other trace contaminants;
- use of ferric hydroxide for phosphate removal in wastewater treatment for eutrophication control;
- use as construction materials including fill material, as an additive to cement and concrete, and in the manufacture of bricks; and
- use of sludge as an adsorbent.

An additional option that has been identified involves the potential use of the iron-rich sludge as an oceanic fertiliser to promote phytoplankton growth and so reduce atmospheric carbon dioxide (as a response to climate change and global warming). In this option the sludge would be transported to deep open oceans (far away from relatively iron rich coastal areas) where it could be dosed at a predetermined rate. While there are a number of potential reuse and recycling options for the pre-treatment sludge, it is apparent that there are significant technical and/or commercial limitations hindering selection of this disposal route:

- the expected low market price of the material (possibly zero);
- reuse options requiring haulage to distant markets/users may not be financially viable because of the low cost of many of the raw/new materials that the pre-treatment sludge would be replacing, as

well as environmental impacts through increased vehicular emission, which include greenhouse gases, - local or regional users of the sludge are more likely to be financially viable;

- while it is possible that local or regional users could be identified now, it is unknown whether demand for the material would still exist once the proposed Desalination Plant becomes operational;
- the high cost, high energy use, lack of commercialisation, limited application and/or potential environmental concerns of some potential reuse options;
- the relatively small quantity of sludge likely to be required for some potential reuse options in comparison to the estimated generation rate for the material. This means that some reuse options may not provide a complete waste management solution on their own; and
- the high salt content of the sludge will severely restrict potential reuse opportunities unless the waste is processed by washing. This will add to the overall processing cost but not necessarily increase the material's market value.

Reuse options are likely to become more (technically) viable in the future, however, whether they are able to compete financially with alternative disposal routes will depend on investment in wastewater treatment plant.

c) Recovery of Energy

This method would involve the recovery of embodied energy within the sludge. The sludge is expected to largely comprise silts and sands, and accordingly the calorific value of the waste stream will be small. This option therefore is not considered to be commercially feasible.

d) Disposal

For the Reference Project the disposal option for the pre-treatment waste includes treatment to separate the solids, which are disposed to landfill. The liquid waste (supernatant) is returned to the head of the plant.

Whilst this management option is least preferred under the waste hierarchy, commercial considerations, including the constancy of the waste stream, the volume of material to be disposed, recovery logistics, and market limitations for the Reference Project suggest disposal to landfill will likely be the preferred outcome.

Conclusions

With regards to the waste avoidance or reduction options discussed previously, it is concluded that:

- accepted practice is to use iron salts over aluminium salts for seawater desalination with reverse osmosis pre-treatment technology due to their lower tendency to form scaling deposits on the reverse osmosis membranes; and
- the Desalination Plant should be able to operate successfully with either conventional or membrane filtration pre-treatment approaches.

An alternative approach is to recover and reuse constituents of the pre-treatment waste. Reuse of solid wastes from surface water treatment plants is relatively well developed. However, reuse of salty sludge from SWRO is not yet fully developed and seldom reported elsewhere. Consideration would need to be given to:

- cost of investing in technology;
- identifying a long term market;
- plant capacity and volumes of waste generated (with respect to market);
- salty waste and environmental impact of de-salting (to enable reuse);
- energy expenditure (versus environmental impact of other disposal options); and
- requirement to dispose of residual waste (i.e. after product has been reclaimed from waste).

The disposal of the waste stream to landfill represents at least a medium term strategy but is low on the waste hierarchy. Further, it may be practically limited by the salt content of the waste stream, the large quantity of waste requiring disposal and EPA classification of the waste stream. Each of these limitations require further consideration and discussion with EPA before existing landfill sites which can accept the waste can be identified and disposal costs confirmed.

Given the difficulties and uncertainty associated with the reuse options, managing the waste stream should in the future evaluate whether landfill is sustainable and inline with State waste strategy. Development of technological solutions for reuse/reclamation might also be more viable at a future date.

Discarded Filter Media

The conventional media filtration pre-treatment process adopted for the Reference Project uses sand, gravel and anthracite to filter matter from the seawater.

a) Reuse

Reuse opportunities for the filter media material are largely dictated by the type and concentration of residuals present and whether the media can practically be removed in separate layers with little mixing of the materials (i.e. with little cross-contamination).

If, following chemical analysis, the sand component of the filter media is classified by EPA as fill material then it is possible that the material could be used as a replacement for raw materials, for a broad range of applications such as road base, backfill or concrete mix. However, use for such applications may be limited due to the presence of residuals from a product quality control perspective, in which case blending with raw materials may be necessary to achieve required product performance specifications. It should be noted that EPA does not regulate the use of wastes classified as fill material, provided it does not give rise to environmental or health impacts.

Review of relevant literature regarding reuse of spent filter media from various water treatment applications revealed the following:

- filters can be cleaned using chemical means for regeneration of filters (Kazuya, 2006);
- Leson (1998) asserts that spent filter material used as biofilters that does not contain VOC residues or heavy metals that would warrant classification as a hazardous waste in the USA; this broadens the potential reuse options available for the spent material;
- sand filters can be cleaned to lengthen the life span of the material by removing accumulated matter from the top of the filter (HDR Engineering Inc., 2002);

- some facilities in the USA dispose of spent sand and gravel material by stockpiling it for uses such as winter road sanding, or as soil additives. But more often than not the material is washed and then stored for later addition back to the filter (HDR Engineering, 2002); and
- companies exist in the Melbourne metropolitan region that specialise in remediation or treatment of soil material removed from contaminated sites.

Foundry sands are similar in composition to the sand used in water treatment filter beds and reuse options for this material may also be applicable. For example, the USA Department of Transportation states that foundry sand can be used as a substitute for natural sand in flowable fill mixes (i.e. controlled low strength material). The Turner-Fairbank Highway Research Centre state that applications of flowable fill include: restoration of utility cuts in country roads, backfilling structures, filling abandoned wells, filling voids under existing pavements, pipe embedments and cement mix (US Department of Transportation 2007).

If EPA classifies the sand as a PIW (Category B or C), it is still possible that it could be used for the applications mentioned previously. However, leach testing would need to be undertaken to demonstrate that leachable components would not have an impact on the receiving environment and blending with raw materials may be required. In some cases, material of this nature is used as landfill cover if it can be demonstrated that this method will not pose an environmental or health risk at the Site. Use of the sand as a fill material (i.e. for site filling), would not be permitted by EPA under current guidelines.

Options for reuse of the anthracite material alone are less abundant. However, reuse options employed at coal fired power stations for coal by-products may provide some guidance. Review of relevant literature identified that reuse options for coal combustion by-products (CCBs) are documented widely and many studies of this nature have been undertaken in the USA in recent years. It must be noted that CCBs differ from the filter bed anthracite as they have undergone some chemical transformation in the combustion process.

Further reuse options include: mixing with solid organic waste to create synthetic soils (Guest et. Al, 2001); in situ holding dams (HLA-Envirosciences, 2007); and the manufacture of bricks and cement (Yazici, 2007). The transferability of these options to the discarded anthracite material reuse is worthy of further investigation and analysis. The anthracite may also be suitable, after drying, for cement manufacture.

b) Treatment

If residuals associated with the filter media limit reuse opportunities, treatment may be applied to remove these residuals. This may include flushing or rinsing the material with water (as an extension to the backwashing process). Alternatively, it may require more intensive treatment, if contaminants are chemically bound to the particles in the filter media and not readily removed.

Depending on the nature of residuals and the ease by which they can be removed from the filter media, the required treatment could be performed on-site or transported off-site and undertaken at premises appropriately licensed and established for the purpose.

c) Disposal

Potentially, all of the spent filter media could be disposed of to landfill. Classification of the filter media as either a PIW or non-PIW will determine the type of landfill able to accept the waste stream.

Treatment prior to disposal would be required in the unlikely event that the material is classified as Category A PIW. Landfill sites able to accept PIW and non-PIW within the general region of the Desalination Plant and any constraints that presently apply to the acceptance of such wastes are discussed in Section 9.4.

Disposal to a landfill in the region not currently licensed to accept Category B or C contaminated soil may be possible, although a licence amendment and potentially a specific management plan for these wastes would be required on the part of the landfill owners/operators. Further, if disposal of fill or Category C material to smaller, regional landfills is not possible, transport to other landfill facilities would be required.

Conclusions

In conclusion, the determination of waste management options for the discarded filter media is limited until the exact characteristics of the material can be determined once the Desalination Plant has been operating. Media materials and pre-treatment chemicals selected by the operating facility may influence the final outcome.

A number of reuse outcomes for discarded filter media are conceptually possible, and may represent a financial benefit for the Desalination Plant. The material may be suitable for reuse similar to that employed for foundry sand and for construction applications. However, the technical and commercial feasibility of reuse options for the discarded filter media may be limited by the extent of contamination of the spent materials upon removal from the pre-treatment process train and facilities able to accept these materials.

Landfilling of the material is the waste management method currently employed by other water treatment facilities utilising filter beds. However, this option may be limited in a commercial sense by long haulage distances, stringent disposal requirements, particularly if the material is found to be PIW, and environmental impacts through increased vehicular emission, which include greenhouse gases.

Lime Sludge

a) Avoidance

Possible alternatives to using hydrated lime to increase the pH and buffer the final water produced by the RO process include:

- application of sodium bicarbonate and calcium sulfate, or sodium bicarbonate and calcium chloride to the desalinated water;
- dosing with carbon dioxide and passing the desalinated water dosed with carbon dioxide through a bed of limestone; or
- blending the desalinated water with mineral rich water such as brackish groundwater or seawater. This method may still require treatment with either hydrated lime or limestone.

None of these processes is considered to be as efficient and reliable as lime dosing and each is likely to involve an alternative chemical wastewater stream.

b) Reuse or Recycling

Lime is used in a variety of industries for a range of different purposes. It can be used in environmental applications including metallurgy, construction, pulp and paper, sugar refining and other food products, as well as numerous other applications (NLA 2008).

Thus there are a number of options for the reuse and recycling of lime-based sludge. These include, but are not limited to:

- agricultural soil additive/ameliorant (Wiley 2005);
- reagent in the treatment of hazardous wastes, municipal biosolids and animal wastes (Wiley 2005);
- scrubbing agent in flue gas treatment (NLA 2008);
- building or fill materials (Wiley 2005);
- recalcination for reuse in the water treatment process (Ohio EPA 1991);
- mixing with compost (Ohio EPA 1991);
- treatment of animal waste (NLA 2008);
- treatment of hazardous waste (NLA 2008);
- building construction (Unimin 2008);
- food production and preservation (Unimin 2008);
- industrial wastewater treatment (Unimin 2008);
- leather tanning (Unimin 2008);
- metal processing and extraction (Unimin 2008);
- paper manufacture (Unimin 2008);
- road construction and soil stabilisation (Unimin 2008); and
- sewage treatment (Unimin 2008).

There is also the possibility of using lime residue from the plant to de-water pre-treatment backwash wastewater and the intake screen washings – other waste streams generated as part of the desalination process.

Reuse of the lime for agriculture provides the possible benefit of being able to recover some of the initial costs of buying the lime. The reuse of the lime for treatment of other waste streams generated by the plant provides the potential benefit of cost savings on purchasing lime for this purpose, and ensuring effective treatment for these wastes. Both options depend on the physical and chemical characteristics of the sludge being suitable for these applications. Companies contacted indicated that they might require the sludge to be dewatered and dried before they take the lime, though some companies were willing to negotiate on this matter.

Use as a scrubbing agent is unlikely to be a viable option, as this practice is not undertaken within reasonable proximity to the Desalination Plant Site.

c) Disposal

The lime sludge may potentially be classified as a Category C(2) PIW for the purposes of disposal. Discussion of landfills within the general region of the Desalination Plant that may be able to accept such PIW is presented in Section 9.4.

It is possible the lime sludge could be discharged to the municipal wastewater collection system (Wiley 2005).

Conclusions

Avoidance of the lime sludge waste stream is unlikely for cost and technical reasons. Reuse or recycling of the lime for agricultural purposes, in the waste treatment sector, or in the treatment of other waste streams generated by the Desalination Plant, appears feasible.

Based on preliminary discussions with interested parties, the waste stream should be able to be reused or recycled avoiding lime waste needing to be disposed of to landfill or the sewer system. However, this is dependent on the physical and chemical characteristics of the sludge, particularly the pH range, which is not able to be determined at this stage of the Project.

Disposal to landfill, while technically viable, represents the loss of a potentially valuable resource and is likely to be an expensive option given high haulage and disposal charges anticipated if the waste is characterised as PIW, As well as environmental impacts through increased vehicular emission, which include greenhouse gases. Similarly, disposal to the wastewater system is likely to be expensive. Neither is favoured, unless the physical or chemical properties of the material, particularly pH, make re-use or recycling impractical.

RO Plant Membrane Cleaning Wastes

a) Avoidance

Complete avoidance of RO membrane cleaning wastes is not possible or practicable for desalination plants employing reverse osmosis. Not cleaning the membranes would lead to a build up of scale and organic matter resulting in a reduction in the throughput and quality of the treated water being produced, increased wear of the membranes and potential failure, as well as greater energy consumption.

Careful selection of cleaning solutions, such as selecting chemicals with a lower or absent heavy metal content, will likely reduce the potential toxicity of spent chemicals and increase potential reuse or recycling.

The use of alternative pre-treatment processes to that proposed for the Reference Project which may lead to reduced chemical use and/or cleaning frequency, and therefore chemical waste reduction, has been discussed earlier in this Section of the report under “Pre-treatment Backwash Wastewater”.

The Reference Project assumes that the cleaning solutions will be used multiple times before they are considered spent (i.e. once they become turbid or strongly coloured) and then require disposal. As part of the design, solutions would be pumped through the RO membranes and then back to holding / storage tanks and reused until cleaning effectiveness is substantially reduced. Waste reduction through the reuse of acids and alkalis is commonly practiced by industry to promote sustainability and cleaner production considerations.

b) Reuse or Recycling

Re-use/recycling will depend on the extent of fouling of ‘spent’ solution, but could reasonably involve:

- on-site regeneration of the cleaning solutions and reuse at the plant;
- direct reuse of the cleaning solutions (i.e. without treatment) by an external user; and
- off-site treatment at a suitable waste treatment facility to enable reuse of the cleaning solutions.

The on-site regeneration of the spent chemicals to enable reuse at the plant is unlikely to be economically viable for the quantities produced. Reuse opportunities may be implemented overtime to achieve incremental improvements in the management of this waste stream.

The off-site treatment of the spent chemicals at industrial waste treatment facilities presently located in Melbourne is likely to be a viable option but waste transport and treatment charges will apply. However, it could provide a temporary solution until reuse/recycling opportunities have been fully evaluated. It also provides a long-term solution in the event that no reuse/recycling opportunities prove viable.

c) Treatment / Disposal

Disposal of membrane cleaning wastes is likely limited to treatment at an off-site industrial waste treatment facility followed by disposal of the supernatant to sewer and precipitate to landfill.

Conclusions

Complete avoidance of the RO plant membrane cleaning waste is not possible or practicable for desalination plants employing reverse osmosis. However, careful selection of cleaning solutions could reduce the toxicity of the spent chemicals and possibly increase the likelihood of reuse or recycling.

A number of possible reuse or recycling opportunities have been identified in this Section, however, the viability of these opportunities is dependent on a range of factors including the type of chemicals used and the type and concentration of contaminants present. Possible reuse opportunities for low grade acids and alkalis include the waste treatment industry to neutralise wastes and for the cleaning of second-hand bricks, for example.

Although low on the waste hierarchy, treatment and disposal at a waste disposal facility is a viable option.

Discarded Cartridge Filter Elements and RO Membrane Elements

Management options for the discarded cartridge filter elements and the RO membrane elements is similar. As such these have been evaluated together; differences between the two element types, however, have been noted.

a) Avoidance

Complete avoidance of the generation of discarded cartridge filter elements and RO membrane elements is not possible as they are both essential components of the desalination process. This option, accordingly, has not been considered further in this document. The use of alternative technologies to desalinate water, thereby avoiding the generation of these waste streams, is beyond the scope of this application and is discussed in Section 7.

b) Reuse

This method involves the reuse of the cartridge filter elements and/or RO membrane elements following their regeneration to remove, as far as is practical or economic, accumulated depositions.

c) Recycling

This method involves the possible dismantling of the elements into their individual components and the recovery of those components, which are economically and technically recyclable for reprocessing. Those components that cannot be recycled for technical reasons (e.g. residue types and/or concentrations) or economic reasons would need to be managed by alternative methods.

Discussions held with Victorian plastic processors indicate that there is an opportunity for the elements to be recycled, either as a whole unit or as individual components. Before this option can be technically and economically evaluated in any detail, further research is required into the properties of the elements and their components, ease and practicality of disassembling the elements, and possible contaminants arising from their use in water treatment. Ultimately, however, demand for the waste streams by the plastic industry is dependent on the comparative market of virgin materials.

d) Recovery of Energy

The spent filter elements and RO membranes, having a high calorific value, could be used as a possible energy source. This method could involve the elements being transported to an appropriate incineration plant with energy recovery, where they could be processed, typically by shredding and then mixing with a range of other materials to ensure homogenisation, prior to combustion and recovery of calorific value. However, energy recovery appears to be unviable at this stage as high disposal charges for these waste streams ensue. Classification of the wastes as PIW could influence the nature of management of this waste.

e) Disposal

This method involves the disposal to landfill of either the entire discarded element (i.e. as a whole unit) or non-reusable, recyclable or combustible components. All elements or components, where applicable, would be drained free of liquids prior to disposal.

Conclusions

Waste avoidance may not be a viable option for these waste streams. Reuse remains, at least in the short to medium term, an unlikely option for the Desalination Plant, as it does for plants elsewhere in the world. Landfilling of discarded cartridge filter elements and RO membrane elements is commonly practiced by desalination plant operators around the world and appears to be a viable option for the Desalination Plant. This option, however, is low on the waste hierarchy as it represents a loss of a potentially valuable resource (in the form of either a material or energy).

Classification of the waste streams as a PIW would have a significant economic impact on this option through higher disposal requirements and haulage distances, with environmental impacts through increased vehicular emission, which include greenhouse gases.

While it is possible, and perhaps likely, that in the current environment the recycling of the elements may not be financially viable, it should be recognised that current sustainable business practice will continue to evolve. Factors that will drive these changes may include:

- Federal and State legislation;

- increased landfill levies and disposal charges;
- increased cost of petroleum-based products (polyester and polypropylene);
- increased demand for recycled products; and
- increased number of discarded elements potentially available for recycling arising from an increase in the number of RO membrane desalination plants established in Australia and overseas.

General Operation and Maintenance Waste

a) Avoidance

Avoidance and reduction of this waste stream would be managed through a site EMP prepared under the Desalination Project EMF (refer to Section 17 of this WAA).

Participation in Sustainability Victoria's Waste Wise program would also be beneficial. Under this program, businesses are assigned a facilitator who would guide the organisation through assessment of waste streams and costs and the development and implementation of a waste reduction action plan. These action plans include targets for waste reduction and strategies for reaching those goals. Certification may be granted if significant achievements have been made in waste reduction. Further, the Waste Wise program purports to enable businesses to gain financial benefits through cost-effective waste reduction and recycling systems and improving efficiency.

b) Reuse/Recycling/Recovery of Energy

As described above, it is expected that the recovery of materials from the operational waste stream for reuse or recycling will be addressed on-site through an EMP and through implementation of a program such as Waste Wise, refer to *Section 7.5.1* of the Waste Management Report (GHD, 2008e). Basic evaluation of reuse and recycling opportunities for each component of the general operation and maintenance waste stream for the Desalination Plant is briefly listed.

Source segregation of office waste is practiced by many businesses in Victoria. Materials commonly recovered include plastic and glass containers, paper and plastic packaging, aluminium and steel cans, scrap paper and cardboard. A number of commercial and municipal organisations operate resource recovery facilities (commonly referred to as materials recovery facilities or MRFs) in metropolitan Melbourne and in the region surrounding the Desalination Plant Site that could potentially accept these materials.

Scrap metal arising from the workshop may also be segregated and sold to scrap metal merchants or recyclable waste merchants.

A number of existing commercial facilities refurbish chemical storage containers for reuse, which provides another waste management option for the Desalination Plant, as it will likely receive delivery of process chemicals in a large number of chemicals containers. EPA's Classification for Large Containers Contaminated with Prescribed Industrial Waste (2007) states that all steel and plastic rigid containers with an original volume equal to or larger than 200 litres, that are contaminated with or contain a residual volume of PIW, must be reused, recycled or used for energy recovery.

It is also possible to recycle office prescribed wastes such as expired batteries and fluorescent tubes through specialist recyclers located in Melbourne.

Reuse of green waste and food scraps generated on-site via composting, alternative treatment or mulching may be feasible for the plant. A small quantity of the organic waste that might be produced at the Plant Site may not be suitable for the reuse options just mentioned and use of commercial composting facilities is unlikely to be financially viable for these wastes. However, such opportunities may be viable if considered together with the intake screen washings.

E-waste, or computer and phone wastes can be disposed of in a safe and environmentally friendly way via Sustainability Victoria's "Byteback" service, which is managed in conjunction with the Australian Information Industry Association (AIIA) and partner information systems/computer manufacturers. The Desalination Plant may be included in this free program, which is normally restricted to small businesses, if the quantities of these wastes are minimal. If inclusion in this program is not possible, a small number of specialist commercial recyclers in metropolitan Melbourne may accept e-wastes from the plant.

c) Treatment

Many small quantities of PIW can be expected to be produced by the Desalination Plant arising from general operation and maintenance activities could be transported off-site and treated at private waste management facilities licensed by EPA to accept such waste.

d) Disposal

It is likely that some waste generated on-site will not be suitable for alternative waste management options and will require landfilling. The majority of wastes generated during the operational phase of the Desalination Plant may be suitable for landfilling, should this option be required.

Conclusions

Avoidance and reduction of this waste stream is most appropriately managed through a site Environment Management Plan (EMP) prepared under the Desalination Project Environmental Management Framework (EMF). Participation in Sustainability Victoria's Waste Wise program would also be beneficial.

Recycling or reuse options appear to be both commercially and technically feasible for a range of wastes expected to be produced at the Desalination Plant including: glass, plastics, paper and cardboard; chemical packaging, scrap metal, batteries, fluorescent tubes, green waste, food scraps; and some hazardous chemical residues.

9.5.2 Desalination Plant Construction

Construction wastes generated by the construction of the Desalination Plant are expected to be similar to those produced by other major construction projects, as such only a summary of waste management options for these wastes is given in Table 9-3. For further discussion of the identification and evaluation of management options for each of the construction waste streams refer *Section 7* of the Waste Management Report (GHD, 2008e).

Table 9-3 Application of the waste hierarchy to Desalination Plant construction wastes[12]

Waste type/source	Application of the waste hierarchy		
	Avoidance/Minimisation	Reuse/Recycling/Energy Recovery	Treatment/Containment/Disposal
Construction spoil – fill material.	Due to nature of works, complete avoidance will not be possible. Optimising the design of the Plant and associated works may reduce the volume of spoil generated.	On-site and off-site reuse options exist for fill material, in engineering fill and landscaping.	Residue to appropriate EPA approved clean fill landfill.
Construction spoil – acid sulfate soils.	Best achieved by avoiding known areas of ASS.	Can be used as backfill material, with acid neutralisation as required.	▪ Treat to reduce acidity, according to EPA Publication 655. ▪ Engineered containment an option. ▪ Disposal to appropriately approved EPA landfill.
Contaminated soil.	Best achieved by avoiding known areas of contaminated soil.	Dependent on level of contamination.	▪ Pre-treatment, as required, prior to backfill or engineered containment. ▪ Disposal to appropriately approved EPA landfill.

[12] Expanded discussion of these wastes is included in Section 9.5.1, following this table.

Waste type/source	Application of the waste hierarchy		
	Avoidance/Minimisation	Reuse/Recycling/Energy Recovery	Treatment/Containment/Disposal
Waste arising from demolition of existing structures.	Possible - extent of demolition may be limited to unsafe structures only.	Transfer to existing outlets specialising in sale of second hand building materials	Residue disposal to appropriately approved EPA landfill.
Waste arising from construction of infrastructure.	Complete avoidance will not be possible. Minimisation with consideration to Sustainability Victoria's: ▪ Construction Waste Minimisation Strategy Check List; and ▪ Guidelines for Preparing Waste Reduction Strategy for Construction.	On-site or off-site segregation of recyclables.	Residue disposal to appropriately approved EPA landfill.
Waste arising from use of temporary infrastructure – concrete batching plant	Maintaining and/or improving plant efficiency.	Excess raw materials reused for subsequent batching. Excess concrete recycled as aggregate.	Residue disposal to appropriately approved EPA landfill.
Waste arising from use of temporary infrastructure – development of truck wash facility	Sealing of haul roads, and restriction of access to disturbed areas.	Blend sediment with construction spoil for reuse as fill or for landscaping.	Residue disposal to appropriately approved EPA landfill.
Waste arising from use of temporary infrastructure – site amenities	▪ Similar to management options for general operation and maintenance waste (refer to Section 9.5.1) ▪ Utilise reusable infrastructure facilities.		

	Application of the waste hierarchy		
Waste type/source	**Avoidance/Minimisation**	**Reuse/Recycling/Energy Recovery**	**Treatment/Containment/Disposal**
Waste arising from landscaping/screen planting works	Consideration to product selection and bulk materials handling.	On-site or off-site segregation of recyclables.	Residue disposal to appropriately approved EPA landfill.
General construction waste	Similar to management options for wastes arising from the construction and/or use of temporary or permanent infrastructure (refer above).		

9.6 Summary and Conclusions

The construction and operation of the Desalination Plant will produce a number of different waste streams. Management options for all the expected waste streams to be produced have been considered in relation to the waste hierarchy in order to optimise avoidance, mitigation and management of waste streams, and protect beneficial uses of natural resources. Through this process management options have been identified which may enable numerous waste streams to be avoided, reduced and/or recycled. Due to financial and/or technical considerations it is likely that some wastes will need to be disposed of to landfill, either as a temporary or permanent measure.

It should be noted that actual waste streams and quantities produced by the Desalination Plant may differ from those considered depending on the design adopted by the Project Company appointed under the PPP contract. However, performance requirements have been identified and outlined in Section 9.7 that the final design must achieve and comply with.

9.7 Environmental Performance Requirements Arising from this Section

As discussed in Sections 1 and 6, the design adopted by the Project Company appointed under the PPP contract is likely to differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Performance Requirements outlined in this Section of the WAA in a manner that would lead to a similar or better waste management outcome.

The Performance Requirements are incorporated into the Environmental Management Framework (see Section 17) and embody the recommendations of environmental management arising from framework. The specific Performance Requirements relevant to this study area are presented below.

Performance Requirements

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop and implement a long term waste minimisation and management plan for the construction and operation phases of the Project;
- In assessing waste management options, adopt the following order of preference:
  - Waste avoidance and/or reduction;
  - Waste reuse, recycling and reclamation;
  - Waste treatment;
  - Waste disposal;
- Remove and otherwise handle any materials containing asbestos in accordance with the requirement of all Laws and Approvals, including the Occupational Health and Safety (Asbestos) Regulations 2003 (Victoria); and
- Promote the efficient use and conservation of resources as part of the training program for all Associates including contractors, subcontractors and operators.

10. EREP

10.1 Introduction

10.1.1 EREP Overview

EPA Victoria's Environment and Resource Efficiency Plans (EREP) program is a regulatory scheme that requires large energy and water users to assess their environmental resource use and waste generation, develop an integrated resource efficiency action plan and report on its implementation. The scheme specifically targets sites that use more than 100 terajoules (TJ) of energy and/or 120 megalitres (ML) of water in any financial year from 2006/07 onwards. A site will need to trigger only one threshold in order to qualify for the program.

Regardless of whether the energy or water use threshold is triggered, a participating site must address its energy use, water use and waste generation.

An EREP will consist of a list of prioritised actions, their projected costs and savings, and proposed implementation and monitoring information. Only actions identified as having a three-year or sooner payback period are required to be implemented. However, EPA Victoria (EPA) strongly encourages participants to consider implementing actions beyond the three-year payback period to improve resource efficiency and reduce waste generation.

The *Environment Protection (Environment and Resource Efficiency Plans) Regulations 2007*, and EREP guidelines (EPA Publication 1198) can be viewed on the EPA Victoria website at http://www.epa.vic.gov.au/bus/erep/default.asp.

10.1.2 EREP and the Desalination Plant

It is expected that once operation of the Desalination Plant commences at the end of 2011, EREP thresholds for energy and/or water use will be triggered within the first financial year of operation, requiring an EREP to be prepared, and subsequently implemented. However, an exemption from this may be available, as is discussed in the following Section.

10.1.3 Exemption from EREP through the Works Approval

The EREP guidelines allow for the proponent of works at a site that is subject to a works approval to apply for an exemption from the requirement to prepare an EREP for up to five years from when the exemption is granted. This is designed to support sites that have had resource efficiency opportunities thoroughly investigated and, if practicable, implemented in their design.

To be eligible for an exemption, the WAA must:

- assess resource efficiency opportunities consistent with EREP requirements; and
- demonstrate that the plant and equipment subject to the works approval are operating at best practice (refer Section 2.2 of this WAA for a discussion on the application of best practice for the Project).

An application for the exemption must be made within three years of EPA issuing the works approval.

This Section of the WAA addresses resource efficiency and waste reduction opportunities at the Desalination Plant, with the view of meeting EREP exemption requirements.

10.1.4 Exemption from an EREP for Construction Activities

On 28 March 2008, EPA Victoria issued a notice of exemption (EPA Victoria, 2008) from EREP for construction activities that are anticipated to finish within two years following a “trigger year” and meet other conditions of the Notice of Exemption. A trigger year is the first financial year, from 2006-07 onwards, in which the construction activity used more than 100 terajoules of energy and/or 120 or more megalitres of water.

To qualify for an exemption, these construction activities must have already assessed resource efficiency and waste minimisation opportunities when designing and planning the construction activity and must also have an active plan and/or management system in place for the efficient management of energy, water and waste for the life of the activity.

Construction of the Desalination Plant is expected to commence in late 2009 with an aim to commence the desalination of water by the end of 2011. This timeframe may allow for site construction activities to be exempt from the need to comply with the EREP regulations. Nevertheless, the exemption still requires construction activities to address resource efficiency and waste minimisation opportunities to the greatest extent practicable, and this is incorporated into the Performance Requirements for the Project.

10.1.5 Scope of Application

As discussed in Sections 1 and 6, the final design of the Project is dependent on the outcomes of a commercial process as part of PPP delivery and is currently not precisely known. For both the EES and WAA, a Reference Project has been developed, together with acceptable Variations, as a basis for project assessment and the obtaining of approvals including works approval.

This Section of the WAA seeks to demonstrate that resource efficiency has been considered and adopted to the extent practicable in the Reference Project and the identified Variations for each Project component which are included within the scope of this application. As discussed elsewhere in this document resource efficiency criteria have been incorporated into Performance Requirements, which govern the Project and will be used for evaluation of bids and in determining Project operational compliance.

10.2 Description of Resource Consuming and Waste Generating Activities

10.2.1 Resource Consuming and Waste Generating Activities

Table 10-1 demonstrates where resources are consumed and wastes generated within the Desalination Project.

Table 10-1 Resource consuming and waste generating activities

Project Components	Energy	Water	Waste
Desalination Plant			
Construction	✓	✓	✓
Seawater screens	✓	✗	✓
Seawater pump station	✓	✗	✗
Pre-treatment plant	✓	✗	✓
Backwash wastewater treatment plant	✓	✗	✓
RO Desalination Plant	✓	✓	✓
Post-treatment plant (Potabilisation)	✓	✗	✓
Clear Water Storage	✓	✗	✗
Treated water pump station	✓	✗	✗
General office / Canteen / Administration	✓	✓	✓
Garden and landscaping	✗	✓	✓

10.2.2 Energy

The EREP regulations consider energy to be any of the following:

1. Energy derived from combustible fuel;
2. Electricity (produced or purchased for consumption);
3. Compressed air (if used to provide energy);
4. Steam (if used to provide energy); and
5. Energy derived from a reductant.

The Desalination Plant will consume a significant amount of energy during both its construction and operation. It is estimated that approximately 82 MW of power will be required to operate the Desalination Plant at a potable supply rate of 150 GL annually (including operation of the plant and the transfer pump station). If the supply rate is increased to 200 GL annually, the estimated power input is 115 MW (including operation of the plant and the transfer pump station). Electricity will be consumed during the following key stages and activities:

- construction of infrastructure and installation of facilities;
- operation of the feedwater and waste screening treatment;
- operation of the reverse osmosis plant; and
- operation of the pump stations that will deliver potable water to Melbourne's water supply system.

Energy Usage by Component

Figure 10-1 demonstrates the proportion of energy consumed by components of the Reference Project, operating in adverse conditions, defined as a raw seawater temperature of 11°C and salinity levels of 40,000 mg/L. The majority of energy will be consumed within the RO system (see Figure 10-1). These proportions reflect the estimated energy distribution following best practice optimisation of each Project component.

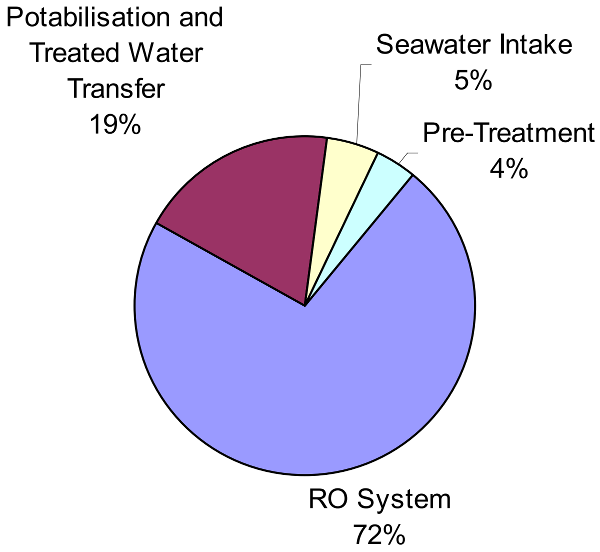


Figure 10-1 Proportionate Energy Usage during Operation (150 GL/year)

A summary of the expected energy sinks within relevant components of the Desalination Project (for both construction and operation) is presented in Table 10-2.

Table 10-2 Identified Energy Consuming Components

Project Components	Energy Sinks
Desalination Plant	
Construction	▪ Lighting ▪ Electronic equipment ▪ Tunnel boring machines (TBM) for tunnelling[13] ▪ Temporary power generation system ▪ Heavy machinery ▪ Transport ▪ Accommodation ▪ Amenities ▪ Concrete production
Seawater screens	▪ Rotating band ▪ Drum screen.
Seawater pump station	▪ Pumps.
Pre-treatment plant	▪ Coagulation system, removal of organic material and suspended solids ▪ Flocculation system ▪ Filtration systems ▪ Filtered seawater tank systems ▪ Recycle pump.
Backwash wastewater treatment plant	▪ Wastewater system ▪ Balancing tank system ▪ Concentrate disposal.
Reverse osmosis Desalination Plant	▪ Pressurised systems ▪ Pumps ▪ Membranes ▪ Filter systems ▪ Booster pumps ▪ Permeate tank system.
Post-treatment plant (Potabilisation)	▪ Pumps ▪ Chlorine/fluoride mixing system ▪ Lime and carbon dioxide mixing system.
Clear water storage	▪ Pumps.
Treated water pump station	▪ Pumps.
Office / Administration	▪ Lighting ▪ HVAC ▪ Appliances ▪ Hot water.
Site	▪ Lighting/security systems
Ongoing operation and maintenance	▪ Vehicles

Exclusions

The various items of infrastructure associated with the supply of power from off-site sources and the delivery of potable water to Melbourne have also been identified as energy sinks (in both construction and operation), and will be assessed for resource efficiency in the course of the EES. These include:

- the booster pump station (including pumps, lighting and metering);
- the pipelines transporting potable water; and
- all associated power transmission lines.

[13] A significant proportion of the construction energy use

However, as the WAA applies only to the Marine Structures and Desalination Plant, they are not included in this assessment, which is directed toward achieving works approval based exemptions.

10.2.3 Water

Water, under the EREP regulations, is considered to be water used at a premises excluding seawater but including rainwater, stormwater, desalinated water, groundwater and recycled (including reused) water, however obtained or supplied (refer *Section 4* of the EREP Regulations).

According to this classification, water use at the premises includes all water to be used during construction, general domestic usage and some in-plant uses. As seawater is not included, water usage in the desalination process is considered to be the consumption of water that has been treated beyond the first pass of the reverse osmosis process only. This includes desalinated water prior to potabilisation.

During operation, all water used on-site (for the plant processes and for amenities and offices) will be obtained from the plant product water and on-site runoff. There may be a small connection to the Wonthaggi supply for essential / support uses (such as offices and amenities supply) that may be utilised in cases of plant shutdown. Construction activities will require water obtained from local mains supply or elsewhere.

Construction

Construction of the Plant and associated infrastructure will have the greatest requirement for water use during the Project. This water will be required for purposes such as dust suppression and concrete batching. The source and quantity of construction water requirements can only be fully identified when the winning proposal has been determined and detailed design takes place. It is unlikely that seawater will be suitable for construction purposes.

Desalination

As previously noted, water usage in the Desalination Plant is considered to be the consumption of water that has been progressed beyond the first pass of the reverse osmosis process only. This includes desalinated water prior to potabilisation.

The uses of desalinated water within the desalination process include in-plant use (clean-in-place, flushing, other) and chemical dosing systems. Water used for such purposes is not required to be of potable quality and is thus utilised prior to undergoing potabilisation. This can be considered an integrated approach to resource efficiency, where energy is conserved through not having to potabilise this water.

Domestic Water Use

Domestic water use is considered to include all water used for offices and amenities and generally consists of drinking water, showers, toilet flushing and hand-basin use. Water for drinking purposes will be sourced from the Clear Water Storage, i.e. the final (potable) product from the desalination process. Non-potable domestic uses will be sourced from on-site runoff (rainwater and stormwater), and supplemented by the Clear Water Storage where required (as outlined in the Performance Requirements in Section 10.5).

Stormwater and Rainwater Harvesting

The Desalination Plant Site will incorporate a considerable area of roof space and impervious surfaces that will generate significant rainfall runoff during storm events. This does not constitute a water use, but presents an opportunity to capture some of this water for re-use in the plant as an alternative to desalinated or mains water. There are opportunities to use harvested stormwater in plant operation, site maintenance and fire water supplement, as required by the Performance Requirements in Section 10.5.

10.2.4 Waste

Waste of varying types will be generated during construction and through operation and maintenance of the Plant and Plant Site. Table 10-3 presents a summary of waste generating activities associated with the Project. A detailed description of each waste type, source and predicted volume is provided in Section 9 (Description of Major Waste Generating Activities).

Table 10-3 Waste Generating Activities

Project Components	Waste Generated
Desalination Plant	
Construction	▪ Construction spoil and site clearing ▪ Temporary construction works ▪ Concrete production waste ▪ Temporary construction site amenities ▪ General construction waste.
Seawater Screens	▪ Intake screen washings.
Seawater Pump Station	▪ None identified.
Pre-treatment Plant	▪ Pre-treatment backwash ▪ Used filter media.
Reverse Osmosis Desalination Plant	▪ Used cartridge filter elements ▪ Used RO membrane ▪ Cleaning wastes.
Post-treatment Plant (potabilisation)	▪ Lime sludge.
Clear Water Storage	▪ None identified.
Treated Water Pump Station	▪ None identified.
Office / Administration	▪ General domestic and office waste.
Ongoing operation and maintenance	▪ General operation and maintenance waste.

10.3 Efficiency Indicators and Benchmarking

10.3.1 Energy

Desalination Plant

Specific Energy Consumption (SEC) [14] is a widely used indicator of overall desalination plant energy efficiency. It is a measure of the total energy required per volume of potable water delivered, generally given as kilowatt-hours per kilolitre of water produced (kWh/kL).

It is difficult to precisely benchmark the overall energy efficiency of the proposed Desalination Plant against equivalent existing facilities due to the influence of feed water temperature and salt content conditions on the SEC of the plant. As the feed water temperature decreases and the salinity increases, the energy requirement will increase if the plant output is to remain constant.

A further benchmarking limitation is the requirement for the plant to deliver low Total Dissolved Solid (TDS) concentration to maintain the high standards of the Melbourne drinking water supply. The implication of such a requirement is a further increase in SEC.

The SEC for the Reference Project has been estimated over a range of the potential operating conditions expected at Wonthaggi. Water quality data suggests that the average temperature and salinity are in the order of 16°C and 37 000 mg/L. On this basis, the average Reference Project SEC is in the order of 4.0 – 4.6 kWh/kL (for the desalination process only, excluding transfer pumping energy). Given low feed water temperature and the high standards of the Melbourne drinking water supply, this range is generally equivalent or better than the SECs observed in other seawater desalination plants in Australia and overseas.Table 10-4 presents the SEC of other Australian and overseas seawater desalination plants.

Table 10-4 Benchmarking against other Desalination Plants

Desalination Plant	Capacity (ML/d)	Status	SEC (kWh/kL)[(1)]	Comment / Source
Perth	125	Operational	3.6-4	Limit uncertain, thought to be about ~4 kWh/kL.
Trinidad	119	Operational	3.8	Source: GCD Alliance, Material Change of Use Application ERA 16, 19 & 7, Table 19.5 (2007)
Singapore	136	Operational	4.3	Source: GCD Alliance, Material Change of Use Application ERA 16, 19 & 7, Table 19.5 (2007)
Israel	326	Operational	3.9	Source: GCD Alliance, Material Change of Use Application ERA 16, 19 & 7, Table 19.5 (2007)
South Europe	120	Operational	4.1	Source: GCD Alliance, Material Change of Use Application ERA 16, 19 & 7, Table 19.5 (2007)

[14] Energy required per volume of potable water delivered.

Desalination Plant	Capacity (ML/d)	Status	SEC (kWh/kL)[(1)]	Comment / Source
Sydney	250	Construction	4.2	Contractual maximum under lowest temperature highest salinity (worst case) conditions. Source: Design and Construct Contract, Schedule 14: Company's Requirements, Sydney's Desalination Project, *Section 1.5* (Sydney Water, 2007).
Gold Coast	125	Construction	4.1	Source: GCD Alliance, Material Change of Use Application ERA 16, 19 & 7, Table 19.5 (2007)

Note:

1. The figures provided for SEC in this comparison consider only the energy used through the desalination process. Transfer pumping energy is excluded, as it is typically site-specific and dependant on local geography and the distance to the existing water supply system.

10.3.2 Water

Desalination Plant

Water consumed during the desalination process will be for in-plant use (CIP, flushing, other), chemical dosing and domestic potable water use.

Benchmarking of operational water use against equivalent uses in other existing desalination plants has not proven practical. The reverse osmosis process is highly dependent on prevailing site conditions and is heavily influenced by the processes undertaken during pre-treatment. This creates difficulty in undertaking a 'like-for-like' comparison with similar facilities.

Offices (Administration, Visitors Centre and Control Building)

For office-type buildings, a typical indicator of efficiency in water-use is the amount of water consumed (Litres) per occupant per day. Typically the number of occupants, types of tap fittings, showers, toilets etc. need to be defined within the design to be able to quantify this efficiency indicator.

A recognised performance benchmark against which this indicator can be evaluated is provided by the Green Building Council of Australia's rating system – *Green Star Office Design Technical Manual v3* (2008). Under this rating system, up to 5 points are available for water consumption performance. These points are awarded for the thresholds[15] listed in Table 10-5. The water conservation rating and definitions are as defined by the National Water Conservation Rating and Labelling Scheme, administered by The Water Services Association of Australia (WSAA) (2001).

[15] Thresholds assume that shower usage in these buildings is low.

Table 10-5 Water Use Benchmarking for Offices

Green Star Points	Water Conservation Rating	Definition	L/Day/Person Benchmark
1	2A	A “good” level of water efficiency	18
2	3A	A “high” level of water efficiency	13
3	4A	A “very high” level of water efficiency	10
4	5A	An “excellent” level of water efficiency	8.5
5	5A + 20% improvement	An “exceptional” level of water efficiency	7

The Green Building Council of Australia (2008) states that to achieve 5 points under the Green Star rating system the office buildings would need to employ methods to reduce water consumption through the specification of greywater recycling and/or rainwater collection systems and waterless urinals, for example.

The Project will be evaluated against this benchmark and will aim to achieve an initial water conservation rating of 2A or greater, as required by a Performance Requirement in Section 10.5.

10.3.3 Waste

It has proven difficult to establish a set of efficiency indicators for the purpose of benchmarking the generation and management of waste arising from operation of the Desalination Plant. In most instances the quantity and quality of waste generated during each process is highly variable and site-specific. Furthermore, waste from a particular process is often highly dependent upon the characteristics of the process train of treatment preceding it.

Accordingly, efficiency indicators have not been identified for waste within the Reference Project. However, waste management options have been assessed against a set of guiding principles based on the Scoping Guidelines and the waste hierarchy, and the Performance Requirements for the Project will require the Project Company to demonstrate best practice waste management.

10.4 Assessment of Resource Efficiency Opportunities

10.4.1 Energy

Energy efficiency is a pivotal objective for the Project, given greenhouse gas and operational cost considerations. For this reason, energy efficiency has been carefully considered in development of the Project. In addition a comprehensive greenhouse gas study of the plant and its components have been prepared to identify greenhouse gas reduction options (Maunsell, 2008b).

Construction

Appropriate measures to incorporate energy efficiency into the construction of the Site (including Marine Structures, Desalination Plant and other associated infrastructure) will be required to be undertaken by the Project Company. This will be addressed by systems and protocols that promote the efficient use of energy and water and a waste management policy that adheres to the principles of the waste hierarchy.

This will include encouraging, where practicable:

- minimising the distance over which construction materials (fill, gravel, sands, cement, etc.) are transported;
- use of newer, more energy efficient mobile and stationary plant;
- use of recycled materials and reuse and recycling of materials on-site;
- use of concrete formwork that is reusable; and
- exclude the use of plywoods that use rainforest hardwood veneers.

Desalination Technology

Two seawater desalination technologies were considered sufficiently mature to be used at the scale required for the Desalination Plant. These were ‘reverse osmosis’, which is based on pumping the sea water through membrane filters to produce fresh water, and ‘thermal’ which uses heat to evaporate off fresh water, which is then recovered by condensation.

All the recently constructed Australian desalination plants have adopted reverse osmosis (see Section 7), as it is more energy efficient, less visually intrusive and more cost effective in an Australian context. Analysis for Melbourne has led to the same conclusion, resulting in the adoption of the more energy-efficient technology (reverse osmosis) as a Project requirement and foundation of the Reference Project and all other Variations and Options.

The energy intensity of reverse osmosis (RO) technology for seawater desalination has halved over the past ten years, with the introduction of energy recovery devices (Sherwood 2006). The best available current RO technology has been considered in the Reference Project and is therefore reflected in this assessment.

Seawater Inlet System

Most of the energy consumed in the seawater inlet system is from pumping seawater to the head of the pre-treatment plant. The actual energy consumption is governed by the following key parameters:

- the difference in water level between the sea and the pre-treatment plant, i.e. the height the water has to be lifted;
- the seawater flow rate; and
- the distance the RO plant is from the coast.

For a seawater RO plant, the required quantity of seawater feed is approximately 2.5 times the quantity of desalinated water produced. As energy consumption is directly proportional to the product of lift and flow, selecting a desalination plant site that minimises lift will result in lower energy consumption. It is more energy efficient to lift product water than seawater, as less water is required to be lifted for the same output. The Reference Project aims to minimise these effects by locating the Plant close to the coast, within constraints of avoiding disturbance to the dune system, as well as cutting a bench for the Plant Site to reduce the lift required. As such, the design complies with the criterion of low lift.

Reducing seawater intake flow will also reduce energy consumption. To reduce the seawater flow the recovery of product water through the RO plant needs to be maximised. The Reference Project has maximised recovery within the constraint of reliable operation. The design also provides the flexibility to increase recovery if operational experience shows that this can be achieved without unacceptable scaling or fouling of the membranes.

The other key factor in minimising energy consumption is to reduce the length of the seawater feed piping in preference to reducing the length of product water piping that transfers water to consumers. This essentially means a desalination plant located as close as possible to the coast. The Reference Project fulfils this criterion.

Parameters that have a lesser impact on energy consumption include:

- efficiency of the seawater pumps; and
- installation of variable speed pump motor drives.

Larger pumps are generally more efficient. These have been selected for the Reference Project.

The Reference Project also includes variable speed (VSD) drives for each of its pumps. These drives allow the pumps to operate at reduced head during times of reduced production demand, supporting maximum pump energy efficiency over the range of Reference Project operating scenarios. Where practical, VSD drives should be installed on pumps and motors by the Project Company (as outlined in the Performance Requirements in Section 10.5).

Pre-treatment Plant

Energy consumption in the pre-treatment plant is largely dependent on the pre-treatment technology selected and the approach taken to sludge disposal.

The Reference Project considers two options for pre-treatment that satisfy the best practice requirements set out in Section 7.2.1. These are:

- a conventional media pre-treatment plant and if required, Dissolved Air Flotation and Filtration (DAFF) as a possible option, requiring the dosing of a coagulant and provision of a wastewater treatment plant to separate the solids; or
- the use of membrane filtration. These are more energy intensive than conventional processes, however these systems can potentially operate with less coagulant dosing[16].

The filtration systems used within the pre-treatment process to decrease the solids loading onto the water treatment plant allowing for effective pre-treatment with limited chemical application and reduced energy consumption. Selection of membrane filters instead of conventional media filters could reduce waste but may also result in higher energy use. An analysis of the energy/waste trade-off is presented in Section 7.

Given the selected pre-treatment technology in the Reference Project, measures taken to optimise energy efficiency include use of variable speed drives on pumps and mixers to cater for a wide range of operating conditions (as outlined in the Performance Requirements in Section 10.5).

Conventional (media) pre-treatment systems considered in the Reference Project include dual media filters (sand/anthracite). Dual filters consume less energy than comparable mono filters.

Desalination Plant

Three areas have been identified that may be optimised in the plant design to minimise energy consumption. These include:

- Civil Layout Optimisation;

[16] Subject to pilot trial confirmation

- Process Selection; and
- Mechanical Equipment Selection.

Opportunities to maximise energy efficiency for each of these areas have been carefully considered and incorporated into the Reference Project.

Civil Layout Optimisation

The civil layout in the Reference Project was benched to reduce the total number of pumps and pumping requirements. All proposed civil layout options require the pre-treatment plant to be placed on a higher bench than the RO plant, allowing for the filtered seawater to be gravity fed to the filtered seawater tanks before being pumped through the RO membranes, reducing the number of pumps required.

The concentrate outfall and diffusers were designed to operate under gravity flow to further reduce the need for pumping.

Process Selection

The Reference Project requires the optimisation of process parameter selection to reduce SEC. The process parameters that can be optimised to reduce SEC while remaining within the raw and treated water quality constraints are membrane type, flux, and membrane age. The Reference Project has adopted the following operational characteristics for each of these parameters to provide an optimum result:

- ***Membrane type*** – high recovery, low energy membrane;
- ***Flux*** – 1st pass: 13 L/m^2/hour; 2nd pass: 35 L/m^2/hour; and
- ***Average membrane age*** – 1st pass: 3.5 years; 2nd pass: 4 years

Ultimately the Reference Project process parameter selection was a balance between capital expenditure (CAPEX) and operating cost. Nonetheless, energy efficiency can be considered a significant component of operating cost.

The provision of a highly automated plant to optimise performance, and to aid optimum operating conditions, will support maximum performance from the RO membranes in terms of energy efficiency, life span and hence cost.

Furthermore, integration of pre-treatment initiatives will extend membrane life and optimise performance, whilst minimising energy consumption through reduction in fouling.

The operational range can be minimised by program planning of annual maintenance shutdown to coincide with the least favourable operating conditions (i.e. low water temperature and high salinity).

Mechanical Equipment Selection

With operating conditions largely fixed by the selected membrane technology and Project requirements, optimisation of mechanical equipment is where the majority of gains in SEC can be achieved.

A number of energy efficiency opportunities have been integrated into the Reference Project for various items of mechanical equipment. These include:

Variable Speed Drives (VSD) – VSD pumps have been selected for the Reference Project to enable the operating speeds of pumps to be adjusted to meet requirements rather than the pumps being throttled. A VSD pump (accounting for losses at reduced pumping speeds) is expected to use considerably less energy than a throttled pump particularly at the lower end of the operating spectrum. This is required by a Performance Requirement as set out in Section 10.5.

Pumps – Pumps were selected to run at their Best Efficiency Point (BEP) at normal operating conditions. The Reference Project has allowed for the pumps to be altered if, through further investigation, it is found that the Desalination Plant will typically operate towards the lower end of the design spectrum. Pump efficiency can be further optimised once load distribution of operational conditions is better known. This is required by another Performance Requirement as set out in Section 10.5.

Energy Recovery Devices (ERD) – Two ERD products were investigated for use in the Desalination Plant and were assessed for efficiency, noise, reliability, leakage and footprint. Both of these were types of positive displacement ERDs, which are considerably more efficient than centrifugal ERDs (these are still in widespread use around the world, however, the positive displacement ERD is used at most new desalination plants). Both performed reasonably consistently across the assessment criteria, particularly in terms of efficiency. Any product with equivalent efficiency is also considered acceptable for inclusion in the Project.

Treated Water Transfer (Transfer Pump Station)

The transfer pump station is expected to be located at the Desalination Plant Site and has therefore been included in this Section of the WAA. The Reference Project indicates that reduction in friction losses present the only opportunity for enhanced energy efficiency in the operating technology.

The size and requirements of the product water delivery transfer pump station are not yet precisely known and will be influenced by the requirements determined by Melbourne Water for pressure and flow at the connection to the Melbourne Water system.

Energy uses within the Transfer Pump Station will include:

- ten pumps with VSD; and
- surge Vessels.

The pumps chosen are designed to run at 85% to 90% efficiency and include VSD for improved efficiency.

Various combinations of pipeline diameters and pump station configurations were investigated for the transfer of the product water to the vicinity of Cardinia Reservoir. The optimal approach is dependent on a balance between several factors including construction time, capital cost, future requirements for higher flows, pumping requirements and the operating philosophy for the Project.

Selection of the pipeline diameter was in itself an optimisation exercise between the initial capital cost of infrastructure, ongoing life-cycle cost to operate the infrastructure, and ensuring the most efficient outcome. For example, a small diameter pipe would significantly increase friction head losses resulting in a large pumping capacity and increased energy consumption. Conversely, a large pipe diameter would reduce the size of the pumping requirement but may not be as cost effective over the life-cycle of the infrastructure. For the Reference Project, it was determined that the optimum pipeline diameter was 1800 mm for both the 150 GL/yr and 200 GL/yr capacity scenarios.

Offices (Administration, Visitors Centre and Control Building)

Given the high-energy requirements of the plant operation itself, energy efficiency initiatives employed in on-site office-type buildings will have a relatively minor impact on overall site energy consumption.

Nevertheless, a requirement will be in place to encourage the provision of a 4-star Green Star design rating for all office type buildings, whilst achieving a minimum Australian Building Greenhouse Rating (ABGR) of 4.5 stars. This will ensure that energy efficiency is suitably considered in the design of these buildings.

Lighting

The Reference Project requires that artificial lighting be minimised where practical during operation. The plant will be required to maintain levels for adequate safety and security purposes. The majority of critical equipment (that may require operational personnel at night) will be within buildings. Extensive lighting is likely to be required throughout the construction period.

10.4.2 Water

Desalination Plant

Since benchmarks for comparison of in-plant water usage (clean-in-place, flushing, other) or chemical dosing are not readily available for a direct comparison, it is difficult to assess the level of efficiency with which the water is currently used in these areas.

Nevertheless, efficiency measures are available, particularly for the clean-in-place (CIP) solutions used for the cleaning of the RO plant membranes which are intended to be reused until they become strongly coloured and there is a loss of cleaning performance (refer GHD, 2008e).

All water used for domestic purposes, such as hand-basins, drinking, showers and toilets is presumed to be efficiently delivered using water efficient fittings.

Offices (Administration, Visitors Centre and Control Building)

A water conservation target of 2A or greater (WSAA, 2001) will be prescribed as a minimum target in the design for all office-type buildings, that is, a design that allows for water consumption equivalent to 18 Litres a day per person or less. It is likely that this would involve the provision of water efficient fittings in combination with demand-side initiatives such as raising water conservation awareness through signage and displays (as outlined in the Performance Requirements in Section 10.5).

Rainwater and Stormwater Harvesting

The selection process to determine stormwater management approach for the Reference Project is based on providing a technically feasible option which meets assumed water quality targets. The approach also takes into account CSIRO recommendations for treatment measures, based on pollutant particle sizes and hydraulic loading (detailed in the EES study *Surface Water EES – Plant* (GHD, 2008d)). The Reference Project adopts a treatment train with the following components:

- an in-line trap to remove likely pollutants from the site such as oil, grease and hydrocarbons;
- a sedimentation basin (or trap) to remove coarser sediments; and
- a wetland system to remove finer sediments and absorbed/dissolved pollutants (i.e. nutrients and metals).

The treated stormwater will be harvested for non-potable on-site uses where appropriate, as required by a Performance Requirement in Section 10.5. The remaining treated stormwater will be discharged to the Powlett River.

The collection and storage of rainfall runoff from roof surfaces around the Site is also incorporated into the Reference Project (as outlined in the Performance Requirements in Section 10.5). This water is generally of better quality than stormwater run-off and can be used to supplement a considerable amount of the Site's water needs, in particular, toilet flushing, cooling towers, irrigation and various other in-plant processes.

10.4.3 Waste

For each waste generating activity, a number of means of avoiding, reducing, reusing, recycling, energy recovery and/or disposal of the resulting waste stream have been investigated. These were selected and evaluated using a set of guiding principles that are broadly consistent with the principles of the EREP program and the waste hierarchy. The principles of sustainable practice, intergenerational equity and integrated decision making were also incorporated into the decision-making process for each waste generating activity. A detailed synopsis of the guiding principles for waste management at the Desalination Plant is provided in Section 9.

In addition to the guiding principles for waste management, the decision-making process has paid due consideration to the commercial status, technical suitability and statutory environmental requirements linked to each identified solution. Waste management is subject to a dynamic environment in which regulatory, commercial and technical viability at a local scale can limit the ability to apply the highest tiers of the waste hierarchy to a particular waste stream. Consideration of practicability supports a level of pragmatism applied to the waste hierarchy, where avoidance, reduction and reuse are accorded highest priority, but are also subject to the limitations of the local environment. Where these 'high tier' opportunities were not considered feasible, options were evaluated with an aim to establish the "best practicable" solution.

10.5 Environmental Performance Requirements Arising from this Section

As discussed in Sections 1 and 6, the design adopted by the Project Company appointed under the PPP contract is likely to differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Performance Requirements outlined in this Section of the WAA in a manner that would lead to a similar or better environmental outcome.

The Performance Requirements are incorporated into the Environmental Management Framework (see Section 17) and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirements relevant to this Section are presented below.

Performance Requirements

Energy

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop and implement construction and operation methods and management systems (including monitoring and reporting) to ensure energy efficiency during Project Activities including:
  - Achieving a Specific Energy Consumption (SEC) for the desalination process that is less than 4.6 kW/kL (calculated using a method agreed with EPA) on an annual average basis, or to satisfaction of EPA;
  - Installing variable speed (VSD) drives on pumps and motors, where practical; and

- Ensuring all pumps are selected to run at their Best Efficiency Point (BEP) under normal operating conditions.

Refer also to Performance Requirements identified in the assessment of GHG emissions (Section 8).

Water

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop and implement construction and operation methods and management systems (including monitoring and reporting) to ensure the efficient use of water resources during Project Activities, including:
  - Minimising water use. Designing offices and associated facilities to achieve a minimum water conservation target of 2A (i.e. less than, or equal to, 18 litres per day per person);
  - Reusing or recycling water, where possible. Where practical, harvesting rainwater and stormwater as a supplementary supply for various non-potable uses such as toilet flushing, cooling tower, irrigation and various in-plant uses where appropriate; and
  - Treating and/or returning surplus water for other non-Project uses or benefits.

Waste

Refer to Performance Requirements identified for waste management (Section 9).

11. Air Environment

This Section of the WAA provides an assessment of the potential air quality impacts from construction and operation of the Desalination Plant on the identified beneficial uses of the air environment.

Further detail on the assessment of the potential impacts on air quality from the construction and operation of the Desalination Plant is provided in the specialists report, *Desalination Project - Report for Assessment of Impacts on Air Quality* (GHD 2008f).

The Air Quality report (GHD, 2008f) forms *Technical Appendix 48* of the EES.

11.1 Regulatory and Other Requirements

As described in Section 2, the following policies are relevant to this Section:

- *SEPP (Air Quality Management) No. S240* (2001) - provides a framework for the management of emissions to the air environment so that the beneficial uses of the air environment are protected, Victoria’s air quality goals and objectives are met and continuous improvement in air quality is achieved;
- *SEPP (Ambient Air Quality) No. S19* (1999) – sets Victoria’s air quality objectives and goals, based on the requirements of the *National Environment Protection Council (Ambient Air Quality) Measure* (NEPM); and
- EPA Publication 480, *Environmental Guidelines for Major Construction Sites* (1996) (Vic).

In application here, potential air emissions from the Desalination Project will be assessed against the design criteria, intervention levels and emission limits prescribed in SEPP (AQM) to check that air emissions after application of best practice management, during construction and operation, protect the identified beneficial uses. Relevant beneficial uses include:

- Human health;
- Health of other forms of life including the protection of ecosystems and biodiversity;
- Visibility;
- Useful life and aesthetic appearance of buildings, structures, property and materials; and
- Local amenity and aesthetic enjoyment.

Air quality objectives specified in the SEPP (AAQ) are used to gauge the acceptability of ambient air quality within an airshed and are not directly used as design criteria to apply to individual emitters. However, the predicted impacts of the Desalination Plant emissions can be assessed with reference to the ‘reserve capacity’ of the airshed before the goals are exceeded. This consideration is pertinent in airsheds with significant existing (and possible future) industrial emissions, such as those occurring within the Port Phillip Air Quality Control Region and the Latrobe Valley Air Quality Control Region. Given that the Desalination Plant will not emit significant amounts of classified air pollutants and is located on the fringe of the Port Phillip Air Quality Control Region, which covers Melbourne, Geelong and Western Port, the issue of reserve capacity is not imperative.

The Environmental Guidelines for Major Construction Sites lists the typical array of dust control measures that will need to be evaluated and detailed as part of a dust management strategy.

11.2 Risk Assessment

Potential impacts on the air environment were assessed for both the construction and operational phases of the Desalination Project. Areas that require attention, taking into account legislative and policy obligations, community and stakeholder concerns, and guidance from the EES Scoping Requirements, were identified during the risk assessment. Approach to environmental impact and risk assessment is described in Section 4 of this WAA.

The risk assessment process was used to identify and rank priority issues assuming the Project controls described in Section 4 of this WAA would be implemented effectively.

The following Sections summarise the outcomes of the risk assessment process, listing the potential environmental impacts on the receiving air environment that were ranked as a medium risk or greater, and direct readers to where these impacts have been addressed in this Section.

11.2.1 Operation

A total of seven potential impacts on the air environment have been identified for the operational phase of the Desalination Plant, all of which were deemed to be low risk.

Of these low risk activities, the cleaning of coarse and fine screenings from seawater intake was selected for discussion in this report on the basis of experience at other desalination plants, which indicates that the only potential emission of concern during plant operation is that of odour.

All of the other low risk activities have been addressed in *Section 10.1* of the Air Quality report (GHD, 2008f) and a concise summary is provided within *Volume 3, Chapter 9* of the EES.

The risk assessment was based on accepted operational practices but did not take into account the mitigation measures embodied in the Performance Requirements. If the Performance Requirements were taken into account, both the likelihood and consequence of these risks would be significantly lower.

11.2.2 Construction

A number of potential impacts on the air environment have been identified for the construction phase of the Desalination Plant. Only one medium risk impact was identified, and this is shown in Table 11-1. No impacts have been assessed as a high risk.

Table 11-1 Potential impacts during construction of the Desalination Plant

Activity	Specific impact	Where addressed in this Section
Medium risk		
Truck movements, earthworks and use of machinery generating dust	Dust impacting on public health and amenity	Sections 11.3.7.2 and 11.4

The risk assessment was based on accepted construction practices but did not take into account the mitigation measures embodied in the Performance Requirements. If the Performance Requirements were taken into account, both the likelihood and consequence of these risks would be significantly lower.

11.3 Air Emissions Assessment

The scope of this assessment is to:

- assess the likely level of dust generation associated with construction of the Desalination Plant, including the seawater intake and discharge outlet tunnels, as well as the likely exposure of nearby residences to dust; and
- assess the likely air emissions during operation of the Desalination Plant as well as the likely exposure of nearby residences.

The method adopted for assessment of air emissions from the Desalination Plant during its construction and operation, in its 150 GL per annum configuration, is outlined in the points below. These points are described in greater detail in the subsequent Sections of this WAA:

- identification of emissions of potential concern from Desalination Plant;
- selection of air quality assessment criteria;
- evaluation of air pollution control equipment (mitigation measures);
- dispersion modelling to predict air quality impact; and
- implications of odour and dust performance requirements.

11.3.1 Emissions of Potential Concern from Construction and Operation of the Desalination Plant

11.3.1.1 Odour

Experience at other desalination plants indicates that the only potential emission of concern during plant operation is that of odour. Sources of odour are linked to the removal of marine biota from the seawater prior to the RO plant. This removal occurs at two stages:

i) initial screening of gross solids at the inlet pump station; and

ii) removal of fine solids from the pre-treatment filters during backwash of these filters - Backwash water is dewatered and the solids are stored prior to disposal off-site.

Both gross and fine solids contain marine biota, the former including seaweed, the latter typically including organic matter such as larvae and plankton. Either can become a significant odour source if the stored mass increases, typically as a result of increased loading in the salt water due to storm events or seasonal conditions. The mode of storage on-site is also important – care must be taken to ensure aerobic conditions so that decomposition does not result in offensive odours emission (reduced sulphides).

Screening

The seawater screening process has been generally described in Section 6.11.1.3.

The Reference Project includes a band screen with small aperture holes used to separate gross solids into wire ‘baskets’. As a basket is filled, it is lifted and moved using an overhead hoist into a de-odourisation room. Here the basket is emptied into a skip and returned to a rack adjacent to the bandscreen. The de-odourisation room is ventilated and the exhaust air will be treated by an Odour Control Plant (OCP) such as an activated carbon filter to reduce odour to acceptable levels before release to atmosphere. The screenings will be held in skips with airtight covers, which will be held in the screening room until a truck comes to take it away.

Filtering

The pre-treatment filtration process has been generally described in Section 6.11.1.5.

The dual media gravity filters included in the Reference Design would be periodically backwashed with filtered seawater, and the backwash water (containing coagulant and fine solids) is typically separated in lamella clarifiers, settled in thickener tanks and then the settled solids are held in thickened solids holding tanks. The moisture content of the thickened solids would normally then be reduced further via plate filter presses. The solids cake from the plate filter presses is then collected in skips and transported off-site for management to land. As these solids in part comprise microscopic marine biota, the stored solids are also a potential odour source. The daily stored volume is expected to be in the range 20-100 m^3.

11.3.1.2 Dust

Significant dust emissions are likely to arise during the construction phase. Once construction is complete all haul routes will be paved and exposed areas landscaped such that on-site dust sources during operation of the Plant will be negligible. The following construction activities involve the movement and placement of top soil/ spoil and can be the source of dust emissions:

- construction of access roadways on-site;
- removal of top soil from plant footprints;
- transfer and stockpiling of excavated material from inlet and outlet tunnels;
- construction of boundary bunds;
- levelling of site to benchmarks; and
- removal of construction solid wastes from site.

In addition, a concrete batching plant may be set up on-site for the construction period, and its operations can give rise to dust emissions.

11.3.2 Air Quality Assessment Criteria

EPA specify design criteria for point sources in Schedule A to SEPP (AQM). In the case of dust (TSP, PM_{10}, $PM_{2.5}$), area sources are excluded from these criteria and the relevant criteria are those specified in the Mining and Extractive Industries PEM[17]. Note that both dust and odour are categorised as unclassified indicators in Schedule A to SEPP (AQM), and amenity is given as the beneficial use to be protected by means of applying the criteria.

11.3.2.1 Odour

Complex odorant blends are nominated as an unclassified indicator and the design criterion is set at 1 OU, 3-minute average to be met at the 99.9th percentile at and beyond the Site boundary. One odour unit is the concentration of an odorant blend at which 50% of the population can detect the presence of odour in a laboratory setting where background odour is absent. Normally in ambient conditions there is a background 'palette' of odour that is not noticed because it is ubiquitous, and this odour level will typically

[17] EPAV 2007 Protocol for Environmental Management – Mining and Extractive Industries. Pubn 1191, December 2007.

vary in the range from 2 OU to 10 OU. Hence the 1 OU criterion is stringent, and ensures that any complying source is unlikely to give rise to off-site odour impact.

11.3.2.2 Dust

Were dispersion modelling of particulate emissions to be conducted, then the relevant assessment criteria for the compliance test would be as given in Schedule B of the SEPP (AQM) (the intervention levels), and in Table 2 of the Mining PEM[2] (assessment criteria). These criteria are given in Table 11-2 below.

Note that these criteria are to be met at the nearest sensitive locations to the Plant Site, not necessarily at the Site boundary.

Table 11-2 Relevant Dust Criteria to Gauge Off-site Dust Impact

Constituent	Criterion, $\mu g/m^3$	Averaging Period
PM_{10} (1) (2)	60	24 hours
$PM_{2.5}$ (1) (2)	36	24 hours
Respirable Crystalline Silica (as $PM_{2.5}$) – RCS (2)	3	Annual

Notes:

1. SEPP – AQM , Schedule B , Intervention Level
2. Mining and Extractive Industries PEM, Table 2, Assessment Criteria

11.3.3 Air Pollution Control Systems

SEPP (AQM) Clause 18 requires generators of emissions to apply best practice to the management of their emissions. The concept of best practice for odour abatement from desalination plants is not readily defined or informed due to the size of the proposed Desalination Plant, and its location – as the composition of inlet screenings and biota that will comprise the source of the odours is not known.

In the case of the inlet pump stations the OCP in the de-odourisation house has been selected as activated carbon filtration in the Reference Project. This type of system has been found to provide high (generally > 99%) removal efficiencies for a wide range of applications. An alternate system that could be considered is bio-filtration using soil bed filters.

At this stage it is not possible to make an informed selection as to which odour abatement technology system would represent 'best practice' as the speciation of VOC’s from the stored screenings is not available in the literature, and this data will not be available until the monitoring results from the Pilot Plant trial is completed. Further, it would be expected that the operation and management of the plant, with regard to the control of odour emissions, would be practised with regard to continual improvement in order to achieve the cleanest air possible.

The air pollution control systems that are included in the Reference Project are outlined under each process component below. The management of residual emissions resulting from process malfunction or system failure is described under the last sub-heading.

11.3.3.1 Screenings Deodorisation House

As discussed in Section 6.11.3.1, the Reference Project provides for mitigation of odour emissions from the deodorisation house using activated carbon treatment of the ventilation exhaust from the building. In this manner odour emissions from skips and wire baskets will be mitigated before release to atmosphere.

The final selection of the OCP technology will be informed by the analysis of the emissions from the screens in the pilot plant trial later this year. Analysis of odorous emissions would typically include VOC speciation, emission flux, and blended odour emission flux from exposed surfaces. The VOC speciation can be used to inform the type of filtration required (eg. bio-filter, activated carbon filter, etc.), and the emission rates can be used to determine the removal efficiency required (i.e. to size the filter). The design of the OCP filtering technology would include a safety factor to account for uncertainties in the testing and variations in the odour emissions from the collected solids. It would be possible for the ultimate plant design to include additional foot print space to enable the retrofitting of further filtering capacity within the OCP, in the event that the design of the OCP, as informed by the pilot plant study, does not adequately abate odour (as manifested via legitimate odour complaints from regional sensitive receivers, or from odour surveys).

The application of activated carbon treatment represents best practice for the management of odour emissions from this type of facility.

11.3.3.2 Filtration

The Reference Project does not currently include abatement of odours from the pre-treatment filtration plant, as these are not considered significant based on the available knowledge of the Perth desalination plant. The control of odours within this plant building would be managed via the design of enclosed thickening tanks and storage tanks and the periodic removal, within sealed skips, of pressed and dewatered solids to off-site containment. Additional abatement of odour within the building, and hence that vented to atmosphere, may be achieved via the increase in the rate of removal of stored solids which will be the primary source of odour.

11.3.4 Residual Air Emissions

The implementation of the good site management practices will greatly reduce the incidence of accidental/upset or uncontrolled emissions to air. Intermittent or episodic residual emissions to air may include:

- failure of the OCP in the deodorisation house leading to potential off-site odour impact; and
- unexpected increase in odour emissions from sludge dewatering building.

Modelling of the first upset scenario was conducted (refer GHD, 2008f) and it was determined that OER_{upset} would need to exceed 5,500 OUm^3/s before potential impact could be perceived at the nearest sensitive receptor.

Note that were the beach to be considered a sensitive land use then its' proximity to the Site boundary might pose a more stringent limit on the derived OER_{upset}. An additional simulation of the upset was conducted to cover this interpretation, where it was assumed that the beach could be resident to bathers/surfers/fisher folk during daylight hours (taken as 7am to 7pm). The simulation gated the OER_{upset} of 5,500 OUm^3/s to these hours, and the result showed that the 5 OU contour did indeed extend across the seaward Site boundary, but only by 40 m. That intrusion places the 5 OU contour within the landwards edge of the frontal dune system, and well clear of the beach. Hence the critical constraint is still the nearest residence.

As the likelihood of occurrence of such an upset is uncertain, a quantitative risk assessment of the effectiveness of the existing separation distance to prevent unacceptable impact on amenity cannot be made. However it is the case that the likelihood of OCP failure can be reduced by (i) effective design of the activated carbon treatment system, and (ii) regular maintenance of the OCP so that the probability of off-site odour impact is effectively eliminated at the nearest off-site receptors.

11.3.5 Air Dispersion Modelling to Predict Air Quality Impact

Where possible, the emission sources are identified and characterised, and dispersion modelling is used to determine the emission rate limits at these sources needed to meet EPA criteria. Site-representative meteorological data has been either measured or synthesised for the Site, and is used to determine the directions of poor dispersion and as input to dispersion modelling

The tasks leading to the dispersion modelling assessment entailed:

- compilation of site-specific meteorological data for a period of not less than one year;
- characterisation of emission sources (which includes discharge parameters and emission rates); and
- dispersion modelling results.

These tasks are described below under relevant headings.

11.3.5.1 Meteorological Data

Site representative meteorological data is essential to conduct dispersion modelling of emissions to air and to determine the general wind climate at the Site. The directional dependence of stable winds is also useful to define directions of good and poor dispersion at the Site.

On-site meteorological data has been available for the 6-month period since the installation of an AWS at the Site on 25 October 2007. The TAPM model was used to synthesise a 12-month hourly meteorological data file for the Site for 2007. A composite 12-month file was then assembled from the TAPM synthesised data and the on-site recorded data. Validation of the model output data is discussed in *Section 3.1.3* of the Air Quality report (GHD, 2008f).

An Ausplume compatible input meteorological data has been extracted from the TAPM meteorological model output. Further detail on this meteorological data is provided in *Section 3* of the Air Quality report (GHD, 2008f).

Wind Climate

Figure 11-1 shows the annual wind rose for the Ausplume meteorological data for the Site and several features can be seen namely:

- wind speed is generally high with a mean wind speed of 5.2 m/s;
- onshore winds are seen to be common with an onshore incidence of 47%, and with winds commonly exceeding 5 m/s;
- there is a distinct offshore wind fan in the E and ENE direction, reflecting the effect of nocturnal drainage flows to the coast; and
- the directional incidence of light winds (< 2 m/s) is confined to this offshore drainage flow.

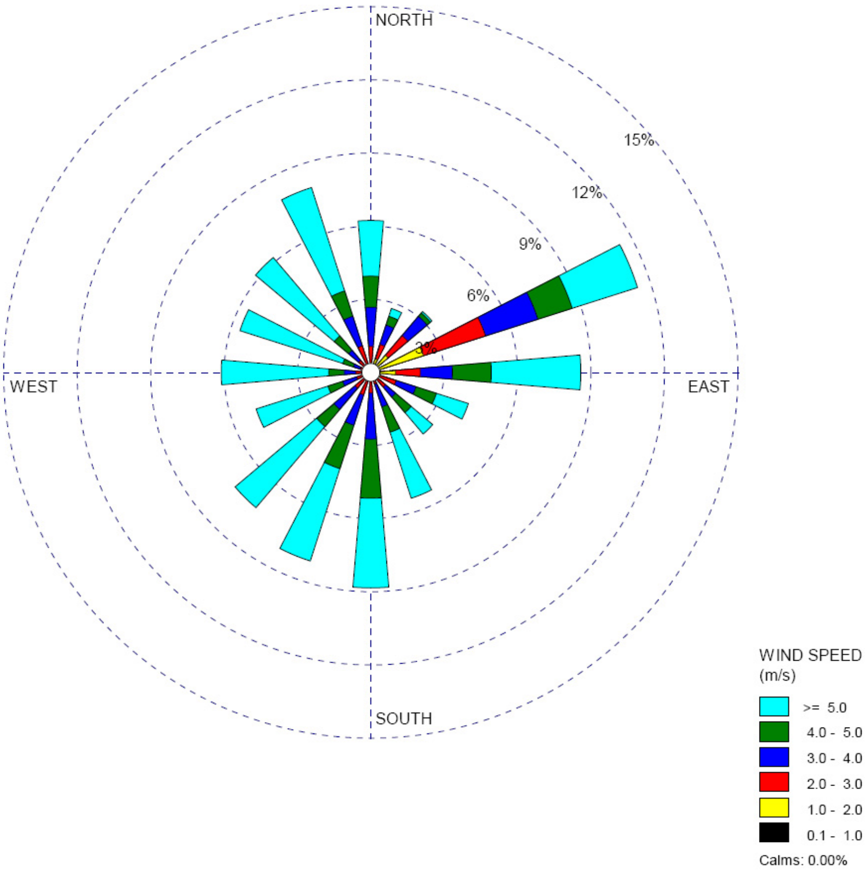


Figure 11-1 TAPM and Desalination Plant Site AWS Combined – Wind Rose

Directions of Good and Poor Dispersion

The directions of good and poor dispersion can be determined from the stability rose for the stability categories E and F (slightly and moderately stable under the Pasquil Gifford System).

Figure 11-2 gives the annual stability rose for E and F stable winds, and it is clear that the high incidence is confined to E and ENE offshore directions. The incidence of stable flows in these directions is 10.2% and 23.7% respectively some 2 fold and ~ 4 fold the mean incidence on all directions of ~ 6.3%.

Similarly, the directions of good dispersion (i.e. where % incidence is less than the mean) is confined principally to the on-shore directions of WSW, W, WNW and NW.

This directional incidence of stable winds is fortunate, in that sensitive receptors (i.e. residences) are all inland of the Site, and are therefore not downwind of the plant in poor dispersion directions. Coastal users' amenity is likely to be confined to daylight hours as there is no lighting in the area and camping is banned in coastal parks.

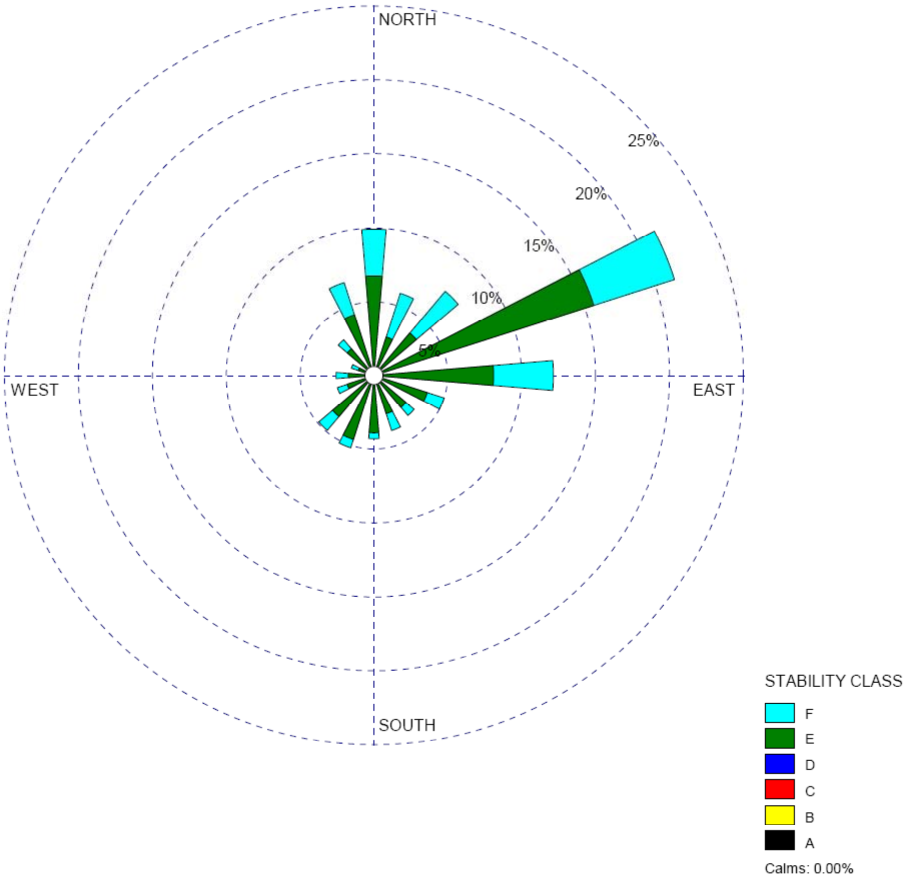


Figure 11-2 TAPM and Desalination Plant Site AWS Combined – E & F Stability Categories

11.3.5.2 Characterisation of Emission Sources

In this Section, existing limitations on the characterisation of both odour emission rates (OERs) and dust emission rates (DERs) during operation and construction phases respectively are discussed. In each case, a method to control the potential off-site impact of these emissions is outlined.

Odour Sources

There are no available OER measurements made of screenings and/or waste solids from desalination plants in the literature. Permission was requested from the operator of the Perth desalination plant to allow OER measurements to be made of these sources however this has not been possible at this stage. In the absence of this information odour dispersion modelling is presented to determine the performance specification with respect to the upper limit on OER from the odour treatment facility in the de-odourisation building.

A similar exercise has been conducted for the solids dewatering building in the pre-treatment stage of the Plant.

Dust Sources

Extensive inventories (USEPA, NPI) for PM_{10} and TSP emissions from earth moving machinery are commonly used to characterise the source DERs from activities on-site during the construction phase. At this stage the Reference Project does not detail the exact type and number of dozers, scrapers, trucks and other earthmoving equipment nor scheduled vehicle movement, so that it is not possible to characterise these sources.

In any event, dust emissions will be controlled by application of EPA's Guidelines for Major Construction Sites, wherein a dust management plan (DMP) will be defined as part of the site EMP.

Emissions from the concrete batching plant are minimised by requiring compliance to EPA Best Practice Environmental Management Guidelines[2] for the concrete batching industry. EPA does not require modelling of dust emissions from batching plants, instead relying on a 100 m buffer to sensitive land uses, plus compliance to the BPEM guidelines.

11.3.6 Dispersion Modelling

Given that source OERs for either potential odour source were not available, odour dispersion modelling was conducted to determine the upper limit for source OER needed in order to validate compliance to the 1 OU criterion. The upper limits so determined can then be used as Performance Requirement applicable to the reference design. The modelling conducted and the results obtained are detailed below.

Note that dust dispersion modelling was not conducted because it was not possible to exactly characterise the sources.

11.3.6.1 Model Configuration

The dispersion model used was the EPA regulatory model AUSPLUME (version 6.0), and the following configuration was used.

- Receptor grid: MGA 94, 4 km x 4 km;
- Grid interval of 40 m;
- Meteorological data: TAPM synthesised for 6 months, plus 6 months on-site measured data;
- Pump Station Building dimensions based upon the Reference Project;
- Dewatering Building dimensions based upon the Reference Project;
- Averaging time of 3 minutes; and
- Terrain: not included – irrelevant for low-level sources.

Further details are given in the AUSPLUME text files included in the Air Quality report (GHD, 2008f).

11.3.6.2 Ventilation Exhaust from De-odourisation House

The Reference Project makes allowance for a de-odourisation facility, and simulations were conducted to determine the outlet OER limit for:

(i) a standard wall louvre exhaust, and

(ii) a stub stack release at 3 m above the ridgeline height of each pump station building.

Predicted Impact – Wall Louvre Release

Figure 4 in the Air Quality report (GHD, 2008f) shows the predicted peak 99.9th percentile odour levels for a source OER of 330 OU m^3/s from each pump station. This OER has been chosen from the results

[2] EPAV 1998 Environmental Guidelines for the Concrete Batching Industry. Pubn. 628, June 1998.

of a preliminary simulation with a nominal OER. That nominal OER was then pro-rated to check the Site boundary odour level was just <1 OU. The 1 OU contour is fully contained on-site, with the closest Site boundary being the seaward one bordering the frontal dunes.

Predicted Impact – Stub Stack Release

Figure 5 in the Air Quality report (GHD, 2008f) shows the predicted impact when the release is made from short stacks 3 m above the pump station building roof ridgeline. The pattern differs from that in *Figure 4* in the Air Quality report (GHD, 2008f) and this is due to the exhaust odour plume escaping the building wake for many wind conditions. The dilution achieved as a consequence is greater and allows for the OER limit on the stack exhausts to be increased to 900 OUm^3/s at each pump station.

11.3.6.3 Emissions from Backwash Wastewater Treatment

The sequence of treatment of the backwash wastewater to separate and thicken the solids is conducted in sealed or housed process units except for the solids thickener tanks that are uncovered. The potential for odour emissions to atmosphere is then limited to:

- open surface of the solids thickener tanks; and
- ventilation of the solids dewatering building.

Neither source is likely to be a significant odour source with respect to off-site odour impact. However a simulation was conducted to determine the OER limit on the ventilation exhaust of each of the two solids dewatering buildings. *Figure 6* in the Air Quality report (GHD, 2008f) shows the predicted pattern of odour impact, and it can be seen that it is the seaward Site boundary that is most exposed to this source. The OER limit on the ventilation exhausts is 5,500 OUm^3/s, in order to confirm that 1OU, 99.9th percentile is met at the Site boundary.

11.3.6.4 Cumulative Impact of Odour Sources

The predicted impacts from the de-odourisation house exhausts and from the solid dewatering buildings exhausts were not modelled in combination as the hedonic tone of each odour emission will be distinct from each other. The screenings emissions will be distinctly maritime in character, while the dewatered solids are is likely to have a character predominantly formed from the coagulant agents used in the filtering process. However, modelling was conducted to determine the degree of synergy when both classes of odour source are considered. The results gave a predicted peak 99.9% odour level at the plant shoreline boundary of 1.37 OU, of which approximately 70% was due to the northern dewatering building exhaust, and the balance due to the contributions of both de-odourisation house exhausts.

The consequence of considering all sources together is that the OER limit on the dewatering building exhaust would reduce from 10,000 OUm^3/s to approximately 6,000 OUm^3/s.

11.3.7 Implications for Odour and Dust Performance Requirements

11.3.7.1 Odour

A qualitative assessment of the ability of the Reference Project to meet the OER limits determined via modelling is made within *Section 7* of the Air Quality report (GHD, 2008f). This is achieved by estimating exhaust flow rates at each emission point, and calculating the corresponding at-source / headspace odour levels (for each of the two identified odour sources). The potential need for and effectiveness of odour control processes is discussed.

This assessment demonstrates that odour emissions from the Desalination Plant (pre-treatment) under routine operations can readily meet the SEPP (AQM) odour criterion off-site, so that odour impact due to site operations will not occur provided that the derived performance requirements on odour emission rate are achieved.

However, it is also the case that the derived odour emission rate limits (viz 330 OU m^3/s and 900 OUm^3/s for wall louvre and stub stack release respectively from the de-odourisation house, and 5500 OUm^3/s in the solids dewatering building exhaust air) are specific to the building dimensions and positions relative to the Site boundaries as given in the Reference Project. As these parameters may change in the adopted PPP Project, the corresponding OER limits may also change, and for this reason it is important that the Performance Criteria be met as defined.

In the event of a malfunction of the deodorisation house, then the uncontrolled emissions are unlikely to cause impact at the most exposed receptor – refer to *Section 9* in the Air Quality report (GHD, 2008f) for further detail.

Further quantification of the potential odour impact from operation of the Desalination Plant can be refined once the results of the pilot plant trial are available and/or if measurements from the Perth plant could be obtained.

11.3.7.2 Dust

Construction activity involving heavy machinery has the potential to generate clouds of dust. Hauling involving truck movements across unsealed surfaces is the biggest source of dust. The use of a grader to clear the construction area also generates dust but such activities will be short lived. The mechanical movement of soil (excavator use and dumping into truck or onto a stockpile) creates an elevated source. Wind erosion from stockpiles or exposed soil surfaces generates the least amount of dust. In addition, a concrete batching plant may be set up on-site for the construction period, and its operations can give rise to dust emissions.

The greatest impact will be close to the source where occupational health and safety controls are involved. It is expected that only a fraction of the generated dust will likely move off-site. EPA's Environmental Guidelines for Major Construction Sites[18] gives controls to limit the impact of this dust away from the actual construction site.

11.4 Mitigation and Management

As set out by requirements included in Section 11.1, during the construction phase, air quality management systems (including monitoring) would be implemented to maintain air quality consistent with SEPP (AQM) intervention levels for dust (particulates) and EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites. Information on the typical array of dust control measures that will need to be evaluated and detailed in a dust management plan to protect the beneficial use of amenity is provided in the Air Quality report (GHD, 2008f).

[18] EPAV 1996 Environmental Guidelines for Major Construction Sites February 1996

In addition to the air pollution control systems incorporated into the Reference Project (as described in Section 6 and Section 11.3.3 of this WAA), air quality management systems would be implemented to maintain air quality consistent with SEPP (AQM).

11.5 Conclusion

This air quality assessment demonstrates that odour emissions under routine operations can readily meet the EPA odour criterion off-site, so that odour impact due to site operations are unlikely to occur. In the event of a malfunction of the de-odourisation room OCP, then the uncontrolled emissions are unlikely to cause impact at the most exposed receptor.

The odour assessment leads to the following conclusions for the following building ventilation exhausts:

- **De-odourisation House**
  - Wall louvre release - OCP likely to be required.
  - Stub stack release - OCP may not be required.
- **Dewatering Building**
  - Stub stack release - odour mitigation unlikely to be required.

The implementation of dust control measures, consistent with EPA's Environmental Guidelines for Major Construction Sites, should limit dust emissions during the construction phase so as not to cause adverse impact at the nearest off-site receptors.

11.6 Environmental Performance Requirements Arising from this Section

As discussed in Section 1 and Section 6 of this WAA, the design adopted by the Project Company appointed under the PPP contract may differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Performance Requirements outlined in this Section of the WAA in a manner that would lead to an equal or better air quality outcome.

The Performance Requirements are incorporated into the EMF (see Section 17 of this WAA) and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirements relevant to this study area are presented below.

Performance Requirements

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop and implement methods and management systems consistent with State Environment Protection Policy (Air Quality Management) and State Environmental Protection Policy (Ambient Air Quality) to limit odour and emissions from the operation of the Desalination Plant;
- Develop and implement methods and management systems (including monitoring) to maintain air quality during construction consistent with State Environmental Protection Policy (Air Quality Management) intervention levels for particulates and EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996); and
- Monitor and report the effect of Project Activities on air quality.

12. Surface Water (non-marine)

This Section of the WAA provides an assessment of potential impacts on the surface water environment arising from construction and operation of the Desalination Plant. Where significant risks were identified, strategies for mitigation and management are provided.

Further details on the assessment of the potential impacts on the surface water environment from construction and operation of the Desalination Plant are provided in the specialist report, *Report for Melbourne Desalination Project: Surface Water EES – Plant* (GHD, 2008d).

The Surface Water report (GHD, 2008d) forms *Technical Appendix 43* of the EES.

12.1 Regulatory and other Requirements

The following legislation, policies and guidelines are relevant to this Section:

- *SEPP (Waters of Victoria) No. S210* (1988) - is the primary legislative tool for the protection of waterways and specifies water quality objectives for estuaries and inlets;
- EPA Publication 480, *Environmental Guidelines for Major Construction Sites* (1996) (Vic);
- EPA Publication 275, *Construction Techniques for Sediment Pollution Control* (1991) (Vic); and
- EPA Publication 347, *Bunding Guidelines* (1992) (Vic).

12.2 Relevant Water Bodies

Powlett River, Lance Creek and Foster Creek are in the same catchment area as the Project Site. The Tarwin River and Bass River are located in adjacent catchments. The floodplain of the Powlett River to the north of the Plant Site is shown in Figure 12-1.

The Project Site is located approximately 1 km south-east of the Powlett River mouth. The river originates north of Outtrim township, over 30 km upstream of the river mouth, and collects water from a 49,953 ha catchment. The Site lies within a 300 ha sub-catchment that drains into an unnamed Powlett River tributary, which functions as the southern Wonthaggi stormwater drain. This tributary discharges to the Powlett River approximately 400 m downstream of the sub-catchment outlet.

Past and ongoing human activities have substantially altered the fluvial geomorphology of the Powlett River, with most of the catchment, including the area surrounding the Project Site, cleared primarily for dry land pasture.

There are a number of channelised farm drains entering Powlett River, however, there are no channels or streams of environmental significance present on-site. A number of small farm dams are scattered around the sub-catchment.

Figure 12-1 Tidal floodplain of the Powlett River immediately north-east of Plant Site

12.3 Risk Assessment

The potential impacts posed by the Reference Project on the surface water environment were assessed for both the construction and operational phases. Areas that require attention, taking into account legislative and policy obligations, community and stakeholder concerns, and guidance from the EES Scoping Requirements, were identified during the risk assessment. The approach to environmental impact and risk assessment is described in Section 4 of this WAA.

The risk assessment process identified and ranked priority issues, and assumed that certain Project controls, described in Section 4, would be implemented effectively.

The risk assessment was based on accepted operational and construction practices but did not take into account the mitigation measures embodied in the Performance Requirements. If the Performance Requirements were taken into account, both the likelihood and consequence of these risks would be significantly lower.

The following Sections summarise outcomes of the risk assessment process, lists potential environmental impacts on the receiving surface water environment and indicates where these impacts are addressed in this Section.

12.3.1 Construction and Operation

In the environmental impact and risk assessment process, only one impact has been assessed as a medium or high risk for construction of the Desalination Plant, as shown in Table 12-2, while Table 12-1 presents the same risk identified for the operation phase. Impacts assessed as low risk are expected to have an insignificant or minor effect on the environment with a rare or unlikely probability of occurrence. Impacts assessed as low risk are briefly discussed within this Section of the WAA and a concise summary of these risks is also presented within *Volume 3, Chapter 7* of the EES.

The risk assessment process determined no construction or operational impact as a high risk.

Table 12-1 Potential impacts during operation of Desalination Plant

Activity	Impact pathway	Where addressed in this Section
Medium risk		
Stormwater run-off during operation	Discharge of site run-off to surrounding waterways impacting on surface water ecosystems	Sections 12.4 and 12.5

Table 12-2 Potential impacts during construction of Desalination Plant

Activity	Impact pathway	Where addressed in this Section
Medium risk		
Earthworks and stockpiling	Sediment discharge to waterways resulting from soil erosion or spoil from earthworks, impacting on surface water ecosystems	Sections 12.4 and 12.5

12.4 Surface Water Assessment

12.4.1 Powlett River Catchment Hydrology

Hydrologic investigations conducted for the Powlett River catchment are described in *Section 3.1* of the Surface Water report (GHD, 2008d). The investigations involved:

- review of available hydrological information;
- development and calibration of a hydrologic catchment model (RORB);
- verification of RORB parameters against historical data; and
- estimation of design flows for a 1 in 50 Annual Exceedance Probability (AEP), 1 in 100 AEP, and Probable Maximum Flood (PMF) storm events.

As discussed in *Section 4.1* of the Surface Water report (GHD, 2008d), the Powlett River is estimated to have a 1 in 100 AEP flow of approximately 158 m^3/s near the river mouth. By comparison, the development of the plant is expected to result in an additional 2.4 m^3/s of run-off from the local sub-catchment during a 1 in 100 AEP event. Assuming peak flows from both the Powlett River catchment and local sub-catchment combine, the plant development will increase the 1 in 100 AEP flow in the Powlett

River (near the mouth) by about 2%. Considering that the Plant Site is situated at the downstream end of the Powlett River, the peak run-off from the plant is likely to occur much earlier than the peak from the Powlett River. Under these conditions, it is considered that the potential impacts on peak flows in the Powlett River are negligible.

12.4.2 Geomorphology of Powlett River System

The existing geomorphology of the Powlett River system including geomorphology of the river, floodplain, river entrance, and seawater levels at the river mouth is described in *Section 3.2* of the Surface Water report (GHD, 2008d).

Potential impacts of the Project on the Powlett River's geomorphology, described in *Section 4.2* of Surface Water report (GHD, 2008d), are summarised below.

It is expected that establishment of impervious areas associated with development of the Site will result in increased stormwater run-off and discharge to the Powlett River. The Reference Project indicates that treated surface run-off would be discharged to the river via one of the partially channelised drains at a relatively straight and stable portion of the river. High flow events may cause localised scour downstream of the discharge point and some localised bank instability. However, it is unlikely that the channel geometry will be significantly affected by the discharge.

Development of the Site may also increase flow velocities and consequently sediment loads discharged to the Powlett River during both the construction and operation phases of the Project. If not mitigated, as discussed in Section 12.5, these could alter the condition of the river system and potentially pose a threat to surface water ecosystems at both the discharge point and further downstream. As discussed in Section 12.5.4, artificial wetlands will be constructed downstream of the Plant Site to treat stormwater prior to its release into the natural environment. Overall, in view of the proposed measures, and taking into account the large size of the Powlett River catchment (49,953 ha) relative to the area of the Plant Site (30 to 40 ha), it is considered that development of the Plant Site is unlikely to have significant impact on the hydrology and geomorphology of the river system.

12.4.3 Powlett River Flood Hydraulics

Section 3.3 of the Surface Water report (GHD, 2008d) describes existing Powlett River flood hydraulics. This Section concludes that the location of the Desalination Plant as described in the Reference Project will remain predominantly flood-free during a 1 in 100 AEP event.

Section 4.3 of the Surface Water report (GHD, 2008d) concludes that the potential impact of the development on flooding characteristics of the Powlett River is expected to be negligible for the following reasons.

The Powlett River floodplain is relatively wide and is unlikely to be constricted by any probable development on the selected Site. The potential for obstructing the flood plain with development of the Desalination Plant Site was tested using TUFLOW hydrodynamic flood and tide simulation software. Two runs were made of the 30-hour 1 in 100 AEP hydrograph, assuming the absence of a sand bar (to conservatively reduce the dampening effects of ponding). The first run assessed the existing flood plain geometry. The second assessed an obstruction from a hypothetical development that blocked off the floodplain to the west of Lower Powlett Road and extended to within 150 m south-west of the Wonthaggi South Drain. These runs did not predict a change in flood levels and indicated that, provided development remains a prudent distance (150 m) from the Powlett River and the Wonthaggi South Drain, there would not be a discernible impact on flood levels.

Likewise, the local increases in impervious area on the selected Plant Site and resultant increase in run-off was found to be insignificant in magnitude with respect to the area of the Powlett River catchment. This was tested using RORB model by increasing the impervious fraction of the sub-area containing the Site. The model did not predict an increase in peak flood flow.

Modelling has demonstrated that development of the Site is unlikely to have a significant effect on the flow patterns, velocities, and depths of flow in the Powlett River and its floodplain.

12.4.4 Local Stormwater Drainage

Following investigation of the existing conditions, described in *Section 3.4* and assessed in *Section 4.4* of the Surface Water report (GHD, 2008d), the potential impacts on stormwater behaviour were examined by:

- determination of catchment boundaries and identification of drainage changes;
- set-up and calibration of SWMM model for the local drainage system;
- estimation of design flows for the 1 in 10 AEP and 1 in 100 AEP storm events; and
- assessment of potential impacts during construction.

For the purpose of this assessment, the Plant details and construction conditions were based on the Reference Project. It is considered that this assessment is likely to be generally representative for a Desalination Plant of this size on this Site.

Construction and operation of the Desalination Plant would necessitate the capture and diversion of the Site's existing natural drainage lines and overland flow paths. The locations of the proposed diversion pathways are shown in *Figure 4-2* of Surface Water report (GHD, 2008d). These channels will be located upstream of the Plant, on the north-western and south-eastern perimeter. Preliminary analyses indicate water flow velocities within the diversion channel would be relatively low and that grass lining would be adequate.

The US EPA's SWMM model (version 5.0) was used to model the peak flows at various locations around the Site under developed conditions. SWMM modelling determined that, without mitigation measures, the development of the Plant Site would cause existing peak flows at most drainage points around the Site to increase significantly.

A HEC-RAS model was used to estimate peak velocities in the local channel to the Wonthaggi stormwater drain and the confluence with the Powlett River. This modelling indicated a slight increase in channel velocities following development of the Site.

Under both existing and developed conditions, it is likely that the peak discharge from the local sub-catchment will discharge to the Powlett River well before the greater river catchment delivers its peak. As the peaks are unlikely to coincide, an increase in the peak flow from the Powlett River is not expected.

Overall, the estimated change in flow conditions near the Plant are not expected to lead to significant increases in downstream velocities or erosion problems. However, where minor erosion does occur, it is considered that remedial works can readily be carried out to protect the streambed and banks.

For further details, refer to *Section 4.4* of Surface Water report (GHD, 2008d).

12.4.5 Stormwater Quality

As discussed in *Section 3.5* of the Surface Water report (GHD, 2008d), significant water quality data for existing catchment conditions are not available. Consequently, the MUSIC water quality model, which can be used to assess the effect of stormwater treatment devices on downstream water quality, was used to estimate existing pollutant loads in the catchment. For further details on the MUSIC modelling and water quality data for estimated existing catchment conditions, refer to *Section 4.5* of Surface Water report (GHD, 2008d).

The MUSIC model was also used to determine total annual pollutant loads obtained for developed conditions at the outlet of the Plant Site.

The results of the MUSIC model in *Table 4-5* of the Surface Water report (GHD, 2008d) indicate that in average rainfall conditions, the annual pollutant loads in the Powlett River would normally increase by up to 140% for suspended solids, 75% for total phosphorus, and 80% for total nitrogen. Under wet weather conditions, the annual loads are estimated to increase by 93% for suspended solids, 42% for total phosphorus, and 39% for total nitrogen. Similarly, under dry weather conditions, the annual loads are estimated to increase by 338% for suspended solids, 210% for total phosphorus, and 198% for total nitrogen.

The pollutant load generated from the Site, under developed conditions, is expressed as a percentage of the pollutant load from the Site catchment in *Table 4-6* of the Surface Water report (GHD, 2008d). In *Table 4-7* of the Surface Water report (GHD, 2008d), it is expressed as a percentage of the pollutant load from the entire Powlett River catchment. In both *Tables 4-6* and *4-7*, the percentage change in pollutant loads is also compared to those for existing or pre-development conditions.

Modelling results indicate that, under developed conditions, the pollutant load from the Site would contribute 20 to 45% of the total load from the Site's sub-catchment. However, when the entire Powlett River catchment is considered, this contribution would be relatively small, at approximately 0.7%.

12.4.6 Beneficial Uses

Clause 10 of the SEPP (Waters of Victoria) (SEPP (WoV)) states that a beneficial use, as defined in the Environment Protection Act 1970, is:

"… a use of the environment which is conducive to public benefit, welfare, safety, health or aesthetic enjoyment and which requires protection from the effects of waste discharges."

Section 5.5.1 of Surface Water report (GHD, 2008d) determines that the Desalination Plant Site would fall within the Estuaries and Inlets category defined by Annex A (3)(d), Part VII of SEPP (WoV). Accordingly, the following beneficial uses from this segment require protection:

- primary contact recreation;
- secondary contact recreation;
- aesthetic enjoyment;
- indigenous cultural and spiritual values;
- non-indigenous cultural and spiritual values;

- aquaculture;
- industrial and commercial use; and
- fish, crustacea, and molluscs for human consumption.

So that new developments do not have an adverse impact on the environment, the SEPP (WoV) stipulates the need to meet environmental water quality objectives defined by industry guidelines and practices.

Section 5.5.2 of the Surface Water report (GHD, 2008d) outlines SEPP (WoV) water quality targets for the Powlett River (Estuaries and Inlets, Marine and Estuarine) that are to be met during the construction and operational phases of the Desalination Plant in order to protect the identified beneficial uses.

12.5 Mitigation and Management

As part of the environmental impact and risk assessment process, *Section 5* of the Surface Water report (GHD, 2008d) proposes a range of mitigation and management measures for implementation to manage potential impacts. These suggested management measures have been formulated in response to the Reference Project and relevant Variations for the Desalination Plant. In effect, the suggested management measures demonstrate how the Reference Project and relevant Variations can achieve the Performance Requirements. These detailed management measures have formed an important input to the Performance Requirements for the Project.

A summary of those measures is provided below.

12.5.1 Mitigation of Impacts – Geomorphology of Powlett River

The potential for adverse impacts due to flow increase in the local stormwater drainage system will be mitigated through management measures put in place to reduce flow velocities to non-erosive levels prior to discharge to the Powlett River. Sediment controls will support that potential entrainment and deposition of sediments loads into the river system to be minimised.

12.5.2 Mitigation of Impacts – Powlett River flood hydraulics

Potential impact of the Desalination Plant on the flood hydraulics of the Powlett River is generally expected to be negligible. Provided that fill on the Site is appropriately set back (150 m) from the Powlett River and the Wonthaggi South Drain, further mitigation measures are considered to be unnecessary.

Preliminary analysis suggests that Lower Powlett Road is presently overtopped by floods of a magnitude of 1 in 2 AEP or smaller. Therefore, it is expected that the road may be upgraded to provide a higher level of flood immunity as part of the infrastructure development works for the Project while taking into account the potential impact of road upgrades on the flood hydraulics of the river floodplain. These details would be assessed during the design phases of the Project.

12.5.3 Mitigation of Impacts - Local stormwater drainage

In order to minimise impacts resulting from changes to the local drainage system, all flow and diversion channels shall be designed to have non-erosive velocities. Where non-erosive velocities cannot be achieved, additional channel lining will be provided to assist in stabilising of the channel bed and banks. Drop structures will be designed to assist in dissipation of the hydraulic energy where necessary.

12.5.4 Mitigation of Impacts - Water Quality

Section 5.5 of the Surface Water report (GHD, 2008d) lists a range of various mitigation measures in regard to protection of water quality. This Section also introduces a selection process for the proposed mitigation measures based on the water quality targets shown in *Table 5-1* of the Surface Water report (GHD, 2008d).

Figure 5-2 of the Surface Water report (GHD, 2008d) highlights suitable treatment measures suitable for various target pollutants/particle size and hydraulic loading and was used to assist in the selection of suitable treatment measures.

The following treatment measures may be appropriate for the Desalination Plant as detailed in the Reference Project design:

- an in-line trap to remove oil, grease, and hydrocarbons that may be discharged from the Plant Site (e.g. Humeceptor);
- a sedimentation basin to remove coarser sediments and provide additional storage to aid spill management;
- a wetland to remove the finer sediments and absorbed/dissolved pollutants (i.e. nutrients and metals); and
- the ability to isolate the in-line trap and sedimentation basin from the wetland, reducing potential for spills to reach waterways.

The MUSIC model was used to compare the pollutant loads under developed conditions with and without management measures in place, as presented in *Section 5.5.4* of the Surface Water report (GHD, 2008d). The pollutant loads for developed conditions with management measures in place was also compared with pre-existing pollutant levels. Following analysis of the results for the worst-case scenario, the forecast was that, with treatment, development of the Desalination Plant will generate a 75th percentile value equal to or below the corresponding background value and, as such, development of the Desalination Plant with appropriate mitigation measures will comply with the SEPP (WoV) requirements. SEPP (WoV) states that in order to account for the local variability of each site, the 75th percentile background water quality level should be adopted as the target for receiving waters, particularly where the background field data indicate that the existing water quality is better than the target environmental objectives or that the targets may not be obtained due to natural variation.

12.5.5 Mitigation of Impacts during Construction

At certain times during construction, bare expanses of earth and uncovered stockpiles will be created. These exposed areas and stockpiles may be on slopes on the Plant Site. On-site work practices would be in place during construction to minimise the potential for erosion from exposed areas and stockpiles. It is expected that management measures will be in place to minimise the potential for transport of erodible material from the construction site to natural waterways during small, frequent rainfall events.

During larger rainfall events, some sediment could enter the stormwater and discharge via the Wonthaggi South tributary to the Powlett River. Good construction practise will minimise this potential

Run-off quality targets likely to be required for this phase of the Project are defined by SEPP (WoV) and current best practice in Australia.

In order to achieve appropriate mitigation, as set out by a Performance Requirement included in Section 12.7, the Environmental Management Framework (EMF) developed for the Project will require a plan for erosion and sediment control and for soil and water management, to be based on mitigation measures given in EPA Publications 480 and 275.

This will also include ongoing monitoring to measure performance against criteria and identify need for additional measures to protect the environment. Depending on construction methodology and additional treatment measures put in place, it may also be necessary to construct sedimentation basins early in the construction phase to treat site run-off.

Specific mitigation measures for onsite implementation during construction and operation of the Desalination Plant are proposed in *Sections 5.6.1* and *5.6.2* respectively of the Surface Water report (GHD, 2008e).

12.6 Summary and Conclusions

Development of the Desalination Plant Site is unlikely to have a significant effect on flow patterns, velocities, depths, and flood behaviour of the Powlett River and its floodplain. Hence, additional mitigation measures are not proposed for this particular aspect.

Likewise, changes in stormwater drainage conditions around the Plant Site are not expected to lead to significant increases in downstream velocities or erosion. However, remedial works can be undertaken readily if minor erosion does occur. Although flow velocities in the local channels will increase only slightly following development and are not expected to exceed the limits for grass-lined channels, a number of mitigation measures have been proposed to minimise potential adverse impacts.

While water pollutant loads, including suspended solids, total phosphorus and total nitrogen, will increase following Plant Site development, it is expected that there will be negligible impact on pollutant loads in the river system with the proposed treatment train in place.

In summary, with appropriate mitigation measures in place, significant surface water related environmental effects are not expected. It is therefore considered unlikely that construction and operation of the proposed Desalination Plant, as described in Section 6 of this WAA, will have any unacceptable impacts on beneficial uses as set out in SEPP (WoV).

12.7 Environmental Performance Requirements arising from this Section

As discussed in Sections 1 and 6 of this WAA, the design adopted by the Project Company appointed under the PPP contract is likely to differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Performance Requirements outlined in this Section of the WAA in a manner that would lead to a similar or better surface water quality outcome.

The Performance Requirements are incorporated into the EMF and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirements relevant to this study area are presented below.

Performance Requirements

Surface Water Quality

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;

- Develop and implement construction methods and management systems that seek to maintain surface water quality consistent with State Environment Protection Policy (Waters of Victoria) and EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996);
- Design and construct Temporary Works to isolate construction runoff from catchment runoff and treat it prior to discharge to receiving waterways;
- Establish a surface water quality monitoring (including reporting) program for the Powlett River, in the vicinity of the Desalination Plant Site in consultation with the EPA; and
- Manage maintenance to avoid release of water with chemical concentrations above State Environment Protection Policy (Waters of Victoria) objectives.

Erosion and Sediment Control

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop, implement and maintain construction methods and management systems consistent with EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996) and EPA Construction Techniques for Sediment Pollution Control (1991) to limit erosion and sediment movement by:
  - Identifying highly erodible soil and avoiding activities involving disturbance of these areas where possible. Where avoidance is not possible, additional control measures to be implemented for these identified areas;
  - Limiting clearance of vegetation, particularly along streams; and
  - Designing drainage outlets and diversion channels to limit flow velocities and erosion.

Flooding Control

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Design and construct Project infrastructure to avoid impacts on flood potential or obtain approval of the relevant Authority to any change in waterway flood levels;
- Design and construct the Desalination Plant to be sufficiently above the 1 in 100 Annual Exceedance Probability (AEP) flood level under expected climate change conditions to allow for the natural closing of the river mouth, coincident levels in Bass Strait and a reasonable allowance for the uncertainty in these estimates (AEP is the probability of exceedance of a given discharge within a period of one year);
- Develop and implement methods and management systems that seek to:
  - Identify and investigate potential interactions with flood protection systems during Project Activities;
  - Maintain existing flood protection systems during Project Activities; and
- Any Project activities on waterways are to be in accordance with the requirements of the relevant Authority.

Waterways and Wetlands

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;

- Develop and implement construction methods and site rehabilitation plans that seek to protect the habitat values of waterways and wetlands including:
  - Developing appropriate construction methods to minimise environmental impacts for crossing sensitive waterways;
  - Site-specific construction methods to minimise environmental impacts including erosion, sedimentation and pollution;
  - Reinstating and revegetating areas of disturbance;
  - Limiting impact on ecological processes such as fish movements and breeding;
- Develop and implement monitoring and reporting on the effects of construction on waterways and wetlands;
- Develop and implement methods and management systems to limit impacts on waterways and wetlands during operation;
- Re-establishment of wetland (unnamed tributary of the Powlett River) on the Desalination Plant site; and
- Design and locate scour and other relief valves to meet the Performance Criteria.

13. Groundwater

This Section of the WAA provides an assessment of potential impacts on groundwater arising from construction and operation of the Desalination Plant. Where significant impacts are identified, strategies for mitigation and management are provided.

Further detail on the assessment of the potential impacts on groundwater from the construction and operation of the Desalination Plant is provided in the specialist report, *Report for Desalination Plant Site: Existing Conditions Report and Impact Assessment - Groundwater,* (GHD, 2008c).

The Groundwater report (GHD, 2008c) forms *Technical Appendix 40* of the EES.

13.1 Regulatory and Other Requirements

Groundwater in Victoria is managed primarily thorough the following legislation:

- *Water Act 1989* (Vic); and
- *Environment Protection Act 1970* (Vic).

In the context of groundwater, the *Water Act 1989* principally deals with the sustainable and equitable management and allocation of the resource. It also seeks to protect (and enhance) elements of the terrestrial phase of the water cycle. The *Environment Protection Act 1970* empowers the EPA to regulate discharge or emission of waste to water, land, or air by a system of works approvals and licences. It has the objectives of preventing and managing pollution and environmental damage, and the setting of environmental quality goals and programs. Importantly, it provides for EPA to make subordinate legislation, including State Environment Protection Policies (SEPPs).

SEPPs identify the beneficial uses of the environment that must be protected and set environmental benchmarks for their protection. Summaries of the relevant SEPPs are provided in Section 2 of this WAA.

The *SEPP (Groundwaters of Victoria) No. S160* (1997) (SEPP (GoV)) specifies groundwater quality indicators and objectives for various beneficial uses. For the majority of beneficial uses, these objectives are from the Australian and New Zealand Environment Conservation Council's (ANZECC) *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC (1992)). For the protection of aquatic ecosystems, the *SEPP (Waters of Victoria)* (SEPP (WoV)) applies. The SEPP (WoV) has been updated and refers to the ANZECC and Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines, the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ (2000)).

Other directly relevant guidelines are:

- EPA Publication 668, *Hydrogeological Assessment (Groundwater Quality) Guidelines* (2006) – Aims to promote a more consistent approach to data collection, reporting and interpretation;
- EPA Publication 840, *The Clean-up and Management of Polluted Groundwater* (2002) – Provides a formalised approach to the clean up of polluted groundwater;
- EPA Publication 669, *Groundwater Sampling Guidelines* (2000) – Provides a standardised approach to the sampling of groundwater; and

- EPA Publication 441, *A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes* (2000) – Provides a standardised approach to the sampling and analysis of groundwater.

In addition, there are EPA guidelines that directly or indirectly protect groundwater during construction activities:

- EPA Publication 480, *Environmental Guidelines for Major Construction Sites* (1996) – These guidelines provide general information on how to avoid and minimise environmental impacts from construction activities;
- EPA Publication 275, *Construction Techniques for Sediment Pollution Control* (1991) – These guidelines provide recommendations on structures and strategies that reduce sediment export from construction sites; and
- EPA Publication 347, *Bunding Guidelines* (1992) – These guidelines specifically apply to above ground storage and transfer areas used for refuelling during construction.

13.2 Risk Assessment

A risk assessment of potential impacts of construction and operation of the Desalination Plant on the groundwater environment identified key areas requiring attention, taking into account the EES Scoping Requirements, legislative and policy obligations, and community and stakeholder concerns. The approach to environmental risk assessment is described in Section 4 of this WAA.

The risk assessment process was used to identify and rank priority issues assuming that Project controls, described in Section 4 of this WAA, would be implemented effectively.

The risk assessment was based on accepted operational and construction practices but did not take into account the mitigation measures embodied in the Performance Requirements. If the Performance Requirements were taken into account, both the likelihood and consequence of these risks would possibly be significantly lower.

The following Sections summarise the outcomes of the risk assessment process, listing potential environmental impacts on the receiving groundwater environment that were ranked as a medium risk or greater and direct readers to where these impacts have been addressed in this Section.

13.2.1 Operation

Only low risk impacts have been identified in the environmental impact and risk assessment process for operation of the Desalination Plant. Impacts assessed as low risk are briefly discussed within this Section of the WAA. A concise summary of these risks is also presented within *Volume 3, Chapter 7* of the EES. No impacts have been assessed as presenting a high or medium risk.

13.2.2 Construction

One impact has been assessed as medium risk in the environmental impact and risk assessment process. This is shown in Table 13-1 following. Impacts assessed as low risk are expected to have an insignificant or minor effect on the environment, with a rare or unlikely probability of occurrence.

Impacts assessed as low risk are briefly discussed within this Section of the WAA. A concise summary of these risks is also provided within *Volume 3, Chapter 7* of the EES document. No impacts have been assessed as presenting a high risk.

Table 13-1 Potential impacts during construction of Desalination Plant

Activity	Impact pathway	Where addressed in this Section
Medium risk		
Tunnelling resulting in sea water intrusion into the existing groundwater table	Sea water intrusion into existing groundwater impacting on native flora and fauna	Sections 13.4.2.1 and 13.5

13.3 Groundwater Assessment

13.3.1 Groundwater Existing Conditions

13.3.1.1 Hydrogeology Data Sources

The study area for which hydrogeological investigations have been carried out is larger than the Plant Site itself as it is necessary to draw upon hydrogeological information from a broader area.

The hydrogeological investigations have relied upon the following data sources:

- geological and hydrogeological reports and mapping;
- State Groundwater Management System (Victorian Data Warehouse) (DSE, 2008);
- site inspections; and
- aerial photography review.

A detailed discussion of the method and findings of hydrogeological investigations and existing groundwater conditions can be found in the Groundwater report (GHD, 2008c). A brief description of the existing groundwater environment is provided in the following Sections.

13.3.1.2 Relevant Groundwater Aquifers

Section 3.3 of the Groundwater report (GHD, 2008c) identifies two aquifers relevant to the Desalination Plant study area. The primary aquifer is that of the Lower Cretaceous Strzelecki Group, which in this report is referred to as the Cretaceous Aquifer. This is principally a fractured rock aquifer system. These indurated sediments are overlain in part by undifferentiated Quaternary (alluvial, swamp and dune system deposits). These sediments are referred to as the Quaternary Aquifer System.

The Quaternary Aquifer System is considered to comprise two water-bearing materials:

- clayey alluvial and swamp sediments overlying the Cretaceous rocks; and
- coastal dune materials.

A minor or perched aquifer system within these unconsolidated sediments is considered likely.

A conceptual hydrogeological model has been prepared for the Desalination Plant Site. The model is shown schematically in *Figure 6* of the Groundwater report (GHD, 2008c) and represents an approximate east-west cross section through the Site. For further details on the model, refer to *Section 3.11* of the Groundwater report (GHD, 2008c).

13.3.1.3 Groundwater Monitoring Network

As described in *Section 3.5* of the Groundwater Report (GHD, 2008c), field investigations were undertaken on the Site in late 2007 by GHD (GHD, 2007c). A total of 8 monitoring bores were installed in drilled bores:

- three monitoring bores were installed in the lithological bores (MDW-03, MDW-07 and MDW-14) to monitor groundwater levels within the deeper Cretaceous bedrock aquifer.
- five monitoring bores were installed in solid flight auger holes (MDW-16 to MDW-20) to monitor any shallow perched aquifer within the Quaternary alluvial deposits. These augered bores ranged in total depth from 8.90 m to 14.85 m.

Construction of the monitoring bores has been summarised in *Table 1* of the Groundwater report (GHD, 2008c). Their locations are shown in *Figure 3* of GHD (2008c).

13.3.1.4 Groundwater Levels

Table 13-2 contains a summary of groundwater monitoring results.

Table 13-2 Summary of monitoring bore standing water levels

Bore ID	5 Nov 2007		16 Nov 2007[1]		20 May 2008		21 May 2008	
	SWL[2]	RLWT[3]	SWL[2]	RLWT[3]	SWL[2]	RLWT[3]	SWL[2]	RLWT[3]
MDW-03	3.57	8.86	3.61	8.82	3.21	9.22	3.21	9.22
MDW-07	2.30	7.62	2.32	7.60	N/A	N/A	4.43	5.49
MDW-14	1.38	2.32	1.38	2.32	N/A	N/A	1.86	1.84
MDW-16	3.65	8.91	3.69	8.87	3.28	9.28	3.28	9.28
MDW-17	1.79	8.80	1.63	8.96	2.43	8.16	2.43	8.16
MDW-18	1.98	7.90	2.00	7.88	3.4	6.48	3.42	6.46
MDW-19	3.25	9.61	3.20	9.66	3.2	9.66	3.2	9.66
MDW-20	5.95	3.39	5.90	3.44	N/A	N/A	5.76	3.58

Note:
1. Water levels following bailing of monitoring bores.
2. SWL – Standing Water Level (m below top of casing).
3. RLWT – Reduced Level Water Table (m Australian Height Datum).

The monitoring data indicates that water levels in both aquifers were generally less than 6 m below the natural surface, and elevated above sea level.

13.3.1.5 Groundwater Flow

As stated in *Section 3.7* of the Groundwater report (GHD, 2008c), groundwater flow at the Site is expected to be a subtle reflection of topography, from the highlands in the north and east, towards the coastal areas and Bass Strait.

The Site is marginally elevated above the floodplain of the Powlett River and separated from the coastline by a dune system. Therefore, a component of flow towards both the Powlett River and Bass Strait could be expected.

In the western and central part of the Site, the groundwater levels recorded in the monitoring bores show a groundwater surface of relative level (RL) 8 to 9 m AHD. The levels then dip to the north-eastern part of the Site where groundwater levels are at 2 to 3 m AHD towards the Powlett River.

Groundwater flow system mapping of the general catchment has been undertaken by the Port Phillip and Westernport Catchment Management Authority. Although the Desalination Plant Site falls outside this mapping area, characteristics of the flow systems can be correlated to the Desalination Plant Site.

13.3.1.6 Groundwater Recharge

Recharge of groundwater to the Quaternary aquifers along the Site is by direct rainfall infiltration from the outcropping Quaternary age dune sands and alluvial sediments.

The Cretaceous aquifer may not be recharged from this direct overhead infiltration on the Desalination Plant Site, as it is overlain with clays, which suggest low permeability and infiltration rates. Recharge may, however, occur in other areas remote from the Site where the Cretaceous aquifer outcrops (GHD, 2008c).

Recharge rates for the aquifers are unknown.

13.3.1.7 Groundwater Discharge

Discharge from the Cretaceous rocks is expected to be principally southwards into the Bass Strait.

Discharge from the Quaternary dune system is expected to have two components:

- seaward i.e. south to south-west to the Bass Strait; and
- landward i.e. as a subdued reflection of topography.

13.3.1.8 Groundwater Quality

Classification of Groundwater

The SEPP (GoV) categorises groundwater into segments based on its quality (the amount of total dissolved solids), with each segment having a particular identified beneficial use. The segments and their beneficial uses are summarised in Table 13-3.

Table 13-3 Protected uses of the segments

Use	Segment (mg/L TDS[1])				
	A1	A2	B	C	D
	0 – 500	501 – 1,000	1,001 – 3,501	3,501 – 13,000	>13,000
Maintenance of Ecosystems	✓	✓	✓	✓	✓
Potable water supply					
Desirable	✓				
Acceptable		✓			

Use	Segment (mg/L TDS[1])				
	A1	A2	B	C	D
	0 – 500	501 – 1,000	1,001 – 3,501	3,501 – 13,000	>13,000
Potable mineral water supply	✓	✓	✓		
Agriculture, parks and gardens	✓	✓	✓		
Livestock Watering	✓	✓	✓	✓	
Industrial	✓	✓	✓	✓	✓
Primary contact recreation (eg. swimming / bathing)	✓	✓	✓	✓	
Buildings and structures	✓	✓	✓	✓	✓

Note: 1. TDS – Total Dissolved Solids (mg/L)

EPA may determine that these beneficial uses do not apply to groundwater where:

- there is insufficient yield;
- the background level of a water quality indicator other than TDS precludes a beneficial use;
- the soil characteristics preclude a beneficial use; or
- a groundwater quality restricted use zone has been declared[19].

The SEPP (GoV) also requires that occupational health and safety (OH&S), odour, and amenity be considered, as vapours sourced from impacted groundwater may present a potential risk to workers, and as odours or discolouration may result in degradation of overall beneficial use.

Background Groundwater Quality (Salinity)

Sampling of the bores in the Cretaceous aquifer (MDW03, MDW07 and MDW14) indicated a variable salinity range of 1,600 mg/L, 2,800 mg/L and 4,600 mg/L. This implies that the Cretaceous aquifer falls within segments B and C as defined by Table 13-3 above (GHD, 2008c).

Sampling of the shallow observation bores also indicated variability in the aquifer. Bore MWD16 had a salinity of 1,500 mg/L, bore MWD17 a salinity of 14,000 mg/L and bores MWD18, MWD19 and MWD20 were marginally over 3,000 mg/L (GHD, 2008c).

Drilling of bore MDW-19 to a depth of 100 m into the Cretaceous aquifer indicated a salinity of 2,500 mg/L. This bore was drilled with the purpose of being a test pumping bore and is therefore analogous to the installation of a production abstraction bore in the Cretaceous aquifer. This suggests the Cretaceous aquifer falls within segment B (GHD, 2008c).

Published Mapping / Hydrogeological Reports

Published salinities for the aquifers generally (based on lithology) are set out in Table 13-4 (Lakey & Tickell, 1981). This implies a higher quality than that suggested by the field monitoring (GHD, 2008c).

[19] EPA Publication 862, *Groundwater Quality Restricted Zone*, July 2002.

Table 13-4 Summary of Groundwater Salinity

Period	Formation	Salinity (mg/L)	Segment
Quaternary	Undifferentiated Sands[1]	<1,000	A
Cretaceous	Strzelecki Group	500 – 5,000	A - C

Source: Lakey & Tickell, 1981
Note: 1. Western Port Basin

13.3.1.9 Groundwater Use

Generally, groundwater is sourced for use through boreholes and wells. There is a low density of bores neighbouring the Desalination Plant, with most bores in the region typically used for stock and domestic purposes.

A total of four bores, identified from the Department of Sustainability and Environment's Groundwater Management System (GMS), are listed within a 3 km radius of the Desalination Plant Site. Details of these bores have been provided in Table 13-5. The nearest private bore to the Desalination Plant Site, bore ID 134581, has a recorded yield of 0.8 L/s and, at the time of drilling, a standing water level of 8 m. Based on the bore depth, the aquifer developed by the bore is considered to be the Cretaceous aquifer (GHD, 2008c).

Table 13-5 Bores neighbouring Desalination Plant Site

Bore ID	Co-ordinates		Date completed	Total depth (m)	Bore use
	Easting	Northing			
63186	373,473.2	5,731,064	21.02.1988	6.5	DM
134581	373,913.2	5,727,203.99	23.01.1998	17	ST DM
S9031447/1	372,520	5,725,610	Not Known	35	Not Known
119097	372,813.2	5,727,483.99	01.01.1980	10.4	IV OB

Notes:
1. DM – Domestic, ST – Stock, IV – Investigation, Ob – Observation.
2. The GMS may not contain all bores. Bores drilled prior to 1969 (proclamation of original Water Act) may not necessarily be registered on the GMS.

Bore yields at the Desalination Plant Site are unknown. In a regional context, bores developing the Cretaceous aquifer typically yield less than 3 L/s. This yield can vary greatly and is generally dependent on the nature of the Cretaceous sediments, and the nature and amount of fracturing and bore depth.

The yields from the Quaternary aquifer are likely to be limited due to shallow aquifer thickness and restricted distribution.

The Desalination Plant does not fall within a Groundwater Management Area (GMA) or Water Supply Protection Area (WSPA) as declared by the *Water Act (1989).* There are no State Groundwater Observation Network bores present on the Site or within a 5 km radius of the Site.

13.3.2 Groundwater Beneficial Uses and Quality Objectives

13.3.2.1 Protected Beneficial Uses

Groundwater is not currently used on-site for any extractive beneficial use. Where no existing beneficial uses can be identified, groundwater beneficial use is assessed in the context of *likely* beneficial use, i.e. those most likely to be realised based on site-specific conditions. The relevant and likely beneficial uses are presented in Table 13-6.

Table 13-6 Groundwater beneficial uses

Beneficial Use Category	Existing	Likelihood	Discussion
Maintenance of Ecosystems	Yes	Yes	Groundwater may discharge into either the Powlett River or Bass Strait.
Agriculture, Parks and Gardens	No	Yes	Groundwater use for irrigation purposes has not been identified neighbouring the Desalination Plant Site, although stock (and domestic) bores have been identified from a search of neighbouring bores and therefore this use is considered relevant.
Stock Watering	Yes	Yes	The site abuts reticulated suburban residential areas and therefore there is limited likelihood of widespread development of groundwater for such use. However, stock (and domestic) bores have been identified from a search of neighbouring bores and therefore this use is considered relevant.
Industrial Water Use	No	Yes	Based on the neighbouring bore search, groundwater bores with industrial use have not been identified. The groundwater could be used for industrial purposes and therefore this use is considered relevant.
Primary Contact Recreation	Yes	Yes	Primary Contact Recreation is applicable to those environments where groundwater is either extracted to fill swimming pools and recreational waters, or where groundwater may discharge into surface water systems which could have recreational use. Natural discharge is expected to be offshore.
Buildings and Structures	No	Yes	Standing groundwater levels on the site is between 1.5 and 6 m below the surface (refer to Table 13-2). The influence of the prevailing drought conditions on SWLs is not known. At these levels groundwater could potentially interact with buried services, cellars / underground structures and foundations. This is therefore considered a relevant beneficial use to be protected at the Site.

13.3.2.2 Groundwater Quality Objectives

In assessing whether the beneficial use of groundwater at the Site has been impacted, criteria provided in Table 13-7 have been applied.

Table 13-7 Groundwater quality indicators

Beneficial Use Category	Water Quality Indicators
Maintenance of Ecosystems	Maintenance of Ecosystems is relevant to the water quality at the point of discharge to the environment. Point of discharge to the Powlett River and Bass Strait have been assumed. The water quality objectives to protect beneficial uses are the criteria specified in the SEPP (WoV) guidelines for estuaries and inlets and open coasts. It is noted that unless specific objectives are specified in this policy, the environmental water quality objectives are those values specified in ANZECC/ARMCANZ (2000).
Agriculture, Parks and Gardens	Those criteria specified in the ANZECC (1992) guidelines for irrigation use.
Stock Watering	Those criteria specified in the ANZECC (1992) guidelines for livestock use.
Industrial Water Use	Those criteria specified in the ANZECC (1992) guidelines for industrial use.
Primary Contact Recreation	Those criteria specified in the ANZECC (1992) guidelines.
Buildings and Structures	The groundwater shall not be corrosive to structures or building materials (pH, sulphate, redox potential).

Saline Interface

At coastal locations, fresh groundwater discharges subterraneously and mixes with saline groundwater beneath the seafloor. This occurs at the Plant Site and is referred to as a saline or seawater interface.

The location of the saline interface at the Plant Site is unknown. However, based on an average groundwater elevation of 5 m above sea level (refer Table 13-2), the theoretical depth of the seawater interface based on the Ghyben-Herzberg relationship (Fetter, 1988) could be in the order of 200 m below sea level.

13.4 Impact Assessment

Section 4.2.1 of the Groundwater report (GHD, 2008c) sets out the methodology used to identify and assess potential impacts of the construction and operation of the Desalination Plant on groundwater quality and availability.

This process is partly based on that described by EPA Publication 668, which is a source – pathway – receptor model. However, the process detailed in the aforesaid guidelines has been expanded as it does not account for impacts to water availability (i.e. quantity).

Potential impacts during the construction and operational phases are discussed below.

13.4.1 Operation

During operation of the Desalination Plant, potential groundwater impacts may arise due to:

- hazardous materials use, handling, and storage;
- disposal / management of site stormwater including creation of wetlands;
- over-development of groundwater for Desalination Plant operational requirements, leading to reduced availability, saline intrusion, and establishment of hydraulic connection between two aquifers of differing water quality which were previously hydraulically isolated;

- saline intrusion from Desalination Plant unlined saltwater intakes or disposal lines; and
- disruption to flows, water table, and/or aquifer.

These potential impacts and mitigation measures are described further in *Table 14* of the Groundwater report (GHD, 2008c).

13.4.2 Construction

13.4.2.1 Quality

As discussed in *Sections 4.2* and *4.3*, including *Table 14*, of the Groundwater report (GHD, 2008c), the construction of the Desalination Plant could include the dewatering of excavations and old mine workings, and the use of groundwater for construction activities. The water quality in the historical mine workings, expected to be within the Cretaceous aquifer, is not known and may be contaminated from historical mining activities. These activities have the potential to impact upon groundwater quality and availability for beneficial uses.

There is a risk that tunnel dewatering works in the Cretaceous aquifer could cause saline intrusion. Saline intrusion occurs where groundwater gradients are altered, enabling the ingress of salt water into freshwater terrestrial aquifers with the potential to impact upon terrestrial and aquatic flora and fauna. The likelihood of this occurrence is discussed further in *Section 4.3.6* of the Groundwater report (GHD, 2008c).

There is also a risk that temporary construction dewatering works required for excavations in saturated materials could cause the exposure and oxidation of acid sulfate soils, as the Plant Site encroaches on the Powlett River's estuarine floodplain. This is addressed in *Section 4.3.5* of the Groundwater report (GHD, 2008c).

As the construction will also involve the use of a wide variety of chemicals e.g. fuels, together with sewage and wastewater, there is a potential risk of leakage and spills to groundwater if not stored and handled correctly.

Run-off during both construction and operation of the Desalination Plant is likely to generate flows that may be of differing water quality to groundwater. However, site erosion, run-off, drainage, and stormwater treatments are likely to reduce migration to the groundwater system and make groundwater impact consequences less severe i.e. flows dilute water quality. Release of contaminants from construction accidents could potentially cause major impacts to groundwater quality, however these would be tend to be localised and spill response is expected to be rapid, reducing potential for spill migration and subsequent impact to the groundwater system.

13.4.2.2 Availability

As stated in *Section 4.3.1* of the Groundwater report (GHD, 2008c), availability of groundwater may be impacted by use in construction or by temporary construction dewatering works. The altering of site grades may also indirectly alter groundwater availability, where water tables in saturated ground may need to be drained.

A reduction in groundwater level as a result of such works could potentially cause:

- exposure of acid sulfate soils (as described above);

- reduction in capacity of neighbouring groundwater bores, or spring fed dams;
- disrupting baseflow to waterways e.g. Powlett River;
- saline intrusion;
- subsidence of compressible, unconsolidated sediments; and
- degradation of flora and fauna habitats.

Alteration of site surface conditions may result in localised changes to groundwater recharge e.g. the erection of structures and paved areas removes groundwater recharge area, or the scraping of topsoil during construction may temporarily increase recharge. For the majority of the Site, changes to the surface conditions and resultant changes to the groundwater regime are not expected to be significant.

13.4.2.3 Subsidence

Whilst this is not strictly an impact to groundwater, subsidence can be a side effect of groundwater removal in unconsolidated, compressible sediments.

13.5 Mitigation and Management

While mitigation measures are presented in greater detail in *Section 4.3* of the Groundwater report (GHD, 2008c), key mitigation measures have been summarised below. The Groundwater report (GHD, 2008c) also discusses the feasibility of mitigation and management measures in *Section 4.4* and concludes that they are likely to be effective and readily implemented.

These suggested management measures have been formulated in response to the Reference Project and its Variations for the Desalination Plant. In effect, the suggested management measures demonstrate how the Reference Project and relevant Variations can achieve Project Performance Requirements . These detailed management measures have formed an important input to the Performance Requirements for the Project.

13.5.1 Mitigation Against Degradation of Water Quality

Environmental management procedures applied to minimise the likelihood of adverse impacts to groundwater e.g. refuelling procedures, bunding, erosion controls, controls on hazardous materials handling, should include:

- any disposal of groundwater must be compliant with Clause 20(1) of SEPP (GoV);
- reinstatement of confinement conditions following excavations intersecting multiple aquifers of differing groundwater quality; and
- management of backfilling, including the use of certified clean fill as backfill material, spoil from excavation, and order of backfilling.

To mitigate against saline intrusion, similar controls as discussed in *Section 4.3.6* of the Groundwater report (GHD, 2008c) should be applied, coupled with a monitoring program i.e. construction methods, groundwater level and quality monitoring, dewatering programs. In considering saline intrusion, the following should be noted:

- upon the cessation of dewatering construction activities, groundwater levels (and hydraulic gradients) are expected to recover, resisting on-going seawater intrusion;

- aquifer recovery (i.e. flushing of salts) will occur over time, with interpreted regional groundwater flow in the Cretaceous aquifer to be towards the coast; and
- intrusion will be confined by the dewatering capture zone. This capture zone is expected to be narrow, and to extend between the site of extraction and the coast. Neighbouring groundwater users are located offsite and up-gradient. Accordingly, impact to offsite groundwater users is considered highly unlikely.

Consideration will be required during detailed designing for the disposal/re-use of extracted groundwater, according to a Performance Requirement set out in Section 17 of this WAA. If re-use is not practicable, disposal options, including aquifer re-injection and offsite disposal, will be determined in line with the extracted groundwater quality, and in accordance with statutory and relevant Authorities' requirements and guidelines.

13.5.2 Mitigation Against Reduced Availability due to Over-extraction

Groundwater bores installed for construction water supply or permanent water supply need to be licensed by Southern Rural Water in accordance with the *Water Act 1989*, and subject to licensing determinations. Such determinations require assessment of impact to neighbouring users, surface water flows and water availability.

Impacts arising from dewatering (or abstraction) can typically be mitigated through a number of means:

- supplying the affected party with an alternate water supply e.g. carting water, deepening the pump intake setting depth;
- altering the construction technique to reduce the need for dewatering e.g. use of sheet piles / contiguous piles, ground freezing;
- careful design of the dewatering methodology e.g. multiple closely spaced bores may create a localised cone of depression;
- increase construction effort e.g. reduces the duration over which dewatering may be required;
- careful timing of the works to periods where water levels may be at their lowest; and
- re-injection of the pumped groundwater between the excavation site and impacted area to impart hydraulic control.

Additional measures to mitigate against water quality, availability, and impacts to groundwater-dependent habitats include:

- avoiding excavations that cut and drain saturated tongues of dune sediments that may extend onto, and which are hydraulically connected to the Desalination Plant footprint;
- cut-offs / trench breakers (lateral trench cut-offs and horizontal cappings, as illustrated in Figure 13-1) installed in trenches to prevent the lateral migration of groundwater via permeable backfill sands and maintain local groundwater flow conditions; and
- alternate water supplies established to maintain environmental water requirements e.g. stormwater used to replenish vegetation that previously relied upon groundwater.

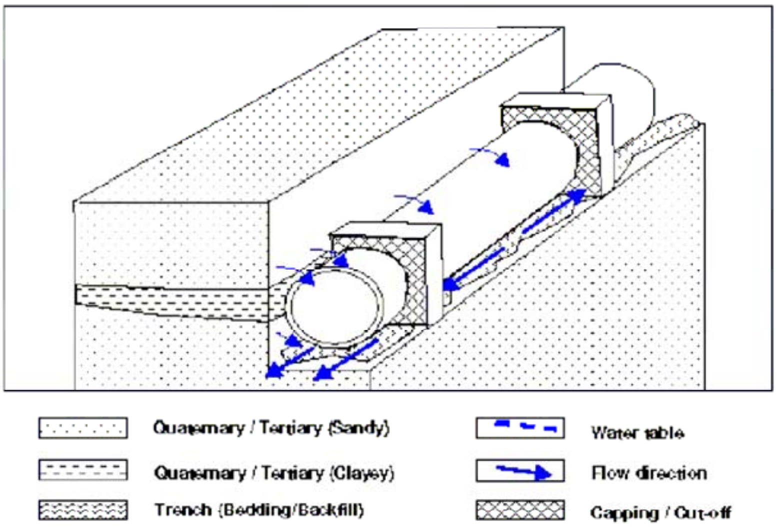


Figure 13-1 Typical trench cut-offs with capping

13.5.3 Mitigation Against Reduced Availability due to Changed Recharge Conditions

Specific mitigation measures are not proposed, as the likelihood of impacting on the overall infiltration at the Site is limited. Nevertheless, following excavation, it is expected there will be:

- rehabilitation of vegetation / grasses;
- grading for erosion control;
- allowances for subsidence with backfilled excavations; and
- removal of temporary access tracks and rehabilitation of ground conditions.

Mitigation measures may be required to help existing infiltration via the wetlands to be maintained.

13.5.4 Mitigation Against Subsidence

Similar controls as those discussed in *Section 4.3.7* of the Groundwater report (GHD, 2008c) will be applied and coupled with a monitoring program i.e. construction methods, groundwater level and quality monitoring, and dewatering programs.

13.6 Summary and Conclusions

Desktop hydrogeological investigations and preliminary field investigations were undertaken to describe existing conditions in and around the Plant Site. Desktop investigations relied upon the State Groundwater Database and published geological and hydrogeological mapping.

There are two aquifers relevant to the Desalination Plant study area. The primary aquifer is the Cretaceous Aquifer and is principally a fractured rock aquifer system. These indurated sediments are overlain in part by undifferentiated Quaternary-age alluvial, swamp, and dune sediments. These materials are collectively referred to as the Quaternary Aquifer System, which has been subdivided into the alluvial sediments and the dune sediments.

Groundwater levels are less than 6 m below the natural surface, but marginally above sea level. Locally, groundwater use is limited, however a stock and domestic bore has been identified 2 km from the Site. Groundwater quality on the Site is variable, ranging from Segment B through Segment D. Most bores indicate Segment B or C range salinity.

In assessing the impact to groundwater, availability (based on groundwater level) and quality were considered the key elements. Classification of impacts considered both construction or short-term impacts, and potential long-term impacts of ongoing Desalination Plant operation. No significant potential impacts were identified for the operational phase of the Desalination Plant.

As discussed in this Section and in more detail in the Groundwater report (GHD, 2008c), with appropriate mitigation, no unacceptable potential impacts were identified for the construction phase.

13.7 Environmental Performance Requirements arising from this Section

As discussed in Sections 1 and 6 of this WAA, the design adopted by the Project Company appointed under the PPP contract is likely to differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Performance Requirement's outlined in this Section of the WAA in a manner that would lead to a similar or better groundwater quality outcome.

The Performance Requirement's are incorporated into the Environmental Management Framework and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirement's relevant to this study area are presented below.

Performance Requirements

- Comply with relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop and implement methods and management systems which do not cause deterioration to groundwater systems including:
  - Consideration of the interaction between surface water and groundwater;
  - Recognition of the interaction with flora and fauna habitats, including wetlands and dune vegetation;
  - Management of extracted groundwater seeking to maximise potential reuse and disposal;
  - Limiting any impact or diminution on the existing flow regime in nearby waterways or on the use of groundwater as a resource arising out of any interception and/or drainage of groundwater;
  - Minimise any reduction of existing groundwater recharge to wetlands resulting from the construction or operation of the Desalinated Plant water supply system;
- Undertake a site-specific assessment, in consultation with the relevant Authority and the EPA, if intercepted groundwater is proposed to be discharged to waterway segments and demonstrate that water quantity, quality, availability and flow will meet the relevant licensing requirements; and
- Monitor groundwater quality during the Project Term in accordance with the requirements of the EPA and/or relevant Authorities.

14. Marine Environment

14.1 Overview

This Section of the WAA provides an assessment of the potential impacts on the marine environment arising from construction and operation of the Desalination Plant. This Section addresses risks identified in the risk assessment process (refer Section 4) that have been assessed as medium or higher and provides strategies for mitigation and management.

Details of the Reference Project Marine Structures are provided in Sections 6 and 7 of this WAA. These Sections include a Project description and discussion of best practice desalination plant design components. The Marine Structures, including the intake and outlet tunnels and risers, and the marine environment in a regional context surrounding these structures are referred to as the 'Project area' in this Section.

14.1.1 Existing Environment

The marine Project area is an environment frequently exposed to strong waves and winds. Local currents are dominated by wind driven longshore currents with low tidal currents that run parallel to the coast. Water quality at the Project area is primarily oceanic, with influences from the Powlett River and Western Port. Water quality data from one year of monitoring indicate salinity stratification during winter and spring and temperature stratification during spring and early summer.

The Project area is approximately one kilometre from the Powlett River.

The estuary wetland of this river supports a number of protected species.

Two coastal protected areas and two marine parks, including Bunurong Marine National Park, are located within twenty kilometres of the Project area. These areas protect significant marine habitat and species.

The intertidal habitat at the Project area is largely sandy beach inhabited by infaunal species with scattered sandstone and mudstone reef platforms that support a diverse array of flora and faunal species. Most of the subtidal habitat in the Project area is dominated by rock reefs. The reef community is dominated by kelp in shallower waters and red macroalgae and invertebrates in deeper waters with increasing dominance of invertebrates in deeper waters. A variety of reef fish live in these areas. The Project area biota is also well represented along other parts of the Victorian coast.

Plankton, pelagic animals and plants that live passively in the water column, play an important role in the marine food chain in the Project area. Locals and visitors swim and surf at Williamsons Beach and recreational boating is common along the coastline encompassing the Project area.

Figure 14-1 characterises conceptually the existing marine environment in the Project area.

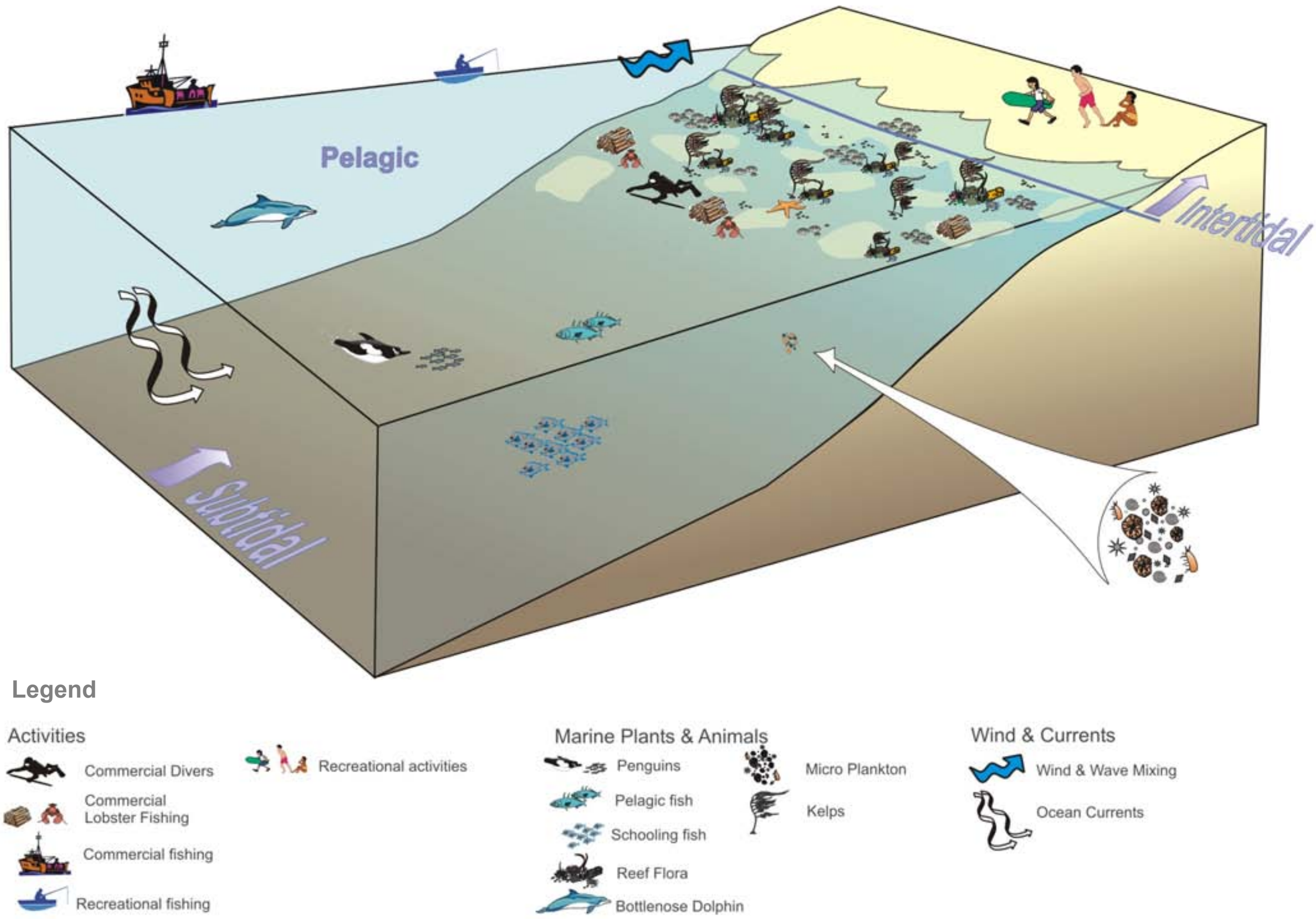


Figure 14-1 Characteristics of the marine environment

The potential impacts on the marine environment identified in the risk assessment (discussed in Section 4 of this report) were as follows:

Operational phase:

- potential impacts from the discharge of concentrate and other chemical wastes;
- impacts on water quality from the above potential discharges;
- entrainment, entrapment and impingement of adult marine organisms and marine vertebrates;
- entrainment, entrapment and impingement of eggs, larvae and other plankton; and
- exclusion zone for marine recreational and commercial activities (located above the Marine Structures during operation).

Construction phase:

- seabed disturbance and clearing;
- potential introduction of marine pests and abalone disease;
- potential impacts from chemical/hydrocarbon spills and loss of drilling fluid;

- release of construction spoil produced from drilling;
- potential impacts from noise generated during construction; and
- exclusion zone for marine recreational and commercial activities (located above the Marine Structures during operation).

Assessment of these potential impacts is provided in the following technical specialists' reports:

- *The Victorian Desalination Project Environmental Effects Statement - Marine Biology Existing Conditions and Impact Assessment*, (CEE, 2008), refer *Technical Appendix 31* of the EES;
- *Near-field Numerical Modelling of the Desalination Plant Outlet Plume* (ASR, 2008b), refer *Technical Appendix 30* of the EES;
- *Mid-field Numerical Modelling of the Desalination Plant Outlet Plume* (ASR, 2008c) refer *Technical Appendix 29* of the EES;
- *Particle Dispersal Modelling Seasonal and spatial variation*, (ASR, 2008d) refer *Technical Appendix 33* of the EES;
- *Assessment of Marine Mammals, Birds and Reptiles for the Desalination Project, Bass Coast, Victoria – Existing Conditions and Impact Assessment Report*, (Biosis, 2008a) refer *Technical Appendix 13* of the EES;
- *Report for the Victorian Desalination Plant – Water and Sediment Quality Assessment* (GHD, 2008g) refer *Technical Appendix 23* of the EES;
- Toxicity Assessment for the Victorian Desalination Project (Hydrobiology and CSIRO, 2008) refer *Technical Appendix 24* of the EES;
- The Desalination Project – Invasive Marine Species Specialist Report (GHD, 2008h) refer *Technical Appendix 27* of the EES;
- Desalination Project: Desalination Plant Component Cultural Heritage Existing Conditions and Impact Assessment, (Biosis, 2008b), refer *Technical Appendix 45* of the EES;
- Desalination Project Environmental Effects Statement Social Impact Assessment Report, (Maunsell, 2008c), refer *Technical Appendix 56* of the EES;
- Wonthaggi Desalination Plant Impact Assessment (Economic), (Essential Economics, 2008), refer *Technical Appendix 11* of the EES; and
- *Victorian Desalination Project Environmental Effects Statement – Underwater Noise* (Bassett Acoustics, 2008), refer *Technical Appendix 22* of the EES.

14.2 Regulatory and other Requirements

The SEPP (WoV), as defined in Section 2.1.2 of this WAA, is the legislation of particular importance to this Section of the WAA.

Other legislation of importance includes:

- Environment Protection and Biodiversity Conservation Act 1999 (Cth.); and
- Flora and Fauna Guarantee Act 1988 (Vic).

14.3 Interpretation and Application of SEPP (WoV)

The SEPP (WoV) specifying the protection of the beneficial uses of the open ocean is the primary legislative tool for the protection of waterways. Table 14-1 outlines the key parts and clauses relevant to this Section of the WAA (as noted in Section 2), and notes the method used to address each Clause and where in this Section each is addressed. Where each Clause is addressed directly in this Section of the report the Clause is noted in a text box and in italics font.

Table 14-1 Summary of key SEPP (WoV) clauses and its assessment method

Part/Clause (SEPP (WoV))	Description	Relevance	Where addressed in this WAA
9	Defines segments of the surface water environment for the purpose of the policy	The relevant segment is Marine and Estuarine (Open coasts) as described in Annex A of the SEPP (WoV)	Section 14.4
10	Identifies the beneficial uses to be protected for each segment of the surface water environment	The relevant beneficial uses of the segment were determined for the Project area as per Table 1 of the SEPP	Section 14.4
11	Describes the level of environmental quality required to protect beneficial uses and values identified in Clause 10, and how this is to be assessed. This Clause links to Schedule A of the policy, which outlines environmental quality indicators and objectives to ensure the protection of beneficial uses	A water quality monitoring program was commissioned for the Project with regard to ANZECC and ARMCANZ Guidelines (2000), to set water quality objectives for the Project area	Section 14.5.5.3

Part/Clause (SEPP (WoV))	Description	Relevance	Where addressed in this WAA
27	Requires that any discharge of waste or wastewater to surface waters be managed in accordance with the waste hierarchy	The waste hierarchy has been applied in design and disposal choices for management of the waste streams	Section 14.5.3
27 (1)	Requires that consideration be given to the existing environmental quality of surface waters and protection of beneficial uses and potential impacts of future wastewater discharges on beneficial uses	The impacts on the water quality posed by the discharge of concentrate was determined by: ▪ Comparison of the existing conditions and water quality objectives; ▪ Determination of trigger values (with reference to the ANZECC and ARMCANZ water quality guidelines); and ▪ Comparison of the concentrate characteristics. The required dilution to return the seawater concentrate to conditions that protect beneficial uses was determined It is implicit that achieving an acceptable dilution will protect beneficial uses and avoid impacts outside the mixing zone[20] (as declared by EPA licence)	Section 14.5.5.3
27 (3) and (4)	Only approve wastewater management practices, including disinfection, that will not increase toxicity of the wastewater discharge; and Only approve a discharge that according to toxicity tests approved by EPA does not display acute lethality at the discharge point nor cause chronic impacts outside any mixing zone	Toxicity testing, using an EPA approved testing method (that also meets the ANZECC and ARMCANZ Guidelines (2000) for toxicity testing), was undertaken using samples from the Perth desalination plant, which is considered representative of the Reference Project concentrate, to demonstrate that acute lethality at the discharge point would be highly unlikely This assessment also indicated that chronic impacts are not expected outside an approved mixing zone	Section 14.5.5.2

[20] The SEPP (WoV) defines a Mixing Zone as: *An area contiguous to a licensed waste discharge point and specified in that licence, where the receiving environmental quality objectives otherwise applicable under the Policy do not apply to certain indicators as specified in the licence. This means that some or all beneficial uses may not be protected in the mixing zone.*

Part/Clause (SEPP (WoV))	Description	Relevance	Where addressed in this WAA
28 (1)	EPA may approve a mixing zone as part of the discharge licence where a discharge cannot be practicably avoided, reused, recycled, and where wastewater management practices are not effective in fully protecting beneficial uses	Demonstration of analysis of alternative wastewater management options is noted for Clause 27	Section 14.5.3
28 (2)	The Environment Protection Authority will, if a licence is approved, ensure that it is consistent with the policy and includes an environmental improvement plan to progressively reduce the impacts of wastewater discharge on beneficial uses, and a monitoring program to assess the impact of a wastewater discharge on beneficial uses	Demonstration of accordance with this Clause is included in sections concerning monitoring of the mixing zone (as declared by EPA licence), ongoing environmental monitoring and the environmental framework	Section 17
28 (3)	The Environment Protection Authority will not approve any new discharges: ▪ to the Aquatic Reserves, Wetlands and Lakes or Estuaries and Inlets segments or to waters in areas of high conservation significance, including those listed in Schedule B, except in accordance with the provisions of Clause 31; ▪ to waters in special water supply catchments or where a discharge will impact on authorised potable supplies; and ▪ where a discharge would pose an environmental risk to beneficial uses and best management practice has not been adopted.	The proposed Site is not located within any Aquatic Reserves, Wetlands and Lakes or Estuaries and Inlets, nor is the area of high conservation significance (refer CEE, 2008) Special water supplies are not drawn from the area Areas such as these have been accounted for in determining the sensitivity areas for the Project (refer Figure 6-3, Section 6 of this WAA) Best Practice has been demonstrated for the Project in Section 7 of this WAA and via the Environmental Management Framework for the Project and the Performance Requirements	Sections 6, 7, and 14.7

Part/Clause (SEPP (WoV))	Description	Relevance	Where addressed in this WAA
30 (1)	In issuing a licence, the Environment Protection Authority may approve a mixing zone where it is not practicable to avoid, re-use, recycle and effectively manage wastewater Within a mixing zone, designated environmental quality objectives do not need to be met and therefore beneficial uses may not be protected The Environment Protection Authority: ▪ will not approve a mixing zone if it will result in: – environmental risks to beneficial uses outside the mixing zone; – harm to humans, unacceptable impacts on plants and animals or where it will cause a loss of aesthetic enjoyment or an objectionable odour	Parameters for a mixing zone (as defined by EPA licence) have been identified using a multi-disciplinary approach, including: ▪ Determination of the dilution requirement using information from the specialist studies completed for the Project including ecotoxicity testing, water quality and sediment sampling and ecological assessment; and ▪ Hydrodynamic modelling of the concentrate behaviour and confirmation that the Reference Project could meet the environmental dilution requirements	Section 14.5.11
37	Chemicals including biocides, fertilisers, oil and fuel, other hazardous substances and prescribed industrial wastes need to be managed to minimise environmental risks to beneficial uses	Residual chemicals in the wastewater discharge must not exceed water quality trigger values Achieving the dilution factors would then logically protect the beneficial uses and minimise impact This is also discussed in Section 7 of this WAA	Sections 7 and 14.5.5

14.4 Beneficial Uses

14.4.1 Overview

The relevant segment of the surface water environment as set out in the SEPP (WoV) is Marine and Estuarine surface waters – Open Coasts. The SEPP (WoV) requires surface waters to be of a suitable quality and quantity to support the beneficial uses of that segment.

The location of the inlet and outlet structures falls within the category of a "largely unmodified" environment. The following beneficial uses are listed for this category in Table 1 of the SEPP (WoV), these are:

- Aquatic Ecosystems that are largely unmodified; and
- Water suitable for:

– Primary contact recreation;
– Secondary contact recreation;
– Aesthetic enjoyment;
– Indigenous cultural and spiritual values;
– Non-indigenous cultural and spiritual values;
– Agriculture and irrigation;
– Aquaculture;
– Industrial and commercial use; and
– Fish, crustacea and molluscs for human consumption.

Not all of these beneficial uses are of practical relevance to the Project. Those that are not addressed in this assessment, and reasons for this are shown in Table 14-2, following. Table 14-2 also provides reference to Technical Specialists' reports prepared for the Project that cover the protection of beneficial uses not discussed in this Section of the WAA.

Table 14-2 Practical relevance of beneficial uses to environmental, social and economic values

Beneficial Use	Practical relevance to Project area	Value [1]	Reference Sections/Reports
Aquatic Ecosystems that are largely unmodified	Yes	The intake and discharge structures are located in an area that is by definition an aquatic ecosystem that is largely unmodified.	CEE, 2008
Primary contact recreation	Yes	Williamsons Beach located adjacent to the Desalination Plant is primarily used by locals for fishing, surfing, walking, horse riding and dog walking. The limited tourist information and poor access to the beach limits tourist numbers.	*Sections 5 and 6 of* Maunsell, 2008c
Secondary contact recreation			
Aesthetic enjoyment	Yes	The coastal landscape has aesthetic value for the local community and landscape views that are valued by tourists.	*Sections 5 and 6 of* Maunsell 2008c
Indigenous cultural and spiritual values	No	The Project area does not appear to have distinct cultural or spiritual values and the Project structures are underground and under water.	*Sections 3,10 and 11 of* Biosis, 2008b

Beneficial Use	**Practical relevance to Project area**	**Value [(1)]**	**Reference Sections/Reports**
Non-indigenous cultural and spiritual values	No	Three shipwrecks are located within a 10 km region off Williamsons beach but there are none known in the Project area.	*Refer Sections 10 and 11 of* Biosis, 2008b
Aquaculture	No	The Project area does not include an area protected for aquaculture under the *Fisheries Act 1995.*	N/A
Industrial and commercial use	Yes	There is no industrial use of the Site but there is commercial fishing for abalone and rock lobster. The proposed operational exclusion zone will have localised impacts on commercial fishing activities through restricted fishing areas.	*Sections 4.3 and 6 of* Essential Economics, 2008
Fish, crustacea and molluscs for human consumption	Yes	The waters in the Project area are used for fishing purposes.	Section 14.5.5.4 *Section and 6 of* Maunsell, 2008c *Section 4.3 and 6 of Essential Economics,* 2008

Notes to Table:

1. Values determined from community consultations and stakeholder engagement – refer *Volume 2* of the EES – including estuary zone, marine species, surfing location, Little Penguins, whale watching, views, dog walking, walking and fishing. These are summarised in Maunsell (2008c).

14.4.2 Risk Assessment

The potential impacts posed by the Reference Project on the marine environment were assessed for both the operational and construction phases. Areas that require attention, taking into account legislative and policy obligations, community and stakeholder concerns, and guidance from the EES Scoping Requirements, were identified during the risk assessment. The approach to environmental impact and risk assessment is described in Section 4 of this WAA.

The risk assessment process identified and ranked priority issues, and assumed that certain Project controls, described in Section 4, would be implemented effectively.

The risks included in the following Sections have been identified in the risk assessment process as either high or medium risks. Low risks, or risks which do not have a clear impact pathway are considered briefly in *Volume 2, Chapter 8* of the EES.

The risk assessment was based on accepted construction and operational practices but did not take into account the mitigation measures embodied in the Performance Requirements. If the Performance Requirements were taken into account, both the likelihood and consequence of these risks would be significantly lower.

The following Sections summarise outcomes of the risk assessment process, lists potential environmental impacts on the receiving marine environment and indicates where these impacts are addressed in this Section.

14.4.3 Desalination Plant Operation

This Section summarises the impacts on beneficial uses with respect to the Desalination Plant operation. Section 14.5 (discharge impact assessment) and Section 14.6 (intake impact assessment) of this WAA provides further detail of the impact assessment for the Desalination Plant operation.

Figure 14-2 conceptualises the interaction of the Marine Structures during the operation of the Desalination Plant. The legend used in Figure 14-1 also applies to this figure.

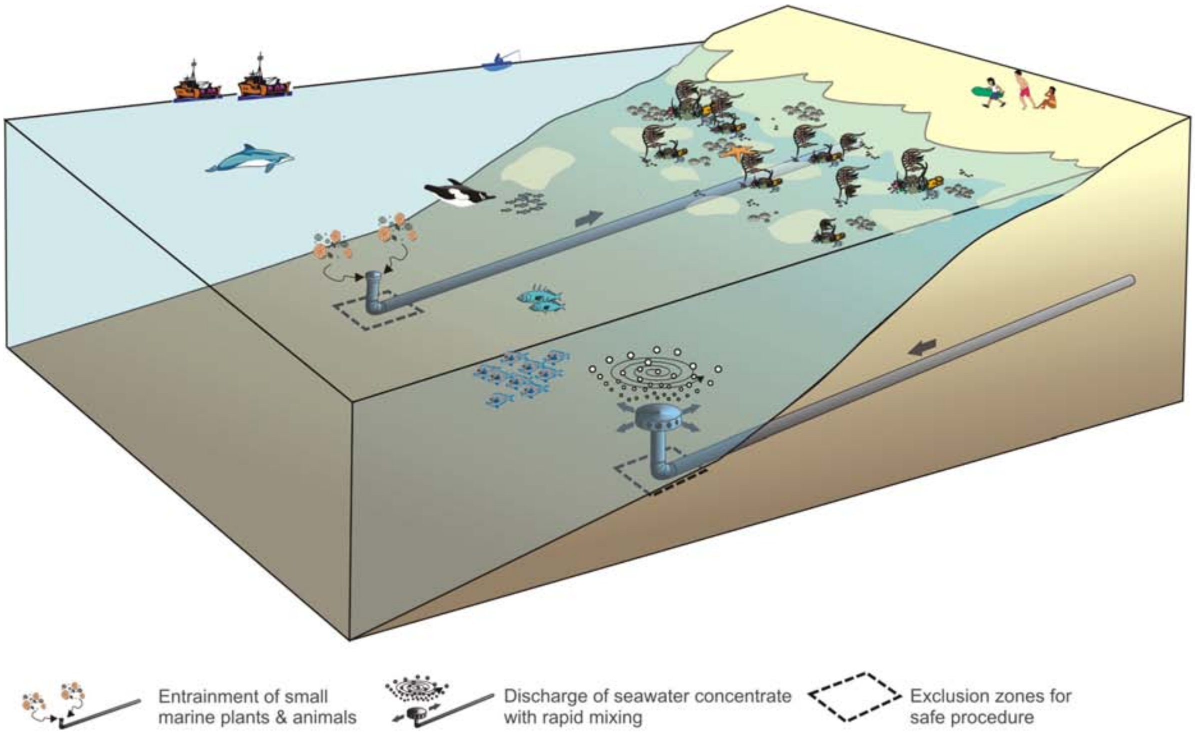


Figure 14-2 Conceptualisation of the operation of the Marine Structures in the Reference Project[21]

Table 14-3 presents a summary of the risks to the environment during operation of the Desalination Plant and the associated combined impacts of the inlet and outlet on beneficial uses (Section 14.7). A discussion of the confidence in these conclusions is provided in Section 14.9.

[21] Note the legend provided for Figure 14-1 also applies to this figure

Table 14-3 Summary assessment of impacts of operation on beneficial uses

Beneficial Use	Impact pathway	Risk	Impact Assessment	Reference
Aquatic Ecosystems that are largely unmodified	Potential toxic impacts from the discharge of concentrate	Ecological impacts translating to reduction in environmental values	Rapid initial dilution of the discharge should reduce the exposure of species to high concentrations for short exposure periods over a relatively short distance Acute toxicity to species is unlikely in the mixing zone (as declared by EPA licence) Chronic toxicity is unlikely but potential for community shift of benthic species inside the mixing zone (as declared by EPA licence)	Section 14.5.5
	Flow on effect from concentrate discharge on ecosystem interaction	Ecological impacts	Water column communities such as Pelagic and Planktonic biota may have short durations of exposure to the concentrate discharge and as such are unlikely to be affected beyond the initial dilution discharge area around the diffuser array Benthic communities (seabed associated communities) will have more variable exposure and therefore will have some impacts beyond the initial dilution discharge area around the diffuser array	Section 14.5.5
	Entrapment and impingement of adult marine organisms and marine vertebrates Entrainment of eggs and larvae and other planktonic species	Ecological impacts	Low risk of entrapment of adult biota expected because of design optimisation Entrainment of eggs, larvae and biota will only reduce a small proportion of the eggs, larvae and biota, which are present in the area	Section 14.6

Beneficial Use	Impact pathway	Risk	Impact Assessment	Reference
	Combined impacts	Ecological impacts	Combined they likely to have a negligible effect on pelagic and planktonic communities	Section 14.7
Primary and Secondary contact recreation	Exclusion zone around the inlet and outlet	Reduced primary contact	As the inlet and outlet will be located away from the shore, exclusion zones around these structures are unlikely to impact most recreation which is based closer inshore and as such no further assessment is required	*Sections 5* and *Section 6* of Maunsell, 2008c
	Impacts on the water quality from potential discharges	Reduces water quality	No water quality impacts outside the mixing zone (as declared by EPA licence)	Sections 14.5.5 and 14.5.11
	Combined impacts	Ecological impacts	Both the inlet and outlet structures are located a safe distance offshore outside of coastal reserve and will not interact with swimming or surfing locations	Section 14.7
Aesthetic enjoyment	No pathway	Visual disturbance	All structures are sub-surface and not visible No impact on beneficial use expected from operation Based on the characteristics of the discharge, it is unlikely the discharge will alter the surface water appearance	*Sections 5* and *Section 6* of Maunsell, 2008c Refer Section 14.5.3
	Combined impacts	Visual disturbance	Both the inlet and outlet structures are located sub-surface and both the structure and plume from a discharge should not be visible Values associated with coastal views will not be compromised	Section 14.7

Beneficial Use	Impact pathway	Risk	Impact Assessment	Reference
Indigenous and Non-indigenous cultural and spiritual values	No pathway	Impact on Indigenous and non-indigenous cultural and spiritual values	No unacceptable impact on beneficial use expected from operation	Refer *Section 10* of Biosis, 2008b
Industrial and commercial use	Potential toxic impacts from the discharge of concentrate and other chemical wastes	Impact to commercial fisheries	Impact assessment as per Aquatic Ecosystems. Low risk to commercially fished species	Section 14.5.5
	Entrainment, entrapment and impingement of adult marine organisms Entrainment, entrapment and impingement of eggs and larvae	Impact to commercial fisheries	Impact assessment as per Aquatic Ecosystems Low risk to commercially fished species	Section 14.6
	Combined impacts	Impact to commercial fisheries	Intake of seawater and discharge is unlikely to reduce commercial fish species numbers to below sustained levels	Section 14.7
Fish, crustacea and molluscs for human consumption	Potential toxic impacts from the discharge of concentrate and other chemical wastes	Discharge of the concentrate should dilute rapidly	Impact assessment as per Aquatic Ecosystems) Low risk to fished species for consumption	Section 14.5.5
	Combined impacts	Reduced stocks	The area avoids the high-relief reef where commercial and recreational fishing takes place	Section 14.7

14.4.4 Desalination Plant Construction

This Section summarises the impacts on beneficial uses with respect to construction. Section 14.8 provides more detail of the impact assessment for construction.

Figure 14-3 conceptualises the expected construction activities to be undertaken for the Marine Structures in the Project area.

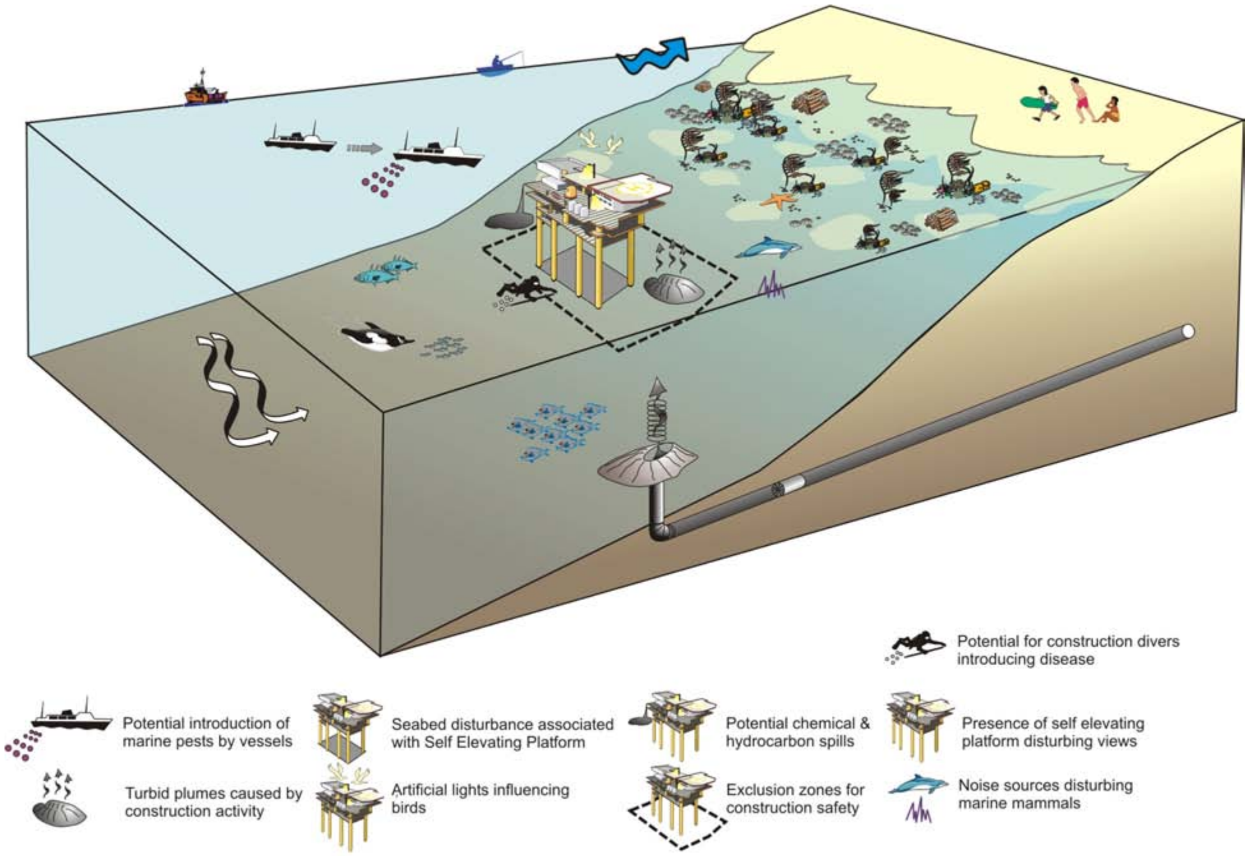


Figure 14-3 Conceptualisation of construction activities for the Marine Structures in the Reference Project[22]

Table 14-4 highlights potential risks to the environment during construction and associated impacts to beneficial uses, and briefly notes the impact assessment findings and where they have been addressed (relevant technical specialist's reports and Sections of this report).

In summary the potential impacts are likely to be of a short duration and the environment is likely to fully recover to pre-construction conditions.

[22] Note the legend provided for Figure 14-1 also applies to this figure.

Table 14-4 Summary assessment of impacts of construction on beneficial uses

Beneficial Use	Impact pathway	Risk	Impact Assessment	Reference
Aquatic Ecosystems that are largely unmodified	▪ Seabed disturbance ▪ Turbid plumes ▪ Vessel movements ▪ Noise ▪ Diver activity ▪ Underwater noise ▪ Chemicals / hydrocarbons	Residual risk will eventuate from seabed disturbance and possible turbid plumes are likely to have localised impacts that are reversible Potential introduction of marine pests and disease Potential impacts from chemical/hydrocarbon spills and loss of drilling fluid Potential noise impact from underwater construction	The risk of long-term systematic impacts on this beneficial use is low All construction impact pathways can be mitigated with suitable management (eg. marine pests, disease and chemical management) Impact in relation to residual risk is considered short term and recoverable	Section 14.8
Primary contact recreation Secondary contact recreation	Exclusion zone for construction	A temporary exclusion zone may interrupt recreational use of the Project area for a limited period	Impacts to the beneficial use are temporary and not widespread - it is therefore not considered further in the WAA	*Section 5* and *Section 6* of Maunsell, 2008c
Aesthetic enjoyment	Presence of barges and vessels	Construction Vessels and localised turbidity from seabed disturbance will adversely affect aesthetic enjoyment, but for a limited period only Reduced beach access	Impacts to the beneficial use are temporary and not widespread - it is therefore not considered further in the WAA Reduced access to Williamsons beach will not occur during construction	*Section 5* and *Section 6* of Maunsell, 2008c Section 14.8

Beneficial Use	Impact pathway	Risk	Impact Assessment	Reference
Indigenous and Non-indigenous cultural and spiritual values	Seabed disturbance	A small area of the seabed will be cleared for the jack-up barge to connect the inlet and outlet structures to the tunnels There is no evidence of shipwrecks in the Project area No areas of Indigenous spiritual significance have been identified for the marine area	No impact on this beneficial use is expected – it is therefore not considered further in the WAA	Refer *Section 10, Section 11* and *Section 12* of Biosis, 2008b
Industrial and commercial use	Exclusion zone	A small exclusion zone will be needed for safe construction of the Marine Structures, which will limit access to the water above the Marine Structures for commercial fishing activities	Impacts to the beneficial use are temporary and not widespread - it is therefore not considered further in the WAA	*Section 5* and *Section 6* of Maunsell, 2008c and *Section 4* and *Section 6* of Essential Economics, 2008
Fish, crustacea and molluscs for human consumption	Exclusion zone	A small exclusion zone will be needed for safe construction of the Marine Structures	Impacts to the beneficial use are temporary and not widespread -it is therefore not considered further in the WAA	*Section 6* of Maunsell, 2008c.
	Hydrocarbon or chemical spills	The risk of long-term systematic impacts on this beneficial use is low. This impact pathway can be mitigated with suitable management	Short term and recoverable	Refer Section 14.8

14.5 Discharge

14.5.1 Relevant clauses of the SEPP (WoV)

The objective of this Section of the report is to address the following key clauses (as noted in Section 14.4, Table 14-1) relevant to the Project marine environment[23].

Clause 10 of the SEPP (WoV), states the beneficial uses of the relevant segment of the environment to be protected. Beneficial uses that may be impacted include (Table 3) *8. Aquatic function;* *9. Primary contact recreation;* *10. Secondary contact recreation;* *11. Industrial and commercial use; and* 12. *Fish, crustacea and molluscs for human consumption.* *Clause 11 of the SEPP (WoV), requires environmental quality objectives be attained to provide a basis for protecting the beneficial uses of the relevant segment of the environment.* *Clause 27 of the SEPP (WoV), states the discharge of wastes and wastewater from licenced and unlicenced premises and activities to surface waters must be managed in accordance with the waste hierarchy, with priority given to avoiding the generation of wastewater*. *Clause 27(4) of the SEPP (WoV), states that the EPA will not approve a wastewater discharge that, according to toxicity tests approved by the EPA, displays acute lethality at the point of discharge or causes chronic impacts outside any declared mixing zone, except that a waste discharge containing a non-persistent substance that degrades within any declared mixing zone may be approved.* *Clause 28 (1) and Clause 30 of the SEPP (WoV), state that a mixing zone may be approved by EPA where it is not practicable to avoid, re-use, recycle and effectively manage wastewater. Within a mixing zone, designated environmental quality objectives do not need to be met and therefore beneficial uses may not be protected.*

14.5.2 Approach

14.5.2.1 Supporting Technical Assessments

The following technical assessments are relevant to this Section:

- *The Desalination Project Marine Biology*, (CEE, 2008), refer *Technical Appendix 31* of the EES;
- *Near-field Numerical Modelling of the Desalination Plant Outlet Plume* (ASR, 2008b), refer *Technical Appendix 30* of the EES;
- *Mid-field Numerical Modelling of the Desalination Plant Outlet Plume* (ASR, 2008c) refer *Technical Appendix 29* of the EES;

[23] Though not necessarily addressed in the following order.

- *Particle Dispersal Modelling Seasonal and spatial variation*, (ASR, 2008d) refer *Technical Appendix 33* of the EES;
- *Assessment of Marine Mammals, Birds and Reptiles for the Desalination Project, Bass Coast, Victoria – Existing Conditions and Impact Assessment Report*, (Biosis, 2008a) refer *Technical Appendix 13* of the EES;
- *Report for the Victorian Desalination Plant – Water and Sediment Quality Assessment* (GHD, 2008g) *refer Technical Appendix 23* of the EES;
- Toxicity Assessment for the Victorian Desalination Project (Hydrobiology and CSIRO, 2008) refer *Technical Appendix 24* of the EES;
- *Desalination Project - Waste Management Assessment* (GHD, 2008e), refer *Technical Appendix 8* of the EES; and
- Technical Discussion Paper, *Characterisation of the Desalination Concentrate Discharge from the Victorian Desalination Plant (*GHD, 2008i), Appendix C of this WAA.

14.5.2.2 Overview

Figure 14-4 shows a risk and impact identification process and more specifically depicts the approach adopted for assessing impacts from the discharge component of operations, with regard to the SEPP (WoV).

The approach adopted by each study is summarised below:

- the water quality study assessed the ambient seawater quality at the location of the intake and outlet for the Project. This assessment allowed the derivation of local water quality trigger values for compounds and elements that will provide the required protection of the relevant Beneficial Uses (SEPP (WoV)). These trigger values were then compared to the estimated concentrate characteristics for the Reference Project to ensure that safe dilutions of the concentrate could be achieved in the Reference Project and protect the relevant beneficial uses in relation to discharge;
- an ecotoxicity assessment was undertaken using concentrate from Perth Seawater Desalination Plant on marine species that were either local or representative of local marine species. Conservative calculations where undertaken to derive safe dilution values to provide 99% protection as required in the SEPP (WoV);
- an assessment of the marine biology and ecology in the Project area was undertaken with a particular focus on benthic, pelagic and planktonic communities. The study identified areas that had higher environmental values and assessed potential impacts on ecology and biology of exposure to concentrate from the Plant (i.e. drawing on ecotoxicity testing results); and
- modelling of the physical behaviour of the concentrate in the receiving water was undertaken to support the water quality, ecotoxicity and marine biology studies. Modelling results also informed the engineering design of the outlets and assessed initial dilution and dispersion of the concentrate in relation to the safe dilution targets identified in the water quality, ecotoxicity and biology studies.

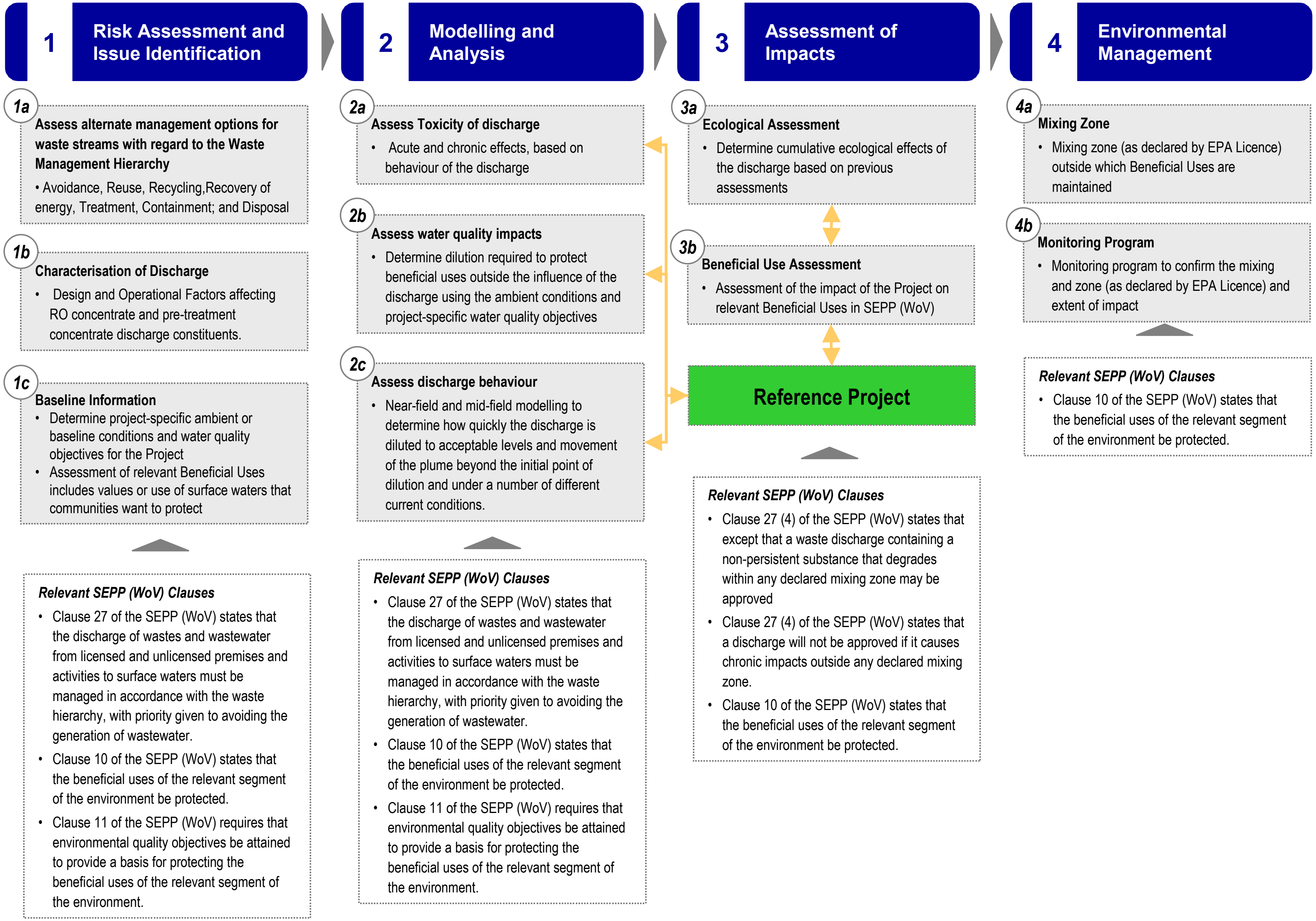


Figure 14-4 Approach for addressing the SEPP

14.5.3 Characterisation of Discharge

The following discharge forms the basis of this assessment:

The RO concentrate is proposed to be discharged to ocean. The waste produced during the pre-treatment stage will be taken to landfill and the supernatant will be returned to the head of the plant, where practicable.

During the commissioning (or recommissioning) process or a rare event such as upset conditions, a portion of the supernatant may be blend into the concentrate stream in a controlled manner and discharged to the ocean. We note that this discharge scenario has been assessed in the ecotoxicity and water quality assessments for the Project and details are provided in Section 14.5.5.

Clause 27 of the SEPP (WoV) states that the discharge of wastes and wastewater from licenced and unlicenced premises and activities to surface waters must be managed in accordance with the waste hierarchy, with priority given to avoiding the generation of wastewater.

Clause 28 (1) states that EPA may approve a discharge where it is not practicable to avoid, re-use, recycle and effectively manage wastewater.

Details of the assessment of management options for pre-treatment waste, undertaken with regard to the waste hierarchy, is included in Section 9 of this WAA and in the Technical Specialists' Report: *Desalination Project* - *Waste Management Assessment* (GHD, 2008e), *Technical Appendix 8* of the EES. A brief assessment of management options with regard to the waste hierarchy for concentrate are included in Appendix A of this WAA. These assessments indicated that a discharge of this nature could not be avoided for the Project, in accordance with the SEPP (WoV) (refer above).

Factors affecting the characteristics of the concentrate discharge are discussed in the *Technical Discussion Paper, Characterisation of the Desalination Concentrate Discharge from the Victorian Desalination Plant (*GHD, 2008i), Appendix C of this WAA. In this paper a mass balance calculation has been presented to support the analysis in this Section of the WAA and are also used to derive water quality dilution estimates for the potential constituents of the discharge.

14.5.4 Siting of Discharge Outlet.

Multibeam surveys and marine ecology assessment of the area immediately adjacent to the desalination plant indicates the presence of high value marine assets (CEE, 2008). These marine assets are biologically diverse, and therefore support a range of beneficial uses, for example, commercial fishing on high relief reef.

As set out by a performance requirement included in Section 17 of this WAA, siting of the outlet would be chosen to:

- ensure that the discharge does not impinge on the Bunurong Marine National Park;
- ensure that the discharge does not impinge on the Kilcunda- Harmers Haven coastal reserve; and
- ensure that the discharge does not impinge on the Project marine sensitivity areas of high relief reef, recognised as the least preferable siting locations (CEE, 2008).

The approach to minimising risks to beneficial uses by this siting is summarised in Table 14-5.

Table 14-5 Risk minimisation through siting the outlet structure in relation to beneficial uses that may be impacted by the discharge

Beneficial use	Risk minimisation to values
Aquatic Ecosystems that are largely unmodified	All high value marine assets and areas of biological diversity (high relief reefs) are avoided.
Primary and secondary contact recreation	The envelope is at a safe distance offshore outside of coastal reserve and will not interact with swimming or surfing locations.
Aesthetic enjoyment	The outlet is located sub-surface and both the structure and plume from a discharge should not be visible. Values associated with coastal views will not be compromised.
Fish, crustacea and molluscs for human consumption	The area avoids the high-relief reef where these species are most prevalent.

It is important to note from this assessment that siting of the outlet structure reduces risk to beneficial uses by the physical outlet location avoiding areas where most beneficial uses apply.

14.5.5 Safe Dilution

14.5.5.1 Overview

Within a discharge environment, constituents are released into the marine environment where they mix with the ambient seawater and return to levels close to normal levels. The concept of "safe dilution" is the point at which concentrations of chemical return to near background or to such a low level that they are not considered to pose a risk to beneficial uses and the required 99% protection as required in the SEPP (WoV).

14.5.5.2 Toxicity Assessment

Clause 27(4) of the SEPP (WoV) states that the EPA will not approve a wastewater discharge that, according to toxicity tests approved by the EPA, displays acute lethality at the point of discharge or causes chronic impacts outside any declared mixing zone, except that a waste discharge containing a non-persistent substance that degrades within any declared mixing zone may be approved.

This sub-section addresses the above Clause by assessing toxicity of the proposed discharge. The method used for toxicity testing meets the requirements of the ANZECC and ARMCANZ guidelines (2000).

Use of Perth Desalination Plant Concentrate to Derive Ecotoxicity 'Safe' Dilution Values

The following describes the rationale for using the Perth Seawater Desalination Plant concentrate as a surrogate for water quality and ecotoxicity assessment and demonstrates the validity of using this data for the Project.

The feed water quality, desalination process and concentrate from the operating Perth desalination plant was compared with the ambient water quality from the Project Site, Reference Project desalination process and estimated concentrate characteristics for the Project to determine if the Perth concentrate was a suitable analogue for analysis.

The assessment showed that:

- differences in seawater composition between Perth and Victorian sampling were few and thought to be insignificant in the context of this assessment;
- differences in process design between the Perth plant and Reference Project have been assessed together with their impact on the waste stream composition data for the Victorian Plant. It was concluded that process differences between both plants could be taken into account and therefore did not prevent meaningful comparison between the sampled and predicted concentrate;
- desk-top mass balance predictions for the Project discharge (for the Reference Project) was compared with waste stream composition data from Perth. Similarities were noted between the mass balance scenario that was closest to that practiced at Perth; and
- it is concluded that if ecotoxicity testing were undertaken on the Reference Project plant discharge (if this form was built), then it is reasonable to expect similar results to those generated by subjecting Victorian marine life to Perth's waste discharge.

Direct Toxicity Assessment

A detailed review of possible process chemicals additives is provided in *Section 3.2* of the Hydrobiology and CSIRO report (2008).

A direct toxicity assessment (DTA) testing program was undertaken for the Project, using samples of salinity adjusted intake water and discharge samples of the Perth Seawater Desalination Plant [24] (refer Hydrobiology and CSIRO 2000). The samples were collected in two separate rounds (April and June, 2008) and represented various waste discharge (or concentrate) scenarios including that available to the Reference Project.

The DTA testing program consisted of exposing a suite of organisms that were either locally relevant to the southern coast of Victoria or generic species where a locally relevant species could not be used to the Perth Seawater Desalination Plant samples. The species and tests used are outlined below:

- Microalgal (*Nitzschia closterium*) 72-hour growth rate test (chronic);
- Sea Urchin (*Heliocidaris tuberculata*) 1-hour fertilisation success test (sub-chronic);
- Sea Urchin (*Heliocidaris tuberculata*) 72-hour larval development test (sub-chronic);
- Scallop (*Mimachlamys asperrima*) 72-hour larval development test (sub-chronic);
- Macroalgal (*Hormosira banksii*) 72-hour germination success test (sub-chronic);
- Amphipod (*Allorchestes compressa*) 96-hour mortality test (acute); and
- Fish (the sand whiting *Sillago ciliata for round one and the Australian bass Macquaria novamaculeata for round two samples*) 96-hour fish imbalance test (acute).

All the above tests were conducted using standardised published protocols adhering to Ecotox Services Australasia and CSIRO internal procedure manuals. The sea urchin fertilisation and larval development tests, Doughboy scallop larval development test and the macroalgal germination test are also NATA accredited. These organisms were selected as: they were representative of marine species of southern Australian waters, they have standardised toxicity protocols available: and available at the time of testing.

[24] It should be noted that different species are typically used in different locations for DTA testing. As such, the results reported here may not be representative of the toxicity effects of the brine or concentrate discharge from the Perth Seawater Desalination Plant on marine organisms of Cockburn Sound.

The selected species meet the minimum data requirements of the Australian and New Zealand water quality guidelines (ANZECC/ARMCANZ (2000)) necessary to conduct DTA and to derive safe dilution factors. The safe dilution factors were calculated using ANZECC/ARMCANZ (2000) methods.

Toxicity tests that exposed the test organisms for short (acute) and long (chronic) exposures were conducted. Chronic toxicity data should be used to derive safe dilution factors for discharges. Therefore, acute to chronic ratios (ACR) are needed to convert the acute toxicity data to estimates of chronic toxicity. The largest ACR obtained from the literature was 1.9. In order to provide conservative (environmentally protective) estimates of toxicity and the size of the safe dilution factor required, the concentrations that caused a 10% toxic effect (EC10 data), rather than the usual 50% effect, were divided by an ACR of 2.5.

Under the terms of the SEPP (WoV) 99% of endemic marine species should be protected. Using EC10 data and an ACR of 2.5 the highest safe dilution factor determined as necessary to protect 99% of marine species in the Reference Project was 29:1. Given the target dilution of the diffusers in the Reference Project, there should be no effect to marine organisms (outside of the designated mixing zone, as declared by EPA licence) and the protection requirements of the SEPP are met. Given this protection requirement is met, the beneficial use of aquatic ecosystems is also maintained.

The results for tests are provided in *Section 5.2* of Hydrobiology and CSIRO (2008).

The following conclusions were drawn from the results of the ecotoxicity assessment, which demonstrate compliance with Clause 27 of the SEPP (WoV):

- the biological effects seen in toxicity testing of Desalination Plant discharge are attributed primarily but not exclusively, to salinity as the samples for the various discharge options were significantly difference to the salinity adjusted intake water samples;
- in order to protect 99% of endemic Victorian marine species from sub-lethal chronic toxic effects the various waste discharge options assessed need to be diluted to and better than 29:1; and
- taking into account the observed temporal variation in toxicity of Desalination Plant discharge samples a dilution factor of 29 or better is needed to protect 99% of endemic Victorian marine species from sub-lethal chronic toxic effects and the aquatic ecosystem beneficial use will be maintained.

In respect to the above assessment, the following matter is relevant to how toxicity of the seawater concentrate has been interpreted under the SEPP (WoV).

Salinity is defined as a physico-chemical stressor and not a toxicant in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000). It is considered that salinity outside (either higher or lower than) the tolerance range of organisms causes osmoregulatory stress. Salinity can also be a modifier of toxicity – in that it generally decreases the toxicity of other toxicants (Chapman et al., 2001), such as some metals and organics by decreasing their solubility (i.e. the 'salting out effect').

Clause 27 (4) of the SEPP (WoV) states that except that a waste discharge containing a non-persistent substance that degrades within any declared mixing zone may be approved.

Compliance with this Clause is demonstrated as the primary component of the concentrate is a natural substance that when released as a seawater concentrate will disperse until the close to ambient salinity of the receiving water body is reached. This process of dispersion is analogous to the process of degradation in which the concentration of a compound decreases over time to the background concentration.

There are several important points to provide context when considering the fate and effect of the desalination process chemical and concentrate for the Project and they are:

- initial dilution from the outlet is rapid in the order of seconds to minutes and therefore exposure times to marine biota are relatively short (ASR 2008b);
- it is well established in ecotoxicology that the magnitude of any adverse effect on organisms, be they osmoregulatory or toxic, is a function of both the length of exposure and concentration of the waste stream or toxicant. The nature of this relationship is that the shorter the duration of the exposure the higher the concentration needs to be to cause adverse effects and conversely the longer the duration the lower the concentration needs to be to cause the same adverse effect (e.g. Connell, 1984; Newman, 1998); and
- given these short exposure times, it would be highly unlikely for acute toxicity to occur within the mixing zone (as declared by EPA licence).

14.5.5.3 Water Quality

Ambient Conditions

Clause 11 of the SEPP (WoV) requires that environmental quality objectives be attained to provide a basis for protecting the beneficial uses of the relevant segment of the environment.

Clause 11 of the SEPP (WoV) indicates that in order to protect beneficial uses, a level of water 'health' needs to be maintained for the marine environment. That is, the water needs to be free of pollutants (e.g. nutrients, sediment, salt and toxicants) at levels that may render the water unsuitable for beneficial uses, in this case, open ocean ecosystems that are largely unmodified.

The *Report for the Victorian Desalination Plant – Water and Sediment Quality Assessment* (GHD, 2008g) details the water quality monitoring program developed to provide information for the purposes of Project process design and impact assessment.

The broad intent of the program was to characterise the chemical composition of the seawater, identify seasonal trends, potential contamination sources and derive local water quality trigger values. The monitoring program included a broad range of parameters to satisfy both design and environmental purposes.

The ambient water quality conditions were calculated as the median (50^{th} percentile) of the data collected and are included in Table 14-6 of this WAA.

The background data currently available at the time of preparing this WAA covers the period from June 2007 to May 2008 with an average of 2 rounds of sampling each month. A complete set of data including seasonal variation is available for all parameters except pH and TSS satisfying SEPP (WoV) requirements. However, with 12 measurements for pH over May/Dec and 19 measurements for TSS collected over July/May, and little evidence of seasonal variation it is considered that the data is representative and the intent of the SEPP WoV requirements is believed to be met. For all other parameters, the data covers seasonal variations and the SEPP WoV requirements are satisfied (refer Table 14-6) of this WAA.

Determination of project-specific environmental quality objectives (or 'trigger values')

> *Clause 11 SEPP WoV defines environmental quality objectives as:*
>
> *" The concentration or level of an indicator that describes the environmental quality required to protect designated beneficial uses"*
>
> *Part VIII, Schedule A, A1 of the SEPP WoV states:*
>
> *"(1) Unless specific objectives are described in the Policy, the environmental quality objectives are those values specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) (the Guidelines). Unless otherwise stated, the level of ecosystem protection in the Guidelines that needs to be used to determine the objective is:*
>
> *(a) 99% for largely unmodified aquatic ecosystems;*
>
> *(b) 95% for slightly to moderately modified aquatic ecosystems;*
>
> *(b) 90% for highly modified aquatic ecosystems.*
>
> *The ANZECC & ARMCANZ Guidelines use the concept of 'trigger values' which are defined as:*
>
> *"… the concentrations (or loads) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem specific investigations or implementation of management/remedial actions." (ANZECC & ARMCANZ, Volume 1, Appendix 1).*
>
> *As defined in table 3.4.1 denoted as level of ecosystem protection (% species)."*
>
> *(5) For the purposes of Tables A1 to A6, where referenced:*
>
> *(b) median and $75^{th}/25^{th}$ percentiles need to be calculated from a minimum of 11 data points collected from monthly monitoring over one year.*

For the purposes of this assessment, the term "environmental quality objectives" and the associated values as defined by the SEPP (WoV) are considered as equivalent to "trigger values" as defined by the ANZECC & ARMCANZ Guidelines. Therefore the term trigger value is interchangeable with environmental quality objectives. Trigger values are the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further investigation or management actions. In the context of assessing the impact on beneficial uses, it is valid to say if the water quality parameter values are less than the corresponding trigger values (environmental quality objectives) then by definition in the SEPP (WoV), they are maintained.

The location of the outlet of the Desalination Project falls into the 'open coast' segment of the SEPP (WoV) and 'marine environment' of the ANZECC & ARMCANZ Guidelines (2000) and, as a largely unmodified aquatic ecosystem, requires 99% ecosystem protection. Within these guidelines the location of the intake and outlet structures of the Desalination Plant fall within the 'marine environment' section.

Specific objectives were provided in the SEPP (WoV) for nutrients and some of the main physiochemical compounds. However in some instances the SEPP (WoV) draws trigger values from the ANZECC & ARMCANZ Guidelines. The ANZECC & ARMCANZ Guidelines contain regional trigger values calculated for some physical and chemical stressors (ANZECC & ARMCANZ, 2000, *Table 3.3.2 and 3.3.3*). For toxicants two types of triggers were developed, high reliability trigger values and low reliability trigger values. These are defined as follows:

- High Reliability Trigger Value from an adequate set of chronic toxicity data:

  "Trigger values that have a higher degree of confidence because they are from an adequate set of chronic toxicity data".

- Low Reliability Trigger Value:

  "Trigger values that have a low degree of confidence because they are derived from an incomplete data set. They are derived using either assessment factors or from modelled data using statistical method. They should only be used as interim indicative working levels" (ANZECC & ARMCANZ, Volume 1, Appendix 1).

Where available, only high reliability trigger values were considered for toxicants. When high reliability triggers are not provided, low reliability triggers are considered. Wherever possible low reliability triggers will be replaced by locally derived triggers where there is sufficient data for calculations.

In determining the default trigger values, the environmental quality objectives for the Open Coast segment as listed in the SEPP (WoV) were considered in the first instance. Where no SEPP (WoV) environmental quality objectives were available, the default trigger values for marine ecosystems and toxicants in marine waters provided in the ANZECC & ARMCANZ Guidelines were considered.

The local trigger values were derived on the basis of both the SEPP (WoV) and the ANZECC & ARMCANZ Guidelines both of which provide different, though similar information on the procedure to be followed. The procedure applied for defining the local Trigger Values was as follows:

- for physicochemical parameters in the background seawater:
  - annual minimum and maximum for dissolved oxygen (SEPP (WoV), Part VIII, Schedule A, A1, Table A5);
  - annual minimum and maximum for salinity, pH and temperature based on the recommendation for dissolved oxygen;
  - 25th percentile for PAR Attenuation (SEPP (WoV), Part VIII, Schedule A, A1, Table A5); and
  - 75th percentile for total suspended solids and turbidity (SEPP (WoV), Part VIII, Schedule A, A1, Table A5).
- for nutrients (nitrogen and phosphorus) in the background seawater: 75th percentile (SEPP (WoV), Part VIII, Schedule A, A1, Table A5), this was also applied for carbon and BOD;
- for identified toxicants: the maximum value (SEPP (WoV), Part VIII, Schedule A, Table A4); and
- for other compounds with no default high reliability trigger value: the maximum value of the dataset was selected to maintain a coherent approach with the SEPP (WoV) recommendation for toxicants.

The adopted trigger values are included in Table 14-6 of this WAA.

A more detailed review of the impact on water quality from the concentrate (that includes chemical additives) is provided in Section 4.6 of *Report for the Victorian Desalination Plant – Water Quality and Sediment Assessment* (GHD, 2008g).

It is important to note that this may not be the case for discharge characteristics that vary from the Reference Project. Dilution requirements for a discharge of different quality will need to be assessed and compared to the trigger values developed for this Project to ensure that the required dilutions can be achieved outside of a mixing zone (as declared by EPA licence) (refer Table 14-6), in accordance with Clause 10 of the SEPP (WoV).

Table 14-6 Comparison between ambient Project area seawater, discharge calculations

	Units	Wonthaggi Ambient	Adopted Trigger Values	MASS BALANCE ESTIMATION: RO Concentrate and Supernatant to Ocean Estimated Discharge	MASS BALANCE ESTIMATION: RO Concentrate to Ocean and Supernatant to head of the plant Estimated Discharge	DILUTIONS FROM MASS BALANCE ESTIMATION: RO Concentrate and Supernatant to Ocean Estimated Discharge	DILUTIONS FROM MASS BALANCE ESTIMATION: RO Concentrate to Ocean and Supernatant to head of the plant Estimated Discharge
		(a)(b)(d)	(b)(c)(d)			(e)	(e)
Physicochemical Parameters							
Salinity (calculated from EC)		35.7	36.1			NA	NA
TSS (0.45 µm)	mg/L	1.3	2.0	0.1	0.0	0.0	0.0
TDS (by analysis)	g/L	38.6	41.6			0.0	0.0
TDS (by calculation from ions)	g/L	36.9	40.6	61	64	5.4	6.4
Total Alkalinity as $CaCO_3$	mgCaCO3/L	121	132			0.0	0.0
Major Ions							
Chloride	mg/L	20,200	20,940	33,200	35,100	16.6	19.1
Sulfate	mg/L	2,910	3,130	4,800	5,100	7.6	9.0
Bromide	mg/L	62	83	100	110	0.8	1.3
Fluoride	mg/L	0.9	1.1	1.5	1.6	1.9	2.3
Calcium	mg/L	420	460	690	730	5.8	6.8
Magnesium	mg/L	1,400	1,550	2,300	2,400	5.0	5.7
Sodium	mg/L	11,430	12,030	18,800	19,800	11.3	13.0
Potassium	mg/L	490	540	800	850	5.2	6.2
Total Barium	µg/L	6	7.3	9.9	10.4	2.0	2.4
Total Boron	mg/L	4.4	5.4	7.2	7.6	1.8	2.2
Total Strontium	mg/L	7.8	11	13	14	0.6	0.8
Total Metals							
Aluminium	µg/L	13.8	57.7	22	22	0.0	0.0
Iron	µg/L	16.9	71.8	72	30	0.0	0.0
Arsenic Total	µg/L	1.6	2.1	2.0	1.4	0.0	0.0
Cadmium	µg/L	0.1	0.7	0.2	0.1	0.0	0.0
Chromium Total	µg/L	0.23	0.47	0.3	0.3	0.0	0.0
Copper	µg/L	0.25	0.3	0.2	0.2	0.0	0.0
Lead	µg/L	0.1	2.2	0.3	0.3	0.0	0.0
Manganese	µg/L	0.58	80	0.9	0.8	0.0	0.0
Mercury	µg/L	0.05	0.1	0.13	0.1	0.5	0.6
Molybdenum	µg/L	11.3	16.4	18	16	0.2	0.0
Nickel	µg/L	0.18	7	0.28	0.25	0.0	0.0
Tin	µg/L	1.75	10	2.8	2.7	0.0	0.0
Zinc	µg/L	1.75	7	2.7	2.3	0.0	0.0
Nutrients							
Ammonia	mgN/L	0.009	0.015	0.015	0.016	0.0	0.1
Nitrite + Nitrate	mgN/L	0.006	0.009	0.010	0.010	0.3	0.5
Total Nitrogen	mgN/L	0.18	0.20	0.3	0.3	4.8	5.6
Soluble Reactive Phosphorus	mgP/L	0.004	0.01	0.005	0.003	0.0	0.0
Total Phosphorus	mgP/L	0.013	0.025	0.02	0.02	0.0	0.0
Organic Compounds							
Total Organic Carbon	mg/L	1.3	1.5	2.1	2.3	3.2	3.8

Notes to Table:

a) Ambient Project area water taken as median of Project data set as presented in this report

b) Salinity estimated by calculation from electrical conductivity (EC) - Not used for calculation of dilutions owing to issues with the ability to compare the EC of different compositions

c) Adoption of Trigger Values described in this report

d) TDS trigger value and ambient is not drawn from values presented here, rather the maximum and median of the TDS results in the Project data set respectively

e) Dilution value is the parts of ambient Project area seawater per unit of discharge to meet the adopted trigger values. Where a result returned a negative dilution value, a dilution of zero was recorded, meaning that the estimate was less than the trigger value.
It should be noted that the trigger value for salinity is 36.1 and is based on the maximum salinity value recorded. Salinity is estimated by calculation from electrical conductivity (EC) and is not used for calculation of dilutions owing to issues with the ability to compare the EC of different compositions. This salinity value is likely to be exceeded, however in assessing this risk, results from the ecotoxicity assessment show that values of 1 above background will meet the requirements of the SEPP (WoV) and maintain beneficial uses outside the mixing zone.

14.5.5.4 Marine Ecology

Overview

Ecological impacts of the discharge are presented as a multidisciplinary overview of marine biological characteristics and ecological processes using the aforementioned testing, modelling and studies. The findings in this Section are sourced from the report *Marine Biology – Existing Conditions and Impact Assessment* (CEE, 2008), included in *Technical Appendix 31* of the EES.

Sections 4 through 12 of CEE (2008) outline the process by which ecological communities in the Project area were characterised. Details of the factors affecting marine life and notable species present are provided for a number of different communities namely, intertidal, subtidal, reef and pelagic. These existing marine life assessments provide the basis for cumulative impact assessment.

The following Section considers potential ecological effects in relation to marine biota most likely to be affected by the discharge, cumulative impacts and considerations for a mixing zone.

Characteristics of exposure and species most likely to be affected

The near-field and mid-field modelling demonstrated that:

- near field and mid field dilution (and, therefore, salinity) are affected by the strength of ambient tidal and oceanographic currents;
- higher dilutions will tend to occur in periods of high current speeds (predominantly spring season);
- lowest dilution will occur in calm periods (i.e. low current speeds); and
- wave events can act to significantly increase the level of dilution achieved.

Additionally, tidal current fluctuations will cause the zones of peak salinity to vary in location. Hence, whilst different areas will experience elevated salinity, the effect will be intermittent in the mid-field.

Biota on the seabed close to the discharge will experience higher ranges in salinity concentrations and more variable salinity than those further from the discharge. Biota on the boundary of the zone affected by elevated salinity may experience prolonged periods of relatively low elevations in salinity i.e. 1 psu above background (CEE, 2008).

Planktonic species, on the other hand, drift into the discharge field, and then travel with the diluting concentrate stream, which returns to background concentration relatively rapidly (refer Figure 14-5). Hence, exposure of plankton to high concentrate concentrations is relatively short - in this case minutes as demonstrated by near-field modelling. After a short duration of exposure, plankton continue on their way, beyond the influence of the discharge (CEE, 2008).

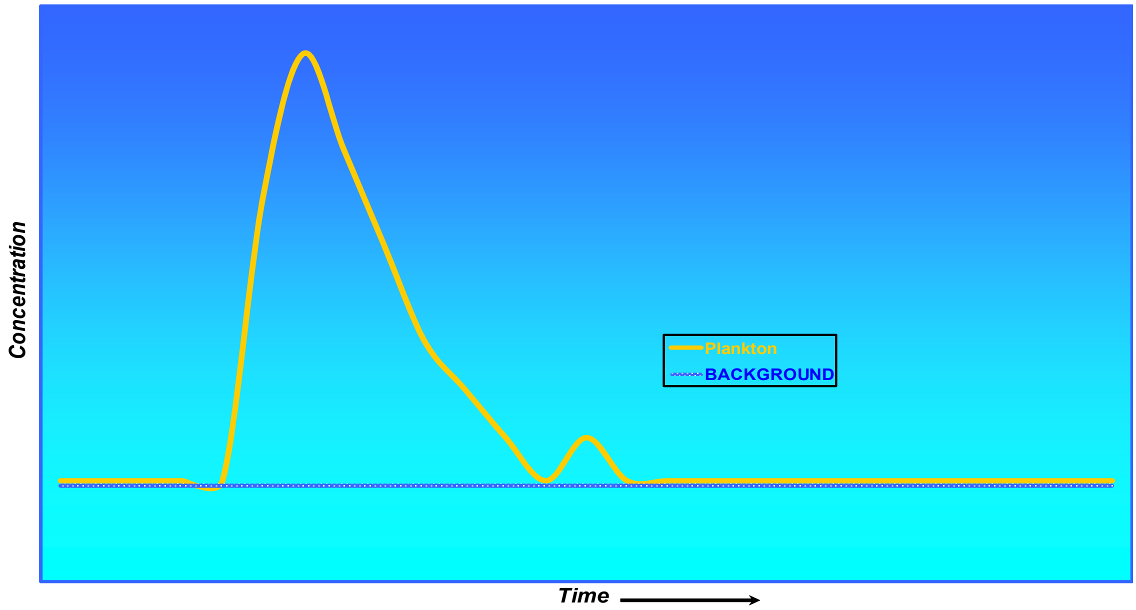


Figure 14-5 Effluent exposure concept for planktonic species

Pelagic species have shorter durations unless they choose to remain in the concentrate field (CEE, 2008).

Impacts of the discharge are therefore mostly restricted to benthic species. The effects of long-term exposure to elevated salinity are most likely to be integrated by sessile seabed biota in the region of the outfall discharge (CEE, 2008).

Salinity in the area will vary according to oceanographic conditions and the area of seabed over which salinity is effectively increased above ambient is relatively small. However, a conservative interpretation of the chronic ecotoxicity tests indicate that some biological processes may be space affected by concentrations as low as 1 psu above ambient (at a 1:30 dilution). Indirect effects may occur as a result of competitive ecological interactions between species disadvantaged, advantaged and unaffected by exposure to low and variable concentrations of concentrate. Long term changes in community structure have occurred in marine communities close to wastewater discharges elsewhere in Victoria. At Boags Rocks for example, the effect of the wastewater discharge extended some kilometres along the shoreline over a period of 10 years (Brown et al 1990). Hence, it is possible that some effects may be expressed in changes to the species composition and abundance of the benthic marine community due to the decreased ability of some biota and species to ecologically compete with others, or to avoid predation as a consequence of long-term, small changes to the salinity regime of the area around the outlet (CEE, 2008).

The available information and ecotoxicity tests indicate that biota are likely to be resilient to short term exposure to high salinity and longer term low salinity variations. The conservative estimate of tolerance from the ecotoxicity tests was that no chronic effect was expected on biota at salinities less than 1 psu above the ambient salinity. Spatial salinity variations of up to 2 psu have been measured offshore from Phillip Island in January (Hoedt and Dimmlich 1995). Hence, the use of 1 psu as a guide to determining an extent of possible chronic effect on marine biological community is a reasonable guideline (CEE, 2008).

Seasonal and spatial factors

Spring is generally considered to be the period of highest biological activity. As discussed in CEE (2008), dilution of the concentrate discharge is likely to be seasonally influenced, with higher dilution more likely to occur during energetic periods (e.g. spring). Overall therefore, the occurrence of higher currents in conjunction with wind and waves during the general period of peak biological activity will tend to mitigate the extent and potential effects of elevated salinity on many sensitive life stages in the region of the discharge (CEE, 2008). A literature review has shown some species have tolerance to elevated salinity levels (Hydrobiology and CSIRO 2008).

Mid field modelling suggests that discharge-induced recirculation currents may also occur in periods of prolonged low currents (refer Figure 14-6 of this WAA). Such currents would be highly variable in strength, with the highest current strengths evident on the seabed (refer left panel of Figure 14-6). Associated currents are estimated to be less than 0.2 m/s within the area affected by recirculation, with vertical currents as low as 1 to 20 mm/s. Currents were predicted to be less than 0.08 m/s beyond 500 m shoreward and longshore from the outfall. The stronger currents (up to 0.2 m/s) are shown to extend offshore from the discharge along the seabed. Salinity within the recirculation area is believed to be generally below 1 psu, except within the proximity of the point of discharge.

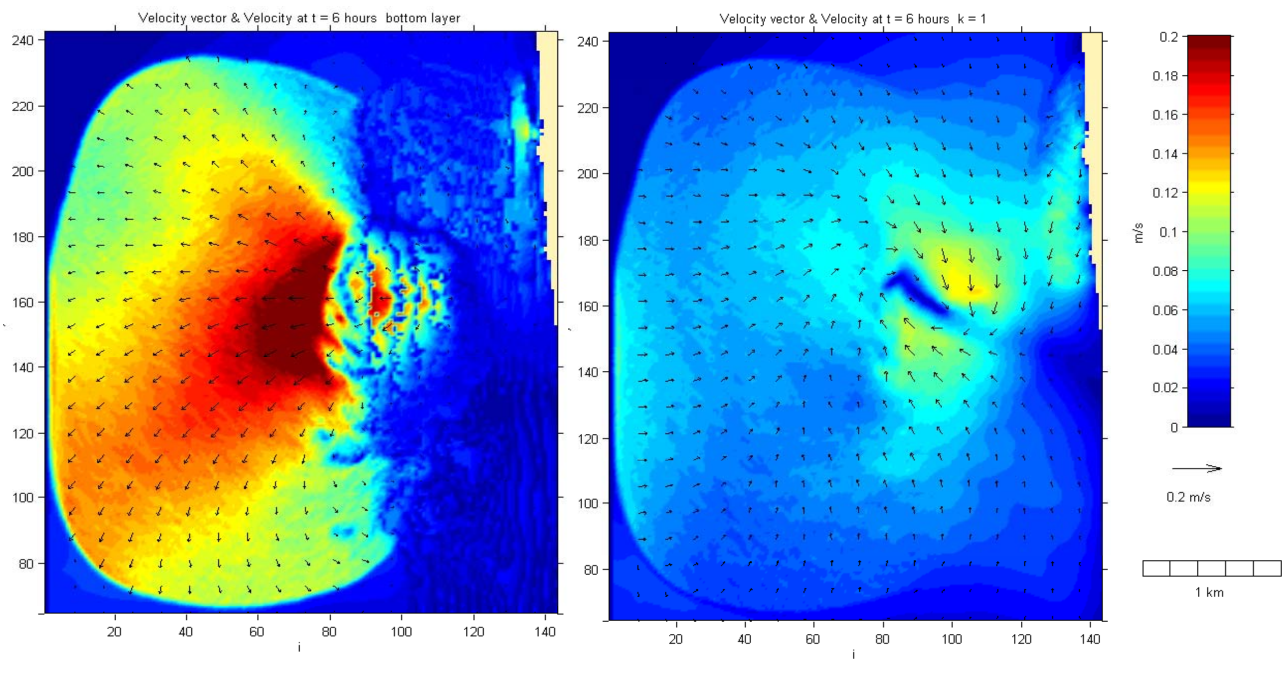


Figure 14-6 Induced recirculation pattern modelled during low currents (at seabed (at left) and surface (at right)

Transport of passive larvae in the region during this period would be low due to low regional currents. In addition, larvae outside the area of recirculation will not be affected (CEE, 2008).

Most non-passive larvae are likely to be unaffected by the discharge-induced recirculation currents (<0.2 m/s), which are within the range of average currents that are experienced on many parts of the Victorian coast beyond Kilcunda and Cape Paterson. Hence, non-passive larvae are likely to be capable of maintaining their preferred pathways over most of the recirculation area, particularly close to the seabed in areas of high relief reef where reef outcrops and kelp reduce currents (CEE, 2008).

Short duration only passive larvae in the vicinity of the discharge are those that are most likely to be affected by these recirculation currents. These may be transported offshore or onshore depending on their position in the water column and the duration and strength of the recirculation pattern (CEE, 2008).

14.5.6 Hydrodynamic Modelling

Hydrodynamic modelling was undertaken to assess the behaviour of the concentrate discharge over two spatial scales to assess the geographical extent and the time taken for the salinity concentration to return to near ambient conditions. These two studies are detailed in ASR (2008b and 2008c). A brief summary of these studies is as follows:

- near-field modelling was undertaken to assess initial dilution of the discharge on exit from the diffuser. Modelling at this scale indicates how quickly a discharge is diluted in the water column adjacent to the diffuser, relative to ambient levels (refer Figure 14-9 of this WAA). The quicker this happens, the less exposure of marine biota to the high concentration plume; and
- mid-field modelling was undertaken to track plume dispersion beyond the near field (i.e. beyond the initial point of dilution) under a number of different ambient current strengths. This assessment provides an understanding of how the plume will behave (dilute) in the vicinity of the seabed as it moves away from the diffuser.

The results of the near-field modelling for the Reference Project were used as inputs to the ASR 3DD hydrodynamic numerical model to forecast the impact of the brine or concentrate over the mid-field (ASR 2008c).

A summary of the calibration and validation of modelling is included in *Section 4.1.1* of *Chapter 4, Volume 2* of the EES.

14.5.6.1 Near-field Modelling

The numerical model *Visjet* (University of Hong Kong diffusion numerical model) was adopted to simulate the near-field diffusion of a high-salinity (65 ppt) effluent stream being discharged in to seawater with an ambient salinity of 35 ppt (ASR, 2008b). Several diffuser designs were modelled as part of the iterative design process. The behaviour of the discharge in the near field was determined by modelling a range of design options constrained by the following:

- the near field plume should not strike the sea surface. This is addressed by adjusting nozzle diameter and angle in order to generate the most appropriate discharge velocity. It was found that in order to keep the plume from reaching the water surface, the discharge velocity from each jet in a discharge rosette should be lower than 6 m/s for a 60^{o} discharge angle and lower than 7 m/s for a 50^{o} discharge angle for a rosette located at 16.5 m depth. Higher discharge velocities provide better dilution, but may lead to an interaction between the plume and the water surface. Higher discharge velocities are possible in deeper water; and

- an adopted 50:1 engineering design dilution target[25].

After a number of iterations, the Reference Project at 200 GL per year includes 6 diffuser heads (each consisting of a 4-nozzle rosette with a 3 m head radius), a spacing of 50 m between each and a cross-shore oriented outfall starting at the 20 m isobath. Discussion of the outlet diffuser design is included in Section 6 of this WAA.

The Reference Project was selected on the basis of a number of factors, including:

- eco-toxicology;
- ecological impacts;
- modelling results; and
- cost.

The Reference Project is capable of meeting the Performance Requirements, including dilution targets, as set out in Section 14.5.8 of this WAA, and as discussed in Section 14.5.10 of this WAA, also meets the policy objectives and targets.

The behaviour of concentrate jets as they discharge from the diffuser nozzles is indicated in Figure 14-7 of this WAA. The figure illustrates that the jet path as it is 'squirted' from the nozzles at an angle upward into the water column. The velocity rapidly decreases as the jet entrains surrounding seawater, and the jet cone enlarges. The near field dilution (also referred to as the engineering dilution) occurs in this zone.

[25] Note that this is separate to the issue of accumulated salinity concentrations on the seabed, as discussed with respect to the mid-field modelling.

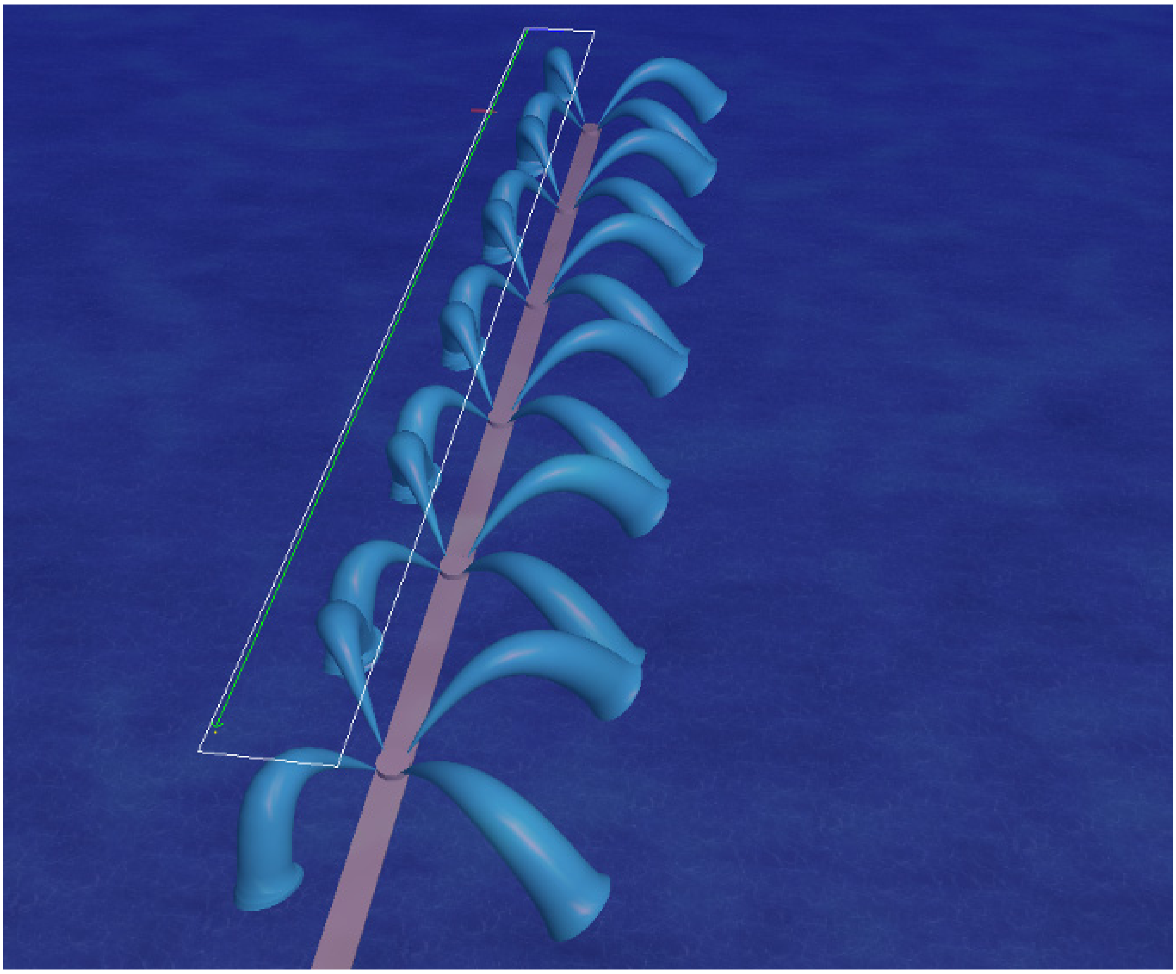
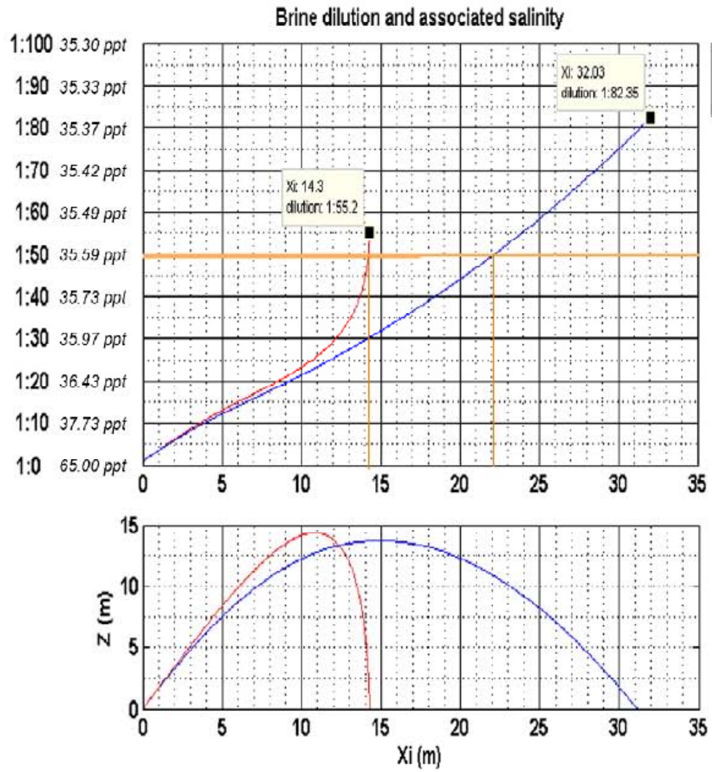
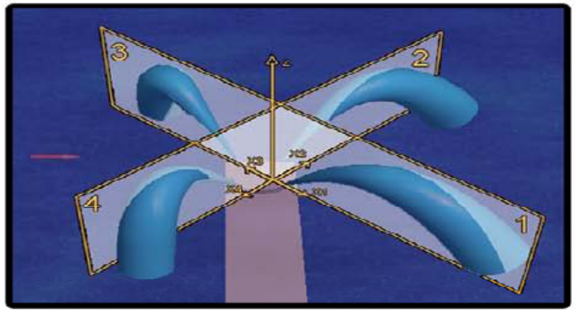


Figure 14-7 The Desalination Plant Reference Project outlet design: a 6-rosette cross-shore oriented outlet with 50 m rosette spacing, 3 m diffuser head radius and located at the 20 m isobath. Note: other diffuser designs are possible and the Project Company may adopt a different diffuser design.

The coordinates of the plume were extracted from Visjet using a curvilinear coordinate system. Velocity and dilution at each point along the plume trajectory were then interpolated from the model. The results were plotted as dilution versus distance in Figure 14-8 of this WAA and as salinity versus time in Figure 14-9 of this WAA. The highest concentrate discharge salinities (at the point of discharge equal to 65 ppt) quickly decrease to around 40 ppt in about 2 seconds. They reduce further to within 1 ppt of background in 60-100 seconds. These figures illustrate the high levels of dilution achieved in the turbulent (jet) mixing zone. Mid-field modelling shows that the plume would then move towards the seabed and predicts the likely behaviour of the plume beyond the near-field.





Dilution	0	20	40	50	60	80	100
Calculated salinity of waste steam (ppt)	65	36.43	35.73	35.59	35.49	35.37	35.30
Modelled time from discharge (sec)	0	4.74	22.87	31.47	40.89	65.15	91.61
Maximum modelled horizontal distance from a nozzle on a rosette (0.04 m/s Current) in meters	0	9.28	18.46	22.19	25.57	31.43	x

Dilution	0	20	40	50	60	80	100
Calculated salinity of waste steam (ppt)	65	36.43	35.73	35.59	35.49	35.37	35.30
Modelled time from discharge (sec)	0	4.86	27.14	37.62	50.2	120.1	262.9
Maximum modelled horizontal distance from a nozzle on a rosette (0.04 m/s Current) in meters	0	8.56	13.71	14.24	x	x	x

Figure 14-8 Salinity and time along jet trajectories, 20 m water depth for each of the four rosettes (ASR, 2008b).

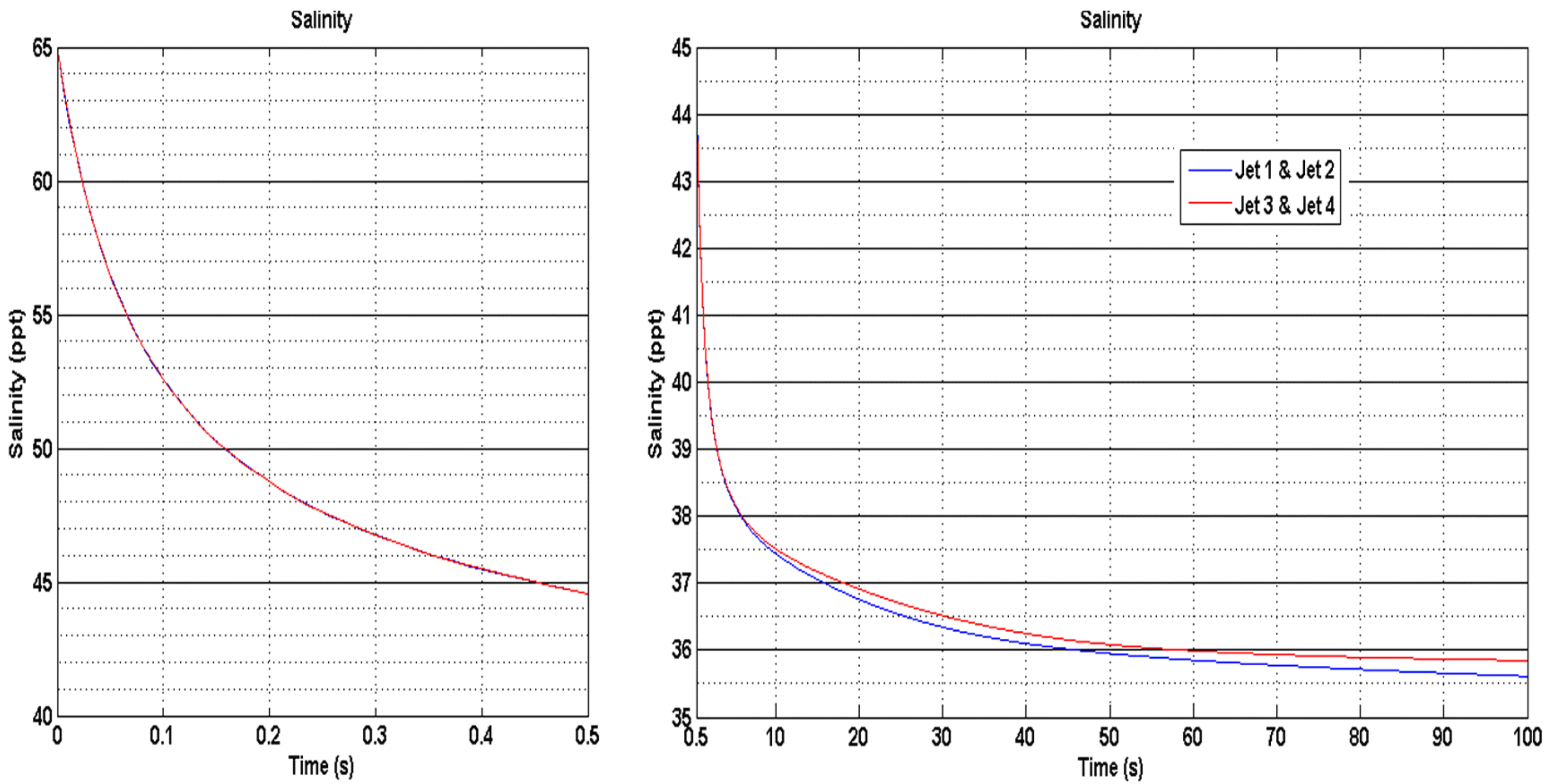


Figure 14-9 Salinity versus time exposure for each jet of a single rosette

In summary:

- the near field modelling indicated that for the selected design option, the 65 ppt discharge salinity decreased to 40 ppt in approximately 2 seconds. These values fell to within 1 ppt of background in 60-100 seconds. Similar results were found for cases with the diffusers located at either the 15 m or 20 m isobaths. These results apply to the water column in the vicinity of the diffuser;
- the near-field modelling was also informative for design optimisation that can be undertaken to allow safe dilution factors;
- mid field modelling by ASR was then completed, based on an ambient salinity of 35.5 psu. However, as discussed in Section 14.5.6.2, ambient currents could lead to transport of the dilute discharge back toward the region of the diffuser in some circumstances, which would reduce the efficiency of the concentrate dilution process at or near the seabed. Figures provided previously suggest the potential for merging of plumes would be associated with a sub set of ambient current conditions only, and potentially at a point where significant dilution has already occurred. The design process will need to confirm whether this occurrence requires any modification of design; and
- generally, pipeline style diffusers can be engineered to meet near and mid field safe dilution requirements. Any of the following elements of the diffuser could be varied (not necessarily in isolation) to create a Variation. For example: water depth at the nozzles, number and diameter of the nozzles, number of rosettes, number of nozzles per rosette, vertical angle of the nozzles, exit velocity, spacing of the rosettes, orientation of the rosettes and / or a pipeline diffuser format. Such variations in the diffuser design could be detailed to comply with the safe dilution and mixing zone requirements as outlined in this WAA.

14.5.6.2 Mid-Field Modelling

Mid field modelling takes into account larger scale ocean currents and potential for the discharged concentrate to remix with itself as in some circumstances where currents reverse and water from near the seabed with slightly elevated salinity is potentially re-entrained into the jet flow from the diffuser.

For the modelling, a fine-scale grid (25 m cell-size) was developed using multi-beam measurements and bathymetric surveys. Model runs (11 steady state scenarios) were undertaken with ASR's Model 3DD in 3-dimensional, density-stratified mode, using the high-level Lagrangian particle model (refer ASR, 2008c). A summary of the calibration and validation of modelling is included in *Section 4.1.1* of *Chapter 4, Volume 2* of the EES.

The mid-field modelling undertaken is based on the selection of 11 steady state scenarios using the discharge Reference Project with results for current speeds ranging from 0.02 to 0.3 m/s. The selected scenarios represent a reasonable spread of currents but only consider one high energy (wave) condition.

The scenarios do not provide a statistical assessment of time varying plume behaviour. A statement as to the conservatism associated with use of these steady state results is provided in Section 14.9 of this WAA.

The mid field modelling used the following project-specific inputs:

- ocean currents in the Project area are mostly parallel to shore and are generally tidal, with:
  - ebb (falling) tides flow to the southeast; and
  - flood (rising) tides flow to the northwest.
- regional winds produce net drift:
  - Strongest net currents occur generally in spring and flow to the southeast;
  - Summer south-easterly winds can result in net current flow to the northwest; and
  - Lowest net currents are likely to occur during periods of calm in autumn.

Several scenarios were modelled, which primarily differed with respect to ambient currents, to simulate varying conditions in the ocean environment (Table 14-7).

Table 14-7 Current parameter values and wave climate for modelling scenarios for the seawater concentrate plume

Modelling scenario	Current		Waves
	Direction (°)	Velocity (m/s)	
1	149	0.02	No wave action modelled
2	149	0.05	No wave action modelled
3	149	0.1	No wave action modelled
4	149	0.2	No wave action modelled
5	149	0.3	No wave action modelled
6	321	0.02	No wave action modelled
7	321	0.1	No wave action modelled
8	149	0.02	5 metre height, 12 second period
9	149	0.2	5 metre height, 12 second period
10	321	0.02	5 metre height, 12 second period
11	321	0.1	5 metre height, 12 second period

Modelling results for eleven scenarios (presented in Table 14-8) show considerable variation in the seabed area with at the boundary of which values of salinity are 36.5 psu.

Table 14-8 Mid-field modelling results

Scenario	Area of seabed (hectares) greater than 36.5 psu
1	0.44
2	0.31
3	0.44
4	1.69
5	0.13
6	0.06
7	1.88
8	1.38
9	0
10	1.81
11	0

With reference to the above:

Scenario 2 represents common conditions in the Project area (with a 0.05 metres per second longshore current moving in an approximately south-south-easterly direction). This modelling predicts that the concentrate would disperse from the outlet, away from shore.

Variations in oceanic conditions at the Project area would influence the behaviour of the concentrate. Comparison between Scenario 4 (no wave action) with Scenario 9 (same current as Scenario 4, but 5-metre high, 12-second period waves) shows that higher wave action results in lower salinity as wave action mixes the plume of seawater concentrate through the water column.

For Scenario 5, the largest current modelled (0.3 metres per second moving in an approximately south-south-easterly direction), modelling predicts that the current elongates the salinity plume in the direction of the current, resulting in a diluted plume extent. Similarly, Scenario 11 shows the elongation of a plume in a north-north-westerly direction due to a north-north-west current (at 0.1 metres per second).

The modelled scenarios show that the intake flow is unlikely to be affected by the discharge from the outlet. Only Scenarios 7 and 11 show a minor increase in salinity of 0.1 and 0.2 psu respectively. Typically, the strong flow around the outlet would quickly move the discharge stream away from the intake area. Additionally, much of the higher salinity water from the outlet would flow beneath the intake, away from the intake stream. Even in the worst-case scenario (i.e. no wave action), although the intake head may at times be in the area of slightly elevated salinity, the discharge would tend to sink by its own mass towards the seabed away from the intake stream.

Discharge-induced recirculation currents (driven by density differences) may also occur in periods of prolonged low current. The modelling shows that recirculation currents would generally be less than 0.2 metres per second (ASR 2008$_7$ Technical Appendix 29). Predicted currents would be less than 0.08 metres per second beyond 500 metres shoreward and longshore from the outfall, with stronger currents (up to 0.2 metres per second) that would extend offshore from the discharge along the seabed. Salinity within the recirculation is expected to be generally below 1 psu, except within the proximity (hundreds of meters) of the point of discharge (CEE 2008, Technical Appendix 31).

Zones where the salinity is greater than or equal to 36.5 psu occur in several locations across the model extent. An indication of the size of the zone is shown in Table 14-8. The modelling shows that these patches occur at small, variable locations within a greater area. Patches would move with tide, wind and wave influence.

The results of the modelling showed that:

- the plume dynamics are essentially unaffected by the presence of the intake;
- following initial dilution the plume sinks to the sea bed and tends to drift down slope (offshore);
- the density-driven (gravitational) circulation causes the plume to spread out over the sea floor in a roughly circular shape, but the spread is biased towards the deeper water offshore and down-current;
- after 6 hours of model simulation, zones of salinity elevated to 36.5 psu (i.e. 1 psu above ambient) or at a 30:1 dilution are typically observed as patches within asymmetrical regions in the order of 500m in radius;
- with 500 m spacing between the intake and outlet, some minor short-circuiting does occur with elevated salinities of only 0.1-0.2 psu in the most conservative of the modelled scenarios. It is understood this does not constitute a problem for the operation of the plant;
- waves substantially increase vertical mixing which results in a plume that is mixed more uniformly through the water column. In these scenarios, the plume tends to cover a larger area including the intake head, even though the salinity range within the overall plume is reduced;
- the salinity at the seabed is generally reduced in the presence of waves; and
- in general, the ambient water sinks at the outlet location, which may give rise to up-welling further offshore, as predicted by the modelling. Vertical velocities associated with this effect will be small, estimated at between 1 and 20 mm/s. Dominant velocities are oriented offshore on the sea bed whilst at the surface, the currents are weaker and tend to move towards the outlet from all directions.

There are several key conclusions that can be reached, in terms of the variability and scale of impact indicated by the mid-field modelling results. These are listed below:

- large areas of seabed will not be continuously exposed to salinity levels exceeding 36.5 psu (that is, 1 psu above ambient);
- In many of these locations, whilst the peaks could be of the order of 2 psu above ambient, it is expected they will be closer to 1 psu above ambient; and
- The areas that are exposed to these salinity levels will vary in size, duration and location.

These conclusions are based on reference to the plots of salinity contours contained in the mid-field modelling report (ASR, 2008c). In particular, note should be taken of the 36.5 psu contour lines, which are highly variable in extent and location. Table 3.2 of the mid-field modelling report (ASR, 2008c) indicates areas ranging in size from 0 ha to 1.8 ha where salinity exceeds 36.5 psu. The area quoted represents the cumulative total of several ‘patches’ of salinity.

14.5.7 Dilution Target from Other Desalination Plants

The adopted initial engineering design target dilution of 50:1 (i.e. in the near field) allows for a more conservative dilution than the environmental dilution targets. Presented in Table 14-9 of this WAA are the dilution targets for other desalination plants in Australia. In summary, safe dilution factors from other RO plants for Australia are between 1:15 and 1:30 and are consistent with the findings for this Project (Section 14.5.5 of this WAA).

Table 14-9 Dilution targets from other desalination plants

	Perth	**Sydney**	**Gold Coast**	**Victoria**
Engineering design dilution target	45:1	30:1 (at edge of near field mixing zone).	40-71:1* (at edge of mixing zone). *71:1 to occur 90% of time and consists of 100% (brine) duty + treated backwash. Plant is designed to operate at 33%, 66% and 100% of capacity which is driving the range of dilutions	50:1
Salinity target derived from environmental target	1.2 ppt above ambient (calculated from the data) and 0.8 ppt and the above the bed requirement detailed below.	1 ppt above ambient.	2 ppt above ambient.	1 ppt above ambient.
Minimum salinity dilution requirement based on above salinity target[26]	20:1	30:1	15:1	30:1

[26] Derived from data on seawater salinity and calculated salinity for each plant.

In this table the definition of ambient salinity is the same as background salinity

	Perth	Sydney	Gold Coast	Victoria
Salinity discussion	Source: *"Comparison of the environmental quality guidelines with the proposed discharge characteristics shows that the salinity of the discharge is the constraining water quality component. The discharge salinity will be typically 75% above the ambient value (around 36 psu). This must be diluted so that the salinity at the edge of the mixing zone is less than 3.4% above ambient to be acceptable. At the boundary, a little further offshore, the salinity elevation has to be less than 2.3% of the ambient value". 80% species protected.*	Source: "*Ambient salinity concentrations vary by greater than 1 ppt. 30 times dilution would be required to achieve ambient salinity concentrations and thus logically minimise or eliminate impacts."* *Species protection not known.*	Source: *"Allowing for error in the model calculations, it is expected that salinity at the sediment surface at the boundary of the mixing zone will not exceed 2 ppt above ambient (i.e. 37.5 ppt compared with ambient salinity of 35.5 ppt) under any operational scenario. This is less than the conservatively adopted 38 ppt sensitivity level. A dilution factor of less than 10 would be required to result in salinity levels above 38 ppt."* Calculation based on ambient salinity of 35.5 and a target of 2 ppt above ambient equates to a dilution of 15:1. Species protection not known.	Ecotoxicity results show a maximum of 30:1 is required to provide 99% species protection under SEPP (WoV) or 1 psu above ambient.

Notes to Table:

[a] Derived from data on seawater salinity and calculated salinity for each plant.

In this table the definition of ambient salinity is the same as background salinity

14.5.8 Dilution Requirements for the Protection of Water Environmental Quality Objectives and Beneficial Uses

Clause 10 of the SEPP (WoV) states that the beneficial uses of the relevant segment of the environment be protected.

In order to assess the required dilution of the proposed discharge option for the protection of the beneficial uses, an assessment was made using the estimated concentrate characteristics that resulted from the mass balance (refer *Technical Discussion Paper – Concentrate Characteristics* (GHD, 2008i), Appendix C of this WAA). The concentrate chemicals characteristics were then compared to the trigger value selected and the discharge dilution required to achieve the trigger value for each monitored parameter was calculated. The results of this analysis were included in Table 14-6 of this WAA.

These values were then compared against the estimated concentrate water quality from the mass balance for the Reference Project and if it exceeds the relevant calculated value for the background/ambient seawater then a trigger level is considered to be exceeded. If a trigger value is not exceeded then the environmental value is considered to be maintained. This is in line with the intent of the SEPP (WoV).

The dilution requirements calculated for each of the parameters are based on the above detailed trigger values. The highest dilution factor for any one parameter is 1 in 20 and this dilution is modelled to occur rapidly and within less than 100 metres from the outlet for the majority of the time.

Based on the preliminary assessment it is concluded that if pre-treatment waste is to be separated and the solids managed on land, a dilution of 1 in 20 (refer Table 14-6 of this WAA) appears to meet all environmental quality targets to be met (refer Table 14-6 of this WAA), in accordance with the SEPP (WoV). A water quality dilution requirement of 1 in 20 is considered conservative, and it is expected that any plant design would allow for a higher dilution as been adopted for the Reference Project.

14.5.9 Other Potential Impacts from the Discharge

The SEPP (WoV) states "Beneficial uses are current or future environmental values or uses of surface waters that are dependent upon clean water. Each beneficial use requires water of a certain quality and quantity for its protection."

Sediment quality is not listed as a specific indicator for the protection of beneficial uses under the SEPP (WoV). However, the protection of sediments from the accumulation of pollutants/toxicants from the discharge is considered within the intent of the SEPP (WoV) contributing to the protection of identified beneficial uses.

The initial design dilution, in combination with the sediment physical characteristics as described in GHD (2008g) and the general lack of sediment present in the area, is likely to minimise potential for accumulation of contaminants from the discharge stream in sediments.

14.5.10 Summary

As listed in Section 14.5.2.1 of this WAA, a number of studies were undertaken to investigate the relevant safe dilutions in relation to relevant Beneficial Uses outlined in the SEPP (WoV) of the discharge of concentrate from the Project.

The following conclusions can be drawn from these studies.

14.5.10.1 Ecotoxicity

The Perth Seawater Desalination Plant concentrate used in DTA tests is a reasonable surrogate for Victorian Plant concentrate. These results indicate that if ecotoxicity testing were undertaken on the Reference Project plant, then it is reasonable to expect similar results to those generated by subjecting Victorian marine life to Perth's waste discharge. Conservative calculations using ACR of 2.5 and EC10 toxicity data require the concentrate to be diluted by 30 times to provide the required 99% species protection (SEPP (WoV)). This result is similar to the dilution required for the Perth Desalination Plant and Sydney Desalination Plant. The toxicity results also show that the major, but not the sole, stressor causing the observed effects was salinity. Moreover, results show that the different species assessed had different tolerances to elevated salt, i.e. some species required dilutions of much less than 30 times dilution to afford 99% protection. This conclusion is also supported in the wider literature on toxicity of desalination concentrate.

14.5.10.2 Water Quality

Constituents in the Reference Project concentrate require less than 20 times dilution, with most requiring less than 10 times dilution to be below the derived water quality triggers values. For the purposes of this assessment, the term “environmental quality objectives” and the associated values as defined by the SEPP (WoV) are considered as equivalent to “trigger values” as defined by the ANZECC & ARMCANZ Guidelines. Therefore the term trigger value is interchangeable with environmental quality objectives. In the context of assessing the impact on beneficial uses, if the water quality parameter values are less than the corresponding trigger values (environmental quality objectives) at the edge of the mixing zone then by definition in the SEPP (WoV), they are maintained.

14.5.10.3 Modelling

The near-field and mid-field modelling results show that:

- initial dilution will occur rapidly in a period of seconds to minutes to around 2 psu above background;
- 30 to 50 times dilution occurs rapidly within the water column and over a distance in the order of 100m from the outlet under near-field scenarios modelled. The process will be confirmed by undertaking additional modelling work (as set out in the Performance Requirements);
- there is the potential for elevated salinity on the sea bed beyond this 100m distance;
- subject to ambient conditions, patches of elevated salinity may occur (for example, small areas where salinity temporarily exceeds 36.5 psu);
- the establishment of a down slope density driven current will predominantly occur during periods of low ambient energy (both waves and current) and will tend to move water away from areas of high relief reef (identified as having higher environmental value), which are located shoreward of the outlet structures. This process will also contribute to diluting the concentrate further; and
- the Marine Park and National Park and Coastal Reserve are not likely to be reached by the concentrate plume.

14.5.10.4 Ecology

Pelagic and planktonic biota are unlikely to be significantly impacted given that they can either avoid the concentrate plume altogether or are only exposed for a short period of time measured in seconds to minutes (refer modelling studies). In support of this conclusion, it is well established in ecotoxicology that the magnitude of any adverse effect on organisms, be they osmoregulatory or toxic, is a function of both the length of exposure and concentration of the waste stream or toxicant. The nature of this relationship is that the shorter the duration of the exposure the higher the concentration needs to be to cause adverse effects and conversely the longer the duration the lower the concentration needs to be to cause the same adverse effect.

Benthic communities (seabed associated communities) will have more variable exposures and therefore potentially have some impacts. The literature suggests that ecological changes from exposure to desalination concentrate ranges from none to small changes.

14.5.10.5 Beneficial Uses

The beneficial use “Aquatic Ecosystems” will be the key factor driving the extent of the mixing zone (as declared by the EPA licence). Of the “Aquatic ecosystems” beneficial use, only benthic species may show some response to salt elevation, if, as assumed for this assessment, a greater than 1 psu change in salinity above ambient may result in a community shift. Pelagic and planktonic species are not likely to be significantly impacted by the discharge.

“Aquatic Ecosystems” is the only beneficial use that may potentially be compromised within the mixing zone (as declared by the EPA licence). Of the “Aquatic ecosystems” beneficial use, it is likely that only benthic species may be compromised, if, as assumed for this assessment, a greater than 1 psu change in salinity above ambient may result in a community shift in this component of the marine environment. Pelagic and planktonic species are not likely to be significantly impacted by the discharge.

A monitoring program will be undertaken to measure impact of the Project operation, consistent with the Project Requirements (refer Section 17 of this WAA).

14.5.11 Mixing Zone

Clause 30 of the SEPP (WoV) outlines the requirements for a mixing zone to be approved as follows.

In issuing a licence, the Environment Protection Authority may approve a mixing zone where it is not practicable to avoid, re-use, recycle and effectively manage wastewater. Within a mixing zone, designated environmental quality objectives do not need to be met and therefore beneficial uses may not be protected. The Environment Protection Authority:

- *(1) will not approve a mixing zone if it will result in:*
  - *(a) environmental risks to beneficial uses outside the mixing zone;*
  - *(b) harm to humans, unacceptable impacts on plants and animals or where it will cause a loss of aesthetic enjoyment or an objectionable odour;*
- *(2) will require affected licence holders to develop and implement and environment improvement plan that includes effective management practices aimed at continuously reducing the size of the mixing zone and preferably achieving its complete elimination;*
- *(3) will regularly review mixing zones and the implementation of environment improvement plans, to ensure that the size of the mixing zones is minimised;*
- *(4) will provide guidance on criteria for establishing an acceptable mixing zone, including requirements for community and stakeholder consultation.*

14.5.11.1 Overview

The size and extent of the mixing zone will be influenced by three design factors for this Project:

- the location of the discharge outlet (siting);
- the design of the outlet (for example: the number of rosettes and jets on each rosette, and their spacing); and
- process chemicals and their concentration in the final ocean discharge and the salinity of the concentrate.

As discussed in Section 1 of this WAA, the Project will be delivered under a Public Private Partnership structure by a Project Company under contract to the State. This means that the ultimate Project design may vary the above three factors that influence the mixing zone: the location of the outlet, its design and the chemicals that may be discharged into the marine environment.

This document describes an approach that aims to minimise the risk to beneficial uses if a Project Company chooses to exercise the flexibility of utilising options under the Project Description. It is implicit in this approach that the Project Company will have to demonstrate that the risk of the variation is acceptable and within the broad risk of the Project Description in relation to beneficial uses.

The following approach is proposed for determination of a mixing zone (to be declared by EPA licence) that would accommodate a Project Company:

- risk posed to beneficial uses by potential changes to the siting of the discharge is mitigated by containing the siting of discharge structure to an acceptable area that avoids ecologically valuable habitats and significant sites; and
- risks posed to beneficial uses by changes in the design as well as process chemicals used by a Project Company are mitigated by assessing appropriate safe dilution factors for discharge into the marine environment.

14.5.11.2 Proposed Mixing Zone

Considering the above, a mixing zone (to be declared by EPA licence) for the Desalination Plant estimated from the commencement of the proposed operation, and in consideration of the requirements as outlined below. An overview of the process is presented in Figure 14-10.

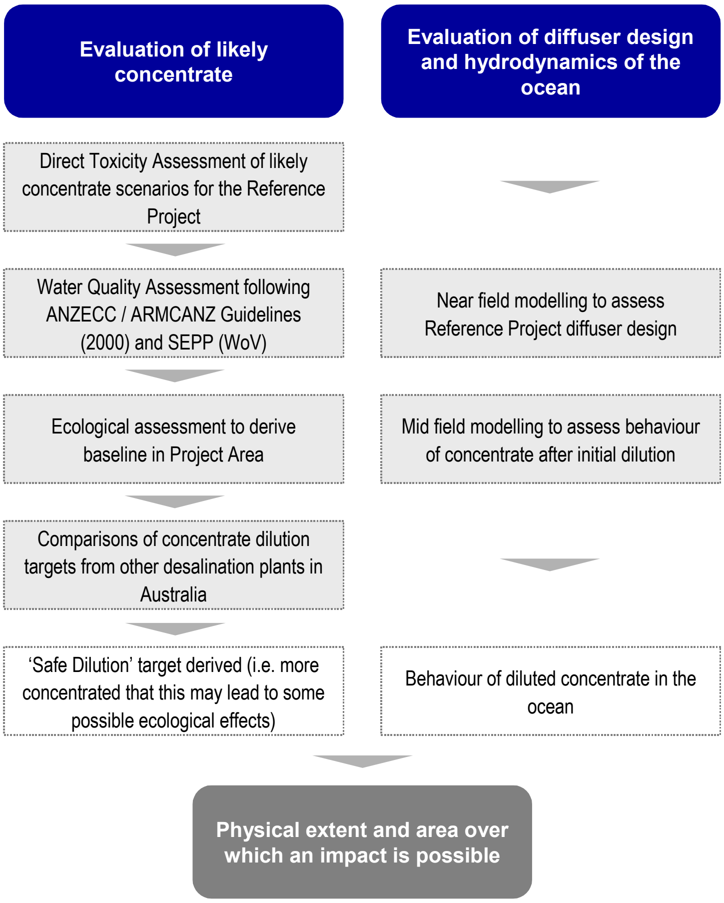


Figure 14-10 Process overview

It is noted that the 11 mid-field scenarios do not cover dynamic tidal conditions, a time history of ambient currents, or a range of wave conditions. However, the results can be used to provide a conservative understanding of potential footprint, for the following reasons:

- steady state conditions have been applied in both dominant tidal directions. When both results are combined, the resulting footprint will tend to be of the same order of size as one based on an oscillating current;
- low ambient currents have been selected for several of the cases. These low current cases ignore the higher velocities that occur closer to the surface; and
- waves have been represented in terms of mixing potential, but do not contribute to horizontal transport.

The implication is that the scale of the mixing zone (as declared by an EPA licence) is unlikely to increase with the consideration of dynamic conditions.

It is suggested therefore, based on interpretation of the near field and far field results, and above discussions, that:

- good dilution (i.e. greater than 1:30 and up to 1:50) will be achieved in the water column within a distance of the order of 100 metres;

- during calm conditions, elevated salinities (i.e. of the order of 1 to 2 psu above ambient) will occur (on the seabed) beyond the 100 metre zone, but within a distance estimated to be approximately 500 metres;
- large areas of seabed will not be continuously exposed to salinity levels exceeding 36.5 psu (that is, 1 psu above ambient);
- in many of these locations, whilst the peaks could be of the order of 2 psu above ambient, it is expected they will be closer to 1 psu above ambient; and
- the areas that are exposed to these salinity levels will vary in size, duration and location.

These conclusions are based on reference to the plots of salinity contours contained in the mid-field modelling report (ASR, 2008c). In particular, note should be taken of the 36.5 psu contour lines, which are highly variable in extent and location. Table 3.2 of the mid-field modelling report (ASR, 2008c) indicates areas ranging in size from 0 ha to 1.8 ha where salinity exceeds 36.5 psu. The area quoted represents the cumulative total of several 'patches' of salinity.

The Performance Requirements require an engineering design dilution target of at least 50:1 into the local ambient water column within 100 metres of the diffuser(s) under all design flow conditions and set a target of 1 psu (or as agreed by EPA) above regional salinity levels, with 95% confidence limits on an annual basis, outside the marine sensitivity areas outlined in Section 6. This will provide protection of the marine sensitivity areas.

The final mixing zone will depend upon the Project Company's specific diffuser design and location. The Performance Requirements will require the Project Company to undertake further modelling, ecotoxicity testing and water quality assessments to establish the final mixing zone with EPA approval.

14.6 Intake

14.6.1 Relevant Clauses of the SEPP (WoV)

The objective of this Section is to address the relevant regulatory requirements with regard to the intake of seawater. The following Clause is most relevant to this Section:

Clause 10 of the SEPP (WoV) requires the beneficial uses of the relevant segment of the environment to be protected.

Beneficial uses that may be impacted by the intake are (from Table 14-2):

- Aquatic Ecosystems;
- Industrial and Commercial; and
- Fish, Crustacea and Molluscs for human consumption.

14.6.2 Approach

Supporting Specialist Studies

To assess the impact the intake of seawater may have on the beneficial uses of the segment (largely unmodified ecosystems) the following studies were undertaken:

- assessment of the marine life in the region (invertebrates fish, birds, mammals etc) potentially affected by the intake (detailed in CEE (2008) and Biosis (2008a)); and
- particle modelling, comprising hydrodynamic modelling and Lagrangian particle dispersal modelling (ASR, 2008d). This modelling was undertaken to represent percentage reductions of particles due to the intake, location and size of source water areas, and any potential downstream impacts on plankton such as fish eggs and larvae, zooplankton and phytoplankton. Model results were then used in an ecological assessment of the consequences of plankton removal (CEE (2008)).

14.6.3 Assessment

Overview

The following provides definitions and explanations of entrainment, entrapment and impingement that are important in the assessment of the effects of the intake on the relevant beneficial uses.

Entrainment

Entrainment is the process of biota being drawn into the intake with the stream of water. Large and small biota may be initially entrained in the intake stream. Fish may subsequently be impinged against screens if the stream velocity is stronger than the speed at which they can swim, whereas smaller biota including phytoplankton, zooplankton and eggs may pass through the first series of screens at the intake. It is likely that any entrained organisms will not survive. Once entrained into the water passing through the tunnel they will be removed by finer filtering or the processes in the facility.

Impingement

Impingement is the process of biota being caught on screens (usually this is discussed with reference to onshore screens). If the intake water travels too fast through the screens then there is a potential that fish and other organisms may be pinned against the screen and unable to swim away, resulting in death as a result of starvation or exhaustion. The size of the organism impinged is related to the screen opening size. Once the animals are impinged on the screens they are generally removed with other debris caught on the screens.

Entrapment

Entrapment is the process of biota being drawn into offshore intake structures where they cannot escape from the tunnel leading to the onshore facility. The amount of larger organisms entrapped may be reduced by the inclusion of best practice intake structure design.

14.6.4 Best Practice Intake Design Considerations

The intake design in the Reference Project (and required by the Project Performance Requirements) uses best practice design criteria to minimise the ingress of marine life. Details of the best practice design for the intake structures are included in Section 7 of this WAA. Most of the information on the effects of seawater intake and preferred design to mitigate the effects is based on the USEPA Clean Water Act *Section 316 (b) (2001),* which developed rules *for minimizing adverse environmental impact associated with the use of (cooling water) intake structures*. The following lists the considerations made in determining the best practice design components (detailed in Section 7 of this WAA):

- optimising the location of the intake with respect to beneficial values;
- optimising the position of the intake opening in the water column to minimise intake of biota in relation to likely biological conditions such through consideration of:
  - location of habitat preferences;
  - larval behaviour;
  - larval distribution; and
  - behaviour and distribution of other biota;
- optimising the size of the screens or bar grills on the offshore intake; and
- optimising the seawater intake velocity, in terms of both speed and direction, at the intake.
  - velocity caps on the intake head, which divert intake flows to a horizontal direction but do not necessarily reduce the intake water speed.

These measures will reduce the effect of entrainment on marine biota but will also reduce the amount of biological material that would otherwise reduce the efficiency of the intake system in terms of blinding of the intake screens, biofouling in the tunnel, fouling of screens and filters and generation of waste material.

14.6.5 Implications of Adult Entrainment for Intake

The Reference Project incorporates features to mitigate entrainment of adult species, which are not present on existing cooling water intakes in Australia or many overseas power station intakes (such as San Onofre or Huntington Beach, USA). These mitigation measures include:

- low intake speed;
- horizontal intake stream;
- bar screens;

- offshore intake in relatively deep water; and
- elevated intake structures.

14.6.6 Assessing the Impact of Entrainment of Plankton

Plankton can generally be considered to be moved around the ocean by the ambient currents, thus they have no ability to swim against even the 0.15 m/s current at the intake head.

To estimate the likely influence of the inlet intake on the behaviour of this group of organisms the following was considered:

- passive particle modelling to predict the percentage removal and source populations of plankton that may be entrained in the inlet described in ASR (2008d -*Particle Dispersal Modelling*);
- field studies involving plankton collection and identification of fish eggs and larvae at various locations near the plant in order to obtain an assessment of the likely numbers, distribution and composition of the populations in the nearshore waters of the Project area; and identification (Acevedo *et al.* (2008);
- along with a literature review to feed the particle model with information on the larval duration of fish and other species that could be entrained in the inlet for fish larvae (CEE, 2008); and
- ecological interpretation of modelling results to assess the impact of the inlet on populations of plankton and subsequently adult populations and communities (CEE, 2008). This assessment includes a comparison with relevant overseas cases, along with consideration of the inherent uncertainties associated with the biological processes and oceanographic variability.

14.6.7 Modelling of Entrainment

Five models of planktonic propagule dispersion were developed for this Project to assist in the assessment of short and long-term effects of entrainment on the characteristics of the marine environment in the long term. These were:

- no planktonic larval period;
- very short planktonic larval period;
- short planktonic larval period;
- widespread propagule release, long planktonic larval period (>30 days); and
- isolated spawning area, defined dispersion pathway, long larval period.

14.6.8 Passive Particle Dispersal Modelling

The following Section summarises the outputs of modelling conducted by ASR to inform the assessment of the potential impacts of the intake. Further details of the approach, equations used and outputs are contained within ASR (2008d).

The assessment was undertaken based on the Reference Project, which includes components for a 200 GL per year capacity.

14.6.8.1 Model Grids

To represent different sources of larvae, particle modelling was carried out by regularly releasing particles in chosen zones within the model grids. Four release areas were investigated:

- uniform - over the entire grid;
- buoyant - over the entire grid in the top 10 % of the water column;
- bays - over Port Phillip Bay and Western Port only; and
- coastal - in a band 16-20 km wide (cross-shore) along the open coast only.

14.6.8.2 Larval Durations

The following larval durations were considered in the modelling to represent different types of larvae that may be potentially impacted by an intake. These larval durations are based on an assessment of the literature regarding local marine biota in the Project area. Modelled durations were:

- 1 day – reef invertebrates and algae;
- 2 days – reef invertebrates and algae;
- 7 days – reef invertebrates, algae and reef fish;
- 14 days – invertebrates, reef fish and pelagic fish;
- 30 days – invertebrates and pelagic fish;
- 60 days – invertebrates and pelagic fish; and
- 120 days– invertebrates and pelagic fish.

For larval duration periods of up to and including 14 days, ASR's Bass and Bays model was used. The higher resolution of the Bass and Bays grid was most suitable for organisms with a shorter larval duration. For the longer periods of 30 to 120 days, ASR's full SEA model was used given the distances travelled by the particles over these times were too large for the smaller grid.

14.6.8.3 Particle Removal

In each simulation, particles were removed from the model after the particles had drifted for the larval duration (e.g. 7 days, 14 days etc.). Larvae were being added to the grid at regular intervals over the full model simulation. The model tracks their age and position from the time of introduction to the grid. Particles were also removed if they reached the "zone of the intake" at which time the model recorded both their initial position and the duration of the time taken to travel from the release position to the intake. By entraining particles passing the intake, the "downstream effects" on particle numbers were revealed. By comparing the counts with and without the intake, the percentage changes could be calculated.

14.6.9 Impacts and Percentage Changes Due to the Intake

The percentage difference in particle numbers measures the fractional impact of the intake on free-drifting particles. The percentage change is generally seen as a shadow downstream from the intake where fewer particles are observed due to their removal by the intake. A representative sample of the results follows.

One-Day larval period

The model output for entrainment of larval durations of 1 day (Figure 14-11 of this WAA) indicates that any reduction in larval numbers greater than approximately 0.1 percent would be expected to be confined to an area around the intake extending approximately 4 km alongshore and over a band up to 1.5 km wide. This reduction is only for those larvae which have visited this zone. The area coloured green in Figure 14-11 of this WAA is where there is no reduction in larval numbers at all. Within this area a 0.5 % to 1 % reduction in the number of larvae may occur in an area 1 km wide and extending approximately 1.8 km alongshore. Figure 14-12 of this WAA shows the area over which larvae may originate. Outside these areas there is no impact on species with one-day larval durations.

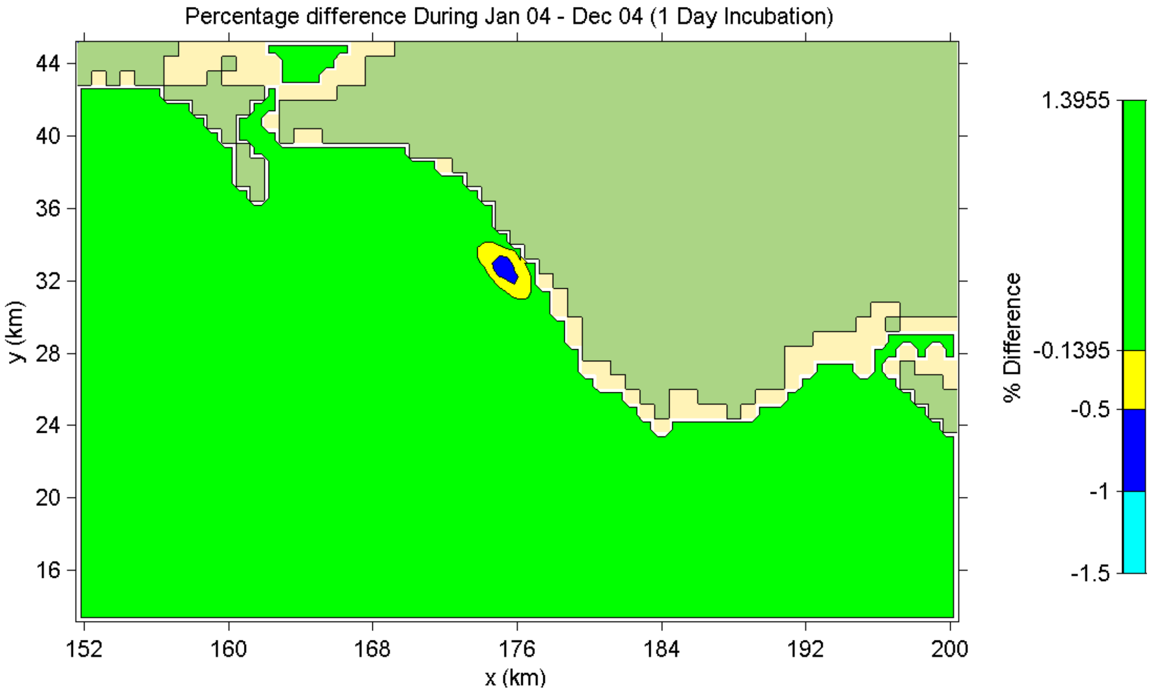


Figure 14-11 Percentage changes in particle numbers for 1-day duration incubation period

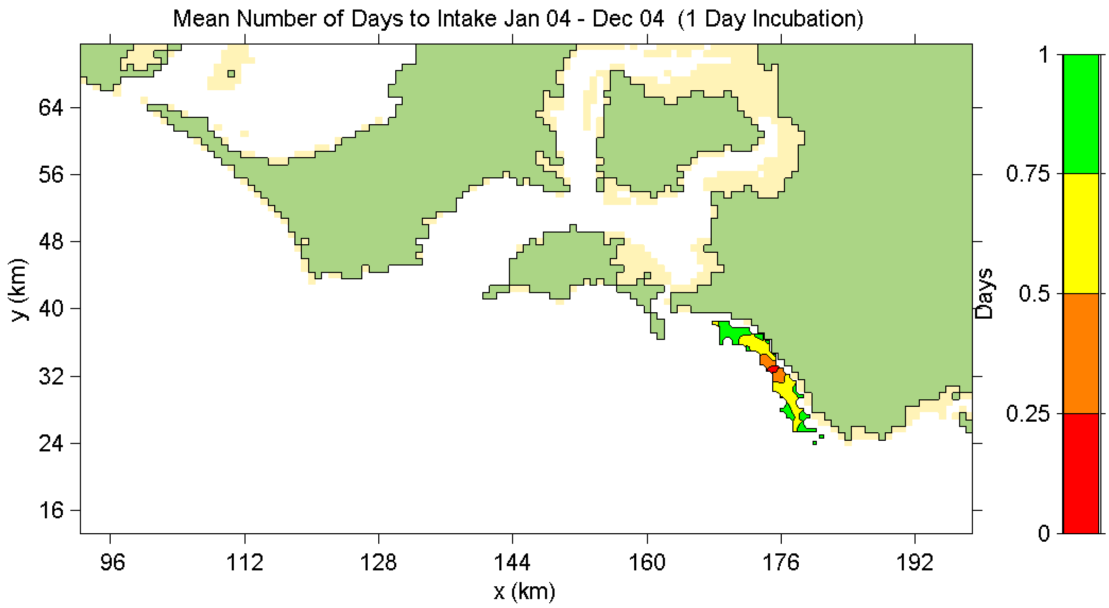


Figure 14-12 Mean time taken for particles to reach intake – 1-day incubation

Entrainment of seven-day larval durations

The integrated particle model was run for short larval durations of 7 days representing species with short larval durations including reef invertebrates, some reef fish and algae (CEE, 2008). The model output for entrainment of larval duration of 7 days (Figure 14-13 of this WAA) indicates that any reduction in larval numbers greater than 0.16 percent would be expected due to being confined to an area extending 16 km alongshore and over a band up to 2 km wide. The area is skewed to the south of the intake due to the predominantly south flowing water currents. A reduction of between 0.5 and 1 % may occur over an area extending approximately 6 km alongshore and 1 km wide. Within this area a 1% to 1.5% reduction in the number of larvae may occur in an area extending approximately 1 km alongshore and 0.5 km wide. The area shaded green on the map would expect to have no larval reduction at all. Figure 14-14 of this WAA shows that larvae reaching the area of the intake with larval durations of 7 days may originate over an area of coastline from the western entrance to Western Port to near Inverloch. Outside this area there is expected to be no influence on larvae with seven days duration.

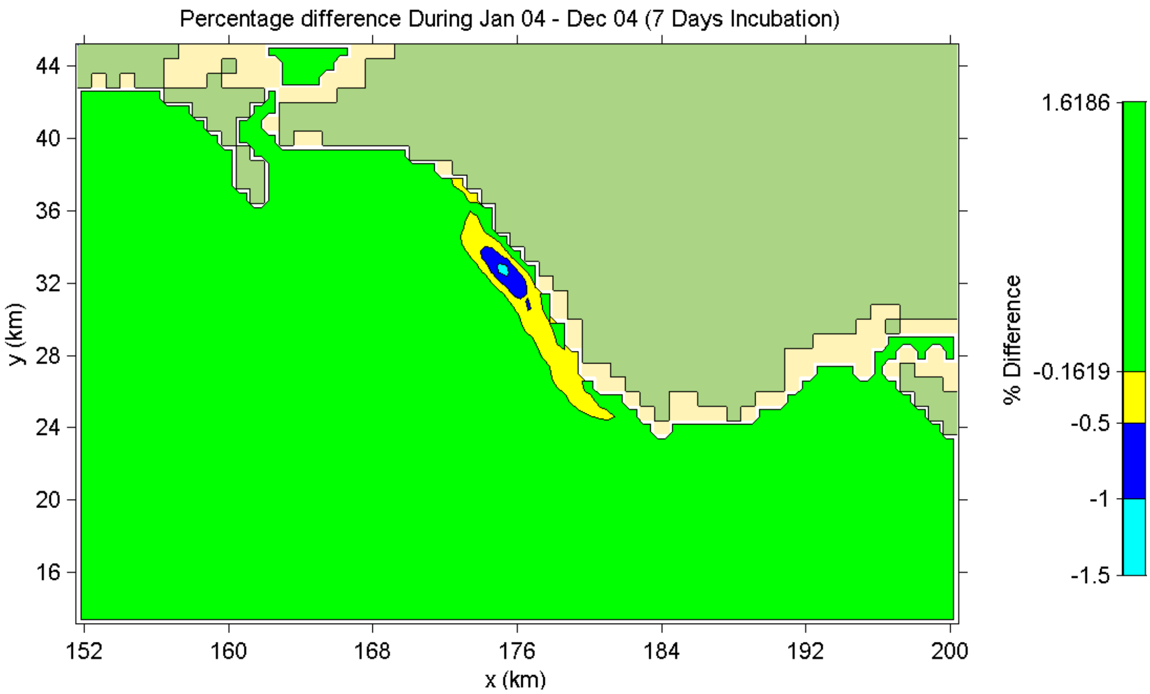


Figure 14-13 Percentage changes in particle numbers for 7-day duration incubation period

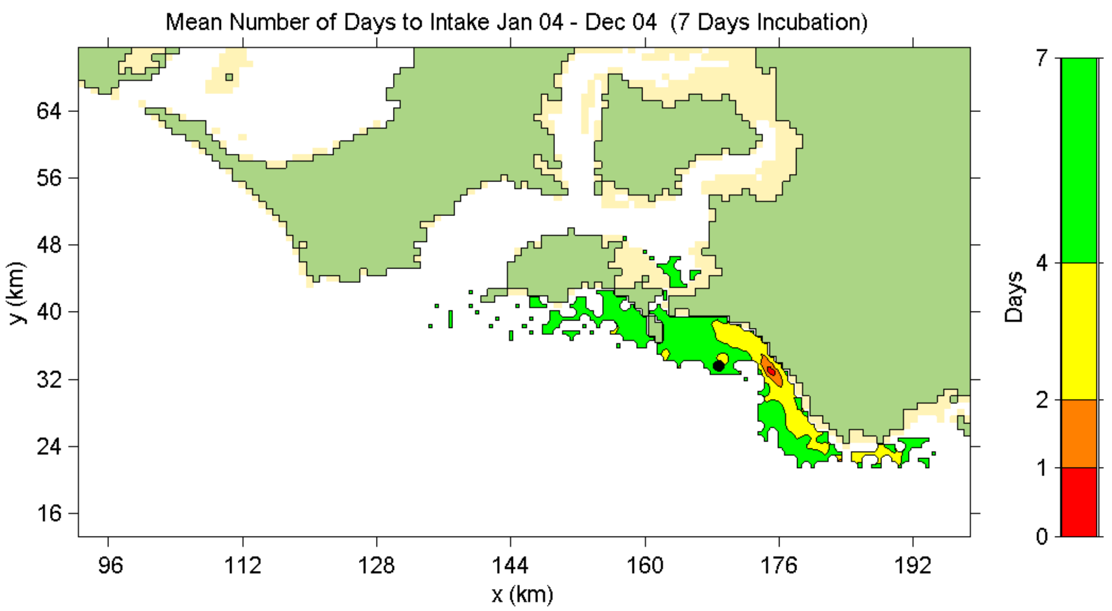


Figure 14-14 Mean time taken for particles to reach intake – 7-day incubations

Entrainment of longer larval durations (30 days, 60 days and 120 days)

The integrated particle model was run for longer larval durations. Species with larval durations of 30, 60 and 120 days are likely to be predominantly invertebrates and pelagic and demersal fish. Some examples of the results of this modelling are detailed below.

The model indicates that for a 30-day larval period (refer Figure 14-15 of this WAA) it can be reasonably concluded that reduction of a low proportion of larval numbers may occur along the coastal band west from the intake as far as Cape Schanck and east to Wilson's Promontory. The reduction in the majority of this region would be from 0.1% to 0.5%. In a smaller area within this region, from Kilcunda to Cape Paterson, a reduction of 0.5% to 1% may occur.

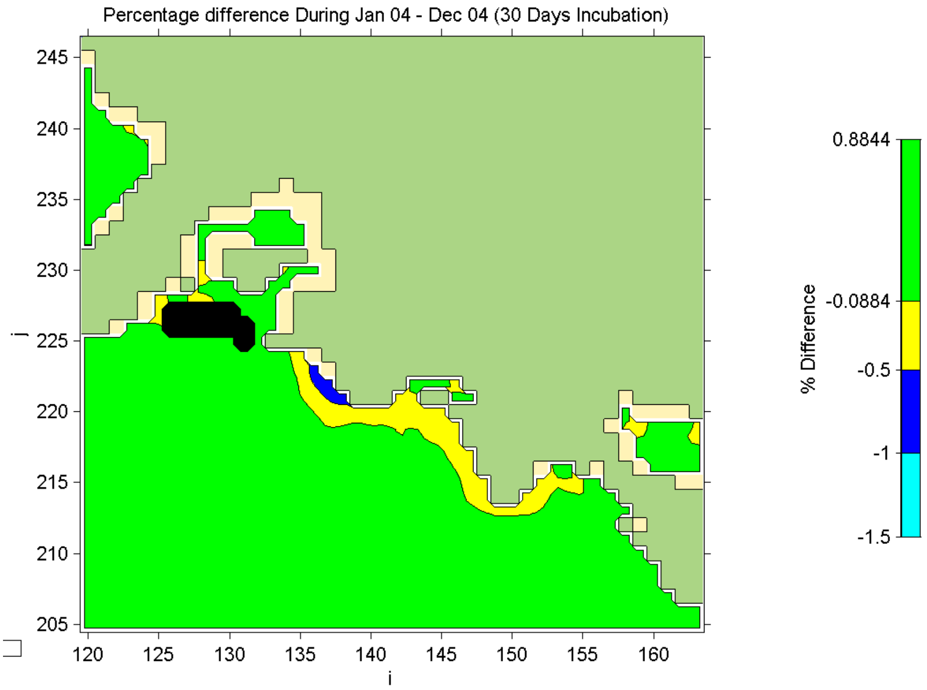


Figure 14-15 **Percentage changes in particle numbers 30-day duration incubation period**

Figure 14-16 of this WAA shows that larvae reaching the intake with 30 days larval duration may originate widely along the Victorian coastline extending from about Lorne to Cape Liptrap.

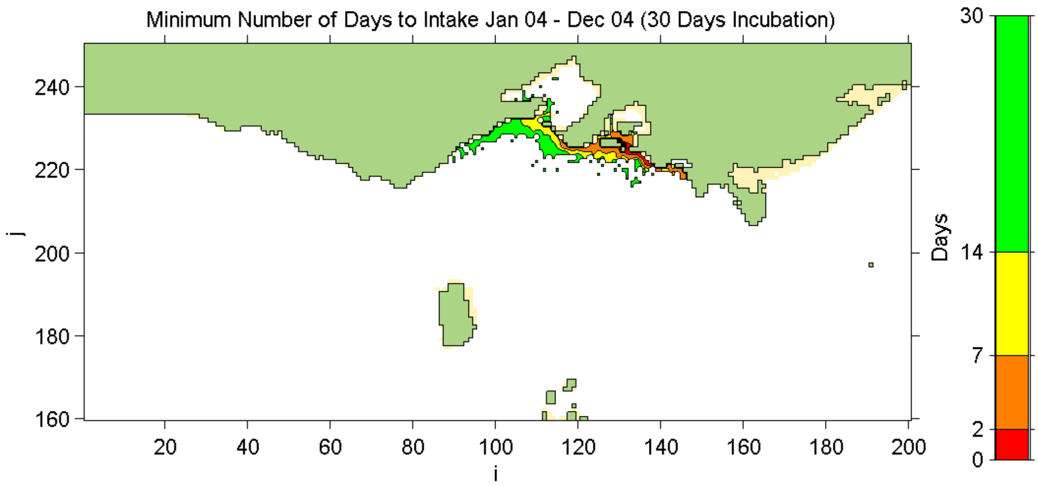


Figure 14-16 Mean time taken for particles to reach intake – 30-day incubations

For a 120 day larval duration (Figure 14-17 of this WAA), a 0.1 to 0.5% reduction in larval numbers may occur in an area extending east toward the southern tip of Wilson's Promontory and west into the eastern entrance of Westernport Bay. The area where a 0.5% to 1% reduction in larval numbers may occur extends from Kilcunda past Inverloch to the west of Cape Liptrap. An area experiencing up to a 1% to 1.5% reduction in larval numbers extends from approximately the Powlett River to Coal Point. The sources of these larvae extend widely across the Victorian coastline (refer Figure 14-18 of this WAA).

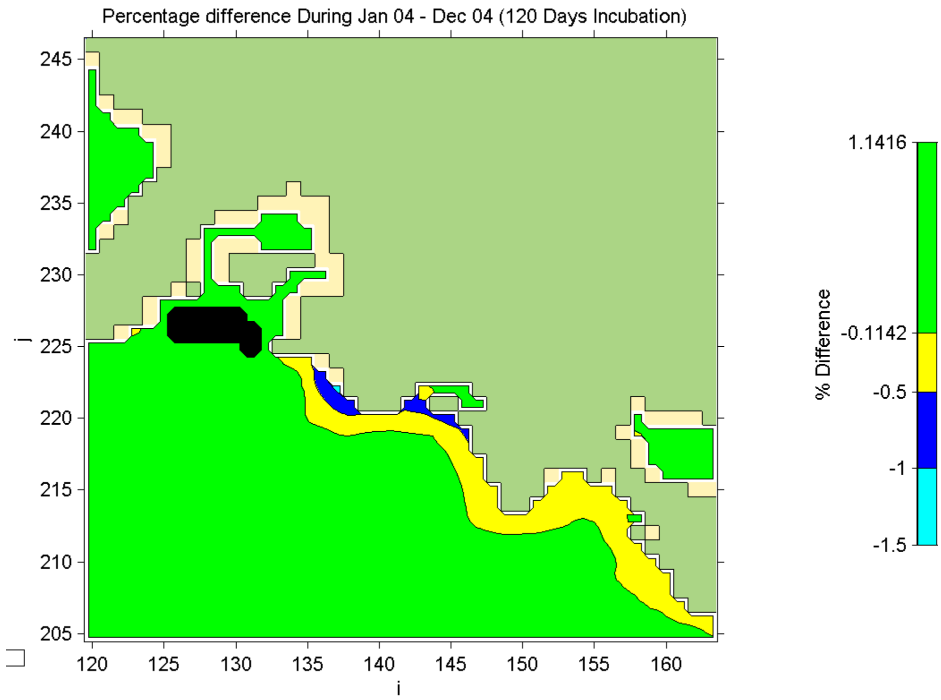


Figure 14-17 Percentage changes in particle numbers for 120-day duration incubation period

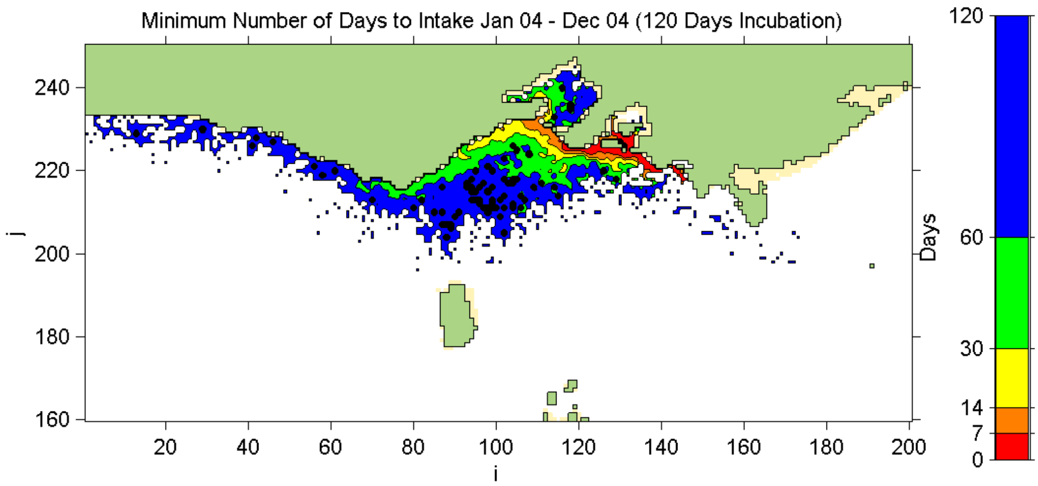


Figure 14-18 Mean time taken for particles to reach intake – 120-day incubations

14.6.10 Summary Ecological Assessment of Modelling Findings

These are based on the ecological interpretation of model predictions CEE (2008).

For 1-day incubation periods, the entrained particles are localised between Kilkunda and Cape Paterson. For incubation periods of 120 days, the intake is shown to entrain particles coming from the coastal region from Portland to Wilson's Promontory.

With the intake present, reductions in particle numbers for incubation periods of up to 14 days were 1.0-1.5% in high-resolution simulations near the intake while reductions of 0.25-0.5% were more widely spread and observed along the coast between the eastern entrance to Westernport Bay and Wilson's Promontory. The larval reductions do not necessarily translate into reductions in adult population.

For the longer duration incubation periods of 30-120 days, the percentage reductions were similar but spread over larger lengths of the Victorian coastline.

The percentage of particles absorbed is highly dependent on the width of the source water zone along the coast. Viable larvae occur around the coast over a region of width from a few kilometres to over 30 km for the short and long duration pelagic periods (*Section 3.2.2* of ASR (2008d)).

Empirical studies in the United States on similar intakes have found similar levels of reductions in plankton from field data. These are discussed in CEE (2008).

14.6.11 Effects of Reduced Plankton Numbers on Adult Populations

The effects of reduced planktonic numbers through the above mentioned processes are likely to vary substantially due to a huge range of biological and environmental variables. On first assumption, reductions of 1% may be thought to result in a 1% reduction in adult populations. However, this is mostly not the case due to the huge sizes of planktonic populations, their high spatial and temporal variability and the consequent episodic nature of successful replenishment events. The uncertain nature of mortality effects during the planktonic phase of marine biota has been referred to as the 'black-box' of population replenishment (Keough and Swearer, 2007).

Many marine biota with planktonic life stages produce substantial amounts of larvae. Replenishment of sustainable adult populations can occur with natural mortality of larval stages of 10^6 for some species and is generally at least 10^2 (CEE 2008).

In other words, sustainable populations can be maintained with natural mortality rates of planktonic stages from 99 percent and up to 99.9999 percent. It is most likely that natural mortality rates are usually substantially below the maximum tolerable mortality rates for robust species and that larval numbers are generally surplus to the number required for maintenance of the adult population (CEE 2008).

Small reductions in larval numbers in addition to natural factors may not affect the sustainability of the population, unless the combination of natural factors and additional mortality combine at times to reduce larval numbers below a level required to sustain the adult breeding population.

14.6.11.1 Impact on Holoplankton at Project Area

As discussed in CEE (2008), the ecosystem components which are assessed at cooling water systems for large power stations in the US do not include holoplankton:

> *"Although almost all planktonic forms (phyto, zoo, and ichthyoplankton) are affected by entrainment, these three studies and most other 316(b) studies have focused on a few organism groups, typically ichthyoplankton and (mero) zooplankton. The effects on phytoplankton and invertebrate holoplankton are typically not studied because their large abundances, wide distributions, and short generation times should make them less susceptible to CWIS impacts (Steinbeck et al 2007)."*

Phytoplankton and zooplankton generation times and corresponding population rates replenishment rates range from days to several months. Particle modelling for plankton duration of these periods (Section 14.6.7 of this WAA) show that reductions in plankton abundance is less than 0.5% over a range of distance around the intake. In terms of the magnitude of natural mortality and natural variability of planktonic population, 1% to 2% may normally be a tolerable addition to natural mortality for replenishment of populations by planktonic recruitment processes. Such reductions would most likely be unmeasurable in plankton population numbers because of the small size of samples in relation to large populations and natural variations in space and time and natural replenishment rates. Hence, the effect of entrainment on highly dispersed, rapid turnover populations of phytoplankton and holo-zooplankton is likely to be minor and the reductions are not likely to be detectable.

14.6.12 Assessment of Impacts of Impingement and Entrapment on Larger Marine Biota

In the Reference Project, the speed at which seawater is drawn into the inlet (0.15 m/s in still water) is close to ambient currents. It is therefore expected that medium sized marine biota, such as seals and penguins will not be impinged on the inlet screens and that entrapment is the likely means by which any impact may occur. Much larger marine biota such as whales and dolphins are excluded from entrapment assessment, because they cannot fit through the inlet opening. Smaller fish and invertebrates however, may be impinged upon the inlet screens under the slow intake because of their smaller size and reduced swimming capability.

To estimate the likely impact of the inlet from entrapment the following was considered:

- an ecological assessment of the likelihood of impingement and entrapment affecting local species at the Project area based on literature review of international work with comparison to field studies from the local site (CEE, 2008); and
- a risk assessment of the likelihood of entrapment of larger biota such as marine mammals, seabirds and reptiles, with a focus on species of interest such as Little Penguins and Australian fur seals (Biosis, 2008a).

14.6.13 Species-Specific Assessment of Entrapment

The Technical Specialists report *Assessment of Marine Mammals, Birds and Reptiles for the Desalination Project, Bass Coast, Victoria – Existing Conditions and Impact Assessment Report* (Biosis, 2008a) contains the following assessment of the potential impacts on specific species or groups.

14.6.13.1 Little Penguin

Much of the following discussion regarding potential impacts on Little Penguins will be generally applicable to other species of diving birds such as Australasian Gannet, Fairy Prion, Common Diving-petrel, Short-tailed Shearwater and cormorant species.

External inlet structures will be designed so that seawater flow rates at the entrance will be 0.15 m/s or lower, in conditions of otherwise still water. Little Penguins can swim strongly against currents considerably greater than that and birds will have no difficulty swimming against intake flow rates and away from the inlets.

If Little Penguins or other medium-sized biota were to enter the seawater inlets they could become trapped in the intake stream. If that were to occur they would be expected to be removed by the pre-treatment process. The simplest means to eliminate this risk is to ensure that spaces between inlet grills are too small to allow such biota to pass through them.

Appropriate external grill spacings to achieve this outcome would be no greater than 100 mm x 100 mm or, if the grill space is greater than 100 mm in any one direction, then a space no greater than 50 mm in any other direction (Dr Peter Dann, *pers.comm,* PINP).

14.6.13.2 Australian and New Zealand Fur Seal

External inlet structures can be designed so that seawater flow rates at the entrance can be as low as 0.15 m/s or lower, in conditions of otherwise still water. All seal species can swim strongly against currents considerably greater than that and they will have no difficulty swimming against intake flow rates and away from the inlets.

If Australian Fur Seals or New Zealand Fur Seals are able to enter the seawater inlets they could become trapped in the intake stream.

14.6.13.3 Summary of mitigation and management of impacts

The grill size of 100 mm horizontal by 100 mm vertical or 50 mm horizontal spacing of vertical bars, as presented in Section 6 of this WAA (Project Description) is included in the Reference Project and Performance Requirements. This will mitigate any further risk to seal species, including Australian Fur Seals or New Zealand Fur Seals.

14.6.14 Entrainment and Project Duration

Natural mortality of larvae is likely to vary from year to year and most natural populations that have larval life histories are robustly adapted to survive these natural variations. Entrainment effects will be constant.

The effect of occasional high natural mortality events may not be detectable in adult populations that are either highly variable themselves, long-lived or highly mobile. The relatively small and localised increase in mortality due to entrainment may not be apparent in these adult populations. However, the duration of the Project means that the progressive reduction in population replenishment may result in decreased numbers of some species. This may result in community composition changes as demonstrated in interaction of community components shown previously.

The onset and extent of detectable impacts of entrainment are likely to vary according to, for example:

- the distribution and abundance of the reproducing component of a population;
- the natural buffer capacity of the planktonic stage susceptible to entrainment;
- proximity to the intakes;
- the duration of larval history;
- the longevity of adult population;
- the mobility of the adult population (pelagic, planktonic, demersal, benthic sessile);
- the characteristics of larval history and recruitment (behaviour); and
- oceanographic conditions (short and long term currents, temperature, stratification).

14.6.15 Conclusions – Ecological Effects of Intake Processes

The following conclusions are drawn concerning the impact the activity of the ingress of seawater may have on the marine environment (refer CEE (2008) and Biosis (2008a):

- within a close proximity of the intake there is a likelihood of a change in the community structure of smaller biota within a short period of the Plant’s operation. It is likely that a gradient structure will establish in this area over the duration of the Project;
- it is highly unlikely that a biological effect would be detectable on marine community structure in the adjacent marine park over the duration of the Project;
- the inlet structure is likely to result in the entrapment of smaller marine biota such as juvenile fish. The composition and amount of biota likely to be entrapped is unquantifiable at this stage. However the amount of adult biota drawn into the intake is likely to be minor;
- the Reference Project has adopted a low intake velocity (0.15 m/s in still water) which is close to ambient currents;
- appropriate external grill spacings to prevent the entrapment of medium sized biota such as Little Penguins has been included in the Reference Project and is required by the Performance Requirements;
- commercial fisheries are unlikely to be impacted by the intake of seawater, particularly if the inlet location is optimised to avoid larval entrainment;

- chlorine dosing of the inlet pipes should not increase impacts from the intake as dosing occurs for water that has already passed into the high velocity Desalination Plant feed water pipework; and
- other impacts from operation of the intake are considered to have a minor or negligible impact.

14.6.16 Impacts of the Intake in Relation to Beneficial Uses and Associated Values

These are the beneficial uses that are relevant to the intake:

- Aquatic Ecosystems;
- Industrial and Commercial; and
- Fish, Crustacea and Molluscs for human consumption assessed in combined operation.

Based on the above assessments, the beneficial uses of the marine environment in relation to aquatic function and commercial use will be maintained as detailed in the previous Section. Compliance with SEPP (WoV) is a Project Requirement, which, in relation to the inlet structures, will be achieved by the above measures or equivalent. Performance Requirements for the Project, intended to minimise or mitigate environmental impact (in accordance with the SEPP (WoV)), have been devised for the inlet structures and are listed in Section 17 of this WAA.

14.7 Combined Operational Impacts of the Project

14.7.1 Relevant Clauses of the SEPP (WoV)

The objective of this Section is to address the relevant regulatory requirements with regard to the intake of seawater. The following Clause is most relevant to this Section:

Clause 10 of the SEPP (WoV) requires the beneficial uses of the relevant segment of the environment to be protected.

Beneficial uses that may be impacted by the combine influence of the discharge and intake include

- *Aquatic function;*
- *Primary contact recreation;*
- *Secondary contact recreation;*
- *Industrial and commercial use;*
- *Fish, crustacea and molluscs for human consumption.*

14.7.2 Approach

The combined operational effects of the intake and discharge have been assessed in terms of the following components of the marine community (CEE, 2008):

- planktonic community component;
- pelagic community component;
- benthic community component;
- fisheries; and

- ecosystem.

14.7.3 Planktonic Community

The combined effect of entrainment and the concentrate discharge are likely to be equivalent to loss of plankton equivalent to approximately 2,000 ML/d or 3,000 ML/d. In a regional context, this is within the magnitude and allowances of the effects of entrainment on planktonic communities. Overall the combined effects of entrainment and the concentrate discharge on holoplankton communities offshore from Project area due to entrainment are likely to be small and very localised (CEE, 2008).

As discussed at length in *Section 18* of CEE (2008), the impacts of entrainment, and therefore the combined consequences of entrainment concentrate discharge, are most likely to be expressed in their effects on the planktonic larval stages of short duration larvae that are locally derived. These are typically benthic species. Some reef species are known to have larvae that remain in proximity to the area of their release, such as abalone.

14.7.4 Pelagic Community

Pelagic biota are unlikely to be directly affected by either entrainment or the concentrate discharge. Some pelagic species may be attracted to the intake structure as an artificial point of interest (such as an artificial 'fish attracting device' or FAD). Entrainment and, to a lesser extent the concentrate discharge, may affect the larvae of pelagic species. However, pelagic larvae and eggs are generally widely dispersed and the effects on the proportion of regional larvae are likely to be small (CEE, 2008).

14.7.5 Benthic Community

The impacts of the concentrate discharge and seawater intake are likely to overlap due to the proximity of the intake and the outlet. It is likely that the effect of the outlet will be greatest in magnitude (community structure change) with a relatively strong effect close to the point of discharge decreasing with distance from the discharge. The effect of entrainment is likely to be more diffuse. The combined effects within the area of overlap, should they overlap in the final engineering design, may be additive to an extent.

Overall, the combined effects of concentrate discharge and entrainment on the benthic community may be expressed as (CEE, 2008):

- area of greatest effect within the concentrate discharge mixing zone; and
- gradient of community change as described for the effect of entrainment outside the mixing zone of the concentrate discharge.

It is likely that the effects will become more obvious over periods of years as adult populations are modified by progressive changes in recruitment. The marine biological community in these areas may be modified compared to the existing marine community, it is expected that many of the same species will be retained and that marine growth will remain abundant in the area.

14.7.6 Commercial Fisheries

Commercial fisheries that may be affected by the operation of the facility include species that are commercially fished in the area of the offshore infrastructure and remote species whose larvae may be affected by entrainment and concentrate.

14.7.6.1 Regional Fisheries

The key commercial fisheries in the region are abalone, rock lobster and reef fish. These are reef biota and are members of the benthic marine community as discussed above. Adults are found in a range of habitats including estuaries, they are resilient to handling and stress in commercial fishing operations and aquaria. They are likely to be relatively tolerant of the effects of dilute concentrate exposure (CEE, 2008).

Abalone and wrasse (reef fish) have relatively short larval periods of five to fourteen days depending on environmental conditions. The combined impacts of entrainment and concentrate discharge described for the larvae of benthic marine community therefore apply to these species. The larvae of abalone, and possibly wrasse, do not behave as passive particles. As discussed previously, abalone larvae appear to maintain their position close to the seabed and possibly within the kelp canopy to optimise the chances of returning to coralline algal encrusted rock in reef habitat when they become competent to settle. This general pattern may be the same for wrasse and a variety of other reef fish and invertebrate species with short larval periods (CEE, 2008).

Rock lobsters have very long larval periods of up to two years. Larval density in the Project area is very low. Consequently, the importance of larval settlement to recruitment of rock lobsters in the area is uncertain. At worst, they will be susceptible to entrainment similar to long-lived larvae as discussed in *Section 18* of CEE (2008).

As for the general reef community, some impacts are likely to influence the population of species.

14.7.6.2 Remote Fisheries

There are numerous pelagic and demersal commercial species that are not commercially fished in the area, but whose larvae may be found in the Project area. Most species with larval stages are understood to have highly dispersed adult populations and dispersed breeding areas, or breeding and recruitment areas that are remote from the region offshore from the Project area (CEE, 2008). The effect of the proposal on most of these species is likely to be very small and limited to a low proportion of larval reduction (less than 0.25%) over a small proportion of their range. The risk of the proposed development to these species is therefore negligible (CEE, 2008).

There may be concern that the development marine infrastructure is in the pathway of King George whiting larval dispersion between western Victoria and Corner Inlet. These larvae require periods of moderate to strong east going current during spring to transport them, typically over a one month period, from approximately the region of the entrances to Port Philip and Western Port to the entrance to Corner Inlet. If currents are weak, they will not reach Corner Inlet within their remaining larval duration period with or without the Project infrastructure. At this stage, the larvae are likely to be mature (competent), but their density is very sparse and unlikely to be quantified in plankton samples (CEE, 2008).

In terms of being affected by entrainment and concentrate, using the average spring flux up to 7.4 km offshore, less than 1 percent of King George whiting would be entrained. It is possible that the pathway of King George whiting is 20 km wide, which would result in a very low proportion of larvae being entrained.

The contribution of the King George whiting stock in Corner Inlet to the breeding population in South Australia and western Victoria is uncertain, but is likely to be relatively small considering the relatively large adult stocks in South Australia and large recruitment in South Australia, Port Phillip and Western Port. Overall, it could be possible that the stocks of juvenile and adult King George whiting in Corner Inlet could be reduced by up to 0.5%, although the proportion is more likely to be far less. In any case, the effect on the total Victorian and South Australian population is likely to be minor (CEE, 2008).

14.7.7 Ecosystem

It is apparent from the above discussion that the combined effects of the proposed development on the marine ecosystem offshore from the Project area are:

- likely to have a negligible effect on pelagic and planktonic communities;
- likely to have some effect on the rocky reef/seabed communities close to the point of discharge, decreasing with distance from the discharge;
- the effects within this area are likely to be a change in the structure of the hard seabed community, with some species becoming less abundant and others becoming more abundant; and
- it is most unlikely that the effects of the proposed development will extend to the marine communities of the Marine and Coastal Park, the Marine National Park or intertidal and shoreline marine communities (CEE, 2008).

14.7.8 Summary Assessment of Impact of Combined Inlet and Outlet in Relation to Beneficial Uses

Table 14-10 summarises the combined impact of the inlet and discharge in relation to beneficial uses.

Table 14-10 Assessment of impact to beneficial uses from the combined inlet and discharge

Beneficial use	Impact assessment
Aquatic Ecosystems that are largely unmodified	All high value marine assets and areas of biological diversity (high relief reefs) are avoided by appropriate siting of both the inlet and the outlet. Combined they are likely to have a negligible effect on pelagic and planktonic communities. Combined they are likely to have an effect on the rocky reef/seabed communities. The effects within the immediate locality of the structures is likely to be a change in the structure of the hard seabed community, with some species becoming less abundant and others becoming more abundant.
Primary and secondary contact recreation	Both the inlet and outlet structures are located a safe distance offshore outside of coastal reserve and will not interact with swimming or surfing locations.
Aesthetic enjoyment	Both the inlet and outlet structures are located sub-surface and both the structure and plume from a discharge should not be visible. Values associated coastal views will not be compromised.
Industrial and Commercial	Intake of seawater and discharge is unlikely to reduce commercial fish species numbers to below sustained levels.

Beneficial use	Impact assessment
Fish, crustacea and molluscs for human consumption	The area avoids the high-relief reef where commercial and recreational fishing is takes place.

14.7.9 Management and Mitigation Measures for Combined Impacts

Pelagic Species

Incorporated in the intake design for the Reference Project are the following mitigation measures:

- horizontal intake currents as a result of the 'velocity cap';
- low water speeds (<0.15 m/s) at the intake; and
- bar screens on the offshore intake.

Benthic Community

As discussed in CEE (2008) the effect of entrainment on benthic species and their larvae may be further reduced by positioning the lower part of the seawater intake at least four metres above the seabed.

Regional Fisheries

The effect of entrainment and concentrate discharge could be substantially reduced by positioning the intake and outlet away from key adult abalone kelp reef habitat. The effect of entrainment on benthic species and their larvae may be further reduced by positioning the lower part of the intake velocity cap at least three or four metres above the seabed.

Performance Requirements for the Project, intended to mitigate environmental impacts from the Marine Structures, in accordance with the SEPP (WoV), are included in Section 14.10 and Section 17 of this WAA.

14.8 Construction

14.8.1 Relevant Clauses of the SEPP (WoV)

The objective of this Section is to demonstrate that the beneficial uses of the marine environment, as required by Clause 10 of the SEPP (WoV), will be protected during the construction of Marine Structures for the Project. Further, the management of chemical use during construction will be considered to see that environmental risks to beneficial uses are minimised.

> *Clause 10 of the SEPP (WoV) states that the beneficial uses of the relevant segment of the environment be protected.*
>
> *Clause 37 of the SEPP (WoV) requires management of chemicals to minimise environmental risks to beneficial uses.*

14.8.2 Approach

As discussed in Section 14.3, a number of impacts have been identified for the construction of the Marine Structures. The Reference Project Marine Structures and variations are detailed in Section 6 of this WAA and provide the basis for assessment of construction impacts. Details of the best practice considerations for the location and design of the intake and outlet pipes, outlet diffuser and inlet riser and potential construction activities are included in Section 7 of this WAA and *Chapter 2, Volume 2* of the EES.

Medium and high risks identified in the risk assessment process (refer Section 4 of this WAA) for construction of the Marine Structures (Reference Project and Variations), that are relevant to the WAA, are discussed in the following Sections with respect to potential impacts. Management and mitigation measures which have informed the Performance Requirements for each are provided for the protection of the marine environment, in line with the policy objectives for protection of beneficial uses. Low risks are discussed in *Chapter 7, Volume 2* of the EES.

As noted in Section 14.4, Table 14-4 of this WAA, a number of social and economic impacts expected during the construction of Marine Structures are assessed in some detail in the technical specialists' reports: *Desalination Project Environmental Effects Statement Social Impact Assessment Report* (Maunsell, 2008c) and *Wonthaggi Desalination Plant Impact Assessment (Economic)* (Essential Economics, 2008). As such, social and economic impacts of the construction are not discussed in this WAA.

Impacts identified in the Project risk assessment that are not directly applicable to this WAA have not been discussed.

14.8.3 Seabed Clearing

The construction of the Marine Structures will require some clearing of the seabed to create a level platform for placement of equipment. This will likely disturb some biological habitats and affect the associated biological communities.

Areas of disturbance from marine construction equipment are likely to be localised where the risers connecting the tunnel reach the seabed surface. Benthic communities are most likely to be affected by the associated clearing activities. There may be localised damage to the seabed and the plants and animals that inhabit these areas. Marine mammals are expected to avoid disturbed areas due to noise and vibration from construction activities, so it is unlikely that clearing activities will affect these species.

The consequence of these activities are not considered to be significant as it is expected that these communities will recover to their original state after construction activities are complete. Disturbances to the seabed and associated biota are usually temporary during construction and secondary effects due to clearing (such as dispersal of sand from the seabed) will be only for a short period of time. Areas disturbed in the marine environment tend to be rapidly colonised by a succession of marine biota, usually resulting in a marine biological assemblage similar to the community that existed prior to disturbance (CEE 2008).

14.8.4 Disease Introduction by Construction Divers

The transit of marine vessels and construction divers has the potential risk of introducing unwanted marine biota into the Project area. The disease of greatest concern is the ganglioneuritis virus that affects abalone. This disease appears to be spread by several vectors, including through the action of ocean currents, the use of abalone as fishing bait and by attaching to diving equipment and boats. It was detected in the wild in western Victoria in May 2006 (CEE, 2008).

Although it is considered unlikely that this disease will be introduced to the Project area due to the industry controlled disinfection procedures developed to limit the consequence of this introduction would be serious and may have significant implications for abalone commercial fishing and the area's abalone population. Additionally, experience from the infection site in western Victoria indicates that the disease can infect large areas after introduction. The Performance Requirements require specific risk management processes to limit the risk of introduction of this abalone disease in the Project area.

14.8.5 Invasive Marine Species

Clause 49 of the SEPP (WoV) states that "activities associated with the introduction and spread of aquatic pests, including ballast water discharge, hull fouling and the release of exotic species, need to be managed to minimise the environmental risks of their introduction and spread".

A series of Policies, systems and guidelines have been developed that have legislative powers under the EPA's *Environment Protection Act 1970* for management of the introduction and spread of invasive marine species (IMS) through commercial vessel ballast and biofouling. The primary policy is the *Waste Management Policy (Ship's Ballast Water) 2004.* This policy aims to prevent the introduction of new invasive species and stop the spread of existing marine pests by preventing the discharge of high risk ballast water into Victorian State waters. To avoid discharges of high risk ballast water, ships must either discharge their ballast safely out at sea or keep high risk ballast water on board. All ships are required to provide EPA with accurate information on the status and risk of any ballast water contained on their ships prior to arriving in Victorian State waters.

The *Environment Protection (Ships' Ballast Water) Regulations 2006* are intended to support the implementation of the Waste Management Policy (Ships' Ballast Water) by prescribing the:

- administrative requirements and services necessary to protect beneficial uses of Victorian State waters; and
- fees for ships visiting a port in Victoria to recover costs associated with delivering these services.

The following assessment of potential for impact from invasive marine species introduced during the construction and operation of Marine Structures and discussion of associated mitigatory measures are encompassed in the report *The Desalination Project – Invasive Marine Species Specialist Report* (GHD, 2008h).

The following recommendations were presented by GHD (2008h).

Appropriate strategies to mitigate risks associated with introducing marine species as a result of construction or operation of the Desalination Plant must address risks associated with ballast deposition and biofouling vectors associated with international and domestic vessel movement activities. To meet this need the following recommendations are provided for all vessels associated with construction or operation of the Desalination Plant to minimise potential IMS introduction risks associated with Desalination Plant vessel movements:

- Strict adherence to current national and Victorian legislative requirements for ballast water movement control from international or domestic locations, as noted above. No release of any high-risk ballast or sediments should be undertaken at the Project Study Site; and
- Development and conduct of a pre-entry risk assessment procedure to determine the likelihood of any vessel associated with construction or operation of the Desalination Plant introducing marine biofouling pests of concern to the Project Study Area bioregion. Conduct of any required activities, including dry-docking, cleaning or chemical treatment, of any vessels or vessel areas considered to be at risk of introducing biofouling marine pests of concern prior to entry to the Project Study Area bioregion. This procedure should be applied not only to international entry vessels but also vessels moving between domestic locations known to be inhabited by marine pests of concern and should consider the risk of domestically spreading marine pests known to occur within the Project Study Area to other bioregions (the hydroid *Cordylophora caspia*).

Assuming adherence to these recommendations, the movement of vessels associated with construction activities of the Desalination Plant ranked under the risk assessment process as a medium risk of introducing marine pests of concern to the Project Study Area. Vessel movements associated with operational activities ranked as a low risk with adherence to the above recommendations. Without adherence to mitigation strategies these risk rankings would change to high and medium respectively. If a marine pest was introduced to the Project Study Area it's discovery would trigger an assessment of how to manage that incursion through the National Consultative Committee on Introduced Marine Pest Emergencies in accordance with the Draft Australian Emergency Marine Pest Plan (refer http://www.daff.gov.au).

Construction or operation activities are not considered likely to alter the local marine ecological processes to result in an increased abundance of already present marine pest within the Project Study Area, assuming adherence to the above and that translocation of pests from adjacent bioregions does not occur. If a marine pest was detected within the Project Study Area as a result of plausible migration into the area through vectors not associated with the Desalination Plant construction or operation the following recommendation should be considered (GHD, 2008h).

14.8.5.1 Infrastructure

The Reference Project states that to enable Marine Structures including seawater intake heads and concentrate outlet diffusers of the Desalination Plant to be installed a number of craft will be required including, but not limited to, the following[27]:

- large Self Elevating Platform (SEP), most likely with accommodation, helipad etc and capability to remain at sea for several months;

[27] Information sourced from EES Project Description

- fast vessels to take the various Project staff and workers on/off the platform when weather conditions permit;
- barges and small tugboats/workboats to lay anchors for the SEP;
- large tugboats for the SEP; and
- support vessels for divers during connection of risers to seawater intake heads and concentrate outlet diffusers.

It is expected that some of these craft, particularly the SEP and associated tugboats, will arrive from international locations (dependent upon the Project Company) and hence pose a potential risk for introduction of internationally sourced marine pest species. It is likely that some of these craft may transit through Australian waters and may enable domestic translocation of marine pest species. A number of introduced marine species are known to occur within and adjacent to the potential construction site and hence disturbance and influences including discharge of a concentrate have the potential to affect the distribution and/or density of these species.

Three risks were examined for marine pests influencing the localised marine environment that may occur as a result of the construction or operation activities of this Desalination Plant (GHD, 2008h):

- introduction of internationally sourced marine pests on construction vessels or equipment;
- introduction of domestically sourced marine pests on construction vessels or equipment; and
- alteration of the natural environment at the construction site promoting increased or altered abundance of resident pest species (GHD, 2008h).

To develop knowledge of marine pests known to be present within the Project area, and of those likely to be introduced, a review was conducted of literature describing findings from surveys conducted with the specific focus of detecting marine pests within Victorian coastal marine waters. This work included review of marine pest baseline survey reports for coastal areas adjacent to the Project Study Area, examination of comprehensive papers describing the invasions of Port Phillip Bay (Hewitt *et al*. 1999, 2004, Hewitt and Campbell 2006) and of a study that addressed the pest species known to occur in Australia to enable the "next pests" for Australia to be characterised (Hayes *et al*. 2005). In addition, data from relevant marine pest internet resources (eg http://www.marine.csiro.au/crimp/nimpis/; http://www.issg.org/database/welcome/; http://www.europe-aliens.org/index.jsp) was utilised to develop an understanding of the marine pests, introduced and cryptogenic species known to occur within the Project area and within the adjacent geographies.

Eight species listed are not known from Australia but all have the potential to be translocated to Australia either through biofouling vessels or equipment (particularly in regards to the seaweed, bivalve, gastropod and crab species) or as a result of ballast water deposition (particularly the toxic dinoflagellate or the comb jelly). Any movements of vessels into Australian waters for construction or operation of the Desalination Project should consider action to demonstrate a low risk of introducing any of these listed pests as a result of any activities they were to undertake for the Desalination Project.

The following conclusions were drawn in regards to this review:

- it is clear from the literature reviewed that Port Phillip Bay remains a heavily invaded system that supports a number of National and Victorian listed pests that are currently not present within the Project area. It has also been shown here that one invasive marine species (IMS) occurs within the Project Study Area that is not recorded from other adjacent habitats; and

- standard operating procedures have been developed in recognition of the risk that marine industries pose in translocating marine pests. The movement of vessels to and from the Desalination Plant area poses no greater risk than any other marine industry in introducing marine pests. Current industry standards are therefore considered appropriate to mitigate the risk of marine pest translocations for the Project.

Further, the Performance Requirements require development and implementation of a marine pest risk management process (including monitoring) to further reduce the risk of the introduction, spread and establishment of marine pests.

14.8.6 Increased Access to Williamsons Beach

Construction activities will increase the number of people working in the Project area potentially resulting in more people accessing the adjacent beach area. In general, Williamsons Beach, which only has a car park and no associated amenities, has lower patronage than other beaches in the area (Maunsell 2008c, refer *Technical Appendix 56* of the EES), which could deter large increases in visitor numbers. The EES Performance Requirements require the implementation of methods and management systems to ensure no adverse effects on the dune system, beach and intertidal zone from Project activities. These Performance Requirements will also mitigate any impacts on the Hooded Plover (refer Biosis Research, 2008a).

14.8.7 Noise

Many marine mammals rely on sound as their primary method of communication. Some species may even use echolocation to determine the physical features of their surroundings. These animals communicate underwater at varying frequencies. Therefore, artificial sources of underwater noise may impact marine mammals by masking biologically important sounds. This could induce a behavioural response causing a temporary threshold shift (TTS) or permanent threshold shift (PTS) in hearing.

Noise modelling was undertaken by Bassett (2008) to estimate geophysical survey construction noise and evaluate the consequence to marine biota. Modelling was undertaken for boomers and sparkers, which are mid-frequency sources used in seismic and hydrographic survey. The modelling estimates the potential for some species of fish to be impacted within two kilometres of geophysical surveys operating at a typical source level of 230 decibels (Bassett 2008).

The impact on cetaceans, sea birds, mammals and reptiles is considered lower than the potential impact on fish. The soft start management procedure in the EPBC Act Policy Statement 2.1, which regulates seismic testing activities as they affect cetaceans, recommends a gradual increase of the geophysical source over a 30-minute period. This is expected to alert animals and enable them to move away from the disturbed area. Since this method will be required by the EES Performance Requirements, cetaceans, sea birds, fish, mammals and reptiles are not expected to be significantly affected by geophysical surveys including the use of air guns (Bassett, 2008).

14.8.8 Drilling Spoil Production

Spoil will be generated from tunnelling and drilling for the Marine Structures. Based on the Reference Project, if a suitable marine spoil disposal site cannot be identified. Most of the drilling spoil will be collected on the jack-up barge and later taken to land for disposal. Any impact on the marine environment is expected to be minimal as the Performance Requirements specify disposal of any spoil from marine construction in accordance with EPA Best Practice Guidelines for Dredging and the National Ocean Disposal Guidelines.

14.8.9 Use of Chemicals and Hydrocarbons

Accidental spills may contaminate the marine environment. It is unlikely that there will be significant effects on the water column or on the marine biota as quantities of chemicals that are likely to be stored on-site will generally be small. Chemical spills that may occur during the construction phase are considered unlikely to result in severe effects on any communities or ecosystems. If a spill was to occur, it is expected to only affect individuals, rather than entire populations. If the spill was to enter the water column, there may be temporary localised effects.

It is considered that only in rare circumstances will accidental spills affect the neighbouring marine park given the quantity of a spill is likely to be small and the marine parks are located at a sufficient distance from the Plant Site to minimise impact. Any potential effect of accidental spillage on marine mammals, sea birds or reptiles is likely to be confined to the construction period. Therefore, accidental spills are not likely to have any significant or long-term effects on any population of marine mammal, sea birds or reptiles (Biosis, 2008a).

Performance Requirements intended to mitigate potential impacts associated with construction of the Marine Structures, in accordance with the SEPP (WoV), are included in Section 14.10 and Section 17 of this WAA.

14.9 Confidence in Marine Studies

To provide confidence in the results presented, marine studies have been reviewed by independent technical specialists (Table 14-11 of this WAA). Further, studies have strictly adhered to adopted guidelines such as the ANZECC / ARMCANZ where appropriate and rigorous QA/QC protocols adopted in sample transfer, handling and laboratory resting. Calibration and validation has also been completed for hydrodynamic models.

Table 14-11 Specialist reviewers for Desalination Project

Study Area	Report	Author	Specialist reviewer
Risk analysis		Maunsell (Peta Barnes).	Dale Cooper (CSIRO).
Marine Biology	Marine Biology	CEE (Scott Chidgey).	The Ecology Lab.
Marine mammals, seabirds and reptiles	Marine mammals, seabirds and reptiles for the Desalination Project, Bass Coast, Victoria.	Biosis (Ian Smales).	Dr Peter Dann and Dr Roger Kirkwood (Phillip Island Nature Park).
Water and sediment Quality	Water and sediment Quality, existing conditions and impact assessment.	GHD (multi author).	Andy Longmore (MAFFRI).
Ecotoxicty	Toxicity Assessment for the Victorian Desalination Plant.	Hydrobiology (Dustin Hobbs) and CSIRO (Dr Michael Warne).	Dr Michael Warne (CSIRO).

Study Area	Report	Author	Specialist reviewer
Hydrodynamic modelling	Multiple.	ASR (Dr Kerry Black and co).	Brett Miller (University of New South Wales). Ross Fryar (GHD). Dr. Ivan Botev (GHD).
Marine pests	The Desalination Project: Invasive Marine Species Specialist report.	GHD (Dr Kerry Neil).	Professor Chad Hewitt (University of Tasmania).

Table 14-12 Calibration and validation locations and period for hydrodynamic models

Model	South-east Australian Hydrodynamic	Bass and Bays	Local model
Calibration and validation locations	Water levels at Portland, Lorne, Project area, Burnie and Spring Bay Current velocity at the Project area.	Water levels at Lorne, Geelong, Williamstown, Stony Point and the Project area. Current velocity at Project area.	Longshore and cross-shore currents velocities at the Project area measured at the 24 m isobath. Currents at the upper, middle and the lower parts of the water column.
Calibration period	September to October 2007	September to October 2007	September to October 2007
Validation period	February to April 2008	February to April 2008	March to April 2008

An additional level of confidence has been applied by integrating marine studies to draw conclusions about impacts to beneficial uses. For example, as noted for the discharge, the results of the water and sediment quality, ecotoxicity and hydrodynamic models were used to make an assessment of the risk to the marine environment in the marine biology report. Study authors worked closely, scrutinising each other's work for consistency.

Furthermore, various studies have aimed to err on the side of caution choosing periods of low currents, or applying conservative safety margins to account for uncertainty (for example, the conservative estimation of the dilution required for safe dilution by using an ACR of 2.5). Table 14-13 provides specific examples of where confidence is built into marine studies used to interpret impacts from the major risks to beneficial uses. Thus, confidence is expected in the conclusions drawn from integrated studies owing to the inherent conservatism used.

Table 14-13 Summary - Confidence

Marine Aspect	Confidence	Outcome
Design	Uses best practice to avoid unacceptable risk. Reduces the risk of an environmental impact by design modification.	Maximises initial dilution of the discharge and entrainment of marine biota. Overestimates the safe dilution for marine biota Reduction of grill spacing on inlets to exclude non-fish vertebrates. Extension of inlet tunnel length to reflect risk related to high relief reef. Refinement of depth and number of outlet rosettes to reflect ongoing modelling process.
Risk assessment	Uses an iterative process to map risks. Draws risk information from a wide variety of groups. Feedback to performance requirements to avoid unacceptable risk.	Check that all major risks identified to the marine environment are assessed. Engineer risk out through design (e.g. extend tunnel length away from high –relief reef).
Ecotoxity	Uses a ACR of 2.5, when literature indicates it is <2. Uses EC10 data to calculate dilution to be conservative and favour protecting the environment. Uses Burrlioz software that uses a conservative algorithm to calculate dilution.	Considered to overestimate the dilution by ~1 -2 times.
Water Quality	Water quality data program QA/QC reviewed by NATA auditor and WQ specialist. Samples analysed by 2 NATA accredited labs. Triggers derived as per ANZECC / ARMCANZ Guidelines. Conservative ANZECC / ARMCANZ Guidelines adopted for unsuitable data.	All water quality parameters require less than a 20:1 dilution to not exceed trigger values, with most of the parameters requiring less than 10:1 dilution.

Marine Aspect	Confidence	Outcome
Hydrodynamic modelling	Particle model uses larger source water zone than proposed for the Reference Project. Mid-field model includes low ambient current scenarios for dispersion of the discharge. Key hydrodynamic models calibrated and validated for use.	Overestimates the amount of particles (plankton) that will entrained by the inlet. Use of low ambient currents tends to minimise estimate of dilution, and maximise footprint. Creates confidence in the model by using real data to calibrate and also demonstrate that it predicts accurately.
Marine Ecology (includes biology and vertebrate studies)	Conservative assumptions in the absence of information. Looks at all mapped risks. Integrates between studies.	Assumes that a biological gradient can be formed at 1 psu above background salinity, whereas there is no evidence to suggest it does. Assumes that small (<2%) larval inter-generational larvae removal will cause a community shift and generational change even against a background of large expected natural mortality (99.9%). Assumes that all species that may occur in the area do occur all the time, for example, leatherback turtles. Assumes that construction will damage all of the area anticipated to have contact with the jack-up barge.

14.10 Environmental Performance Requirements Arising from this Section

As discussed in Sections 1 and 6, the design adopted by the Project Company is likely to differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Project Performance Requirements outlined in this Section of the WAA in a manner that would lead to a similar or better marine environment outcome.

The Performance Requirements are incorporated into the Environmental Management Framework (see Section 17 of this WAA) and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirements relevant to this study area are presented below.

The Project has adopted 1 psu above background salinity as a conservative basis for impact assessment, which has been incorporated into the Project Performance Requirements.

However it is possible that a larger psu target could be applied and achieves the required protection of beneficial uses. The following analyses provide some evidence that a higher psu target could be acceptable to EPA:

- water quality analysis indicates a maximum 1:20 safe dilution was required for the chemical constituents in the Reference Project;
- ecotoxicity testing on the discharge scenarios for Reference Project showed a range of conservative safe dilutions from 1:17 to 1:30 provide the required ecosystem protection. The calculated safe dilutions were conservative; and
- an increase in salinity of 1 psu above ambient has been used to assess ecological impacts in the Project area. This salinity value was derived from the ecotoxicty testing.

Whilst at this point in time, the impact of the concentrate discharge is unquantifiable until actual biological conditions in the vicinity of the operating discharge are documented. In the mean time it appears that a salinity increase of less than 1 psu above ambient is a useful conservative guide to providing protection to marine communities.

Performance Requirements

Intake

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Provide an external grill space no greater than 100 mm x 100 mm or, if the grill space is greater than 100 mm in any one direction, then the space should be no greater than 50 mm in any other direction. Alternatively implement other measures to achieve the Performance Criteria;
- Locate and design intake structure:
  - To not significantly affect the beneficial uses associated with the designated areas of high relief reef and coastal reserve presented in Figure PR Sensitivity Area – Marine Area, in *Technical Appendix 5* to the EES document;
  - To achieve a horizontal velocity of less than 0.15 m/s (during still conditions) or any other measure demonstrated to achieve the Performance Criteria;
  - So that the lowest point of intake area is at least 4 metres above surrounding seafloor level;
- Demonstrate through hydrodynamic modelling of intake structures and behaviour that the Project will limit entrainment to meet performance criteria; and
- Monitor and report on possible effects of entrainment on marine biota and demonstrate compliance with the relevant performance criterion.

Discharge

<u>*General*</u>

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Meet the requirements of the EPA with regard to the Works Approval Application and Discharge Licence.

<u>*Engineered Mixing*</u>

- Achieve a minimum engineering design dilution target of at least 50:1 into the local ambient water column within 100 metres of the diffuser(s) under all design flow conditions.

Area to be Approved by EPA

- Define an area to be approved by EPA, which at its boundary achieves not more than 1 psu (or as agreed with the EPA) above regional ambient salinity, 95% of the time on an annual basis, outside the designated areas presented in Figure PR Sensitivity Area – Marine Area, in *Technical Appendix 5* of the EES.

Visibility

- No discoloration of the sea surface visible from land due to surface strike of the discharge plume(s).

Validation and Monitoring

- Develop and implement a monitoring program to demonstrate the performance of the Project in operation for protection of beneficial use that will:
  - Demonstrate protection of beneficial uses outside the area to be approved by EPA;
  - Assess the extent, magnitude and level of impacts of discharge on marine flora and fauna;
  - Assess the long term impacts of the outlet discharge(s); and
  - Document the condition of high relief reef ecosystems.
- Demonstrate through modelling that the projected operation will meet the relevant Performance Criteria;
- Conduct tracer testing to demonstrate compliance of the Marine Structures with the Performance Criteria; and
- Direct Toxicity Assessment (DTA) and water quality assessment shall be undertaken to confirm that representative concentrate (which contains representative chemical additives) meets the requirements of the State Environment Protection Policy (Waters of Victoria) environmental quality objectives of 99% ecosystem protection for largely unmodified aquatic ecosystems.

Invasive Marine Species

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop and implement a marine pest risk management and monitoring process (including a process directed to addressing the risks of introducing pests by vessels and equipment); and
- Develop and implement a risk management process specifically for limiting risk of abalone disease.

General Construction

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop, implement and maintain methods and management systems to protect marine flora and fauna;
- No construction in the designated areas, which creates a long-term impact, presented in Figure PR Sensitivity Area – Marine Area, in *Technical Appendix 5* of the EES;
- Trenching is not permitted in the designated areas presented in Figure PR Sensitivity Area – Marine Area, in *Technical Appendix 5* of the EES;
- Manage any geotechnical investigation program to avoid significant impacts on the high relief reef in the designated area and marine fauna in general; and

- Any spoil from marine construction to be disposed of in accordance with EPA Best Practice Guidelines for Dredging and the National Ocean Disposal Guidelines for Dredged Material.

15. Soils and Land

This Section of the WAA provides an assessment of potential land contamination within the boundary of the Site, including the potential occurrence of acid sulfate soils (ASS). Where significant risks have been identified, strategies for mitigation and management are provided.

Further details on the assessment of potential land contamination and occurrence of ASS within the Site are provided in the specialist reports, *Report for Victorian Desalination Project: Land Contamination Existing Conditions and Impact Assessment – Plant Site* (GHD, 2008a), and *Desalination Plant Site – Existing Site Conditions and Impacts and Risk Assessment: Geology, Geomorphology and Acid Sulphate Soils* (Boyd and Rosengren, 2008).

These specialist reports form *Technical Appendix 36* and *Technical Appendix 37* of the EES respectively.

The Geology, Geomorphology and ASS report (Boyd and Rosengren, 2008) also provides an assessment of potential impacts of development of the Desalination Plant on geology and geomorphology of the Site. This is not included in the scope of this WAA, however a discussion is provided in *Volume 3, Chapter 5* of the EES.

15.1 Regulatory and Other Requirements

15.1.1 Land Contamination

The following legislation, policies and guidelines are relevant to this policy area:

- *SEPP (Prevention and Management of Contamination of Land) No. S95* (2002);
- *National Environment Protection (Assessment of Site Contamination) Measure* (1999);
- EPA Publication 859, *Prevention and Management of Contamination of Land*, July 2002; and
- EPA Publication 441, *A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes,* March 2000.

The SEPP (Prevention and Management of Contamination of Land) establishes a range of general uses of land in Victoria. Land use categories listed in the SEPP include:

- Parks and Reserves - which generally encompasses parks and forested areas as defined by the relevant Commonwealth or State regulatory authority;
- Agricultural - which includes land used for animal husbandry and growing of crops;
- Sensitive use - which includes land used for residential purposes, a child care centre, pre-school, or primary school;
- Recreation/Open space - which generally encompasses land used for recreational purposes;
- Commercial - which includes land used for a range of commercial and business activities; and
- Industrial - which includes land used for utilities and a range of industrial activities.

Table 1 of the SEPP (Prevention and Management of Contamination of Land) outlines the beneficial uses that are to be protected for each of the identified land use categories. The listed beneficial uses for land include:

- Maintenance of natural ecosystems, modified ecosystems and highly modified ecosystems,
- Human health,
- Buildings and structures,
- Aesthetics; and
- Production of food, flora and fibre.

It is assumed that the proposed land use of the Desalination Plant Site will be Industrial (as the Desalination Plant is considered a utility), in which case the beneficial uses would include:

- Maintenance of Ecosystems (highly modified);
- Human Health; and
- Buildings and Structures.

Table 2 of the SEPP (Prevention and Management of Contamination of Land) identifies indicators of environmental quality and objectives to ensure the protection of beneficial uses. This information is presented in Table 15-1 below.

Table 15-1 Indicators and objectives for land

Beneficial Use	Indicators	Objectives
Maintenance of ecosystems	Chemical substances or waste identified through the application of the *National Environment Protection (Assessment of Site Contamination) Measure (Schedule B(2), Appendix 1)* or any other chemical substance or waste.	Contamination must not adversely affect the maintenance of relevant ecosystems and the level of any indicator must not be greater than (a) any regional Ecological Investigation Level developed in accordance with the National Environment Protection (Assessment of Site Contamination) Measure and published by the Authority for a region in which the site is located. Until such time that regional Ecological Investigation Levels applicable to the site are published, the Interim Urban Ecological Investigation Levels nominated in the National Environment Protection (Assessment of Site Contamination) Measure shall be used in place of any regional Ecological Investigation Level, or (b) levels derived using the risk assessment methodology described in the National Environment Protection(Assessment of Site Contamination) Measure, or (c) levels approved by the Authority.

Beneficial Use	Indicators	Objectives
Human health	Chemical substances or wastes identified through the application of the *National Environment Protection (Assessment of Site Contamination) Measure* (Schedule B(2), Appendix 1) or any other chemical substance or waste.	Contamination must not cause an adverse effect on human health and the level of any indicator must not be greater than – (a) the investigation level specified for human health in the *National Environment Protection (Assessment of Site Contamination) Measure*, or (b) levels derived using a risk assessment methodology described in the *National Environment Protection (Assessment of Site Contamination) Measure,* or (c) levels approved by the Authority.
Buildings & structures	pH, sulfate, redox potential, salinity or any chemical substance or waste that may have a detrimental impact on the structural integrity of buildings or other structures.	Contamination must not cause the land to be corrosive to or adversely affect the integrity of structures or building materials.
Aesthetics	Any chemical substance or waste that may be offensive to the senses	Contamination must not cause the land to be offensive to the senses of human beings.
Production of food and flora and fauna	Chemical substances or waste identified through the application of the *National Environment Protection (Assessment of Site Contamination) Measure* (Schedule B(2), Appendix 1) or any other chemical substance or waste.	Contamination of land must not: adversely affect produce quality or yield; and (b) affect the level of any indicator in food, flora and fibre produced at the site (or that may be produced) such that the level of that indicator is greater than that specified by the *Australia New Zealand Food Authority, Food Standards Code*.

15.1.2 Acid Sulfate Soils

The following legislation, policies and guidelines are relevant to this policy area:

- *Industrial Waste Management Policy (Waste Acid Sulfate Soils)* (1999) (Vic) (IWMP (WASS))– provides a framework to guide the management of waste ASS in Victoria; and
- EPA Publication 655, *Acid Sulfate Soil and Rock* (1999) (Vic) – relates to the design and construction works where ASS may be disturbed, including management and disposal measures.

15.1.3 Other Guidelines

In addition, there are EPA guidelines that directly or indirectly protect land from contamination during construction and operational activities, including:

- EPA Publication 480, *Environmental Guidelines for Major Construction Sites* (1996) (Vic) – These guidelines provide general information on how to avoid and minimise environmental impacts from construction activities;
- EPA Publication 275, *Construction Techniques for Sediment Pollution Control* (1991) (Vic) – These guidelines provide recommendations on structures and strategies that reduce sediment export from construction sites; and
- EPA Publication 347, *Bunding Guidelines* (1992) (Vic) – These guidelines specifically apply to above ground storage and transfer areas used for refuelling during construction.

15.2 Risk Assessment

Potential environmental risks associated with soils and land were assessed for both the construction and operational phases of the Desalination Project. Areas that require attention, taking into account legislative and policy obligations, community and stakeholder concerns, and guidance from the EES Scoping Requirements, were identified during the risk assessment. Approach to environmental impact and risk assessment is described in Section 4 of this WAA.

The risk assessment process was used to identify and rank priority issues assuming the Project controls described in Section 4 of this WAA would be implemented effectively.

The risk assessment was based on accepted operational and construction practices but did not take into account the mitigation measures embodied in the Performance Requirements. If the Performance Requirements were taken into account, both the likelihood and consequence of these risks would be significantly lower.

The following Sections summarise outcomes of the risk assessment process, listing potential environmental impacts associated with soils and land that were ranked as a medium risk or greater and direct readers to where these impacts have been addressed in this Section.

15.2.1 Operation

There have not been any potential environmental impacts associated with land contamination and potential for ASS identified for the operational phase of the Desalination Plant.

15.2.2 Construction

One impact associated with soils and land has been assessed as medium in the environmental impact and risk assessment process, shown in Table 15-2. Impacts assessed as low are briefly discussed within this Section of the WAA, however a concise summary is provided within *Volume 3, Chapter 5* of the EES (*Section 5.3.1*). No impacts have been assessed as high risks.

Table 15-2 Potential impacts during construction of Desalination Plant

Activity	Impact Pathway	Where addressed in this Section
High risk		
Transportation and use of chlorine at the Plant Site	Accidental chlorine release impacting on public health and safety	Section 15.3.1
Medium risk		
Excavation and tunnelling	Encountering contaminated soils which may affect human health or the environment	Sections 15.3.1, 15.4.1

15.3 Soils and Land Assessment

15.3.1 Assessment of Potential Land Contamination

Potential for contamination from historical land uses

A review of historical titles and aerial photographs indicates that the majority of the land associated with the Plant Site was used for farming/grazing. This type of land use has the potential to lead to both point source contamination (such as dip sites, holding pens and small waste burial sites) and dispersed contamination (due to application of fertilisers or other pastoral improvement substances). However, it was concluded that the likelihood of significant land contamination at the Plant Site is low.

The most notable land activity at the Site was the Wonthaggi State Coal Mine workings. A review of the AMC Consultant's report *Wonthaggi Historic Mining and Geological Data* (2007), based on an investigation of subsurface conditions resulting from past mining operations, concluded that there appears to be no identifiable activities associated with the potential for significant contamination within the Plant Site. Mining activities were located (close to 100 m) underground, with minimal surface disturbance. The extent of these mining activities is indicated by Figure 5-1 (see Section 5).

The Plant Site is subject to the Bass Coast Planning Scheme. With the exception of the former Wonthaggi State Coal Mine site, there were no identified planning overlays associated with previous or current industrial use or requirements for environmental audit.

A search of the EPA Priority Sites Register indicated that there were no listed sites within the Desalination Plant Site or surrounding area. A copy of the relevant extracts of the EPA Priority Site Register search is included in *Appendix C* of the Land Contamination report (GHD, 2008a).

Further detail on the assessment of potential existing land contamination at the Desalination Plant Site is provided in *Section 3* of the Land Contamination report (GHD, 2008a).

Potential for contamination from Project activities

In order to identify and manage any impacts arising from the storage and use of chemicals, fuels, and machinery resulting in accidental spillage during the construction and operation of the Desalination Plant a Preliminary Hazard Analysis (PHA) was conducted.

For detail on the PHA refer to the specialist report, *Report for Victorian Desalination Project - Preliminary Hazard Analysis* (GHD 2008j). The PHA report forms *Technical Appendix 54* of the EES.

The purpose of the PHA was to consider events associated with construction and operation of the Desalination Plant (and its facilities) that may have the potential for off-site impact. Table 15-3 lists the types and indicative storage quantities of materials that are likely to be present at the Desalination Plant during operation (refer GHD (2008j)).

Management and mitigation measures, which intend to prevent loss of containment and potential soils and land contamination from chemical use and/or storage areas have been incorporated into the Performance Requirements for the Project, which are included in Section 15.6.

Table 15-3 Materials stored on-site

Chemical	No. of Tanks	Storage Volume
Sodium Hypochlorite (NaOCl)	2	76 m^3
Ferric Chloride ($FeCl_3$)	8	304 m^3
Polyelectrolyte	200 bags	5000 kg
Sulphuric Acid (H_2SO_4)	8	304 m^3
Sodium Bisulphite (SBS)	4	152 m^3
Antiscalant	1	38 m^3
Caustic Soda (NaOH)	8	304 m^3
Lime ($Ca(OH)_2$)	4	1200 m^3
Chlorine (Cl_2)	20	18.4 t
Fluorosilicic Acid (H_2SiF_6)	1	38 m^3
Polyelectrolyte 1	300 bags	7500 kg
Polyelectrolyte 2	16 bags	400 kg
Polyelectrolyte	16 bags	400 kg
Diesel	2	190 m^3
Oil	2	90 m^3
Natural gas	Pipeline	200 mm diameter at 10.5 MPa

15.3.2 Assessment for Potential Occurrence of Acid Sulfate Soils

A preliminary study of potential acid sulfate soils (PASS) along the Victorian coast (Rampant (Ed.), 2003) determined the presence of high acid sulfate soils at greater than one metre depth in a drill hole near the lower Powlett River bridge. This suggests the presence of a potential broad area of PASS along the lower Powlett River estuary and floodplain, from the Bass Highway to the river mouth, as indicated by Figure 15-1.

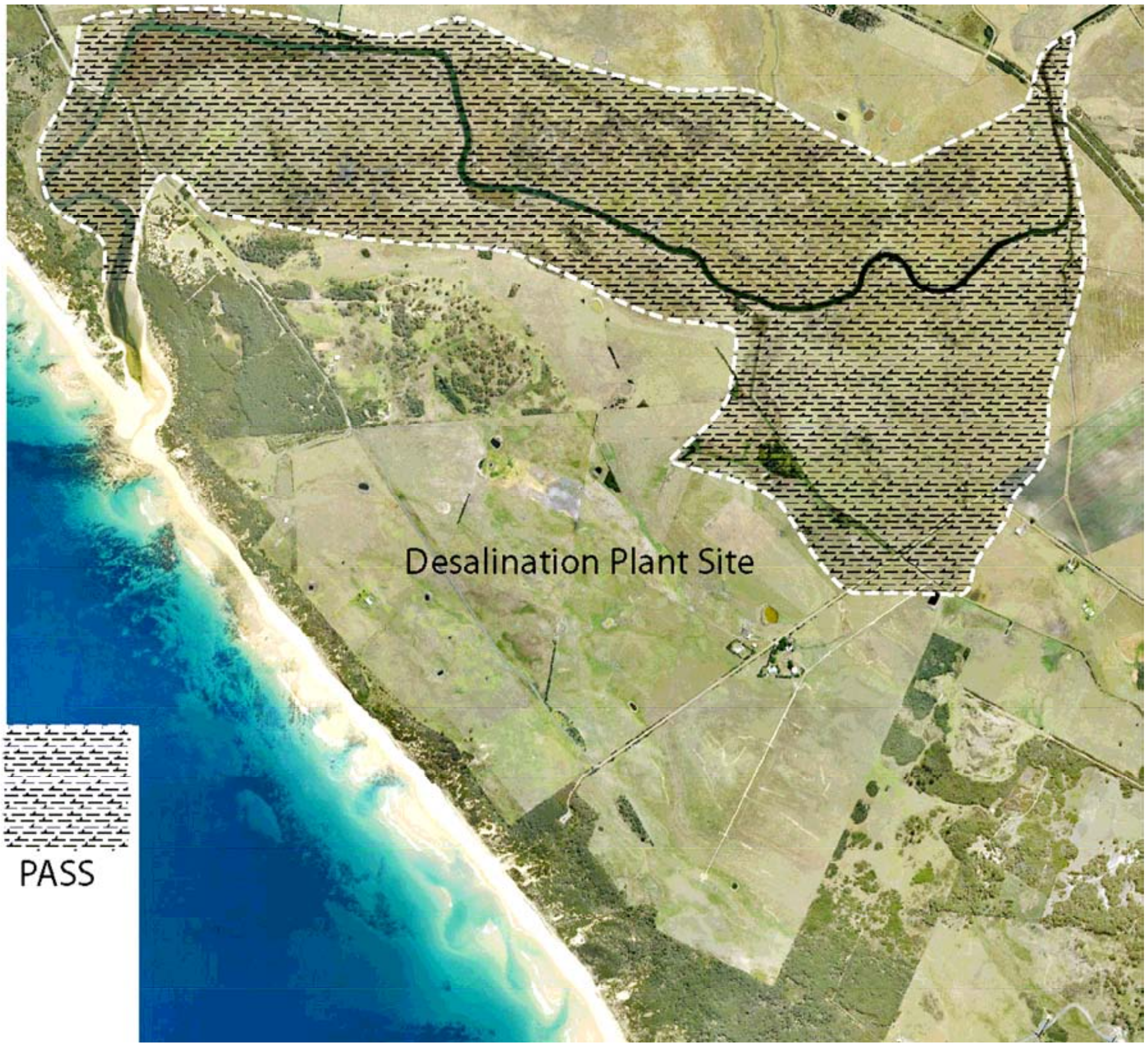


Figure 15-1 Predicted extent of potential acid sulfate soil area along lower Powlett River

Only the lowest terrain at the eastern edge of the Site is considered to be a potential PASS area. The greater part of the Site is not considered to have PASS, as it is too elevated to have been underwater in earlier geological eras.

The surface soils at the Desalination Plant Site are considered to be very low PASS. Although deeper soils in the area may be of coastal and marine origin from submergence at higher sea levels during the Last Interglacial period (over 100,000 years ago) the potential for ASS materials to be preserved is considered low for two reasons:

- the materials are predominantly sandy rather than marsh/mud deposits and are low in organic content; and
- subaerial exposure, oxidation and leaching during the 100,000 years of lower sea level, has greatly reduced the potential for unoxidised sulfides to remain.

It is still possible that some unoxidised sulphides remain deeper in the sand bodies.

Further detail on the assessment of potential for occurrence of ASS at the Desalination Plant Site is provided in *Section 3.6* of the Geology, Geomorphology and ASS report (Boyd and Rosengren, 2008).

15.4 Mitigation and Management

15.4.1 Contaminated Land Risks and Mitigation

Risks identified for the construction phase include encountering contaminated soils during excavation and tunnelling, with both having the potential to impact upon human health and social amenity due to odour emissions. However, the probability that this will occur is considered unlikely, as the potential for soil contamination to be present at the Site is considered low. In the Reference Project, construction of the Desalination Plant is intended to avoid the extent of the mine shafts. Relevant Performance Requirements intended to mitigate risks of uncovering contaminated soils during construction of the Desalination Plant are listed in Section 15.6.

As noted, measures for managing any potential impacts associated with usage and storage of chemicals on-site (refer Section 15.3.1) during both the construction and operation phases of the Project (for example loss of containment and spillages) have been devised for the Project EMF.

Where contaminated soils are identified or occur as a result of chemical spills on-site, an assessment will be undertaken to confirm the contaminant type, concentration and extent. The assessment should be undertaken in accordance with the SEPP (Prevention and Management of Contamination of Land) and the National Environment Protection (Assessment of Site Contamination) Measure. Where concentrations of contaminants exceed the objectives for the protection of identified beneficial uses of the SEPP as a result of contamination caused by construction or operation activities, soil remediation and groundwater contamination investigations may be required. Where remediation works are required, remediation of soil and groundwater (if required) should be completed to the extent practicable.

Where soils are to be imported to the Site (for example, for the purpose of site levelling and temporary construction requirements), all soils shall comply with the requirements of EPA Publication 448 and meet the following minimum requirements:

- shall be free of waste materials and be classified as fill material as defined by EPA Publication 448[28];
- have contaminant concentrations less than Table 2 (EPA Publication 448); and
- shall meet the requirements of the SEPP (Prevention and Management of Contamination of Land).

The EMF developed for the Desalination Project will incorporate the need to comply with relevant legislation and policies for contaminated soils and land (see Section 17).

15.4.2 Management of PASS

Future geotechnical investigations are intended for the Project for verifying the presence of PASS within the Plant Site (Boyd and Rosengren, 2008). If encountered, future work on the Site would be managed as follows.

[28] Tested and proven to meet required criteria through laboratory analysis by a suitably certified laboratory.

The Act requires that any ASS encountered during construction be managed in accordance with the waste hierarchy. Where avoidance is not possible and materials must be disturbed, the requirements of the IWMP (WASS) will be implemented.

The IWMP (WASS) states that management requirements of an EMP can be tailored to suit the level of environmental risk posed by an acid sulfate soil to a disposal site. This may help to reduce management costs for ASS where it can be demonstrated that the ASS are self-neutralising or have other mitigating factors to prevent acid discharge to the environment (see also EPA Publication 655, *Acid Sulfate Soil and Rock*).

The EMF developed for the Desalination Project will incorporate the need to comply with relevant state legislation and policies for PASS (see Section 17).

15.5 Summary and Conclusions

Based on the non-intrusive review of existing conditions, the potential for significant, widespread land contamination at the Plant Site is considered low. However, historic and current land uses identified in the area may give rise to shallow dispersed or point source contamination associated with agricultural uses, or isolated point source contamination associated with land filling and waste disposal and minor commercial activities. Should contaminated soils be identified during construction works, appropriate management measures have been identified to mitigate potential environmental risks and protection of beneficial uses. Management and mitigation may be achieved through applying appropriate practices through the EMF.

PASS potentially exist in the north east corner of the Site, though these are not expected to be disturbed during the construction or operation of the Desalination Plant. If ASS are encountered during construction, a number of mitigation measures have been recommended that, if adopted, should allow management of the environmental risks.

It is expected that intrusive investigations will be undertaken in future as part of geotechnical investigations. These works will incorporate fieldwork and testing to verify the presence of PASS and will provide further information with regards to the presence of potentially contaminated soils.

Performance Requirements in relation to management of ASS and contaminated soils have been identified and outlined in the Section below that must be achieved and complied with by the Project Company.

15.6 Environmental Performance Requirements Arising from this Section

As discussed in Sections 1 and 6, the design adopted by the Project Company appointed under the PPP contract is likely to differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Performance Requirements outlined in this Section of the WAA in a manner that would lead to a similar or better environmental outcome.

The Performance Requirements are incorporated into the Environmental Management Framework (see Section 17) and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirements relevant to this study area are presented below.

Performance Requirements

Contaminated Land

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Assess any contamination in accordance with the National Environment Protection (Assessment of Site Contamination) Measure, NEPC 1999 and other relevant guidelines;
- Identify any contaminated land and properties and assess the potential for long term impacts;
- Detail the methodology for any soil removal, assessment, reuse and management;
- Manage decontamination of any buildings being demolished or sites in which pre-existing land, water or ground contamination is identified or exposed;
- Identify procedures to manage contaminated soil and buildings during the construction works, including during building demolishing; and
- Develop and implement methods and management systems that seek to protect human health and the environment.

Hazardous Materials and Dangerous Goods

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop and implement methods and management systems (including contingency plans) that:
  - Limit the on-site and on-vessel storage and/or use of hazardous substances and dangerous goods;
  - Manage hazardous materials and dangerous goods to avoid environmental damage;
  - Install bunds (if appropriate) and take precautions to reduce the risk of spills entering the stormwater drainage system;
  - Seek to contain any spills captured by the stormwater drainage system; and
  - Provide for management of hydrocarbon spills.

Acid Sulfate Soils

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Identify and where possible avoid disturbing areas of Potential Acid Sulfate Soils; and
- Develop and implement methods and management systems to manage Acid Sulfate Soils and construction where Acid Sulfate Soils are encountered to minimise environmental impacts.

16. Noise

This Section of the WAA provides an assessment of the potential noise impacts from the construction and operation of the Desalination Plant.

Further details on the noise assessment are provided in the *Report for the Desalination Project - Impact Assessment Report: Noise and Vibration (Plant)* (GHD, 2008k).

This report forms *Technical Appendix 50* of the EES.

16.1 Regulatory and Other Requirements

The following legislation, guidelines and standards apply to the control of noise from industry:

- *SEPP (Control of Noise from Commerce, Industry and Trade) No. S31* (1989) – sets the maximum allowable noise limit in a noise sensitive area, taking into account the time of day, land use zoning, and existing background noise levels where background noise levels are comparable to Metropolitan Melbourne;
- EPA Publication N3/89, *Interim Guidelines for Control of Noise from Industry in Country Victoria*, (1989) (Vic) – sets the minimum noise limits, taking into account the time of day, for noise from industry where background noise levels are very low;
- EPA Publication 480, *Environmental Guidelines for Major Construction Sites* (1996) (Vic); and
- EPA Publication TG302/92, *Noise Control Guideline* (1992) (Vic).

Publication N3/89 states that in provincial and rural areas where background noise levels are comparable to Metropolitan Melbourne, the methodology outlined in N-1 should be applied to calculate applicable limits. Where the background noise is very low (i.e. below 25 dB (A) at night and 30 dB (A) during the day) the Interim Guidelines prescribe minimum limits for noise from industry (refer to Section 16.3.3 of this WAA).

Given that the Desalination Plant Site has a relatively high background noise level from surf/swell and wind noise, residual noise emissions from the Desalination Project, after application of appropriate mitigation practices, have been assessed against noise limits derived from both SEPP N-1 (N1) and N3/89 so that the identified beneficial uses of normal domestic and recreational activities including, in particular, sleep at night are protected.

With respect to construction activities, EPA Publication 480, TG302/92 and N3/89 provide guidance on noise goals, depending on background noise levels, and noise control measures.

16.2 Risk Assessment

The risk of noise impacts from the Desalination Plant was assessed for both the construction and operational phases. Areas that require attention, taking into account legislative and policy obligations, community and stakeholder concerns, and guidance from the EES Scoping Requirements, were identified during the Project risk assessment. Approach to environmental impact and risk assessment is described in Section 4 of this WAA.

The risk assessment process was used to identify and rank priority issues, assuming the adoption of the Project controls described in Section 4 of this WAA.

The risk assessment was based on accepted operational and construction practices but did not take into account the mitigation measures embodied in the Performance Requirements. If the Performance Requirements were taken into account, both the likelihood and consequence of these risks would be significantly lower.

The following Sections summarise outcomes of the risk assessment process, listing potential environmental impacts on the receiving environment that were ranked as a medium risk or greater, and direct readers to where these impacts have been addressed in this report.

16.2.1 Operation

A total of four potential impacts associated with operation of the Desalination Plant have been identified. One of these impacts has been assessed as a medium risk, as shown in Table 16-1.

Table 16-1 Potential impacts during operation of Desalination Plant

Activity	Specific impact	Where addressed in this Section
Medium risk		
Plant operation, maintenance activities	Noise and vibration impacts on sensitive receptors	Section 16.3, Section 16.5.1

16.2.2 Construction

In the environmental impact and risk assessment process, a total of two potential impacts associated with the construction of the Desalination Plant were identified. Two of the impacts identified were assessed as presenting a medium risk. These are shown in Table 16-2.

Table 16-2 Potential impacts during construction of Desalination Plant

Activity	Specific impact	Where addressed in this Section
Medium Risk		
All construction activities	Noise and vibration impacts on sensitive receptors	Section 16.4, Section 16.5.2
All construction activities	Noise and vibration disturbing native fauna	*Volume 3, Chapter 7* of the EES – Flora & Fauna

16.3 Noise Assessment - Operation

The method adopted for the assessment involved the following, which are described in greater detail in the subsequent Sections:

- identification of potentially sensitive receptors in the noise catchment;
- baseline noise and vibration monitoring;
- determination of operational noise limits; and
- use of noise modelling to predict the noise impact at sensitive receptors.

16.3.1 Sensitive Receptors and Surrounding Environment

A total of 12 potentially sensitive residences were identified within a distance of 1.5 km of the centre of the Site, based on Site visits and aerial photography review.

Dwellings within the Site were not considered in the assessment as they will be acquired and will form part of the Plant Site.

The existing noise environment at the Site is characterised by surf, wind, rain and general agricultural sources. There is also a low volume of slow traffic on Lower Powlett Road and Mouth of Powlett Road.

Local industry consists of agriculture (grazing and dairy), which have minimal associated noise emissions. A small saw mill is located approximately 500 m to the east on Lower Powlett Road. The saw mill operates on a sporadic basis. However, its operation would be likely to influence ambient noise levels at nearby receptors.

Figure 2 in the Noise and Vibration report (GHD, 2008k) shows the locations of sensitive receptors and existing local noise sources.

16.3.2 Baseline Monitoring

A baseline monitoring program was completed, and results from this program were used to characterise the existing noise environment.

16.3.2.1 Monitoring Program

Long-term (for a period of two weeks) unattended noise monitoring was conducted at five locations to determine existing background noise levels in the vicinity of the proposed facility. As a quality assurance measure, short-term attended noise monitoring was conducted at each noise logger location at the commencement and/or completion of each logging period.

Monitoring equipment specifications, rationale for the selection of the noise monitoring locations and environmental factors, such as meteorological conditions and extraneous existing noise sources, which were taken into consideration during the monitoring programme, are detailed in *Section 3.1* of the Noise and Vibration report (GHD, 2008k).

16.3.2.2 Monitoring Results

The baseline noise monitoring study determined:

- existing ambient noise in the study area is characterised by natural sources, namely, surf/swell, wind, rain and wildlife/agriculture and results in significantly varying background and ambient noise conditions:
  - during certain meteorological conditions (low relative humidity and unstable atmospheric conditions during the daytime) the influence of surf/swell and wind noise lessens and background noise levels were as low as 30 dB(A); and
  - under noise-enhancing wind and/or swell conditions (temperature inversions and elevated relative humidity during the night-time), background noise levels were at times in excess of 50 dB(A).
- with the exception of vehicle traffic and stock movements, there were no obvious sources of vibration in the study area and existing vibration levels are low.

Further detail on the characterisation of the existing noise environment, including recorded monitoring data, is given in *Section 4* of the Noise and Vibration report (GHD, 2008k).

16.3.3 Operational Noise Limits

16.3.3.1 Legislative Background

At present, there are no regulations or State Environment Protection Policies (SEPPs) that impose industrial noise limits in regional Victoria (i.e. in and around the study area). The EPA Victoria Interim Guidelines for Control of Noise from Industry in Country Victoria (N3/89) are used as a guide to determine operational noise goals applicable at residential premises within regional locations throughout Victoria that have the potential to be exposed to noise emissions from the proposed works.

With consideration to the guidance provided in N3/89, the selection of appropriate noise goals for locations in regional Victoria can be summarised as followed:

- for cases where the recorded background sound levels (L_{A90}) at rural locations are very low (i.e. less than 25 dB(A) at night or 30 dB(A) during the day), N3/89 provides a list of the minimum applicable sound level goals for comparison against effective industrial noise impact (L_{Aeq});
- in cases where recorded background sound levels at residential locations are comparable to Metropolitan Melbourne, N3/89 makes reference to procedures for determining noise limits outlined in the SEPP-N1. These limits are also comparable against the L_{Aeq}; and
- in cases where the recorded background is *not* very low (i.e. *greater* than 25 dB(A) at night or 30 dB(A) during the day), but is *not* considered to be comparable to Metropolitan Melbourne, N3/89 makes no recommendations. The identification of project-specific noise goals in such situations is therefore, by necessity, a discretionary decision based on professional judgement between the goals outlined in N3/89 and the SEPP N-1.

16.3.3.2 Determination of Operational Noise Goals

Background noise levels and applicable regulation are summarised in Table 16-3 :

Table 16-3 Summary of background noise level

Monitoring location	Day (L_{A90})	Evening (L_{A90})	Night (L_{A90})	Applicable regulation
N1	42	39	38	SEPP N1
N2	37	37	38	SEPP N1
N3	41	42	45	Not applicable (shore front)
N4	33	35	37	N3/89 (day, evening), SEPP N1 (night)
N5	32	34	34	N3/89 (day, evening), SEPP N1 (night)

Based on the above, and an approach agreed with the EPA, the approach adopted to determine applicable noise criteria for the Plant Site operational noise emissions is as follows:

- application of N3/89 for the day-time and evening-time period at all receivers. Although it is noted that SEPP N1 could be applicable during the day-time and evening-time period at receivers representative of monitoring locations N1 and N2, application of N3/89 provides a measure of conservatism and consistency for all receivers; and
- application of SEPP N1 for the night-time period for all receivers. The SEPP N1 procedure enables determination of criteria based on local zoning and background noise levels.

Given the above, project-specific operational noise criteria are provided in Table 16-4.

Table 16-4 Operational Noise Limits dB(A) Assessed According to SEPP N1

Receiver	Representative monitoring location	Operational noise criteria dB(A)		
		Day	Evening	Night
R1	N1	45	37	41
R2	N1	45	37	41
R3	N2	45	37	41
R4	N5	45	37	40
R5	N2	45	37	42
R6	N5	45	37	39
R7	N5	45	37	39
R8	N5	45	37	39
R9	N5	45	37	39

Receiver	Representative monitoring location	Operational noise criteria dB(A)		
		Day	Evening	Night
R10	N5	45	37	39
R11	N5	45	37	39
R12	N5	45	37	39

It should be noted that the noise limits used in the operational noise assessment assume no penalty due to tonality or other character adjustments. Tonality and other character adjustments should be addressed at detailed design stage with the following consequences if found present:

- reduced noise limits with consideration to the relevant provisions of SEPP N1; or
- additional noise control to be integrated to the plant design so as to eliminate tonality and other character adjustments.

Adoption of (and compliance with) these project-specific noise goals will provide adequate protection of beneficial uses of the environment at nearby sensitive receptors during periods of low ambient noise.

16.3.4 Noise Modelling

The modelling assumed that the Desalination Plant would operate 24-hours per day, seven days per week. In that context, 37 dB(A) is the most stringent criterion applicable to site noise emissions over day, evening and night periods.

Noise modelling was conducted to determine requirements enabling the Desalination Project in its 200 GL per year configuration to achieve 37 dB(A) at the sensitive receptors.

The following tasks were carried out in the conduct of the noise modelling assessment:

- noise model configuration;
- compilation of available sound power data of noise sources to identify significant plant items; and
- analysis of noise model results to assess compliance with adopted noise limits.

These tasks are described below under relevant headings.

16.3.4.1 Noise Model

Acoustic modelling was undertaken using Computer Aided Noise Abatement (Cadna-A) software to predict the effects of industrial noise generated by the Desalination Plant operational activities.

Cadna-A, by Datakustik, is a computer program for the calculation, assessment and prognosis of noise exposure. Cadna-A calculates environmental noise propagation according to ISO 9613-2.

Cadna-A considers local topography, weather conditions, reflection, ground absorption, relevant building structures, site sources and the location of the receiver areas to predicted received noise levels. The method specified in ISO 9613-2 consists specifically of octave-band algorithms (with nominal midband frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound.

Adverse weather conditions that enhance noise propagation in the atmosphere and which were modelled included temperature inversion conditions (stable atmosphere) and a 5 m/s southerly wind (blowing from source to receptors). In assessing meteorological conditions, the CONCAWE method was applied instead of ISO 9613-2 weather correction.

In building the noise model, a number of assumptions were made, including assumptions relating to:

- location of noise sources as per Reference Project;
- sound power levels for operational noise sources;
- building details and building component transmission loss;
- topography and ground absorption effects;
- local meteorological conditions;
- exclusions; and
- model accuracy and uncertainty.

Detail on the assumptions and their implications on the model are detailed in *Section 8.3* of the Noise and Vibration report (GHD, 2008k).

16.3.4.2 Noise Sources

A complete list of all noise sources considered in the assessment with their location within the Project Site is provided in the Noise and Vibration report (GHD, 2008k).

A summary of significant[29] operational (200 GL per annum) Desalination Plant noise sources is presented in Table 16-5.

Note that all modelled sources are assumed to run continuously.

Table 16-5 Inventory of significant Desalination Plant operational noise sources

Item	Source	Power consumption kW	Duty units No. / module	Type	Location	Indoor/outdoor
1	Seawater pump	761	2	Vertical turbine	Seawater pump station and screening building	Indoor
8	Backwash air blower	169	1		Pre-treatment building	Indoor
19	Clarified water return pump	75	1	Vertical turbine	Treated wastewater storage tank	Outdoor
21	Feed pump	47	1	Centrifugal	Pre-treatment wastewater tank	Outdoor

[29] Selection of sources based on relative contribution to predicted noise impact.

Item	Source	Power consumption kW	Duty units No. / module	Type	Location	Indoor/outdoor
23	Feed booster pump RO	780	8	Multistage vertical centrifugal	Cartridge filters and feed booster pumps	Indoor
24	Feed booster pump ERD	142	8	Vertical centrifugal	Cartridge filters and feed booster pumps	Indoor
25	HP pump 1st pass	1400	8	Multistage centrifugal	Reverse osmosis bunker	Indoor
26	ERD booster pump	199	8	Centrifugal	Reverse osmosis bunker	Indoor
27	Feed pump second pass	1103	4	Multistage centrifugal	Reverse osmosis bunker	Indoor
31	CIP	209	0.5	Centrifugal	Reverse osmosis clean in place	Indoor
32	RO flushing pumps	209	1	Centrifugal	Permeate pump station	Indoor
33	Chemical service pumps	90	2	Centrifugal	Permeate pump station	Indoor
34	Permeate pumps	200	2	Vertical centrifugal	Permeate pump station	Indoor
48	Treated water transfer pump	2604	2	Centrifugal	Treated water pump station	Indoor

The estimated sound power levels for each significant plant item in Table 16-5 above are shown in Table 16-6 below.

Table 16-6 Estimated sound power levels for significant Desalination Plant noise sources

Item	Noise source	Octave band centre frequency (Hz) / L_w dB(A)									
		31.5	63	125	250	500	1000	2000	4000	8000	Sum
1	Sea water pump	46	60	72	81	86	93	91	87	79	96
8	Backwash air blower * [30]	61	74	79	83	88	92	92	86	78	97
19	Clarified water return pump	47	61	73	82	87	94	92	88	80	97
21	Pre-treatment waste water tank feed pump	47	61	71	80	88	89	87	84	79	94
23	Feed booster pump RO	64	78	88	97	105	106	104	101	96	110
24	Feed booster pump ERD	54	68	78	87	95	96	94	91	86	101
25	HP pump first pass	67	81	91	100	108	109	107	104	99	114
27	ERD booster pump	55	69	79	88	96	97	95	92	87	102
26	Feed pump second pass	66	80	90	99	107	108	106	103	98	113
31	CIP pump	56	70	80	89	97	98	96	93	88	103
32	RO flushing pump	56	70	80	89	97	98	96	93	88	103
33	Chemical service pump	51	65	75	84	92	93	91	88	83	98
34	Permeate pump	56	70	80	89	97	98	96	93	88	103
48	Treated water transfer pump	71	85	95	104	112	113	111	108	103	118

Further to the above, Cadna-A calculation protocols were used to determine internal noise levels in all buildings containing indoor sources (refer to Table 16-5). These were based on a conservative average 0.05 internal absorption coefficient (representing acoustically hard surfaces) and the overall surface of the subject buildings. Results for significant buildings are presented in Table 16-7 below.

Table 16-7 Estimated internal sound pressure levels dB(A) for significant buildings

Building	Internal Noise Level dB(A)									
	31.5	63	125	250	500	1000	2000	4000	8000	Sum
Cartridge and feed booster pumps	55	69	79	88	96	97	95	92	87	101
Permeate pump station - 2 modules serviced	48	62	72	81	89	90	88	85	80	95

[30] assumed 15 dB(A) attenuation enclosure

Building	Internal Noise Level dB(A)									
	31.5	63	125	250	500	1000	2000	4000	8000	Sum
RO clean in place - 2 modules serviced	49	63	73	82	90	91	89	86	81	95
Treated water pump station - 3 modules serviced	62	76	86	95	103	104	102	99	94	108
Treated water pump station - 4 modules serviced	63	77	87	96	104	105	103	100	95	110
RO bunker	58	72	82	91	99	100	98	95	90	105

16.3.5 Noise Model Results

Model results indicate that operation of the Desalination Plant in its 200 GL configuration would comply with the 37 dB(A) noise limit at the sensitive receivers under both modelled neutral and adverse weather conditions, which implies that beneficial uses identified in SEPP N1 would be protected. In particular, sleep disturbance during the night period is not expected to be an issue due to the continuous nature of the noise sources and the elevated ambient noise levels that typically occur during the night.

The model results for all model scenarios are provided in the Noise and Vibration report (GHD, 2008k).

16.4 Noise Assessment – Construction

16.4.1 Construction Noise Goals

The EPA Interim Guidelines for the Control of Noise from Industry in Country Victoria (N3/89) and the EPA Noise Control Guidelines (TG 302/92) apply during construction. N3/89 allows an additional 10 dB(A) during the construction period of an industrial facility for the day period only and no adjustments for other time periods.

Clause 12 of TG 302/92 is relevant to the construction of industrial premises. These guidelines place no restriction on construction noise during normal working hours (7 am to 6 pm Monday to Friday, 7 am to 1 pm Saturdays), but require:

- for the first 18 months of construction, construction noise must not exceed background by more than 10 dB(A) outside normal working hours;
- once construction has been ongoing for 18 months or more, construction noise must not exceed background by more than 5 dB(A) outside normal working hours; and
- construction noise to be inaudible inside a dwelling between 10 pm and 7 am.

TG 302/92 also allows for construction works to continue through the night when it is a matter of necessity and provided that residents are given notification. As outlined in *Section 5* of the EPA's Environmental Guidelines for Major Construction Sites, limits from N3/89 and TG302/92 are not statutory. Therefore, all noise nuisances from construction activities should be reduced wherever possible.

For this assessment, TG 302/92 will be applied to all receivers in the vicinity of the Desalination Plant. However, where normal work is proposed outside the provisions of the TG302/92 guidelines, specific provisions addressing targetted measures to minimise the impact of noise that might cause sleep disturbance or extreme amenity loss at night are required. This is further discussed in Section 16.5.2.

16.4.2 Predicted Noise Impacts

Construction noise impacts associated with the Project were conservatively estimated using the well-known distance attenuation relationship described in Equation (1).

$$SPL = SWL - 20Log(d) + 10Log(Q) - 11 \qquad \text{Equation (1)}$$

Where *d = distance (m) between source and receiver;*

Q = Directivity index (2 for a flat surface);

SPL = sound pressure level at the distance d from the source; and

SWL = sound power level of the source.

Typical noise levels produced by the types of construction plants anticipated to be used were sourced from Australian standard AS 2436: 1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites* and from GHD's internal database. These conservatively represent the loudest construction noise sources expected to be found on-site and are summarised in Table 16-8.

Table 16-8 Predicted plant item noise levels, dB(A)

Plant	Estimated sound power level of the source [dB(A)]	Estimated sound pressure level dB(A) at distance (m)						
		50	100	200	400	600	1 200	2 400
Crane	115	73	67	61	55	51	45	39
Bulldozer	115	73	67	61	55	51	45	39
Excavator	118	76	70	64	58	54	48	42
Back Hoe	108	66	60	54	48	44	38	32
Compactor	110	68	62	56	50	46	40	34
Dump Truck	106	64	58	52	46	42	36	30
Road Truck	110	68	62	56	50	46	40	34
Compressor	107	65	59	53	47	43	37	31
Concrete Pump	109	67	61	55	49	45	39	33
Concrete Saw	118	76	70	64	58	54	48	42
Paver	113	71	65	59	53	49	43	37
Diesel Generator	104	62	56	50	44	40	34	28

Other construction noise sources such as the concrete batching plant are expected to have similar sound power levels to the noise sources shown in the above table.

The magnitude of off-site noise impact associated with construction will be dependent upon a number of factors:

- the intensity of construction activities;
- the location of construction activities;
- the type of equipment used;
- existing local noise sources;
- intervening terrain; and
- the prevailing weather conditions.

In addition, construction machinery will likely move about the study area, variously altering the directivity of the noise source with respect to individual receivers. During any given period the machinery items to be used in the study area will operate at maximum sound power levels for only brief stages. At other times the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any single point in time. Finally, certain types of construction machinery will be present in the study area for only brief periods during construction.

Nevertheless, Table 16-8 suggests that construction noise goals outlined in the previous Section may potentially be exceeded. On the basis of night-time background noise levels in the order of 35-40dB(A) (as monitored), noise impacts exceeding background + 10dB(A) are likely to occur within approximately 400m from a residence.

It is anticipated that construction may occur 24 hours per day, seven days per week to meet the Project timelines. Noise exceedances, if any, are more likely to occur over the night-time and on weekends when construction noise goals are more stringent.

As outlined in the EPA Environmental Guidelines for Major Construction Sites, *while no specific statutory controls exist for noise from construction sites, all noise nuisance should be reduced wherever possible from vehicles, fixed machinery within the site, blasting, general construction activities, and from movements of vehicles servicing the site.*

As a result, the issue of potential noise exceedances is practically best addressed by the implementation of a range of noise control measures and monitoring adapted to the construction activities occurring simultaneously at a single point in time.

16.5 Mitigation and Management

16.5.1 Operation

Key noise control features of the Reference Project (being outlined here as an example of measures that can be taken to achieve the Performance Requirements) include:

- continuous wall along Project Site perimeter;
- screening wall along northern side of Clarified Water Return Pump (Module 3, 150 GL only);

- roofing of cartridge filter and feed booster pumps buildings constructed from concrete, or material providing equivalent noise attenuation;
- roofing of treated water transfer pump station constructed from concrete, or material providing equivalent noise attenuation;
- roofing of permeate pump station buildings constructed from concrete, or material providing equivalent noise attenuation;
- roofing of CIP building constructed from concrete, or material providing equivalent noise attenuation;
- RO process units enclosed in concrete housing (bunker) within the RO building; and
- upgraded roofs for Module 4 RO and pre-treatment buildings (200 GL per year only).

Further detail is provided in *Section 8* of the Noise and Vibration report (GHD, 2008k).

16.5.2 Construction

A Project Management Framework will be developed including incorporation of performance requirements of the Project Company. It is anticipated that an environmental management plan for the Desalination Plant component will be developed by Project contractors in order to address performance requirements. A performance requirement for the noise and vibration component is "Develop and implement a noise mitigation strategy for construction activities".

The noise mitigation measures recommended for construction are generally consistent with EPA Noise Control Guideline (TG302/92) and the EPA Environmental Guidelines for Major Construction Sites (Publication 480). They are expected to protect the amenity of local noise and vibration sensitive receivers throughout the construction period.

Where normal work is proposed outside the provisions of the TG302/92 guidelines, the noise mitigation strategy should have specific provisions addressing targetted measures to minimise the impact of noise that might cause sleep disturbance or extreme amenity loss at night.

The following parts of this Section of the WAA provide guidance as to potential management and mitigation measures for consideration.

- **Work Approach / Community Relations**
  - All site workers (including subcontractors and temporary workforce) should be sensitised to the potential for noise and vibration impacts upon local residents and encouraged to take all practical and reasonable measures to minimise noise during the course of their activities;
  - The constructor or site developer (as appropriate) should establish contact with the local residents and communicate the construction program and progress on a regular basis, particularly when noisy or vibration generating activities are planned;
  - The constructor or site developer (as appropriate) should provide a community liaison phone number and permanent site contact so that noise and/or vibration related complaints, if any, can be received and addressed in a timely manner; and
  - Consultation and cooperation between the Site and neighbours to the Site will assist in minimising uncertainty, misconceptions and adverse reactions to noise and vibration.

- **Construction Program**
  - Review work methods with a preference for quieter and non-vibration generating methods wherever possible. This is particularly important for night-time activities;
  - Review fixed and mobile equipment fleet with a preference for more recent and silenced equipment wherever possible. Equipment used on-site would typically be in good condition and good working order; and
  - Use equipment that is fit for the required tasks in terms of power requirements.
- **Construction Site Configuration / Equipment Use and Siting**
  - All plant on site should be operated in accordance with the manufacturer's instructions;
  - Fixed equipment (i.e. pumps, generators, compressors) should be located as far as practicable from the nearest residences. In particular, diesel generators should be located at least 1000m from any existing residence;
  - Material dumps should be located as far as practicable from the nearest residences;
  - Whenever possible, loading and unloading areas should be located as far as practicable from the nearest residences;
  - Equipment which is used intermittently should be shut down when not in use;
  - All engine covers should be kept close while equipment is operating; and
  - As far as possible, materials dropped from heights into or out of trucks should be minimised.
- **Night-time Construction Activities**

Where normal work is proposed outside the provisions of the TG302/92 guidelines, the noise mitigation strategy should have specific provisions addressing targeted measures to minimise the impact of noise that might cause sleep disturbance or extreme amenity loss at night.

These measures could include:

  - community engagement prior to commencement with targeted discussion about preferred noise impact minimisation;
  - 24 hour hotline for complaints;
  - a specialist communications officer to liaise with the community and other affected stakeholders;
  - provisions for temporary acoustic barriers (where effective) specifically for noise control;
  - provision for temporary relocation of affected residents for the duration of specific noisy activities; and
  - in extreme cases consider offsite attenuation measures such as upgrading glazing.
- **Noise and Vibration Monitoring**

Noise and vibration monitoring should be undertaken by a qualified professional and with consideration to the relevant standards and guidelines. Attended noise and vibration monitoring should be undertaken in the following circumstances:

  - when vibration-generating activities are conducted within 30 metres of a residence. Prior to works, establish whether there is a risk for building damage. If a building damage risk is identified, alternative work methods should be implemented so the vibration impacts are reduced to acceptable levels. Monitoring results should be reported;

- upon receipt of a noise and/or vibration complaint. Monitoring should be undertaken and reported within (say) 3 to 5 working days. If exceedances are detected, the situation should be reviewed in order to identify means to reduce the impact to acceptable levels. In case of vibration complaints, both building damage and human perception issues should be considered; and
- night-time noise measurements should be undertaken on a regular basis during the first few months of the construction works to provide an understanding of acceptable night-time work activities to site management.

16.6 Environmental Performance Requirements Arising from this Section

As discussed in Sections 1 and 6 of this WAA, the design adopted by the Project Company appointed under the PPP contract is likely to differ from the Reference Project. Nevertheless, the final design must achieve, and comply with, the Performance Requirements outlined in this Section of the WAA in a manner that would lead to a similar or better noise management outcome.

The Performance Requirements are incorporated into the Environmental Management Framework (see Section 17 of this WAA) and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirements relevant to this study area are presented below.

Performance Requirements

- Comply with the relevant Performance Criteria set out in Table 17-3, Section 17;
- Develop and implement a communication strategy with the key stakeholders and the community to manage the impacts of construction noise and limit disturbance to local amenity;
- Model and report predicted airborne noise levels during operation to demonstrate that the design meets the Performance Criteria. As part of the modelling and reporting exercise, include an assessment of tonality and other character adjustments with consideration to the relevant provisions of State Environment Protection Policy N1. If found present, tonality or character adjustments should be eliminated through the detailed design stage. Alternatively reduced noise limits, with consideration to State Environment Protection Policy N1, may be applicable;
- Develop and implement a noise mitigation strategy for construction activities;
- Night-time construction works outside the provisions of TG302/92 should be subject to a specific noise mitigation strategy, through consultation with the EPA, prior to commencement of works; and
- Monitor and report on airborne noise levels.

17. Ongoing Environmental Management and Monitoring

17.1 Environmental Management Framework

This Section presents an Environmental Management Framework (EMF) for the Desalination Project, including the Performance Requirements and how this framework would be applied in a project delivery process.

The EMF is guided by the environmental evaluation framework in Section 2 of this WAA, which includes relevant policy, legislation and guidelines.

DSE has developed an EMF to manage environmental aspects of the Desalination Project for the design, construction and operation phases of the Project. The purpose of this EMF has been to support that activities are planned and carried out in a manner that is consistent with statutory requirements, and which avoids potentially adverse effects on the environment or manages them to an acceptable level.

As discussed in Section 1 of this WAA, the Victorian Government intends to appoint a Project Company to finance, design, construct, operate and maintain the Desalination Project.

The Victorian Government's Project Agreement with the Project Company will include the EMF and Performance Requirements approved for the Project. Implemented through a Project Agreement, the EMF will require the Project Company to:

- comply with the Performance Requirements, including performance criteria and minimum requirements;
- develop, implement and maintain an overarching project environmental management plan (PEMP) for the Project and discrete environmental management plans (EMPs) for the design, construction, operation and maintenance phases of each of the relevant Project components:
  - Marine Structures;
  - Desalination Plant; and
- comply with conditions as set out by EPA works approval and EPA Waste Discharge Licence.

This EMF is consistent with DSE's environmental management policies and the AS/NZS/ISO 14000 Environmental Management Systems Standards series. DSE's environmental management system (EMS) will be further developed to cover all significant environmental aspects of the Project in an auditable manner.

The EMF provides a structure for:

- management of the Project in a way that achieves compliance with environmental legislation;
- setting environmental objectives and targets;
- programmed monitoring, auditing, review and reporting of environmental performance;
- establishment of methods for assessing performance of the Project's environmental commitments;
- supports continual improvement in environmental management and performance;
- developing and implementing appropriate environmental plans and procedures for all phases of the Project; and

- implementation of an emergency response system, that is protective of the community, environment and plant infrastructure.

Figure 17-1 shows the framework comprising three levels set out in Table 17-1.

Table 17-1 Environmental Management Framework Levels

Level	Description
Level 1	Environmental Management Framework ▪ incorporating Project governance and Performance Requirements, prepared by DSE
Level 2	Project Environmental Management Plan ▪ to be prepared by the Project Company
Level 3	Individual Environmental Management Plans ▪ for design, construction, operation and management phases of each relevant Project component

Each EMP will be prepared in the context of the environmental management systems of the organisation responsible for the activities. All plans will be consistent with the requirements of ISO 14001 and relevant policy, legislation and approvals.

The Project Environmental Management Plan (PEMP) will address the management actions and commitments associated with environmental matters specific to the Desalination Project.

Specific EMPs for each Project component will address environmental issues. These plans will be required by the Project Agreement and it is expected that they will form part of the licences, consents and permits for construction and operation of Project components.

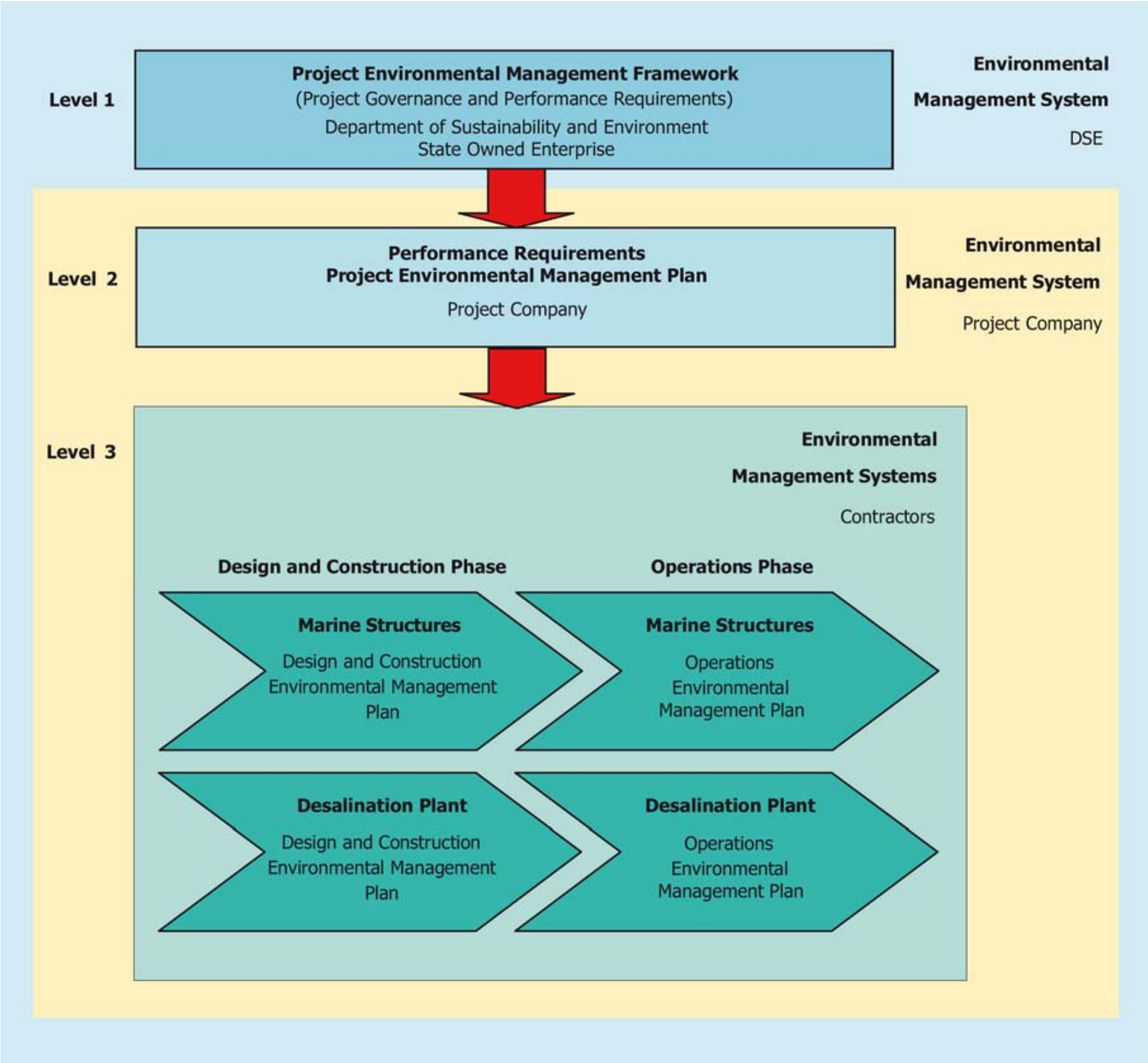


Figure 17-1 Environmental Management Framework

17.2 Performance Requirements

The environmental Performance Requirements developed by DSE for delivery of the Desalination Project are presented in Table 17-3 at the end of this Section. The Project Agreement will require the Project Company to achieve and comply with these Performance Requirements.

The Performance Requirements are described as 'outputs', that is, the performance that the Desalination Project must achieve rather than the process used to achieve it.

This performance-based approach to environmental management delivers a balance between:

- achieving acceptable outcomes for the community and environmental values; and
- a Project delivery mode with sufficient flexibility to address specific challenges that optimise innovation and efficiencies in Project development construction and operation.

The WAA and EES investigations have identified impacts and risks for the Reference Project and variations considered in the environmental assessment and approvals process. The detailed management and mitigation measures identified in the specialists' investigations present suggested measures, which provide guidance as to how the Reference Project could achieve its Performance Requirements. These measures have been taken into account in the formulation of the Project Performance Requirements.

The Performance Requirements have also been guided by the Environmental Evaluation Framework described in Section 2 of this WAA, and by relevant policy, legislation and guidelines.

Where possible and practicable, unacceptable environmental risks have been 'designed out' of the Desalination Project. The Reference Project demonstrates a feasible design solution and *outcomes*, rather than the detail of the design, which is addressed through the Performance Requirements.

The Performance Requirements make reference to a number of figures as part of the requirements. These figures are presented in *Technical Appendix 5* of the EES. Sensitivity mapping for the four Project components. The figures present specific sites or ecological features which should not be disturbed during the construction and operational phases based on recommendations in the cultural heritage, waterways and flora and fauna EES investigations provided in the Technical Appendices to the EES. Such areas should be considered as exclusion areas for construction activities. In addition buffers have been defined around environmental assets and values as appropriate. The areas within these buffers are afforded the same level of protection as specific site or ecological features.

17.3 Environmental Management Principles - Government Context

The EMF for the Desalination Project has been developed within the context of Victoria's Environmental Sustainability Framework and DSE's environmental management systems.

DSE is Victoria's lead government agency for sustainable management of water resources, climate change, bushfires, public land, forests, and ecosystems. *Victoria's Environmental Sustainability Framework* (Victorian Government, April 2005, *Our Environment, Our Future: Victoria's Environmental Sustainability Framework*) is a key driver of the Government's commitment to make Victoria a world leader in environmental sustainability. The *Environmental Sustainability Framework* provides Government, business, and the community with direction for building environmental considerations into the way Victorians work and live. All Victorian Government departments and agencies have been required to include *Environmental Sustainability Framework* directions in all their operational planning and business, including their environmental management systems from July 2006. All Government departments now have environmental management systems to reduce the environmental impacts from office-based energy, water, transport fuel, paper consumption and waste disposal.

17.4 Legislative Compliance

In developing environmental Performance Requirements for the Desalination Project, DSE conducted a review of applicable environmental legislative requirements. *Technical Appendix 2* of the EES contains a summary of the legislative framework relevant to the overall Project, and Section 2 of this WAA lists the legislative requirements that are specific to works approvals. The relevant environmental legislative requirements and potential compliance requirements in statutory approvals for the Project will be embodied in individual Project component EMPs which will be further guided by the overall Project EMP.

EPA may require the preparation of an Environment Improvement Plan (EIP), consistent with the *Guidelines for the Preparation of Environment Improvement Plans* (EPA 2002), for the Desalination Plant. This EIP may also be required to address the requirements as set out by Clause 15 of the IWMP (PIW), where a waste stream generated on-site may be classified as a PIW.

Any such EIP will effectively be the same as the Project EMP to be developed for the Desalination Plant. The Performance Requirements developed for the Desalination Plant would form the basis for both the Project EMP and the EIP for the Desalination Plant.

17.5 Roles and responsibilities

Fulfilling the responsibilities and accountabilities across all elements of the environmental management framework involves the participation of DSE, the Project Company and its contractors involved with the Project. The key responsibilities are shown in Table 17-2.

Table 17-2 Environmental management responsibilities

Organisation	Role	Key responsibilities
DSE State Owned Enterprise	Develop the Desalination Project	Establish, implement, maintain, monitor and improve, through "continual improvement" the Environmental Management Framework. Develop and administer the Project Performance Requirements. Ensure that prior to commencement of work, the Project Company has complied with relevant Performance Requirements, such as preparing and implementing a Project Environmental Management Plan, conducting, monitoring and notifying the community. Review the Project Company's performance against the Performance Requirements and take corrective action as necessary. Complete environmental audits for compliance.
Project Company	Implement the Desalination Project	Establish, implement, maintain, monitor and improve, through "continual improvement" the Environmental Management Framework. Implement the Performance Requirements for the Project. Engage an independent environmental representative. Complete environmental audits of compliance. Liaise with and coordinate communication with relevant agencies for the smooth and efficient delivery of the Project. Obtain relevant approvals, licences and permits before starting site works. Ensure that, prior to commencement of work;

Organisation	Role	Key responsibilities
		contractors have complied with relevant Performance Requirements, such as preparation and will implement a works specific Environmental Management Plan. Review contractors' performance against the Performance Requirements and take corrective action as necessary. Establish and maintain open and effective communications with stakeholders.
Contractors	Implement specific works	Establish, implement, maintain, monitor and improve, through "continual improvement" the Environmental Management Plan for the relevant design and construction, or operations phase of the Project works component. Implement relevant Performance Requirements. Complete environmental audits for compliance. Review performance against the Performance Requirements and take corrective action as necessary.

The Victorian Government will review the environmental performance of the Project Company before awarding the Desalination Project. Site works may not commence until the Project EMP prepared by the Project Company has been accepted by the Victorian Government and/or EPA, and is consistent with the Project Agreement and any condition of statutory approvals.

The Project Company would be responsible for compliance with environmental legislation and the Project Performance Requirements. This includes providing adequate resources, including:

- personnel to establish, implement, maintain, monitor and improve through "continual improvement" environmental management plans, systems and performance;
- staffing for all environmentally-critical roles;
- ongoing verification that environmentally-critical activities are carried out in accordance with the Performance Requirements;
- ongoing assurance of competencies; and
- promptly addressing environmentally-related deficiencies.

Through the Project Agreement, the Project Company will be required to nominate a suitably qualified person to serve as an Environmental Management Representative. The principal role of this representative would be to report on the performance of the PEMP and environmental management system.

The Project Company would be required to check that each of its contractors has appropriate systems in place to manage environmental risks.

17.6 Environmental Management Plans for Project Components

The Project Agreement and the EMF requires EMPs to address governance and environmental Performance Requirements for the design, construction, and operations phases of each Project component.

Each plan is likely to include:

- an outline of the regulatory framework under which the Project or Project component will be undertaken, including a list of required approvals;
- identification of environmental conditions and issues, particularly where there are sensitive areas, and potential impacts, including those matters described in this WAA;
- identification of the environmental issues to be managed and measures to be taken to meet the environmental requirements;
- timeframes for commencement, carrying out and completion of environmental management measures;
- a schedule identifying frequency and extent of planned environmental monitoring and reporting;
- auditing, monitoring and reporting requirements to ensure compliance with the environmental requirements, including approach to “continual improvement” and method to address non-conformances. Specific monitoring programs are required for the design, construction, and operations and maintenance phases of the Project;
- environmental risk management assessments and measures;
- a framework, and procedures for the management of non-conformances, including corrective action and prevention;
- emergency, incident management and communication protocols and procedures; and
- a site induction and training plan, to check that all Project personnel receive the appropriate Project environmental awareness training.

Each plan would address the following management system elements:

- environmental policy;
- planning and identification of environmental aspects;
- assessment and control of risks;
- legal and other requirements;
- objectives, targets and management programs;
- resources, roles, responsibilities and authorities;
- competence, training and awareness;
- documentation, record keeping;
- control of documents;
- communication;
- operational control;
- emergency preparedness and response;

- monitoring and measurement criteria, extent and scheduling;
- performance evaluation, including compliance;
- incident and non-conformity investigation, corrective and preventive action;
- management and control of records;
- auditing;
- continual improvement; and
- management review.

Individual EMPs for Project Components would address specific environmental aspects, as relevant to the nature of the works, including:

- archaeological cultural heritage management, including fossils;
- flora and fauna management;
- pest and weed management;
- air quality management;
- contaminated soil management;
- soil and acid sulphate soil management;
- surface water and groundwater management;
- erosion and sediment control;
- stormwater management;
- noise and vibration management;
- waste management;
- rural design and landscaping, including visual effects;
- traffic management;
- third party infrastructure management;
- hazardous materials management;
- energy management;
- protection of amenity and access to community infrastructure; and
- local industry participation.

17.7 Evaluating Environmental Outcomes

The program for evaluation of environmental outcomes will include monitoring, auditing, reporting, and management review of environmental performance.

17.7.1 Monitoring

The purpose of environmental performance monitoring is to measure conformance with, and the effectiveness of, established environmental limits, controls and processes identified in environmental management plans and developed from Project Performance Requirements. This way, opportunities for continual improvement will be identified. The Project environmental performance will be monitored by the following mechanisms:

- environmental monitoring[31] – monitoring of environmental conditions, including background conditions and areas that could be impacted by the Project. Environmental monitoring data informs activities which can be modified in response. Specific recommendations for environmental monitoring have been included in specialist assessment areas of this WAA, where relevant. An environmental monitoring program would be reviewed and approved by relevant specialists prior to implementation.
- process monitoring – monitoring of operational activities (e.g. equipment tracking, failure mode analysis and failure criticality). An indicative failure mode analysis and corresponding process monitoring and review requirements are presented as Appendix B. It is expected that a design and site-specific failure mode analysis would be undertaken during the detailed design phase, that would provide a basis to develop and implement ongoing process monitoring at the site.
- management performance monitoring – monitoring of the implementation and effectiveness of the environmental management system (e.g. nature of complaints, number of corrective actions completed, and opportunity for continual improvement). Monitoring data informs the overall management of the activities. It does not directly inform operational aspects, but may have an indirect effect through the management review and continual improvement process.

17.7.2 Audits

The EMF will require establishment of an internal and external program of audits, meeting regulatory requirements and international standards through both the Project's construction and operations phases. The nature and frequency of audits will be appropriate to the activities in the Project phase and relevant associated environmental risks.

Audit programs, documented at all levels of the EMF, include:

- environmental management system and ISO 14001 audits (where appropriate);
- independent audits by suitably qualified auditors; and
- specific activity audits.

Audit results and completion of corrective actions arising from audits will be documented, reviewed and reported at the relevant appropriate management level.

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[31] Environmental monitoring includes, a proactive, planned monitoring program with defined scope and extent, incorporating quality and audit, as well as responsive monitoring.

17.7.3 Emergency Preparedness and Response

The EMF will require establishment of an emergency preparedness and response program for both the Project's construction and operations phases. The nature of the program will be appropriate to the activities in the Project phase and relevant associated environmental risks.

Emergency preparedness and response addressed in the EMF, include:

- policies for the development, and implementation of an emergency preparedness and response program;
- resourcing to support implementation of the program; and
- procedures for emergency response, including, implementation, monitoring, corrective action, continual improvement, "close-out", audit and reporting of events.

Actions arising from emergency events will be documented, reviewed and reported at the relevant appropriate management level.

17.7.4 Reports

DSE, the Project Company, and any contractors will implement a program of internal reporting.

Reporting is likely to address:

- compliance status against approvals, including any WAA and licence requirements;
- applications for approvals, and responses from relevant authorities;
- implementation and effectiveness of environmental controls and conditions relating to design and construction activities and operations and maintenance activities;
- details and analysis of environmental monitoring results, and measures of continual improvement;
- consultation; and
- number and details of any complaints, including a summary of main areas and issues of complaint, action taken, responses given/implemented, including emergency response and intended strategies to reduce complaints or events of a similar nature.

17.7.5 Management Review

An annual review of the EMF and the PEMP during construction and operations will be conducted to check that it:

- continues to be effective, suitable and adequate over the lifecycle of the Project, including transition from the construction phase to the operations phase;
- incorporates all conditions and requirements arising out of approvals and directives from government agencies during all phases of the Project;
- incorporates all changes to policy, objectives and other elements of the environmental management system arising from monitoring, auditing, changing construction and operations circumstances and the commitment to continual improvement; and
- continues to meet legislative and other requirements.

17.8 Stakeholder Consultation

Stakeholder consultation is a significant component of the EMF for the Project. Appropriate procedures to ensure open and transparent stakeholder consultation will be implemented at all levels, filtering down from the EMF to the PEMP and through to the Project component EMPs.

The Project Company will be required by the Project Agreement to develop and implement a consultation and communication plan, which identifies key stakeholders and details strategies for engaging stakeholders in the Project during construction and operation.

Table 17-3 Environmental Performance Requirements

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
Waterways and Wetlands	✓	✓	Protect waterways and wetlands.	Comply with the State Environment Protection Policy (Waters of Victoria). No significant impact on Western Port Ramsar site. Maintain the environmental values of waterways and wetlands. Compliance with all relevant Authority requirements for waterway crossings.	Comply with the Performance Criteria. Develop and implement construction methods and site rehabilitation plans that seek to protect the habitat values of waterways and wetlands including: • Developing appropriate construction methods to minimise environmental impacts for crossing sensitive waterways • Site specific construction methods to minimise environmental impacts including erosion, sedimentation and pollution • Reinstating and revegetating areas of disturbance • Limiting impact on ecological processes such as fish movements and breeding Develop and implement monitoring and reporting on the effects of construction on waterways and wetlands. Develop and implement methods and management systems to limit impacts on waterways and wetlands during operation. Re-establishment of wetland (unnamed tributary of the Powlett River) on the Desalination Plant site. Design and locate scour and other relief valves to meet the Performance Criteria.

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
Resource Efficiency	✓	✓	Minimise resource use including energy, water and chemical use during Project Activities. Design to provide a holistic, best practice solution encompassing minimal resource usage and emissions to the receiving environment.	Comply with the Environment and Resource Efficiency Plans reporting and management requirements. Design the Pre-Treatment, Desalination and Potablisation systems to minimise chemical usage and to select chemical products that are proven to have minimal adverse effect on the receiving environment.	Comply with the Performance Criteria. Develop and implement construction and operation methods and management systems (including monitoring and reporting) to ensure the efficient use of water resources during Project Activities, including: • Minimising water use. Designing offices and associated facilities to achieve a minimum water conservation target of 2A (i.e. less than, or equal to, 18 litres per day per person) • Reusing or recycling water, where possible. Where practical, harvesting rainwater and stormwater as a supplementary supply for various non-potable uses such as toilet flushing, cooling tower, irrigation and various in-plant uses where appropriate • Treating and/or returning surplus water for other non-Project uses or benefits Develop and implement construction and operation methods and management systems (including monitoring and reporting) to ensure energy efficiency during Project Activities including: • Achieving a Specific Energy Consumption (SEC) for the desalination process that is less than 4.6 kW/kL (calculated using a method agreed with EPA) on an annual average basis, or to satisfaction of EPA • Installing variable speed (VSD) drives on pumps and motors, where practical • Ensuring all pumps are selected to run at their Best Efficiency Point (BEP) under normal operating conditions

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
Flooding Control	✓	✓	Protect public and private assets from flooding.	Limit impacts of flooding from Project Activities.	Comply with the Performance Criterion. Design and construct Project infrastructure to avoid impacts on flood potential or obtain approval of the relevant Authority to any change in waterway flood levels. Design and construct the Desalination Plant to be sufficiently above the 1 in 100 Annual Exceedance Probability (AEP) flood level under expected climate change conditions to allow for the natural closing of the river mouth, coincident levels in Bass Strait and a reasonable allowance for the uncertainty in these estimates (AEP is the probability of exceedance of a given discharge within a period of one year). Develop and implement methods and management systems that seek to: • Identify and investigate potential interactions with flood protection systems during Project Activities • Maintain existing flood protection systems during Project Activities Any Project activities on waterways are to be in accordance with the requirements of the relevant Authority.
Groundwater	✓	✓	Protect the beneficial uses of groundwater.	Minimise impact on groundwater. Minimise impacts on the interaction between groundwater and flora and fauna habitats, including wetlands and dune	Comply with Performance Criteria. Develop and implement methods and management systems which do not cause deterioration to groundwater systems including: • Consideration of the interaction between surface water and groundwater • Recognition of the interaction with flora and fauna habitats, including

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
				vegetation. Comply with the Water Act 1989 and State Environment Protection Policy (Groundwaters of Victoria) requirements for groundwater quantity, quality, availability and flow including meeting any Authority licensing requirements.	wetlands and dune vegetation • Management of extracted groundwater seeking to maximise potential reuse and disposal • Limiting any impact or diminution on the existing flow regime in nearby waterways or on the use of groundwater as a resource arising out of any interception and/or drainage of groundwater • Minimise any reduction of existing groundwater recharge to wetlands resulting from the construction or operation of the Desalinated Plant water supply system Undertake a site specific assessment, in consultation with the relevant Authority and the EPA, if intercepted groundwater is proposed to be discharged to waterway segments and demonstrate that water quantity, quality, availability and flow will meet the relevant licensing requirements. Monitor groundwater quality during the Project Term in accordance with the requirements of the EPA and/or relevant Authorities.
Surface Water Quality	✓	✓	Protect and maintain surface water quality.	Minimise impacts on surface water quality. Comply with State Environment Protection Policy (Waters of Victoria). Achieve the Urban Stormwater Best Practice Environmental Management Guidelines performance objectives during construction and operation.	Comply with the Performance Criteria. Develop and implement construction methods and management systems that seek to maintain surface water quality consistent with State Environment Protection Policy (Waters of Victoria) and EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996). Design and construct Temporary Works to isolate construction runoff from catchment runoff and treat it prior to discharge to receiving waterways. Establish a surface water quality monitoring (including reporting) program for the Powlett River, in the vicinity of the Desalination Plant Site in

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
				Comply with EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996). Stormwater treatment system is to be fully integrated into the overall detail design of the Desalinated Water Supply System and include spill management infrastructure to protect surface water quality.	consultation with the EPA. Manage maintenance to avoid release of water with chemical concentrations above State Environment Protection Policy (Waters of Victoria) objectives.
Erosion and Sediment Control	✓	✓	Minimise erosion and sediment movement.	Comply with EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996) and EPA Construction Techniques for Sediment Pollution Control (1991).	Comply with Performance Criterion. Develop, implement and maintain construction methods and management systems consistent with EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996) and EPA Construction Techniques for Sediment Pollution Control (1991) to limit erosion and sediment movement by: • Identifying highly erodible soil and avoiding activities involving disturbance of these areas where possible. Where avoidance is not possible, additional control measures to be implemented for these identified areas • Limiting clearance of vegetation, particularly along streams • Designing drainage outlets and diversion channels to limit flow

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
					velocities and erosion
Acid Sulfate Soils	✓		Manage Acid Sulfate Soils.	Manage potential and actual acid sulfate soils in accordance with relevant legislation, standards and guidelines including the waste hierarchy. Comply with EPA's Industrial Waste Management Policy (Waste Acid Sulfate Soils) and EPA Publication 655, Acid Sulfate Soil and Rock.	Comply with Performance Criteria. Identify and where possible avoid disturbing areas of Potential Acid Sulfate Soils. Develop and implement methods and management systems to manage Acid Sulfate Soils and construction where Acid Sulfate Soils are encountered to minimise environmental impacts.
Contaminated Land	✓	✓	Protect beneficial uses of land.	Manage and remediate contaminated soils. Comply with the State Environment Protection Policy (Prevention and Management of Contamination of Land). Protect human health and ecosystems from exposure to contaminated soil.	Comply with Performance Criteria. Assess any contamination in accordance with the National Environment Protection (Assessment of Site Contamination) Measure, NEPC 1999 and other relevant guidelines. Identify any contaminated land and properties and assess the potential for long term impacts. Detail the methodology for any soil removal, assessment, reuse and management. Manage decontamination of any buildings being demolished or sites in which pre-existing land, water or ground contamination is identified or exposed. Identify procedures to manage contaminated soil and buildings during the construction works, including during building demolishing.

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
					Develop and implement methods and management systems that seek to protect human health and the environment.
Hazardous Materials and Dangerous Goods	✓	✓	Protect beneficial uses of air, land, water, human and environmental health, from the impacts of hazardous materials and dangerous goods.	Manage, store, handle and dispose any hazardous substances and dangerous goods in accordance with relevant policies, regulations and guidelines including the Victorian Workcover Authority and Australian Standard AS1940 Storage and Handling of Flammable and Combustible Liquids, EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996) and EPA Publication 347 – (Bunding Guidelines).	Comply with the Performance Criteria. Develop and implement methods and management systems (including contingency plans) that: • Limit the on-site and on-vessel storage and/or use of hazardous substances and dangerous goods • Manage hazardous materials and dangerous goods to avoid environmental damage • Install bunds (if appropriate) and take precautions to reduce the risk of spills entering the stormwater drainage system • Seek to contain any spills captured by the stormwater drainage system • Provide for management of hydrocarbon spills
Waste - General	✓	✓	Manage waste from the construction and operation phases of the Project consistent with the requirements of	Minimise waste through the adoption of best practice waste reduction and disposal procedures consistent with the EPA waste hierarchy.	Comply with the Performance Criterion. Develop and implement a long term waste minimisation and management plan for the construction and operation phases of the Project. In assessing waste management options, adopt the following order of preference: • Waste avoidance and/or reduction

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
			the Government/ EPA Waste Management Policies.		• Waste reuse, recycling and reclamation • Waste treatment • Waste disposal Remove and otherwise handle any materials containing asbestos in accordance with the requirement of all Laws and Approvals, including the Occupational Health and Safety (Asbestos) Regulations 2003 (Victoria). Promote the efficient use and conservation of resources as part of the training program for all Associates including contractors, subcontractors and operators.
Air Quality - Dust	✓		Protect air quality.	Limit dust emissions. Compliance with the State Environmental Protection Policy (Air Quality Management) and EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996). Minimise dust impacts on sensitive receiver sites.	Comply with the Performance Criteria. Develop and implement methods and management systems (including monitoring) to maintain air quality during construction consistent with State Environmental Protection Policy (Air Quality Management) intervention levels for particulates and EPA Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites (1996).

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
Air Quality – Odour and Emissions		✓	Protect air quality.	Limit odour and emissions from Desalination Plant operations. Compliance with the State Environment Protection Policy (Air Quality Management) and State Environmental Protection Policy (Ambient Air Quality). Comply with the EPA Licence for the Desalination Plant.	Comply with the Performance Criteria. Develop and implement methods and management systems consistent with State Environment Protection Policy (Air Quality Management) and State Environmental Protection Policy (Ambient Air Quality) to limit odour and emissions from the operation of the Desalination Plant. Monitor and report the effect of Project Activities on air quality.
Airborne Noise	✓	✓	Protect neighbourhood amenity.	Minimise impacts from airborne noise. During construction, comply with TG302/92 for Desalination Plant. During construction, comply with Section 5 of EPA Publication 480, TG302/92 and N3/89 (depending on background noise levels) for the Transfer Pipeline and Electricity Grid Connection and Assets. Comply with EPA N3/89 during day and evening, and	Comply with the Performance Criteria. Develop and implement a communication strategy with the key stakeholders and the community to manage the impacts of construction noise and limit disturbance to local amenity. Model and report predicted airborne noise levels during operation to demonstrate that the design meets the Performance Criteria. As part of the modelling and reporting exercise, include an assessment of tonality and other character adjustments with consideration to the relevant provisions of State Environment Protection Policy N1. If found present, tonality or character adjustments should be eliminated through the detailed design stage. Alternatively reduced noise limits, with consideration to State Environment Protection Policy N1, may be applicable. Develop and implement a noise mitigation strategy for construction activities.

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
				with State Environment Protection Policy N1 at night-time for Desalination Plant operational activities. Comply with EPA N3/89 for pipeline and power operational activities.	Night-time construction works outside the provisions of TG302/92 should be subject to a specific noise mitigation strategy, through consultation with the EPA, prior to commencement of works. Monitor and report on airborne noise levels.
Greenhouse Gas	✓	✓	Minimise greenhouse gas emissions.	Energy Efficient Design in accordance with Protocol for Environmental Management - Greenhouse Gas Emissions and Energy Efficiency in Industry (EPA Victoria), 2006. Comply with the Environment and Resource Efficiency Plans reporting and management requirements.	Comply with the Performance Criteria. Monitor and report in accordance with the National Greenhouse and Energy Reporting (Measurement) Systems and Technical Guidelines 2008 v1.0 (Department of Water Climate Change, 2008). Demonstrate design, selection of project components and consumables minimises Greenhouse Gas Emissions to the extent reasonably practicable.

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
Marine					
Marine Flora and Fauna - General	✓	✓	Protect marine flora and fauna. No significant impact on Bunurong Marine National Park and on the protected values of marine parks.	Minimise to the extent practicable the impacts on marine flora and fauna from Project Activities. Limit impacts on ecology of high relief reef.	Comply with the Performance Criteria. Develop, implement and maintain methods and management systems to protect marine flora and fauna. No construction in the designated areas, which creates a long-term impact, presented in Figure PR Sensitivity Area – Marine Area, in *Technical Appendix 5* to the EES document. Trenching is not permitted in the designated areas presented in Figure PR Sensitivity Area – Marine Area, in *Technical Appendix 5* to the EES document. Manage any geotechnical investigation program to avoid significant impacts on the high relief reef in the designated areas and marine fauna in general. Any spoil from marine construction to be disposed of in accordance with EPA Best Practice Guidelines for Dredging and the National Ocean Disposal Guidelines for Dredged Material.
Marine Flora and Fauna – Intake	✓	✓	Minimise impacts on marine flora and fauna from intake structure. Minimise impact on Bunurong	Prevent entry of penguins and other diving birds into the intake structure. Limit entrainment of marine biota.	Comply with Performance Criteria. Provide an external grill space no greater than 100 mm x 100 mm or, if the grill space is greater than 100 mm in any one direction, then the space should be no greater than 50 mm in any other direction. Alternatively implement other measures to achieve the Performance Criteria. Locate and design intake structure: • To not significantly affect the beneficial uses associated with the

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
			Marine National Park and on the protected values of marine parks.		designated areas of high relief reef and coastal reserve presented in Figure PR Sensitivity Area – Marine Area, in *Technical Appendix 5* to the EES document • To achieve a horizontal velocity of less than 0.15 m/s (during still conditions) or any other measure demonstrated to achieve the Performance Criteria • So that the lowest point of intake area is at least 4 metres above surrounding seafloor level Demonstrate through hydrodynamic modelling of intake structures and behaviour that the Project will limit entrainment to meet Performance Criteria. Monitor and report on possible effects of entrainment on marine biota and demonstrate compliance with the relevant Performance Criterion.
Marine Flora and Fauna – Outlet	✓	✓	Minimise impacts on marine flora and fauna from siting and operation of Outlet structure. Minimise impact on Bunurong Marine National Park and on the protected	Comply with State Environment Protection Policy (Waters of Victoria). No observable accumulation of solid matter or staining on the beach.	Comply with Performance Criteria. Meet the requirements of the EPA with regard to the Works Approval Application and Discharge Licence. Achieve a minimum engineering design dilution target of at least 50:1 into the local ambient water column within 100 metres of the diffuser(s) under all design flow conditions. Define an area to be approved by the EPA which at its boundary achieves not more than 1 psu (or as agreed with the EPA) above regional ambient salinity, 95% of the time on an annual basis, outside the designated areas presented in Figure PR Sensitivity Area – Marine Area, in *Technical Appendix 5* to the EES document. No discoloration of the sea surface visible from land due to surface strike of the plume(s).

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
			values of marine parks. Minimise impact on ecosystem integrity.		Develop and implement a monitoring program to demonstrate performance of the Project in operation for the protection of beneficial use that will: • Demonstrate protection of beneficial use outside the areas to be approved by EPA • Assess the extent, magnitude and level of impacts of discharge on marine flora and fauna • Assess the long term impacts of outlet discharge(s) • Document condition of high relief reef ecosystems Demonstrate through modelling that the projected operation will meet the Performance Criteria. Conduct tracer testing to demonstrate compliance of the marine structures with the Performance Criteria. Direct Toxicity Assessment (DTA) and water quality assessment shall be undertaken to confirm that representative concentrate (which contains representative chemical additives) meets the requirements of the State Environment Protection Policy (Waters of Victoria) environmental quality objectives of 99% ecosystem protection for largely unmodified aquatic ecosystems.

Subject	Timing		Objective	Performance Criteria	Performance Requirements
	D&C Activities	O&M Activities			
Marine Pests	✓	✓	Avoid the introduction, spread and establishment of marine pests.	Compliance with the Commonwealth and State legislative requirements for Ballast Water.	Comply with the Performance Criterion. Develop and implement a marine pest risk management and monitoring process (including a process directed to addressing the risks of introducing pests by vessels and equipment). Develop and implement a risk management process specifically for limiting risk of abalone disease.

18. References

Legislation and Policy

Coastal Management Act 1995 (Vic).

Environment Effects Act 1978 (Vic).

Environment Protection Act 1970 (Vic).

Environment Protection (Industrial Waste) Act 1985 (Vic).

Environment Protection (Prescribed Waste) Regulations 1998 (Vic).

Environment Protection and Biodiversity Conservation Act 1999 (Cth).

Environment Protection (Fees) Regulations 2001 (Vic).

Environment Protection (Resource Efficiency) Act 2002 (Vic).

Environment Protection (Ships' Ballast Water) Regulations 2006 (Vic).

Environment Protection (Environment and Resource Efficiency Plans) Regulations 2007, (Vic).

Environment Protection (Scheduled Premises and Exemptions) Regulations 2007 (Vic).

EPA Victoria, 1998, *Industrial Waste Strategy – Zeroing in on Waste*, Pathways to Cleaner Production for Victorian Industries.

EPA Victoria, 2008, *Notice of Exemption of Temporary Construction Activities*, issued March 2008. [http://www.epa.vic.gov.au/bus/erep/docs/Notice-of-exemption-of-temporary-construction-activities.pdf].

Flora and Fauna Guarantee Act 1988 (Vic).

Government of Victoria, 2000, *Partnerships Victoria Policy Framework.*

Industrial Waste Management Policy (Prescribed Industrial Waste), 2000, (Vic).

Industrial Waste Management Policy (Waste Acid Sulfate Soils) , 1999 (Vic).

Mineral Resources (Sustainable Development) Act 1990 (Vic).

National Environment Protection Council, 1998, *National Environment Protection (Ambient Air Quality) Measure.*

National Environment Protection Council, 1999, *National Environment Protection (Assessment of Site Contamination) Measure*.

National Environment Protection Council, 1998, *National Pollutant Inventory*.

National Greenhouse and Energy Reporting Act 2007 (Cth).

Planning and Environment Act 1987 (Vic).

Project Development and Construction Management Act 1995 (Vic).

State environment protection policy (Control of Noise from Commerce, Industry and Trade), 1989 (Vic).

State environment protection policy (Waters of Victoria), 1990 (Vic).

State environment protection policy (Ambient Air Quality), 1999 (Vic).

State environment protection policy (Used Packaging Materials), 2000 (Vic).

State environment protection policy (Air Quality Management), 2001 (Vic).

State environment protection policy (Groundwaters of Victoria), 2002 (Vic).

State environment protection policy (Prevention and Management of Contaminated Land), 2002 (Vic).

Victorian Government, 2005, *Towards Zero Waste Strategy*.

Waste Management Policy (Ships' Ballast Water), 2004 (Vic).

Waste Management Policy (Siting, Design and Management of Landfills), 2004 (Vic).

Waste Management Policy (Used Packaging Materials), 2006 (Vic).

Water Act 1989 (Vic).

Guidelines, Codes and Standards

ANZECC, 1992, *Australian Water Quality Guidelines for Fresh and Marine Waters*, Australian and New Zealand Environment and Conservation Council.

ANZECC and ARMCANZ, 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

Department of Climate Change, 2007, *Technical Guidelines for the Estimation of Greenhouse Emissions and Energy at Facility Level* (discussion paper).

DPCD, 2008, *Scoping Requirements – Desalination Project Environment Effects Statement.*

EPA Publication 275, *Construction Techniques for Sediment Pollution Control*, May 1991.

EPA Publication 347, *Bunding Guidelines*, December 1992.

EPA Publication 441.7, *A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes*, March 2000.

EPA Publication 448.3, *Classification of Wastes*, May 2007.

EPA Publication 480, *Best Practice Environmental Management – Environmental Guidelines for Major Construction Sites*, February 1996.

EPA Publication 609, *Industrial Waste Strategy – Zeroing in on Waste*, July 1998.

EPA Publication 628, *Environmental Guidelines for the Concrete Batching Industry,* November 1998.

EPA Publication 655, *Acid Sulfate Soil and Rock,* August 1999.

EPA Publication 668, *Hydrogeological Assessment (Groundwater Quality) Guidelines,* September 2006.

EPA Publication 669, *Groundwater Sampling Guidelines*, April 2000.

EPA Publication 788, *Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills*, October 2001.

EPA Publication 824, *Protocol for Environmental Management: Greenhouse Gas and Energy Efficiency in Industry*, January 2002.

EPA Publication 840, *The Clean-up and Management of Polluted Groundwater,* April 2002.

EPA Publication 859, *Prevention and Management of Contamination of Land*, July 2002.

EPA Publication 862, *Groundwater Quality Restricted Zone*, July 2002.

EPA Publication 996, *Guidelines for the Hazard Classification of Solid Prescribed Industrial Wastes,* June 2005.

EPA Publication AQ 2/86, *Recommended Buffer Distances for Industrial Residual Air Emissions*, July 1990.

EPA Publication N3/89, *Interim Guidelines for Control of Noise from Industry in Country Victoria*, April 1989.

EPA Publication TG 302/92, *Noise Control Guidelines*, July 1992.

EPA Information Bulletin 1100, *Draft Classification for Large Containers Contaminated with Prescribed Industrial Waste,* April 2007.

EPA Publication 1191, *Protocol for Environmental Management – Mining and Extractive Industries*, December 2007.

EPA Publication 1198, *EREP Guidelines: Environment & Resource Efficiency Plans*, February 2008.

EPA Publication 1208, *Best Practice Guidelines for Landfills Accepting Category C Prescribed Industrial Waste*, April 2008.

EPA Victoria, 2002, *Protocol for Environmental Management on Greenhouse Gas Emissions and Energy Efficiency in Industry.*

Government of Victoria, *Towards Zero Waste*, 2005.

Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, prepared by the World resources Institute/World Business Council for Sustainable Development.

National Environment Protection Council*, National Environment Protection (Assessment of Site Contamination) Measure*, 1999

National Environment Protection Council, *National Pollutant Inventory*, 1998.

Standards Australia and Standards New Zealand, 2004, AS/NZS 4360:2004, Australian/New Zealand Standard: Risk Management, 2004.

Standards Australia, 2008, AS/NZS 2927: 2001 *The Storage and Handling of Liquefied Chlorine Gas*, accessed June 2008.

Standards Australia, 2008, AS 2436: 1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*, accessed June 2008.

Standards Australia, 2008, AS 1940-2004 - *Storage and Handling of Flammable and Combustible Liquids*, accessed June 2008.

Standards Australia, 2008, AS/NZS 1680.1:2006 - *Interior and Workplace Lighting: General Principals and Recommendations*, accessed June 2008.

Standards Australia, 2008, AS 2293.1-2005 - *Emergency Escape Lighting and Exit Signs for Buildings – System Design Installation and Operations*, accessed June 2008.

World Business Council for Sustainable Development (WBCSD) & World Resources Institute (WRI), 2004, *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.*

EES Technical Appendices and Project Technical Discussion Papers

ASR, 2008a, *Local Fine-resolution Model: Calibration and Validation*, Marine Consulting and Research, Raglan, New Zealand (EES Technical Appendix 20).

ASR, 2008b, *Near-field Numerical Modelling of the Desalination Plant Outlet Plume,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 30).

ASR, 2008c, *Mid-field Numerical Modelling of the Desalination Plant Outlet Plume*, prepared for the Department of Sustainability and Environment (EES Technical Appendix 29).

ASR, 2008d*, Particle Dispersal Modelling Seasonal and spatial variation,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 33).

Bassett Acoustics, 2008, *Victorian Desalination Project Environmental Effects Statement – Underwater Noise*, prepared for the Department of Sustainability and Environment (EES Technical Appendix 22).

Biosis, 2008a, *Assessment of Marine Mammals, Birds and Reptiles for the Desalination Project, Bass Coast, Victoria – Existing Conditions and Impact Assessment Report,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 13).

Biosis, 2008b, *Desalination Project: Desalination Plant Component Cultural Heritage Existing Conditions and Impact Assessment,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 45).

Boyd and Rosengren, 2008, *Existing site conditions, Impacts and Risk Assessment Geology, Geomorphology and Acid Sulfate Soils.* Report prepared for the Department of Sustainability and Environment (EES Technical Appendix 37).

CEE, 2008, *The Desalination Project Marine Biology*, June 2008, CEE Pty Ltd Environmental Scientists and Engineers, Richmond, VIC, Australia, prepared for the Department of Sustainability and Environment (EES Technical Appendix 31).

Essential Economics, 2008, *Wonthaggi Desalination Plant Impact Assessment (Economic),* prepared for the Department of Sustainability and Environment (EES Technical Appendix 11).

GHD, 2008a, *Report for Victorian Desalination Project: Land Contamination Existing Conditions and Impact Assessment – Plant Site,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 36).

GHD, 2008b, *Existing Conditions Report: Air Quality – Desalination Plant,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 47).

GHD, 2008c, *Report for Desalination Plant Site: Existing Conditions and Impact Assessment – Groundwater,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 40).

GHD, 2008d, *Report for Desalination Project: Surface Water EES – Plant,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 43).

GHD, 2008e, *Desalination Project – Waste Management Assessment Report*, prepared for the Department of Sustainability and Environment (EES Technical Appendix 8).

GHD, 2008f, *Desalination Project - Report for Assessment of Impacts on Air Quality,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 48).

GHD, 2008g, *Report for Melbourne Desalination Plant –Water and Sediment Quality Assessment,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 23).

GHD, 2008h, *The Desalination Project – Invasive Marine Species Specialist Report*, prepared for the Department of Sustainability and Environment (EES Technical Appendix 27).

GHD, 2008i, *Technical Discussion Paper: Characterisation of the Desalination Concentrate Discharge from the Victorian Desalination Plant,* prepared for the Department of Sustainability and Environment (Appendix C of this WAA).

GHD, 2008j, *Report for Victorian Desalination Plant – Preliminary Hazard Analysis*, prepared for the Department of Sustainability and Environment (EES Technical Appendix 54).

GHD, 2008k, *Report for the Desalination Project: Impact Assessment Report – Noise and Vibration (Plant)*, prepared for the Department of Sustainability and Environment (EES Technical Appendix 50).

Hydrobiology and CSIRO, 2008, *Toxicity Assessment for Victorian Desalination Project*, prepared for the Department of Sustainability and Environment (EES Technical Appendix 24).

Maunsell, 2008a, *EES Risk Assessment,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 6).

Maunsell, 2008b, *Victorian Desalination Project Greenhouse Gas Assessment*, prepared for the Department of Sustainability and Environment (EES Technical Appendix 7).

Maunsell, 2008c, *Desalination Project Environmental Effects Statement Social Impact Assessment Report,* prepared for the Department of Sustainability and Environment (EES Technical Appendix 56).

Other References

Acevedo S, Jenkins G, Murphy H, 2008, *The horizontal and vertical distribution of fish eggs and larvae in relation to the proposed Desalination Plant for Victoria, September to December 2007*. Fisheries Victoria Internal Report No 11, 27 pages. Department of Primary Industries, Queenscliff, Victoria, Australia.

AMC Consultants, 2007, *Wonthaggi Historic Mining and Geological Data*.

Australian Institute of Building, 2008, *Building Code of Australia.*

Beaudry Corporation, 2008, website: http://www.beaudreyusa.com/drumscreens.htm (accessed June 2008).

Brehant, A., Bonnelye, V. & Perez, M., 2002, 'Comparison of MF/UF Pre-treatment with Conventional Filtration Prior to RO Membranes for Surface Seawater Desalination', *Desalination*, 144, pp. 353-360.

Brown, V. B., Davies, S. A., Synnot, R. N., 1990, 'Long-term monitoring of the effects of treated sewage effluent on the intertidal macroalgal community near Cape Schanck, Victoria, Australia', In *Botanica Marina*. 33:85–98.

Burashid, K., Hashim, A., Kannari, T., Tada, K. & Iwahori, H., 2005, *UF Membrane Performance Experience at Addur; Expectations, Reality and Prospects*, IDA Conference Singapore, September 11-16.

CEE, 2007, *Intake and Discharge Environmental Considerations*, CEE Pty Ltd Environmental Scientists and Engineers, Richmond, VIC, Australia.

Chapman JC, Warne MStJ, Patra RW, 2001, 'Considerations when applying the revised toxicant guidelines', *Australasian Journal of Ecotoxicology*, 7, 157 - 174.

Chidgey, 2005, *Reclaimed Water Discharge at Anglesea- Marine Ecosystem Assessment*, CEE Consultants report to Barwon Water.

Commonwealth of Australia, 2007*, National Greenhouse and Energy Reporting Act 2007.*

Connell, DW, Miller GJ., 1984, *Chemistry and Ecotoxicology of Pollution*, John Wiley & Sons, New York.

Cooley, H., Gleick, P. H., Wolff, G., 2006, *Desalination, with a Grain of Salt: A Californian Perspective*, Pacific Institute for Studies in Development, Environment, and Security, Oakland, California.

Department of Climate Change, 2007, *Technical Guidelines for the Estimation of Greenhouse Emissions and Energy at Facility Level* (discussion paper).

Department of Climate Change, 2008, *National Greenhouse and Energy Reporting (Measurement) Determination.*

DPCD, 2008, *Scoping Requirements – Desalination Project Environment Effects Statement.*

Dr Peter Dann, pers.comm, PINP.

Department of Sustainability and Environment, Sustainability Victoria and Metropolitan Waste Management Group, *Draft Metropolitan Waste and Resource Recovery Strategic Plan, Part 3: Draft Metropolitan Landfill Schedule (undated)* (Vic).

Department of Sustainability and Environment, 2004, *Our Water, Our Future.*

Department of Sustainability and Environment, 2006, *Central Region Sustainable Water Strategy – Action to 2055.*

Department of Sustainability and Environment, 2007, *Our Water, Our Future – The next stage of the Government's Water Plan.*

Department of Sustainability and Environment, 2008, *State Groundwater Management System – Victorian Data Warehouse*, Australia, http://www.vicwaterdata.net/vicwaterdata/home.aspx, accessed April/May 2008.

Department of Sustainability and Environment, 2008, *Victorian Desalination Project Environment Effects Statement Volumes 1 –5*, prepared for the Department of Sustainability and Environment.

EPA Victoria, 2008, *Notice of Exemption of Temporary Construction Activities*, issued March 2008. [http://www.epa.vic.gov.au/bus/erep/docs/Notice-of-exemption-of-temporary-construction-activities.pdf].

Fetter, 1988, *Applied Hydrogeology,* 2nd Edition, Macmillan Publishing.

Fukuoka District Waterworks Agency, 2008, website: http://www.f-suiki.or.jp/english/water/ (accessed June 2008).

Fritzmann, C., Niewersch, C., Jansen, A., Wintgens, T. & Melin, T., 2007, *Comparative Life Cycle Assessment Study of Pretreatment Alternatives for RO Desalination*, IDA World Congress Maspalomas, Gran Canaria, Spain, October 21-26.

GCD Alliance, 2007, *Material Change of Use Application ERA 16, 19 & 7.*

GHD and Melbourne Water, 2007, *Seawater Desalination Feasibility Study.*

GHD, 2007a, *Desalination Project – EES Referral Report*, prepared for the Department of Sustainability and Environment.

GHD, 2007b*, Report for Proposed Callignee South Road Landfill. Documentation Supporting Works Approval Application*. Report prepared by GHD Pty Ltd for Latrobe City Council.

GHD, 2007c, *Desalination Project. Preliminary report on Geology, Geomorphology and Surface Water*, prepared for the Department of Sustainability and Environment.

Guest, C.; Johnston, C.; King, J.; Alleman, J.; Tishmack, J. and Norton, D. 2001, 'Chemical Characterization of Synthetic Soil from Composting Coal Combustion and Pharmaceutical By-Products'*, Journal of Environmental Quality*, Vol. 30, pp 246-253.

Hayes, K, Sliwa, C., Migus, S., McEnnulty, F and Dunstan, P, 2005, *National Priority Pests – Part II. Ranking of Australian Marine Pests*, CSIRO Marine Research report for the Australian Government Department of the Environment and Heritage.

HDR Engineering Inc. 2002, *Handbook of Public Water Systems*, John Wiley and Sons, USA.

Herrenknecht Tunnelling Systems, 2008, website: http://www.herrenknecht.com/ (accessed May 2008)

Hewitt C.L., Campbell M.L., Thresher R.E., Martin R.B. (eds), 1999, *The Introduced Species of Port Phillip Bay, Victoria.* Centre for Research on Introduced Marine Pests Technical Report No. 20, CSIRO Marine Research, Hobart. 344 pp.

Hewitt C.L., Campbell M.L., Thresher R.E., Martin R.B., Boyd S., Cohen B.F., Currie D.R., Gomon M.F., Keogh M.J., Lewis J.A., Lockett M.M., Mays N., McArthur M.A., O'Hara T.D., Poore G.C.B., Ross D.J., Storey M.J., Watson J.E., Wilson R.S, 2004, 'Introduced and cryptogenic species in Port Phillip Bay, Victoria, Australia', *Marine Biology* 144: 183-202.

Hewitt, C.L. and Campbell, M.L., 2006, *Marine Pests Advice: A Review of Maine Pests in Port Phillip Bay and Dredged Material Management Issues – Channel Deepening Project – Supplementary Environmental Effects Statement.*

HLA-Envirosciences Pty Ltd., 2007, *Environmental Assessment Scoping Report for Upgrade and Expansion of Coal Combustion Product Management Facility at Eraring Power Station*.

Hoedt FE and Dimmlich WF, 1995, 'Egg and larval abundance and spawning localities of the anchovy (Engraulis australia) and pilchard (Sardinops neopilchardus) near Phillip Island, Victoria', *Marine & Freshwater Research*. 46: 735-743.

Kazuya, T., 2006, 'Research on development of reuse technology of spent chemical filters', in *Dai-dan Technical Current News*, Vol. No. 99, pp 2-6.

Keough and Swearer, 2007, 'Early Life Histories of Marine Invertebrates and Fishes', Chapter 2 in *Marine Ecology,* Connell and Gillanders (eds.), Oxford University Press, South Melbourne.

Lakey & Tickell, 1981, *Explanatory notes on the Western Port Groundwater Basin 1:100,000 Hydrogeological Map - Geological Survey Report No. 69*, Victorian Geological Survey.

Lattemann, S. & Höpner, T., 2003, *Seawater Desalination: impacts of brine and chemical discharge on the marine environment*, Institute for Chemistry and Biology of the Marine Environment, University of Oldenburg, Germany, Balaban publishers.

Leson, G., 1998, 'Biofilters in Practice', *Bioremediation: Principles and Practice*. Subhas K. Sikdar, Robert L. Irvine eds, USA.

Maunsell, 2007, *Regional Waste Infrastructure Study: Final Report*, prepared by Maunsell / Aecom for Gippsland Regional Waste Management Group.

Newman MC., 1998, *Fundamentals of Ecotoxicology. Ann Arbor Press*, Chelsea, MI, USA. 402p.

NLA, 2008, *National Lime Association* website, Australia, http://www.lime.org/ENV02/ENV802.htm#HW, accessed April/May 2008.

Ohio EPA, 1991, Ohio *EPA Lime Sludge Disposal Guidelines*, Ohio, USA.

Pankratz & Tonner, 2006, *An Environmental Literature Review and Position Paper for Reverse Osmosis Desalination Plant Discharges – Contract No. CN-05-12269- 29 April 2006.*

Pearce, G.K., (2007), *The Case of UF/MF Pre-treatment to RO in Seawater Applications*, Desalination, 203, pp. 286-295.

Perrier Sorem, 2008, website: http://www.perriersorem.com/Navig/filtration_equipment.htm (accessed June 2008).

Raimondi, 2008, *Estimation of ecological impacts due to use of seawater in a desalinization facility (in a NEPA / CEQA context) - Entrainment and Impingement Losses*, online reference to a presentation, accessed May 2008, www.owue.water.ca.gov/recycle/desal/Docs/Entrainment_impingement.pdf.

Rampant (Ed), 2003, *Acid sulfate soil hazard maps: guidelines for coastal Victoria*. Department of Primary Industries. Research Centre for Land Protection.

Sherwood Design Engineers, 2006, *Water Management Challenges in the Loreto Region*. Presented to the International Community Foundation, December 2006.

Steinbeck J, Hedgepeth J, Raimondi P, Cailliet G, and D. Mayer, 2007, *Assessing power plant cooling water intake system entrainment impacts*. California Energy Commission. Report CEC-700-2007-010.

Sydney Water, 2005, *Environmental Assessment of the Concept Plan for Sydney's Desalination Plant.*

Sydney Water, 2007, *Volume 2 - Design and construct contract: Schedule 14 - Company's requirements.*

The Green Building Council of Australia, 2008, *Green Star Office Design v3 Technical Manual,* www.gbca.org.au.

Unimin, 2008, website information for Unimin Australia, http://www.unimin.com.au, accessed April/May 2008.

US Department of Transportation, 2007, *Turner-Fairbank Highway Research Centre Information for reuse of foundry sand*. Website: www.tfhrc.gov, accessed 28/4/08.

USEPA, 1997. *'Paint Filter Liquids Test' in Test Methods for Evaluating Solid Wastes – Chemical/Physical Methods*

USEPA, 2001, *Clean Water Act*.

USEPA, 2001, *Nation Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities; Final Rule. Federal Register. Part II*. Environmental Protection Agency 40 CFR Parts 9, 122, 123, 124 and 125.

VandeVenter, L., Williams, S., Garana, E. & Clunie, W., 2005, *Large scale desalination demonstration project feasibility study Corpus Christi*, Texas, IDA Conference Singapore, September 11-16.

Verbeek, V., 2005, *Concept Design to Installation and Commissioning, Energy Recovery for SWRO in Singapore,* International Desalination Association World Congress: SP05-216.

Voutchkov, Nikolay, 2007, *Advances and Challenges of Seawater Desalination in California*, IDA World Congress-Maspalomas REF: IDAWC/MP07-100.

Water Services Association of Australia, 2001, *National Water Conservation Rating and Labelling Scheme.*

Wiley, 2005, *Water Treatment Principles & Design, 2nd Edition*, MWH.

Wilf, M. & Schierach, M.K., 2001, 'Improved Performance and Cost Reduction of RO Seawater Systems Using UF Pre-treatment', *Desalination*, 135, pp. 61-68.

World Business Council for Sustainable Development (WBCSD) & World Resources Institute (WRI), 2004, *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.*

Yazici, H., 2007, 'Utilization of coal combustion by-products in building blocks', in *Fuel*, Volume 86, Issues 7-8.

Appendix A

Concepts Considered for the Project

Table A-1 Concepts considered for the Project

Key element	Reference Project	Variation	EES Option	Description	Reason included or excluded
Intake concepts					
Direct intake in deep water	✓			Intake concept draws into the plant water from above the sea floor via an intake head structure offshore i.e. outside the wave zone.	Approach adopted at other major desalination plants in Australia.
Indirect - seabed filtration			✓	A sub-surface intake constructed in deep water that draws water into the Plant via a filter that is constructed in the seabed floor.	Requires further investigation however, considered less likely to be adopted due to the scale of construction.
Direct - surface water Inlet channel				Intake concept that draws into the plant via a channel constructed on the shoreline. Water flows into and along a channel and is then pumped from the channel to the plant.	Impacts on coastal landscape values. Highly visible.
Direct - floating plant				Inlet concept that involves a floating desalination plant with a direct seawater intake and treated water is then piped to shore.	Considered not likely to be adopted at the inlet capacity required and has visual impacts.
Indirect - onshore vertical wells or horizontal wells				On-shore (usually on the beach) sub-surface intake where water is extracted from sand below the beach and seabed on the shoreline. Vertical wells draw the water down into a well; horizontal wells have a number of collection arms that extend from a central well. The well structure can protrude above the surface of the beach.	Impacts on coastal landscape values. Physical conditions at the Project location may not be suitable for this option.
Indirect - beach galleries				Sub-surface intake constructed in the intertidal zone that consists of a number of perforated collection pipes in the bottom of an infiltration sand box.	Impacts on coastal landscape values. Physical conditions at the Project location not suitable for this option.
Indirect - horizontal directional drains				Sub-surface intake that consists of horizontal holes bored under the seafloor. Seawater is filtered through the natural seafloor and into the pipewells (perforate pipes).	Physical conditions (hydrogeology) at the Project location do not appear to be suitable for this option.
Intake head					

Key element	Reference Project	Variation	EES Option	Description	Reason included or excluded
Mushroom structure	✓			Intake structure draws in seawater horizontally.	Approach adopted at some other major desalination plants in Australia.
Intake head - vertical				Inlet structure draws in water vertically.	Vertical velocities have greater impact on marine life and also intake more sand and sediment.
Intake head island				A large concrete structure that is permanently located in the ocean to accommodate and protect fine screens and provide a platform for operational equipment (eg. generators, air compressors) and maintenance.	May reduces entrainment however the structure will extend from the seafloor to above the ocean surface. May have an impact on coastal process. Construction and maintenance practices need to be investigated.
Intake screening					
Grill on intake head and active screen onshore	✓			Intake mushroom head with grill size to reduce entrainment of larger marine biota.	Approach adopted at some other major desalination plants in Australia, noting smaller grill spacing to manage effects on local biota.
Passive fine screen at intake head		✓		Passive fine screen on mushroom intake head to reduce entrainment. Requires air backwashing. Screen size of 0.5 to 10 millimetres.	Exclusion of a higher proportion of marine biota in the ocean is an advantage, however it needs to be proven to be practical as the passive screens tend to become fouled and may be difficult to clean (by divers) under frequent rough weather conditions, typically observed in Bass Strait.

Key element	Reference Project	Variation	EES Option	Description	Reason included or excluded
Grill on intake head and active screen on shore with fish return				Intake mushroom head with grill size to reduce marine biota entrainment and impingement, active screens that allow fish return.	Fish return systems have not been included in any of the other major Australian desalination plants due to the practical difficulties at this scale. There would need to be a significant increase in screen size to minimise damage to the fish, and new tunnels installed to return fish to the ocean outside the surf zone (given that construction on the beach is not permitted). Even if constructed, there is a risk that not all fish would survive, and the numbers of fish who enter the tunnel has already been managed to an extent by the adoption of mushroom heads with low velocity in deep water some distance offshore. Further, fish return has not been requested by the ecologists as a mitigation measure. Given the practical difficulties, the risks and the lack of recommendations to mitigate this impact, fish return has not been adopted for the Reference Project, or as a variation
Intake head - alternative entrainment mitigation measures				Mushroom intake and alternative entrainment mitigation such as fish net barriers, fine mesh travelling band screens, behavioural barriers.	Unproven approach: considered unlikely to be practical for the Project location, wave climate and Inlet volume required.
Marine Structures – outlet design options for concentrate outlets					
Rosette diffuser	✓			A number of diffuser heads are connected to tunnel risers. On each head are a number of nozzles angled to avoid the plume reaching the sea floor. The diffuser heads are evenly spaced along the end section of the tunnel.	Approach adopted at some other major desalination plants in Australia.

Key element	Reference Project	Variation	EES Option	Description	Reason included or excluded
Pipeline diffuser / pipes on seabed		✓		Connected to a tunnel riser is either a number of small pipes or a large pipe that extend outwards above the sea floor. Each pipeline has a number of nozzles angled to avoid the plume reaching the sea floor.	Approach adopted at some other major desalination plants in Australia.
Beach discharge				Concentrate is discharged on the beach or shoreline directly from an open channel or pipe. There is no initial dilution achieved.	Does not meet environmental objectives to protect beneficial uses of the coastal environment.
Marine Structures locations					
Offshore on low profile reef	✓			Location offshore away from high profile reef.	Approach adopted at some other major desalination plants in Australia.
Alternative locations		✓		Location offshore in alternative location on low profile reef or on sand in deeper water.	Adopts the same arrangement of Marine Structures in an alternative location, which could also meet performance criteria.
Offshore to the plant site, on high profile reef				Location offshore on high profile reef.	Impacts on marine environment - high profile reef identified as higher value environment.

Key element	Reference Project	Variation	EES Option	Description	Reason included or excluded
Pre-treatment concepts					
Media filtration	✓			Use of granular media to capture particles.	Approach adopted at other major desalination plants in Australia.
Additional clarification stages, such as Dissolved Air Flotation (DAF)		✓		Clarification (such as DAF) may be required upstream of media filtration depending on feed water quality.	
Membrane filtration (MF/UF)		✓		SWRO pre-treatment might employ microfiltration or ultrafiltration in place of granular filters. This is referred to as MF/UF pre-treatment. Coagulation prior to MF/UF pre-treatment is likely to be needed depending on the water quality and the membrane supplier.	Could reduce the amount of pre-treatment waste. Further technical investigation is required. Some commercial risks due to the large scale of the Project.
Pre-treatment waste management					
Disposal to landfill	✓			Wet solids are separated from the pre-treatment wastewater. The solids are carted for management to land and the supernatant is returned to the head of the plant, where practicable, otherwise discharged to ocean. This may include uses of the solids such as landfill cover or as an absorbent material.	Approach adopted at other desalination plants in Australia.
Discharge to ocean outfall (Note: EES Option subject to works approval)			✓	The pre-treatment wastewater is discharged with the concentrate to the outfall. Pre-treatment waste may or may not contain coagulant, however worldwide experience shows that coagulation is generally used even for MF/UF.	Could be a viable option that reduces the need for landfill disposal of waste however requires further investigation and EPA approval. May be a cost and energy advantage to the Project.
Recycling or reuse				Chemical recovery and / or beneficial reuse of waste material.	High cost, not previously demonstrated for SWRO pre-treatment sludge at this scale. Significant further investigation required.
Brine disposal					

Key element	Reference Project	Variation	EES Option	Description	Reason included or excluded
Direct to sea - outfall	✓			Ocean outfall – constructing a conduit (eg. tunnel) from the Desalination Plant to offshore diffusers.	Most commonly used in Australia and worldwide.
Evaporation - ponds				Conventional/solar – using heat from the sun to evaporate the water leaving salt crystals behind. The salt crystals can either be harvested for use in industry or disposed to landfill.	Excessive area required in this climate. May not be possible given very low net evaporation.
Evaporation - mechanical				Mechanical evaporators use energy (e.g. steam, electricity, etc.) to evaporate the water and recover salt.	High energy use. Costly. Limited market for product salt.
Direct to sea - channel				Sea channel – constructing a concrete or earthen channel from the Desalination Plant through the dunes and beach to the sea.	Does not meet environmental objectives to protect beneficial uses of the coastal environment.
Direct to sea - existing infrastructure				Combine with wastewater outfall – the existing Wonthaggi Outfall located south east of the proposed treatment plant could be used as a means of disposing of the Concentrate. The Concentrate would be piped or channelled in order to intercept the outfall.	Not feasible. Capacity of the existing local outfall is not sufficient, by two orders of magnitude.
Irrigation				Livestock irrigation – using the Concentrate as a source of water for livestock. Spray irrigation – using the Concentrate to irrigate salinity tolerant crops or ornamental plants (e.g. lawns, parks, golf courses).	Not feasible. Salinity level not suitable for land application.
Well injection				Deep well injection – disposing the Concentrate in wells drilled deep into formations that are well isolated from potential potable water aquifers. Beach well injection – similar to deep well injection, the Concentrate would be disposed to wells located at or near the shoreline.	Not feasible at the Project location.

Appendix B

Indicative Failure Mode Analysis

Victorian Desalination Project
Indicative Failure Mode Analysis
Seawater intake activities

ID	Component	Function	Failure Mode	Failure Cause	Failure Effect	Safeguards	Detection Method	Redundancy Provided	Failure Criticality	Actions
1	Coarse Screens	Screen-out coarse materials from feed flow, maintaining a velocity low enough to not disturb flora fauna	Blockage of screen	Excessive marine growth Plastic debris	Reduced flow from single intake. Effect can appear gradually and suddenly.		Annual inspection could detect incipient failure	4 intakes for 200GL/year plant capacity	Medium	Review inspection frequency during operational phase
2	Coarse Screens	Screen-out coarse materials from feed flow, maintaining a velocity low enough to not disturb flora fauna	Loss of screen Mechanical damage	Corrosion Vandalism Mechanical impact Error (human) induced during maintenance/ installation	Reduced screening capacity. Potential for damage to large marine life. Potential for impact to recreational divers. Breach environmental license terms.		Annual inspection (larger marine life passing to onshore active screens) could detect incipient failure	On shore active screen will prevent large debris reaching downstream process	**High**	Implement monitoring of removal of drum screens. Develop strategy to manage recreational diver interface. Ensure screen design minimises potential for incorrect installation. Develop a procedure for sign-off of maintenance and replacement of screens.
3	Coarse Screens	Screen-out coarse materials from feed flow, maintaining a velocity low enough to not disturb flora fauna	Loss of entire screen structure	Catastrophic mechanical damage due to, e.g. Ship wreck	Potentially some plant downtime to repair screen structure.	Rigidity of screen Located outside of shipping lanes Area is a no-anchor/passage zone Identified on marine navigational charts	Annual inspection Debris in drum screen (from impact damage)		Low	(As above) Confirm/ review if screens structure is/ should-be identified on marine navigational charts
4	Outlet nozzles/ diffusers	Diffuse brine outlet into seawater (dilute)	Diffuser failure	Mechanical damage	Environmental impact and breach of license terms.	Diver inspections	Detected by lower level in Return Flows Chamber	6 Rosettes for 200GL/year plant capacity	**High**	Review monitoring methodology/ frequency for diffuser inspection. Review means of monitoring hydraulic flows.
5	Risers - Inlet	Provide seawater flow to plant	Blockage	Marine growth	Reduced flow to plant	Chlorine dosing	Low flow detection	4 intakes for 200GL/year plant capacity	Medium	Review and implement a shutdown strategy
6	Tunnels	Provide seawater flow to plant	No further issues identified.							
7	Pumps	Provide seawater flow to plant	Mechanical/electrical failure on pumps	Mech/ Elec failure	Loss of flow from pumps			Redundancy of pumps	Low	
8	Seawater Intake Pumps	Provide seawater flow to plant	Local control (PLC) failure	Random	Up to 1 day downtime to replace PLC.	Spares and redundant capacity. Access to qualified maintenance team		Each pump provided with individual PLC	Low	
9	Seawater Intake Pumps	Provide seawater flow to plant	SCADA failure	As Above					Low	
10	Seawater bypass system	Bypass seawater flow around plant	Valve stuck closed	Mechanical failure (random)	No environmental flow and high brine concentration in discharge	Regular full-cycle operation	Flow meter	-	Low	No further actions
11	Seawater bypass system	Bypass seawater flow around plant	Valve stuck open	Mechanical failure (random)	Reduced flow to plant	Isolation valve provided (short-term fix)	Flow meter	-	Low	No further actions

12	Seawater bypass system	Bypass seawater flow around plant	Flowmeter failure	Mechanical failure (random)	Reduced fine-control capability	Monitoring of other operational parameters. Meter can be isolated for maintenance	-	-	Low	No further actions
13	Intake	Provide seawater flow to plant	Spurious shutdown	Failure of instrument - read high	Potential for spurious plant shutdown - short duration	Multiple layers of HC detection	Redox		Low	Review and/or control logic - spurious alarm and shutdown. Review maintenance practices (calibration of detector, etc.)
14	Intake	Provide seawater flow to plant	Hydrocarbons (HC) into plant	Failure of monitoring/ HC instrument - read low/ no	HC to membrane units extended plant downtime to repair membrane unit. Reduced capacity	Multiple layers of HC detection	Redox		**High**	Review and/or control logic - spurious alarm and shutdown. Review maintenance practices (calibration of detector, etc.)
15	Intake	Provide seawater flow to plant	Hydrocarbons into plant	Groundwater (presuming contaminated) ingress into tunnel	HC to membrane units extended plant downtime to repair membrane unit. Reduced capacity	Multiple layers of HC detection	Redox		**High**	Review need for groundwater sampling during construction (to confirm potential for contaminated groundwater to be present).
16	Chemical dosing	Chlorine/ hypochlorite dosing	Failure of dosing	Blocked or failed dosing lines in tunnel	No dosing and marine growth	Redundant dosing lines provided	Loss of pressure	Redundant dosing lines provided	Low	Review means of detecting chlorine dosing failure
17	Screenings handling	Collect screenings	No further issues identified.							

Pretreatment

ID	Component	Function	Failure Mode	Failure Cause	Failure Effect	Safeguards	Detection Method	Redundancy Provided	Failure Criticality	Actions
1	Flow metering	Chemical dosing rate control	Flow meter failure	Mechanical failure	Shutdown of single module (50% plant flow)		Instrument alarm		Medium	Review requirement for redundant flow meter. Review calibration of flowmeter. Review provision of a clamp-on flowmeter. Consider listing flowmeter as critical spare item.
2	Mixer	Mix chemicals within seawater stream	Blockage of dosing lines	Chemical build-up	No chemical dosing. Reduced water quality and/or short-duration shutdown	Sparge in dosing line Alternative dosing points Operator maintenance	Water quality detection Gradual increase in dosing pressure (operator monitors)	Redundant dosing lines	Low	Consider listing sparges as critical spare item.
3	Filter inlet/ distribution chamber	Feed seawater to filters	Valve (filter inlet) fails open/ closed	Stuck Motor failure	Backwash of filter not possible, requiring filter bank isolation (loss of 25% of flow)	Maintenance	Alarm on valve failure		Low	Review need for stop-board isolation for individual filter penstock valves
4	Filters	Tertiary filtration of seawater	Filter blockage (Valve failure)	Algal build-up	Reduced run time on filtration backwash cycle	Covered building (photosynthesis unlikely) Chlorination Regular backwash	Differential Pressure Turbidity Silt density index		Low	No further actions

5	Backwash system	Clean filters on backwash cycle	Backwash flow meter failure	Instrumentation failure	Cannot monitor backwash flow		Instrument alarm	Flowrate can be inferred from VSDs.	Low	Review requirement for redundant flow meter. Review calibration of flowmeter. Review provision of a clamp-on flowmeter. Consider listing flowmeter as critical spare item.
6	Backwash system	Clean filters on backwash cycle	Failure (stuck) valve on backwash header	Mechanical failure	Increased backwash cycle time	Manual control of valve possible	Alarm on valve position	-	Low	No further actions
7	Filtrate recirculation pumps	-	(per recycle valves)							
8	Filtered water tank	In-process storage of filtered water	Failure of level transmitter	Instrumentation failure	Cannot operate pumps normally (override mode available)				Low	Review the need for critical spare level transmitter
9	Chemical dosing	Chemical dosing	Failure of dosing	Blocked or failed dosing lines	No dosing	Redundant dosing lines provided	Loss of pressure	Redundant dosing lines provided	Low	Review means of detecting chemical dosing failure
10	(remaining components by exception - no issues)									

Reverse Osmosis

ID	Component	Function	Failure Mode	Failure Cause	Failure Effect	Safeguards	Detection Method	Redundancy Provided	Failure Criticality	Actions
1	Train pumps (including RO booster pumps)	Feed RO membranes	Pump fails	Mechanical failure	Loss of feed		Alarms (e.g. low flow)	Remaining pumps to RO units	Low	Review spares and maintenance requirement for RO equipment
2	Valves	(as identified previously for valves)								
3	Cooling water system	Cool 1st and 2nd pass high pressure pumps	Loss of cooling water	Electro-mechanical failure Loss of control	Reduced capacity		Alarms (e.g. low flow)	(see below for each module)	**High**	Review critical spares list
4	Seawater cooling pumps and Circulation pumps on hot-side	Cooling	Single pump fails	Electro-mechanical failure	Standby pump starts		Pressure detection on cooling circuit	Duty-standby pump arrangement	Low	
5	ERD recirc pump and unit	(per RO pumps)	Pump fails	Mechanical failure	Loss of feed		Alarms (e.g. low flow)	Remaining pumps to ERD units	Low	Review spares and maintenance requirement for RO equipment
6	First-pass permeate header manifold valves	(per valve header issues identified previously)								
7	Second-pass feed pumps	Feed 2nd pass	Pump fails	Mechanical failure	Reduction of feed If and only if second pump fails		Alarms (e.g. low flow)		Low	Review spares and maintenance requirement for RO equipment

8	Concentrate outlet header from 1st pass RO units	Common header to all 1st pass units	(Maintenance required)	Corrosion Mechanical impact	Maintenance on common header requires plant shutdown			-	**High**	Review configuration of common header to allow maintenance of individual units without having to shutdown plant
9	CIP headers	Provide cleaning supply for RO membranes	(Maintenance required)	Corrosion Mechanical impact	Maintenance on cleaning header			-	Low	Review configuration of cleaning header to allow maintenance of individual units without having to shutdown CIP system
10	Flushing headers	Provide flushing supply for RO membranes	(Maintenance required)	Corrosion Mechanical impact	Maintenance on flushing header			-	Medium	Review configuration of flushing header to allow maintenance of individual units without having to shutdown flushing system
11	Neutralisation tank	Neutralise CIP and flushing water	Failure of timely neutralisation	Equipment failure	Delay in CIP operation.				Low	Review sizing and operational duration (batch) of neutralisation system
12	SBS dosing	Neutralise chlorine in process stream	Failure of dosing (2 pumps must fail)	Equipment failure	Shutdown on single module - short duration		Low flow alarm/s ORP alarm/s	Duty stand by pumps permitted	Low	Review and/or control logic - spurious alarm and shutdown. Review location of ORP probes.
13	Anti-scalant dosing tank	To protect membrane integrity	Single tank for either anti-scalants		Whole plant shutdown					Review need for day tank (anti-scalant)

Control System

ID	Component	Function	Failure Mode	Failure Cause	Failure Effect	Detection Method	Safeguard	Redundancy Provided	Failure Criticality	Actions
1	SCADA	Supervisory control	Loss of supervisory control	Network failure	Loss of control from control room	Obvious to operator		Local PLCs maintain state prior to SCADA failure	Low	
2	PLCs	Local control	PLC down	Card (I/O) failure	Loss of local control	SCADA Alarm	Operator local control Steady state is maintained Spares holdings (including back-up of PLC software)		Low	

Waste Handling

ID	Component	Function	Failure Mode	Failure Cause	Failure Effect	Safeguards	Detection Method	Redundancy Provided	Failure Criticality	Actions
1	Thickener Feed Pumps	Feed backwash to waste treatment	Loss of flow	Pump failure PLC failure	Standby pump starts		Low flow (meter)	Duty standby arrangement	Low	
2	Coagulation Tank	Coagulate sludge	Poor mixing and coagulation	Mixer failure	Poor lamella performance Increased polymer use Exceedance of discharge allowances	Supernatant is diluted prior to discharge	Alarm on mixer (sludge/ turbidity monitoring)	-	Medium	Consider recirculation options for high-turbidity-supernatant, e.g. back to waste water holding tank.
3	Flocculation Tank	Flocculatation	(as per Coagulation Tank)							
4	Clarifier	Separation of phases	(as per Coagulation Tank)							
5	Sludge Holding Tank Feed Pumps	Feed sludge to holding tanks (fixed-speed)	No flow	Pump suction failure	Standby pump starts	Spares and maintenance	Pump temperature sensor (for no flow)	Duty-standby arrangement	Low	Review flow switch requirements in HAZOP

6	Sludge Holding Tank	Buffer tank	(as per Coagulation Tank)							
7	Sludge pumps	Feed sludge to centrifuge/s (VSD)	No flow	Pump suction failure	Standby pump starts	Spares and maintenance	Pump temperature sensor (for no flow) Flowmeter (no flow)	Duty-standby arrangement	Low	
8	Centrifuge	Dewater sludge	Loss of centrifuge	Electromechanical failure	Standby centrifuge starts	Spares and maintenance	Alarms Maintenance inspections	Duty-standby arrangement	Medium	Review whether centrifuge should operate as 3 duty. Review spares requirements
9	Conveyor	Remove bulk dewatered sludge	No flow	Blockage Over-current	Conveyor failure results in diverter chute diverts sludge to skip (if bin is full, diversion is to other centrifuge train)	Electronic shear pin Diverter chute Spring-loaded flap gates at either end of conveyor	Limit switch on flap gates	Spare centrifuge train	Low	
10	Centrate pumps	-	(per wastewater pumps)							
11	Polymer dosing	-	(per previous chemical dosing issues)							

Appendix C

Technical Discussion Paper

DP3 Characterisation of Concentrate Discussion Paper

CLIENTS | PEOPLE | PERFORMANCE

Victorian Desalination Project

Technical Paper

DP3 Characterisation of Concentrate Discussion Paper

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Contents

Executive Summary

A Reference Project has been developed to inform the Environmental Effects Statement (EES) and other approval processes for the Victorian Desalination Project. The EES process requires consideration of variations to the proposed Reference Project for which approval is being sought. A series of Technical Papers have been prepared to document the investigations undertaken to consider potential variations.

There are two types of Technical Papers: Options Papers and Discussion Papers. The Options Papers present information on the project variations to consider their feasibility specifically for the Victorian Desalination Project and determine if they meet the Project Objectives. Discussion papers present information about different project elements and how they are typically considered for a desalination project.

The application of different approaches and technologies to any desalination project requires consideration of the project objectives, geographic location and physical conditions. A range of options was considered in the papers, some of which are not feasible for the Victorian Desalination Project. The investigations documented in the Technical Papers have been undertaken at a desktop level drawing on public information about experiences elsewhere.

The desalination plant will separate salts from seawater and generate different waste streams. One of these is the concentrate discharge. The Project will be executed as a Public Private Partnership (PPP) and therefore detailed characterisation of the concentrate will only be known when the design of the successful bidder is finalised. However, this paper shows the stream will have the following broad characteristics:

1. Flow rate up to 50% higher than the flow rate of desalinated water production based on a typical recovery of 40-45% through the process
2. Increased concentration (a little less than twice the background) of salts and other constituents of the feed sea water
3. Low levels (typically in the order of 0.5 to 5 mg/L) of constituents added during the desalination process such as coagulants, antiscalants and others.
4. Final outputs will depend on choices made by PPP Company but constraints outlined in this paper show they are likely to fall within predictable ranges.

The actual composition will vary depending on a range of factors, including process design choices. This paper sets out the principles of the processes, key process choices and provides an indicative concentrate composition for the Reference Project.

1. Introduction

1.1 Context

A Reference Project has been developed to inform the Environmental Effects Statement (EES) and other approval processes for the Victorian Desalination Project. The EES process requires consideration of variations to the proposed Reference Project for which approval is being sought. A series of Technical Papers have been prepared to document the investigations undertaken to consider potential variations.

There are two types of Technical Papers: Options Papers and Discussion Papers. The Options Papers present information on the project variations to consider their feasibility specifically for the Victorian Desalination Project and determine if they meet the Project Objectives. Discussion papers present information about different project elements and how they are typically considered for a desalination project.

The purpose of the Technical Options Papers is to develop a broad list of options that are potential variations to the Reference Project, and are likely to be technically feasible and meet the Project Objectives. The aim is to present a discussion that allows consideration of a range of potential variations. It is not intended for the papers to differentiate between the options nor to draw conclusions for the project, as the PPP procurement process depends on innovation in private sector and therefore any option could potentially be pursued. The papers do however outline reasons why the options for the Reference Project were selected.

The application of different approaches and technologies to any desalination project requires consideration of the project objectives, geographic location and physical conditions. A range of options was considered in the papers, some of which are not feasible for the Victorian Desalination Project.

The investigations documented in the Technical Papers have been undertaken at a desktop level drawing on public information on experiences elsewhere. The technical papers broadly touch on environmental impacts and risks, however further consideration of the topics covered in the Technical Papers is provided in the Risk Assessment and Environmental Specialist Reports that are technical appendices of the EES.

The Technical Papers provide an overview of the Reference Project in comparison with the many options available. The Reference Project is documented in the EES.

1.2 Victorian Desalination Project Overview

The Victorian Government proposes to construct a seawater desalination plant on the Bass Coast, three kilometres west of Wonthaggi. The plant and ancillary infrastructure would supply water to the Melbourne Water supply system and other regional supply systems. The Victorian Government has announced that the Victorian Desalination Project will be delivered as a Public Private Partnership (PPP) under the Partnerships Victoria Policy, and will be operational by 2011.

The Victorian Desalination Project has four components:

- Marine Structures consisting of the seawater intake and the saline concentrate outlet structures;
- Desalination Plant with reverse osmosis desalination technology;

- Transfer Pipeline (approximately 85 kilometres) connecting the Desalination Plant to the Melbourne water supply network; and
- Power Supply to the Desalination Plant, Transfer Pipeline and ancillary infrastructure.

2. Objectives and Scope

This paper presents a summary of the Victorian Desalination Plant ocean discharge composition. The objectives of this paper are to:

- Outline factors that affect seawater desalination discharge composition;
- Outline waste stream discharge scenarios for the Victorian Desalination Plant based on the Reference Project; and
- Describe the ocean discharge composition for the Victorian Desalination Plant from the scenarios developed, focussing on the Reference Project.

This Technical Paper has been prepared solely for the purposes of providing technical information to support the Environmental Effects Statement and Works Approval Application for the Victorian Desalination Project. This paper in whole or part cannot be used for any other purpose.

2.1 Overview

The desalination process is based on the use of reverse osmosis membranes, and the concentrate stream will be discharged to the ocean. There is a range of other technical papers which describe the process and discharge dilution arrangements. RO concentrate from the desalination process is to be disposed of to the ocean (alternative disposal options are the focus of *Technical Paper MS4: Concentrate Disposal Options Paper*).

Seawater desalination involves removal of dissolved salts from seawater to produce a product of potable water standard. A membrane based seawater RO process will be used for the Victorian Desalination Plant. This will produce a desalinated (potable) water stream and a saline waste discharge (brine) concentrate stream.

The discharge concentrate will consist primarily of the natural constituents of seawater but which have been raised to higher concentration levels due to the RO process. These levels will be determined by the recovery rate of the RO process. Typically recovery rates of 40% to 45% are achieved which means the seawater constituents in the concentrate will be at about twice their concentration in the background seawater.

However, in addition to the concentrate, the discharge stream to the ocean may also contain constituents from chemicals used in other parts of the desalination processes such as:

- Intermittent chlorination
- Pre-treatment
- Dechlorination

- pH correction
- Prevention of membrane scaling
- Membrane cleaning
- Post treatment of permeate for potabilisation

The process design will include a selection of discharge routes and outfalls for waste streams generated from these additional processes. The options adopted will impact on ocean discharge characterisation. The Reference Project process design has been used as a basis to determine discharge characterisation but the developer of the Victorian Desalination Plant will determine the ultimate process design. Note that requirements for the concentrate discharge to meet environmental and regulatory requirements could drive process design, particularly chemical choices.

The choice of pre-treatment methodology and the management of pre-treatment waste will have the most significant impacts on ocean discharge characterisation for the Victorian Desalination Plant. *Technical Paper DP1: Pre-treatment Technology Concepts Options Paper*, discusses pre-treatment technology options and *Technical Paper DP2: Pre-Treatment Waste Management Options Paper* discusses alternatives for pre-treatment waste disposal.

This report outlines the factors that would affect ocean discharge composition for the Victorian Desalination Plant based on the Reference Project and includes a characterisation analysis using pre-treatment discharge scenarios within this reference.

2.2 Key aspects of Reference Project

Appendix A includes the Reference Project process design for the Victorian Desalination Plant.

The key process aspects of this design are that:

- Seawater concentrate is disposed to the ocean;
- The pre-treatment method selected is coagulation followed by media filtration
- In one alternative, pre-treatment waste is separated into a liquid (supernatant) stream and a solids stream with the solids stream discharged to landfill and the supernatant returned to the process
- In the other alternative, pre-treatment backwash is blended steadily with the concentrate and sent to the ocean; and
- The discharge from the post-treatment process will not be discharged into the ocean. Post-treatment is undertaken to ensure potability of desalinated water and will involve addition of lime and other chemicals. The residue from this process (lime sludge) is considered a potentially useful product as it does not contain salt and potentially can be reused.

3. Importance of Discharge Characterisation to the Project

The Victorian Desalination Plant will be required to meet legislative standards for discharge of its waste streams. Characterisation of the waste stream is important to identify whether it will be of suitable standard prior to release.

Once the final waste stream from the desalination process is discharged the only control will be dilution. This paper outlines the possible alterations to the discharge composition prior to the dilution step.

4. Project Specific Constraints

The following constraints have been found relevant to the discharge characterisation process:

- Size of the project;
- Feed water composition; and
- Treated water quality targets (which drive process choices).

5. Factors Affecting Discharge Characterisation

The composition of discharge for the Victorian Desalination Plant will be described by constituents present and their concentration levels. The extract in Figure 1 summarises impacts to discharge characteristics identified by Safrai & Zask (2008).

Discharge characteristics are mainly a result of:

- Feed water source and composition – SWRO and BWRO and its raw constituents' concentrations.
- Pretreatment method and its rejects – whether pretreatment rejects are discharged to the seas, whether it is treated and how (sand filter, UF, etc.)
- Additives – including types, such as phosphate antiscalants (polyphosphonates) or phosphate free; concentrations and loads
- Recovery rate – affect constituent concentrations but has no effect on loading rate
- Operational regime – such as intermittent or continuous disposal of untreated backwash water. It might be reflected in peaks of high concentrations for TSS and turbidity or homogenous concentrations of the brine
- Flow rate – affect mainly on the pollutants loads.

Figure 1 Extract showing Influences to Discharge Composition (Safrai & Zask, 2008)

The following factors will influence discharge composition for the Victorian Desalination Plant by either defining the constituents present, introducing new constituents or altering concentration levels;

- Feed seawater composition
- Reverse Osmosis (RO) process design
- Choice of chemicals
- Chemical reactions (and implicitly pH conditions)
- Pre-treatment waste discharge disposal design
- Outlet design

The following sections provide a discussion on how these factors will impact on the Victorian Desalination Plant ocean discharge composition.

5.1 Seawater composition

Typically seawater comprises inorganic chemicals such as sodium chloride, magnesium and calcium, naturally occurring organic acids such as humic and fulvic acids (WHO, 2007) and a wide range of other constituents. Seawater at the Victorian Desalination Plant Intake has been characterised by sampling and testing and is referred to in the project Expression of Interest (EOI), DSE 2008. This characterisation has been adopted for the Reference Project and for analysis undertaken for this paper.

Appendix A includes the seawater composition data provided in the EOI. The characterisation shows dominance of ions and dissolved solids and trace quantities of metals. The composition shows that the Victorian coastal water at the desalination plant location has the typical characteristics of ocean waters.

Seawater composition will impact on discharge characterisation. The process of desalination aims to separate the seawater into two streams, the product water, and the waste (concentrate) stream. This concentrate then forms the dominant component of the ocean discharge. Identifying the feed seawater constituents therefore describes the majority of the ocean discharge constituents.

5.2 Reverse Osmosis (RO) process design

The objective of RO for the Victorian Desalination Plant will be to remove constituents in seawater using a pressurised process. RO membranes are used to achieve this in a two pass system illustrated in Figure 2. Pre-treated seawater is to be passed through the first series of membranes producing a first pass permeate and the first concentrate stream. The permeate will then be put through a second series of RO membranes to produce a final second pass permeate and a second concentrate stream. The concentrate from the second pass is returned to the process at the start of the first pass. This is a schematic representation only, and the analysis in this paper is based on the more complex Reference Project.

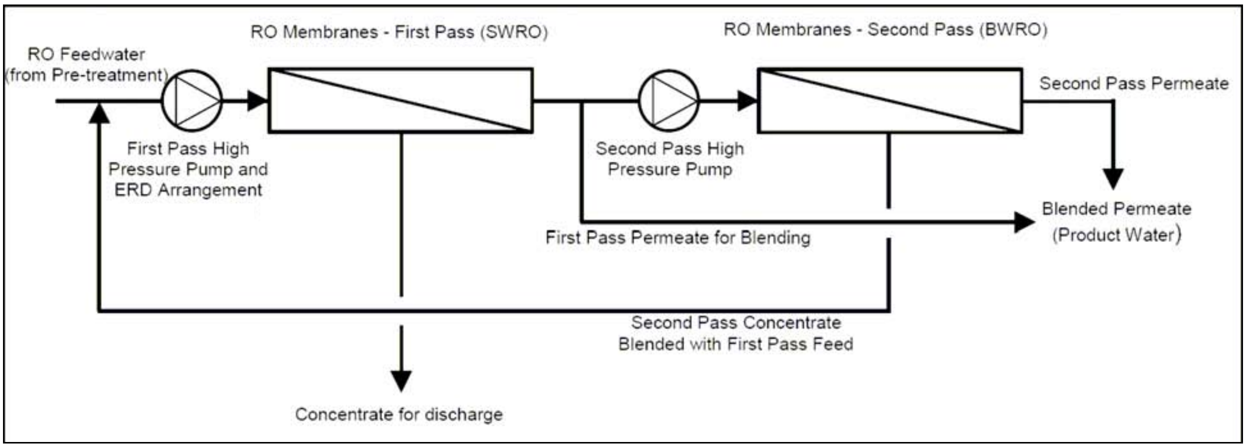


Figure 2 Victorian Desalination Plant RO Process Flow (Simplified Schematic) (GHD 2008)

Concentrate (and therefore ocean discharge) characterisation will depend on the quantity of seawater constituents rejected by the RO membranes. The greater the membrane efficiency (the recovery) the more concentrated the rejected seawater constituents will be. The Reference Project assumes the RO process will operate at a recovery rate of 40% to 45% which implies the concentrate discharge will contain a little less than twice the concentration of constituents in seawater.

The adopted RO process also impacts on the characterisation of ocean discharge by allowing flexibility in the location of other treatment processes. The two pass design allows for additional chemicals to be dosed at the second pass RO feed which may characterise the second pass concentrate stream differently from the first pass concentrate stream.

5.3 Chemical Selection

Various chemicals will be added to the seawater feed at different stages of the desalination process. These chemicals impact on the discharge characterisation either directly by adding new constituents or indirectly through chemical reactions. A separate technical paper, *Technical Paper DP4: Desalination Plant Chemical Use Options Paper*, focuses on the chemicals chosen for the Victorian Desalination Plant. These chemicals are summarised in Table 1 along with the process within which they are being used and some possible chemical alternatives that might be selected by the Project's proponent.

Table 1 Summary of selected chemicals and possible alternatives for the Reference Project for the Victorian Desalination Plant

Ref No.	Process Section	Purpose	Reference Project Approach	Chemical Symbol	Some Possible Alternatives
1	Pre-treatment	Disinfection and prevention of biological growth	Sodium hypochlorite	$NaOCl$	Calcium hypochlorite ($Ca(OCl)_2$) Chlorine (Cl_2) Chloramine
2	Pre-treatment	pH correction	Sulphuric acid	H_2SO_4	Hydrochloric acid (HCl)
3	Pre-treatment	Coagulation	Ferric chloride	$FeCl_3$	Alum ($Al_2(SO_4)_3 \cdot 18H_2O$) * Polyaluminium chloride ($(Al_2(OH)_nCl_{6-n}$ x $H2O]_m$; ($1 \leq n \leq 5, m \geq 10$) * Ferric sulfate ($Fe_2(SO_4)_3$) Ferrous sulfate ($FeSO_4$)
4	Pre-treatment	Flocculation	Proprietary polyelectrolyte	N/A	Other proprietary polyelectrolytes
5	Desalination	Dechlorination	Sodium bisulphite	$NaHSO_3$	Sulphur dioxide (SO_2)
6	Desalination	Membrane Scale Prevention	Proprietary antiscalant	N/A	Other proprietary antiscalants
7	Desalination	pH correction (Boron removal)	Sodium hydroxide	$NaOH$	Sodium carbonate (Na_2CO_3) Lime ($Ca(OH)_2$)
8	Desalination	Membrane Cleaning	Hydrochloric acid Citric acid Sodium hydroxide	HCl CH_3COOH $NaOH$	Sulfuric acid (H_2SO_4) Ethylenediaminetetraacetic Acid (EDTA) SBS
9	Potabilisation	Water Stabilisation	Limewater Carbon dioxide	$Ca(OH)_2$ CO_2	Calcium chloride ($CaCl_2$) & Sodium carbonate (Na_2CO_3) Calcium chloride ($CaCl_2$) & Sodium hydroxide (NaOH) Sulfuric acid (H_2SO_4) Hydrochloric acid (HCl)
10	Potabilisation	Fluoridation	Fluorosilicic acid	H_2SiF_6	Sodium fluoride (NaF) Sodium silicofluoride (Na_2SiF_6)

Ref No.	Process Section	Purpose	Reference Project Approach	Chemical Symbol	Some Possible Alternatives
11	Potabilisation	Disinfection	Chlorine	Cl_2	Sodium hypochlorite (NaOCl) Calcium hypochlorite ($Ca(OCl)_2$) Chloramine
12	Wastewater Treatment	Solids thickening and dewatering	Proprietary polyelectrolyte	N/A	Other proprietary polyelectrolytes

* Potential aluminium scaling from aluminium based coagulants favours use of iron based coagulants for seawater desalination.

Refer to *Technical Paper DP4: Desalination Plant Chemical Use Options Paper* for further information

Note that chemicals identified for use in the potabilisation process would not typically find their way into the concentrate stream, unless the proponent's design includes the disposal of lime sludge with the concentrate, or, in circumstances such as commissioning, where the product water is disposed of by blending it with the concentrate for disposal.

The chemicals to be adopted for flocculation and prevention of scaling are yet to be identified, however generalisations can be made on their impact on ocean discharge characterisation as discussed in Section 6. The majority of the chemicals outlined will have an indirect impact on chemical composition of concentrate through their chemistry in the process flow. However some processes such as coagulation and flocculation have the effect of adding new constituents into the process. The following section summarises how the chemicals outlined in Table 1 will react in the desalination process.

5.4 The role of pH

One of the key factors that will affect chemical reactions along the desalination process, and thus discharge composition, will be pH. The physical conditions necessary for chemical reactions to take place in the process flow are dependent on pH. Figure 3 summarises locations in the Reference Project process design where dosing is undertaken to modify pH prior to a process.

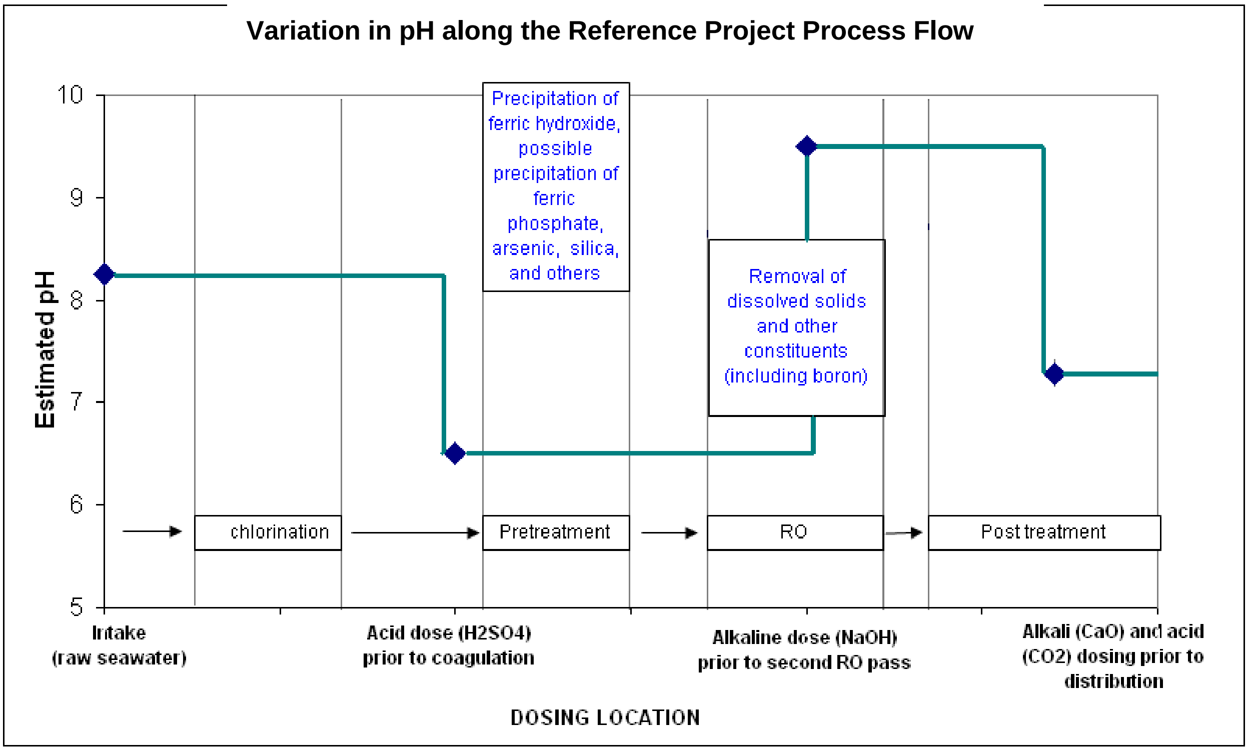


Figure 3 pH impact on the desalination process

As Figure 3 shows, the pH conditions are related to removal of constituents (precipitation). This eventually impacts on discharge characterisation. Precipitation will occur, and is desired, during the coagulation process. Within the RO process the aim is to avoid precipitation.

The purpose of coagulation is to remove turbidity and other undesirable contaminants from the feed water (*Technical Paper DP1: Pre-treatment Technology Concepts Options Paper* provides further information). Turbidity typically comprises inorganic and organic colloids as well as microorganisms. A coagulant is used to destabilise these constituents and cause them to aggregate into larger particles or precipitates which can then be removed. Flocculation speeds up the aggregation process. The effectiveness of the precipitation process is dependent on pH (Faust, Aly, 1998). Ferric Chloride has been selected for the Reference Project coagulant and its dosage is dependent on pH as well as the turbidity of the raw water.

The other key process aspect where a pH change is required is during the second pass feed of the RO train. The objective here is to increase the solubility of constituents that are not removed after coagulation and the first RO pass which could cause scaling if they precipitate.

Calcium, Magnesium, Barium, and Strontium are examples of constituents which could cause scaling. There is also a requirement to alter the ionic balance to improve rejection of some ions. Boron is an example of such constituents and Figure 4 shows how the efficiency of Boron removal varies with pH.

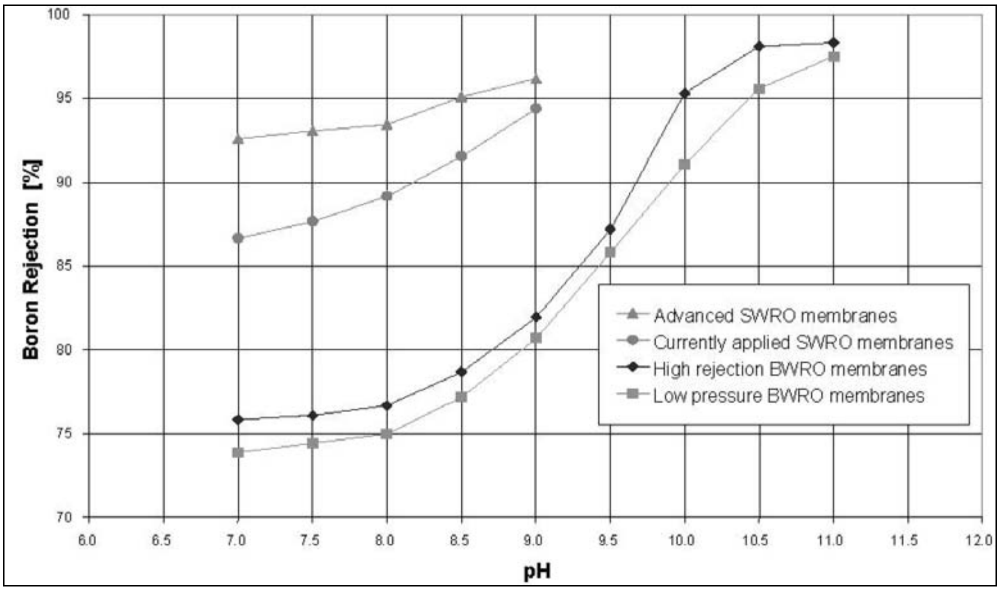


Figure 4 Boron removal efficiency and pH (Fritmann *et al.*, 2007)

Figure 4 shows a difference in Boron removal efficiency from about 86% under neutral conditions to close to 95% under alkaline conditions for general seawater RO (SWRO) plants. Optimum removal of boron is an important aspect of process efficiency and operating costs, as well as impacting on the characterisation of the RO discharge stream (concentrate).

In summary ocean discharge characterisation depends on the waste streams generated at each stage of the desalination process and the constituents of these waste streams are in turn dependant on the physical conditions prevalent, particularly the pH.

Characterisation analysis for this paper makes assumptions on the precipitation levels as outlined in Section 6 but operating conditions (i.e. pH) of the final design will determine actual precipitation rates.

5.5 Chemistry of reactions

A number of chemical reactions will occur along the desalination process that will impact on discharge characterisation. Most of the chemicals introduced upstream of the RO process end up in the discharge (concentrate) stream. The key steps along the desalination process that will generate waste streams include dosing processes as well as the RO process itself. At the dosing locations various chemical reactions occur that typically alter the constituents present. Conditions necessary for these reactions to occur include pH and temperature.

The role of pH is discussed in Section 5.4 and is critical to the level of reactivity and therefore the change in concentration levels in the discharge. Optimum temperature conditions also impact on reactivity levels for example in the solubility states of constituents. In this regard constituent composition can differ in the same process discharge over summer as compared to winter.

The chemistry involved for the key steps in the Reference Project desalination process and the impacts on discharge characterisation are summarised in Table 2.

Table 2 Desalination Process Chemistry

Process	Key Chemical Equations	Changes to Concentrate Composition
Chlorination	$NaOCl \rightarrow Na^{+} + OCl^{-}$	No additional compounds other than slight addition of sodium, chloride and oxygen.
Acid Dosing	$H_2SO_4 + H_2O \rightarrow H_3O^{+} + HSO^{4-}$	Acid dosing does not generate an independent waste stream although its effect is to increases the solubility of feed water to assist with particulate removal later in the treatment process.
Coagulant Dosing	**Coagulation** $FeCl_3 + 6H_2O \rightarrow Fe(OH)_3.3H_2O + 3HCl$	Coagulation introduces iron salts to the pre-treatment waste stream. Flocculation also introduces new constituents dependent on the chemical make up of the product used. The coagulant can also contain small levels of other compounds such as metals
Flocculant Dosing	**Flocculation** (Organic polymers; non toxic and acceptable for addition to drinking water)	This process precipitates inorganic and organic colloidal particles and disposes them to the pre-treatment waste stream. This will impact on the ocean discharge composition depending on how the pre-treatment waste stream is handled.
Dechlorination	$NaHSO_3 + HOCl \rightarrow H_2SO_4 + NaCl$	Dechlorination removes chlorine residuals introduced in the chlorination process, to protect the RO membranes from oxidation.
Membrane Cleaning	(Acids and bases, surfactants)	The Reference Project assumes acids and bases would be the main cleaning agents at low volumes compared to the ocean discharge stream. Waste streams from the cleaning process would be neutralised and stored prior to discharge, which would then be done by gradual blending with the concentrate. (Cleaning occurs every few months). TDS would be added to the discharge composition through neutralisation of the acids and bases. Additional compounds may be introduced depending on the chemical constituents of market cleaning products. Trace levels of surfactants and chelating agents may be included.
Antiscalant Dosing	(Most antiscalants are phosphorus based)	The chemistry and compounds introduced to the discharge stream will vary depending on the antiscaling product used. Addition of phosphorus based compounds is likely. Such chemicals are typically proprietary commercial products. Some commonly used antiscalants for seawater RO include Aqua Feed AF-650, Permatreat-191, PTP-100, Flocon-100, Belgard-BRO and SHMP (Hashim & Hajjaj, 2005). Detailed composition on these products is considered market sensitive information. Some available information is provided in the appendices.
Caustic Soda Dosing	$NaOH \rightarrow Na^{+} + OH^{-}$	The role of caustic soda dosing is to alter pH. This does not directly change the discharge characterisation other than some increase in sodium levels.
Post Treatment		It is assumed post treatment waste is not included in concentrate discharge.

5.6 Pre-treatment waste disposal

Technical Paper DP2: Pre-treatment Waste Management Options Paper provides a discussion on the alternatives for management of backwash water from the pre-treatment process.

There are three key alternatives:

- Pre-treatment wastewater combined with concentrate for ocean disposal
- Pre-treatment waste thickened and dewatered with solids disposed to landfill and supernatant combined with concentrate for ocean disposal
- Pre-treatment waste thickened and dewatered with solids disposed to landfill, supernatant returned to the head of the plant and concentrate disposed to the ocean

In the first alternative the full filtration backwash stream will be flow-balanced in a tank and will then be blended with the concentrate stream for disposal. It will therefore add ferric hydroxide floc, containing solids and organics originating from the seawater to other concentrate constituents.

In the second and third alternative, the iron hydroxide precipitate (bound with solids and organics from the ocean) will be dewatered to around 30% solids: 70% water and sent to landfill. There will be residual levels of iron and other constituents which are not completely removed by the pre-treatment filtration stage (or remain in solution) and which therefore may end up in the concentrate under the second alternative.

5.6.1 Pre-treatment waste discharge scenarios

Chemical analysis for the Victorian Desalination Plant Reference Project has been undertaken for the purpose of characterising the ocean discharge stream. This analysis has been based on three alternative process flow options stemming from the three pre-treatment waste discharge options. Variation in how pre-treatment waste is handled will modify the discharge composition as discussed in Section 2.1.

Three scenarios for pre-treatment waste discharge have been developed. Pre-treatment discharge options are discussed in detail in *Technical Paper DP2: Pre-treatment Waste Management Options Paper*. The scenarios are:

i. All pre-treatment waste is included in the ocean discharge stream (**Case 1**). Figure 5 shows the process flow for this option.

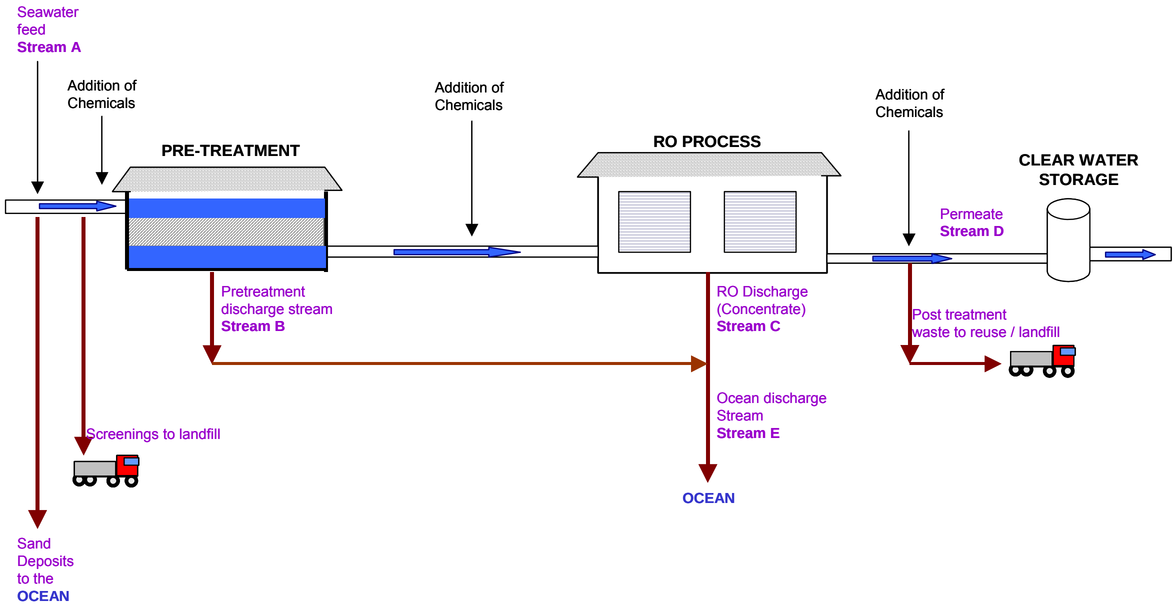


Figure 5 Case 1 Discharge Scenario

ii. The pre-treatment waste is separated into a liquids (supernatant) stream and a solids stream. The supernatant is then included in the ocean discharge stream while the solids are disposed to landfill (**Case 2**). Figure 6 shows the process flow aspects for this option.

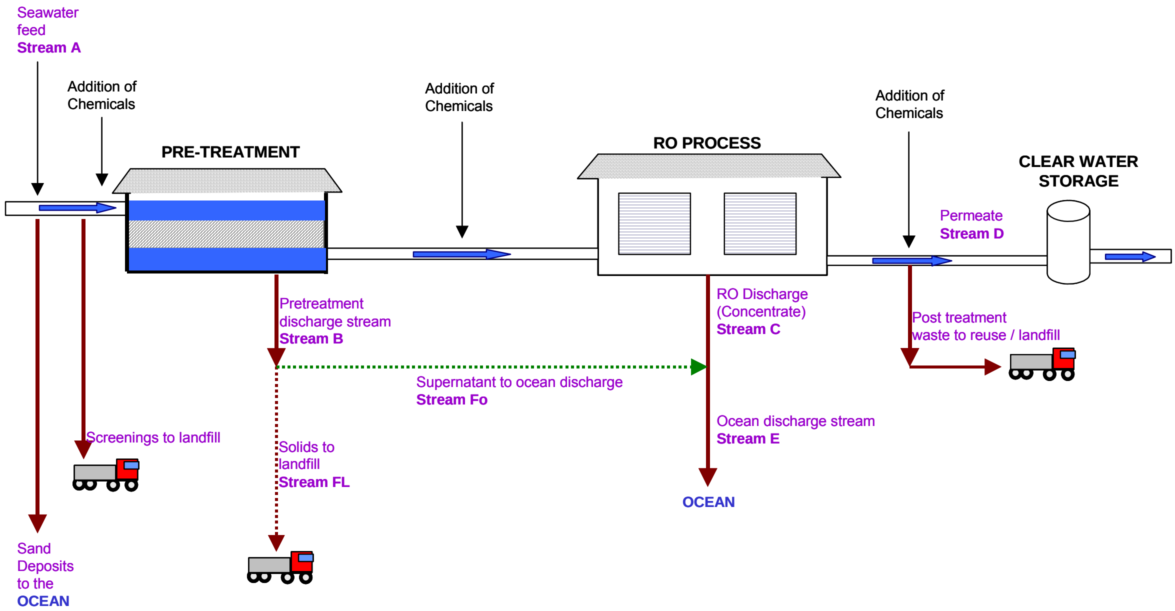


Figure 6 Case 2 Discharge Scenario

iii. Similar to Case 2 only the supernatant is recycled by returning it to the head of the plant. Solids are still discharged to landfill (**Case 3**). Figure 7 shows the process flow for this option.

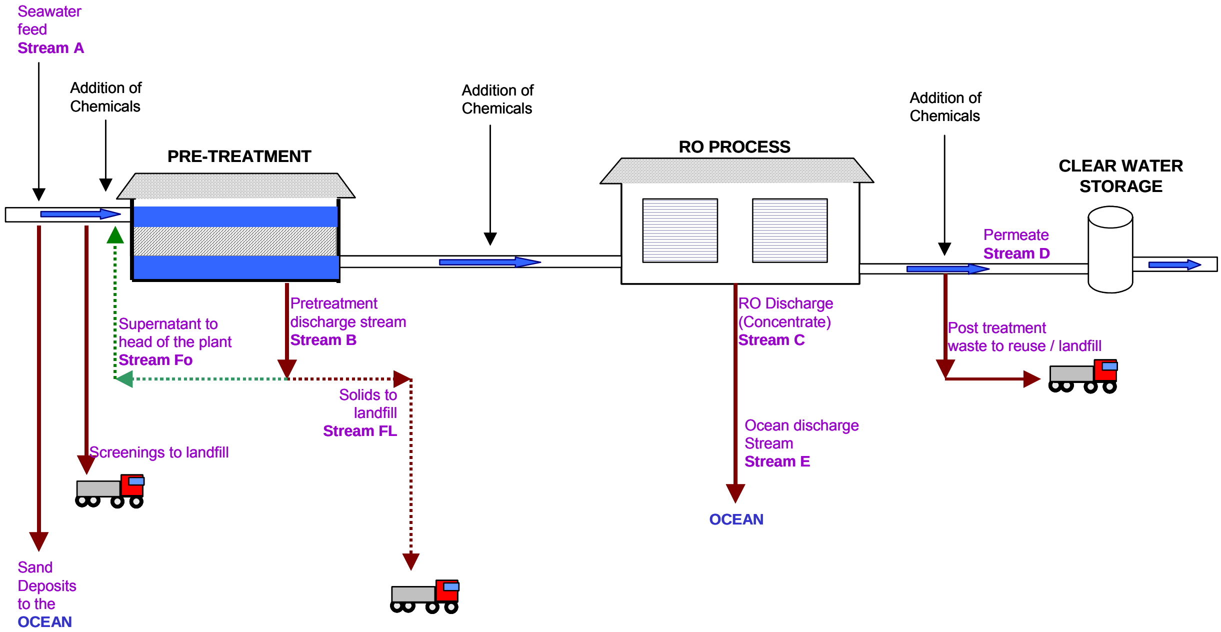


Figure 7 Case 3 Discharge Scenario (Reference Project)

The following sections of this paper provide an analysis of the discharge outfall characterisation based on these developed scenarios.

5.7 Outlet Design

The outlet diffusers are designed to achieve an engineering design dilution target of at least 50 parts of the water surrounding the nozzles mixed with 1 part of water in the nozzle within 100 m of the diffusers. The following simplistic illustrative calculation shows the principle, and considers TDS (salinity) as an example.

Assuming the seawater surrounding the nozzles has a TDS of 35 ppt, this will be elevated through the desalination process to 60-70 ppt assuming RO recovery around 40%.

Assuming 50 parts of seawater surrounding the nozzle at 35 ppt is added to 1 part concentrate at 60-70 ppt, the TDS at this point will be between:

$$\{(50 \times 35) + (1 \times 60)\} \div 51 = 35.5 \text{ ppt}$$

$$\{(50 \times 35) + (1 \times 70)\} \div 51 = 35.7 \text{ ppt}$$

Based the above calculation, once the initial dilution occurs, the TDS at that point will be:

$$(0.5 \div 35) \times 100 \text{ to } (0.7 \div 35) \times 100 = 1.4\% \text{ to } 2.0\% \text{ above background levels}$$

Further dilution will then occur as the stream continues to disperse.

6. Victorian Desalination Plant Concentrate Characterisation

A mass balance has been undertaken to characterise the Victorian Desalination Plant discharge composition. This mass balance was undertaken as a spreadsheet analysis using Microsoft Excel, and inputs drawn from ROSA modelling for the Reference Project. The following sections explain the approach adopted, the assumptions made and a discussion of the characterisation obtained.

6.1 Mass Balance

The aim of undertaking a mass balance for the desalination process is to track chemical inputs and outputs in order to define the composition of the final (ocean) discharge. A key factor that will affect this process is the handling of pre-treatment waste. The mass balance includes three pre-treatment discharge scenarios as presented in Section 5.6.1.

Figure 5 to Figure 7 to show that tracking of the chemical inputs and outputs for the process will be defined at five key stages, the:

- seawater composition (Stream A)
- pre-treatment discharge composition (Stream B), which can be separated into Streams Fo and FL
- concentrate discharge composition (Stream C)
- permeate composition (Stream D)
- ocean discharge composition (Stream E), prior to dilution

The methodology that has been adopted to calculate the chemical components for each of these process streams is summarised in Table 3.

Table 3 Summary of Mass Balance Methodology

Process Stream	Constituents likely in Stream	Calculation of constituent concentrations in final discharge (Stream E)
Stream A Feed Seawater	Dissolved constituents	(Constituent Concentration in Stream A)*(Flow of Stream A/ Flow of Stream E) ≈ ×2
	Dissolved constituents that will coagulate	(see Stream Fo **OR** Stream FL depending on discharge scenario)
	Particulate matter	(see Stream Fo **OR** Stream FL depending on discharge scenario)
Stream B Pre-treatment Waste	Added chemicals that precipitate	(see Stream Fo **OR** Stream FL depending on discharge scenario)
	Added chemicals that do not precipitate, concentration will be similar to filtered seawater	≈ ×2 (minor dilution of Stream E may occur, depending on discharge scenario)
Stream C Concentrate	Added chemicals in solution.	≈ ×2 the concentration in filtered seawater

Process Stream	Constituents likely in Stream	Calculation of constituent concentrations in final discharge (Stream E)
Stream Fo Supernatant	Same as treated seawater, but with some residual solids (assumption of even blending into concentrate stream)	≈ ×2 (minor dilution of Stream E may occur, depending on discharge scenario)
Stream FL Solids	Solids (from thickening and dewatering process) – Suspended solids in seawater and precipitated constituents from the coagulation and flocculation stage.	0 (discharged to landfill)

Table 3 shows that majority of the constituents in the seawater end up at about twice the concentration in the discharge to the ocean (N.B: Stream E is prior to final dilution at the point of discharge into the ocean). Chemicals added along the desalination process also either end up in a solid form or at around twice their dosed concentration in the discharge to the ocean outfall.

The scenarios developed in Section 5.6.1 dictate whether the pre-treatment waste as a whole (Stream B) is blended into concentrate or separated into a liquid (supernatant) and solids (Streams Fo and FL). Following the separation the scenarios also dictate whether the supernatant is discharged to the ocean or returned at the head of the plant. In either case the constituents end up at around twice their original concentration or not present in the discharge to ocean at all.

A spreadsheet output of the mass balance undertaken illustrating the results obtained is included in Appendix B.

6.2 Assumptions

The mass balance chemical analysis for the Victorian Desalination Plant is based on the following assumptions:

- Steady state ‘normal’ operation and does not necessarily account for commissioning and other possible circumstances.
- Metal leaching (which occurs as pipework corrodes from contact with acidic or highly saline effluent) is assumed not to be relevant for the plant. This is based on the selection of stainless steel and glass reinforced plastic (GRP) pipework, which have high corrosion resistance. Metal leacheate constituents have therefore not been included in the discharge characterisation.
- It is assumed waste from the post treatment process will not to be discharged into the ocean. Post treatment is undertaken to ensure potability of desalinated water and will involve addition of lime and other chemicals. The residue from this process (lime sludge) is considered a useful product and potentially may be reused. Chemical compounds in this waste stream are therefore not included in the mass balance analysis.
- It has been assumed that sand and screenings from the seawater intake are to be trucked to landfill. Intake of sand is largely avoided by inlet design. Screenings comprise solids and biota from seawater. It is possible that the screenings may be crushed and fed into the concentrate stream, however, this is unlikely until site specific information is collected as inorganic materials (plastics) could be introduced to the concentrate discharge which is not desirable.

- The overall recovery rate for the Reference Project is 42% (Case 3), or 39% when the supernatant or backwash water is directed to the outlet (Cases 1 and 2).
- It is assumed all dissolved constituents from the intake and pre treatment that are directed to the RO membranes and rejected by the membranes. It is therefore assumed that relatively low amounts of chemical constituents that are added to seawater go through to permeate.
- Assumptions have been made as to what proportions of chemical compounds are precipitated out of solution at various stages of the process flow. The ratios adopted are included in Appendix B. For most of the constituents that will precipitate the ratio adopted was 50%, i.e. half precipitates and half doesn't. The exception was iron, which was assumed to precipitate (99%) at the pre-treatment stage. Further detailed analysis is required to refine this assumption. In practice this assumption is conservative and is likely to overestimate concentrations in the concentrate stream.
- Assumptions have also been made on flow rates in order to undertake concentration calculations, as well as chemical dose rates and dosing frequencies. These figures are included in Appendix B. In summary, intermittent chlorination of the inlet works and dechlorination are assumed to take place once a day while most other dosing is assumed to take place continuously.
- For Case 1 and 2, it is assumed that any residual chlorine in the pre-treatment wastewater from intermittent chlorination of the inlet works is consumed during blending with concentrate prior to discharge or alternatively SBS could be added prior to discharge.
- The detailed composition of flocculant and antiscalant (including trace levels of other compounds) has not been defined, as these products tend to be proprietary. In these cases the approach has been to include the dose rates and assume the same calculation path as illustrated in Table 3 providing a characterisation of the quantities.
- Cleaning chemicals have not been included in the mass balance analysis, because membrane cleaning is likely to:
  - occur periodically (say 3-4 times per year) depending on fouling/scaling rate of the membranes;
  - largely comprise of acids and bases in series which will be neutralised prior to disposal;
  - be of significantly smaller volume compared to the concentrate and can therefore be blended with the concentration for dilution prior to disposal.

  It is anticipated that around 8 000 to 16 000 m^3 of each cleaning solution will be used per year, depending on the required cleaning frequency. The neutralised cleaning chemicals are expected to be stored on site and slowly bled into the concentrate. The Reference Project allows for this to occur over the course of a day which provides an approximate dilution ratio of greater than 1:1 000.
- It is assumed that contaminants do not build up due to the recycling of supernatant to the head of the plant.

6.3 Results

The mass balance analysis illustrated that the dissolved constituents naturally occurring in seawater are doubled in concentration by the Reverse Osmosis process, but are diluted back to near intake levels once dilution at the outlet occurs. The characterisation of the ocean discharge comprised the same constituents present in seawater and some new compounds were also introduced (via the process chemicals).

In summary characterisation of ocean discharge for the Victorian Desalination Plant is similar for each of the three discharge scenarios. The key difference being in the presence of Total Metals, specifically Iron. There will be more metals discharged to the ocean when all pre-treatment waste is directed to the outfall. Reductions in Total Metals presence in the ocean discharge, and particularly for Iron, are achieved where pre-treatment waste is separated into a supernatant and solid stream and the solids are discharged to landfill.

7. Conclusions

The composition of the concentrate will depend on the final bidder’s process design. However, it has been possible to estimate and predict the composition of concentrate based on the Reference Project.

In seawater RO desalination, more than half of the water extracted from the ocean is rejected by the membranes. This water has a salinity about twice that of seawater and contains trace levels of chemicals added during the process.

This paper shows the stream will have the following broad characteristics:

1. Flow rate up to 50% higher than the flow rate of desalinated water production based on a typical recovery of 40-45% through the process.
2. Increased concentration (a little less than twice the background) of salts and other constituents of the feed sea water.
3. Low levels (typically in the order of 0.5 to 5 mg/L) of constituents added during the desalination process such as coagulants, antiscalants and others.
4. Final outputs will depend on choices made by PPP Company but constraints outlined in this paper show they are likely to fall within predictable ranges.

The actual composition will vary depending on a range of factors, including process design choices. This paper sets out the principles of the processes, key process choices and provides an indicative concentrate composition for the Reference Project.

8. References

Andrzejewski P, Kasprzyk-Hordern B and Nawrocki J (2005). The hazard of N-nitrosodimethylamine (NDMA) formation during water disinfection with strong oxidants. Desalination, **176**, 1-3, 37-45.

Ahmed, M., Shayya, W.H. Hoey, D. Al-Handaly, J. Brine disposal from reverse osmosis desalination plants in Oman and the United Arab Emirates, *Desalination,* 133, pp. 135-147

Auckland Regional Council, technical paper, overview of the Effects of Residual Flocculants on Aquatic receiving Environments. *(http://www.arc.govt.nz/albany/fms/main/Documents/Plans/Technical%20 publications/201-250/TP226%20Overview%20of%20the%20effects%20of%20residual% 20flocculants%20on%20aquatic%20receiving%20environments.pdf)*

Australian Government National Health and Medical Research Council http://www.nhmrc.gov.au

Australian Government Department of the Environment, Water, Heritage and the Arts http://www.environment.gov.au/index.html

Dow Liquid Separations FILMTEC™ Reverse Osmosis Membranes Technical Manual

Elhassadi, A., (2007), Pollution of water resources from industrial effluents: a case study – Benghazi, Libya", *Desalination*, 222, pp. 286-293

EPA Victoria http://www.epa.vic.gov.au/

Fabbricino M and Korshin G V (2005). Formation of disinfection by-products and applicability of differential absorbance spectroscopy to monitor halogenation in chlorinated coastal and deep ocean seawater. Desalination, **176**, 1: 57-69

Faust Samuel D., Aly Osman M., (1998) *Chemistry of Water Treatment*, 2nd Edition, Lewis Publishers

Fritzmann C., Lowenber J., Wintgens T., Melin T.,(2007) *State-of-the-art of reverse osmosis desalination*, ELSEVIER Desalination 216 (2007) 1-76

Hashim,A. & Hajjaj, M., (2005), Impact of desalination plants fluid effluents on the integrity of seawater, with Arabian Gulf in perspective, *Desalination*, 182, pp. 373-393

Iwahashi M, Katsugari T, Tani Y, Tsutsumi K and Kakiuchi K (2003). Mechanism for Degradation of Poly(Sodium Acrylate) by Bacterial Consortium No. L7-98. Journal of Bioscience and bioengineering, **95**, 5, 483-487.

Kidson, R., Trousdale, S., Wood, J. & Allen, G., (2008), Environmental Monitoring Program for Sydney's Desalination Plant, Journal of the Australian Water Association, March 2008

Kohut KD and Andrews SA (2003). Polyelectrolyte Age and N-Nitrosodimethylamine Formation in Drinking Water Treatment. Water Quality Research Journal of Canada, **34**, 4, 719-735.

Latteman S and Höpner T (2003). Seawater desalination – Impacts of Brine and Chemical Discharge on the Marine Environment. Institute for hemistry and Biology of the Marine Environment (ICBM), University of Oldenburg, Germany.

Metcalf & Eddy, (2003) *Wastewater Engineering – Treatment and Reuse*, 4th Edition, McGraw Hill New York

Metcalf & Eddy, (2007) *Water Reuse – Issues, Technologies, and Applications*, 1st Edition, McGraw Hill New York

Millero, F.J., (2006), *Chemical Oceanography*, Taylor & Francis Group.

Mitch W.A., Sharp JO, Trussell R.O., Valentine R.L., Alvarez-Cohen L. and Sedlak D.L. (2003). N-Nitrosodimethylamine (NDMA) as a Drinking Water Contaminant: A Review. *Environmental Engineering Science* 20 (5), pp. 389–404

Ravizky, A., & Nadav, N., (2006), Salt production by the evaporation of SWRO brine in Eilat: a success story, *Desalination*, 205, pp. 374-379

Safrai I., Zask A., (2008) *Reverse Osmosis desalination plants – marine environmentalist regulator point of view*, ELSEVIER Desalination 220 (2008) 72-84, p76

SFPUC (San Fransico Public Utility Commission) (2007), Nitrosodimethylamine (NDMA) Information. http://www.sfwater.org/detail.cfm/MC_ID/10/MSC_ID/51/MTO_ID/NULL/C_ID/1865#eight

Victorian Legislation and Parliamentary Documents http://www.legislation.vic.gov.au/

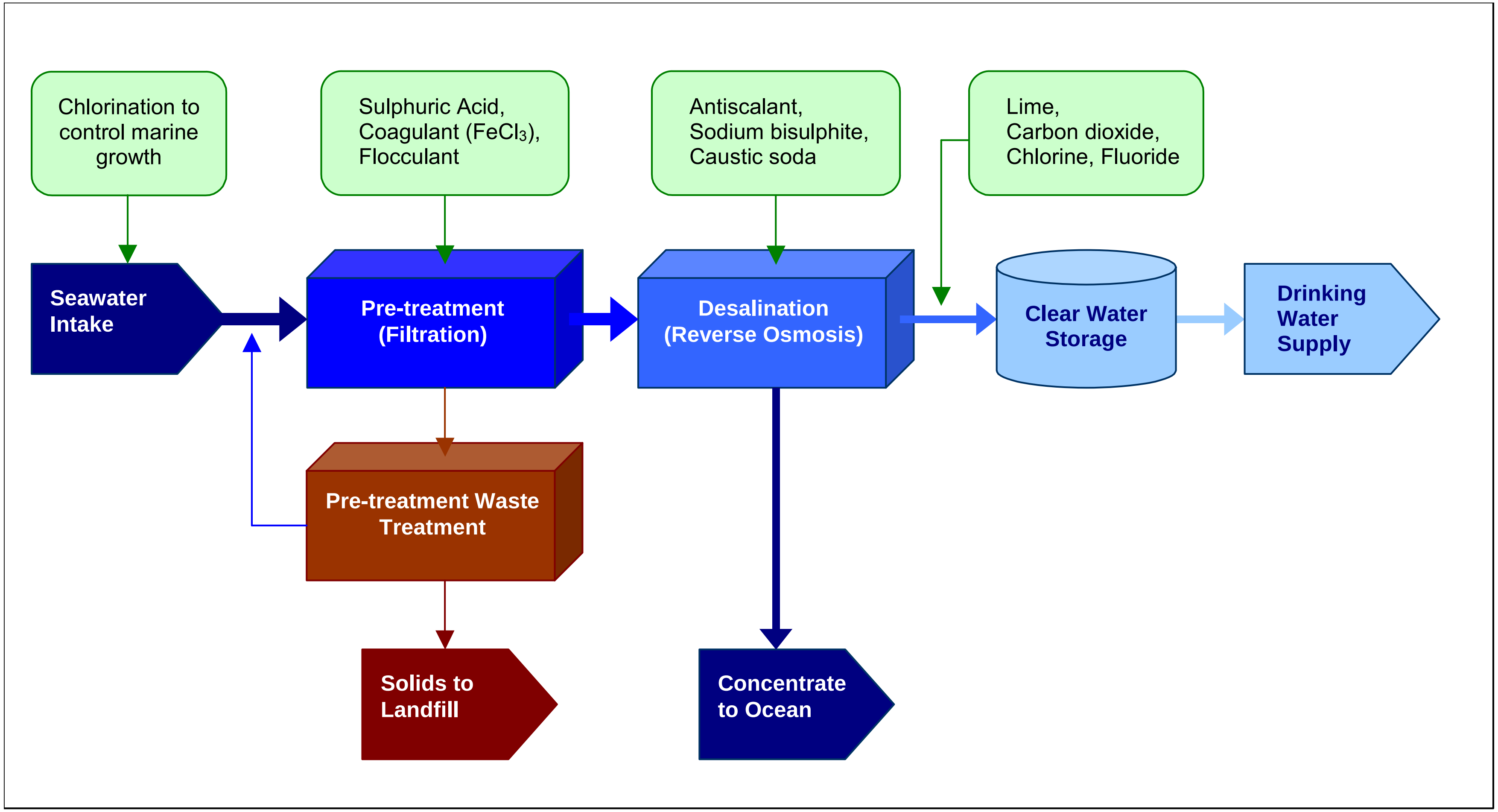
Warne M (2008). Draft report on the toxicity and environmental fate of desalination plant pre-treatment chemicals. CSIRO

Welker Environmental Consultancy, (2002) 'Metropolitan Desalination Proposal – Section 46 Review' on behalf of Water Corporation.

Wilf, M., (2007), *The Guidebook to Membrane Desalination Technology – Reverse Osmosis, Nanofiltration and Hybrid Systems Process, Design, Applications and Economics*, Balaban Desalination Publications

World Health Organisation (WHO), Public Health and the Environment Geneva (2007), Desalination for Safe Water Supply – Guidance for Health and Environmental Aspects Applicable to Desalination

Appendix A: Reference Project Process Flow Diagram

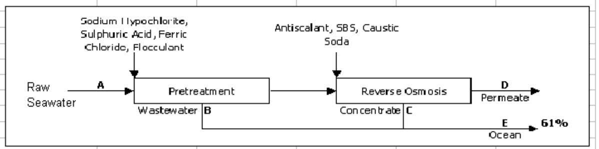


Appendix B: Mass Balance Results

DSE/Victorian Desalination Project

Components of Concentrate

Plant Inputs		Plant Outputs	
Seawater Flow to RO (ML/d)	1035	Stream B (ML/d)	87
Seawater Inflow (ML/d)	1122	Stream C (ML/d)	596
Recovery Rate 1st Pass %	45	Stream D (ML/d)	439
Recovery Rate 2st Pass %	90	Stream E Case 1 (ML/d)	683
Permeate TDS (mg/L)	10	Stream E Case 2 (ML/d)	683
		Stream E Case 3 (ML/d)	596



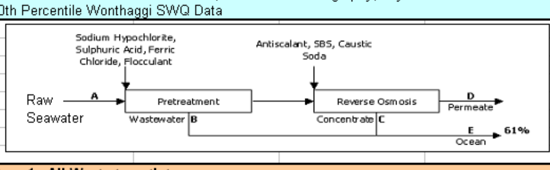
Chemical	Average Dose Rate (mg/L)	Maximum Dose Rate (mg/L)	Dosing Frequency (% time)	Disposal Scenarios	
Sodium Hypochlorite	0	0	4.17%	Case 1	All Waste to outlet
Sulphuric Acid	30	45	100.00%	Case 2	Solids to landfill, supernatant to outfall
Ferric Chloride	5	10	100.00%	- Solids in	0.5 mg/L
Flocculant	0.05	0.5	100.00%	Supernatant	
Antiscalant 1st Pass	1	1.5	100.00%	Case 3	Solids to landfill, supernatant to head of the plant (Reference Design)
Antiscalant 2nd Pass	2	2.5	100.00%		Seawater Inflow = Seawater Flow to RO
Sodium Bisulphite	15	15	4.17%	**Key**	
Caustic Soda	15	30	100.00%		Adopted Values for Reference Project
					Text Book Value Ref: Frank J Millero, Chemical Oceanography, Taylor & Francis Publishers
					50th Percentile Wonthaggi SWQ Data

Estimated Properties of Discharge Streams				Average Chemical Dose Rates			Maximum Chemical Dose Rates		
Analyte	Units	Stream A Raw Seawater	Proportion in Stream B (Precipitation and Adsorption)	Case 1 Stream E	Case 2 Stream E	Case 3 Stream E	Case 1 Stream E	Case 2 Stream E	Case 3 Stream E
Physicochemical Parameters									
TSS (0.45 µm)	mg/L	1.3	N/A	10.37	0.0637	0.00	19.27	0.06	0.00
TDS		36939	N/A	60675	60675	64140	60675	60675	64140
pH			N/A						
Alkalinity by PC Titrator									
Total Alkalinity	mgCaCO3/L	121		199	199	210	199	199	210
Dissolved Major Anions									
Chloride	mg/L	20200	0.00%	33180	33180	35075	33180	33180	35075
Sulfate	mg/L	2910	0.00%	4828	4828	5104	4919	4919	5206
Bromide	mg/L	62	0.00%	102	102	108	102	102	108
Fluoride	mg/L	0.9	0.00%	1.48	1.48	1.56	1.48	1.48	1.56
Dissolved Major Cations									
Calcium	mg/L	420	0.00%	690	690	729	690	690	729
Magnesium	mg/L	1400	0.00%	2300	2300	2431	2300	2300	2431
Sodium	mg/L	11430	0.00%	18775	18775	19847	18775	18775	19847
Potassium	mg/L	490	0.00%	805	805	851	805	805	851
Total Boron	mg/L	4.4	0.00%	7.2	7.2	7.6	7.2	7.2	7.6
Total Strontium	mg/L	7.8	0.00%	12.8	12.8	13.5	12.8	12.8	13.5
Metals									
Dissolved Metals									
Dissolved Aluminium	µg/L	4.4	0.00%	7.2	7.2	7.6	7.2	7.2	7.6
Dissolved Iron	µg/L	4.4	0.00%	7.2	7.2	7.6	7.2	7.2	7.6
Dissolved Manganese	µg/L	0.25	0.00%	0.41	0.41	0.43	0.41	0.41	0.43
Dissolved Silica	mg/L	0.06	50.00%	0.10	0.07	0.05	0.10	0.07	0.05
Total Metals									
Aluminium	µg/L	13.8	10.00%	22.7	22.3	21.6	20.6	20.4	21.6
Iron	µg/L	16.9	99.00%	2856	72	30	5686	127	60
Arsenic	µg/L	1.6	50.00%	2.7	2.0	1.4	2.9	2.1	1.4
Antimony	µg/L	0.147	10.00%	0.241	0.237	0.230	0.254	0.249	0.230
Total Barium	µg/L	6	0.00%	10	10	10	10	10	10
Cadmium	µg/L	0.1	25.00%	0.2	0.2	0.1	0.2	0.2	0.1
Chromium Total	µg/L	0.23	25.00%	0.38	0.35	0.30	0.38	0.35	0.30
Copper	µg/L	0.15	25.00%	0.25	0.23	0.20	1.58	1.23	0.20
Lead	µg/L	0.1	25.00%	0.4	0.3	0.3	1.1	0.9	0.4
Manganese	µg/L	0.58	20.00%	0.95	0.90	0.81	8.50	6.95	0.81
Mercury	µg/L	0.05	10.00%	0.13	0.13	0.13	0.15	0.15	0.14
Molybdenum	µg/L	11.3	20.00%	18.6	17.6	15.7	18.6	17.6	15.7
Nickel	µg/L	0.18	20.00%	0.30	0.28	0.25	1.37	1.14	0.25
Selenium	µg/L	0.134	10.00%	0.31	0.31	0.32	0.35	0.34	0.32
Tin	µg/L	1.75	10.00%	2.87	2.83	2.73	2.87	2.83	2.73
Zinc	µg/L	1.75	25.00%	2.87	2.65	2.28	4.23	3.67	2.28
Nutrients									
Ammonia	mgN/L	0.009	0.00%	0.015	0.015	0.016	0.016	0.016	0.016
Nitrite	mgN/L	0.001	0.00%	0.002	0.002	0.002	0.002	0.002	0.002
Nitrate	mgN/L	0.005	0.00%	0.008	0.008	0.009	0.008	0.008	0.009
Total Kjeldahl Nitrogen	mgN/L	0.17	0.00%	0.28	0.28	0.30	0.28	0.28	0.30
Total Nitrogen	mgN/L	0.18	0.00%	0.30	0.30	0.31	0.30	0.30	0.31
Soluble Reactive Phosphorus	mgP/L	0.004	50.00%	0.007	0.005	0.003	0.007	0.005	0.003
Total Phosphorus	mgP/L	0.013	20.00%	0.021	0.020	0.018	0.021	0.020	0.018
Organic Compounds									
Dissolved Organic Carbon	mg/L	1.2	0.00%	2.0	2.0	2.1	2.0	2.0	2.1
Total Organic Carbon	mg/L	1.3	0.00%	2.1	2.1	2.3	2.1	2.1	2.3
Total Cyanide	mg/L	2.25	0.00%	3.70	3.70	3.91	3.70	3.70	3.91
CTAS Surfactants	mg/L	2.5	0.00%	4.1	4.1	4.3	4.1	4.1	4.3
MBAS Surfactants	mg/L	0.04	0.00%	0.07	0.07	0.07	0.07	0.07	0.07
Total THM	ug/L	1.5	0.00%	2.5	2.5	2.6	2.5	2.5	2.6
Total Sulfide	ug/L	8.5	0.00%	14.0	14.0	14.8	14.0	14.0	14.8
Microbiological									
Chlorophyll a	ug/L	0.55	99.00%	0.90	0.02	0.01	0.90	0.02	0.01
Phaeophytin	ug/L	0.14	99.00%	0.23	0.00	0.00	0.23	0.00	0.00
Enterococci	CFU/100mL	0.5	99.00%	0.8	0.0	0.0	0.8	0.0	0.0
Enterococci	MPN/100mL	0.5	99.00%	0.8	0.0	0.0	0.8	0.0	0.0
Escherichia coli	CFU/100mL	0.5	99.00%	0.8	0.0	0.0	0.8	0.0	0.0
Escherichia coli	MPN/100mL	1	99.00%	2	0	0	2	0	0
Chemical Compounds									
Antiscalant 1st Pass	mg/L	0		1.6	1.5	1.7	1.5	1.5	1.7
Antiscalant 2nd Pass	mg/L	0		1.4	1.4	1.6	1.4	1.4	1.6
Flocculant	mg/L	0	100.00%	0.1	0.0	0.0	0.8	0.0	0.0

DSE/Victorian Desalination Project
Effects of Dilution: Case 1 - All Waste to outlet

Plant Inputs		Plant Outputs	
Seawater Flow to RO (ML/d)	1035	Stream B (ML/d)	87
Seawater Inflow (ML/d)	1122	Stream C (ML/d)	596
Recovery Rate 1st Pass %	45	Stream D (ML/d)	439
Recovery Rate 2st Pass %	90	Stream E Case 1 (ML/d)	683
Permeate TDS (mg/L)	10	Stream E Case 2 (ML/d)	683
		Stream E Case 3 (ML/d)	596

Chemical	Average Dose Rate (mg/L)	Key	
Sodium Hypochlorite	0		Adopted Values for Reference Project
Sulphuric Acid	30		Text Book Value Ref: Frank J Millero, Chemical Oceanography, Taylor & Francis Publishers
Ferric Chloride	5		50th Percentile Wonthaggi SWQ Data
Flocculant	0.05		
Antiscalant 1st Pass	1		
Antiscalant 2nd Pass	2		
Sodium Bisulphite	15		
Caustic Soda	15		

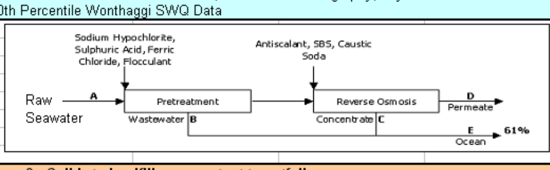


Estimated Properties of Discharge Streams at Specified Dilutions			Case 1 - All Waste to outlet			
Analyte	Units	Stream A Raw Seawater	Stream E No Dilution	Stream E 15:1 Dilution	Stream E 30:1 Dilution	Stream E 50:1 Dilution
Physicochemical Parameters						
TSS (0.45 µm)	mg/L	1.3	10.4	1.9	1.6	1.5
TDS		36939	60675	38423	37705	37404
pH						
Alkalinity by PC Titrator						
Total Alkalinity	mgCaCO3/L	121	198.75	125.86	123.51	122.52
Dissolved Major Anions						
Chloride	mg/L	20200	33180	21011	20619	20455
Sulfate	mg/L	2910	4828	3030	2972	2948
Bromide	mg/L	62	102	64	63	63
Fluoride	mg/L	0.9	1.48	0.94	0.92	0.91
Dissolved Major Cations						
Calcium	mg/L	420	690	437	429	425
Magnesium	mg/L	1400	2300	1456	1429	1418
Sodium	mg/L	11430	18775	11889	11667	11574
Potassium	mg/L	490	805	510	500	496
Total Boron	mg/L	4.4	7.2	4.6	4.5	4.5
Total Strontium	mg/L	7.8	12.8	8.1	8.0	7.9
Metals						
Dissolved Metals						
Dissolved Aluminium	µg/L	4.4	7.2	4.6	4.5	4.5
Dissolved Iron	µg/L	4.4	7.2	4.6	4.5	4.5
Dissolved Manganese	µg/L	0.25	0.41	0.26	0.26	0.25
Dissolved Silica	mg/L	0.06	0.10	0.06	0.06	0.06
Total Metals						
Aluminium	µg/L	13.8	22.7	14.4	14.1	14.0
Iron	µg/L	16.9	2855.8	194.3	108.5	72.6
Arsenic	µg/L	1.6	2.7	1.7	1.6	1.6
Antimony	µg/L	0.147	0.241	0.153	0.150	0.149
Total Barium	µg/L	6	9.9	6.24	6.12	6.08
Cadmium	µg/L	0.1	0.2	0.1	0.1	0.1
Chromium Total	µg/L	0.23	0.38	0.24	0.23	0.23
Copper	µg/L	0.15	0.25	0.16	0.15	0.15
Lead	µg/L	0.1	0.4	0.1	0.1	0.1
Manganese	µg/L	0.58	0.95	0.60	0.59	0.59
Mercury	µg/L	0.05	0.13	0.05	0.05	0.05
Molybdenum	µg/L	11.3	18.6	11.8	11.5	11.4
Nickel	µg/L	0.18	0.30	0.19	0.18	0.18
Selenium	µg/L	0.134	0.313	0.145	0.140	0.138
Tin	µg/L	1.75	2.87	1.82	1.79	1.77
Zinc	µg/L	1.75	2.87	1.82	1.79	1.77
Nutrients						
Ammonia	mgN/L	0.009	0.015	0.009	0.009	0.009
Nitrite	mgN/L	0.001	0.002	0.001	0.001	0.001
Nitrate	mgN/L	0.005	0.008	0.005	0.005	0.005
Total Kjeldahl Nitrogen	mgN/L	0.17	0.28	0.18	0.17	0.17
Total Nitrogen	mgN/L	0.18	0.30	0.19	0.18	0.18
Soluble Reactive Phosphorus	mgP/L	0.004	0.007	0.004	0.004	0.004
Total Phosphorus	mgP/L	0.013	0.021	0.014	0.013	0.013
Organic Compounds						
Dissolved Organic Carbon	mg/L	1.2	2.0	1.2	1.2	1.2
Total Organic Carbon	mg/L	1.3	2.1	1.4	1.3	1.3
Total Cyanide	mg/L	2.25	3.70	2.34	2.30	2.28
CTAS Surfactants	mg/L	2.5	4.1	2.6	2.6	2.5
MBAS Surfactants	mg/L	0.04	0.07	0.04	0.04	0.04
Total THM	ug/L	1.5	2.5	1.6	1.5	1.5
Total Sulfide	ug/L	8.5	14.0	8.8	8.7	8.6
Microbiological						
Chlorophyll a	ug/L	0.55	0.90	0.57	0.56	0.56
Phaeophytin	ug/L	0.14	0.23	0.15	0.14	0.14
Enterococci	CFU/100mL	0.5	0.8	0.5	0.5	0.5
Enterococci	MPN/100mL	0.5	0.8	0.5	0.5	0.5
Escherichia coli	CFU/100mL	0.5	0.8	0.5	0.5	0.5
Escherichia coli	MPN/100mL	1	2	1	1	1
Chemical Compounds						
Antiscalant 1st Pass	mg/L	0	1.6	0.1	0.1	0.0
Antiscalant 2nd Pass	mg/L	0	1.4	0.1	0.0	0.0
Flocculant	mg/L	0	0.1	0.0	0.0	0.0

DSE/Victorian Desalination Project
Effects of Dilution: Case 2 - Solids to landfill, supernatant to outfall

Plant Inputs		Plant Outputs	
Seawater Flow to RO (ML/d)	1035	Stream B (ML/d)	87
Seawater Inflow (ML/d)	1122	Stream C (ML/d)	596
Recovery Rate 1st Pass %	45	Stream D (ML/d)	439
Recovery Rate 2st Pass %	90	Stream E Case 1 (ML/d)	683
Permeate TDS (mg/L)	10	Stream E Case 2 (ML/d)	683
		Stream E Case 3 (ML/d)	596

Chemical	Average Dose Rate (mg/L)	Key	
Sodium Hypochlorite	0	(light cyan)	Adopted Values for Reference Project
Sulphuric Acid	30	(yellow)	Text Book Value Ref: Frank J Millero, Chemical Oceanography, Taylor & Francis Publishers
Ferric Chloride	5	(teal)	50th Percentile Wonthaggi SWQ Data
Flocculant	0.05		
Antiscalant 1st Pass	1		
Antiscalant 2nd Pass	2		
Sodium Bisulphite	15		
Caustic Soda	15		



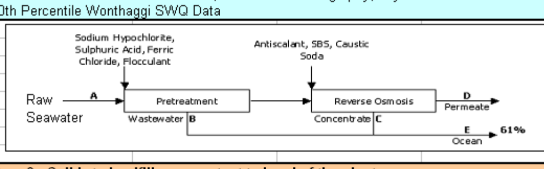
Estimated Properties of Discharge Streams at Specified Dilutions			Case 2 - Solids to landfill, supernatant to outfall			
Analyte	Units	Stream A Raw Seawater	Stream E No Dilution	Stream E 15:1 Dilution	Stream E 30:1 Dilution	Stream E 50:1 Dilution
Physicochemical Parameters						
TSS (0.45 µm)	mg/L	1.3	0.1	1.2	1.3	1.3
TDS		36939	60675	38423	37705	37404
pH						
Alkalinity by PC Titrator						
Total Alkalinity	mgCaCO3/L	121	199	126	124	123
Dissolved Major Anions						
Chloride	mg/L	20200	33180	21011	20619	20455
Sulfate	mg/L	2910	4828	3030	2972	2948
Bromide	mg/L	62	102	64	63	63
Fluoride	mg/L	0.9	1.5	0.9	0.9	0.9
Dissolved Major Cations						
Calcium	mg/L	420	690	437	429	425
Magnesium	mg/L	1400	2300	1456	1429	1418
Sodium	mg/L	11430	18775	11889	11667	11574
Potassium	mg/L	490	805	510	500	496
Total Boron	mg/L	4.4	7.2	4.6	4.5	4.5
Total Strontium	mg/L	7.8	12.8	8.1	8.0	7.9
Metals						
Dissolved Metals						
Dissolved Aluminium	µg/L	4.4	7.2	4.6	4.5	4.5
Dissolved Iron	µg/L	4.4	7.2	4.6	4.5	4.5
Dissolved Manganese	µg/L	0.25	0.41	0.26	0.26	0.25
Dissolved Silica	mg/L	0.06	0.07	0.06	0.06	0.06
Total Metals						
Aluminium	µg/L	13.8	22.3	14.3	14.1	14.0
Iron	µg/L	16.9	71.9	20.3	18.7	18.0
Arsenic	µg/L	1.6	2.0	1.6	1.6	1.6
Antimony	µg/L	0.147	0.237	0.153	0.150	0.149
Total Barium	µg/L	6	9.9	6.24	6.12	6.08
Cadmium	µg/L	0.1	0.2	0.1	0.1	0.1
Chromium Total	µg/L	0.23	0.35	0.24	0.23	0.23
Copper	µg/L	0.15	0.23	0.15	0.15	0.15
Lead	µg/L	0.1	0.3	0.1	0.1	0.1
Manganese	µg/L	0.58	0.90	0.60	0.59	0.59
Mercury	µg/L	0.05	0.13	0.05	0.05	0.05
Molybdenum	µg/L	11.3	17.6	11.7	11.5	11.4
Nickel	µg/L	0.18	0.28	0.19	0.18	0.18
Selenium	µg/L	0.134	0.310	0.145	0.140	0.137
Tin	µg/L	1.75	2.83	1.82	1.78	1.77
Zinc	µg/L	1.75	2.65	1.81	1.78	1.77
Nutrients						
Ammonia	mgN/L	0.009	0.015	0.009	0.009	0.009
Nitrite	mgN/L	0.001	0.002	0.001	0.001	0.001
Nitrate	mgN/L	0.005	0.008	0.005	0.005	0.005
Total Kjeldahl Nitrogen	mgN/L	0.17	0.28	0.18	0.17	0.17
Total Nitrogen	mgN/L	0.18	0.30	0.19	0.18	0.18
Soluble Reactive Phosphorus	mgP/L	0.004	0.005	0.004	0.004	0.004
Total Phosphorus	mgP/L	0.013	0.020	0.013	0.013	0.013
Organic Compounds						
Dissolved Organic Carbon	mg/L	1.2	2.0	1.2	1.2	1.2
Total Organic Carbon	mg/L	1.3	2.1	1.4	1.3	1.3
Total Cyanide	mg/L	2.25	3.70	2.34	2.30	2.28
CTAS Surfactants	mg/L	2.5	4.1	2.6	2.6	2.5
MBAS Surfactants	mg/L	0.04	0.07	0.04	0.04	0.04
Total THM	ug/L	1.5	2.5	1.6	1.5	1.5
Total Sulfide	ug/L	8.5	14.0	8.8	8.7	8.6
Microbiological						
Chlorophyll a	ug/L	0.55	0.02	0.52	0.53	0.54
Phaeophytin	ug/L	0.14	0.00	0.13	0.14	0.14
Enterococci	CFU/100mL	0.5	0.0	0.5	0.5	0.5
Enterococci	MPN/100mL	0.5	0.0	0.5	0.5	0.5
Escherichia coli	CFU/100mL	0.5	0.0	0.5	0.5	0.5
Escherichia coli	MPN/100mL	1	0	1	1	1
Chemical Compounds						
Antiscalant 1st Pass	mg/L	0	1.5	0.1	0.0	0.0
Antiscalant 2nd Pass	mg/L	0	1.4	0.1	0.0	0.0
Flocculant	mg/L	0	0.0	0.0	0.0	0.0

DSE/Victorian Desalination Project

Effects of Dilution: Case 3 - Solids to landfill, supernatant to head of the plant (Reference Project)

Plant Inputs		Plant Outputs	
Seawater Flow to RO (ML/d)	1035	Stream B (ML/d)	87
Seawater Inflow (ML/d)	1122	Stream C (ML/d)	596
Recovery Rate 1st Pass %	45	Stream D (ML/d)	439
Recovery Rate 2st Pass %	90	Stream E Case 1 (ML/d)	683
Permeate TDS (mg/L)	10	Stream E Case 2 (ML/d)	683
		Stream E Case 3 (ML/d)	596

Chemical	Average Dose Rate (mg/L)	Key	
Sodium Hypochlorite	0		Adopted Values for Reference Project
Sulphuric Acid	30		Text Book Value Ref: Frank J Millero, Chemical Oceanography, Taylor & Francis Publishers
Ferric Chloride	5		50th Percentile Wonthaggi SWQ Data
Flocculant	0.05		
Antiscalant 1st Pass	1		
Antiscalant 2nd Pass	2		
Sodium Bisulphite	15		
Caustic Soda	15		



Estimated Properties of Discharge Streams at Specified Dilutions

Case 3 - Solids to landfill, supernatant to head of the plant (Reference Project)

Analyte	Units	Stream A Raw Seawater	Stream E No Dilution	Stream E 15:1 Dilution	Stream E 30:1 Dilution	Stream E 50:1 Dilution
Physicochemical Parameters						
TSS (0.45 µm)	mg/L	1.3	0.0	1.2	1.3	1.3
TDS		36939	64140	38639	37816	37472
pH						
Alkalinity by PC Titrator						
Total Alkalinity	mgCaCO3/L	121	210	127	124	123
Dissolved Major Anions						
Chloride	mg/L	20200	35075	21130	20680	20492
Sulfate	mg/L	2910	5104	3047	2981	2953
Bromide	mg/L	62	108	65	63	63
Fluoride	mg/L	0.9	1.6	0.9	0.9	0.9
Dissolved Major Cations						
Calcium	mg/L	420	729	439	430	426
Magnesium	mg/L	1400	2431	1464	1433	1420
Sodium	mg/L	11430	19847	11956	11702	11595
Potassium	mg/L	490	851	513	502	497
Total Boron	mg/L	4.4	7.6	4.6	4.5	4.5
Total Strontium	mg/L	7.8	13.5	8.2	8.0	7.9
Metals						
Dissolved Metals						
Dissolved Aluminium	µg/L	4.4	7.6	4.6	4.5	4.5
Dissolved Iron	µg/L	4.4	7.6	4.6	4.5	4.5
Dissolved Manganese	µg/L	0.25	0.43	0.26	0.26	0.25
Dissolved Silica	mg/L	0.06	0.05	0.06	0.06	0.06
Total Metals						
Aluminium	µg/L	13.8	21.6	14.3	14.1	14.0
Iron	µg/L	16.9	30.3	17.7	17.3	17.2
Arsenic	µg/L	1.6	1.4	1.6	1.6	1.6
Antimony	µg/L	0.147	0.230	0.152	0.150	0.149
Total Barium	µg/L	6	10.4	6.28	6.14	6.09
Cadmium	µg/L	0.1	0.1	0.1	0.1	0.1
Chromium Total	µg/L	0.23	0.30	0.23	0.23	0.23
Copper	µg/L	0.15	0.20	0.15	0.15	0.15
Lead	µg/L	0.1	0.3	0.1	0.1	0.1
Manganese	µg/L	0.58	0.81	0.59	0.59	0.58
Mercury	µg/L	0.05	0.13	0.06	0.05	0.05
Molybdenum	µg/L	11.3	15.7	11.6	11.4	11.4
Nickel	µg/L	0.18	0.25	0.18	0.18	0.18
Selenium	µg/L	0.134	0.316	0.145	0.140	0.138
Tin	µg/L	1.75	2.73	1.81	1.78	1.77
Zinc	µg/L	1.75	2.28	1.78	1.77	1.76
Nutrients						
Ammonia	mgN/L	0.009	0.016	0.009	0.009	0.009
Nitrite	mgN/L	0.001	0.002	0.001	0.001	0.001
Nitrate	mgN/L	0.005	0.009	0.005	0.005	0.005
Total Kjeldahl Nitrogen	mgN/L	0.17	0.30	0.18	0.17	0.17
Total Nitrogen	mgN/L	0.18	0.31	0.19	0.18	0.18
Soluble Reactive Phosphorus	mgP/L	0.004	0.003	0.004	0.004	0.004
Total Phosphorus	mgP/L	0.013	0.018	0.013	0.013	0.013
Organic Compounds						
Dissolved Organic Carbon	mg/L	1.2	2.1	1.3	1.2	1.2
Total Organic Carbon	mg/L	1.3	2.3	1.4	1.3	1.3
Total Cyanide	mg/L	2.25	3.91	2.35	2.30	2.28
CTAS Surfactants	mg/L	2.5	4.3	2.6	2.6	2.5
MBAS Surfactants	mg/L	0.04	0.07	0.04	0.04	0.04
Total THM	ug/L	1.5	2.6	1.6	1.5	1.5
Total Sulfide	ug/L	8.5	14.8	8.9	8.7	8.6
Microbiological						
Chlorophyll a	ug/L	0.55	0.01	0.52	0.53	0.54
Phaeophytin	ug/L	0.14	0.00	0.13	0.14	0.14
Enterococci	CFU/100mL	0.5	0.0	0.5	0.5	0.5
Enterococci	MPN/100mL	0.5	0.0	0.5	0.5	0.5
Escherichia coli	CFU/100mL	0.5	0.0	0.5	0.5	0.5
Escherichia coli	MPN/100mL	1	0	1	1	1
Chemical Compounds						
Antiscalant 1st Pass	mg/L	0	1.7	0.1	0.1	0.0
Antiscalant 2nd Pass	mg/L	0	1.6	0.1	0.1	0.0
Flocculant	mg/L	0	0.0	0.0	0.0	0.0