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 (80th percentile) as well as indicate the potential for more significant impacts (95th and 99th 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.

REFERENCES

Collier, C.J., Lavery, P.S., Masini, R.J. and Ralph, P.J. (2007) *Morphological, growth and meadow characteristics of the seagrass* Posidonia sinuosa *along a depth related gradient of light availability*, Marine Ecology Progress Series Vol. 337: 103–115

Dennison, W.C., Orth, K.A., Moore, R.J., Stevenson, J.C., Carter, V., Kollar, S., Batiuk, R.A., (1993) *Assessing water quality with submersed aquatic vegetation*, BioScience Vol 43, 86–94.

Duarte, C.M. (1991) *Seagrass depth limits*, Aquatic Botany Vol 40, 363–378.

Erftemeijer, P.L.A., Osinga, R., and Mars, A.E. (1993) *Primary production of seagrass beds in South Sulawesi (Indonesia): a comparison of habitats, methods and species*, Aquatic Botany Vol 46, 67–90.

Erftemeijer, P.L.A and Stapel, J. (1999) *Primary production of deep-water* Halophila ovalis *meadows*, Aquatic Botany Vol 65 71–82.

Gordon, D.M., Grey, K.A., Chase, S.C., Simpson, C.J., (1994) *Changes to the structure and productivity of a* Posidonia sinuosa *meadow during and after imposed shading*. Aquatic Botany Vol 47, 265–275.

Longstaff, B.J., Loneragan, N.R., O'Donohue, M. and Dennison, W.C. (1999) *The effects of light deprivation on the survival and recovery of the seagrass* Halophila ovalis, Journal of Experimental Marine Biology and Ecology Vol 234, 1–27.

Longstaff, B.J. and Dennison, W.C. (1999) *Seagrass survival during pulsed turbidity events: the effects of light deprivation on the seagrasses* Halodule pinifolia *and* Halophila ovalis, Aquatic Botany Vol 65, 105–121

Ralph, P.J., Durako, M.J., Enríquezc, S., Collier, C.J. and Doblin, M.A. (2007) Impact *of light limitation on seagrasses*, Journal of Experimental Marine Biology and Ecology Vol 350 176–193