INITIAL MIXING OF BRINE
AT CAPE PRESTON

Prepared for:

HGM

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1. CAPE PRESTON BRINE DISCHARGE MODELLING

1.1 INTRODUCTION

D.A. Lord and Associates (DAL) were requested by HGM to undertake modelling of the near field mixing of brine to be discharged from the proposed AUSTEEL plant. The purpose of the modelling is to estimate the extent of the initial mixing zone for environmental impact assessment purposes.

Initial modelling based on lower brine discharges has been undertaken (HGM, 2000). Two cases were considered:

- Case 1: Surface discharge from the end of a jetty into 11 m of water; and
- Case 2: Shoreline discharge into a shallow, possibly inter-tidal region

The modelling was based upon determining regions which salinity was greater than 1.8 above ambient salinity (assumed to be 34.5). This criteria was based upon EPA (1993) criteria for acceptable median salinity changes.

Results from the initial HGM modelling indicated that salinity would not exceed ambient values by more than 1.8[1] outside a radius of 50 m from the discharge point at the end of the jetty. The shoreline discharge had a larger initial mixing zone due to the shallowness of the receiving body. The maximum dimensions, outside of which the ambient salinity would not be exceeded, were 800 m in the alongshore direction and less than 50 m in the cross-shore direction.

Case 1 results were based upon the worst case of discharge into a quiescent water body. As possible alongshore impact of the brine discharge were considered important Case 2 (nearshore) simulations were based upon an expected alongshore current of 0.23 m/s.

Since the HGM study the proposed brine discharges have risen in magnitude from an annual discharge of 55 Mm^3 to 70 Mm^3. The purpose of this investigation is to determine if the maximum dimensions of the region encompassing the zone where the median ambient salinity is exceeded by 1.8 have changed.

1.2 MODEL STUDY

1.2.1 Case 1: Discharge from the end of the Jetty

Case 1 was simulated as a discharge from a multi-port diffuser using the PLUMES (EPA, 1994) dilution model. The program does not simulate negatively buoyant plumes directly and was consequently adapted according to methodology outlined in the users manual.

The methodology to simulate the negatively buoyant plume involved assuming a positively buoyant discharge with the same absolute difference in density between the discharge and the ambient receiving water. This approach is based upon the assumption that the absolute density differences between the plume elements and the local ambient fluid are the same so that forces acting on the plume element are the

[1] Salinity throughout this report is referred to without units according to the Practical Salinity Scale. On this scale salinity is defined as a ratio of conductivities and therefore cannot have units.

same regardless of the direction (either upwards or downwards) of motion. There is evidence to suggest that this approach is valid (EPA, 1994).

Key variables used for the modelling are presented in Table 1.1.

Table 1.1 Brine discharge parameters

Parameter	Value	Notes
Ambient Density	1023 kg/m^3	-
Discharge Density	1044 kg/m^3	Salinity above ambient is 27
Peak Discharge	2.2 m^3/s	Operation discharge will be 1.9 m^3/s
Ambient Flow	0.1 m/s	Estimate of mean current speed

Results from the PLUMES model indicate that salinity criteria will be met (less than a 1.8 increase above ambient) outside from a 150 m radius from the diffuser.

The values are highly sensitive to the current speed and to the diffuser configuration. Many diffuser configurations were modelled. To increase the dispersion of brine it is preferable to maximise the initial dilution as much as possible before the plume reaches the bottom. When the plume reaches the bottom, environmental processes which determine the mixing are weaker than those at the surface due to the likely trapping of high salinity water within the bottom boundary layer.

Furthermore tidal currents will advect the plume in an oscillatory motion (tidal excursion). A conservative estimate of the enlargement of this area due to the tidal excursion may be made if it is assumed that the 150 m diameter plume does not mix with the surrounding water but moves with the tidal flow.

During normal operating conditions the discharge is lower and consequently the environmental salinity criteria are not expected to be exceeded outside a region of 100 m from the discharge point.

The tidal excursion at Cape Preston has been estimated to range between 2,200 m and 7,800 m (DAL, 2000). However, these estimates would have a strong directional component. Generally, the tidal ellipse would be aligned along bathymetry contours, with a smaller component in the cross-shore direction.

A region of environmental significance is found on the northern end of Preston Island, approximately 1,600 m from the brine discharge. Although this distance is within the tidal excursion, the distance from the brine to the coral is in a cross-shore direction, thereby the likelihood that brine in excess of the guidelines would be transported to the coral region by tidal excursion is likely to be low.

In addition, the bathymetry slopes upward from the discharge point towards the corals. The plume formed by the brine discharge will be denser than the ambient water and as a result will, in quiescent conditions, flow downwards.

Given that the tidal excursion is large compared to the distance between the brine discharge and the coral these estimates should be viewed with caution. A more detailed numerical modelling study of the region undertaken with field measurements will allow the far-field dispersion of the plume to be characterised with considerably more confidence.

1.2.2 Case 2: Shoreline discharge

Shoreline discharges were simulated with the CORMIX-GI model. Simulations were undertaken with the same parameters listed in Table 1.1. The ambient velocity was increased to 0.23 m/s, consistent with previous shoreline discharge modelling. The modelled depth into which the brine was discharged was 1 m.

Results indicated that the brine plume would become attached to the shore and flow in the direction of the ambient current. Salinity criteria are not expected to be exceeded outside a region 30 m offshore and 100 m in the alongshore direction from the diffuser. This is somewhat smaller than the initial modelling undertaken by HGM for the shoreline discharge and may be attributable to the sloping bathymetry inhibiting vertical mixing and therefore dilution of the brine plume.

It has been indicated that the region may be inter-tidal. If this is the case, at stages during the tidal cycle brine will be discharged onto the beach face before entering the sea. This scenario has not been modelled, although the initial mixing and therefore dilution may be lower. Consequently, the region in which environmental criteria are not met may be larger.

It must be noted that the region in which the environmental criteria is met, like the discharge from the jetty, is heavily dependent upon the discharge configuration.

1.3 SUMMARY OF RESULTS

Model results for Case 1 indicate that the environmental criteria for salinity used by HGM would be met outside a radius of 150 m of the brine discharge.

Model results for Case 2 indicated that the environmental criteria for salinity would be met outside of an offshore distance of 30 m and an alongshore distance of 100 m (in the direction in which the ambient current is flowing towards) from the shoreline discharge. The offshore extent of the brine discharge may be greater if there are local variations in the bathymetry.

The initial dilution is heavily dependent upon the brine diffuser configuration for both cases.

It would be unlikely that brine discharged from the end of the jetty would reach the coral on the northern end of Preston Island. However, current meter measurements will be needed at some stage to verify this statement and to design the brine discharge infrastructure.

2. REFERENCES

EPA (1993) Western Australian Water Quality Guidelines for Fresh and Marine Waters. Bulletin 711. Perth, Western Australia.

EPA (1994) Dilution Models for Effluent Dishcarges. Third Edition. EPA/600/R-93/139, June 1994.

HGM (2000) Iron Ore Mine and Downstream Processing, Cape Preston, Western Australia. Public Environmental Review. Prepared for AUSTEEL Pty Ltd.