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ALKIMOS WATER ALLIANCE

ALKIMOS WASTEWATER TREATMENT SCHEME

MANAGEMENT PLAN FOR CONSTRUCTION AND ONGOING PRESENCE OF THE OCEAN OUTLET PIPELINE

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30 July 2008

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REV	DESCRIPTION	ORIG	REVIEW	WORLEYPARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	N. Cowlishaw	A. Costen	N/A	12 June 08	N/A	
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1 INTRODUCTION

The locale of Alkimos lies on the coast of Western Australia, around 40 km north-north-west of the Perth CBD and adjacent to the existing suburbs of Quinns Rocks, Mindarie, Merriwa and Ridgewood (Figure 1-1). The Alkimos Wastewater Scheme is proposed to cater for anticipated population growth in the Alkimos catchment, which is expected to reach around 150,000 by 2030 (Water Corporation 2008). The Alkimos Wastewater Scheme will dispose of treated wastewater to the ocean. Construction of the ocean outlet associated with the scheme is proposed to commence in late 2008. A 3.7 km pipeline (including a 300 m diffuser at the ocean end) will be laid following excavation and clearing of the pipeline route.

Following advice from the Environmental Protection Authority (EPA) on the level of assessment required for approval of the Alkimos Wastewater Scheme, a Public Environmental Review (PER) document was prepared for the proposal (Water Corporation 2005) and submitted to the EPA. Bulletin 1239 was subsequently published by the EPA, which provided advice and recommendations to the Minister for the Environment on the environmental factors and principles relevant to the proposal. These recommendations then formed the basis for the conditions of Ministerial Statement 755, dated 12 November 2007 (Appendix A). The proposal will be implemented as documented and described in schedules 1, 2 and 3 of the Ministerial Statement, subject to the conditions and procedures of the statement.

This document comprises the Management Plan for Construction and ongoing Presence of the Ocean Outlet Pipeline (MPCOOP) for the Alkimos Wastewater Scheme and was prepared to address conditions 8 and 9 of Ministerial Statement No. 755. Condition 8 requires the preparation and implementation of an Ocean Outlet Pipeline Construction Management Plan (Marine), while Condition 9 requires the preparation and implementation of a Seabed and Benthic Habitat Monitoring and Management Plan. To decrease repetition and increase practicality for implementation, these documents have been combined into a single document. As required by Condition 8, all relevant environmental elements likely to be impacted during construction are also addressed in the MPCOOP.

The MPCOOP sources information from the PER, Bulletin 1239 and additional information gathered after publication of those documents. This method produces a robust assessment of the primary and secondary impacts and allows development of effective management and monitoring measures to reduce the project’s footprint on the environment adjacent to the proposed ocean outlet pipeline. The MPCOOP has been developed to predict and assess the potential impacts of construction of the Alkimos ocean outlet and to ensure that activities associated with the construction of the ocean outlet are undertaken and managed in a way that minimises impacts on the marine environment.

The operational management and monitoring plan has been developed based on the implementation outcomes of the MPCOOP and also informs the development of Standard Operating Procedures (SOPs), which will be prepared for each component of the operational activities to ensure that they are consistently carried out in a way that minimises impacts to the environment.

The proponent for the Alkimos Wastewater Scheme is the Water Corporation of Western Australia. However, the Alkimos Water Alliance (AWA) was formed to complete the design and construction of the project. The AWA is a commercial venture involving the Water Corporation and a joint venture from the private sector involving Multiplex, McMahon and Züblin, and various sub-contractors, which brings together experts in the fields of engineering, environment, procurement, construction and management.

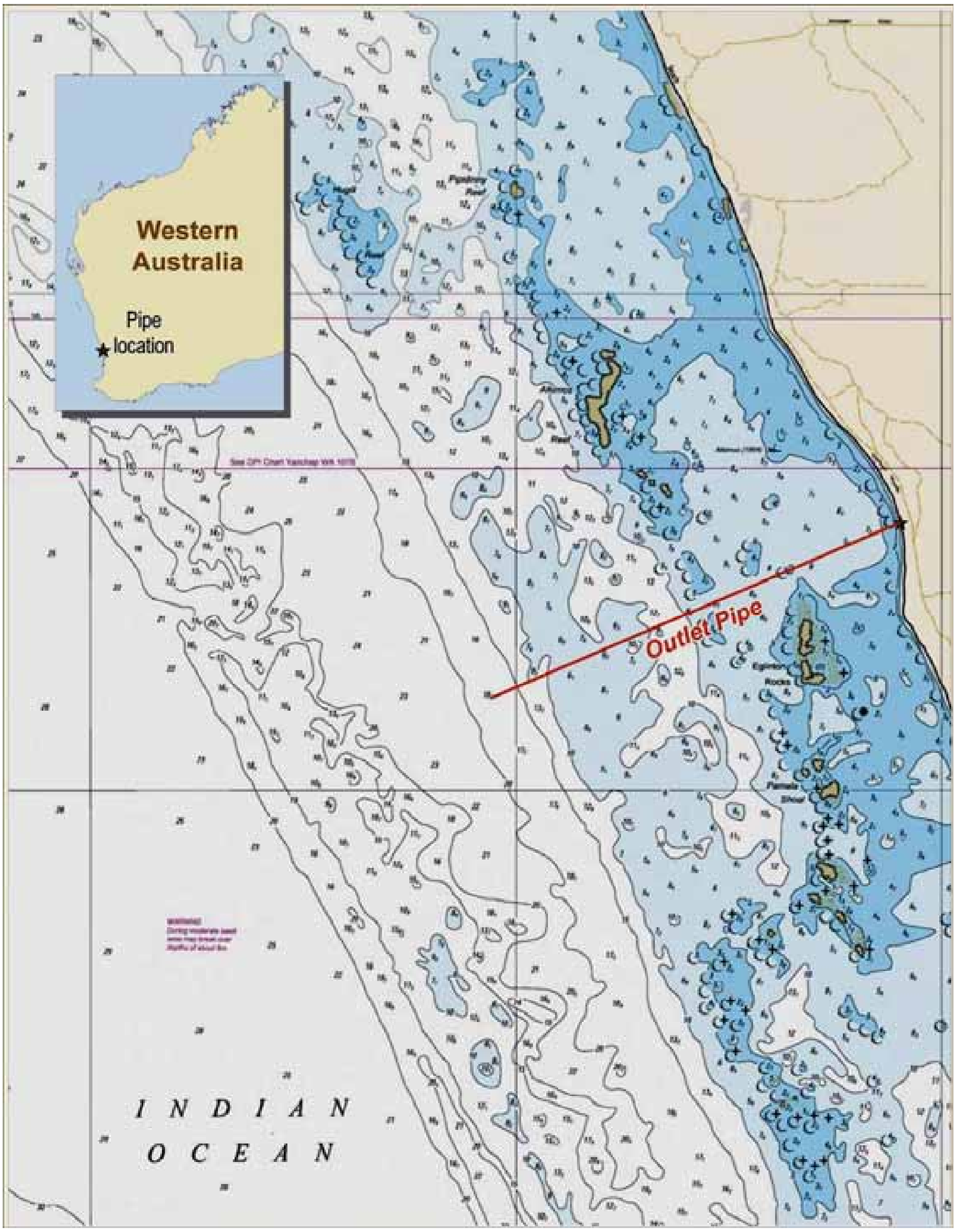

Figure 1-1: Project location

The AWA was formed specifically to progress the design and construction of:

- earthworks for the wastewater treatment plant
- ocean outfall and launch site
- land-based connection between the wastewater treatment plant and the launch site
- part of the Quinns main sewer.

1.1 Objectives

This MPCOOP provides details on the predicted environmental impacts, monitoring program and management procedures to be implemented during construction of the Alkimos ocean outlet. Furthermore, it outlines how these measures and monitoring program will be effectively implemented by the Alkimos Water Alliance. The objectives of the MPCOOP are consistent with those of the Ministerial Statement for the proposal and the Water Corporation's Environmental Policy (Appendix C) and Sustainability Principles (Appendix D). This document has been independently reviewed by two specialists, Professor Eric Paling and Mr Ian LeProvost (Appendix L). Responses to their comments have been incorporated into the document where appropriate and the final table in Appendix L notes how the original document has been modified.

The objectives of the MPCOOP are to:

- predict direct and indirect impacts likely to result from construction of the ocean outlet through the input of high quality, detailed baseline data into calibrated and verified models
- use predicted impacts to develop relevant, thorough and effective monitoring and management strategies
- minimise direct and indirect impacts through the implementation of a hierarchy of proactive and reactive management actions
- ensure the maintenance of the ecological integrity of the marine waters surrounding the Alkimos ocean outlet
- ensure that the final area of disturbance from the construction of the ocean outlet (taking into account rehabilitation works and the ongoing presence of the pipeline) will be within the area defined in Schedule 4 of Ministerial Statement 755 (Appendix A)
- implement this plan to inform operational management plans for the Alkimos Wastewater Scheme.

1.2 Ocean Outfall Environmental Assessment Process

The potential environmental issues associated with the Alkimos Wastewater Treatment Scheme were assessed in a Public Environmental Review (PER) (Water Corporation, 2006) in accordance with Part IV of the Environmental Protection Act 1986.

The key environmental and other factors assessed in the PER were:

- the precautionary principle
- intergenerational equity
- valuation, pricing and incentives
- waste minimisation
- conservation of biological diversity and ecological integrity
- terrestrial flora
- terrestrial fauna
- geo-heritage
- air quality
- marine ecosystem (sediment, benthic habitat and water column).

1.3 Environmental Aspects

The PER and Bulletin 1239 for the proposal identified the primary environmental aspects that may be impacted by the project. These aspects require detailed analysis and include:

- water quality
- benthic primary producers and their habitat
- seabed condition (subtidal, intertidal and beaches) and littoral drift
- marine fauna (marine mammals, fish and benthic fauna).

1.4 Legal and other Requirements

The state and Commonwealth legislation, policies and standards relevant to managing the environmental impacts of the ocean outlet construction are listed below. All construction works will be carried out in accordance with these documents. It is also a requirement under the Environmental Protection Act 1986 that the project be carried out in accordance with Ministerial Statement 755, issued by the Minister for the Environment.

1.4.1 Legislation, regulations, policies and standards

- *Environmental Protection Act 1986*
- Environmental Protection Regulations 1987
- *Wildlife Conservation Act 1950*
- Wildlife Conservation Regulations 1970

- *Pollution of Waters by Oil and Noxious Substances Act 1987*
- *Shipping and Pilotage Act 1967*
- *Marine and Harbours Act 1981*
- EPA Guidance Statement No. 29. Benthic Primary Producer Habitat Protection for Western Australia
- Environmental Quality Objectives (EQO) for the Perth coastal environment
- Supporting Document for the State Environmental (Cockburn Sound) Policy 2005.

1.4.2 Commonwealth and international legislation, policies and standards

- *Environment Protection and Biodiversity Conservation Act 1999*
- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*
- Australian Quarantine Regulations 2000
- ANZECC /ARMCANZ marine water quality guidelines (2000)
- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978 relating thereto (MARPOL 7/78).

1.5 Proponent Contact Details

The proponent for the construction and operation of the Alkimos Wastewater Treatment Plant and ocean outlet proposal is the Water Corporation, as identified in Condition 2-1 of Ministerial Statement 755. The contact details for the Water Corporation are shown inTable 1-1. As required by Condition 2-2 of the Ministerial Statement, the Chief Executive Officer of the Department of Environment and Conservation (DEC) will be notified by the Water Corporation of any change of name and address of the proponent within 30 days of any such change.

Table 1-1: Contact details for the proponent

Proponent	Water Corporation
Location	629 Newcastle Street Leederville WA 6007
Postal Address	Water Corporation PO Box 100 Leederville WA 6902
Contact person	Michael Mulrennan Project Director, Major Metropolitan Wastewater Treatment Project Management Branch Water Corporation
Telephone	Switchboard Ph: (08) 9420 2420 Direct: (08) 9420 2193 Mob: 0408 098 890
Facsimile	(08) 9228 1070
E-mail	michael.mulrennan@watercorporation.com.au
Emergency Telephone	131375 (24 hours)

2 SCOPE AND FRAMEWORK

The scope of the MPCOOP is designed primarily to satisfy conditions 8 and 9 of Ministerial Statement 755 (Appendix A). Conditions 1 to 5 have also been addressed in this document. Appendix B presents the Water Corporation's interpretation of these conditions and references the relevant sections of this document.

This document addresses the environmental impacts that are likely to result from construction of the proposed ocean outlet and provides a set of mitigating measures that will minimise predicted impacts through management and monitoring. The methods that have been used to achieve these objectives have been derived through the formulation and implementation of an Environmental Impact Assessment and Monitoring/Management Plan (EIAMMP) framework.

2.1 EIAMMP Process

The EIAMMP process is an integrated, concept-based framework that uses a four-staged approach (Figure 2-1).

Stage 1 – Baseline Data Acquisition

Detailed baseline ecological, biophysical and geotechnical data is collected in addition to the proposed engineering methodology. This information has been collated as part of the submission of the initial Water Corporation PER document and provides the basis for the development of site-specific predicted impacts and management and monitoring of the proposed development.

Stage 2 – Impact Prediction

The metocean and biophysical data collected in Stage 1 is then used as inputs into modelling investigations undertaken as part of Stage 2. Modelling outputs assist in determining the extent of the proposed development disturbance footprint (both primary and secondary). Direct and indirect impacts are then identified through determining extent and magnitude of each of the modelled effect outputs. Ecological baseline data is then used to determine the level of impact by defining species tolerance and habitat types that are likely to be impacted by the modelled footprints.

Stage 3 – Impact Validation (Construction) and Monitoring

Once direct and indirect impacts have been defined, a set of management actions and monitoring regimes that will assist in minimising the effects of those predicted impacts on the environment during construction are developed. The environmental management and monitoring systems that will be used during construction have been developed using a tiered management action structure. A set of trigger levels have been developed based on modelling outputs and baseline data to define any change in the environment from baseline conditions. A set of management actions associated with the defined trigger levels are developed to ensure that any environmental impact is detected and mitigated.

Stage 4 – Impact Validation (Operation) and Monitoring

Monitoring and management actions developed during the validation of construction data will be reviewed and incorporated where applicable into operation data validations. Impacts associated with the operation of the pipeline are limited to only the operation of the pipeline itself and do not include impacts associated with the discharge at the outfall.

Framework stages 1 to 4 have been provided in sections 3 to 6 of this document.

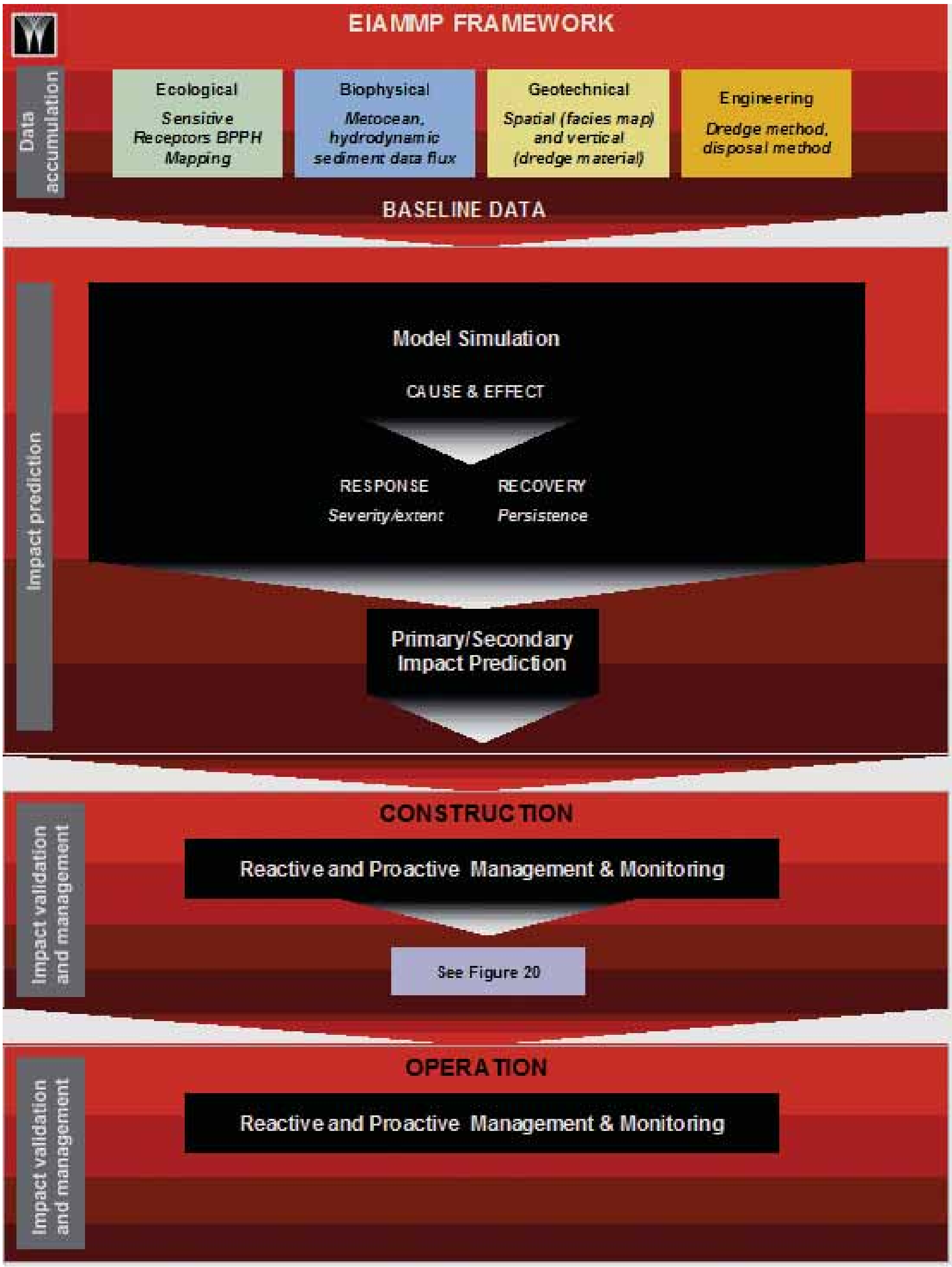

Figure 2-1: EIAMMP framework process

3 DATA ACQUISITION (STAGE 1)

A number of technical studies were undertaken in the Alkimos region following completion of the PER to refine existing information and to develop a detailed description of the environments that might be affected by the proposed developments. Data collected under the current study (referred to in Appendix H) was input into a site-specific hydrodynamic model to ensure that accurate outputs were achieved (Section 4.2). The data gathered and analysed during the PER and additional biophysical studies is presented in the following sections to describe the existing environment in the vicinity of the proposed construction works.

3.1 Climate and Meteorology

The Alkimos region experiences a Mediterranean climate, semi-arid with wet, mild winters and warm, dry summers, and lies within the 700-800 mm/yr rainfall isohyets. The average maximum temperature is 24 ° C and the average minimum temperature is 14 °C (Oceanica 2005a).

3.1.1 Wind

The nearest wind recording site is the Bureau of Meteorology Station at Perth Airport. While wind data from this station provides an indication of wind conditions at the proposed development site, it is likely that observed wind speeds in the study area would generally be greater than those at Perth Airport due to the site's proximity to the coast (Atteris 2005).

The wind regime in the Perth coastal region (including Alkimos) is driven largely by the seasonal migration of the anti-cyclonic belt (pressure systems) to the north in winter and to the south in summer (D'Adamo and Mills 1995).

During the morning period, the wind is predominately offshore (from north-east or east), changing to onshore (from west or south-west) with an increase in speed during the mid-afternoon. An onshore wind occurs approximately 40% of the time during afternoon periods in the winter, increasing to 60% of the time during spring and summer, generally between 20 and 30 km/hr. Autumn and winter have the highest proportion of offshore wind observations during afternoon periods and also the highest proportion of calm conditions (≤5 knots) (18% and 20% respectively) (Atteris 2005).

3.2 Hydrodynamics

3.2.1 Currents

Nearshore and surface ocean currents along the Perth metropolitan coastline are largely wind-driven. A combination of factors, including friction of the wind at the sea surface and associated pressure gradients across the ocean surface, influences the direction and magnitude of water movement in the Alkimos coastal region. Nearshore currents in the Alkimos area can be complex due to interactions between regional currents, local wind-forced currents, waves, and irregularly shaped shallow reef systems. The maximum current speed experienced 1.8 km and 3.4 km from shore at Alkimos during the April, May and June 2005 monitoring was 0.46 m/s. Mean current speeds ranged from 0.12 m/s to 0.07 m/s during this period, depending on water depth. Data collected during May and June 2008 is consistent with the 2005 data (Appendix H).

The reef systems offshore from the Alkimos coastline dissipate a significant proportion of ocean wave energy before it reaches the shore. However, the irregular bathymetry of the coastal shelf within 3 km of the shore diffract and refract swell waves, producing a complex pattern of nearshore water movement and wave energy which results in a relatively high energy coastal environment.

Marine waters offshore from Alkimos are generally well mixed and display minimal stratification due to the high energy coastline in the region (Appendix H; Oceanica 2005).

3.2.2 Waves

Two broad categories of waves are associated with coastal processes in the Alkimos region. Swell waves, typically with long periods, are generated over large distances in the Southern and Indian oceans and regularly reach heights of 2 m on approach to the Perth coastline. As swell waves cross the continental shelf, they are refracted from the south-south-west to a more westerly direction (Mills *et al.* 1997). Sea waves, or local wind-driven waves, have a shorter period, and generally travel away from the dominant wind direction and so change their angle of propagation with seasonal changes in wind direction. Sea waves tend to achieve greater wave heights than swell waves (exceeding 4 m under windy conditions) (MP Rogers and Associates 1998). Sea waves tend to only interact with the seabed in relatively shallow waters and so can break on shore at an angle.

The reefs offshore from the Alkimos coast are likely to dissipate a significant amount of the ocean wave energy entering the area. The irregular bathymetry of the coastal shelf within 5 km of the shore diffracts and refracts swell waves, producing a complex pattern of nearshore water movement and wave energy. This distribution of wave energy in the nearshore environment typifies the energetic coastal marine environment of the area. Sea waves are generated from both nearshore reef and offshore non-reef areas. As with swell waves, those waves generated outside of the nearshore reef system may penetrate the nearshore area to differing degrees based on the local bathymetry. Sea waves generated inside the reef system by wind-forcing are more likely to move in a downwind direction and approach the shore at an angle close to that of the predominant wind direction (Mills *et al.* 1997).

Waves generated by the sea-breeze typically achieve heights of 0.5 m to 1.5 m and are propagated from the south to south-west (MP Rogers and Associates 1998). The maximum wave height recorded at Alkimos during the current and wave sensor deployment period, 30 April 2005 to 26 June 2005, was 4.6 m. Wave direction was predominantly from the west, with a mean wave period of between 4.9 seconds and 15.0 seconds (3-hour averages) (Fugro GEOS 2005). Data collected during May and June 2008 for the current project is consistent with the 2005 data (Appendix H).

3.2.3 Tides

The predominantly diurnal tides in the Alkimos region are relatively small, with a maximum spring tidal range of 0.6 m and an astronomical tidal range (LAT to HAT) of 1.2 m (at Fremantle) (WAPC 2003). Yanchep tides (8 km north of Alkimos) are approximately 20 minutes ahead of those recorded at Fremantle (50 km to the south of Alkimos) (Pattiaratchi *et al.* 1995). Tidal forcing is unlikely to play a significant role in the local oceanographic processes at Alkimos (MP Rogers and Associates 1998). Figure 3-1 and Figure 3-2 show typical spring and neap tidal cycles from Two Rocks Marina, 15 km to the north of the proposed pipeline route.

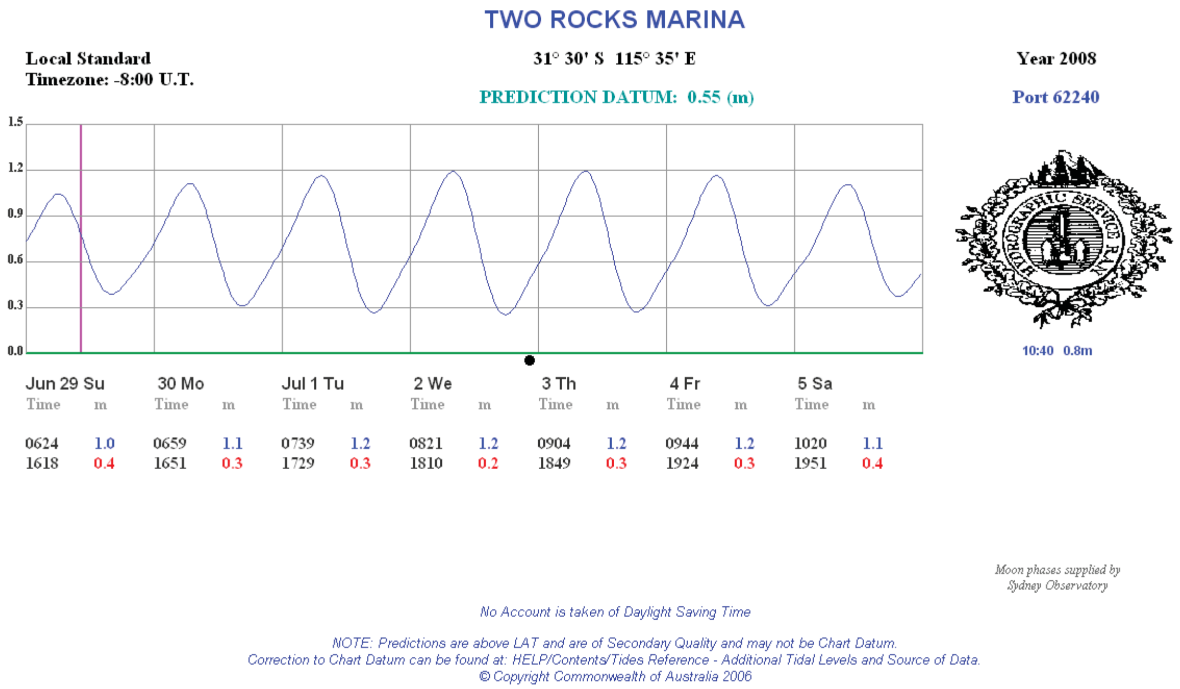

Figure 3-1: Typical spring tidal cycle predicted for Two Rocks Marina located 15 km north-north-west of the proposed development site

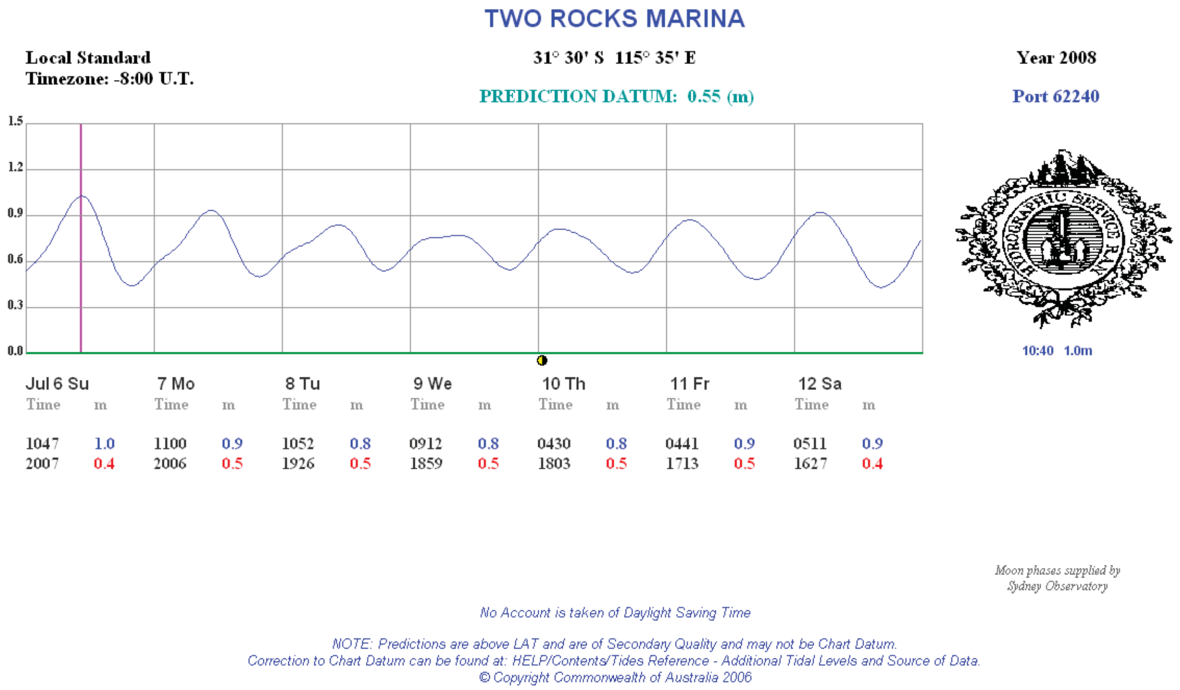

Figure 3-2: Typical neap tidal cycle predicted for Two Rocks Marina located 15 km north-north-west of the proposed development site

3.2.4 Sediment Transport

Natural coastal sediment transport driven by the hydrodynamics has remained relatively constant since monitoring began in the 1960s. Maximum distances of beach erosion of between 45 m and 55 m have previously been recorded. Some significant areas of erosion have occurred where dune vegetation is degraded or damaged (Oceanica 2006). The shoreline for approximately 1 km south of the proposed development site is eroding at an estimated rate of 7,300 m^3 per year, with sediment moving in a predominately northerly direction. The shoreline that extends 1.5 km to the north of the proposed development site is estimated to be accumulating sediment at around 15,000 m^3 each year.

3.3 Water Quality

3.3.1 Physicochemical

Baseline water quality investigations were undertaken between 2004 and 2006 by Oceania (Appendix E). The waters adjacent to Alkimos are typical of Australian sub-tropical/ temperate coastal waters, with dissolved oxygen (DO) concentrations remaining high throughout the year, reflecting an exposed and dynamic environment (Oceanica 2005) and being generally compliant with ANZECC/ARMCANZ guidelines for Western Australian marine waters. The temperature ranged from 16 °C to 23 °C in response to seasonal changes in air temperature. Salinity generally displayed low variability temporally and spatially, ranging from 35.2 to 36.8 g/L across the study area; slight haloclines form sporadically during certain periods.

Rough sea conditions are often experienced due to afternoon sea breezes during summer months and during winter storm events. These conditions promote sediment resuspension, causing natural elevations in turbidity, sediment deposition and light attenuation at the seabed (Oceanica 2005). Recent monitoring and subsequent hydrodynamic modelling indicate that light attenuation in the area is highly variable over both short (<12hrs) and longer periods (up to 30 days).

3.3.2 Chemical

In general, the nutrient concentrations in the shore (adjacent to beach), nearshore (2 km offshore), and offshore (3 km offshore) waters at Alkimos are similar to other Perth coastal waters, being generally low (oligotrophic), and with nitrogen being the primary productivity-limiting element.

Total phosphorous (TP) and filterable reactive phosphorous (FRP) concentrations were generally low across the study area, ranging from 9-29 µg/l and 7-22 µg/l respectively. Concentrations of TP and FRP generally decreased between the shoreline and offshore sites, and also between autumn and winter, with peak concentrations being recorded at nearshore sites during December, with secondary peaks occurring throughout the area during March (Water Corporation 2005).

Total nitrogen (TN) concentrations comprised mainly organic nitrogen compounds with ammonia, nitrate and nitrite concentrations representing <10% of total nitrogen content. TN concentrations were generally higher in shoreline environments compared with nearshore and offshore areas, ranging from 90 to 400 µg/L.

Nitrate and nitrite concentrations were generally higher at offshore and nearshore locations compared with shore locations, with peaks in nitrate and nitrite concentrations observed in June; this was consistent with the seasonal winter peaks in nitrates and nitrites of Perth coastal waters (Kinhill 1999). In contrast, ammonium levels were the highest at shore sites, peaking during late summer and dropping during the spring /winter period to below the reporting limit of 3 µg.N/L. FRP concentrations typically display slightly lower concentrations at offshore sites than at nearshore and shore sites (for both surface and bottom waters).

Chlorophyll-a concentrations at Alkimos are relatively uniform between shore, nearshore and offshore sites, and between surface and bottom waters, with the range of concentrations being of a similar magnitude to those recorded as part of the Perth Coastal Waters Study (Lord and Hillman 1995).

No indication of contamination by either thermotolerant coliforms or enterococci was recorded during studies in the Alkimos area (Water Corporation 2005).

Both the physical and chemical characteristics of the marine waters in the areas proposed for the pipeline and outfall construction are typical of a coastal system. There are minimal influences from catchment runoff and there is an absence of other potential sources of pollution.

3.4 Marine Ecology

The intertidal and subtidal areas of the proposed pipeline and outfall comprise a shallow, high energy coastal environment that ranges in depth from approximately 0 m LAT (lowest astronomical tide) at the shoreline to approximately 20 m LAT at the proposed outfall location. The study area is dominated by a limestone reef system that extends approximately 3 km from the shoreline. The limestone reef areas combine with variable sand patches that provide high habitat complexity for colonisation and recruitment of a range of marine species. The area supports a high diversity of flora and fauna, including important benthic primary producer habitat (BPPH) and a variety of marine mammals, fish and benthic fauna. A benthic habitat mapping investigation of the proposed pipeline and outfall route was undertaken by Oceanica in 2005 and forms the primary source of baseline information for the description of the benthic marine habitats adjacent to the proposed pipeline and outfall.

3.4.1 Marine Benthic Communities

The benthic communities in the vicinity of the ocean outlet comprise a range of seagrass, reef and sand habitats. Sand is the most common habitat found within the study area (56%) followed by moderate and high relief reef habitats, 20% and 14% respectively (Table 3-1). Sand patches provide habitat for three species of seagrass (*Posidonia* sp., *Halophila* sp. and *Heterozostera* sp.) while reef areas provide habitat for a number of macroalgal species (including *Ecklonia radiata*, *Sarcomenia delesserioides* and *Codium* sp.) and seagrass species, *Thalassodendron pachyrhizum* and (*Amphibolis* sp.). The baseline BPPH investigations are detailed in Appendix F.

Dense seagrass beds (>80% cover) generally consist of *Amphibolis* spp. and *Posidonia australis.* Other seagrass species, *Halophila ovalis* and *Heterozostera tasmanica*, exist in isolated patches with variable cover, ranging from 20% to 100%.

Table 3-1: Summary of habitats identified in the vicinity of the ocean outlet route

Habitat Name	Habitat Description	Area (ha)	% of Total
Seagrass Habitats			
Posidonia spp.	Sand areas covered by patches of *Posidonia* spp. (*P. sinuosa, P. angustifolia, P. australis*)	0.20	0.1
Amphibolis spp.	Reef areas covered by continuous *Amphibolis* spp. (Both *A. griffithii* and *A. antarctica* recorded, often growing together)	2.78	0.8
Amphibolis spp. and reef	Reef areas covered by patchy *Amphibolis* spp and algal communities	10.16	3.1
Halophila sp.	Inshore, sheltered sand areas covered by continuous *Halophila ovalis*	0.02	0.0
Heterozostera sp.	Inshore, sheltered sand areas covered by continuous *Heterozostera tasmanica*	0.00	0.0
Thalassodendron sp.	Reef areas covered by patched of *Thalassodendron pachyrhizum*	0.02	0.0
Mixed *Halophila* sp. and *Heterozostera* sp.	Inshore, sheltered sand areas covered by a combination of *Halophila ovalis* and *Heterozostera tasmanica* seagrasses	0.16	0.0
Sand Habitats			
Sand	Unvegetated areas in which sand was dominant	185.70	55.9
Wrack material	Sand areas covered by unattached seagrass leaves and algae	3.58	1.1
Reef Habitats			
Low relief reef	Low lying (average height <0.5 m above surrounding seabed) vegetated limestone reef, often with a thin veneer of sand	20.28	6.1
Reef	Moderately (0.5-1.0 m) raised limestone reef characterised by a dense cover of algae, including *Gelinaria ulvoidea*, *Dictyomenia* sp., *Plocamium* sp. and *Callophyllis* sp.	64.68	19.5
High relief reef	Limestone reef outcrops characterised by high relief (average height >1.0 m above surrounding seabed), vertical walls and Ecklonia radiata on upper surfaces. Other algal species included *Sarcomenia delesserioides* and *Codium* sp.	46.01	13.9
Exposed reef	Limestone reef within high energy environment, subject to strong surge and breaking waves. Generally little colonisation with only cover consisting of short green algal turf and zoanthids (colonial anemones)	1.29	0.4
	TOTAL	**331.9**	**100**

The primary habitat for seagrass species within study area has been identified between 500 m and 750 m along the proposed alignment from the shoreline. Within this area, *Amphibolis* sp. is the dominant species. Figure 3-3 shows the BPPH surrounding the outfall alignment.

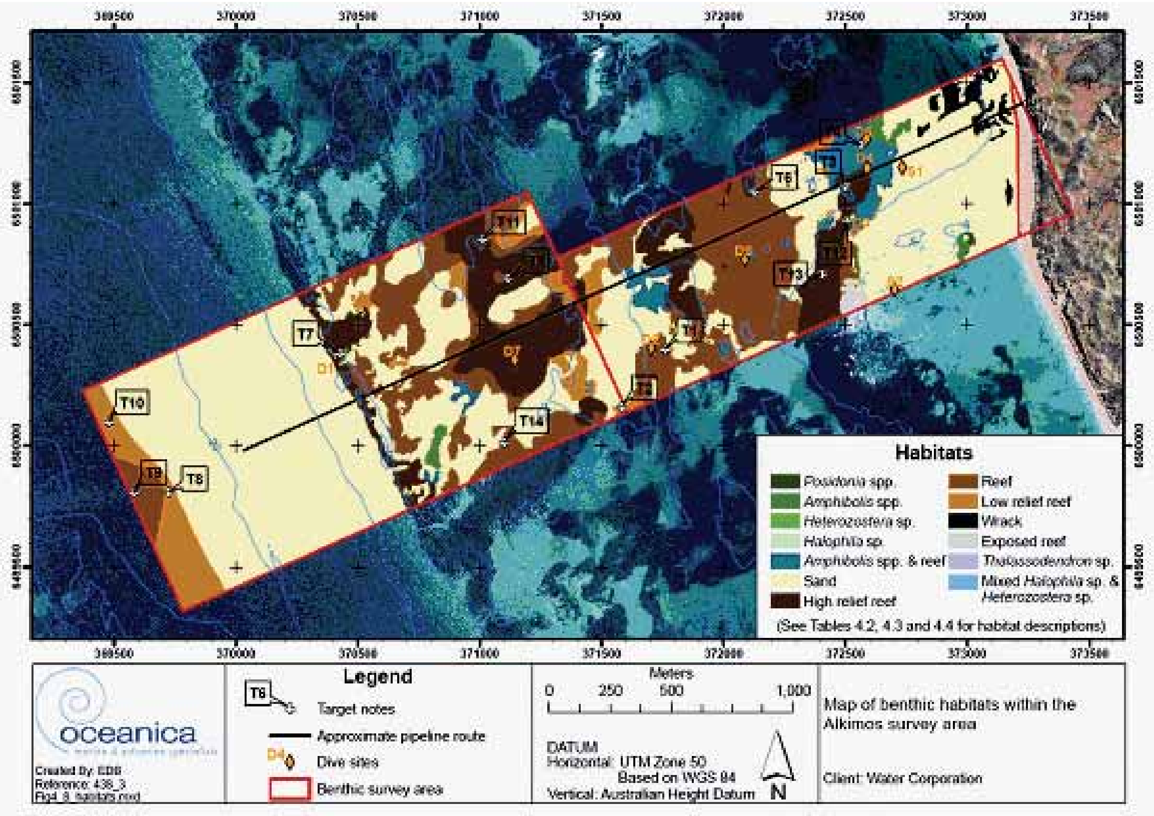

Figure 3-3: BPPH identified within the proposed pipeline route area
(from Oceanica 2005)

3.4.2 Marine Fauna

A diverse range of marine fauna occurs along the Alkimos coastline. Marine mammals, (including whales, dolphins, and Australian sea lions), cartilaginous and bony fish, marine reptiles and birds are known to inhabit or pass through the Alkimos region. The area exhibits a relatively low diversity and abundance of benthic fauna, with polychaetes and crustaceans comprising the dominant benthic taxa. All of the above groups may be affected by construction of the ocean outlet.

Whales such as the humpback whale (*Megaptera novaeangliae*), southern right whale (*Eubalaena australis*) and blue whales ('true' blue whale, *Balaenoptera musculus musculus* and pygmy blue whale, *B. musculus brevicauda*) migrate southwards between September and November each year. Humpback whale cows and calves migrate southwards two to four weeks after other whale species and are more likely to be encountered nearer to the shoreline (within 5 nautical miles). Southern right whales travel close to the coastline (within 1 km); however, only small numbers of this species are observed in the Perth region and limited research has been undertaken.

Bottlenose dolphins (*Tursiops* sp.) occur all year round in the Perth Metropolitan Area. They are distributed around the entire Australian coast, but are more abundant in sheltered areas such as embayments. It is highly likely that dolphins will be in the vicinity pipeline route during construction.

Australian sea lions (*Neophoca cinerea*) are the world's rarest species of sea lion, occurring only in Western and South Australia. Near Perth, sea lion haul out sites are located on Seal, Carnac, Penguin, Dyer and Little islands and Burns Rock. There is little information on where they feed or how far they travel for food, although females have been recorded up to 53 km offshore (Shaugnessy 1999). Given the proximity of the above islands to the Alkimos region and their previously recorded range, it is possible that they will occur in the study area.

At least 245 species of bony fish and about 36 species of cartilaginous fish are expected to occur in the Alkimos region (Hutchins and Thompson 1995). Seagrass habitats such as the *Amphibolis griffithii* meadows found near the pipeline route are thought to be capable of supporting 600 individual fish, comprising approximately 36 species, per hectare (Hyndes *et al.* 2003).

Marine reptiles that potentially occur in the Alkimos region include turtles and sea snakes. Three species of marine turtle, the leatherback turtle (*Dermochelys coriacea*), green turtle (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*), may occur in the Alkimos region, although leatherback turtles are the only species that have previously been identified in the region (Environment Australia 2003).

Infauna communities in the study area display low species diversity, crustaceans and polychaetes representing the main taxa. Crustaceans represent 80% of individuals sampled from areas nearer to the proposed outfall, while polychaetes were more abundant in areas located mid-way along the proposed pipeline route. Molluscs are not common along the proposed pipeline route, although they are locally abundant in areas associated with finer sediments (Oceanica 2005; Appendix F).

3.5 Geotechnical Information

Detailed geotechnical investigations facilitated further clarification of the topography, hardness of the rock strata and determination of the sand/rock interface, which assisted in the refinement of the pipeline alignment and construction methods to produce the most acceptable environmental outcome.

3.5.1 Geology and Geomorphology

The geology of the offshore Alkimos region comprises sand and limestone belonging to the Tamala Limestone unit, overlain by siliceous and calcareous sand. Caprock occurs at the upper surface of the Tamala Limestone, which is composed of calcisilite, calcarenite and calcirudite.

The area is dominated by reef systems, which extend over the full length of the pipeline route. The reef systems are made up of three former dune complexes, now lithified, which run parallel to those on the land in a generally north-north-westerly direction.

The inner reef system extends from the shoreline to less than 2 km from shore. The inner reef becomes shallower and harder than the other reefs, and is the strongest limestone of the three reefs. The upper surface of the inner reef is caprock, composed of dense calcium carbonate (calcrete) up to 1.5 m thick, which occurs as peaks above the surrounding sand. The caprock is likely to have an unconfined compressive strength (UCS) of about 10.0 MPa, while the strength of the underlying limestone is likely to be about 3.0 MPa (Atteris 2005).

The middle reef system occurs between 2 and 3 km from shore and has an average depth of approximately 11 m LAT. The middle reef is older than the inner reef and may have a residual, partly eroded, caprock layer. The limestone UCS is expected to be approximately 0.5 to 1.0 MPa (Atteris 2005). A 1.3 km wide valley, infilled with sand, separates the middle reef from the outer reef; the ocean outlet diffuser will be located beyond the outer reef.

The outer reef comprises primarily reef remnants in the form of a 600 m wide ridge, more than 3 km from the shore. In the area of the ocean outlet route, the ridge occurs at a depth of between 15 and 20 m below MSL, although it rises to the south and north to within 5 m of the water surface where it is known as a significant marine hazard. The outer reef is considerably eroded and leached, with the caprock fully worn down in places. The UCS of limestone from the outer reef is approximately 0.3 to 0.5 MPa (Atteris 2005).

3.5.2 Sediment Composition

Sediment investigations were undertaken at both nearshore and offshore sites adjacent to the proposed pipeline route (Oceanica 2006, Appendix G). Sediments were sampled to a depth of 2 cm at each site and analysed for a range of physical and chemical constituents.

The sediments varied from coarse to fine sand, with the inshore sites displaying slightly coarser sediments on average (Oceanica 2005a and 2005b). The majority of near-shore sediments are predominantly (22% to 60%) coarse sands, with a grain-size less than 1000 μm. Offshore sediments are generally finer, being 59% medium sands, ranging between <280 μm and <500 μm. The presence of finer sediment further offshore is likely to be due to the greater water depths and the subsequently lower energy environment compared to the near-shore areas. Geophysical investigations found no fine sediments (silt and clay fractions <63 μm) in surficial sediments of the area around the outlet pipeline route, reflecting the moderate-to-high energy regime of the area.

The sediments at Alkimos have a low organic content, with concentrations of nutrients in offshore sediments within the range expected for clean coastal sediments. Metal concentrations in the area are below guideline values, and pesticides and herbicides are below normal reporting limits (Oceanica 2006). No spatial chemical variability was found between sites and/or between nearshore and offshore sampling areas.

3.6 Engineering

The design and proposed construction techniques for the ocean outlet have been developed to minimise both direct and indirect impacts on the marine environment and have been refined since publication of the PER. Those changes are not considered substantial; however, approval for such changes will be sought from the EPA in accordance with Section 45C of the *Environmental Protection Act* 1986. Details of the construction and the proposed schedule of works are provided below.

3.6.1 Route Design

The final design of the ocean outlet pipeline route has been optimised to avoid significant onshore areas and also minimises the extent of offshore blasting and excavation required. The horizontal alignment presented as "Route C" in the PER has been adopted because it coincides with an existing blow-out in the primary dune and avoids limestone cliff features to the south (Figure 3-4). The vertical alignment of the pipeline is similar to that represented as the "base case" in the PER (Figure 3-4). Drilling and blasting will be required to aid in the excavation of reef areas.

3.6.2 Blasting and Excavation

The ocean outlet pipeline will be laid generally at the natural grade of the seabed to minimise the need for excavation. However, some clearing (up to 10 m wide) will be required to ensure a smooth profile for the pipeline to be pulled along during installation. Excavation up to 5 m deep is also required through small sections of the reefs that occur offshore of Alkimos with excavated material to be placed alongside the trench. Excavation and backfilling of a pipeline trench will also be undertaken from the shoreline out to 5 m below sea level to ensure that the pipeline is not visible from the shore.

Controlled drilling and blasting is expected to be required along 1.2 km of the 3.7 km pipeline route to assist in preparation of the pipe route through any areas of reef (Figure 3-5). Drilling and blasting is an effective method because the detonations are confined to the seabed material, generating small cracks in the rock to break it into dredgeable sizes and to the required depth. Sub-sea blasting techniques have developed significantly over the years and their application in environmentally sensitive areas has become accepted (Atteris 2005). Excavation of the blasted rock will be undertaken with a backhoe dredge. These techniques were selected because they reduce the volume of excavation required and minimise increases to turbidity in comparison with other techniques such as cutter suction dredging. Excavation will be undertaken in 200 m sections, each section expected to take approximately two weeks.

The backhoe dredge will comprise a spud-mounted barge with a large excavator mounted at one end. Backhoe dredges are generally non-self-propelled and require auxiliary vessel assistance. Once in position, the dredge lowers its spuds (legs) to the seabed and raises its pontoon above the water level, providing a stable and secure working platform. It then uses its excavator bucket to pick up the seabed material and deposit the contents to the side of the trench. The backhoe dredge (Figure 3-6) is capable of maintaining a trench level of +/- 0.25 m of that required.

Excavations close to the shoreline will be done by a land-based excavator, because the water depths and wave conditions in these areas are too difficult for the offshore backhoe dredge to operate. A groyne and cofferdam will be constructed to facilitate his part of the excavations (Section 3.6.4).

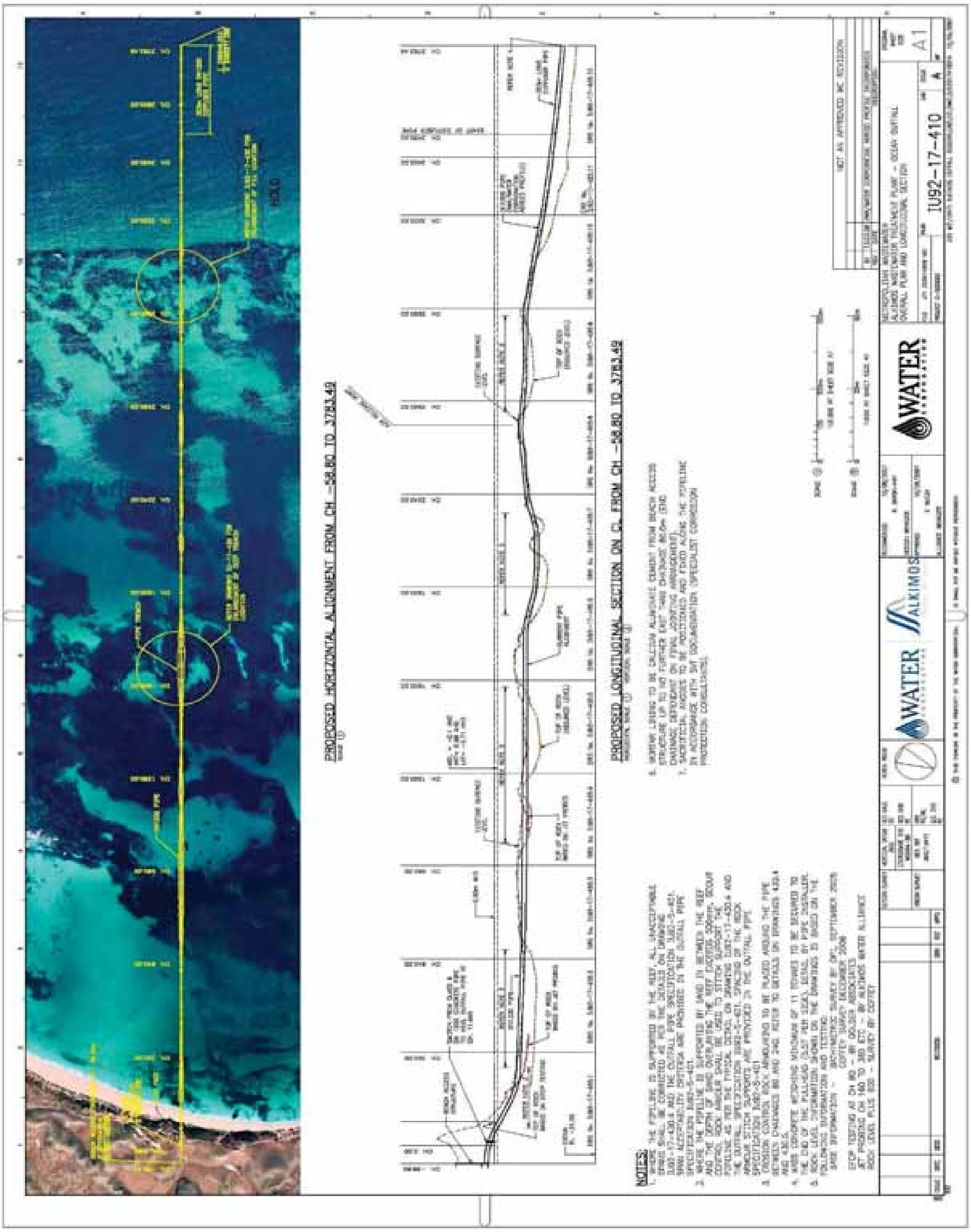

Figure 3-4: Horizontal and vertical alignment of the ocean outlet pipeline

Prior to any excavation, a multi-beam survey will be completed along the length of the ocean outlet route to provide a detailed understanding of the existing seabed topography. This will facilitate the appropriate and efficient removal and placement of spoil during excavation. Multi-beam surveys will be undertaken weekly throughout the excavation to monitor compliance with the prescribed route design and extent of disturbance.

Blasting will be undertaken in sections by first drilling a pattern of holes at approximately 1-m spacings to a depth of around 3 m using an underwater drill rig (Figure 3-7). Prior to placement of the drill rig, divers will survey the area to ensure correct placement to minimise direct impacts to BPPH. Each hole will require relocation of the rig. The exact pattern and sequence of drill holes will be determined on site after assessment of the sea floor.

Trial blasts will be undertaken to determine the required charge-size for blasting; it is anticipated that the charge will not need to exceed 10 kg of Powergel which will be discharged by an electrical detonator from the surface. The blast is likely to lift the rock surface up to 10 cm.

It is estimated that 27,500 m^3 of material will be excavated along the length of the pipeline route. The majority of excavation is required from two locations on the inner reefs (Figure 3-5), with about 10,000 m^3 to be removed from each location. The remaining 7,500 m^3 will be excavated from other locations along the pipeline route. The excavated material will comprise approximately 90% rock (24,750 m^3) and about 10% (2,750 m^3) sand.

Excavated spoil will be side-cast below water level to minimise impacts to water quality and BPPH. On average, the side cast spoil is likely to form mounds approximately 6.5 m wide and 1 m high. Spoil will be deposited to one side only to preserve BPPH wherever required. Upon completion of dredging, divers will inspect the condition of the trench and a multi-beam survey will be undertaken to assess the trench topography. The full description of the management methods is in the Dredge Management Plan.

3.6.3 Pipeline Fabrication and Launch Site

The launch site, approximately 300 m long by 60 m wide, is located about 200 m from the coast. The site will be levelled to act as a stringing yard for construction and launching of the pipe; a temporary construction facility and platform will also be established. The base elevation is around RL 12 m and RL 16 m AHD. The ground surface is RL 12 m to RL 24 m AHD and cut and fill will be required for the establishment of the site. A typical pipe launch site is shown in Figure 3-8.

Welding of 12 m long pipe joints into pipe strings will be done at the temporary construction facility. The pipe will be assembled into 14 strings, each approximately 268 m in length. The pipe launch site will be further addressed in the Terrestrial Construction Management Plan for the project.

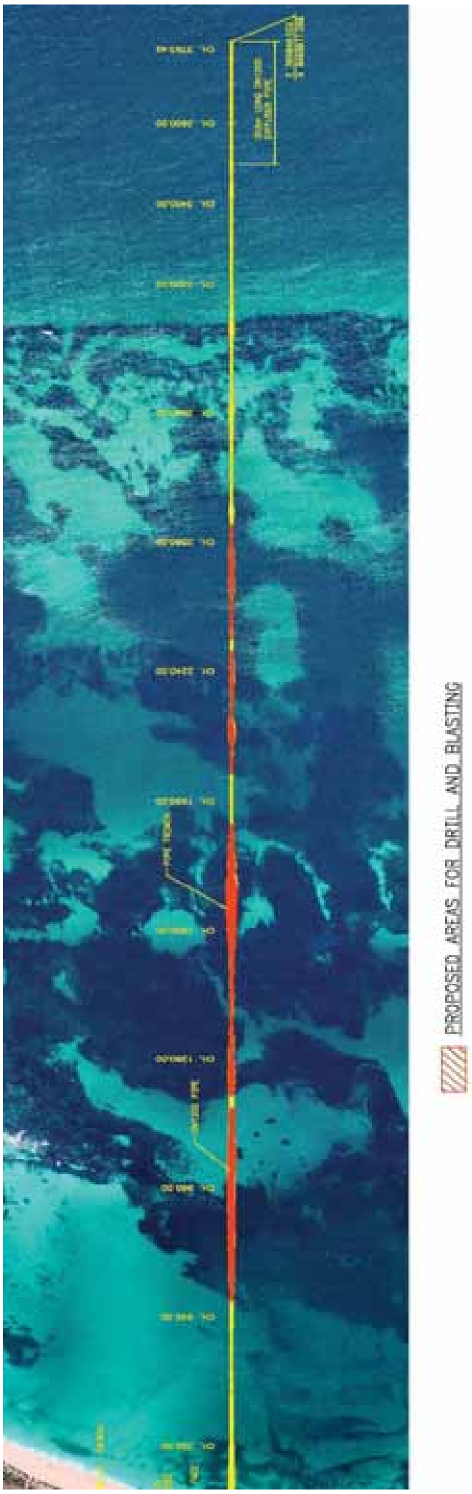

Figure 3-5: Locations of drilling and blasting

Figure 3-6: Typical backhoe dredge (Atteris 2006)

Figure 3-7: Typical diver-operated drill rig

3.6.4 Groyne and Cofferdam

A groyne and cofferdam (Figure 3-9) will be constructed to allow dewatering to be undertaken and to protect the seaward portion of the excavation from wave action. The groyne will also provide a safe working platform for land-based excavations. Approximately 1,500 m^3 of rock armour will be stockpiled in the launch site corridor and then transported to the beach by front end loaders. Excavators will place the rock armour in the ocean to create a groyne.

A sheet pile cofferdam will be constructed inside the completed groyne platform by drilling and blasting, then driving the sheet piles into the seabed at least 4 m below the pipeline invert level. The cofferdam will extend 100 m from the shoreline, with two front wings running north-south braced by a series of props and whalers, beam structures that will be located just above the high water mark to hold the 12 m long sheet piles together and to prevent them from bending inwards. The cofferdam will prevent natural backfilling of the shoreline trench during construction and pipeline installation and maintain the stability of the trench.

Figure 3-8: A typical pipe sting launch site (Atteris 2006)

3.6.5 Pipeline Installation

The offshore and onshore components of pipeline installation will be carried out as described in the following section. The various onshore and offshore work areas will operate 24 hours per day.

3.6.5.1 Offshore installation

Mobilisation of offshore pipeline installation equipment will occur simultaneously with onshore pipeline fabrication (Section 3.6.7). A 60 m x 19 m barge with a four point mooring system and specialised winching equipment will be positioned offshore as shown in Figure 3-10.

The barge will pull against two 15-tonne reaction anchors, likely to be positioned approximately 5.5 km offshore. These anchors will be preinstalled by an anchor-handling tug with a bollard-pull of approximately 50 tonnes. Prior installation will ensure that the anchors have pulled down and set into the seabed so that there is little risk of them pulling out or flipping during construction. Diver surveys will be undertaken prior to mooring to ensure anchors are located in areas free of BPPH.

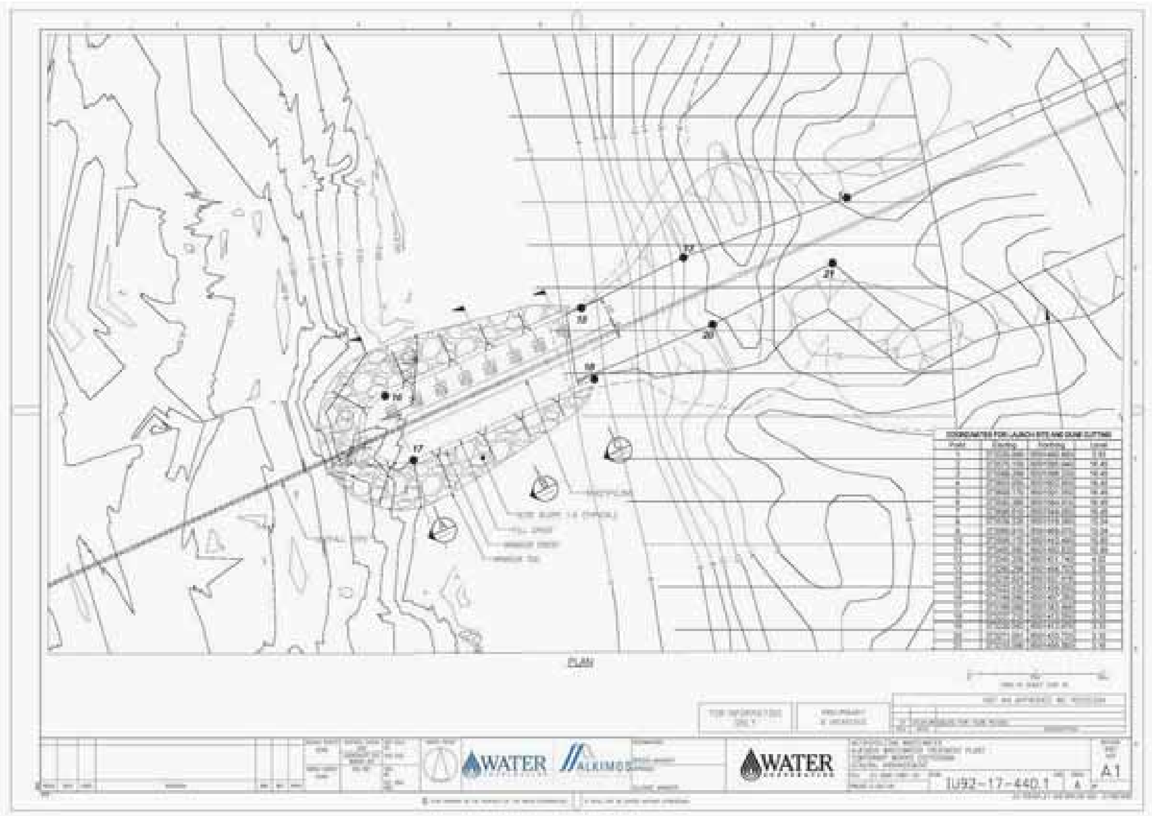

Figure 3-9: Design and location of the groyne and cofferdam

The barge will occupy five different locations during the pipeline installation. Each repositioning of the barge will require relocation of the four mooring anchors. The proposed mooring locations are shown in Figure 3-10. Floats will be attached to anchor chains to lift them off the seafloor and minimise impacts on BPPH from chain sway and drag.

Pipeline installation will be carried out by pulling the pipeline in sections from shore through the excavated trench using cables from the pipe to the barge. A pull head will be installed to connect the first pipe string to the pulling wire. A marker float will be installed at the pull head to allow visual confirmation of the pipe position in relation to the sought pipeline alignment.

The winch onboard the barge will recover the wire connected to the pull head and, when the tail end of the first pipe string is aligned with the leading end of the second string, pulling will stop to allow the two pipe strings to be welded together. A field joint will be constructed using quick-set mortar and then prepared for corrosion coating according to standard industry practice. Installation will then recommence and the process repeated until all pipe strings have been pulled into position.

The diffuser pipe string will be the first section pulled from the launch yard. Successive pipe strings will then be installed. The diffuser ports will be blind flanged during installation to ensure that water does not enter the pipeline during the pulling operation, because the pipe is required to remain buoyant during installation.

The pipeline installation barge and a supporting tug boat will be fitted with differential GPS to ensure accurate positioning of the vessels and to ensure correct alignment of the pipeline. Divers will also verify correct placement of the pipe in the trench.

Following completion of the offshore pipeline installation, divers will remove the flanges from the diffuser ports and allow the pipe to flood. The pull head will remain in place to enable diver access to the pipeline. A de-aeration manifold and air release ports will also be installed to prevent a build up of noxious gas at any high points in the pipeline.

The excavation/dredging and pipeline tow-out process is shown in Figure 3-11.

3.6.5.2 Onshore installation

Where the pipeline alignment occurs above or just below sea level, conveyors will be used, spaced along the route, to avoid overstressing the pipe and to reduce pull loads during installation of the pipe strings. The conveyors may be installed onto small pad footings, depending on the ground conditions on the trench floor.

A dune crossing excavation is required to allow the outlet pipe to traverse from the launch pad to the ocean. This component of the works is further addressed in the Terrestrial Construction Management Plan for the project.

Some excavation of material backfilled during launch site preparation will be required to ensure correct alignment of the pipeline. Standard earthmoving equipment will be used for this process. The cofferdam will also need to be plugged and dewatered to allow the pipe to be welded.

Figure 3-10: Proposed locations of pipeline installation barge mooring anchors

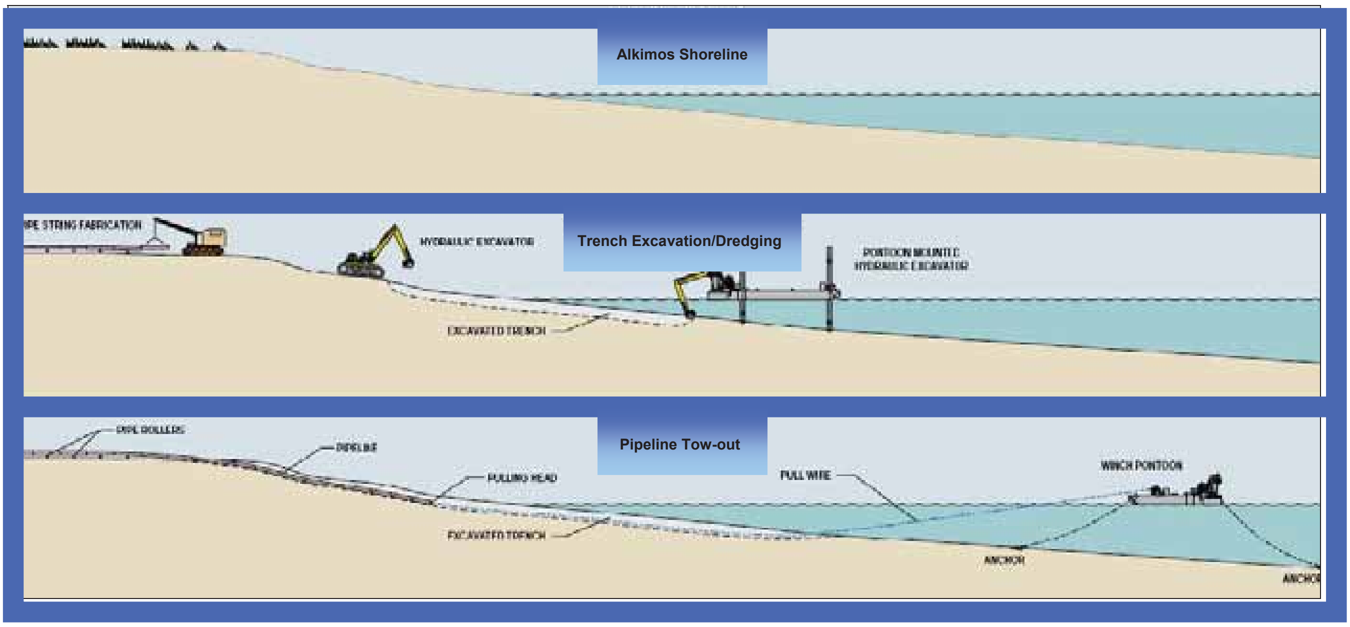

Figure 3-11: Trench excavation/dredging process

3.6.5.3 Outfall access structure

An outfall beach access structure will be installed around the last shoreward section of pipeline. This will consist of a standard tunnel shaft built from the ground up, using conventional civil work techniques. Precast components will be used where possible in shaft walls, and the shaft will be progressively backfilled as construction proceeds. A cathodic protection system will also be installed and made ready for commissioning.

3.6.6 Backfilling

3.6.6.1 Offshore backfilling

No active backfilling of the ocean outfall pipeline trench will be undertaken because it would result in increased impacts to water quality and BPPH due to redistribution of sediments into the water column and physical disturbance to BPPH near side-cast spoil. The energetic and dynamic marine/coastal environment of the Alkimos area will allow natural redistribution of excavated sediments, resulting in natural backfilling of the trench over time.

3.6.6.2 Onshore backfilling

Backfilling of the onshore pipeline trench will be undertaken using standard earthmoving equipment. Upon completion of backfilling, the cofferdam sheet piles will be extracted. The groyne material will also be removed and placed in the primary sand dune area as part of the rehabilitation process. Care will be taken when reinstating the sand dunes to ensure that the final dune slope is stable in the long term. Rehabilitation of the onshore components of the project is further detailed in the Terrestrial Construction Management Plan. On completion of pipeline installation, the groyne and cofferdam will be removed and the beach area above will be backfilled with limestone and sand to depths consistent with those prior to construction.

3.6.7 Ocean Outfall Construction Schedule

The construction of the pipeline is proposed to occur over approximately 14 months between July 2008 and September 2009 (Figure 3-12). Construction of the ocean outfall is proposed to commence in late 2008 with the establishment of the stringing and launch sites. Offshore drilling and blasting will be undertaken from October to December 2008, followed by dredging from December 2008 to February 2009. To avoid debris accumulating in the excavated trench, the dredging program is scheduled to be completed immediately prior to pipeline installation. The pipe pull barge will be mobilised to site by the end of February 2009, and the main pulling anchors will be deployed in early March 2009. Installation of the pipeline will occur in the first half of April 2009, with the flooding down of the pipeline scheduled for mid-April. The timing of the pipeline installation works has been proposed to coincide with generally favourable weather conditions in the area during this time. The outfall beach access structure will be installed around the last section of pipeline between May and June 2009. The groyne and cofferdam will only remain in place for six to eight months over the summer-autumn period. Demobilisation of construction equipment, reinstatement of onshore areas and site rehabilitation will be undertaken from April to August 2009.

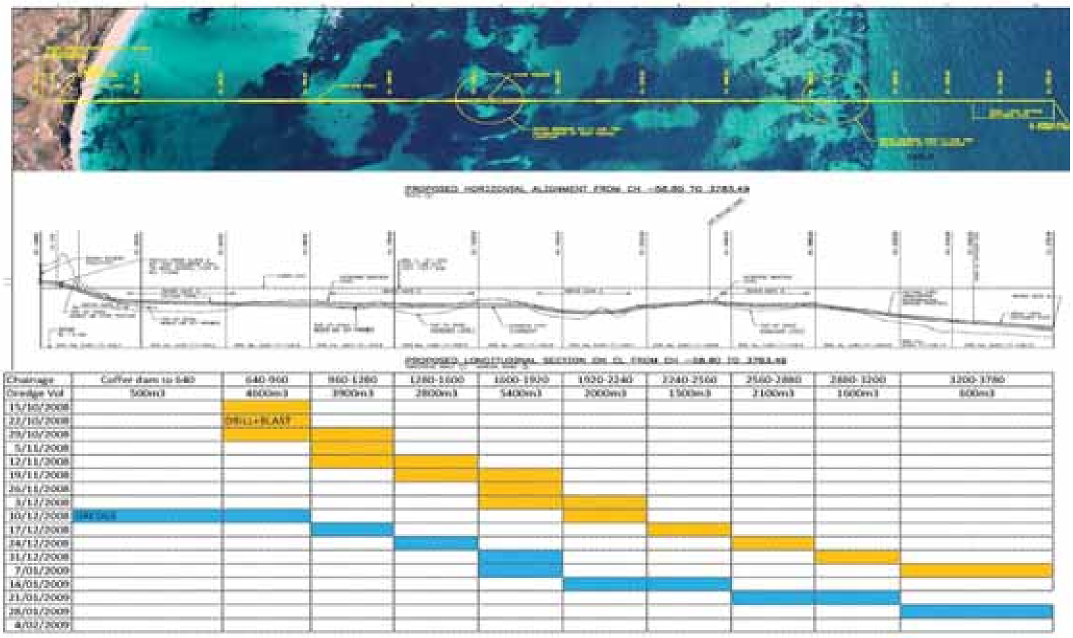

Figure 3-12: Construction schedule

4 IMPACT PREDICTION (STAGE 2)

Detailed modelling was undertaken to predict and spatially define direct and indirect impacts likely to result from the construction of the Alkimos ocean outlet. Modelling of the long-term stable state of the marine environment following construction was also completed, taking into account indirect effects of construction and ongoing impacts once installation of the pipeline has been completed. The details of the model, including inputs and outcomes, predictions of primary and secondary, and indirect and direct, impacts are summarised below and detailed in Appendix H. The boundaries of the study area were established to conform to the management area which is defined by the EPA's BPPH Guidance Statement #29.

4.1 Model Type

The MIKE 3 model was used to predict the extent and severity of potential impacts on BPPH. Mike 3 is a three-dimensional model which can simulate vertical movement and variations in the water column such as current flow, wave height and direction, stratification and buoyancy flows. Additional modules were used with the primary hydrodynamic engine to simulate advection, dispersion and sediment transport that is likely to occur during construction.

The model encompasses a domain of about 18 km onshore in a south-east/north-west direction and a 6 km across-shore domain in a south-west/north-east direction, as shown in Figure 4-1. The Mike 3 model uses a sigma layer code net and a flexible mesh grid, which allows flexibility of resolution. Within the 50 km^2 management unit, model resolution is generally 400 m, increasing to 20 m at the pipeline route alignment (Figure 4-1 and Figure 4-2).

4.2 Model Inputs

Detailed technical investigations were undertaken to gather background data as previously described (Section 3), which were fed into the model to ensure high accuracy of outputs. Field data collection was undertaken over several months to provide locally accurate wave, current, light and turbidity input to models. Hydrodynamic modelling was undertaken by refining existing models using the DHI Mike 3 system and incorporating detailed metocean data from the proposed outlet area (Figure 4-3). A baseline model was established and a light attenuation model was integrated into it. Model calibration was then completed comparing wave/current models with previously gathered data. A comparison of the light attenuation model outputs was also undertaken against *in situ* measurements to ensure correct calibration.

The calibrated wave/current modelling was used to determine the material characteristics for dredging. Modelling of the dredging program and associated management strategies was also completed.

4.3 Predicted Impacts (Construction)

The full modelling report is presented in Appendix H. This section summarises the key outcomes of the modelling. The modelling has predicted the direct and indirect impacts that are likely to result from construction and operation of the Alkimos ocean outlet. The prediction of impacts has been based on a review of existing literature and the application of modelling outputs detailed in the previous sections. Figure 4-4 provides a general summary of impacts associated with dredging activities which have been considered in the determination of likely impacts during the construction.

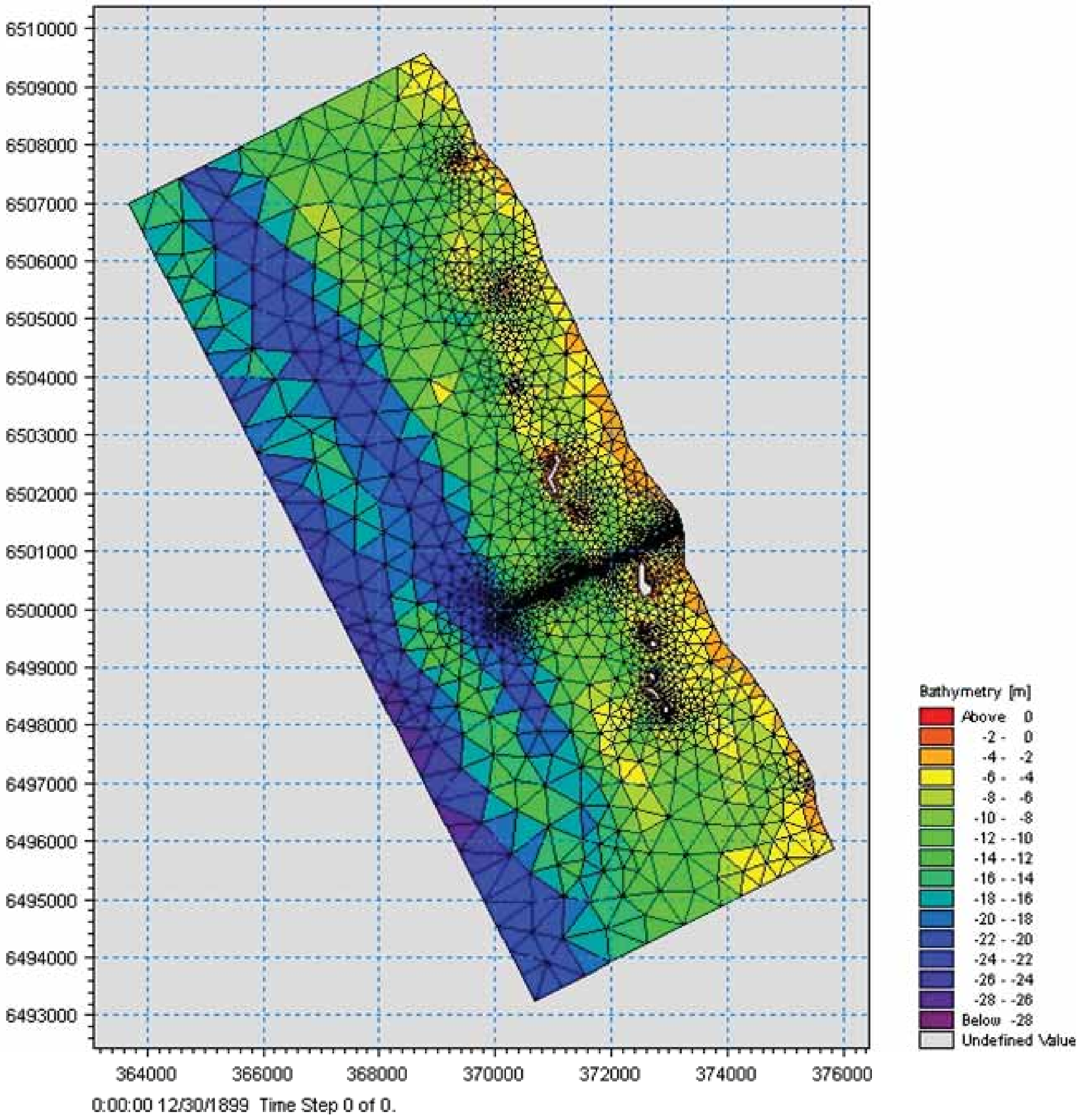

Figure 4-1: Domain and resolution of the Mike 3 model, used to predict and spatially define environmental impacts of the Alkimos ocean outlet construction

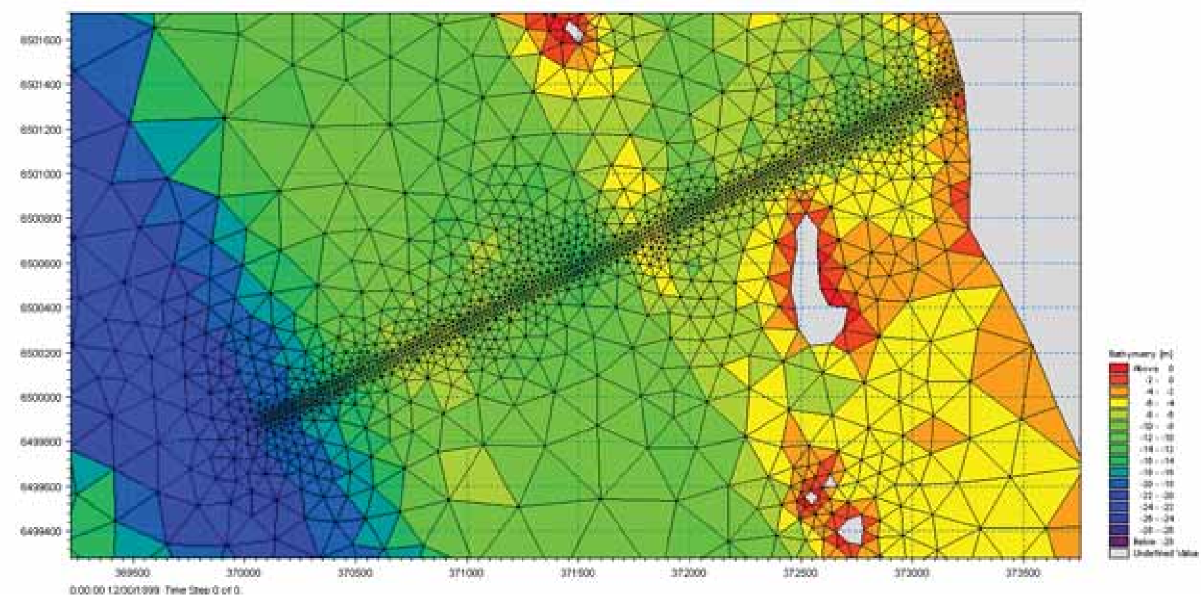

Figure 4-2: Close up of the outlet pipeline trench in the Mike 3 model, used to predict and spatially define environmental impacts of the Alkimos ocean outlet construction

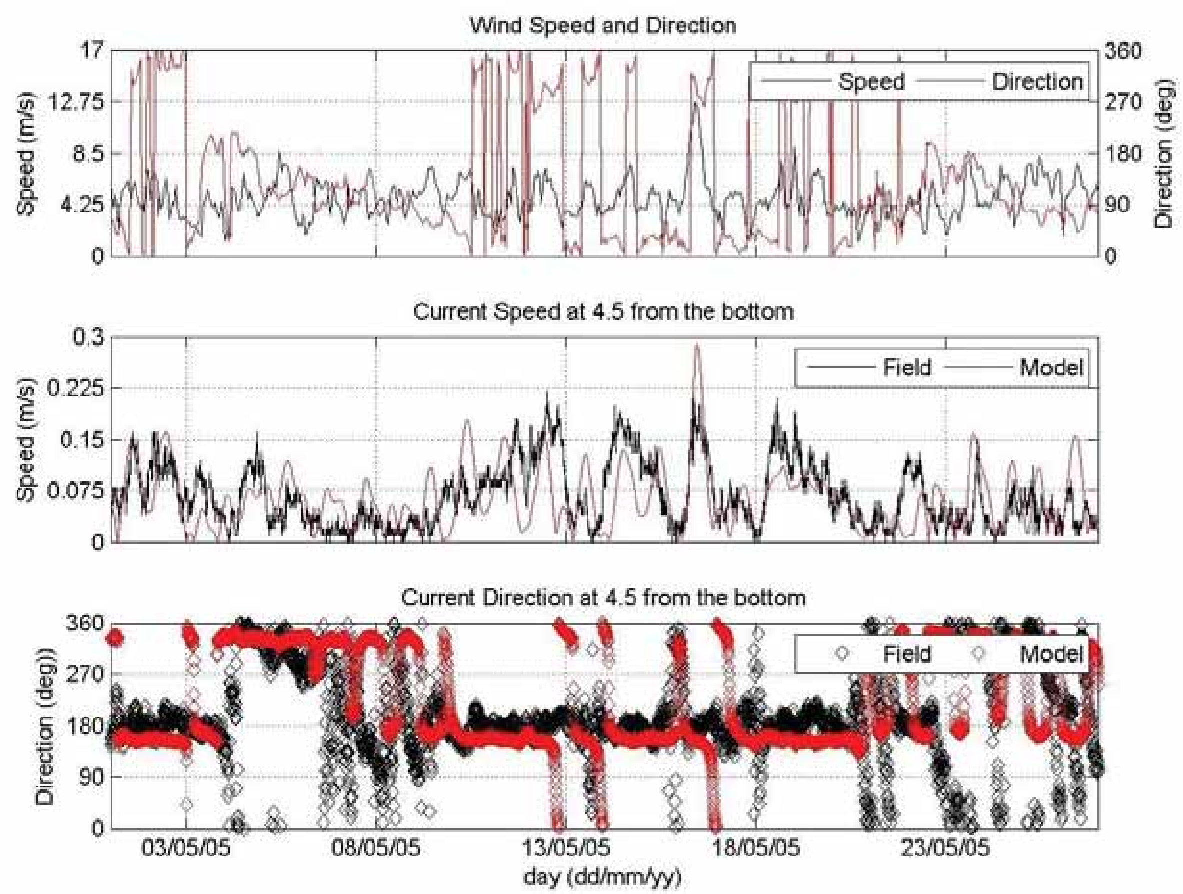

Figure 4-3: 2008 Alkimos wind and current data inputs into the hydrodynamic model

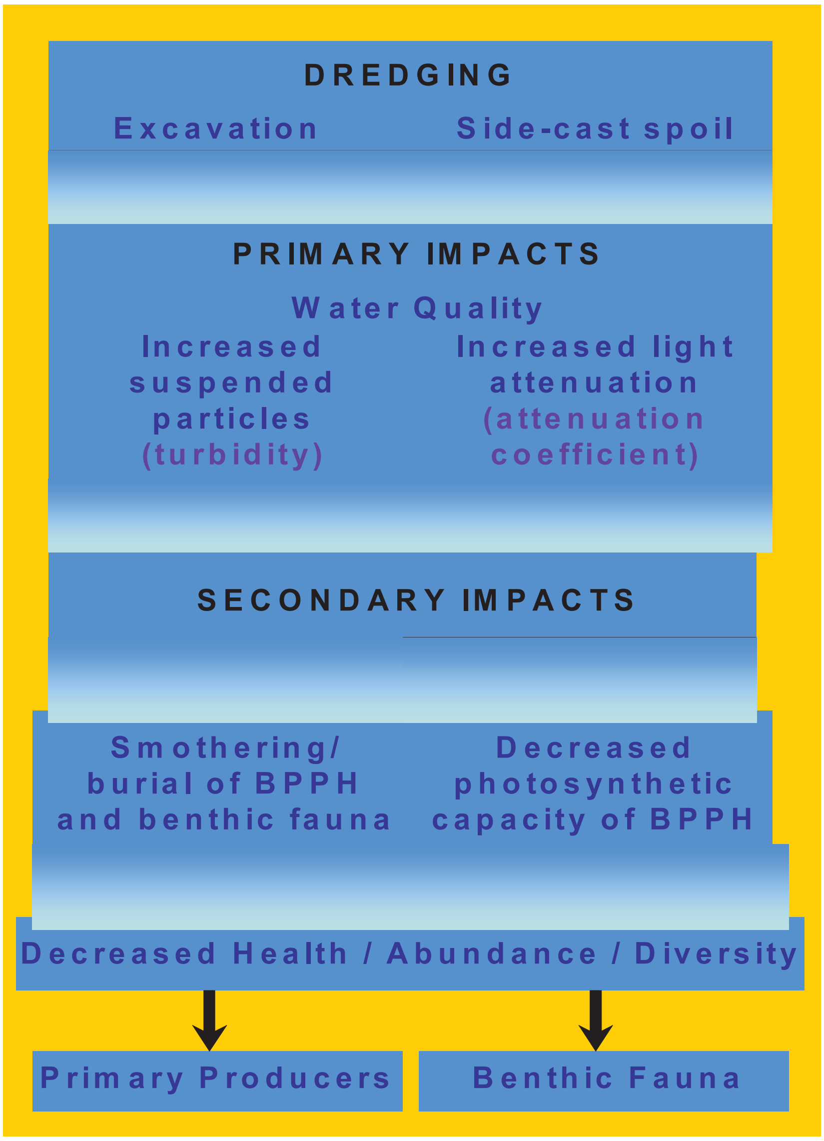

Figure 4-4: General impacts associated with construction of the ocean outlet

4.3.1 Water Quality

Impacts to water quality resulting from construction of the ocean outlet are expected to be very low, and will be a function of the combination of the frequency of the dredging events, the intensity of the events (affecting the amount of material mobilised), and duration (over how many days they occur). The primary impact to water quality is expected to be a short-term increase in turbidity on each dredging day, resulting in a localised increase in light attenuation which will disappear before the commencement of dredging on the third day. No toxicants will be introduced to the environment during construction of the ocean outlet and the dredged material is not expected to produce any toxic material.

The amount of dredging required is relatively minor and will be undertaken at a very slow rate. The use of a backhoe dredge will cause minimal disturbance to sediments other than those actually being moved. Those sediments that are disturbed are likely to be dispersed quickly due to the high energy environment (which will mitigate the severity of any localised impacts), and will also settle rapidly due to the mainly medium-to-coarse grain-size occurring throughout the area. Medium-grained sediments are expected to settle at a rate of at least 0.05 m/s, while coarse sediments will settle at a rate of more than 0.2 m/s (Oceanica 2006).

The following model outputs show the phased effect of the turbidity and light attenuation generated by the blasting and dredging. The plume from each successive day can be seen as a discrete boundary, with no persistence of the more than two days of plume.

The validation of predicted impacts to water quality is addressed in Section 5.1.

4.3.2 Benthic Primary Producer Habitat

4.3.2.1 Direct Impacts

Construction of the outlet pipeline will directly impact BPPH within a 10 m wide corridor, centred along the pipeline route. Where no excavation is required, clearing will not be undertaken and direct impacts will result only from pulling the pipe over the seabed. In areas where trenching and side-casting are required, direct impacts to BPPH may extend up to 25 m either side of the route due to excavation of BPPH and covering BPPH with spoil.

The area of BPPH loss from construction of the ocean outlet (through clearing and excavation) was initially estimated to be approximately 7 ha, equating to a loss of approximately 0.34% of BPPH within the 50 km^2 management unit (assuming that 41% of the management unit is vegetated) (Water Corporation 2005). An additional 0.37 ha of BPPH loss is also predicted to occur due to anchor chain sway and drag. However, following publication of Bulletin 1239, refinement of the trenching and side-casting design has resulted in a reduction in the overall BPPH area likely to be lost or damaged along the pipeline route due to clearing and excavation to 4.3 ha (Table 4-1). This equates to approximately 0.021% of the BPPH within the 50 km^2 management unit. Algal assemblages are likely to recover within one to two years, despite any impacts due to construction (Oceanica 2005c).

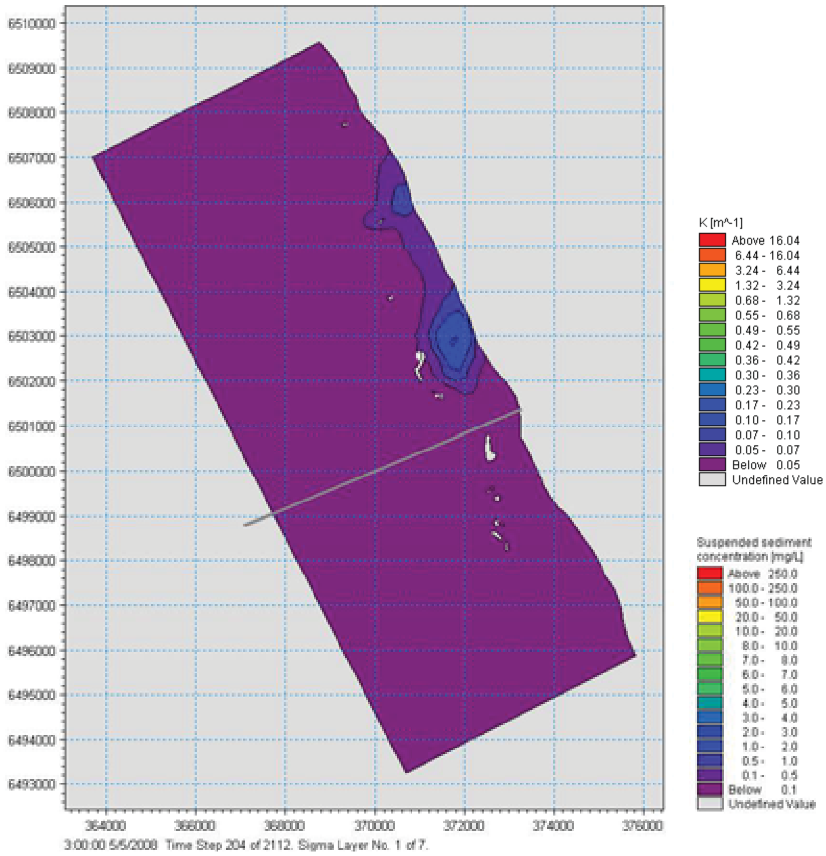

Figure 4-5: Two consecutive days of model output showing dissipation of each day's plume before the beginning of the third day's dredging under south-east wind conditions

Further model outputs showing the plume behaviour under a range of conditions are in Appendix H.

Table 4-1: Comparison between PER and final design of total BPPH loss

Habitat Type	Habitat Loss (ha)	
	Bulletin 1239	**Final Design**
Amphibolis spp. & reef	0.508	0.773
High relief reef	3.421	1.818
Low relief reef	0.276	0.103
Reef	2.693	1.602
Total BPPH Loss	6.898	4.296 (0.8 ha seagrass)

4.3.2.2 Indirect Impacts

Indirect impacts to BPPH associated with increased turbidity may also occur from dredging and side casting activities, but are generally less predictable than direct impacts. The benthic primary producers that could be impacted by construction of the ocean outlet include both seagrasses and macro-algae species.

Benthic species have been shown to be tolerant of a wide range of light climates, with influencing factors to these tolerances including species composition and light intensity. Losses in productivity of such areas do not necessarily correspond to exposure to lower light levels, as many species can become adapted to low levels of light while still retaining some productivity. Of rather more importance to the BPPH is their tolerance to variability in the light climate, which can have significant effects on productivity and survival (Collings *et al.* 2006).

The effects on BPPH may include:

- reduced photosynthetic capacity due to increased turbidity and thus increased light attenuation from the re-suspension of sediments disturbed during dredging and side-casting activities
- loss from erosion halos that may form around excavated or backfilled areas.

Indirect impacts to water quality resulting from construction of the ocean outlet are expected to be minimal, based on the influence of the combination of low frequency, intensity and duration of the dredging events. The primary indirect impact to benthic habitats is anticipated to be a short-term increase in light attenuation with minimal smothering effects from sediment deposition (Appendix H). Geotechnical and sediment investigations have identified generally coarse sediment fractions throughout the proposed offshore dredge/ excavation area. Coarse sediments, when disturbed, require a higher level of energy to remain in suspension compared with finer fractions. Consequently, coarse sediments do not tend to migrate from the point of disturbance and so are likely to remain mainly within the zone of direct impact.

Benthic habitats located within the sediment plume footprint have the potential to be impacted through light attenuation and sediment deposition. However, baseline water quality and hydrodynamic conditions indicate that the study area experiences regular elevated turbidity and sediment re-suspension events. This suggests that photosynthetic species that survive in the study area are relatively tolerant to periods of high turbidity, light attenuation and sediment deposition (Oceanica 2006). Background light attenuation levels in the area indicate that the BPPH is adapted to a natural range of between 0.03 and 0.38 m^{-1}. The range of light attenuation expected to persist more than 1 day after dredging generally lies within these limits (Appendix H). Two and a half days following completion of dredging, the SSC has returned to background (Figure 4-6).

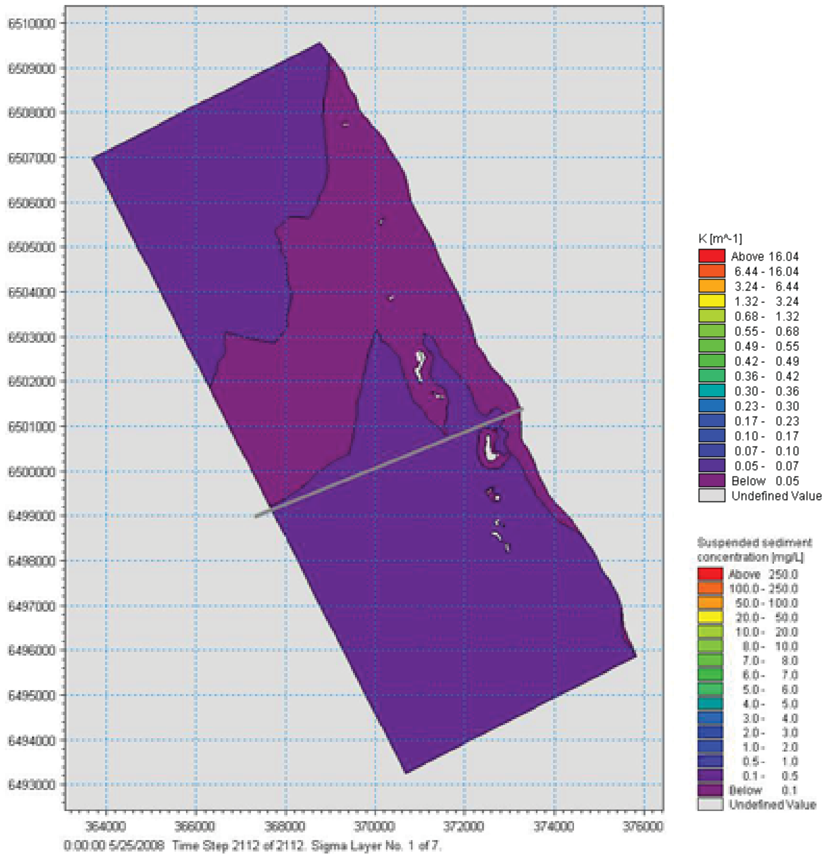

Figure 4-6: Two and a half days after dredging, the SSC has returned to background levels

Some seagrass species are able to tolerate higher rates of light deprivation than others. A theoretical Minimum Light Requirement (MLR) for growth of seagrasses has been estimated at 11% of surface irradiance (Duarte 1991); however, seagrasses globally have been reported to have values between 4 and 29% of the Photosynthetic Photon Flux Density (PPFD) of sub-surface irradiance (Dennison *et al.* 1993). Species with a larger store of biomass (such as *Amphibolis* and *Posidonia*) are considered better equipped to survive temporarily reduced light climates. *Posidonia sinuosa* has been observed to survive for more than five months below its minimum light requirement (Gordon *et al.* 1994), which Collier *et al.* (2007) found to be 8.5% of sub-surface irradiance (1200 mol photons m^{-2} yr^{-1}). Collier *et al.* (2007) observed shoot loss occurring after 106 days of moderate (27% of sub-surface irradiance) and heavy (9% of sub-surface irradiance) shading, although complete loss of shoots had not occurred after 206 days of shading. The extent and rate of recovery of morphological and physical variables were found to indicate that *Amphibolis griffithii* is largely able to withstand a single episode of high-light attenuation increase over a three-month period (Mackey *et al.* 2007). However, *Halophila ovalis* has been reported to have a low degree of tolerance, surviving for only 38 days when deprived entirely of light (Longstaff *et al.* 1999).

Although most algal species are able to rapidly recolonise areas following disturbance, seagrass species are highly susceptible to disturbances and generally have very low recovery rates. Seagrass species in the vicinity of the ocean outlet and associated recovery potential are listed in Table 4-2.

As described above, impacts to *Posidonia, Amphibolis* and *Thalassodendron* seagrass species are considered to be irreversible according to EPA (2004). However, Paling et al. (2002) and Paling et al. (2007) have reported significant success in rehabilitation of *Posidonia* and *Amphibolis* in Australian waters; this issue will require validation following pipeline construction, but any measure of recovery of seagrasses will further reduce the impacts on BPPH. Validation of predicted impacts to BPPH is addressed in Section 5.2.

Table 4-2: Recovery potential of seagrass species in the vicinity of the ocean outfall

Seagrass Species	Recovery Potential
Amphibolis sp.	Irreversible * probably reversible**
Halophila sp.	Reversible *
Heterozostera sp.	Reversible *
Posidonia sp.	Irreversible * probably reversible**
Thalassodendron sp.	Irreversible *

* (EPA 2004); ** Paling et al. (2002); Paling et al. (2007)

4.3.3 Seabed (subtidal, intertidal and beaches)

No long-term impacts on littoral drift and shoreline stability are expected to arise from the construction and presence of the ocean outfall. The pipeline will be buried 5 m below the beach surface at the high water mark, and the groyne and cofferdam will be removed following pipeline installation. The Oceanica investigations into the Alkimos site concluded that the construction and operation of the Alkimos ocean outfall is unlikely to significantly impact the coastal processes in the Alkimos nearshore or offshore region (Oceanica 2006).

Some short-term impacts to sediment movement processes, such as beach accretion and erosion immediately adjacent to the groyne, may result from the pipeline construction program. It is anticipated that the predominant short-term impact will be accumulation of sediments on the southern side of the cofferdam and that erosion of sediments to the north of the cofferdam will be relatively minor. The coffer dam and groyne will be removed following the completion of construction, so any short-term accumulation of sand on the southern side is expected to be dissipated soon thereafter. Validation of predicted impacts to the seabed is addressed in Section 5.3.

4.3.4 Benthic Fauna

Direct impacts to benthic fauna are likely to result from trenching and excavation of the pipeline route. Affected areas comprise a 10 m corridor along the entire pipeline route as well as a strip up to 25 m wide adjacent to either side of the proposed trench in areas where excavation and side-casting is required due to both the direct excavation of sediments and covering of habitat with dredge spoil. The area of direct impact on benthic habitats has been minimised by the final design of the pipeline route.

Indirect impacts to benthic fauna may also result from the pipeline construction due to resettling of disturbed sediments and subsequent smothering of benthic fauna beyond the direct impact zone. Although the rate of resettling is likely to be relatively fast due to the predominantly large grain-size of the sediments, the volume of sediments disturbed will be low and dispersion will be rapid. Increased turbidity from construction is expected to be within the natural range for the area. Additionally, the high energy environment will cause continual redistribution of sediments throughout the area. Therefore, indirect impacts to benthic fauna are likely to be low due to the small concentration of sediments likely to resettle in any one area, creating a low potential for smothering of benthic fauna beyond the direct impact zone.

4.3.5 Noise Effects on Megafauna and Fish

All vertebrates have the potential to be affected by noise and vibration that will be produced as a function of construction activities. The potential sources of noise and vibration that have been considered include excavation, drilling, engine noise, blasting, pipe-lay barges, dredging vessels, and support and pipe installation vessels. Noise emissions have the potential to impact on marine fauna in the following ways:

- attraction to the noise source
- increased stress levels
- disruption to underwater acoustics (marine mammals)
- behavioural changes
- localised avoidance
- secondary ecological effects (e.g. domino effect due to the effect on one species - one or a number of species may be affected).

4.3.5.1 Marine Mammals

Marine mammals have an extremely sensitive acoustics system. A number of marine mammal species have a discrete and narrow range of acoustics which they use for communication, navigation and feeding. Some anthropogenically sourced sounds and noises are at frequencies and or intensities that are similar to various species' acoustic sensitivity ranges and can mask communications between individuals (McCauley *et al.* 1996). Increased frequency and intensity of underwater sound can impact on marine mammals by:

- adversely affecting prey species (causing prey to leave the region)
- masking of communication signals (leading to reduced detection of predators and prey, with associated risks to survival)

- behavioural responses, such as avoidance of the area, deep diving
- temporary or permanent shifts in hearing ability
- damage to hearing and other organs (McCauley and Cato 2003).

Acoustic interference from vessels can also lead to a variety of responses from cetaceans, including changes in vocalisation patterns, propensity to approach the vessel, deep diving, reduced time on the surface and disorientation of mother and calf (Truelove 1997).

Marine mammals are potentially impacted by noise sources with a frequency of 500 Hz or higher. Lower frequencies have been found to have minimal effects. Humpback whales communicate by receiving sounds up to 192 dB, while dolphins have been shown to receive sound to 120 dB with no adverse effects (Schlundt *et al.* 2000). In other studies, white whales and bottle nose dolphins were exposed to sound up to 202 dB with no noticeable effect. The underwater noise emissions from the proposed construction activities show that dredging using a clam shell dredge emits noise at a frequency of 250 Hz at 150-162 dB. While a clam shell dredge is not the proposed dredge type, an excavator dredge tends to be a lot smaller and is therefore likely to emit less noise at lower frequencies. In conclusion, it is likely that marine mammals are able to receive much higher acoustic intensities at much higher frequencies than the likely outputs of the dredge vessels and dredge excavator and therefore predicted impacts are likely to be minimal. Table 4-3 provides a summary of a range of anthropogenic and marine noise sources and associated acoustic intensity and frequency range.

The underwater noise emissions from the proposed construction activities show that dredging using a clam shell dredge emits noise at a frequency of 250 Hz at 150-162 dB. While a clam shell dredge is not the proposed dredge type, an excavator dredge tends to be a lot smaller and is therefore likely to emit less noise at lower frequencies. In conclusion, it is likely that marine mammals are able to receive much higher acoustic intensities at much higher frequencies than the likely outputs of the dredge vessels and dredge excavator and therefore predicted impacts are likely to be minimal.

4.3.5.2 Marine Turtles

Turtles are thought to receive frequencies of between 100-700 Hz, but no definitive studies have been undertaken. Given the flighty behaviour of many marine turtles in the environment, it is likely that individuals will move out of an area if noise reaches a level that becomes uncomfortable.

4.3.5.3 Fish

Production of noise from dredging, construction and vessel movements are likely to cause behavioural impacts to fish. A range of literature has identified that fish generally move away from the sounds of approaching vessels, the magnitude of the observed effect diminishing with water depth, and the behaviour returns to pre-noise conditions once the noise has passed (Olsen 1990).

More recent studies have found that fish responses to noise are more complex. Studies by Rostad *et al.* (2006) have determined that some fish species are attracted to vessel noise. It is unlikely that the noise associated with construction, vessel movement and dredging will cause significant impact on fish species. Fish tend to become attracted to ports and areas where shipping movements are common due to the presence of underwater structures such as the piles associated with wharf and jetty facilities (Pers. Obs.). Generated noise intensities in these areas are likely to be substantially higher than those that are likely to be associated with the proposed dredging and pipeline construction, so noise impacts by the construction activities on fish are expected to be minimal.

Table 4-3: Acoustic intensity and frequency of marine mammals and noise sources

Source	Acoustic Intensity (dB re 1μPa)	Frequency Range (Hz)
Great whales	130 – 188	16 – 8,000
Toothed whales (vocal)	125 – 180	1,600 – 120,000
Toothed whales (echolocation)	180 – 228	6,000 – 130,000
Dugongs	Unknown	1,000 – 8,000
Earthquakes (≤4)	35 – 199	10 – 50
Ships	177	5 – 100
Seismic	215 – 265	10 – 300
Extraction operations	182	Unknown
Cutter-suction dredge (working)	~180	100
Clamshell dredge (working)	150 – 162	250

4.3.6 Blasting Effects on Fish and Megafauna

Shock waves associated with underwater blasting can impact marine fauna by causing behavioural changes, physical injury or death (if they are close to the blast). Impacts will depend on the size of the charge, the composition of the explosive, water depth, the distance from the blast and the size and type of species.

Impacts associated with underwater blasting on marine species have been assessed previously by the Canadian Department of Fisheries (CDF) and ICI Australia. Methods have been developed by both organisations to estimate lethal ranges and safe distances for marine species when close to underwater blasting. The CDF technique takes into account animal weight and target depth and may be considered more accurate than the ICI method. However, there are a number of other factors such as species, size, explosive type and size, seabed type, species physiology and animal orientation to the blast that may vary the magnitude of the impact, making the determination of the safe distances difficult.

4.3.6.1 Marine Mammals

The primary effects of sub-sea blasting on marine mammals are damage to the lungs and auditory systems. Table 4-4 provides an estimate of effective distances for marine mammals assuming a water depth of 10 m, with individuals near the seabed and an explosive weight of 78 kg (SKM 2006). Given that 10 kg charges at about 3 m hole-depth are likely to be used for any blasting along the ocean outlet route, blast-effect zones are predicted to be considerably reduced compared with those in Table 4-4.

Table 4-4: Estimated blast effect zones for marine mammals in 10 m water depth

Distance	Effects
0 m – 387 m	No mortality. High incidence of moderately severe blast injuries, including eardrum rupture. Animals should recover.
387 m – 645 m	High incidence of slight blast injuries, including eardrum rupture. Animals should recover.
645 m – 1075 m	Low incidence of trivial blast injuries.
> 1075 m	Safe level. No injuries.

(from a confined 78 kg charge explosion)

In consideration of impact distances, injuries associated with those distances, and the location of the proposed blasting sites, it is highly unlikely any cetaceans will be close enough to any blasting activities to cause severe harm (<387 m). No known critical whale areas (such as breeding, feeding, resting or calving areas) occur in or close to the construction area, although humpback and southern right whales are known to occur in the general location, including a known humpback whale aggregation area along the Perth coast (DEH 2005a). There is a blue whale aggregation in the Perth Canyon, west of Rottnest Island, but this is over 30 nautical miles to the west of the construction area (DEH 2005b) and is unlikely to be affected by any blasting activities. Migration routes of humpback whales pass to the west of the construction area, with the peak migration periods occurring from late June to mid July and from mid September to mid October (DEH 2005a). Humpback whale populations are unlikely to be affected by blasting activities as blasting is currently proposed to be undertaken past the end of the humpback migrating season, between October and December.

Baleen whales and some toothed whales are particularly sensitive to low frequency sounds, such as those that will be created by blasting. Smaller dolphins and porpoises have peak sensitivities in the higher frequencies and are likely to be less disturbed by blasting (DEWR 2007).

It is likely that marine mammals will avoid blasting areas. Such temporary displacements are not considered to likely to result in any biological cost to the animals (DEWR 2007). However, the effects of blasting on marine fauna are not fully understood, so a precautionary approach is required in the management of these impacts. Accordingly, a conservative exclusion zone of 1 km will be implemented in addition to a blast management plan.

4.3.6.2 Marine Turtles

Although marine turtles do not have an external hearing organ, they can detect sound through their skull and shell via bone-conducted vibrations (Lenhardt 1983). While research into the effect of persistent sound on turtles is inconclusive, their response to sound varies with different frequencies and intensities (Environment Australia 2003). Under experimental conditions, marine turtles are thought to detect low frequency noise and have been shown to exhibit a startle response to some noises (Lenhardt 1983). In the Gulf of Mexico, explosive removal of platforms has resulted in turtle deaths, both directly from the explosion and also from drowning after being startled (Minerals Management Service 1997).

Little specific information is available on the risk to marine reptiles from sub-sea blasting. In the absence of relevant data, turtles will be considered to face similar physiological risk as mammals. Blasting is likely to cause temporary disturbance and avoidance effects in turtles that are present in the vicinity of the blasting activities.

Proposed blasting activities will be undertaken by initially drilling the substrate prior to placing the explosive at the required blasting depth. This ensures that the energy released on detonation of the explosive is captured within the substrate. This will result in a minimal release of energy into the areas where marine species may be present.

4.3.6.3 Fish

Finfish in the immediate vicinity of the blast area may be killed or injured as a direct result of blasting. Those fish with a swim bladder are likely to be most affected by underwater shock due to rupturing of, or other damage to, the swim bladder. Those fish without a swim bladder, such as juvenile fish where the swim bladder has not fully developed, sharks and rays, are less likely to be affected. While an increase in explosive charge size increases the chances of mortality, other factors such as reflection of the blast impulse off the seabed and proximity to the blast area can also affect mortality rates (Yelverton *et al.* 1975). Other studies by Yelverton *et al.* (1975) found that small fish inhabiting areas close to the seabed are likely to be most affected, with larger fish (~750 g) generally having a lower mortality rate than small fish (~0.02 g). Other effects of blasting on fish include disorientation, decreased movement, and erratic gill movement. The internal organs most commonly damaged by blasts are the swim bladder, kidney and liver (Yelverton *et al.* 1975). Spiral curling of fish embryo and disruption/deformation of egg membranes has also been observed as a result of 50 gm charges of TNT (WBM Oceanics1993)

A study of the effects of seismic air guns (used in geological exploration) on caged pink snapper (*Chrysophrys auratus*) in Western Australia showed that very intense sounds could have a significant impact on the auditory system of fishes, with extensive damage to the hearing organs of the fish resulting (Popper *et al.* 2002). As most fish use hearing to detect predators, find prey, communicate and find mates, a loss of hearing can be detrimental. Under natural conditions, however, fish can be expected to swim away from such loud noises, which would reduce impacts on fish from blasting.

Table 4-5 provides the approximate effect distance for blasting on fish using the CFD method above (the calculation assumes fish are demersal, water depth is 10 m and the blast weight is 78 kg). Given that 10 kg charges are likely to be used for blasting of the ocean outlet alignment, blast effect zones are predicted to be considerably smaller than those in Table 4-5.

Table 4-5: Estimated blast effect zones for 10 kg marine fish species in 10 m water depth

Distance	Effects
0 m – 215 m	50% Mortality
215 m -301 m	1% Mortality
>301 m	Safe level. No injuries

(from a confined 78 kg charge explosion)

Blasting proposed to be undertaken will use minimal charges and will be relatively minor. Small areas (1,200 linear metres of pipe route) require blasting and direct mortality or injury to fishes is likely to be minimal. Proposed management and monitoring of impacts to marine fauna species is addressed in Section 5.4.2.

The proposed blasting will be undertaken by drilling appropriate substrates to approximately 3 m ensuring that the energy released on detonation is captured mainly within the substrate. This will result in a minimal release of energy into the areas where fish and other Megafauna may be present.

4.3.7 Heritage

The *Alkimos* shipwreck lies approximately 500 m to the north of the ocean outlet pipeline route, while the wreck of the *Eglinton* lies more than 2.5 km to the south of the pipeline route. Although no direct impacts to these shipwrecks are anticipated, it is important that construction vessels avoid the area surrounding the wrecks to prevent potential impacts to the heritage of the site. Avoidance of these areas will also minimise safety risks posed by these wrecks.

4.3.8 Air Quality

Likely sources of air emissions during construction of the ocean outlet are limited to exhaust emissions from the dredge plant and equipment, which are considered minor emissions. Given the location of works offshore from Alkimos and the relative remoteness of works from existing human infrastructure, regional air quality is not expected to be impacted.

4.4 Predicted Impacts (Pipeline Presence)

Few impacts are predicted as a result of the ongoing presence of the ocean outlet pipeline. Sources of any such impacts are limited to maintenance activities and natural processes (such as movement of water and sediments).

4.4.1 Water Quality

Impacts to water quality resulting from the ongoing presence of the ocean outlet are expected to be very low. The primary impact to water quality will be limited to any leaks or spills of fuel from operational or maintenance vessels and equipment. Very small volumes of fuel are likely to be stored on these vessels, so any impacts from a leak or spill would be minor.

Validation of predicted impacts on water quality is addressed in Section 6.1.

4.4.2 Benthic Primary Producer Habitat

Potential impacts to BPPH may result from launching and anchoring of vessels during maintenance operations. Anchoring and subsequent chain sway and drag could cause direct loss of BPPH in the vicinity of the ocean outlet, while boat propellers can scour seagrasses in shallow areas. Although only small areas are generally affected by such influences, the scouring can interfere with the physical integrity of a seagrass bed and can increase edge effects, such as erosion and loss of detritus and nutrients, and this is much greater within a seagrass meadow than if an equivalent area were lost from the edge (Lukatelich *et al.* 1987). The low recovery potential of seagrasses further emphasises the need for appropriate management for such impacts.

Other potential impacts include erosion halos under the pipeline (although these are not expected to be extensive) and the introduction of marine pests on fouled hulls or in ballast water. The pipeline and side-cast rock are expected to form a substrate for recolonisation by primary producers, particularly algae, which may counter some of the minor losses.

Validation of predicted impacts on BPPH is addressed in Section 6.2.

4.4.3 Seabed (subtidal, intertidal and beaches)

No long-term impacts are expected to result from the ongoing presence of the ocean outlet pipeline. However, minor erosion halos may occur under the pipeline in some areas. The pipeline is not predicted to significantly influence local water movement or sediment transport processes.

Validation of predicted impacts on the seabed is addressed in Section 6.3.

4.4.4 Heritage

No direct impacts to wrecks of the *Alkimos*, approximately 500 m north of the pipeline route, or the *Eglinton*, more than 2.5 km to the south, are anticipated.

No areas of known Aboriginal heritage occur in the vicinity of the ocean outlet.

Validation of predicted impacts on heritage is addressed in Section 6.5.

4.4.5 Air Quality

Likely sources of air emissions during operation of the ocean outlet are limited to exhaust emissions from maintenance vessels and equipment, which are considered minor emissions. Although the suburb of Alkimos will be developed over coming years, the offshore location of maintenance works and the small scale of any such works will minimise emissions and no impacts to regional air quality are predicted.

Validation of predicted impacts on air quality is addressed in Section 6.6.

4.5 Impact Risk Assessment

The Australian Standards for Risk Assessment have been used to evaluate the risks and consequences of the works. The risk assessment presented below identifies those aspects of the construction and operation of the ocean outlet that are likely to impact upon the environment. The likelihood (Table 4-6) and consequence (Table 4-7) of these impacts occurring is defined to determine the risk of the impact (Table 4-8). The likelihood of the impact occurring is then reassessed in light of management measures to be implemented and the residual risk is determined (Table 4-8). As a conservative measure, the consequence of each impact is assumed to remain constant despite the implementation of management measures. The ranking of the risks follows the criteria in Table 4-9.

Table 4-6: Rating of risk likelihood

Rating	Descriptor	Description
A	Rare	The event may occur only in exceptional circumstances
B	Unlikely	The event could occur at some time
C	Possible	The event should occur at some time
D	Likely	The event will probably occur in most circumstances
E	Almost certain	The event is expected to occur in most circumstances

Table 4-7: Rating of risk consequence

Rating	Descriptor	Natural Environment	Social Environment
1	Insignificant	Limited damage to minimal area of low significance.	Low level (repairable damage) to commonplace structure.
2	Minor	Minor effects on biological or physical environment.	Minor medium term social impacts on local population.
3	Moderate	Moderate short term effects but not affecting ecosystem function.	Ongoing social issues. Permanent damage to items of cultural significance.
4	Significant	Serious medium term environmental effects.	Ongoing serious social issues. Permanent damage to items of cultural significance.
5	Major	Very serious long term impairment of ecosystem function.	Vary serious widespread social impacts. Irreparable damage to highly valued items.
6	Critical	Significant impact on highly valued species, habitat or ecosystems.	Irreparable damage to highly values items of cultural significance or breakdown of social order.
7	Catastrophic	Very significant impact on highly valued species, habitat or ecosystems.	Irreparable damage to high value items, items of great cultural significance or complete breakdown of social order.

Table 4-8: Risk ranking matrix

		Likelihood				
		A - Rare	B - Unlikely	C - Possible	D - Likely	E - Almost certain
Consequence	1- Insignificant	1	2	4	7	11
	2 - Minor	3	5	8	12	16
	3 - Moderate	6	9	13	17	21
	4 - Significant	10	14	18	22	26
	5- Major	15	19	23	27	30
	6 - Critical	20	24	28	31	33
	7 - Catastrophic	25	29	32	34	35

Table 4-9: Risk ranking matrix key

	Insignificant 1–6
	Minor 7–13
	Moderate 14–22
	Major 23–29
	Catastrophic 30–35

Table 4-10: Environmental aspect/impact table used in Scoping Document

Aspect	Potential impact	Likelihood (without mitigation)	Consequence	Risk	Proposed mitigation	Likelihood (with mitigation)	Certainty	Residual risk
Activity associated with proposal.	*Effect activity can have directly or indirectly on environmental factor.*	Table 4-6	Table 4-7	Table 4-8	*Management measures (excluding offsets) to be put in place to avoid or minimise potential impact caused by aspect.*	*Based on* Table 4-6 *after assessment of likely effectiveness of management measures has been taken into account.*	*Based on level of reliability of data, studies, modelling used to assess what environmental values will be affected and used to predict impact.*	*Based on* Table 4-8.
Placement of drill barge	BPPH damage / mortality	Possible (C)	Moderate (3)	Minor (13)	Surveys to position footings away from BPPH	Rare (A)	High	Insignificant (6)
Drilling	Significant alteration of seabed geomorphology	Likely (D)	Minor (2)	Minor (12)	Surveys to correctly position drill holes Experienced and qualified operators	Unlikely (B)	High	Insignificant (5)
	Disturbance to marine mammals and turtles from noise and vibration	Possible (C)	Moderate (3)	Moderate (13)	Surveys to determine presence of marine mammals and turtles	Unlikely (B)	High	Minor (9)

Aspect	Potential impact	Likelihood (without mitigation)	Consequence	Risk	Proposed mitigation	Likelihood (with mitigation)	Certainty	Residual risk
Blasting	Significant alteration of seabed geomorphology	Likely (D)	Moderate (3)	Moderate (17)	Surveys to correctly position charges Trials to determine appropriate charge size Experienced and qualified operators	Unlikely (B)	High	Minor (9)
	Disturbance to marine mammals and turtles from noise and vibration	Possible (C)	Moderate (3)	Minor (13)	Marine Mammal Observers onboard to monitor for presence of marine mammals and turtles No blasting if marine mammals or turtles within 1 km	Unlikely (B)	Moderate	Minor (9)
	Direct mortality of marine mammals and turtles	Possible (C)	Significant (4)	Moderate (18)	Surveys to determine presence of marine mammals and turtles No blasting if marine mammals or turtles within 1 km	Unlikely (B)	Moderate	Moderate (14)
	Direct mortality of marine fish	Likely (D)	Moderate (3)	Moderate (17)	Trials to determine appropriate charge size Experienced and qualified operators	Possible (C)	Moderate	Minor (13)

Aspect	Potential impact	Likelihood (without mitigation)	Consequence	Risk	Proposed mitigation	Likelihood (with mitigation)	Certainty	Residual risk
Excavation	Increased turbidity beyond natural variation	Likely (D)	Moderate (3)	Moderate (17)	Dredging techniques Monitoring and impact intervention program	Unlikely (B)	High	Minor (9)
	Significant direct BPPH damage / mortality	Almost Certain (E)	Significant (4)	Major (26)	Dredging techniques Pipeline route selection	Unlikely (B)	High	Moderate (14)
	Decreased BPPH photosynthetic capacity	Possible (C)	Moderate (3)	Minor (13)	Dredging techniques Monitoring and impact intervention program	Unlikely (B)	High	Minor (9)
	Smothering / burial of BPPH	Possible (C)	Moderate (3)	Minor (13)	Dredging techniques Monitoring and impact intervention program	Unlikely (B)	High	Minor (9)
Presence of side-cast spoil	Increased turbidity beyond natural variation	Unlikely (B)	Minor (2)	Insignificant (5)	Low volume of spoil to be side-cast	Unlikely (B)	High	Insignificant (5)
	Direct BPPH damage / mortality	Likely (D)	Significant (4)	Moderate (22)	Surveys to position spoil away from BPPH	Rare (A)	High	Minor (10)
	Decreased BPPH photosynthetic capacity	Unlikely (B)	Minor (2)	Insignificant (5)	Low volume of spoil to be side-cast Surveys to position spoil away from BPPH	Unlikely (B)	High	Insignificant (5)

Aspect	Potential impact	Likelihood (without mitigation)	Consequence	Risk	Proposed mitigation	Likelihood (with mitigation)	Certainty	Residual risk
Presence of side-cast spoil	Smothering / burial of BPPH	Unlikely (B)	Moderate (3)	Minor (9)	Low volume of spoil to be side-cast Surveys to position spoil away from BPPH	Rare (A)	High	Insignificant (6)
Groyne and cofferdam construction	Significant change to beach profile	Likely (D)	Moderate (3)	Moderate (17)	Engineering techniques Removal of structure following construction completion Rehabilitation of beach area	Unlikely (B)	Moderate	Minor (9)
Anchoring & mooring	Significant direct BPPH damage / mortality	Likely (D)	Significant (4)	Moderate (22)	Surveys to position anchors away from BPPH Floats on anchor chains	Unlikely (B)	Moderate	Moderate (14)
Pipe pull	Significant direct BPPH damage / mortality	Possible (C)	Significant (4)	Moderate (18)	Experienced & qualified operators GPS tracking of pipe alignment	Rare (A)	High	Minor (10)
Ongoing presence of pipeline	Alteration of natural hydrodynamics	Unlikely (B)	Moderate (3)	Minor (9)	Monitoring and impact intervention program	Rare (A)	High	Insignificant (6)
Maintenance of ocean outlet	Fuel spills/leaks	Possible (C)	Moderate (3)	Minor (13)	Regular maintenance of vessels and equipment. Low volumes of fuel, spill kit and boom available, clean up	Unlikely (B)	High	Minor (9)

5 IMPACT VALIDATION (CONSTRUCTION) STAGE 3

A program of proactive and reactive management measures, integrated with routine and reactive monitoring, has been developed to limit construction impacts to those predicted in Section 4.4.

The following sections define the management and monitoring actions associated with key environmental elements to be implemented during construction in order to minimise and validate predicted impacts (Figure 5-1). The management and monitoring actions described below will ensure that the disturbance footprint from construction of the ocean outlet (direct and indirect impacts) will be no greater than those defined in the Ministerial Statement for the project.

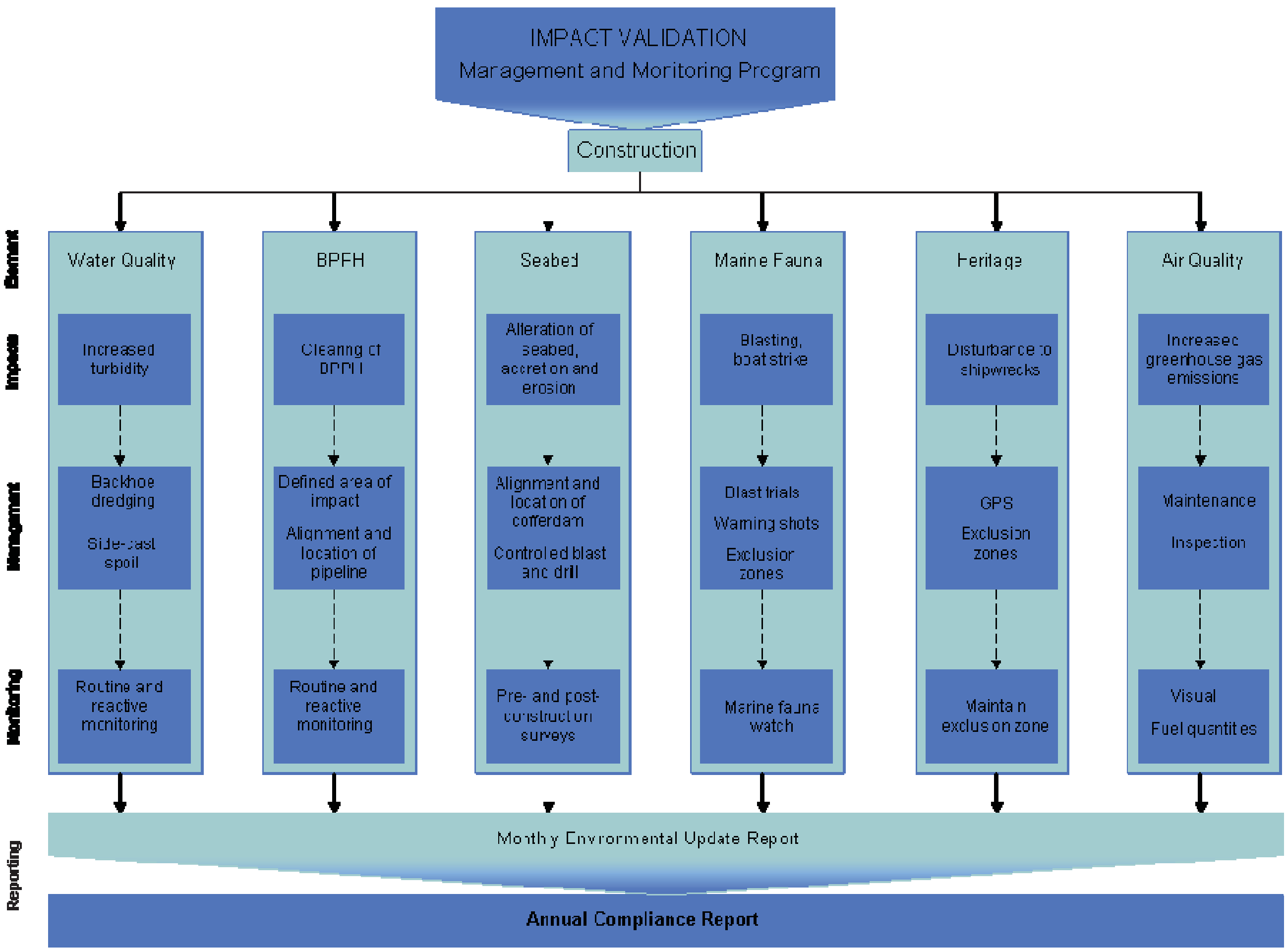

Figure 5-1: The management and monitoring program to be implemented for key environmental elements

A Regulatory Committee will be formed on commencement of construction activities to facilitate liaison between the proponent, regulators and environmental managers. The committee will investigate and determine appropriate contingency actions for any exceedance in environmental trigger values identified herein. The committee will comprise representatives from the AWA, DEC and environmental consultants and will be available for comment and consultation throughout the duration of construction stages.

5.1 Element 1: Water Quality

5.1.1 Summary of Predicted Impacts

The primary predicted impact of construction on water quality is the generation and migration of turbid plumes.

Turbidity resulting from excavation of sand habitats (which comprise the majority of the pipeline route) is likely to be minimal and short-lived, given the predominantly medium and course sands along the pipeline route, although excavation of reef areas may release some finer sediments (silt and clay fractions <63 µm). Given the highly energetic environment in which the outfall will be constructed, disturbed sediments are also expected to disperse rapidly.

It is important to note that elevated suspended sediment concentrations oscillate with the tide, and hence marine flora and fauna communities are unlikely to be subjected to constant elevated turbidity levels.

Examples of different impacts under a range of weather scenarios are in Appendix H.

5.1.2 Procedures

Element	Water Quality
Performance Objective	• *To minimise the spatial and temporal extent of turbid plumes during dredging and side-casting activities.*
Proactive Management Actions	• Backhoe dredging (as opposed to cutter suction dredging) will be utilised to reduce generation of fine sediments. • Side-casting of material will be undertaken to minimise disturbance of sediments in the water column by maintaining the bucket below the surface to prevent overflow. • The backhoe bucket will be raised to the minimal possible height above the seabed. • Dredging will be reassessed if wind speed and wave height exceed the operational parameters of the dredge. • Prior to commencement of work, all construction equipment will be inspected by a qualified mechanic to reduce the risk of hydrocarbon spills and minimise green house gas emissions.

	• The backhoe dredge shall cease work and relocate to the eastern side of Eglinton Rocks in medium to heavy swells (>1.5 m) or in other weather conditions considered dangerous. • In extreme weather conditions, all vessels will cease work and relocate to Mindarie Keys. • A tug boat will be on standby at all times in case of emergency and to provide a fuel store. • No or limited backfilling of the pipeline trench will be undertaken to prevent further disturbance to side-cast sediments. • All wastes and spillages will be contained and appropriate storage and disposal practices will be implemented. • A spill cleanup kit will be provided to deal with spills on the dredge and an oil spill boom will also be available at all times for containment of oil spills on water. • In the event of a spill to the marine environment, the dredging contractor is to undertake the following procedure: ▪ Stop the source of the spill. ▪ Prevent the oil/chemical from entering the water and mop up the spill with appropriate absorbent material from the onboard spill kit. The absorbent material is to be stored onboard until it can be appropriately disposed of offshore to a licensed facility. ▪ Notify the following personnel immediately: • AWA Marine Superintendent – Paul Harries 0417 099 433 • AWA Oil Response – Kate McManus 0448 978 752 • AWA Environment Manager – Jason Hick 0409 940 969 ▪ After details of the incident have been confirmed and compiled into an incident report, AWA will coordinate the notification of relevant agencies and additional stakeholders.
Performance Indicators	• Decreased water quality due to construction does not result in a net loss of BPPH. • No contamination of the marine environment by hazardous substances from the dredge. • In the event of a spill to the marine environment, the aforementioned procedures have been undertaken.
Monitoring	• Implementation of Water Quality Routine Monitoring Plan (Figure 5-2) • A Reactive Benthic Habitat Monitoring Plan will be instigated through exceedance in water quality trigger values (Figure 5-2). • Weather conditions will be monitored at all times. • Establishment of impact and reference habitat monitoring sites.

	• Plume dispersion and sediment deposition modelling outputs will be used to determine extent of the area of impact. • Reference sites will be established outside the predicted area of impact and will contain similar habitat types and physical conditions (such as bathymetry) to impact sites. • Routine monitoring events will be undertaken as follows: ▪ Reference and impact sites will be monitored within the same 24 hour period. ▪ Continuous logging of turbidity and light attenuation will be undertaken using *in situ* data loggers. ▪ Data loggers will be downloaded every 14 days. ▪ Data will then be collated for impact sites and compared with data from reference sites. ▪ Data will also be compared with pre-construction data. • Dredging Contractor to monitor the operation on a continual basis and report any incidents that are likely to cause environmental harm to the project location and surrounding areas.
Responsibility	• The AWA Environment Manager is responsible for ensuring that each of the monitoring programs is implemented. These programs may be subcontracted to a specialist sub-consultant. • The Dredging Contractor is responsible for monitoring the dredging operation and undertaking management actions assigned to them.
Reporting	• A brief summary report will be prepared following each monitoring event. The findings of these reports will be incorporated into every second issue of the Weekly Environmental Report, which will be provided to the AWA Manager and made available to the Water Corporation, EPA and DEC on request. • Primary findings from the previous month will be incorporated into the Monthly Environmental Update Report, which will be provided to the AWA Manager, Water Corporation, EPA and DEC. • Primary findings and evidence of compliance with the Ministerial Statement will be compiled in the Annual Compliance Report. This report will be provided to AWA Manager, Water Corporation, EPA and DEC and will also be made publicly available. • A comprehensive report will be prepared on completion of the final water quality monitoring event and submitted within 30 days of completion of monitoring to the AWA Manager, Water Corporation, EPA and DEC. • The Dredging Contractor will immediately report any incidents affecting water quality to the AWA Environment Manager.

	• The Dredging Contractor must complete an environmental incident report and corrective action report as soon as practicable, but within 24 hours of an incident occurring, and forward this to the Superintendent's Dredging Site Representative. • The Superintendent's Dredging Site Representative will report immediately any incidents affecting water quality to the Superintendent's Representative and the AWA Manager. • The AWA Environment Manager must report, to the Regulatory Committee, any exceedance of predicted turbidity levels within 24 hours.
Corrective Action	• Inform Regulatory Committee if impact site water quality exceeds the 80th percentile of that at reference sites. Continue monitoring and reporting. Review trigger values for water quality. • Level 1 Management Implement one or more of the following ▪ Reduce dredging adjacent to affected area. ▪ Utilise tidal flow to minimise turbidity reaching the affected area. ▪ Inform Regulatory Committee. ▪ Immediately report findings to DEC. ▪ Continue monitoring. • Level 2 Management Implement one or more of the following: ▪ Relocate the dredge. ▪ Reduce dredging adjacent to affected area. ▪ Inform Regulatory Committee. ▪ Immediately report findings to DEC. ▪ Continue monitoring. • Level 3 Management Implement one or more of the following: ▪ Reduce dredging to 12 hour shifts. ▪ Inform Regulatory Committee. ▪ Immediately report findings to DEC. ▪ Continue Monitoring.

	- Cease dredging adjacent to affected area.
	  - Immediately report findings to DEC.
	  - Seek direction of Regulatory Committee.
	  - Continue monitoring.

The locations of reference and impact water quality monitoring sites will be determined following further consultation with the DEC.

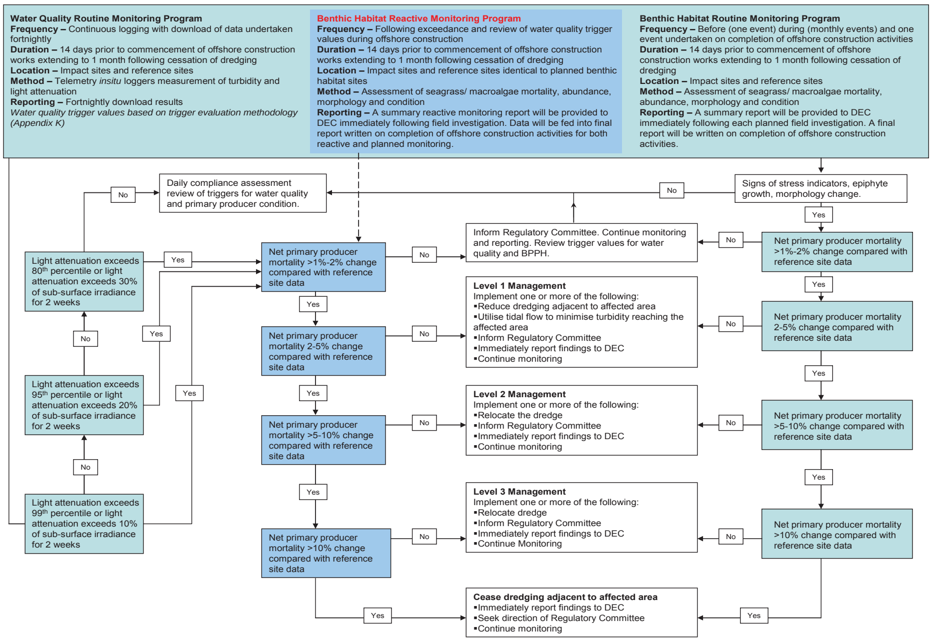

Figure 5-2: Conceptual model for the proposed integrated routine water quality, reactive benthic habitat and routine benthic habitat monitoring and management

5.2 Element 2: Benthic Primary Producer Habitat

5.2.1 Summary of Predicted Impacts

Direct impacts to BPPH are predicted to result from clearing and excavation along the pipeline route and from anchor chain drag. A total of 4.3 ha of BPPH are expected to be directly impacted by construction of the ocean outlet.

Indirect impacts to BPPH may also result from the resuspension and deposition of dredged sediments. Indirect impacts include reduced photosynthetic capacity due to smothering of leaves from redeposited sediments, decreased light attenuation below the species' compensation level and BPPH loss from erosion halos that may form around excavated areas. Indirect impacts beyond those normally experienced in the area are not anticipated to occur. No BPPH is expected to be permanently indirectly impacted by construction of the ocean outlet. Only short-lived changes to water quality are expected to result from the dredging operations, the side-cast dredged material and pipeline construction.

A Regulatory Committee will be formed to enable liaison between the proponent, regulators and monitoring experts. The committee will investigate and determine appropriate contingency actions for any exceedance in water quality and BPPH trigger values. This committee will comprise representatives from the AWA, DEC and the water quality and BPPH monitoring consultants.

5.2.2 Procedures

Element	Benthic Primary Producer Habitat
Performance Objective	• *To minimise direct and indirect impacts to BPPH during construction of the ocean outfall.*
Proactive Management Actions	• The pipeline route will be selected to minimise the area of BPPH directly impacted by avoiding areas of BPPH wherever possible and minimising the need for blasting and excavation. • Blasting drill holes will be surveyed to avoid BPPH wherever possible. • Controlled drill and blast (not surface blasting) will be utilised. • Backhoe dredging (as opposed to cutter suction dredge) will be utilised to minimise direct and indirect impacts to BPPH. • The dredging contractor will ensure that all equipment is not significantly fouled and does not contain any introduced marine pests. • Barge spuds will be installed during dredging to ensure trench width is controlled and within the defined alignment. • The barge spuds will be located within the construction footprint.

	• Multi-beam surveys will be conducted during dredging to ensure correct alignment. • Dredged material will be side-cast to one side of the trench (instead of both sides) where this will avoid or minimise burial of BPPH. • The width of side-cast spoil mounds will be limited to a maximum of 25 m. • Anchor and mooring locations will be surveyed to refine their placement to avoid or minimise impacts to BPPH. • The pipe-pull anchors will be set prior to commencement of construction to ensure they do not flip out and damage reef areas. • Floats will be attached to anchor chains to lift them off the sea floor wherever possible. • Backfilling under pipe with aggregate will be undertaken wherever necessary to refill erosion halos.
Performance Indicators	• Direct loss of BPPH does not exceed the area predicted in Section 4.4.2. • No net loss of BPPH occurs as a result of indirect impacts from construction (i.e. decreased water quality).

Monitoring	• Implementation of Benthic Habitat Routine Monitoring Plan (Figure 5-2).
	• A Reactive Benthic Habitat Monitoring Plan will be instigated through exceedance in water quality performance indicators (Figure 5-2).
	• Establishment of impact and reference habitat monitoring sites, each within a specific BPPH type.
	• The number of monitoring locations per habitat type will be dependent on percent coverage of that habitat type within the proposed area of impact.
	• Plume dispersion and sediment deposition modelling outputs will be used to determine extent of indirect impact.
	• Reference sites will be established outside the predicted area of impact and will contain similar habitat types and physical conditions (such as bathymetry) to impact sites
	• Routine monitoring events will be undertaken as follows:
	    • Reference and impact sites will be monitored within the same 24 hour period.
	    • A quadrat frame attached to a video camera will be lowered to the seabed from the sampling vessel.
	    • At each site 20 photo quadrats will be taken.
	    • For each quadrat, the following information will be recorded:

	• species • percent cover of each species • morphology type • extent of sedimentation • cover of epiphytic growth • signs of disease or mortality. • Data will then be collated for each habitat type within the impact sites and compared with data from reference sites. • Data will also be compared with pre-construction data.
Responsibility	• The AWA Environment Manager is responsible for ensuring that each of the monitoring programs is implemented. These programs may be subcontracted to a specialist sub-consultant. • The Dredging Contractor is responsible for monitoring the dredging operation and undertaking management actions assigned to them.
Reporting	• A brief summary report will be prepared following each monitoring event. The findings of these reports will be incorporated into every fourth issue of the Weekly Environmental Report, which will be provided to the AWA Manager and made available to the Water Corporation, EPA and DEC on request. • Primary findings from the previous month will be incorporated into the Monthly Environmental Update Report, which will be provided to the AWA Manager, Water Corporation, EPA and DEC. • Primary findings and evidence of compliance with the Ministerial Statement will be compiled in the Annual Compliance Report. This report will be provided to AWA Manager, Water Corporation, EPA and DEC and will also be made publicly available. • A comprehensive report will be prepared on completion of the final BPPH monitoring event and submitted within 30 days of completion of monitoring to the AWA Manager, Water Corporation, EPA and DEC. • The Dredging Contractor will immediately report any incidents affecting BPPH to the AWA Environment Manager. • The Dredging Contractor must complete an environmental incident report and corrective action report as soon as practicable, but within 24 hours of an incident occurring, and forward this to the Superintendent's Dredging Site Representative. • The Superintendent's Dredging Site Representative will report immediately any incidents affecting BPPH to the Superintendent's Representative and the AWA Manager.

	• The AWA Environment Manager must report, to the Regulatory Committee, any exceedance of the predicted direct or indirect loss of BPPH.
Corrective Action	• Inform Regulatory Committee if impact site water quality exceeds the 80th percentile of that at reference sites. Continue monitoring and reporting. Review trigger values for water quality. • Level 1 Management Implement one or more of the following ▪ Reduce dredging adjacent to affected area. ▪ Utilise tidal flow to minimise turbidity reaching the affected area. ▪ Inform Regulatory Committee. ▪ Immediately report findings to DEC. ▪ Continue monitoring. • Level 2 Management Implement one or more of the following: ▪ Relocate the dredge. ▪ Reduce dredging adjacent to affected area. ▪ Inform Regulatory Committee. ▪ Immediately report findings to DEC. ▪ Continue monitoring. • Level 3 Management Implement one or more of the following: ▪ Reduce dredging to 12 hour shifts. ▪ Inform Regulatory Committee. ▪ Immediately report findings to DEC. ▪ Continue Monitoring. • Cease dredging adjacent to affected area ▪ Immediately report findings to DEC. ▪ Seek direction of Regulatory Committee. ▪ Continue monitoring.

The locations of reference and impact BPPH monitoring sites will be provided following further consultation with the DEC.

5.3 Element 3: Seabed (subtidal, intertidal and beaches)

5.3.1 Summary of Predicted Impacts

Short-term impacts to sediment movement processes, such as beach accretion to the south of the cofferdam and erosion immediately adjacent to the northern side of the groyne, may result from construction of the pipeline, however no long term or significant impacts are expected.

5.3.2 Procedures

Element	Seabed
Performance Objective	• *To minimise short-term impacts to existing sediment transport processes and resulting beach profiles as a result of construction of the ocean outfall, and* • *To avoid long-term impacts to existing sediment transport processes and resulting beach profiles due to the ongoing presence of the ocean outfall.*
Proactive Management Actions	• The groyne and cofferdam will be constructed on a tidally exposed relief limestone reef to minimise erosion. • Construction will be undertaken during the summer months, when lower wave energies generally occur. • The cofferdam will be aligned to counter the erosion effects of littoral drift on the beach to the north. • The cofferdam will be constructed and the pipeline installed within the minimum timeframe to reduce the temporal extent of impacts. • The cofferdam and groyne will be removed following completion of the construction program and boulders will be placed into the fore-dune for stability. • The void left by the cofferdam will be backfilled. • The drill and blast design will ensure rock fractures will not extend beyond 0.5 m outside the disturbance footprint. • All construction works shall be undertaken by suitably qualified and experienced operators.

Performance Indicators	• Southern side of cofferdam - beach accretes beyond end of cofferdam (approx. 40 m). • Northern side of cofferdam - beach erodes more than 40 m into beach from existing shore. • No damage to the seabed outside the area predicted in Section 4.4.1.
Monitoring	• Multi-beam side-scan sonar survey will be conducted prior to commencement and weekly during construction to ensure that trenching is adhering to the planned alignment. Monitoring will be conducted weekly or more often if deemed necessary. • Blasting and excavation will be continually monitored by GPS on-board support vessels and the excavation barge. The locations of spoil, anchors and moorings will also be verified using GPS. • Spot dives will be conducted as required during construction to provide verification of anchor and mooring movements, trench alignment and other factors as deemed necessary • Following construction, a survey will be undertaken to map the seabed condition. This will be compared to pre-construction surveys. Such surveys will be repeated every 12 months for a minimum of three years and will comprise a quantitative assessment of changes to the seabed.
Responsibility	• The AWA Environment Manager is responsible for ensuring that each of the monitoring programs is implemented. These programs may be subcontracted to a specialist sub-consultant. • The Dredging Contractor is responsible for monitoring the dredging operation and undertaking management actions assigned to them.
Reporting	• A brief summary of monitoring undertaken and current state of seabed condition will be incorporated into the Monthly Environmental Update Report, which will be submitted to the AWA Manager, Water Corporation, EPA and DEC. • Primary findings and evidence of compliance with the Ministerial Statement will be compiled in the Annual Compliance Report. This report will be provided to AWA Manager, Water Corporation, EPA and DEC and will also be made publicly available. • A report will be prepared and submitted to the DEC CEO within 6 months of completion of construction, detailing the condition of the seabed and any proposed or completed rehabilitation. This will be repeated following annual seabed surveys for at least three years after completion of construction. • The Dredging Contractor must complete an environmental incident report and corrective action report as soon as practicable, but within 24 hours of an incident occurring, and forward this to the Superintendent's Dredging Site Representative.

	• The Superintendent's Dredging Site Representative forwarding the aforementioned incident and corrective action reports to the Superintendent's Representative and the AWA Manager as soon as possible.
Corrective Action	• The contingency actions that may be implemented to address excessive accretion on the southern side of the cofferdam include: ▪ Excavation of accreted sand using a land-based excavator from the top of the cofferdam. Excess sand would either be removed and added to the launch site stockpile or transported to the north side of the cofferdam (depending upon erosional status of the northern side); or ▪ Utilise a sand/water pump to remove sand by conducting temporary sand bypass operation. ▪ Contingency measures that may be implemented to address excessive erosion on either side of the cofferdam include: • Sand replenishment from the dune/launch site stockpile; • Rock armouring consistent with construction of the cofferdam; or • Utilise a sand/water pump to move sand by conducting temporary sand bypass operation.

5.4 Element 4: Marine Fauna

5.4.1 Summary of Predicted Impacts

Direct impacts to benthic fauna are predicted to result from clearing, excavation and blasting associated with the project. These impacts will be restricted to a 10 m corridor along the entire pipeline route as well up to 25 m adjacent to either side of the proposed trench in areas where excavation and side-casting is required. Indirect impacts to benthic fauna may also result from construction due to resettling of disturbed sediments and subsequent smothering of benthic fauna. However, these impacts are likely to be within the natural variation of conditions experienced in the area and are not predicted to cause significant loss of benthic fauna.

No direct impacts to marine mammals or turtles are predicted to result from construction of the ocean outlet, although the potential for boat strike exists. Indirect impacts, including from noise and vibration associated primarily with blasting may occur.

Direct mortality of fish may also result from blasting.

5.4.2 Procedures

Element	Marine Fauna
Performance Objective	• *To minimise direct and indirect impacts to marine fauna during construction of the ocean outfall.*
Proactive Management Actions	• Controlled drill and blast (as opposed to surface blasting) will be used. • Trial blasts will be conducted to establish the minimum quantity of charge required for blasting. • Blasting will be suspended in response to sightings of marine mammals or turtles within 1 km of the blast area. • Warning shots will be fired prior to blasting to discourage marine fauna from remaining near the blast area. • A Blast Management Plan will be prepared and implemented by the Blasting Contractor during construction of the ocean outlet. • There shall be no littering by personnel associated with construction of the ocean outfall. All rubbish will be placed in dedicated waste bins and returned to shore for appropriate disposal. • Work vessels must not block the direction of travel of any wildlife, particularly a whale, dolphin, sea lion or turtle, or any passage of escape available to wildlife from an area where escape is otherwise prevented by a barrier, shallow water, vessel or some other obstacle to the animal's free passage. • Wherever possible, a distance of at least 300 m will be maintained from any whale and a whale shall never be deliberately approached by construction personnel or vessels. • Wherever possible, a distance of at least 150 m will be maintained from any dolphin and a dolphin shall never be deliberately approached by construction personnel or vessels. • Wherever possible, a distance of at least 50 m will be maintained from any sea lion or turtle and a sea lion or turtle shall never be deliberately approached by construction personnel or vessels. • Vessels will not stop suddenly or change direction suddenly if a whale, dolphin, turtle or sea lion is in close proximity to the vessel. • All construction personnel shall comply with all relevant components of the Australian National Guidelines for Whale and Dolphin Watching 2005 (Appendix I).

	• Wherever possible, wide, deep channels will be used as transport routes for work vessels. Shallow areas and seagrass beds will be avoided. • Wherever possible outboard motors on work vessels should be able to tilt up (rather than lock-down) in the event of a collision with marine fauna.
Performance Indicators	• No marine mammal or turtle mortalities during construction. • No significant change in diversity and abundance of benthic fauna outside the defined construction footprint.
Monitoring	• Post-construction benthic fauna monitoring will be undertaken within 2 months of completion of construction and compared qualitatively to pre-construction diversity detailed in the Oceanica Benthic Habitat Mapping and Infauna Survey (2005). • Post-construction sampling will be undertaken consistent with the methods used during pre-construction benthic surveys (Oceanica, 2005). • Monitoring sites will be adjacent to those used for pre-construction surveys (Oceanica, 2005). • Visually monitoring for the presence of marine mammals and turtles within a 1.5 km radius of active blasting will be undertaken prior to and throughout blasting. • A dedicated marine fauna watch will be in place to search for marine mammals and turtles during all voyages of work vessels to avoid boat strike. • The approximate number of dead fish resulting from each blast will be observed and recorded in the Marine Fauna Log Book.
Responsibility	• The AWA Manager is responsible for ensuring that each of the monitoring programs is implemented. These programs may be subcontracted to a specialist sub-consultant. • The Blasting Contractor is responsible for monitoring the dredging operation and undertaking management actions assigned to them. • The Dredging Contractor is responsible for monitoring the dredging operation and undertaking management actions assigned to them.
Reporting	• A brief summary of any interactions with marine fauna will be incorporated into the Monthly Environmental Update Report, which will be submitted to the AWA Manager, Water Corporation, EPA and DEC. • Primary findings and evidence of compliance with the Ministerial Statement will be compiled in the Annual Compliance Report. This report will be provided to AWA Manager, Water Corporation, EPA and DEC and will also be made publicly available.

	• Any injury or mortality of marine mammals, turtles or other protected fauna will be reported immediately to the AWA Environment Manager, who will then report the incident to Water Corporation, EPA and DEC as soon as practicable but within 48 hours. • All sightings of marine mammals or turtles, within 1.5 km of construction activities or work vessels will be recorded in a Marine Fauna Log Book and reported quarterly to the Australian Fisheries Management Authority (AFMA).
Corrective Action	• Should the presence of marine mammals or turtles be observed within a 1.5 km radius of the blast area, the following contingency actions will be undertaken: ▪ The marine mammal or turtle will be closely observed by one support vessel. ▪ If the marine mammal or turtle enters a 1 km radius of the blast area, blasting will cease. ▪ Blasting may only resume when the marine mammal or turtle is outside a 1 km radius of the blast area. ▪ If the animal remains within the specified radius for more than 15 minutes, a small warning blast may be detonated in an attempt to move the animal out of the area. ▪ If any marine mammal or turtle is observed to be in distress, as a result of the project or otherwise, the AWA Environment Manager should be notified immediately, along with DEC's Wildcare Hotline on (08) 9474 9055 (24-hour emergency number) or the DEC Duty Officer on (08) 9334 0224.

5.5 Element 5: Heritage

5.5.1 Summary of Predicted Impacts

The Alkimos shipwreck lies approximately 500 m to the north of the ocean outlet pipeline route, while the wreck of the Eglinton lies more than 2.5 km to the south of the pipeline route. Although no direct impacts to these shipwrecks are anticipated, it is important that construction vessels avoid the area surrounding the wrecks to prevent potential impacts to the heritage of the site. Avoidance of these areas will also minimise safety risks posed by these wrecks.

5.5.2 Procedures

Element	Heritage
Performance Objective	• *To avoid impacts to the Alkimos and Eglinton shipwrecks.*
Proactive Management Actions	• The precise locations of the Alkimos and Eglinton will be recorded on GPS systems used by all work vessels ▪ Alkimos: 31°36.613437; 115° 39.24134 ▪ Eglinton: 31° 38.4500; 115° 39.5400 • All vessel skippers will be made aware of the presence of the wrecks in the area • Work vessels shall not occupy the waters within 100 m of either shipwreck at any time
Performance Indicators	• No damage occurs to the Alkimos or Eglinton wrecks due to construction activities or vessels.
Monitoring	• The location of construction activities and vessels will be monitored to ensure they do not encroach on a 100 m buffer surrounding each wreck.
Responsibility	• Marine Superintendent is responsible for ensuring all skippers are aware of the presence of the wrecks. • Vessel skippers are responsible for remaining at least 100 m from wrecks.
Reporting	• The responsible party must complete an environmental incident report and corrective action report as soon as practicable, but within 24 hours of an incident occurring, and forward this to the Superintendent's Site Representative. • The Superintendent's Site Representative forwarding the aforementioned incident and corrective action reports to the Superintendent's Representative and the AWA Manager as soon as possible.
Corrective Action	• Relevant authorities will be notified of any incident involving the Alkimos or Eglinton wrecks within 24 hours of an incident occurring.

5.6 Element 6: Air Quality

5.6.1 Summary of Predicted Impacts

Likely sources of air emissions during construction of the ocean outlet are limited to exhaust emissions from the dredge plant and equipment, which are considered minor emissions. Given the location of works offshore from Alkimos and the relative remoteness of works, it is not expected that regional air quality will be impacted.

5.6.2 Procedures

Element	Air Quality
Performance Objective	• *To minimise air emissions produced during construction works.*
Proactive Management Actions	• All plant and equipment used during the construction works shall be regularly maintained to comply with the relevant exhaust emission guidelines. • Prior to commencement of work, all construction equipment will be inspected by a qualified mechanic to reduce the risk of hydrocarbon spills and minimise green house gas emissions.
Performance Indicators	• There shall be no visible dark emissions from vessel exhausts.
Monitoring	• The Dredging Contractor is to visually monitor emissions and repair or replace equipment parts as required.
Responsibility	• The Dredging Contractor is responsible for visual monitoring of emissions from the dredge.
Reporting	• The Dredging Contractor is to report any visible dark emissions from the dredge to the Superintendent's Dredging Site Representative who will advise the AWA Manager. • The Dredging Contractor must provide the AWA Manager with details of the total amount of fuel used during the construction works.
Corrective Action	• Repair or replace emission control devices.

6 IMPACT VALIDATION (OPERATION) STAGE 4

A program of proactive and reactive management measures, integrated with routine and reactive monitoring, has been developed to limit the impacts of operation of the ocean outlet to those predicted in Section 4.5. The following sections define the management and monitoring actions associated with key environmental elements to be implemented during operation. These actions are intended to minimise and validate predicted impacts.

Operation of the ocean outlet in this section refers to the ongoing presence of the pipeline in the environment, as well as the potential impacts of any maintenance undertaken on the pipeline. The impacts of ocean outlet discharge are outside the scope of this document and are covered in a separate document that will be prepared to satisfy Ministerial Condition 11.

6.1 Element 1: Water Quality

6.1.1 Summary of Predicted Impacts

The primary predicted impact on water quality is the potential for fuel spills or leaks during maintenance activities. Although a major spill or leak is not predicted to occur, emergency procedures must be in place in case of such an incident. A minor risk of small scale incidents also exists.

6.1.2 Procedures

Element	**Water Quality**
Performance Objective	• *To minimise the potential for and impact of fuel spills or leaks during maintenance activities.*
Proactive Management Actions	• A program of regular preventative maintenance will be implemented for all vessels and equipment to be used during operation of the ocean outlet. • Prior to commencement of maintenance work, all vessels and equipment will be inspected by a qualified mechanic to reduce the risk of fuel spills and leaks. • All wastes and spillages will be contained on board vessels and appropriate storage and disposal practices will be implemented. • A spill cleanup kit will be provided to deal with spills on the maintenance vessels and an oil spill boom will also be available at all times for containment of spills on water.
Performance Indicators	• No contamination of the marine environment by hazardous substances from maintenance activities. • In the event of a spill to the marine environment, the aforementioned procedures have been undertaken.

Monitoring	• Maintenance Contractor to monitor the maintenance activities on a continual basis and report any incidents that are likely to cause environmental harm to the project location and surrounding areas.
Responsibility	• The AWA Environment Manager is responsible for ensuring that each of the monitoring programs is implemented. These programs may be subcontracted to a specialist sub-consultant. • The Maintenance Contractor is responsible for monitoring all maintenance operations and undertaking management actions assigned to them.
Reporting	• The Maintenance Contractor will immediately report any incidents affecting water quality to the AWA Environment Manager. • The Maintenance Contractor must complete an environmental incident report and corrective action report as soon as practicable, but within 24 hours of an incident occurring, and forward this to the AWA Environment Manager. • The AWA Environment Manager must report, to the Regulatory Committee, any incidents affecting water quality within 24 hours.
Corrective Action	• In the event of a spill to the marine environment, the dredging contractor is to undertake the following procedure: ▪ Stop the source of the spill. ▪ Prevent the oil/chemical from entering the water and mop up the spill with appropriate absorbent material from the onboard spill kit. The absorbent material is to be stored onboard until it can be appropriately disposed of offshore to a licensed facility. ▪ Notify the following personnel immediately: • AWA Marine Superintendent – Paul Harries 0417 099 433 • AWA Oil Response – Kate McManus 0448 978 752 • AWA Environment Manager – Jason Hick 0409 940 969 • After details of the incident have been confirmed and compiled into an incident report, AWA will coordinate the notification of relevant agencies and additional stakeholders.

6.2 Element 2 Benthic Primary Producer Habitat

6.2.1 Summary of Predicted Impacts

Potential impacts to BPPH may result from launching and anchoring of vessels (including for maintenance) during operation, as well as from erosion halos underneath the pipeline.

6.2.2 Procedures

Element	Benthic Primary Producer Habitat
Performance Objective	• *To avoid loss of BPPH during to launching and anchoring of vessels during operation.*
Proactive Management Actions	• Skippers will be instructed on the environmental sensitivities of the area and their responsibility in regard to protecting BPPH. • Vessels shall not be launched within or close to seagrass beds and vessel routes shall avoid areas with shallow seagrass beds. • 'Cyclone' rather than 'Swing' moorings shall be installed where moorings are required. • There shall be no anchoring of vessels within seagrass areas unless in an emergency situation. • The Maintenance Contractor will ensure that all equipment is not significantly fouled and does not contain any introduced marine pests. • Preventative maintenance will be undertaken in areas with the potential for erosion halos to occur.
Performance Indicators	• No net loss of BPPH resulting from operation of the ocean outlet.
Monitoring	• For the first 2 to 3 years of operation, surveys will be undertaken to monitor the extent of BPPH. This will be compared to pre-construction and post-construction surveys. Monitoring techniques identical to those used during construction will be utilised. • Maintenance Contractor to monitor the maintenance activities on a continual basis and report any incidents that are likely to cause loss of BPPH in the project location and surrounding areas.
Responsibility	• The AWA Environment Manager is responsible for ensuring that each of the monitoring programs is implemented. These programs may be subcontracted to a specialist sub-consultant. • The Maintenance Contractor is responsible for monitoring all maintenance operations and undertaking management actions assigned to them.
Reporting	• The Maintenance Contractor will immediately report any incidents affecting BPPH to the AWA Environment Manager. • The Maintenance Contractor must complete an environmental incident report and corrective action report as soon as practicable, but within 24 hours of an incident occurring, and forward this to the AWA Environment Manager.

	• The AWA Environment Manager must report, to the Regulatory Committee, any incidents affecting BPPH within 24 hours. • A report will be prepared and submitted to the DEC CEO annually for at least the first three years of operation, detailing the extent of BPPH in the vicinity of the ocean outlet and any proposed or completed rehabilitation.
Corrective Action	• An investigation will be undertaken into the cause of any net loss of BPPH. • Backfilling with aggregate of eroded areas under or adjacent to the pipeline.

6.3 Element 3: Seabed (subtidal, intertidal and beaches)

6.3.1 Summary of Predicted Impacts

No long term impacts are expected to result from the ongoing presence of the ocean outlet pipeline. However, minor erosion halos may occur under the pipeline in some areas. The pipeline is not predicted to significantly influence local water movement and sediment transport processes.

6.3.2 Procedures

Element	**Seabed**
Performance Objective	• *To avoid long-term impacts to the seabed due to the ongoing presence of the ocean outlet.*
Proactive Management Actions	• The pipeline has been designed and constructed to avoid long-term impacts to the seabed. • Preventative maintenance will be undertaken in areas with the potential for erosion halos to occur. • Preventative maintenance of beach areas will be undertaken if necessary to maintain the integrity of such areas.
Performance Indicators	• No significant change to seabed outside the area of direct impact.
Monitoring	• The condition of the pipeline and surrounding seabed will be monitored regularly to detect any maintenance requirements. • For at least the first three years of operation, surveys will be undertaken to map the seabed condition. This will be compared to pre-construction surveys. Such surveys will comprise a quantitative assessment of changes to the seabed.
Responsibility	• The AWA Environment Manager is responsible for ensuring that all monitoring programs are implemented. These programs may be subcontracted to a specialist sub-consultant.

	• The Maintenance Contractor is responsible for monitoring the dredging operation and undertaking management actions assigned to them.
Reporting	• The Maintenance Contractor will immediately report any incidents affecting the seabed to the AWA Environment Manager. • The Maintenance Contractor must complete an environmental incident report and corrective action report as soon as practicable, but within 24 hours of an incident occurring, and forward this to the AWA Environment Manager. • The AWA Environment Manager must report, to the Regulatory Committee, any incidents affecting the seabed within 24 hours. • A report will be prepared and submitted to the DEC CEO annually for 2 to 3 years after the beginning of operation, detailing the seabed condition in the vicinity of the ocean outlet and any proposed or completed rehabilitation.
Corrective Action	• The contingency actions that may be implemented to address excessive accretion on beach areas include: ▪ excavation of accreted sand using a land-based excavator ▪ sand replenishment ▪ rock armouring to increase stability ▪ backfilling with aggregate of eroded areas under or adjacent to the pipeline.

6.4 Element 4: Marine Fauna

6.4.1 Summary of Predicted Impacts

Direct impacts to marine fauna are predicted to result from activities associated with maintenance activities to the proposed pipeline route. Maintenance activities including vessel movements, chemical spills, noise and vibration affects from the use of tools and other mechanical equipment have the potential to impact on marine fauna.

No direct impacts to marine fauna are predicted to result from operation of the ocean outlet, although the potential for boat strike exists. Indirect impacts, including noise and vibration and chemical spills associated maintenance activities are possible.

6.4.2 Procedures

Element	Marine Fauna
Performance Objective	• *To minimise direct and indirect impacts to marine fauna during operation of the ocean outfall.*
Proactive Management Actions	• Controlled drill and blast (as opposed to surface blasting) will be used. • Work vessels must not block the direction of travel of any wildlife, particularly a whale, dolphin, sea lion or turtle, or any passage of escape available to wildlife from an area where escape is otherwise prevented by a barrier, shallow water, vessel or some other obstacle to the animal's free passage. • Wherever possible, a distance of at least 300 m will be maintained from any whale and a whale shall never be deliberately approached by construction personnel or vessels. • Wherever possible, a distance of at least 150 m will be maintained from any dolphin and a dolphin shall never be deliberately approached by construction personnel or vessels. • Wherever possible, a distance of at least 50 m will be maintained from any sea lion or turtle. No Sea lions or turtles will be deliberately approached by personnel or vessels. • Vessels will not stop suddenly or change direction suddenly if a whale, dolphin, turtle or sea lion is in close proximity to the vessel. • All construction personnel shall comply with all relevant components of the Australian National Guidelines for Whale and Dolphin Watching 2005 (Appendix I). • Wherever possible, wide, deep channels will be used as transport routes for work vessels. Shallow areas and seagrass beds will be avoided. • Wherever possible outboard motors on work vessels should be able to tilt up (rather than lock-down) in the event of a collision with marine fauna. • Noise and vibration will be kept to a minimum whilst work is been undertaken. • All chemicals will be stored in a bunded area with appropriate spill kits. • Any chemical spills will actioned and contained as appropriate. • Chemical spills to the marine environment will be reported immediately to the Regulatory Committee for actioning.
Performance Indicators	• No marine mammal or turtle mortalities during construction. • No significant change in diversity and abundance of benthic fauna outside the defined construction footprint.

Monitoring	• Visual Onsite monitoring for live, injured or dead marine fauna will be undertaken during maintenance activities. • Observations will be recorded in the Marine Fauna Log Book.
Responsibility	• The AWA Manager is responsible for ensuring that each of the monitoring programs is implemented. These programs may be subcontracted to a specialist sub-consultant. • The Dredging Contractor is responsible for monitoring the dredging operation and undertaking management actions assigned to them.
Reporting	• A brief summary of any interactions with marine fauna will be incorporated into the Annual Environmental Update Report, which will be submitted to the AWA Manager, Water Corporation, EPA and DEC. • Primary findings and evidence of compliance with the Ministerial Statement will be compiled in the Annual Compliance Report. This report will be provided to AWA Manager, Water Corporation, EPA and DEC and will also be made publicly available. • Any injury or mortality of marine mammals, turtles or other protected fauna will be reported immediately to the AWA Environment Manager, who will then report the incident to Water Corporation, EPA and DEC as soon as practicable but within 48 hours. • All sightings of marine mammals or turtles, within 1.5 km of construction activities or work vessels will be recorded in a Marine Fauna Log Book and reported to the Australian Fisheries Management Authority (AFMA).
Corrective Action	• If any marine mammal or turtle is observed to be in distress, as a result of the project or otherwise, the AWA Environment Manager should be notified immediately, along with DEC's Wildcare Hotline on (08) 9474 9055 (24-hour emergency number) or the DEC Duty Officer on (08) 9334 0224.

6.5 Element 5: Heritage

6.5.1 Summary of Predicted Impacts

Impacts to the Alkimos and Eglinton shipwrecks may result from interference operation vessels and equipment.

6.5.2 Procedures

Element	Heritage
Performance Objective	• *To avoid impacts to the* Alkimos *and* Eglinton *shipwrecks.*
Proactive Management Actions	• The precise locations of the *Alkimos* and *Eglinton* will be recorded on GPS systems used by all work vessels. ▪ *Alkimos*: 31°36.613437; 115 ° 39.24134 ▪ *Eglinton*: 31 ° 38.4500; 115 ° 39.5400 • All vessel skippers will be made aware of the presence of the wrecks in the area. • Work vessels shall not occupy the waters within 100 m of either shipwreck at any time.
Performance Indicators	• No damage to the *Alkimos* or *Eglinton* wrecks due to construction activities or vessels.
Monitoring	• The location of operational activities and vessels will be monitored to ensure they do not encroach on a 100 m buffer surrounding each wreck.
Responsibility	• Marine Superintendent is responsible for ensuring all skippers are aware of the presence of the wrecks. • Vessel skippers are responsible for remaining at least 100 m from wrecks.
Reporting	The responsible party must complete an environmental incident report and corrective action report as soon as practicable, but within 24 hours of an incident occurring, and forward this to the AWA Environment Manager.
Corrective Action	• Relevant authorities will be notified of any incident involving the *Alkimos* or *Eglinton* wrecks within 24 hours of an incident occurring.

6.6 Element 6: Air Quality

6.6.1 Summary of Predicted Impacts

Likely sources of air emissions during operation of the ocean outlet are limited to exhaust emissions from maintenance vessels and equipment.

6.6.2 Procedures

Element	**Air Quality**
Performance Objective	• *To minimise air emissions produced during operation.*
Proactive Management Actions	• All plant and equipment used during the operation shall be regularly maintained to comply with the relevant exhaust emission guidelines. • Prior to commencement of work, all equipment will be inspected by a qualified mechanic to minimise green house gas emissions.
Performance Indicators	• There shall be no visible dark emissions from vessel exhausts.
Monitoring	• The Maintenance Contractor is to visually monitor emissions and repair or replace equipment parts as required.
Responsibility	• The Maintenance Contractor is responsible for visual monitoring of emissions from the dredge.
Reporting	• The Maintenance Contractor is to report any visible dark emissions from the plant or equipment to the AWA Environment Manager. • The Maintenance Contractor must provide the AWA Environment Manager with details of the total amount of fuel used during the operational works.
Corrective Action	• Repair or replace emission control devices.

7 REPORTING AND AUDITING

Internal and external reporting will be undertaken throughout the duration of implementation of the MPCOOP. All reports will be made available to the Water Corporation, DEC and EPA upon request. Records and copies of reports completed as part of the MPCOOP will be maintained throughout the life of the Alkimos Wastewater Scheme.

7.1 Compliance Auditing

Weekly progress meetings monitoring the project's environmental performance will be held between the Environment and Community Relations Manager, Site Environmental Coordinator and Marine Superintendent, with findings from these being directly reported back to the Alliance Manager. All monitoring undertaken on site (either daily/weekly/monthly) by the Site Coordinator/Engineer will be documented in a dedicated monitoring log book and updated into a data base available to the Site Environmental Coordinator for review. This data will be discussed within the weekly progress meetings.

Throughout the construction periods, internal Environmental Audits will be undertaken monthly by the Environment and Community Relations Manager and the Site Environmental Coordinator. Audit will ensure compliance with the MPCOOP is being achieved with a view to immediately rectifying any identified shortcomings. All audit findings will be reported to the Alliance Manager.

Quarterly Environmental Audits by the Water Corporation Environment Branch will also be conducted to ensure compliance with the MPCOOP. Audit findings will be reported directly to the Environment and Community Relations Manager and the Alliance Manager.

The AWA in conjunction with the Water Corporation will undertake annual Compliance Audits to ensure compliance with all the conditions outlined in Ministerial Statement 755. Detailed audit reports will be made available to the DEC Audit and Compliance Branch.

7.2 Internal Reporting

The AWA will prepare a Weekly Environmental Report following each weekly meeting between the Marine Superintendent, the Site Environmental Coordinator and the Environmental and Community Relations Manager. Weekly Environmental Reports will include:

- issues raised and outcomes of weekly meetings
- review of induction procedures (where required) and records of personnel inducted
- updates on progress of construction (including dredging) and the observed degree of resultant disturbance to the environment
- environmental issues, incidents and near-misses occurring during construction and actions taken or proposed resolutions.

Weekly Environmental Reports will be provided to the Alliance Manager and made available to the Water Corporation, DEC and EPA upon request.

7.3 External Compliance Reporting

7.3.1 Monthly Environmental Update Report

The Water Corporation and DEC will be provided with Monthly Environmental Update reports pertaining to the MPCOOP. Monthly Environmental Updates will include:

- primary findings from Weekly Environmental Reports
- primary monitoring outcomes
- any exceedance of trigger values and subsequent implementation of contingency actions
- environmental issues, incidents and near-misses occurring during construction and actions taken or proposed resolutions
- overall compliance with the MPCOOP.

7.3.2 Annual Environmental Compliance Report

The AWA, on behalf of the Water Corporation, will submit Annual Environmental Compliance Reports to the DEC for the duration of the MPCOOP documenting compliance over the previous 12 months with the MPCOOP and all Ministerial Conditions relevant to construction of the ocean outlet. (Appendix B details the interpretation of the relevant conditions). The report will include:

- endorsement of the Water Corporation's CEO (or delegate thereof)
- implementation and outcomes of compliance auditing
- verification of compliance with relevant Ministerial Conditions and MPCOOP
- non-compliances, non-conformances and corrective and preventative actions undertaken
- assessment of the effectiveness of corrective and preventative actions undertaken
- description of the current state and progress of construction of the MPCOOP.

Annual Environmental Compliance Reports will also address all requirements of Condition 4-3 of the Ministerial Statement in regard to the whole Alkimos Wastewater Scheme and will be made publicly available via the water Corporation's website.

7.3.3 Performance Review Report

The implementation and outcomes of the MPCOOP will also be documented as part of a Performance Review Report, which will be submitted to the EPA on completion of the construction of the project. In relation to the MPCOOP, the Performance Review Report will address:

- major environmental issues associated with construction of the ocean outlet pipeline
- environmental achievements associated with construction of the ocean outlet pipeline
- overall compliance with the MPCOOP.

The Performance Review Report will also address all requirements of Condition 5-1 of the Ministerial Statement in regard to the whole Alkimos Wastewater Scheme.

8 ROLES AND RESPONSIBILITIES

In order to ensure that AWA adequately resources and complies with the MPCOOP throughout the life of the project, various responsibilities have been delegated to personnel within the Alkimos Wastewater Scheme. These roles and responsibilities are outlined in Appendix J.

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APPENDIX A - MINISTERIAL STATEMENT NO. 755

Published on 12 November 2007 Statement No. 755

STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF THE ENVIRONMENTAL PROTECTION ACT 1986)

ALKIMOS WASTEWATER TREATMENT PLANT – SITE B
CITY OF WANNEROO

Proposal: The construction and operation of a wastewater treatment plant, and associated ocean outfall, on the Alkimos-Eglinton Dunal System with an ultimate processing capacity of 160 megalitres per day, as documented in schedule 1 of this statement.

Proponent: Water Corporation

Proponent Address: 629 Newcastle Street, LEEDERVILLE WA 60072

Assessment Number: 1529

Report of the Environmental Protection Authority: Bulletin 1239

The proposal referred to in the above report of the Environmental Protection Authority may be implemented. The implementation of that proposal is subject to the following conditions and procedures (See note 1 at foot of this statement):

1 Proposal Implementation

1-1 The proponent shall implement the proposal as documented and described in schedules 1, 2 and 3 of this statement subject to the conditions and procedures of this statement.

2 Proponent Nomination and Contact Details

2-1 The proponent for the time being nominated by the Minister for the Environment under sections 38(6) or 38(7) of the Environmental Protection Act 1986 is responsible for the implementation of the proposal.

2-2 The proponent shall notify the Chief Executive Officer of the Department of Environment and Conservation (CEO) of any change of the name and address of the proponent for the serving of a notice or other correspondence within 30 days of such change.

3 Time Limit of Authorisation

3-1 The authorisation to implement the proposal provided for in this statement shall lapse and be void within five years after the date of this statement if the proposal to which this statement relates is not substantially commenced.

3-2 The proponent shall provide the CEO with written evidence which demonstrates that the proposal has substantially commenced on or before the expiration of five years from the date of this statement.

4 Compliance Reporting

4-1 The proponent shall submit to the CEO environmental compliance reports annually reporting on the previous twelve-month period, unless required by the CEO to report more frequently.

4-2 The environmental compliance reports shall address each element of an audit program approved by the CEO and shall be prepared and submitted in a format acceptable to the CEO.

4-3 The environmental compliance reports shall:

1. be endorsed by signature of the proponent's Chief Executive Officer or a person, approved in writing by the CEO, delegated to sign on behalf of the proponent's Chief Executive Officer;
2. state whether the proponent has complied with each condition and procedure contained in this statement;
3. provide verifiable evidence of compliance with each condition and procedure contained in this statement;
4. state whether the proponent has complied with each key action contained in any environmental management plan or program required by this statement;
5. provide verifiable evidence of conformance with each key action contained in any environmental management plan or program required by this statement;
6. identify all non-compliances and non-conformances and describe the corrective and preventative actions taken in relation to each non-compliance or non-conformance;
7. provide an assessment of the effectiveness of all corrective and preventative actions taken; and
8. describe the state of implementation of the proposal.

4-4 The proponent shall make the environmental compliance reports required by condition 4-1 publicly available in a manner approved by the CEO.

5 Performance Review

5-1 The proponent shall submit a Performance Review report every five years after the start of construction to the Environmental Protection Authority, which addresses:

1. the major environmental issues associated with implementing the project; the environmental objectives for those issues; the methodologies used to achieve

these; and the key indicators of environmental performance measured against those objectives;

2. the level of progress in the achievement of sound environmental performance, including industry benchmarking, and the use of best available technology where practicable;
3. investigations undertaken in relation to developing alternative options to ocean disposal of treated wastewater, including wastewater re-use;
4. significant improvements gained in environmental management, including the use of external peer reviews;
5. stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed; and
6. the proposed environmental objectives over the next five years, including improvements in technology and management processes.

6 Terrestrial Construction Management Plan

6.1 Up to three launch/recovery chambers may be used for tunneling of the overland pipeline. These chambers are to be located within the footprint of the WWTP and the footprint of the launch site. Any intermediate chamber is to be located outside a Bush Forever site or Conservation Area as identified by the Water Corporation, to be rehabilitated upon completion of the tunneling.

6-2 Prior to commencement of clearing for the installation of the pipeline, the proponent shall prepare and submit, a Terrestrial Construction Management Plan (the Plan) that meets the objective of Condition 6-3 and the requirements of Condition 6-4 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.

6-3 The objective of the Plan is to protect native vegetation and landforms on the site outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3.

6-4 The Plan shall address the following:

1. modification and configuration (dimension, shape and gradient) of the launch site as far as practicable to minimise the impact of the on terrestrial vegetation and formations launch site dimensions;
2. access roads;
3. sheds, amenities, and other facilities to be installed;
4. management of activities in areas outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3;
5. depth of burial of pipe sufficient to withstand a one-in-one hundred year storm;
6. impacts on the beach profile;
7. Bush Forever site, including *Frankenia pauciflora*;
8. Threatened Ecological Communities; and

9. rehabilitation of the launch site/s.

6-5 The proponent shall implement the Plan.

6-6 The proponent shall make the Plan available in a manner approved by the CEO.

6-7 Prior to ground-disturbing activities and in consultation with the Department of Environment and Conservation, the proponent shall put in place measures (which may include fencing and/or signposting) to delineate and protect the locations of plants, vegetation, or other areas of particular conservation significance.

In carrying out rehabilitation activities, the proponent shall only use native plant species of local provenance, defined as plant material or seeds collected within ten kilometres of the project site, except with permission in writing from the CEO.

7. Stability of dunes

7-1 The proponent shall construct the WWTP and associated works to ensure the ongoing stability of the dunal system outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3.

8. Ocean Outlet Pipeline Construction Management Plan (Marine)

8-1 Prior to commencement of installation of the pipeline, the proponent shall prepare and submit an Ocean Outlet Pipeline Construction Management Plan (the Plan) that meets the objectives set out in Condition 8.2 that meets the requirements of 8.3 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

8-2 The objectives of the Plan is to

(a) ensure the maintenance of the ecological integrity of the marine waters surrounding the Alkimos site; and

(b) ensure the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4

8-3 The Plan shall address the following:

1 route design;

2. define the spatial definition of the extent of the disturbance footprint

(a) direct loss of habitat due to construction,

(b) indirect loss of habitat due to construction (sediment plume impacts – loss of light and burial) ;

3. prediction and spatially definition of the long-term stable’ state of the marine environment following construction and taking into account indirect effects of construction and on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect

impacts (construction and ongoing impact (see Note 9).

4 amount and type of material to be excavated;

5 rehabilitation of excavated trenches;

6 blasting techniques and areas where blasting occurs;

7 identify where drilling and open-cut techniques (minimising open-cut technique) are to be used for the entire pipe installation;

8 positioning of pipe-laying vessels, mooring pattern design and dredge support vessels;

9 management of benthic community in construction areas;

10 monitoring and establishment of impact from anchoring, wire and chain sweep techniques, marine dredging and supra-tidal excavation techniques used;

11 identification of areas to be dredged, excavated and the timing and duration of dredging/excavation;

12 water quality targets for criteria that will trigger management of sedimentation and protection of benthic community;

13 monitoring reporting, and mitigating impacts on natural littoral drift processes from construction activities and beach profiles during construction; and

14 the management actions and contingencies that will be implemented in the event that criteria for water quality targets required by point 12 above are not being met.

8-4 To ensure that the diffuser is located in a position to reduce the likelihood of plume impacts on high relief algal reefs immediately to the east of the outlet, the proponent shall extend the pipe length by 200 metres from the end of the pipe shown in Figure 4.17 of the proponent's Public Environmental Review document, Version 3, 8 November 2005. This will give a total pipe length of 3.7 kilometres from the high water mark.

8-5 The proponent is to ensure that the extent of the disturbance footprint (direct and indirect loss of habitat) is no greater than that defined in Condition 8-3 (2).

8-6 The proponent is to ensure that the extent of the disturbance footprint (direct impacts) shall be within the area defined in Figure 5 and Table 4 in Schedule 4.

8-7 The proponent is required to minimise indirect impacts as far as practicable within this boundary during construction.

8-8 The pipeline will be laid within the area defined in Figure 5 and Table 4 in Schedule 4, and the 'line' of direct disturbance footprint will also be within the area. (see note 9).

8-9 The proponent shall implement the Plan.

8-10 The proponent shall make Plan publicly available in a manner approved by the CEO.

9 Seabed and Benthic Habitat Monitoring and Management Plan

9-1 Prior to commencement of construction of the Alkimos ocean outlet in the marine environment, the proponent shall prepare and submit a Seabed and Benthic Habitat Monitoring and Management Plan (the Plan) that meets the objectives of condition 9-

Published on 12 November 2007 Statement No. 755

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CITY OF WANNEROO

Proposal: The construction and operation of a wastewater treatment plant, and associated ocean outfall, on the Alkimos-Eglinton Dunal System with an ultimate processing capacity of 160 megalitres per day, as documented in schedule 1 of this statement.

Proponent: Water Corporation

Proponent Address: 629 Newcastle Street, LEEDERVILLE WA 60072

Assessment Number: 1529

Report of the Environmental Protection Authority: Bulletin 1239

The proposal referred to in the above report of the Environmental Protection Authority may be implemented. The implementation of that proposal is subject to the following conditions and procedures (See note 1 at foot of this statement):

1 Proposal Implementation

1-1 The proponent shall implement the proposal as documented and described in schedules 1, 2 and 3 of this statement subject to the conditions and procedures of this statement.

2 Proponent Nomination and Contact Details

2-1 The proponent for the time being nominated by the Minister for the Environment under sections 38(6) or 38(7) of the Environmental Protection Act 1986 is responsible for the implementation of the proposal.

2-2 The proponent shall notify the Chief Executive Officer of the Department of Environment and Conservation (CEO) of any change of the name and address of the proponent for the serving of a notice or other correspondence within 30 days of such change.

3 Time Limit of Authorisation

3-1 The authorisation to implement the proposal provided for in this statement shall lapse and be void within five years after the date of this statement if the proposal to which this statement relates is not substantially commenced.

3-2 The proponent shall provide the CEO with written evidence which demonstrates that the proposal has substantially commenced on or before the expiration of five years from the date of this statement.

4 Compliance Reporting

4-1 The proponent shall submit to the CEO environmental compliance reports annually reporting on the previous twelve-month period, unless required by the CEO to report more frequently.

4-2 The environmental compliance reports shall address each element of an audit program approved by the CEO and shall be prepared and submitted in a format acceptable to the CEO.

4-3 The environmental compliance reports shall:

1. be endorsed by signature of the proponent's Chief Executive Officer or a person, approved in writing by the CEO, delegated to sign on behalf of the proponent's Chief Executive Officer;
2. state whether the proponent has complied with each condition and procedure contained in this statement;
3. provide verifiable evidence of compliance with each condition and procedure contained in this statement;
4. state whether the proponent has complied with each key action contained in any environmental management plan or program required by this statement;
5. provide verifiable evidence of conformance with each key action contained in any environmental management plan or program required by this statement;
6. identify all non-compliances and non-conformances and describe the corrective and preventative actions taken in relation to each non-compliance or non-conformance;
7. provide an assessment of the effectiveness of all corrective and preventative actions taken; and
8. describe the state of implementation of the proposal.

4-4 The proponent shall make the environmental compliance reports required by condition 4-1 publicly available in a manner approved by the CEO.

5 Performance Review

5-1 The proponent shall submit a Performance Review report every five years after the start of construction to the Environmental Protection Authority, which addresses:

1. the major environmental issues associated with implementing the project; the environmental objectives for those issues; the methodologies used to achieve

these; and the key indicators of environmental performance measured against those objectives;

2. the level of progress in the achievement of sound environmental performance, including industry benchmarking, and the use of best available technology where practicable;
3. investigations undertaken in relation to developing alternative options to ocean disposal of treated wastewater, including wastewater re-use;
4. significant improvements gained in environmental management, including the use of external peer reviews;
5. stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed; and
6. the proposed environmental objectives over the next five years, including improvements in technology and management processes.

6 Terrestrial Construction Management Plan

6.1 Up to three launch/recovery chambers may be used for tunneling of the overland pipeline. These chambers are to be located within the footprint of the WWTP and the footprint of the launch site. Any intermediate chamber is to be located outside a Bush Forever site or Conservation Area as identified by the Water Corporation, to be rehabilitated upon completion of the tunneling.

6-2 Prior to commencement of clearing for the installation of the pipeline, the proponent shall prepare and submit, a Terrestrial Construction Management Plan (the Plan) that meets the objective of Condition 6-3 and the requirements of Condition 6-4 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.

6-3 The objective of the Plan is to protect native vegetation and landforms on the site outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3.

6-4 The Plan shall address the following:

1. modification and configuration (dimension, shape and gradient) of the launch site as far as practicable to minimise the impact of the on terrestrial vegetation and formations launch site dimensions;
2. access roads;
3. sheds, amenities, and other facilities to be installed;
4. management of activities in areas outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3;
5. depth of burial of pipe sufficient to withstand a one-in-one hundred year storm;
6. impacts on the beach profile;
7. Bush Forever site, including *Frankenia pauciflora*;
8. Threatened Ecological Communities; and

9. rehabilitation of the launch site/s.

6-5 The proponent shall implement the Plan.

6-6 The proponent shall make the Plan available in a manner approved by the CEO.

6-7 Prior to ground-disturbing activities and in consultation with the Department of Environment and Conservation, the proponent shall put in place measures (which may include fencing and/or signposting) to delineate and protect the locations of plants, vegetation, or other areas of particular conservation significance.

In carrying out rehabilitation activities, the proponent shall only use native plant species of local provenance, defined as plant material or seeds collected within ten kilometres of the project site, except with permission in writing from the CEO.

7. Stability of dunes

7-1 The proponent shall construct the WWTP and associated works to ensure the ongoing stability of the dunal system outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3.

8. Ocean Outlet Pipeline Construction Management Plan (Marine)

8-1 Prior to commencement of installation of the pipeline, the proponent shall prepare and submit an Ocean Outlet Pipeline Construction Management Plan (the Plan) that meets the objectives set out in Condition 8.2 that meets the requirements of 8.3 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

8-2 The objectives of the Plan is to

(a) ensure the maintenance of the ecological integrity of the marine waters surrounding the Alkimos site; and

(b) ensure the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4

8-3 The Plan shall address the following:

1 route design;

2. define the spatial definition of the extent of the disturbance footprint

(a) direct loss of habitat due to construction,

(b) indirect loss of habitat due to construction (sediment plume impacts – loss of light and burial) ;

3. prediction and spatially definition of the long-term stable' state of the marine environment following construction and taking into account indirect effects of construction and on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect

impacts (construction and ongoing impact (see Note 9).

4 amount and type of material to be excavated;

5 rehabilitation of excavated trenches;

6 blasting techniques and areas where blasting occurs;

7 identify where drilling and open-cut techniques (minimising open-cut technique) are to be used for the entire pipe installation;

8 positioning of pipe-laying vessels, mooring pattern design and dredge support vessels;

9 management of benthic community in construction areas;

10 monitoring and establishment of impact from anchoring, wire and chain sweep techniques, marine dredging and supra-tidal excavation techniques used;

11 identification of areas to be dredged, excavated and the timing and duration of dredging/excavation;

12 water quality targets for criteria that will trigger management of sedimentation and protection of benthic community;

13 monitoring reporting, and mitigating impacts on natural littoral drift processes from construction activities and beach profiles during construction; and

14 the management actions and contingencies that will be implemented in the event that criteria for water quality targets required by point 12 above are not being met.

8-4 To ensure that the diffuser is located in a position to reduce the likelihood of plume impacts on high relief algal reefs immediately to the east of the outlet, the proponent shall extend the pipe length by 200 metres from the end of the pipe shown in Figure 4.17 of the proponent's Public Environmental Review document, Version 3, 8 November 2005. This will give a total pipe length of 3.7 kilometres from the high water mark.

8-5 The proponent is to ensure that the extent of the disturbance footprint (direct and indirect loss of habitat) is no greater than that defined in Condition 8-3 (2).

8-6 The proponent is to ensure that the extent of the disturbance footprint (direct impacts) shall be within the area defined in Figure 5 and Table 4 in Schedule 4.

8-7 The proponent is required to minimise indirect impacts as far as practicable within this boundary during construction.

8-8 The pipeline will be laid within the area defined in Figure 5 and Table 4 in Schedule 4, and the 'line' of direct disturbance footprint will also be within the area. (see note 9).

8-9 The proponent shall implement the Plan.

8-10 The proponent shall make Plan publicly available in a manner approved by the CEO.

9 Seabed and Benthic Habitat Monitoring and Management Plan

9-1 Prior to commencement of construction of the Alkimos ocean outlet in the marine environment, the proponent shall prepare and submit a Seabed and Benthic Habitat Monitoring and Management Plan (the Plan) that meets the objectives of condition 9-

2 and the requirements of 9-3 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.

9-2 The objective of this Plan is to ensure that seabed and benthic habitat loss outside the area of direct loss defined in the Plan required by Condition 8-3 (2) is avoided during construction and re-instated following construction.

9-3 This Plan shall address:

1. Procedures for obtaining and providing to the CEO, within six months following the completion of pipeline installation, an accurate total area and geographically referenced location map of areas of seabed (subtidal, intertidal and beaches) modification and benthic primary producer habitats lost or damaged during pipeline construction, including specific identification of any areas of loss or damage that are in excess or outside of those areas defined and predicted in the Plan required by Condition 8
2. Prediction and spatial definition of long-term stable' state of the marine environment following construction and taking into account on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impacts) (see also Condition 8-3 (3));
3. The establishment of a quantitative annual monitoring program of the seabed and benthic habitat condition in, and adjacent to, areas of seabed and benthic primary producer habitats damaged during pipeline installation and the ongoing presence of the infrastructure; and
4. The indicator(s) and criteria to be used to trigger cessation or reduction in the frequency of monitoring after three years following construction or, in the event of the trigger level referred to in item 3 above being exceeded, after the proponent has demonstrated the success of contingency actions in reducing the rate of annual seagrass loss or damage to less than the contingency trigger level referred to in item 3 above, for three successive years; and
5. Reporting procedures.

9-4 If within six months of completion of construction the marine habitat outside the area of direct impact has not returned to the state predicted in Condition 9-3 (3) the proponent is to commence contingency actions to ensure that the rate of post-construction seabed and/or benthic primary producer habitat loss or damage, is restricted and reduced.

9-5 The proponent shall implement the Plan.

9-6 The proponent shall make Plan publicly available in a manner approved by the CEO.

10 Fauna Management

10-1 Prior to ground-disturbing activity, the proponent shall prepare and submit a Fauna Management Plan (the Plan) that meets the requirements of Condition 10-2 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

10-2 The Plan shall address:

1 clearing of the construction area in a step-wise fashion as the plant expands, to reduce impacts on fauna;

2 avoidance of clearing land when Carnaby Cockatoos are actively breeding or foraging in the area; and

3 presence of terrestrial fauna and their translocation.

10-3 The proponent shall implement Plan.

10-4 The proponent shall make Plan publicly available in a manner approved by the CEO.

11 Marine Treated Wastewater Discharge Monitoring and Management Plan

11-1 Prior to commissioning of the wastewater treatment plant, the proponent shall prepare and submit a Marine Treated Wastewater Discharge Management Plan (the Plan) that meets the objective and Environmental Quality Objectives described in 11-2 and the requirements set out in 11-3 as determined by of the Minister for the Environment

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority and the Department of Environment and Conservation

11-2 The objective of the Plan is to ensure that the discharge of Alkimos treated wastewater is managed to achieve simultaneously the following Environmental Quality Objectives as described in the document, Perth's Coastal Waters: Environmental Values and Objectives (Environmental Protection Authority, February 2000).

- Environmental Quality Objective 1 (Maintenance of ecosystem integrity), with spatially-assigned levels of protection as shown in figure 2 of schedule 1;
- Environmental Quality Objective 2 (Maintenance of aquatic life for human consumption) assigned to all parts of the marine environment surrounding the Alkimos ocean outlet with the exception of zones shown in figure 2 of schedule 1; and
- Environmental Quality Objectives 3 and 4 (Maintenance of primary contact recreation values, and Maintenance of secondary contact recreation values) assigned to all parts of the marine environment surrounding the Alkimos ocean outlet with the exception of zones shown in figure 2 of schedule 1.

11-3 The Plan shall address:

1. within the Zone of Low Ecological Protection (i.e. within a 100 metres from the diffuser as shown in figure 1, schedule 2), the proponent shall seek to achieve the ANZECC & ARMCANZ1 80% species protection guideline "trigger" levels (as published from time to time) for bio-accumulating toxicants;
2. within the Zone of High Ecological Protection (i.e. beyond a 100 metres from the diffuser as shown in figure 1, schedule 2), the proponent shall seek to achieve the ANZECC & ARMCANZ 99% species protection guideline "trigger" levels (as published from time to time) for toxicants (with the exception of cobalt, where the 95% guideline shall apply),

3. the establishment of indicators and associated “trigger” levels for further investigations (environmental quality guidelines) for nutrients and social quality objectives;
4. the establishment of “trigger” levels for the implementation of remedial and/or preventative actions to protect the water quality and the environment off Alkimos (environmental quality standards) for toxicants, nutrients and social quality objectives;
5. the monitoring and evaluation, including remodelling, of the social and environmental effects of discharging treated wastewater into the marine environment off Alkimos to assess performance in the protection and maintenance of environmental values and objectives;
6. the specific management actions that will be implemented in the event that environmental quality standards levels are not met, including the option of modifying the diffuser to increase dilution;
7. a program to undertake whole-of-effluent toxicity testing of treated wastewater;
8. the monitoring and reporting of diffuser performance in terms of achieving required number of initial dilutions within the area of low level of ecosystem protection compared to the initial dilutions in schedule 1 under low energy/calm meteorological and sea-state conditions; and
9. the protocols and schedules for reporting performance against the Environmental Quality Objectives.

11-4 The proponent shall implement the Plan.

11-5 The proponent shall make the Plan publicly available in a manner approved by the CEO.

11-6 In the event that a guideline “trigger” level referred to in condition 11-3 is exceeded, the proponent shall report the matter to the Department of Environment and Conservation within one working day of determining that this has occurred, and shall initiate an investigation against the environmental quality standards and into the cause of the exceedance in accordance with the framework developed in the Revised Environmental Quality Criteria Reference Document (Cockburn Sound)2, to the requirements of the Minister for the Environment on advice of the Department of Environment and Conservation.

11-7 In the event that an environmental quality standard referred to in condition 11-3 is exceeded, the proponent shall initiate a management response to determine the source and remedy the exceedance in accordance with the implementation framework for the National Water Quality Management Strategy, to the requirements of the Minister for the Environment on advice of the Department of Environment and Conservation

Note:

1 ANZECC & ARMCANZ guidelines are published in Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

2 Revised Environmental Quality Criteria Reference Document (Cockburn Sound), A supporting document to the draft Environmental Protection (Cockburn Sound) Policy 2002, Environmental Protection Authority Report 20, November 2002.

3 Implementation framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Guidelines Nos 4 & 7: National Water Quality Management Strategy), Report of the Environmental Protection Authority, Bulletin 1078, November 2002.

11-8 Prior to submitting a Works Approval application for the plant, the proponent shall:

1. estimate the expected typical physico-chemical composition and flow rates of all wastewater streams discharging into the environment from the site;
2. estimate, for all non-negligible contaminants and nutrients, the total annual loads of contaminants and nutrients in the wastewater discharge exiting the site;
3. estimate, for normal and worst-case conditions, the concentrations of contaminants and nutrients (for agreed averaging periods) in the wastewater discharge exiting the site; and
4. Establish a reporting process that is an inventory of toxicants that enter and leave the plant.

11-9 Prior to submitting a Works Approval application for the plant, the proponent shall provide information to show how “best practicable technology” and waste minimisation principles for contaminants and nutrients have been adopted for the wastewater discharge.

11-10 Within three months following commissioning and stabilizing of plant operations, the proponent shall conduct an analysis demonstrating that effluent properties are substantially consistent with predictions. Similar analyses shall also be conducted within three months following every major increase in the volume of treated wastewater discharged from the plant or any significant change in effluent characteristics.

11-11 The proponent shall develop a Contingency Wastewater Management Plan which will consider alternate options for wastewater treatment and/or disposal in the event that the Water Quality Objectives are not met.

11-12 In the event that effluent properties are not substantially consistent with predictions (refer to condition 11-9), the proponent shall conduct toxicological studies on the actual effluent, or provide acceptable alternative information such as risk assessment, to the timing and other requirements of the Minister for the Environment.

These studies and/or information shall be consistent with ANZECC requirements

11-13 In the event that the findings resulting from condition 11-12 indicate that the effluent poses a significant risk to the diversity of the species and biological communities and abundance/biomass of marine life, the proponent shall implement the Contingency Wastewater Management Plan required by condition 11-11.

11-14 The proponent shall review and revise the Contingency Wastewater Management Plan required by condition 11-11.

11-15 The proponent shall make any revisions of the Contingency Wastewater Management Plan, as required by condition 11-11, publicly available in a manner approved by the CEO

12 Odour Management Plan

12-1 Prior to commencement of operation, the proponent shall prepare and submit an Odour Management Plan (the Plan) to meet the objective set out in Condition 12-2 and the requirement in Condition 12-3 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

12-2 The Objective of the Plan is to manage the impacts of odour on health and amenity.

12-3 The Plan shall address

1. an initial dynamic olfactometry determination;
2. the biofilter acclimation period;
3. procedures for the replacement of the biofilter media;
4. regular checks of biofilter loading to ensure that the biofilter is balanced and to identify any short circuits (e.g. surface flow rate measurements and smoke tests);
5. the size of the stack;
6. compliance with the odour criteria, and trigger mechanisms for remedial actions when appropriate;
7. regular qualitative determination of odour from the facility;
8. odour surveys every five years;
9. contingency plans during upset or maintenance conditions;
10. contingency plans in the event of exceedances; and
11. complaint registration, investigation and response.

12-4 The proponent shall implement the Plan.

12-5 The proponent shall make the Plan publicly available in a manner approved by the CEO

12-6 The proponent shall operate the plant at all times to ensure that odour at all adjacent odour sensitive premises meets criterion for odours set out in condition 12-7 .

12-7 The odour criterion referred to in Condition 12-6 shall be 5 odour units (OU) (based on the 99.9 percentile 1 hour averaging Australia Standard OU) or as specified by the CEO from time to time through amendment of the operating licence issued under Part V of the *Environment Protection Act 1986*.

13 Decommissioning and Closure Plan

13-1 At least two years prior to the anticipated date of decommissioning and closure, or at a time agreed by the Environmental Protection Authority, the proponent shall prepare and submit a Decommissioning and Closure Plan (the Plan) that meets the requirements of Condition 13-2 as determined by the Minister for the Environment

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

13-2 The Plan shall address:

1. removal or, if appropriate, retention of plant and infrastructure in consultation with relevant stakeholders;
2. rehabilitation to a standard suitable for the agreed new land use(s); and
3. identification of contaminated areas, including provision of evidence of notification and proposed management measures to relevant statutory authorities.

13-3 The proponent shall implement the Plan until such time as the Minister for the Environment determines, on advice of the Environmental Protection Authority, that the proponent's decommissioning and closure responsibilities have been fulfilled.

13-4 The proponent shall make the Plan publicly available in a manner approved by the CEO.

Notes

1. In the event that implementation of this proposal at Site B (Assessment No. 1529) is approved, implementation of the similar proposal at Site A (Assessment No. 1582), will not be approved.
2. The CEO may seek the advice of the Environmental Protection Authority, government agencies and relevant parties, as necessary, for the preparation of written notice to the proponent
3. The proponent should consult with relevant stakeholders, including but not necessarily limited to, the Department of Fisheries (regarding potential impacts on a rock lobster puerulis monitoring site) and the City of Wanneroo in the preparation of the management plans required by these conditions as and where appropriate.
4. The proponent is required to apply for a Works Approval and Licence for this project under the provisions of Part V of the *Environmental Protection Act 1986.*
5. The CEO will review the licence when the wastewater flow reaches 40 Megalitres per day, and periodically thereafter.
6. The proponent has committed to undertake best engineering design and construction practices to ensure the stability of the dune systems affected by the excavation for the WWTP and associated works.
7. It is expected that the proponent would address the use of additional odour Reduction Technology as required through the licensing process under Part V of the *Environment Protection Act 1986.*
8. These conditions do not in any way remove the proponent's obligation to comply with all relevant conditions contained in the Ministerial Statement 722, particularly in respect of the proponent's responsibility to develop and implement management plans for the installation of minor infrastructure on the land known as Areas 9a, 10a and 10b.

9. It is expected that the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4.

David Templeman MLA
MINISTER FOR THE ENVIRONMENT; CLIMATE CHANGE; PEEL

Schedule 1

Alkimos Wastewater Treatment Plant – Site B, City of Wanneroo
(Assessment No. 1529)

General Description

The construction and operation of a wastewater treatment plant, and associated ocean outfall, on the Alkimos-Eglinton Dunal System with an ultimate processing capacity of 160 megalitres per day.

The main characteristics of the proposal are summarised in Table 1 below.

Table 1: Summary of Key Proposal Characteristics

Characteristic	Site B
Indicative life of project	Staged capacity to be implemented as follows: **Indicative Timing** — **Installed Capacity (ML/d) of inflow** 2009/10 — 10 2020 — 40 2030 — 60 2040 — 80 2050 — 120 Beyond 2050 — 160
Treatment process	Wastewater will be treated to an advanced secondary standard based upon the activated sludge process similar to that recently constructed at Woodman Point wastewater treatment plant. Additional treatment processes will be utilised to make the treated wastewater "fit for purpose" for disposal and re-use opportunities as and when they become available/viable. Odours will be vented via an approximately 50 metre tall stack.
Toxicant concentrations	Projected loads and flows will result in toxicant concentrations meeting the ANZECC & ARMCANZ 80% species protection guideline values for bio-accumulating toxicants within 100 metres of the ocean outlet diffuser, and meeting the ANZECC & ARMCANZ 99% species protection guideline values for bio-accumulating toxicants beyond 100 metres from the ocean outlet diffuser.
Connecting Pipeline Length Diameter Construction method	 750 metres approximately 1000 to 1200mm inner diameter and 1400 to 1500mm outer diameter Drilling/boring method of pipe installation
Outlet pipeline Description Length Diameter Construction method	 Discharge up to 40ML/d advanced secondary treated wastewater beyond 2009. Duplication of the outlet may be required in the future, dependent upon availability of other disposal/reuse options at that time. 3.7 kilometres 1000 to 1200mm inner diameter and 1400 to 1500mm outer diameter Open-cut pipe installation

Characteristic	Site B
Outlet diffuser Length Diameter Number of ports Port spacing Port diameter Dilution	 300 metres 1200mm inner diameter and 1400 to 1500mm outer diameter 100 3 metres 100mm The average dilution of the wastewater stream in the ocean will be at least 1:300 with the dilution being above 1:200 99% of the time within 100 metres of the ocean outlet diffuser.
Marine habitat loss arising from the construction of the pipeline	Not more than 7ha of seagrass (cumulative benthic primary producer habitat losses less than 1%)
Power requirements	3 Megawatts (ultimate)
Power source	Western Power grid
Volume of excavation	Not more than 3,000,000 cubic metres
Clearing of vegetation required Treatment plant site (including batters) Ocean outlet launch Site 1B Access roads within buffer Haul roads within buffer Quinns sewer route-within buffer to treatment plant **Total**	 19ha 6.6ha 0.7ha 1.3ha 0.6ha **Not more than 29 ha**
Odour buffer	A 600 metre Public Purpose Reserve Buffer as gazetted (Western Australian Planning Commission, 2006) on 7 July 2006.

Abbreviations
ha = hectares
ML/d = Megalitres per day
mg/L = milligrams per litre

Figures (attached)

Figure 1: Alkimos Location Map
Figure 2: Areas where Environmental Quality Objectives are to apply

Figure 1: Alkimos Location Map

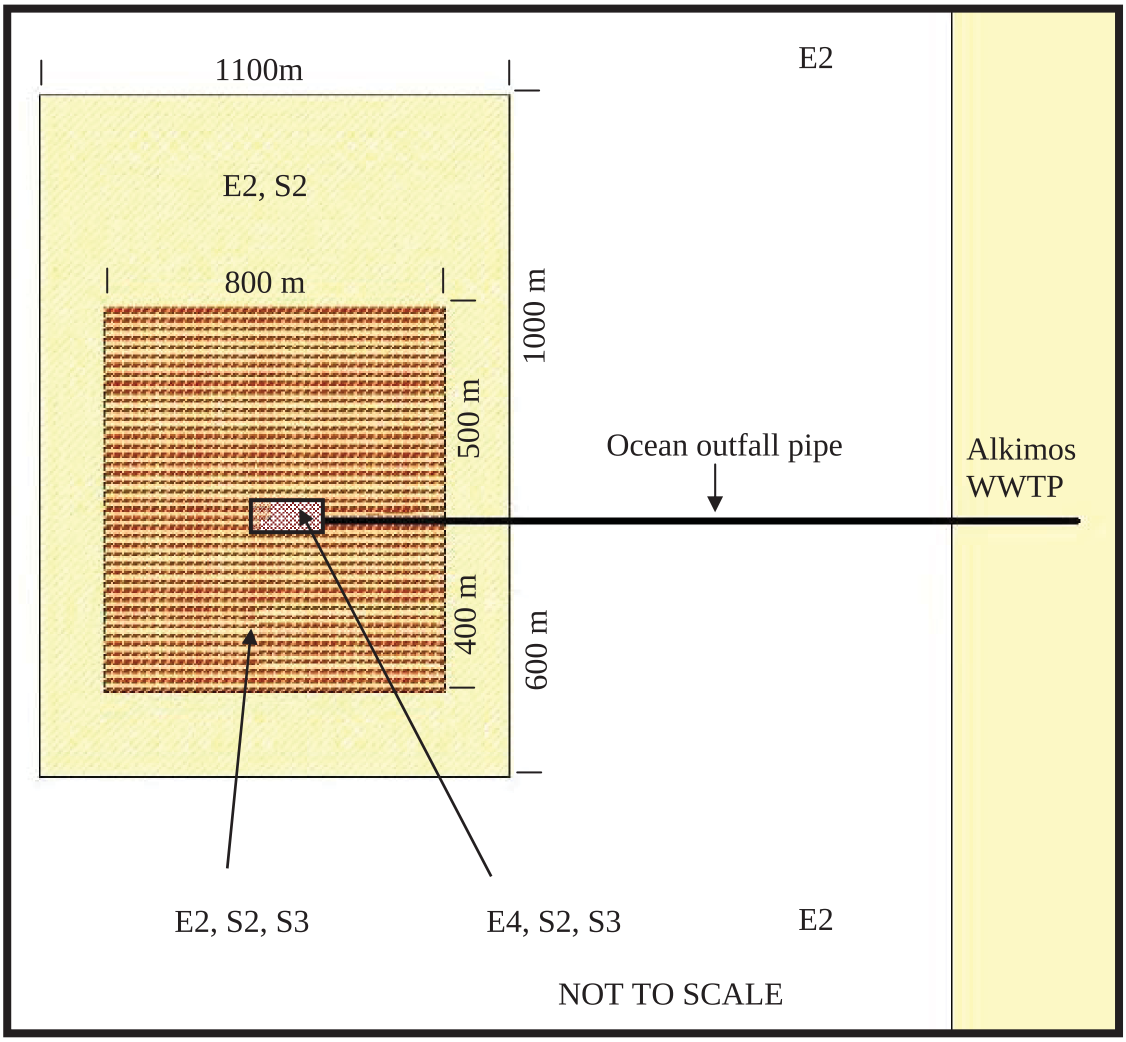


Figure 2: Areas where Environmental Quality Objectives are to apply

Key

E2: High level of ecosystem protection (everywhere more than 100 metres from the diffuser)
E4: Low level of ecosystem protection (within 100 metres of the diffuser)
S2: Not safe to harvest seafood
S3: Not safe for primary contact recreation

Note

Outlet diffuser length not exceeding 300 metres.

Schedule 2

Disturbance footprint for the wastewater treatment plant

The construction and operation of the wastewater treatment plant shall not extend beyond the limits defined in Figure 3 and Table 2 below.

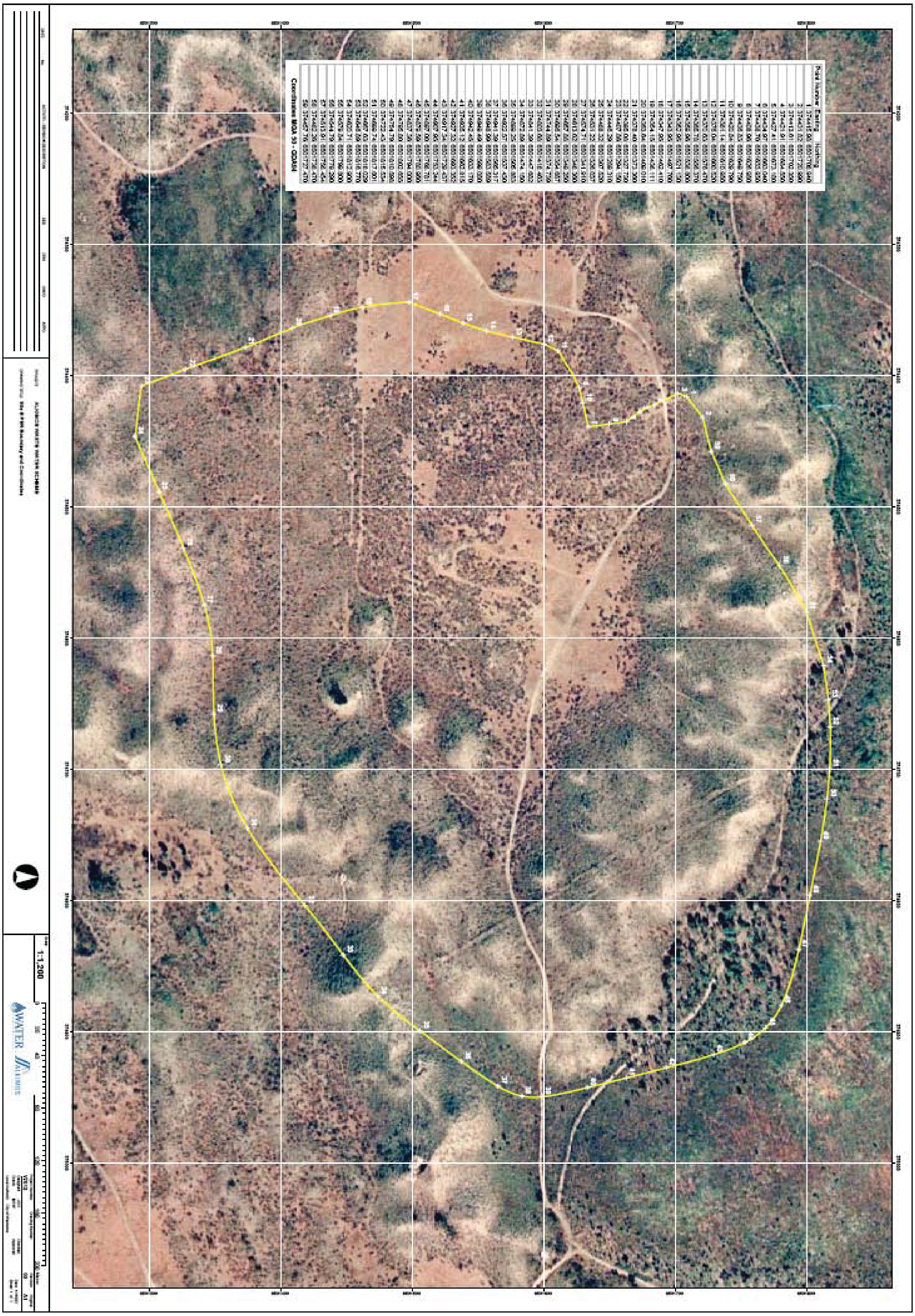


Figure 3: Disturbance footprint for the wastewater treatment plant

Table 2: Coordinates of disturbance footprint for wastewater treatment plant

Point Number	Easting	Northing
1	374415.98	6501708.940
2	374431.82	6501720.990
3	374413.61	6501702.350
4	374421.91	6501684.550
5	374427.41	6501673.180
6	374434.97	6501663.040
7	374438.70	6501633.930
8	374408.96	6501626.980
9	374436.83	6501649.750
10	374420.84	6501629.790
11	374381.14	6501610.980
12	374376.04	6501600.520
13	374370.63	6501576.470
14	374365.78	6501556.370
15	374359.96	6501538.800
16	374352.95	6501521.130
17	374343.95	6501497.760
18	374347.95	6501462.410
19	374354.15	6501438.111
20	374363.64	6501409.010
21	374378.40	6501373.360
22	374395.08	6501327.730
23	374407.86	6501294.150
24	374446.29	6501289.310
25	374488.32	6501307.520
26	374531.22	6501326.037
27	374574.71	6501341.910
28	374613.62	6501348.360
29	374657.88	6501349.250
30	374696.54	6501354.687
31	374744.89	6501374.739
32	374803.68	6501418.463
33	374841.39	6501447.682
34	374872.89	6501474.150
35	374899.25	6501505.883
36	374922.57	6501537.430
37	374941.39	6501565.317
38	374948.99	6501583.589
39	374949.49	6501599.080
40	374942.45	6501633.170
41	374935.12	6501662.815
42	374927.32	6501693.352

43	374917.34	6501729.437
44	374907.95	6501753.244
45	374897.00	6501768.781
46	374879.59	6501780.960
47	374837.36	6501794.000
48	374795.80	6501802.655
49	374754.79	6501810.598
50	374722.43	6501815.534
51	374699.74	6501817.601
52	374667.63	6501818.029
53	374646.89	6501816.770
54	374620.71	6501812.900
55	374579.84	6501799.800
56	374544.79	6501779.290
57	374513.91	6501758.454
58	374482.26	6501738.470
59	374457.76	6501727.470

Schedule 3

Disturbance footprint for the launching site

The construction and operation of the launching site shall not extend beyond the limits defined in Figure 4 and Table 3 below.

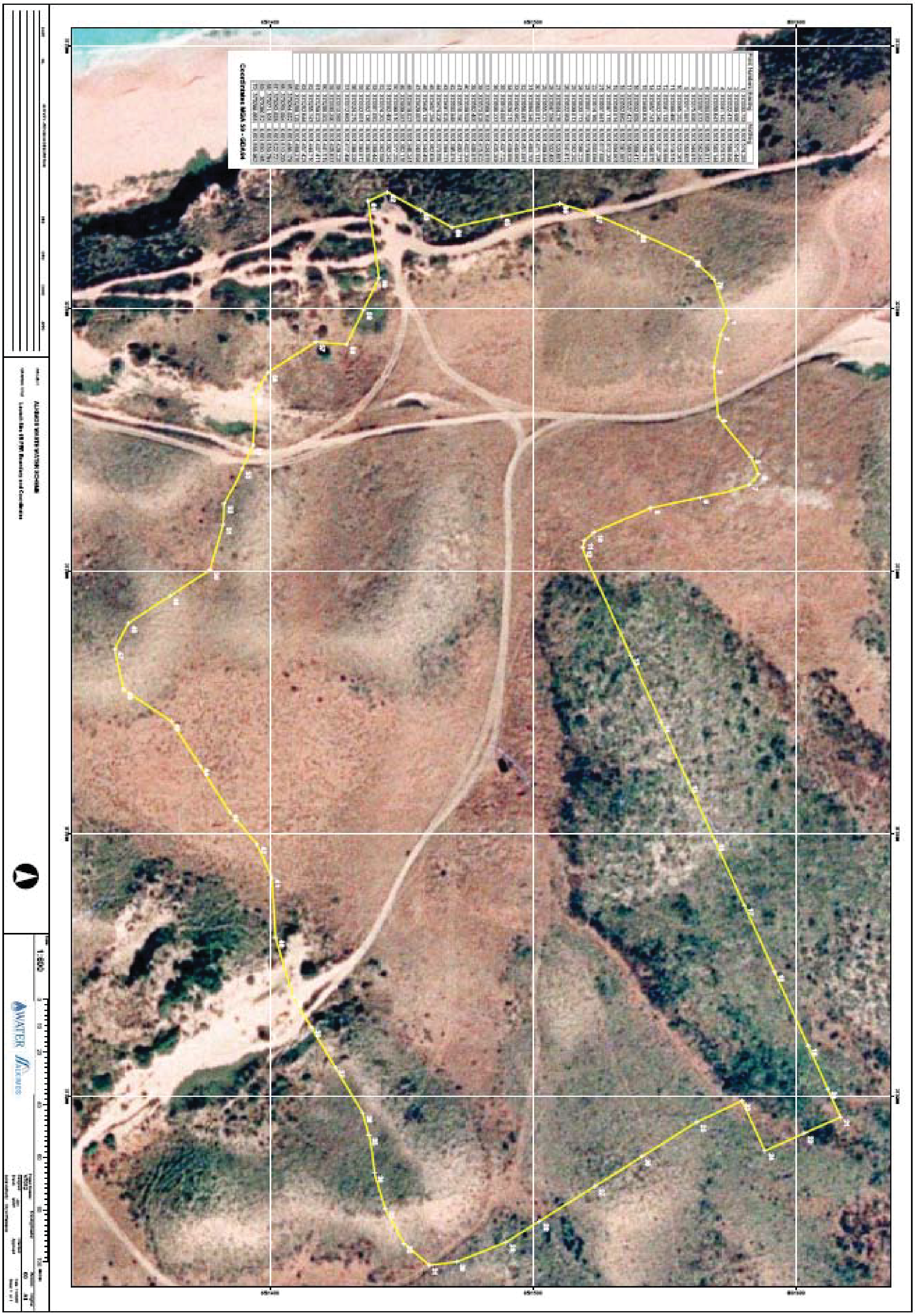


Figure 4: Disturbance footprint for the launching site

Table 3: Coordinates of disturbance footprint for launching site

Point Numbers	Easting mE	Northing mE
1	373303.753	6501574.263
2	373309.956	6501571.443
3	373322.475	6501568.849
4	373341.142	6501570.579
5	373356.647	6501583.144
6	373363.063	6501585.817
7	373367.073	6501582.342
8	373375.895	6501544.915
9	373371.987	6501563.607
10	373385.252	6501523.261
11	373388.460	6501519.518
12	373391.133	6501518.984
13	373432.249	6501537.296
14	373457.741	6501548.875
15	373480.639	6501559.275
16	373502.959	6501569.412
17	373527.421	6501580.523
18	373552.662	6501591.987
19	373580.874	6501604.801
20	373597.175	6501612.205
21	373607.941	6501617.095
22	373614.169	6501603.084
23	373601.793	6501579.668
24	373620.773	6501588.223
25	373609.813	6501562.292
26	373622.908	6501541.612
27	373634.276	6501523.661
28	373647.584	6501502.483
29	373655.527	6501489.844
30	373663.012	6501471.131
31	373664.349	6501460.705
32	373656.061	6501451.081
33	373642.962	6501443.863
34	373629.215	6501439.958
35	373614.897	6501437.722
36	373606.337	6501435.308
37	373589.104	6501424.978
38	373573.828	6501415.822
39	373562.405	6501408.975
40	373539.593	6501402.203
41	373516.780	6501400.777
42	373503.948	6501395.074
43	373491.829	6501384.737
44	373474.326	6501373.550
45	373457.254	6501362.638
46	373445.135	6501344.459
47	373429.807	6501340.894
48	373419.827	6501346.241
49	373409.387	6501362.176

50	373399.510	6501377.252
51	373382.400	6501382.242
52	373374.202	6501382.598
53	373361.082	6501389.442
54	373352.136	6501393.586
55	373332.851	6501393.812
56	373324.279	6501399.338
57	373312.663	6501417.496
58	373313.565	6501429.225
59	373300.390	6501435.637
60	373288.302	6501441.519
61	373259.023	6501437.411
62	373255.747	6501444.710
63	373262.644	6501457.423
64	373269.129	6501469.376
65	373264.922	6501488.179
66	373259.994	6501510.203
67	373263.828	6501522.721
68	373271.106	6501539.784
69	373280.520	6501560.165
70	373288.866	6501568.962

Schedule 4

Ocean Outlet Pipeline (and diffuser) 'containment' zone

Figure 5: Ocean Outlet Pipeline (and diffuser) 'containment' zone

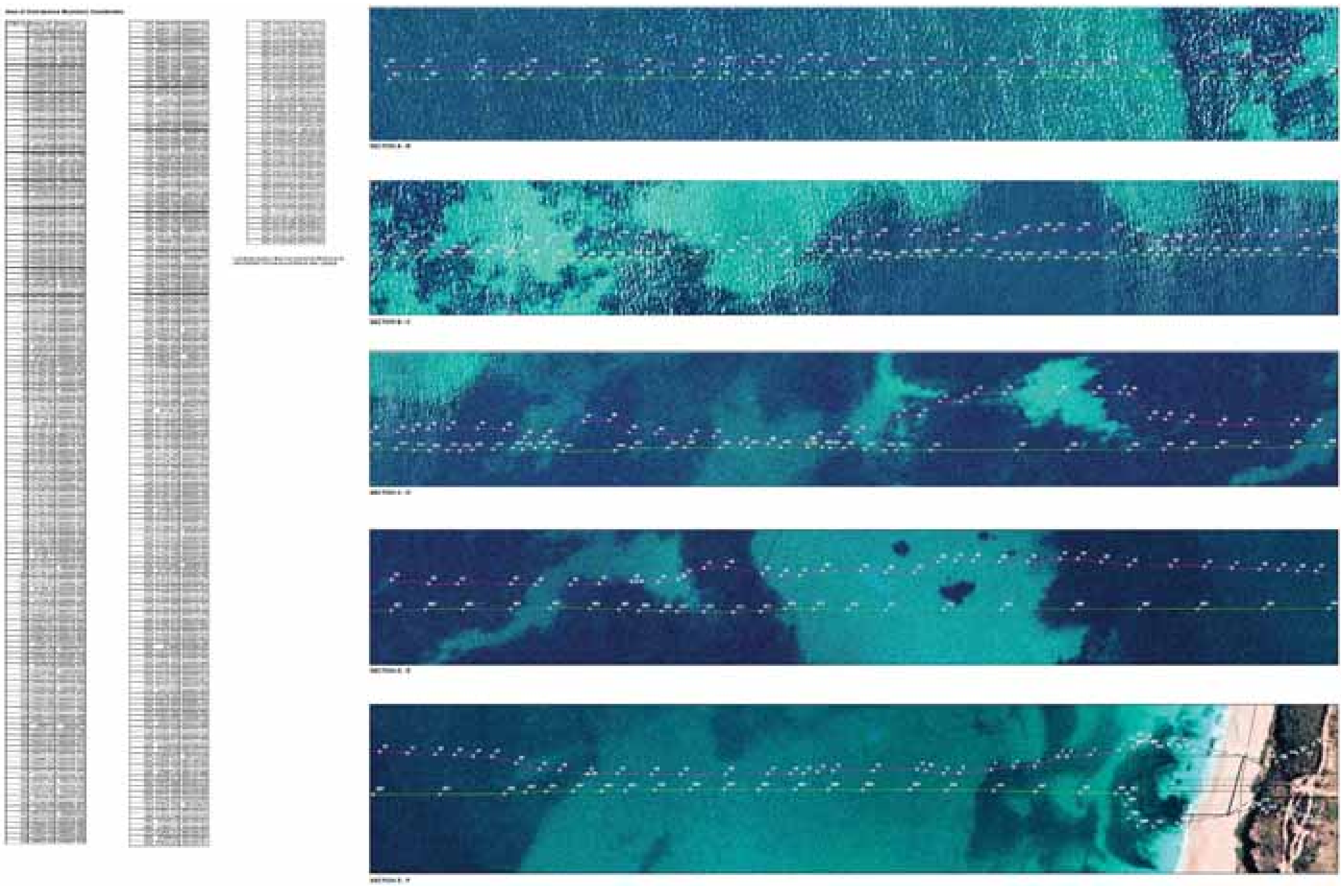


Table 4: Coordinates of the Ocean Outlet Pipeline (and diffuser) 'containment' zone

Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN
1	373116.063	6501411.317	47	372234.770	6501009.350	93	371257.979	6500562.156	139	370261.039	6500105.993	185	370624.436	6500256.744
2	373095.786	6501397.697	48	372220.458	6501002.620	94	371244.778	6500555.084	140	370213.995	6500084.650	186	370642.673	6500264.954
3	373078.120	6501388.638	49	372205.318	6500997.874	95	371232.132	6500547.012	141	370178.390	6500073.435	187	370661.366	6500272.150
4	373071.365	6501385.482	50	372175.115	6500990.389	96	371208.910	6500536.606	142	370165.338	6500067.684	188	370676.344	6500277.853
5	373056.569	6501369.599	51	372158.296	6500982.003	97	371186.770	6500526.686	143	370141.920	6500055.061	189	370686.340	6500282.444
6	373040.458	6501361.980	52	372145.559	6500968.264	98	371164.071	6500515.918	144	370127.212	6500048.430	190	370698.092	6500288.008
7	373024.214	6501352.260	53	372142.185	6500964.335	99	371147.517	6500504.560	145	370103.796	6500036.566	191	370709.097	6500292.795
8	373000.458	6501338.448	54	372127.439	6500955.323	100	371134.712	6500498.066	146	370083.334	6500025.669	192	370720.646	6500298.810
9	372988.624	6501332.975	55	372110.458	6500948.048	101	371123.888	6500493.907	147	370042.338	6500007.438	193	370729.926	6500302.558
10	372973.669	6501328.909	56	372106.906	6500946.615	102	371101.151	6500489.519	148	370000.536	6499988.498	194	370743.593	6500308.739
11	372966.597	6501327.218	57	372082.353	6500933.731	103	371084.250	6500486.608	149	369953.639	6499967.653	195	370766.968	6500320.153
12	372932.851	6501310.635	58	372060.458	6500923.036	104	371058.693	6500475.665	150	369914.175	6499949.761	196	370793.217	6500332.493
13	372902.144	6501296.737	59	372033.540	6500911.077	105	371039.260	6500466.758	151	369873.116	6499931.323	197	370815.119	6500342.306
14	372890.458	6501290.821	60	372013.971	6500903.169	106	371028.035	6500461.692	152	369844.256	6499918.671	198	370836.860	6500352.479
15	372880.458	6501284.831	61	371972.920	6500884.842	107	371012.877	6500451.994	153	369851.820	6499909.651	199	370853.337	6500359.726
16	372870.458	6501279.939	62	371950.458	6500875.067	108	370996.425	6500439.912	154	369880.932	6499922.936	200	370868.923	6500366.516
17	372852.791	6501272.153	63	371920.458	6500864.890	109	370979.601	6500430.392	155	369916.467	6499939.008	201	370880.754	6500371.905
18	372820.458	6501257.283	64	371900.458	6500858.761	110	370959.575	6500426.363	156	369941.078	6499950.113	202	370890.736	6500376.528
19	372785.649	6501241.645	65	371886.749	6500853.440	111	370930.471	6500413.083	157	369954.785	6499956.204	203	370906.122	6500381.322
20	372762.968	6501231.573	66	371858.929	6500866.899	112	370904.597	6500401.564	158	369974.929	6499965.050	204	370914.708	6500384.172
21	372736.648	6501220.489	67	371850.214	6500864.310	113	370887.010	6500391.383	159	370007.662	6499980.037	205	370926.953	6500391.080
22	372714.660	6501210.367	68	371828.271	6500854.456	114	370870.439	6500379.210	160	370047.890	6499997.864	206	370937.427	6500397.048
23	372712.578	6501209.393	69	371796.847	6500840.345	115	370829.313	6500360.754	161	370086.997	6500015.744	207	370945.080	6500399.536
24	372690.458	6501203.156	70	371749.109	6500818.907	116	370799.335	6500347.214	162	370107.292	6500024.254	208	370951.905	6500403.865
25	372674.485	6501196.970	71	371723.410	6500807.367	117	370778.860	6500340.367	163	370125.700	6500032.084	209	370963.944	6500408.792
26	372654.345	6501193.539	72	371714.380	6500793.839	118	370754.438	6500330.450	164	370140.196	6500038.861	210	370976.547	6500414.900
27	372633.487	6501190.597	73	371696.060	6500786.072	119	370722.777	6500318.603	165	370166.616	6500050.818	211	370993.238	6500421.672
28	372618.805	6501184.221	74	371683.161	6500765.840	120	370704.638	6500310.458	166	370187.743	6500059.917	212	371006.798	6500425.651
29	372603.784	6501178.650	75	371665.415	6500757.016	121	370684.978	6500305.350	167	370207.640	6500069.312	213	371016.122	6500429.298
30	372588.858	6501172.707	76	371635.386	6500726.381	122	370666.586	6500296.463	168	370231.195	6500080.327	214	371025.153	6500433.598
31	372566.810	6501163.903	77	371620.458	6500719.184	123	370650.925	6500284.034	169	370247.928	6500087.590	215	371037.906	6500439.374
32	372545.073	6501155.577	78	371600.458	6500704.739	124	370631.585	6500272.223	170	370270.506	6500097.753	216	371050.436	6500445.647
33	372518.678	6501144.634	79	371595.186	6500697.218	125	370624.624	6500261.206	171	370322.536	6500121.032	217	371066.175	6500452.098
34	372486.605	6501130.736	80	371561.549	6500681.801	126	370607.918	6500254.469	172	370351.751	6500134.090	218	371075.389	6500455.990
35	372463.627	6501123.487	81	371537.760	6500671.308	127	370592.733	6500246.784	173	370376.407	6500145.093	219	371088.942	6500462.425
36	372444.595	6501118.193	82	371511.214	6500666.955	128	370577.500	6500240.700	174	370388.260	6500150.432	220	371104.500	6500471.721
37	372430.458	6501111.852	83	371491.219	6500657.995	129	370562.572	6500240.734	175	370429.261	6500168.978	221	371117.131	6500477.767
38	372406.792	6501098.601	84	371459.435	6500646.871	130	370541.578	6500234.082	176	370455.918	6500180.409	222	371126.997	6500482.648
39	372384.436	6501088.439	85	371435.329	6500637.508	131	370523.331	6500226.214	177	370482.612	6500191.757	223	371137.965	6500487.519
40	372363.842	6501080.565	86	371413.056	6500640.295	132	370503.465	6500221.381	178	370503.140	6500199.747	224	371153.452	6500494.529
41	372350.458	6501074.799	87	371391.203	6500629.594	133	370477.717	6500208.375	179	370521.717	6500209.642	225	371167.995	6500501.201
42	372337.102	6501067.523	88	371362.866	6500600.917	134	370444.576	6500190.023	180	370539.892	6500217.990	226	371181.202	6500505.967
43	372322.544	6501051.273	89	371345.478	6500592.563	135	370401.202	6500169.195	181	370554.971	6500225.909	227	371190.332	6500510.045
44	372300.458	6501041.385	90	371324.272	6500591.143	136	370377.652	6500159.488	182	370575.162	6500234.651	228	371200.199	6500514.926
45	372280.458	6501033.589	91	371300.837	6500581.947	137	370335.740	6500140.122	183	370591.550	6500242.096	229	371214.751	6500521.577
46	372250.458	6501020.962	92	371275.035	6500570.162	138	370307.914	6500126.650	184	370606.204	6500248.522	230	371237.469	6500532.016

Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN
231	371253.471	6500537.879	278	372403.146	6501052.277	325	373242.126	6501456.491
232	371267.447	6500543.373	279	372358.363	6501032.166	326	373233.816	6501453.297
233	371282.679	6500550.952	280	372458.421	6501077.099	327	373219.613	6501451.004
234	371293.913	6500555.228	281	372509.920	6501100.225	328	373213.811	6501449.859
235	371304.413	6500561.138	282	372554.660	6501120.316	329	373203.641	6501447.425
236	371322.569	6500569.529	283	372606.044	6501143.390	330	373187.162	6501442.817
237	371339.497	6500578.214	284	372656.243	6501166.052	331	373167.851	6501437.471
238	371348.170	6500580.871	285	372671.197	6501174.252	332	373162.576	6501435.013
239	371358.655	6500586.816	286	372687.450	6501181.998	333	373160.326	6501435.778
240	371370.513	6500592.144	287	372708.271	6501191.778	334	373152.720	6501433.094
241	371384.477	6500595.223	288	372730.208	6501201.512	335	373139.717	6501429.133
242	371430.015	6500615.870	289	372748.388	6501209.849	336	373135.146	6501428.374
243	371443.543	6500624.804	290	372771.007	6501220.507	337	373133.289	6501428.347
244	371475.638	6500638.769	291	372798.287	6501232.992	338	373130.901	6501425.703
245	371490.036	6500645.765	292	372824.716	6501244.930	339	373128.197	6501422.377
246	371521.158	6500659.456	293	372851.251	6501256.631	340	373125.852	6501418.594
247	371545.703	6500670.709	294	372879.554	6501269.278			
248	371573.945	6500683.490	295	372905.180	6501280.563			
249	371597.680	6500694.104	296	372931.740	6501292.208			
250	371610.473	6500699.793	297	372968.231	6501308.592			
251	371618.037	6500702.477	298	372996.690	6501320.891			
252	371630.053	6500707.453	299	373033.412	6501336.761			
253	371648.681	6500714.792	300	373065.667	6501350.372			
254	371666.422	6500721.665	301	373100.803	6501364.890			
255	371676.845	6500726.247	302	373128.438	6501376.583			
256	371706.873	6500739.723	303	373137.644	6501380.494			
257	371781.862	6500773.378	304	373140.136	6501371.157			
258	371826.878	6500793.581	305	373147.282	6501361.799			
259	371880.541	6500817.665	306	373156.996	6501358.611			
260	371910.848	6500831.574	307	373169.384	6501363.487			
261	371930.628	6500841.231	308	373186.386	6501374.716			
262	371956.793	6500853.758	309	373209.968	6501389.578			
263	371986.000	6500866.832	310	373227.847	6501402.327			
264	372022.424	6500883.365	311	373239.697	6501413.317			
265	372052.343	6500897.295	312	373247.788	6501415.289			
266	372083.547	6500910.804	313	373243.560	6501416.901			
267	372106.576	6500920.551	314	373251.998	6501414.234			
268	372122.624	6500926.312	315	373261.323	6501416.150			
269	372140.232	6500933.481	316	373269.418	6501417.296			
270	372152.113	6500938.758	317	373276.423	6501417.499			
271	372173.210	6500947.924	318	373283.361	6501418.843			
272	372196.282	6500957.573	319	373290.473	6501421.860			
273	372216.932	6500967.734	320	373268.857	6501486.965			
274	372235.201	6500978.313	321	373264.885	6501482.828			
275	372257.203	6500987.903	322	373258.539	6501474.608			
276	372283.948	6500999.139	323	373254.717	6501470.122			
277	372313.430	6501011.989	324	373247.834	6501463.198			

ATTACHMENT 1 TO STATEMENT 755

CHANGE TO PROPOSAL

PROPOSAL: Alkimos Wastewater Treatment Plant Site B

PROPONENT: Water Corporation

CHANGE OF PROPOSAL: Change of permanent clearing areas

Amendment of Schedule 1 - Key Proposal Characteristics

Characteristic of previously approved proposal:

Characteristic	**Site B**
Clearing of vegetation required	
Treatment plant site (including batters)	19 ha
Ocean outlet launch Site 1B	6.6 ha
Access roads within buffer	0.7 ha
Haul roads within buffer	1.3 ha
Quinns sewer route-within buffer to treatment plant	0.6 ha
Total	**Not more than 29 ha**

Characteristic of changed proposal:

Characteristic	**Site B**	
Clearing of vegetation required	**Disturbed**	**After Rehabilitation**
Treatment plant site (including batters)	29.5 ha	15.4 ha
Ocean outlet launch Site 1B	6.7 ha	0.1 ha
Access roads within buffer	4.0 ha	1.1 ha
Haul roads within buffer	3.5 ha	0.0 ha
Quinns sewer route-within buffer to treatment plant	0.6 ha	0.6 ha
Total	**44.3 ha**	**18.1 ha**

Approved under delegation
from the Minister for the Environment: ....

Approval date: 12.3.08

Modified Schedule 2

Disturbance footprint for the Wastewater Treatment Plant

The construction and operation of the wastewater treatment plant shall not extend beyond the limits defined in Figure 1 and Figure 2 below.

NUMBER	EASTING	NORTHING
1	374309.8	6501315.6
2	374354.7	6501318.8
3	374369.7	6501326.3
4	374383.8	6501328.7
5	374391.7	6501298.5
6	374397.7	6501262.1
7	374418.1	6501247.8
8	374425.6	6501249.3
9	374438.4	6501242.9
10	374455.4	6501250.0
11	374466.9	6501249.8
12	374485.1	6501257.7
13	374493.9	6501263.7
14	374505.1	6501276.2
15	374513.6	6501282.2
16	374539.8	6501285.9
17	374562.7	6501297.5
18	374589.0	6501307.2
19	374601.6	6501325.9
20	374599.6	6501348.4
21	374596.3	6501364.5
22	374612.6	6501368.3
23	374646.2	6501360.6
24	374682.0	6501353.4
25	374697.2	6501350.6
26	374714.4	6501358.2
27	374750.3	6501388.1
28	374770.2	6501412.1
29	374796.5	6501443.4
30	374817.6	6501464.7
31	374834.2	6501470.7
32	374840.8	6501478.4
33	374841.5	6501489.5
34	374837.1	6501500.0
35	374837.3	6501505.9
36	374862.9	6501525.2
37	374872.6	6501534.2
38	374883.1	6501549.9
39	374895.3	6501559.7
40	374925.6	6501604.4
41	374917.6	6501629.0
42	374906.2	6501659.4
43	374897.8	6501679.1
44	374882.3	6501695.1
45	374861.9	6501745.4
46	374835.0	6501768.7
47	374812.0	6501790.6
48	374767.4	6501791.8
49	374756.5	6501793.6
50	374732.5	6501791.8
51	374707.2	6501798.2
52	374682.7	6501793.4
53	374650.8	6501790.5
54	374618.9	6501798.4
55	374602.2	6501802.4
56	374583.8	6501796.2
57	374555.1	6501800.6
58	374544.0	6501793.3
59	374528.9	6501771.6
60	374515.2	6501757.4
61	374499.8	6501750.6
62	374483.1	6501757.7
63	374471.2	6501751.0
64	374468.2	6501738.2
65	374468.2	6501727.9
66	374452.5	6501717.5
67	374436.4	6501713.4
68	374434.1	6501717.7
69	374425.1	6501713.8
70	374418.9	6501715.5
71	374398.5	6501702.4
72	374348.9	6501681.1
73	374331.6	6501673.7
74	374315.0	6501670.6
75	374300.8	6501657.7
76	374280.7	6501644.2
77	374274.1	6501638.0
78	374258.8	6501623.6
79	374288.8	6501595.7
80	374287.9	6501550.0
81	374276.9	6501537.1
82	374289.0	6501531.9
83	374262.4	6501519.1
84	374272.6	6501498.2
85	374287.5	6501484.5
86	374294.7	6501451.5
87	374303.5	6501421.5
88	374313.4	6501395.4
89	374318.7	6501382.9
90	374304.1	6501372.9
91	374279.2	6501365.1
92	374251.6	6501358.3
93	374195.0	6501331.5
94	374196.1	6501314.2
95	374172.7	6501296.5
96	374201.9	6501286.6
97	374192.1	6501253.0
98	374237.7	6501252.9
99	374309.6	6501253.3
100	374309.5	6501298.7

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D

PROJECT **ALKIMOS WASTEWATER SCHEME**

DRAWING TITLE **FIGURE 1 : WWTP Coordinates of Clearing**

Coordinate System: MGA Zone 50, GDA94

Scale: **1:2,800** 0 50 100 200 300 400 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	SK01	00	A3

Designed JGH Checked Date 15/02/09
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo

NUMBER	EASTING	NORTHING
1	374259.7	6501329.2
2	374265.9	6501320.4
3	374306.9	6501337.0
4	374352.5	6501355.4
5	374419.4	6501382.5
6	374437.0	6501341.3
7	374493.4	6501365.5
8	374562.2	6501395.0
9	374625.6	6501422.3
10	374671.2	6501441.9
11	374698.9	6501453.9
12	374742.7	6501504.2
13	374783.4	6501551.0
14	374787.7	6501550.3
15	374808.2	6501573.9
16	374810.4	6501574.0
17	374843.3	6501611.8
18	374796.4	6501721.1
19	374747.9	6501729.6
20	374707.6	6501736.7
21	374705.8	6501734.3
22	374660.6	6501742.3
23	374608.9	6501751.4
24	374586.7	6501741.8
25	374584.5	6501736.7
26	374549.8	6501721.9
27	374501.8	6501701.5
28	374484.4	6501694.1
29	374448.5	6501678.3
30	374386.5	6501651.7
31	374352.9	6501637.4
32	374323.3	6501624.6
33	374293.7	6501612.0
34	374320.7	6501549.1
35	374327.1	6501534.2
36	374311.1	6501527.0
37	374302.5	6501521.5
38	374297.4	6501512.4
39	374301.2	6501494.0
40	374315.2	6501460.4
41	374339.9	6501403.0
42	374354.1	6501369.7
43	374305.3	6501348.7
44	374275.8	6501336.1

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT ALKIMOS WASTEWATER SCHEME

DRAWING TITLE FIGURE 2 : WWTP Coordinates of Permanent Disturbance

Coordinate System: MGA Zone 50, GDA94

Scale: 1:2,500

0 40 80 160 240 320 Metres

WATER CORPORATION | ALKIMOS

Project Number 12769 | Drawing Number SK02 | Revision 00 | Original A3

Designed JGH | Checked | Date 15/02/08

Drawn MGW | Approved | Sheet 1 of 1

Local Authority City of Wanneroo

Modified Schedule 3

Disturbance footprint for the launching site

The construction and operation of the launching site shall not extend beyond the limits defined in Figure 5 and Figure 6 below.

NUMBER	EASTING	NORTHING
1	373608.0	6501615.7
2	373620.2	6501588.6
3	373601.7	6501580.3
4	373616.4	6501551.8
5	373641.8	6501511.6
6	373660.6	6501477.0
7	373663.2	6501471.2
8	373663.7	6501460.9
9	373655.9	6501451.1
10	373629.5	6501440.5
11	373616.6	6501439.0
12	373592.4	6501431.6
13	373581.7	6501423.9
14	373571.5	6501410.7
15	373551.4	6501406.2
16	373532.4	6501402.4
17	373515.4	6501400.8
18	373503.1	6501395.1
19	373488.9	6501383.3
20	373468.0	6501370.3
21	373457.0	6501363.0
22	373444.1	6501345.5
23	373430.4	6501342.1
24	373420.2	6501347.5
25	373400.8	6501377.8
26	373374.5	6501383.5
27	373352.4	6501394.4
28	373332.9	6501394.3
29	373324.7	6501400.0
30	373313.3	6501417.2
31	373313.9	6501429.6
32	373301.5	6501412.2
33	373283.0	6501402.2
34	373258.9	6501405.1
35	373245.3	6501413.0
36	373218.8	6501407.8
37	373209.9	6501434.2
38	373231.5	6501450.3
39	373236.7	6501455.3
40	373248.5	6501480.7
41	373261.0	6501500.5
42	373260.7	6501510.2
43	373272.0	6501540.4
44	373280.9	6501560.0
45	373290.9	6501569.2
46	373304.0	6501573.5
47	373314.4	6501570.1
48	373330.1	6501569.2
49	373340.8	6501569.8
50	373353.0	6501579.7
51	373362.6	6501584.7
52	373366.5	6501562.2
53	373375.4	6501545.0
54	373386.6	6501521.4
55	373394.2	6501519.1
56	373400.1	6501522.4
57	373438.3	6501539.5
58	373505.4	6501569.7
59	373563.3	6501595.7

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D

PROJECT **ALKIMOS WASTEWATER SCHEME**

DRAWING TITLE **FIGURE 5 : Launch Site Coordinates of Clearing**

Coordinate System: MGA Zone 50, GDA94

Scale: **1:1,500**

0 25 50 100 150 200 Metres

WATER CORPORATION | ALKIMOS Water Alliance

Project Number	Drawing Number	Revision	Original
12769	SK05	00	A3

Designed JGH Checked Date 15/02/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo

NUMBER	EASTING	NORTHING
1	373579.4	6501422.2
2	373574.3	6501415.3
3	373563.4	6501437.4
4	373549.2	6501466.2
5	373538.8	6501478.3
6	373528.9	6501486.2
7	373519.9	6501493.4
8	373504.8	6501496.1
9	373484.5	6501498.4
10	373461.5	6501499.1
11	373432.3	6501498.7
12	373395.4	6501497.9
13	373385.1	6501494.1
14	373386.8	6501489.3
15	373384.4	6501478.3
16	373378.9	6501470.3
17	373370.0	6501469.1
18	373358.9	6501471.4
19	373355.5	6501475.3
20	373352.6	6501487.0
21	373355.2	6501496.1
22	373361.2	6501501.3
23	373368.9	6501503.4
24	373377.1	6501502.7
25	373394.4	6501505.1
26	373415.6	6501507.0
27	373443.7	6501508.5
28	373475.2	6501508.5
29	373499.4	6501506.2
30	373518.9	6501502.2
31	373537.4	6501494.3
32	373548.4	6501481.6
33	373556.0	6501469.0
34	373570.2	6501440.6

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT ALKIMOS WASTEWATER SCHEME

DRAWING TITLE FIGURE 6 : Launch Site Coordinates of Permanent Disturbance

Coordinate System: MGA Zone 50, GDA94

Scale: 1:1,000 — 0 15 30 60 90 120 150 Metres

WATER CORPORATION | ALKIMOS

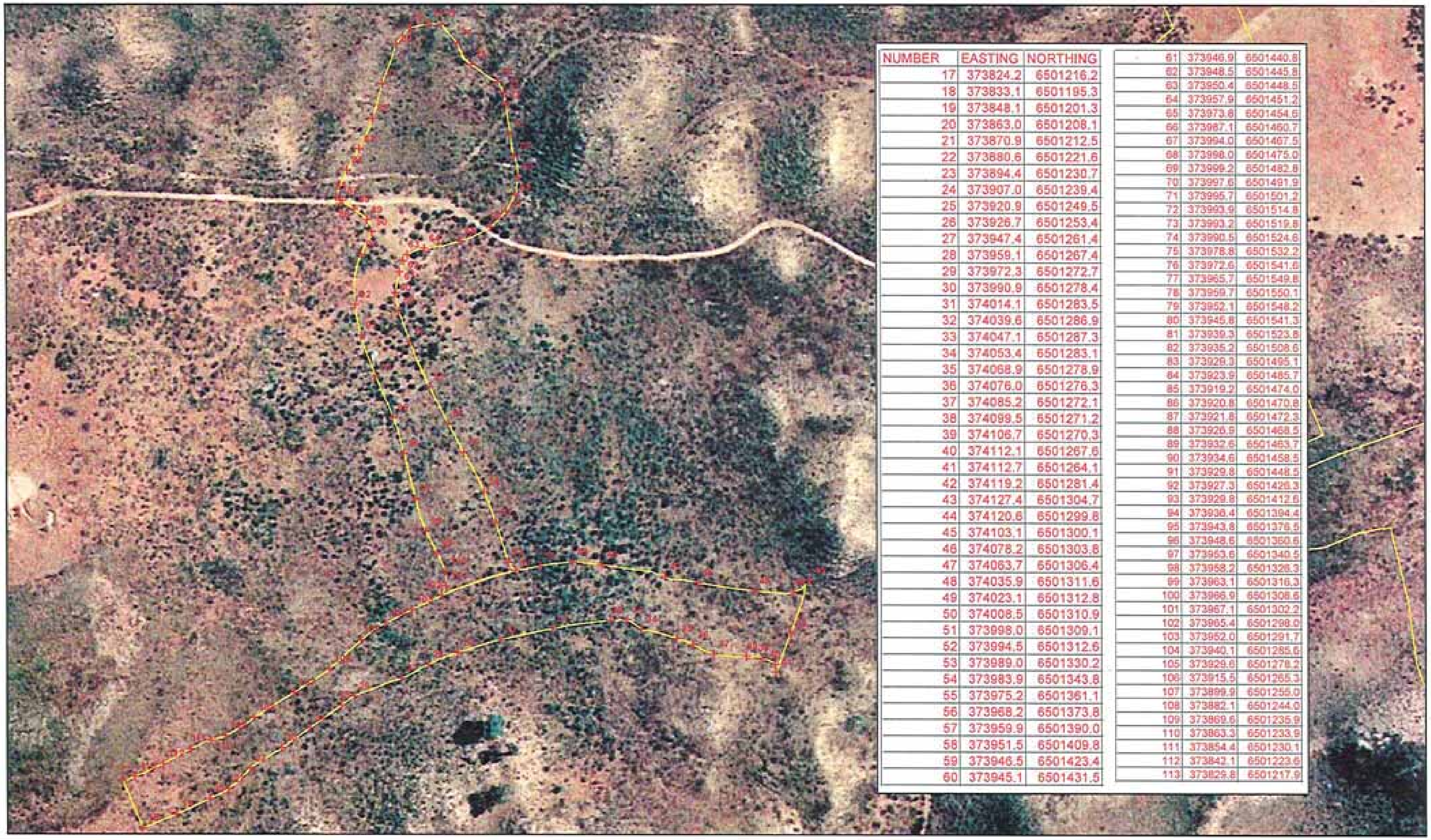
Project Number	Drawing Number	Revision	Original
12769	SK06	00	A3

Designed JGH Checked Date 15/02/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo

Modified Schedule 5

Disturbance footprint for the access roads

The construction and operation of the launching site shall not extend beyond the limits defined in Figure 3 and Figure 4 below.



NUMBER	EASTING	NORTHING
17	373824.2	6501216.2
18	373833.1	6501195.3
19	373848.1	6501201.3
20	373863.0	6501208.1
21	373870.9	6501212.5
22	373880.6	6501221.6
23	373894.4	6501230.7
24	373907.0	6501239.4
25	373920.9	6501249.5
26	373926.7	6501253.4
27	373947.4	6501261.4
28	373959.1	6501267.4
29	373972.3	6501272.7
30	373990.9	6501278.4
31	374014.1	6501283.5
32	374039.6	6501286.9
33	374047.1	6501287.3
34	374053.4	6501283.1
35	374068.9	6501278.9
36	374076.0	6501276.3
37	374085.2	6501272.1
38	374099.5	6501271.2
39	374106.7	6501270.3
40	374112.1	6501267.6
41	374112.7	6501264.1
42	374119.2	6501281.4
43	374127.4	6501304.7
44	374120.6	6501299.8
45	374103.1	6501300.1
46	374078.2	6501303.8
47	374063.7	6501306.4
48	374035.9	6501311.6
49	374023.1	6501312.8
50	374008.5	6501310.9
51	373998.0	6501309.1
52	373994.5	6501312.6
53	373989.0	6501330.2
54	373983.9	6501343.8
55	373975.2	6501361.1
56	373968.2	6501373.8
57	373959.9	6501390.0
58	373951.5	6501409.8
59	373946.5	6501423.4
60	373945.1	6501431.5

61	373946.9	6501440.8
62	373948.5	6501445.8
63	373950.4	6501448.5
64	373957.9	6501451.2
65	373973.8	6501454.6
66	373987.1	6501460.7
67	373994.0	6501467.5
68	373998.0	6501475.0
69	373999.2	6501482.8
70	373997.6	6501491.9
71	373995.7	6501501.2
72	373993.9	6501514.8
73	373993.2	6501519.8
74	373990.5	6501524.6
75	373978.8	6501532.2
76	373972.6	6501541.6
77	373965.7	6501549.8
78	373959.7	6501550.1
79	373952.1	6501548.2
80	373945.8	6501541.3
81	373939.3	6501523.8
82	373935.2	6501508.6
83	373928.3	6501495.1
84	373923.9	6501485.7
85	373919.2	6501474.0
86	373920.8	6501470.8
87	373921.8	6501472.3
88	373926.9	6501468.5
89	373932.6	6501463.7
90	373934.6	6501458.5
91	373929.8	6501448.5
92	373927.3	6501426.3
93	373929.8	6501412.6
94	373936.4	6501394.4
95	373943.8	6501376.5
96	373948.6	6501360.6
97	373953.6	6501340.5
98	373958.2	6501328.3
99	373963.1	6501316.3
100	373966.9	6501308.6
101	373967.1	6501302.2
102	373965.4	6501298.0
103	373952.0	6501291.7
104	373940.1	6501285.6
105	373929.6	6501278.2
106	373915.5	6501265.3
107	373899.9	6501255.0
108	373882.1	6501244.0
109	373869.6	6501235.9
110	373863.3	6501233.9
111	373854.4	6501230.1
112	373842.1	6501223.6
113	373829.8	6501217.9

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **ALKIMOS WASTEWATER SCHEME**

DRAWING TITLE **FIGURE 3 : Access Road Coordinates of Clearing**

Coordinate System: MGA Zone 50, GDA94

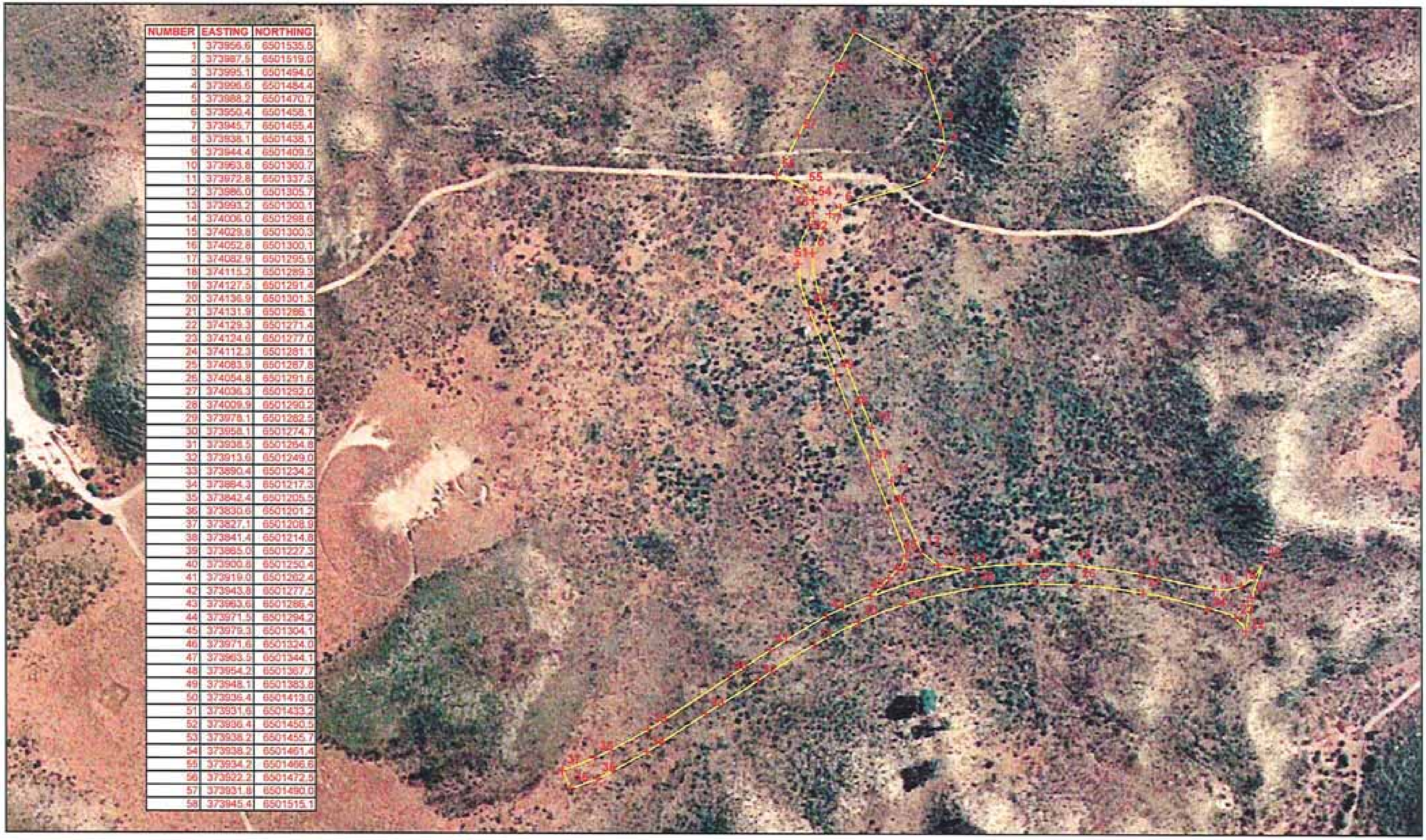
Scale: **1:1,600**

0 25 50 100 150 200 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	SK03	00	A3

Designed JGH Checked Date 15/02/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo



NUMBER	EASTING	NORTHING
1	373956.6	6501535.5
2	373987.5	6501519.0
3	373995.1	6501494.0
4	373996.6	6501484.4
5	373988.2	6501470.7
6	373950.4	6501458.1
7	373945.7	6501455.4
8	373938.1	6501438.1
9	373944.4	6501409.5
10	373963.8	6501360.7
11	373972.8	6501337.3
12	373986.0	6501305.7
13	373993.2	6501300.1
14	374006.0	6501298.6
15	374029.8	6501300.3
16	374052.8	6501300.1
17	374082.9	6501295.9
18	374115.2	6501289.3
19	374127.5	6501291.4
20	374136.9	6501301.3
21	374131.9	6501286.1
22	374129.3	6501271.4
23	374124.6	6501277.0
24	374112.3	6501281.1
25	374083.9	6501287.8
26	374054.8	6501291.6
27	374036.3	6501292.0
28	374009.9	6501290.2
29	373978.1	6501282.5
30	373958.1	6501274.7
31	373938.5	6501264.8
32	373913.6	6501249.0
33	373890.4	6501234.2
34	373864.3	6501217.3
35	373842.4	6501205.5
36	373830.6	6501201.2
37	373827.1	6501208.9
38	373841.4	6501214.8
39	373865.0	6501227.3
40	373900.8	6501250.4
41	373919.0	6501262.4
42	373943.8	6501277.5
43	373963.6	6501286.4
44	373971.5	6501294.2
45	373979.3	6501304.1
46	373971.6	6501324.0
47	373963.5	6501344.1
48	373954.2	6501367.7
49	373948.1	6501383.8
50	373936.4	6501413.0
51	373931.6	6501433.2
52	373936.4	6501450.5
53	373938.2	6501455.7
54	373938.2	6501461.4
55	373934.2	6501466.6
56	373922.2	6501472.5
57	373931.8	6501490.0
58	373945.4	6501515.1

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D

PROJECT **ALKIMOS WASTEWATER SCHEME**

DRAWING TITLE **FIGURE 4 : Access Road Coordinates of Permanent Disturbance**

Coordinate System: MGA Zone 50, GDA94

Scale: **1:1,600**

0 25 50 100 150 200 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	SK04	00	A3

Designed JGH Checked Date 15/02/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo

APPENDIX B - WATER CORPORATION'S INTERPRETATION OF CONDITIONS UNDER MINISTERIAL STATEMENT NO. 755 AND RELEVANT SECTION OF MPCOOP

Conditions under Ministerial Statement No. 755		Water Corporation Interpretation	MPCOOP Section
8. Ocean Outlet Pipeline Construction Management Plan (Marine)			
8-1	Prior to commencement of installation of the pipeline, the proponent shall prepare and submit an Ocean Outlet Pipeline Construction Management Plan (the Plan) that meets the objectives set out in Condition 8.2 that meets the requirements of 8.3 as determined by the Minister for the Environment. In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.	This document provides details that aim to meet objectives set out in condition 8.2 and requirement in section 8.3.	This document
8-2	The objectives of the Plan is to (a) ensure the maintenance of the ecological integrity of the marine waters surrounding the Alkimos site; and (b) ensure the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4.	The MPCOOP has been prepared to meet the objectives set out in Condition 8-2	Section 1.1
8-3	The Plan shall address the following:		
	1 route design;	The MPCOOP addresses the route location and design	Section 3.6.1
	2. define the spatial definition of the extent of the disturbance footprint (a) direct loss of habitat due to construction, (b) indirect loss of habitat due to construction (sediment plume impacts – loss of light and burial) ;	The MPCOOP addresses the spatial extent of direct and indirect habitat loss due to construction. Impacts have been predicted through the use of models.	Section 4.4.1 Section 4.4.2
	3. prediction and spatially definition of the long-term stable' state of the marine environment following construction and taking into account indirect effects of construction and on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impact (see Note 9).	The MPCOOP addresses the long-term spatial extent of ongoing and indirect impacts. Impacts have been predicted through the use of models.	Section 4.4 Section 4.5

	4 amount and type of material to be excavated;	The MPCOOP details the volume of material to be excavated.	Section 3.5.2 Section 3.6.2
	5 rehabilitation of excavated trenches;	The MPCOOP details how, when and where rehabilitation will be undertaken.	Section 3.6.7
	6 blasting techniques and areas where blasting occurs;	The MPCOOP details how, when and where blasting will be undertaken.	Section 3.6.2 Section 3.6.7
	7 identify where drilling and open-cut techniques (minimising open-cut technique) are to be used for the entire pipe installation;	The MPCOOP details how, when and where drilling and open-cut techniques will be used.	Section 3.6.2 Section 3.6.7
	8 positioning of pipe-laying vessels, mooring pattern design and dredge support vessels;	The MPCOOP details how, when and where vessels and moorings will be positioned.	Section 3.6.2 Section 3.6.5 Section 3.6.7
	9 management of benthic community in construction areas;	Benthic communities will be managed through a hierarchy of proactive and reactive management and monitoring strategies.	Section 5.2.2
	10 monitoring and establishment of impact from anchoring, wire and chain sweep techniques, marine dredging and supra-tidal excavation techniques used;	Modelling was undertaken to predict impacts. Monitoring and management strategies have been developed in response to the predicted impacts	Section 4.4.3 Section 5.2.2 Section 6.2.2
	11 identification of areas to be dredged, excavated and the timing and duration of dredging/ excavation;	The MPCOOP details the location, timing and duration of areas to be dredged and excavated.	Section 3.6.2 Section 3.6.7

	12 water quality targets for criteria that will trigger management of sedimentation and protection of benthic community;	The MPCOOP provides water quality targets that will trigger management of sedimentation and protection of benthic communities	Section 5.1.2
	13 monitoring reporting, and mitigating impacts on natural littoral drift processes from construction activities and beach profiles during construction; and	The MPCOOP details predicted impacts on littoral drift and provides monitoring, management and reporting requirements.	Section 5.3.2
	14 the management actions and contingencies that will be implemented in the event that criteria for water quality targets required by point 12 above are not being met.	The MPCOOP details reactive management actions to be implemented if defined water quality targets are not being met.	Section 5.1.2
8-4	To ensure that the diffuser is located in a position to reduce the likelihood of plume impacts on high relief algal reefs immediately to the east of the outlet, the proponent shall extend the pipe length by 200 metres from the end of the pipe shown in Figure 4.17 of the proponent's Public Environmental Review document, Version 3, 8 November 2005. This will give a total pipe length of 3.7 kilometres from the high water mark.	The diffuser will be located in accordance with Condition 8-4.	Section 1
8-5	The proponent is to ensure that the extent of the disturbance footprint (direct and indirect loss of habitat) is no greater than that defined in Condition 8-3 (2).	The extent of significant (>10% net loss) direct and indirect loss of habitat will be confined to the area defined in Condition 8-3 (2).	Section 5.1 Section 5.2
8-6	The proponent is to ensure that the extent of the disturbance footprint (direct impacts) shall be within the area defined in Figure 5 and Table 4 in Schedule 4.	Direct impacts will be confined to the area defined in Condition 8-6.	Section 5.1 Section 5.2
8-7	The proponent is required to minimise indirect impacts as far as practicable within this boundary during construction.	Proactive and reactive monitoring and management strategies will be implemented and are described in the MPCOOP.	Section 5.1 Section 5.2
8-8	The pipeline will be laid within the area defined in Figure 5 and Table 4 in Schedule 4, and the 'line' of direct disturbance footprint will also be within the area. (see note 9).	The pipeline will be laid and the line of direct disturbance footprint will be in accordance with Condition 8-8.	Section 3.6.1 Section 5.1 Section 5.2

8-9	The proponent shall implement the Plan.	The Water Corporation will implement the MPCOOP during, and for 2 to 3 years following construction of the ocean outlet.	Section 1
8-10	The proponent shall make Plan publicly available in a manner approved by the CEO.	The MPCOOP will be made publicly available via the Water Corporation's website	Section 1
9 Seabed and Benthic Habitat Monitoring and Management Plan			
9-1	Prior to commencement of construction of the Alkimos ocean outlet in the marine environment, the proponent shall prepare and submit a Seabed and Benthic Habitat Monitoring and Management Plan (the Plan) that meets the objectives of condition 9- 2 and the requirements of 9-3 as determined by the Minister for the Environment. In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.	The Seabed and Benthic Habitat Monitoring and Management Plan comprises a component of the MPCOOP. The MPCOOP has been prepared to encompass the requirements of Condition 9.	This document
9-2	The objective of this Plan is to ensure that seabed and benthic habitat loss outside the area of direct loss defined in the Plan required by Condition 8-3 (2) is avoided during construction and re-instated following construction.	The MPCOOP has been prepared to meet the objectives set out in Condition 9-2	Section 1.1
9-3	This Plan shall address:		
	1. Procedures for obtaining and providing to the CEO, within six months following the completion of pipeline installation, an accurate total area and geographically referenced location map of areas of seabed (subtidal, intertidal and beaches) modification and benthic primary producer habitats lost or damaged during pipeline construction, including specific identification of any areas of loss or damage that are in excess or outside of those areas defined and predicted in the Plan required by Condition 8.	Monitoring of seabed and BPPH will be undertaken following completion of pipeline installation and compared with baseline data. Mapped results will be provided to the CEO.	Section 5.3.2
	2. Prediction and spatial definition of long-term stable' state of the marine environment following construction and taking into account on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impacts) (see also Condition 8-3 (3));	The MPCOOP addresses the long-term spatial extent of ongoing and indirect impacts. Impacts have been predicted through the use of models.	Section 4.4.3

	3. The establishment of a quantitative annual monitoring program of the seabed and benthic habitat condition in, and adjacent to, areas of seabed and benthic primary producer habitats damaged during pipeline installation and the ongoing presence of the infrastructure; and	A quantitative annual monitoring program of the seabed and benthic habitat condition will be implemented during and following construction as detailed in the MPCOOP.	Section 6.1.2 Section 6.2.2
	4. The indicator(s) and criteria to be used to trigger cessation or reduction in the frequency of monitoring after three years following construction or, in the event of the trigger level referred to in item 3 above being exceeded, after the proponent has demonstrated the success of contingency actions in reducing the rate of annual seagrass loss or damage to less than the contingency trigger level referred to in item 3 above, for three successive years; and	A quantitative annual monitoring program of the seabed and benthic habitat condition will be implemented during and following construction as detailed in the MPCOOP.	Section 6.1.2 Section 6.2.2
	5. Reporting procedures.	Reporting procedures for seabed and benthic habitat condition are provided in the MPCOOP.	Section 7.2 Section 7.3
9-4	If within six months of completion of construction the marine habitat outside the area of direct impact has not returned to the state predicted in Condition 9-3 (3) the proponent is to commence contingency actions to ensure that the rate of post-construction seabed and/or benthic primary producer habitat loss or damage, is restricted and reduced.	Marine habitats will be managed through a hierarchy of proactive and reactive management and monitoring strategies, including contingency actions.	Section 6.1.2 Section 6.2.2
9-5	The proponent shall implement the Plan.	The Water Corporation will implement the MPCOOP during and for 2 to 3 years following construction of the ocean outlet.	Section 1
9-6	The proponent shall make Plan publicly available in a manner approved by the CEO.	The MPCOOP will be made publicly available via the Water Corporation's website (insert in section text "provided this method is approved by the DEC CEO")	Section 1

Note 9. It is expected that the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4.

APPENDIX C - WATER CORPORATION ENVIRONMENT POLICY

Environmental Policy

WATER CORPORATION

Introduction

The Water Corporation provides essential water, wastewater and drainage services to the people of Western Australia. We take water from the environment and return drainage water and treated wastewater and its by-products back into the environment.

In doing this, we aim to provide sustainable, safe and reliable water services to customers and the community.

This policy applies to the Statewide operations of the Water Corporation, which includes all activities, services and products provided by the Corporation to its customers, in accordance with its operating licence.

All employees, and where practicable, 'second parties' (Water Corporation agents, alliance participants, contractors and suppliers) will comply with and support implementation of this policy.

Commitment

The Corporation is committed to:

- playing a leading role in the sustainable future of Western Australia's water resources;
- compliance with applicable environmental legal requirements and with other environmental requirements to which the Corporation subscribes;
- preventing pollution and minimising the adverse effects of our activities; and
- excellence and continual improvement in environmental performance, including conserving natural resources and ecological systems and enhancing them where practicable.

How

Our commitments will be met by:

- providing appropriate services, resources and infrastructure to meet our stated objectives;
- identifying, assessing and managing our environmental risks;
- developing and implementing environmental improvement programmes with measurable targets;
- regularly reviewing and auditing our environmental systems and performance;
- developing and maintaining appropriate incident response plans and minimising the adverse environmental consequences of any accidents; and
- promoting efficient use of resources and minimisation of waste.

Our Environmental Management System provides the framework for developing, implementing, monitoring and reviewing our environmental objectives, targets and actions.

PCY230 Environmental Policy
31 October 2007
CDMS#: 375822

Peter D Moore
Chief Operating Officer

APPENDIX D - WATER CORPORATION SUSTAINABILITY PRINCIPLES

Sustainability Principles

WATER CORPORATION

In the delivery of our services we aspire to:

- **Social**
  - *Protect the health and safety of all and support the wellbeing of our employees and customers*
  - *Respect the values of all*
  - *Enhance community capacity*

- **Economic**
  - *Preserve our capacity to provide water services to meet present and future needs*
  - *Find efficiencies that reduce internal and external costs*
  - *Enhance the economic value to our customers, suppliers and the community while delivering shareholder returns*

- **Environment**
  - *Prevent harm to the environment*
  - *Conserve the values of the environment*
  - *Enhance the resilience of the natural and human environment*

In the delivery of our services we will:

- **Ethical**
  - *Meet our legal requirements and do the right thing*
  - *Be accountable for our business and responsible for our actions*
  - *Be trustworthy in our actions and honest in our communications*

- **Stakeholder**
  - *Maintain our mandate to operate our water business*
  - *Responsibly advocate the water service needs of the community to our shareholder*
  - *Enhance our capacity to support WA's water future*

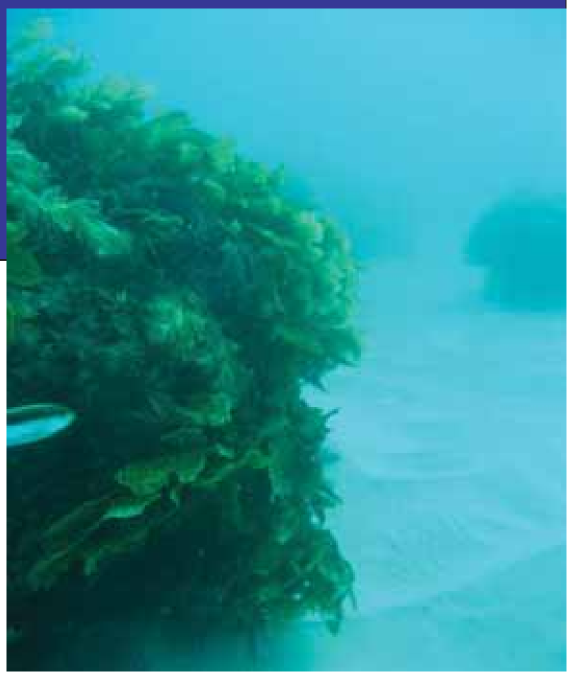
- **Governance**
  - *Maintain best practice business systems and follow our corporate procedures and policies*
  - *Make decisions with humility, recognising our duty to be properly informed and account for what we cannot know*
  - *Listen to and consider our stakeholder's views throughout planning and decision making*

APPENDIX E - ALKIMOS MARINE STUDIES PROGRAMME INTERIM WATER QUALITY CHARACTERISATION DATA REPORT

Alkimos Marine Studies Programme

Interim Water Quality Characterisation Data Report

December 2004 to July 2005



Alkimos Marine Studies Programme

Interim Water Quality Characterisation Data Report

December 2004 to July 2005

Prepared for:

Water Corporation of Western Australia

Prepared by:

Oceanica Consulting Pty Ltd

November 2005

Report No. 436/1

Client: Water Corporation of Western Australia

Revisions history

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		Recipients	No. Copies & Format	Date	Reviewer	Date
1	P. Whittle				S. Turner	10 Jul 05
2	P. Whittle				M. Bailey	5 Sep 05
3	P. Whittle	B. Moulds	1 x electronic	3 Nov 2005	M. Bailey	3 Nov 05

Status

This report is "Draft" until the author and director have signed it off for final release. A "Draft" report should not be used for any purpose other than to be reviewed with the intention of generating a "Final" version.

Approved for final release: Author Director Date: 3/11/05

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1. Introduction

In December 2004, Oceanica Pty Ltd were contracted by the Water Corporation of Western Australia (Water Corporation) to assess the marine water quality in the vicinity of a proposed treated wastewater ocean outlet at Alkimos, Western Australia. This Water Quality Characterisation programme is part of a group of studies aimed at assessing the impacts on the marine environment from the proposed outlet. Other marine studies conducted as part of the Alkimos Marine Studies Programme are:

- Phytoplankton Surveys (December 2004 to ongoing);
- Benthic Habitat Mapping (February 2005);
- Sediment Survey (February 2005);
- Groundwater Infiltration to Marine Sediments (May 2005);
- Hydrodynamic Modelling (Worley Parsons);
- Data management (including uploading of data to 'Seabase');
- Oceanographic Measurements (supporting hydrodynamic modelling and the PER); and
- Public Environmental Review (PER) document.

1.1 Background

In the 1970's the Water Corporation identified the need for a wastewater treatment plant (WWTP) to service the planned residential growth in Perth's North West Metropolitan Corridor. Following evaluation of several different options, the Water Corporation selected Alkimos Lot 101 as the preferred site for what will be known as the Alkimos WWTP, and finalised the acquisition of this site from the Urban Land Council in 1987 (Figure 1.1).

An "in principle agreement" was formalised on the 29th June 2001 with the signing of the Alkimos Eglinton Relocation, Construction and Development Agreement between the Water Corporation, LandCorp and Eglinton Estates (the principal landowners within the structure plan area). This agreement identified the Alkimos WWTP site as acceptable to all parties.

Projected growth in the catchment indicates that approximately 80 ML/d will require treatment at the Alkimos WWTP by 2050. Ultimately plant inflows could grow to 160 ML/d.

1.2 Objectives

The objective of the Water Quality Characterisation component of the Alkimos Marine Studies Programme was to undertake regular field measurements over the period December 2004-November 2005 to characterise the water quality of the marine waters around the proposed Alkimos Wastewater Treatment Plant (WWTP) Ocean Outlet.

The project provides background information on the seasonal and spatial variability in water quality (nutrients, primary productivity and microbiological indicators) in the Alkimos region, which are comparable with data collected at Perth's other ocean outlets (Ocean Reef, Swanbourne and Sepia Depression) through the Perth Ocean Outlet Monitoring (PLOOM) Programme.

It is anticipated that information from the ongoing water quality sampling and analysis programme will be used in the future identification of suitable management criteria for marine water quality at Alkimos.

This interim data report has been generated to provide water quality characterisation information for inclusion in the "*Alkimos Waste Water Treatment Plant - Public Environmental Review*" (Water Corporation 2005a).

The collected data from December 2004 to July 2005 will used to:

- Establish the existing water quality conditions in the Alkimos region prior to the construction and operation of the proposed Alkimos WWTP Ocean Outlet; and,
- Assess the potential effects of the treated wastewater discharge on the marine receiving environment.

1.3 Key Tasks

1. <u>Nutrient-Related Water Quality Surveys:</u>

Nutrient-related water quality surveys were undertaken at each of the six shoreline sites, six near-shore (~9.5-12.5 m) and six offshore (~14-15.5 m) sites at monthly intervals over the period December 2004-July 2005.

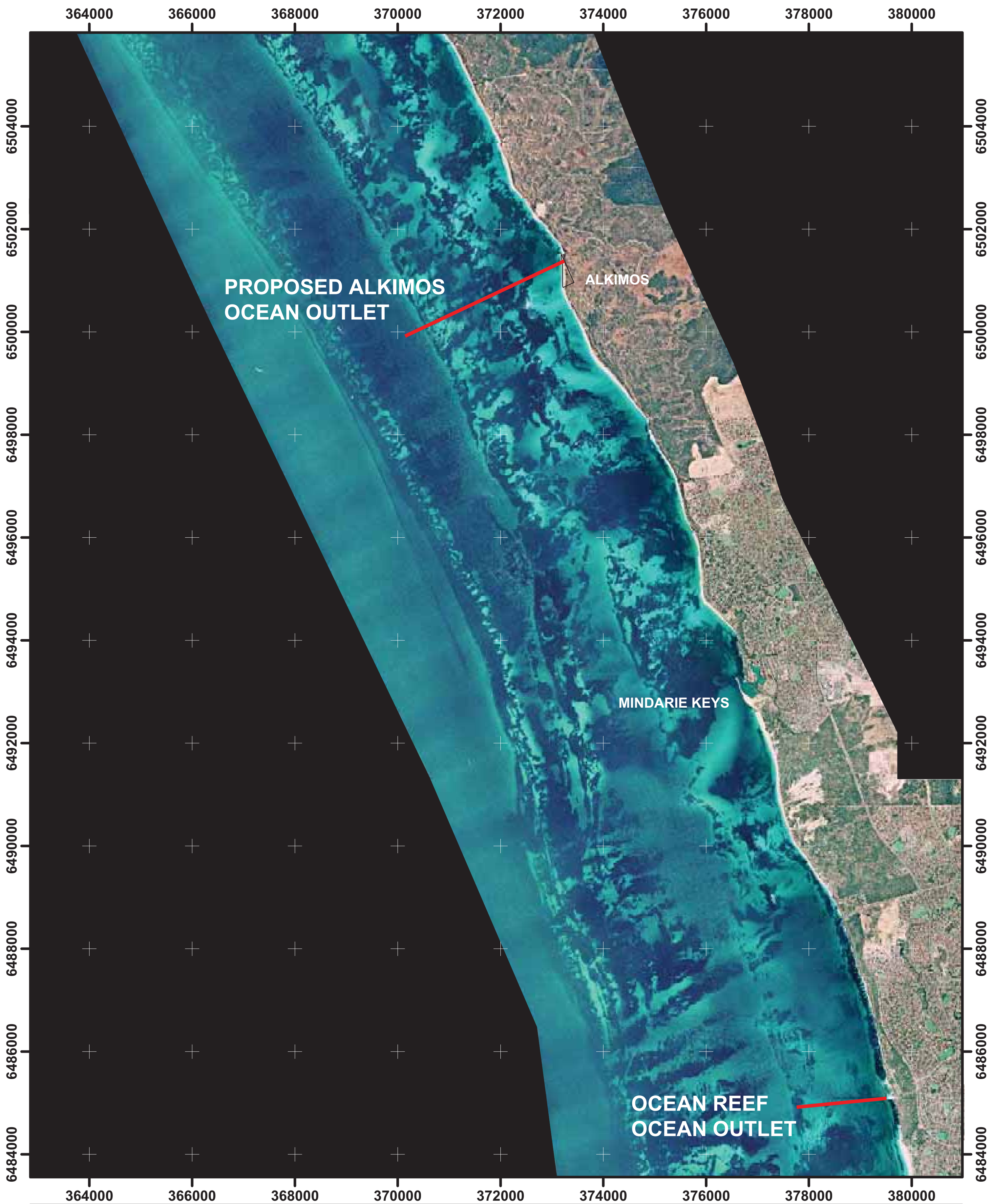
2. <u>Human-Health Water Quality Surveys:</u>

Human-health water quality surveys (microbiological sampling) were undertaken at monthly intervals over summer 2004-2005 (December-May) at each of the 6 shoreline sites, 6 near-shore and 6 offshore sites. Microbiological sampling was not undertaken during the winter months as this is outside of the prime recreational swimming season.

3. <u>Preparation of a Water Quality Characterisation Report:</u>

An interim Water Quality Characterisation Data Report was prepared (this document) including details on the field methods, analytical techniques, results, and a detailed description and interpretation of the water quality conditions over the study period.

The sampling results are presented graphically to assist with interpretation. All the data collected during the sampling programme is tabulated and presented in the appendix sections of this report.



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marine & estuarine specialists

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P:\Water Corporation\Alkimos\
Figure 1.1 Alkimos and Ocean Reef.mxd

0 1 2 4 Kilometers

DATUM
Horizontal: UTM Zone 50,
Based on WGS 84
Vertical: N/A

2

Figure 1.1

Alkimos location
and aerial photograph.

Client: Water Corporation
June 2005

2. Methods

2.1 Field Sites

Water quality sampling sites were chosen to provide a representative sample of shoreline, nearshore and offshore waters in the vicinity of the proposed Alkimos Ocean Outlet (AOO). Figure 2.1 displays the location of the water quality monitoring sites with the site coordinates provided in Appendix A.

2.2 Water Quality Sampling

On each sampling event, at each of the six nearshore and six offshore water quality sampling sites, water samples were collected from the surface (approximately 1 m below the surface) and bottom (approximately 2 m above the seafloor) of the water column. Water samples were collected with a Rule (2.1 L/s) submersible pump, which was flushed with seawater for 30 s (>10 tubing volumes) prior to collection of the sample at each depth and site.

On the first sampling occasion in December 2004, at one nearshore and one offshore site, an additional depth-integrated sample was collected over the top half of the water column as part of method justification.

At each of the shoreline sites, water samples were collected by filling sample containers directly in waist-deep water.

The following samples were collected from each depth at each of the sampling sites:

- Two 125 mL unfiltered samples in HDPE bottles for total phosphorus and total nitrogen analysis;
- Two 10 mL filtered (through a 45 µm filter onsite) samples in PP tubes for ortho-phosphate, ammonium and nitrate + nitrite analysis;
- One 4-10 L filtered (through a GF/C filter onsite) sample for chlorophyll-*a* and phaeophytin analysis; and
- One pre-sterilised 250 mL plastic bottle for thermo-tolerant coliform and enterococci analysis.

With the exception of the pre-sterilised sample bottles used for the microbiological analyses, all the sample containers were flushed with seawater at each site prior to filling. Immediately after collection all the samples were placed on ice out of direct sunlight.

All sampling was conducted in general accordance with the standard operating procedures developed for Cockburn Sound (EPA 2005a).

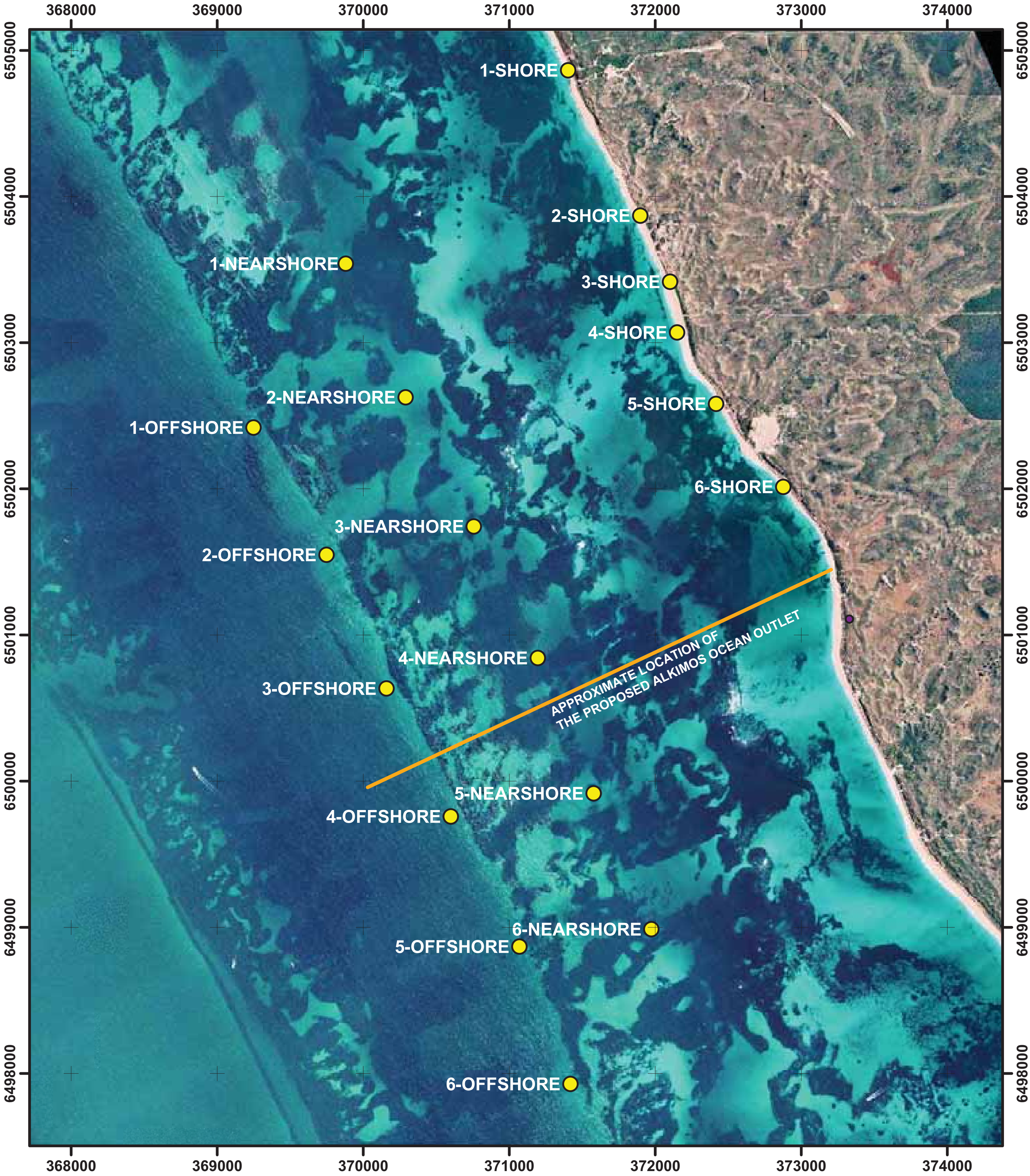
Table 2.1 summarises the parameters measured on each sampling event between December 2004 and May 2005.

Table 2.1 Parameters measured for each sampling event

Parameter	20/12/04	19/01/05	10/02/05	17/03/05	21/04/05	12/05/05	22/06/05	19/07/05
Physical Profiles								
Temperature (^{o}C)	✓	✓	✓	✓	✓	✓	✓	✓
Salinity (ppt)	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Oxygen (%, mg/L)	✓	✓	✓	✓	✓	✓	✓	✓
Secchi (m)	✓	✓	✓	✓	✓	✓	✓	✓
Light Attenuation ($log_{10}\ m^{-1}$)	✓	✓	✓	✓	✓	✓	✓	✓
Wind (m/s, direction)	✓	✓	✓	✓	✓	✓	✓	✓
Weather (observations)	✓	✓	✓	✓	✓	✓	✓	✓
Nutrients								
Total Phosphorus (μg P/ L)	✓	✓	✓	✓	✓	✓	✓	✓
Ortho-Phosphate (μg P/ L)	✓	✓	✓	✓	✓	✓	✓	✓
Total Nitrogen (μg N/ L)	✓	✓	✓	✓	✓	✓	✓	✓
Ammonia[1] (μg N/L)	✓	✓	✓	✓	✓	✓	✓	✓
Nitrate + Nitrite (μg N/ L)	✓	✓	✓	✓	✓	✓	✓	✓
Primary Production								
Chlorophyll-*a* (μg/L)	✓	✓	✓	✓	✓	✓	✓	✓
Phaeophytin (μg/L)	✓	✓	✓	✓	✓	✓	✓	✓
Microbiological								
Thermo-Tolerant Coliforms (CFU/100 mL)	✓	✓	✓	✓	✓	✓		
Faecal streptococci (as enterococci) (MPN/100 mL)	✓	✓	✓	✓	✓	✓		

Notes:

1. *The method used for detection of ammonium actually converts all ammonium to ammonia and data is reported as ammonia. At the pH of seawater NH_x species are predominantly ammonium (Libes 1992).*



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Reference: 435_1
P;\Water Corporation\Alkimos\Water Quality
Figure 2.1 Alkimos WQ sites.mxd

Meters
0 500 1,000 2,000

DATUM
Horizontal: UTM Zone 50,
Based on WGS 84
Vertical: N/A

2

Figure 2.1

Alkimos Water Quality Sampling Sites

Client: Water Corporation
June 2005

2.3 Laboratory Analysis

The water samples were analysed for the following suite of parameters:

Nutrients

- Total Phosphorus
- Filterable Reactive Phosphorus
- Total Nitrogen
- Ammonium Nitrogen
- Nitrate + Nitrite Nitrogen

Primary Production

- Chlorophyll-*a*
- Phaeophytin

Microbiological Indicators

- Thermo-tolerant Coliforms
- Faecal Streptococci (as Enterococci)

Standard laboratory analytical procedures were employed throughout (see Table 2.2). All nutrient, primary production and microbiological parameters were measured using NATA certified procedures.

Table 2.2 Analytical methods and reporting limits for each of the water quality parameters measured

Parameter	Analytical Method(1)	Reporting Limit	Unit
Nutrients			
Total Phosphorus	Lachat-Automated Flow Injection Analyser (4700)	5(2)	$\mu g\ P\ L^{-1}$
Filterable Reactive Phosphorus	Lachat-Automated Flow Injection Analyser (4100)	2(2)	$\mu g\ P\ L^{-1}$
Total Nitrogen	Lachat-Automated Flow Injection Analyser (2700)	50(2)	$\mu g\ N\ L^{-1}$
Ammonium	Lachat-Automated Flow Injection Analyser (2000)	3(2)	$\mu g\ N\ L^{-1}$
Nitrate + Nitrite	Lachat-Automated Flow Injection Analyser (2100)	2(2)	$\mu g\ N\ L^{-1}$
Primary Production			
Chlorophyll-*a*	Acetone extraction (3000)	0.1(2)	$\mu g\ L^{-1}$
Phaeophytin	Acetone extraction (3000)	0.1(2)	$\mu g\ L^{-1}$
Microbiological Indicators			
Thermo-tolerant Coliforms	Membrane filtration	Dilution dependent(3)	CFU 100 mL^{-1}
Faecal streptococci (as Enterococci)	Membrane filtration	Dilution dependent(3)	MPN 100 mL^{-1}

Notes:
1. *Numbers in brackets refer to the MAFRL analysis method number.*
2. *Method detection limit determined from 3.2 x standard deviation of 10 standard samples.*
3. *The upper and lower detection limits for thermo-tolerant coliform and faecal streptococci are dependent on the dilution of the original sample.*

2.4 Water Column Structure

On each sampling occasion at each of the six nearshore and six offshore sites, a YSI 6600/YSI 600XL multi-parameter water quality sensor was lowered through the water column to provide *in situ* information on the physical structure of the water column.

At each site the following water column measurements were obtained:

- Light intensity profile (to provide vertical light attenuation coefficients);

- Salinity depth profile;
- Temperature depth profile;
- Dissolved oxygen depth profile; and
- Secchi depth (measured by lowering a Secchi disk to limit of visibility).

2.5 Weather Conditions

Sampling was undertaken over the summer, autumn and winter months (December 2004-July 2005) in generally fair conditions (daily average wind speed < 8 m/s). Figure 2.2 displays a summary of the wind speed and direction at Ocean Reef for the seven days preceding each sampling event.

It can be seen from the December 2004 to February 2005 (summer) wind data that a strong southerly component existed prior to sampling, likely to drive northerly surface currents in the study area. A change to lighter easterly winds predominated in March 2005, possibly driving localised upwelling of bottom waters near the coast. A return to southerly winds was seen prior to the April 2005 sampling event although somewhat lighter than southerlies seen during summer. Easterlies and a northerly component dominated prior to the May 2005 sampling event. The northerlies were relatively light (<8 m/s) and unlikely to produce significant southerly wind driven surface currents. Lighter north-easterlies (<8 m/s) and stronger southerlies (>10 m/s) dominated prior to the June sampling event and strong westerlies prior to the July 2005 sampling. Strong westerlies are likely to drive surface, longshore currents with periodic "rips" drawing shoreline surface waters into the nearshore / offshore zone.

2.6 Data Management and Analysis

The data from the Water Quality Characterisation Project were verified, validated and then formatted to be suitable for uploading and importation into 'Seabase'. Verification of data involved ensuring all requested parameters were returned for the required sites, dates and depths and that the required analytical methods were used. The values for required parameters were checked for outliers and inconsistencies through graphing of the data. At the time of reporting some data was awaiting validation and repeat analysis where required. All water quality data will be uploaded to 'Seabase' when QA/QC requirements are met.

All raw data is held on file at Oceanica in either hardcopy or electronic form.

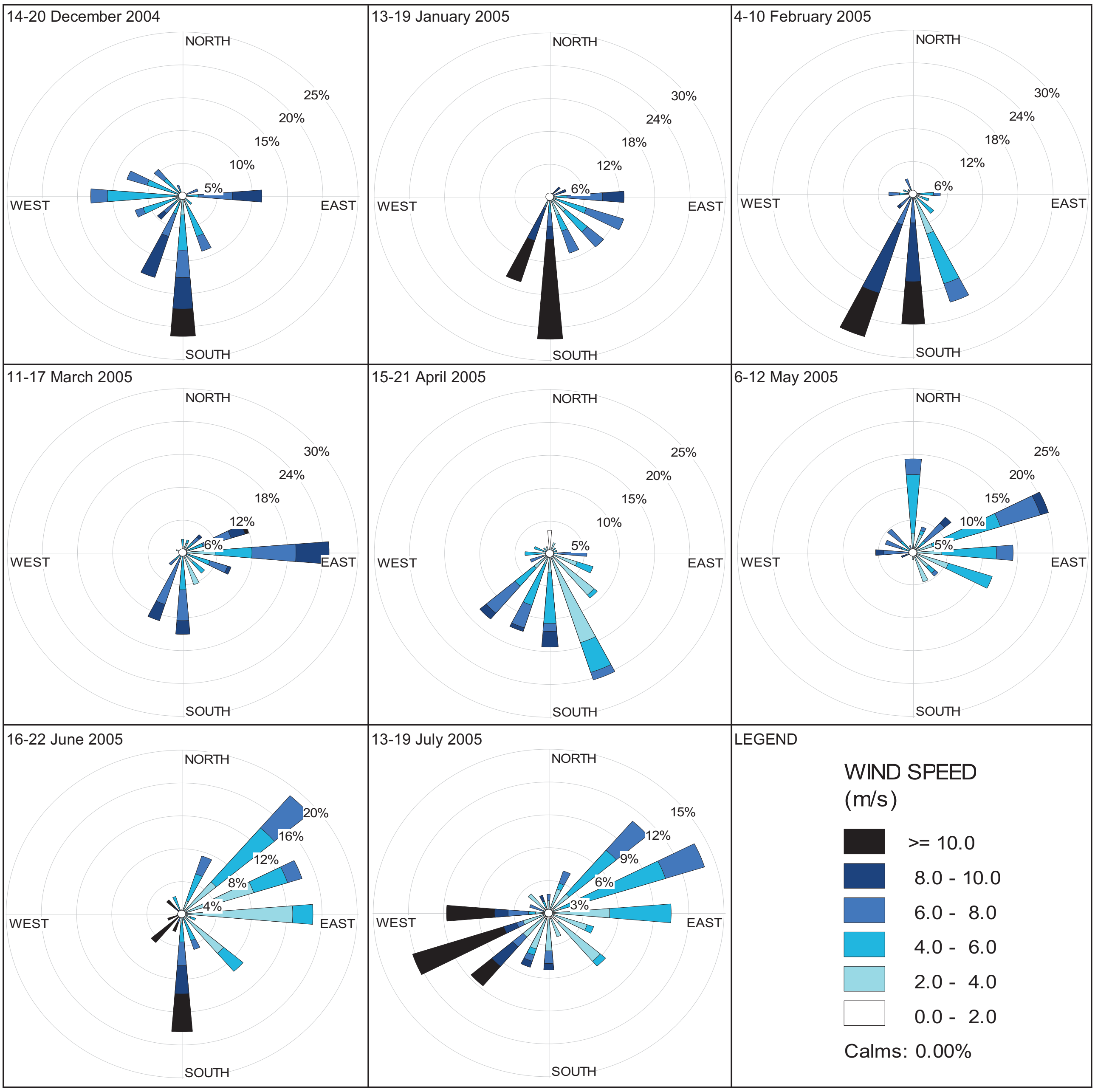


Figure 2.2 Summary of Wind Speed and Direction at Ocean Reef for the 7 days prior to each sampling event (December 2004 to July 2005)

Note: Data supplied by Climate and Consultative Services, Bureau of Meteorology, Perth, Western Australia (email dated 1 June 2005 and 26 Aug 2005). Wind speed and directions binned from hourly averaged data. Wind roses indicate the direction wind was blowing "from".

3. Results

3.1 Water Column Structure

The temperature, salinity and dissolved oxygen (DO) profiles for all twelve deeper water sites (Nearshore 1-6 and Offshore 1- 6) are presented graphically in Figures 3.1 to 3.8. Figure 3.9 displays a summary of the mean temperature, salinity and DO concentrations for surface and bottom waters between December 2004 and July 2005.

For the majority of the sampling events the water column was well mixed at both nearshore and offshore sites. Notable exceptions were on 20 December 2004, 21 April 2005 and 19 July 2005. On these dates a change in water temperature (thermocline) and slight change in salinity (halocline) was evident at between 2 m to 8 m depth in December (most conspicuous offshore, Figure 3.1b), 4 m to 8 m (nearshore) and 8 m to bottom (offshore) in April (Figures 3.5a and 3.5b) and 7 m to 12 m offshore in July (Figure 3.8e).

Water temperature ranged from a maximum of 23.26 ^{o}C on 20 December 2004 (site Nearshore-5 surface waters) to a minimum of 16.11 ^{o}C on 22 June 2005 (site Nearshore-2 bottom waters). As would be expected due to solar insolation at the surface, bottom waters (<1 m above bottom of profiles) were cooler than surface waters (<1 m below surface) for both nearshore and offshore sites. The average temperature difference between surface and bottom waters was 0.13 ^{o}C (standard deviation = 0.16) for nearshore and 0.18 ^{o}C (standard deviation = 0.22) for offshore sites (Figure 3.9a). Water temperature varied between 22.1 ^{o}C and 23.2 ^{o}C over the summer, dropping ~ 2 ^{o}C over the autumn period (17 March to 12 May 2005) (Figure 3.9a). A further ~ 3 ^{o}C drop in average water temperature was observed from autumn to winter (12 May 2005 to 22 June 2005)(Figure 3.9a).

Salinity ranged from a maximum of 36.77 ppt (calculated units) on 10 February 2005 at site Nearshore-3 (throughout the water column) (Figure 3.3c) to a minimum of 35.22 ppt on 22 June 2005 in surface waters at site Offshore-6 (Figure 3.7d). Salinity displayed a similar behaviour to temperature over the study period with a maximum occurring on 10 February 2005 and a steady decrease over the autumn /winter from 10 February to 22 June 2005 (Figure 3.9b). Salinity was routinely higher at the nearshore sites in comparison to the offshore sites with the exception of 19 January and 12 May 2005 where the water column appears to have been well mixed both horizontally and vertically within the sampling area.

3.2 Dissolved Oxygen

Dissolved Oxygen (DO) profiles for the twelve deeper water sites (Nearshore 1-6 and Offshore 1-6) are presented graphically in Figures 3.1(e-h) to 3.8(e-h). A summary of the mean DO saturation (%) over the reporting period is presented in Figure 3.9c.

Waters within the sampling area remained well oxygenated throughout the monitoring period. The lowest recorded oxygen saturation was 87.4 % in the bottom waters of site Nearshore-4 on 17 March 2005. The maximum recorded DO saturation was 117.1 % at site Nearshore 6 on 20 December 2005. On this date, Nearshore-6 exhibited a distinct increase in DO concentration (0.6 mg/L increase) in the water column between 5 m and 11 m that was notably absent from other sites. A general reduction in DO saturation was observed over the autumn of 2005 at both nearshore and offshore sites (Figure 3.9c). DO saturation increased to above 100 % in July 2005, likely due to vertical mixing bringing the colder winter waters into equilibrium with the atmosphere.

On 19 July 2005 site Offshore-6 exhibited an increase in DO concentrations from the surface to a depth of ~12 m. This pattern was not observed in any of the other five offshore sites whose DO profiles displayed a relatively uniform DO concentration with depth (Figure 3.8h). Temperature profiles from the same date (Figure 3.8b) show that the warmer surface layer was mixed deeper at Offshore-6 than at most other offshore sites.

Using statistical analysis (paired t-tests) to determine differences between surface (<1 m deep) and bottom (<1 m above bottom of profile) water, the influence of temperature and salinity on DO saturation was apparent. While the DO concentration (in mg/L) was not significantly different between surface and bottom waters ($P = 0.12$, $n = 72$), the percent DO saturation (as a function of water temperature, salinity and depth) was significantly different ($P = 0.015$, $n = 72$). This result is expected as the cooler bottom waters (with greater dissolved oxygen holding capacity) are primarily supplied with dissolved oxygen from the warmer surface waters.

The median DO concentrations in surface (~0.5 m bellow surface) and bottom (~0.5 m above the bottom) waters were above the ANZACC/ARMCANZ (2000) guideline for coastal marine waters of >90 % saturation. While site Nearshore-4 displayed DO saturation levels at slightly less than 90 % (17 March 2005), these low levels were only recorded for this single site on the one sampling event.

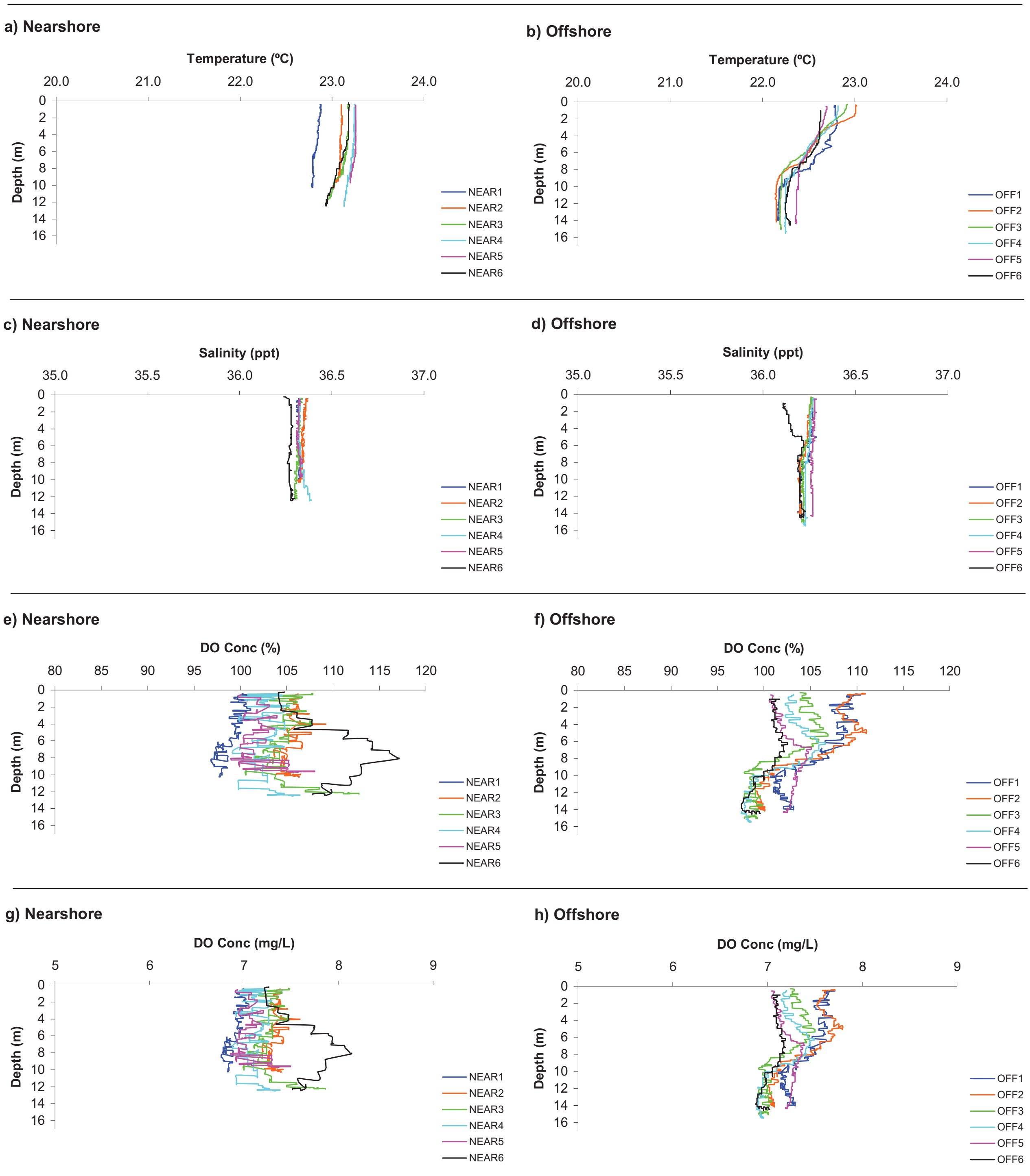


Figure 3.1(a-h) Temperature, Salinity, DO saturation and DO concentration for Alkimos water quality sites – 20 December 2004

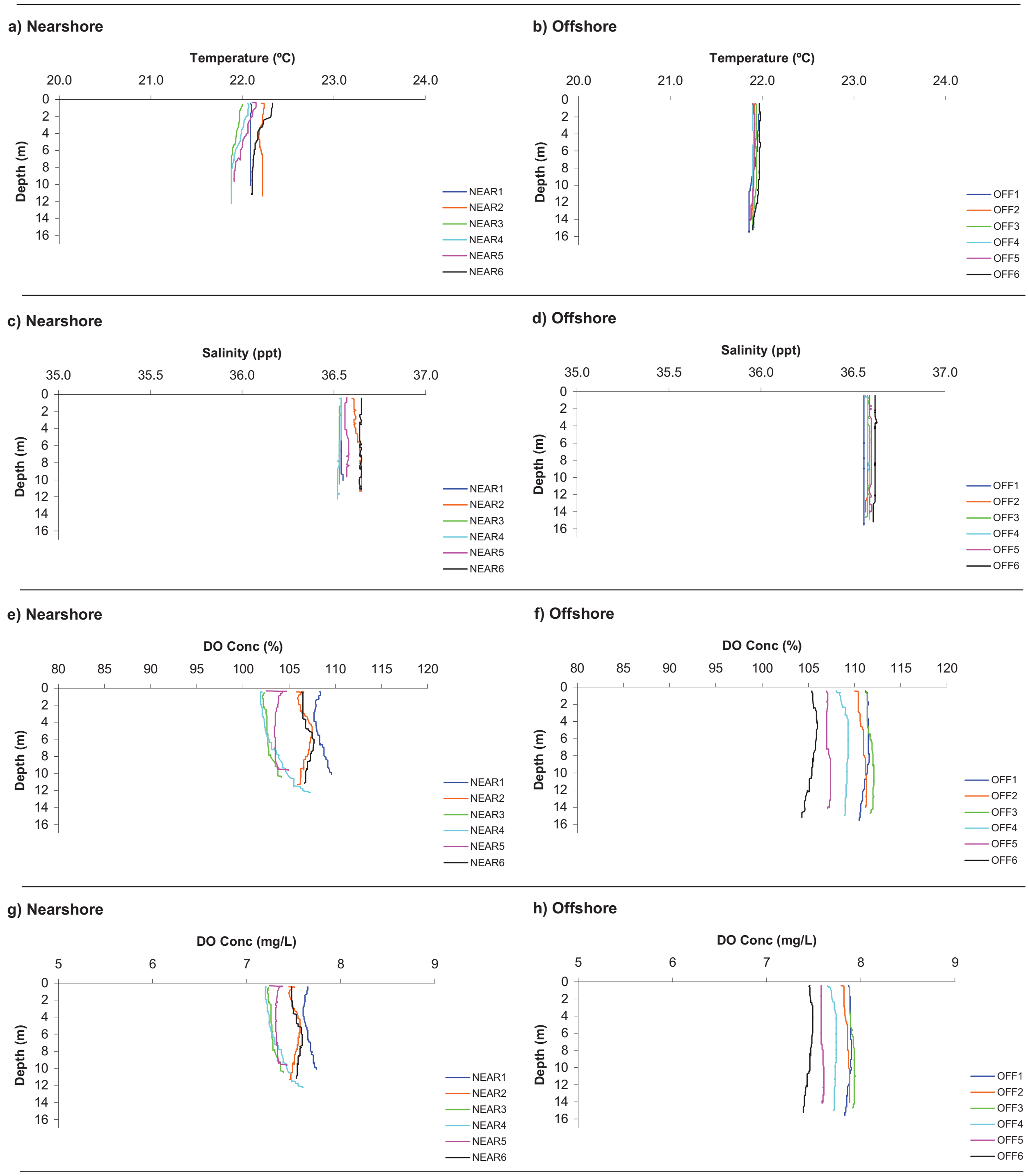


Figure 3.2(a-h) Temperature, Salinity, DO saturation and DO concentration for Alkimos water quality sites – 19 January 2005

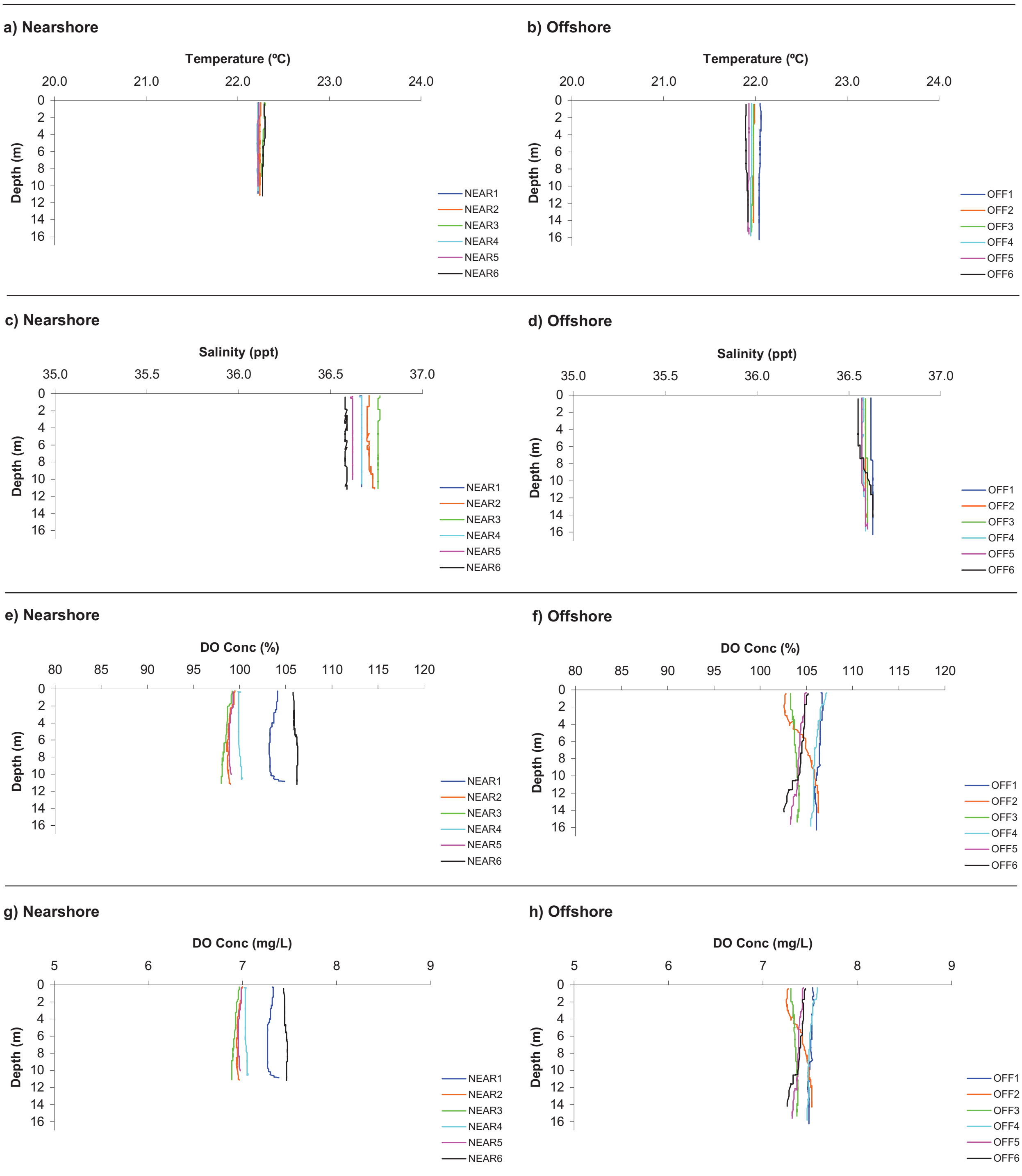


Figure 3.3(a-h) Temperature, Salinity, DO saturation and DO concentration for Alkimos water quality sites – 10 February 2005

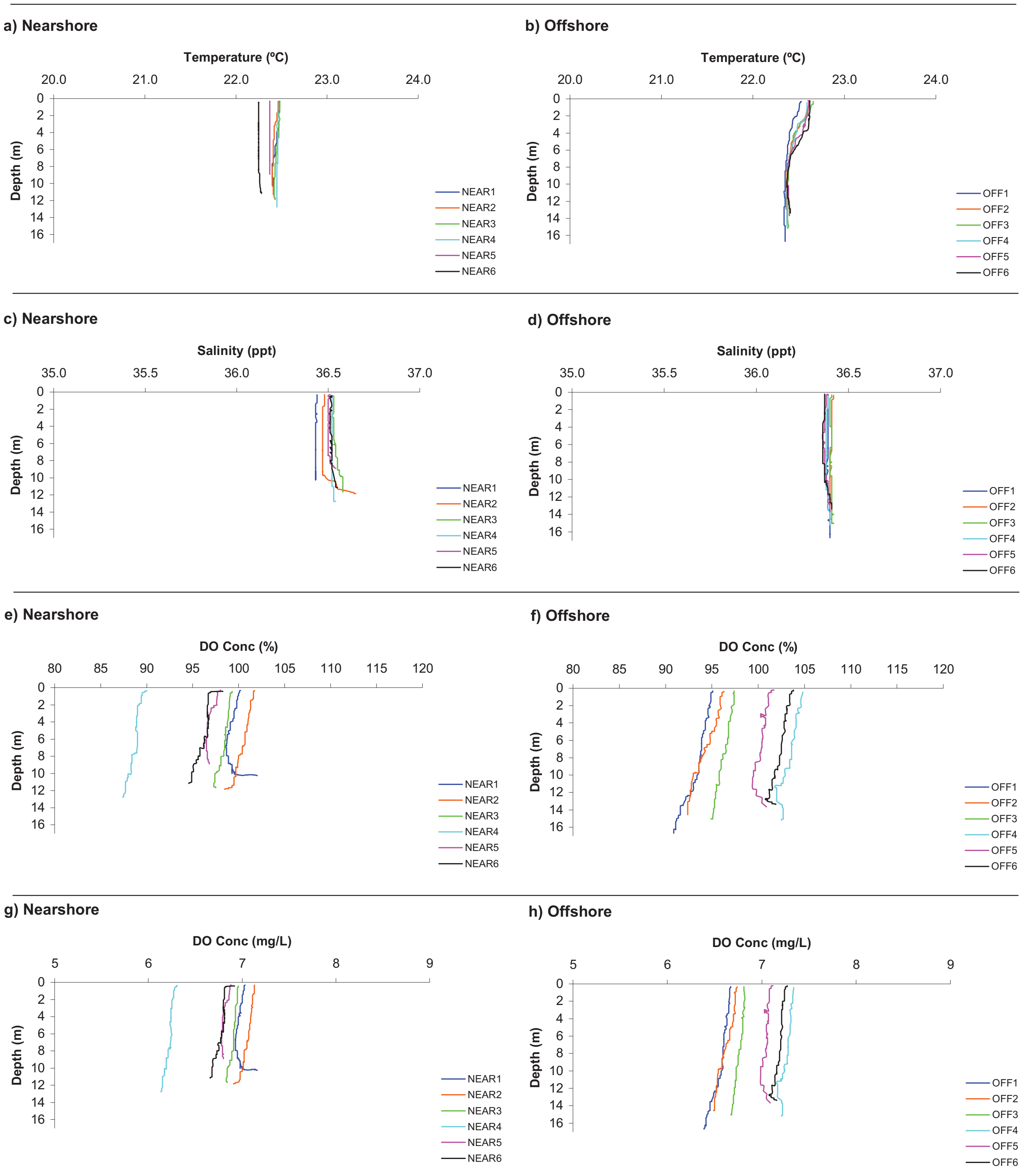


Figure 3.4(a-h) Temperature, Salinity, DO saturation and DO concentration for Alkimos water quality sites – 17 March 2005

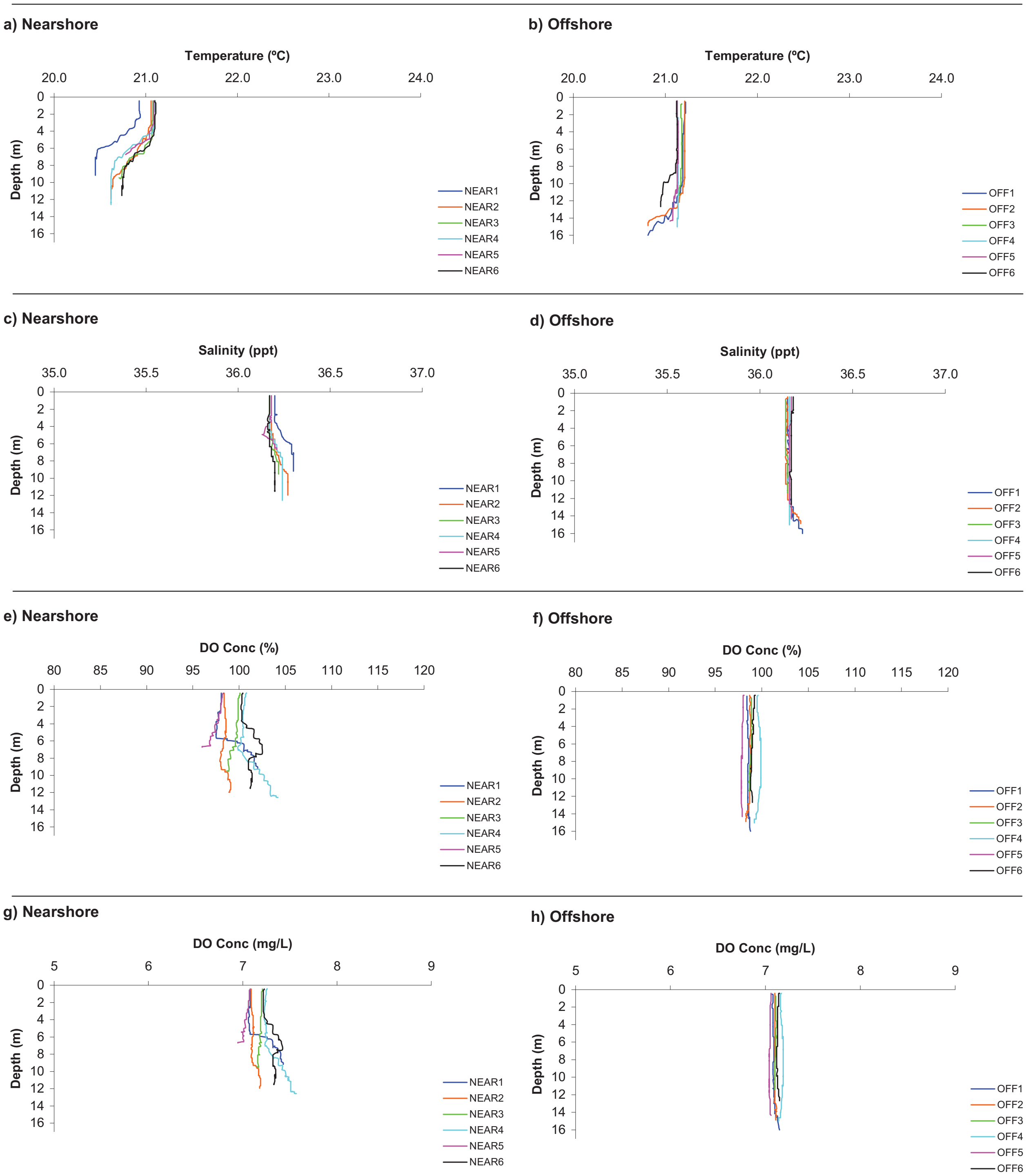


Figure 3.5(a-h) Temperature, Salinity, DO saturation and DO concentration for Alkimos water quality sites – 21 April 2005

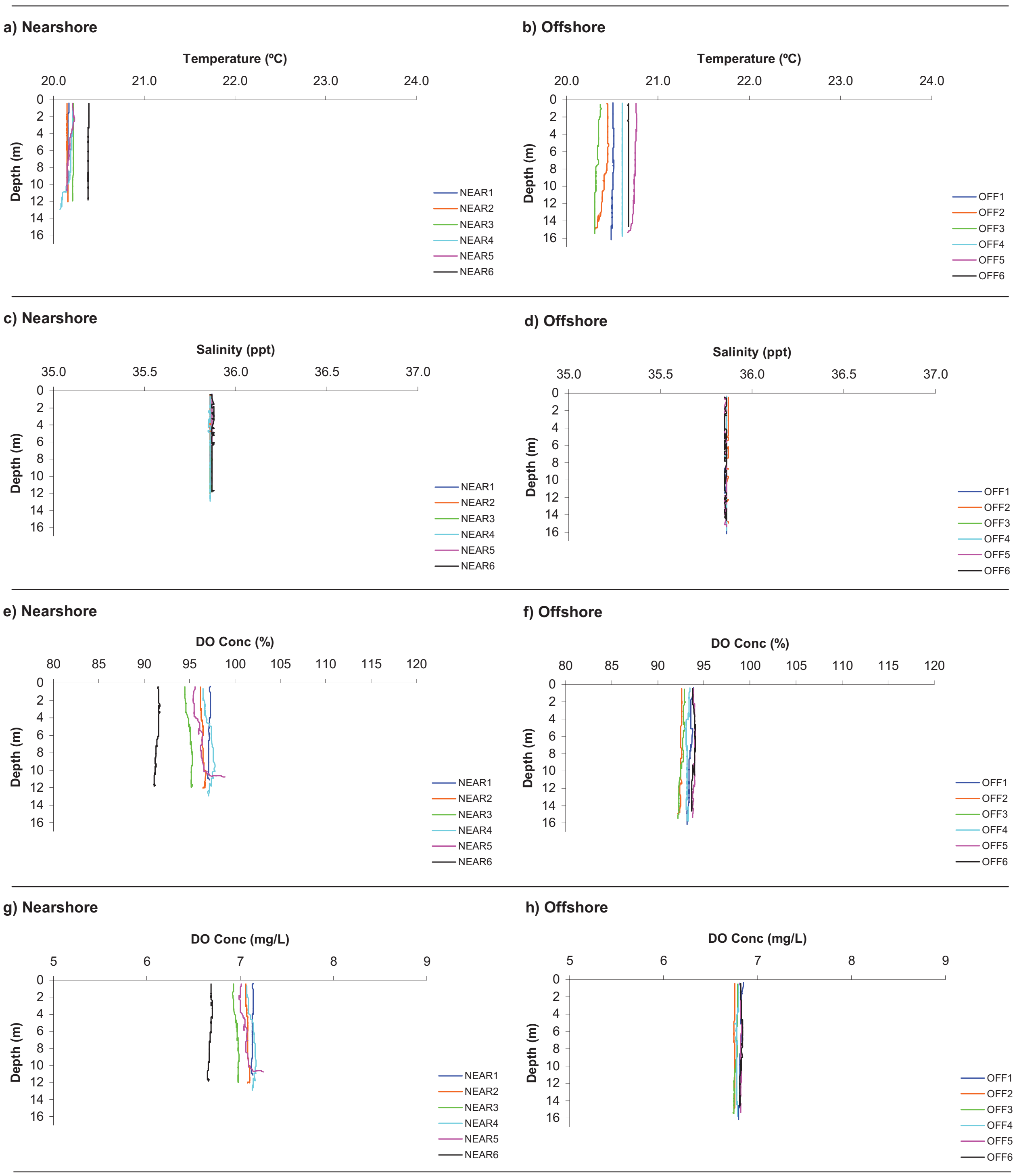


Figure 3.6(a-h) **Temperature, Salinity, DO saturation and DO concentration for Alkimos water quality sites – 12 May 2005**

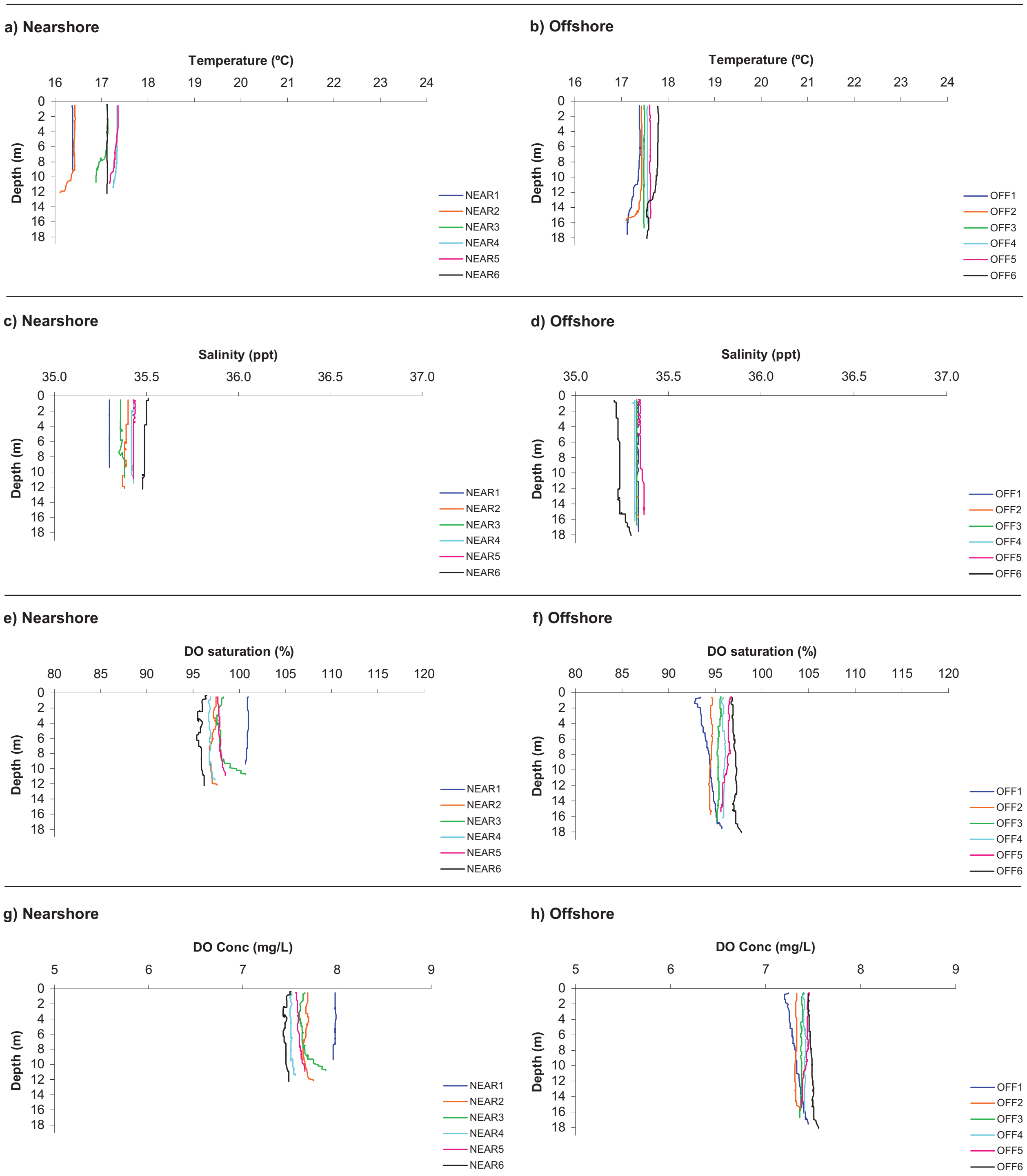


Figure 3.7(a-h) Temperature, Salinity, DO saturation and DO concentration for Alkimos water quality sites – 22 June 2005

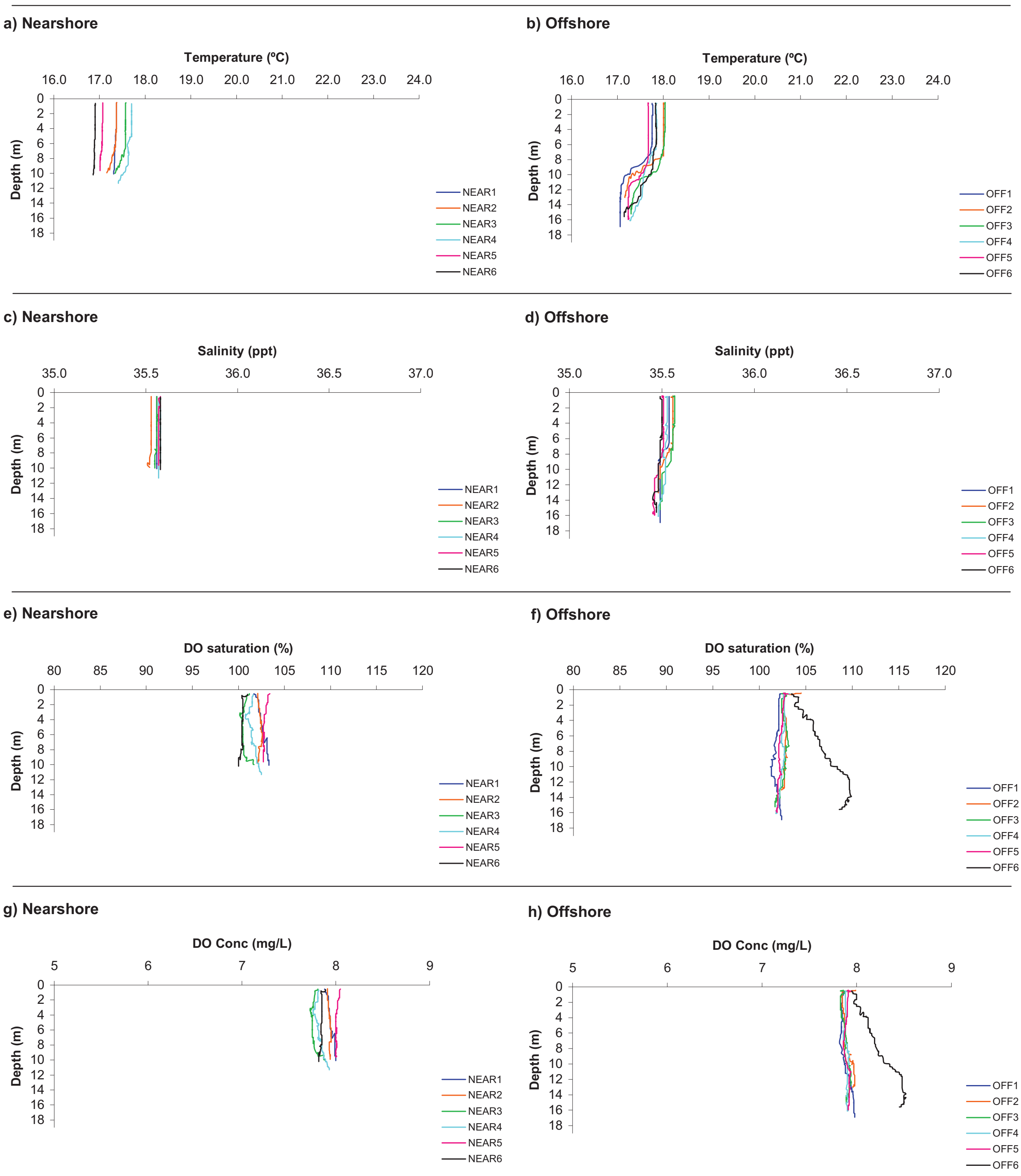
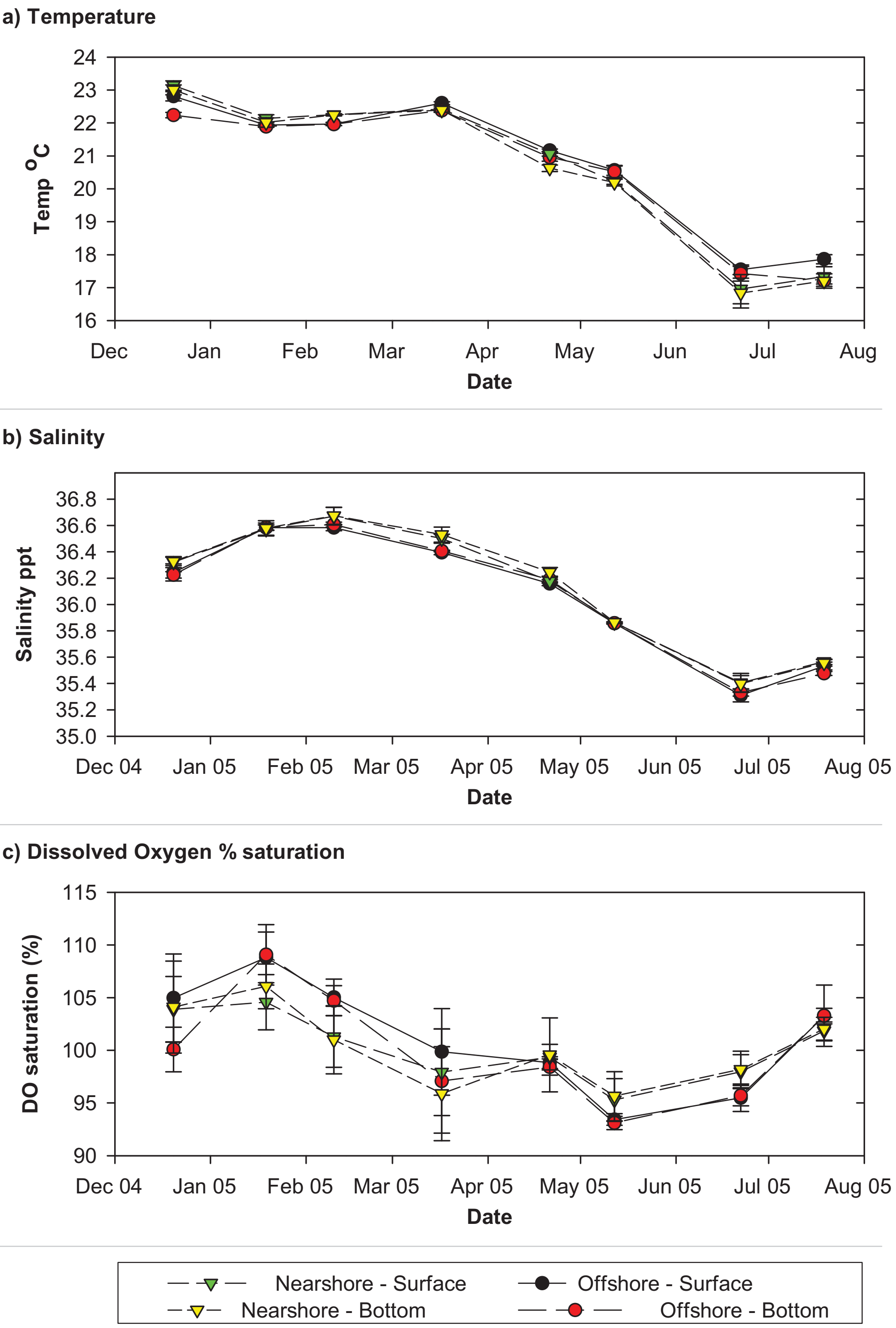


Figure 3.8(a-h) Temperature, Salinity, DO saturation and DO concentration for Alkimos water quality sites – 19 July 2005



Notes: Error bars represent 1 standard deviation (6 sites).

Figure 3.9 Alkimos mean surface and bottom water temperature, salinity and dissolved oxygen – December 2004 to July 2005

3.3 Nutrients and Chlorophyll

As part of method validation, an "integrated sample" was taken over the top half of the water column, together with the normal discrete depth surface and bottom water samples, at sites Offshore-6 and Nearshore-6 during the first sampling event (20 December 2004). The comparison of the integrated upper water column samples with surface and bottom water samples is presented in Figure 3.10. It can be seen from Figure 3.10 that while values from the integrated samples were not intermediate between surface and bottom water samples for most nutrients, values of a similar range were returned. Depth integrated sampling of the top half of the water column is used for the PLOOM intensive summer and seasonal water quality monitoring programmes (Oceanica, 2005a).

Table 3.1 presents the median, 20th percentile and 80th percentile values for nutrient parameters and chlorophyll-a at the Alkimos water quality sites for the period December 2004 to July 2005. The mean offshore, nearshore and shoreline nutrient concentrations for surface and bottom waters for each sampling event are presented graphically in Figure 3.11(a-f). Nutrient concentrations for individual sites are presented graphically in Figure 3.12(a-r) to Figure 3.17(a-r). Only surface water samples were taken at shore sites (from waist deep water) due to insufficient water depth to take bottom water samples.

Discussion of the results for individual nutrient and chlorophyll parameters is presented in Sections 3.3.1 to 3.3.6. For most parameters a brief comparison is made to the findings of the Perth Coastal Waters Study (PCWS) (Lord and Hillman 1995). The PCWS was undertaken between July 1992 and December 1994 to "*determine the loads of nitrogen contained in treated wastewater that can be discharged into Perth's coastal waters and maintain environmental values*" (Lord and Hillman 1995). The PCWS results present a general snapshot of the nutrient related water quality of the Perth coastal waters during the study period (July 1992 and December 1994) though the study area was largely restricted to waters to the south of the current Alkimos water quality sites.

Table 3.1 Median, 20th percentile and 80th percentile values for nutrients and chlorophyll-a at Alkimos water quality shore, nearshore and offshore sites – December 2004 to July 2005

Parameter	Site[1]	n	20th %ile[3]	Median	80th %ile
Total Phosphorus (µg.P/L)	All	237	13.0	16.0	21.1
	Shore	45	15.5	19.0	23.0
	Near-S	48	14.0	15.5	19.7
	Near-B	48	15.0	16.0	22.0
	Off-S	48	12.0	14.0	19.9
	Off-B	48	13.0	14.0	17.0
Filterable Reactive Phosphorus (µg.P/L)	All	237	8.0	10.0	14.0
	Shore	45	9.0	11.0	14.0
	Near-S	48	9.0	10.0	13.9
	Near-B	48	9.0	11.0	15.0
	Off-S	48	8.0	8.0	12.7
	Off-B	48	8.0	9.0	10.9
Total Nitrogen (µg.N/L)	All	237	120	140	170
	Shore	45	140	170	260
	Near-S	48	120	130	150
	Near-B	48	110	135	150
	Off-S	48	101	140	160
	Off-B	48	120	150	170
Ammonia[2] (µg.N/L)	All	237	3.0	3.0	3.0
	Shore	45	3.0	5.0	8.0
	Near-S	48	3.0	3.0	3.0
	Near-B	48	3.0	3.0	3.0
	Off-S	48	3.0	3.0	3.0
	Off-B	48	3.0	3.0	3.0
Nitrate+nitrite (µg.N/L)	All	237	4.0	8.0	14.0
	Shore	45	4.0	6.0	12.0
	Near-S	48	5.0	8.0	12.0
	Near-B	48	5.0	8.0	12.9
	Off-S	48	3.1	7.5	22.5
	Off-B	48	4.0	10.0	15.9
Chlorophyll-a (µg/L)	All	237	0.3	0.5	0.7
	Shore	45	0.4	0.6	0.8
	Near-S	48	0.3	0.4	0.6
	Near-B	48	0.3	0.4	0.6
	Off-S	48	0.3	0.5	0.6
	Off-B	48	0.4	0.5	0.8

Notes: *1. See Figure 2.16 for site locations; "Shore" sites located in waste deep water along Alkimos shoreline; "Near-S" refers to nearshore surface water samples. "Near-B" refers to nearshore bottom water samples "Off-S" refers to offshore surface water samples; "Off-B" refers to offshore bottom water samples;*

2. The majority of ammonia samples were below the reporting limit of 3 µg.N/L. The full reporting limit value (3) was used in calculating percentile and median values for these samples;
3. Percentiles were calculated using the Hazen percentile calculating macro in Microsoft Excel (hazen-percentile-calculator update 27_5_05.xls; McBride 2002).

3.3.1 Total phosphorus

Total Phosphorus (TP) concentrations ranged from 9 µg/L to 29 µg/L over the reporting period with average concentrations generally decreasing from shore sites to offshore sites (Table 3.1). Shore sites displayed distinctly higher TP concentrations than nearshore or offshore sites on 19 January 2005 (Figure 3.11a). This pattern of TP concentrations and distribution is consistent with the findings of the PCWS (Lord and Hillman 1995) of higher TP concentrations nearshore. While mean TP concentrations at Alkimos water quality sites over the reporting period were approximately a third higher than those of the PCWS, the range in values was less.

The lowest average concentration and variability of TP was observed in the offshore bottom waters. There was a trend towards lower TP values across all sites from March 2005 to July 2005 although concentrations were relatively stable over the April to June (2005) period (Figure 3.11a).

A summary graph of total phosphorus concentrations and standard deviations (error bars) for shore, nearshore and offshore sites is presented in Figure 3.11a. Individual data points for all sites and dates are presented in Figure 3.12(a-r).

3.3.2 Filterable Reactive Phosphorus (FRP)

FRP concentrations tended to follow a similar temporal pattern to TP with a general decrease in concentrations across all sites from autumn to winter (Figure 3.11b). The spatial distribution of FRP mean concentrations was similar to that for TP with a decrease in concentrations from shore to offshore sites (Table 3.1). Offshore bottom sites contained the lowest mean FRP concentrations over the reporting period. Between-site variability in FRP concentrations was greatest on 20 December 2004 and least on 22 June 2005.

Filterable reactive phosphorus (FRP) concentrations varied within a range of 7 to 22 µg.P/L over the reporting period with an average across all sites of 10.8 µg.P/L. Peak concentrations of FRP during the sampling period were recorded at nearshore sites in December 2004. A secondary peak was seen across all sites in March 2005 with concentrations generally dropping through spring/winter. The lowest FRP concentrations for shore, nearshore and offshore sites were recorded in July 2005. These temporal patterns in FRP concentrations are in contrast to the findings of the Perth Coastal Waters Study (Lord and Hillman 1995) where summer median FRP values were lower than winter values.

A summary graph of FRP concentrations and standard deviations (error bars) is presented in Figure 3.11b. Individual data points for all sites and dates are presented in Figure 3.13(a-r).

3.3.3 Total Nitrogen

The ammonia and nitrate+nitrite components on average comprised less than 10 % of the total nitrogen pool, suggesting particulate nitrogen (probably organic) as the dominant reservoir of this element in the system (other than inert dissolved nitrogen gas). Total nitrogen (TN) concentrations ranged from 90 to 400 µg N/L over the reporting period, with a mean value of 149 µg.N/L. Little temporal change in the mean TN values was seen over the reporting period with the exception of the shoreline sites (Figure 3.11c and Figure 3.14[a-r]). Shoreline TN values were higher than nearshore and offshore sites for the majority of sampling events and were distinctly elevated on the 19 January 2005 sampling event (Figure 3.11c). Total nitrogen concentrations did not appear to follow the temporal or spatial trends of ammonia or nitrate+nitrite.

In general the TN concentrations in the current study were considerably lower than those found during the PCWS. Only Alkimos shore sites recorded TN values at the lower range of those found during the PCWS (Lord and Hillman 1995).

A summary graph of mean TN concentrations and ± standard deviations (error bars) is presented in Figure 3.11c. Individual data points for all sites and dates are presented in Figure 3.14(a-r).

3.3.4 Ammonia

The median ammonia concentration for all sites over the reporting period was below the reporting limit (3 µg N/L). The median concentration across all sites and dates was 3.0 µg N/L (calculated using the reporting limit value where determined values were below the reporting limit) (Table 3.1). A maximum value of 22 µg N/L was recorded on three occasions, all at shoreline sites (Shore-4 and Shore-6 on 21 April 2005and, Shore-1 on 10 February 2005). Shore sites on average displayed elevated ammonia concentrations in comparison to nearshore and offshore sites (Table 3.1 and Figure 3.11d). Mean ammonia concentrations at shore sites steadily decreased from January through to July 2005 to reach below reporting limits at all sites (< 3 µg.N/L).

Ammonia concentrations were on average lower at the Alkimos water quality sites during the reporting period than those of the summer 1994 PCWS (Lord and Hillman 1995).

A summary graph of ammonia concentrations and standard deviations (error bars) is presented in Figure 3.11d. Individual data points for all sites and dates are presented in Figure 3.15(a-r).

Note: Both ammonium (NH_3^+) and ammonia (NH_4) species are presented as ammonia in the water quality data. The analytical method used for the detection of these species converts all ammonium ion to ammonia and detects ammonia. Due to pH and solubility considerations, most NH_x in seawater is predicted to occur as the more soluble ammonium ion (Libes, 1992).

3.3.5 Nitrate + Nitrite

Nitrate (NO_3^-) and nitrite (NO_2^-) concentrations are combined for reporting purposes. The nitrate+nitrite (NO_x^-) concentrations for Alkimos ranged from 2 to 25 µg N/L over the reporting period with a mean value of 11.1 µg.N/L (Table 3.1). Concentrations of NO_x were elevated across all sites on 22 June 2005 in comparison to previous sampling events (Figure 3.11e). NO_x displayed a different temporal and spatial pattern of distribution than TN or ammonia with the highest and most variable concentrations occurring in March and June 2005.

Nitrate+nitrite concentrations were generally higher at offshore and nearshore sites than at shore sites. The Alkimos nitrate+nitrite concentrations peaked in June (2005), reflecting the seasonal winter peak in nitrate typical of Perth coastal waters (Kinhill 1999).

Mean NO_x concentrations at all Alkimos water quality sites were higher than those recorded for the PCWS. The mean value for NO_x at Alkimos sites exceeded the 90th percentile value of the PCWS sites (winter 1993 only) for all dates except during the summer sampling in December 2004 and January 2005. When the mean Alkimos concentrations for each sampling event are compared to the 90th percentile value of the PCWS sites for summer 1994 (Table 5.1 in Lord and Hillman 1995), only the 22 June 2005 data are in higher.

A summary graph of nitrate+nitrite concentrations and standard deviations (error bars) is presented in Figure 3.11e. Individual data points for all sites and dates are presented in Figure 3.16(a-r).

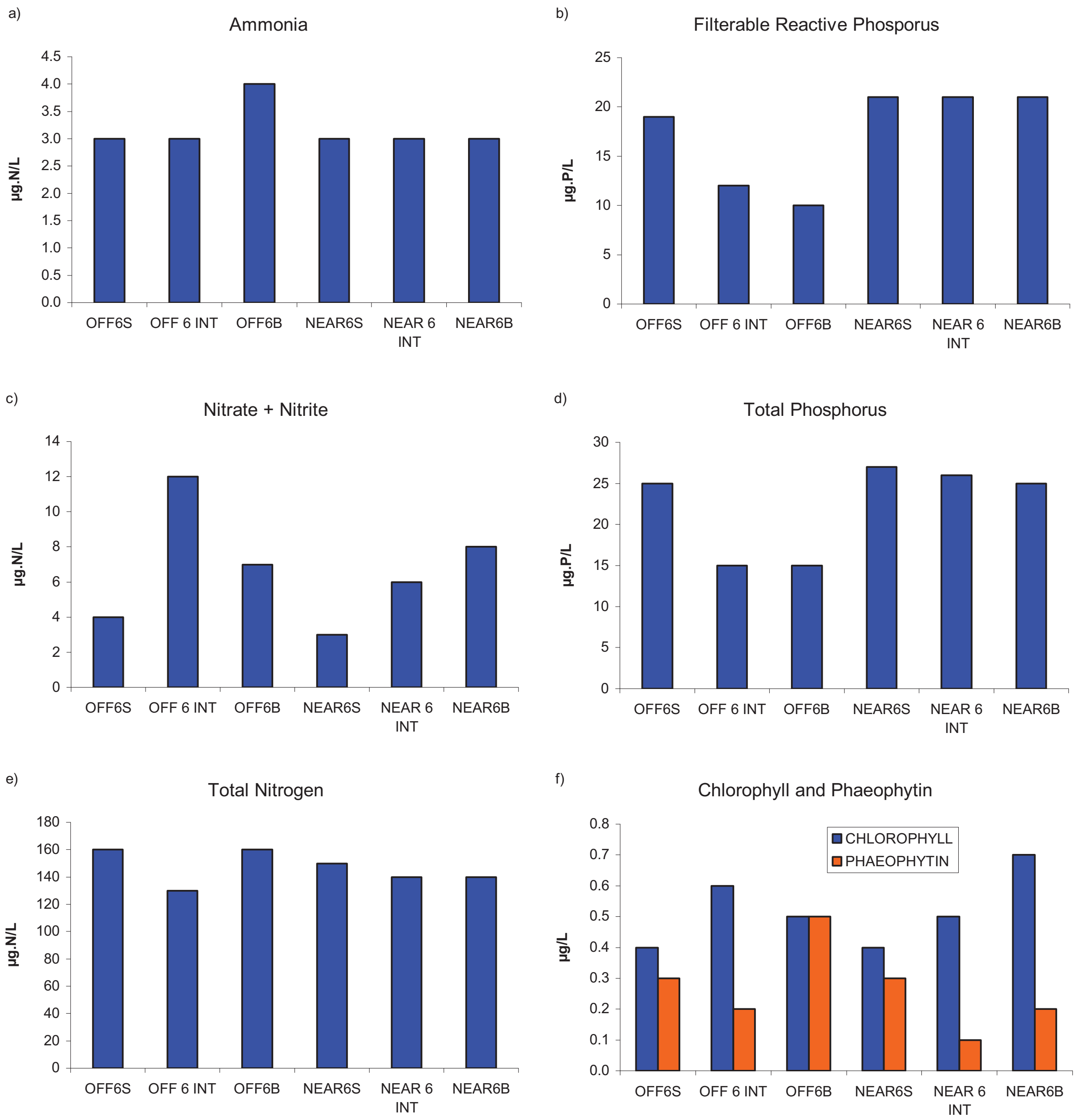
3.3.6 Chlorophyll-a

The findings of the Alkimos phytoplankton survey programme are presented in detail in a separate report as part of the Alkimos Marine Studies Programme (Oceanica 2005b). The distribution of phytoplankton biomass at Alkimos (as determined by chlorophyll-a concentrations) is summarised here in reference to overall water quality at the site. A summary graph of chlorophyll *a* concentrations and standard deviations (error bars) is presented in Figure 3.11f. Individual data points for all sites and dates are presented in Figure 3.17(a-r).

Chlorophyll-a (Chl-a) concentrations at Alkimos were relatively uniform between shore, nearshore and offshore sites and between surface and bottom water samples (Table 3.1).

Chl-a concentrations at Alkimos water quality sites ranged from the reporting limit (0.1 µg/L) to 1.9 µg/L for the reporting period. The mean value across all sites and dates was 0.5 µg/L. The highest concentrations of Chl-a for the reporting period were recorded in the bottom waters of nearshore and offshore sites in March 2005, suggesting either resuspension of these pigments from the sediments or photo-inhibition of the water column phytoplankton population in the vicinity of the surface samples. Persistent easterly winds prior to the March 2005 sampling event (Figure 2.2) may have induced some sediment resuspension through upwelling of bottom waters. Shore sites contained elevated Chl-a concentrations in comparison to other sites in April, May and June 2005 (Figure 3.11f).

Chl-a concentrations were generally elevated at shore, nearshore and offshore sites in comparison to the PCWS nearshore values. The mean Chl-a concentrations at shore and offshore bottom water sites exceeded the 90th percentile values for the PCWS (Lord and Hillman 1995).



Site Codes:

OFF6S = Offshore Site 6 (Surface)	NEAR6S = Nearshore Site 6 (Surface)
OFF 6 INT = Offshore Site 6 (Integrated)	NEAR 6 INT = Nearshore Site 6 (Integrated)
OFF6B = Offshore Site 6 (Bottom)	NEAR6B = Nearshore Site 6 (Bottom)

Figure 3.10(a-f) Comparison of upper water column depth integrated samples with samples collected at specific depths (20 December 2004)

Note: Ammonia concentrations for samples OFF6S, NEAR6S, NEAR6B and NEAR 6 INT were below the reporting limit of 3 µg.N/L. These samples are presented here as at the reporting limit for comparison purposes.

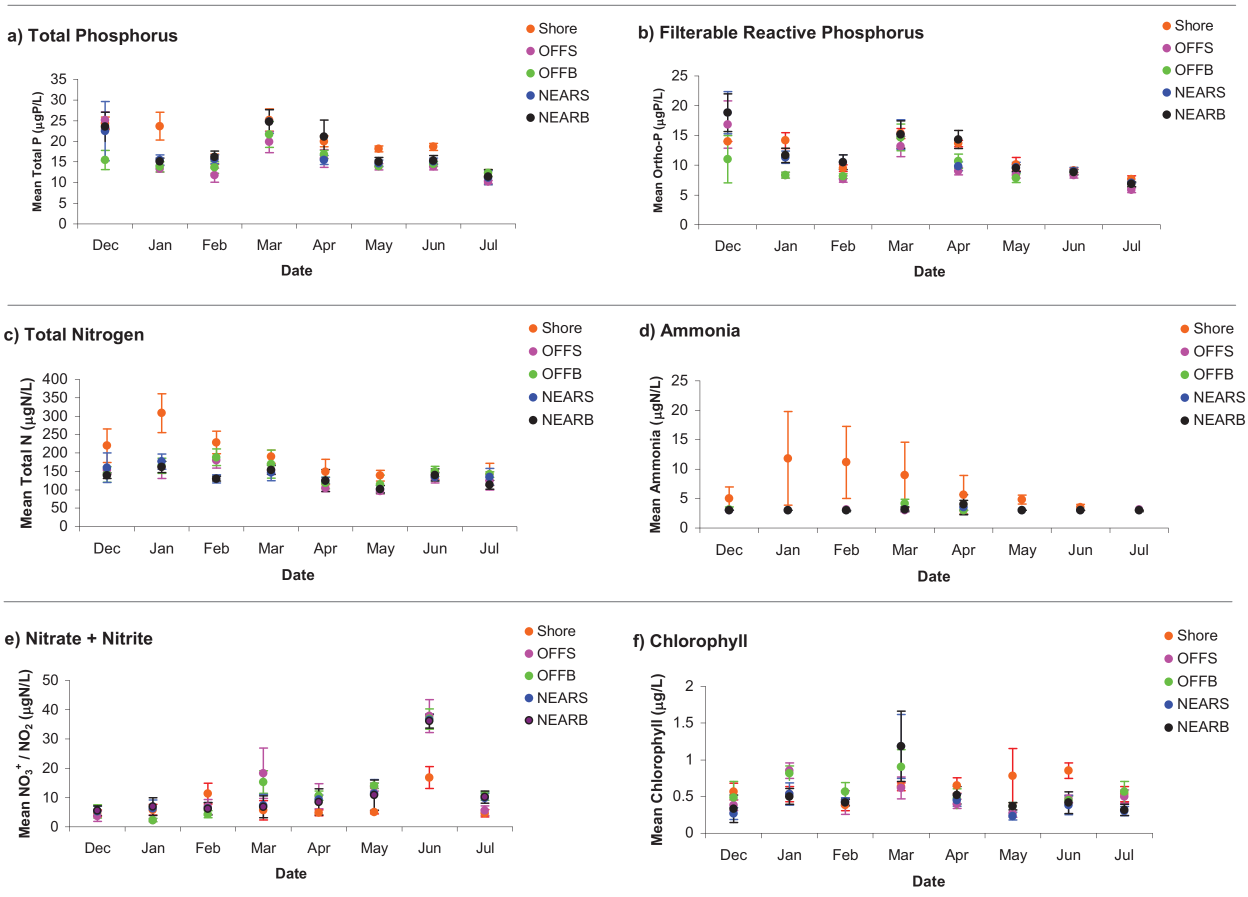


Figure 3.11(a-f) Summary plots of mean nutrients and mean Chlorophyll at Alkimos water quality sites (December 2004 to May 2005)

Note: error bars represent 1 standard deviation (six samples).

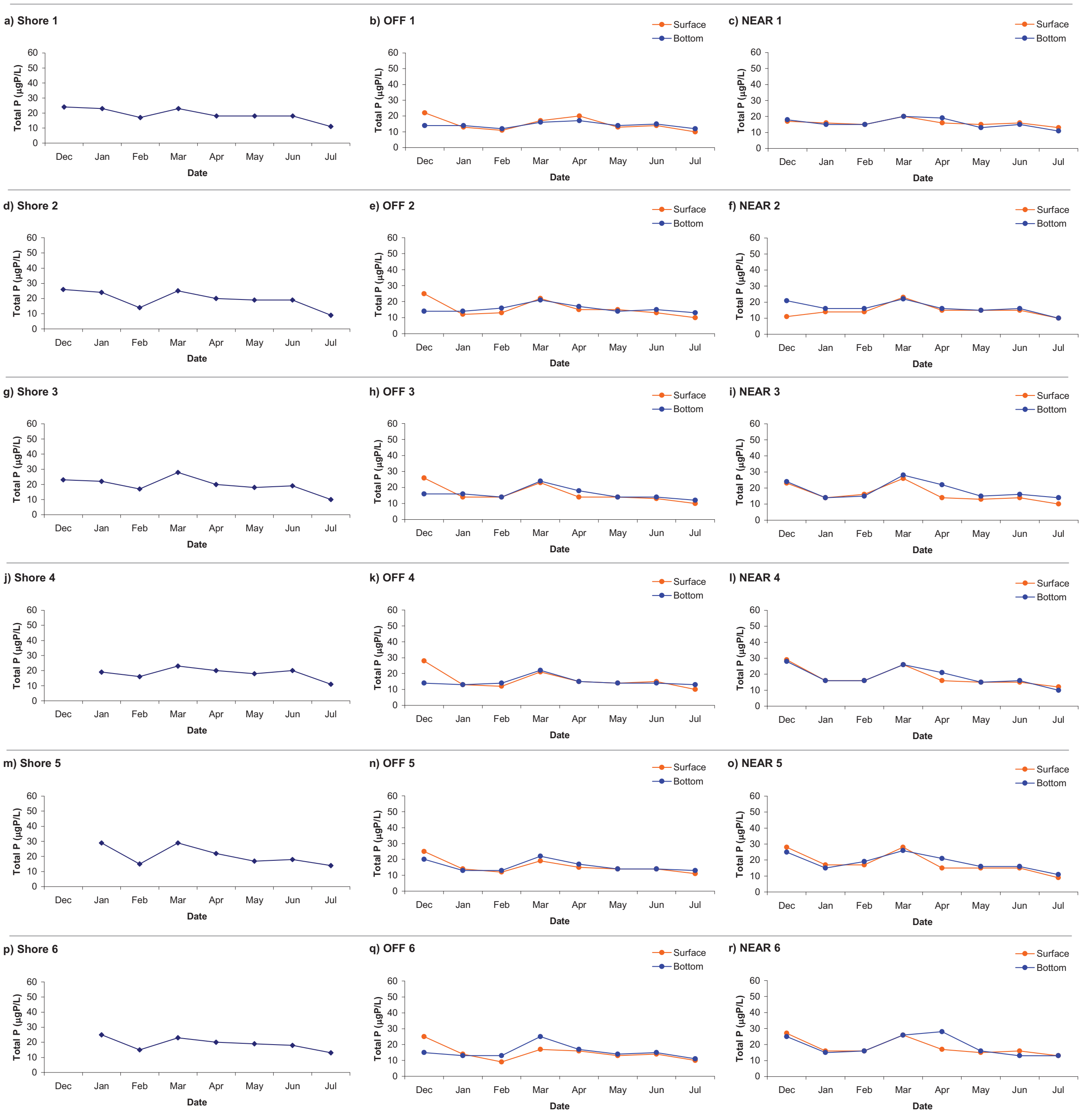


Figure 3.12(a-r) Total Phosphorus concentrations for Alkimos water quality sites – December 2004 to July 2005

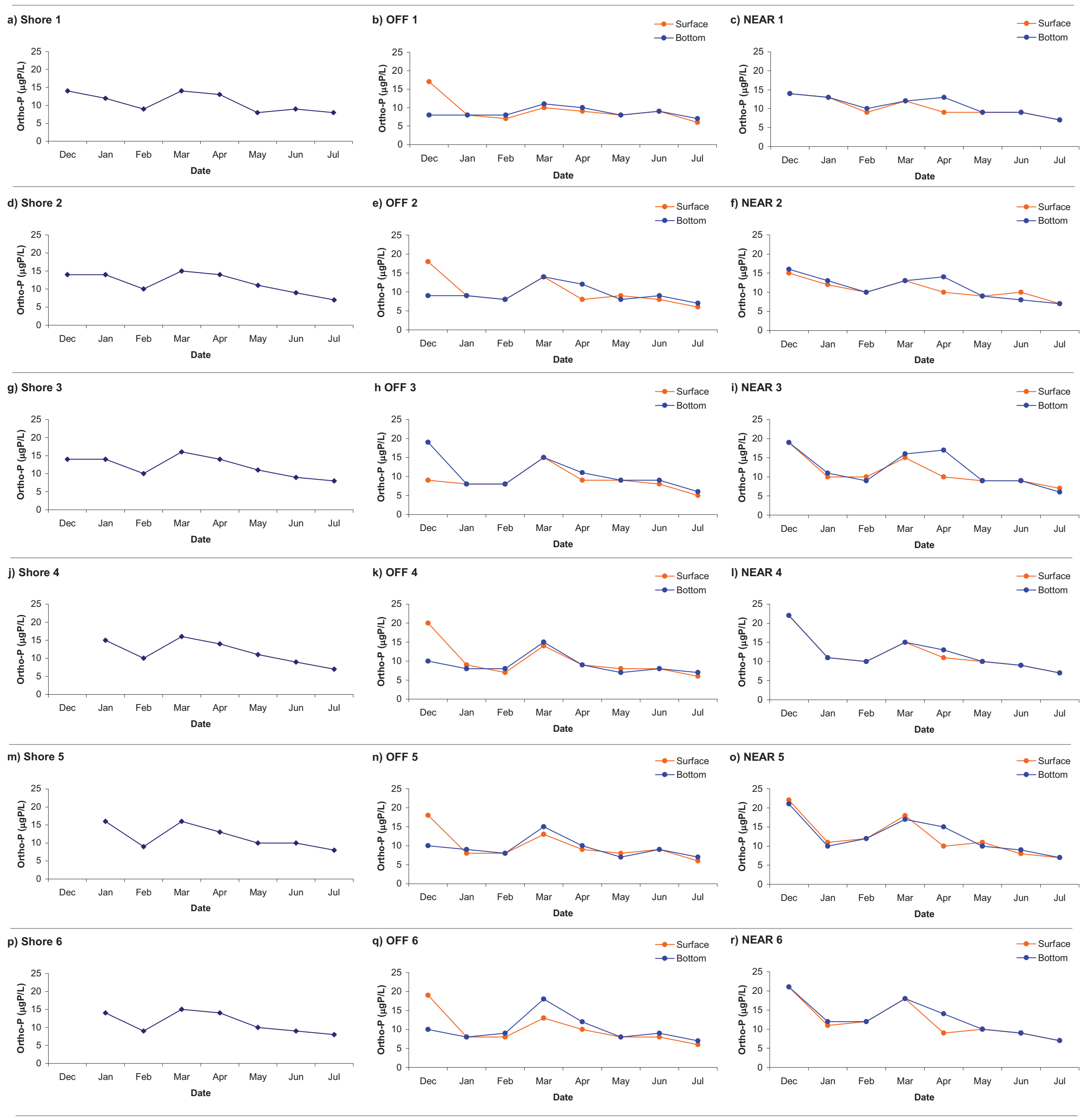


Figure 3.13(a-r) **Filterable Reactive Phosphorus (FRP) concentrations for Alkimos water quality sites – December 2004 to July 2005**

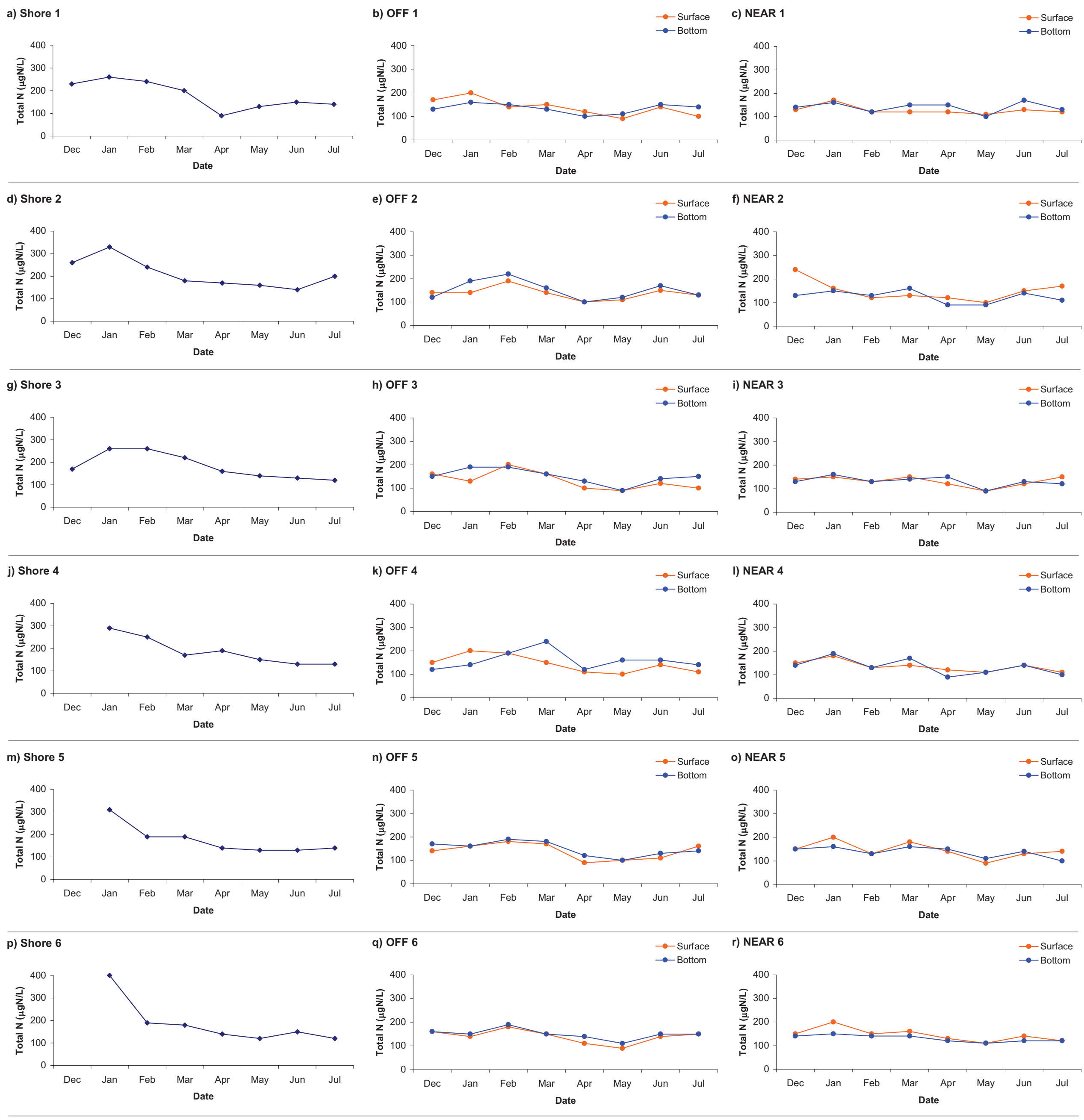


Figure 3.14(a-r) Total Nitrogen concentrations for Alkimos water quality sites – December 2004 to July 2005

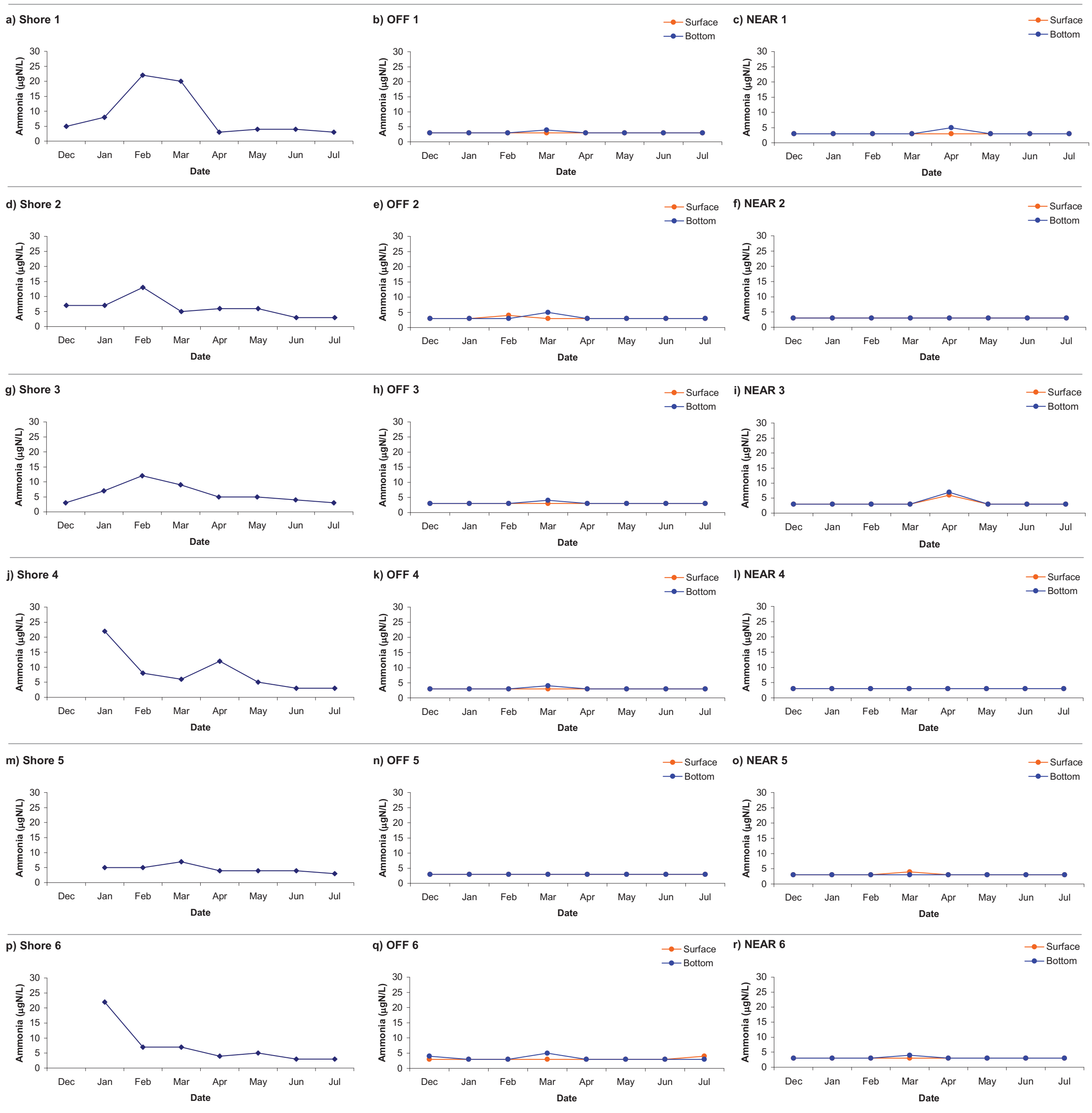


Figure 3.15(a-r) Ammonia concentrations for Alkimos water quality sites – December 2004 to July 2005

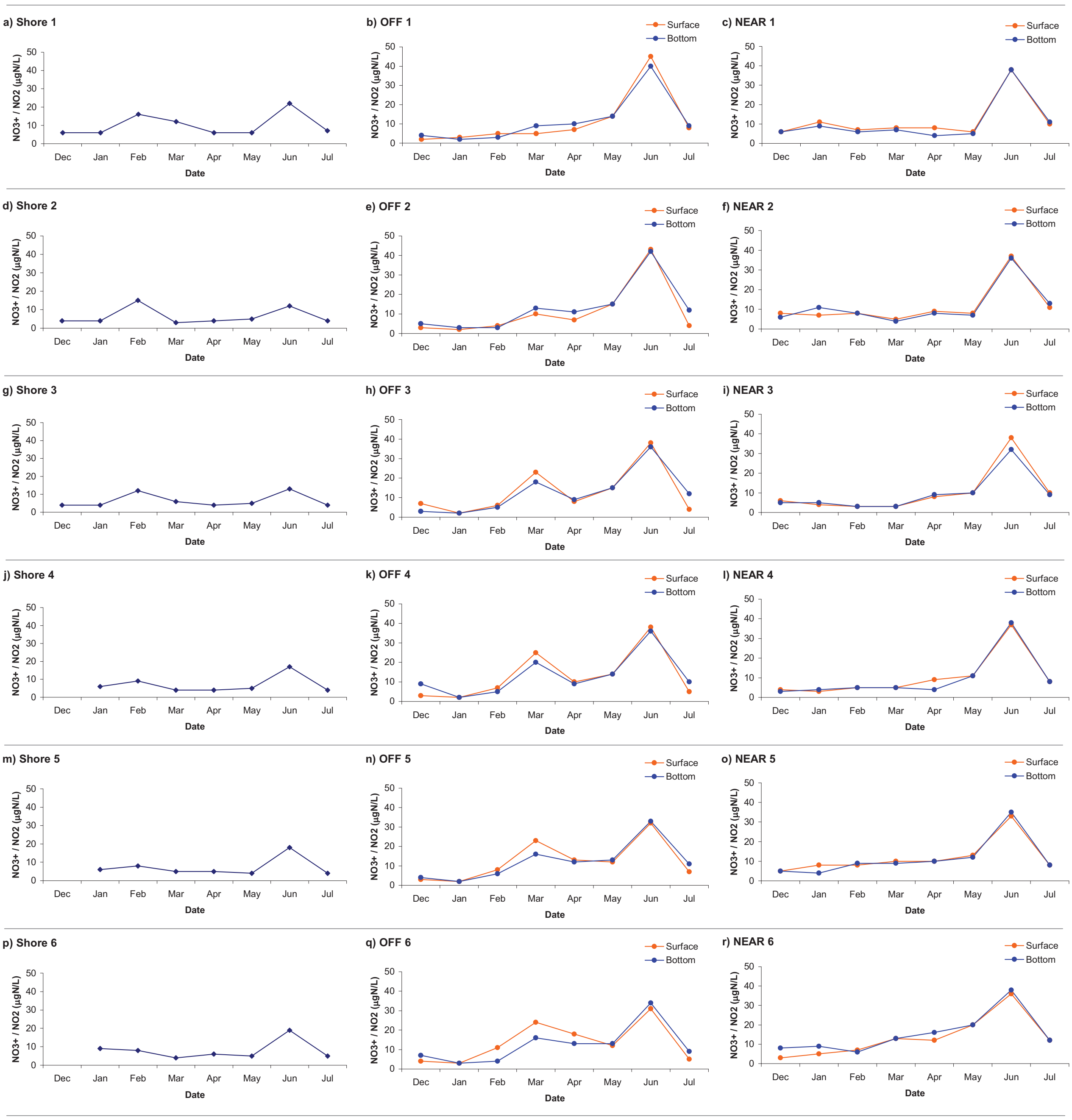


Figure 3.16(a-r) Nitrate + Nitrite concentrations for Alkimos water quality sites – December 2004 to July 2005

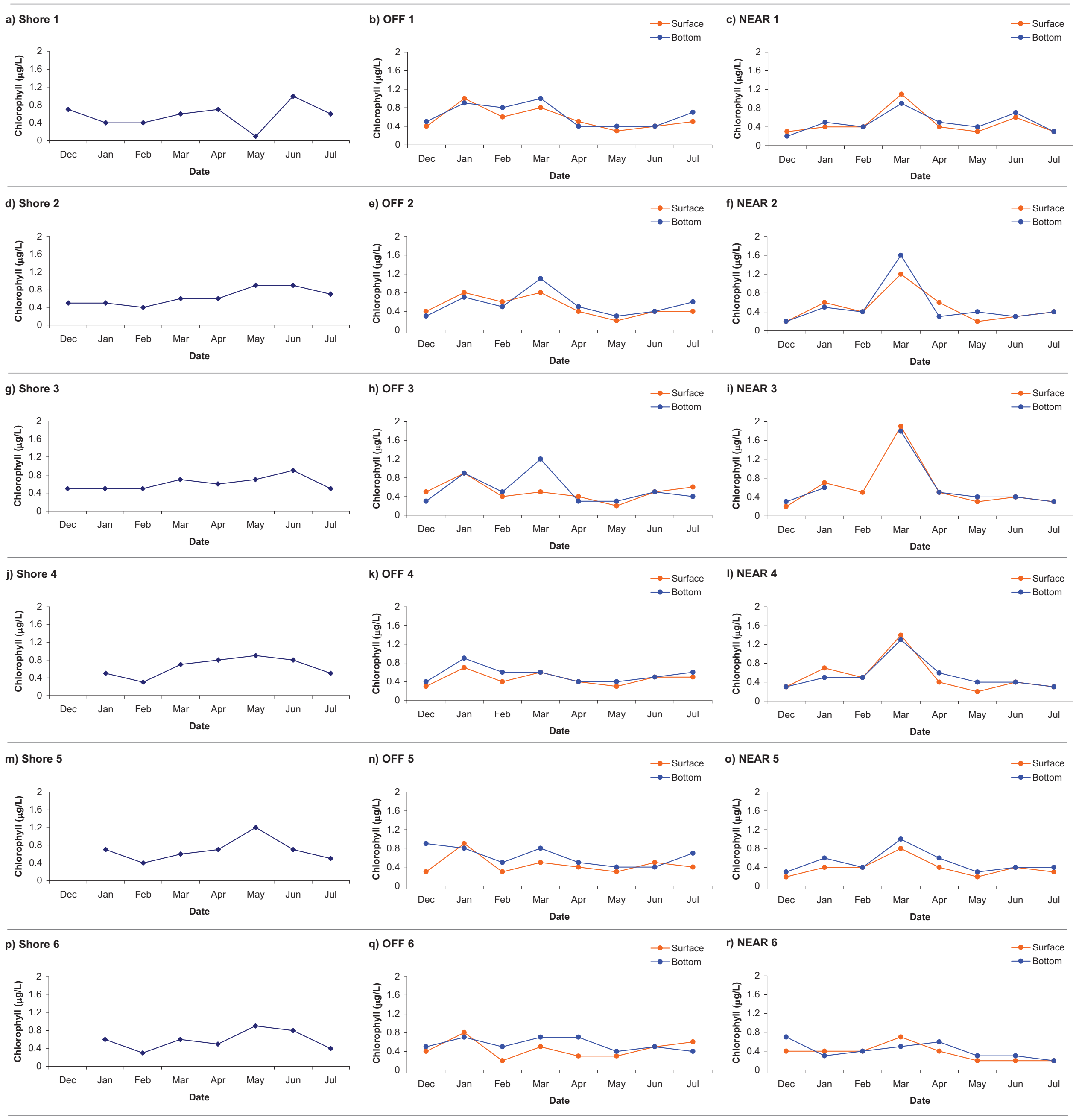


Figure 3.17(a-r) Chlorophyll *a* concentrations for Alkimos water quality sites – December 2004 to July 2005

3.4 Microbiological

Microbiological sampling was conducted for the period December 2004 to May 2005 to capture this parameter during the peak recreational use (swimming) period. It is planned to recommence microbiological sampling for the Alkimos water quality sites in October 2005.

3.4.1 Thermotolerant Faecal Coliforms (TTC)

TTC values were very low or below the assay limit at all sites and sampling times. Only two samples returned detectable TTC (of 177 taken) with both samples displaying the minimum of one coliform in a 50 ml sample (to give an estimated value of 2 TTC/100ml). No spatial or seasonal pattern was evident from these two results.

Certificates of Analysis for microbiological parameters are presented in Appendix D.

3.4.2 Enterococci

Enterococci values were very low or below the assay limit at all sites and sampling times. Only two samples returned detectable enterococci (of 177 taken) with both samples displaying the minimum of one count in a 10 ml sample (to give an estimated value of 10 MPN/100ml). The two positive samples were not the same dates or sites as the two positive TFC results. No spatial or seasonal pattern was evident from these two results.

Certificates of Analysis for microbiological parameters are presented in Appendix D.

4. Comparison of results with Ocean Reef water quality

The Water Corporation operates three major wastewater treatment plants (WWTP's) in the Perth metropolitan area, all of which discharge treated wastewater into the marine environment via ocean outlets. The Ocean Reef outlet (discharging treated water from the Beenyup WWTP) is approximately 17 km to the south of the proposed Alkimos ocean outlets (Figure 4.1). The volumes of water discharged from the Ocean Reef outlet are of similar magnitude to that proposed for the Alkimos outlet (at eventual long-term planned output) and in a similar oceanographic setting (Figure 4.1). Key differences in the oceanographic settings of the two sites are a longer and deeper outlet pipe (and diffuser system) at Alkimos that is likely to allow for greater mixing than present at Ocean Reef. The water residence times and mixing characteristics at Alkimos are currently being investigated under a separate study in the Alkimos Marine Studies Programme.

The Ocean Reef outlet was first operational in 1978, discharging treated water from Beenyup (with a capacity of 27 ML/day). Beenyup WWTP has since undergone several expansions and currently discharges approximately 110 ML/day of treated wastewater through two outlets at Ocean Reef. These outlets are located 1.6 km (outlet A) and 1.8 km (outlet B) from shore and discharge via diffuser units of 195 m length at each outlet. Table 4.1 compares design parameters for the Ocean Reef and Alkimos ocean outlets.

Table 4.1 Comparison of design parameters for the Ocean Reef and proposed Alkimos ocean outlets

Parameter	Ocean Reef	Alkimos (proposed)
Commissioned[1,2]	1978	2009-2010
Initial installed capacity[1,2]	27 ML/d	10 ML/d
Operating capacity[1]	112.5 ML/d (as of 2003)	Continuous upgrade (70 ML/d by 2040)
Projected final capacity[1]	150 ML/d	80 ML/d
Distance of outlet from shore[3,4]	1.6 km and 1.8 km (two outlets: A and B)	3.2 km
Diffuser Length[3]	195 m	300 m
Outlet depth	10 m	20 m

Notes:

1. *Value taken from the EPA referral document for the Alkimos WWTP (Water Corporation 2005b);*
2. *Value taken from Water Corporation web-site on 7June 2005 (www.watercorporation.com.au);*
3. *Value taken from the 2003 summer water quality report for the Water Corporation ocean outlets in Perth coastal waters (DALSE 2003).*

This section reviews the baseline data collected at Alkimos in relation to data from the operational outlets at Ocean Reef.

4.1 Key Issues

The key issues with regards to environmental water quality values for treated wastewater ocean outlets can be summarised as follows:

- Eutrophication of marine waters through addition of bioavailable nutrients;
- Induction of "harmful" algal blooms through nutrient additions;
- Increase in "nuisance" macro-benthic algal species through nutrient additions; and,

- Harmful toxicological effects to benthic organisms through a build-up of metals, pesticides, biocides and/or other toxicants present in increased concentrations in wastewater.

The key issues with regards to social water quality values for treated wastewater ocean outlets can be summarised as follows:

- Human infection with faecal bacterium present in treated wastewater during recreational contact (i.e. swimming, surfing, boating);
- Human ingestion and infection with faecal bacterium present in seafood as a result of contact with treated wastewater; and,
- Lowering of aesthetic values through the presence of a potentially visible plume above outlets with due to a combination of changed refractive properties caused by salinity and increased suspended solids concentrations.

These issues have been managed through a series of operational requirements present in environmental licences and agreements made between the Water Corporation and government authorities. The monitoring of the water quality impacts at the Ocean Reef ocean outlets has been primarily conducted through the Perth Long-Term Ocean Outlet Monitoring Programme (PLOOM). The main findings of the PLOOM programme with relation to water quality at the Ocean Reef site are (Oceanica 2005a) provided in Sections 4.2 and 4.3.

4.2 Physical and chemical parameters

Treated wastewater outlets can impact physical and chemical characteristics of the marine environment through the introduction of water of lower salinity, different temperature and/or different dissolved oxygen characteristics. Wastewater from the Ocean Reef outlets is buoyant (of lower density) in comparison to the surrounding marine waters (Oceanica 2005a). The dilution levels for the Ocean Reef outlet are monitored by comparing nutrient concentrations in surface waters directly above the diffuser with background surface concentrations from the adjacent area. The diffusers at Ocean Reef have a calculated initial dilution (using nutrient concentrations) of ~ 1:70 to 1:200 (dilution is specific to modelled environmental conditions) (Oceanica 2005a).

The water column structure and physical parameters (i.e. salinity and temperature) can change over short timeframes at any given location in coastal waters. For this reason a direct comparison of the Ocean Reef (OR) water column structure with that of the Alkimos region cannot be made within the scope of the current study. However several observations can be made about the influence of the OR outlet on the ambient water column structure that are relevant to the proposed Alkimos ocean outlet (Oceanica 2005a):

- Treated wastewater is largely freshwater, and therefore buoyant and rises to the surface as a plume. The plume rapidly mixes with the ambient seawater and has attained a similar salinity (to seawater) as it reaches the ocean surface (<0.5 % lower salinity at 10 m above the diffuser);
- The treated wastewater has been diluted of the order of 100 times by the time it reaches the surface (at 10 m above the diffusers);
- Water temperature is not substantially altered. The plume buoyancy may act to reduce thermal stratification directly above the diffusers;
- The detectable wastewater plume at Ocean Reef typically extends from 0.5 to 2.5 km from the ocean outlet (detected using nutrient concentrations).

4.3 Nutrient and primary production parameters

The monitoring programme for the Ocean Reef outlet (PLOOM) includes a suite of nutrient and primary production parameters aimed at detecting changes in the local marine environment due to the discharge of treated wastewater. Together with studies of oceanographic processes, water column structure and modelling, the PLOOM programme has made the following findings with regards to the effects of the Ocean Reef ocean outlet on the adjacent marine environment (Oceanica 2005a):

- The wastewater plume typically extends 0.5-2.5 km from the outlets at Ocean Reef. There are localised elevated nutrient (nitrogen) levels in the water column downstream of the outlets (predominantly northwards under prevailing winds);
- The results of near-field/far-field modelling and field measurements indicate a reduction in wastewater concentrations of up to three orders of magnitude over a distance of several tens of metres from the diffusers;
- Nutrient-related water quality undergoes consistent seasonal changes, with the highest background concentrations of nitrate + nitrite and filterable reactive phosphorus occurring in winter;
- There is a corresponding seasonality in phytoplankton biomass (measured as chlorophyll-a concentrations) with a peak in chlorophyll-a concentrations in spring and autumn at Ocean Reef. There is no evidence of an increase in toxic or harmful algal blooms;
- There is some evidence for enhanced periphyton growth at sites located 1-2 km 'downstream' of the ocean outlets, but any effect of treated wastewater discharge becomes negligible well before areas of natural reef are encountered;
- Seagrass shoot densities are higher at sites near the Ocean Reef Ocean Outlets than at reference sites, which is the opposite to the pattern expected for adverse nutrient effects (i.e. a reduction in seagrass shoot density) and may represent a slight positive growth response to low-level nutrient enrichment;
- There is no indication of a loss in vegetated habitats around the outlets as a result of the discharge of treated water;
- There is no indication that there are outlet-related influences on the abundance or biomass of benthic macroinvertebrates in sediments around the ocean outlets;
- There is no detectable contamination of sediments or fauna by metals or pesticides from treated wastewater discharged from the ocean outlets.
- There is no indication of significant growth of "nuisance" algae around the outlets.

The information returned to date from the Alkimos Water Quality Characterisation programme (December 2004 to July 2005) indicates that the nutrient concentrations at Alkimos are within the range of those found at background sites at Ocean Reef (Figure 4.2). The four Ocean Reef "seasonal" water quality monitoring sites (N1, N2, N3, N6) were chosen for comparison between Ocean Reef and Alkimos water quality. These sites are sampled once each season and are located to sample the water quality adjacent to, and to the north and south of the Ocean Reef ocean outlets.

Ocean Reef sampling site N2 (Figure 4.1) is located directly above the diffuser array at the ocean outlet. It can be seen from Figures 4.2a-c that nutrient concentrations at Site N2 are routinely elevated, while at sites N6 and N3 (1 km and ~4 km "downstream" of N2 respectively) concentrations are of a similar order to those found at Alkimos. Site N1 is located 4 km to the south of the outlet and under the prevailing current conditions is likely to represent "ambient" water quality not directly influenced by the Ocean Reef outlets. Site N3 is approximately 12 km south of the Alkimos water quality sites and is in shallower waters than the proposed Alkimos ocean outlet. Site N4 was located 8 km north of the Ocean Reef outlets and approximately 6 km south of the Alkimos site Offshore-6. In the spring of 2003 Site N4 was replaced by Site N6, located approximately 1.2 km north of the Ocean Reef ocean outlets.

Ammonium concentrations at Alkimos were routinely at or close to the reporting limit of 3 µg.N/L. Sites close to or "downstream" of the Ocean Reef ocean outlets (N2, N6 and N3) often displayed elevated concentrations of ammonium in comparison to "background" levels displayed by sites N1 and N4 (Figure 4.2a).

Nitrate + nitrite (NO_x) concentrations at Alkimos were of a similar magnitude to the Ocean Reef sites N1, N4 and N6. Site N2 routinely displayed elevated NO_x concentrations relative site more distant from the Ocean Reef ocean outlets (Figure 4.2b).

As with ammonium and NO_x, Filterable Reactive Phosphorus (FRP) concentrations at Alkimos were of a similar order of magnitude to those at Ocean Reef sites N1, N3, N4 and N6. Only site N2 (closest to the ocean outlets) displayed FRP concentrations that were routinely elevated above "background" levels (Figure 4.2c).

Chlorophyll-a concentrations at Alkimos were of a similar magnitude to those found at the Ocean Reef sites during the reporting period (Figure 4.2d). Chlorophyll *a* does not have the same degree of correlation to the proximity of the Ocean Reef ocean outlets as found for the other nutrient parameters presented in Figure 4.2. Further characterisation of the primary production regime at Alkimos is available in the phytoplankton survey report completed for the Alkimos Marine Studies Programme (Oceanica 2005b).

It is likely that the Alkimos site will be subject to greater mixing (and hence dispersal of the treated wastewater plume) than the Ocean Reef site due to the greater depth of the diffuser and lower levels of protection by offshore reefs (outlet further offshore at Alkimos) (Table 4.1). Modelling of the mixing regime at Alkimos is currently being undertaken as part of the Alkimos Marine Studies Programme, the results will be presented in a separate hydrodynamics report.

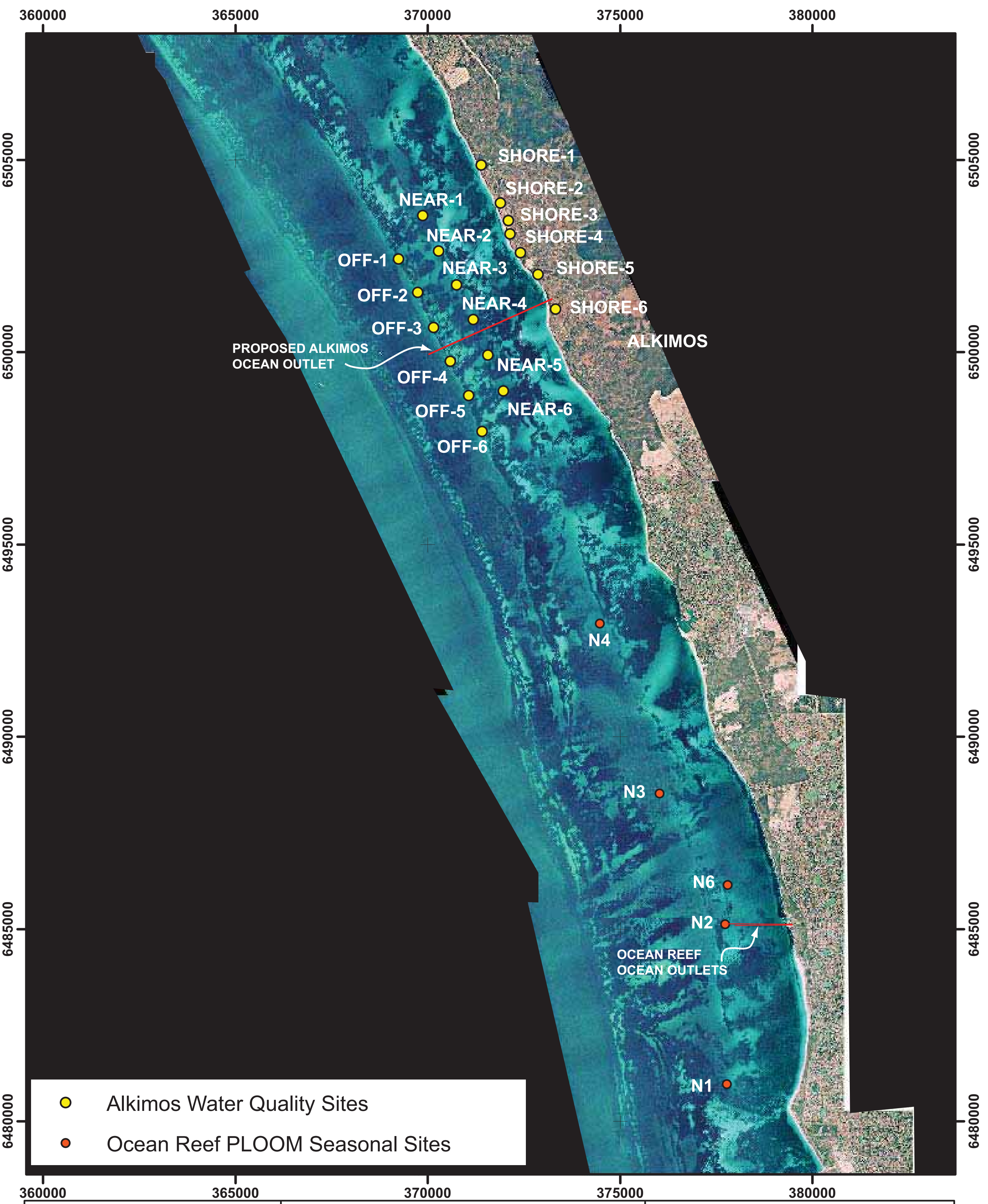
4.4 Microbiological (human health) issues

The treated wastewater discharged from the Ocean Reef outlets contains elevated concentrations of faecal bacteria in comparison to the background marine receiving waters. The PLOOM programme monitors the concentrations of faecal bacteria (through thermo-tolerant coliforms (TTC) and Enterococci determinations) in the vicinity of the Ocean Reef outlets as a measure of the dispersion and die-off rates after wastewater discharge. The main findings of the 2003/2004 PLOOM monitoring with regards to microbiological issues were (Oceanica 2005a):

- There is rapid die-off of bacteria and rapid dilution of contaminants (140-fold dilution achieved in the mixing zone); and

- There is no bacterial contamination of beaches adjacent to the outlets, with national primary (swimming) and secondary (sailing, boating) contact recreation human health criteria met within 250 m of the outlets.

The dilution and dispersal of microbiological contaminants at Alkimos will depend largely on the mixing regime in the vicinity of the outlet. Experience from the Ocean Reef outlets indicates that reporting limit levels of faecal bacteria (as TTC and Enterococci) are likely to be reached within 2000 m of the outlet at Alkimos (DALSE 2004; Oceanica 2005c).



oceanica
marine & estuarine specialists

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Reference: 442/1
Figure 4.1 Alkimos and Ocean Reef.mxd

0 1.25 2.5 5 Kilometers

DATUM
Horizontal: UTM Zone 50,
Based on WGS 84
Vertical: N/A

N

Figure 4.1

Alkimos and Ocean Reef water quality sampling site locations

Client: Water Corporation June 2005

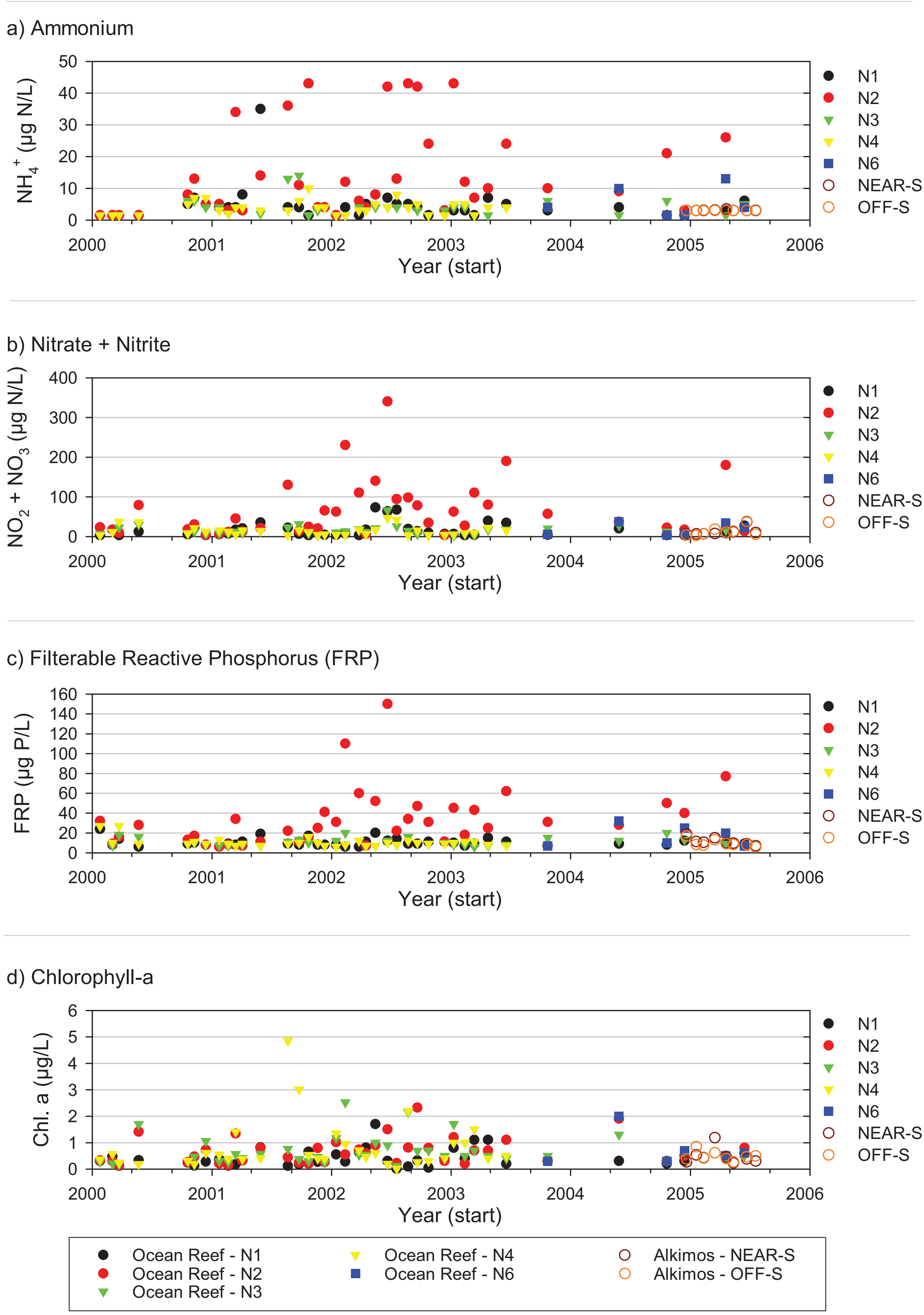

Figure 4.2 Comparison of Ocean Reef and Mean Alkimos Nutrient and Chlorophyll Concentrations

Notes: The station "Ocean Reef – N2" is directly above the Ocean Reef ocean outlets;
Alkimos sampling began in December 2004;

5. Conclusions

The water quality characterisation programme for the proposed Alkimos ocean outlet (December 2004 - July 2005) has provided sufficient information for the preliminary characterisation of the nutrient regime and water-column structure in the vicinity of the proposed outlet. The Alkimos marine waters are essentially un-polluted, with all nutrient parameters being either below reporting limits or within the ranges returned by the PLOOM programme Ocean Reef background sites (with an Ocean Reef background seasonal monitoring site some 6 km to the south, Site N4). The water column structure was either well mixed or slightly stratified in the deeper waters (~15 m) over the reporting period and well oxygenated. The combination of the Leeuwin Current offshore (southward), wind driven surface currents nearshore (predominantly northward) and wave/reef interactions in the vicinity of the proposed outlet are likely to prevent significant periods of density stratification.

The water quality issues of primary concern from the operation of the proposed Alkimos treated wastewater ocean outlet are likely to be:

- Localised increases in surface water nutrient concentrations in the vicinity of the ocean outlet, dissipating to background concentrations over a spatial scale of several kilometres; and
- Localised increases in the faecal bacteria concentrations (as measured by thermo-tolerant coliform and Enterococci assays), dissipating to background concentrations over a spatial scale of several kilometres.

Evidence from the PLOOM programme indicates that the ecological and human health values of the coastal waters outside of a suitably sized zone can be maintained with proper ocean outlet management (Oceanica 2005a).

6. Acknowledgements

Data analysis and preparation of the Interim Water Quality Characterisation Data Report was undertaken by Oceanica (Mark Bailey, Stephanie Turner and Phillip Whittle). Ewan Buckley, Eve Hollingsworth and Marie Gouteff (all Oceanica) assisted with data collation and figure preparation. Katy Rawlins (Oceanica) assisted with report formatting.

Ms Celeste Wilson (MAFRL) co-ordinated the field data and sample collection and laboratory analysis. Mr Mark Nener and Mr Mathew Hegney (Water Corporation) co-ordinated and undertook the shoreline water quality sampling.

The Western Australian Water Examination Laboratory (PathCentre) analysed water samples for the microbiological parameters (NATA accredited). Water quality analysis was undertaken by MAFRL. MAFRL incorporates a fully equipped NATA accredited facility for the analysis of fresh, estuarine and marine samples.

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Appendix A

Site Co-ordinates

Appendix A Site Co-ordinates

WGS 84	Name	Easting	Northing	Site Depth
UTM Zone 50	WWTP	373329	6501108	-
UTM Zone 50	1-OFFSHORE	369249	6502419	13.9 m
UTM Zone 50	2-OFFSHORE	369749	6501548	14.2 m
UTM Zone 50	3-OFFSHORE	370160	6500634	15.0 m
UTM Zone 50	4-OFFSHORE	370600	6499758	15.5 m
UTM Zone 50	5-OFFSHORE	371070	6498868	14.4 m
UTM Zone 50	6-OFFSHORE	371419	6497928	14.5 m
UTM Zone 50	1-NEARSHORE	369881	6503540	10.3 m
UTM Zone 50	2-NEARSHORE	370291	6502626	10.3 m
UTM Zone 50	3-NEARSHORE	370758	6501742	12.3 m
UTM Zone 50	4-NEARSHORE	371196	6500842	12.5 m
UTM Zone 50	5-NEARSHORE	371578	6499916	9.7 m
UTM Zone 50	6-NEARSHORE	371974	6498987	12.4 m
UTM Zone 50	1-SHORE	371404	6504863	Waist deep
UTM Zone 50	2-SHORE	371898	6503869	Waist deep
UTM Zone 50	3-SHORE	372102	6503416	Waist deep
UTM Zone 50	4-SHORE	372150	6503069	Waist deep
UTM Zone 50	5-SHORE	372417	6502581	Waist deep
UTM Zone 50	6-SHORE	372877	6502013	Waist deep

Appendix B

Certificates of Analysis - Microbiological

Appendix B Certificates of Analysis - Microbiological

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APPENDIX F - ALKIMOS MARINE STUDIES PROGRAMME BENTHIC HABITAT MAPPING AND INFAUNA SURVEY

oceanica

marine & estuarine specialists

Alkimos Marine Studies Programme

Benthic Habitat Mapping and Infauna Survey

July 2005

Alkimos Marine Studies Programme

Benthic Habitat Mapping and Infauna Survey

Prepared for:

Water Corporation of Western Australia

Prepared by:

Oceanica Consulting Pty Ltd

July 2005

Report No. 438/1

Client: Water Corporation of Western Australia

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2	S. SHUTE	S. TURNER	1xHard Copy	11/05/05	S. TURNER	19/05/05
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Status

This report is "Draft" until the author and director have signed it off for final release. A "Draft" report should not be used for any purpose other than to be reviewed with the intention of generating a "Final" version.

Approved for final release:

Author Director Date: 6/7/05

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Executive Summary

Following the identification, in the 1970s, of the need for a wastewater treatment plant (WWTP) to service the planned residential growth in Perth's North West Metropolitan Corridor, the Water Corporation selected Alkimos Lot 101 as the preferred site for what will be known as the Alkimos WWTP.

Oceanica were commissioned by the Water Corporation to undertake a suite of independent studies in regard to the Alkimos WWTP, the results of which will then be integrated to determine the existing environmental conditions prior to construction and operation of the WWTP and pipeline as well as determining the potential environmental impacts of the discharge and the means to monitor and manage any impacts.

The objectives of the benthic habitat mapping component of the work were to determine the distribution of seagrasses, reef, and bare sand in the area surrounding the proposed pipeline, record the nature, distribution and abundance of flora and fauna associated with these habitats and to address issues related to the Benthic Primary Producer Habitat Protection Guidance Statement (BPPH) (EPA 2004). This work was undertaken using classification of digital aerial imagery, groundtruthing using towed video, spot dives and snorkelling, and by the collection of sediment cores for infaunal analysis.

The classification of aerial imagery was found to be effective for the mapping of vegetated and unvegetated habitats, with 60.3 % of the mapping considered to be of high reliability. Groundtruthing was used to differentiate the different vegetated habitats. The collection of voucher specimens and the capture of still photographs aided in the detailed description of each habitat type. Eleven types of vegetated habitat were identified, consisting of four reef types and seven seagrass habitat types. The most widespread habitat type recorded was sand (55.9%) followed by reef (19.5%) and high relief reef (13.9%).

Sediment cores were taken and the infaunal species identified and enumerated to allow description of the communities present within the sand areas. The infaunal communities at each site sampled were found to be similar, exhibiting low species diversity and abundance.

The application of Benthic Primary Producer Habitat (BPPH) Protection Guidance Statement 29 (EPA 2004) was addressed by the assessment of historic and predicted effects on vegetated habitats within a 50 km^2 BPPH management unit. It was estimated that up to 0.1% of vegetated habitats within the management unit could be disturbed during construction of the pipeline. The findings of historic studies conducted at Ocean Reef suggest that any effects on the distribution or health of benthic habitats due to the operation of the WWTP would be extremely small-scale in spatial extent.

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1. Introduction

1.1 Project background

In the 1970's the Water Corporation of Western Australia (Water Corporation) identified the need for a wastewater treatment plant (WWTP) to service the planned residential growth in Perth's North West Metropolitan Corridor. Following evaluation of several different options, the Water Corporation selected Alkimos Lot 101 as the preferred site for what will be known as the Alkimos WWTP, and finalised the acquisition of this site from the Urban Land Council in 1987 (Figure 1.1).

An "in principle agreement" was formalised on the 29th June 2001 with the signing of the Alkimos Eglinton Relocation, Construction and Development Agreement between the Water Corporation, LandCorp and Eglinton Estates (the principal landowners within the structure plan area). This agreement identified the Alkimos WWTP site as acceptable to all parties.

Projected growth in the catchment indicates that approximately 80 ML/d will require treatment at the Alkimos WWTP by 2050. Ultimately plant inflows could grow to 160 ML/d.

Mapping of the benthic habitat present at Alkimos will aid in the identification of potential impacts from the construction and operation of the proposed WWTP, as well as aiding in the selection of a suitable pipe route.

Figure 1.1 Alkimos WWTP: aerial photograph and location map

1.2 Regional benthic habitat

The shallow (<20 m deep) nearshore waters off Perth include a variety of habitats, varying from meadow forming seagrasses that are dominant in the more sheltered sandy areas, to limestone reefs and platforms supporting a variety of algal communities, in the more exposed coastal waters (Lord & Hillman 1995). The low nutrient environment and high water clarity mean that seagrasses are a common feature and may typically be found in the depth range ~1 m to ~15 m.

The Ocean Reef area, located to the south of the Alkimos site, consists of limestone low relief reef (platform reef) and high relief reef, scattered seagrass meadows and sand patches. It was found that the dominant feature of the region was its dynamic nature, with physical processes driving the large-volume movement of sand (DALSE 2004a) and therefore the relative areas of seagrass, reef and sand at any one time. For example, large areas of limestone platform were found to be repeatedly buried and exposed as sandy sediments were transported through the area (Alex Wiley & Associates 2001).

Examination of aerial imagery of the region from Ocean Reef to Yanchep suggests that the benthic habitat is likely to be similar over the entire area. Low relief reef, high reef (dominated by macro algae), mobile sand beds and seagrasses, which are adapted to the higher energy areas of the coast such as *Posidonia coriacea*, have been recorded from Ocean Reef.

1.3 Historical benthic habitat studies at Alkimos

There is limited site specific information available to describe the marine environment at Alkimos. A brief reconnaissance study was undertaken by DA Lord & Associates (1997) to examine the characteristics of the coast between Burns Beach and Yanchep to determine whether the Alkimos beach area opposite Lot 101 had features that made it significantly more valuable for community recreation than any other area. Relevant findings from this study were:

- The main attraction to this part of the coast is a series of offshore reefs and limestone platforms that are located within one to two kilometres from the shore. These provide a dampening effect on wave energy, and also generate sites for recreation (snorkelling, diving, fishing and surfing). These reefs and platforms are most prominent over approximately four kilometre of coastline, located evenly north and south of Lot 101; and
- The section of coastline between Burns Beach and Yanchep has the same types of habitat (beaches, shallow water sandy areas, seagrasses, limestone platforms, and reef) that exist further south in the Marmion Marine Park. However limestone reef and platform habitat are not nearly as widespread as in the Marmion Marine Park.

2. Benthic Habitat Mapping Survey

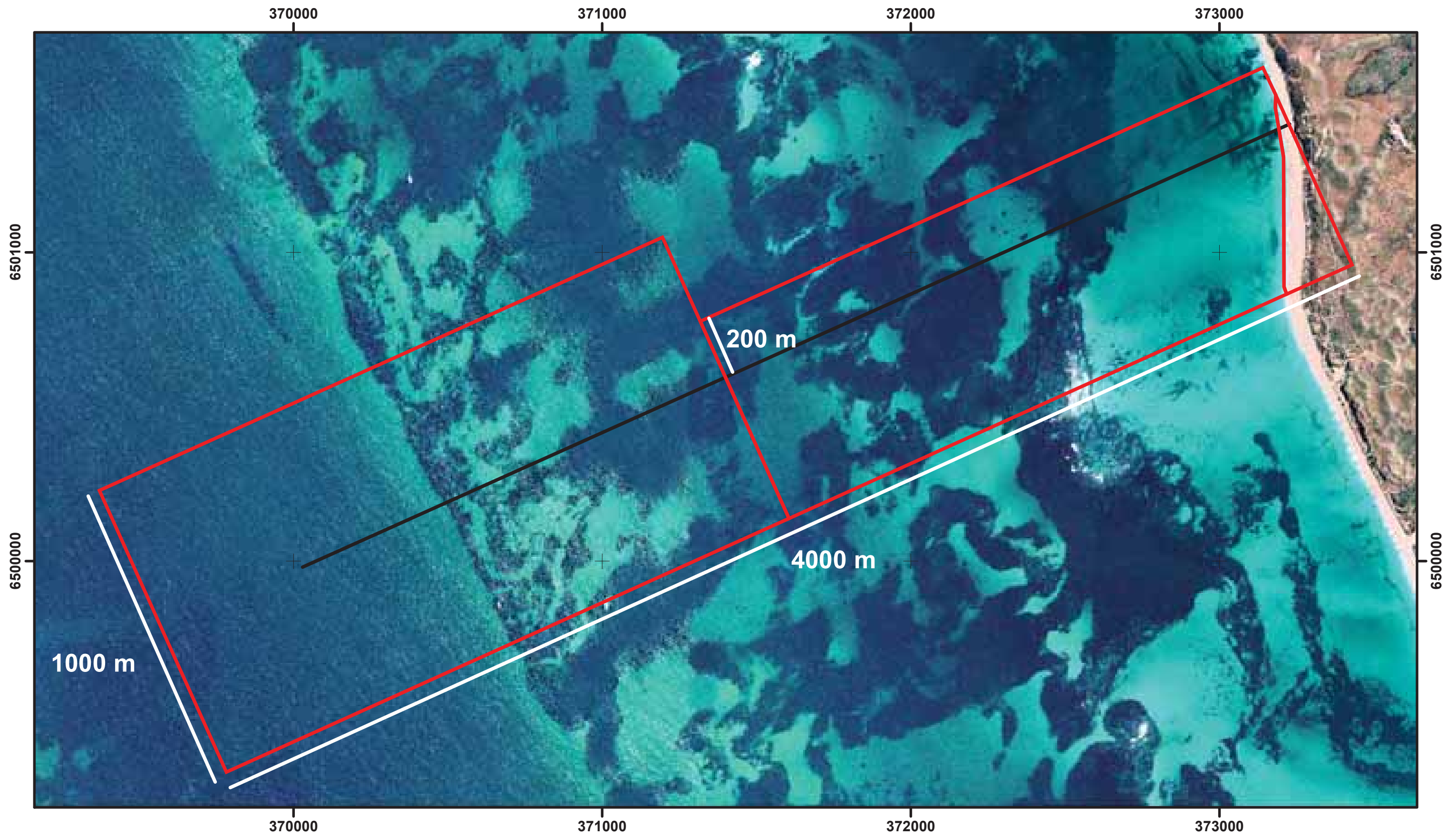
2.1 Objectives

- Determine the distribution of seagrasses, reef, and bare sand in the area surrounding the proposed pipeline (Figure 2.1);
- Record the nature, distribution and abundance of flora and fauna associated with these habitats; and
- Address issues related to the Benthic Primary Producer Habitat Protection Guidance Statement (BPPH) (EPA 2004), with the data used to predict direct and indirect losses, and changes, of BPPH within the defined management unit following construction and operation of the proposed WWTP.

2.2 Key Tasks

- Mapping of benthic habitats (vegetated and unvegetated habitats) from the Perth Metropolitan Aerial Photography 2004 digital imagery;
- Groundtruthing of the benthic habitats using towed video to determine the distribution of sand, seagrass and reef habitats;
- More detailed groundtruthing of the benthic habitats using diving. This will provide confirmation of species identification and information needed for more detailed habitat descriptions; and
- Core sampling within sediment-dominated areas to characterise the benthic infaunal communities present.

A study investigating the detailed physical and chemical characteristics of the sediment-dominated areas will be reported separately.



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Benthic habitat survey area

Approximate pipeline route

Meters
0 250 500 1,000

DATUM
Horizontal: UTM Zone 50
Based on WGS 84
Vertical: N/A

Figure 2.1
Benthic habitat mapping survey area

Client: Water Corporation
January 2005

3. Methods

3.1 Classification of aerial imagery

3.1.1 Imagery capture

Rectified digital aerial imagery was captured on 12th March 2004 on behalf of Oceanica by Fugro Spatial Solutions Pty Ltd.

The imagery was captured as colour vertical aerial photography using an aircraft-mounted Leica RC30 camera (number 13149) with a super-wide angle lens with a focal length of 152.68 mm. The photography was captured from a flying height of approximately 3,825 m, resulting in a nominal scale of capture of 1:25,000 (on film FSC034). The location of the camera during each exposure was determined using a real-time differential GPS and this information was used in the georeferencing of the imagery and the production of the photograph mosaic (orthophotograph).

The original negatives of the aerial photography were scanned on a DSW600 Leica photogrammetric scanner in 24 bit colour at a resolution of 15 microns. The resultant pixel resolution is 0.375 m x 0.375 m. The digital imagery was aerotriangulated using control points from existing orthophotography and ground control points.

The orthophotograph has been georeferenced to the Geocentric Datum of Australia 1994 (GDA94) and is presented in UTM coordinates (MGA94, Zone 50). The orthophotograph is aligned north–south and has a spatial accuracy of 0.7 mm at a scale of 1:25,000.

3.1.2 Classification of the imagery

Imagery covering the study area was classified using a supervised tonal classification within ERMapper to differentiate between the dark tones corresponding to vegetated habitats, and light tones corresponding to unvegetated habitats. In addition to these two classifications, land and deep water were also classified separately. A land area was included in the classification to enable future comparative mapping of habitats in the area to be carried out, even if shoreline change occurs. Deep water was classified separately, as in these areas the benthic habitat type (vegetated or unvegetated) could not be reliably determined from the aerial imagery.

To best classify the benthic habitats the green band was used for the classification of the aerial imagery. The red band provides little water penetration and the blue band, whilst providing good water penetration, also picks up white caps and sun glint features which obscure the benthic habitats.

Initially a raster file was generated storing the habitat information. Within raster files each area is divided into rows and columns, which form a regular grid structure. Each cell within this matrix contains location co-ordinates as well as an attribute value, in this case a value representing vegetated habitat, unvegetated habitat, land and deep water. The raster grid files were then converted to vector files. In vector data, the basic units of spatial information are points, lines (arcs) and polygons. Each of these units is composed simply as a series of one or more co-ordinate points. This vector data was then imported into a Geographical Information System (GIS) for mapping purposes.

3.2 Groundtruthing

The classification of the aerial imagery (providing classification of the area into vegetated and unvegetated categories) was supplemented by groundtruthing undertaken by towed underwater video and spot dives. This detailed groundtruthing data was used to augment the two-dimensional spatial data from the aerial photography analysis and enabled definition of benthic habitat assemblages within the study area.

3.2.1 Towed video

Towed underwater video transects were completed on 1st and 3rd February 2005 to provide a visual record of the habitat types. A total of 24 towed video transects, ranging from approximately 200 m to 1 km in length, were carried out to cover the survey area (Figure 3.1). Previously 18 video tows had been completed to the north of the survey area due to errors in the supply and interpretation of the initial survey co-ordinates.

The underwater video was towed behind the vessel approximately 0.5 m from the seabed at a speed of approximately 1.8 km/hr.

Video analysis

The video record was paused at ~10 second intervals or when a change in habitat type was observed, and a number of habitat descriptors recorded, including:

- Benthic habitat type;
- Percentage cover of different genera/species estimated at intervals through the video footage through examination of proportions of vegetated habitat and bare substrate visible within frame; and
- Presence of epiphyte material noted where conspicuous in footage.

3.2.2 Spot dives

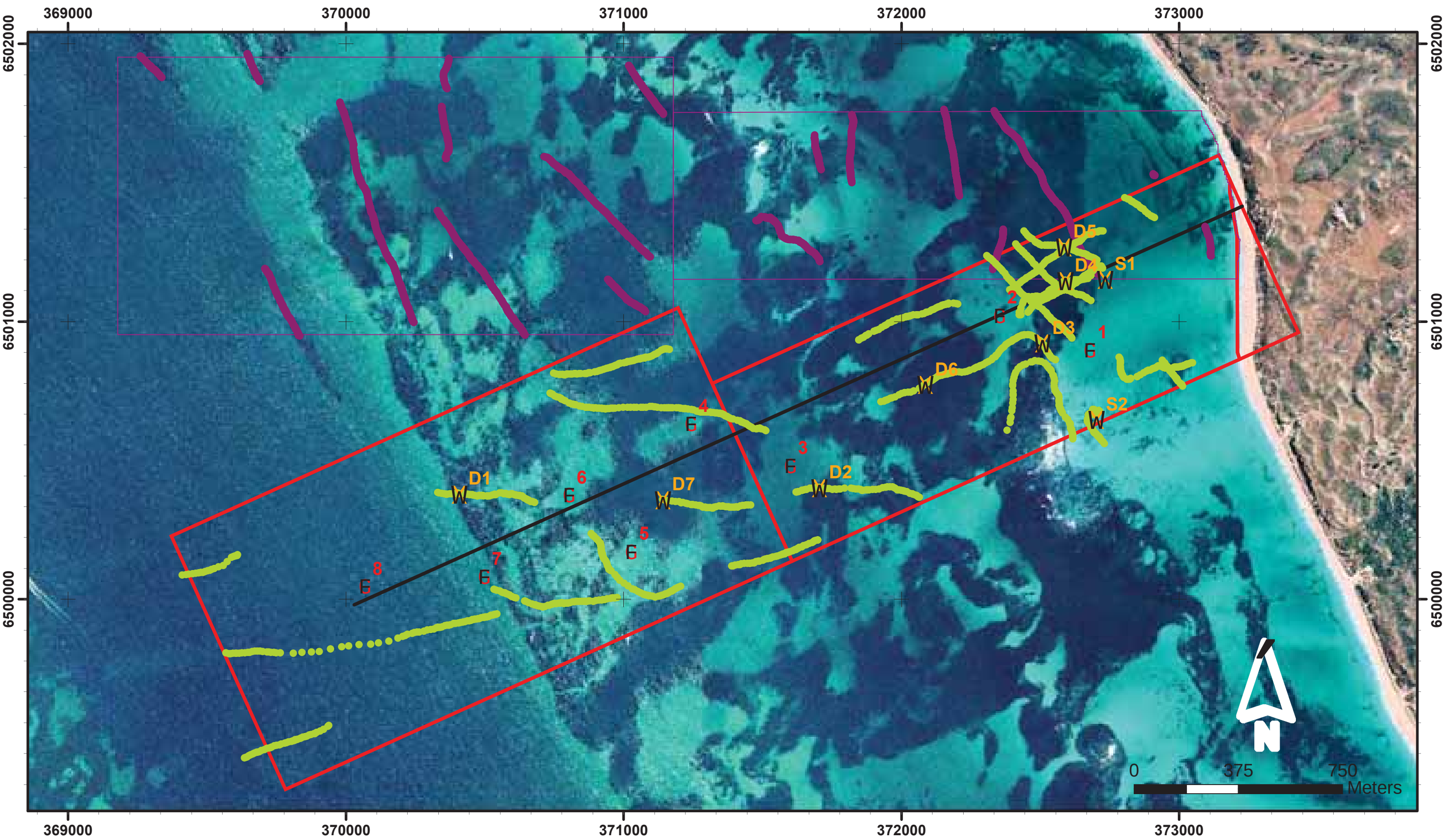
Habitat groundtruthing

Nine spot dives within areas of interest, identified from the video groudtruthing as exhibiting a high degree of physical complexity or diversity, were undertaken to collect more detailed information, for example species composition and abundance (Figure 3.1). Stills photography and the collection of seagrass and algal specimens enabled detailed description of the seagrass and reef habitats.

Infaunal[1] sample collection

Sediment cores were collected for infaunal analysis to provide further information on the sand habitats. At eight sand-dominated sites (selected by examination of the aerial imagery), five replicate sediment cores (internal diameter of 103 mm) were collected to a depth of 200 mm (Figure 3.1). Four replicate samples from each site were sieved on a 1.0 mm sieve, whilst the fifth was sieved on a 0.5 mm sieve to capture smaller infauna not retained on the 1.0 mm mesh. Samples were preserved and sent to the Marine and Freshwater Research Laboratory (MAFRL) at Murdoch University for the identification and enumeration of all infauna. Faunal identification has been carried out to species level where possible.

[1] Infauna is the animal community living within the sediment, such as polychaete worms, molluscs and crustaceans.



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Spot dive sites

Infaunal core sites

Video transects surveyed 1st & 3rd February 2005

Video transects initially surveyed using inaccurate co-ordinates

Benthic survey area

Approximate pipeline route

DATUM
Horizontal: UTM Zone 50
WGS 84
Vertical: N/A

Figure 3.1
Location of towed video transects, dive sites and core sites

Client: Water Corporation
February 2005

Infaunal sample analysis

The infaunal community structure at Alkimos was investigated by examination of the individual and species numbers recorded within each sample and by the use of multivariate analysis methods through use of PRIMER 4.0 software.

Multivariate methods measure the similarity coefficients between samples. Hierarchical clustering (CLUSTER) was used to assess the similarity of sites based on the faunal components. The procedure generates a dendrogram indicating the relationships between sites based on a similarity matrix.

Full methods for the application of both the hierarchical clustering and the MDS analysis are given in Clarke and Warwick (1994). The multivariate analysis was performed on the four replicate samples which had been sieved on a 1 mm mesh size.

3.3 Habitat mapping

Mapping of habitat types within the vegetated areas classified from the aerial imagery was carried out by hand digitising within ArcGIS 9.0. Habitat types in areas not directly covered by towed video transects were inferred from examination of the aerial imagery, surrounding habitat types, particularly those recorded to the north and south in similar water depths, and bathymetric data (DPI, 1978).

4. Results

4.1 Classification of aerial imagery

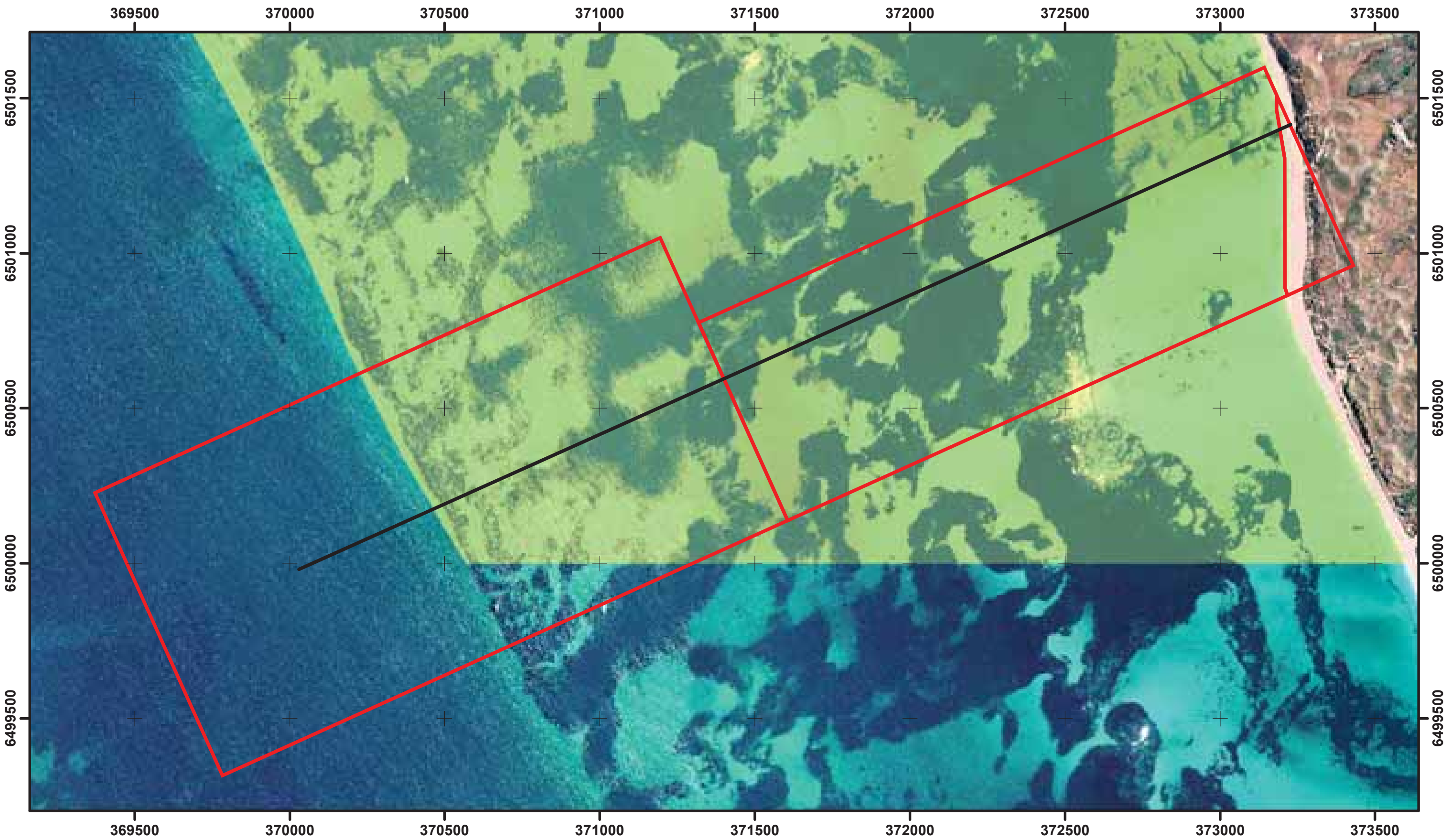
Two benthic habitat types were distinguished from classification of the aerial imagery: vegetated and unvegetated. The vegetated areas are distinguished from the unvegetated areas as they have a distinctly darker phototone on the imagery. Comparison of the classification against the video groundtruthing results have shown that the classification of the aerial imagery effectively captured the majority of the vegetated habitat areas (dark tones) and unvegetated sand areas (light tones) (Figure 4.1).

The reliability of the habitat mapping was dependent on the quality of the imagery, the water clarity and the water depth. The quality of the 2004 imagery was generally very high, although some areas of sunglint were recorded. Areas of surf and turbid water also affected the reliability of the mapping (Figure 4.2).

Three mapping reliability categories were defined on the basis of the light penetration through the water column and the definition of the vegetated habitats (Table 4.1). These reliability categories were determined from visual inspection of the imagery, and subsequent classification, and were defined on the image (Figure 4.2). The majority of the 2004 imagery was considered to be of high reliability (60.3 %). Areas of deep water (≤ 15 m) towards the offshore end of the survey area could not be mapped due to insufficient water penetration in these depths. Areas in which wrack material overlays sand (inshore) and areas affected by sun glint (offshore) were classified as having medium reliability, with the majority of the areas being classified correctly but with indistinct boundaries. Areas influenced by surf, in which the benthic habitats are generally obscured, or where habitats were incorrectly classified (determined by comparison with video groundtruthing results) were categorised as being of low reliability.

Table 4.1 Categories of mapping reliability

Mapping reliability	Description
High	Typically in shallow waters where light penetration through the water column to the seafloor enables clear distinction of the vegetated and unvegetated areas.
Medium	Light penetration through the water column to the seabed is somewhat obscured by sun glint, or wrack material overlying sand gives a similar tone to deeper unvegetated habitat; vegetated and unvegetated areas can be distinguished but often with indistinct boundaries.
Low	Light penetration through the water column to the seabed is limited. This may be due to several factors including: severe sun glint from the water surface, surf, high turbidity, deep water and cloud cover.



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Legend

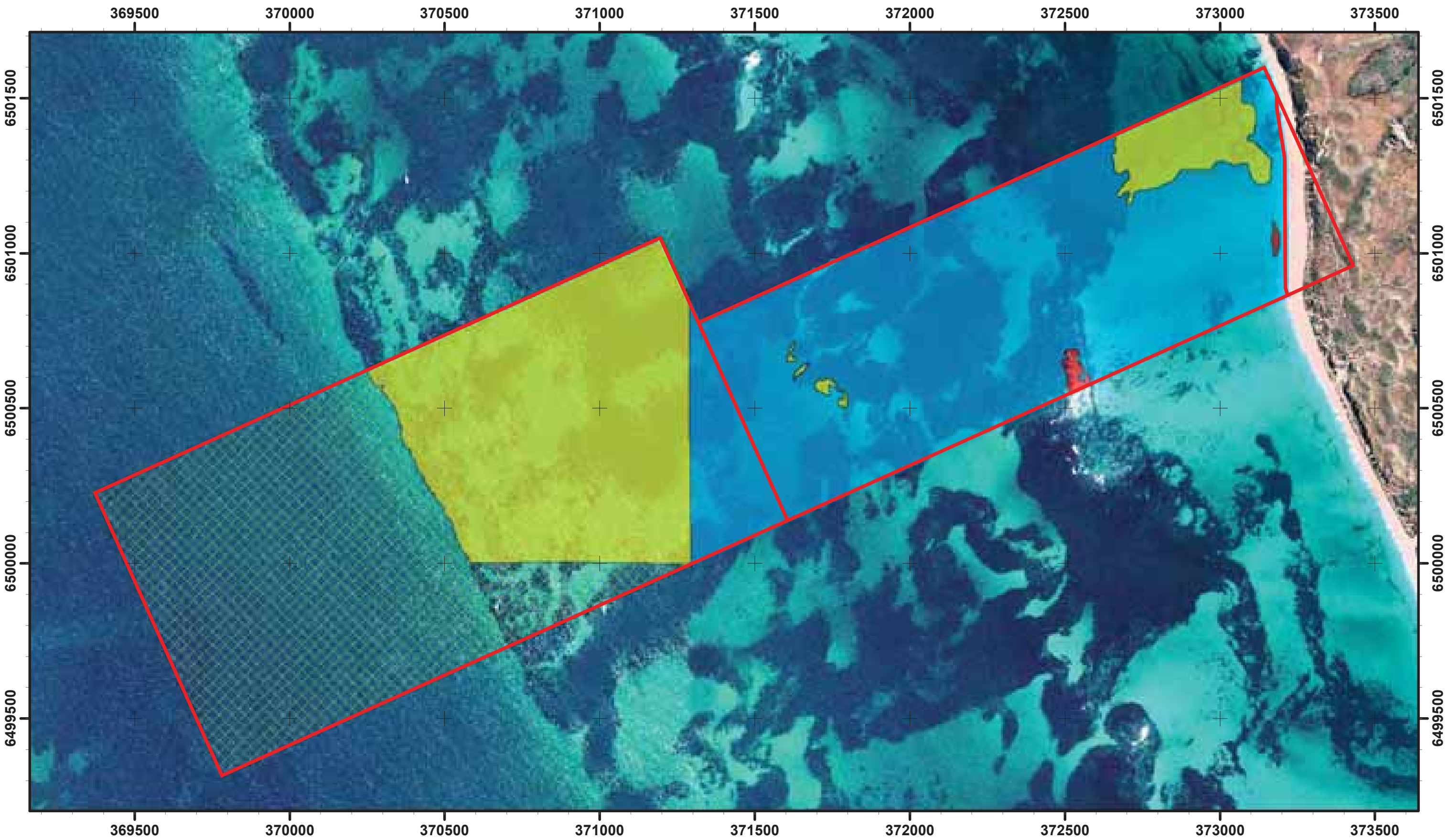
- Approximate pipeline route
- Benthic survey area
- Unvegetated
- Vegetated

Meters
0 250 500 1,000

DATUM
Horizontal: UTM Zone 50
Based on WGS 84
Vertical: N/A

Figure 4.1
Classification of aerial imagery into vegetated and unvegetated habitats

Client: Water Corporation
February 2005



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Benthic survey area

Image classification reliability

Low
High
Medium
Not Mapped

Meters
0 250 500 1,000

DATUM
Horizontal: UTM Zone 50
Based on WGS 84
Vertical: N/A

Figure 4.2
Reliability of supervised tonal classification of aerial imagery

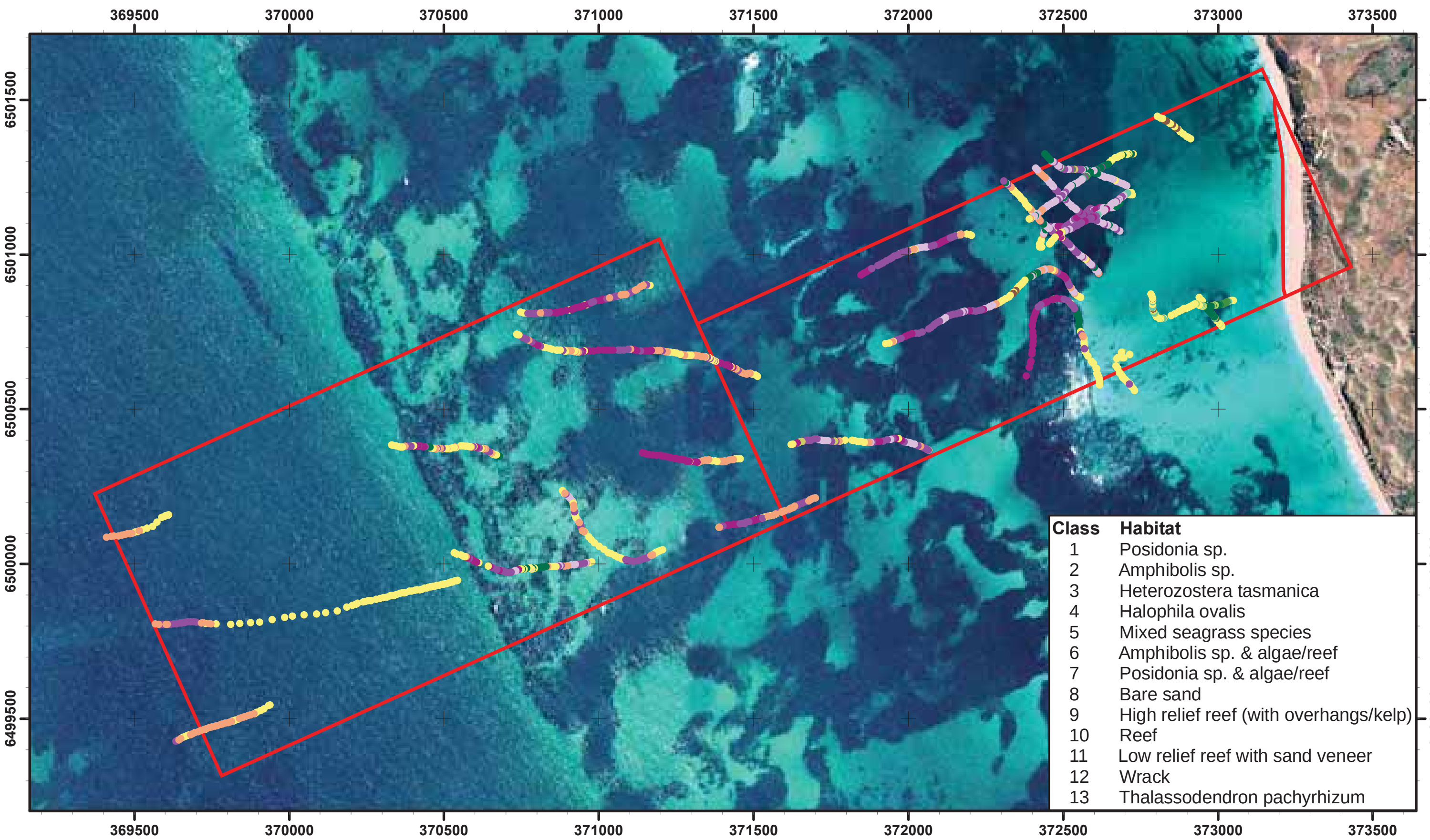
Client: Water Corporation
February 2005

4.2 Towed video groundtruthing

The towed video footage allowed the differentiation of seagrass, reef and sand habitats, including the separation of wrack material overlying sand from vegetated areas. The video footage also provided detailed information on the species assemblages and substrate characteristics along each transect (Figure 4.3). This information greatly aided the detailed description of each habitat, and in the mapping of different habitat types. Information on discrete features, such as caves, reef archways and isolated seagrass patches, was also obtained (Appendix A).

In several locations, the towed video recorded discrete patches of habitat different to that within the surrounding area. For example discrete patches of the seagrass *Thalassodendron pachyrhizum* were recorded within predominantly reef habitats. Similarly discrete *Posidonia australis* (tapeweed) beds were identified inshore amongst more extensive *Heterozostera marina* (eelgrass) and *Halophila ovalis* (paddleweed) seagrass beds. Whilst these discrete habitat areas have been mapped where recorded from the towed video transects, they could not be identified and mapped within areas not covered by towed video. Therefore the most accurate representation of habitats present occurs along each video transect, with habitats in other areas mapped through extrapolation of the video data and examination of the aerial imagery and bathymetry.

The towed video groundtruthing also provided detailed habitat information for deep water areas not mappable from the aerial photography. Video lines run at the far western end of the survey area, in water depths to 22 m and too great for the effective use of aerial photography in the mapping of benthic habitats, identified the existence of a low relief reef formation running parallel to the shoreline approximately 3.8 km offshore (Figure 4.3).



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Benthic survey area

Habitat Classes

1 2 3 4 5 6 7 8 9 10 11 12 13

Meters
0 250 500 1,000

DATUM
Horizontal: UTM Zone 50
Based on WGS 84
Vertical: N/A

Figure 4.3
Classification of habitat types from towed video

Client: Water Corporation
February 2005

4.3 Detailed habitat information from diving

Spot dives were undertaken in areas identified from the video groundtruthing to exhibit a high degree of physical complexity or diversity. The dives provided information on the species assemblages and reef morphology within each habitat type, and provided a better understanding of the spatial variability within each habitat type.

Stills photographs of conspicuous species recorded from each dive site are included in Appendix B. In addition to stills photography, seagrass and algal samples were collected for subsequent identification (Appendix C).

The data collected from the spot dives allowed the habitat types to be more accurately defined than those initially used to classify the video imagery (Figure 4.3).

4.4 Habitats identified

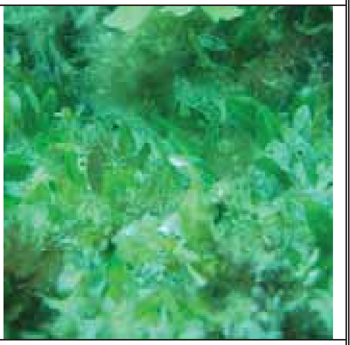
A range of seagrass, reef and sand habitats were identified within the survey area. Both patchy and continuous seagrass beds composed of *Amphibolis* spp. were identified whilst patches of *Heterozostera tasmanica*, *Halophila ovalis*, *Posidonia* spp. and *Thalassodendron pachyrhizum* were also recorded. Relatively large beds of *Posidonia australis* were recorded in inshore sheltered areas whilst smaller patches of *Posidonia sinuosa* and *Posidonia angustifolia* were recorded amongst reef habitat further from the shore.

A variety of reef structures were also recorded, ranging from low relief pavement reef, often covered by a thin veneer of sand, to high relief reef exhibiting vertical walls and overhangs. Soft substrate, consisting of medium/fine sands, was found over much of the study area. A complex mosaic of habitats was found in some areas, with several habitat types in close association with each other (for example at dive site D5). The main habitat types identified, together with a short description, are given in Table 4.2, Table 4.3 and Table 4.4.

Seagrass habitats

Table 4.2 Seagrass habitats identified

Habitat name	Habitat description	Habitat photograph
***Posidonia* spp.**	Sand areas covered by patches of *Posidonia* spp. (*P. sinuosa*, *P. angustifolia*, *P. australis*)	

Habitat name	Habitat description	Habitat photograph
Amphibolis spp.	Reef areas covered by continuous *Amphibolis* spp. (Both *A. griffithi* and *A. antarctica* recorded, often growing together)	
***Amphibolis spp.* and reef**	Reef areas covered by patchy *Amphibolis* spp. and algal communities	
***Halophila* sp.**	Inshore, sheltered sand areas covered by continuous *Halophila ovalis*	
***Heterozostera* sp.**	Inshore, sheltered sand areas covered by continuous *Heterozostera tasmanica*	
***Thalassodendron* sp.**	Reef areas covered by patches of *Thalassodendron pachyrhizum*	
Mixed *Halophila* sp. and *Heterozostera* sp.	Inshore, sheltered sand areas covered by a combination of *Halophila ovalis* and *Heterozostera tasmanica* seagrasses	

Sand habitats

Table 4.3 Sand habitats identified

Habitat name	Habitat description	Habitat photograph
Sand	Unvegetated areas in which sand was dominant	
Wrack material	Sand areas covered by unattached seagrass leaves and algae	No photograph available

Reef habitats

Table 4.4 Reef habitats identified

Habitat name	Habitat description	Habitat photograph
Low relief reef	Low lying (average height <0.5 m above surrounding seabed) vegetated limestone reef, often with a thin veneer of sand	
Reef	Moderately (0.5-1.0 m) raised limestone reef characterised by a dense cover of algae, including *Gelinaria ulvoidea*, *Dictyomenia* sp., *Plocamium* sp. and *Callophyllis* sp.	
High relief reef	Limestone reef outcrops characterised by high relief (average height >1.0 m above surrounding seabed), vertical walls and *Ecklonia radiata* on upper surfaces. Other algal species included *Sarcomenia delesseroides* and *Codium* sp.	

Habitat name	Habitat description	Habitat photograph
Exposed reef	Limestone reef within high energy environment, subject to strong surge and breaking waves Generally little colonisation with only cover consisting of short green algal turf and zoanthids (colonial anemones)	

4.5 Infaunal cores

Analysis of the infaunal sediment samples revealed a species-poor community within the sandy habitats offshore of the Alkimos proposed WWTP. Polychaetes and crustaceans were the dominant phyla both in terms of the number of species and individuals (Figure 4.4, Figure 4.5, Appendix D). However, their relative abundance varied markedly between sites, ranging from 80% crustaceans/20% polychaetes at site 8, towards the end of the proposed pipeline, to 20% crustaceans/70% polychaetes at site 3, towards the middle of the proposed pipeline (Figure 4.5).

Molluscs were only recorded from sites 1 and 7 but comprised 36% of species numbers at the former site. Their distribution may be related to the sediment particle size, with sites 1 and 7 (along with site 2) exhibiting the finest sediments recorded from the infaunal cores (Table 4.5).

Figure 4.4 Polychaetes visible within infauna sample

4.5.1 Community characteristics

Site 1 exhibited the highest species and individual numbers, with sites 6 and 8 exhibiting the coarsest sediments and the lowest species and individual numbers (Table 4.5).

Table 4.5 Mean individual and species numbers and diversity recorded from each site

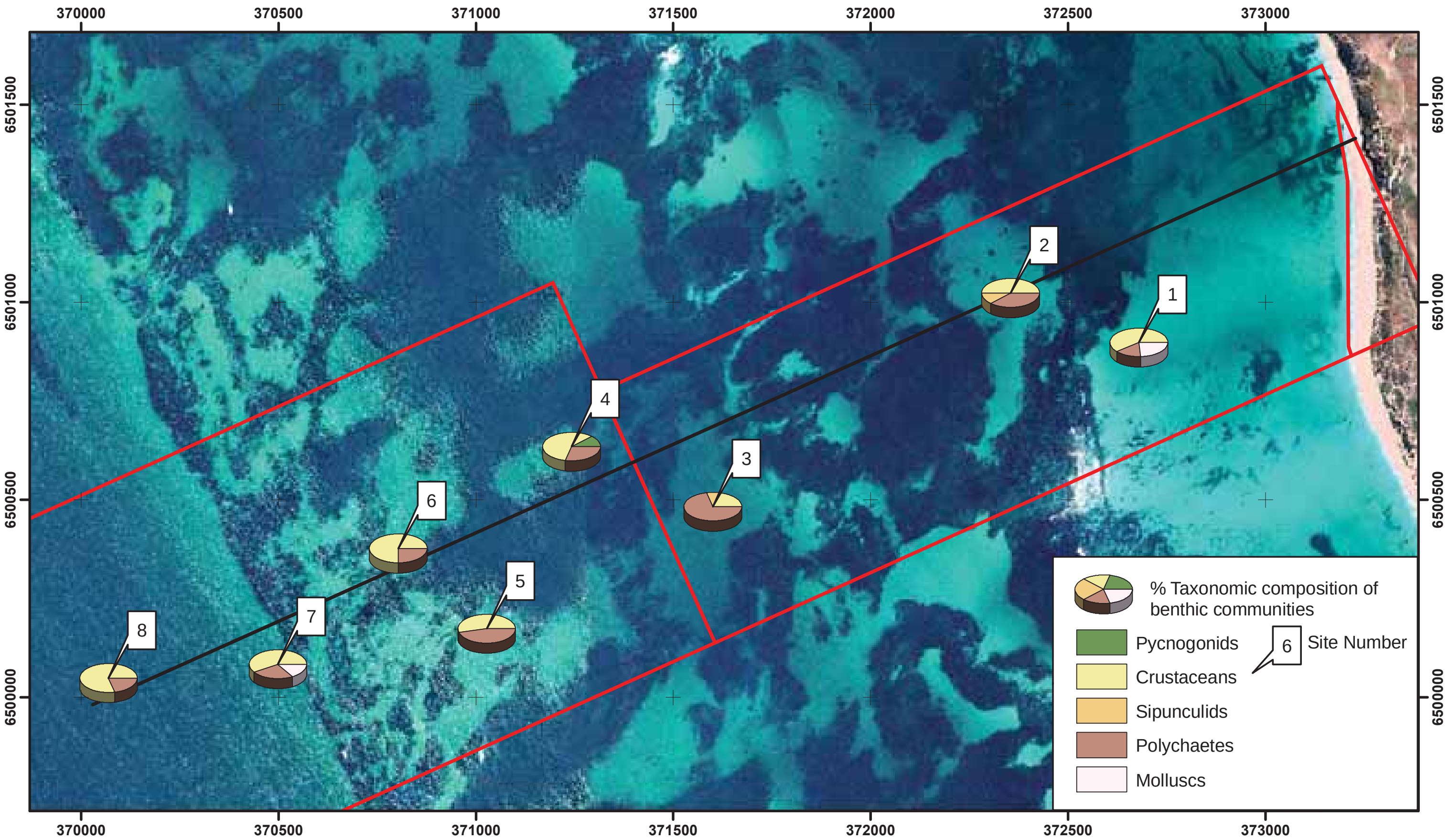
Site	Sediment type	Individual Numbers*	Species Numbers*	Species Diversity*
1	Medium/fine clean sand	24	11	1.9
2	Medium/fine clean sand	21	8	1.2
3	Medium sand with fines	18	7	1.0
4	Medium clean sand	11	7	1.4#
5	Medium clean sand	15	9	2.1
6	Coarse shell sand	4	4	1.4
7	Medium/fine clean sand	9	7	1.2
8	Medium sand with coarse shell sand	5	3	0.9#

C
alculated from four replicate samples sieved on 1 mm sieve.
#Calculated from one replicate only due to low species numbers at these sites.

There is high variability between most samples, even replicates from the same site, and no distinct shift in the community structure is shown with changing water depth, sediment type or distance offshore. However, the presence of one individual of each of four bivalve mollusc species at site 1 (inshore), compared to only one individual at sites 7 and 8, and no individuals from any of the other sites, suggests that the infaunal community at this site is markedly different from that at other sites.

Multivariate analysis

The low number of both individuals and species recorded within all samples limits the use of multivariate analysis. This analysis was carried out, with the results from untransformed data given in Appendix E. Due to the low number of both individuals and species recorded within all samples, small differences within each sample account for large differences within the cluster analysis. For example, samples 3-4 and 4-2 are shown to be extremely similar, but this is due to the presence of two individuals of the polychaete *Armandia* sp. within each sample.



oceanica

Created By: EDB
Reference: 438_6
Infauna.mxd

Legend

Approximate pipeline route
Benthic survey area

0 175 350 700 Meters

DATUM
Horizontal: UTM Zone 50
Based on WGS 84
Vertical: N/A

Figure 4.5
Distribution of infauna numbers between taxonomic groups

Client: Water Corporation
May 2005

4.5.2 Infauna community recorded on finer sieve

Examination of samples sieved on a smaller sieve size (0.5 mm) indicates that a similar number of species and individuals were recorded at most sites as were retained on a 1.0 mm sieve (Appendix D). However, at sites 2 and 7 the number of individuals retained did vary markedly between sieve sizes. At site 2, the number of individuals recorded on the 0.5 mm sieve was over double the mean number recorded in the 1.0 mm-sieved samples, with these animals consisting of an amphipod species and a polychaete species (*Armandia* sp.) also recorded from the 1.0 mm-sieved samples. At site 7 a large number of individuals of a single amphipod species, also recorded from the 1.0 mm-sieved samples, led to the 0.5 mm-sieved sample exhibiting markedly greater individual numbers than the other four samples combined.

Overall only two species (the polychaete *Dispio* sp. and the bivalve *Venerid* sp.) were recorded from the 0.5 mm-sieved samples only (samples 3-5 and 8-5), suggesting that the majority of infaunal species present fall into the larger size category (>0.5 mm).

4.6 Habitat map

4.6.1 Target notes

To map discrete habitat features or detailed habitat information recorded from the video groundtruthing, target notes have been identified on the habitat map (Figure 4.6) and associated habitat information given in Table 4.6.

Table 4.6 Target notes from video footage

Target note	General habitat type	Feature description
T1	Reef	Patch of *Thalassodendron pachyrhizum*
T2	Reef	Patch of *Thalassodendron pachyrhizum*
T3	Reef	Dense *Heterozostera tasmanica*
T4	Amphibolis spp. & reef	Mixed *Amphibolis* sp. & *Posidonia* sp.
T5	High relief reef	*Ecklonia radiata* cover 80%
T6	High relief reef	*Ecklonia radiata* cover 100%
T7	High relief reef	Large overhang
T8	Low relief reef	Vegetation cover 80%
T9	Low relief reef	Sand cover 40%
T10	Low relief reef	Vegetation cover <10%
T11	High relief reef	*Ecklonia radiata* cover 100%
T12	High relief reef	Archway
T13	High relief reef	Overhangs
T14	High relief reef	Overhangs

4.6.2 Habitat coverage

Table 4.7 Habitat type coverage within the Alkimos survey area

Habitat type	Area (ha)	% of total
***Posidonia* sp.**	0.20	0.1
Amphibolis sp.	2.78	0.8
***Amphibolis sp.* and reef**	10.16	3.1
***Halophila* sp.**	0.02	0.0
***Heterozostera* sp.**	0.00	0.0
***Thalassodendron* sp.**	0.02	0.0

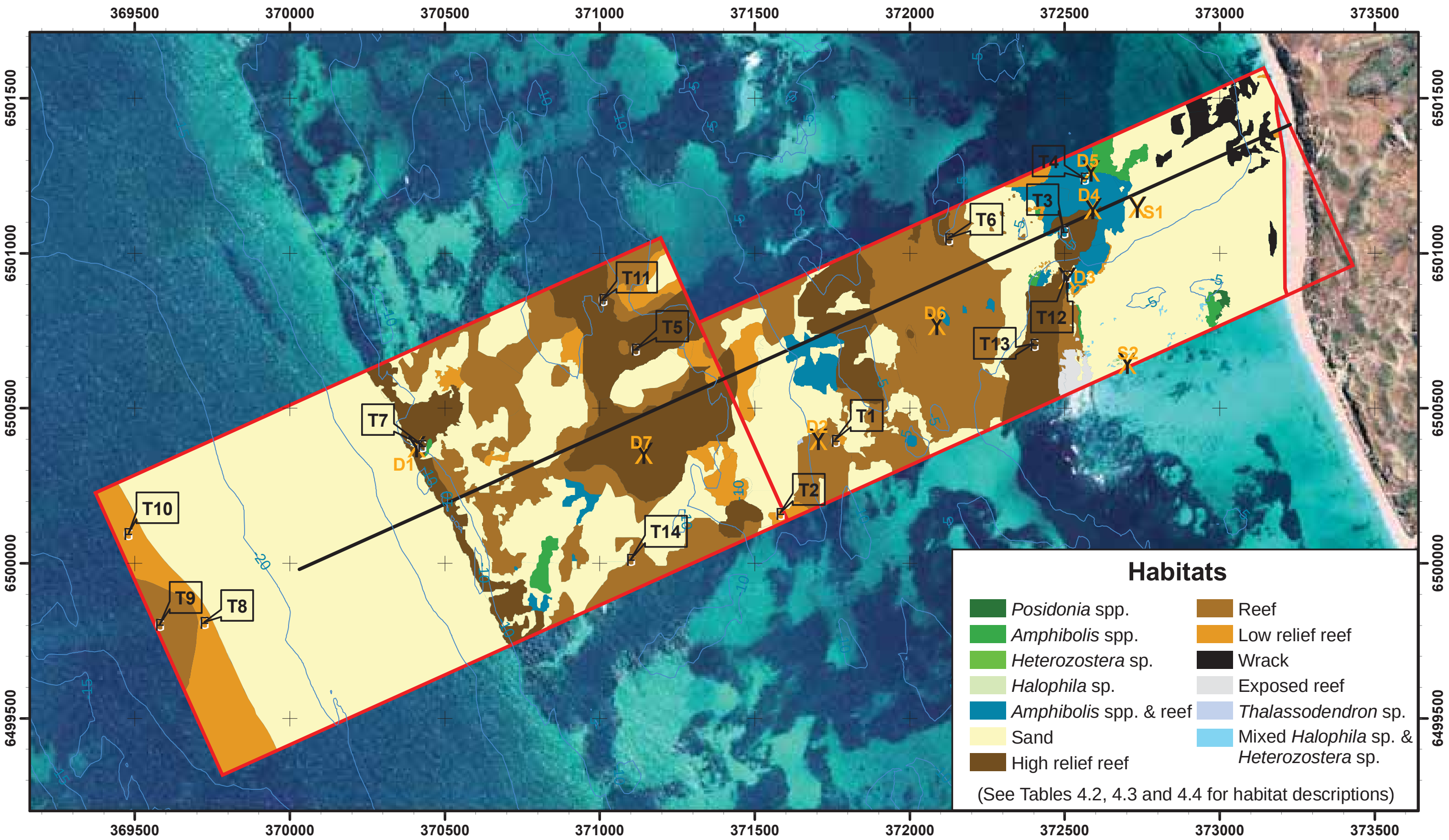
Mixed *Halophila* sp. and *Heterozostera* sp.	0.16	0.0
Wrack	3.58	1.1
Low relief reef	20.28	6.1
Reef	64.68	19.5
High relief reef	46.01	13.9
Exposed reef	1.29	0.4
Sand	185.70	55.9
TOTAL	**331.9**	**100**

4.6.3 Vegetation percentage cover

Within each seagrass habitat the percentage cover of seagrass species was estimated from the towed video footage. Generally, the *Amphibolis* spp. and *Posidonia australis* beds were dense, with covers >80%. Other *Posidonia* species (*Posidonia sinuosa* and *Posidonia angustifolia*) were found to occur within isolated patches only, within broader scale reef habitat. The more ephemeral seagrass species, *Halophila ovalis* and *Heterozostera tasmanica*, were found to be more variable in cover, ranging from 20% to 100% (Appendix A).

4.6.4 Presence of epiphytes

Generally conspicuous epiphytic filamentous red and brown algae were observed on both *Amphibolis antarctica* and *Amphibolis griffithii* seagrasses. *Posidonia* spp., *Heterozostera tasmanica*, *Halophila ovalis* and *Thalassodendron pachyrhizum* seagrasses all showed little epiphytic growth when viewed in the video footage or during the spot dives (Appendix A).



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Reference: 438_3
Fig4_8_habitats.mxd

Legend

T6 Target notes

Approximate pipeline route

D4 Dive sites

Benthic survey area

Meters
0 250 500 1,000

DATUM
Horizontal: UTM Zone 50
Based on WGS 84
Vertical: Australian Height Datum

Figure 4.6
Map of benthic habitats within the Alkimos survey area

Client: Water Corporation
February 2005

5. Application of Benthic Primary Producer Habitat (BPPH) Protection Guidance Statement

5.1 EPA Guidance Statement 29: Benthic Primary Producer Habitat (EPA, 2004)

The EPA's Guidance Statement No. 29 addresses the protection of Benthic Primary Producers (BPP) such as seagrasses, seaweeds and turf algae. It covers both BPP and BPP Habitats (BPPH), that is, the BPPs and the substrate which can or does support them.

The EPA recommends the delineation of a management unit of 50 km^2 in which issues such as ecosystem integrity, cumulative impact and biodiversity are addressed (EPA 2004). A proposed management unit, centring on the Alkimos survey area (and proposed pipeline), is given in Figure 5.1.

Within this management unit the following calculations are required;

1) All loss/damage to BPPH caused by human activities since European habitation of Western Australia;
2) Current area of BPPH; and
3) Loss/damage of BPPH likely to result from proposed works.

The BPPH guidance statement defines six categories of marine ecosystem protection, and the cumulative loss thresholds for each. The area offshore of Alkimos, as a high protection area, falls under category B, in which a cumulative loss of 1% of the historic BPPH is acceptable.

5.2 Historic losses of BPPH

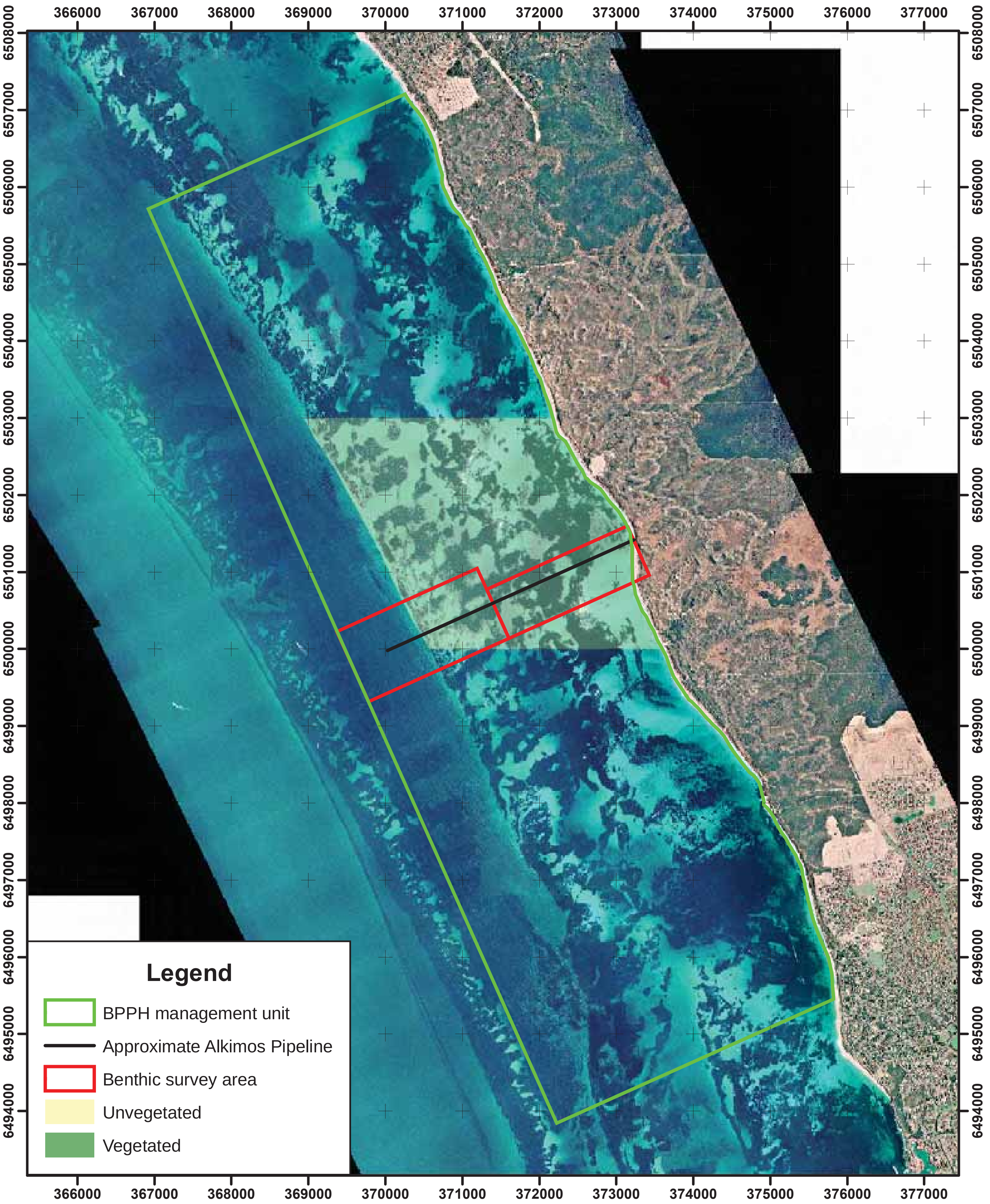
The area offshore of Alkimos is undisturbed with regard to dredging or land reclamation works, so there have been no historic losses of BPPH within the management unit.

5.3 Current extent of BPPH within management unit

The current coverage of BPPH within the management unit can be estimated from the extrapolation of habitat coverage data already obtained from the classification of aerial imagery within a 9.7 km^2 region of the proposed BPPH management unit (Figure 4.1, Figure 5.1).

Within the 9.7 km^2 mapping region, approximately 4.0 km^2 of vegetated habitats were mapped, representing 41% of the total area. The detailed groundtruthing of a 3.3 km^2 area within the proposed management unit revealed vegetated habitats to cover 1.5 km^2 (43%)[2] of the area (Table 4.7). It is therefore likely that approximately 41 to 43% of the BPPH management unit consists of vegetated habitats.

[2] Vegetated habitats not including wrack material



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Created By: EDB
Reference: 442_1
BPPH_unit.mxd

0 1 2 3 Kilometers

DATUM
Horizontal: UTM Zone 50,
Based on WGS 84
Vertical: N/A

Figure 5.1
Suggested boundary for BPPH management unit ($50\ km^2$)

Client: Water Corporation
April 2005

5.4 Loss/damage of BPPH expected from proposed pipeline construction and operation

5.4.1 Direct losses of BPPH from construction

The proposed pipeline route (yet to be finalised, Figure 2.1) crosses a number of vegetated habitats including *Amphibolis* spp. beds and reef (Figure 4.6). Over its entire length the pipeline route covers approximately 1.3 km of sand habitat and 2.3 km of vegetated habitat. Details regarding the pipeline placement and anchoring are yet to be finalised, but it likely that the pipe will either be tunnelled throughout its length, or installed by surface methods which would involve an approximately 10 m wide trench being excavated through the reef features.

The first method would cause very little impact on the overlying habitats, except at the end of the pipeline where the pipe would reach the seabed surface, and diffusers will be constructed or deployed.

The second method would cause the disturbance of approximately 2.3 ha (0.02 km^2) of vegetated habitat (length of 2.3 km x width 0.01 km) and have a total footprint of 3.6 ha (0.04 km^2) (length of 3.6 km x width 0.01 km). This represents a loss of approximately 0.1%[3] of the vegetated habitats present within the BPPH management unit (21 km^2) and the disturbance of 0.07% of the overall management unit. This falls well below the 1% cumulative loss threshold set out in the guidance statement (EPA 2004).

However, back-filling and the presence of the pipe are likely to counter the loss of any hard substrate, meaning that the area of hard substrate is increased (the upper half of a 3.6 km long, 1.0 m diameter pipe represents over 5,655 m^2 of hard substrate). It is likely that the faunal and algal communities recolonising the trench region would be similar to those previously found in the area, although seagrass species are unlikely to recolonise this region.

5.4.2 Indirect losses of BPPH from operation of pipeline

As a component of the Perth Long-Term Ocean Outlet Monitoring (PLOOM) Programme there have been a number of surveys undertaken at Ocean Reef over the 1995-2003 period to identify any changes to the natural macroalgal communities which may be attributable to the disposal of treated wastewater (D.A. Lord & Associates *et al*., 2000, DALSE 2004, DALSE 2002). The projected discharge rate of treated wastewater (TWW) at Alkimos by 2050 is similar to the current discharge rate at Ocean Reef (80 ML d^{-1} compared to 110 ML d^{-1} currently discharged at Ocean Reef) so an examination of the findings from the PLOOM studies give a good indication of possible effects at Alkimos.

Macroalgal communities

The PLOOM Programme included comparison of the macroalgal community structure on platform, pavement and reef habitat at sites near the Ocean Reef Ocean Outlets, through which approximately 110 ML d^{-1} of TWW is discharged, and at control sites during spring, summer and autumn. These surveys found no evidence of adverse effects resulting from treated wastewater discharge, as indicated by the absence of macroalgae species that tend to flourish under conditions of nutrient enrichment. The mean proportion of so-called ‘nuisance’ algae in the kelp and

[3] Calculated on 42% vegetated habitat cover

assemblage communities during spring, summer and autumn were all below criteria identified during the Perth Coastal Waters Study for healthy macroalgal communities (D.A. Lord & Associates *et al*., 2000). These studies concluded that habitat was the main determinant of macroalgal biomass, and that within habitats it was not possible to identify spatial or temporal differences in macroaglal composition or biomass which could be related to the discharge of treated wastewater from the Ocean Reef Ocean Outlets (D.A. Lord & Associates *et al*. 1998).

A study undertaken under the PLOOM programme by DALSE and UWA (DALSE and UWA 2002) included observations of the presence of recognised so-called 'nuisance' macroalgae species and seagrass condition (e.g. the presence of epiphytes). Variable amounts of 'nuisance' green algae (e.g. *Ulva*, *Chaetomorpha*), brown and red filamentous macroalgae were reported on the reefs within 1 km of the Ocean Reef Ocean Outlets (DALSE and UWA 2002). Higher densities of *Ulva* were observed in macroalgal communities present on pavement and high-relief reefs located 0.5-1.5 km south and 1 km north of the outlets, relative to nearby reference sites, although its distribution was patchy and inconsistent. A macroalgal plate study (DALSE 2004) also failed to show an increased biomass of nuisance macroalgae closer to the Ocean Reef outlets, suggesting that the discharge of this volume of TWW does not cause a change in macroalgal assemblage on the surrounding seabed.

Within 1 km of the outlets, an increase in microphytobenthos films and mats on sand habitats was observed compared to sand habitat located more than 1.5 km away from the outlets (DALSE and UWA 2002), suggesting that the discharge may be affecting these communities.

Seagrass health

One potential effect on seagrass health resulting from an increase in the ambient nutrient concentration is the increased growth of epiphytic algal species. Epiphytes were not, however, noticeably greater in cover on seagrass located in the immediate vicinity of the Ocean Reef outlets relative to seagrass observed in areas more distant from the outlets (DALSE and UWA 2002; DALSE 2003). The low epiphyte loads on seagrass in the vicinity of the outlets were considered to be at least partially attributable to the dominance of fast-growing, ephemeral species with high leaf turn-overs (e.g. *Heterozostera tasmanica*, *Halophila ovalis*) and thus shorter periods of time available for epiphytic colonisation. The other dominant species in the region, *Posidonia coriacea*, has a thick smooth cuticle covering the leaf which will also act to reduce epiphyte colonisation.

A study into the condition of seagrasses at Ocean Reef (DALSE, 2004) indicated no clear trend between seagrass health (measured as leaf and shoot density) and proximity to the ocean outlets. Four sampling sites were located around the Ocean Reef Ocean Outlets: two reference sites located 4,000 m north and south of the outlets, and two potential impact sites located 500 m north and south of the outlets. A high degree of variability was recorded in *Posidonia coriacea* leaf and shoot densities from year to year at both reference and potential impact sites, and leaf and shoot densities at the potential impact sites were generally higher than at the reference sites. This is counter-intuitive to the cause-effect basis for the derivation of the seagrass condition criteria, which assumes that there will be a decrease in seagrass shoot density under conditions of nutrient enrichment, but is supported by other literature (for example Udy *et al*. 1999) documenting increased seagrass growth with nutrient inputs.

Therefore at this stage the effects of the discharge of TWW on seagrasses cannot be reliably predicted. However, the results of the studies discussed above suggest that a broad-scale loss of seagrasses from the area surrounding the pipeline is unlikely.

Habitat distribution

Changes in the distribution of benthic habitats in a 3,150 ha study area surrounding the Ocean Reef outlets was investigated in 2004 using the examination of high resolution aerial imagery captured in 2002 and 2004 (Oceanica 2004). The vegetated areas were distinguishable from the unvegetated areas by their distinctly darker phototone on the imagery. A net loss of 29 ha (2.9%) of vegetated habitat area was mapped between 2002 and 2004. However, there were no strong spatial patterns in the distribution of losses or gains in vegetated habitat within the study area over this period, although the losses generally occurred within 2 km of the shoreline. In addition, the area is highly dynamic, and much of the change was attributed to the movement of mobile sands within the area. Therefore it is highly unlikely that a broad-scale change in habitat distribution will occur following the construction and operation of the ocean outlet.

6. Summary

The supervised tonal classification of aerial imagery was found to be effective for the mapping of vegetated and unvegetated habitats, with 60.3 % of the mapping considered to be of high reliability. Groundtruthing using towed video and spot dives allowed the identification of eleven types of vegetated habitat, divided according to their topography and the dominant floral community, consisting of four reef types and seven seagrass habitat types. The most widespread habitat type recorded was sand (55.9%) followed by reef (19.5%) and high relief reef (13.9%), with these habitat types recorded extensively from elsewhere within the Perth Metropolitan area.

The infaunal communities at each site sampled were found to be similar, exhibiting low species diversity and abundance. This is in line with the findings of other studies (for example Wildsmith *et al*. 2005) which have found the infaunal assemblages within nearshore high energy environments in Western Australia to exhibit low numbers of individuals and species.

It was estimated that up to 0.1% of vegetated habitats within the management unit could be disturbed during construction of the pipeline, though it is likely that similar communities to those currently found within the reef habitats would rapidly (<12 months) re-establish onto the pipe and disturbed reef surfaces. The findings of historic studies conducted at Ocean Reef suggest that any effects on the distribution or health of benthic habitats due to the operation of the WWTP would be extremely small-scale in spatial extent.

The predicted cumulative losses of BPPH (0.1% of the vegetated habitats within the BPPH management unit and 0.07% of the overall BPPH management unit) fall well below the 1% loss threshold for high protection areas as set out in the guidance statement (EPA 2004). Therefore this proposal would the EPA objective on BPPH protection.

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8. Acknowledgements

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Appendix A

Towed video records

APPENDIX A TOWED VIDEO RECORDS

Transect	REC_No	Class (1-13)[1]	Comments	Depth (m)	Easting	Northing	Habitat type
01b	198	8		6.0	372429.36	6501038.48	Bare sand
01b	210	8		6.1	372424.68	6501032.88	Bare sand
01b	221	8		6.1	372424.79	6501023.64	Bare sand
01b	232	8		6.4	372431.12	6501023.72	Bare sand
01b	245	8		6.3	372430.83	6501047.74	Bare sand
01b	257	11		6.5	372436.94	6501064.44	Low relief reef with sand veneer
01b	262	6		5.9	372438.48	6501068.16	Amphibolis sp. & algae/reef
01b	267	6		6.2	372439.99	6501073.72	Amphibolis sp. & algae/reef
01b	277	2		5.9	372444.67	6501079.32	Amphibolis sp.
01b	283	2		5.9	372447.78	6501083.05	Amphibolis sp.
01b	288	2		6.0	372450.89	6501086.79	Amphibolis sp.
01b	292	10		6.2	372452.46	6501088.65	Reef
01b	306	10		6.3	372458.78	6501088.73	Reef
01b	316	6		6.3	372460.40	6501085.06	Amphibolis sp. & algae/reef
01b	321	10		6.4	372463.57	6501085.10	Reef
01b	328	10		6.7	372471.43	6501088.89	Reef
01b	332	6		6.6	372473.01	6501088.91	Amphibolis sp. & algae/reef
01b	341	9	cave	6.4	372484.05	6501090.89	High relief reef (with overhangs/kelp)
01b	347	9		6.0	372490.38	6501090.97	High relief reef (with overhangs/kelp)
01b	356	9	vertical surfaces	6.3	372498.30	6501089.22	High relief reef (with overhangs/kelp)
01b	363	10		6.8	372506.23	6501087.47	Reef
01b	371	10		6.1	372512.48	6501093.09	Reef
01b	379	10		6.4	372520.33	6501098.73	Reef
01b	393	10		6.4	372531.27	6501108.10	Reef
01b	397	6		6.4	372532.83	6501109.97	Amphibolis sp. & algae/reef
01b	401	10		6.7	372537.53	6501113.72	Reef
01b	408	9		6.9	372543.81	6501117.50	High relief reef (with overhangs/kelp)
01b	416	9		7.3	372550.11	6501119.42	High relief reef (with overhangs/kelp)
01b	428	9		7.1	372561.18	6501119.56	High relief reef (with overhangs/kelp)
01b	438	10		7.1	372572.20	6501123.39	Reef
01b	452	10		7.2	372578.41	6501132.70	Reef
01b	458	10		7.0	372576.79	6501136.38	Reef
01b	468	10		6.6	372583.01	6501143.85	Reef
01b	475	3	small patch	6.9	372589.29	6501147.62	Heterozostera tasmanica
01b	476	10		6.9	372589.29	6501147.62	Reef
01b	483	10		6.6	372597.24	6501144.02	Reef
01b	487	6		6.6	372598.85	6501142.19	Amphibolis sp. & algae/reef
01b	493	9		6.9	372600.48	6501138.52	High relief reef (with overhangs/kelp)

[1] Class number allocated to each habitat type during initial classification of habitat types. See Figure 4.3 for habitats corresponding to each class number.

Transect	REC_No	Class (1-13)[1]	Comments	Depth (m)	Easting	Northing	Habitat type
01b	500	10		7.3	372602.05	6501138.54	Reef
01b	507	9		6.6	372606.73	6501144.14	High relief reef (with overhangs/kelp)
01b	519	9	overhang	6.5	372617.73	6501149.82	High relief reef (with overhangs/kelp)
01b	527	10		6.8	372625.63	6501149.91	Reef
01b	531	6		6.6	372630.37	6501149.97	Amphibolis sp. & algae/reef
01b	536	6		6.5	372636.70	6501150.05	Amphibolis sp. & algae/reef
01b	541	2		6.6	372641.44	6501150.11	Amphibolis sp.
01b	547	6		6.9	372647.77	6501150.18	Amphibolis sp. & algae/reef
01b	555	6		7.1	372655.67	6501150.28	Amphibolis sp. & algae/reef
01b	560	6		7.4	372663.55	6501152.23	Amphibolis sp. & algae/reef
01b	568	2		7.3	372673.01	6501154.19	Amphibolis sp.
01b	580	2		7.9	372683.95	6501165.41	Amphibolis sp.
01b	596	2		8.7	372691.64	6501182.14	Amphibolis sp.
01b	599	11		8.4	372691.60	6501185.83	Low relief reef with sand veneer
01b	607	11		8.6	372701.02	6501191.49	Low relief reef with sand veneer
01b	616	11		8.8	372707.32	6501193.41	Low relief reef with sand veneer
01b	625	8		8.5	372716.83	6501191.68	Bare sand
01b	633	8		8.4	372724.73	6501191.78	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
02b	12	11		4.9	372615.57	6500939.14	Low relief reef with sand veneer
02b	18	6		5.2	372612.35	6500944.65	Amphibolis sp. & algae/reef
02b	27	6		5.4	372605.95	6500950.11	Amphibolis sp. & algae/reef
02b	35	2		5.7	372601.12	6500957.44	Amphibolis sp.
02b	40	2		6.2	372597.94	6500959.25	Amphibolis sp.
02b	48	10		5.9	372594.72	6500962.91	Reef
02b	51	6		6.1	372591.52	6500966.56	Amphibolis sp. & algae/reef
02b	59	6		6.5	372585.12	6500972.03	Amphibolis sp. & algae/reef
02b	67	6		6.0	372580.31	6500977.51	Amphibolis sp. & algae/reef
02b	75	11		6.9	372575.50	6500983.00	Low relief reef with sand veneer
02b	79	8		7.1	372572.32	6500984.81	Bare sand
02b	83	8		6.7	372569.14	6500986.61	Bare sand
02b	85	6		7.0	372567.53	6500988.44	Amphibolis sp. & algae/reef
02b	93	11		6.9	372564.33	6500992.10	Low relief reef with sand veneer
02b	98	10		6.4	372562.74	6500992.08	Reef
02b	101	6		6.6	372559.56	6500993.89	Amphibolis sp. & algae/reef
02b	106	6		6.4	372554.80	6500995.68	Amphibolis sp. & algae/reef
02b	114	6		6.4	372551.58	6500999.33	Amphibolis sp. & algae/reef
02b	122	10		6.9	372545.20	6501004.80	Reef
02b	128	10		6.8	372540.41	6501008.43	Reef
02b	134	10		6.7	372537.17	6501013.94	Reef
02b	142	10		6.5	372532.39	6501017.57	Reef
02b	149	10		6.3	372527.57	6501023.06	Reef
02b	152	6		6.0	372526.00	6501023.04	Amphibolis sp. & algae/reef
02b	159	10		6.4	372522.74	6501030.39	Reef
02b	172	10		6.1	372516.36	6501035.85	Reef
02b	181	10		6.1	372508.35	6501043.15	Reef
02b	197	9		6.2	372497.18	6501052.25	High relief reef (with overhangs/kelp)
02b	201	9		6.3	372495.57	6501054.08	High relief reef (with overhangs/kelp)
02b	203	8		5.6	372495.57	6501054.08	Bare sand
02b	206	9	cave	5.5	372492.39	6501055.89	High relief reef (with overhangs/kelp)
02b	209	9		5.1	372489.20	6501057.69	High relief reef (with overhangs/kelp)
02b	217	9		5.0	372482.84	6501061.31	High relief reef (with overhangs/kelp)
02b	223	9		5.8	372478.05	6501064.95	High relief reef (with overhangs/kelp)
02b	229	8		6.5	372473.26	6501068.58	Bare sand
02b	235	8		6.7	372470.07	6501070.39	Bare sand
02b	236	10		6.4	372466.89	6501072.20	Reef
02b	246	10		6.4	372460.47	6501079.51	Reef
02b	254	6		6.4	372455.68	6501083.15	Amphibolis sp. & algae/reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
02b	256	6		6.2	372455.68	6501083.15	Amphibolis sp. & algae/reef
02b	264	6		6.1	372447.71	6501088.60	Amphibolis sp. & algae/reef
02b	270	6		6.1	372442.90	6501094.08	Amphibolis sp. & algae/reef
02b	279	2		6.3	372436.53	6501097.70	Amphibolis sp.
02b	285	2		6.7	372430.12	6501105.01	Amphibolis sp.
02b	290	10		7.0	372426.93	6501106.82	Reef
02b	292	11		7.2	372425.33	6501108.65	Low relief reef with sand veneer
02b	298	11		7.0	372423.70	6501112.32	Low relief reef with sand veneer
02b	304	11		7.0	372418.89	6501117.81	Low relief reef with sand veneer
02b	312	6		7.0	372414.08	6501123.29	Amphibolis sp. & algae/reef
02b	317	2		6.8	372412.45	6501126.97	Amphibolis sp.
02b	323	2		7.0	372409.25	6501130.62	Amphibolis sp.
02b	329	2		7.3	372406.07	6501132.43	Amphibolis sp.
02b	333	8		0.0	372402.85	6501136.09	Bare sand
02b	341	8		7.4	372398.04	6501141.57	Bare sand
02b	347	11		7.7	372396.42	6501145.25	Low relief reef with sand veneer
02b	352	11		7.4	372393.23	6501147.05	Low relief reef with sand veneer
02b	356	8		7.8	372390.03	6501150.71	Bare sand
02b	362	8		7.5	372386.82	6501154.37	Bare sand
02b	372	8		7.9	372380.40	6501161.68	Bare sand
02b	386	8		7.9	372373.94	6501172.69	Bare sand
02b	398	8		8.2	372365.95	6501179.98	Bare sand
02b	412	8		8.1	372361.11	6501187.31	Bare sand
02b	420	8		8.4	372354.72	6501192.77	Bare sand
02b	433	8		8.3	372346.73	6501200.07	Bare sand
02b	445	8		8.1	372340.31	6501207.38	Bare sand
02b	449	8	skirting reef 10	8.4	372338.71	6501209.21	Bare sand
02b	463	11		8.0	372332.29	6501216.52	Low relief reef with sand veneer
02b	469	11		8.5	372325.90	6501221.98	Low relief reef with sand veneer
02b	476	11		7.2	372322.69	6501225.64	Low relief reef with sand veneer
02b	477	10		7.1	372321.11	6501225.62	Reef
02b	481	6		7.2	372317.90	6501229.28	Amphibolis sp. & algae/reef
02b	486	2		7.4	372314.72	6501231.09	Amphibolis sp.
02b	493	2		8.0	372309.93	6501234.72	Amphibolis sp.
02b	496	10		7.8	372308.33	6501236.55	Reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
03b	16	6		6.5	372683.47	6501074.87	Amphibolis sp. & algae/reef
03b	25	10		6.7	372672.35	6501080.27	Reef
03b	33	6		6.7	372667.53	6501085.76	Amphibolis sp. & algae/reef
03b	40	6		6.8	372662.77	6501087.54	Amphibolis sp. & algae/reef
03b	49	6		6.7	372653.22	6501092.97	Amphibolis sp. & algae/reef
03b	55	2		6.8	372648.45	6501094.76	Amphibolis sp.
03b	59	6		7.1	372645.28	6501094.72	Amphibolis sp. & algae/reef
03b	63	6		7.2	372642.10	6501096.53	Amphibolis sp. & algae/reef
03b	71	10		7.2	372634.20	6501096.43	Reef
03b	80	6		7.1	372629.41	6501100.07	Amphibolis sp. & algae/reef
03b	90	6		6.9	372615.11	6501105.44	Amphibolis sp. & algae/reef
03b	97	10		7.5	372608.74	6501109.05	Reef
03b	106	10		7.3	372597.63	6501112.61	Reef
03b	116	9		7.4	372584.94	6501116.15	High relief reef (with overhangs/kelp)
03b	124	10		7.2	372576.99	6501119.75	Reef
03b	134	10		7.1	372572.20	6501123.39	Reef
03b	142	9		7.5	372567.44	6501125.18	High relief reef (with overhangs/kelp)
03b	148	10		7.1	372564.25	6501126.98	Reef
03b	159	10		7.2	372556.28	6501132.43	Reef
03b	165	9	Cave	6.5	372553.05	6501137.93	High relief reef (with overhangs/kelp)
03b	171	10		6.5	372548.28	6501139.72	Reef
03b	179	6		6.5	372543.47	6501145.21	Amphibolis sp. & algae/reef
03b	186	6		6.5	372540.28	6501147.02	Amphibolis sp. & algae/reef
03b	193	6		6.4	372535.49	6501150.65	Amphibolis sp. & algae/reef
03b	200	6		6.4	372529.13	6501154.27	Amphibolis sp. & algae/reef
03b	207	6		6.3	372525.92	6501157.93	Amphibolis sp. & algae/reef
03b	217	6		6.4	372517.92	6501165.22	Amphibolis sp. & algae/reef
03b	229	6		6.0	372511.48	6501174.38	Amphibolis sp. & algae/reef
03b	232	10		6.6	372508.30	6501176.19	Reef
03b	242	6		5.9	372503.49	6501181.67	Amphibolis sp. & algae/reef
03b	244	2		6.2	372503.47	6501183.52	Amphibolis sp.
03b	252	6		6.7	372498.68	6501187.16	Amphibolis sp. & algae/reef
03b	264	6		6.9	372489.10	6501194.43	Amphibolis sp. & algae/reef
03b	274	10		6.8	372482.66	6501203.59	Reef
03b	284	10		6.7	372476.28	6501209.05	Reef
03b	295	6		7.1	372469.84	6501218.21	Amphibolis sp. & algae/reef
03b	300	6		7.3	372466.63	6501221.87	Amphibolis sp. & algae/reef
03b	307	6		7.3	372463.42	6501225.52	Amphibolis sp. & algae/reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
03b	313	6		7.7	372457.03	6501230.99	Amphibolis sp. & algae/reef
03b	319	6		7.7	372453.80	6501236.49	Amphibolis sp. & algae/reef
03b	327	6		7.8	372449.01	6501240.13	Amphibolis sp. & algae/reef
03b	336	6		8.2	372442.60	6501247.44	Amphibolis sp. & algae/reef
03b	339	11		8.3	372442.60	6501247.44	Low relief reef with sand veneer
03b	344	11		8.2	372437.81	6501251.08	Low relief reef with sand veneer
03b	350	11		8.4	372434.60	6501254.73	Low relief reef with sand veneer
03b	360	11		8.4	372428.21	6501260.20	Low relief reef with sand veneer
03b	370	11		8.2	372421.82	6501265.66	Low relief reef with sand veneer
03b	380	6		8.1	372416.98	6501272.99	Amphibolis sp. & algae/reef
03b	386	6		8.2	372412.17	6501278.48	Amphibolis sp. & algae/reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
04b	17	6		8.9	372705.40	6501221.11	Amphibolis sp. & algae/reef
04b	25	6		8.8	372700.61	6501224.75	Amphibolis sp. & algae/reef
04b	31	6		8.8	372695.84	6501226.53	Amphibolis sp. & algae/reef
04b	40	6		8.7	372687.89	6501230.13	Amphibolis sp. & algae/reef
04b	51	6		8.5	372678.36	6501233.71	Amphibolis sp. & algae/reef
04b	59	6		8.7	372672.01	6501235.48	Amphibolis sp. & algae/reef
04b	68	8		8.4	372668.81	6501239.14	Bare sand
04b	77	10		8.2	372660.86	6501242.73	Reef
04b	79	6		8.0	372660.86	6501242.73	Amphibolis sp. & algae/reef
04b	85	6		8.1	372654.51	6501244.50	Amphibolis sp. & algae/reef
04b	94	6		0.0	372644.98	6501248.08	Amphibolis sp. & algae/reef
04b	109	6		7.0	372635.47	6501249.81	Amphibolis sp. & algae/reef
04b	114	6		7.6	372630.71	6501251.60	Amphibolis sp. & algae/reef
04b	124	6		7.0	372622.76	6501255.20	Amphibolis sp. & algae/reef
04b	134	6		6.0	372614.80	6501258.80	Amphibolis sp. & algae/reef
04b	142	2		6.7	372611.62	6501260.61	Amphibolis sp.
04b	152	2		6.7	372603.70	6501262.36	Amphibolis sp.
04b	160	2		6.7	372598.93	6501264.15	Amphibolis sp.
04b	167	2		6.8	372595.74	6501265.96	Amphibolis sp.
04b	175	2		6.8	372589.40	6501267.73	Amphibolis sp.
04b	177	2	plus patch posidonia sp.?	6.6	372589.40	6501267.73	Amphibolis sp.
04b	185	5	A.Griffithi + patch Thalassodendron & Posidonia sp.	6.9	372584.64	6501269.51	Mixed seagrass species
04b	189	2		6.7	372581.47	6501269.47	Amphibolis sp.
04b	196	2		6.7	372578.29	6501271.28	Amphibolis sp.
04b	207	5	A.Griffithi + patch Posidonia sp.	6.8	372571.94	6501273.05	Mixed seagrass species
04b	211	6		6.9	372571.94	6501273.05	Amphibolis sp. & algae/reef
04b	216	2		6.8	372567.19	6501273.00	Amphibolis sp.
04b	223	6		6.6	372562.45	6501272.94	Amphibolis sp. & algae/reef
04b	234	10		6.7	372557.68	6501274.73	Reef
04b	243	10		6.8	372548.20	6501274.61	Reef
04b	253	10		7.2	372540.30	6501274.51	Reef
04b	258	13	patch Thalassodendron	7.5	372537.14	6501274.47	Thalassodendron pachyrhizum
04b	265	10		7.4	372530.81	6501274.40	Reef
04b	270	7		7.4	372527.65	6501274.36	Posidonia sp. & algae/reef
04b	276	10		7.5	372524.48	6501274.32	Reef
04b	284	6		7.7	372518.17	6501274.24	Amphibolis sp. & algae/reef
04b	289	6		7.4	372516.58	6501274.22	Amphibolis sp. & algae/reef
04b	304	10		7.5	372505.51	6501274.08	Reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
04b	314	10		7.4	372497.57	6501277.68	Reef
04b	316	7	patch Posidonia sp.?	7.5	372494.38	6501279.49	Posidonia sp. & algae/reef
04b	322	6		7.7	372491.19	6501281.30	Amphibolis sp. & algae/reef
04b	327	10		7.7	372488.01	6501283.11	Reef
04b	332	6		7.3	372486.40	6501284.94	Amphibolis sp. & algae/reef
04b	339	6		7.6	372483.22	6501286.74	Amphibolis sp. & algae/reef
04b	361	10		8.0	372472.02	6501297.69	Reef
04b	367	6		8.1	372467.25	6501299.48	Amphibolis sp. & algae/reef
04b	375	6		8.2	372464.07	6501301.29	Amphibolis sp. & algae/reef
04b	379	2		8.2	372459.28	6501304.93	Amphibolis sp.
04b	388	2		8.0	372454.47	6501310.41	Amphibolis sp.
04b	399	2		8.2	372448.05	6501317.72	Amphibolis sp.
04b	410	2		8.4	372441.64	6501325.04	Amphibolis sp.

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
05b	13	8		8.2	372912.25	6501373.32	Bare sand
05b	21	8		8.2	372905.88	6501376.93	Bare sand
05b	31	8		8.1	372899.51	6501380.55	Bare sand
05b	50	8		8.2	372888.35	6501387.81	Bare sand
05b	62	8		8.3	372878.77	6501395.08	Bare sand
05b	76	8		8.4	372872.34	6501404.24	Bare sand
05b	84	12		8.2	372867.58	6501406.03	Wrack
05b	88	12		8.1	372862.79	6501409.67	Wrack
05b	92	8		8.2	372861.18	6501411.49	Bare sand
05b	106	12		8.1	372853.19	6501418.79	Wrack
05b	113	12		8.1	372848.43	6501420.58	Wrack
05b	115	8		8.2	372846.82	6501422.40	Bare sand
05b	121	8		8.1	372842.05	6501424.19	Bare sand
05b	129	12		8.2	372834.08	6501429.64	Wrack
05b	131	12		8.0	372832.48	6501431.47	Wrack
05b	137	12		8.1	372827.71	6501433.26	Wrack
05b	144	8		8.2	372821.32	6501438.72	Bare sand
05b	153	8		8.2	372814.97	6501440.49	Bare sand
05b	161	8		8.2	372805.42	6501445.92	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
06b	20	8		4.1	373012.98	6500766.63	Bare sand
06b	28	8		4.1	373009.74	6500772.14	Bare sand
06b	38	8		4.1	373004.96	6500775.77	Bare sand
06b	41	2		3.9	373004.96	6500775.77	Amphibolis sp.
06b	43	8		3.8	373004.96	6500775.77	Bare sand
06b	50	8		4.1	372996.94	6500784.92	Bare sand
06b	56	2	seedlings	4.0	372993.69	6500792.27	Amphibolis sp.
06b	58	12		3.7	372992.11	6500792.25	Wrack
06b	60	5	Posidonia sp. & Amphibious sp.	3.6	372990.50	6500794.08	Mixed seagrass species
06b	62	3		3.8	372990.48	6500795.92	Heterozostera tasmanica
06b	64	2		3.4	372988.88	6500797.75	Amphibolis sp.
06b	68	2		3.7	372985.67	6500801.41	Amphibolis sp.
06b	73	3		3.5	372980.86	6500806.89	Heterozostera tasmanica
06b	74	2		3.4	372980.86	6500806.89	Amphibolis sp.
06b	80	2		3.6	372976.05	6500812.38	Amphibolis sp.
06b	88	2		3.7	372971.24	6500817.86	Amphibolis sp.
06b	94	2		3.7	372966.43	6500823.35	Amphibolis sp.
06b	101	2	edge of seagrass bed (border with sand)	3.7	372961.57	6500832.52	Amphibolis sp.
06b	104	2		3.9	372959.97	6500834.35	Amphibolis sp.
06b	107	8		4.1	372956.76	6500838.01	Bare sand
06b	108	8		4.1	372956.76	6500838.01	Bare sand
06b	110	2		4.1	372955.16	6500839.84	Amphibolis sp.
06b	117	1	Posidonia sp.? or Heterozostera	4.8	372950.31	6500849.02	Posidonia sp.
06b	118	8		4.9	372950.31	6500849.02	Bare sand
06b	122	8		5.2	372947.09	6500852.67	Bare sand
06b	131	8		5.3	372940.68	6500859.98	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
07b	17	8		4.6	372556.46	6500860.81	Bare sand
07b	25	8		4.3	372553.27	6500862.62	Bare sand
07b	34	8		4.1	372543.71	6500868.04	Bare sand
07b	43	11		3.8	372537.33	6500873.51	Low relief reef with sand veneer
07b	47	6		3.5	372535.70	6500877.18	Amphibolis sp. & algae/reef
07b	55	6		3.3	372530.89	6500882.67	Amphibolis sp. & algae/reef
07b	61	6		2.8	372527.64	6500890.02	Amphibolis sp. & algae/reef
07b	65	11		2.4	372524.45	6500891.83	Low relief reef with sand veneer
07b	70	10		2.7	372521.20	6500899.18	Reef
07b	77	10		2.7	372517.97	6500904.68	Reef
07b	85	10		2.8	372514.69	6500913.88	Reef
07b	93	9	archway	3.3	372508.26	6500923.04	High relief reef (with overhangs/kelp)
07b	99	9		3.1	372503.45	6500928.53	High relief reef (with overhangs/kelp)
07b	103	9	deep gullies, verticle surfaces	2.9	372498.66	6500932.16	High relief reef (with overhangs/kelp)
07b	110	9	arches and walls	4.2	372489.10	6500937.59	High relief reef (with overhangs/kelp)
07b	118	10		6.0	372481.12	6500943.03	Reef
07b	125	11		5.5	372473.18	6500946.63	Low relief reef with sand veneer
07b	131	8		6.7	372466.81	6500950.25	Bare sand
07b	139	11		6.5	372458.88	6500952.00	Low relief reef with sand veneer
07b	143	11		6.3	372454.14	6500951.94	Low relief reef with sand veneer
07b	152	11		6.0	372443.07	6500951.80	Low relief reef with sand veneer
07b	156	6		6.1	372439.93	6500949.92	Amphibolis sp. & algae/reef
07b	162	6		6.0	372435.19	6500949.86	Amphibolis sp. & algae/reef
07b	167	11		6.3	372432.05	6500947.97	Low relief reef with sand veneer
07b	172	11		6.2	372425.75	6500946.05	Low relief reef with sand veneer
07b	178	6		5.8	372419.47	6500942.27	Amphibolis sp. & algae/reef
07b	181	2		0.0	372417.92	6500940.41	Amphibolis sp.
07b	185	2		0.0	372413.20	6500938.50	Amphibolis sp.
07b	190	2		5.8	372406.92	6500934.73	Amphibolis sp.
07b	195	8		5.0	372403.78	6500932.84	Bare sand
07b	196	2		6.0	372402.20	6500932.82	Amphibolis sp.
07b	200	6		5.7	372399.08	6500929.09	Amphibolis sp. & algae/reef
07b	205	2		6.0	372394.36	6500927.18	Amphibolis sp.
07b	213	2		5.0	372388.08	6500923.41	Amphibolis sp.
07b	219	2		5.9	372381.80	6500919.64	Amphibolis sp.
07b	225	8		6.0	372377.10	6500915.88	Bare sand
07b	234	8		6.4	372370.88	6500908.42	Bare sand
07b	243	8		6.0	372364.62	6500902.80	Bare sand
07b	250	8		6.4	372358.36	6500897.18	Bare sand
07b	261	8		6.5	372352.13	6500889.71	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
07b	269	12		7.0	372347.48	6500882.26	Wrack
07b	277	8		6.9	372341.22	6500876.64	Bare sand
07b	282	12		6.9	372339.68	6500872.92	Wrack
07b	290	8		7.0	372330.27	6500867.26	Bare sand
07b	298	8		7.3	372325.59	6500861.66	Bare sand
07b	306	8		7.6	372314.60	6500855.98	Bare sand
07b	316	8		7.4	372305.18	6500850.33	Bare sand
07b	325	8		7.8	372295.77	6500844.67	Bare sand
07b	334	8		7.9	372287.90	6500840.87	Bare sand
07b	338	11		8.0	372283.18	6500838.97	Low relief reef with sand veneer
07b	344	11		7.6	372280.05	6500837.08	Low relief reef with sand veneer
07b	348	6		6.9	372272.17	6500835.14	Amphibolis sp. & algae/reef
07b	354	6		6.4	372265.89	6500831.36	Amphibolis sp. & algae/reef
07b	360	6		6.8	372261.17	6500829.46	Amphibolis sp. & algae/reef
07b	370	6		7.1	372247.01	6500823.74	Amphibolis sp. & algae/reef
07b	375	9		6.8	372243.87	6500821.85	High relief reef (with overhangs/kelp)
07b	379	10		6.6	372235.98	6500819.91	Reef
07b	385	10		6.4	372229.69	6500817.98	Reef
07b	394	10		6.9	372218.64	6500816.00	Reef
07b	401	10		6.9	372209.13	6500817.73	Reef
07b	411	9		6.7	372198.06	6500817.59	High relief reef (with overhangs/kelp)
07b	423	10		7.2	372185.44	6500815.59	Reef
07b	425	6		6.7	372182.28	6500815.55	Amphibolis sp. & algae/reef
07b	431	10		7.2	372177.56	6500813.64	Reef
07b	435	6		0.0	372174.39	6500813.61	Amphibolis sp. & algae/reef
07b	438	6		7.7	372174.39	6500813.61	Amphibolis sp. & algae/reef
07b	445	10		7.2	372166.54	6500809.81	Reef
07b	452	10		7.2	372163.38	6500809.77	Reef
07b	459	10		7.9	372155.49	6500807.83	Reef
07b	470	10		8.0	372146.03	6500805.86	Reef
07b	480	10		7.9	372138.15	6500803.92	Reef
07b	490	10		8.0	372131.85	6500801.99	Reef
07b	500	10		8.1	372125.58	6500798.22	Reef
07b	506	6		8.0	372120.88	6500794.47	Amphibolis sp. & algae/reef
07b	519	6		8.2	372114.60	6500790.69	Amphibolis sp. & algae/reef
07b	525	6		8.0	372109.90	6500786.94	Amphibolis sp. & algae/reef
07b	533	6		8.1	372105.18	6500785.04	Amphibolis sp. & algae/reef
07b	542	10		8.2	372102.04	6500783.15	Reef
07b	551	10		8.1	372094.18	6500779.36	Reef
07b	562	10		8.2	372086.35	6500773.72	Reef
07b	571	10		7.6	372081.65	6500769.96	Reef
07b	583	10		7.4	372073.84	6500762.47	Reef
07b	595	10		7.0	372065.97	6500758.68	Reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
07b	620	10		6.0	372045.54	6500749.19	Reef
07b	632	10		6.0	372034.52	6500745.36	Reef
07b	642	10		5.8	372025.03	6500745.24	Reef
07b	654	10		7.3	372012.41	6500743.24	Reef
07b	656	9	overhang	6.5	372012.41	6500743.24	High relief reef (with overhangs/kelp)
07b	664	9		7.6	372001.39	6500739.41	High relief reef (with overhangs/kelp)
07b	672	9		8.0	371991.95	6500735.59	High relief reef (with overhangs/kelp)
07b	685	10		7.8	371977.81	6500728.03	Reef
07b	695	10		8.2	371966.79	6500724.20	Reef
07b	702	10		8.3	371960.49	6500722.27	Reef
07b	712	8		8.5	371952.63	6500718.48	Bare sand
07b	715	11		8.7	371949.49	6500716.59	Low relief reef with sand veneer
07b	721	11		8.3	371943.19	6500714.67	Low relief reef with sand veneer
07b	725	8		8.6	371938.47	6500712.76	Bare sand
07b	737	8		8.0	371927.43	6500710.78	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
08b	15	8		6.7	372066.07	6500366.95	Bare sand
08b	17	10		6.6	372064.49	6500366.93	Reef
08b	22	10		6.3	372061.30	6500368.74	Reef
08b	29	10		6.4	372056.51	6500372.38	Reef
08b	35	10		6.7	372051.75	6500374.17	Reef
08b	45	10		6.6	372042.22	6500377.75	Reef
08b	49	11		7.6	372040.62	6500379.57	Low relief reef with sand veneer
08b	61	10		6.5	372031.11	6500381.30	Reef
08b	72	6		5.5	372019.98	6500386.71	Amphibolis sp. & algae/reef
08b	81	6		5.2	372012.05	6500388.46	Amphibolis sp. & algae/reef
08b	87	6		4.8	372007.29	6500390.25	Amphibolis sp. & algae/reef
08b	95	6		0.0	371999.35	6500392.00	Amphibolis sp. & algae/reef
08b	102	6		5.3	371993.01	6500393.77	Amphibolis sp. & algae/reef
08b	108	10		5.6	371986.69	6500393.69	Reef
08b	116	9		5.9	371978.72	6500399.14	High relief reef (with overhangs/kelp)
08b	123	9		6.1	371972.34	6500402.75	High relief reef (with overhangs/kelp)
08b	126	8		6.8	371969.16	6500404.56	Bare sand
08b	135	9		5.8	371959.68	6500404.44	High relief reef (with overhangs/kelp)
08b	140	10		5.9	371950.19	6500404.33	Reef
08b	146	6		5.8	371943.89	6500402.40	Amphibolis sp. & algae/reef
08b	156	10		5.8	371932.84	6500400.42	Reef
08b	164	10		6.4	371920.25	6500396.56	Reef
08b	174	9		6.4	371907.63	6500394.56	High relief reef (with overhangs/kelp)
08b	182	9		7.0	371898.14	6500394.44	High relief reef (with overhangs/kelp)
08b	191	10		7.0	371885.51	6500392.44	Reef
08b	195	6		7.1	371879.19	6500392.36	Amphibolis sp. & algae/reef
08b	199	11		7.3	371874.45	6500392.30	Low relief reef with sand veneer
08b	209	11		7.3	371863.38	6500392.17	Low relief reef with sand veneer
08b	215	11		7.7	371858.64	6500392.11	Low relief reef with sand veneer
08b	216	8		0.0	371858.64	6500392.11	Bare sand
08b	223	8		7.8	371853.87	6500393.90	Bare sand
08b	231	8		8.2	371845.95	6500395.65	Bare sand
08b	239	8		8.3	371836.46	6500395.53	Bare sand
08b	247	8		8.4	371826.96	6500397.26	Bare sand
08b	255	8		8.9	371819.02	6500399.01	Bare sand
08b	274	8		9.1	371796.89	6500398.74	Bare sand
08b	286	8		10.2	371781.11	6500396.69	Bare sand
08b	290	11		9.9	371776.36	6500396.63	Low relief reef with sand veneer
08b	297	10		9.3	371766.90	6500394.67	Reef
08b	302	13		9.1	371762.14	6500396.46	Thalassodendron pachyrhizum

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
08b	309	10		8.6	371752.67	6500394.49	Reef
08b	322	6		8.6	371739.98	6500398.03	Amphibolis sp. & algae/reef
08b	332	6		8.6	371733.66	6500397.95	Amphibolis sp. & algae/reef
08b	338	6		8.8	371727.34	6500397.87	Amphibolis sp. & algae/reef
08b	349	6		8.7	371720.99	6500399.64	Amphibolis sp. & algae/reef
08b	359	6		8.7	371711.48	6500401.37	Amphibolis sp. & algae/reef
08b	367	10		9.3	371705.13	6500403.14	Reef
08b	378	10		9.6	371697.23	6500403.04	Reef
08b	391	10		9.9	371686.21	6500399.21	Reef
08b	399	10		10.4	371679.89	6500399.13	Reef
08b	408	10		10.6	371671.98	6500399.04	Reef
08b	423	10		10.4	371659.38	6500395.18	Reef
08b	427	13		10.5	371656.23	6500395.15	Thalassodendron pachyrhizum
08b	431	13		10.8	371649.92	6500393.22	Thalassodendron pachyrhizum
08b	435	13		10.5	371645.20	6500391.31	Thalassodendron pachyrhizum
08b	442	9		10.7	371642.04	6500391.27	High relief reef (with overhangs/kelp)
08b	451	9		11.6	371631.02	6500387.44	High relief reef (with overhangs/kelp)
08b	454	8		11.6	371627.86	6500387.40	Bare sand
08b	461	8		11.4	371623.14	6500385.50	Bare sand
08b	463	8		11.5	371621.56	6500385.48	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
09b	35	8		12.2	371457.71	6500339.10	Bare sand
09b	45	8		12.5	371449.79	6500339.00	Bare sand
09b	54	8		12.5	371441.89	6500338.90	Bare sand
09b	62	11		12.1	371435.59	6500336.98	Low relief reef with sand veneer
09b	70	11		12.1	371429.27	6500336.90	Low relief reef with sand veneer
09b	78	11		12.8	371421.39	6500334.95	Low relief reef with sand veneer
09b	92	11		11.9	371411.95	6500331.14	Low relief reef with sand veneer
09b	99	11		11.9	371407.18	6500332.93	Low relief reef with sand veneer
09b	107	11		12.2	371400.89	6500331.00	Low relief reef with sand veneer
09b	116	11		11.5	371396.14	6500330.94	Low relief reef with sand veneer
09b	122	11		12.3	371388.23	6500330.85	Low relief reef with sand veneer
09b	128	8		11.9	371381.92	6500330.77	Bare sand
09b	135	8		11.8	371377.15	6500332.56	Bare sand
09b	145	8		11.9	371367.67	6500332.44	Bare sand
09b	155	8		12.0	371359.73	6500334.19	Bare sand
09b	160	11		11.9	371356.55	6500336.00	Low relief reef with sand veneer
09b	165	11		11.6	371351.83	6500334.09	Low relief reef with sand veneer
09b	172	11		11.4	371345.48	6500335.86	Low relief reef with sand veneer
09b	181	11		11.6	371334.47	6500332.03	Low relief reef with sand veneer
09b	190	11		10.3	371326.58	6500330.08	Low relief reef with sand veneer
09b	194	11		10.4	371323.45	6500328.19	Low relief reef with sand veneer
09b	198	9		10.5	371318.70	6500328.13	High relief reef (with overhangs/kelp)
09b	203	9		9.9	371313.94	6500329.92	High relief reef (with overhangs/kelp)
09b	207	9	large reef blocks and sand gullies	10.5	371310.78	6500329.88	High relief reef (with overhangs/kelp)
09b	215	9		10.6	371304.45	6500329.81	High relief reef (with overhangs/kelp)
09b	222	9		10.1	371298.13	6500329.73	High relief reef (with overhangs/kelp)
09b	225	8		10.0	371294.95	6500331.54	Bare sand
09b	228	9		10.2	371293.36	6500331.52	High relief reef (with overhangs/kelp)
09b	236	9		9.4	371285.46	6500331.42	High relief reef (with overhangs/kelp)
09b	245	9		8.8	371279.09	6500335.03	High relief reef (with overhangs/kelp)
09b	252	9		9.2	371274.32	6500336.82	High relief reef (with overhangs/kelp)
09b	258	9		9.1	371269.58	6500336.76	High relief reef (with overhangs/kelp)
09b	272	9		8.5	371260.07	6500338.49	High relief reef (with overhangs/kelp)
09b	282	9		8.6	371250.56	6500340.22	High relief reef (with overhangs/kelp)
09b	290	9		8.7	371244.25	6500340.14	High relief reef (with overhangs/kelp)
09b	303	9		8.7	371231.55	6500343.68	High relief reef (with overhangs/kelp)

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
09b	312	9		8.8	371225.21	6500345.45	High relief reef (with overhangs/kelp)
09b	323	9		8.7	371214.12	6500347.16	High relief reef (with overhangs/kelp)
09b	332	9		8.5	371207.79	6500347.08	High relief reef (with overhangs/kelp)
09b	342	9		8.2	371199.84	6500350.68	High relief reef (with overhangs/kelp)
09b	356	9		8.5	371187.20	6500350.52	High relief reef (with overhangs/kelp)
09b	370	9		8.2	371174.52	6500352.21	High relief reef (with overhangs/kelp)
09b	385	9		8.3	371161.86	6500353.90	High relief reef (with overhangs/kelp)
09b	399	9		7.8	371150.76	6500355.61	High relief reef (with overhangs/kelp)
09b	413	9		8.8	371141.23	6500359.19	High relief reef (with overhangs/kelp)

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
10b	17	8		8.2	370978.04	6500006.08	Bare sand
10b	27	8		8.5	370970.16	6500004.13	Bare sand
10b	34	8		8.1	370965.41	6500004.07	Bare sand
10b	38	11		8.1	370962.25	6500004.03	Low relief reef with sand veneer
10b	42	6		8.0	370959.10	6500003.99	Amphibolis sp. & algae/reef
10b	50	10		7.3	370954.38	6500002.09	Reef
10b	64	10		7.2	370941.75	6500000.08	Reef
10b	74	10		7.5	370932.29	6499998.12	Reef
10b	83	6		7.7	370925.97	6499998.04	Amphibolis sp. & algae/reef
10b	91	6		0.0	370921.25	6499996.13	Amphibolis sp. & algae/reef
10b	103	6		5.7	370911.77	6499996.01	Amphibolis sp. & algae/reef
10b	117	11		6.6	370900.72	6499994.03	Low relief reef with sand veneer
10b	129	11		6.9	370891.26	6499992.06	Low relief reef with sand veneer
10b	143	10		7.2	370880.17	6499993.77	Reef
10b	149	6		6.8	370875.42	6499993.71	Amphibolis sp. & algae/reef
10b	156	10		7.4	370869.13	6499991.79	Reef
10b	160	10		7.3	370865.96	6499991.75	Reef
10b	164	10		7.5	370864.39	6499991.73	Reef
10b	166	8		0.0	370862.80	6499991.71	Bare sand
10b	170	8		8.8	370858.06	6499991.65	Bare sand
10b	182	8		8.9	370850.16	6499991.55	Bare sand
10b	190	8		8.7	370842.25	6499991.45	Bare sand
10b	199	11		8.6	370835.93	6499991.37	Low relief reef with sand veneer
10b	207	2		8.0	370831.19	6499991.31	Amphibolis sp.
10b	215	2		7.5	370823.30	6499989.37	Amphibolis sp.
10b	223	2		7.6	370816.99	6499989.29	Amphibolis sp.
10b	233	2		7.0	370807.53	6499987.32	Amphibolis sp.
10b	242	2		6.9	370801.22	6499985.40	Amphibolis sp.
10b	248	2		7.5	370796.48	6499985.34	Amphibolis sp.
10b	251	8		7.5	370793.32	6499985.30	Bare sand
10b	257	2		7.5	370787.00	6499985.22	Amphibolis sp.
10b	259	8		7.5	370785.43	6499983.35	Bare sand
10b	264	6		8.0	370780.67	6499985.14	Amphibolis sp. & algae/reef
10b	267	8		8.2	370779.07	6499986.97	Bare sand
10b	272	6		8.0	370774.35	6499985.06	Amphibolis sp. & algae/reef
10b	273	8		8.0	370774.35	6499985.06	Bare sand
10b	282	2		8.0	370768.03	6499984.98	Amphibolis sp.
10b	292	8		8.4	370760.15	6499983.04	Bare sand
10b	298	2		9.1	370753.82	6499982.96	Amphibolis sp.
10b	304	8		8.7	370750.66	6499982.92	Bare sand
10b	310	8		8.8	370745.92	6499982.86	Bare sand
10b	316	9		8.4	370741.20	6499980.95	High relief reef (with overhangs/kelp)
10b	326	6		8.1	370733.34	6499977.16	Amphibolis sp. &

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
							algae/reef
10b	333	6		8.6	370728.60	6499977.10	Amphibolis sp. & algae/reef
10b	347	10		8.0	370717.58	6499973.27	Reef
10b	356	10		9.6	370709.70	6499971.32	Reef
10b	363	10		9.5	370704.93	6499973.11	Reef
10b	373	10		9.0	370697.01	6499974.86	Reef
10b	381	10		9.6	370690.66	6499976.63	Reef
10b	393	10		9.0	370682.73	6499978.38	Reef
10b	396	9		9.1	370679.57	6499978.34	High relief reef (with overhangs/kelp)
10b	408	10		9.9	370671.62	6499981.93	Reef
10b	422	10		9.8	370658.91	6499987.32	Reef
10b	434	9		10.3	370649.38	6499990.89	High relief reef (with overhangs/kelp)
10b	440	8		11.2	370644.61	6499992.68	Bare sand
10b	479	8		11.3	370612.86	6500003.37	Bare sand
10b	485	9		9.8	370606.51	6500005.14	High relief reef (with overhangs/kelp)
10b	495	9	verticle wall & banded sweep	10.3	370598.56	6500008.74	High relief reef (with overhangs/kelp)
10b	500	9		10.6	370596.96	6500010.56	High relief reef (with overhangs/kelp)
10b	509	9		11.0	370590.58	6500014.18	High relief reef (with overhangs/kelp)
10b	519	10		11.1	370582.64	6500017.78	Reef
10b	527	9		11.1	370577.87	6500019.56	High relief reef (with overhangs/kelp)
10b	534	11		12.6	370573.08	6500023.20	Low relief reef with sand veneer
10b	540	8		12.6	370568.34	6500023.14	Bare sand
10b	547	8		12.5	370563.57	6500024.93	Bare sand
10b	556	8		12.9	370555.63	6500028.53	Bare sand
10b	574	8		12.8	370542.93	6500032.06	Bare sand
10b	591	8		13.0	370533.40	6500035.64	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
11b	68	8		9.1	372726.26	6501324.84	Bare sand
11b	72	12		9.0	372721.52	6501324.78	Wrack
11b	76	2		9.0	372719.94	6501324.76	Amphibolis sp.
11b	82	2		8.9	372715.19	6501324.70	Amphibolis sp.
11b	84	8		8.9	372713.61	6501324.68	Bare sand
11b	87	2		9.0	372708.89	6501322.78	Amphibolis sp.
11b	90	8		9.2	372707.32	6501322.76	Bare sand
11b	98	8		9.2	372699.40	6501322.66	Bare sand
11b	106	2		9.3	372693.11	6501320.74	Amphibolis sp.
11b	109	8		9.2	372689.94	6501320.70	Bare sand
11b	119	8		9.1	372682.09	6501316.91	Bare sand
11b	127	8		9.0	372675.80	6501313.13	Bare sand
11b	135	8		8.9	372667.92	6501311.19	Bare sand
11b	149	8		8.9	372656.95	6501303.66	Bare sand
11b	157	8		8.5	372650.72	6501296.20	Bare sand
11b	165	2		8.4	372646.04	6501290.59	Amphibolis sp.
11b	171	2		8.3	372642.90	6501288.71	Amphibolis sp.
11b	177	2	Amphibolis Griffithii	8.1	372636.60	6501286.78	Amphibolis sp.
11b	187	2		7.6	372631.88	6501284.88	Amphibolis sp.
11b	191	2	patch Posidonia sp.	7.5	372627.19	6501281.12	Amphibolis sp.
11b	193	10		7.4	372625.60	6501281.10	Reef
11b	197	2		7.0	372622.47	6501279.22	Amphibolis sp.
11b	208	2		7.2	372613.03	6501275.41	Amphibolis sp.
11b	214	10	patch Posidonia sp.	6.9	372608.30	6501273.50	Reef
11b	216	10	patch Posidonia sp.	7.3	372606.74	6501271.63	Reef
11b	218	2		7.2	372606.74	6501271.63	Amphibolis sp.
11b	224	2		7.1	372600.44	6501269.71	Amphibolis sp.
11b	225	6		7.2	372600.44	6501269.71	Amphibolis sp. & algae/reef
11b	238	2		6.7	372589.45	6501264.03	Amphibolis sp.
11b	248	2		6.9	372583.19	6501258.41	Amphibolis sp.
11b	257	6		6.8	372576.93	6501252.79	Amphibolis sp. & algae/reef
11b	261	1		6.0	372575.38	6501250.92	Posidonia sp.
11b	262	1		6.0	372575.38	6501250.92	Posidonia sp.
11b	263	1		6.7	372573.82	6501249.06	Posidonia sp.
11b	267	10		6.6	372569.10	6501247.15	Reef
11b	274	1		6.5	372565.96	6501245.26	Posidonia sp.
11b	276	5	Amphibious & Posidonia sp.	6.4	372564.40	6501243.40	Mixed seagrass species
11b	279	6		6.9	372561.26	6501241.51	Amphibolis sp. & algae/reef
11b	284	6		6.5	372559.70	6501239.64	Amphibolis sp. & algae/reef
11b	292	6		6.7	372551.87	6501234.00	Amphibolis sp. & algae/reef
11b	301	6		6.5	372545.59	6501230.23	Amphibolis sp. & algae/reef
11b	310	6		6.4	372537.73	6501226.44	Amphibolis sp. & algae/reef
11b	322	2		6.5	372529.89	6501220.80	Amphibolis sp.
11b	324	6		6.6	372526.73	6501220.76	Amphibolis sp. & algae/reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
11b	334	6	patch Posidonia sp.	6.6	372520.47	6501215.14	Amphibolis sp. & algae/reef
11b	341	6		6.3	372515.79	6501209.54	Amphibolis sp. & algae/reef
11b	347	6		6.3	372514.24	6501207.67	Amphibolis sp. & algae/reef
11b	358	10		6.5	372508.01	6501200.20	Reef
11b	369	6		6.4	372501.77	6501192.74	Amphibolis sp. & algae/reef
11b	377	10		6.4	372497.07	6501188.98	Reef
11b	386	10		7.0	372492.40	6501183.38	Reef
11b	393	6	A. Griffithii	7.0	372487.70	6501179.63	Amphibolis sp. & algae/reef
11b	399	10		6.9	372483.00	6501175.88	Reef
11b	407	6	A. Antartica	7.2	372476.73	6501172.10	Amphibolis sp. & algae/reef
11b	411	6	A.Griffithi	7.2	372473.59	6501170.22	Amphibolis sp. & algae/reef
11b	423	6		7.4	372467.31	6501166.44	Amphibolis sp. & algae/reef
11b	431	6		7.3	372461.03	6501162.67	Amphibolis sp. & algae/reef
11b	442	6		7.1	372451.61	6501157.01	Amphibolis sp. & algae/reef
11b	451	6		7.6	372446.92	6501153.26	Amphibolis sp. & algae/reef
11b	462	6		7.5	372439.08	6501147.62	Amphibolis sp. & algae/reef
11b	470	11		7.4	372432.80	6501143.85	Low relief reef with sand veneer
11b	481	11		7.2	372428.13	6501138.25	Low relief reef with sand veneer
11b	490	11		7.1	372420.29	6501132.61	Low relief reef with sand veneer
11b	494	6		7.3	372417.15	6501130.72	Amphibolis sp. & algae/reef
11b	502	2		7.1	372410.90	6501125.10	Amphibolis sp.
11b	508	6		7.3	372407.75	6501123.21	Amphibolis sp. & algae/reef
11b	513	6		7.3	372401.48	6501119.44	Amphibolis sp. & algae/reef
11b	519	8		7.3	372396.78	6501115.69	Bare sand
11b	521	11		7.4	372395.20	6501115.67	Low relief reef with sand veneer
11b	525	8		7.6	372390.48	6501113.76	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
12b	23	8		8.6	372721.48	6501199.13	Bare sand
12b	30	8		8.8	372716.74	6501199.07	Bare sand
12b	36	8		8.8	372708.86	6501197.13	Bare sand
12b	39	5	Amphibous, Heterozostera	8.9	372708.86	6501197.13	Mixed seagrass species
12b	49	5		8.8	372702.58	6501193.36	Mixed seagrass species
12b	57	6		8.7	372696.30	6501189.58	Amphibolis sp. & algae/reef
12b	62	10		8.6	372690.02	6501185.81	Reef
12b	66	10		8.4	372688.48	6501182.10	Reef
12b	72	10		8.7	372683.76	6501180.19	Reef
12b	74	6		8.4	372682.20	6501178.32	Amphibolis sp. & algae/reef
12b	82	10		8.2	372677.51	6501174.57	Reef
12b	84	6		8.3	372677.53	6501172.72	Amphibolis sp. & algae/reef
12b	90	10		8.0	372672.81	6501170.82	Reef
12b	94	6	Amphibous Griffithii	8.2	372669.67	6501168.93	Amphibolis sp. & algae/reef
12b	99	6	Amphibous Griffithii	7.9	372668.11	6501167.06	Amphibolis sp. & algae/reef
12b	103	6	Amphibous Antartica	7.6	372661.82	6501165.14	Amphibolis sp. & algae/reef
12b	108	6	Amphibous Griffithii	7.7	372658.67	6501163.25	Amphibolis sp. & algae/reef
12b	115	6		7.6	372653.97	6501159.50	Amphibolis sp. & algae/reef
12b	121	6		7.2	372652.44	6501155.79	Amphibolis sp. & algae/reef
12b	128	6		7.1	372647.75	6501152.03	Amphibolis sp. & algae/reef
12b	137	6		6.7	372639.90	6501146.39	Amphibolis sp. & algae/reef
12b	139	9	overhang	6.9	372639.90	6501146.39	High relief reef (with overhangs/kelp)
12b	144	6		6.8	372635.21	6501142.64	Amphibolis sp. & algae/reef
12b	151	6		6.7	372630.51	6501138.89	Amphibolis sp. & algae/reef
12b	161	6	Amphibous Antartica	6.6	372621.09	6501133.23	Amphibolis sp. & algae/reef
12b	171	6		6.8	372614.84	6501127.61	Amphibolis sp. & algae/reef
12b	173	5	patch Posidonia sp.	6.8	372613.26	6501127.59	Mixed seagrass species
12b	183	10		6.0	372606.98	6501123.82	Reef
12b	190	9		7.7	372599.12	6501120.02	High relief reef (with overhangs/kelp)
12b	198	10		7.5	372591.26	6501116.23	Reef
12b	206	10		7.4	372584.98	6501112.46	Reef
12b	216	10		7.7	372573.96	6501108.63	Reef
12b	222	9		8.0	372570.82	6501106.74	High relief reef (with overhangs/kelp)
12b	234	10		8.0	372559.82	6501101.06	Reef
12b	240	10		7.6	372555.10	6501099.16	Reef
12b	249	10		7.7	372547.27	6501093.52	Reef
12b	258	10		7.6	372539.41	6501089.72	Reef
12b	269	10	sand patches	7.1	372528.41	6501084.05	Reef
12b	277	6		7.0	372520.55	6501080.25	Amphibolis sp. & algae/reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
12b	287	10		6.8	372512.66	6501078.31	Reef
12b	296	6		6.4	372506.39	6501074.54	Amphibolis sp. & algae/reef
12b	305	3	??	6.4	372496.95	6501070.72	Heterozostera tasmanica
12b	306	8		6.6	372495.37	6501070.70	Bare sand
12b	312	8		5.6	372490.67	6501066.95	Bare sand
12b	315	9	overhang	5.9	372489.09	6501066.93	High relief reef (with overhangs/kelp)
12b	320	9		5.8	372485.97	6501063.20	High relief reef (with overhangs/kelp)
12b	327	9		5.9	372481.28	6501059.44	High relief reef (with overhangs/kelp)
12b	332	9		6.3	372474.99	6501055.67	High relief reef (with overhangs/kelp)
12b	333	8		6.6	372474.99	6501055.67	Bare sand
12b	340	8		6.5	372470.32	6501050.07	Bare sand
12b	347	8	some Amphibous sp.	6.4	372464.09	6501042.60	Bare sand
12b	356	8	some Amphibous sp.	6.5	372460.99	6501037.02	Bare sand
12b	362	8		6.4	372456.30	6501033.27	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
13b	117	8		4.5	373049.90	6500850.24	Bare sand
13b	125	8		4.6	373045.16	6500850.18	Bare sand
13b	137	8		4.8	373035.70	6500848.21	Bare sand
13b	142	5	Amphibous, Heterozostera	4.5	373034.14	6500846.35	Mixed seagrass species
13b	148	2		4.2	373029.39	6500846.29	Amphibolis sp.
13b	149	1		4.2	373029.39	6500846.29	Posidonia sp.
13b	155	1		4.0	373026.26	6500844.40	Posidonia sp.
13b	160	1		4.2	373024.70	6500842.54	Posidonia sp.
13b	170	1	some Caulerpa Distichophylla	4.9	373018.39	6500840.61	Posidonia sp.
13b	178	1		5.0	373015.26	6500838.73	Posidonia sp.
13b	184	1		4.9	373008.93	6500838.65	Posidonia sp.
13b	189	2	Amphibous Griffithii	4.8	373007.38	6500836.78	Amphibolis sp.
13b	192	1		4.8	373004.21	6500836.74	Posidonia sp.
13b	196	2	Amphibous Griffithii	5.0	373002.63	6500836.72	Amphibolis sp.
13b	202	2	Amphibous Antartica	4.9	372997.91	6500834.82	Amphibolis sp.
13b	206	2	Caulerpa Distichophylla	5.0	372996.33	6500834.80	Amphibolis sp.
13b	211	1		5.4	372991.59	6500834.74	Posidonia sp.
13b	214	3	Caulerpa Distichophylla	5.2	372991.59	6500834.74	Heterozostera tasmanica
13b	220	3		5.3	372988.43	6500834.70	Heterozostera tasmanica
13b	225	2		5.0	372985.26	6500834.66	Amphibolis sp.
13b	230	3		5.3	372983.69	6500834.64	Heterozostera tasmanica
13b	238	1	also dense Caulerpa Cactoides	4.9	372980.54	6500832.76	Posidonia sp.
13b	243	2	Antartica Griffithii	4.5	372977.40	6500830.87	Amphibolis sp.
13b	252	2	Antartica Griffithii	4.5	372974.25	6500830.83	Amphibolis sp.
13b	264	2	Antartica Griffithii	4.4	372966.33	6500830.73	Amphibolis sp.
13b	277	2	Antartica Griffithii	4.2	372959.99	6500832.50	Amphibolis sp.
13b	281	5	Amphibous & Posidonia	4.1	372956.83	6500832.47	Mixed seagrass species
13b	285	2		4.2	372956.83	6500832.47	Amphibolis sp.
13b	289	3		4.4	372953.67	6500832.43	Heterozostera tasmanica
13b	293	3		4.5	372952.08	6500832.41	Heterozostera tasmanica
13b	297	8		5.0	372948.93	6500832.37	Bare sand
13b	301	8		5.0	372947.32	6500834.20	Bare sand
13b	304	5	Heterzozostera & H. Ovalis	5.0	372947.32	6500834.20	Mixed seagrass species
13b	305	8		5.0	372944.16	6500834.16	Bare sand
13b	309	4		5.1	372942.55	6500835.99	Halophila ovalis
13b	311	5	Heterzozostera & H. Ovalis	5.1	372942.55	6500835.99	Mixed seagrass species
13b	313	3		5.1	372940.98	6500835.97	Heterozostera tasmanica
13b	315	8		5.1	372939.39	6500835.95	Bare sand
13b	322	8		5.3	372936.21	6500837.76	Bare sand
13b	331	8		5.3	372929.86	6500839.53	Bare sand
13b	333	3		4.7	372929.86	6500839.53	Heterozostera tasmanica
13b	334	3		5.0	372926.71	6500839.49	Heterozostera tasmanica
13b	335	8		5.0	372926.71	6500839.49	Bare sand
13b	341	8		5.3	372923.56	6500837.60	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
13b	350	8		5.2	372917.29	6500833.83	Bare sand
13b	356	8		5.3	372914.14	6500831.94	Bare sand
13b	364	8		5.1	372907.85	6500830.02	Bare sand
13b	371	8		5.4	372904.70	6500828.13	Bare sand
13b	380	8		5.4	372896.85	6500824.34	Bare sand
13b	390	8		5.3	372890.52	6500824.26	Bare sand
13b	400	8		5.2	372884.25	6500820.49	Bare sand
13b	415	8		5.2	372873.25	6500814.81	Bare sand
13b	432	8		5.1	372860.69	6500807.27	Bare sand
13b	445	12		5.0	372849.69	6500801.59	Wrack
13b	446	8		5.0	372849.69	6500801.59	Bare sand
13b	468	8		4.6	372826.07	6500793.91	Bare sand
13b	470	5	Heterzozostera & H. Ovalis	4.6	372822.93	6500792.02	Mixed seagrass species
13b	475	1		4.7	372816.61	6500791.94	Posidonia sp.
13b	476	8		4.3	372816.61	6500791.94	Bare sand
13b	479	1	and Heterozostera	4.4	372811.86	6500791.88	Posidonia sp.
13b	481	8		4.5	372811.86	6500791.88	Bare sand
13b	489	8		4.7	372802.31	6500797.31	Bare sand
13b	495	8		4.6	372799.08	6500802.81	Bare sand
13b	501	8		4.6	372797.45	6500806.49	Bare sand
13b	503	3		4.8	372795.85	6500808.32	Heterozostera tasmanica
13b	507	5	Heterzozostera & H. Ovalis (20% cover)	4.7	372794.23	6500811.99	Mixed seagrass species
13b	511	5	Heterzozostera & H. Ovalis (30% cover)	4.7	372792.62	6500813.82	Mixed seagrass species
13b	515	4		4.9	372792.57	6500817.52	Halophila ovalis
13b	519	8		5.3	372790.95	6500821.19	Bare sand
13b	521	12		5.2	372790.92	6500823.04	Wrack
13b	525	8		5.0	372789.30	6500826.72	Bare sand
13b	527	5	Heterzozostera & H. Ovalis	5.0	372789.28	6500828.56	Mixed seagrass species
13b	531	5	Heterzozostera & H. Ovalis	5.4	372789.23	6500832.26	Mixed seagrass species
13b	537	5		5.4	372789.19	6500835.95	Mixed seagrass species
13b	539	8		5.5	372789.17	6500837.80	Bare sand
13b	547	5		5.4	372789.05	6500847.04	Mixed seagrass species
13b	551	5	Heterozostera & H. Ovalis	5.0	372789.01	6500850.73	Mixed seagrass species
13b	552	8		5.9	372789.01	6500850.73	Bare sand
13b	556	12		5.9	372788.94	6500856.27	Wrack
13b	558	8		5.8	372788.92	6500858.12	Bare sand
13b	566	8		5.8	372787.24	6500865.49	Bare sand
13b	573	8		5.9	372784.02	6500871.00	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
14b	29	8		12.7	371512.89	6500605.86	Bare sand
14b	38	8		12.8	371508.10	6500609.50	Bare sand
14b	51	8		13.1	371497.00	6500613.06	Bare sand
14b	56	8		13.2	371490.65	6500614.83	Bare sand
14b	59	11		13.1	371489.06	6500614.81	Low relief reef with sand veneer
14b	66	11		12.7	371482.75	6500614.73	Low relief reef with sand veneer
14b	72	11		13.5	371478.03	6500612.82	Low relief reef with sand veneer
14b	84	11		13.4	371468.52	6500614.55	Low relief reef with sand veneer
14b	96	11		13.4	371462.15	6500618.17	Low relief reef with sand veneer
14b	107	11		13.1	371455.77	6500621.79	Low relief reef with sand veneer
14b	116	10		13.4	371450.98	6500625.42	Reef
14b	124	11		13.1	371444.62	6500629.04	Low relief reef with sand veneer
14b	126	8		13.5	371443.01	6500630.87	Bare sand
14b	129	11		12.9	371441.43	6500630.85	Low relief reef with sand veneer
14b	134	11		12.1	371438.25	6500632.66	Low relief reef with sand veneer
14b	139	9		12.2	371433.48	6500634.44	High relief reef (with overhangs/kelp)
14b	145	11		10.7	371430.30	6500636.25	Low relief reef with sand veneer
14b	149	8		10.3	371427.11	6500638.06	Bare sand
14b	152	9		10.5	371423.95	6500638.02	High relief reef (with overhangs/kelp)
14b	160	9		10.5	371419.16	6500641.66	High relief reef (with overhangs/kelp)
14b	170	9		12.0	371409.66	6500643.39	High relief reef (with overhangs/kelp)
14b	184	9		12.0	371395.36	6500648.75	High relief reef (with overhangs/kelp)
14b	195	9		12.3	371387.43	6500650.50	High relief reef (with overhangs/kelp)
14b	205	9		12.5	371381.09	6500652.27	High relief reef (with overhangs/kelp)
14b	210	8		12.7	371377.90	6500654.08	Bare sand
14b	215	10		12.2	371374.71	6500655.89	Reef
14b	218	8		12.6	371373.12	6500657.72	Bare sand
14b	222	10		12.6	371368.35	6500659.50	Reef
14b	224	8		12.8	371366.77	6500659.49	Bare sand
14b	232	8		12.9	371361.98	6500663.12	Bare sand
14b	234	10		12.7	371360.39	6500663.10	Reef
14b	238	8		12.5	371357.21	6500664.91	Bare sand
14b	241	8		12.5	371355.60	6500666.74	Bare sand
14b	244	10		12.5	371352.45	6500666.70	Reef
14b	249	10		12.6	371349.26	6500668.51	Reef
14b	252	8		12.4	371346.10	6500668.47	Bare sand
14b	256	11		12.4	371342.94	6500668.43	Low relief reef with sand veneer
14b	264	11		12.1	371336.59	6500670.20	Low relief reef with sand veneer
14b	274	11		0.0	371330.27	6500670.12	Low relief reef with sand veneer

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
14b	286	11		11.9	371322.34	6500671.87	Low relief reef with sand veneer
14b	295	11		12.1	371316.02	6500671.79	Low relief reef with sand veneer
14b	301	11		11.7	371312.83	6500673.60	Low relief reef with sand veneer
14b	313	11		11.7	371304.93	6500673.50	Low relief reef with sand veneer
14b	317	11		12.0	371301.77	6500673.46	Low relief reef with sand veneer
14b	321	8		11.8	371298.60	6500673.42	Bare sand
14b	326	8		11.6	371293.86	6500673.36	Bare sand
14b	334	8		11.5	371289.12	6500673.30	Bare sand
14b	341	8		11.3	371285.96	6500673.26	Bare sand
14b	349	8		11.2	371279.63	6500673.19	Bare sand
14b	350	11		11.4	371278.06	6500673.17	Low relief reef with sand veneer
14b	358	11		10.9	371271.71	6500674.93	Low relief reef with sand veneer
14b	366	11		11.1	371268.52	6500676.74	Low relief reef with sand veneer
14b	370	11		10.9	371265.36	6500676.70	Low relief reef with sand veneer
14b	371	8		11.1	371263.78	6500676.68	Bare sand
14b	387	8		11.1	371252.67	6500680.24	Bare sand
14b	401	8		10.9	371244.74	6500681.99	Bare sand
14b	417	8		10.3	371232.07	6500683.68	Bare sand
14b	429	8		9.0	371224.14	6500685.43	Bare sand
14b	432	11		10.4	371222.56	6500685.41	Low relief reef with sand veneer
14b	441	11		10.2	371216.24	6500685.33	Low relief reef with sand veneer
14b	453	11		9.6	371206.73	6500687.06	Low relief reef with sand veneer
14b	459	10		9.4	371205.15	6500687.04	Reef
14b	469	11		9.5	371198.80	6500688.81	Low relief reef with sand veneer
14b	478	11		9.2	371190.90	6500688.71	Low relief reef with sand veneer
14b	492	11		9.1	371176.67	6500688.54	Low relief reef with sand veneer
14b	499	9		8.5	371170.34	6500688.46	High relief reef (with overhangs/kelp)
14b	506	9		8.5	371164.03	6500688.38	High relief reef (with overhangs/kelp)
14b	514	9	Ecklonia & Caulerpa sp.	8.2	371160.86	6500688.34	High relief reef (with overhangs/kelp)
14b	520	9	Ecklonia & Caulerpa sp.	7.9	371154.54	6500688.26	High relief reef (with overhangs/kelp)
14b	530	9	Ecklonia	7.8	371146.63	6500688.16	High relief reef (with overhangs/kelp)
14b	544	10		7.8	371135.57	6500688.02	Reef
14b	560	9	Ecklonia 100%	7.7	371122.89	6500689.72	High relief reef (with overhangs/kelp)
14b	570	9	Ecklonia 100%	7.2	371114.97	6500691.46	High relief reef (with overhangs/kelp)
14b	574	9	Dusky Morwong	7.8	371111.81	6500691.42	High relief reef (with overhangs/kelp)
14b	585	11		8.0	371103.88	6500693.17	Low relief reef with sand veneer
14b	595	10		7.5	371095.98	6500693.08	Reef
14b	611	10		8.0	371081.77	6500691.05	Reef
14b	627	10		7.3	371070.70	6500690.91	Reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
14b	637	10		7.7	371062.80	6500690.81	Reef
14b	655	9	Ecklonia 90%	8.5	371046.99	6500690.62	High relief reef (with overhangs/kelp)
14b	666	9	Ecklonia 90%	7.6	371037.50	6500690.50	High relief reef (with overhangs/kelp)
14b	678	9	Ecklonia 100%	7.8	371026.44	6500690.36	High relief reef (with overhangs/kelp)
14b	691	9	Ecklonia 100%	7.9	371015.37	6500690.22	High relief reef (with overhangs/kelp)
14b	709	9	Ecklonia 90%	7.5	370999.56	6500690.03	High relief reef (with overhangs/kelp)
14b	728	9	Ecklonia 100%	8.3	370983.78	6500687.98	High relief reef (with overhangs/kelp)
14b	747	9	Ecklonia 100%	8.7	370969.55	6500687.81	High relief reef (with overhangs/kelp)
14b	758	9	Ecklonia 100%	10.7	370961.64	6500687.71	High relief reef (with overhangs/kelp)
14b	767	8		11.0	370955.33	6500687.63	Bare sand
14b	773	9		11.0	370949.02	6500685.70	High relief reef (with overhangs/kelp)
14b	784	10		11.7	370941.12	6500685.60	Reef
14b	791	11		11.5	370934.82	6500683.68	Low relief reef with sand veneer
14b	797	11		11.6	370931.64	6500685.49	Low relief reef with sand veneer
14b	799	8		12.0	370930.05	6500685.47	Bare sand
14b	807	11		11.8	370923.72	6500685.39	Low relief reef with sand veneer
14b	815	8		11.4	370922.13	6500687.22	Bare sand
14b	825	8		11.5	370914.22	6500687.12	Bare sand
14b	829	11	80% sand	11.4	370911.06	6500687.08	Low relief reef with sand veneer
14b	838	11		11.0	370904.73	6500687.00	Low relief reef with sand veneer
14b	848	11	80% sand	11.3	370899.97	6500688.79	Low relief reef with sand veneer
14b	854	8		11.9	370893.67	6500686.86	Bare sand
14b	860	8		11.4	370890.48	6500688.67	Bare sand
14b	866	10		11.6	370885.74	6500688.61	Reef
14b	882	8		12.1	370876.23	6500690.34	Bare sand
14b	891	8		11.4	370868.33	6500690.24	Bare sand
14b	900	8		11.0	370863.58	6500690.18	Bare sand
14b	916	8		11.2	370850.89	6500693.72	Bare sand
14b	927	8		11.4	370841.39	6500695.45	Bare sand
14b	941	8		11.6	370828.69	6500698.99	Bare sand
14b	952	8		10.3	370820.76	6500700.74	Bare sand
14b	959	10		9.9	370812.84	6500702.48	Reef
14b	967	9		10.2	370804.88	6500706.08	High relief reef (with overhangs/kelp)
14b	980	9		10.3	370790.56	6500713.29	High relief reef (with overhangs/kelp)
14b	990	10		10.2	370784.20	6500716.91	Reef
14b	1000	10		10.0	370776.24	6500720.51	Reef
14b	1002	11		10.7	370774.64	6500722.33	Low relief reef with sand veneer
14b	1014	10	sand patches	9.8	370768.27	6500725.95	Reef
14b	1022	10	70% sand	10.2	370761.92	6500727.72	Reef
14b	1033	10	70% sand	10.6	370753.97	6500731.31	Reef
14b	1045	10	70% sand	10.6	370746.00	6500736.76	Reef

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
14b	1051	8		10.0	370742.81	6500738.57	Bare sand
14b	1059	8		10.4	370738.05	6500740.36	Bare sand
14b	1061	8		10.1	370736.45	6500742.18	Bare sand

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
15b	32	2		8.8	370679.71	6500347.90	Amphibolis sp.
15b	34	2		8.3	370679.71	6500347.90	Amphibolis sp.
15b	42	2		8.7	370671.75	6500351.49	Amphibolis sp.
15b	44	8		8.6	370670.17	6500351.47	Bare sand
15b	48	8	Skirting edge of seagrass bed	8.5	370667.01	6500351.43	Bare sand
15b	56	8		8.5	370660.64	6500355.05	Bare sand
15b	60	8		8.5	370657.47	6500355.01	Bare sand
15b	62	11		8.8	370655.88	6500356.84	Low relief reef with sand veneer
15b	66	8		8.6	370654.27	6500358.66	Bare sand
15b	70	11		8.2	370652.69	6500358.64	Low relief reef with sand veneer
15b	76	10		8.3	370647.90	6500362.28	Reef
15b	82	10		8.4	370643.13	6500364.07	Reef
15b	92	10		8.0	370638.34	6500367.71	Reef
15b	100	11		8.2	370635.14	6500371.36	Low relief reef with sand veneer
15b	104	11		8.5	370628.81	6500371.28	Low relief reef with sand veneer
15b	108	8		9.1	370627.21	6500373.11	Bare sand
15b	110	11		8.6	370625.63	6500373.09	Low relief reef with sand veneer
15b	115	8		9.0	370620.89	6500373.03	Bare sand
15b	123	10		7.8	370614.54	6500374.80	Reef
15b	131	10		8.6	370611.38	6500374.76	Reef
15b	137	9	Ecklonia	8.7	370606.61	6500376.55	High relief reef (with overhangs/kelp)
15b	148	8		10.0	370598.69	6500378.30	Bare sand
15b	153	10		10.5	370595.52	6500378.26	Reef
15b	161	11		10.4	370589.23	6500376.33	Low relief reef with sand veneer
15b	165	8		10.2	370587.62	6500378.16	Bare sand
15b	173	8		0.0	370582.88	6500378.10	Bare sand
15b	183	8		10.3	370576.53	6500379.87	Bare sand
15b	195	8		10.5	370570.21	6500379.79	Bare sand
15b	207	8		10.4	370562.28	6500381.54	Bare sand
15b	220	8		10.6	370554.38	6500381.44	Bare sand
15b	240	8		10.7	370540.22	6500375.72	Bare sand
15b	242	8		11.3	370540.22	6500375.72	Bare sand
15b	246	11		10.4	370537.04	6500377.53	Low relief reef with sand veneer
15b	248	11		10.6	370535.48	6500375.66	Low relief reef with sand veneer
15b	250	8		11.1	370533.89	6500375.64	Bare sand
15b	260	8		10.6	370527.60	6500373.71	Bare sand
15b	271	8		11.2	370518.14	6500371.75	Bare sand
15b	280	8		11.6	370511.81	6500371.67	Bare sand
15b	281	11		11.3	370510.23	6500371.65	Low relief reef with sand veneer
15b	284	8		11.3	370508.65	6500371.63	Bare sand
15b	298	8		11.0	370496.00	6500371.47	Bare sand
15b	300	10		0.0	370494.40	6500373.30	Reef
15b	306	11		10.3	370489.66	6500373.24	Low relief reef with sand veneer

Transect	REC_No	Class (1-13)	Comments	Depth (m)	Easting	Northing	Habitat type
15b	310	11		10.8	370486.49	6500373.20	Low relief reef with sand veneer
15b	313	8		10.9	370481.75	6500373.14	Bare sand
15b	315	10		10.9	370480.17	6500373.12	Reef
15b	319	8		10.8	370475.45	6500371.21	Bare sand
15b	322	11		11.3	370473.87	6500371.19	Low relief reef with sand veneer
15b	331	8		11.1	370465.95	6500372.94	Bare sand
15b	342	8		11.1	370458.01	6500374.69	Bare sand
15b	345	2		10.6	370456.41	6500376.52	Amphibolis sp.
15b	351	2		10.6	370450.09	6500376.44	Amphibolis sp.
15b	357	2		10.5	370445.35	6500376.38	Amphibolis sp.
15b	363	10		10.3	370440.58	6500378.17	Reef
15b	368	9		10.4	370435.84	6500378.11	High relief reef (with overhangs/kelp)
15b	371	9	Large overhang	10.8	370432.68	6500378.07	High relief reef (with overhangs/kelp)
15b	379	9	Large overhang	10.4	370426.33	6500379.84	High relief reef (with overhangs/kelp)
15b	381	9	Large overhang	11.1	370424.75	6500379.82	High relief reef (with overhangs/kelp)
15b	388	10		9.8	370418.43	6500379.74	Reef
15b	391	9		9.8	370416.84	6500379.72	High relief reef (with overhangs/kelp)
15b	402	9	Large overhang	10.1	370407.36	6500379.60	High relief reef (with overhangs/kelp)
15b	408	8		11.6	370402.59	6500381.39	Bare sand
15b	412	8	Sand patch	11.1	370399.43	6500381.35	Bare sand
15b	416	10		11.6	370394.72	6500379.44	Reef
15b	422	10		10.9	370391.55	6500379.40	Reef
15b	432	10		11.5	370383.65	6500379.30	Reef
15b	442	11		11.6	370375.75	6500379.21	Low relief reef with sand veneer
15b	452	8		12.6	370366.28	6500377.24	Bare sand
15b	457	8		12.5	370361.54	6500377.18	Bare sand
15b	467	8		12.9	370355.19	6500378.95	Bare sand
15b	481	8		0.0	370345.68	6500380.68	Bare sand
15b	497	8		12.8	370336.17	6500382.41	Bare sand
15b	503	8		13.1	370331.41	6500384.19	Bare sand

Appendix B

Dive survey photographs

High relief reef and sand	Ray (Urolophidae family) on sand
	
Sponges under overhang	Sponge dominated epifauna under overhang

Dive site D1 – Conspicuous/characteristic species

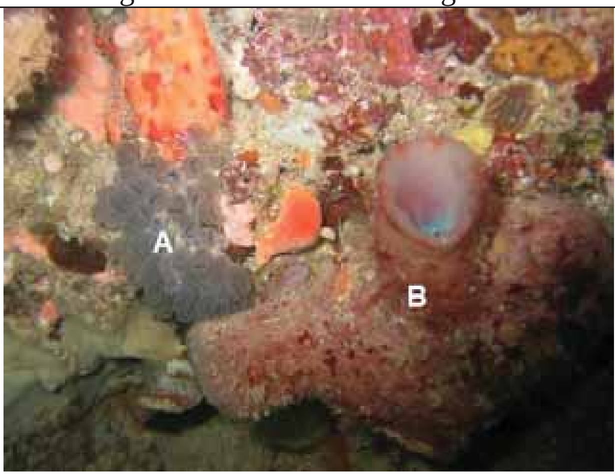
Myliobatis australis (Eagle ray)

Amphibolis antarctica

Thalassodendron pachyrhizum

Ecklonia radiata

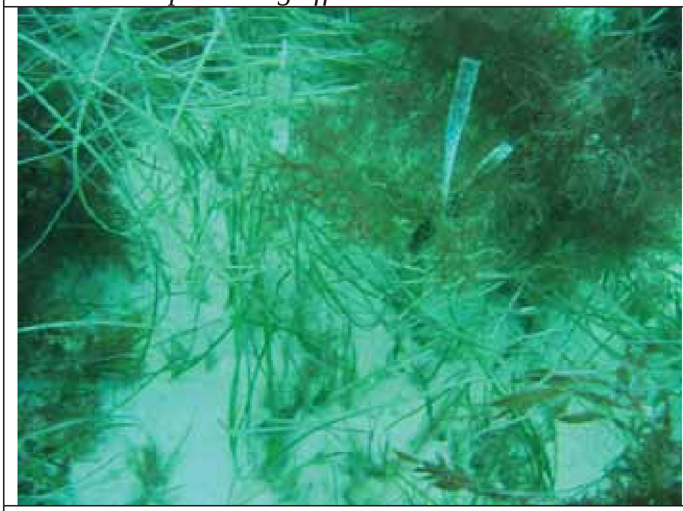
Dive site D2 – Conspicuous/characteristic species

	
Chelmonops curiosus (Western Talma)	*Pseudocaranx dentex* (Skipjack trevally)
	
High relief reef and overhang	Fan worm
	
Clavelina sp. (A) & *Herdmania momus* (B)	*Triphyllozoon* sp.

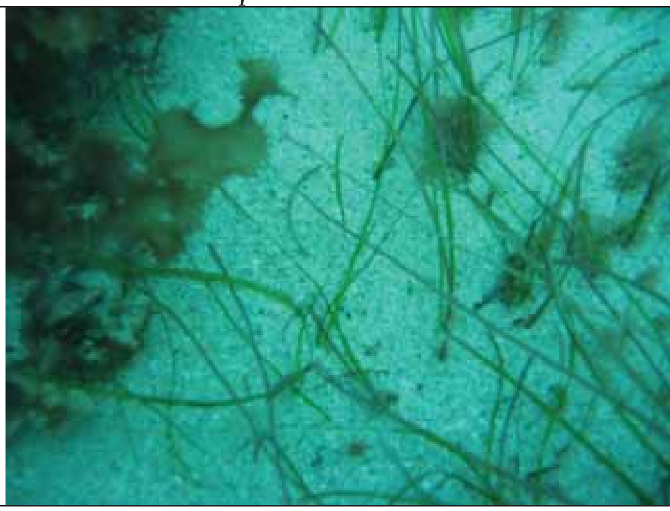
Dive site D3 – Conspicuous/characteristic species

Amphibolis griffithii

Amphibolis antarctica

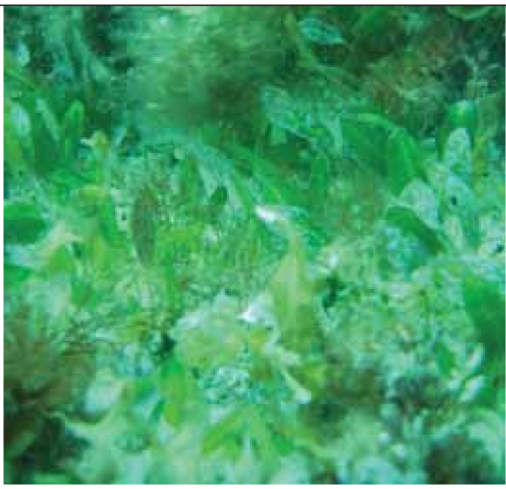


Heterozostera tasmanica



Heterozostera tasmanica

Dive site D4 – Conspicuous/characteristic species

	
Halophila ovalis	*Amphibolis griffithii*
	
Posidonia sp.	*Posidonia* sp.
	
Posidonia sinuosa	*Thalassodendron pachyrhizum*

Dive site D5 – Conspicuous/characteristic species

Ecklonia radiata

Gelinaria ulvoidea

Sponge (Thorectidae family)

Sponge

Dive site D6 – Conspicuous/characteristic species

Sarcomenia delesseroides

Codium sp.

High relief reef with *Ecklonia radiata*

Dive site D7 – Conspicuous/characteristic species

	
Amphibolis antarctica	*Posidonia australis*
	
Reef overhang	*Caulerpa* sp. on overhang
	
Heterozostera tasmanica	Ray over *Halophila ovalis and Posidonia australis*

Snorkel site S1 – Conspicuous/characteristic species

Appendix C

Dive survey sample photographs

L to R: *Thalassodendron pachyrhizum, Amphibolis Antarctica, Amphibolis griffithii, Gelinaria ulvoidea.*

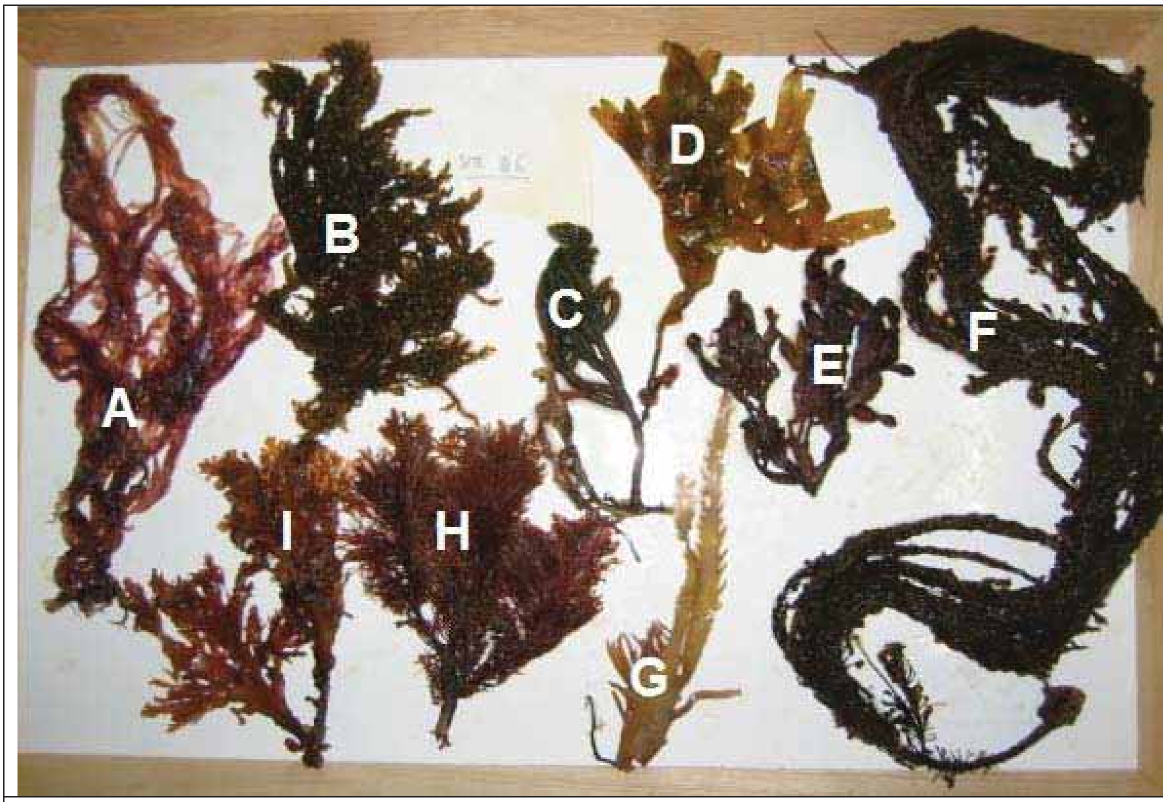
Dive site D2 – Conspicuous/characteristic species

Heterozostera tasmanica

Dive site D4 – Conspicuous/characteristic species

	
L to R: *Posidonia angustifolia*, *Posidonia sinuosa*, *Posidonia sinuosa* (stunted)	L to R: *Dictyomenia* sp., *P. angustifolia*, *P. sinuosa*, *Thalassodendron pachyrhizum*, *P. sinuosa*.

Dive site D5 – Conspicuous/characteristic species



Sarcomenia delesserioides (A), *Delisea* sp. (B), *Codium* sp. (C), *Dictoya* sp. (D), *Osmundaria* sp. (E), *Encyothalia cliftonii* (F), *Gelinaria ulvoidea* (G), *Plocamium* sp. (H) and *Callophyllis* sp. (I).

Dive site D6 – Conspicuous/characteristic species

L to R: *Sarcomenia delesserioides*, *Plocamium sp.*, green alga indet.

Dive site D7 – Conspicuous/characteristic species

L to R: *Posidonia angustifolia*, *Heterozostera tasmanica* (top), *Halophila ovalis* (bottom), *Amphibolis griffithii.*

Dive site S1 – Conspicuous/characteristic species

L to R: *Heterozostera tasmanica, Halophila ovalis, Posidonia australis.*

Dive site S2 – Conspicuous/characteristic species

Appendix D

Infauna sample data

Phylum	Class	Order	Species	1-1	1-2	1-3	1-4	1-5	2-1	2-2	2-3	2-4	2-5	3-1	3-2	3-3	3-4	3-5
Nematoda			Nematode sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pycnogonida			Pycnogonid sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Crustacea	Ostracoda		Ostracod sp. 2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Isopod sp. 2	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
Crustacea	Malacostraca	Isopoda	Isopod sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Isopod sp. 4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Paranthurid sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Mysidacea	Gastrosaccus sorrentoensis	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipod sp. 27	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 46	1	0	0	0	0	0	0	1	0	2	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 47	3	3	1	1	0	0	4	2	0	6	0	0	0	0	1
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sipuncula			Sipunculan sp. 2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Sipuncula			Sipunculan sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Annelida	Polychaeta	Scolecida	Armandia sp.	3	2	0	1	1	0	2	4	0	4	2	3	5	2	0
Annelida	Polychaeta	Eunicida	Eunicid sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Phyllodicida	Glycera sp. 2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Annelida	Polychaeta	Scolecida	Aricidea sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Phyllodicida	Pisionid sp.	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Spionida	Syllid sp. 5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Annelida	Polychaeta	Scolecida	Scoloplos sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Eunicida	Lumbrinerid sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Annelida	Polychaeta	Spionida	Dispio sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mollusca	Bivalvia	Veneroida	Venerid sp 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia		Laternula sp2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

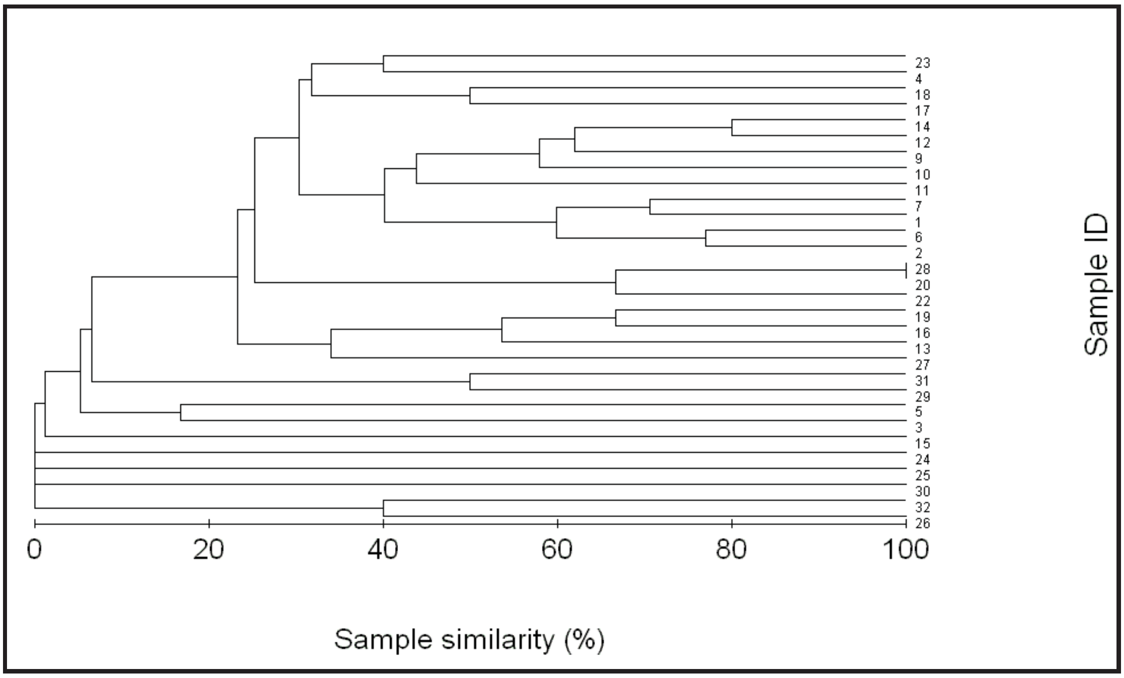
Phylum	Class	Order	Species	4-1	4-2	4-3	4-4	4-5	5-1	5-2	5-3	5-4	5-5	6-1	6-2	6-3	6-4	6-5
Nematoda			Nematode sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pycnogonida			Pycnogonid sp. 2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Ostracoda		Ostracod sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Isopod sp. 2	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0
Crustacea	Malacostraca	Isopoda	Isopod sp. 3	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Isopod sp. 4	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Paranthurid sp. 1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Mysidacea	Gastrosaccus sorrentoensis	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipod sp. 27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 46	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 48	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 49	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 50	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 51	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sipuncula			Sipunculan sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sipuncula			Sipunculan sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Scolecida	Armandia sp.	1	2	0	1	0	1	1	1	1	1	0	0	1	0	0
Annelida	Polychaeta	Eunicida	Eunicid sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Phyllodicida	Glycera sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Scolecida	Aricidea sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Phyllodicida	Pisionid sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Annelida	Polychaeta	Spionida	Syllid sp. 5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Scolecida	Scoloplos sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Eunicida	Lumbrinerid sp.	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Annelida	Polychaeta	Spionida	Dispio sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia		Laternula sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Phylum	Class	Order	Species	7-1	7-2	7-3	7-4	7-5	8-1	8-2	8-3	8-4	8-5
Nematoda			Nematode sp.	0	0	0	0	0	0	1	0	0	0
Pycnogonida			Pycnogonid sp. 2	0	0	0	0	0	0	0	0	0	0
Crustacea	Ostracoda		Ostracod sp. 2	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Isopod sp. 2	0	0	0	1	2	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Isopod sp. 3	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Isopod sp. 4	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Isopoda	Paranthurid sp. 1	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Mysidacea	Gastrosaccus sorrentoensis	0	0	1	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipod sp. 27	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 46	0	0	0	0	0	1	0	2	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 47	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 48	0	3	0	0	12	0	0	0	1	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 49	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 50	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 51	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Amphipo sp. 52	0	1	0	0	0	0	0	0	0	0
Sipuncula			Sipunculan sp. 2	0	0	0	0	0	0	0	0	0	0
Sipuncula			Sipunculan sp. 3	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Scolecida	Armandia sp.	0	0	0	1	0	0	0	0	0	0
Annelida	Polychaeta	Eunicida	Eunicid sp. 2	0	0	1	0	0	0	0	0	0	0
Annelida	Polychaeta	Phyllodicida	Glycera sp. 2	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Scolecida	Aricidea sp.	0	0	0	0	0	0	0	0	0	1
Annelida	Polychaeta	Phyllodicida	Pisionid sp.	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Spionida	Syllid sp. 5	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Scolecida	Scoloplos sp.	0	0	0	0	0	0	0	1	0	0
Annelida	Polychaeta	Eunicida	Lumbrinerid sp.	0	0	0	0	1	0	0	0	0	0
Annelida	Polychaeta	Spionida	Dispio sp.	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 3	0	0	0	0	0	0	0	0	0	1
Mollusca	Bivalvia		Laternula sp2	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 4	1	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 5	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 6	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneroida	Venerid sp 7	0	0	0	0	0	0	0	0	0	0

Appendix E

Hierarchical clustering (CLUSTER) analysis (dendrogram)

Appendix E Hierarchical clustering (CLUSTER) analysis (dendrogram)



Sample IDs as follows: 1 to 4 represent samples 1-1 to 1-4, 5 to 8 represent samples 2-1 to 2-4, 9 to 12 represent samples 3-1 to 3-4, 13 to 16 represent samples 4-1 to 4-4, 17 to 20 represent samples 5-1 to 5-4, 21 to 24 represent samples 6-1 to 6-4, 25 to 28 represent samples 7-1 to 7-4 and 29 to 32 represent samples 8-1 to 8-4.

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APPENDIX G - ALKIMOS MARINE STUDIES PROGRAMME SEDIMENT SURVEY

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marine & estuarine specialists

ALKIMOS Marine Studies Programme

SEDIMENT SURVEY

May 2005

Alkimos Marine Studies Programme

SEDIMENT SURVEY

Prepared for:

Water Corporation of Western Australia

Prepared by:

Oceanica Consulting Pty Ltd

May 2005

Report No. 439/1

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Revisions history

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2	S. Shute	B. Moulds	1xHard Copy	27/5/05	B. Moulds	

Status

This report is "Draft" until the author and director have signed it off for final release. A "Draft" report should not be used for any purpose other than to be reviewed with the intention of generating a "Final" version.

Approved for final release:

Author Director Date: 27/5/05

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Executive Summary

Sediment samples were collected from six near-shore and six offshore sites off Alkimos on 9th February 2005 by Murdoch University's Marine and Freshwater Research Laboratory (MAFRL). At each site, three replicate surface sediment samples were collected by ADAS commercially qualified divers, with each sample being a composite from five sub-samples of the top 2-cm of sediment obtained from the four corners and the centre of a 1 m^2 quadrat. One replicate from each site was analysed for grain-size distribution, nutrients, total organic carbon, organic matter content, carbonate content, metals, pesticides and herbicides.

The sediments were found to be clean sands with a low organic matter content. The dominant grain size varied from coarse to fine sand. Concentrations of nutrients were within the range expected for clean coastal sediments and all metals concentrations were well below guideline levels. Pesticide and herbicide levels within the sediments were below reporting limits at all sites.

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1. Introduction

1.1 Background

In the 1970's the Water Corporation of Western Australia (Water Corporation) identified the need for a wastewater treatment plant (WWTP) to service the planned residential growth in Perth's North West Metropolitan Corridor. Following evaluation of several different options, the Water Corporation selected Alkimos Lot 101 as the preferred site for what will be known as the Alkimos WWTP, and finalised the acquisition of this site from the Urban Land Council in 1987.

An "in principle agreement" was formalised on the 29th June 2001 with the signing of the Alkimos Eglinton Relocation, Construction and Development Agreement between the Water Corporation, LandCorp and Eglinton Estates (the principal landowners within the structure plan area). This agreement identified the Alkimos WWTP site as acceptable to all parties.

Projected growth in the catchment indicates that approximately 80 ML/d will require treatment at the Alkimos WWTP by 2050. Ultimately plant inflows could grow to 160 ML/d.

1.2 Objectives of the Sediment Survey Project

The objectives of the Sediment Survey component of the Alkimos Marine Studies Programme were to characterise the sediments (grain-size, nutrients, total organic carbon, organic matter, carbonate) and measure the concentrations of metals, pesticides and herbicides in the sediment at sites in the vicinity of the proposed Alkimos Wastewater Treatment Plant (WWTP) Ocean Outlet.

The data will be compared against the appropriate guidelines where applicable (ANZECC/ARMCANZ (2000) Interim Sediment Quality Guidelines (ISQG)) and will assist with the assessment of the potential effects of the treated wastewater discharge on the coastal waters.

2. Methods

2.1 Sample collection

Sediment samples were collected from six near-shore and six offshore sites off Alkimos on 9th February 2005 by staff from Murdoch University's Marine and Freshwater Research Laboratory (MAFRL) (Figure 2.1, Appendix A).

At each site, three replicate surface sediment samples were collected by ADAS commercially qualified divers using 9.5 cm diameter polycarbonate corers (Australian Standard AS/NZS 5667.12:1999). Corers were pre-rinsed with dilute acid, de-ionised water and a suitable solvent. The corers were washed between sampling sites with site water before re-sampling.

Sediment samples were placed in pre-cleaned polyethylene containers supplied by the analytical laboratory (Australian Standard AS/NZS 5667.12:1999) and kept on ice while in transit to the analytical laboratory.

Each of the samples was a composite from five sub-samples of the top 2-cm of sediment obtained from the four corners and the centre of a 1 m² quadrat (EPA, 2004). Surface samples represent the best sample for detection of change in contamination, and are also an important part of the sediment profile in terms of biological effects (sediment feeding, water/sediment interactions).

2.2 Analysis of sediment samples:

One replicate sediment sample from each site was analysed for:

- Grain-size distribution;
- Nutrients (total Kjeldahl nitrogen and total phosphorus);
- Total organic carbon (organically bound carbon);
- Organic matter content (percentage of organic matter – includes carbon, hydrogen, nitrogen, etc.);
- Carbonate content;
- Metals (arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver, zinc); and
- Pesticides and herbicides (organochlorine pesticides, organophosphate pesticides and triazine herbicides).

2.3 Analytical methods

All chemical analyses were undertaken following NATA (National Association of Testing Authorities) accredited laboratory procedures (Table 2.1).

Table 2.1 Analytical methods and reporting limits for each of the sediment parameters to be measured

Parameter	Analytical Method(1)	Reporting Limit	Unit
Sediment Characteristics			
Grain-size	Laser diffraction and wet sieving	0.02 µm – 10 mm	% volume
Nutrients	Lachat QC 8000 Flow Injection Analyser	P: 0.05 N: 0.1	mg g^{-1}

Parameter	Analytical Method(1)	Reporting Limit	Unit
Total Organic Carbon	Shimadzu TOC 5000A	0.4	% C
Organic matter content	Loss on ignition (LOI) at 550°C	0.01	% weight
Carbonate content	Loss on ignition (LOI) at 1,000°C	0.01	% weight
Metals(1)			
Arsenic (As)	ICP-AES(2)	1	mg kg^{-1}
Cadmium (Cd)	ICP-AES(2)	0.06	mg kg^{-1}
Chromium (Cr)	ICP-AES(2)	0.2	mg kg^{-1}
Copper (Cu)	ICP-AES(2)	0.2	mg kg^{-1}
Lead (Pb)	ICP-AES(2)	1	mg kg^{-1}
Mercury (Hg)	Cold vapour AAS(3)	0.01	mg kg^{-1}
Molybdenum (Mo)	ICP-AES(2)	0.5	mg kg^{-1}
Nickel (Ni)	ICP-AES(2)	0.4	mg kg^{-1}
Selenium (Se)	ICP-AES(2)	2	mg kg^{-1}
Silver (Ag)	ICP-AES(2)	1	mg kg^{-1}
Zinc (Zn)	ICP-AES(2)	0.5	mg kg^{-1}
Pesticides and Herbicides(4)			
Organochlorine pesticides	GC-ECD/NPD	0.01	mg kg^{-1}
Organophosphate pesticides	GC-ECD/NPD	0.1	mg kg^{-1}
Triazine herbicides	GC-ECD/NPD	0.1	mg kg^{-1}

Notes:

1. *Metal analysis conducted on aqua regia (HCl/HNO_3) digest extracts to enable comparison with the ANZECC/ARMCANZ (2000) Guidelines which are based on data that have used a strong acid digestion to extract the metal.*
2. *Inductively Coupled Plasma Atomic Emission Spectrometry.*
3. *Cold vapour Atomic Absorption Spectrometry.*
4. *Gas chromatography-electron capture detector/nitrogen-phosphorus detector.*

Low level analysis for pesticides, herbicides and silver was also undertaken on a subset of samples to obtain reporting limits below the guideline screening levels. The reporting limits for the low level analyses are given below (Table 2.2).

Table 2.2 Analytical methods and low level reporting limits for certain sediment parameters

Parameter	Analytical Method(1)	Detection Limit	Unit
Metals(1)			
Silver (Ag)	ICP-AES(2)	0.5	mg kg^{-1}
Pesticides and Herbicides(3)			
Organochlorine pesticides	GC-ECD/NPD	0.001	mg kg^{-1}
Organophosphate pesticides	GC-ECD/NPD	0.01	mg kg^{-1}
Triazine herbicides	GC-ECD/NPD	0.01	mg kg^{-1}

Notes:

1. *Metal analysis conducted on aqua regia (HCl/HNO_3) digest extracts to enable comparison with the ANZECC/ARMCANZ (2000) Guidelines which are based on data that have used a strong acid digestion to extract the metal.*
2. *Inductively Coupled Plasma Atomic Emission Spectrometry.*
3. *Gas chromatography-electron capture detector/nitrogen-phosphorus detector.*

Legend

Sample Locations

Approximate pipeline route

Figure 2.1

Location of sediment sampling sites

oceanica

Author: EDB | Date: 16/5/05
Proj Ref: 439_1
File Ref: SedSamp_Locns.mxd
Horizontal: Datum | UTM Zone 50 Based on WGS84
Vertical: Datum | N/A

Data Sources: Planned_WQSQ_sites, Pipeline3_5km, oceanica_2004.ecw

WATER CORPORATION

3. Results

3.1 Grain-size distribution

The majority of the near-shore sediments (Sites NEAR 1, 4, 5 and 6) were predominantly (22 to 60%) coarse sands (<1000 µm), with samples NEAR 2 and 3 dominated by medium sands (Table 3.1, Figure 3.1, Appendix B). Site NEAR 6 exhibited the coarsest sediment in the region, with large fractions of coarse and very coarse sands as well as 7.5% gravel.

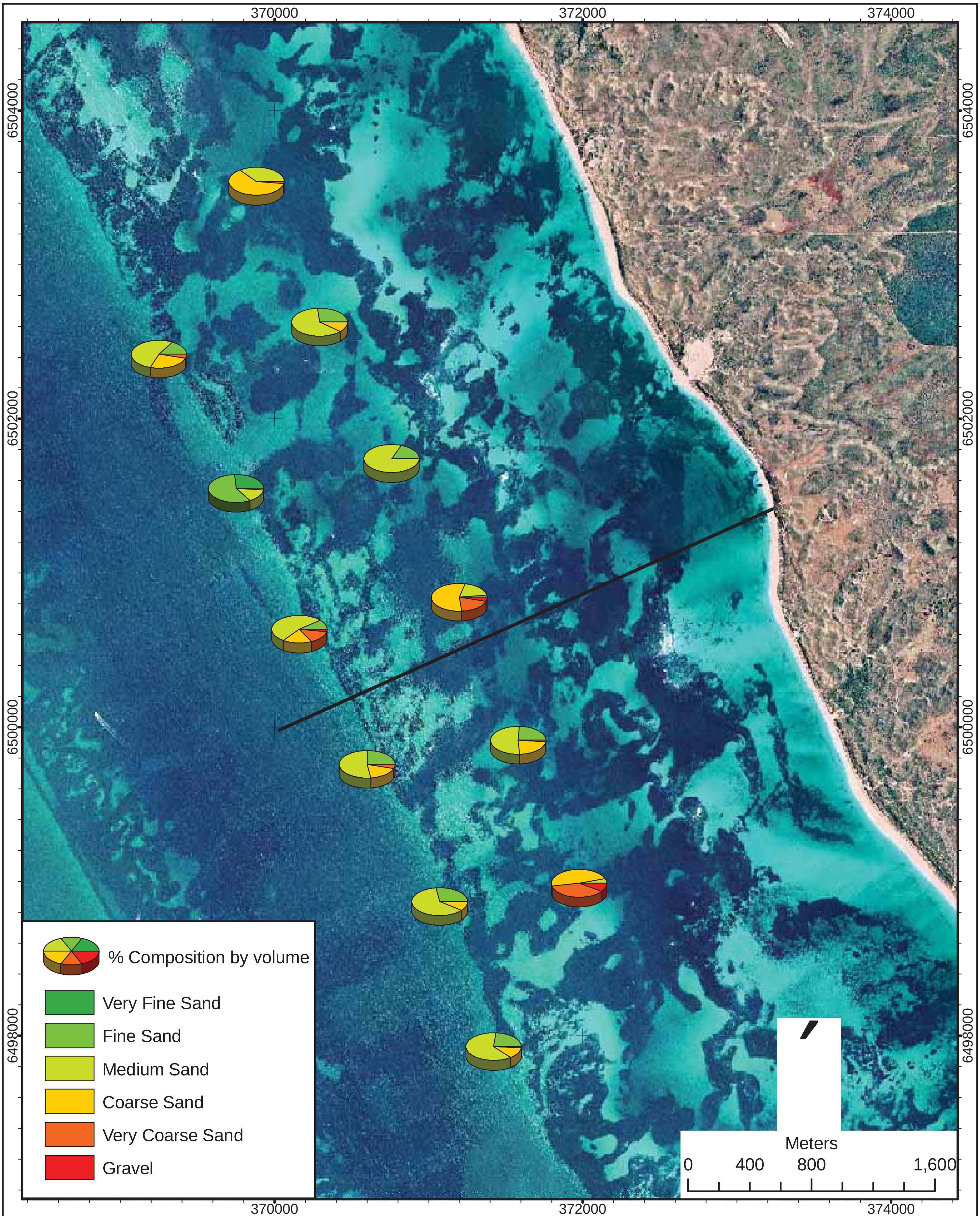
The offshore sediments were generally finer than the inshore sediments, being predominantly composed of medium sands (52 to 64%), with the exception of those at site OFF 2 which were mainly fine sands (59%) (Table 3.1, Figure 3.1, Appendix B). The presence of finer sediments offshore is likely to be due to this region being a low energy environment, due to the greater water depths, compared to the inshore region which exhibits shallower water and high energy (i.e. breaking waves and strong surge).

Sediments at all sites were found to contain no fines (silt and clay fractions (<63 µm)).

Table 3.1 Particle size analysis results (% within each size fraction)

		Volume (%)											
Wentworth Classification	**Size (µm)**	NEAR1	NEAR2	NEAR3	NEAR4	NEAR5	NEAR6	OFF1	OFF2	OFF3	OFF4	OFF5	OFF6
Silt & clay	**<63**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Very fine sand	**<70**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00
	<79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69	0.00	0.00	0.00	0.00
	<89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.14	0.00	0.00	0.00	0.00
	<100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.94	0.00	0.00	0.00	0.00
	<112	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.86	0.00	0.00	0.00	0.00
	<126	0.00	0.5	0.0	0.00	0.43	0.00	0.00	8.73	0.00	0.44	0.32	0.04
Fine sand	**<141**	0.00	0.73	0.00	0.00	1.14	0.00	0.12	10.17	0.00	1.19	1.02	0.37
	<158	0.00	1.75	0.21	0.00	2.03	0.00	0.64	11.03	0.05	2.12	2.06	1.33
	<178	0.00	3.18	1.34	0.00	3.20	0.00	1.40	11.13	0.58	3.33	3.48	2.59
	<200	0.00	4.98	2.92	0.20	4.52	0.01	2.54	10.49	1.39	4.68	5.22	4.29
	<224	0.00	6.97	5.06	0.54	5.90	0.08	4.00	9.21	2.62	6.09	7.09	6.26
	<251	0.06	8.90	7.61	0.99	7.19	0.17	5.62	7.54	4.18	7.42	8.88	8.27
Medium sand	**<282**	0.75	10.53	10.27	1.58	8.29	0.30	7.25	5.69	5.94	8.52	10.40	10.09
	<316	2.12	11.56	12.66	2.25	9.02	0.45	8.62	3.95	7.69	9.24	11.36	11.39
	<355	4.43	11.86	14.48	2.93	9.32	0.61	9.57	2.44	9.20	9.51	11.65	11.98
	<399	7.30	11.34	15.36	3.54	9.14	0.77	9.87	0.64	10.19	9.27	11.20	11.75
	<447	10.29	10.10	15.22	4.00	8.47	0.90	9.48	0.04	10.53	8.55	10.07	10.70
	<500	12.65	8.35	14.07	4.27	7.45	1.01	8.49	0.00	10.13	7.44	8.45	9.04
Coarse sand	**<1000**	60.40	9.00	0.00	56.60	22.20	48.30	28.30	1.10	22.10	18.10	8.00	10.70
Very coarse sand	**<2000**	1.80	0.50	0.80	19.70	1.40	39.90	3.50	0.50	13.30	3.60	0.70	1.10
Gravel	**<10000**	0.20	0.10	0.00	3.40	0.30	7.50	0.60	0.00	2.10	0.50	0.10	0.10

Note: Shaded cells indicate dominant particle size fraction



Legend

Approximate pipeline route

Figure 3.1

Particle size distribution

oceanica
marine & estuarine specialists

WATER CORPORATION

Author: EDB	Date: 16/5/05
Proj Ref: 439_1	
File Ref: Particle_size.mxd	
Horizontal: Datum	UTM Zone 50 Based on WGS84
Vertical: Datum	N/A

Data Sources: Planned_WQSQ_sites, Pipeline3_5km, oceanica_2004.ecw

3.2 Nutrients, total carbonate, organics and organic carbon

The samples all contained little organic material as shown by the loss on ignition at 550°C (maximum 4.67% at Site OFF 2) (Table 3.2). The carbonate content of all the sediments, given by the loss on ignition at 1000°C, was similar with a maximum of 39.84% carbonate recorded at Site OFF 2 (Table 3.2).

The nutrient concentrations within the sediments were relatively low at all sites, with the highest concentration of total Kjeldahl nitrogen (TKN) being 0.4 mg/g (Site OFF 2) and total phosphorus (Total P) 0.41 mg/g (Site NEAR 1) (Table 3.2). These concentrations are within the range expected for clean sandy coastal sediments (DEP 1996).

The total organic carbon (TOC) content in all samples was below 0.4% C.

Table 3.2 Sediment nutrient, organic matter and carbonate concentrations

	TKN	TOTAL P	TOC	% LOSS ON	% LOSS ON
	mg.N/g	mg.P/g	% C	IGNITION	IGNITION
Reporting Limit	<0.1	<0.05	<0.4	AT 550°C	AT 1000°C
NEAR1.1	0.2	0.41	<0.4	4.36	33.96
NEAR2.1	0.2	0.36	<0.4	4.14	32.72
NEAR3.1	0.2	0.25	<0.4	3.68	30.99
NEAR4.1	0.2	0.33	<0.4	3.37	29.10
NEAR5.1	0.3	0.36	<0.4	4.28	35.08
NEAR6.1	0.3	0.40	<0.4	4.32	37.71
OFF1.1	0.2	0.36	<0.4	3.55	33.65
OFF2.1	0.4	0.37	<0.4	4.67	39.84
OFF3.1	0.2	0.35	<0.4	2.99	30.81
OFF4.1	0.2	0.30	<0.4	3.32	32.55
OFF5.1	0.2	0.32	<0.4	2.97	31.61
OFF6.1	0.2	0.32	<0.4	2.58	31.31

3.3 Metals

The concentration of metals in all samples was low, with Ag, Mo, Pb, Hg and Se below or equal to the reporting limits, and below the Interim Sediment Quality Guidelines (ISQG-low) levels (where applicable) at all sites (Table 3.3). Metals As, Cd, Cr, Cu, Ni and Zn were well below the ISQG-low levels (Table 3.3).

No marked variation in metals concentrations were observed between near-shore and off-shore sediments.

3.4 Pesticides and herbicides

The concentrations of all organochlorine and organophosphate pesticides and triazine herbicides were below normal reporting limits (0.01, 0.1 and 0.1 mg/kg respectively) (Appendix C, Appendix D). No ISQG apply to these compounds.

A selection of samples (NEAR 1, 3 and 5, OFF 1, 3 and 5) were analysed at low levels so that the reporting limits for the organochlorine pesticides would meet, where possible, the ISQG-low levels. The concentrations of DDT, DDE and DDD in all samples fell below the reporting limits (which were below the guideline levels).

The concentrations of chlordane, dieldrin, endrin and lindane were also below the reporting limits. However, the low level reporting limits (Chlordane 0.001 mg/kg, dieldrin 0.001 mg/kg, endrin 0.001 mg/kg and lindane 0.001 mg/kg were above the ISQG-low concentrations (Chlordane 0.0005 mg/kg, dieldrin 0.00002 mg/kg, endrin 0.00002 mg/kg and lindane 0.00032 mg/kg) (Appendix D).

Table 3.3 Sediment nutrient, organic matter and carbonate concentrations

	TKN	TOTAL P	TOC	% LOSS ON	% LOSS ON
	mg.N/g	mg.P/g	% C	IGNITION	IGNITION
Reporting Limit	<0.1	<0.05	<0.4	AT 550°C	AT 1000°C
NEAR1.1	0.2	0.41	<0.4	4.36	33.96
NEAR2.1	0.2	0.36	<0.4	4.14	32.72
NEAR3.1	0.2	0.25	<0.4	3.68	30.99
NEAR4.1	0.2	0.33	<0.4	3.37	29.10
NEAR5.1	0.3	0.36	<0.4	4.28	35.08
NEAR6.1	0.3	0.40	<0.4	4.32	37.71
OFF1.1	0.2	0.36	<0.4	3.55	33.65
OFF2.1	0.4	0.37	<0.4	4.67	39.84
OFF3.1	0.2	0.35	<0.4	2.99	30.81
OFF4.1	0.2	0.30	<0.4	3.32	32.55
OFF5.1	0.2	0.32	<0.4	2.97	31.61
OFF6.1	0.2	0.32	<0.4	2.58	31.31

Table 3.4 Sediment metals concentrations

	Ag	As	Cd	Cr	Cu	Mo	Ni	Pb	Se	Zn	Hg
	Concentration (mg/kg)										
Reporting Limit	<1 / <0.5*	<1	<0.06	<0.2	<0.2	<0.5	<0.4	<1	<2	<0.5	<0.01
ISQG-low	1.0	20	1.5	80	65	n/a	21	50	n/a	200	0.15
NEAR1.1	<0.5*	3	0.10	15	<0.2	<0.5	0.5	<1	<2	0.7	<0.01
NEAR2.1	<1	2	0.08	13	<0.2	<0.5	0.4	<1	<2	0.6	<0.01
NEAR3.1	<0.5*	2	0.06	12	<0.2	<0.5	<0.4	<1	<2	0.7	<0.01
NEAR4.1	<1	2	0.07	9.7	<0.2	<0.5	<0.4	<1	<2	0.9	<0.01
NEAR5.1	<1	2	0.08	10	0.2	<0.5	<0.4	<1	<2	1.3	<0.01
NEAR6.1	<0.5*	2	0.09	9.4	<0.2	<0.5	<0.4	<1	<2	1.1	<0.01
MEDIAN	1	2	0.08	11	0.2	0.5	0.45	1	2	0.8	0.01
OFF1.1	<0.5*	2	0.08	13	<0.2	<0.5	<0.4	<1	<2	0.6	<0.01
OFF2.1	<1	1	0.08	9.4	<0.2	<0.5	<0.4	<1	2	0.7	<0.01
OFF3.1	<0.5*	3	0.08	11	<0.2	<0.5	0.4	<1	<2	0.5	<0.01
OFF4.1	<1	2	0.07	12	<0.2	<0.5	0.4	<1	<2	0.7	<0.01
OFF5.1	<1	2	0.06	12	<0.2	<0.5	<0.4	<1	<2	0.7	<0.01
OFF6.1	<0.5*	2	0.08	13	<0.2	<0.5	0.4	<1	<2	0.7	<0.01
MEDIAN	1	2	0.08	12	0.2	0.5	0.4	1	2	0.7	0.01

*Note: *Low level analysis carried out. Medians calculated on normal reporting limits.*

4. Discussion

4.1 Spatial variation

The sediments in the Alkimos region exhibit some spatial variation in terms of particle size distribution, with coarse sands predominating at the near shore sites and fine sands most common offshore (Figure 3.1).

No clear spatial pattern was evident in the sediment chemical data, with little variation between either near-shore and off-shore sites or northern and southern sites.

Organic content, carbonate content and TOC content were similar at all sites. Similarly the nutrient and metals concentrations showed relatively little variation between sites.

4.2 Contaminant levels

The levels of all potential contaminants were well below the guideline levels. The concentrations of TKN and total phosphorus, which are not covered under the guidelines (ANZECC/ARMCANZ, 2000), all fell below reporting limits and within the range expected for clean sandy coastal sediments. Pesticides and herbicides were all below reporting limits.

The sediments recorded at Alkimos were very similar to those recorded at Ocean Reef in December 2003 (DALSE 2004). Sediments at Ocean Reef were predominantly fine to coarse sands with less than 4% fines (<63 µm) and a low organics content (<5%). Concentrations of arsenic, cadmium, chromium, cobalt, lead, mercury, selenium, silver and zinc in the sediments at Ocean Reef were all below the ISQG-low levels. Similarly the concentrations of pesticides and herbicides were below reporting limits at all sites (DALSE 2004), indicating that there has been no long-term accumulation of metals or pesticides in the sediments at Ocean Reef. At the same time as these studies were being carried out, a review of results from the monitoring programs undertaken at Ocean Reef over the previous 12 years was also completed. This review found that although the concentrations of some metals in the sediments at Ocean Reef had varied over time, they had never exceeded the ISQG-low levels (DALSE 2004). Similarly the concentrations of pesticides and herbicides had remained below reporting limits over the entire 12 year period.

5. Acknowledgements

This report was prepared by **Spencer Shute** (Oceanica) and reviewed by **Stephanie Turner** (Oceanica). The sediment sampling was undertaken by **Celeste Wilson**, **Kris Wienczugow** and **Dave Tunbridge** (MAFRL). Sample analysis was completed by MAFRL, with the exception of the particle size analysis (CSIRO Minerals) and the Pesticide and herbicide analysis (NMI). Figure preparation was completed by **Ewan Buckley** (Oceanica). Formatting of the report was completed by **Katy Rawlings** (Oceanica).

6. References

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Appendix A

Site Coordinates

Appendix A: Site Coordinates

WGS 84	Name	Easting	Northing	Site Depth
UTM Zone 53	OFF-1	369249	6502419	13.9 m
UTM Zone 52	OFF-2	369749	6501548	14.2 m
UTM Zone 51	OFF-3	370160	6500634	15.0 m
UTM Zone 54	OFF-4	370600	6499758	15.5 m
UTM Zone 55	OFF-5	371070	6498868	14.4 m
UTM Zone 56	OFF-6	371419	6497928	14.5 m
UTM Zone 62	NEAR-1	369881	6503540	10.3 m
UTM Zone 61	NEAR-2	370291	6502626	10.3 m
UTM Zone 60	NEAR-3	370758	6501742	12.3 m
UTM Zone 59	NEAR-4	371196	6500842	12.5 m
UTM Zone 58	NEAR-5	371578	6499916	9.7 m
UTM Zone 57	NEAR-6	371974	6498987	12.4 m

Appendix B

Laboratory reports-Particle Size Analysis

Appendix B: Laboratory reports-Particle Size Analysis

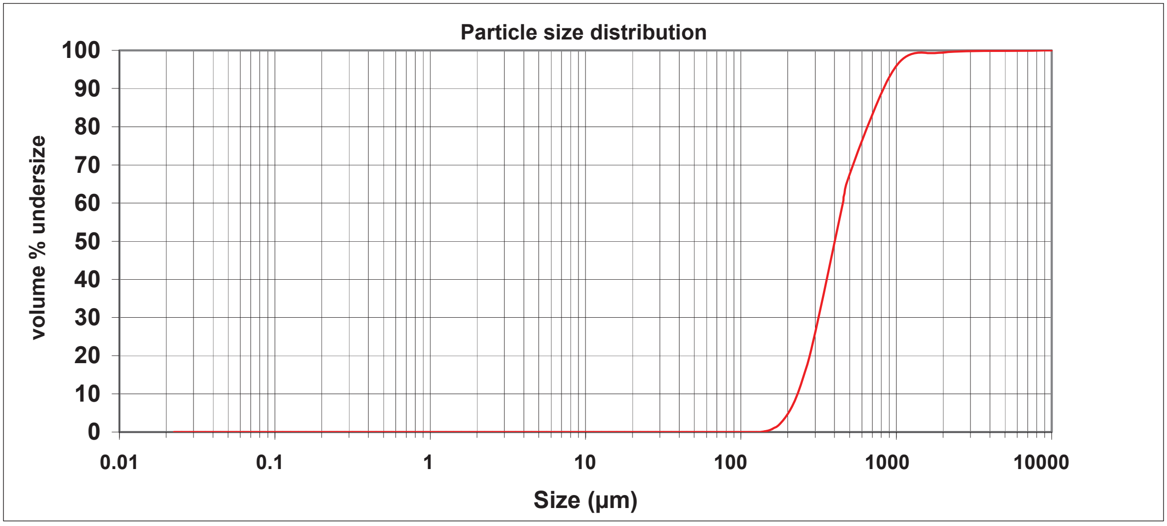
Analysis Report

CSIRO
Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 OFF 1.1
Batch No : R05866
PAS ID No : P46734

Analysis :	Size distribution by laser diffraction and wet sieving	**Result units:**	Volume
Dispersant:	Water	**Analysis model:**	General purpose
Additives:	10 millilitres sodium hexametaphosphate		
Sonication:	10 minutes ultrasonic bath		

Span:	1.38	**Vol. Wighted mean D[4,3]:**	485.50 µm	**d(0.1)**	220.00 µm
		Surface weighted mean D[3,2]	371.71 µm	**d(0.5)**	405.00 µm
				d(0.9)	780.00 µm



Size (µm)	Vol Under %
0.020	0.00
0.022	0.00
0.025	0.00
0.028	0.00
0.032	0.00
0.036	0.00
0.040	0.00
0.045	0.00
0.050	0.00
0.056	0.00
0.063	0.00
0.071	0.00
0.080	0.00
0.089	0.00
0.100	0.00
0.112	0.00
0.126	0.00

Size (µm)	Vol Under %
0.142	0.00
0.159	0.00
0.178	0.00
0.200	0.00
0.224	0.00
0.252	0.00
0.283	0.00
0.317	0.00
0.356	0.00
0.399	0.00
0.448	0.00
0.502	0.00
0.564	0.00
0.632	0.00
0.710	0.00
0.796	0.00
0.893	0.00

Size (µm)	Vol Under %
1.002	0.00
1.125	0.00
1.262	0.00
1.416	0.00
1.589	0.00
1.783	0.00
2.000	0.00
2.244	0.00
2.518	0.00
2.825	0.00
3.170	0.00
3.557	0.00
3.991	0.00
4.477	0.00
5.024	0.00
5.637	0.00
6.325	0.00

Size (µm)	Vol Under %
7.096	0.00
7.962	0.00
8.934	0.00
10.024	0.00
11.247	0.00
12.619	0.00
14.159	0.00
15.887	0.00
17.825	0.00
20.000	0.00
22.440	0.00
25.179	0.00
28.251	0.00
31.698	0.00
35.566	0.00
39.905	0.00
44.774	0.00

Size (µm)	Vol Under %
50.238	0.00
56.368	0.00
63.246	0.00
70.963	0.00
79.621	0.00
89.337	0.00
100.237	0.00
112.468	0.00
126.191	0.00
141.589	0.12
158.866	0.76
178.250	2.16
200.000	4.70
224.404	8.70
251.785	14.32
282.508	21.57
316.979	30.19

Size (µm)	Vol Under %
355.66	39.76
399.05	49.63
447.74	59.11
500.00	67.60
1000.00	95.90
2000.00	99.40
10000.00	100.00

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

Analysis Report

CSIRO
Division of Minerals
Particle Analysis Service

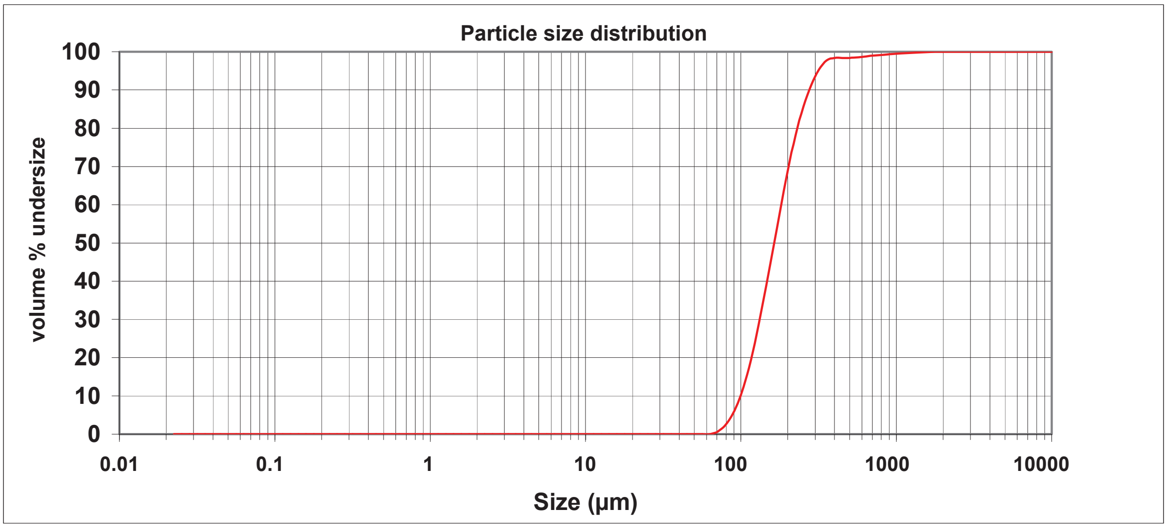
Sample Name : OCA 05-16 OFF 2.1

Batch No : R058666

PAS ID No : P46735

Analysis :	Size distribution by laser diffraction and wet sieving	**Result units:**	Volume
Dispersant:	Water	**Analysis model:**	General purpose
Additives:	10 millilitres sodium hexametaphosphate		
Sonication:	10 minutes ultrasonic bath		

Span:	1.03	**Vol. Wighted mean D[4,3]:**	185.29 µm	**d(0.1)**	100.00 µm
		Surface weighted mean D[3,2]	153.23 µm	**d(0.5)**	165.00 µm
				d(0.9)	270.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	97.72
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	98.36
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.03	447.74	98.40
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.71	500.00	98.40
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	2.40	1000.00	99.50
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	5.54	2000.00	100.00
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	10.48	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	17.34		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	26.07		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	36.24		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	47.27		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	58.40		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	68.89		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	78.10		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	85.64		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	91.33		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	95.28		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

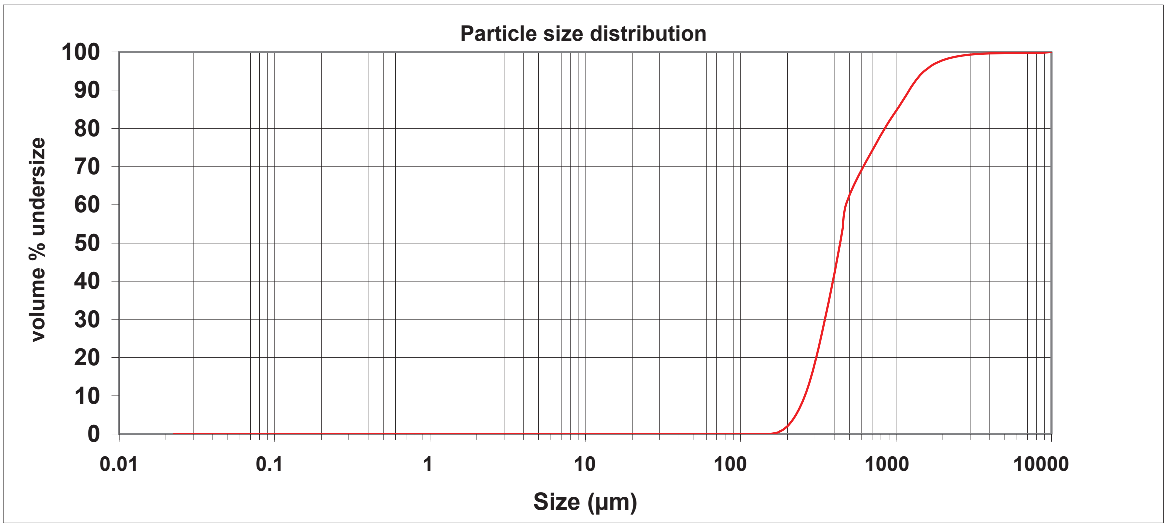
Analysis Report

CSIRO
Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 OFF 3.1
Batch No : R058666
PAS ID No : P46736

Analysis : Size distribution by laser diffraction and wet sieving
Result units: Volume
Dispersant: Water
Analysis model: General purpose
Additives: 10 millilitres sodium hexametaphosphate
Sonication: 10 minutes ultrasonic bath

Span: 2.32
Vol. Wighted mean D[4,3]: 642.69 µm
Surface weighted mean D[3,2] 426.25 µm
d(0.1) 250.00 µm
d(0.5) 410.00 µm
d(0.9) 1200.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	31.65
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	41.84
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	52.37
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	62.50
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	84.60
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	97.90
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.00		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	0.00		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	0.05		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	0.63		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	2.02		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	4.64		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	8.82		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	14.76		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	22.45		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

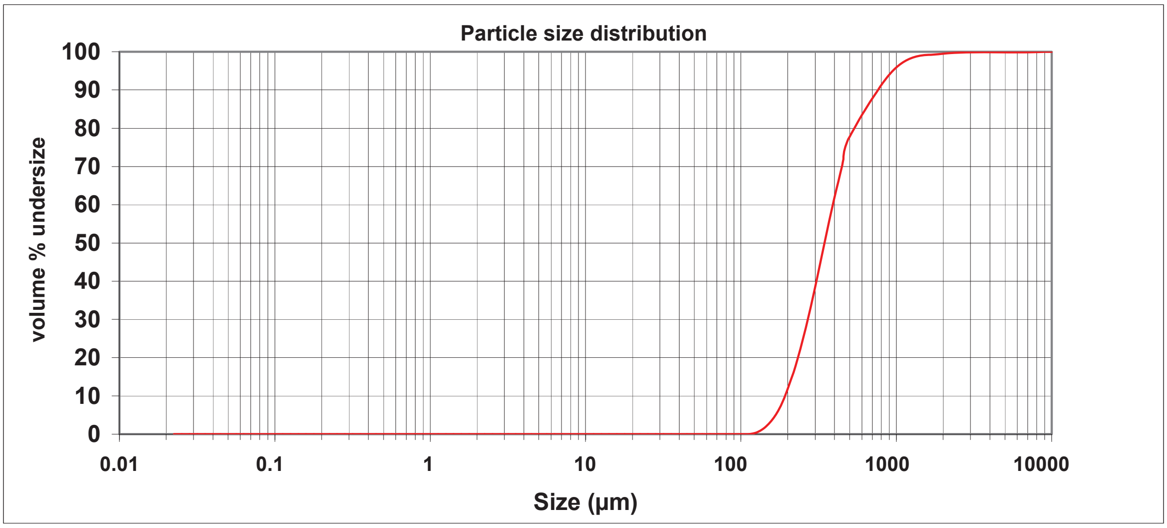
Analysis Report

CSIRO
Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 OFF 4.1
Batch No : R058666
PAS ID No : P46737

Analysis :	Size distribution by laser diffraction and wet sieving	**Result units:**	Volume
Dispersant:	Water	**Analysis model:**	General purpose
Additives:	10 millilitres sodium hexametaphosphate		
Sonication:	10 minutes ultrasonic bath		

Span:	1.47	**Vol. Wighted mean D[4,3]:**	433.64 µm	**d(0.1)**	190.00 µm
		Surface weighted mean D[3,2]	318.69 µm	**d(0.5)**	340.00 µm
				d(0.9)	690.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	52.54
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	61.81
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	70.36
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	77.80
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	95.90
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	99.50
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.44		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	1.63		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	3.75		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	7.08		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	11.76		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	17.85		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	25.27		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	33.79		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	43.03		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

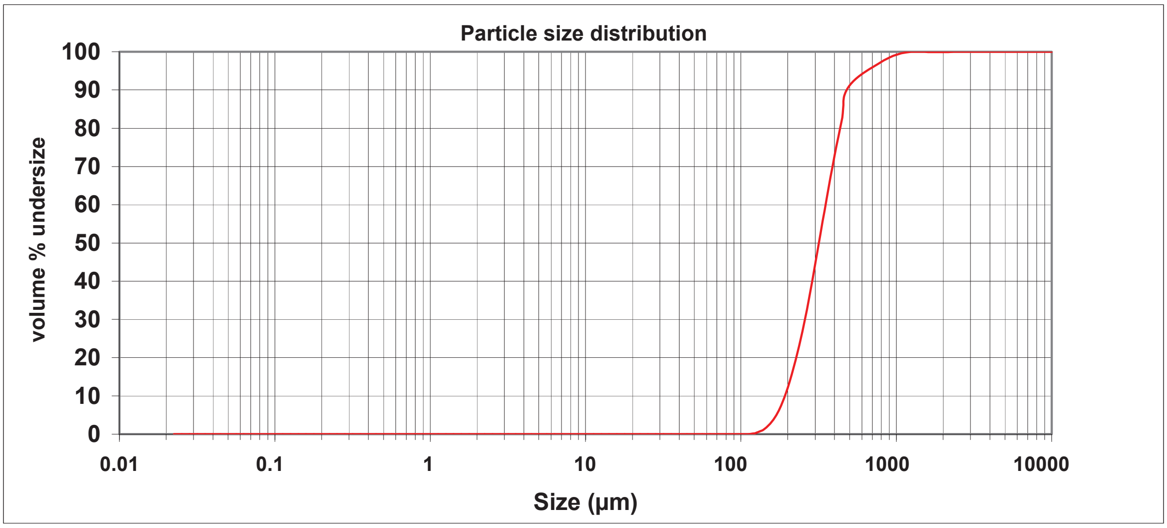
Analysis Report

Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 OFF 5.1
Batch No : R058666
PAS ID No : P46738

Analysis :	Size distribution by laser diffraction and wet sieving	**Result units:**	Volume
Dispersant:	Water	**Analysis model:**	General purpose
Additives:	10 millilitres sodium hexametaphosphate		
Sonication:	10 minutes ultrasonic bath		

Span:	0.94	**Vol. Wighted mean D[4,3]:**	355.95 µm	**d(0.1)**	190.00 µm
		Surface weighted mean D[3,2]	296.85 µm	**d(0.5)**	320.00 µm
				d(0.9)	490.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	61.48
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	72.68
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	82.75
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	91.20
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	99.20
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	99.90
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.32		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	1.34		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	3.40		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	6.88		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	12.10		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	19.19		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	28.07		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	38.47		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	49.83		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

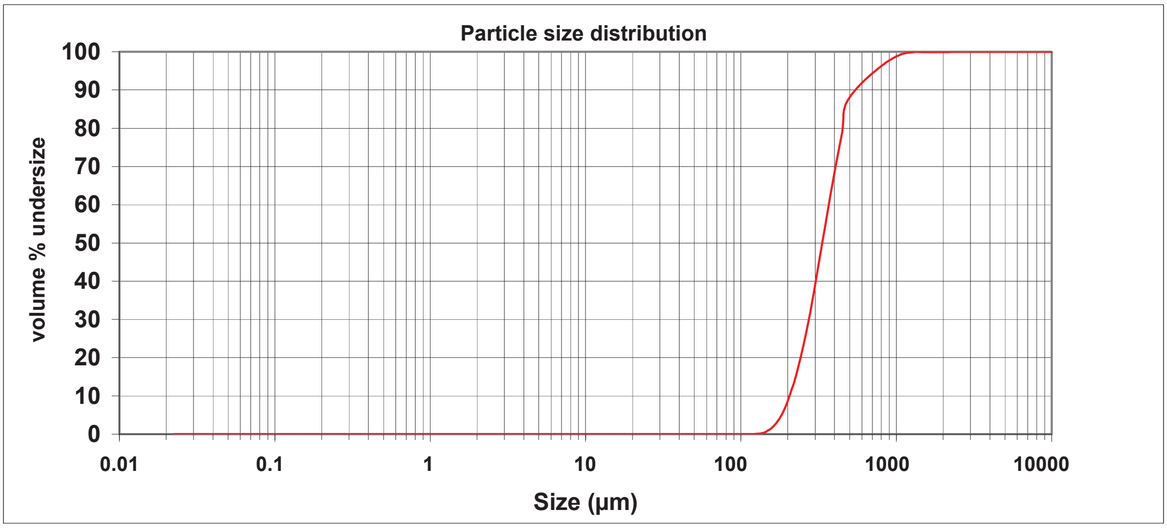
Analysis Report

Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 OFF 6.1
Batch No : R058666
PAS ID No : P46739

Analysis :	Size distribution by laser diffraction and wet sieving	**Result units:**	Volume
Dispersant:	Water	**Analysis model:**	General purpose
Additives:	10 millilitres sodium hexametaphosphate		
Sonication:	10 minutes ultrasonic bath		

Span:	0.87	**Vol. Wighted mean D[4,3]:**	379.42 µm	**d(0.1)**	200.00 µm
		Surface weighted mean D[3,2]	315.93 µm	**d(0.5)**	335.00 µm
				d(0.9)	490.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	56.61
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	68.36
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	79.06
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	88.10
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	98.80
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	99.90
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.04		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	0.41		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	1.74		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	4.33		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	8.62		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	14.88		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	23.15		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	33.24		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	44.63		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

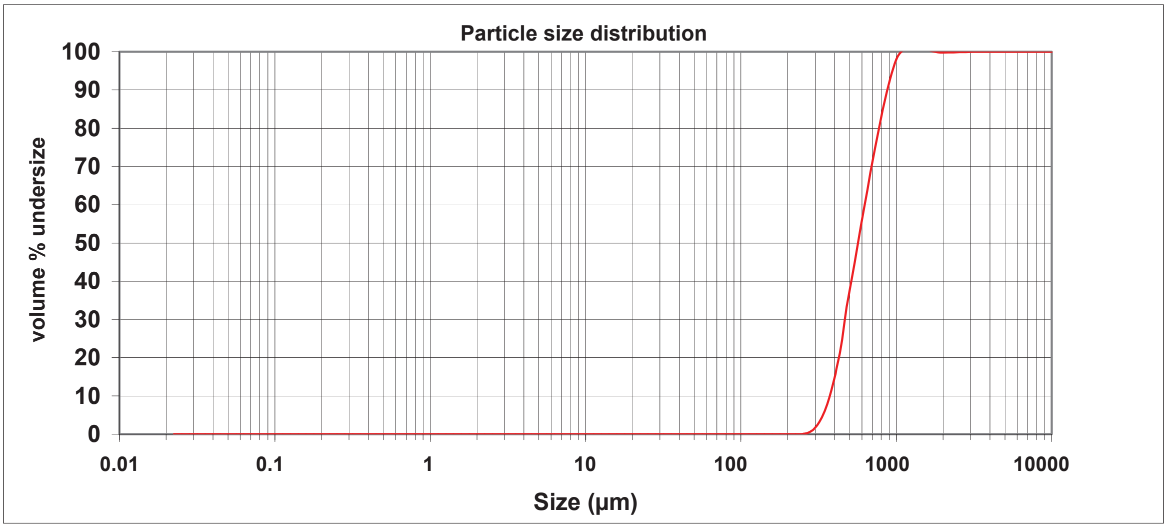
Analysis Report

CSIRO
Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 near 1.1
Batch No : R058666
PAS ID No : P46740

Analysis : Size distribution by laser diffraction and wet sieving
Result units: Volume
Dispersant: Water
Analysis model: General purpose
Additives: 10 millilitres sodium hexametaphosphate
Sonication: 10 minutes ultrasonic bath

Span:	0.95	**Vol. Wighted mean D[4,3]:**	617.21 µm	**d(0.1)**	360.00 µm
		Surface weighted mean D[3,2]	555.47 µm	**d(0.5)**	560.00 µm
				d(0.9)	890.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	7.36
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	14.66
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	24.95
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	37.60
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	98.00
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	99.80
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.00		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	0.00		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	0.00		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	0.00		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	0.00		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	0.00		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	0.06		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	0.81		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	2.93		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

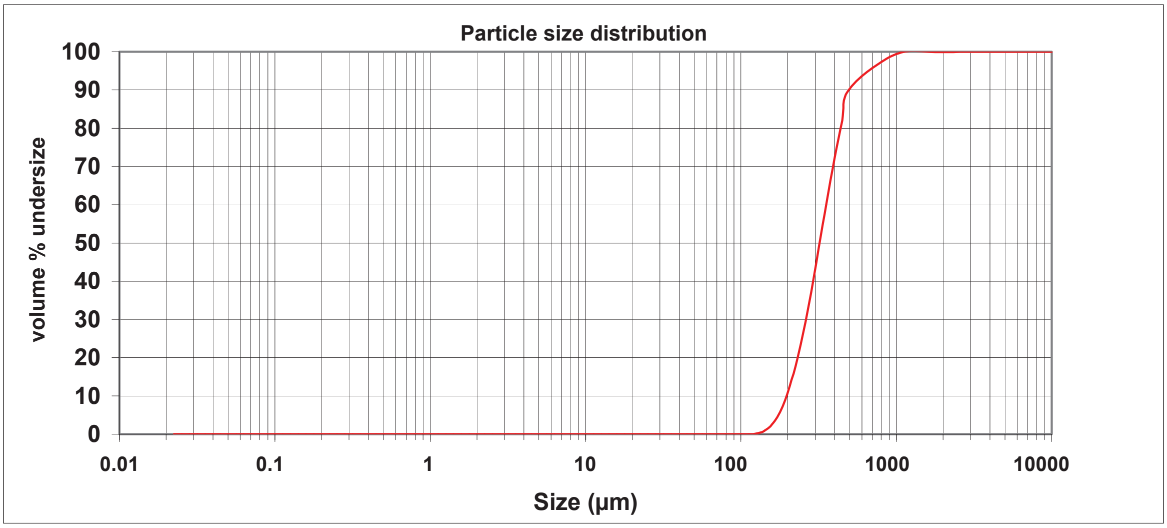
Analysis Report

Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 near 2.1
Batch No : R058666
PAS ID No : P46741

Analysis :	Size distribution by laser diffraction and wet sieving	**Result units:**	Volume
Dispersant:	Water	**Analysis model:**	General purpose
Additives:	10 millilitres sodium hexametaphosphate		
Sonication:	10 minutes ultrasonic bath		

Span:	0.86	**Vol. Wighted mean D[4,3]:**	359.07 µm	**d(0.1)**	195.00 µm
		Surface weighted mean D[3,2]	301.87 µm	**d(0.5)**	330.00 µm
				d(0.9)	480.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	60.61
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	71.95
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	82.05
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	90.40
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	99.40
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	99.90
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.15		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	0.88		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	2.63		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	5.81		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	10.79		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	17.76		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	26.66		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	37.19		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	48.75		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

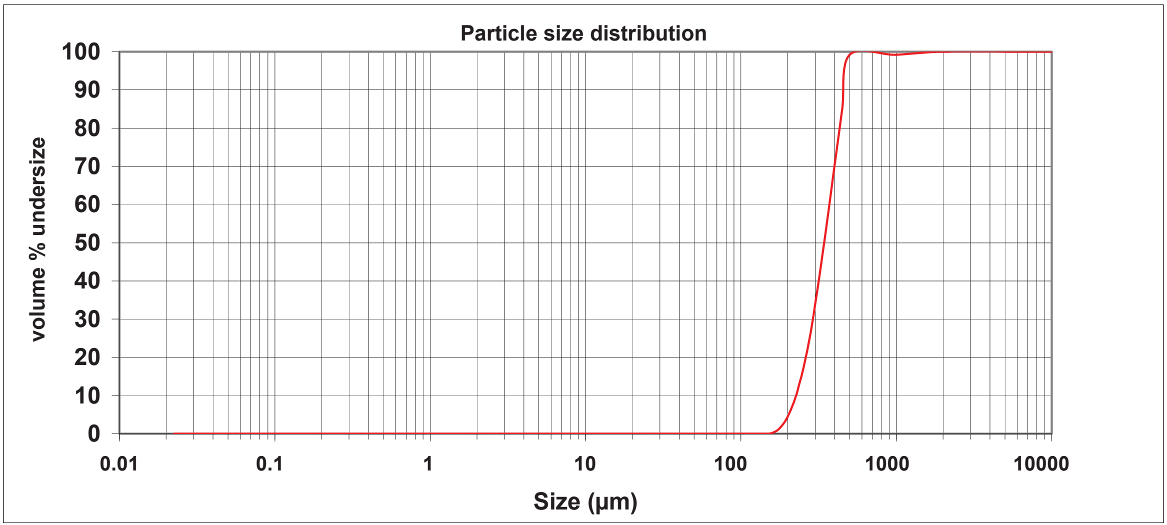
Analysis Report

Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 near 3.1
Batch No : R058666
PAS ID No : P46742

Analysis : Size distribution by laser diffraction and wet sieving
Result units: Volume
Dispersant: Water
Analysis model: General purpose
Additives: 10 millilitres sodium hexametaphosphate
Sonication: 10 minutes ultrasonic bath

Span: 0.70
Vol. Wighted mean D[4,3]: 354.17 µm
Surface weighted mean D[3,2] 321.54 µm
d(0.1) 220.00 µm
d(0.5) 320.00 µm
d(0.9) 445.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	54.55
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	69.91
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	85.13
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	99.20
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	99.20
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	100.00
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.00		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	0.00		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	0.21		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	1.55		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	4.47		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	9.53		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	17.14		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	27.41		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	40.07		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

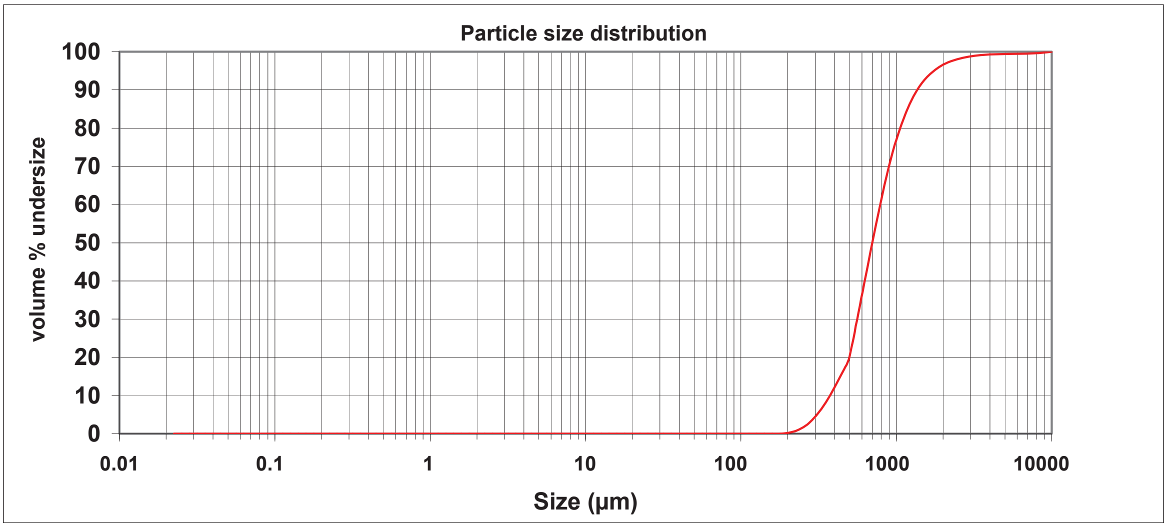
Analysis Report

Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 near 4.1
Batch No : R058666
PAS ID No : P46743

Analysis : Size distribution by laser diffraction and wet sieving
Result units: Volume
Dispersant: Water
Analysis model: General purpose
Additives: 10 millilitres sodium hexametaphosphate
Sonication: 10 minutes ultrasonic bath

Span: 1.57
Vol. Wighted mean D[4,3]: 792.73 µm
Surface weighted mean D[3,2] 553.98 µm
d(0.1) 350.00 µm
d(0.5) 635.00 µm
d(0.9) 1350.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	8.49
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	12.03
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	16.03
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	20.30
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	76.90
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	96.60
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.00		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	0.00		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	0.00		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	0.00		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	0.20		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	0.74		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	1.73		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	3.31		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	5.56		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

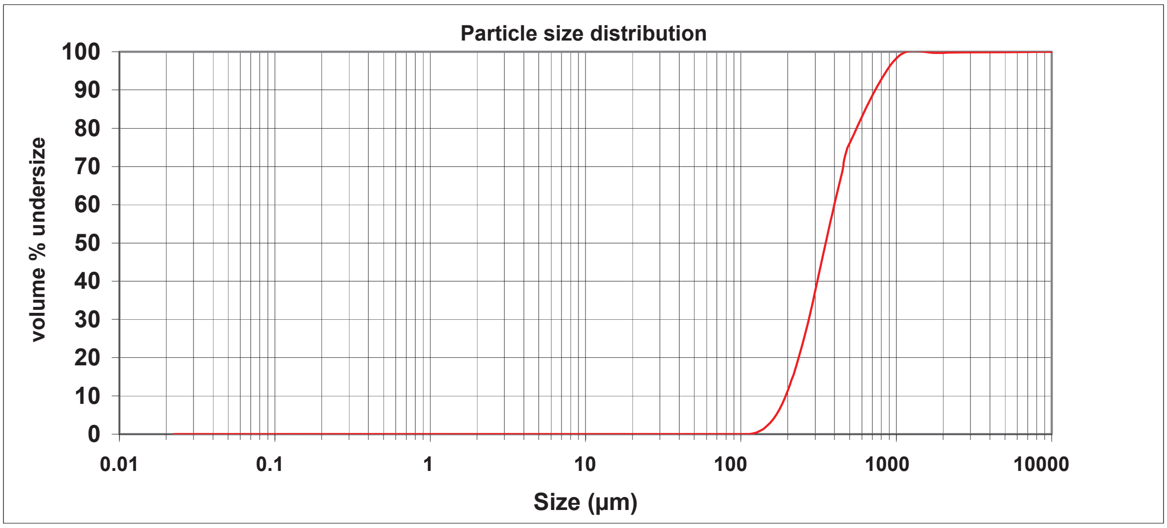
Analysis Report

Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 near 5.1
Batch No : R058666
PAS ID No : P46744

Analysis :	Size distribution by laser diffraction and wet sieving	**Result units:**	Volume
Dispersant:	Water	**Analysis model:**	General purpose
Additives:	10 millilitres sodium hexametaphosphate		
Sonication:	10 minutes ultrasonic bath		

Span:	1.40	**Vol. Wighted mean D[4,3]:**	418.07 µm	**d(0.1)**	190.00 µm
		Surface weighted mean D[3,2]	321.26 µm	**d(0.5)**	358.00 µm
				d(0.9)	690.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	51.04
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	60.18
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	68.65
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	76.10
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	98.30
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	99.70
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.43		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	1.57		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	3.60		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	6.80		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	11.32		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	17.22		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	24.41		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	32.70		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	41.72		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

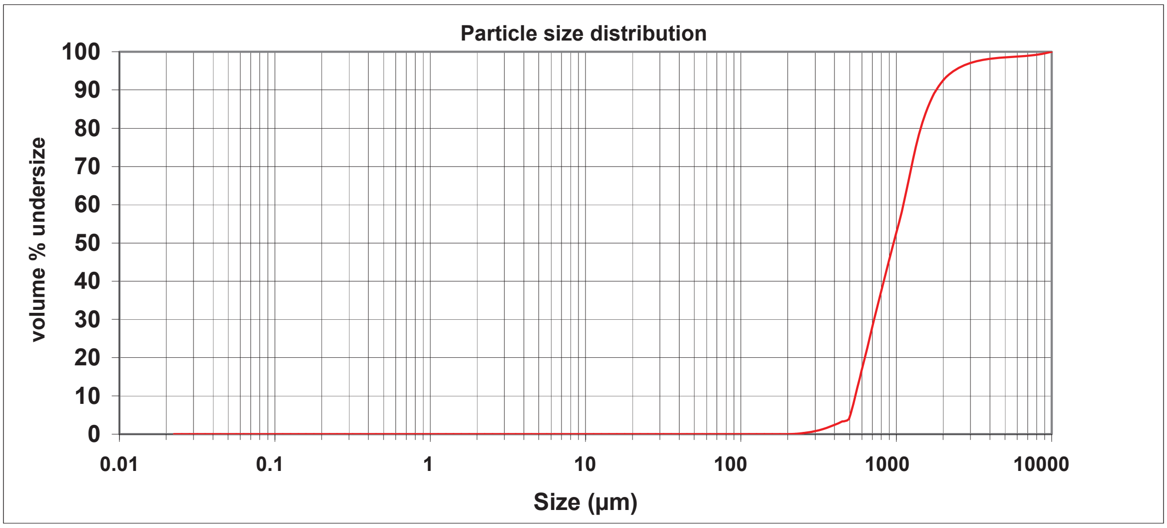
Analysis Report

CSIRO
Division of Minerals
Particle Analysis Service

Sample Name : OCA 05-16 near 6.1
Batch No : R058666
PAS ID No : P46745

Analysis :	Size distribution by laser diffraction and wet sieving	**Result units:**	Volume
Dispersant:	Water	**Analysis model:**	General purpose
Additives:	10 millilitres sodium hexametaphosphate		
Sonication:	10 minutes ultrasonic bath		

Span:	1.33	**Vol. Wighted mean D[4,3]:**	1043.35 µm	**d(0.1)**	540.00 µm
		Surface weighted mean D[3,2]	663.70 µm	**d(0.5)**	950.00 µm
				d(0.9)	1800.00 µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.00	7.096	0.00	50.238	0.00	355.66	1.62
0.022	0.00	0.159	0.00	1.125	0.00	7.962	0.00	56.368	0.00	399.05	2.39
0.025	0.00	0.178	0.00	1.262	0.00	8.934	0.00	63.246	0.00	447.74	3.29
0.028	0.00	0.200	0.00	1.416	0.00	10.024	0.00	70.963	0.00	500.00	4.30
0.032	0.00	0.224	0.00	1.589	0.00	11.247	0.00	79.621	0.00	1000.00	52.60
0.036	0.00	0.252	0.00	1.783	0.00	12.619	0.00	89.337	0.00	2000.00	92.50
0.040	0.00	0.283	0.00	2.000	0.00	14.159	0.00	100.237	0.00	10000.00	100.00
0.045	0.00	0.317	0.00	2.244	0.00	15.887	0.00	112.468	0.00		
0.050	0.00	0.356	0.00	2.518	0.00	17.825	0.00	126.191	0.00		
0.056	0.00	0.399	0.00	2.825	0.00	20.000	0.00	141.589	0.00		
0.063	0.00	0.448	0.00	3.170	0.00	22.440	0.00	158.866	0.00		
0.071	0.00	0.502	0.00	3.557	0.00	25.179	0.00	178.250	0.00		
0.080	0.00	0.564	0.00	3.991	0.00	28.251	0.00	200.000	0.01		
0.089	0.00	0.632	0.00	4.477	0.00	31.698	0.00	224.404	0.09		
0.100	0.00	0.710	0.00	5.024	0.00	35.566	0.00	251.785	0.26		
0.112	0.00	0.796	0.00	5.637	0.00	39.905	0.00	282.508	0.56		
0.126	0.00	0.893	0.00	6.325	0.00	44.774	0.00	316.979	1.01		

Note: Data from 500µm to 10000µm by wet screening, from 0.02µm to 500µm by laser diffraction.

Appendix C

Normal level pesticide and herbicide laboratory analysis reports

Australian Government

National Measurement Institute

REPORT OF ANALYSIS

Report No. RN476443

Client	: OCEANICA CONSULTING P O BOX 3172 LPO BROADWAY NEDLANDS WA 6009	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: OCEA26/050211 : QT-00782 : : 9-FEB-2005 : 9-FEB-2005
Attention	: STEPHANIE TURNER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: BRIAN WOODWARD	**Phone**	: (02) 94490151

Lab Reg No.	Sample Ref	Sample Description
W05/002174	NEAR 1.1	MARINE SEDIMENT
W05/002175	NEAR 2.1	MARINE SEDIMENT
W05/002176	NEAR 3.1	MARINE SEDIMENT
W05/002177	NEAR 4.1	MARINE SEDIMENT

Lab Reg No.		W05/002174	W05/002175	W05/002176	W05/002177	
Sample Reference	**Units**	**NEAR 1.1**	**NEAR 2.1**	**NEAR 3.1**	**NEAR 4.1**	**Method**
Organochlorine (OC) Pesticides						
HCB	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Heptachlor	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Heptachlor epoxide	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Aldrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
gamma-BHC (Lindane)	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
alpha-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
beta-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
delta-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
trans-Chlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
cis-Chlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Oxychlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Dieldrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDE	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDD	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDT	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin Aldehyde	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin Ketone	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
alpha-Endosulfan	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
beta-Endosulfan	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endosulfan Sulfate	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Methoxychlor	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Triazine Herbicides						
Atrazine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Hexazinone	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Metribuzine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Prometryne	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Simazine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19

REPORT OF ANALYSIS

Report No. RN476443

Lab Reg No.		W05/002174	W05/002175	W05/002176	W05/002177	
Sample Reference	**Units**	**NEAR 1.1**	**NEAR 2.1**	**NEAR 3.1**	**NEAR 4.1**	**Method**
Organophosphate (OP) Pesticides						
Dichlorvos	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Demeton-S-Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Diazinon	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Dimethoate	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorpyrifos	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorpyrifos Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Malathion (Maldison)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Fenthion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Ethion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Fenitrothion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorfenvinphos (E)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorfenvinphos (Z)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Parathion (Ethyl)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Parathion Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Pirimiphos Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Pirimiphos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Azinphos-Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Azinphos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Surrogate						
Surrogate OC Rec.	%	98	98	95	107	NR_19
Surrogate OP Rec.	%	90	96	86	104	NR_19
Dates						
Date extracted		11-FEB-2005	11-FEB-2005	11-FEB-2005	11-FEB-2005	
Date analysed		14-FEB-2005	14-FEB-2005	14-FEB-2005	14-FEB-2005	

Danny Slee, Section Manager
Organics - NSW, (Accreditation No: 198)

23-FEB-2005

Lab Reg No.		W05/002174	W05/002175	W05/002176	W05/002177	
Sample Reference	**Units**	**NEAR 1.1**	**NEAR 2.1**	**NEAR 3.1**	**NEAR 4.1**	**Method**
Trace Elements						
Total Solids	%	82.1	74.9	78.1	77.6	NT2_49

REPORT OF ANALYSIS

Report No. RN476443

Lab Reg No.		W05/002174	W05/002175	W05/002176	W05/002177	
Sample Reference	Units	NEAR 1.1	NEAR 2.1	NEAR 3.1	NEAR 4.1	Method

Dr Honway Louie, Section Manager
Inorganics - NSW, (Accreditation No: 198)

23-FEB-2005

REPORT OF ANALYSIS

Report No. RN476443

Client	: OCEANICA CONSULTING P O BOX 3172 LPO BROADWAY NEDLANDS WA 6009	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: OCEA26/050211 : QT-00782 : : 9-FEB-2005 : 9-FEB-2005
Attention	: STEPHANIE TURNER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: BRIAN WOODWARD	**Phone**	: (02) 94490151

Lab Reg No.	Sample Ref	Sample Description
W05/002178	NEAR 5.1	MARINE SEDIMENT
W05/002179	NEAR 6.1	MARINE SEDIMENT
W05/002180	OFF 1.1	MARINE SEDIMENT
W05/002181	OFF 2.1	MARINE SEDIMENT

Lab Reg No.		**W05/002178**	**W05/002179**	**W05/002180**	**W05/002181**	
Sample Reference	**Units**	**NEAR 5.1**	**NEAR 6.1**	**OFF 1.1**	**OFF 2.1**	**Method**
Organochlorine (OC) Pesticides						
HCB	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Heptachlor	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Heptachlor epoxide	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Aldrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
gamma-BHC (Lindane)	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
alpha-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
beta-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
delta-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
trans-Chlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
cis-Chlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Oxychlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Dieldrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDE	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDD	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDT	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin Aldehyde	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin Ketone	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
alpha-Endosulfan	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
beta-Endosulfan	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endosulfan Sulfate	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Methoxychlor	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Triazine Herbicides						
Atrazine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Hexazinone	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Metribuzine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Prometryne	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Simazine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Organophosphate (OP) Pesticides						
Dichlorvos	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19

REPORT OF ANALYSIS

Report No. RN476443

Lab Reg No.		**W05/002178**	**W05/002179**	**W05/002180**	**W05/002181**	
Sample Reference	**Units**	**NEAR 5.1**	**NEAR 6.1**	**OFF 1.1**	**OFF 2.1**	**Method**
Organophosphate (OP) Pesticides						
Demeton-S-Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Diazinon	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Dimethoate	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorpyrifos	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorpyrifos Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Malathion (Maldison)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Fenthion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Ethion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Fenitrothion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorfenvinphos (E)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorfenvinphos (Z)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Parathion (Ethyl)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Parathion Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Pirimiphos Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Pirimiphos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Azinphos-Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Azinphos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Surrogate						
Surrogate OC Rec.	%	96	98	95	98	NR_19
Surrogate OP Rec.	%	87	105	87	82	NR_19
Dates						
Date extracted		11-FEB-2005	11-FEB-2005	11-FEB-2005	11-FEB-2005	
Date analysed		14-FEB-2005	14-FEB-2005	14-FEB-2005	14-FEB-2005	

Danny Slee, Section Manager
Organics - NSW, (Accreditation No: 198)

23-FEB-2005

Lab Reg No.		**W05/002178**	**W05/002179**	**W05/002180**	**W05/002181**	
Sample Reference	**Units**	**NEAR 5.1**	**NEAR 6.1**	**OFF 1.1**	**OFF 2.1**	**Method**
Trace Elements						
Total Solids	%	70.4	72.5	76.1	68.9	NT2_49

Dr Honway Louie, Section Manager
Inorganics - NSW, (Accreditation No: 198)

23-FEB-2005

REPORT OF ANALYSIS

Report No. RN476443

Client	: OCEANICA CONSULTING P O BOX 3172 LPO BROADWAY NEDLANDS WA 6009	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: OCEA26/050211 : QT-00782 : : 9-FEB-2005 : 9-FEB-2005
Attention	: STEPHANIE TURNER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: BRIAN WOODWARD	**Phone**	: (02) 94490151

Lab Reg No.	Sample Ref	Sample Description
W05/002182	OFF 3.1	MARINE SEDIMENT
W05/002183	OFF 4.1	MARINE SEDIMENT
W05/002184	OFF 5.1	MARINE SEDIMENT
W05/002185	OFF 6.1	MARINE SEDIMENT

Lab Reg No.		**W05/002182**	**W05/002183**	**W05/002184**	**W05/002185**	
Sample Reference	**Units**	**OFF 3.1**	**OFF 4.1**	**OFF 5.1**	**OFF 6.1**	**Method**
Organochlorine (OC) Pesticides						
HCB	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Heptachlor	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Heptachlor epoxide	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Aldrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
gamma-BHC (Lindane)	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
alpha-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
beta-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
delta-BHC	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
trans-Chlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
cis-Chlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Oxychlordane	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Dieldrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDE	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDD	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
pp-DDT	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin Aldehyde	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endrin Ketone	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
alpha-Endosulfan	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
beta-Endosulfan	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Endosulfan Sulfate	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Methoxychlor	mg/kg	<0.010	<0.010	<0.010	<0.010	NR_19
Triazine Herbicides						
Atrazine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Hexazinone	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Metribuzine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Prometryne	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Simazine	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Organophosphate (OP) Pesticides						
Dichlorvos	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19

REPORT OF ANALYSIS

Report No. RN476443

Lab Reg No.		W05/002182	W05/002183	W05/002184	W05/002185	
Sample Reference	Units	OFF 3.1	OFF 4.1	OFF 5.1	OFF 6.1	Method
Organophosphate (OP) Pesticides						
Demeton-S-Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Diazinon	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Dimethoate	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorpyrifos	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorpyrifos Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Malathion (Maldison)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Fenthion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Ethion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Fenitrothion	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorfenvinphos (E)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Chlorfenvinphos (Z)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Parathion (Ethyl)	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Parathion Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Pirimiphos Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Pirimiphos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Azinphos-Methyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Azinphos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	NR_19
Surrogate						
Surrogate OC Rec.	%	90	92	92	93	NR_19
Surrogate OP Rec.	%	82	80	83	75	NR_19
Dates						
Date extracted		11-FEB-2005	11-FEB-2005	11-FEB-2005	11-FEB-2005	
Date analysed		14-FEB-2005	14-FEB-2005	14-FEB-2005	14-FEB-2005	

Danny Slee, Section Manager
Organics - NSW, (Accreditation No: 198)

23-FEB-2005

Lab Reg No.		W05/002182	W05/002183	W05/002184	W05/002185	
Sample Reference	Units	OFF 3.1	OFF 4.1	OFF 5.1	OFF 6.1	Method
Trace Elements						
Total Solids	%	80.1	76.4	77.9	77.4	NT2_49

Dr Honway Louie, Section Manager
Inorganics - NSW, (Accreditation No: 198)

23-FEB-2005

REPORT OF ANALYSIS

All results are expressed on a dry weight basis. TE ref 05SM19-01.

This Laboratory is accredited by the National Association of Testing Authorities, Australia.
The tests reported herein have been performed in accordance with its scope of accreditation.
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NATA Accredited Laboratory
Number: 198

Sample/s analysed as received.
This Report supersedes reports: *RN476187* *RN476373*

Australian Government

National Measurement Institute

QUALITY ASSURANCE REPORT

Client: Oceanica Consulting **NMI Job No : OCEA26/050211**

Sample Matrix: Soil

Analyte	LOR	Blank	LCS	Sample Duplicates			Matrix Spike
			Recovery	Sample	Duplicate	RPD	Recovery
	mg/kg	mg/kg	%	mg/kg	mg/kg	%	%
OC Pesticides				**W05/002184**			**Blank Soil**
HCB	0.010	<0.010	-	<0.010	<0.010	-	-
Heptachlor	0.010	<0.010	108	<0.010	<0.010	-	106
Heptachlor epoxide	0.010	<0.010	-	<0.010	<0.010	-	-
Aldrin	0.010	<0.010	104	<0.010	<0.010	-	110
gamma-BHC (Lindane)	0.010	<0.010	104	<0.010	<0.010	-	106
alpha-BHC	0.010	<0.010	-	<0.010	<0.010	-	-
beta-BHC	0.010	<0.010	-	<0.010	<0.010	-	-
delta-BHC	0.010	<0.010	-	<0.010	<0.010	-	-
trans-Chlordane	0.010	<0.010	-	<0.010	<0.010	-	-
cis-Chlordane	0.010	<0.010	-	<0.010	<0.010	-	-
Oxychlordane	0.010	<0.010	-	<0.010	<0.010	-	-
Dieldrin	0.010	<0.010	148	<0.010	<0.010	-	130
pp-DDE	0.010	<0.010	-	<0.010	<0.010	-	-
pp-DDD	0.010	<0.010	-	<0.010	<0.010	-	-
pp-DDT	0.010	<0.010	120	<0.010	<0.010	-	110
Endrin	0.010	<0.010	108	<0.010	<0.010	-	108
Endrin Aldehyde	0.010	<0.010	-	<0.010	<0.010	-	-
Endrin Ketone	0.010	<0.010	-	<0.010	<0.010	-	-
alpha-Endosulfan	0.010	<0.010	-	<0.010	<0.010	-	-
beta-Endosulfan	0.010	<0.010	-	<0.010	<0.010	-	-
Endosulfan Sulfate	0.010	<0.010	-	<0.010	<0.010	-	-
Methoxychlor	0.010	<0.010	-	<0.010	<0.010	-	-
Surrogate OC Rec.		99	86	92	89	3.3	89
OP Pesticides				**W05/002184**			**Blank Soil**
Dichlorvos	0.10	<0.10	-	<0.10	<0.10	-	-
Demeton-S-Methyl	0.10	<0.10	-	<0.10	<0.10	-	-
Diazinon	0.10	<0.10	125	<0.10	<0.10	-	120
Dimethoate	0.10	<0.10	-	<0.10	<0.10	-	
Chlorpyrifos	0.10	<0.10	113	<0.10	<0.10	-	116
Chlorpyrifos Methyl	0.10	<0.10	-	<0.10	<0.10	-	-
Malathion (Maldison)	0.10	<0.10	-	<0.10	<0.10	-	-
Fenthion	0.10	<0.10	-	<0.10	<0.10	-	-
Ethion	0.10	<0.10	122	<0.10	<0.10	-	118
Fenitrothion	0.10	<0.10	-	<0.10	<0.10	-	-
Chlorfenvinphos (E)	0.10	<0.10	-	<0.10	<0.10	-	-
Chlorfenvinphos (Z)	0.10	<0.10	-	<0.10	<0.10	-	-
Parathion (Ethyl)	0.10	<0.10	108	<0.10	<0.10	-	112
Parathion Methyl	0.10	<0.10	-	<0.10	<0.10	-	-
Pirimiphos Ethyl	0.10	<0.10	-	<0.10	<0.10	-	-
Pirimiphos Methyl	0.10	<0.10	-	<0.10	<0.10	-	-
Azinphos Methyl	0.10	<0.10	-	<0.10	<0.10	-	-
Azinphos Ethyl	0.10	<0.10	-	<0.10	<0.10	-	
Surrogate OP Rec.		98	92	83	78	6.2	92

LCS = Laboratory Control Spike
Results expressed in percentage (%) or mg/kg wherever appropriate.
' - ' = Not Applicable.
Method used : AGAL Method NR19
Acceptable Spike recovery is 40-150% (For OC Compounds).
Acceptable Spike recovery is 40-150% (For OP Compounds).
Acceptable RPD (Relative Percentage Difference) on Spikes and Duplicates is 40%.
QA No : PESTS959g

Signed:

F.S.

Danny Slee, Senior Chemist,
Environmental

Date: **23/02/2005**

Send results and invoice to
Stephanie Turner
Oceanica Consulting
PO Box 3172
LPO Broadway
Nedlands
WA 6009

Chain of Custody

Marine and Freshwater Research Laboratory

Murdoch University
Environmental Science
Murdoch, Western Australia 6150

Upon Receipt of samples please fax back to MAFRL on Fax: (08) 93606613 Ph: (08) 9360 2907

Date Received:	Date Sampled: 9/2/05	Send Results to:
Time Received	Sampled by: MAFRL	
Received by:	Client:	
File Code: OCA05-16	Phone/Fax:	Student Project: (Yes / No)
Data Sent:	Account:	Invoiced:

Sample Preservation: None / Warm / Cool / On Ice / Frozen / Acidified / Other

Sample Type: Water / Bore / Fresh / Estuarine / Marine / Brine / Plant / Sediment / Soil / Other

No	Sample Code	Sampling Date	Analysis Required							
			CC	CP	triazines					
1	Near 1-1	9/2/05					W05/002174			
2	Near 2-1						W05/002175			
3	Near 3-1						W05/002176			
4	Near 4-1						W05/002177			
5	Near 5-1						W05/002178			
6	Near 6-1						W05/002179			
7	Off 1-1						W05/002180			
8	Off 2-1						W05/002181			
9	Off 3-1						W05/002182			
10	Off 4-1						W05/002183			
11	Off 5-1						W05/002184			
12	Off 6-1						W05/002185			
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Appendix D

Low level pesticide and herbicide laboratory analysis reports

Appendix D: Low level pesticide and herbicide laboratory reports

	1-NEAR	3-NEAR	5-NEAR	1-OFF	3-OFF	5-OFF
Organochlorine (OC) Pesticides (mg/kg)						
HCB	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Heptachlor	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Heptachlor epoxide	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Aldrin	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
gamma-BHC (Lindane)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
alpha-BHC	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
beta-BHC	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
delta-BHC	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
trans-Chlordane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
cis-Chlordane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Oxychlordane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Dieldrin	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
pp-DDE	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
pp-DDD	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
pp-DDT	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Endrin	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Endrin Aldehyde	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Endrin Ketone	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
alpha-Endosulfan	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
beta-Endosulfan	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Endosulfan Sulfate	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Methoxychlor	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Triazine Herbicides (mg/kg)						
Atrazine	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Hexazinone	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Metribuzine	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Prometryne	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Simazine	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Organophosphate (OP) Pesticides (mg/kg)						
Dichlorvos	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Demeton-S-Methyl	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Diazinon	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Dimethoate	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chlorpyrifos	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chlorpyrifos Methyl	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Malathion (Maldison)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Fenthion	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ethion	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Fenitrothion	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chlorfenvinphos (E)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chlorfenvinphos (Z)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Parathion (Ethyl)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Parathion Methyl	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Pirimiphos Methyl	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Pirimiphos Ethyl	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Azinphos-Methyl	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Azinphos Ethyl	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Note: ISQG-low concentrations for the following compounds fall below reporting limit (ISQG-low in brackets):

Chlordane (0.0005 mg/kg), dieldrin (0.00002 mg/kg), endrin (0.00002 mg/kg), lindane (0.00032 mg/kg)

Oceanica Consulting Pty Ltd

99 Broadway, Nedlands. PO Box 3172, Broadway, Nedlands, Western Australia 6009

Tel: (08) 9389 9669 Fax: (08) 9389 9660 oceanica@oceanica.com.au ABN 89 093 752 811

APPENDIX H - ALKIMOS OUTFALL DREDGE MANAGEMENT PLAN

HYDRODYNAMIC AND SEDIMENT TRANSPORT MODELLING OF DREDGE PLUME

WorleyParsons

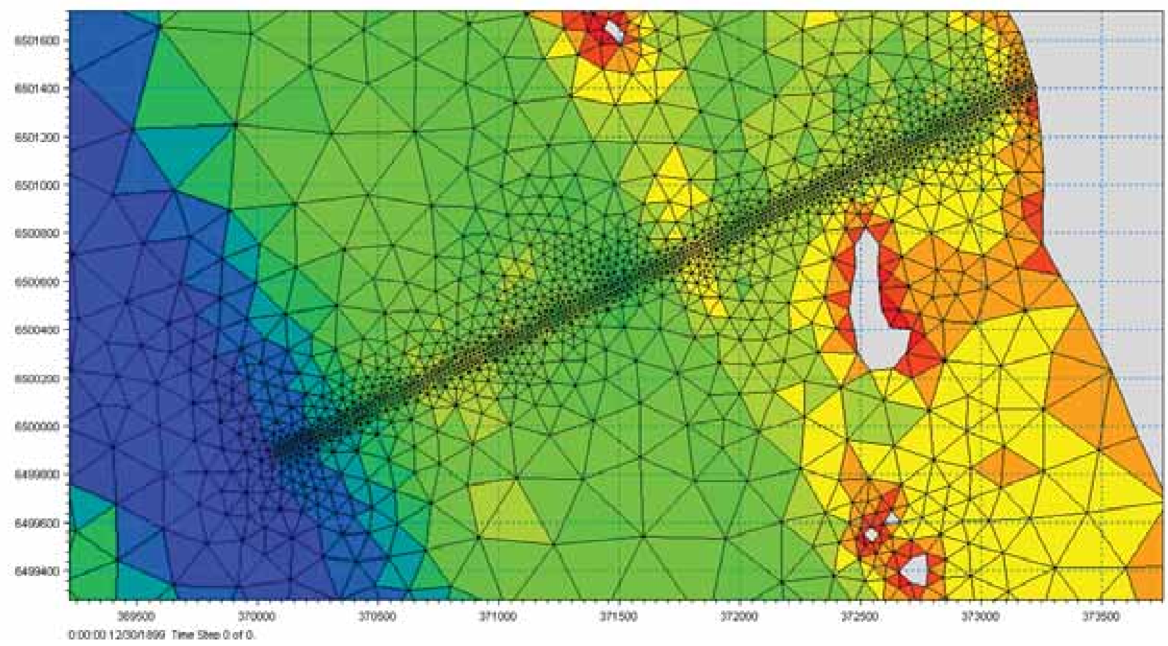
resources & energy

ALKIMOS ALIANCE

HYDRODYNAMIC, SEDIMENT TRANSPORT, AND LIGHT MODELLING OF DREDGE PLUME

ALKIMOS OUTFALL DREDGE MANAGEMENT PLAN

HYDRODYNAMIC AND SEDIMENT TRANSPORT MODELLING OF DREDGE PLUME



301012-00064/0

28-Jul-08

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resources & energy

ALKIMOS ALIANCE

HYDRODYNAMIC, SEDIMENT TRANSPORT, AND LIGHT MODELLING OF DREDGE PLUME

SYNOPSIS

This technical report summarises the results fo hydrodynamic, wave, sediment transport, and light modeling performed in support of the MPCOOP.

Disclaimer

1 INTRODUCTION

The Alkimos Aliance has engaged Worley Parsons Ltd. to provide assistance with a dredge management plan associated with the construction of the Alkimos Outfall pipeline under the terms defined in the proposal dated on 18 February 2008.

As outlined below, this document reports the following items of the detailed hydrodynamic and sediment transport modeling, scoped in Task 1 of the proposal:

- Rework and refine the existing models to provide the integrated modelling framework using the DHI Mike3 system
- Calibrate the wave and current models to early field data obtained from two wave and current monitoring locations at the site
- Determine expected material characteristics for the dredging program, match with methodology and define timing and progression
- Model the proposed dredging program under calibrated hydrodynamic conditions
- Model the light attenuation likely to result from the predicted suspended sediment concentrations.

2 MODELLING APPROACH

The modeling was designed to simulate the dispersion of sediments in response to the dredging operations for the Alkimos outfall pipeline. The final goal of this modeling exercise was to provide evolution maps (patterns) of dredged sediments in the water column (dispersion) and evolution maps of dredged sediments deposition onto the sea bed. These results were ultimately used as a basis for assessment of potential impacts of the dredged material to the light climate of the Alkimos reef region (hereafter also referred as to the Alkimos Local Area).

The modeling framework consisted of a three-dimensional (3-D) hydrodynamic model and a 2-D spectral wave model as drivers for a sediment transport model in the area adjacent to the pipeline location, including the 50 Km^2 management area. To properly reproduce swell and storm conditions in the local area, the wave model received an input from a larger scale wave model of the Indian Ocean. A schematic of this approach is sketched in Figure 2-1.

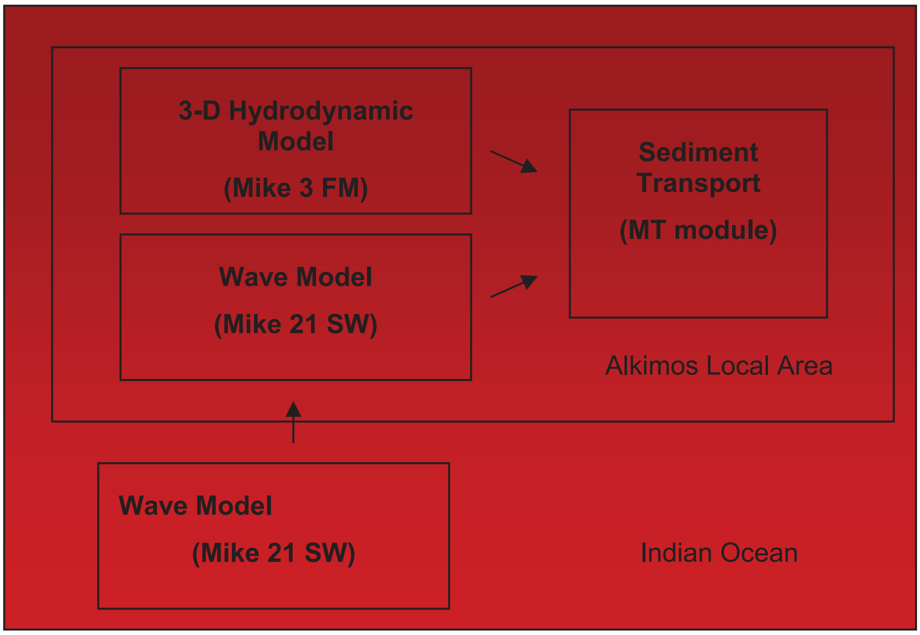

Figure 2-1: Schematic of the modeling approach used in this work.

A subset of the DHI Mike Series models is used for the modeling. The Mike 3 MT module (hereafter MT) was used to simulate the sediment transport in the Alkimos local area (DHI 2007a). In this study, the MT model simulated the effects of transport, deposition, and re-suspension of the dredged material. The suspension and movement of the dredged material in the water column is subject to the effects of the water flow and turbulence as provided by the hydrodynamic and wave models. The ocean bed is idealized as having a layer that is susceptible to erosional processes. This layer may have several fractions of sediment classes.

The 3-D hydrodynamic model, called Mike 3D FM, provides a numerical solution of the Navier Stokes equations with a hydrostatic approximation for the vertical momentum equation (DHI 2007b). The model simulates the water velocities and mass transport in a coastal area subject to wind stress tidal forcing, and bottom drag. The water is considered homogeneous (there is no density stratification) and a Smagorinsky and a k-e turbulence closure scheme is used to model the eddy viscosities in the horizontal and vertical directions, respectively. Dispersive transport (used for the sediments) is scaled with the viscosity results of the closure scheme (DHI 2007a). A flexible (unstructured) mesh in the horizontal with a sigma vertical coordinate system is used to represent and discretise the domain, allowing for better design of model resolution in the proximities of the pipeline and in the shallow reef areas.

The spectral wave model Mike 21 SW is used for the simulation of the wave field in the local Alkimos region and in the Indian Ocean Model (DHI 2007c). Mike21 SW solves the wave action conservation equation using the directional-frequency wave action spectrum as the dependent variable. The model simulates growth, decay and transformation of wind-generated waves and swells in offshore and coastal areas. It includes non-linear wave-wave interaction, dissipation due to white capping, bottom friction and depth induced wave breaking, and refraction and shoaling due to depth variation. The mesh configuration for the Alkimos local region used in Mike 21 SW is the same mesh used in Mike 3D FM.

The light climate was modelled using the Hydrolight© 4.3 model (Mobley 2006). This model calculates the radiative transfer equation using an invariant imbedding technique to quickly compute radiance distributions and quantities derived from those distributions for natural water bodies (Mobley et al. 1993). The inputs to Hydrolight include absorbing and scattering properties of the water body, sea surface and bottom conditions, and the sun and sky radiance incident on the sea surface. The absorbing and scattering properties of the water are based on the concentrations of the main optically active constituents (chlorophyll, suspended sediments, and coloured dissolved organic matter). Additional refinement comes from information about the properties of these constituents, such as spectral absorbance and scattering dependence, particle size, and angular scattering distribution of particles.

3 MODEL SET-UP

3.1 Wave Model

3.1.1 Indian Ocean Model Domain and Simulation Parameters

The large scale model covers the Indian Ocean, part of the Southern Ocean, and the Timor, Arafura and Arabian Seas. The western and eastern boundaries are at Port Elizabeth in South Africa, and the Great Australian Bight. The model domain, mesh, and bathymetry are shown in Figure 3-1. Higher resolution was assigned in the Alkimos local area as shown in Figure 3-2. The key model parameters for the simulations used in the Indian Ocean are presented in

Table 3-1. Results of the model were validated against directional wave measurements south of Rottnest Island, sourced from the Department of Planning and Infrastructure (DPI).

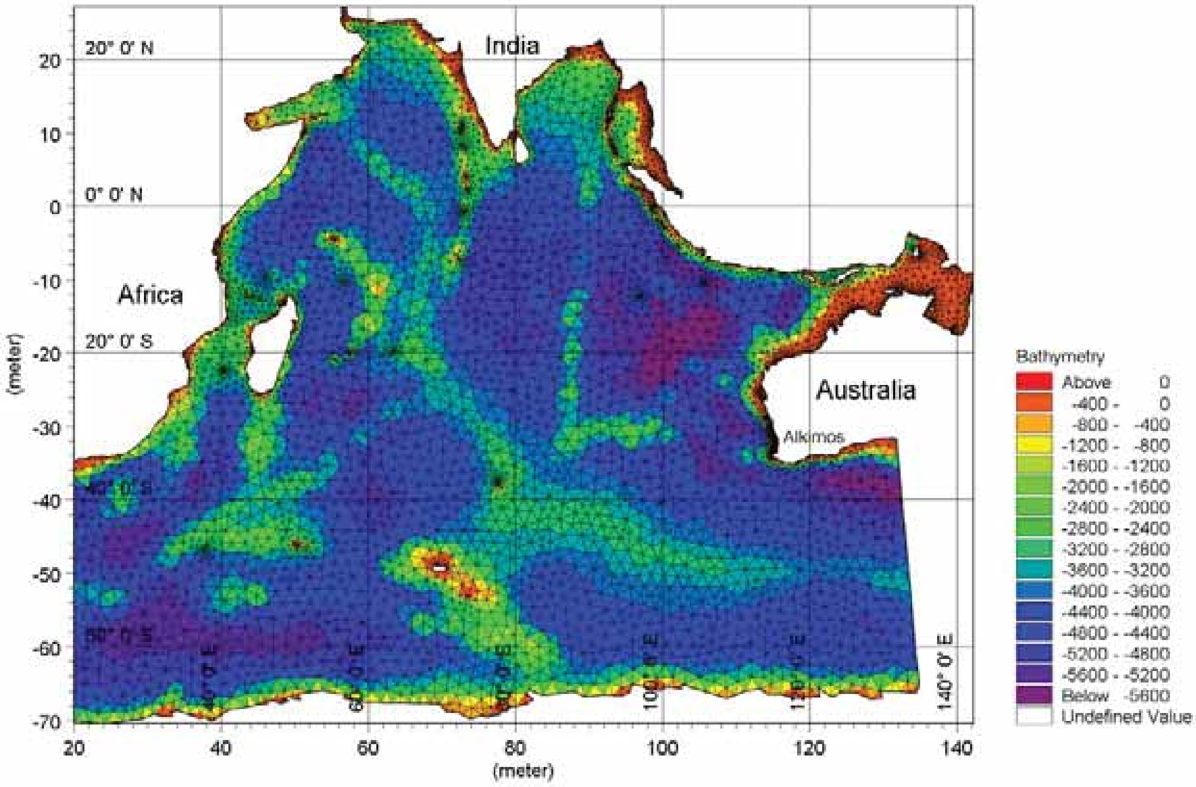

Figure 3-1: Indial Ocean Model domain, mesh and bathymetry.

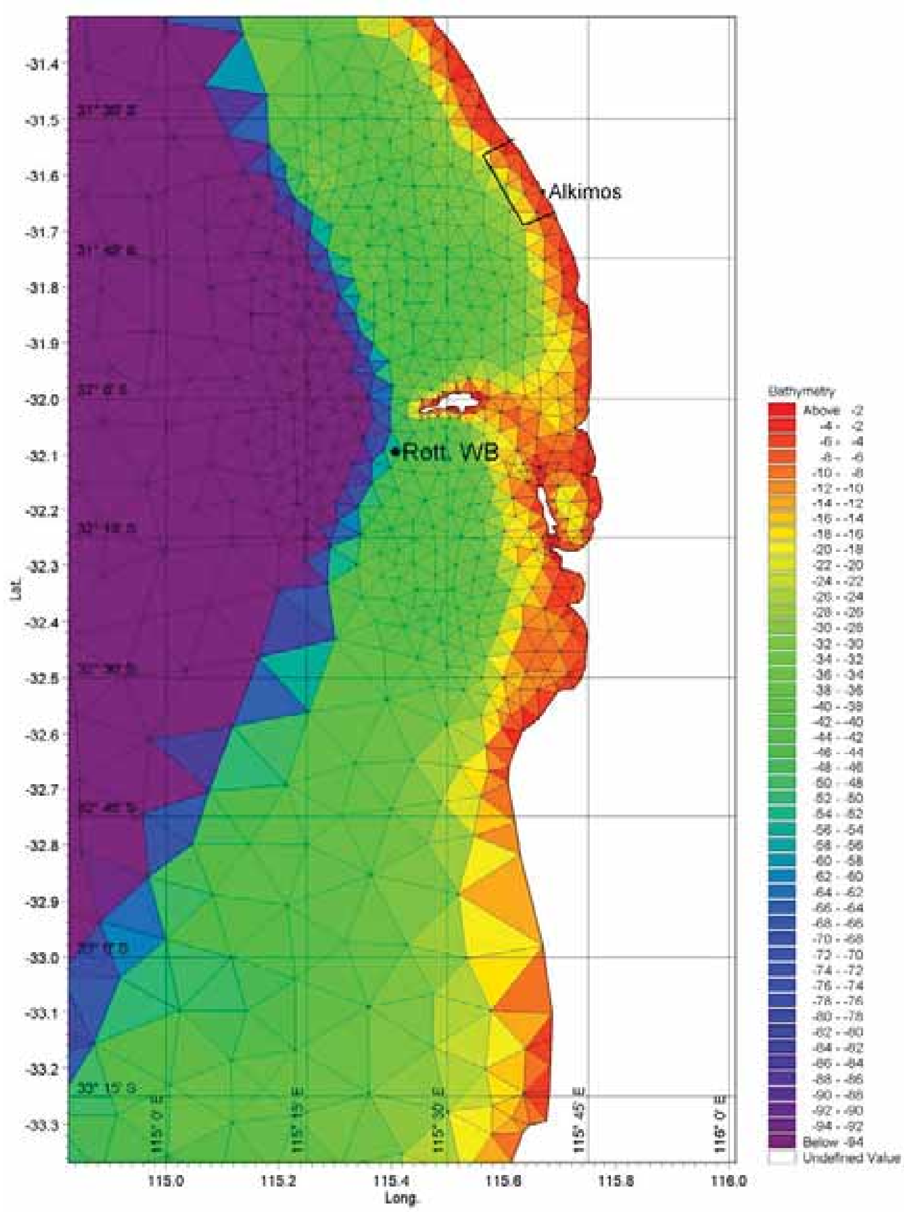

Figure 3-2: Zoom view of the Indian Ocean Model domain, mesh and bathymetry in the Perth Metropolitan Coastline. Rott WB indicates the location of DPI directional wave measurements. The rectangle shows the location of the domains used in the Alkimos local region wave and hydrodynamic models.

Table 3-1: Key model parameters for the Indian Ocean Model

Parameter	Value
Maximum Time-step	10 mins
Frequency Discretisation	28 bins with logarithmic scale Minimum frequency - 0.04 Hz Frequency amplification factor - 1.1
Directional Discretisation	10° bins over 360° rose
Simulation Period	10/04/2008 – 30/05/2008
Spatial Resolution	150 – 240 km in the open ocean 3 – 4 Km in the Perth Metropolitan Coastline

3.1.2 Indian Ocean Model Forcing

The wind forcing used in the Indian Ocean Model was derived from 3-hourly wind data from the Global Data Assimilation Scheme (GDAS) output sourced from the National Oceanic & Atmospheric Administration's (NOAA) Wavewatch III model files. Local winds at Rottnest Island sourced from the Bureau of Meteorology (BOM) were integrated with the global data set. The original data given in a 1x1.25 degree was interpolated onto a 1x1 degree grid of the Indian Ocean before application in the model.

3.1.3 Alkimos Model Domain and Simulation Parameters

The regional scale model covers an area of approximately 90 km^2 (15.8 X 5.8 km) with the Alkimos pipeline location located towards the south of the domain. The model domain, mesh, and bathymetry are shown in Figure 3-3. To detail the flow and transport at the dredging location, a grid resolution of 100m was assigned along the pipeline bearing. In the 50 km^2 management area, a grid of resolution no larger than 600 m was imposed (Figure 3-3). Outside this area the grid resolution was allowed to increase up to approximately 700m. The key model parameters for the simulations used in the Alkimos local model are presented in Table 3-2. Results of the model were validated against directional wave measurements at station B08 (Figure 3-3).

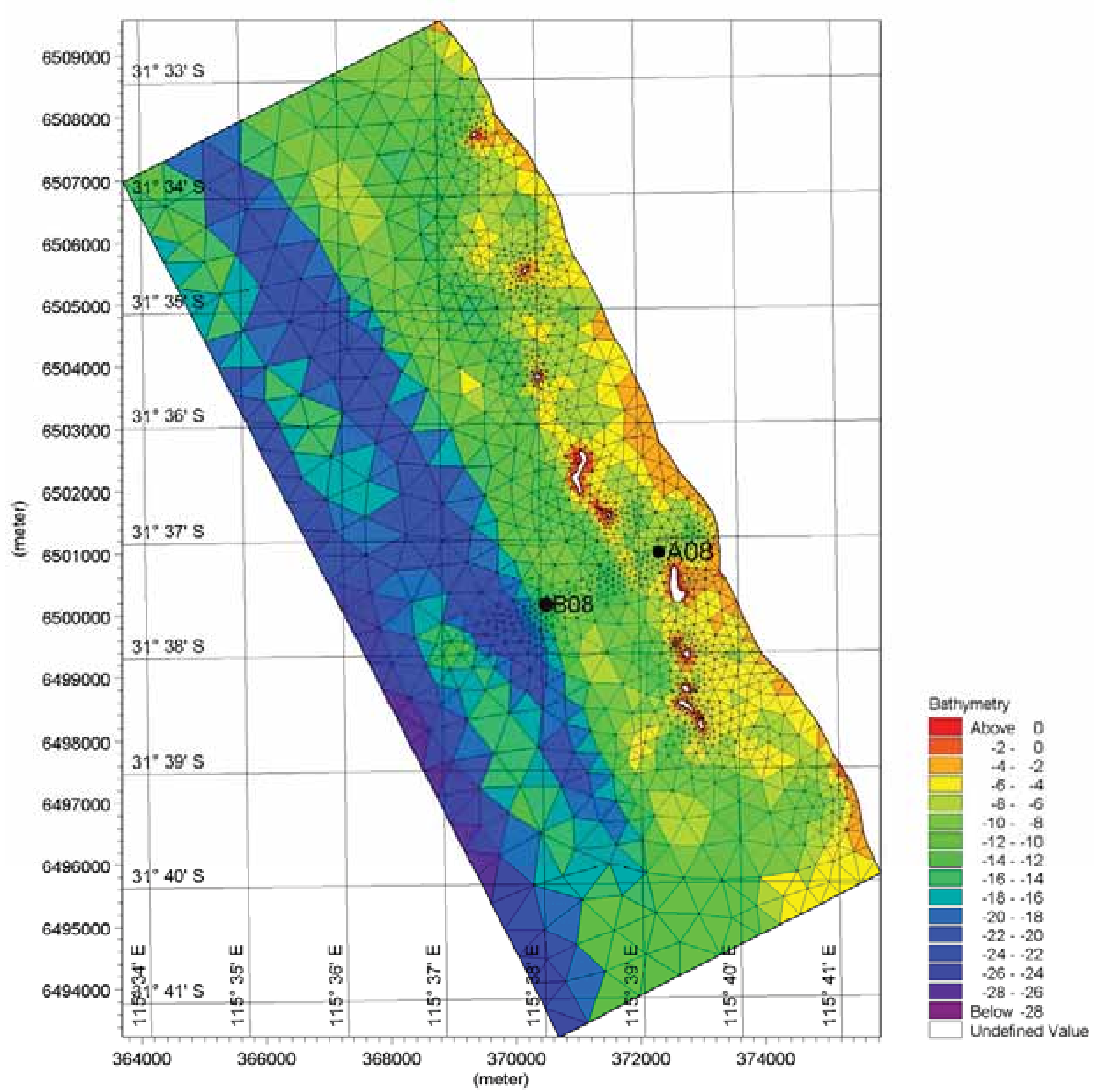

Figure 3-3: Alkimos local region model domain, mesh and bathymetry. The points A08 and B08 indicate the location directional wave measurements (A08) and current measurements (A08 and B08).

Table 3-2: Key model parameters for the Alkimos local region wave model

Parameter	Value
Maximum Time-step	20 mins
Frequency Discretisation	20 bins with logarithmic scale Minimum frequency - 0.04 Hz Frequency amplification factor - 1.2
Directional Discretisation	10° bins over 360° rose
Simulation Period	10/04/2008 – 30/05/2008
Spatial Resolution	100 m at the trench line 100-600 m at the Management Zone Up to 700 m elsewhere

3.1.4 Alkimos Local Model Forcing

The Alkimos local model was forced using wind and wave data. The spectral wave data, output from the Indian Ocean Model, were used at the water boundaries of the refined model. Wind data, collected at the Water Corporation's Alkimos hill wind station at 10 min. sampling interval, was used at the free-surface. The wind forcing for the simulation period is shown in Figure 3-4.

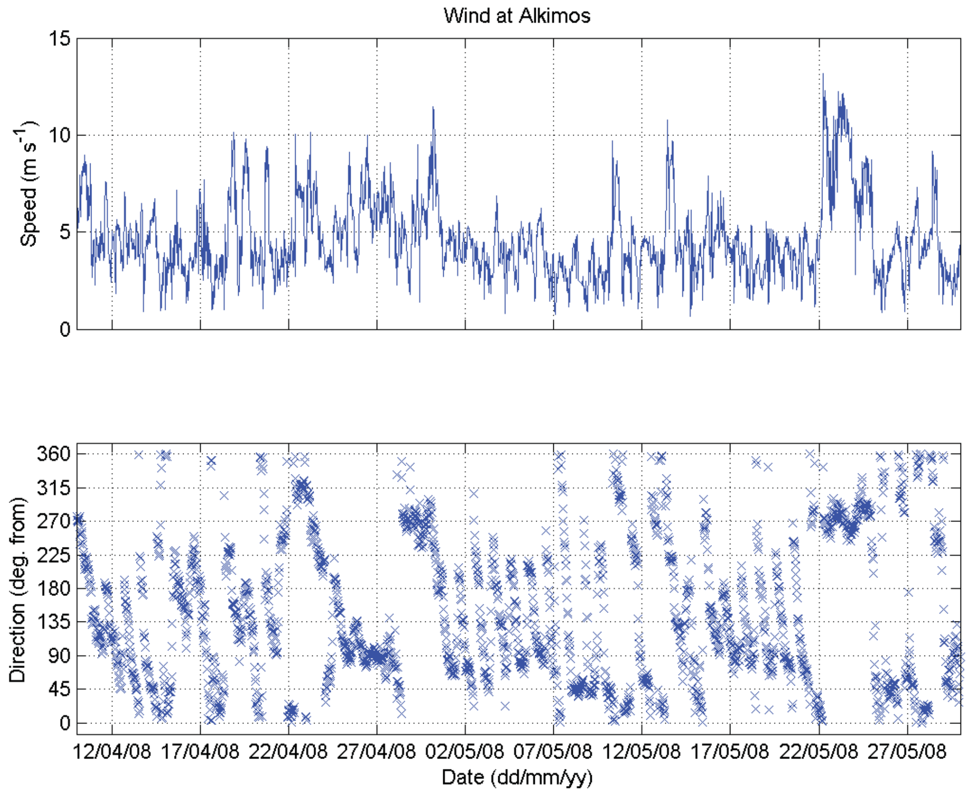

Figure 3-4: Wind forcing used in the Alkimos local area model

3.2 Hydrodynamic Model

3.2.1 Model Domain and Simulation Parameters

The same model domain used for the Alkimos local region wave model was used for the 3D hydrodynamic model (Figure 3-3). The simulation parameters are presented in Table 3-3. Data obtained from current meters at Stations A08 and B08 were used to calibrate the simulations (Figure 3-3).

Table 3-3: Key model parameters for the Alkimos local region hydrodynamic model

Parameter	Value
Minimum Time-step (flow and transport)	0.001 s
Maximum Time-step (flow and transport)	0.5 s
Simulation Period	15/04/2008 – 27/05/2008
Number of Layers	7
Horizontal Spatial Resolution	100 m at the trench line 100-600 m at the Management Zone Up to 700 m elsewhere
Wind drag coefficient	0.00226 for Ws ≤ 7 m/s 0.00582 for Ws ≥ 25 m/s 1.98×10^{-4} Ws $+8.76 \times 10^{-4}$ for 7 < Ws < 25 Where Ws is the wind speed.
Bed-resistance roughness height	5 cm

3.2.2 Model Forcing

The hydrodynamic model is forced with the same Alkimos Hill wind data used in the Alkimos local region wave model. The tidal elevations from tide tables at Two Rocks Marina were used at the three water boundaries of the domain. Comparisons of water levels (not shown) indicated that the tidal record at Alkimos required a time shift of approximately -45 minutes relative to the Two Rocks tidal record. These time-shifted tidal elevations were applied to the northern boundary of the domain and a 40 minute time shift was applied to the southern boundary of the domain. A linear variation between the north and south boundaries was applied at the western boundary.

3.3 Sediment Transport Model

3.3.1 Domain Characteristics

The same model domain depicted in Figure 3-3 and Table 3-3 was used to simulate the sediment transport in the water column.

3.3.2 Simulation Set-up

The MT model required information about the dredging process, the characteristics of the sediment being excavated and the dredging operation schedule.

The dredging operation schedule was simulated using the following assumptions. Firstly, the required volume of dredging was calculated for 20 metre long sections along the length of the pipeline. The volume of the bucket of the backhoe dredger was designed to be $3m^3$. Each cycle of the backhoe involved lowering the bucket, filling the bucket, raising the bucket and discharging the sediment. One full cycle was assumed to take 90 seconds (**Figure 3-5**). Once each 20 metre section was fully dredged to the required depth, the dredge would move seaward to the next 20 metre section. Based on these assumptions, the dredging would take a total of 22 days, with working shifts ranging from 9 to 11 hours beginning at 3:00 am of each day. The duration of shifts varied to ensure that the relevant 20 metre section was fully dredged by the end of the working day.

Information about the discharge of sediment during the dredging process was also required. The release of sediment was assumed to occur only when the sediment was discharged, with a given mass of sediment released for 10 seconds of each 90 second cycle (**Figure 3-5**). The suspension of sediment in the water column as a result of the actual excavating action was assumed to be negligible in magnitude compared to the dredge discharge. Note that as a result, the cloud of fine particles in each backhoe cycle may persist slightly longer than predicted, but the concentration of these particles has been assumed to be insignificant, given the small time scale of each cycle (90s) in comparison to the working shift time scale (36000s). In practice, there is little difference between making this assumption and discharging the same amount of sediments continuously over the shift (**Figure 3-5**).

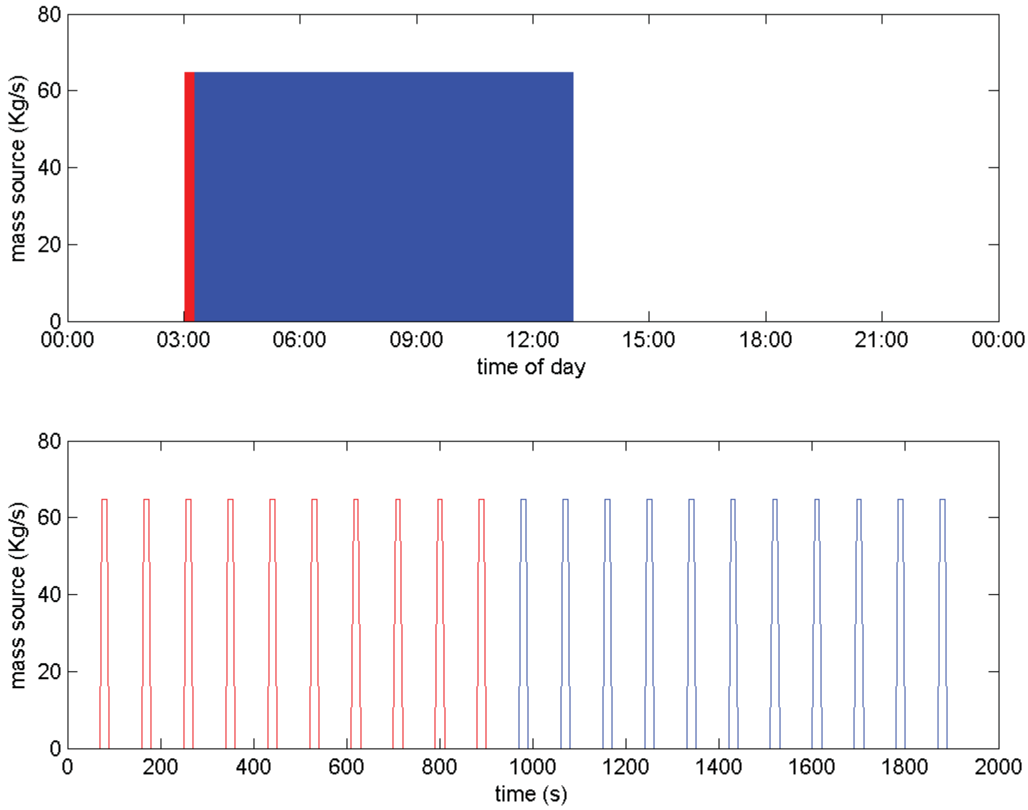

Figure 3-5: Dredging operation cycle. Top panel: a typical working shift starting at 03:00 AM with a duration of about 10 hours. Bottom panel: zoom of the red region in the top panel, highlighting each backhoe cycle.

The dredging operation was modeled using 63 point sources over the length of the proposed pipe route (Figure 3-6). It was assumed that material resulting from blasting the local reef cap rock would constitute the dredged material over the whole trench line. This is a conservative approach because fine particles are only available from where there is cap rock and therefore where blasting is required. Along the actual trench line, there are several sections which will not require blasting. Simple excavation would only mobilize naturally-occurring material, which is more coarse.

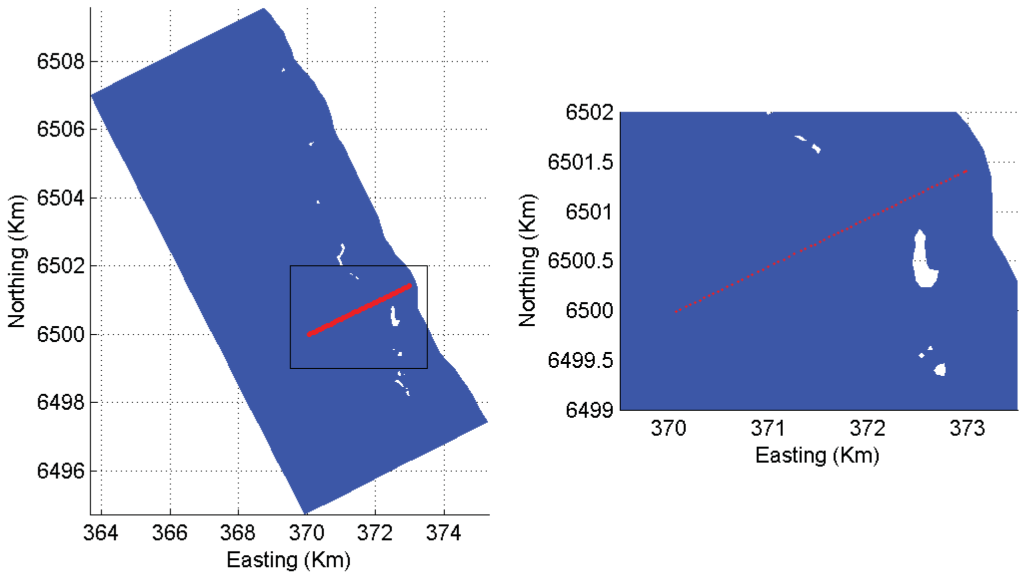

Figure 3-6: Left panel: location of the sources of dredging material in the domain; Right panel: zoom of the dredging area in the area depicted by the rectangle in the left panel

The composition of the cap rock to be blasted was inferred from a geotechnical drilling report (Atteris 2006). Both calcarenites and calcisiltites were present in the cap rock; therefore it was assumed that the blasted material would have a mixed composition of silts, sands, and gravel, all of which would have fractions of carbonates and silicates. Although the dredged material would consist of different particle size fractions, it was assumed that only fine particles, that are not naturally occurring, would present an impact on the region's light climate. A particle size corresponding to medium-sized silt grains of 0.03 mm median diameter was simulated (Table 3-4).

The parameters governing settling and resuspension of the dredged material are presented in Table 3-4. The mean settling velocities and the critical shear stresses for deposition were calculated according to Soulsby (1997). The dredged material was discharged at the bottom most layer at each of the sources location. The sediment was then transported according to the local flow conditions, including settling and resuspension processes.

Table 3-4: Key model parameters for the MT model

	Parameter	Assumed Value
Water Column	Median sediment size - D_{50}	0.03 mm
	Mean settling velocity	0.00067 m/s
	Critical shear stress for deposition	0.08 N/m^2
	Mass discharged per cycle	648 Kg
Sea Bed	Erosion coefficient	0.00005 kg/m^2/s
	Critical shear stress for Erosion	0.25 N/m^2
	Density	1,400kg/m^3

3.4 Light Model

The light model was resolved over the entire PAR spectrum (from 400nm to 700nm) in one waveband. Optical properties were calculated at 1m depth intervals over the vertical. Diffuse attenuation coefficient (K_o) was calculated to be the average of K_o from 1m to 12 m. Optically active constituents other than suspended sediments were held constant among model runs, with a chlorophyll concentration of 0.5 mg m^{-3} and a coloured dissolved organic matter (CDOM) “concentration” (absorbance at 440nm, a_{440}) of 0.01m^{-1}. All water column constituents (chlorophyll, CDOM, and suspended sediments) were held constant over the vertical, which is consistent with hydrodynamic and sediment transport model estimates of vertical structure. The other assumptions, used in the model are outlined (Table 3-5).

Table 3-5: Key model parameters for the Hydrolight Model

Parameter	Assumed Value/ Source
Water absorption	Pope and fry (Pope and Fry 1997)
Chlorophyll absorption	After (Morel 1988)
CDOM absorption	Exponential model with 0.014 slope (Bricaud et al. 1981)
Suspended Sediment Absorption	Empirical absorption spectrum for calcareous sand after (Ahn 1990)
Chl scattering	After (Loisel and Morel 1998)
Mineral scattering	Empirical scattering spectrum for calcareous sand (Ahn 1990)
Phase function chlorophyll	Based on backscattering ration of 0.005 after (Fournier and Forand 1994; Mobley et al. 2002; Twardowski et al. 2006)
Phase function mineral	Based on backscattering ratio of 0.025 after (Fournier and Forand 1994; Mobley et al. 2002; Twardowski et al. 2006)
Sky	Based on May 3; 23:15 GMT; 31.619°S, 115.652°W, zero cloud cover
Wind speed	5 m s^{-1} (consistent with May observations)
Bottom	Empirical reflectance spectrum for coral sand after (Maritorena et al. 1994)

4 RESULTS AND VALIDATION

4.1 Wave Model

4.1.1 Indian Ocean Model

The Indian Ocean wave model was compared to measured directional wave data from the DPI Rottnest Buoy for the period of April and May 2008. The location of the DPI buoy is shown in Figure 3-2. Time series plots of measured and modeled MIKE 21 SW significant wave height, peak period, mean period and direction are presented in Figure 4-1 and Figure 4-2.

These comparissons show a good match between the measured and the modeled wave data. The Indian Ocean model can therefore be used with confidence to provide the boundary conditions for the regional Alkimos wave model.

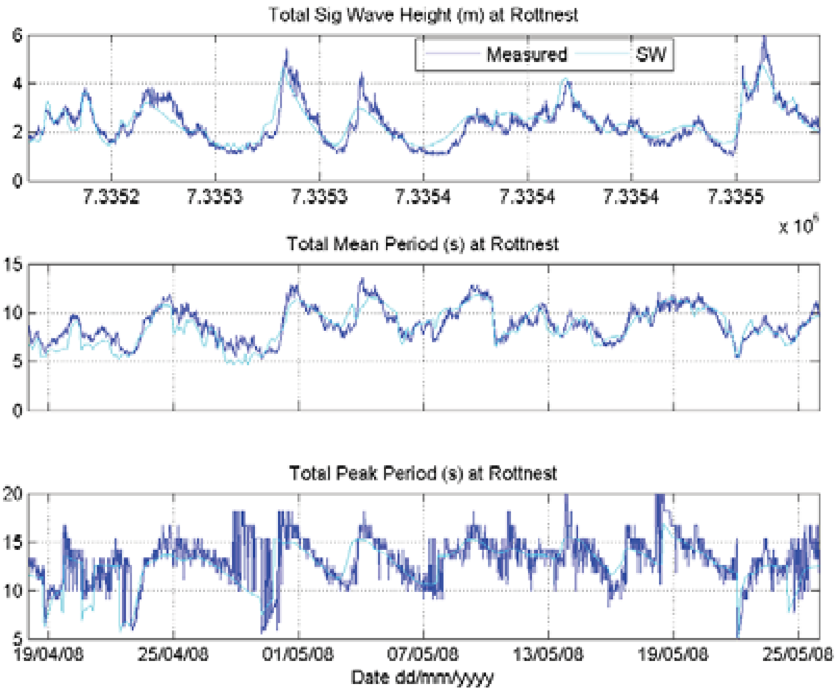

Figure 4-1: Time series of measured and modeled (SW) total significant wave height, total mean period and total peak period at the Rottnest buoy

Figure 4-2: Time series of measured and modeled peak direction for sea and swell at the Rottnest buoy

4.1.2 Alkimos Model

The results of the Indian Ocean wave model were used as boundary conditions for the Alkimos regional wave model. The refined wave model was validated at a buoy located at Alkimos (see Figure 3-3 for location). Time series of the modeled and measured data at the Alkimos site are shown in Figure 4-3 to Figure 4-5, including significant wave height, peak period and peak direction. After validation, the refined regional model was used to create an hourly spatial wave field covering the domain of the hydrodynamic model.

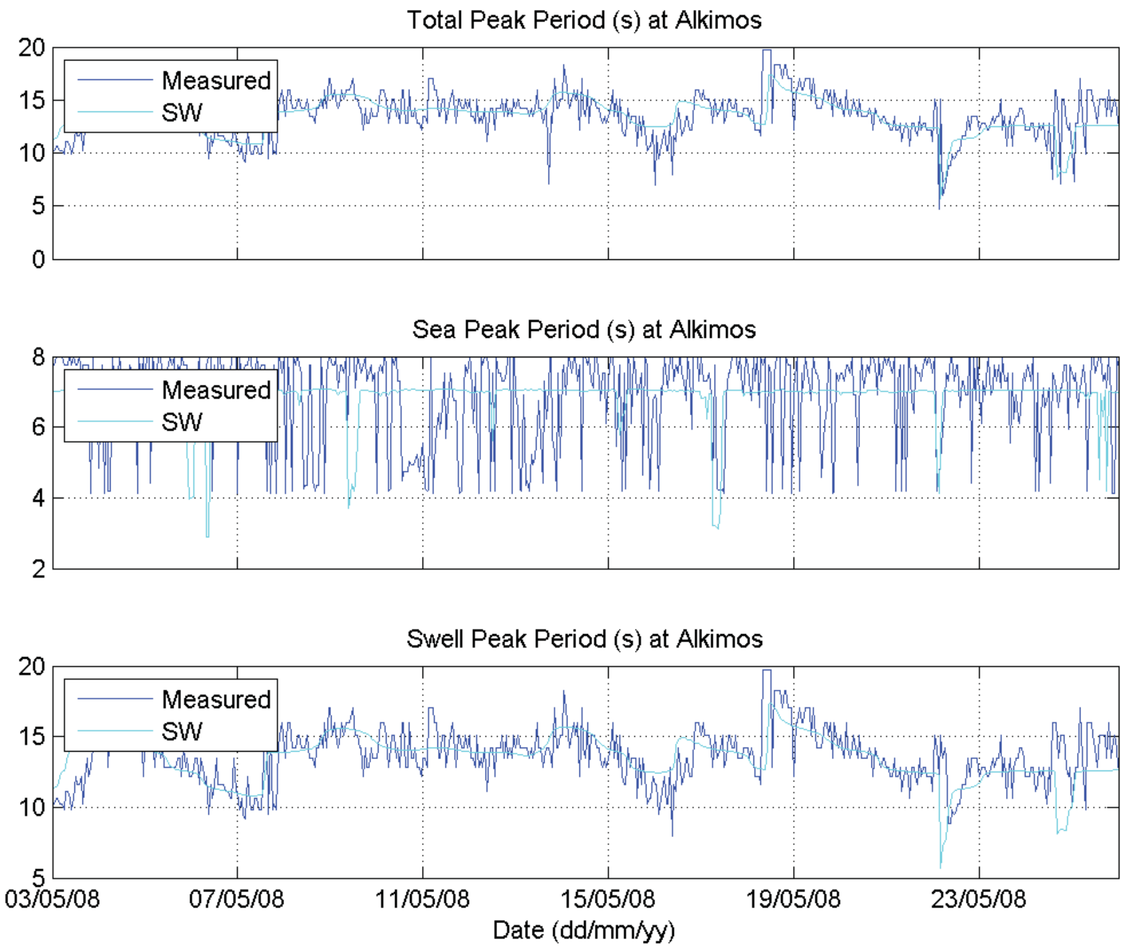

Figure 4-3: Time series of measured and modeled (SW) total, sea and swell peak period at the Alkimos station A08.

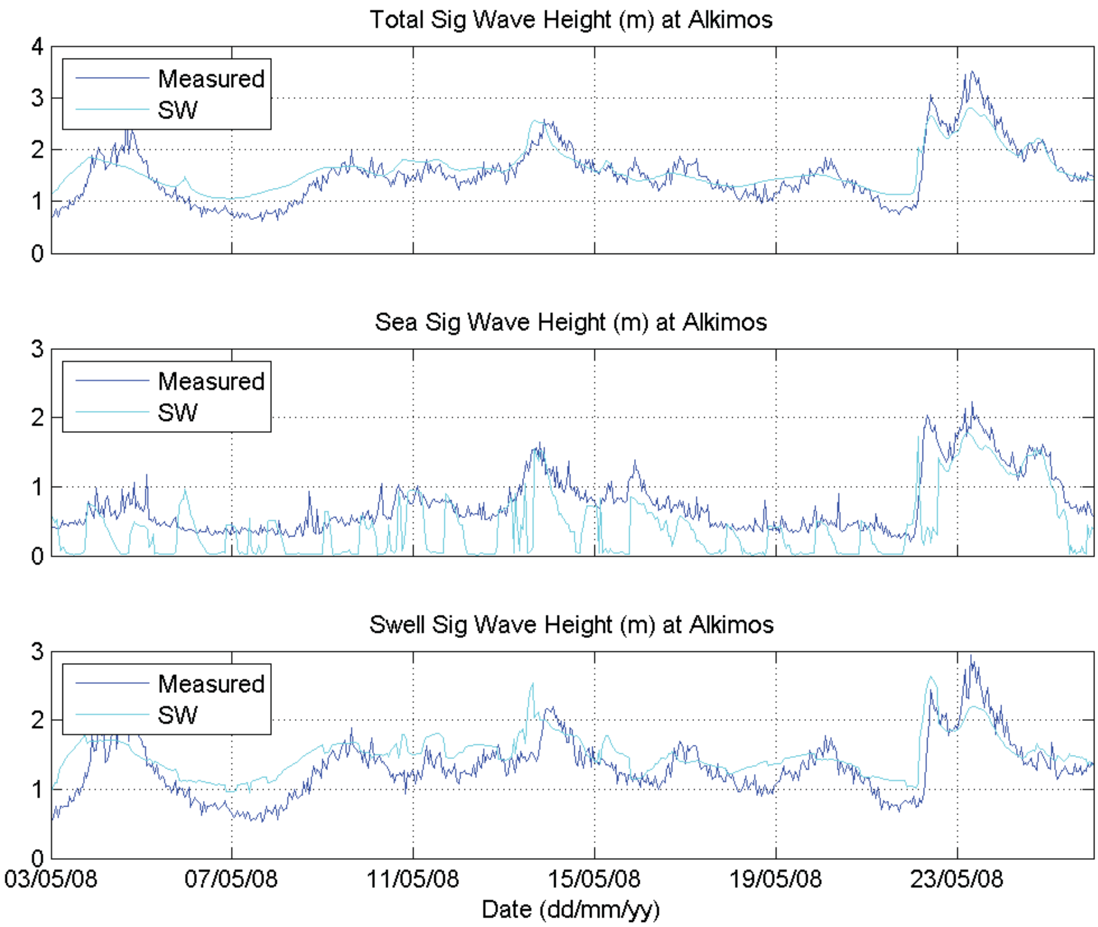

Figure 4-4 Time series of measured and modeled (SW) total, sea and swell significant wave height at the Alkimos station A08.

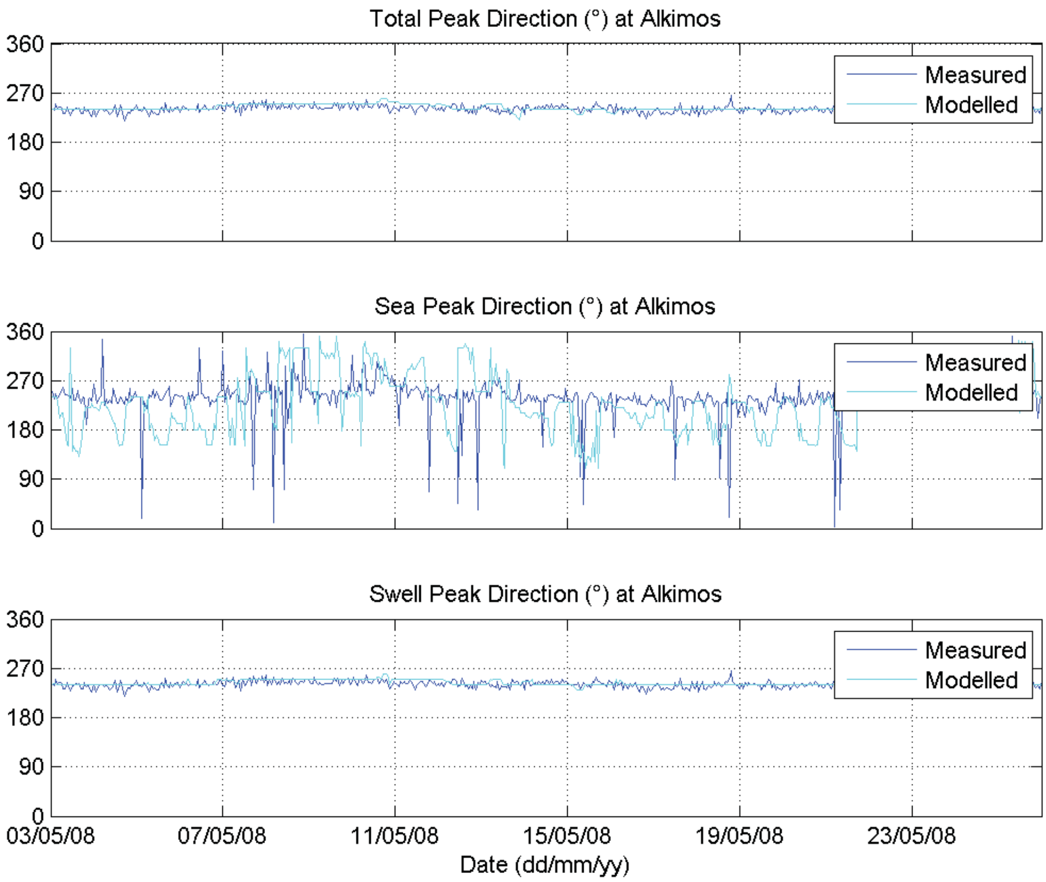

Figure 4-5: Time series of measured and modeled (SW) total, sea and swell direction at the Alkimos station A08.

4.2 Hydrodynamic Model

Current speeds and directions at stations A08 (measured at 3.3 m and 10.0 m from the bottom) and B08 (measured at 4.2 and 6.2 m from the bottom) were used to assess the skill of the hydrodynamic model (Figure 4-6 to Figure 4-9). It is noteworthy that markedly low speeds were recorded at both stations, particularly at the inshore station (A08 - Figure 3-3). The main statistics of the hourly averaged measured and modeled records are presented in Table 4-1 and Table 4-2.Results are particularly good for the offshore station in the surface (10.0 m) where the current signal is stronger. The model is able to predict the southward current movement that accompanies northerly winds (Figure 4-6 and Figure 4-7). From days 05/05 to 06/05 and 13/05 to 18/05, predominantly in the surface at the offshore station, the model was able to capture the reversal of current direction that followed a daily wind shift from westerlies to easterlies (Figure 4-6 and Figure 4-7). A markedly good representation of the magnitude of current speeds was also obtained. (Table 4-1)

The model simulates this same flow reversal at the inshore station. Although the reversal is shown to occur in the surface (6.4 m) at the inshore station (days 15/05 to 18/05), the current velocities in the bottom (2.4 m) at the inshore station did not always demonstrate the reversal (Figure 4-8 and Figure

4-9). It is speculated that the effect of the reef south of station A08 on the development of the northward current flow is not modeled well. Nonetheless, the model is capable of reproducing the persistent southward flow between 09/05 and 16/05 at similar speeds observed in the field (Figure 4-8 and Figure 4-9, and Table 4-2). The reef south of Station A08 does not seem to impact the model skill for northerly winds as it does for southerly winds. The model is able to replicate the flow more adequately at station A08 during northerly wind conditions.

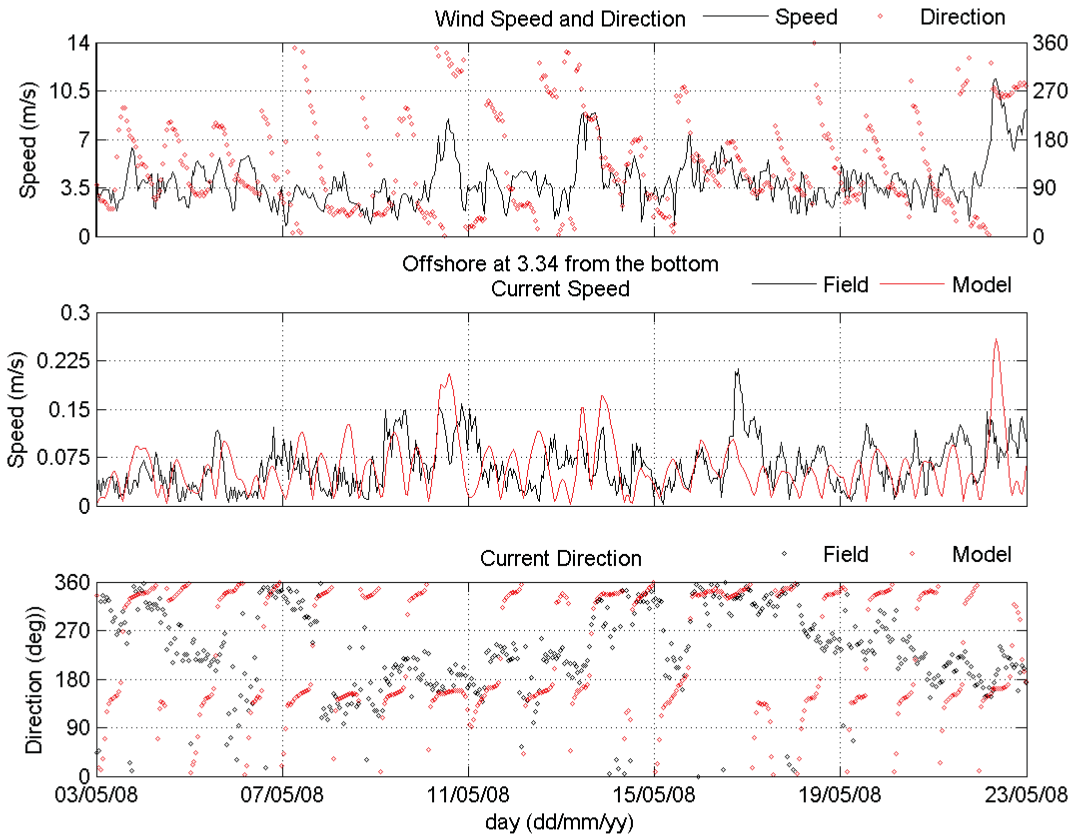

Figure 4-6: Top panel: wind measurement at Alkimos Hill (used for reference). Middle panel: Current speeds 3.3 m from the bottom at station B08 (offshore). Bottom panel: Current direction 3.3 m from the bottom at station B08. Note that wind direction represents the direction the wind is blowing from and current direction represents the direction the current is moving to.

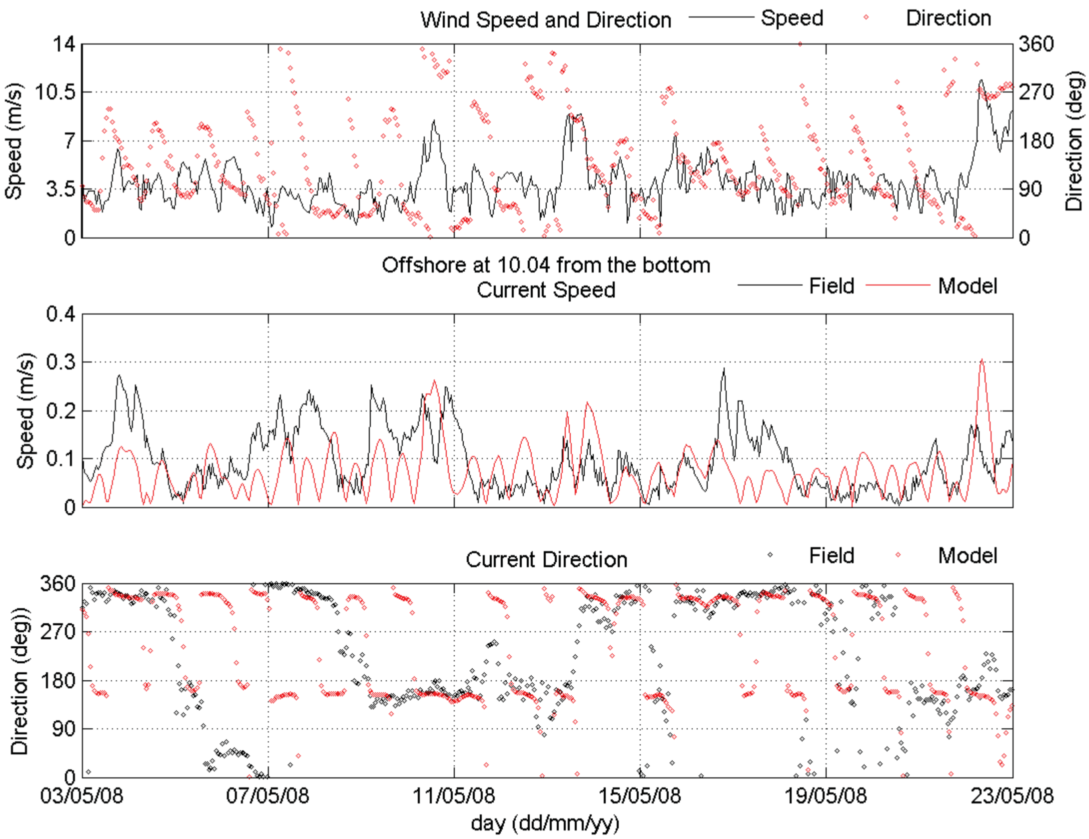

Figure 4-7: Top panel: wind measurement at Alkimos Hill (used for reference). Middle panel: Current speeds 10.0 m from the bottom at station B08 (offshore). Bottom panel: Current direction 10.0 m from the bottom at station B08.

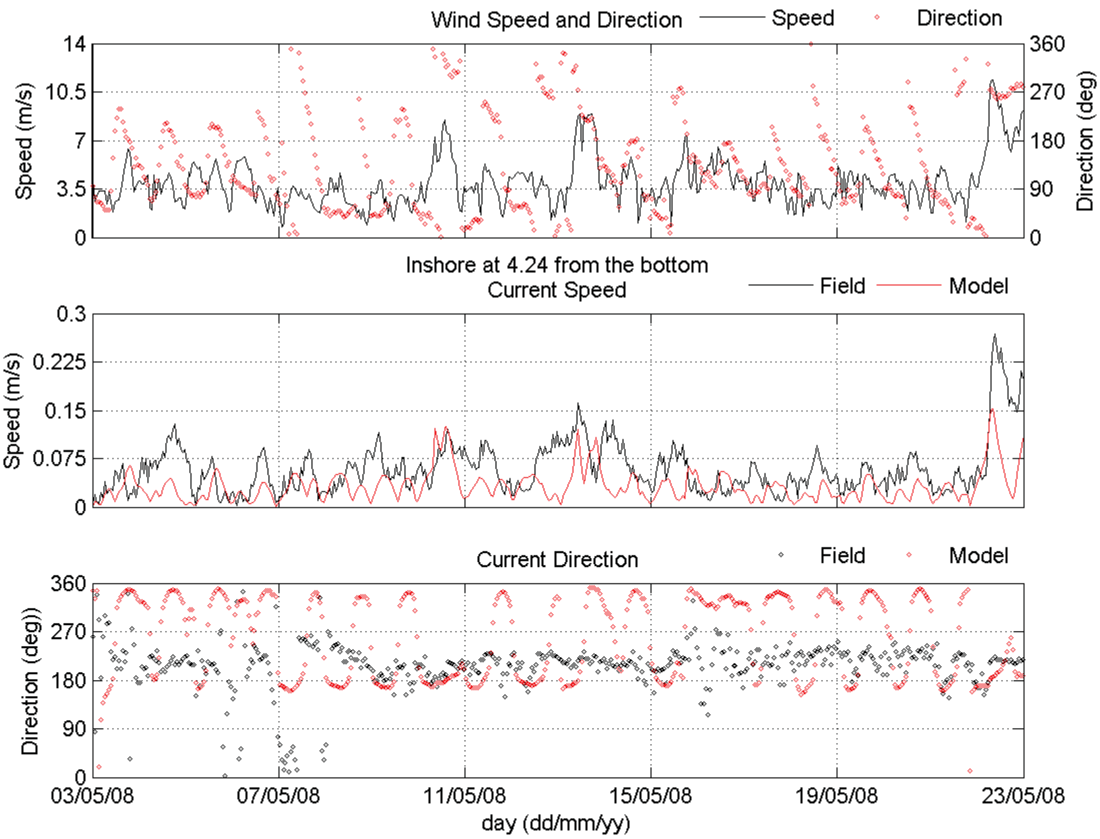

Figure 4-8: Top panel: wind measurement at Alkimos Hill (used for reference). Middle panel: Current speeds 4.2 m from the bottom at station A08 (inshore). Bottom panel: Current direction 4.2 m from the bottom at station A08.

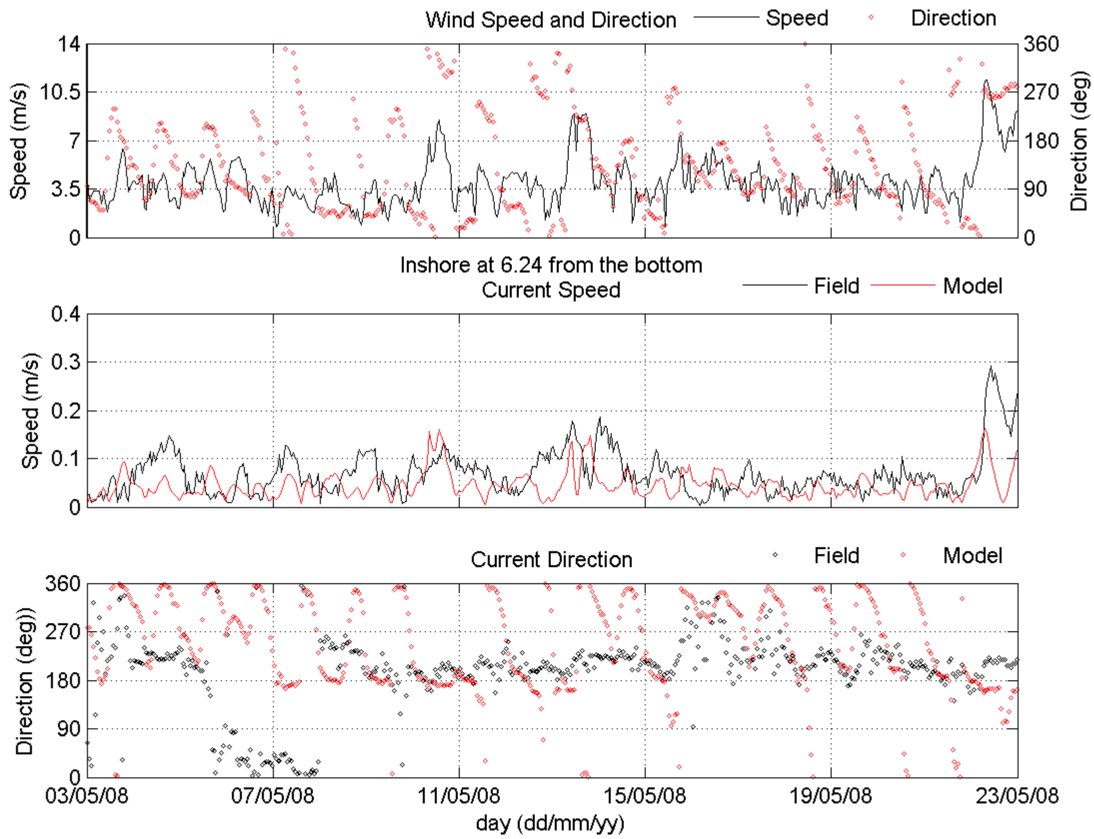

Figure 4-9: Wind measurement, top panel, at Alkimos Hill, Current speeds (middle panel) and current direction (bottom panel) 6.2 m from the bottom at station A08 (inshore).

Table 4-1: Statistics of measured and modeled current speeds at station B08 (offshore).

Statistic	Speed at 3.3 m from bottom		Speed at 10.0 m from bottom	
	Measured (m/s)	Modeled (m/s)	Measured (m/s)	Modeled (m/s)
20 %ile	0.03	0.03	0.04	0.03
Mean, ± Std Dev	0.06±0.04	0.06±0.04	0.10±0.06	0.07±0.05
Median	0.06	0.05	0.08	0.07
95 %ile	0.13	0.15	0.22	0.17
98%ile	0.15	0.19	0.25	0.23
Maximum	0.21	0.26	0.29	0.31
RMS error	-	0.05	-	0.08

Table 4-2: Statistics of measured and modeled current speeds at station A08 (inshore).

Statistic	Speed at 4.2 m from bottom		Speed at 6.2 m from bottom	
	Measured (m/s)	Modeled (m/s)	Measured (m/s)	Modeled (m/s)
20 %ile	0.03	0.01	0.03	0.02
Mean, ± Std Dev	0.06±0.04	0.03±0.02	0.07±0.05	0.05±0.03
Median	0.05	0.03	0.06	0.04
95 %ile	0.13	0.09	0.15	0.11
98%ile	0.20	0.11	0.22	0.14
Maximum	0.27	0.15	0.29	0.16
RMS error	-	0.05	-	0.05

4.3 Light Model

Field measurements collected from April through June demonstrate full water column light attenuation coefficients (LAC) ranging from 0.03 to 0.38 m^{-1} (converted from measurements made in the 11th meter based on model-derived conversion coefficient). Measurements of turbidity (assumed to be roughly equivalent to suspended sediment concentration, SSC) range from 0 to 600 (5th/95th percentile = 1.2 to 28.3) with a median of 4.1 mg l^{-1}. The relationship between SSC and LAC (approximated by the equation LAC = 0.064 · (SSC) + 0.04) was derived from a Hydrolight model meant to simulate station B08 under a range of suspended sediment loads. This relationship predicts a similar range of LAC to that measured in the field under most SSC concentrations (Table 4-3). This is a conservative estimate, demonstrated by the fact that measured LAC rarely goes above 0.1 m^{-1} although turbidity, while mainly below 5 ntu, is highly variable and frequently exceeds 10 ntu (Figure 4-10)

Table 4-3: Approximate relationship (derived from Hydrolight modelling) between suspended sediment concentration (SSC), midday light attenuation coefficient (LAC), and the corresponding depths to which key threshold light levels extend under those conditions.

SSC	LAC	Depth (m) receiving X% of Subsurface Irradiance				
		1%	4%	11%	29%	50%
0.00	0.001	4605.17	3218.88	2207.27	1237.87	693.15
0.00	0.010	460.52	321.89	220.73	123.79	69.31
0.00	0.025	184.21	128.76	88.29	49.51	27.73
0.16	0.050	92.10	64.38	44.15	24.76	13.86
0.55	0.075	61.40	42.92	29.43	16.50	9.24
0.94	0.100	46.05	32.19	22.07	12.38	6.93
2.50	0.200	23.03	16.09	11.04	6.19	3.47
4.06	0.300	15.35	10.73	7.36	4.13	2.31
5.63	0.400	11.51	8.05	5.52	3.09	1.73
7.19	0.500	9.21	6.44	4.41	2.48	1.39
11.09	0.750	6.14	4.29	2.94	1.65	0.92
15.00	1.000	4.61	3.22	2.21	1.24	0.69
16.56	1.100	4.19	2.93	2.01	1.13	0.63
18.13	1.200	3.84	2.68	1.84	1.03	0.58
19.69	1.300	3.54	2.48	1.70	0.95	0.53
21.25	1.400	3.29	2.30	1.58	0.88	0.50
22.81	1.500	3.07	2.15	1.47	0.83	0.46
24.38	1.600	2.88	2.01	1.38	0.77	0.43
25.94	1.700	2.71	1.89	1.30	0.73	0.41
27.50	1.800	2.56	1.79	1.23	0.69	0.39
29.06	1.900	2.42	1.69	1.16	0.65	0.36
30.63	2.000	2.30	1.61	1.10	0.62	0.35
46.25	3.000	1.54	1.07	0.74	0.41	0.23
61.88	4.000	1.15	0.80	0.55	0.31	0.17
77.50	5.000	0.92	0.64	0.44	0.25	0.14
93.13	6.000	0.77	0.54	0.37	0.21	0.12
108.75	7.000	0.66	0.46	0.32	0.18	0.10
124.38	8.000	0.58	0.40	0.28	0.15	0.09
140.00	9.000	0.51	0.36	0.25	0.14	0.08
155.63	10.000	0.46	0.32	0.22	0.12	0.07
233.75	15.000	0.31	0.21	0.15	0.08	0.05
311.88	20.000	0.23	0.16	0.11	0.06	0.03
390.00	25.000	0.18	0.13	0.09	0.05	0.03
468.13	30.000	0.15	0.11	0.07	0.04	0.02
624.38	40.000	0.12	0.08	0.06	0.03	0.02
780.63	50.000	0.09	0.06	0.04	0.02	0.01

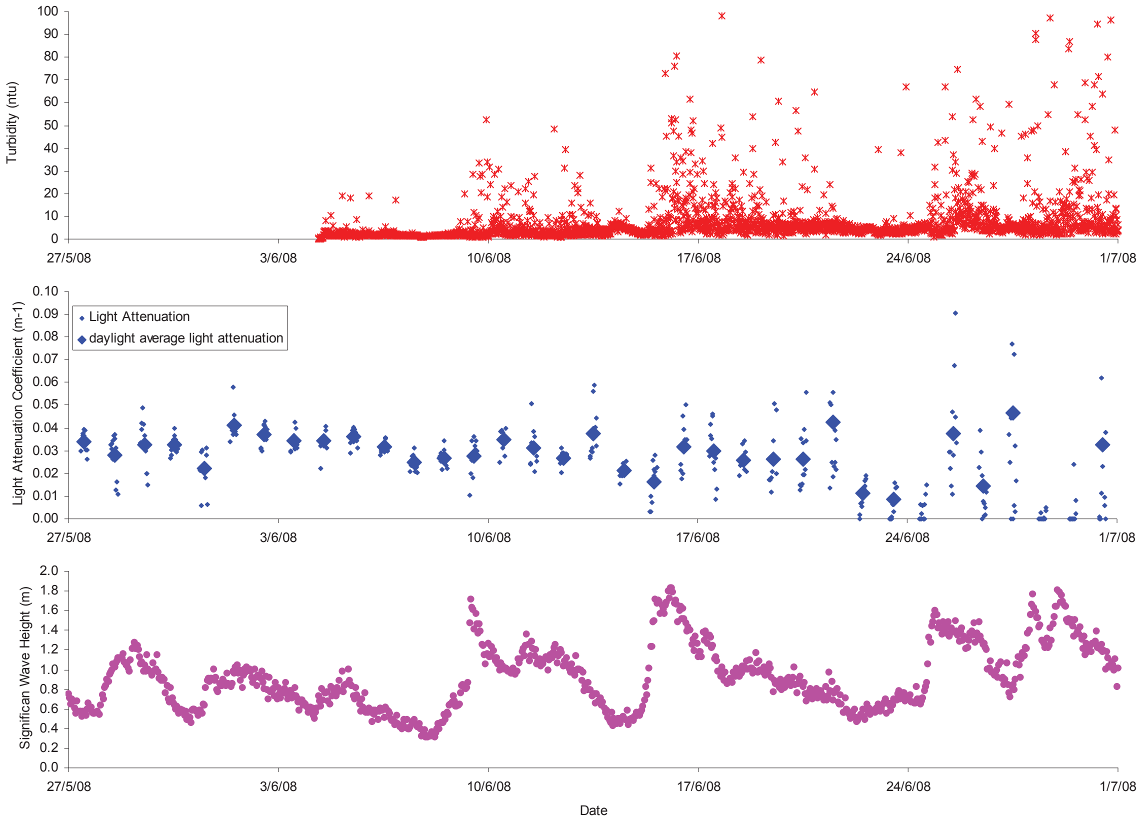

Figure 4-10: Measured turbidity and light attenuation coefficient at Station A08 during June

4.4 Dredge Plume Sediment Transport Model

4.4.1 Dredge Plume Characteristics

The transport of the dredge plume is presented from Figure 4-11 to Figure 4-17 below. The model predicted three main patterns of dispersion according to the location of dredging and prevalent wind conditions.

Table 4-4 summarizes these patterns.

Table 4-4: Main patterns of the dredge plume dispersion

Pattern	Prevailing Wind Condition	Dredge Location	Characteristics
1	Southerly / Easterly	Inshore of station A08	Relatively rapid northward movement Highly dispersive Relatively low tendency to settle
2	Northerly / North-Westerly	At the proximities of A08	Relatively rapid southward movement Moderately dispersive Relatively very low tendency to settle
3	Westerly shifting through Southerly to Easterly	Offshore of station A08	Stagnant nature Poorly dispersive Relatively high tendency to settle

Pattern 1 identifies the movement of the dredge plume as a result of dredging in the inshore area (east station A08) of the management region subject to prevalent southerly and easterly winds (Figure 4-11 and Figure 4-12). These conditions were simulated in the period between 03/05 and 07/05. Under these conditions, despite the action of the easterly winds, the model results indicated a northward movement of the plume confined to the shallow inshore areas. Concentrations at the trench line location reached a maximum at the end of the dredging working shift (Figure 4-11) with about 550 mg/L at the centre of the plume decaying to 1 mg/L in about 600 m (depending on direction). Just before starting the dredging operations on the next day, the plume traveled more than 2.5 Km and was diluted to concentrations well below 3 mg/L (Figure 4-12). These conditions should be similar to what is expected for summer months when the afternoon southerly sea-breeze becomes the predominant forcing of the system. During summer, however, the breeze is expected to be stronger and more persistent, providing more efficient dispersal of the plume. Note also that these results refer to the bottom most layer of the model where the largest concentrations are found.

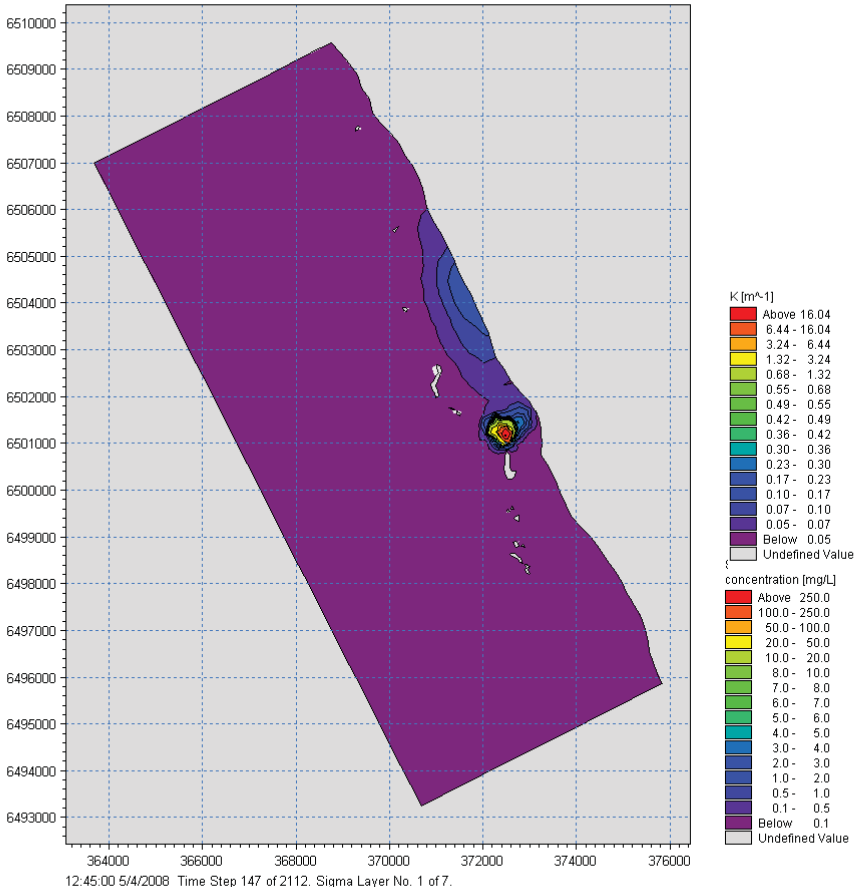

Figure 4-11: Dredge plume transport under conditions described by Pattern 1. Snapshot of the model taken at 04/05 12:45 PM just after finishing the second day of dredging.

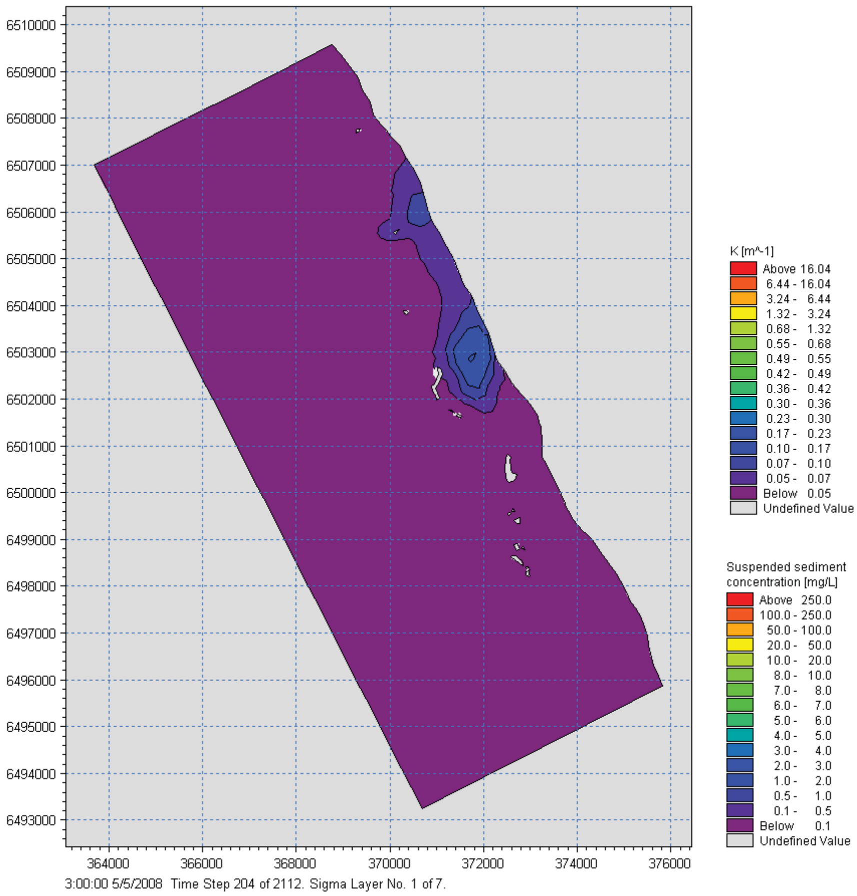

Figure 4-12: Dredge plume transport under conditions described by Pattern 1. Snapshot of the model taken at 05/05 03:00 AM just before commencement of third day of dredging. Prevailing wind conditions on the previous 12 hours were 3.3 m/s South-easterly winds.

Pattern 2 identifies the movement of the dredge plume as a result of dredging in the proximity of station A08 (Figure 4-13 and Figure 4-14). This location was chosen because it has a large expanse of cap rock and dredging would be intensive (note that the model set-up takes the local dredging volumes into account). Such a pattern was simulated on day 10/05 (Figure 4-13) for which the model presented a more qualitative agreement with the field data (Figure 4-8 and Figure 4-9). The plume was elongated to the south as a result of the northerly winds with concentrations varying from approximately 200 mg l^{-1} at its centre to 5 mg l^{-1} about 1 km away from the southern end of the domain (Figure 4-13). It is also interesting to note that new plumes appeared as a result of re-suspension north of the dredging area. For times when resuspension was observed, the wind speeds were over 6 m/s (Figure 4-13). Concentrations of these plumes never reached above 10 mg l^{-1} (not shown).

At the start of the next dredging cycle in the following day (11/05) the plume moved south east with the largest concentrations lower than 14 mg l^{-1} about 1 km away from the southern end of the domain. At this time, concentrations at the location of the dredging were well below 1 mg l^{-1} (Figure 4-14).

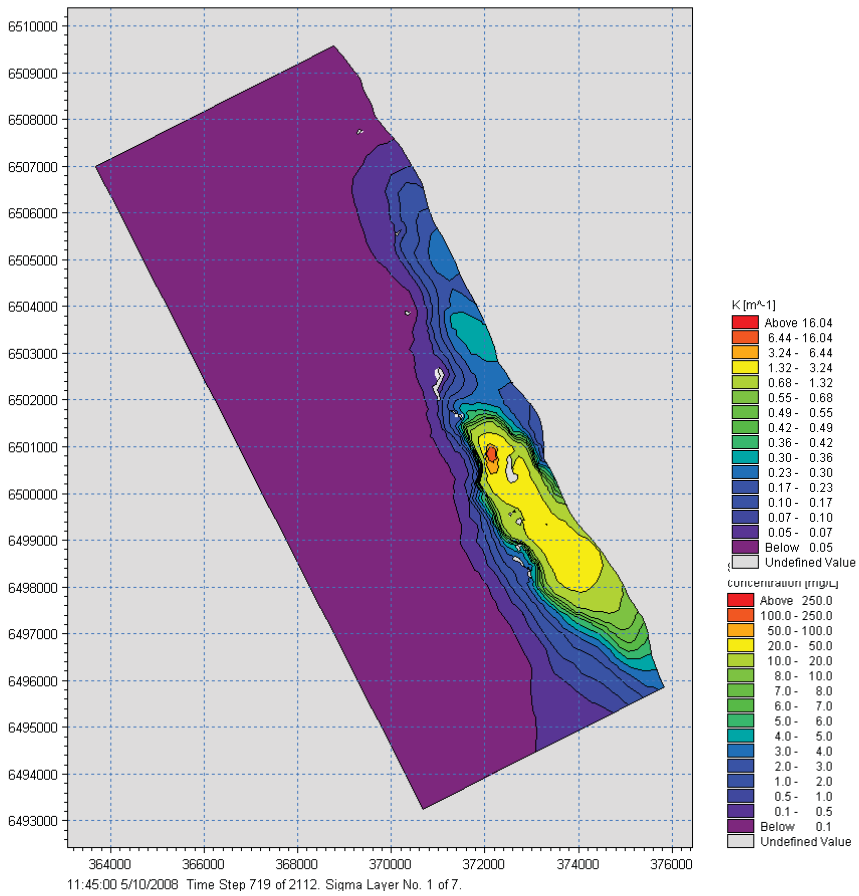

Figure 4-13: Dredge plume transport under conditions described by Pattern 2. Snapshot of the model taken at 10/05 11:45 AM just after finishing seventh day of dredging.

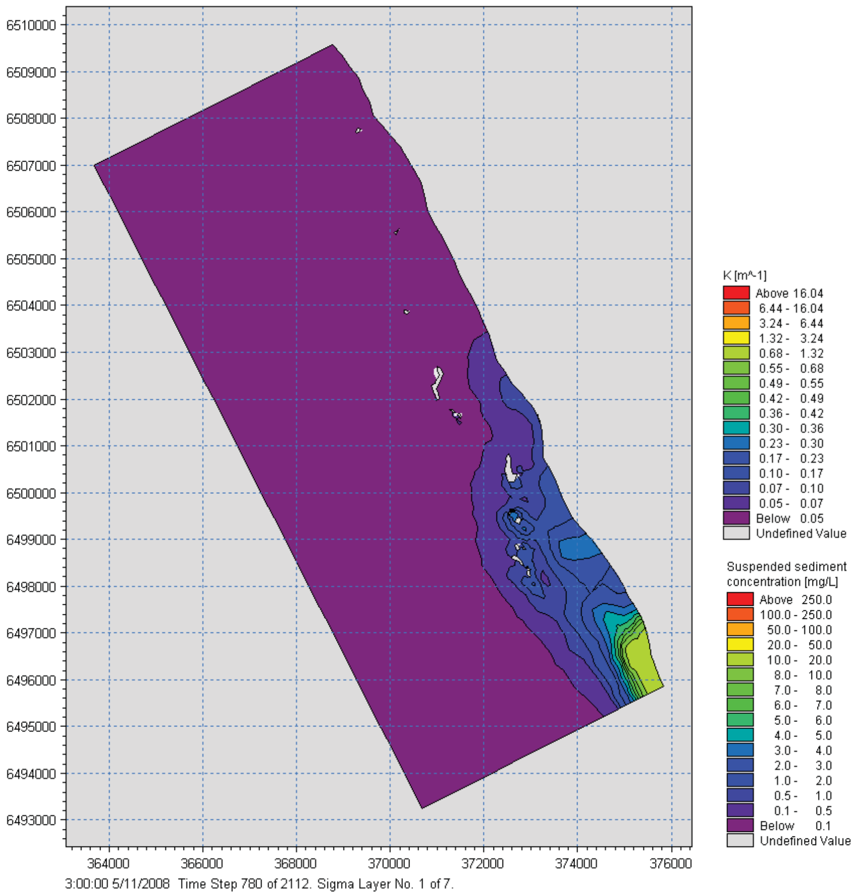

Figure 4-14: Dredge plume transport under conditions described by Pattern 2. Snapshot of the model taken at 11/05 03:00 AM just before commencement of eighth day of dredging. Prevailing wind conditions on the previous 12 hours were 3.1 m/s North-westerly winds.

Pattern 3 identifies the movement of the dredge plume as a result of dredging in the offshore area (west of station A08) subject to a wind shifting from westerly (through southerly) to easterly winds. Under such conditions, current speeds were relatively low and current directions changed from southward at the end of the dredging shift (18/05) to northward by the start of next day of dredging (Figure 4-6). The dredge plume therefore remained relatively stagnant in this period with its centre moving as far as 1 km south of the source (Figure 4-15) and subsequently, as the current changed its course of direction, moving as far as 2.8 km north of the source by commencement of the next day of dredging. Concentrations at the centre of the plume at this time were lower than 9 mg l^{-1} (Figure 4-16). The model indicated that this region where the plume was relatively stagnant is where sediment settling is more likely to occur away of the zone of direct impact (see section 4.4.2).

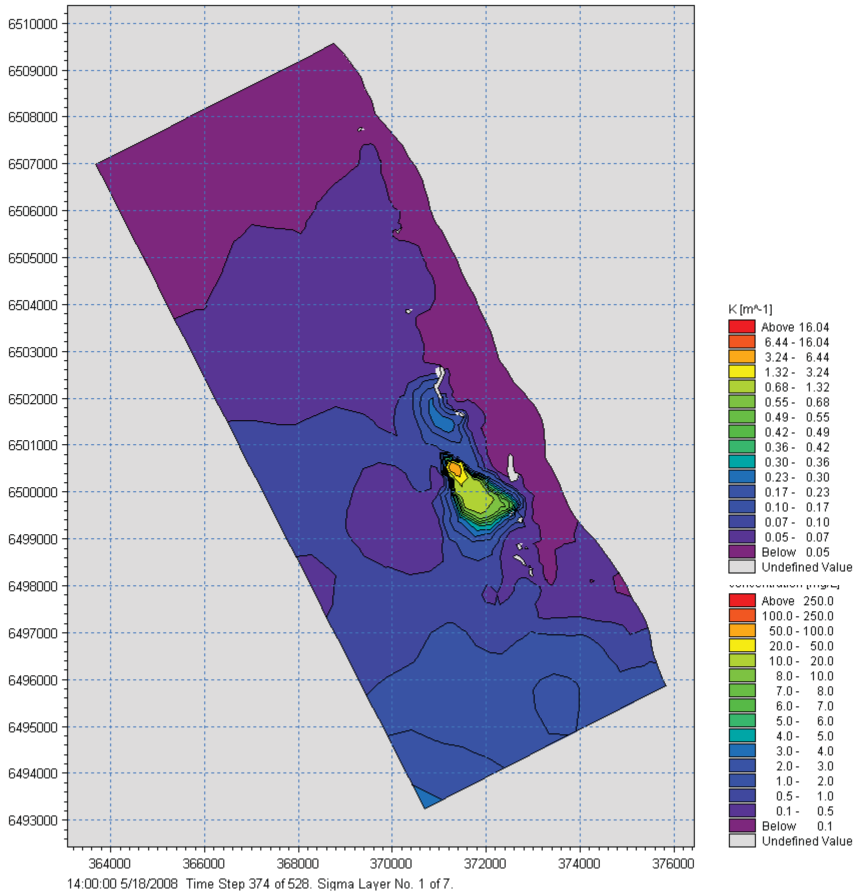

Figure 4-15: Dredge plume transport under conditions described by Pattern 3. Snapshot of the model taken at 18/05 14:00 PM just after finishing fifteenth day of dredging.

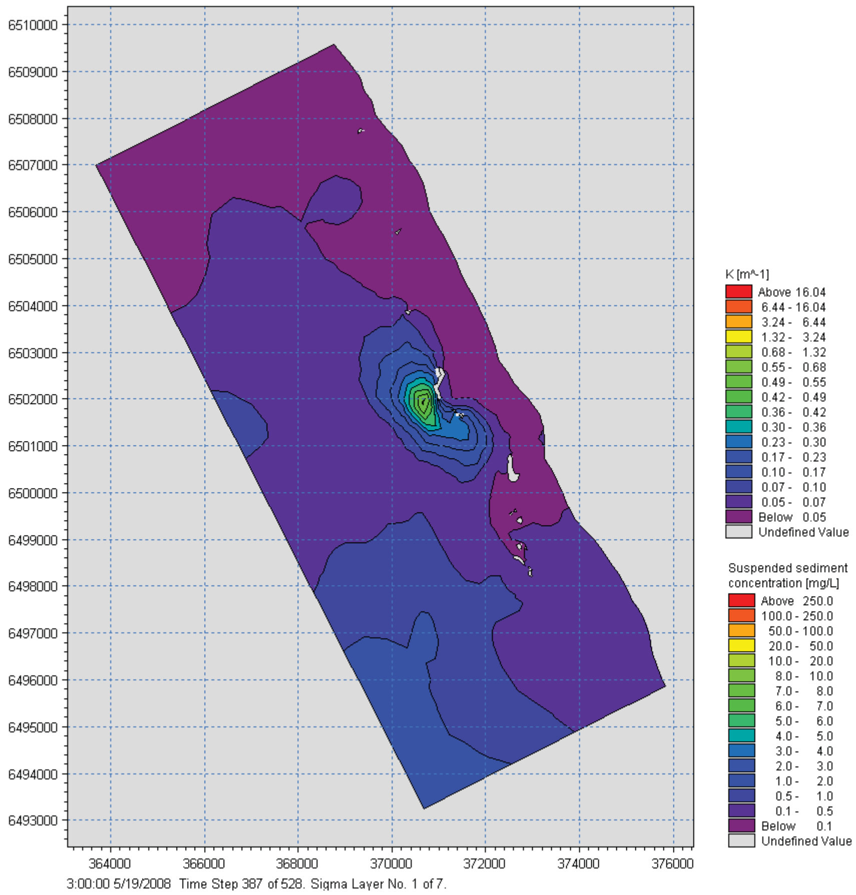

Figure 4-16: Dredge plume transport under conditions described by Pattern 3. Snapshot of the model taken at 19/05 03:00 AM just before commencement of the sixteenth day of dredging. Prevailing wind conditions on the previous 12 hours were 3.1 m/s North-westerly winds.

Figure 4-17 presents the simulated conditions at the end of the last day of dredging. It can be seen that plume concentrations were below 1 mg l^{-1} everywhere. This state, however, was largely affected by the strong winds observed on 23/05.

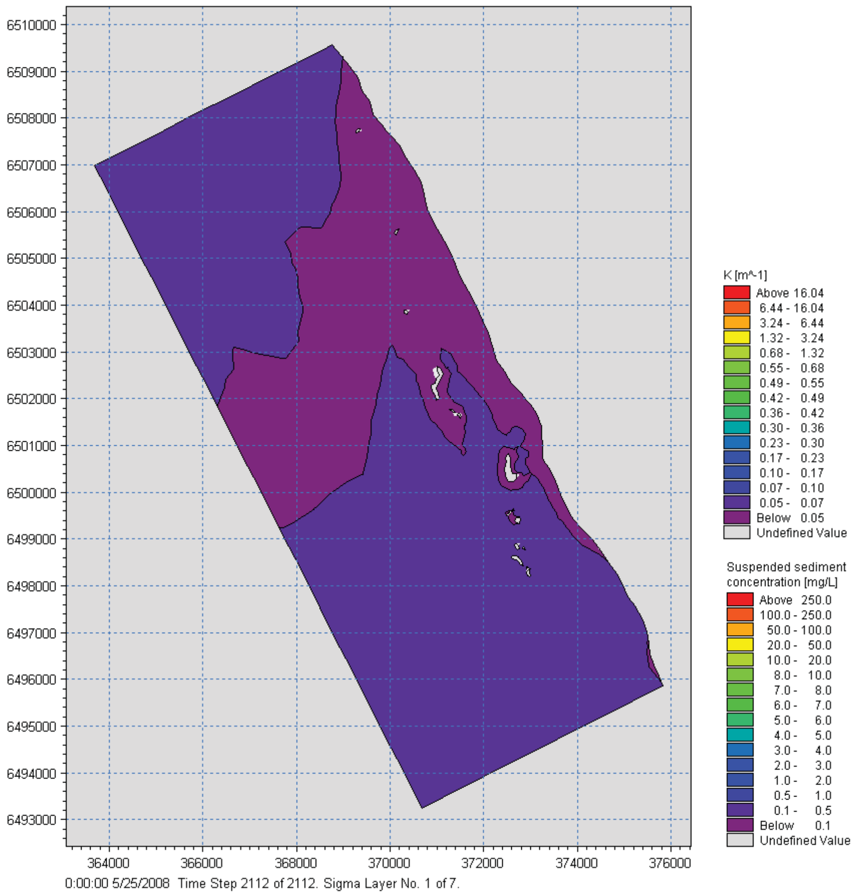

Figure 4-17: Dredge plume by the end of the simulation.

4.4.2 Deposition of dredged material

Maps of the maximum extent of accumulated sediments are presented in Figure 4-19 and Figure 4-20. It can be seen that most of the material remained in the zone of dredging (direct impact zone), with a maximum deposition of about 5 kg m^{-2} (Figure 4-20). Assuming a bulk density of the spoils of 1400 kg m^{-3}, this represents roughly a 4 mm layer thickness. This can be used to put the deposition maps displayed at a larger-range scale into context (Figure 4-19). Although a large area of the management zone had deposited sediments across the whole simulation domain, their deposition in the most impacted zones was considerably smaller than 1 kg m^{-2} (or less than 1 mm thickness). Maps of the accumulated deposition of sediments at the end of the simulation (Figure 4-18 and Figure 4-21) show that, whilst the deposited spoils in the zone of direct impact were slowly eroded, elsewhere in the study area the amount of deposition was noticeably reduced, particularly in the north and west. The values of suspended sediments presented in Figure 4-17 indicate that the remaining spoils should present a negligible source of sediments in the Alkimos local region.

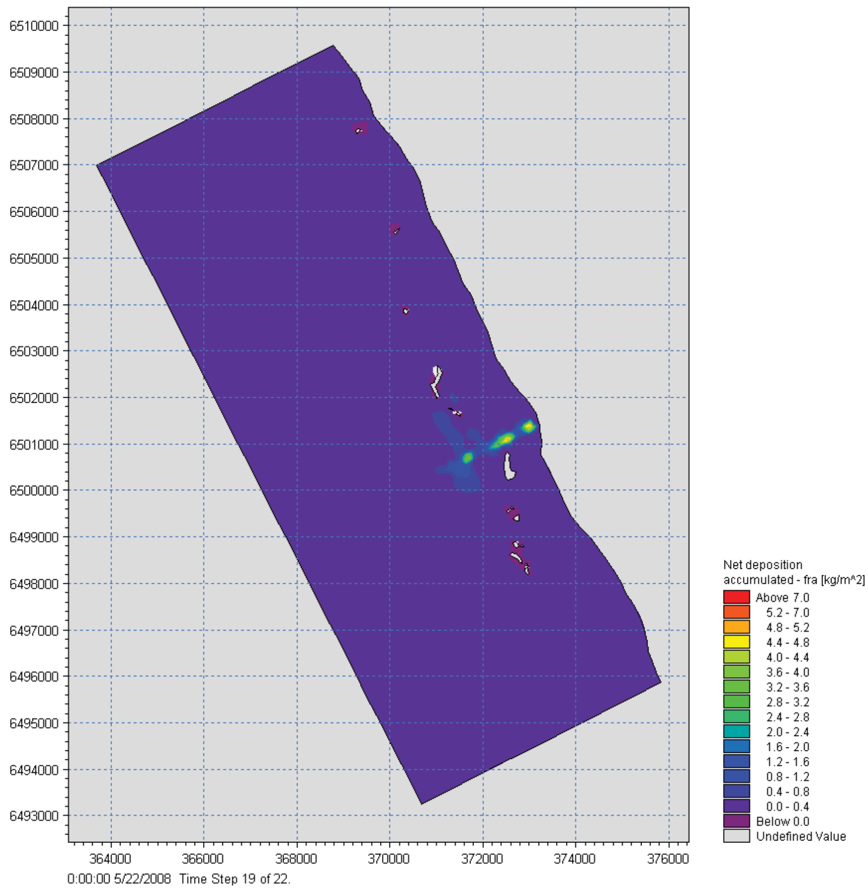

Figure 4-18: Deposition map at the the maximum extent of deposition shown with a linear legend.

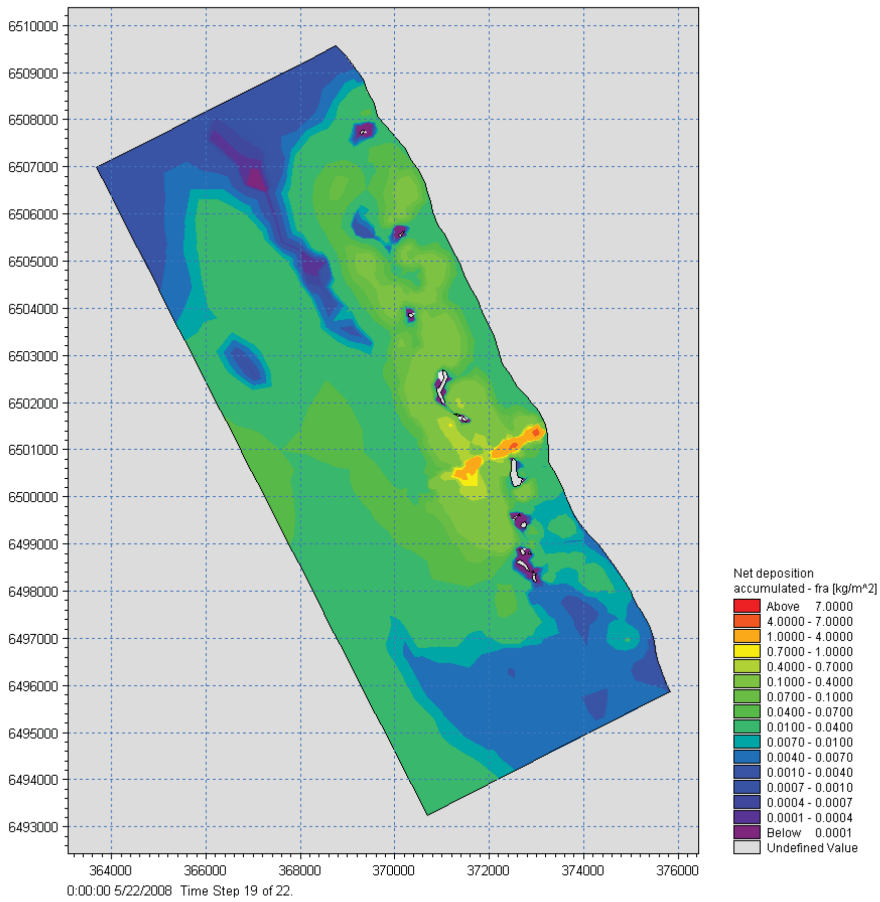

Figure 4-19: Deposition map at the maximum extent of deposition shown with a large-range legend.

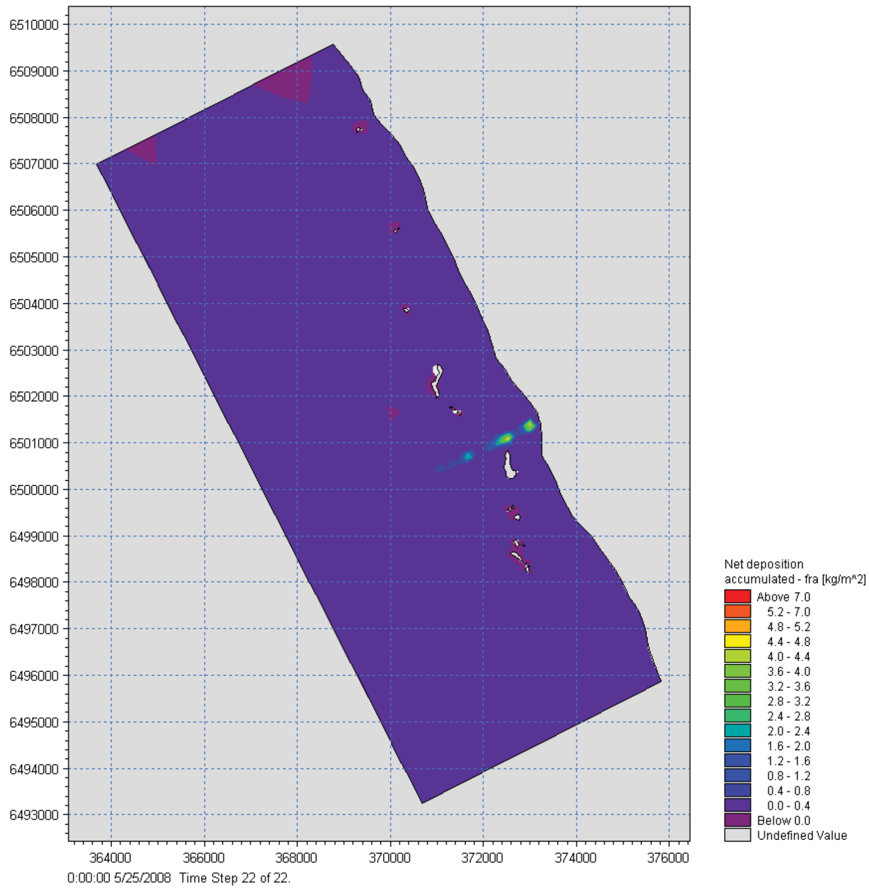

Figure 4-20: Deposition map at the end of the simulation shown with a linear legend.

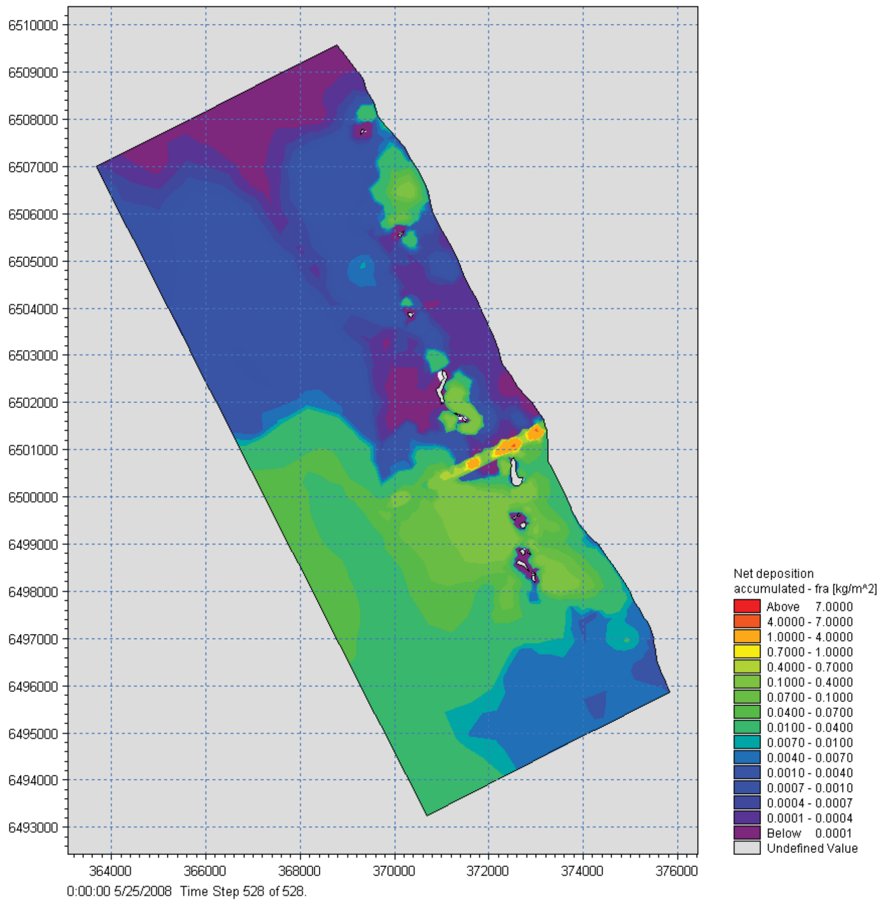

Figure 4-21: Deposition map at the end of the simulation shown with large-range legend

5 CONCLUSIONS

- Movement and deposition of the simulated dredge plume followed three main patterns that were dependent on the location of dredging and wind characteristics.
- Dispersion of the plume was more effective under southerly winds.
- Deposition of sediments was more effective in the offshore areas of the dredging.
- Translation of the plume was more efficient in the inshore zone.
- Winds exceeding 6 m s^{-1} were capable of re-suspending material deposited at the sea bed.
- Sediment deposition away from the direct zone of impact is practically negligible.
- Suspended sediment concentrations are elevated for very short periods (less than one day) at any one location due to efficient settling and dispersion, and plume migration.
- Sediment plumes from consecutive days of dredging remain separate under constant wind conditions, but can merge under changeable wind conditions.
- Suspended sediment concentrations in the plume associated with each day of dredging, and also for the full dredge program, return to background levels within three days of the completion of dredging operations.

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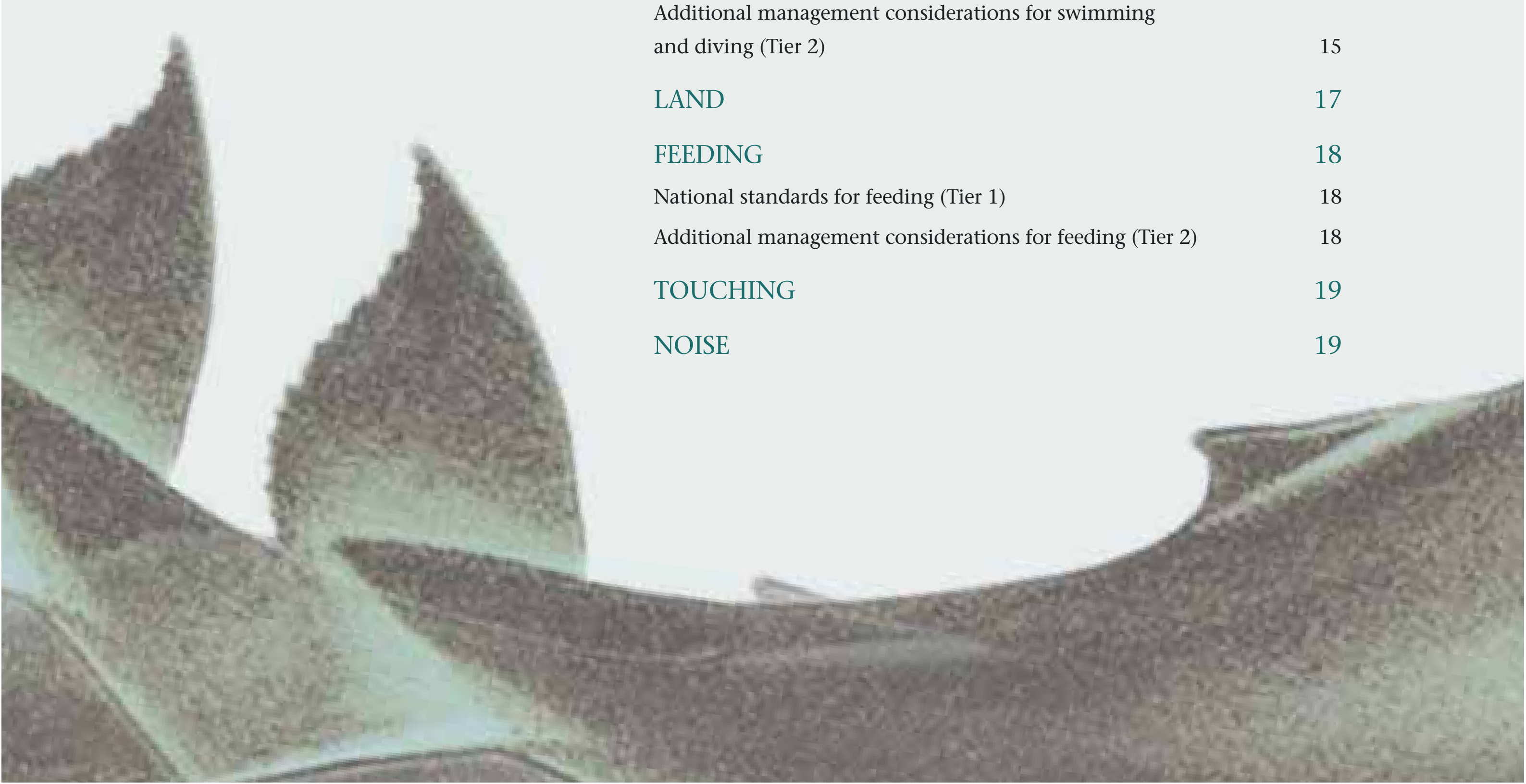
APPENDIX I - AUSTRALIAN NATIONAL GUIDELINES FOR WHALE AND DOLPHIN WATCHING 2005

TABLE OF CONTENTS



INTRODUCTION

Australia is privileged to have 45 species of whales and dolphins that live in or migrate through our waters. Such an abundance of species provides a fabulous opportunity for people to have high quality whale and dolphin watching experiences. These opportunities also enable Australia to have and promote a sustainable industry that allows the public to view and learn about these animals in their natural habitat.

Associated with this is the responsibility to ensure that potential impacts from watching whales and dolphins (either commercially or recreationally) are managed appropriately. The intent of these guidelines is to provide a framework that allows people to observe and interact with whales and dolphins in a way that does not cause harm to the animals.

The Australian National Guidelines for Whale and Dolphin Watching 2005 were developed jointly by all Australian, state and territory governments through the Natural Resource Management Ministerial Council, and represent a consistent national policy for the management of whale and dolphin watching. They build upon and replace the Australian National Guidelines for Cetacean Observation, published in 2000.

AIMS OF THE GUIDELINES

The guidelines set a national standard and aim to:

- minimise the impacts of whale and dolphin watching on individuals and populations of whales and dolphins; and
- ensure that people know how to act appropriately when watching whales and dolphins.

ROLE OF THE GUIDELINES

The guidelines set a national standard and help to inform governments to make consistent decisions when designing policy or legislation for whale and dolphin watching.

The guidelines provide advice on watching whales and dolphins in the wild, including observations from the land, water or air as well as activities such as swimming and diving, feeding, touching, and making noise. They are relevant to all Australian waters (Commonwealth, State and Territory) and cover all people watching whales and dolphins including both commercial operators and the general public.

Image courtesy of Ross Isaacs

ANIMALS IN DISTRESS

For the safety of both people and animals, these guidelines do not apply in situations where whales and dolphins are in distress – e.g. when stranded, entangled, sick or injured.

In these cases all people must only interact with animals under the guidance and approval of the relevant Australian Government, state or territory management authority.

All jurisdictions have laws that prohibit people without approval from interfering (kill, injure, take, trade, keep, move or touch) with whales or dolphins.

It is important to note that each government in Australia applies these guidelines through various laws and regulations as best suits the situation of the particular jurisdiction. In some cases the laws of a jurisdiction may differ from the guidelines and it is the responsibility of the whale and dolphin watching industry and the public to be aware of the laws that apply.

The relevant laws within each jurisdiction, information about areas of special interest for whale and dolphin watching, and more detailed information about the biology, population status, distribution and habitat of whales and dolphins can be accessed from the following government websites:

- Australian Government Department of the Environment and Heritage
  www.deh.gov.au/whales
- Great Barrier Reef Marine Park Authority
  www.gbrmpa.gov.au
- New South Wales Department of Environment and Conservation
  www.environment.nsw.gov.au
- Northern Territory Department of Infrastructure Planning and Environment
  www.ipe.nt.gov.au
- Queensland Environmental Protection Agency
  www.epa.qld.gov.au
- South Australian Department for Environment and Heritage
  www.environment.sa.gov.au
- Tasmanian Department of Primary Industries, Water and Environment
  www.dpiwe.tas.gov.au
- Victorian Department of Sustainability and Environment
  www.dse.vic.gov.au
- Western Australian Department of Conservation and Land Management
  www.naturebase.net

STRUCTURE OF THE GUIDELINES

The guidelines are organised into two categories—Tier 1 (national standards) and Tier 2 (additional management considerations).

TIER 1
(national standards)

Tier 1 applies to all people watching whales and dolphins and outlines the general requirements for protecting animals.

TIER 2
(additional management considerations).

Tier 2 provides advice for areas or activities that may require alternative levels of management and will apply primarily to the commercial whale and dolphin watching industry. Tier 2 provisions may be appropriate for:

- specially authorised whale and dolphin watching operations where scientific evidence supports different management arrangements;
- regions with specific site characteristics (e.g. geography, sensitive species, important populations, marine parks etc); or
- areas with intense whale and dolphin watching effort.

ALLOWING ANIMALS TO INTERACT WITH PEOPLE

For the protection of animals and for the long-term sustainability of the whale and dolphin watching industry, it is important that whale and dolphin watching be conducted in a manner that allows animals to choose the nature and extent of any contact with people.

It is essential that everyone wishing to watch whales and dolphins understands the important distinction between moving towards an animal, and an animal moving towards them. The guidelines refer to active approaches by people and stipulate the distances that people are allowed to move towards whales and dolphins. When those distances are reached, people must stand off and wait.

Sometimes whales and dolphins will move towards people to distances much closer than outlined in the guidelines. This situation is not in conflict with the guidelines.

DISTURBANCE

Whales and dolphins may be disturbed by the presence of people, vessels or aircraft. Disturbance to animals, particularly from cumulative effects, may lead to long-term negative impacts.

Although not well understood, the following are some of the potential problems that may be caused by disturbance:

- disruption of behaviour (e.g. feeding, nursing, mating, migrating and other behaviours);
- displacement from or avoidance of important habitat areas (e.g. resting, feeding, breeding and calving areas);
- stress;
- injury;
- increased mortality; and
- reduced breeding success.

It is important that people recognise signs of disturbance and immediately move away from animals that are disturbed. The following reactions may indicate that a whale or dolphin is disturbed:

- attempts to leave the area or moves away from the vessel quickly or slowly;
- regular changes in direction or speed of swimming;
- hasty dives;
- changes in breathing patterns;
- increased time spent diving compared to time spent at the surface;
- changes in acoustic behaviour; and
- aggressive behaviours such as tail slashes, and trumpet blows.

EDUCATION

The whale and dolphin watching industry provides an opportunity to educate the public about the habitat and behaviour of these animals.

To be considered 'best practice', operators should provide an educational component to their tours. It is recommended that operators educate their customers about the rules and guidelines that exist at state and national levels to guide operators and protect whales and dolphins.

Australian Government, state or territory management authorities also have a responsibility to work with the whale and dolphin watching industry to develop and improve the content and quality of educational material provided to clients. The training and where appropriate accreditation of all people involved in the industry—owners, operators and their staff—is strongly encouraged.

Image courtesy of The Great Barrier Reef Marine Park Authority

WHALES AND DOLPHINS IN AUSTRALIAN WATERS

For the purposes of these guidelines, 'dolphins' are those species that are part of the taxonomic Family Delphinidae. All other species should be considered 'whales'.

While there are 45 species of whales and dolphins found in our waters, a much smaller number of species are commonly encountered when whale and dolphin watching. These include:

WHALES	DOLPHINS
• Blue whale	• Bottlenose dolphin
• Bryde's whale	• Common dolphin
• Humpback whale	• False killer whale
• Minke whale	• Indo-Pacific humpback dolphin
• Southern right whale	• Killer whale
• Sperm whale	• Pilot whale
	• Australian snubfin dolphin (Irrawaddy)
	• Spinner dolphin

More information about whales and dolphins can be found on the Australian Government Department of the Environment and Heritage website – www.deh.gov.au/whales

ANIMALS OF SPECIAL INTEREST

In some circumstances, greater levels of protection than stipulated in these guidelines may be required for individual or groups of whales or dolphins. Jurisdictions may choose to apply additional management measures for these 'animals of special interest' in order to ensure the safety of both people and animals.

VESSELS

One of the most common ways of watching a whale or dolphin in their natural habitat is through the use of a vessel. However, inappropriate vessel use may lead to a range of negative impacts.

Although the full effects are unknown, some of the possible impacts of vessel presence on whales and dolphins include: disruption of important behaviour; displacement from or avoidance of important habitat areas; stress; injury; increased mortality and reduced breeding success.

If vessels are managed appropriately the impacts of whale and dolphin watching can be minimised. Vessels should be manoeuvred with care around whales and dolphins, and erratic vessel behaviour around animals should not occur. Responsible vessel operation, for example by allowing animals the choice to interact, will not only minimise impacts but also provide people with a more enjoyable experience.

PROHIBITED VESSELS

Certain vessels are prohibited for use in whale and dolphin watching. These include all personal motorised watercraft (e.g. jet skis and underwater scooters), parasails, remotely operated craft, wing-in-ground effect craft, and hovercraft.

Prohibited vessels should not approach closer than 300m to any whale or dolphin. If a prohibited vessel incidentally moves to within this distance it should slow down and avoid the whale or dolphin, moving away from the animal at a no wake speed to at least 300m.

ALLOWABLE VESSELS

Vessels to which the national standards apply include all other motorised, paddle and/or sail craft (e.g. motorboats, yachts, kayaks, canoes, surfskis, inflatable craft).

NATIONAL STANDARDS FOR VESSELS (TIER 1)

In order to minimise potential impacts on whales and dolphins, vessels should comply with the approach distances and operating procedures outlined in these guidelines and summarised in Table 1.

Note, if a whale or dolphin surfaces in the vicinity of your vessel when you are travelling for a purpose other than whale and dolphin watching, take all care necessary to avoid collisions. This may include stopping, slowing down and/or steering away from the animal.

WHALES

Figure 1 illustrates the allowable approach distances for whales. The caution zone (shown in yellow) is the area within 300m either side of a whale. No more than three vessels are allowed within the caution zone at any one time and vessels should operate at no wake speeds within this zone.

The no approach zone is within 100m of a whale, and also includes the area directly in front of or behind a whale out to 300m. Vessels should not enter the no approach zone and should not wait in front of the direction of travel of an animal or pod of animals. Vessels should also avoid repeated attempts to interact with whales if they show signs of disturbance.

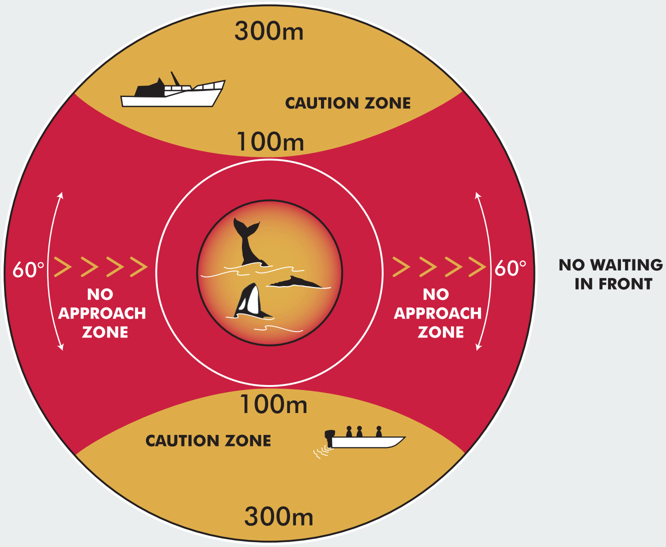


Figure 1 – approach distances for whales

DOLPHINS

Figure 2 illustrates the allowable approach distances for dolphins. The caution zone (shown in yellow) is the area within 150m either side of a dolphin. No more than three vessels are allowed within the caution zone at any one time and vessels should operate at no wake speeds within this zone.

The no approach zone is within 50m of a dolphin, and also includes the area directly in front of or behind a dolphin out to 150m. Vessels should not enter the no approach zone and should not wait in front of the direction of travel of an animal or pod of animals. Vessels should also avoid repeated attempts to interact with dolphins if they show signs of disturbance.

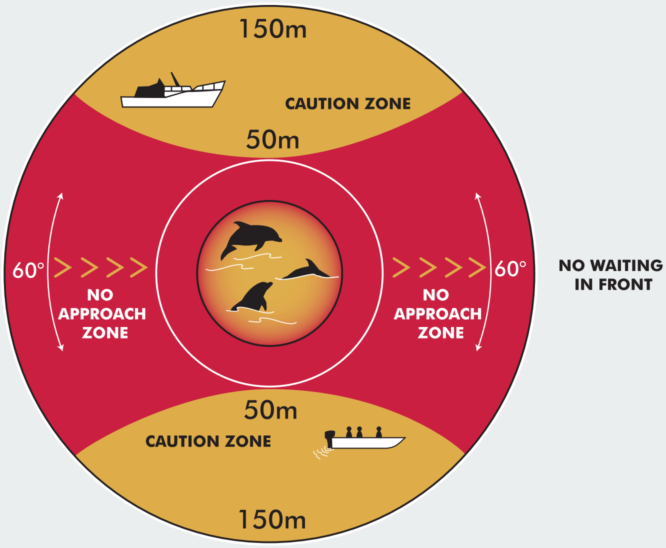


Figure 2 – approach distances for dolphins

Image courtesy of The Great Barrier Reef Marine Park Authority

REQUIREMENTS	DISTANCE TO A WHALE	DISTANCE TO A DOLPHIN
CAUTION ZONE • no wake speed • maximum of 3 vessels • do not enter caution zone if animals are stranded, entangled or distressed	BETWEEN 300 and 100 metres	BETWEEN 150 and 50 metres
NO APPROACH ZONE • do not enter • no waiting in front of direction of travel • do not approach from the rear	WITHIN 100 metres	WITHIN 50 metres
BOW RIDING • do not deliberately encourage bow riding • when animals are bow riding—do not change course or speed suddenly • if there is a need to stop—reduce speed gradually		

CONFINED WATERWAYS

In confined or crowded waterways such as bays, estuaries, channels and rivers it may not be possible for vessels to maintain approach distances or the appropriate number of boats within the caution zone. In these instances take all necessary caution to avoid whales and dolphins.

OPERATION OF VESSELS WHEN WATCHING WHALES AND DOLPHINS

Along with complying with the caution zone and no approach zone surrounding whales and dolphins, vessels must be operated around animals in an appropriate manner.

The recommended and most effective method of approaching a whale or dolphin is from the side and slightly to the rear of the animal. Do not intercept the path of travel or approach head-on, and do not pursue whales and dolphins.

ENTERING AND WITHIN THE CAUTION ZONE

When entering and within the caution zone vessels should be operated with caution to avoid disturbing whales and dolphins. Vessels should:

- be limited to no more than three vessels within the caution zone at any one time;
- not be deliberately placed to drift into the no approach zone;
- move at slow speed and avoid making sudden or repeated changes in direction;
- avoid making sudden or excessive noise (including from the people on board);
- not restrict the movement of animals in against the shore; and
- not approach calves or pods containing calves. For the purposes of these guidelines, a calf is defined as an animal which is less than half the length of the mother to which it usually remains in close proximity.

If a whale or dolphin shows signs of avoidance or disturbance, vessels should cease attempting to watch the animals and move at once outside the caution zone at a no wake speed.

LEAVING THE CAUTION ZONE

When leaving whales and dolphins, vessels should move off at a slow no wake speed gradually increasing speed when reaching the limit of the caution zone from the closest animal.

BOW RIDING

Vessels should not seek to deliberately encourage animals to bow ride. However, in the event that dolphins or small whales bow ride, vessels should maintain course and speed. In cases where vessels need to stop, this should be done through a gradual reduction in speed.

DISTURBANCE

The following reactions may indicate that a whale or dolphin is disturbed:

- attempts to leave the area or vessel (quickly or slowly);
- regular changes in direction or speed of swimming;
- hasty dives;
- changes in breathing patterns;
- increased time spent diving compared to time spent at the surface;
- changes in acoustic behaviour; and
- aggressive behaviours such as tail slashes, and trumpet blows.

ADDITIONAL MANAGEMENT CONSIDERATIONS FOR VESSELS (TIER 2)

Many species of whale and dolphin are resident in or dependent upon specific areas for their survival. In these areas there is a greater potential for vessels to have a detrimental impact.

Impacts can include disruption of important behaviour, displacement from or avoidance of important habitat areas, stress, injury, increased mortality and reduced breeding success. In these areas, or areas where there is a substantial whale and dolphin watching industry there may be a need to establish additional management measures. These measures (Tier 2) may be applied through various administrative means including regulations, permits, licenses and management plans.

Additional management measures may lead to a range of different outcomes to those outlined in the national standards, including the potential to allow closer interactions than specified in Tier 1. Closer interactions may be appropriate in some situations because of the geography of the local area (e.g. due to the shape and nature of inlets) and/or due to more stringent restrictions on other elements of vessel operation (e.g. limits on the time spent with animals, number of trips per day etc).

Given that for many whale and dolphin species, the time and intensity of watching may also have a significant impact on a population it is recommended that the following issues be considered when developing additional management measures for vessels:

- maximum watching time with a pod;
- maximum cumulative watching time from all vessels with a pod/population per day;
- time required between successive watching attempts;
- establishment of no approach times (e.g. when the animals are likely to be feeding, resting etc);
- the need for temporal or spatial exclusion zones;
- the need to restrict the numbers of vessels; and
- conducting research on the species biology and behaviour, seasonal requirements and habitat requirements.

In some instances, such as for scientific or educational purposes, or commercial filming it may be necessary for vessels to approach closer to a whale or dolphin than outlined in the national standards (Tier 1). This may only occur under the authorisation of the relevant state, territory or Australian Government agency.

In these cases all vessels must operate within the conditions of authorisation.

AIRCRAFT

Aircraft may disturb whales and dolphins due to their speed, noise, shadow, or downdraft in the case of helicopters.

Aircraft should be operated in accordance with the provisions outlined below. Note, these provisions do not apply where general civil aviation rules do not allow for the requirements to be met (e.g. due to take off and landing requirements).

NATIONAL STANDARDS FOR AIRCRAFT (TIER 1)

HELICOPTERS (INCLUDING GYROCOPTERS)

As illustrated in Figure 3, a person operating a helicopter or gyrocopter in the vicinity of whales and dolphins must:

- not fly lower than 500m (1650 feet) within a 500m (1650 feet) radius of a whale or dolphin;
- not hover over the no fly zone;
- avoid approaching a whale or dolphin from head on;
- avoid flying directly over, or passing the shadow of the helicopter directly over a whale or dolphin; and
- cease the activity if the whale or dolphin shows signs of disturbance.

OTHER AIRCRAFT

As illustrated in Figure 4, a person operating any other airborne craft including fixed wing, gliders, hang-gliders, hot air balloons and airships in the vicinity of whales and dolphins must:

- not fly lower than 300m (1000 feet) within a 300m (1000 feet) radius of a whale or dolphin;
- not approach a whale or dolphin from head on;
- not land on the water to observe whales or dolphins;
- avoid flying directly over, or passing the shadow of the aircraft directly over a whale or dolphin; and
- cease the activity if the whale or dolphin shows signs of disturbance.

DISTURBANCE

The following reactions may indicate that a whale or dolphin is disturbed:

- attempts to leave the area or vessel (quickly or slowly);
- regular changes in direction or speed of swimming;
- hasty dives;
- changes in breathing patterns;
- increased time spent diving compared to time spent at the surface;
- changes in acoustic behaviour; and
- aggressive behaviours such as tail slashes, and trumpet blows.

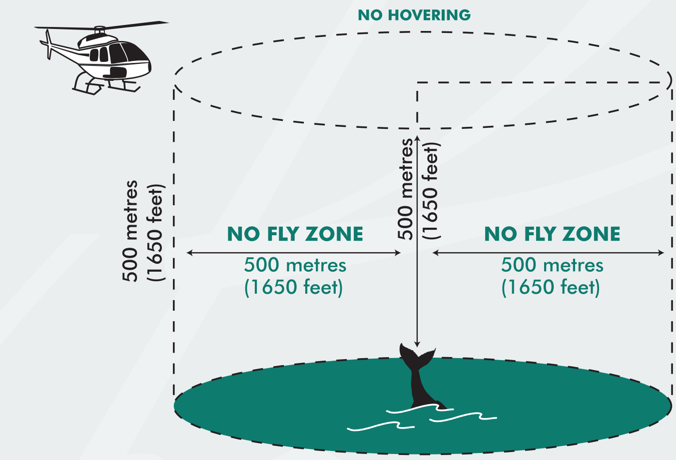


Figure 3 - approach distances for helicopters

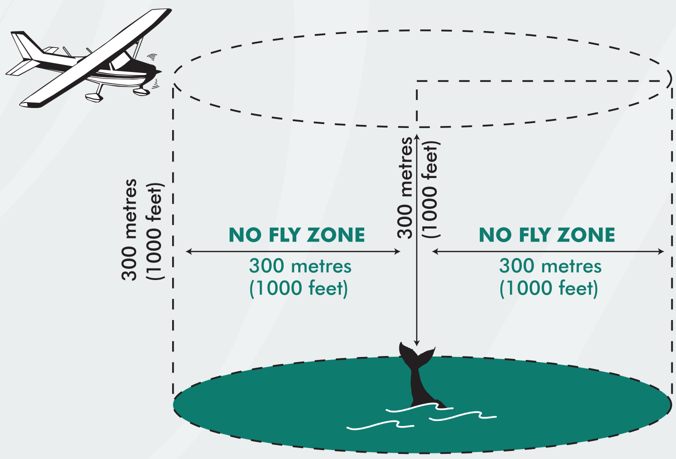


Figure 4 – approach distances for aircraft

ADDITIONAL MANAGEMENT CONSIDERATIONS FOR AIRCRAFT (TIER 2)

In some instances such as for scientific or educational purposes, or commercial filming it may be necessary for aircraft to approach closer to a whale or dolphin than outlined in the national standards.

This may only occur under the authorisation of the relevant state, territory or Australian Government agency. In these cases all aircraft must operate within the conditions of authorisation.

SWIMMING AND DIVING

Swimming (which includes snorkelling) or diving with a whale or dolphin may place both people and animals at risk. Risks to humans include injury and possible death from forceful interactions, and transmission of diseases. The greatest risk to whales and dolphins may be from the misuse of vessels and the inappropriate placement of people in the water, forcing animals to actively avoid interaction.

In Australia these impacts and risks are minimised by ensuring that swim programs are conducted by people who are authorised by the relevant state, territory or Australian Government agency to operate swimming programs or for scientific or educational purposes, and limiting diving to those people who are authorised for scientific or educational purposes.

Only people operating under authorisation should deliberately swim or dive in the vicinity of a whale or dolphin.

NATIONAL STANDARDS FOR SWIMMING AND DIVING (TIER 1)

Deliberately swimming or diving (including the use of SCUBA or hookah gear) with whales and dolphins is prohibited unless under the authorisation of the relevant state, territory or Australian Government agency. If incidentally in the vicinity of a whale or dolphin:

- Swimmers (including snorkellers) and divers should not enter the water closer than 100m to a whale or 50m to a dolphin, and should not approach closer than 30m to any animal.
- Sometimes whales or dolphins will approach or pass close to swimmers or divers. In this situation you are not in contravention of the guidelines. If approached by a whale or dolphin move slowly to avoid startling the animal and do not attempt to touch it or swim toward it.

Image courtesy of Robert Thorn

ADDITIONAL MANAGEMENT CONSIDERATIONS FOR SWIMMING AND DIVING (TIER 2)

AUTHORISED SWIMMING PROGRAMS

In order to ensure the long-term sustainability of swimming operations, commercial swim programs should be accompanied by ongoing research to monitor whale and dolphin responses to swimmers, and to help track any changes in animal behaviour that may have implications for animals or people. Consideration should also be given to undertaking research prior to the development or expansion of operations. Research should focus on the biology and behaviour, seasonal requirements, and habitat requirements of the target population of whales or dolphins.

Authorised swim programs may in some cases allow for closer interactions than those specified in Tier 1 because of more stringent restrictions on swimmer behaviour and due to increased management oversight from the relevant Australian Government, state or territory management authority.

Specific issues to be considered when developing or reviewing swimming operations include:

- limits on the number of vessels and/or swimmers;
- maximum watching time with a pod/ population per day including:

  maximum time for each interaction;

  time required between successive swim attempts; and

  maximum cumulative watching time from all vessels/swimmers;
- establishment of no approach times (e.g. when the animals are likely to be feeding, resting etc);
- the need for temporal or spatial exclusion zones;
- distance of swimmers to animals; and
- the use of mermaid lines or boom nets.

Image courtesy of The Great Barrier Reef Marine Park Authority

Vessels should be operated in accordance with applicable parts of these guidelines and any other regulations, codes of practice or restrictions applicable to the area and species. Vessels should not actively tow swimmers and no other vessel should be closer than 100m to a vessel conducting swims.

Operators should not place swimmers directly in the path of an animal or group of animals. Swimming should not occur with whale or dolphin calves, or pods containing calves. For the purposes of these guidelines, a calf is defined as an animal which is less than half the length of the mother to which it usually remains in close proximity.

Attempts at swimming with whales or dolphins should stop if the animals show signs of disturbance.

DISTURBANCE

The following reactions may indicate that a whale or dolphin is disturbed:

- attempts to leave the area or vessel (quickly or slowly);
- regular changes in direction or speed of swimming;
- hasty dives;
- changes in breathing patterns;
- increased time spent diving compared to time spent at the surface;
- changes in acoustic behaviour; and
- aggressive behaviours such as tail slashes, and trumpet blows.

SCIENTIFIC OR EDUCATIONAL PURPOSES

In some instances, such as for scientific or educational purposes, it may be necessary for swimmers or divers to deliberately interact with whales or dolphins. This may only be carried out under the authorisation of the relevant state, territory or Australian Government agency. In these cases swimmers or divers must operate within the conditions of authorisation.

LAND

Watching from land causes the least disturbance to whales and dolphins. Cliffs and headlands can provide excellent vantage points for viewing many different species of whales and dolphins.

It is important to be aware of the impact you may have on the environment and remember coastal dunes and headlands can be sensitive areas.

STRANDED ANIMALS

For the safety of both people and animals, people must avoid interacting with stranded animals unless under the guidance and approval of the relevant Australian Government, state or territory management authority.

All jurisdictions have laws that prohibit people without approval from interfering (kill, injure, take, trade, keep, move or touch) with whales or dolphins.

FEEDING

There are environmental, health and safety concerns associated with deliberate feeding of whales and dolphins. In most cases feeding by humans has been shown to have adverse effects, sometimes severe, on the whales and dolphins concerned.

Only people operating within a specially authorised feeding program should deliberately feed a whale or dolphin.

NATIONAL STANDARDS FOR FEEDING (TIER 1)

A person should not deliberately feed or attempt to feed a wild whale or dolphin.

This includes throwing food or rubbish in the water in the vicinity of whales and dolphins, and feeding from boats.

ADDITIONAL MANAGEMENT CONSIDERATIONS FOR FEEDING (TIER 2)

FEEDING PROGRAMS

Feeding is permitted only under programs authorised by the relevant Australian Government, state or territory agency. In these cases feeding programs must operate within the conditions of authorisation. There should be no further establishment or expansion of feeding programs.

All existing feeding programs should be accompanied by ongoing research to monitor whale and dolphin responses to help track any changes in animal behaviour that may have implications for animals or people.

TOUCHING

Touching whales and dolphins is not permitted unless under the guidance and approval of the relevant Australian Government, state or territory management authority.

If you are approached by a whale or dolphin, avoid touching or sudden movements that might startle it.

NOISE

Whales and dolphins have sensitive hearing and sound plays an important role in their communication, navigation and prey location.

Noise that humans introduce into the environment can mask important sounds or damage animals hearing. It is very difficult to determine how whales and dolphins may react to a particular sound or how severe the effects may be, so production of noise should be minimised.

- Vessels and aircraft should be maintained in good condition to minimise the transfer of noise into the water.
- Avoid making loud or sudden noises near whales or dolphins. If a whale or dolphin comes close to shore or your boat, remain quiet.
- Do not intentionally make any noise to attract whales or dolphins. This incudes playback of underwater sound of recorded whale or dolphin sounds or song.

APPENDIX J - ROLES AND RESPONSIBILITIES

Roles and Responsibilities for Site-based Staff

ROLE	RESPONSIBILITY
Alliance Manager	The Alliance Manager is responsible for the approval and implementation of this MPCOOP. The Alliance Manager shall: - Actively promote sound environmental management and ensure that all project personnel are fully conversant with this and any incumbent responsibilities. - Be aware of meetings, audits and reviews pertaining to environmental matters resulting from the MPCOOP. - Ensure that the MPCOOP is adopted into the construction management system and procedures.
Environment and Community Relations Manager	The Environment and Community Relations Manager is accountable to the Alliance Manager and is responsible for ensuring the AWA is adequately resourced to comply with and implement the MPCOOP. The Environment and Community Relations Manager shall: - Advise on environmental requirements' and ensure compliance with all current statutory obligations - Ensure potential subcontractors have suitable experience and knowledge to conduct any potential work in compliance with the MPCOOP. - Ensure performance is monitored, documented and reported to senior management. - Review marked out clearing areas and sign a Ground Disturbing Activity Form prior to any clearing. In conjunction with the Site Environmental Coordinator, review the document every 3 months and install system improvements

Marine Superintendent	The Marine Superintendent is accountable to the Alliance Manager. The Marine Superintendent has the authority to assess the environmental implications of installation Methodology/design on marine habitat and make changes as appropriate in consultation with the Manager of Environment and Community Relations. The Marine Superintendent shall: - Develop a construction methodology compliant with the MPCOOP. - Liaise with the Environment and Communications Manager and the Site Environmental Coordinator with respect to Fauna issues which may occur on site. - Ensure that a Ground Disturbing Form has been signed off by the Alliance Manager and the Environment and Community Relations Manager prior to any ground disturbing activities being undertaken.
Site Environmental Coordinator	The Site Environmental Coordinator reports to the Environment and Community Relations Manager. This position provides daily site environmental management, advice of the environment issues to site construction personnel and assists them in managing environmental issues. The Site Environmental Coordinator shall: - Monitor environmental performance of construction activities on a daily basis. - Distribute information in relation to the MPCOOP and have the readily available. - Be available to consult with subcontractors should there be any queries in relation to the MPCOOP. - Facilitate training of personnel on site. - Report back to the Environment and Communications Manager on a weekly basis regarding any issues associated with the MPCOOP.

Supervisors & Site Engineers	Supervisors shall be responsible for determining the course of actions to be taken, to ensure minimal impact to fauna and fauna habitat. Supervisors shall: - Be aware of the MPCOOP and have a copy of it on site at all times. - Provide leadership which encourages a consultative interaction with team members. - Be responsible for ensuring that sufficient resources are available for the implementation of the MPCOOP. - Comply with and adhere to the requirements of the MPCOOP, instruction and procedures - Ensure that the personnel under their supervision have an understanding of the MPCOOP and are provided with the necessary instructions and support to perform their tasks in a manner which minimises impacts on the environment.
Personnel and Subcontractors	All personnel, including subcontractors, are responsible for the environment, in so far as they have some control, either direct of indirectly. Each person shall: - Participate in environmental meetings and awareness training though an induction process prior to entering site. - Be responsible for keeping the workplace in a clean and tidy condition. - Immediately report all incidents/accidents Comply with and adhere to the requirements of the MPCOOP, instruction and procedures.

APPENDIX K - TRIGGER EVALUATION METHODOLOGY

TRIGGER EVALUATION METHODOLOGY

INTRODUCTION

The primary impact of decreased water quality as a result of construction of the ocean outfall will be on benthic primary producer habitat (BPPH). An increase in turbidity will decrease light attenuation, which potentially reduces the photosynthetic capacity and subsequently, the health of BPPH. Therefore, monitoring of water quality and BPPH are integrated in order to validate predicted primary impacts on water quality and secondary impacts on BPPH. During construction, an exceedance in water quality trigger values will instigate a reactive monitoring program for BPPH.

Setting appropriate trigger levels is an integral part of an effective monitoring program. The aim of trigger levels is to provide timely advice of a potential problem. Therefore, setting a trigger that is likely to be constantly breached by natural conditions diminishes the usefulness of the trigger value. The sections below detail the background information and methodology used to set the water quality trigger levels presented in the Management Plan for Construction of the Ocean Outlet Pipeline (MPCOOP) for the Alkimos Wastewater Scheme.

LIGHT ATTENUATION PERCENTILE

Light attenuation will be measured at both impact sites (within the area of predicted impacts) and reference sites (outside the area of predicted impacts) during construction of the ocean outlet as a measure of water quality. Due to the need to prevent constant breach of trigger values from natural conditions, median values (e.g. median of background light attenuation levels) are of little use as trigger values. Instead, trigger levels developed for light attenuation during construction of the ocean outfall will instigate reactive monitoring when the light attenuation at impact sites exceeds the 80th, 95th or 99th percentile of that at reference sites. By comparing impact and reference sites, changes to light attenuation can be directly attributed to construction. The 80th percentile was selected to provide an early indication of water quality impacts, while the 95th and 99th percentiles will show more sever impacts are potentially occurring. This method will increase the robustness of the monitoring program by reducing breaches due to natural conditions and by indicating conditions with the potential to cause stress to BPPH.

MINIMUM LIGHT REQUIREMENTS FOR BENTHIC PRIMARY PRODUCERS

Benthic primary producers require light to drive photosynthesis, which allows them to grow and survive. For photosynthesis to occur light must infiltrate through the water column to the depth at which seagrasses or macroalgae are growing. Light is absorbed and scattered as it passes through the water column, decreasing the level of light occurring at depth. Increased suspended solids, which may result from construction of ocean outlet, increases the scattering and absorption of light, therefore increasing light attenuation (i.e. decreasing the amount of light that reaches BPPH).

Different seagrass and macroalgae species have varying tolerances to the severity and duration of reduced light availability. Some species have a low degree of tolerance, surviving for only one month when deprived of light (e.g., the seagrass *Halophila ovalis*, Longstaff *et al.* 1999). Other species show a high degree of tolerance, such as the seagrass *Posidonia sinuosa*, which has been observed to survive for more than five months below its minimum light requirements (MLR) (Gordon *et al.* 1994). Changes in leaf physiology (e.g. amino acid content, chlorophyll content and d13C) and morphological changes (e.g. biomass, shoot density, canopy height) may also result from decreased light attenuation.

If light availability is sustained below a species' MLR for extended periods, complete loss of that species is likely to occur (Ralph *et al.* 2007). Due to the lower light availability at depth, it is expected that deeper seagrass will demonstrate stronger responses to light reduction than shallower seagrasses. Additionally, large, persistent species are generally regarded as requiring more light than smaller, transient species as they require more carbon to develop and maintain biomass (Duarte 1991).

A theoretical MLR for growth of seagrasses have been estimated at 11% of surface irradiance (Duarte, 1991), however seagrasses globally have been reported to have values between 4 and 29% of the Photosynthetic Photon Flux Density (PPFD - light with wavelength (λ) of about 350-700 nm) just below the water's surface (Dennison *et al.* 1993).

In Cockburn Sound, near Perth, the seagrass *Posidonia sinuosa* was found to have a MLR of 8.5% of sub-surface irradiance (1200 mol photons m-2 yr-1) (Collier *et al.* 2007). Shoot loss was found to result in this species after 106 days of moderate (27% of sub-surface irradiance) and heavy (9% of sub-surface irradiance) shading, although complete loss of shoots had not occurred after 206 days (Collier *et al.* 2007).

The seagrass *Amphibolis griffithii* was observed to respond rapidly to severe, short-term reductions in light availability (Mackey *et al.* 2007). A dramatic reduction in aboveground tissue resulted from decreased light attenuation, which would have the effect of reducing the total plant respiratory load (Mackey *et al.* 2007). However, responses at the scale of shoots and whole meadows also allowed plants to respond rapidly to improved light conditions. The extent and rate of recovery of morphological and physical variables were found to indicate that *A. griffithii* is largely able to withstand a single episode of high-intensity photosynthetically active radiation (PAR) reduction over a three month period (Mackey *et al.* 2007).

Halophila ovalis generally displays a low tolerance to light deprivation. Erftemeijer *et al.* (1993) found the MLR for shallow-water *H. ovalis* ranged from 50 to 340 mmol photonsm−2 s−1, while Erftemeijer and Stapel (1999) recorded *H. ovalis* to have a MLR of 33 mmol photons m−2 s−1 at a depth of 15 m. Longstaff and Dennison (1999) found the biomass of *H. ovalis* receiving 0% of ambient light, declined rapidly during the first 38 days of light deprivation, with nearly all the *H. ovalis* having died by day 38. Overall, *H. ovalis* has a very limited tolerance to light deprivation when compared to larger species of seagrass (Longstaff *et al.* 1999). Rapid die-off during light deprivation in conjunction with slow recovery rates implies that long-term survival of *H. ovalis* would be greatly affected by a series of light deprivation events occurring in short succession. (Longstaff *et al.*1999).

Due to the low recovery potential of seagrasses a conservative trigger level will be utilised to trigger reactive monitoring during construction of the ocean outlet. A range of 10 to 30% of sub-surface irradiance reaching BPPH, sustained continuously over a 14 day period will instigate reactive monitoring. The range of sub-surface irradiance covers the estimated MLRs for a variety of seagrass species. Given that even benthic primary producers with a low tolerance to increased light attenuation can survive with complete light deprivation for a month, it is considered appropriate that a continuous two-week period of low-light availability will be required to instigate reactive monitoring and management actions.

CONCLUSIONS

Trigger values for light attenuation and MLR have been established to instigate the reactive monitoring program during construction of the ocean outlet. The trigger values set for light attenuation will minimise breaches by natural conditions and provide an early indication of problems (80^{th} percentile) as well as indicate the potential for more significant impacts (95^{th} and 99^{th} percentile).

Any decrease in light attenuation has the potential to cause secondary impacts to BPPH by limiting photosynthesis. If light is maintained below a species' MLR for an extended period, stress or mortality may result. The MLR trigger values of 10 to 30% of subsurface irradiance will indicate the potential for real impacts on BPPH. These conservative triggers will allow intervention prior to exceedance of the MLR of benthic species in the vicinity of the ocean outlet.

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APPENDIX L - REVIEWERS' REPORTS AND EXPLANATION OF AMENDMENTS IN RESPONSE

PROFESSOR ERIC PALING

MR IAN LEPROVOST

WORLEYPARSONS AMENDMENTS IN RESPONSE TO REVIEWERS' COMMENTS

Marine and Freshwater
Research Laboratory
Environmental Science

David Coremans,
Senior Environmental Scientist,
Cardno BSD

23rd July 2008

Review of:	**'Alkimos Wastewater Treatment Scheme: Management Plan for construction and ongoing presence of the ocean outlet pipeline'** Prepared for Alkimos Water Alliance
Author/s:	WorleyParsons Services Pty Ltd.
Date:	Final draft dated 14th July 2008
Review by:	Associate Professor Eric Paling Marine and Freshwater Research Laboratory, Environmental Science, Murdoch University
Review for:	Alkimos Water Alliance

Dear David,

Thank you for the opportunity to review the final draft of the above document. As requested, I have provided a brief introduction to my qualifications and experience.

Reviewer qualifications

Associate Professor Eric Paling is a marine scientist who has spent the last 19 years in Environmental Science at Murdoch University, where he coordinates or lectures in units focusing upon oceanography, marine pollution, coastal environments, groundwater and statistics. His research expertise focuses upon water quality and benthic primary producers, specifically seagrasses, mangroves and macroalgae. He directs the Marine and Freshwater Research Laboratory (MAFRL), a well-regarded, externally funded, NATA-accredited and AQIS-approved water quality analysis facility which possesses analysts and field research members able to assist in a wide variety of projects from wastewater treatment impacts to coral, desalination plants and biological surveys for the oil and gas industry. Since 1987 he has produced 37 refereed book chapters or journal articles, 120 technical reports and since 2001 has procured over 9.6 million dollars in research funding. He is the most well-published seagrass rehabilitation researcher in Australia and he has brought it to the stage that it is now considered a feasible option for restoring marine ecosystems. He has also carried out a number of impact studies on mangroves for iron ore and salt industries based in the Pilbara and Kimberley and facilitated their environmental approval. He also assisted the EPA in writing the Pilbara mangrove policy. He is familiar with environmental impact assessment and management, and regularly reviews documents both in WA and interstate for regulatory authorities. He worked for the Department of Conservation and Environment from 1983 to 1986 under Drs Chittleborough and Ottaway. His PhD, which was funded by the DCE, involved studying nutrient dynamics in Perth benthic primary producers because there was little information available to guide decision making. He has consulted and researched on a number of topics relevant to wastewater outfalls, specifically PLOOM, BLOOM and he was a researcher for the Perth Coastal Waters Study for two years examining the effects of nutrients on seagrass epiphytes. He can provide a detailed CV upon request.

Scope of this review
As requested, I have ordered this review to conform to the sequence of the relevant conditions laid out in Ministerial Statement No. 755 to provide a straight forward framework to assist the Alkimos Alliance, the Water Corporation and the DEC in their deliberations and assessment. I have therefore used as headings (and subheadings) the conditions under Statement No. 755, followed by the Water Corporation interpretation of the condition.

My understanding was that the overarching objective of my review was to seek to determine whether the management plan provided sufficiently addressed the specific matters raised in Conditions 8-3 and 9-3 to meet the environmental objectives and requirements of Conditions 8-2 and 9-2 in the context of the pipeline's position in the environment and the risk its construction presents to it. Additionally where there were aspects/elements of the objectives and requirements I believed had not been met, I should provide clear advice outlining how this can be best rectified.

Specifically that my review was to assess the following:

- Whether the management plan/s address the specific matters as specified in Conditions 8-3 and 9-3 respectively for the OOCMP and the SBHMMP, to a sufficient degree to ensure confidence that the environment is protected in line with the Minister's objectives enunciated in Conditions 8-2 and 9-2;
- Requirements other than those in 8-3 and 9-3 that are contained within the conditions;
- The residual risk to the environment posed by the proposal, if managed in accordance with the management plan, given the scale and nature of the construction activities and the values and attributes of the existing environment; and
- The degree to which the management framework is likely to achieve outcomes that are considered environmentally acceptable in the context of known management practices for similar small scale marine works in high energy, sandy-limestone coastal areas in Australia and abroad.

I have read all material made available to me including the animation CDs and appendices, and I will summarise my comments upon these specific aims at the end of the document. I have also added comments on sections not specified in the above scope.

Conditions under Ministerial Statement No. 755		Water Corporation Interpretation	MPCOOP Section
8. Ocean Outlet Pipeline Construction Management Plan (Marine)			
8-1	Prior to commencement of installation of the pipeline, the proponent shall prepare and submit an Ocean Outlet Pipeline Construction Management Plan (the Plan) that meets the objectives set out in Condition 8.2 that meets the requirements of 8.3 as determined by the Minister for the Environment. In preparing the Plan the Proponent shall consult with the Environmental Protection Authority	This document provides details that aim to meet objectives set out in condition 8.2 and requirement in section 8.3.	This document
8-2	The objectives of the Plan is to (a) ensure the maintenance of the ecological integrity of the marine waters surrounding the Alkimos site; and (b) ensure the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4.	The MPCOOP has been prepared to meet the objectives set out in Condition 8-2	Section 1.1

I am satisfied that the MPCOOP, as it stands, has indeed met the above objectives. It provides a detailed and coherent plan to ensure that the ecological integrity of the environment (and waters) around the pipeline will be maintained while minimising the impacts associated with the pipes construction and installation. The supporting documentation (appendices) consist of valid studies designed to meet these objectives and have been well carried out.

8-3	The Plan shall address the following:		
	1 route design;	The MPCOOP addresses the route location and design	Section 3.6.1

The MPCOOP adequately addresses the route design and location and I was impressed that efforts had been made to minimise impact upon benthic primary producer habits (BPPHs). Since the PER, a 37% reduction in impact has been achieved with the final design (Table 4-1).

	2. define the spatial definition of the extent of the disturbance footprint (a) direct loss of habitat due to construction, (b) indirect loss of habitat due to construction (sediment plume impacts – loss of light and burial) ;	The MPCOOP addresses the spatial extent of direct and indirect habitat loss due to construction. Impacts have been predicted through the use of models.	Section 4.4.1 Section 4.4.2

I believe the MPCOOP has adequately addressed the spatial extent of the direct disturbance footprint. The studies on which it is based upon (Appendix F) are valid and complete and undertaken by a reputable team. The fact that only 0.1% of the vegetated habitat will be lost in the management unit easily brings it under Guidance Statement 29's criteria.

The MPCOOP addressed indirect loss of habitat due to sediment plume impacts, i.e. loss of light and burial, within the disturbance footprint (immediately adjacent to the pipe construction) via modelling. I have examined the sediment characteristics (Appendix G) and the modelling scenarios (Appendix H) and am satisfied that the modelling is valid and that its conclusions as to sediment resuspension, light levels and settlement have been correctly represented in the main body of the MPCOOP document. The model itself is well defined and the domains and grid size are nice for the job. The predicted deposition suggests a maximum of 4 mm of sand, I do not see any BPP having a problem coping with this level.

One point I would make however is that the predicted indirect loss regarding seagrass needs to be updated. The MPCOOP has reported (correctly) the current (and outmoded) EPA/DEC view that losses of *Posidonia*, *Amphibolis* and *Thalassodendron* are "irreversible" (although the EPA, 2004 document is not placed in the reference section of the MPCOOP). For the former two species this is incorrect. I have just finished transplanting over three hectares of *Posidonia* in Cockburn Sound with excellent survival and growth. I have also transplanted seagrass (both *Posidonia* and *Amphibolis*) in energetic areas such as Success Bank with good results both manually and mechanically (see list of refereed book and journal articles at the end of this report). The losses are not 'irreversible' and I suspect they will return to the area within a few years. If this is the case, then there would have been no net loss of this particular BPPH. The monitoring details listed in this MPCOOP should pick this up in the future and I strongly recommend the results are published far and wide.

	3. prediction and spatially definition of the long-term stable' state of the marine environment following construction and taking into account indirect effects of construction and on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impact (see Note 9).	The MPCOOP addresses the long-term spatial extent of ongoing and indirect impacts. Impacts have been predicted through the use of models.	Section 4.4 Section 4.5

The MPCOOP document has adequately addressed the 'stable' state of the marine environment surrounding the impact area (and beyond). The present environment itself has also been properly mapped and defined. This particular marine environment is under a state of flux normally, with shifting sands causing substrates to become exposed (and then colonised by BPP). The construction and persistence of the pipeline will not alter this. It is in part the reason that, due to sediment characteristics (i.e. quite coarse grains) and the hydrological activity of the area, that the actual construction (and its dredging techniques to lessen sediment escape) will have a minor impact in this area.

In regard to long term indirect impacts, the only problem I see is possible scour around the pipe when it is in place. Though I do see that there are proper management actions in place to deal with this particular contingency. The pipe itself, where it is exposed, will provide a substrate for BPPs where it goes over reef and it will be filled in with sand in areas where sand excavation occurs. The hard substrate provided by the pipe may partially mitigate for any loss of reef area.

	4 amount and type of material to be excavated;	The MPCOOP details the volume of material to be excavated.	Section 3.5.2 Section 3.6.2

I am satisfied that the amount and type of material to be excavated has been detailed correctly and that more detailed geotechnical work will be done immediately prior to excavation and blasting.

	5 rehabilitation of excavated trenches;	The MPCOOP details how, when and where rehabilitation will be undertaken.	Section 3.6.7

The MPCOOP addresses this condition and has come up with a good solution. It seems to me that when the pipe is placed through/within reef areas that the sediment will probably fill in by itself. Pipe going through excavated trenches is also not to be backfilled. The MPCOOP correctly assumes (in my mind) that natural forces will move sediment into it and fill it in over time (although this will also be monitored). I believe this is the correct approach as it has been put in place to minimise disturbance to any BPPs that may have been affected by the side cast dredging. Although it appears that the side cast material will, with correct effort, not be placed on dense BPPH. 'Redredging' the material to backfill the trench would provide two further disturbances, the physical action on any BPPH and the resuspension of more sediment. By letting the material infill naturally, the disturbance to the environment is minimised.

	6 blasting techniques and areas where blasting occurs;	The MPCOOP details how, when and where blasting will be undertaken.	Section 3.6.2 Section 3.6.7

The MPCOOP has adequately detailed how, when and where blasting will take place and the procedures for minimising blast damage to fauna is well addressed (Section 5.4.2). As an aside, it seems to me that the predicted blast effects on fauna should more specifically address the type of blast that takes place in this project. Table 4-5 (which needs a heading revision) details blast effect zones, but it would be expected that the type of charge delivered (3 m below the substrate) would very much reduce the blast radii predicted within it.

	7 identify where drilling and open-cut techniques (minimising open-cut technique) are to be used for the entire pipe installation;	The MPCOOP details how, when and where drilling and open-cut techniques will be used.	Section 3.6.2 Section 3.6.7

The MPCOOP has adequately detailed the excavation techniques with minimisation of sediment effects from the dredging.

	8 positioning of pipe-laying vessels, mooring pattern design and dredge support vessels;	The MPCOOP details how, when and where vessels and moorings will be positioned.	Section 3.6.2 Section 3.6.5 Section 3.6.7

The MPCOOP has adequately addressed the pipe-laying vessels, mooring pattern design and dredge support vessel configuration and I am satisfied that due diligence has been detailed in regard to minimising damage to the BPPH within the impact area.

	9 management of benthic community in construction areas;	Benthic communities will be managed through a hierarchy of proactive and reactive management and monitoring strategies.	Section 5.2.2

I was impressed with the detail of hierarchical proactive and reactive strategies put in place to protect the BPPHs in construction areas. In my experience many EMPs I have reviewed are often deficient in this area. The MPCOOP details the management and monitoring strategies (and corrective actions) very well.

	10 monitoring and establishment of impact from anchoring, wire and chain sweep techniques, marine dredging and supra-tidal excavation techniques used;	Modelling was undertaken to predict impacts. Monitoring and management strategies have been developed in response to the predicted impacts	Section 4.4.3 Section 4.5.3 Section 5.2.2 Section 6.2.2

I am satisfied that more than adequate prediction of impacts has occurred and that appropriate monitoring techniques will be put in place to address any issues that occur. Usually the best method to minimise impact to BPPH by maintenance or construction vessels is to not moor in them and I believe the MPCOOP addresses this. The impact risk assessment framework (Section 4.5, rather than 4.5.3 as listed in the table above) also deals appropriately with addressing any impacts, as do Sections 5.2.2 and 6.2.2.

	11 identification of areas to be dredged, excavated and the timing and duration of dredging/ excavation;	The MPCOOP details the location, timing and duration of areas to be dredged and excavated.	Section 3.6.2 Section 3.6.7

The MPCOOP adequately identifies areas to be dredged and their timing and duration.

	12 water quality targets for criteria that will trigger management of sedimentation and protection of benthic community;	The MPCOOP provides water quality targets that will trigger management of sedimentation and protection of benthic communities	Section 5.1.2

The primary water quality issue is total suspended sediment (TSS). The incidence of spills from vessels is likely to be low and correct contingency measures are in place to deal with these. I am quite satisfied that the triggers and procedures put in place to manage TSS will result in a high level of protection for the BPPHs. I was impressed on the level of detail provided in regard to monitoring and management actions (Section 5.1.2).

	13 monitoring reporting, and mitigating impacts on natural littoral drift processes from construction activities and beach profiles during construction; and	The MPCOOP details predicted impacts on littoral drift and provides monitoring, management and reporting requirements.	Section 5.3.2

Clearly there will be effects on longshore drift while the groyne for the pipeline construction is present. But the timing of its presence (summer) and the duration of works (short) will reduce associated impacts. I am satisfied that the corrective actions to be put in place if necessary(.i.e. the possibility of sand pumping etc.) will protect the beach system. Once the groyne is removed, the list of procedures given should, I believe, return the beach system to its natural state. I do not consider there will be any long term impact from the onshore works.

	14 the management actions and contingencies that will be implemented in the event that criteria for water quality targets required by point 12 above are not being met.	The MPCOOP details reactive management actions to be implemented if defined water quality targets are not being met.	Section 5.1.2

As noted above (Condition 8-3, 12), I am satisfied that the management actions and contingency measures to be put in place if water quality (TSS) targets are exceeded (or spills occur) is more than adequate.

8-5	The proponent is to ensure that the extent of the disturbance footprint (direct and indirect loss of habitat) is no greater than that defined in Condition 8-3 (2).	The extent of significant (>10% net loss) direct and indirect loss of habitat will be confined to the area defined in Condition 8-3 (2).	Section 5.1 Section 5.2
8-6	The proponent is to ensure that the extent of the disturbance footprint (direct impacts) shall be within the area defined in Figure 5 and Table 4 in Schedule 4.	Direct impacts will be confined to the area defined in Condition 8-6.	Section 5.1 Section 5.2
8-7	The proponent is required to minimise indirect impacts as far as practicable within this boundary during construction.	Proactive and reactive monitoring and management strategies will be implemented and are described in the MPCOOP.	Section 5.1 Section 5.2
8-8	The pipeline will be laid within the area defined in Figure 5 and Table 4 in Schedule 4, and the 'line' of direct disturbance footprint will also be within the area. (see note 9).	The pipeline will be laid and the line of direct disturbance footprint will be in accordance with Condition 8-8.	Section 3.6.1 Section 5.1 Section 5.2

I was not asked specifically to comment on the above. In general however the proponent has moved the end diffuser in accordance with requests generated from the PER to minimise impacts on nearby high relief reefs. The area is quite energetic and as is detailed in Appendix F, results from PLOOM monitoring suggest that off this particular coast, very few (if any) effects on BPPH can be picked up from operation of the wastewater outfall. I am satisfied that conditions 8-6 to 8-8 (inclusive) are being met by this MPCOOP. In terms of condition 8-5, I am still of the view that although some direct loss of seagrass will occur, in some species (i.e. *Posidonia* and *Amphibolis*) it will recover in a few years and therefore form a 'no net loss' scenario. This will reduce the overall area threshold for the management area in terms of allowable BPPH loss.

Condition 9. Seabed and Benthic Habitat Monitoring and Management Plan

9 Seabed and Benthic Habitat Monitoring and Management Plan				
9-1	Prior to commencement of construction of the Alkimos ocean outlet in the marine environment, the proponent shall prepare and submit a Seabed and Benthic Habitat Monitoring and Management Plan (the Plan) that meets the objectives of condition 9- 2 and the requirements of 9-3 as determined by the Minister for the Environment. In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.	The Seabed and Benthic Habitat Monitoring and Management Plan comprises a component of the MPCOOP. The MPCOOP has been prepared to encompass the requirements of Condition 9.	This document	
9-2	The objective of this Plan is to ensure that seabed and benthic habitat loss outside the area of direct loss defined in the Plan required by Condition 8-3 (2) is avoided during construction and re-instated following construction.	The MPCOOP has been prepared to meet the objectives set out in Condition 9-2	Section 1.1	
9-3	This Plan shall address:			
	1. Procedures for obtaining and providing to the CEO, within six months following the completion of pipeline installation, an accurate total area and geographically referenced location map of areas of seabed (subtidal, intertidal and beaches) modification and benthic primary producer habitats lost or damaged during pipeline construction, including specific identification of any areas of loss or damage that are in excess or outside of those areas defined and predicted in the Plan required by Condition 8	Monitoring of seabed and BPPH will be undertaken following completion of pipeline installation and compared with baseline data. Mapped results will be provided to the CEO.	Section 5.3.2	

I am satisfied that there are adequate procedures in place (as detailed in Section 5.3.2 and 5.4.2) to monitor the beaches and the condition of the BPPH. The initial surveys were appropriate and the same techniques will be used to map after construction. The mapping in particular was well done and I see no reason that it will not be able to pick up changes if they occur (within the errors of mapping technique).

	2. Prediction and spatial definition of long-term stable' state of the marine environment following construction and taking into account on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impacts) (see also Condition 8-3 (3));	The MPCOOP addresses the long-term spatial extent of ongoing and indirect impacts. Impacts have been predicted through the use of models.	Section 4.5.3

I am satisfied that the prediction of impacts during construction have been adequately dealt with. I am also happy with the MPCOOPs view of the long term indirect effects – which will be, in my mind, rather negligible. The presence of the infrastructure (i.e. the pipe) is relatively minor and will probably be quite benign. It will mitigate, in part, for the loss of some hard substrate during installation and I suspect the trenches that will backfill over time will be recolonised by seagrasses (also mitigating for loss caused during construction). Appropriate monitoring is, of course, required to verify this.

	3. The establishment of a quantitative annual monitoring program of the seabed and benthic habitat condition in, and adjacent to, areas of seabed and benthic primary producer habitats damaged during pipeline installation and the ongoing presence of the infrastructure; and	A quantitative annual monitoring program of the seabed and benthic habitat condition will be implemented during and following construction as detailed in the MPCOOP.	Section 6.1.2 Section 6.2.2

As noted above, appropriate monitoring is required to verify the non-existence of long term impacts outside those predicted by this MPCOOP – which are expected to be negligible. I am satisfied with the monitoring program to be put in place suggested in this document and the reporting procedures.

	4. The indicator(s) and criteria to be used to trigger cessation or reduction in the frequency of monitoring after three years following construction or, in the event of the trigger level referred to in item 3 above being exceeded, after the proponent has demonstrated the success of contingency actions in reducing the rate of annual seagrass loss or damage to less than the contingency trigger level referred to in item 3 above, for three successive years; and	A quantitative annual monitoring program of the seabed and benthic habitat condition will be implemented during and following construction as detailed in the MPCOOP	Section 6.1.2 Section 6.2.2	

(also commented upon above) The quantitative annual monitoring program is sufficient to determine if there are any long term effects of this pipeline. The criteria used to reduce monitoring are also adequate. I do not believe there will be a need for "…contingency actions to reduce the rate of annual seagrass loss or damage…" as I do not see this as occurring. Rather I see the opposite, a recolonisation by seagrass of the appropriate habitats once the natural backfilling process is completed. I believe that sufficient monitoring should be focussed upon this aspect so that it can be used for future environmental decisions.

	5. Reporting procedures.	Reporting procedures for seabed and benthic habitat condition are provided in the MPCOOP.	Section 7.2 Section 7.3

The reporting procedures are adequately addressed in the MPCOOP.

9-4	If within six months of completion of construction the marine habitat outside the area of direct impact has not returned to the state predicted in Condition 9-3 (3) the proponent is to commence contingency actions to ensure that the rate of post-construction seabed and/or benthic primary producer habitat loss or damage, is restricted and reduced.	Marine habitats will be managed through a hierarchy of proactive and reactive management and monitoring strategies, including contingency actions.	Section 6.1.2 Section 6.2.2

I am satisfied that the contingency actions provided in this MPCOOP will, if necessary, allow for the reduction an restriction of any seabed or BPPH damage.

General comments

If Perth is to allow its population to grow, the only current socio-economically feasible option to deal with its ever increasing waste is to construct wastewater treatment plants that have outfalls to the ocean. I am a great fan of the concept that "past behaviour predicts future performance" and I believe it can be validly applied ecologically in regard to the Alkimos Wastewater Treatment Plant. We already have precedents to this activity; there are several wastewater outfalls that have been constructed and have been discharging off the Perth coast for many years. In none of these have we seen a major (or in some cases even measurable) impact on BPPHs in terms of their construction. Operationally, with one exception (Woodmans Point), we have yet to pick up statistically significant changes in the environment caused by wastewater discharge. The coast of Perth is hydrologically active enough to disperse added nutrients quickly and with few effects. Thus, one is forced to logically conclude that the environmental impact of both the construction and marine operation of this treatment plant will also be minimal.

I am also cognizant of the advances in technology that have allowed construction to take place with minimal impact on the seafloor. These advances have been met with increasingly stringent environmental conditions by regulatory authorities in regard to the proportion of BPPHs that may be effected in relation to specific management units. I firmly believe that the

MPCOOP has adequately addressed the direct and indirect impacts that will be associated with this project. I found it to be reasonably well written and to contain enough information to support its conclusions. Its supporting documents are technically valid and use up to date methods to derive data in terms of surveys and the modelling approach taken.

In conclusion, I believe the MPCOOP sufficiently addresses the matters raised in Ministerial Conditions 8-2 and 9-3; and the procedures and practices contained within it will minimise the risks to the environment of the construction and long term presence of the proposed pipeline. Predicted areas of impact fall very much below the threshold within the BPPH management unit and it therefore meets the EPA objective on BPPH protection.

Yours sincerely,

Eric Paling
Associate Professor Eric Paling
Director – Marine and Freshwater Research Laboratory
Associate Professor – Marine Science

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Comments from Mr Ian LeProvost

Conditions under Ministerial Statement No. 755		Water Corporation Interpretation	MPCOOP Section	Reviewer Comments
8. Ocean Outlet Pipeline Construction Management Plan (Marine)				
8-1	Prior to commencement of installation of the pipeline, the proponent shall prepare and submit an Ocean Outlet Pipeline Construction Management Plan (the Plan) that meets the objectives set out in Condition 8.2 that meets the requirements of 8.3 as determined by the Minister for the Environment. In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.	This document provides details that aim to meet objectives set out in condition 8.2 and requirement in section 8.3.	This document	The document is titled Management Plan for the Construction and Ongoing Presence of the Ocean Outlet Pipeline (MPCOOP). I confirm that this document has been prepared in response to the requirements of condition 8.1 in that it includes an Ocean Outlet Pipeline Construction Plan. It also addresses requirements of condition 9-1 (The preparation of a Seabed and Benthic Habitat Monitoring and Management Plan and indicates that the two conditions have been addressed in the one document to save repetition. The document also addresses conditions 1,2, 4 and 5. This approach is supported.
8-2	The objectives of the Plan is to (a) ensure the maintenance of the ecological integrity of the marine waters surrounding the Alkimos site; and (b) ensure the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4.	The MPCOOP has been prepared to meet the objectives set out in Condition 8-2	Section 1.1	The objectives of the MPCOOP are clearly stipulated in section 1.1 of the document and address the objectives of both conditions 8-2 and 9-2, plus requirements of the Water Corporation's Environmental Policy and Sustainability Principles.

8-3	The Plan shall address the following:			
	1 route design;	The MPCOOP addresses the route location and design	Section 3.6.1	I confirm that route design is addressed in section 3.6.1 and in figures 3.4 and 3.12. The route has been optimised to both avoid significant onshore areas and minimise the amount of blasting and excavation required.
	2. define the spatial definition of the extent of the disturbance footprint (a) direct loss of habitat due to construction, (b) indirect loss of habitat due to construction (sediment plume impacts – loss of light and burial) ;	The MPCOOP addresses the spatial extent of direct and indirect habitat loss due to construction. Impacts have been predicted through the use of models.	Section 4.4.1 Section 4.4.2	I confirm that the spatial extent of direct impacts is described in section 4.3.3 (Not 4.4.1) as being within a 10m wide corridor centred along the pipeline route, except where excavation and side-casting is required when direct impacts may extend up to 25m from the pipeline centreline. Table 4-1 indicates that that a total habitat loss of 4.296 ha is anticipated as a result of pipeline excavation works. This represents a reduction in total area of BPPH loss of some 2.6 ha (or some 30%) from the total area originally assessed by the EPA in Bulletin 1239. It is also worth noting that of this area, only 0.8 ha is seagrass habitat, the rest being algal dominated reef. The indirect loss of habitat is also addressed in section 4.3.3 and identified to be short term and localised light attenuation and minimal smothering by sediment. Appendix H provides greater detail and confirms (by modelling) that sediment deposition away from the zone of direct impact is practically negligible. Hence the total scale of habitat loss anticipated is that defined in Table 4-1. Given that most of the excavation work is required to remove fractured limestone rock from the pipeline trench, the finding that there will be no additional habitat loss as a result of indirect impacts is hardly surprising and one has to question why it was considered necessary to go to the

				expense of developing a model to confirm such an obvious conclusion. This is particularly questionable when it is realised that the side-cast rock will soon be recolonised by algae and other sessile invertebrates that colonise the adjacent reef and in the long-term provide replacement BPPH.
	3. prediction and spatially definition of the long-term stable' state of the marine environment following construction and taking into account indirect effects of construction and on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impact (see Note 9).	The MPCOOP addresses the long-term spatial extent of ongoing and indirect impacts. Impacts have been predicted through the use of models.	Section 4.4 Section 4.5	I was unable to find spatial definition of the long term state of the environment other than the direct impact areas described above, and in a commitment that Table 4 schedule 4 of Statement 755 was acceptable to the proponent. My understanding is that defined in item 2 above and based on figure 3-5
	4 amount and type of material to be excavated;	The MPCOOP details the volume of material to be excavated.	Section 3.5.2 Section 3.6.2	The amount and type of material to be excavated is described in section 3.6.2 as being 27,500m3 in total, and comprising mostly limestone rock, with only 2,750 comprising coarse to medium sands. The geology of the rock is described in section 3.5.1 as belonging to the Tamala limestone unit and being overlain by caprock comprised primarily of calcarenite, and calcirudite.
	5 rehabilitation of excavated trenches;	The MPCOOP details how, when and where rehabilitation will be undertaken.	Section 3.6.7	Section 3.6.6 indicates that it is not intended to backfill or rehabilitate the trench except in the portion close to shore out to 5m depth where the pipeline will be buried with sand. Natural sediment dynamics will eventually refill the remainder of the trench where it occurs in sandy areas. The cut through the reef is unlikely to refill completely.

	6 blasting techniques and areas where blasting occurs;	The MPCOOP details how, when and where blasting will be undertaken.	Section 3.6.2 Section 3.6.7	The areas where blasting will occur are clearly delineated in section 3.6.2 and figure 3-5 as areas where limestone reef occurs. Approx 1.2 km of the 3.7km route will be drilled, blasted and excavated by backhoe excavator. Modern sensitive blasting techniques are to be used to fracture the rock in place, and testing will be undertaken to ensure that the amount of explosive used is just enough to fracture the rock without generating fly rock. Section 3.6.7 presents the construction schedule and indicates when blasting will take place.
	7 identify where drilling and open-cut techniques (minimising open-cut technique) are to be used for the entire pipe installation;	The MPCOOP details how, when and where drilling and open-cut techniques will be used.	Section 3.6.2 Section 3.6.7	As indicated above and in my comment on item 2 above, the proponent has achieved an ~30% reduction in area of excavation required.
	8 positioning of pipe-laying vessels, mooring pattern design and dredge support vessels;	The MPCOOP details how, when and where vessels and moorings will be positioned.	Section 3.6.2 Section 3.6.5 Section 3.6.7	The positioning of pipe-laying vessels and mooring pattern design is addressed in section 3.6.5 and described in figure 3-10 (which could be clearer, or presented at a larger scale so that vision impaired reviewers can read it).
	9 management of benthic community in construction areas;	Benthic communities will be managed through a hierarchy of proactive and reactive management and monitoring strategies.	Section 5.2.2	I confirm that a wide range of pro-active management actions are described in section 5.2.2. The proposed actions are comprehensive and will minimise loss of BPPH.

	10 monitoring and establishment of impact from anchoring, wire and chain sweep techniques, marine dredging and supra-tidal excavation techniques used;	Modelling was undertaken to predict impacts. Monitoring and management strategies have been developed in response to the predicted impacts	Section 4.4.3 Section 4.5.3 Section 5.2.2 Section 6.2.2	Section 4.4.3 describes the anticipated impacts on BPPH from pipeline installation works. There was no section 4.5.3 in the document that I reviewed. Monitoring of impact from anchoring and backhoe excavation works on BPPH and seabed is clearly described in sections 5.2.2 and 5.3.2 respectively. Validation of impact scale on BPPH and seabed is addressed in sections 6.2.2 and 6.3.2 respectively. The scope of monitoring works proposed appears excessive for what is in reality a very small excavation project of coarse rocky material, which will be gradually moving along a pipeline route and be completed within 3 months and presents such low risk to the integrity of the ecosystem.
	11 identification of areas to be dredged, excavated and the timing and duration of dredging/ excavation;	The MPCOOP details the location, timing and duration of areas to be dredged and excavated.	Section 3.6.2 Section 3.6.7	Figure 3-5 clearly shows the location of areas to be blasted and excavated. Figure 3-12 is less clear, but presents the timing and duration schedule. Section 3.6.7 describes the construction timing clearly. In summary, excavation works will take some 12 weeks to cover some 1.2 km of reef habitat. This work will be undertaken between December 2008 and February 2009.
	12 water quality targets for criteria that will trigger management of sedimentation and protection of benthic community;	The MPCOOP provides water quality targets that will trigger management of sedimentation and protection of benthic communities	Section 5.1.2	Section 5.1.2 describes a wide range of procedures aimed at minimising spatial and temporal extent of turbid plumes and sedimentation resulting from excavation works. Figure 5-2 presents the water quality criteria that will be used to initiate management actions. The management actions are clearly specified. Note that this figure would be easier to read if presented at a larger scale.

				Given the excavation method, the material being excavated (limestone rock) and the intermittent nature of seabed and water quality disturbance from such a work method and the negligible indirect impacts predicted and reasonably expected, and the very low risk that these woks pose to ecosystem integrity, the scope of monitoring works proposed is in my opinion excessive.
	13 monitoring reporting, and mitigating impacts on natural littoral drift processes from construction activities and beach profiles during construction; and	The MPCOOP details predicted impacts on littoral drift and provides monitoring, management and reporting requirements.	Section 5.3.2	I confirm that monitoring reporting, and mitigating actions on natural littoral drift processes from construction activities nearshore are described clearly in section 5.3.2. However these do not appear to involve monitoring of beach and nearshore profiles either side of the groyne to determine if sand is either accumulating on the south side or eroding on the north side, and if as a result there is a need for sand bypass. The mitigation actions are clear, but the triggers for those actions are not.
	14 the management actions and contingencies that will be implemented in the event that criteria for water quality targets required by point 12 above are not being met.	The MPCOOP details reactive management actions to be implemented if defined water quality targets are not being met.	Section 5.1.2	I confirm that the level 1, 2 and 3 management actions to be implemented if water quality targets are not being met are clearly defined in section 5.1.2 and figure 5-2.
8-4	To ensure that the diffuser is located in a position to reduce the likelihood of plume impacts on high relief algal reefs immediately to the east of the outlet, the proponent shall extend the pipe length by 200 metres from the end of the pipe shown in Figure 4.17 of the proponent's Public Environmental Review document, Version 3, 8 November 2005. This will give a total pipe length of 3.7 kilometres from the high water mark.	The diffuser will be located in accordance with Condition 8-4.	Section 1	I confirm that the diffuser will be located in accordance with Condition 8-4. Figure 3.12 (when viewed through a magnifying glass!) shows the location of the diffuser and its distance offshore.

8-5	The proponent is to ensure that the extent of the disturbance footprint (direct and indirect loss of habitat) is no greater than that defined in Condition 8-3 (2).	The extent of significant (>10% net loss) direct and indirect loss of habitat will be confined to the area defined in Condition 8-3 (2).	Section 5.1 Section 5.2	The scale and boundary of the disturbance footprint is not defined clearly, but is described generally as being within a 10m wide corridor centred along the pipeline route, except where excavation and side-casting is required when direct impacts may extend up to 25m from the pipeline centreline. Table 4-1 indicates that a total habitat loss of 4.296 ha is anticipated.
8-6	The proponent is to ensure that the extent of the disturbance footprint (direct impacts) shall be within the area defined in Figure 5 and Table 4 in Schedule 4.	Direct impacts will be confined to the area defined in Condition 8-6.	Section 5.1 Section 5.2	The proponent has accepted the Ministerial condition. I assume that the proponent has checked that his optimised pipeline route still sits inside the boundary defined by the coordinates presented in Table 4 of Schedule 4. I have not been able to do this and therefore cannot comment.
8-7	The proponent is required to minimise indirect impacts as far as practicable within this boundary during construction.	Proactive and reactive monitoring and management strategies will be implemented and are described in the MPCOOP.	Section 5.1 Section 5.2	Proactive and reactive monitoring and management strategies are described in section 5.1 (Water quality) and 5.2 (Protection of BPPH). I have already commented that in my opinion the amount of monitoring proposed is excessive for the low level of risk that this project poses to ecosystem integrity and function.
8-8	The pipeline will be laid within the area defined in Figure 5 and Table 4 in Schedule 4, and the 'line' of direct disturbance footprint will also be within the area. (see note 9).	The pipeline will be laid and the line of direct disturbance footprint will be in accordance with Condition 8-8.	Section 3.6.1 Section 5.1 Section 5.2	As indicated earlier, the proponent has accepted the Ministerial condition. I assume that the proponent has checked that his optimised pipeline route still sits inside the boundary defined by the coordinates presented in Table 4 of Schedule 4. I have not been able to do this and therefore cannot comment.

8-9	The proponent shall implement the Plan.	The Water Corporation will implement the MPCOOP during, and for 2 to 3 years following construction of the ocean outlet.	Section 1	The Proponent has committed to implement the proposal in accordance with the Ministerial Statement and schedules 1, 2, 1nd 3 of that statement in section (end of 2nd para). Throughout the document, the proponent has committed to implementing the Plan for at least three years. I note that in this Table B, the Proponent commits to implementing the MPCOOP during and for 2-3 years following construction of the ocean outlet. This wording is not consistent with what appears in the text of the MPCOOP.
8-10	The proponent shall make Plan publicly available in a manner approved by the CEO.	The MPCOOP will be made publicly available via the Water Corporation's website	Section 1	As above.

9 Seabed and Benthic Habitat Monitoring and Management Plan				
9-1	Prior to commencement of construction of the Alkimos ocean outlet in the marine environment, the proponent shall prepare and submit a Seabed and Benthic Habitat Monitoring and Management Plan (the Plan) that meets the objectives of condition 9- 2 and the requirements of 9-3 as determined by the Minister for the Environment. In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.	The Seabed and Benthic Habitat Monitoring and Management Plan comprises a component of the MPCOOP. The MPCOOP has been prepared to encompass the requirements of Condition 9.	This document	The document is titled Management Plan for the Construction and Ongoing Presence of the Ocean Outlet Pipeline (MPCOOP). I confirm that this document has been prepared in response to the requirements of condition 8.1 in that it includes an Ocean Outlet Pipeline Construction Plan. It also addresses requirements of condition 9-1 (The preparation of a Seabed and Benthic Habitat Monitoring and Management Plan and indicates that the two conditions have been addressed in the one document to save repetition. This approach is supported.
9-2	The objective of this Plan is to ensure that seabed and benthic habitat loss outside the area of direct loss defined in the Plan required by Condition 8-3 (2) is avoided during construction and re-instated following construction.	The MPCOOP has been prepared to meet the objectives set out in Condition 9-2	Section 1.1	The objectives of the MPCOOP are clearly stipulated in section 1.1 of the document and address the objectives of both conditions 8-2 and 9-2, plus requirements of the Water Corporation's Environmental Policy and Sustainability Principles. However it is clear from the MPCOOP that the Proponent only proposes to re-instate the nearshore area out to 5m depth following construction. Excavated areas will be left open and allowed to fill by natural sediment dynamics over time and the sidecast berm will be left in place to minimise further disturbance to BPPH.

9-3	This Plan shall address:			
	1. Procedures for obtaining and providing to the CEO, within six months following the completion of pipeline installation, an accurate total area and geographically referenced location map of areas of seabed (subtidal, intertidal and beaches) modification and benthic primary producer habitats lost or damaged during pipeline construction, including specific identification of any areas of loss or damage that are in excess or outside of those areas defined and predicted in the Plan required by Condition 8	Monitoring of seabed and BPPH will be undertaken following completion of pipeline installation and compared with baseline data. Mapped results will be provided to the CEO.	Section 5.3.2	I confirm that procedures for obtaining and providing to the CEO, within six months following the completion of pipeline installation, an accurate total area and geographically referenced location map of areas of seabed modification and benthic primary producer habitats lost or damaged during pipeline construction are provided in section 5.3.2. They involve the monitoring of seabed and BPPH following completion of pipeline installation and comparison with baseline data. Mapped results will be provided to the CEO within 6 months as required.
	2. Prediction and spatial definition of long-term stable' state of the marine environment following construction and taking into account on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impacts) (see also Condition 8-3 (3));	The MPCOOP addresses the long-term spatial extent of ongoing and indirect impacts. Impacts have been predicted through the use of models.	Section 4.5.3	I was unable to find spatial definition of the long term state of the environment other than the direct impact areas described above, and in Table 4 schedule 4 of Statement 755. Based on my experience of that environment, I would anticipate that after construction, there will be no visible expression of the pipeline through the beach and out to 5m depth of water. Where there has not been any excavation, the pipeline will be exposed on the seafloor and the 10 m wide disturbance area will have been recolonised by organisms suited to the substrate. The pipeline itself will also be colonised by algae and sessile invertebrates in much the same way that other ocean outlets off the metropolitan coast are. Where excavation has occurred there will be a low rock berm generally some 6m wide and 1m high on one side of the pipeline route. Note direct impacts up to 25 m wide have been predicted. Where the excavation is through a reef, it is likely that the pipeline will remain exposed as the trench is unlikely to completely refill with sand. The marine environment outside the predicted disturbance envelope should remain unaffected.

	3. The establishment of a quantitative annual monitoring program of the seabed and benthic habitat condition in, and adjacent to, areas of seabed and benthic primary producer habitats damaged during pipeline installation and the ongoing presence of the infrastructure; and	A quantitative annual monitoring program of the seabed and benthic habitat condition will be implemented during and following construction as detailed in the MPCOOP.	Section 6.1.2 Section 6.2.2	I confirm that the procedures describing a quantitative annual monitoring program of the seabed and benthic habitat condition are presented in section 6.2.2 and 6.3.2 of this document.
	4. The indicator(s) and criteria to be used to trigger cessation or reduction in the frequency of monitoring after three years following construction or, in the event of the trigger level referred to in item 3 above being exceeded, after the proponent has demonstrated the success of contingency actions in reducing the rate of annual seagrass loss or damage to less than the contingency trigger level referred to in item 3 above, for three successive years; and	A quantitative annual monitoring program of the seabed and benthic habitat condition will be implemented during and following construction as detailed in the MPCOOP.	Section 6.1.2 Section 6.2.2	This topic is addressed in sections 6.2 (for BPPH) and 6.3 (for seabed). I was unable to find any criteria to be used to trigger cessation or reduction in the frequency of monitoring after three years following construction . In addition this Table B indicates that the proponent may wish to cease implementing the MPCOOP within two years after construction of the ocean outlet although this is not stated in the text of the MPCOOP.
	5. Reporting procedures.	Reporting procedures for seabed and benthic habitat condition are provided in the MPCOOP.	Section 7.2 Section 7.3	I confirm that reporting procedures for seabed and benthic habitat condition are presented in section 6.2.2. and 6.3.2 and also in sections 7.2 and 7.3 and that they address the requirements of condition 4 and 5.
9-4	If within six months of completion of construction the marine habitat outside the area of direct impact has not returned to the state predicted in Condition 9-3 (3) the proponent is to commence contingency actions to ensure that the rate of post-construction seabed and/or benthic primary producer habitat loss or damage, is restricted and reduced.	Marine habitats will be managed through a hierarchy of proactive and reactive management and monitoring strategies, including contingency actions.	Section 6.1.2 Section 6.2.2	The management and contingency procedures are described in sections 6.2.2. and 6.3.2. However note that the proponent has predicted that there will be negligible indirect impacts arising out of the construction works. Hence the need for re-instatement or rehabilitaiion is likely to be very low. Also, the habitats so created will be rapidly recolonised by benthic algae and sessile invertebrates naturally.

9-5	The proponent shall implement the Plan.	The Water Corporation will implement the MPCOOP during and for 2 to 3 years following construction of the ocean outlet.	Section 1	The Proponent has committed to implement the proposal in accordance with the Ministerial Statement and schedules 1,2, 1nd 3 of that statement in section (end of 2nd para). In Table B, the Proponent commits to implementing the MPCOOP during and for 2-3 years following construction of the ocean outlet.
9-6	The proponent shall make Plan publicly available in a manner approved by the CEO.	The MPCOOP will be made publicly available via the Water Corporation's website (insert in section text "provided this method is approved by the DEC CEO")	Section 1	As above.

Conditions under Ministerial Statement No. 755		Water Corporation Interpretation	MPCOOP Section	Reviewer Comments	Amendments based on reviewer's comments
8. Ocean Outlet Pipeline Construction Management Plan (Marine)					
8-1	Prior to commencement of installation of the pipeline, the proponent shall prepare and submit an Ocean Outlet Pipeline Construction Management Plan (the Plan) that meets the objectives set out in Condition 8.2 that meets the requirements of 8.3 as determined by the Minister for the Environment. In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.	This document provides details that aim to meet objectives set out in condition 8.2 and requirement in section 8.3.	This document	The document is titled Management Plan for the Construction and Ongoing Presence of the Ocean Outlet Pipeline (MPCOOP). I confirm that this document has been prepared in response to the requirements of condition 8.1 in that it includes an Ocean Outlet Pipeline Construction Plan. It also addresses requirements of condition 9-1 (The preparation of a Seabed and Benthic Habitat Monitoring and Management Plan and indicates that the two conditions have been addressed in the one document to save repetition. The document also addresses conditions 1,2, 4 and 5. This approach is supported.	None
8-2	The objectives of the Plan is to (a) ensure the maintenance of the ecological integrity of the marine waters surrounding the Alkimos site; and (b) ensure the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4.	The MPCOOP has been prepared to meet the objectives set out in Condition 8-2	Section 1.1	The objectives of the MPCOOP are clearly stipulated in Section 1.1 of the document and address the objectives of both conditions 8-2 and 9-2, plus requirements of the Water Corporation's Environmental Policy and Sustainability Principles.	None

8-3	The Plan shall address the following:				
	1 route design;	The MPCOOP addresses the route location and design	Section 3.6.1	I confirm that route design is addressed in section 3.6.1 and in figures 3.4 and 3.12. The route has been optimised to both avoid significant onshore areas and minimise the amount of blasting and excavation required.	None
	2. define the spatial definition of the extent of the disturbance footprint (a) direct loss of habitat due to construction, (b) indirect loss of habitat due to construction (sediment plume impacts – loss of light and burial) ;	The MPCOOP addresses the spatial extent of direct and indirect habitat loss due to construction. Impacts have been predicted through the use of models.	Section 4.4.1 Section 4.4.2	I confirm that the spatial extent of direct impacts is described in section 4.3.3 (Not 4.4.1) as being within a 10m wide corridor centred along the pipeline route, except where excavation and side-casting is required when direct impacts may extend up to 25m from the pipeline centreline. Table 4-1 indicates that that a total habitat loss of 4.296 ha is anticipated as a result of pipeline excavation works. This represents a reduction in total area of BPPH loss of some 2.6 ha (or some 30%) from the total area originally assessed by the EPA in Bulletin 1239. It is also worth noting that of this area, only 0.8 ha is seagrass habitat, the rest being algal dominated reef. The indirect loss of habitat is also addressed in section 4.3.3 and identified to be short term and localised light attenuation and minimal smothering by sediment. Appendix H provides greater detail and confirms (by modelling) that sediment deposition away from the zone of direct impact is practically negligible. Hence the total scale of habitat loss anticipated is that defined in Table 4-1.	Noted

				Given that most of the excavation work is required to remove fractured limestone rock from the pipeline trench, the finding that there will be no additional habitat loss as a result of indirect impacts is hardly surprising and one has to question why it was considered necessary to go to the expense of developing a model to confirm such an obvious conclusion. This is particularly questionable when it is realised that the side-cast rock will soon be recolonised by algae and other sessile invertebrates that colonise the adjacent reef and in the long-term provide replacement BPPH.	Text amended to add "side-cast rock" to the text of 22nd para 4.4.3.
	3. prediction and spatially definition of the long-term stable' state of the marine environment following construction and taking into account indirect effects of construction and on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impact (see Note 9).	The MPCOOP addresses the long-term spatial extent of ongoing and indirect impacts. Impacts have been predicted through the use of models.	Section 4.4 Section 4.5	I was unable to find spatial definition of the long term state of the environment other than the direct impact areas described above, and in a commitment that Table 4 schedule 4 of Statement 755 was acceptable to the proponent. My understanding is that defined in item 2 above and based on figure 3-5	None
	4 amount and type of material to be excavated;	The MPCOOP details the volume of material to be excavated.	Section 3.5.2 Section 3.6.2	The amount and type of material to be excavated is described in section 3.6.2 as being 27,500m3 in total, and comprising mostly limestone rock, with only 2,750 comprising coarse to medium sands. The geology of the rock is described in section 3.5.1 as belonging to the Tamala limestone unit and being overlain by caprock comprised primarily of calcarenite, and calcirudite.	None

	5 rehabilitation of excavated trenches;	The MPCOOP details how, when and where rehabilitation will be undertaken.	Section 3.6.7	Section 3.6.6 indicates that it is not intended to backfill or rehabilitate the trench except in the portion close to shore out to 5m depth where the pipeline will be buried with sand. Natural sediment dynamics will eventually refill the remainder of the trench where it occurs in sandy areas. The cut through the reef is unlikely to refill completely.	None
	6 blasting techniques and areas where blasting occurs;	The MPCOOP details how, when and where blasting will be undertaken.	Section 3.6.2 Section 3.6.7	The areas where blasting will occur are clearly delineated in section 3.6.2 and figure 3-5 as areas where limestone reef occurs. Approx 1.2 km of the 3.7km route will be drilled, blasted and excavated by backhoe excavator. Modern sensitive blasting techniques are to be used to fracture the rock in place, and testing will be undertaken to ensure that the amount of explosive used is just enough to fracture the rock without generating fly rock. Section 3.6.7 presents the construction schedule and indicates when blasting will take place.	None
	7 identify where drilling and open-cut techniques (minimising open-cut technique) are to be used for the entire pipe installation;	The MPCOOP details how, when and where drilling and open-cut techniques will be used.	Section 3.6.2 Section 3.6.7	As indicated above and in my comment on item 2 above, the proponent has achieved an ~30% reduction in area of excavation required.	None
	8 positioning of pipe-laying vessels, mooring pattern design and dredge support vessels;	The MPCOOP details how, when and where vessels and moorings will be positioned.	Section 3.6.2 Section 3.6.5 Section 3.6.7	The positioning of pipe-laying vessels and mooring pattern design is addressed in section 3.6.5 and described in figure 3-10 (which could be clearer, or presented at a larger scale so that vision impaired reviewers can read it).	The figure has been landscaped and enlarged

	9 management of benthic community in construction areas;	Benthic communities will be managed through a hierarchy of proactive and reactive management and monitoring strategies.	Section 5.2.2	I confirm that a wide range of pro-active management actions are described in section 5.2.2. The proposed actions are comprehensive and will minimise loss of BPPH.	None
	10 monitoring and establishment of impact from anchoring, wire and chain sweep techniques, marine dredging and supra-tidal excavation techniques used;	Modelling was undertaken to predict impacts. Monitoring and management strategies have been developed in response to the predicted impacts	Section 4.4.3 Section 4.5.3 Section 5.2.2 Section 6.2.2	Section 4.4.3 describes the anticipated impacts on BPPH from pipeline installation works. There was no section 4.5.3 in the document that I reviewed. Monitoring of impact from anchoring and backhoe excavation works on BPPH and seabed is clearly described in sections 5.2.2 and 5.3.2 respectively. Validation of impact scale on BPPH and seabed is addressed in sections 6.2.2 and 6.3.2 respectively. The scope of monitoring works proposed appears excessive for what is in reality a very small excavation project of coarse rocky material, which will be gradually moving along a pipeline route and be completed within 3 months and presents such low risk to the integrity of the ecosystem.	Number cross-reference has been fixed. None None
	11 identification of areas to be dredged, excavated and the timing and duration of dredging/ excavation;	The MPCOOP details the location, timing and duration of areas to be dredged and excavated.	Section 3.6.2 Section 3.6.7	Figure 3-5 clearly shows the location of areas to be blasted and excavated. Figure 3-12 is less clear, but presents the timing and duration schedule. Section 3.6.7 describes the construction timing clearly. In summary, excavation works will take some 12 weeks to cover some 1.2 km of reef habitat. This work will be undertaken between December 2008 and February 2009.	None

	12 water quality targets for criteria that will trigger management of sedimentation and protection of benthic community;	The MPCOOP provides water quality targets that will trigger management of sedimentation and protection of benthic communities	Section 5.1.2	Section 5.1.2 describes a wide range of procedures aimed at minimising spatial and temporal extent of turbid plumes and sedimentation resulting from excavation works. Figure 5-2 presents the water quality criteria that will be used to initiate management actions. The management actions are clearly specified. Note that this figure would be easier to read if presented at a larger scale. Given the excavation method, the material being excavated (limestone rock) and the intermittent nature of seabed and water quality disturbance from such a work method and the negligible indirect impacts predicted and reasonably expected, and the very low risk that these woks pose to ecosystem integrity, the scope of monitoring works proposed is in my opinion excessive.	None Figure has been enlarged None
	13 monitoring reporting, and mitigating impacts on natural littoral drift processes from construction activities and beach profiles during construction; and	The MPCOOP details predicted impacts on littoral drift and provides monitoring, management and reporting requirements.	Section 5.3.2	I confirm that monitoring reporting, and mitigating actions on natural littoral drift processes from construction activities nearshore are described clearly in section 5.3.2. However these do not appear to involve monitoring of beach and nearshore profiles either side of the groyne to determine if sand is either accumulating on the south side or eroding on the north side, and if as a result there is a need for sand bypass. The mitigation actions are clear, but the triggers for those actions are not.	5.3.2 Proactive Management Action 5th and 6th dot-points note that the cofferdam will be removed following completion of construction, so any change will be temporary and will revert following removal. (Therefore no trigger is needed).

	14 the management actions and contingencies that will be implemented in the event that criteria for water quality targets required by point 12 above are not being met.	The MPCOOP details reactive management actions to be implemented if defined water quality targets are not being met.	Section 5.1.2	I confirm that the level 1, 2 and 3 management actions to be implemented if water quality targets are not being met are clearly defined in section 5.1.2 and figure 5-2.	None
8-4	To ensure that the diffuser is located in a position to reduce the likelihood of plume impacts on high relief algal reefs immediately to the east of the outlet, the proponent shall extend the pipe length by 200 metres from the end of the pipe shown in Figure 4.17 of the proponent's Public Environmental Review document, Version 3, 8 November 2005. This will give a total pipe length of 3.7 kilometres from the high water mark.	The diffuser will be located in accordance with Condition 8-4.	Section 1	I confirm that the diffuser will be located in accordance with Condition 8-4. Figure 3.12 (when viewed through a magnifying glass!) shows the location of the diffuser and its distance offshore.	Figure has been enlarged
8-5	The proponent is to ensure that the extent of the disturbance footprint (direct and indirect loss of habitat) is no greater than that defined in Condition 8-3 (2).	The extent of significant (>10% net loss) direct and indirect loss of habitat will be confined to the area defined in Condition 8-3 (2).	Section 5.1 Section 5.2	The scale and boundary of the disturbance footprint is not defined clearly, but is described generally as being within a 10m wide corridor centred along the pipeline route, except where excavation and side-casting is required when direct impacts may extend up to 25m from the pipeline centreline. Table 4-1 indicates that a total habitat loss of 4.296 ha is anticipated.	None

8-6	The proponent is to ensure that the extent of the disturbance footprint (direct impacts) shall be within the area defined in Figure 5 and Table 4 in Schedule 4.	Direct impacts will be confined to the area defined in Condition 8-6.	Section 5.1 Section 5.2	The proponent has accepted the Ministerial condition. I assume that the proponent has checked that his optimised pipeline route still sits inside the boundary defined by the coordinates presented in Table 4 of Schedule 4. I have not been able to do this and therefore cannot comment.	None
8-7	The proponent is required to minimise indirect impacts as far as practicable within this boundary during construction.	Proactive and reactive monitoring and management strategies will be implemented and are described in the MPCOOP.	Section 5.1 Section 5.2	Proactive and reactive monitoring and management strategies are described in section 5.1 (Water quality) and 5.2 (Protection of BPPH). I have already commented that in my opinion the amount of monitoring proposed is excessive for the low level of risk that this project poses to ecosystem integrity and function.	None None
8-8	The pipeline will be laid within the area defined in Figure 5 and Table 4 in Schedule 4, and the 'line' of direct disturbance footprint will also be within the area. (see note 9).	The pipeline will be laid and the line of direct disturbance footprint will be in accordance with Condition 8-8.	Section 3.6.1 Section 5.1 Section 5.2	As indicated earlier, the proponent has accepted the Ministerial condition. I assume that the proponent has checked that his optimised pipeline route still sits inside the boundary defined by the coordinates presented in Table 4 of Schedule 4. I have not been able to do this and therefore cannot comment.	None
8-9	The proponent shall implement the Plan.	The Water Corporation will implement the MPCOOP during, and for 2 to 3 years following construction of the ocean outlet.	Section 1	The Proponent has committed to implement the proposal in accordance with the Ministerial Statement and schedules 1, 2, 1nd 3 of that statement in section (end of 2nd para). Throughout the document, the proponent has committed to implementing the Plan for at least three years. I note that in this Table B, the Proponent commits to implementing the MPCOOP during and for 2-3 years following construction of the ocean outlet. This wording is not consistent with what appears in the text of the MPCOOP.	6.2.2 and 6.3.1 monitoring changed to "2 to 3 years". This limit of 3 years means that monitoring ceases after 3 years, but is not written in the document.

8-10	The proponent shall make Plan publicly available in a manner approved by the CEO.	The MPCOOP will be made publicly available via the Water Corporation's website	Section 1	As above.	
9 Seabed and Benthic Habitat Monitoring and Management Plan					
9-1	Prior to commencement of construction of the Alkimos ocean outlet in the marine environment, the proponent shall prepare and submit a Seabed and Benthic Habitat Monitoring and Management Plan (the Plan) that meets the objectives of condition 9- 2 and the requirements of 9-3 as determined by the Minister for the Environment. In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.		This document	The document is titled Management Plan for the Construction and Ongoing Presence of the Ocean Outlet Pipeline (MPCOOP). I confirm that this document has been prepared in response to the requirements of condition 8.1 in that it includes an Ocean Outlet Pipeline Construction Plan. It also addresses requirements of condition 9-1 (The preparation of a Seabed and Benthic Habitat Monitoring and Management Plan and indicates that the two conditions have been addressed in the one document to save repetition. This approach is supported.	None
9-2	The objective of this Plan is to ensure that seabed and benthic habitat loss outside the area of direct loss defined in the Plan required by Condition 8-3 (2) is avoided during construction and re-instated following construction.		Section 1.1	The objectives of the MPCOOP are clearly stipulated in section 1.1 of the document and address the objectives of both conditions 8-2 and 9-2, plus requirements of the Water Corporation's Environmental Policy and Sustainability Principles. However it is clear from the MPCOOP that the Proponent only proposes to re-instate the nearshore area out to 5m depth following construction. Excavated areas will be left open and allowed to fill by natural sediment dynamics over time and the sidecast berm will be left in place to minimise further disturbance to BPPH.	None

9-3	This Plan shall address:				
	1. Procedures for obtaining and providing to the CEO, within six months following the completion of pipeline installation, an accurate total area and geographically referenced location map of areas of seabed (subtidal, intertidal and beaches) modification and benthic primary producer habitats lost or damaged during pipeline construction, including specific identification of any areas of loss or damage that are in excess or outside of those areas defined and predicted in the Plan required by Condition 8	Monitoring of seabed and BPPH will be undertaken following completion of pipeline installation and compared with baseline data. Mapped results will be provided to the CEO.	Section 5.3.2	I confirm that procedures for obtaining and providing to the CEO, within six months following the completion of pipeline installation, an accurate total area and geographically referenced location map of areas of seabed modification and benthic primary producer habitats lost or damaged during pipeline construction are provided in section 5.3.2. They involve the monitoring of seabed and BPPH following completion of pipeline installation and comparison with baseline data. Mapped results will be provided to the CEO within 6 months as required.	None
	2. Prediction and spatial definition of long-term stable' state of the marine environment following construction and taking into account on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impacts) (see also Condition 8-3 (3));	The MPCOOP addresses the long-term spatial extent of ongoing and indirect impacts. Impacts have been predicted through the use of models.	Section 4.5.3	I was unable to find spatial definition of the long term state of the environment other than the direct impact areas described above, and in Table 4 schedule 4 of Statement 755. Based on my experience of that environment, I would anticipate that after construction, there will be no visible expression of the pipeline through the beach and out to 5m depth of water. Where there has not been any excavation, the pipeline will be exposed on the seafloor and the 10 m wide disturbance area will have been recolonised by organisms suited to the substrate. The pipeline itself will also be colonised by algae and sessile invertebrates in much the same way that other ocean outlets off the metropolitan coast are. Where excavation has occurred there will be a low rock berm generally some 6m wide and 1m high on one side of the pipeline route. Note direct	None. We do not have a long term state of the environment. The environment in that region is subject to substantial natural variation due to its exposed location.

				impacts up to 25 m wide have been predicted. Where the excavation is through a reef, it is likely that the pipeline will remain exposed as the trench is unlikely to completely refill with sand. The marine environment outside the predicted disturbance envelope should remain unaffected.	
	3. The establishment of a quantitative annual monitoring program of the seabed and benthic habitat condition in, and adjacent to, areas of seabed and benthic primary producer habitats damaged during pipeline installation and the ongoing presence of the infrastructure; and	A quantitative annual monitoring program of the seabed and benthic habitat condition will be implemented during and following construction as detailed in the MPCOOP.	Section 6.1.2 Section 6.2.2	I confirm that the procedures describing a quantitative annual monitoring program of the seabed and benthic habitat condition are presented in section 6.2.2 and 6.3.2 of this document.	None
	4. The indicator(s) and criteria to be used to trigger cessation or reduction in the frequency of monitoring after three years following construction or, in the event of the trigger level referred to in item 3 above being exceeded, after the proponent has demonstrated the success of contingency actions in reducing the rate of annual seagrass loss or damage to less than the contingency trigger level referred to in item 3 above, for three successive years; and	A quantitative annual monitoring program of the seabed and benthic habitat condition will be implemented during and following construction as detailed in the MPCOOP.	Section 6.1.2 Section 6.2.2	This topic is addressed in sections 6.2 (for BPPH) and 6.3 (for seabed). I was unable to find any criteria to be used to trigger cessation or reduction in the frequency of monitoring after three years following construction. In addition this Table B indicates that the proponent may wish to cease implementing the MPCOOP within two years after construction of the ocean outlet although this is not stated in the text of the MPCOOP.	6.2.2 monitoring changed to “2 to 3 years”. This limit of 3 years means that monitoring ceases after 3 years.

	5. Reporting procedures.	Reporting procedures for seabed and benthic habitat condition are provided in the MPCOOP.	Section 7.2 Section 7.3	I confirm that reporting procedures for seabed and benthic habitat condition are presented in section 6.2.2. and 6.3.2 and also in sections 7.2 and 7.3 and that they address the requirements of condition 4 and 5.	None
9-4	If within six months of completion of construction the marine habitat outside the area of direct impact has not returned to the state predicted in Condition 9-3 (3) the proponent is to commence contingency actions to ensure that the rate of post-construction seabed and/or benthic primary producer habitat loss or damage, is restricted and reduced.	Marine habitats will be managed through a hierarchy of proactive and reactive management and monitoring strategies, including contingency actions.	Section 6.1.2 Section 6.2.2	The management and contingency procedures are described in sections 6.2.2. and 6.3.2. However note that the proponent has predicted that there will be negligible indirect impacts arising out of the construction works. Hence the need for re-instatement or rehabilitation is likely to be very low. Also, the habitats so created will be rapidly recolonised by benthic algae and sessile invertebrates naturally.	None
9-5	The proponent shall implement the Plan.	The Water Corporation will implement the MPCOOP during and for 2 to 3 years following construction of the ocean outlet.	Section 1	The Proponent has committed to implement the proposal in accordance with the Ministerial Statement and schedules 1,2, 1nd 3 of that statement in section (end of 2nd para). In Table B, the Proponent commits to implementing the MPCOOP during and for 2-3 years following construction of the ocean outlet.	6.2.2 and 6.3.1 monitoring changed to “2 to 3 years”. This limit of 3 years means that monitoring ceases after 3 years.
9-6	The proponent shall make Plan publicly available in a manner approved by the CEO.	The MPCOOP will be made publicly available via the Water Corporation’s website (insert in section text “provided this method is approved by the DEC CEO”)	Section 1	As above.	

In his review, Professor Eric Paling noted a contrary view to that expressed by EPA (2004) regarding the irreversible nature of damage to seagrasses. The text of the relevant section has been amended to reflect that advice as follows:

"*This document has been independently reviewed by two specialists, Professor Eric Paling and Mr Ian LeProvost (Appendix L). Responses to their comments have been incorporated into the document where appropriate and the final table in Appendix L notes how the original document has been modified*".