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MEMORANDUM

ATTN: David Luketina	**CC:**
COMPANY: Water Corporation	**FROM:** Sarah Scott, Karen Hillman
PROJECT NO.: 663_001	**DATE:** 20 February 2008
SUBJECT: Impact of dredging on seagrass health	

1. Proposed disturbance

The Water Corporation is proposing to construct a desalination plant at Binningup south of Perth. This proposal will include the offshore installation of two to four pipes for both the intake and the outlet. These pipes will be completely buried under the sediment until the water depth is at least 6m (approximately 400m offshore) and then level with or slightly protruding above the seabed for the rest of the length. The pipeline will extend no further than 1,050m offshore, in a water depth of 10-12m. The construction may include the use of a cutter suction or backhoe dredge. The first 400m or so of dredging is in medium to coarse grained sand (Fugro, 2007) and will be 650m or more from the nearest areas of dense seagrass (UWA marine research group 2008). The remainder of the dredging (i.e. from 400 m to up to 1,050m offshore) will be in both sand and limestone. and will be no longer than four months. Dredging will not be continuous. The timing of the dredging is yet to be determined.

The turbidity associated with dredging along the pipeline route has the potential to affect marine biota in the region, due to:

- shading effects on seagrasses; and
- settlement of sediment particles on invertebrates, particularly filter-feeding organisms (eg ascidians, bryozoans, sponges, corals).

2. Habitats in the region

The marine benthic habitats in the vicinity of the proposed Southern Seawater Desalination Plant (SSDP) were characterised following towed underwater video taken in December 2007 (UWA marine research group 2008). Habitats comprised (i) no biota (i.e. free of obvious fauna in video footage), (ii) vegetation and sessile invertebrates, (iii) sessile invertebrates and (iv) vegetation (see Figure 1 and Figure 2).

The area mapped was described as highly disturbed (by natural wave energy), with large areas of reef pavement devoid of biota and where biota occurred they occupied a small proportion of the total reef surface (UWA marine research group 2008). Megaripples and sediment sheets were observed midshore suggesting that sediment was highly mobile (UWA marine research group 2008). The area had similar reef and seagrass communities to those reported to the north and south of the site although diversity and abundance of species in this region appeared to be poorer. The mosaic of seaweeds and benthic invertebrates was most developed on reefs 300-500m offshore with areas further inshore exhibiting an extensive pavement bare of invertebrates and seaweed which the authors suggested was due to the pavement being covered and scoured by shifting sands frequently (UWA marine research group 2008).

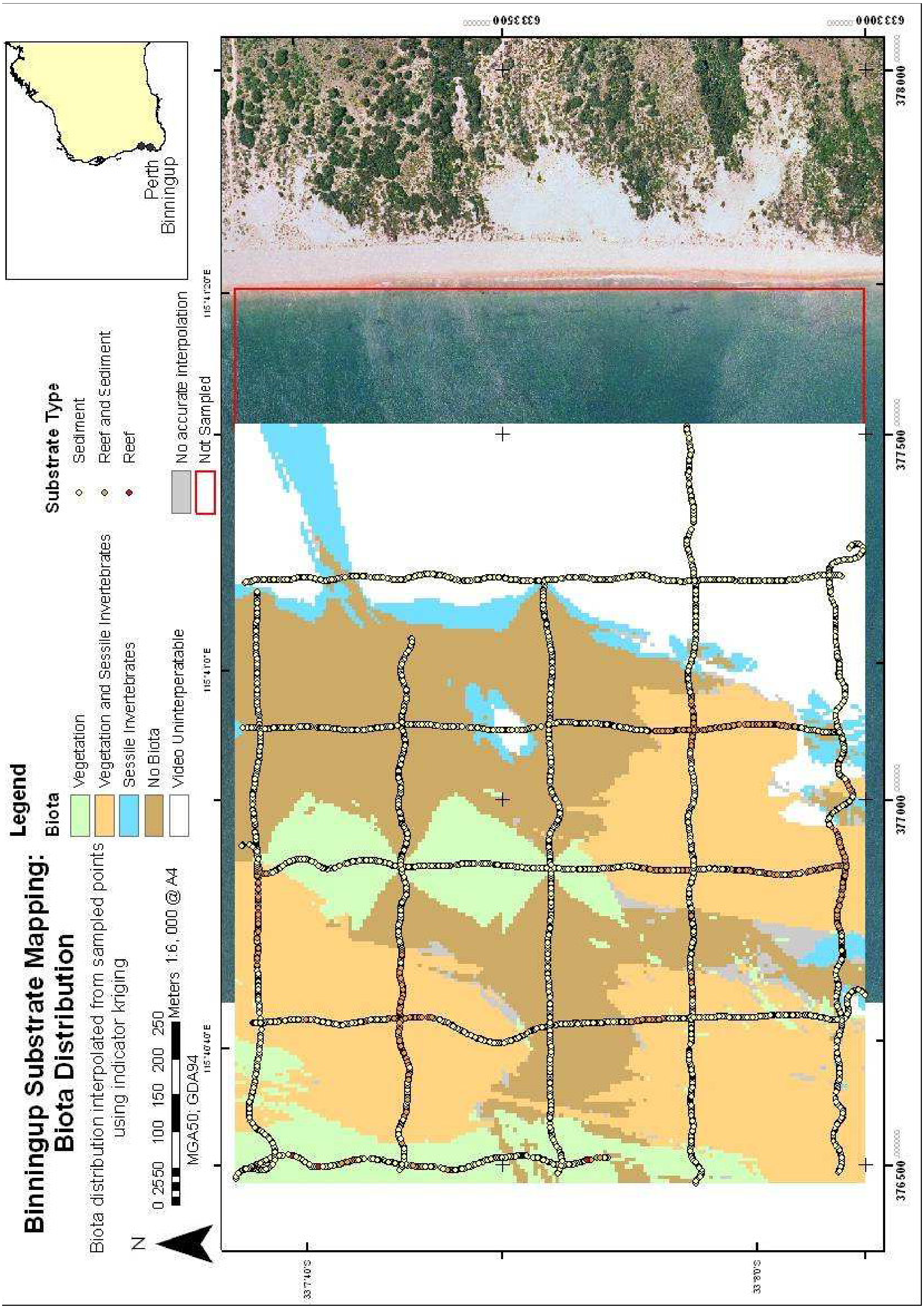

Figure 1 **Binningup Substrate Mapping: Biota distribution**

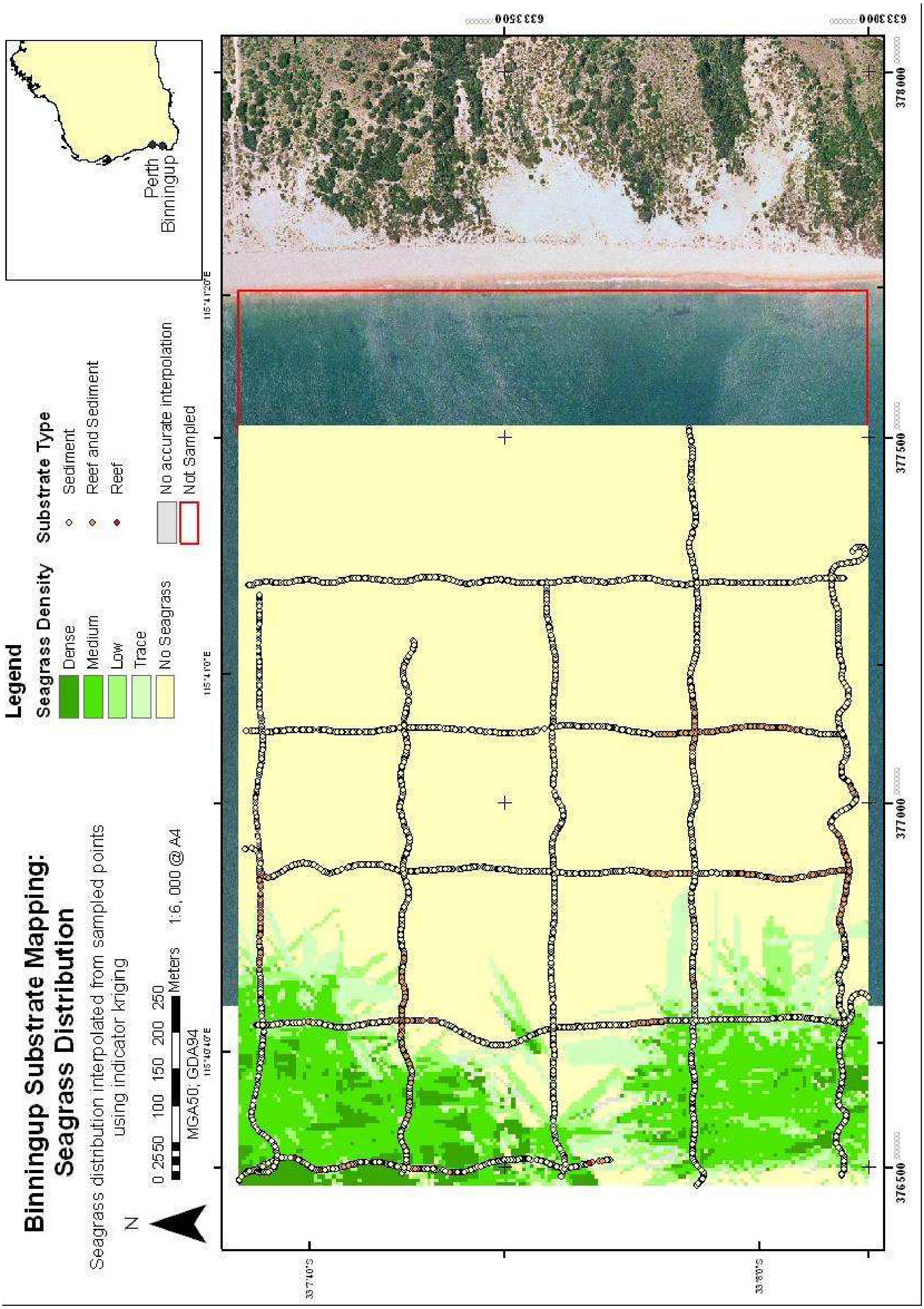

Figure 2 **Binningup Substrate Mapping: Seagrass Distribution**

It should be noted that weather conditions at the time of the survey (between 4th and 6th of December 2007) resulted in high turbidity, and therefore poor quality video imagery for the habitat mapping (UWA marine research group 2008). This meant identification of biota could only be carried out at a relatively coarse level. For example, it was possible to identify 'macroalgae' but not types of red, green and brown alga, and there were similar problems identifying types of invertebrates. The limitations of the video footage are described in full in UWA marine research group (2008).

2.1. Seagrasses

The seagrasses recorded in this study were *Posidonia angustifolia* and *Posidonia coriacea* with *Posidonia angustifolia* comprising 98.7% of all seagrass recorded (UWA marine research group 2008) (Figure 2). The more extensive offshore meadows occurred on sand whereas closer inshore a mosaic of seagrass, seaweed and sessile benthic invertebrates occurred on relatively low relief reef and pavement (UWA marine research group 2008). No *Amphibolis* species were present although this genus often colonises areas along with *Posidonia angustifolia* after the colonisation of *Posidonia coriacea* which is an early successional species (UWA marine research group 2008). There were also no smaller, more delicate species (for example *Heterozostera* or *Halophila*) probably due to the high sediment movement in this area (UWA marine research group 2008).

Seagrass mapping shows that dense seagrass occurs more than 1200m offshore along the proposed pipe alignment[1] (UWA marine research group 2008). There is no dense seagrass recorded in shallower water due to the high sediment movement in this area; seagrass was observed from 650m offshore however it was sparse and patchy (UWA marine research group 2008). The habitat mapping survey did not extend out to the offshore depth limit of the seagrass (*P. angustifolia* is known to occur to depths of 30m in Geographe Bay) and as such it is unknown how far from shore and to what water depth the seagrass extends in this area.

2.2. Macroalgae and invertebrates

The specific types of macroalgae present were often not possible to discern due to the video quality, and as a result most of the macroalgae were described as undifferentiated (UWA marine research group 2008). The green alga *Codium* was discernable in 6.4% of the algae assemblages due to its distinctive morphology (UWA marine research group 2008).

The mosaic of seaweeds and benthic invertebrates was most developed on reefs 300-500m offshore with areas further inshore exhibiting an extensive pavement bare of invertebrates and seaweed which the authors suggested was due to the pavement being covered and scoured by shifting sands frequently (UWA marine research group 2008).

Fauna were often described as undifferentiated due to the low quality of the video footage (Table 2.1). Of the identified invertebrates the predominant sessile invertebrates were sponges and ascidians (sea squirts) which often occurred together

Table 2.1 Proportion of minutes of video footage descriptions for sessile invertebrates

Sessile Invertebrates	Proportion of Invertebrates %
Undifferentiated	43.5
Sponges	25.2
Ascidians	24.9
Hard Corals	5.0
Bryozoa	1.3
Hydriods	0.1

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[1] The proposed pipeline alignment coincides with the central east-west sampling point transect in Figure 1 and Figure 2.

3. Factors affecting potential impacts on seagrass due to dredge plume

3.1. Timing for dredging to reduce impact on seagrass

Until recently, the accepted view to minimise any turbidity-related impacts on seagrass was to carry out dredging between late autumn and early spring, when growth rates are lowest and food reserves (stored in seagrass rhizomes) at their highest (which help seagrass cope with the low light levels over this period). However, recent shading studies carried out over three months on *Amphibolis,* have found a greater impact when shading commenced in autumn than in spring (McMahon pers. comm.). As the morphology and growth characteristics of *Amphibolis* and *Posidonia* are quite different *Posidonia* may respond differently to dredging. It is not believed that any studies have taken place to investigate differences in the impact of light reduction with season in *Posidonia*, nor can it be assumed that dredging would be best carried out between late autumn and early spring.

3.2. Previous studies on light tolerance in seagrasses

The seagrass species *Posidonia angustifolia* and *P. sinuosa* were described in 1979 and prior to this were known as narrow leaved forms of *Posidonia australis* (Cambridge & Kuo, 1979). The depth range of *P. angustifolia* is 2-35m whereas *P. australis* and *P. sinuosa* occur from the low water mark to 15m (Cambridge & Kuo, 1979): this indicates that *P. angustifolia* can survive at lower light levels than the other two species. These three species are very similar in terms of morphology and growth and as very little research has taken place on *P. angustifolia,* details on *P. sinuosa* have been included in this memo.

Meadows of *P. sinuosa* and *P. angustifolia* are known to occur at depths from 2m to 14m in Geographe Bay, below 14m seagrasses become sparse and patchy in distribution (D.A. Lord and Associates, 1995). Structurally large species such at *Posidonia* can survive for more than 140 days of shading (Collier 2006; Ralph et al. 2007). Westphalen *et al.* (2004) reported that *Posidonia angustifolia* has a relatively higher below ground component than *P sinuosa* or *P. australis*, although this is probably traded off against a slower rate of growth. The ability to store large quantities of carbon may be a benefit in terms of enabling the plant to tolerate extended periods of sub-optimal light but a high below ground biomass poses a substantial oxygen demand that cannot be fulfilled by dissolved oxygen in the water column (Westphalen *et al.*, 2004)). Thus, while the storage of carbohydrates assists seagrasses to tolerate low light levels to some degree, a severe and/or extended loss of photosynthetic capacity may result in profound root anoxia and even the localised production of poisonous sulphides which may adversely affect the growth or survival of sediment infauna (i.e. invertebrate fauna in the sediments) (Westphalen *et al.*, 2004). From the many studies that have taken place it is clear, however, that species with larger below-ground biomass, such as *Posidonia*, are better adapted to longer periods of sub-minimum light (Erftemeijer & Robin Lewis III, 2006).

The time taken to produce measureable responses (typically shoot loss) due to reduced light levels, is generally longer in *P. sinuosa* than most other seagrass species, with some shoots surviving over 12 months below minimum light requirements (Collier 2006). The minimum light requirement at depth limit for *P. sinuosa* is around 8% of sub-surface irradiance (Collier 2006, DEP 1996). In Cockburn Sound, *P. sinuosa* at a water depth of 7m (close to the depth limit of seagrass in Cockburn Sound)—when shaded to ~3% of sub-surface irradiance for just over 6 months continuously—exhibited a significant decrease in shoot density, but did survive (Collier 2006). Gordon et al (1994) found that *P. sinuosa* shoots survived 24 months with a light availability of 12% ambient.

The studies of Collier (2006) have established that the minimum light requirement for *P. sinuosa* is around 8% of sub-surface irradiance, and that it is capable of surviving over 6 months in light levels of 3% of sub-surface irradiance. In seagrass ecological studies, the measure of water clarity usually used to determine the depth limits at which seagrass can occur is the light attenuation coefficient (LAC). The LAC is simply a mathematically expression of the rate at which light levels decline with depth, as follows:

$$\text{Light Attenuation Coefficient } (LAC) = \frac{\log_{10}(\text{irradiance at depth}) - \log_{10}(\text{irradiance at surface})}{\text{Depth difference } (m)}$$

LAC can also be calculated using light levels expressed in terms of natural logs, and this must be taken into account when comparing results from different studies. The Cockburn Sound State Environmental Policy's Manual of Standard Operating Procedures states that light should be measured as μmol/m^2/sec and the light attenuation should be calculated on a $\log_{10}$ basis (Government of Western Australia 2005). Although the LAC is often negative the convention is to report absolute values rather than negative values. The LAC required to achieve 8% and 3% of sub-surface irradiance at various water depths have been calculated, and are shown in Table 3.1 and Table 3.2, respectively. The relationship between LAC and the water depth that 8% and 3% of sub-surface irradiance can reach is also shown in Figure 3.

Table 3.1 **Relationship between 8% of sub-surface irradiance, depth and LAC**

Depth that 8% of sub- surface irradiance reaches	LAC_{log10} (m^{-1})
10	0.11
12	0.09
14	0.08

Table 3.2 **Relationship between 3% of sub-surface irradiance, depth and LAC**

Depth that 3% of sub-surface irradiance reaches	LAC_{log10} (m^{-1})
10	0.15
12	0.13
14	0.11

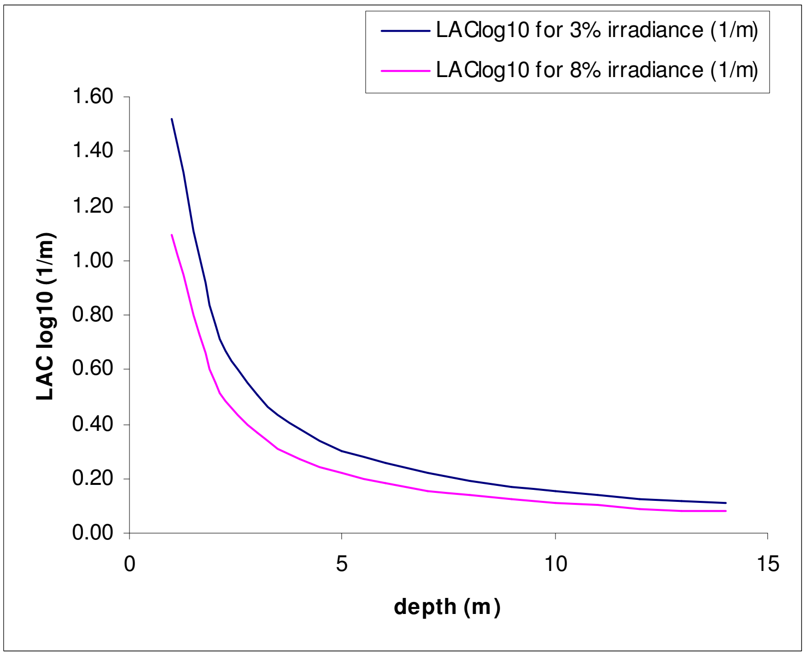

Figure 3 **Relationship between LAC $_{\log 10}$ (m^{-1}) and the water depth that 3% and 8% of sub-surface irradiance can reach**

Collier (2006) found that although shoots in the shade at 7m survived after receiving only 3 % of subsurface irradiance for just over 6 months, after 384 days of recovery (ie shading removed) the biomass in this treatment was still significantly lower than the control treatment. Thus although the seagrass may survive events of high shading the recovery time may be long.

4. Background turbidity in Binningup region

Turbidity has been shown to be variable at the proposed site for the SSDP (GHD 2007). Natural turbidity (NTU) measured by the Seaglider in July and August 2007 ranged from 5 to >10NTU in the lower 2 m where seagrass is found (GHD 2007). Variation in the turbidity was related to the three different weather conditions observed during the study (calm winter conditions, stormy winter conditions with substantial resuspension of particles and calm winter conditions with high river flows. Based on the Seaglider measurements, turbidity associated with calm winter conditions was <1 NTU, stormy winter conditions 4-5 NTU and high river flow 5-6 NTU (GHD 2007). The maximum recorded turbidity at the sites was in excess of 30 NTU on the seafloor (KBR 2007).

5. Relationship between turbidity and light attenuation

There are no data that enable the derivation of relationships between turbidity and light attenuation for dredging exercises in the Binningup region, but some relevant data are available for Perth's southern metropolitan coastal waters—which involve the dredging of calcareous sand and limestone (ie similar to the study region). Cockburn Cement Limited recently undertook a survey of the water characteristics associated with their dredge plume, involving the dredging of calcareous sands in Owen Anchorage[2] (Oceanica DRAFT), while Fremantle Ports have collated water quality data from the dredge plume associated with AMC's July 2007 dredging of limestone in Jervoise Bay Southern Harbour, Cockburn Sound[3].

The Cockburn Cement study found a range of Total Suspended Solids (TSS), from 7-50 mg/L, turbidity from 6-12 NTU and a Light Attenuation Co-efficient, LAC, of 0.27-0.34 μmol/m^2/sec from samples taken within the dredge plume immediately after dredging. The particle size distribution from the dredge plume was approximately 10% sand, 90% silt and 0.5% clay. The relationships between TSS, NTU and LAC for Cockburn Cement's dredging on Parmelia Bank are shown in Figure 4, with light attenuations of 0.12/m to 0.18/m found 1.3 km to 1.5 km from the dredge.

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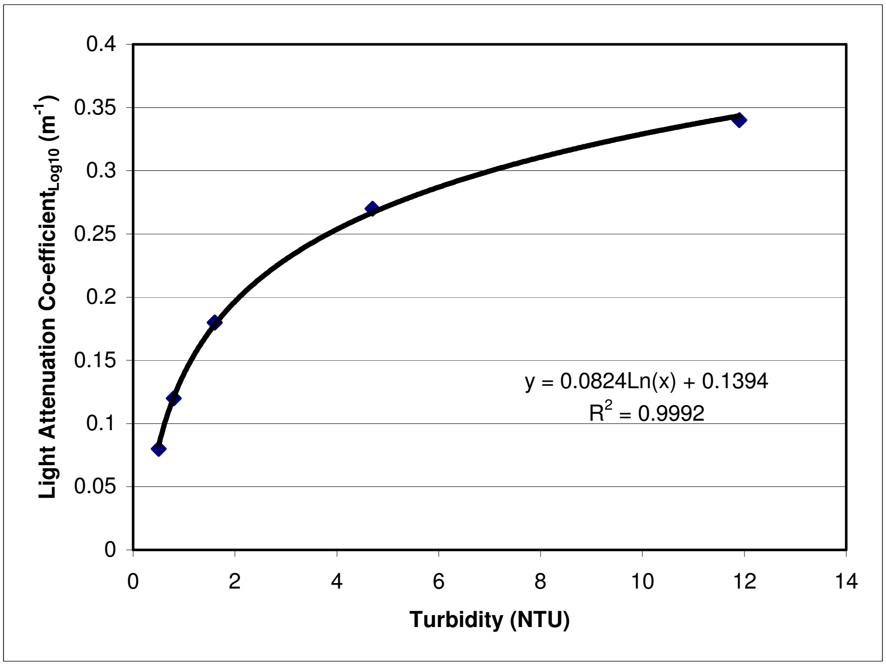
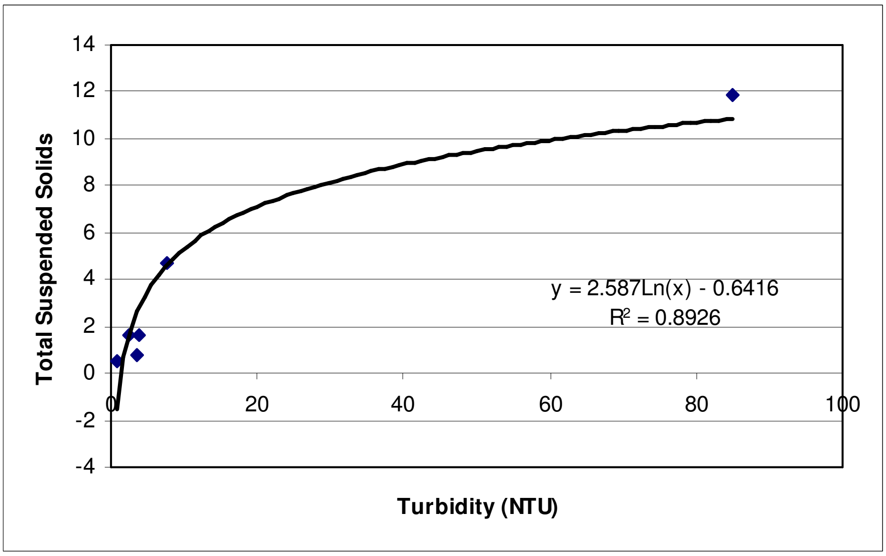
[2] Data made available courtesy of Cockburn Cement Ltd, as supplied by analytical laboratories involved in the study. Cockburn Cement Ltd accepts no liability for the accuracy of these data, or any conclusions drawn from them.

[3] Data made available courtesy of Fremantle Ports, as supplied by analytical laboratories involved in the study. Fremantle Ports accepts no liability for the accuracy of these data, or any conclusions drawn from them.





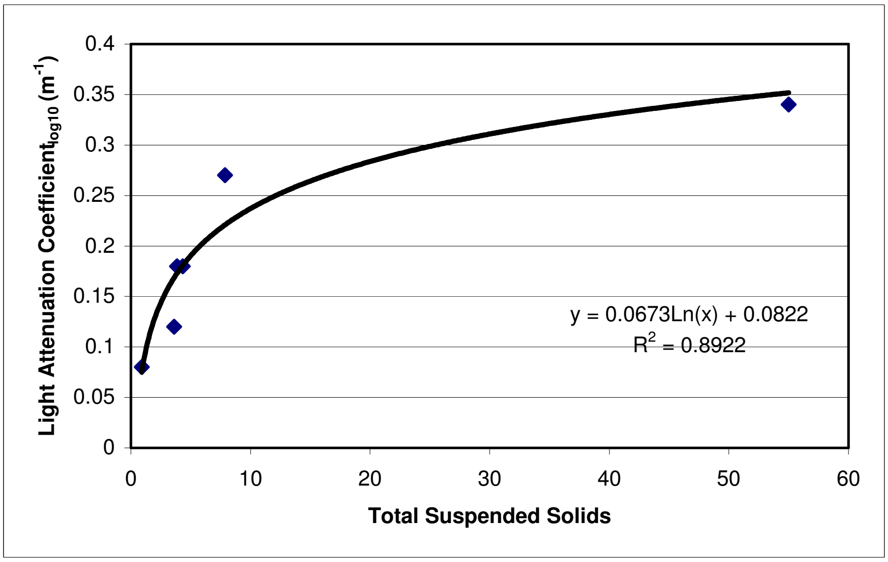


Figure 4 **Relationship between turbidity, total suspended solids and the light attenuation co-efficient at Parmelia Bank**

Dredging at the Australian Marine Complex, AMC, in Henderson took place between the 4th and 20th of July 2007. During the AMC dredging, water quality monitoring was undertaken at a variety of sites, including:

- within 50 m of the dredge cutter head (sites DX1, DX2, D1-D5)
- within 150-250 m of the dredge (site FP4)
- 350-400 m of the dredge (site FP3)

In summary, TSS values obtained were as follows:

- Sites within 50 m of the dredge cutter head (DX1, DX2, D1-D5): 12–91 mg/L
- Sites within 150-250 m of the dredge (FP4): 2.6–8.3 mg/L
- Sites within 350-400 m of the dredge (site FP3): 2.3–6 mg/L

Some particle size distribution measurements were also taken within the dredge plume, and results obtained were as follows:

- Sites within 50 m of the dredge cutter head (DX1, D1) – one sampling occasion (18th July): 1.9–4.2% (by volume) clay, and 85–93% silt
- A site within 250 of the dredge (FP2) – one sampling occasion (10th July): ~5% clay and 90% silt.

The AMC results indicated a silt content similar to those found in the Cockburn Cement dredge plume survey on Parmelia Bank, but a clay content that was ~2-3 times higher: this is attributed to the generation of fine 'rock flour' during the grinding and cutting of limestone. Due to the higher clay content associated with the turbidity plume generated by dredging of rock, the relationships between TSS, NTU and LAC would differ to that found during Cockburn Cement's dredging: the same TSS level would result in higher NTU and LAC.

6. Potential impact of proposed dredging – shoreward section

6.1. Seagrass health

The first 400m (i.e. shoreward section) of dredging along the pipeline route will be in medium to coarse grained sand with a content of 'fines' (silt and clay particles, less than 63 microns in diameter) that is likely to be less than approximately 2%. This is based on particle size data for the vicinity of the pipeline route, in water depths of approximately 10 m, where silt and clay comprised 0.8–2.2% by volume (Douglas & Partners 2008). As the first 400 m of the pipeline route is in shallower water and therefore subject to greater wave energy, the %fines content should be even less.

Sand-sized particles in dredge plumes rapidly settle out within a short distance of dredging, with the large majority of turbidity in dredge plumes due to silt and clay sized particles. As the fines content of the sediment to be dredged in the shoreward section of the pipeline route is likely to be less than 2%, and dredging will be 650m or more from the nearest areas dense seagrass (Douglas & Partners 2008, UWA marine research group 2008), it is anticipated that the level of turbidity reaching seagrasses will be minimal during this phase of dredging.

6.2. Invertebrates

For the reasons described above (i.e. low fines content of material being dredged, distance from nearest reef habitat), it is also anticipated that invertebrate fauna will be little affected by turbidity during this phase of dredging - particularly given that the pipeline route is devoid of sessile invertebrates (see Figure 1).

7. Potential impact of proposed dredging – seaward section

7.1. Seagrass health

The dredging proposed from 400 m to up to 1,050m offshore) will be of both sand and limestone, and will take no longer than 4 months to complete. The dredge plume will therefore have to travel over 650m westward to influence the nearest dense seagrass at the beginning of this phase of dredging, and 150 m at the end of this phase (assuming the proposed pipeline route is located such that the nearest dense seagrass meadow is 1,200 m offshore). To influence seagrass further north or south, the plume will have to travel further.

The results of Cockburn Cement's study indicate that there is the potential for light attenuation in waters over the seagrass meadows closest to the proposed dredging activity at Binningup to be reduced to levels around 3% of subsurface irradiation, if the dredge plume moved due west. As noted above, the work of Collier (2006) found *P. sinuosa* survived when shaded to 3% of subsurface irradiation for just over 6 months, but biomass and shoot density was affected and had not recovered a year after shading was removed. Shading effects due to the turbidity associated with dredging tend, however, to be intermittent and of varying intensity. For example, during an ~6 month dredging programme for the Southern Harbour in Jervoise Bay, Cockburn Sound, monitoring of seagrass sites (*P. australis* and *P. sinuosa*) ~500 m and 1.5 km from the dredging activity found no impact at the more remote site, whereas the closer site had intermittent periods where minimum light requirements were not met: this produced one brief period where the number of leaves/shoot declined, but recovery was also quick (DALSE 2002).

As dredging at the site will be for no longer than 4 months, will not be continuous, and plume movement over the seagrass meadows will be intermittent according to current direction, available information does not indicate that turbidity associated with the proposed dredging will result in the loss of seagrass. Furthermore, at Binningup, the main species to be affected by the proposed dredging will be *P. angustifolia*, which appears to tolerate lower light levels than *P. australis* and *P. sinuosa*. However, depending on the degree to which the dredge plume moves west (ie over the seagrass meadows), there is some potential for temporary impacts on biomass and shoot density.

7.2. Invertebrates

Natural levels of turbidity in bottom waters in the Binningup region (see Section 4) encompass the range of turbidity likely to be generated by dredging. Sessile invertebrates in the region are therefore species able to cope with periodic elevations in turbidity. Furthermore, the assemblage of invertebrate species present are those adapted to a high degree of sediment movement, with frequent bare areas evident on reefs (see Section 2) indicating that removal and re-colonisation of sessile biota is an ongoing process. As such, if any localised losses of invertebrate communities occur due to the turbidity generated by dredging, they should rapidly establish once dredging ceases. Impacts on invertebrate communities are therefore expected to be minimal, highly localised (i.e. confined to areas of reef where the dredge plume causes high turbidity on a regular basis) and temporary.

References

Cambridge M.L. & Kuo J., 1979. Two new species of seagrasses from Australia, *Posidonia sinuosa* and *P.angustifolia* (Posidoniaceae). *Aquatic Botany*, Vol. 6, pp. 307-328.

Collier, C.J., 2006. *Characterising responses of the seagrass Posidonia sinuosa to changes in light availability*. Ph.D. thesis, Faculty of Computing, Health and Science. Perth, Edith Cowan University

DALSE, 2002, *Independent Turbidity Monitoring Consultant Quarterly Report #3. Jervoise Bay Southern Harbour Turbidity Monitoring Programme and Southern and Northern Harbour Water and Sediment Quality Monitoring*, Prepared for Department of Industry and Technology by DAL Science & Engineering Pty Ltd, Report no. 02/207/3, Perth, Western Australia, May 2002.

D.A. Lord and Associates, 1995. *Geographe Bay Study 1993-1995 Summary Report*, Prepared by D.A. Lord and Associates, in association with Centre for Water Resarch and Department of Botany, University of Western Australia for Water Authority of Western Australia (Southwest Region), June 1995.

Department of Environmental Protection, 1996, *Southern Metropolitan Coastal Waters Study (1991-1994) Final Report*, Report 17, Perth, Western Australia, November 1996.

Douglas & Partners (2008), *Jet Probing and Drilling Program - Desalination Plant Two, Binningup*, Ref 42592/46737

Duarte, CM, 1991, Seagrass depth limits, *Aquatic Botany*, vol. 40, pp. 363–377.

Erftemeijer P. L. A, & Robin Lewis III R.R., 2006. Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin*, Vol. 52, pp. 1553-1572.

GHD, 2007, *Southern Seawater Desalination Plant – Marine Investigations, Report for Oceanography of Southern Seawater Desalination Plant, Seaglider Transects* (July – August 2007), Prepared for Kellogg, Brown & Root Pty Ltd. November 2007

Gordon, DM, Grey, KA, Chase, SC & Simpson, CJ, 1994, Changes to the structure and productivity of a *Posidonia sinuosa* meadow during and after imposed shading, *Aquatic Botany*, vol. 47, pp. 265–275.

Government of Western Australia, 2005, *Manual of Standard Operating Procedures for Environmental Monitoring Against the Cockburn Sound Environmental Quality Criteria (2003-2004): A supporting document to the State Encironmental (Cockburn Sound) Policy 2005*, Environmental Protection Authority, Report 21, Western Australia, January 2005.

Kellogg Brown & Root Pty Ltd, 2007, *Southern Seawater Desalination Plant – Marine Investigations, Water Quality Monitoring – Stage 1*, Prepared for Water Corporation, November 2007

Oceanica DRAFT, *Turbidity Management Plan - Characterisation of Volvox Anglia Dredge Plume and Potential Impacts on Adjacent Habitats*, Prepared for Cockburn Cement Limited by Oceanica Consulting Pty Ltd, Report no. 337/1, Perth, Western Australia, January 2008.

Ralph P.J., Durako M.J., Enríquez S., Collier C.J. & Doblin M.A., 2007, Impact of light limitation on seagrasses. *Journal of Experimental Marine Biology and Ecology*, vol. 350, pp 176-193

University of Western Australia Marine Research Group, 2008, *Characterising the Marine Benthic Habitats of the Proposed Southern Seawater Desalination Plant (SSDP) Site: Interpretation from Underwater Towed Video & Map Interpolation*, Report to KBR, 17 January 2008

Westphalen, G., Collings, G., Wear, R., Fernandes, M., Bryars, S. and Cheshire, A. 2004 *A review of seagrass loss on the Adelaide metropolitan coastline*. ACWS Technical Report No. 2 prepared for the Adelaide Coastal Waters Study Steering Committee. South Australian Research and Development Institute (Aquatic Sciences) Publication No. RD04/0073, Adelaide.