Austeel Pty Ltd

Iron Ore Mine and Downstream Processing, Cape Preston, Western Australia

Supplementary Environmental Review

Prepared by

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Contents

1 Introduction

1.1 Background

Austeel Pty Ltd (Austeel) proposes to develop a project for the production of up to a nominal 6.9 million tonnes per annum (Mtpa) of iron pellets and 4.7 Mtpa of Direct Reduced Iron/Hot Briquetted Iron (DRI/HBI) at Cape Preston, 80 km south-west of Karratha in the Pilbara Region of Western Australia.

Austeel's main shareholder is Mineralogy Pty Ltd (Mineralogy). The Austeel project consists of the following international companies whose roles are set out hereunder.

- Corus – operators of the Austeel Project;
- Lurgi – design and construction of the Concentrator, Pellet and DRI/HBI plants;
- Danieli – construction of steel plant in Newcastle;
- Macsteel – purchase of finished steel product;
- Thiess – mining contractor;
- Andhika – management of Cape Preston port;
- Mineralogy – holds mining tenements over the Fortescue magnetite iron ore deposit;
- BP – gas supply as participant in the North West Shelf Joint Venture;
- Chevron – gas supply as participant in the North West Shelf Joint Venture;
- Shell – gas supply as participant in the North West Shelf Joint Venture;
- Woodside – gas supply as participant in the North West Shelf Joint Venture;
- MIMI – ownership in the North West Shelf Joint Venture;
- Industrial Bank of Japan – financial adviser; and
- Clough Engineering – port and onshore infrastructure at Cape Preston.

Mineralogy holds the mining rights over the George Palmer iron ore deposit and leases associated with port facilities and infrastructure. Mineralogy has granted rights to Austeel to use part of its tenements for the development and operation of the project.

In broad terms the project identified the following main components in the Public Environmental Review (PER) document:

- iron ore mining;
- ore concentration ;
- ore pelletising;
- production of DRI/HBI;
- waste dumps;
- tailings dam;
- conveyor transfer of product to Cape Preston;
- product stockpiles and materials handling;
- port development, including a small craft harbour, import jetty, export jetty and berthing pocket; and
- infrastructure including access roads, haul roads, construction camps, village, power station, power distribution network and reverse osmosis desalination plant.

Following further engineering and economic evaluation, a number of project changes have occurred. These changes are outlined in Section 1.2 below.

This report also details additional environmental studies that have been conducted to date and the ongoing studies yet to be completed, as part of the environmental approvals process relating to the proposed project.

1.2 Project Changes

The following changes to the project have occurred:

- increase in mining rate and reduction to project life;
- net increase (~10ha) in total area disturbed (incorporates increases to the plant site and power station area and clearing for a gas pipeline lateral whilst allowing for a reduction in area for the removal of the southern tailings dam);
- increased power (and natural gas) demand (Extra two 160MW operating gas turbines plus two back-up turbines);

- increased ore concentration (to 13.4Mtpa);
- increase in pellet production (additional 6.9Mtpa for export);
- removal of the southern tailings dam (eastern tailings dam only);
- minimisation of waste dump encroachment into the Fortescue River Floodplain;
- identification of two options for the gas pipeline lateral;
- consideration of the option to haul product to the port site rather than use conveyor;
- modified jetty design; and
- increase in project workforce and changes to on-site accommodation.

Table 1.1 provides an overview of the key characteristics of the project and compares the project as defined in the original PER to the current proposal. The environmental implications of the changes are discussed in the following sections.

The main reason for these changes is due to the incorporation of increased production of iron ore pellets for export. This has resulted in an increase in demand for raw materials (ore, seawater for process water, natural gas for power, and other consumables involved in the concentrating and pelleting processes) as illustrated in the Annual Mass Balance Flow Diagram (Figure 1.1) and quantified in Table 1.2.

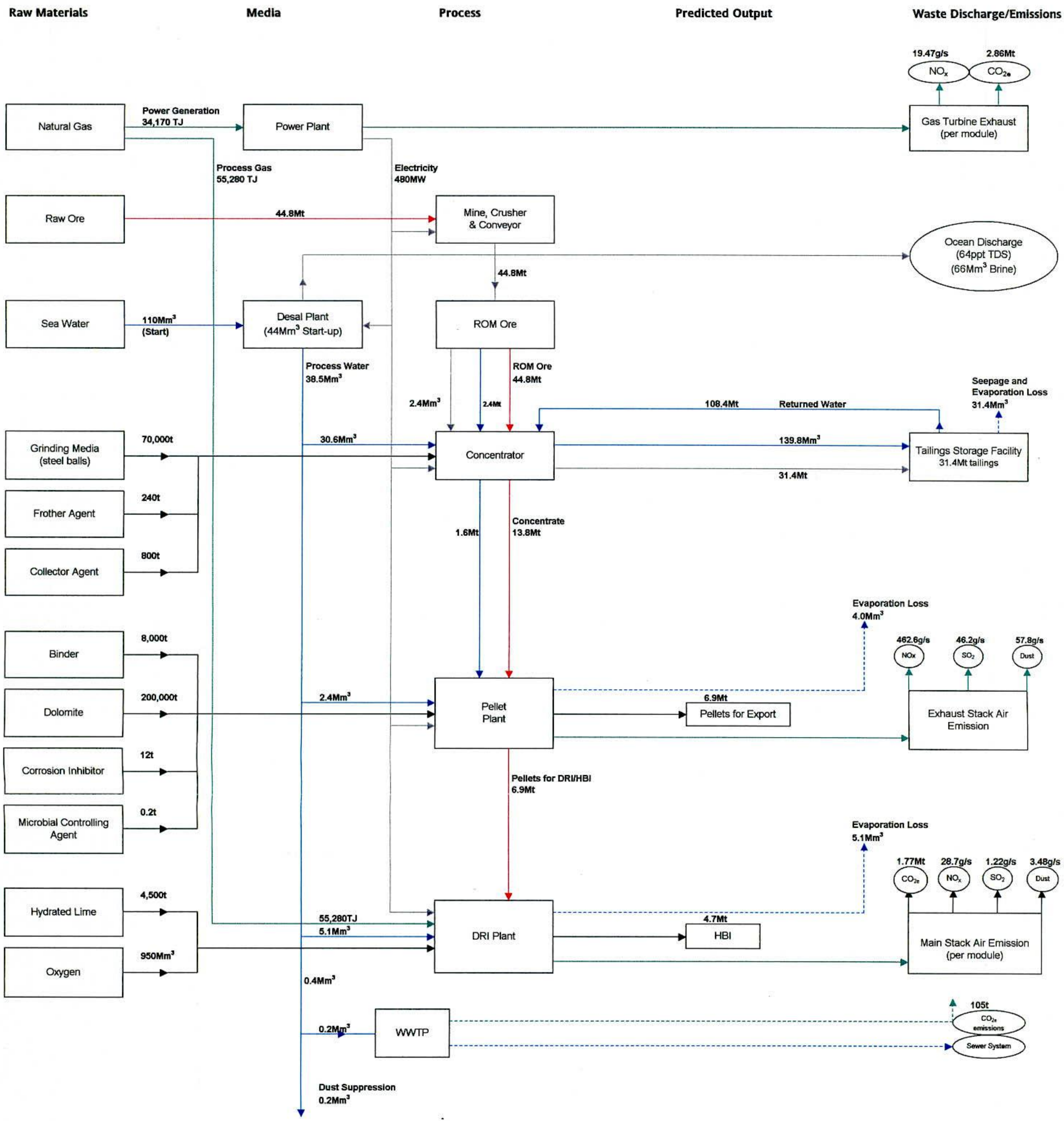


Figure 1.1: Annual Mass Balance Flow Diagram for the Austeel Project

Table 1.1: Changes to Key Characteristics of the Project

Element	Original Project Characteristics (as per PER)	Current Project Characteristics (SER)	Additional Impact	Proposed Mitigation
General				
Construction period	Approximately 3 years.	Approximately 3 years.	None	-
Project life	Minimum of 30 years (estimated 40 years)	20 years.	None	-
Mining				
Ore reserves	Over 800Mt.	Over 1,400Mt.	None	-
Ore mining rate	~22.4Mtpa.	~44.8Mtpa.	None	-
Pit depth	~200m.	~220m.	None	-
Overburden and waste	17Mt (Year 0) to 9Mt (Year 20). No pit backfilling at project completion.	~34Mt (Year 0) to 18Mt (Year 20). No pit backfilling at project completion.	Increase in waste on an annual basis. Same volume over project life.	None required.
Stripping ratio	1.6:1 (Year 1) to 0.62:1 (Year 20). Long term 0.27:1.	~1.6:1 (Year 1) to 0.62:1 (Year 20). Long term ~0.27:1.	None	-
Materials handling	Conventional drill, blast and haul. In-pit crushing.	Conventional drill, blast and haul. In-pit crushing.	Frequency of blasting doubled. Blasting confined to pit. No additional impacts.	None required.
Dewatering rate	1 to 2ML/day.	1 to 2ML/day.	Negligible effect on groundwater drawdown.	None required
Dewatering disposal	To process water stream.	To process water stream.	None	-
Concentrator				
Production	Ore concentration (6.7Mtpa).	Ore concentration (~13.4Mtpa).	Increased process water demand. Increase in size of desalination plant.	Brine modelling underway.
Waste	Tailings (15.7Mtpa).	Tailings (~31.4Mtpa).	Use of eastern tailings dam only. No southern tailings dam. Reduced impacts over the life of the project.	None required.
Pelletising				
Production	Pelletising (6.9Mtpa).	Pelletising (~13.8Mtpa), where 6.9Mtpa is for export and 6.9Mtpa required for HBI production.	Increased dust and air emissions (NO_X, SO_2).	Air quality modelling underway.
DRI/HBI				
Production	DRI/HBI (4.7Mtpa).	DRI/HBI (nominal 4.7Mtpa).	None	-
Port				
Stockyard	Product stockpiles. 1Mt capacity stockyard.	Product stockpiles. ~1Mt capacity stockyard.	None	-
Materials handling	Stackers and reclaimers.	Stackers and reclaimers.	None	-
Port developments	Causeway (1.1km) to Preston Island. Jetty trestle. Small craft harbour. Import berth.	Causeway (1.1km) to Preston Island. Jetty trestle (realigned for safety reasons). Small craft harbour. Berthing pocket.	Impact on area of higher coral cover.	Coral does not have high conservation value. Impact unavoidable.
Dredging	Up to 4.5Mm^3. Disposed offshore.	Up to 4.5Mm^3. Disposed offshore.	None	-
Infrastructure				
Power	320MW (operational) open cycle gas fired power station (with 160MW of installed standby).	640MW (operational) open cycle gas-fired power station (with 320MW of installed standby).	Increased power plant CO_2 and NO_X emissions.	Air quality modelling is being undertaken to investigate compliance with relevant standards.
Conveyor / haul road	~ 25km in length between HBI plant and port.	~ 25km in length between HBI plant and port.	None	-

Element	Original Project Characteristics (as per PER)	Current Project Characteristics (SER)	Additional Impact	Proposed Mitigation
Gas supply	76,000Tjpa.	~89,450Tjpa.	Increase in greenhouse gas emissions from 4.4Mtpa (3.8Mt on-site and 0.6Mt from upstream production) to 5.4Mtpa (4.6Mt on-site, 0.8Mt upstream). Reduction in greenhouse gas emissions over project life from 176Mt to 108Mt.	Offset measures being investigated.
Water	Desalination plant (22Mm^{3}pa). Brine disposal either adjacent to the western shore of Cape Preston or off of the jetty.	Desalination plant (initially ~44Mm^3 pa during start-up to build up initial water capacity, decreasing to 38.5Mm^3 pa during normal operations). Brine disposal either adjacent to the western shore of Cape Preston or off of the jetty.	Increase in brine disposal from 33Mm^3 to 57.8Mm^3.	Additional brine modelling being undertaken to determine the area of impact.
Roads	General traffic, ore truck, mine access, and conveyor and port access.	General traffic, ore truck, mine access, and conveyor and port access.	None	-
Buildings	Administration, maintenance workshops, storage and villages.	Administration, maintenance workshops, storage and villages.	Increased area for accommodation villages (see below). No significant vegetation affected.	Vegetation clearing kept to a minimum.
Sewage	Sewage treatment plant.	Sewage treatment plant.	Increase in plant size. No additional impact.	-
Disturbance Areas				
Area of pit	220ha.	220ha.	None	-
Plant site / power station	103ha.	220ha.	Increase in area of disturbance. No significant vegetation affected.	Clearing restricted to minimum necessary.
Port stockyard	25ha.	25ha.	None	-
Tailings dam	960ha	800ha	No southern tailings dam. Reduced area of impact.	-
Waste dumps	465ha	465ha	None	-
Site roads	45ha.	45ha.	None	-
Services corridor	73ha	73ha	None	-
Villages	15ha	15ha	None	-
Gas pipeline lateral	-	36ha	Area previously undefined. No significant vegetation affected. Further surveys to be conducted.	Clearing restricted to minimum necessary.
Water storage dams	-	17ha	Area previously undefined. No significant vegetation affected. Further surveys to be conducted.	Clearing restricted to minimum necessary.
Total area disturbed	1,906ha.	1916ha.	Slight increase in overall area of impact.	Commitments contained in the PER will mitigate any impacts.
Area rehabilitated	1,686ha (assuming no pit rehabilitation).	1696ha (assuming no pit rehabilitation).	-	-
Workforce				
Construction	5,000 peak.	~5,000 people during peak construction.	Reduced numbers.	-
Permanent	Up to 700. 40 at mine site. 660 commute from Karratha.	Up to 970 people during operations. 400 housed at the mine site, 20 at Cape Preston. 550 commute from Karratha.	Additional personnel onsite.	Commitment already made to manage the issue in consultation with relevant agencies.

Table 1.2: Consumables

Material	Use	Annual Consumption	Fate
Iron Ore	Product	~44.8 Mt	DRI/HBI
Natural Gas	Power station, DRI plant	34,170 TJ 55,280 TJ	Electricity generation DRI process gas
Steel Balls	Concentrator	70,000 t	Grinding Media. Dissolved in process water
Collector Agent (e.g. Oleic acid)	Concentrator	800 t	Portion destroyed to NO_X, H_2O and CO_2 in pellet plant. Portion attached to tailings.
Frother Agent (e.g. Pine oil)	Concentrator	240 t	Recycled in concentrator.
Dolomite	Pellet Plant	200,000 t	Incorporated in pellets.
Binder (e.g. Peridur)	Pellet Plant	8,000 t	Incorporated in pellets.
Corrosion Inhibitor	Cooling water in Pellet Plant	12 t	Contained in cooling water circuit.
Microbiological Controlling Agent	Cooling water in Pellet Plant	0.2 t	Contained in cooling water circuit.
Hydrated Lime	DRI Plant	4,500 t	DRI
Oxygen	DRI Plant	950 Mm^3	Process requirements.
Process Water	Mine, stockpiles, roads etc	0.2 Mm^3	Dust suppression.
	Concentrator	44.0 Mm^3 38.5 Mm^3	Initially during start-up. During normal operations. 31.4 Mm^3 lost to evaporation and seepage in the Tailings Storage Facility. 66 Mm^3 brine discharged to ocean
	Pellet Plant	2.4 Mm^3	
	DRI Plant	5.1 Mm^3	
	Domestic use	0.2 Mm^3	Waste water treatment plant

1.2.1 Increase in Pellet Production

The project will now incorporate the additional production of 6.9 Mtpa of pellets for export. With the reduction in project life from 40 years to 20 years the following will occur:

- no increase in the size of the pit, waste dumps, tailing dam or port stockyard over the project life;
- increase in the size of the plant and power station sites by 117ha and inclusion of 17ha of water storage dams;
- increase in power supply by 320MW;
- increase in water supply by 22Mm^3pa during startup and 16.5Mm^3pa during operations; and
- increase in shipping movements.

<u>**Environmental Outcomes**</u>

- Increase in land disturbance by 134ha. This comprises 55ha of Horseflats Land System (PER Table 8.12, Hpg), 65ha of Paraburdoo LS (11ha of Px1, 51ha of Px2, 3ha of PC1-3), 3 ha of Newman LS (Nh) and 8ha of River Land System (Rf1).

  Of these lands systems, CALM has identified that the quality of the Horseflats LS (moderate to high) in the project area gives the Land System conservation significance due to its severe degradation elsewhere in the Pilbara. CALM suggests that the proponent minimises impact to this land system and actively pursues strategies and mechanisms to manage the system in the long term.

  Response to Question 62 in Response to Public Submissions identifies that 14.9% (274ha of 1835ha mapped) of the Land System will be impacted. This Land System covers around 13,500ha within 90km of the project area (although it is recognised that the condition of this Land System will vary throughout this area).

  Austeel will consult with CALM regarding strategies and mechanisms for minimising the impact to this Land System and to develop an appropriate management plan to ensure long term conservation of the land system within the project area.

- an increase in power supply by 320MW will increase greenhouse gas emissions from 4.4Mtpa (3.8Mt onsite and 0.6Mt upstream) to 5.5Mtpa (4.7Mt onsite, 0.8Mt upstream). Total emissions for the project life will decrease from 176Mt to 110Mt.

An increase in gas usage from 76,000Tjpa to 89,450 Tjpa will also result in increased levels of SO_x, NO_x and particulates. The results of additional modelling are presented in Section 2.1.7 and Appendix D.

- an increase in brine disposal from 33Mm^{3}pa to 66Mm^{3}pa will increase the area affected. The results of the brine modelling are presented in Section 2.1.8 and Appendix E.
- shipping movements will increase from 2 per week to around 4 – 5 per week depending on ship size. Austeel has already made commitments in relation to ballast water management and oil spill contingency planning.

1.2.2 Southern Tailings Dam

The southern tailings dam option (as presented in the PER) has been removed from current project design. The preferred location of the tailings storage facility (TSF) had always been that depicted east of the plant site (Figure 1.2). However, at the time of preparing the PER the proponent did not hold title to the land and it was unknown how long tenure might take, so the southern tailings dam option was presented. Tenure has now been obtained and as such the southern tailings dam is not required. Refer to Section 2.1.5 for TSF specifications and results of geotechnical investigations recently undertaken.

Environmental Outcomes

- concentration of all tailings at a single TSF;
- disturbance to a single area and shorter pipe runs between the concentrator and the TSF;
- the diversion of Du Boulay Creek is avoided; and
- removal of impact on 160ha.

1.2.3 Waste Dumps

The waste dumps will be designed to avoid significant encroachment into the Fortescue River floodplain. A more accurate flood level assessment of the Fortescue River is currently being undertaken (refer Section 2.2.1). The external surfaces, particularly the toe, of the waste dumps can also be protected by rock armour to prevent erosion by floodwaters. The waste dumps will only contain overburden and interburden material that is already part of the natural environment.

Environmental Outcomes

- avoid potential erosion of the waste dumps by floodwaters.

1.2.4 Gas Pipeline Lateral

Austeel has plans for natural gas to be supplied from the existing Dampier to Bunbury Natural Gas Pipeline (DBNGP) corridor. The supply of gas to the project will be via a lateral from the DBNGP corridor to the power station and plant site. Two alignments are currently under consideration (Figure 1.2) and the preferred alignment will be finalised following further environmental, heritage and geotechnical investigations.

Environmental Outcomes

- use of DBNGP pipeline easement for any new pipeline avoids duplication of a natural gas pipeline, resulting in minimal land clearing; and
- clearing of ~36ha to accommodate the gas pipeline lateral. All vegetation types impacted by the lateral are well represented in the area (refer to PER).

1.2.5 Options for Transport of Product to Port

Option A: Conveyor to Port

The PER documented that a conveyor would be used to transport product to the port. This option is still being considered.

Option B: Haul Road to Port

The construction of a haul road approximately 25km in length would enable road trains to carry product to the port (Figure 1.2). These road trains could have up to 8 trailers per unit and carry up to 350 tonnes per train at up to 80km/hr.

SITE LAYOUT

FIGURE 1.2

The road design would require a 16m formation with up to 12m seal width and a pavement base course of 250mm. The road alignment and drainage would be designed for a 5-year rainfall runoff event. This would allow the road trains to cross water over the road up to 300mm deep, enabling continual support to the project operations. Two sub options are being considered: crossing the creek at the same location as the conveyor or skirting the eastern side of the creek.

Environmental Outcomes

- either option, conveyor or haul road, would have minimal impact on the environment;
- the conveyor option would have slightly less greenhouse gas emissions, however these emissions are insignificant relative to the CO_2 emissions generated by the power station and process plant; and
- the road option can avoid direct impact on mangroves should the eastern alignment be selected.

1.2.6 Modified Jetty Alignment

The jetty has been realigned and is now directed to the north west from Preston Island rather than to the north (Figure 1.3). The design of the jetty has been modified so that the main jetty is now aligned almost in a direct line from the causeway. This was due to geotechnical issues and safety concerns associated with the old alignment and now permits more favourable ship handling under the prevailing wind and wave conditions.

Environmental Outcomes

- impact on medium coral cover (~3.4ha); and
- impact on high coral cover (~0.6ha).

This impact is unavoidable. The total area of high coral cover is around 4ha and, given its size, is not considered by Austeel to be a major fish habitat. None of the marine habitats affected have significance in a regional sense.

1.2.7 Changes to On-site Accomodation

Accommodation on-site will now include Single Person Quarters and houses both at the mine site and at Cape Preston (Figure 1.2). This change recognises the operating regime of the project, providing a more suitable and safe option for shift-working personnel. It is expected that up to 420 personnel will be accommodated in the project area, with 400 located at the mine site and 20 located at Cape Preston. Around 550 personnel will commute from Karratha.

Environmental Outcome

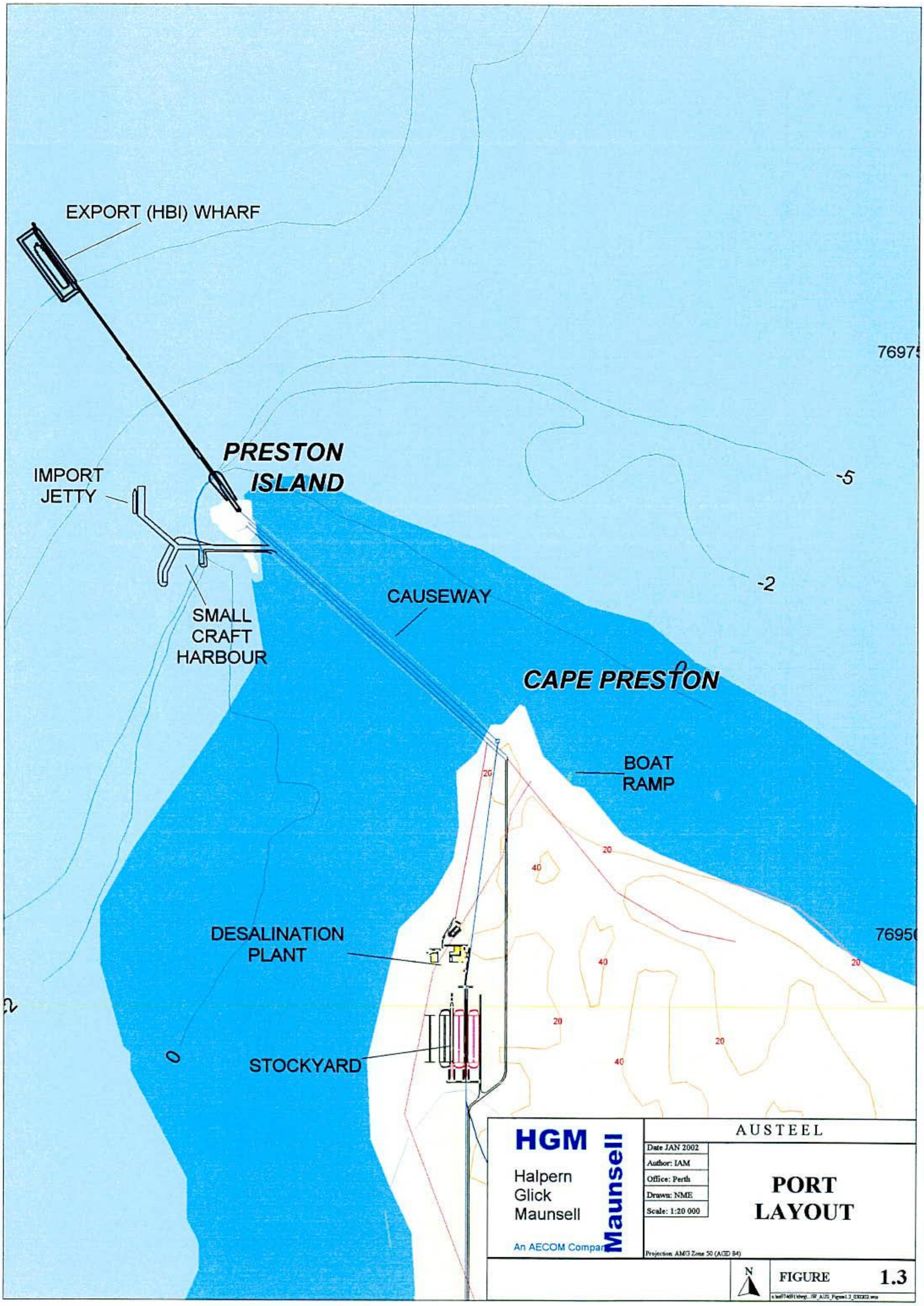
- no additional clearing is required to accommodate the increased numbers on-site.

1.2.8 Mine Void

As identified in the PER no backfilling of the mine pit will occur due to the dumped waste sterilising future ore reserves. Initial ore reserve calculations (Ypma, 1992) demonstrate that proven ore grade material exists to a depth of at least 275m. Beyond this depth allowance must be made for larger quantities of up-faulted blocks of Whaleback shale, however the upper 80-90m of the Joffre Shale could also provide suitable grade ore (refer Figure 14, Ypma 1992). 1992 calculations indicated that at a mining depth to 275m a total mineable ore reserve of around 870Mt occurs with an average grade of 26.05% and an ore to waste and overburden ratio of 2.93:1.

Environmental Outcome

- no backfilling of mine pit will be carried out;
- future mining reserves will not be sterilised in accordance with DMPR policies; and
- groundwater levels will be permanently reduced with the permanent loss of nearby phreatophytic vegetation (Section 2.1.6).



EXPORT (HBI) WHARF
IMPORT JETTY
PRESTON ISLAND
SMALL CRAFT HARBOUR
CAUSEWAY
CAPE PRESTON
BOAT RAMP
DESALINATION PLANT
STOCKYARD
-5
-2
0
20
40
76975
76950
HGM
Halpern
Glick
Maunsell
Maunsell
An AECOM Company
AUSTEEL
Date JAN 2002
Author: IAM
Office: Perth
Drawn: NME
Scale: 1:20 000
Projection AMG Zone 50 (AGD 84)
PORT LAYOUT
N
FIGURE 1.3

2 Environmental Studies

2.1 Additional Studies

2.1.1 Stygofauna Survey

2.1.1.1 March 2001 Survey

Survey

Between the 26th and the 31st March 2001, a stygofauna survey was undertaken on the George Palmer Orebody ('A' bores, Figure 2.1), the proposed plant area ('B' bores) and the alluvials on Mardie Station ('M' bores). One of the main objectives of the survey was to identify whether any stygofauna would be impacted upon by the dewatering process. The bores sampled were selected to provide information on the stygofauna present within areas of varying groundwater level drawdown impact, where 'A' bores demonstrate areas of high impact, 'B' bores demonstrate areas of moderate to high impact, and 'M' bores demonstrate areas of nil to low impact (Figure 2.1). The stygofauna sampling was performed using standard techniques developed by the WA Museum. This involved using a haul net with a 100μm mesh to a diameter suitable for individual bores. Where the water quality was adequate, at least three separate haul samples were taken from the entire column at each site. Samples were examined for fauna under a stereo microscope and the specimens were preserved in 70% ethanol and submitted to Dr. Brenton Knott at the University of Western Australia for identification.

A total of 46 bores in the mine area (Figure 2.3) were sampled for stygofauna over a 6 day period.

Geology

The geology and hydrogeology of the area is described in the PER (HGM 2000) and is based on a report by Aquaterra (2000).

All of the 'A' bores are located within the steeply dipping (45° to 60° to the west) Joffre Member of the Brockman Iron Formation. No karst or calcrete formations are intersected in the drill holes. Altered dolerite dykes are the main aquifers through the orebody with communication between dolerite aquifers being by means of joints and fractures. The banded iron formations themselves have low porosity and permeability. Most of the 'A' bores are relatively deep 100+ metres and are unslotted since their primary purpose was for resource assessment.

The 'B' bores are located in Maddina Volcanics and are relatively shallow (~20m). They are unslotted and their primary purpose was for geotechnical assessment of the plant site.

The 'M' bores are all relatively shallow (~20m) and slotted at various depths. They draw water primarily from the Fortescue River Alluvium.

Both the Brockman Iron Formation or the Maddina Volcanics are indurated rocks with no primary porosity or permeability. They are not regarded as aquifers in the project area.

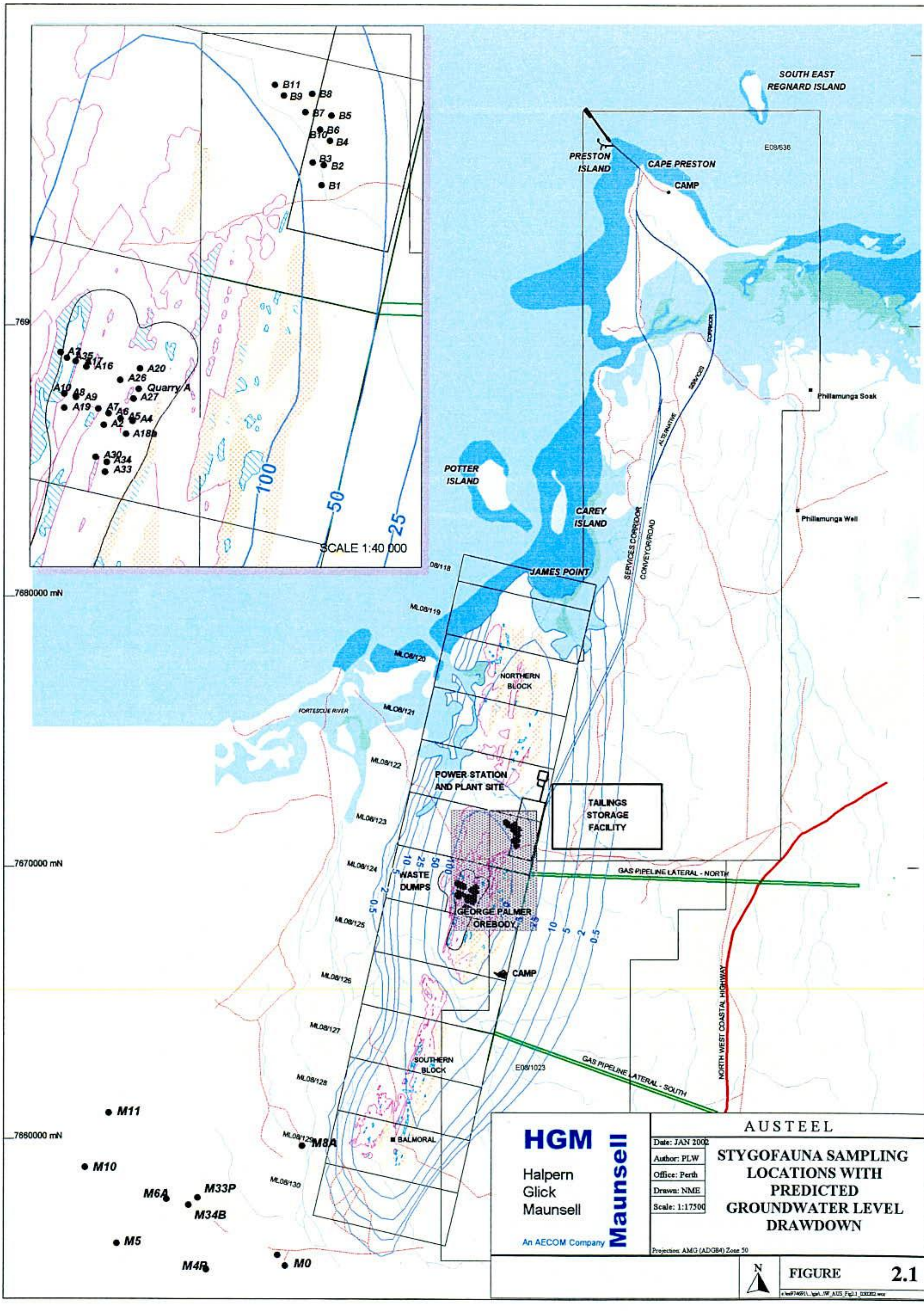
Findings

The survey findings are summarised in Table 1 of Brenton Knott's unpublished report "Summary of Findings, Point Preston Stygofauna" (Appendix A). Table 1 also provides details of water depth in each bore. In brief, the report states that all but two of the vials contained specimens which were identified, based on their morphological attributes (eyeless, attenuation and lack of pigment) and aquatic habitat, as being stygofauna. The stygofauna was dominated, both in terms of numbers of specimens and in diversity by crustaceans [amphipods, a thermosbaenacean, isopods, copepods (cyclopoid and harpacticoid) and ostracods]. The other aquatic fauna comprised turbellarian and oligochaete worms, and an acarine.

The two remaining non-stygofaunal specimens were a beetle and a Diplura (insect relative).

Overall, the stygofauna specimens collected comprised:

- Amphipoda (4 species, 39 individuals);
- Isopoda (1 species, 19 individuals);
- Thermosbaenacea (1 species, 78 individuals);



HGM Halpern Glick Maunsell
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AUSTEEL

Date: JAN 2002	STYGOFAUNA SAMPLING LOCATIONS WITH PREDICTED GROUNDWATER LEVEL DRAWDOWN
Author: PLW	
Office: Perth	
Drawn: NME	
Scale: 1:17500	

Projection: AMG (AGD84) Zone 50

FIGURE 2.1

- Copepoda (2 species, >400 individuals);
- Ostracoda (2 species, 13 individuals);
- Acarina (1 species, 2 individuals);
- Oligochaeta (3 species, 9 specimens); and
- Turbellaria (2 specimens).

Amphipoda

Four species of Amphipods were identified. One species, genus *Nedsia*, is known to be common and abundant in groundwaters of Cape Range peninsula, Barrow Island and in bore samples from the Fortescue catchment (T Finston, *pers. comm.* 17 August 2001). The *Nedsia* specimens [recorded in Table 1 as sp.2 (Figure A in Appendix A)] are larger than the other amphipod specimens [sp.3 (Figure D); sp.4 (Figure B); and sp.5 (Figure C)], whose affinities have been difficult to determine and have not been resolved.

The distribution of the amphipods within the project area (Figure 2.1) were:

- Species 2 amphipods recorded from 4 'B' bores (5 individuals) and 11 'M' bores (30 individuals);
- Species 3 amphipod recorded from 'M6A' bore (1 individual);
- Species 4 amphipods recorded from 2 'M' bores (2 individuals); and
- Species 5 amphipod recorded from 'M10' bore (1 individual);

No amphipods were recorded from 'A' bores (in the George Palmer Orebody).

Thermosbaenacea

The specimens collected were found to belong to the order Thermosbaenacea due to the position of the brood pouch (in this case, dorsal formed by the carapace, refer Figure E in Appendix A). The finding of this specimen is described as very significant since the main distribution of the Thermosbaenacea is in subterranean habitats of the Mediterranean coast and in the Caribbean (ie. a Tethyan distribution). Recently they have been recorded in the Pilbara.

Thermosbaenaceans were recorded in 4 'B' bores (17 individuals) and 14 'M' bores (61 individuals). None were recorded from 'A' bores.

Ostracoda

Two species of ostracoda were collected from six bores [1 'B' bore (1 individual) and 5 'M' bores (12 individuals)]. Figure F in Appendix A illustrates the Species 1 ostracod mostly collected (12 specimens) during the March 2001 survey. Although ostracods have been found throughout the project area and on nearby pastoral leases, none were recorded from 'A' bores.

Copepoda

The dominant copepod present in the collected samples was the cyclopoid copepod (Figures G and H in Appendix A). Based on leg morphology, only one species was identified, although there was considerable size range and sexual dimorphism in the samples. Cyclopoid copepods were recorded from most bores within the project area.

Only a single Harpacticoid copepod species was recorded from the project area. Harpacticoids were recorded from 'A7' bore (1 individual) and 7 'M' bores (12 individuals).

A review of the subterranean copepods collected from the Pilbara area is currently being undertaken, hence it is too soon to comment on any affinity with Cape Preston specimens.

Acarina

The two specimens of acarine (Figure I in Appendix A) collected appear to be of the same species. Both specimens were recorded from 'M' bores.

Isopoda

The specimens collected suggest a new genus of isopod (refer Figure J, K and L in Appendix A). Unfortunately, the specimens were very delicate and not in "mint" condition.

A total of 19 individuals of the isopod species were recorded from 'A10' bore. This species was not recorded elsewhere within the project area.

Oligochaeta

The oligochaete specimens were identified by Dr. Adrian Pinder. Three families were represented, Enchytraeidae, Phreodrilidae and mature Turbificidae (listed in Table 1 as (E), (P) and (T) in Appendix A, respectively). The specimens were recorded from 7 'A' bores (7 individuals) and 2 'M' bores (4 individuals).

Turbellaria

Microturbellarians are difficult to work with unless studied live. The specimens collected were solidly opaque and consequently it was not possible to observe any morphological detail. The 2 specimens were recorded from 'M2B' bore.

Conclusion

The March survey represents the first time that this area has been extensively surveyed for stygofauna. The key findings are:

- all species collected from the ore body (excluding the isopod) were also represented in areas that will not be affected directly by mining or by groundwater drawdown; and
- the species of isopod was only collected from a single deep bore on the orebody. No bores of a similar depth were available for sampling off of the orebody.

2.1.1.2 October 2001 Survey

Consultations have been held with Dr. Stuart Halse (CALM), Dr. Phillip Playford (EPA Representative for stygofauna issues) and Mrs. Terrie Finston and Dr. Brenton Knott (UWA, Department of Zoology) regarding the March 2001 survey. As a result, it was identified that the key species of interest was the isopod from Bore 'A10'.

As a consequence, a second stygofauna survey was undertaken on 2nd – 8th October 2001. The objective of this survey was to gather more information on the distribution of the isopod species that was recorded from the 'A10' bore during the March 2001 survey (as such identification work has not been conducted on all of the specimens collected).

During the October 2001 stygofauna survey, all bores previously sampled in March 2001 were resurveyed using the same methodology. A preliminary investigation indicated that the isopod species collected in the March 2001 survey was also collected (9 specimens) in bores A10, A34 and A6 during the October 2001 survey (No stygofauna were collected from A34 and A6 during March 2001).

Peter Serov (Invertebrate Identification) has identified the isopod as an Oniscid (related to slaters). It is believed to be the first subterranean Oniscid ever recorded. Identification and descriptive work is continuing with a view to publication of the results.

Conclusions

Work conducted to date has identified the Oniscid isopod as the species of interest. To date it has only been identified from bores occurring on the orebody.

Groundwater investigations have demonstrated that the Fortescue River Alluvials and the orebody are hydraulically connected with flow through the orebody originating from the surrounding alluvials (Aquaterra 2000). As a consequence the orebody is not an isolated habitat and it would be expected that stygofauna would move freely between the alluvials and the orebody. The orebody receives all of its groundwater input from the surrounding Fortescue River Alluvials.

Based on the hydraulic connectivity of the orebody and the alluvials it is expected that isopods are present throughout the region. To support this, it has been documented that less mobile stygofauna (such as the large amphipod species (sp. 2) and the small ostracods collected during this survey) are well represented throughout the sampling area.

The lower numbers of isopods collected is likely to be a result of low isopod densities and undersampling and as a consequence it is highly unlikely that the project will result in the loss of this species.

In addition it should be noted that the George Palmer Orebody is only one of a number of surface expressions of an orebody that extends to a depth of 100's of metres and for 100's of kilometres to the south. On the basis of the information collected to date, Austeel believes that it is highly unlikely that the project will result in the loss of any species.

Austeel makes the following commitments in relation to stygofauna:

1. Additional sampling will be undertaken by Austeel in the project area during operations to increase the understanding of stygofauna distribution in the Pilbara.

2. Austeel will hold discussions with CALM on the possible provision of assistance to the proposed Pilbara Biological Survey.

2.1.2 Marine Turtle Nesting Activities

The Department of Conservation and Land Management (CALM) conducted an inspection of sea-turtle nesting activity on the beaches of Cape Preston (CALM, 2000) on the morning of 28 December 2000 between 0630 and 0845 hours, just after a low tide of 0.65m which occurred at 0625 hours. No live sea turtles were observed. A dead mature male Green Turtle was discovered on the beach east of Cape Preston.

Low densities of nesting activities were encountered (12 old nests) over 7.5km of suitable beach. Two forms of turtle tracks, 'alternate' and 'opposite' (two distinct types) were discovered indicating that at least three species of turtles were nesting on Cape Preston. The two distinct types of 'opposite' tracks suggest that both Green and Flatback Turtles were nesting, whilst the 'alternate' tracks indicate that either Hawksbill and/or Loggerhead Turtles are also nesting on the beaches.

The project will not have any significant impact on the turtle nesting beaches and a management plan will be developed in consultation with CALM to ensure that there are no indirect impacts on turtles.

Austeel commits that, prior to port construction occurring, a Marine Turtles Management Plan will be developed in consultation with CALM. Specifically, Austeel will commit to:

- undertake further surveys of sea turtle nesting activities on Cape Preston;

- develop and implement management strategies (with performance indicators) and monitoring programs for sea turtle nesting areas to ensure that the project operations do not have a significant impact on the beach area functions and values (to the satisfaction of the EPA on the advice of CALM); and

- report on monitoring results against performance indicators and proposals for remediation (if required) in the Annual Environmental Report (to the requirements of the EPA on the advice of CALM).

Management Practices

- adoption of appropriate set backs from western shore of Cape Preston to avoid direct impact on the beach area and minimise disturbances to turtle nesting; and
- installation of appropriate lighting at the port site to minimise the potential impacts on turtle hatchlings;

2.1.3 Migratory Birds Survey

Parts of the project area are utilised by migratory shorebirds for feeding and/or roosting. A four-day survey between 23rd and 26th February 2001 was carried out and 17 shorebirds listed under the international agreements JAMBA and CAMBA were recorded. In addition, two species of migratory terns that are also listed under both international agreements were also recorded.

The number of migratory shorebirds present at Cape Preston during the survey period was not considered to be internationally or nationally important.

The area of highest bird use was at the mouth of the mangrove creek separating Cape Preston from the mainland. There will be no direct project impact in this area. The closest area of impact is approximately 1km upstream where there is the possibility that a bridge will be constructed to carry the overland conveyor to the port.

Given the low numbers and species recorded within the Cape Preston region and the limited habitat disturbance proposed, the project is unlikely to have a significant impact on migratory shorebirds.

2.1.4 Aboriginal Heritage Studies

Austeel commissioned Mr Rory O'Connor to conduct an ethnographic survey and Mr Gary Quartermaine to conduct an archaeological survey on the existence of aboriginal heritage sites within Austeel's mining tenements in the Fortescue River/Cape Preston area in order to prevent the unintentional disturbance of sites during project construction and operation.

The archaeological survey commenced in April 2001. A report on the results of the archaeological survey was prepared in May 2001 and has been made available to the Aboriginal Affairs Department (AAD). Seventy-two newly recorded sites and seventy-three sites previously recorded in files at the AAD were found in the vicinity of the survey areas. Eleven of the previously recorded sites and seventy-one of the newly recorded sites are within the project boundaries.

The ethnographic survey commenced in May 2001 and a report on its findings has been made available to AAD.

The ethnographic survey was carried out in the company of members from all native title claimant groups and other relevant interested people. The survey recorded twenty-eight sites of significance within the project area. The report provides recommendations for the management of these sites. A number of sites were requested by the Aboriginal people to be kept confidential and these have not been listed in the report. Austeel has respected this request for confidentiality, and advises that the project will not impact on these sites.

Austeel has conducted archaeological and ethnographic studies of the project area with representatives from all native title claimant groups. None of the groups represented expressed concern that the project would significantly impact on cultural and social values of the area. The project will impact on around 6% of the lease areas with no significant impact on coastal areas that would have traditionally been used for fishing.

Austeel recognises that an Aboriginal Heritage Management Plan will need to be prepared.

2.1.5 Geotechnical Study

Geotechnical investigations were carried out for the concept design of the Tailings Storage Facility (TSF). The study included a site investigation programme using test pits and percussion drilled boreholes, followed by laboratory testing of typical soil samples.

A total of 30 test pits were excavated to depths from 0.6m to 3.1m below the existing ground surface, with the majority of the testpits stopped at refusal on rock. Representative disturbed samples were collected from the test pits for later laboratory examination and testing.

The fieldwork included the drilling of 7 boreholes to depths varying from 5.3m to 30m below existing ground surface using 90mm diameter rotary percussion (RC) drilling techniques. The purpose of the drilling was to attempt to determine the depth of the soil profile and the underlying rock type. The recovered samples were logged on site, and representative samples of the cuttings were collected for identification and future reference.

The groundwater was monitored by taking measurements in the 7 open holes from the RC borehole drilling. Each of the holes were fitted with a 120mm diameter PVC casing in the upper 1m to ensure that the hole remained open long enough for groundwater inspection and testing. After measuring the standing water level, each hole was tested to determine the bulk soil permeability by conducting an open hole falling-head test. The results of the tests were analysed using the BS5930:1981 Hvorslev Method.

Laboratory testing was carried out in accordance with the general requirements of the relevant Australian Standard. The testing was carried out by SRC Laboratories, a Perth based NATA registered testing authority.

Overall the ground conditions can be generalised according to the following two subsurface sequences:

- calcretes and weathered sediments overlying basalts on the western side of the TSF site; and

- outcropping and shallow basalts located throughout the remainder of the TSF site.

A sediment profile of the TSF site indicates:

- gravelly to sandy red/brown clay extending to depths of 0.4m to 2.0m, overlying;
- light brown to creamy white calcrete (calcium carbonate rich) to depths of 4.0m to 6.0m, overlying;
- interbedded layers of mottled purple/red/brown chert/shale/tuff extending to depths varying from 5.7m to 30.0m, overlying;
- light grey green basalt extending for the remainder of the investigation sequence up to 30m.

The groundwater within the project area is generally associated with weathered and fractured bedrock. Shearing and veining may locally enhance the permeability of the bedrock. Groundwater in the study area is likely to be of low salinity. No groundwater was intercepted within any of the 30 test-pits. It should be noted that groundwater levels will vary with the seasons and there is potential for development of perched groundwater tables following periods of rainfall.

Ground permeabilities determined by the Hvorslev Method from falling head tests indicate that within the calcrete sand and gravel soils the permeability is in the range 10^{-7} to 10^{-8} m/s, while within the basalts the permeability is greater than 10^{-8} m/s.

The laboratory testing results indicate that the majority of the soils located on the site are sandy clays and gravelly clays of medium to high plasticity (CI-CH), high natural moisture content (>11.1%), Standard Maximum Dry Density (SMDD) of between 1.67 and 1.92 t/m^3 and Standard Optimum Moisture Content (SOMC) of greater than 17%. The calcrete materials within the soil profiles are gravely clayey sands (SC) of low to medium plasticity, low natural moisture content (<11%), SMDD of between 1.96 and 2.08 t/m^3 and SOMC of less than 13.5%.

Based on the results of the site investigation and laboratory testing of near surface soils it has been concluded that the site is suitable for the development of a tailings storage facility. The near surface soils comprise a thin veneer of intermediate to high plasticity sandy clays (gilgai), ironstone clayey sands and clayey gravels, overlying low permeability cemented calcrete sands and gravels. The soils overly weathered shales and tuffs or fresh basalt. The presence of these materials would tend to indicate the seepage losses could be in the order of 10^{-7} m/s and the falling head testing indicating the majority of seepage loss in the calcrete sands and gravels.

The TSF will comprise a broad sidehill type storage with the eastern containment structure formed by the basaltic footslopes. Premier embankments will be constructed on the remaining three sides in order to form the storage structure. The initial perimeter embankments will be constructed using compacted clayey borrow material sourced within the storage area to form an upstream embankment zone. The downstream embankment zone may be constructed with compacted clayey mine waste or borrow material. The perimeter embankments will be raised and lengthened in stages utilising either compacted clayey borrow material, mine waste or dried tailings.

The design concept for the TSF is that it will be divided into 4 individual cells using internal embankments to reduce water losses. The TSF will have a catchment area located upstream of the active tailings deposition area. The embankments will create water storage with inflow from the catchment area. The TSF will be designed such that a 1 in 100-year storm event can be temporarily stored behind the main embankments and the design will incorporate a spillway associated with the final stage of construction.

2.1.6 Groundwater Level Drawdown Modelling

Aquaterra Pty Ltd was commissioned to undertake groundwater modelling to assess potential groundwater impacts resulting from the mining of the George Palmer Orebody (Figure 1 in Appendix B). Methodology adopted to predict pit inflows, drawdowns and final standing water levels in the open pit is presented in the report, "Austeel Iron Ore Project, Prediction of Groundwater Level Drawdown" (Aquaterra, 2001). A summary of the modelling result is presented below.

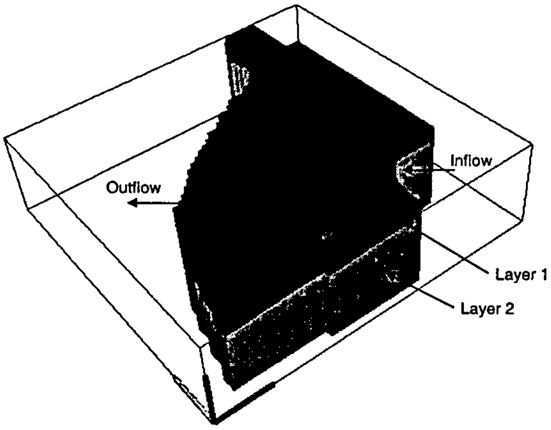
Model Setup

The model consisted of a two-layer system, with the first layer representing the Fortescue River Alluvium and the shallower parts of the Brockman Iron Formation and basement rocks. The second layer represents the Brockman Iron Formation and basement rocks. Details on the existing geological and hydrological regime were presented in the Aquaterra report "Assessment of Minesite Surface Water and Groundwater Issues" (Aquaterra, 2000).

The model was set up using the MODFLOW package running under the PMWIN graphical interface (version 5.1.7). The model was set up in the AMG grid coordinate system with a non-uniform grid size ranging between 1000m at the model boundaries and 50m in the vicinity of the orebody.

A conceptual block model is presented below in Figure 2.2.

Figure 2.2: Conceptual Block Model



The model is bounded to the west and northwest by a constant head outflow boundary (coastline) and to the east and southeast by a specified inflow boundary (Figure 2 in Appendix B). No recharge from rainfall or infiltration was specified in the model. In this regard, the modelling approach was conservative, especially with respect to the Fortescue River Alluvium, where infiltration from the river is the main recharge mechanism. As such, model predictions will tend to over predict drawdowns in the longer term (in both the basement and the alluvium).

Model Calibration

The model was calibrated to steady state conditions using the measured groundwater levels which were a combination of groundwater levels measured by GSWA and Aquaterra, presented in Aquaterra (2000). There was insufficient data to attempt transient calibration.

A good match was obtained between the measured and calibrated water levels over the modelled area. The calibrated aquifer parameters is summarised in Table 2.1. The values presented in Table 2.1 are estimates based on typical values for the aquifers.

Table 2.1: Calibrated Aquifer Parameters

Parameter	Layer 1				Layer 2	
	Alluvium	Clays	Brockman	Basement	Brockman	Basement
Aquifer Type	Unconfined				Confined/Unconfined	
Horizontal Conductivity (m/d)	50 - 150	1	0.01	1×10^{-3}	0.01	1×10^{-3}
Vertical Conductivity (m/d)	5 - 15	0.1	0.01	1×10^{-3}	0.01	1×10^{-3}
Anisotropy Ratio	1				10	
Unconfined Storage	0.10	0.01	1×10^{-3}		1×10^{-3}	
Confined Storage	-		1×10^{-4}		1×10^{-4}	

The steady state water balance (presented in Table 2.2) shows that by far the major source of groundwater inflow into the model is through the alluvium unit (~4.75×10^6 m^3/yr).

Table 2.2: Calibrated Water Balance

Unit	Inflow	Outflow
Layer 1		
Alluvium	13,015 m^3/d	13,117 m^3/d
Clays	62 m^3/d	23 m^3/d
Basement	2.2 m^3/d	2.2 m^3/d
Layer 2	114 m^3/d	52 m^3/d
TOTAL	13,193 m^3/d	13,194 m^3/d

The apparent flow imbalances in some of the above water balance components are a result of flow from the basement into the alluvium. The results of the above water balance is consistent with groundwater throughflow calculations made by Commander (Hydrogeology of the Fortescue River Alluvium, 1993) who states that that annual throughflow is between 2.29 and 9.16 x 10^6 m^3/yr. The variation in hydraulic conductivity across the model area for layers 1 and 2 is presented in Appendix B, Figures 5 and 6 respectively.

Prediction Scenarios

The prediction of drawdown impacts and pit inflows were based on the proposed mine plan after years 5, 10 and 20 supplied by HGM (refer Appendix B, Figures 7 and 8). The calibrated model was used to predict drawdown impacts and pit inflows resulting from maintaining water levels below the base of the pit.

The results of modelling indicate that inflows into the open pit is likely to be between 600 and 1,000 m^3/d, which equates to a total volume of approximately 5.5 GL over the 20 year mining period (refer Appendix B, Figure 9).

Significant drawdown impacts do not extend into the alluvial aquifer. At the end of the 20-year mining period, the 0.5m drawdown contour extends approximately 3.5km to the west and 5km to the east from the centre of the pit. (refer Appendix B, Figures 10 to 12 for drawdown contours after 5, 10 and 20 years respectively). Table 2.3 presents the predicted drawdown at a number of wells and locations along drainage paths in the vicinity of the George Palmer Orebody. Drawdown hydrographs for these locations are presented in Appendix B, Figure 13.

Table 2.3: Predicted Drawdown

Location	Predicted Drawdown (m)		
	Year 5	Year 10	Year 20
Violet Well	0.0	0.1	0.4
Balmoral H.S.	5.8	13	24
Tarquin Well	0.0	1.2	7.5
Marda Well	0.0	0.2	2.9
Creek Location 1	0.1	0.1	0.2
Creek Location 2	51	87	103
Creek Location 3	0.1	1.4	7.2
Creek Location 4	0.2	0.9	1.9
Creek Location 5	16	31	46
Creek Location 6	0.0	0.1	3.3

Note: refer to Figure 1 in Appendix B for location of wells and creek positions

The most significant drawdowns were produced at Creek Locations 2 and 5 (on Du Boulay and Edward Creeks, refer Figure 1 in Appendix B) along the strike of the orebody. The least significant drawdowns are predicted in the Fortescue River Alluvium.

An assessment of final standing water levels after cessation of mining in Year 20 was also carried out. The principal outflow mechanism is evaporation losses from the free water surface in the pit and from seepage faces on the pit walls. The outflow due to evaporation from the open pit has been calculated to be approximately 4,000 m^3/d. This rate is based on an annual evaporation rate of 3,150 mm and a pan factor of 0.6. Therefore, losses from the pit due to evaporation greatly exceeds inflows into the pit, which results in final standing water levels at the base of the pit. Pit void recovery modelling has verified the fact that under conditions simulated by the model, final pit water levels will not recover above the base of the pit resulting in a dry pit void.

Sensitivity Analysis

During calibration the model was found to be most sensitive to the adopted hydraulic conductivity values. Additional prediction runs were performed to gauge the sensitivity of the model predictions to possible variations (within realistic limits) in the aquifer hydraulic conductivity. The following sensitivity analysis simulations were performed.

- Base Case – hydraulic conductivity of 1 x 10^{-2} m/d for orebody and
- 1 x 10^{-3} m/d for the basement and remainder of Brockman Fm;
- Sens 1 – hydraulic conductivity of 1 x 10^{-2} m/d for entire Brockman Fm and 1 x 10^{-3} for the basement;

- Sens 2 – hydraulic conductivity of 1×10^{-2} m/d for the Brockman Fm and 5×10^{-3} m/d for the basement;
- Sens 3 – hydraulic conductivity of 1×10^{-2} m/d for the Brockman Fm and 1×10^{-4} m/d for the basement.

Table 2.4 (and Figures 14 to 16 in Appendix B) summarise the increase in pit inflow rate and drawdown after 20 years resulting from each of the above simulations. It shows that pit inflows during mining could peak as high as 1,600m^3/d, but that there are little significant variations in predicted drawdowns for the possible variations in hydraulic conductivity.

Table 2.4: Impact of Sensitivity Simulations

	Base Case	Sens 1	Sens 2	Sens 3
Pit Inflow (m^3/d)	600 to 1,000	1,450	1,600	1,200
Drawdown				
Violet Well	0.4	0.4	0.4	0.5
Balmoral H.S.	24	16	13	20
Tarquin Well	7.5	30	23	27
Marda Well	2.9	9	14	1
Creek Location 1	0.2	0.6	0.4	1.1
Creek Location 2	103	76	69	83
Creek Location 3	7.2	16	19	2.2

Note: drawdowns and flows given are those predicted at the end of Year 20

Conclusions

A simple groundwater model was developed to assess pit inflows, drawdown impacts and final standing water levels as a result of mining of the George Palmer Orebody. The model was calibrated to steady state water levels using average inflows from the model boundaries. However, the model is considered to be conservative, as it does not take into account alluvial recharge processes. As such, the model tended to over predict longer-term drawdowns in all aquifers. The model also did not predict seasonal groundwater level recoveries in both the alluvium and basement rocks. For example, at Du Boulay and Edwards Creeks (where maximum drawdowns are predicted) the model did not account for the recharge to the basement rocks from infiltrating streamflow.

The results of groundwater modelling has shown:

- Pit inflows to be around 600 to 1,000m^3/d, although sensitivity modelling has shown that this rate could be as high as 1,600 m^3/d.
- Drawdown impacts extend elliptically in a north-south direction from the George Palmer Orebody. The 0.5m drawdown contour extends 3.5km to the west, 5km to the east and 15km to the north and south of the George Palmer Orebody.
- Significant drawdown impacts are not observed in the Fortescue Alluvium.
- The most significant drawdowns are predicted to occur along the strike of the orebody where Du Boulay and Edward Creeks cross the Brockman Iron Formation to the north and south.
- Final standing pit water levels have been predicted to be below the base of the pit (ie the pit will not refill with water by groundwater inflow processes).

Indirect impacts will occur in both creeks systems through groundwater drawdown affecting phreatophytic vegetation. This impact is unavoidable. Shallow rooted species will be unaffected by dewatering and consequently a vegetation cover will be retained. However, there will be permanent loss of phreatophytic vegetation depending on the specific vegetation type and the drawdown level. Figure 2.3 depicts the permanent groundwater level drawdown after 20 years mining and the phreatophytic vegetation types likely to be affected. Table 2.5 illustrates the area (ha) of phreatophytic vegetation (by type) occurring within each predicted groundwater level drawdown.

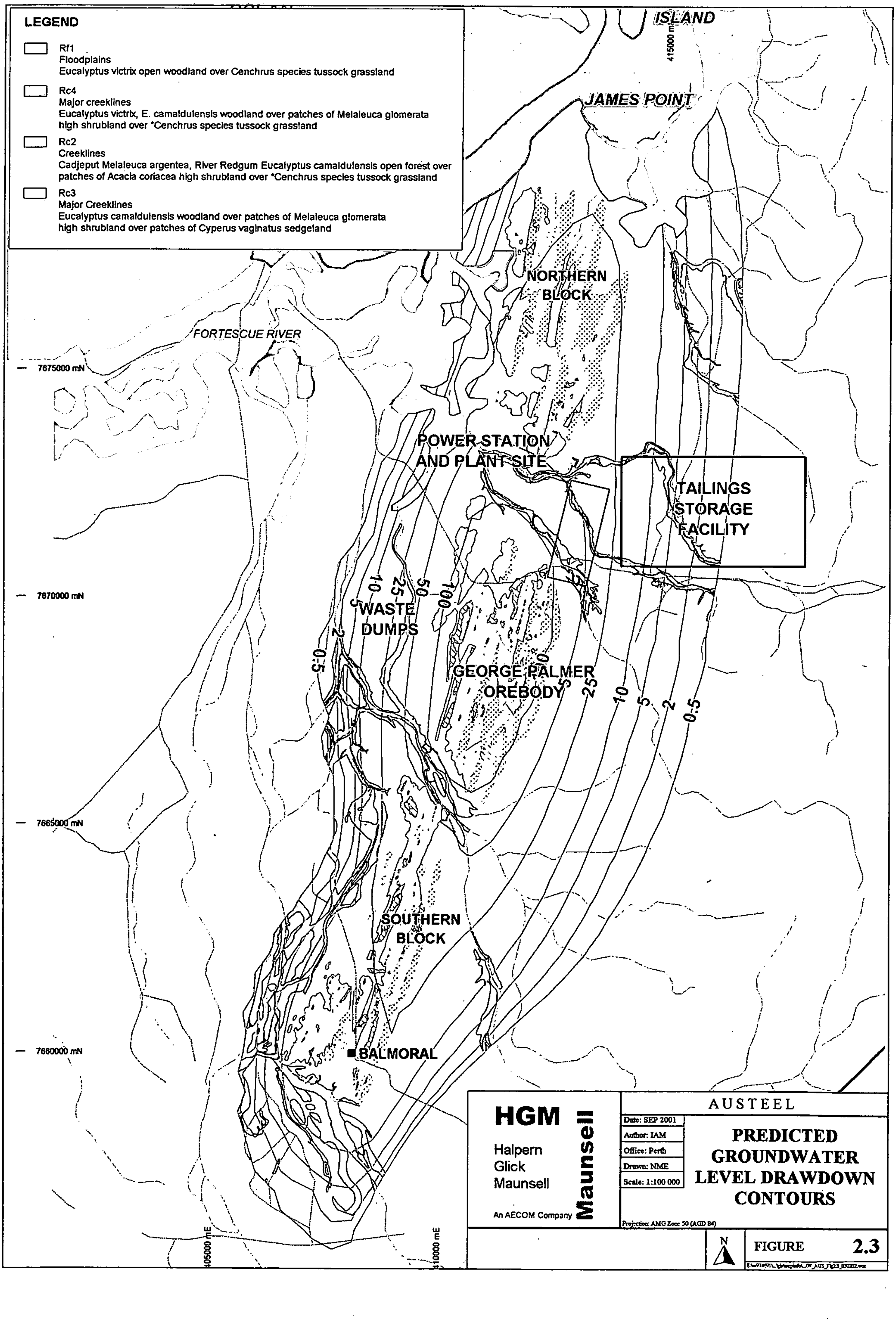

LEGEND
Rf1
Floodplains
Eucalyptus victrix open woodland over Cenchrus species tussock grassland
Rc4
Major creeklines
Eucalyptus victrix, E. camaldulensis woodland over patches of Melaleuca glomerata high shrubland over *Cenchrus species tussock grassland
Rc2
Creeklines
Cadjeput Melaleuca argentea, River Redgum Eucalyptus camaldulensis open forest over patches of Acacia coriacea high shrubland over *Cenchrus species tussock grassland
Rc3
Major Creeklines
Eucalyptus camaldulensis woodland over patches of Melaleuca glomerata high shrubland over patches of Cyperus vaginatus sedgeland
ISLAND
JAMES POINT
415000 mE
NORTHERN BLOCK
FORTESCUE RIVER
7675000 mN
POWER STATION AND PLANT SITE
TAILINGS STORAGE FACILITY
7670000 mN
WASTE DUMPS
GEORGE PALMER OREBODY
10
25
50
100
5
2
0.5
7665000 mN
SOUTHERN BLOCK
7660000 mN
BALMORAL
405000 mE
410000 mE
HGM
Halpern
Glick
Maunsell
An AECOM Company
Maunsell
AUSTEEL
Date: SEP 2001
Author: IAM
Office: Perth
Drawn: NME
Scale: 1:100 000
Projection: AMG Zone 50 (AGD 84)
PREDICTED GROUNDWATER LEVEL DRAWDOWN CONTOURS
N
FIGURE 2.3

Table 2.5: River Vegetation - Potential Area Affected

River Vegetation (code)	Potential Area Affected							
	Groundwater Level Drawdown Contour (m)							Total (ha)
	0.5 - 2.0	2.0 - 5.0	5.0 - 10.0	10.0 - 25.0	25.0 - 50.0	50.0 - 100.0	100.0+	
Rc2						0.14		**0.14**
Rc3	14.58	36.94	23.37	7.27	4.01	4.43	0.48	**90.6**
Rc4	15.95	15.73	34.18	79.26	0.71			**146.33**
Rf1	141.46	145.79	193.83	206.73	98.37	173.44	1.86	**959.62**
Total Area (ha)	**171.99**	**198.46**	**251.38**	**293.76**	**103.09**	**178.01**	**2.34**	**1196.69**

Note: refer Figure 2.3 for vegetation code description.

These vegetation associations, although not well represented in the areas mapped for the Austeel project, occur over extensive areas adjacent to the Fortescue River.

2.1.7 Atmospheric Emissions

Remodelling of Austeel's air emissions has been undertaken to incorporate the increase in pellet production and power demand. The air quality impacts due to an additional pellet plant and two additional gas turbines on air quality have been modelled using the USEPA air dispersion model ISCPRIME and Karratha meteorology originally used. A complete report is provided in Appendix D. Model predictions indicate that the local impacts of sulphur dioxide and nitrogen dioxide will increase, however the maximum ground level concentrations are still within the NEPM standards. For particulate matter the model predicts two exceedances occurring within 500m of the plant area, whilst outside the lease boundary (approximately 1.5km) the concentrations drop to 50% of the NEPM standard. There is negligible increase in ozone concentrations for the region.

2.1.8 Brine Disposal Modelling

A complete report is provided in Appendix E. In summary, offshore disposal of brine would result in environmental criteria for salinity not being met within a radius of 150m. For the nearshore disposal option criteria would not be met within an offshore distance of 30m and a longshore distance of 100m. None of the discharge options would impact on sensitive marine communities.

2.2 Ongoing Studies

2.2.1 Fortescue River Floodplain Modelling

Aquaterra Pty Ltd has been commissioned to undertake a level survey for eight cross sections across the Fortescue River floodplain. Data on the hydraulic roughness and nature of the river flow-paths and floodplains will be used to further refine the HEC-RAS hydraulic backwater model for the Fortescue River floodplain. Using this model, an estimate of the 100 year average recurrence interval (ARI) pre and post development flood levels for the floodplain, based on stream flow data supplied by Water and Rivers Commission (WRC), will be determined.

Modelled floodplain levels will be used for detailed planning phases of the project, such as waste dump location so as to avoid significant encroachment into the 100-year flood level.

2.2.2 Biological Survey

A flora and fauna survey of the project area was conducted in April 2000. Austeel has commissioned an additional survey, the timing of which will be determined in consultation with CALM. Austeel will consult with CALM during the study to ensure the survey adequately addresses any outstanding conservation issues and obtain assistance in preparing appropriate management plans dealing with flora and fauna conservation.

2.2.3 Marine Survey

A marine survey of the Cape Preston area was previously undertaken in April 2000. Six marine communities were mapped, all characteristic of nearshore regions along the Pilbara coast. There was little coral cover in the majority of the survey area and the coral occurring was similar to the coral occurring on reefs between Onslow and Dampier. None of the marine communities had significance in a regional sense. None of the habitats were identified as unique.

Once the location of the spoil ground for the offshore disposal of dredge spoil has been identified an additional marine survey will be conducted. The scope of the survey will be discussed with CALM.

Any outstanding information needed to support the application for a dredge spoil-dumping permit (under the Commonwealth *Environmental Protection (Sea Dumping) Act* 1981) will be collected during the survey.

3 Other Environmental Issues

3.1 Greenhouse Gas Abatement

3.1.1 Historical Background

Australia's net greenhouse gas emissions totalled 386 million tonnes (Mt) in 1990 whilst Western Australia's net greenhouse gas emissions totalled 46 Mt carbon dioxide equivalent ($CO_{2\text{-}e}$). It is predicted that Western Australia's emissions of carbon dioxide will double its 1990 levels by 2010 (ref: SOE, 1998).

Nationally, it is expected that without any reduction measures Australia's greenhouse gas emissions would increase by 43% from the 1990 levels by the year 2010. Only by implementing a combination of "no regrets" and "beyond no regrets" measures (see Table 3.1) would Australia be able to achieve limiting greenhouse gas emissions to 108% of the 1990 levels in the year 2010 (EPA Bulletin 985). This effectively requires that all prospective new projects must achieve a 24.5% reduction in greenhouse gas emissions from the predicted "business as usual" level in 2010.

Table 3.1: National Greenhouse Targets

National Greenhouse Strategy Target	Factored Increase (based on 100 for no change) for Year 2010	Reduction Percentage from "Business As Usual"
"Business as Usual"	143	0
Implementation of "No Regrets"	128	10.5
PM Statement of Beyond "No Regrets"	118	17.5
Inclusion of land use and trading – Kyoto target	108	24.5
No change on 1990 emission level	100	30.1

3.1.2 Western Australia's Regulatory Framework

The EPA's Draft Guidance for the Assessment of Environmental Factors Number 12 *Minimising Greenhouse Gases and National Greenhouse Gas Strategy* requires proponents to:

1. using the methodology developed and periodically updated by the National Greenhouse Gas Inventory Committee estimate the gross emissions of greenhouse gases that might be emitted from the proposed project for each year of its operation in absolute and in carbon dioxide equivalent figures;

2. using the methodology developed and periodically updated by the national Greenhouse Inventory Committee estimate:

   - the gross removals of greenhouse gases from either sink enhancement programs or carbon dioxide stabilising techniques; and

   - loss of land sink through land clearing,

   linked to the proposed project for each year of its operation in carbon dioxide equivalent figures;

3. indicate the intended measures and efficient technologies to be adopted to minimise greenhouse gas emissions in the proposed project, including appropriate abatement measures;

4. compare the greenhouse gas emissions of this proposed project (per unit of product and/or other agreed performance indicators) with similar established projects using the same and different technologies; and

5. as a matter of information, indicate whether the proposed project will be entered into the Commonwealth Governments "Greenhouse Challenge" voluntary cooperative program (whether on a project specific basis company wide arrangement or within an industrial grouping, as appropriate).

These criteria meet both National and State greenhouse compliance requirements.

3.1.3 Sources of Greenhouse Gas Emissions from the Project

For this project the greenhouse gases produced of relevance are carbon dioxide (CO_2), methane (CH_4), sulphur dioxide (SO_2) and various oxides of nitrogen (NO_X).

The sources of greenhouse gas emissions from the project include:

- the power station consisting of six open-cycle gas turbines. The combustion of natural gas in the power station for supplying electricity to the mine site, processing plant, conveyor and shiploading operations at the port will emit oxides of nitrogen and carbon dioxide.
- the pellet plant with emissions from a main stack with pollutants of concern being oxides of nitrogen;
- the DRI plant with the production of process gases for the reduction of iron oxides to iron metal in the reformer, emitting carbon dioxide. The three DRI modules emit combustion products (oxides of nitrogen and sulphur dioxide) via main stacks;
- combustion of diesel fuel in mobile equipment used for construction and mining;
- decomposition of cleared vegetation;
- explosives used in blasting; and
- decomposition of domestic wastewater.

3.1.4 Calculation of Greenhouse Gas Emissions

Calculations were carried out using the Detailed Technology Approach as outlined in IPCC guidelines and contained in the following National Greenhouse Gas Inventory Committee Workbooks (using WA source data):

- Fuel Combustion Activities (Stationary Sources);
- Fuel Combustion Activities (Mobile Sources);
- Land Use Change and Forestry (Carbon Dioxide from the Biosphere); and
- Waste.

3.1.5 Greenhouse Gas Emission Estimates

Electricity Generation and Process Gas Production

The majority (98%) of the CO_2 emissions from the project is the result of electricity generation and process gas production. Overall, the combustion of 89,450 TJpa of natural gas is required for the project. Approximately 34,170 TJpa is required for an operating 640 MW power station, in order to supply the electricity demand for the mine site, processing plant, conveyor and shiploading operations at the port, and 55,280 TJpa for the production of process gases in the reformer, to enable the three module DRI plant to produce 4.7 Mtpa HBI. Overall, this total natural gas consumption equates to approximately 5.4 Mtpa CO_2 emissions, given by the stationary emissions equation:

$$C = F \times E \times P/100$$

where

- C is the amount of CO_2 emitted from gas combustion (*10^9* kg/yr = Mtpa);
  (4.6 Mtpa at peak production in end use combustion emissions)
  (5.4 Mtpa at peak production accounting for full fuel cycle emissions)

- F is the amount of natural gas fuel combusted (TJ);

(89,450 TJ at peak production)

- E is the CO_2 emission factor of natural gas;
  (52.1 x 10^3 kg CO_2/TJ Emission Factor for natural gas end use combustion);
  (60.8 x 10^3 kg CO_2/TJ Full Fuel Cycle Emission Factor accounting for natural gas production, transmission, combustion and fugitive emissions)

- P is the oxidation factor for natural gas;
  (99.5% for natural gas).

The full fuel cycle emission factor in the above equation takes into account:

- fugitive emissions from venting, flaring, and transmission/distribution losses;
- emissions from energy use in production, transmission and distribution; and
- emissions from combustion at the point of use (ie Power Plant and DRI Plant).

The full fuel cycle emission factor is based on a report commissioned by the Australian Gas Association (AGA) (Energetics, 2000, *Assessment of Greenhouse Gas Emissions from Natural Gas*, Research Paper Number 12, www.gas.asn.au). Allowance has been made for a decrease in the emissions from energy use in the production of the medium pressure natural gas to be used for the Austeel project, based on North West Shelf Gas data provided by Woodside Energy Limited (pers. comm.). The upstream CO_2 emissions from production and delivery to the Austeel project site (including fugitive emissions) of 89,450 TJ of medium pressure (feedstock) natural gas is approximately 0.8 Mtpa at peak production.

The power station uses approximately 34,170 TJ of natural gas for electricity generation, which equates to approximately 1.8 Mtpa CO_2 emissions or around one third of the total greenhouse gas emissions generated from project operations.

The stationary plant and equipment requiring electricity as its primary energy source include:

- the reverse osmosis (desalination) plant;
- mine and concentrator;
- the oxygen plant and pellet plant;
- 3 DRI modules and the Hot Briquetting System;
- product conveyor for transporting pellets and HBI from plant to port (a distance of 25km); and
- port and general facilities.

The remaining 55,280TJ of natural gas used for the production of process gases (reducing gases, hydrogen and carbon monoxide) equates to approximately 2.9 Mtpa CO_2 emissions.

To reduce the production of greenhouse gases further the proponent has considered the option of installing a combined cycle power station at an additional cost of $180M to $200M. Energy efficiency would increase from 34% to 54% (a 37% increase in efficiency). Based on the use of 34,170 TJpa of gas for power production the installation of a combined cycle power station could reduce gas consumption by around 12,640 TJpa with a reduction in greenhouse gas emissions of approximately 655,400 tpa (14.1% reduction). Given the high up-front cost of this option, combined cycle power generation is not considered economic.

Mobile Equipment Emissions

Mobile emissions include all greenhouse gas emissions released from non-stationary mining equipment such as heavy haulage trucks, mobile generators and fleet vehicles used on site. The fuel source of choice for all mobile equipment is diesel.

The following mobile equipment inventory (Table 3.2) detailing fuel use characteristics specifies the types and numbers of vehicles to be used on site.

Table 3.2: Mobile Equipment Inventory

Equipment Type	Run Time Usage (hrs/yr)	Number of Vehicles (#)	Fuel Consumption (L/hr)	Emission Factor (g/MJ)	Energy Density (MJ/L)	Total CO_2 Emissions (Mg/yr = tpa)
475t Hydraulic Shovel	7,300	4	230	69.7	38.6	18,069
190t Rear Dump Truck	7,300	20	215	69.7	38.6	84,452
90kpound Drill Rig	7,300	4	180	69.7	38.6	14,141
Tiger 690 Bulldozer	7,300	2	100	69.7	38.6	3,928
Cat D10 Bulldozer	7,300	4	90	69.7	38.6	7,070
70t Water Truck	7,300	1	50	69.7	38.6	982
Motor Grader	7,300	1	75	69.7	38.6	1,473
Light Vehicles	7,300	40	20	66.0	34.2	13,182
					TOTAL	**143,297**

The total emissions of greenhouse gases per annum from fuel combustion in the engine of a mobile source using a specified fuel type is given by the equation:

$$C = U \times V \times F \times E \times D \times 10^{-9}$$

Where:

- C is the total CO_2 equivalent emissions (in Mg/yr = tpa)
  (143,297 tpa)
- U is the vehicle usage (hrs) per year;
  (refer to Table 3.2)
- V is the number of vehicles in each class;
  (refer to Table 3.2)
- F is the fuel consumption (L/hr);
  (refer to Table 3.2)
- E is the emission factor for CO_2 equivalent greenhouse gas emission (g/MJ); and
  (refer to Table 3.2)
- D is the energy density of the fuel (MJ/L).
  (refer to Table 3.2)

The variation of mobile equipment emissions each year is directly proportional to the quantities of ore and waste removed from the pit. Mobile equipment usage during the mine site construction phase of the project is assumed to be the same as that for the site operating at peak production. During the first year of operation (Year 3 in Table 3.4) both construction and overburden stripping are occurring, hence a large increase in greenhouse gas emissions from mobile equipment for that year.

Vegetation Clearing

Around 1,900ha of spinifex and low scrub vegetation will be cleared in the project area, with most areas to be eventually re-vegetated.

The local ecosystem of the project area has a relatively low capacity for carbon sequestration, however vegetation that does become established in rehabilitated areas (approximately 1,700ha) will eventually help offset some of the greenhouse gas emissions over the life of the project.

Any cleared vegetation from the mine site, port or general facilities will be left to decompose or be used in the construction and stabilisation of banks and drains. The decomposition of native vegetation occurs slowly, oxidising to CO_2 in approximately a decade. An estimate for emissions of CO_2 from decaying vegetation takes into account the type of vegetation present before clearing, the area of vegetation cleared, and the rate of clearing, as given by the equation:

$$C = A_{10} \times B \times C_c \times J$$

where

- C is the CO_2 released by the decay of vegetation;
  (5,390 *tpa)* (refer Table B in Appendix C)
- A_{10} is the average annual rate of clearing over the decade up to and including the inventory year (in ha/annum);
  (Approximately 70ha/annum)
- B is the above-ground dry biomass per unit area (t/ha);
  (for "woodland and scrub" = 42)
- C_c is the carbon content of biomass before clearing (dimensionless);
  (0.5)
- J converts from carbon flux to CO_2 taking into account molecular weight of CO_2.
  (44/12)

It is assumed for the purpose of the above calculation that all of the vegetation is removed, including any roots below ground. On average, 70ha per annum of vegetation is to be cleared throughout the life of the project, and this equates to an average of 5,390 tonnes of CO_2 being released per year.

Blasting

ANFO explosives will be used on site. Based on blasting assessments carried out on other iron ore mining projects, the CO_2 emissions arising from blasting are estimated at around 2,000 tpa during peak operations.

Variation in blasting emissions throughout the life of the mine will be directly proportional to the quantities of ore and waste removed from the pit.

Table 3.3 details the quantities of greenhouse gas released through the combustion of ANFO explosives.

Table 3.3: ANFO Explosive

Greenhouse Gas	GHG/explosive (kg/t)
CO_2	163.7
CH_4	0
CO	16.3
NO	3.5

Wastewater

Domestic wastewater from workers living and working on site will be treated via a package treatment plant with discharge either to non-overflow lagoons or for use in irrigation. The greenhouse gas methane is released into the atmosphere in small quantities as waste decomposes.

The population in the remote project location is unsewered and all waste decomposition will therefore take place within a septic tank system. The overall BOD load settling out of the wastewater as solids would undergo anaerobic decomposition given by the equation:

$$M = (BOD) \times P \times Q \times F_{anu} \times EF_m$$

where:

- M is the amount of CH_4 emitted from unsewered population (Gg/yr);

(0.0009-0.0049 Gg per annum (ie 10^3 tpa))

- BOD is the biochemical oxygen demand of untreated waste (Gg/L);
  ($3.25x10^{-10}$ Gg/L)

- P is population size
  (5000 *workers for peak construction phase, 900 during mine operational phase);*

- Q is quantity of wastewater from each member of the population (L/annum);
  (91,250 L/person/annum)

- F_{anu} is the fraction of unsewered BOD anaerobically treated;
  (0.15)

- EF_m is the methane emission factor;
  (0.22 Gg CH_4/Gg BOD)

Hence the methane emissions based on a mine site population of 5000 workers during the construction phase would lead to approximately 0.005 Gg/annum or 5 tpa methane gas released into the atmosphere. Whilst during the operation phase with only 900 workers waste decomposition would lead to 0.9 tpa CH_4 released.

After initial estimates of methane have been calculated, they are converted to CO_{2e} emissions using a Global Warming Potential (GWP) factor of 21. GWP describes the importance of different greenhouse gases in comparison to CO_2. Hence the carbon dioxide equivalent (CO_{2-e}) emissions of methane from the project are therefore estimated at between 19 and 105 tpa CO_{2-e}.

Summary of Project Emissions

Table 3.4 provides a summary for the total estimated carbon dioxide equivalent (CO_{2-e}) emissions from the project (refer to Table 1 in Appendix C for yearly figures for the project lifetime).

Table 3.4: CO_{2-e} Emissions Per Year of Operation

Source	Year (emissions in 10^3 tonnes)					
	1	2	3	4-6	7-14	15+
Process gas and electricity generation	0	0	1,159	4,637	4,637	4,637
Upstream Natural Gas Production and Delivery	0	0	194	774	774	774
Natural Gas Full Fuel Cycle	**0**	**0**	**1,353**	**5,411**	**5,411**	**5,411**
Mobile plant equipment	143	143	224	143	138	129
Vegetation clearing	2	3	5	6	7	5
Blasting	0	0	1	2	2	2
Wastewater	0.10	0.10	0.10	0.02	0.02	0.02
Total (rounded)	**145**	**146**	**1,583**	**5,562**	**5,558**	**5,547**

3.1.6 Management of Greenhouse Gas Emissions

Management of emissions requires the Proponent to comply with the EPA's "Draft Guidance for the Assessment of Environmental Factors No. 12, Minimising Greenhouse Gases" and the Commonwealth's "The National Greenhouse Strategy." These guidelines have been addressed as follows:

- the estimates of annual emissions have been based on the methodology developed by the Greenhouse Inventory Committee with additional input from suppliers of equipment, fuel and explosives (refer to National Greenhouse Gas Inventory Committee Workbooks);

- the Proponent will calculate the total greenhouse gas (CO_{2e}) emissions for the project, and report them to the DEP on a regular basis;

- the total area that will be cleared for the project will be approximately 1,900ha. The vegetation types associated with this landform are a mixture of spinifex and low scrub. Such an environment has a relatively low capacity for sequestration and thus to act as a land sink. At the completion of mining, around 1,700ha will be rehabilitated;

- the use of natural gas as the primary fuel source for the project represents a commitment by the Proponent to maintain lowest possible emissions and to choose environmentally responsible alternatives where possible; and

- energy efficient designs will be used where possible, and the Proponent will explore, on an ongoing basis, mechanisms by which reported greenhouse gas emissions may be reduced. Such mechanisms may include other alternative energy sources together with monitoring and information systems to minimise energy usage.

At nominally 6.9 Mtpa pellets and 4.7 Mtpa DRI/HBI production, greenhouse gas emissions are calculated at 5.4 Mtpa $CO_{2\text{-}e}$ emissions (using the full fuel cycle emission factor) for the whole project. This represents about 1.4% of Australia's 1990 baseline for greenhouse gases. The construction and operation of the Project will result in a net increase in Australia's greenhouse gas emissions. The project involves CO_2 production by virtue of its requirement for power generation and process gas.

The project maximises the effective use of energy with the major energy efficient features being:

- recovery of maximum heat from the cooling of hot pellets;

- recovery of heat from the reformer flue gas to preheat the feed gas mixture and the burner combustion air; and

- the use of gas for direct reduction to produce metallic iron without using energy to melt the iron which occurs in smelting.

Comparison with other Technologies

The production of 4.7 Mtpa DRI/HBI (only) involves the combustion of around 72,430 TJpa of natural gas that produces 3.8 Mtpa CO_2 emissions (refer PER Section 10.3.2, Table 10.5), which equates to 15.4 GJ per tonne of product. In comparison, BHP's HBI plant at Port Hedland is 15.5 GJ per tonne of product (BHP DRI, 1994) and AUSI Irons proposed DR/HBI at Cape Lambert is 15 GJ per tonne of product (Dames and Moore, 1995)). However, this comparison of project efficiencies, based on a simplistic relation between natural gas combustion and HBI production, may not be representative due to differing project parameters. In particular, the BHP HBI Plant figures excluded a power plant (as shown below).

The best information that we can easily obtain is from EPA Report and Recommendations - Bulletin 746, Page 50, on the Ausi Iron Project. The emissions, as documented in Bulletin 746, in comparison to the Austeel Project are provided below:

• Ausi Iron (HBI, power plant, port and mine)	0.78 t $CO_{2\text{-}e}$ / t HBI
• Austeel (HBI, power plant, conveyor, port, mine)	0.80 t $CO_{2\text{-}e}$ / t HBI
• BHP (HBI only (no port, mine, or power plant))	0.85 t $CO_{2\text{-}e}$ / t HBI
• Austeel (HBI only (no port, mine or power plant))	0.61 t $CO_{2\text{-}e}$ / t HBI

Effectively, Austeel and Ausi Iron have similar efficiency when the total project is considered, with any minor differences easily accounted for by differences in the project (such as process selection, extent of mining and extent of port requirements, conveyor, distance to the port, etc.) and assumptions made on the extent of land clearing, use of mobile equipment, etc. In relation to the HBI component only, Austeel is around 28% more efficient than BHP.

Further comparison using data published in Appendix D, Chapter 14, "Economics of Production and Use of DRI" of *Direct Reduced Iron, Technology and Economics of Production and Use* (Iron & Steel Society, 1999. Edited by J. Feinman and D.R. Mac Rae), gives the following information, presented for each different type of DRI Process technologies:

- the consumption of natural gas (mbtu) (= 1.055 GJ) per Mt of product:

Finmet:	11.55
HYL III:	11.33
MIDREX	10.30

- the consumption of electricity (kWh) per Mt of product:

Finmet:	150
HYL III:	Not Available
MIDREX	130

- the consumption of water (m^3) per Mt of product:

Finmet:	2.50
HYL III:	1.76
MIDREX	1.50

- the consumption of iron ore pellets (Mt) per Mt of product:

Finmet:	Not Applicable
HYL III:	1.154
MIDREX	1.154

where: Finmet technology is used by BHP HBI Project;
HYL III technology is used by Ausi Iron Project; and
MIDREX technology is proposed by the Austeel Project.

Clearly, in this independent comparison MIDREX technology was shown to be more efficient in relation to energy and resource use, which also translates to reduced greenhouse gas emissions per unit product. Midrex was also the most expensive technology and the additional cost exceeded $400M based on the bids received by Austeel. Austeel interalia chose Midrex to minimise greenhouse gas emissions.

3.1.7 Minimising Greenhouse Gas Emissions

Technological Improvements in the MIDREX Direct Reduction Process

The MIDREX Process was developed during the 1960s by the Midland Ross Corporation, which had pioneered shaft furnace technology and stoichiometric gas reforming for use in processing minerals.

The success of the MIDREX Direct Reduction Process relies on two major reactor vessels, the reduction shaft furnace and the reformer. Beginning in the 1960's, MIDREX pioneered shaft furnace technology and stoichiometric gas reforming for use in the reduction of iron oxide to metallic iron. During the quarter century since commercialisation, many technical improvements have been made, including larger and more efficient shaft furnaces, in-situ reforming, greater heat recovery, higher reducing gas temperatures, and improved catalysts. MIDREX continues to enhance the technology in the areas of furnace utilisation, energy efficiency, and environmental emissions.

In the reformer, catalyst-filled tubes are heated to high temperatures. As the feed gas passes through the catalyst, the methane and steam in the feed gas is reformed to produce a reducing gas which is used in the shaft furnace for reduction of iron oxide. Methane reforming must take place at elevated temperatures in the range of 900 to 1000°C to promote the reforming reactions and avoid the carbon deposition reactions. In order to achieve the elevated temperatures a significant amount of heat must be produced inside the reformer. Burners located in the floor of the reformer produce this heat. The flue gas from these burners is the only significant source of greenhouse gases from the MIDREX Process.

The continued developments of the MIDREX Process enhance direct reduction economics as well as provide a greater environmental benefit since it results in more efficient use of natural gas and electricity. Continued development of the MIDREX Direct Reduction Process has resulted in technological innovations providing for enhanced productivity and economics, and reduced greenhouse gas emissions.

The many technological improvements include larger shaft furnaces, in-situ reforming, greater heat recovery, improved catalysts and hot briquetting. MIDREX continues to advance the state-of-the-art in shaft furnace, direct reduction technology in the areas of raw material flexibility, shaft furnace productivity and energy efficiency.

The single most important factor of the MIDREX Process has been increasing the shaft furnace productivity through improving the rate and degree to which CO and H_2 are consumed.

The specific measures to minimise the total net greenhouse gas emissions for this project includes:

- Increased Furnace Utilisation

Utilisation is the ratio of total reducing gases ($CO + H_2$) consumed by the reduction reactions to the amount of reducing gases required according to equilibrium conditions. Utilisation is a measure of the effectiveness of the reducing gas in the reducing reactions occurring in the furnace. MIDREX has increased the utilisation ~10% over the last 25 years. (Note: MIDREX has increased the utilisation ~6% over the last 10 years.)

- Increased In-situ Reforming

  In-situ reforming is reforming reactions taking place in the furnace. Increasing in-situ reforming decreases the heat load on the reformer. MIDREX has increased in-situ reforming ~20% over the last ten years.

- Higher Reducing Gas Temperatures

  Increasing the reducing gas temperatures in the furnace improves the kinetics of the reducing reactions. With the development of oxide coating over the last ten years, MIDREX has increased the reducing gas temperatures ~23%.

- Increased Reducing Gas Quality

  Reducing gas quality is the ratio of reductants ($CO + H_2$) to oxidants ($CO_2 + H_2O$) in the reducing gas. Reducing gas quality is an indicator of the reducing potential of the reducing gas. Increasing the reducing gas quality increases the reducing potential of the reducing gas. MIDREX has increased the reducing gas quality ~18% over the last ten years.

- Decreased Reformer Size

  Increasing the reducing gas potential decreases the heat load on the reformer thus decreasing the required size of the reformer. A smaller reformer requires fewer burners and therefore requires less natural gas. The reformer size has been decreased ~37% over the last 25 years. (Note: The reformer size has been decreased ~19% over the last 10 years.)

- Greater Heat Recovery

  MIDREX utilises the hot flue gas exiting the reformer in a heat recovery system. By passing the flue gas across heat exchangers, much of the heat is recovered by preheating certain gasses. With the development of improved alloys, the preheat temperatures can be increased without sacrificing the life of the tubes in the heat exchangers. The combustion air preheat temperature has been increased ~23% and the feed gas preheat temperature has been increased ~38% over the last ten years. Ten years ago, MIDREX did not preheat the natural gas. Now MIDREX preheats the natural gas thereby recovering more heat from the flue gas.

All of the actions above have an impact on decreasing the "process" natural gas as well as the reformer "burner" natural gas. Also, the actions above decrease the heat losses in the system, which further decreases the overall required natural gas. Obviously reducing the overall natural gas required by the plant translates into the reduction of CO_2 emissions.

A comparison of project greenhouse gas emissions for plant design twenty five years ago and that over ten years ago (before the 1990 emission levels were reported) can be made to demonstrate the continual advancement in processing technology in iron-making (Table 3.5). This reflects the technological advancements made prior to the inception of the project and indicates the saving in greenhouse gas emissions by choosing MIDREX technology rather than traditional iron making methods.

Table 3.5: Estimated CO_2 Emissions (tpa) – Plant Design 25 years ago vs. Plant Design Ten Years Ago

Reduction Measure	Plant Design 25 Years Ago	Plant Design >10 Years Ago	CO_2 Reduction (Overall %)
Increased Furnace Utilisation	326,131	314,483	1.0
In-situ Reforming	84,668	84,668	0.0
Reducing Gas Temperatures	108,860	108,860	0.0
Reducing Gas Quality	145,146	145,146	0.0
Decreased Reformer Size	178,656	169,337	0.8
Greater Combustion Air Preheat	52,486	52,486	0.0
Greater Feed Gas Preheat	259,152	132,187	10.9
No Natural Gas Preheat	9,720	9,720	0.0
Total	**1,164,819**	**1,016,887**	**12.7**

Greenhouse Gas Reduction Measures

Austeel will prepare a Greenhouse Gas Emissions Management Plan. The management plan will be a detailed assessment of project greenhouse gas emissions, focussing on minimising greenhouse gas emissions using the EPA Guidance notes and the National Greenhouse Strategy. In particular, the management plan will include the "specific measures to minimise the total net greenhouse gas emissions" for the proposal and "an analysis of the extent to which the proposal meets the requirements of the National Greenhouse Strategy using a combination of "no regrets" and "beyond no regrets" measures as discussed below.

'No Regrets' Measures

In the past ten years significant improvement has been made in the reduction of emissions from the MIDREX process including greenhouse gases. The sole source of greenhouse gas emissions from the MIDREX process is the reformer flue gas stack. In order to reduce the emission of greenhouse gases from the reformer, MIDREX has made enhancements to the direct reduction process in order to decrease the heat load on the reformer as well as improve the efficiency of the shaft furnace, which leads to a decrease in the size of the reformer. Plants designed ten years ago used a feed gas preheated temperature of 540°C and a combustion air preheated temperature of 650°C. Plants were designed with no preheating of the natural gas. Also, the temperature of the reducing gas to the furnace was limited to around 800°C to prevent clustering of the iron in the furnace.

Plants designed currently use a feed gas preheated temperature of 580°C and a combustion air preheated temperature of 675°C thus lowering the heat load required within the reformer. The natural gas is also preheated to a temperature of 350°C. With the introduction of lime coating for the iron oxide in the shaft furnace, plants are currently designed with elevated reducing gas temperatures of ~1000°C. The increased reducing gas temperature is the result of oxygen addition to the gas leaving the reformer before entering the furnace. The higher reducing gas temperature provides improved kinetics for the reduction and reforming reactions occurring in the furnace, which leads to higher utilisation of the reducing gas and increased furnace efficiency. As the furnace utilisation increases, the size of the reformer decreases due to the additional amount of reforming occurring in the furnace. As the size and required heat load of the reformer decreases, the amount of greenhouse gases produced in the reformer also decreases. As a result of the increased preheat temperatures and improved kinetics in the furnace, the overall estimated plant reduction in potential greenhouse gas emissions (referred to as the CO_2 reduction) may be summarised as follows in Table 3.6, which makes comparison between current plant design and plant design ten years ago.

Table 3.6: Estimated CO_2 Emissions (tpa) – Plant Design Ten Years Ago vs. Current Plant Design

Reduction Measure	Plant Design Ten Years Ago	Plant Design Current	CO_2 Reduction (Overall %)
Increased Furnace Utilisation	314,483	288,062	2.6
Increased In-situ Reforming	84,668	77,555	0.7
Higher Reducing Gas Temperatures	108,860	99,714	0.9
Increased Reducing Gas Quality	145,146	132,952	1.2
Decreased Reformer Size	169,337	155,111	1.4
Greater Combustion Air Preheat	52,486	23,714	2.8
Greater Feed Gas Preheat	132,187	59,725	7.2
Natural Gas Preheat	9,720	4,392	0.5
Total	**1,016,887**	**841,225**	**17.3**

'Beyond No Regrets' Measures

For future plants, with the rising concern of energy efficiency and greenhouse gas emissions, MIDREX is continuously developing improvements to the direct reduction process. One area that MIDREX is concentrating on for the future is the shaft furnace and specifically the reactions that take place in the shaft furnace. Increasing the amount of oxygen to the reducing gas will increase the reducing gas temperature thus improving the kinetics for the reduction and reforming reactions. This will lead to improved furnace utilisation and efficiency beyond the current design. Another area MIDREX is focusing on is increased heat recovery for the combustion air, feed gas, and natural gas. A current study has demonstrated that with increased furnace utilisation and heat recovery a reduction in greenhouse gases of 3.6% is possible (841,225 t pa to 810,839 t pa, per module), as shown in Table 3.7 below.

Table 3.7: Estimated CO_2 Emissions (tpa) – Future Plant Design vs. Current Plant Design

Reduction Measure	Plant Design Future	Plant Design Current	Improvement %
Increased Furnace Utilisation	275,401	288,062	1.5
Increased In-situ Reforming	74,179	77,555	0.4
Higher Reducing Gas Temperatures	97,182	99,714	0.3
Increased Reducing Gas Quality	132,952	132,952	0.0
Decreased Reformer Size	147,514	155,111	0.9
Greater Combustion Air Preheat	23,714	23,714	0.0
Greater Feed Gas Preheat	55,505	59,725	0.5
Natural Gas Preheat	4,392	4,392	0.0
Total	**810,839**	**841,225**	**3.6**

Current studies show the possibility of a ~9% increase in utilisation, ~5% increase in in-situ reforming, ~8% increase in reducing gas temperatures, ~12% decrease in reformer size, and ~3% increase in feed gas preheat.

More research and observation is required in order to determine the extent to which these improvements can occur while achieving optimum conditions inside the reformer, heat recovery, and shaft furnace. MIDREX will continue to make improvements in these areas for the future.

Summary of Greenhouse Gas Reduction

MIDREX's pursuance in technology development has lead to improvement in shaft furnace productivity, energy efficiency, raw material flexibility and environmental considerations with regard to greenhouse gas emissions. Table 3.8 illustrates the progression of CO_2 emission reduction MIDREX has achieved during the last twenty-five years and intends to achieve in the future.

Table 3.8: Progression of CO_2 Emissions Reduction (tpa)

	1,164,819	**Plant Design 25 Years Ago**
Increased Furnace Utilisation	-11,648	
Decreased Reformer Size	-9,319	
Greater Feed Gas Preheat	-126,965	
	1,016,887	**Plant Design 10 Years Ago**
Increased Furnace Utilisation	-26,421	
Increased In-situ Reforming	-7,113	
Higher Reducing Gas Temperatures	-9,146	
Increased Reducing Gas Quality	-12,194	
Decreased Reformer Size	-14,226	
Greater Combustion Air Preheat	-28,772	
Greater Feed Gas Preheat	-72,462	
Natural Gas Preheat	-5,328	
	841,225	**Current Plant Design**
Increased Furnace Utilisation	-12,661	
Increased In-situ Reforming	-3,376	
Higher Reducing Gas Temperatures	-2,532	
Decreased Reformer Size	-7,597	
Greater Feed Gas Preheat	-4,220	
	810,839	**Future Plant Design**

Twenty-five years ago, MIDREX only preheated the combustion air. The changes made over the last twenty-five years plus the future changes indicates a greenhouse gas emission reduction given by:

Reduction in CO_2 Emissions = (1,164,819 – 810,839) / 1,164,819
= 30.4%

In the last ten years, however, MIDREX has made improvements to the heat recovery, reformer operation, and shaft furnace utilisation. These changes made over the last ten years plus the future changes reflects a reduction in greenhouse gas emissions from the 1990 emission levels, calculated as:

Reduction in CO_2 Emissions = (1,016,887 – 810,839) / 1,016,887
= 20.3%

3.1.8 Proponent Commitments

Prior to commissioning of the project the Proponent will prepare a Greenhouse Gas Emissions Management Plan (Commitment 14) to:

- ensure that greenhouse gas emissions from the project are adequately addressed and best available efficient technologies within the commercial viability of the project are used to minimise total net greenhouse gas emissions or greenhouse gas emissions per unit or product; and

- mitigate greenhouse gas emissions in accordance with the Framework Convention on Climatic Change 1992 and consistent with the National Greenhouse Strategy.

Austeel will use best engineering technology and management practices in designing, constructing and operating the plant to reduce greenhouse gas emissions to as low as reasonably practicable (ALARP) within the commercial confines of project economics.

Austeel has also held discussions with a West Australian company on the opportunities to establish a plantation crop with other environmental benefits such as recovery of salt affected land. The preferred crop at this stage is oil mallee which has the ability to sequester carbon in both above and below ground biomass, has an established seedling pipeline and silverculture practice developed by CALM, possess improved genetics and other collateral environmental benefits such as salinity reduction when planted in aquifer recharge zones.

Austeel commits to continuing these discussions during the operation phase of the project with a view to developing and implementing a programme which, in part, provides some carbon sequestration to offset some of the emissions generated by the project, together with significant conservation benefits through recovery of salt affected land.

3.2 Sediment Transport Modelling

Austeel believes that detailed modelling of the causeway is unnecessary given that the area does not contain any sensitive or conservation significant marine communities, i.e. the potential environmental downside is non existent. All that modelling will achieve is definition of a "zone of influence" rather than determining the acceptability or otherwise of the development.

To overcome any concern regarding the causeway Austeel makes the following commitment:

> *Detailed modelling will be undertaken to demonstrate the environmental acceptability of the structure ultimately constructed between Cape Preston and Preston Island. The results of the modelling will be provided to the EPA for review prior to construction commencing. If modelling demonstrates the need for maintenance of water flow, pipes will be installed as necessary in the causeway.*

3.3 Conservation Offsets

Austeel recognises that development of the project in the Cape Preston region will result in an unavoidable loss to the State conservation reserve assets. However, the project does not impact on areas of high conservation value.

Under the State Agreement Act, Mineralogy has granted rights to Austeel to use part of its tenements for the development and operation of the project. These tenements are essential for the development of the project and future projects as envisaged by the State Agreement. Austeel does not own any of the tenements and is not in a position to relinquish land back to the state.

In negotiating the State Agreement Act Mineralogy agreed to relinquish substantial areas of the Burrup Peninsula for which it had priority to be granted. This substantial offset was made to secure Mineralogy rights to Preston Island and Cape Preston for development of the project as set out in the State Agreement Act and executed by the Premier.

Austeel (and Mineralogy) will hold further discussions with CALM and the Conservation Commission of Western Australia (CCWA) with regard to specific recognised high conservation areas in order to establish an agreement on the conservation management for these key areas.

The following commitment is made by Austeel:

Austeel commits to the implementation of best practice environmental management and rehabilitation within the project area. Details of progress against management objectives will be reported in Annual Environmental Reports. Best practice environmental management will include protection of turtle nesting sites, vermin control, management of mesquite and ongoing research in areas such as stygofauna.

In addition, the commitments made by Austeel in relation to greenhouse gas sequestration and recovery of salt affected land (Section 3.1.8) will also provide conservation offsets for the project.

Appendix A

Cape Preston Stygofauna Summary of Findings

Dr. Brenton Knott, May 2001.
University of WA, Department of Zoology.

SUMMARY OF FINDINGS, POINT PRESTON STYGOFAUNA

Brenton Knott, Department of Zoology, The University of Western Australia, 35 Stirling Highway, Crawley... WA... 6009.

The fauna were identified 'blind': At the time of identifying the fauna I had no knowledge even of where Point Preston is, nor did I have any knowledge on the sampling details (strategy plus methods). I was simply, by mutual agreement with Mr Paul West, given a collection of vials containing specimens preserved in alcohol. Subsequently, through separate, brief discussions with both Mr Ian McCardle and with Paul, I now know that Point Preston occurs at the mouth of the Fortescue River on the northern Pilbara coastline, and although I have been informed of the sampling strategy, I cannot remember details of those brief discussions other than sampling was conducted both within and outside the area of proposed impact. Consequently, I am unable to comment whether the fauna is restricted to one area or occurs in both.

The results are summarised in Table 1. The fauna of all but two vials contain specimens which, based on their morphological attributes (eyeless, attenuation, and lack of pigment) and aquatic habitat can reasonably be interpreted as stygofauna. As such, and given the forms represented, the fauna is zoologically important. The fauna was dominated both in terms of numbers of specimens and in diversity by crustaceans (amphipods, a spelaeogriphacean, an isopod, copepods (cyclopoid and harpacticoid), and an ostracod. The other aquatic elements comprise turbellarian and oligochaete worms, and an acarine. The two, non-stygofaunal specimens are a heavily pimented, eyed beetle in vial B8 (collected 29 March, 2001; no 'D' number included) and what is probably a member of the Diplura in vial B8 D2 (also collected 29 March, 2001). Although it is more likely a member of the soil fauna which has fallen into the bore, and therefore not a stygofaunal element, the specimen is zoologically important. Diplurans originally were classified as primitive, wingless insects, but now they are classified as a separate Class within the Superclass Hexapoda (Kristensen 1991), i.e. having a phylogenetic lineage which is separate from that of the true insects. The specimen from Point Preston is classified as a dipluran, but since it has an additional head appendage not seen in forms already described it may represent a new higher taxon, a view also taken by entomologist Dr Helen Jacob of this department. Alternatively, it may not be a dipluran, in which case both Helen and I have no idea on the affinities of the specimen.

Amphipoda

This was the most diverse group found, with one species common and abundant. The form listed as sp. 2 is a species of *Nedsia* (Figure A in Plate 1); the genus occurs in ground waters from Cape Range peninsula, Barrow Island and is being found in borewater samples from the Fortescue catchment (T. Finston, *pers. comm.* 17 August 2001). Although Bradbury and Williams (1996) have described seven species of *Nedsia* from Barrow Island, there is insufficient character variation in the Point Preston specimens to recognise more than one species present. Larger than the other amphipods, it has elongated uropod three with small inner ramus and outer ramus of two broad, flat articles. The gnathopod 1 (with square palm) is smaller than gnathopod 2 (palm oblique).

The affinities of the remaining three amphipods are much more difficult to determine, and none have been resolved here. Although lacking a complete uropod three, the specimen from vial B2 D2 L (collected 29 March 2001) and listed in Table 1 as **species 3** (Figure D, Plate 1) is markedly attenuated and with reduced abdominal epimera; lacking an accessory flagellum; the gnathopods are distinctive, gnathopod 1 is small and tending to chelate, gnathopod 2 is much larger than gnathopod 1 and with a massive propod; the telson is split to the base, with long lobes; uropod 1 has a small ventral seta (not a spine): these features together are quite distinctive. The two specimens of **species 4** (Figure B, Plate 1) from vial M6A D1 have an accessory flagellum with a long basal article and very short (and narrower than the basal) terminal article; gnathopd 1 is slightly larger than gnathopod 2, with both propods long and narrow; very distinctive features are the massive peduncles of the pleopods, the clear extension of uropod 2 beyond the limit of uropod 1, and the spine at the disto-lateral corner of the peduncle of uropods 1 and 2; the telson is very short. These features all point to species 4 being a bogidiellid, and if so it is not conspecific with *Bogidomma australis* described by Bradbury and Williams (1996) from Barrow Island. **Species 5** (Figure C, Plate 1) from vial M10 D1 is squat, has an accessory flagellum with 2 articles; with massive gnathopod 1 larger than large gnathopod 2; the outer ramus of uropod 3 comprises 2 articles; the telson is long and cleft to the base; the most obvious characteristic feature of the specimen is the large expansion of coxal and ischium plates, and of the abdominal epimera.

Given the smallness of these specimens which, unfortunately are incomplete in the case of species 3 and 4 lacking uropod 3, it will be necessary to dissect them in order to determine details of gill arrangement and sexual status.

Isopoda

The specimen in the vial labelled Amphipoda, A10 (lacking a 'D' designation) is not an amphipod but a small (<2 mm) isopod, almost certainly of a new genus, and I would not be surprised if it turned out to be an asellote. The same species is represented by the specimen in 'syncarid' vial A 10 D2 collected 27 March 2001. The isopod affinities are demonstrated in the 7 pereopods, none developed as a gnathopod; the pleon is shorter than the pereon, with pleomere 1 short, pleomeres 1-5 inclusive free, pleomere 6 is a pleotelson; the telson is a rounded projection; 1 pair of uropoda; pleopoda simple plates. The right mandible bears two stout spines at the base of the teeth on the incisor process which may function as a *lacinia mobilis*; the left mandible has a definite *lacinia mobilis* plate plus 1 stout spine.

Unfortunately, the specimens are clearly very delicate because none are in 'mint' condition.

Thermosbaenacea

The forms initially classified into the vials as syncarids but in fact they belong to the order Thermosbaenacea - (Malacostraca). I can see evidence of only one species. These malacostracan crustaceans might be either thermosbenacean or spelaeogriphacean, the differences between the two groups are obscure. I have seen only illustrations of both groups before, never a real specimen and in reading through the literature (limited) besides differences in mouthparts and limb arrangements, one obvious difference is in the position of the brood pouch. In spelaeogriphaceans, the brood pouch is ventral, formed from oostegites. In thermosbaenaceans, the brood pouch is dorsal, formed by the carapace. The Point Preston specimens have a dorsal brood pouch (Figure E, Plate 1). Spelaeogriphaceans (to 8.6 mm in length) are thought to have affinities with tanaids, syncarids, and thermosbaenaceans. Thermosbaenaceans are smaller (< 4 mm); the Point Preston specimens look similar to *Halosbaena* (described from Curaçao): Tethyan affinities are thereby established. Before this find, I had understand that thermosbenaceans had been found recently from bores in the Pilbara, although Dr Humphreys made no mention of this in his talk in the Parmelia workshop last week (16 August). He did show a map with spelaeogriphaceans recorded from coastal areas about the mouth of the Fortescue River. Does this mean that both Spelaeogriphacea and Thermosbaenacea occur around the mouth of the Fortescue River? Whatever the final decision on the placement of the Point Preston specimens, and the weight of morphological evidence must be in favour of Thermosbaenacea, the find is very significant. The main distribution of the Thermosbaenacea is in subterranean habitats of the Mediterranean coast and in the Caribbean, i.e. a Tethyan distribution. Spelaeogriphaceans are known elsewhere from a cave stream on Table Mountain, South Africa.

If my surmise is correct concerning their higher taxonomic placement as Thermosbaenacea, then their co-occurrence with an hadziid amphipod (*Nedsia* sp.) is interesting: hadziids and thermosbaenaceans rarely co-occur (Stock 1982).

Copepoda

The dominant copepod present in the samples is a cyclopoid (Figures G & H, Plate 2). Based on leg morphology, I can find evidence of only one species, although there is some considerable size range, and sexual dimorphism.

The harpacticoids were more diverse, but only a single specimen was found of each form.

Subterranean copepods from the Pilbara area currently are being described, and it is premature to comment further here on the classification of the Point Preston specimens.

Ostracoda

Ostracoda were collected only infrequently, a total of 10 specimens from six bores. The most common form (nine specimens) is illustrated (Figure F, Plate 1); the second morph, same length is flatter, 'bean shaped' and lacking in the setation.

Acarina

The two specimens of acarine (Figure I, Plate 2) appear to be of the same species.

Oligochaeta

The oligochaetes have been identified by Dr. Adrian Pinder, an expert in oligochaetes. Three families are represented; Enchytraeidae (and cannot identify further); Phreodrilidae (cannot identify further but possibly all of the same species), and mature Tubificidae but Adrian is not familiar with the form.

Turbellaria

Microturbellarians are difficult to work with unless studied live. The specimens here are solidly opaque and consequently it is not possible to see any morphological detail.

References

Bradbury, J. H. and W. D. Williams (1996). Freshwater amphipods fromBarrow Island, Western Australia. *Records of the Australian Museum* 48: 33-74.

Kristensen, N. P. (1991). Phylogeny of extant hexapods. In: *The Insects of Australia*, CSIRO, Second Edition Volume 1: 125-140.

Stock, J. H. (1982). The influence of hadziid Amphipoda on the occurrence and distribution of Thermosbaenacea and cyclopoid Copepoda in the West Indies. *Pol. Arch. Hydrobiol.* 29: 275-282.

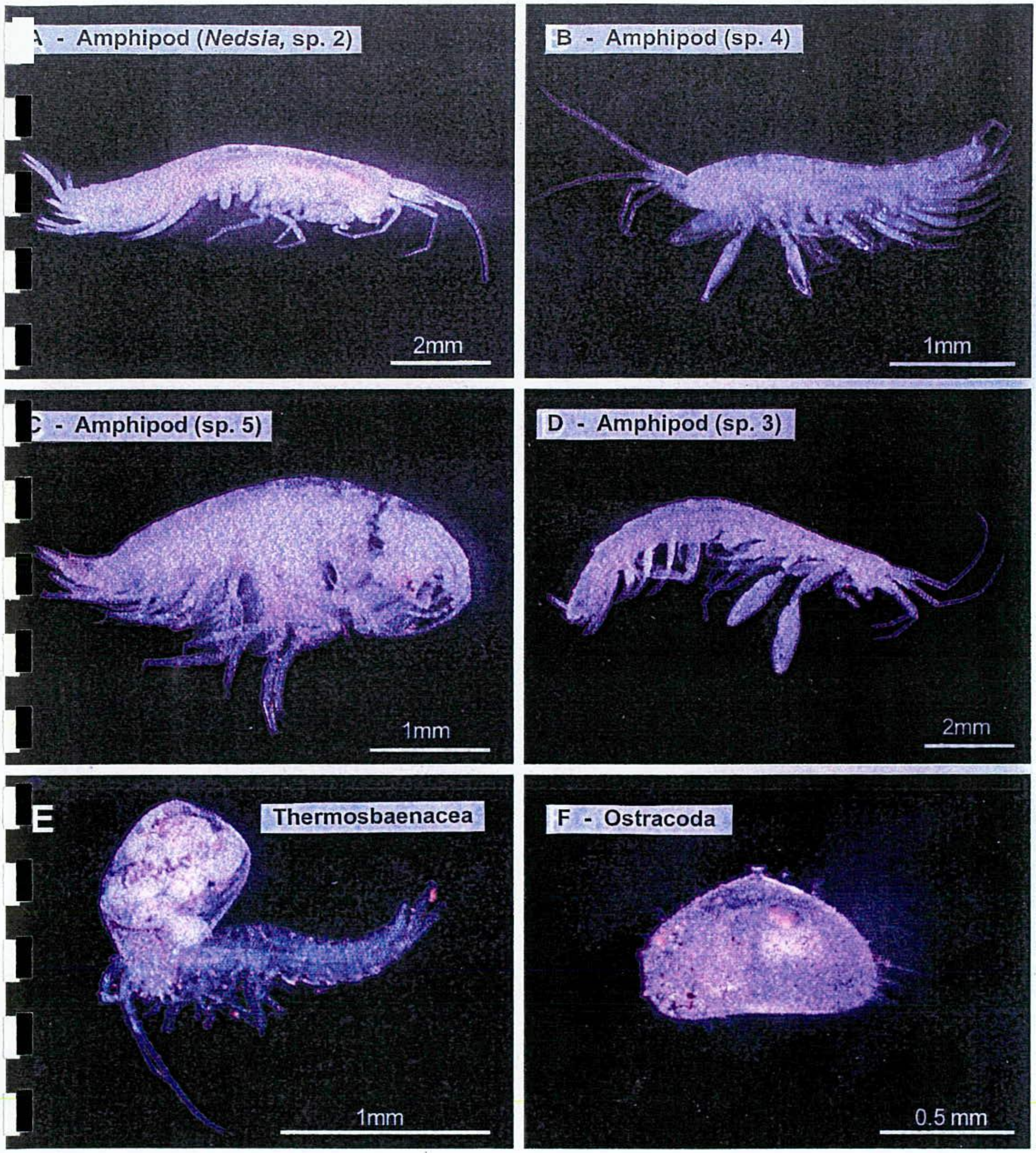
CAPE PRESTON STYGOFAUNA, MAY 2001

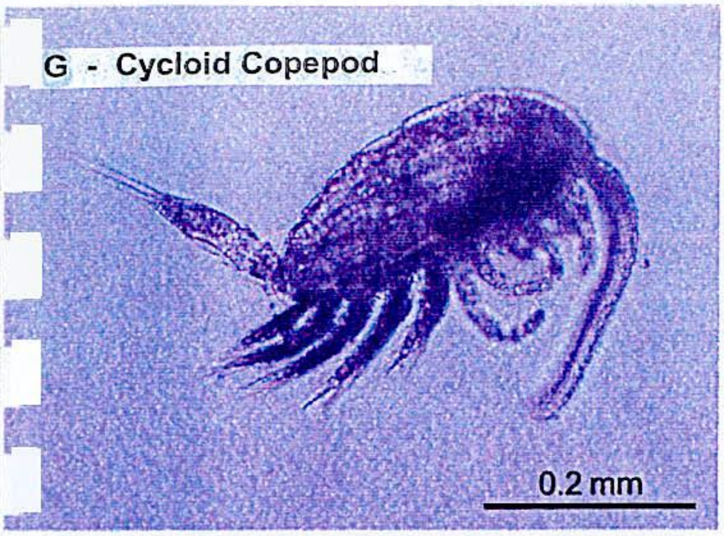
Summary of Headings in Table 1

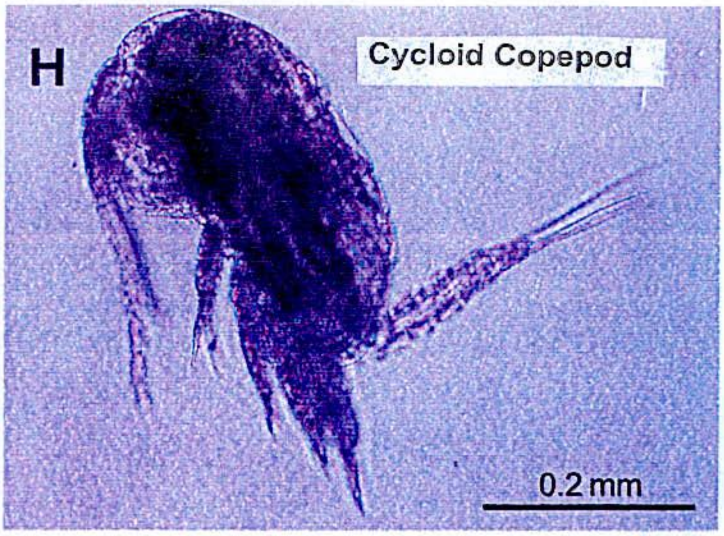
Site:	Sampling bore.
Drag #:	'D' number on sample.
Date:	Date of sampling
Amphi.:	Amphipoda. Four species, designated sp.2, sp.3, sp.4 and sp.5. sp.2: *Nedsia*, relatively common, represented mostly by juvenile specimens. sp.3: Unknown genus. sp.4: Unknown genus (possibly *Bogidomma* species). sp.5: Unknown genus. (Note: sp.1 turned out not to be an amphipod).
Therm.:	Thermosbaenacea. Before this find, thermosbenaceans had been found recently from bores in the Pilbara, but their main distribution was understood as being subterranean habitats of the Mediterranean coast and in the Caribbean.
Iso.:	Isopoda. A new and significant genus. Unfortunately, the specimens are clearly very delicate because none are in 'mint' condition.
Cy. Cop.:	Cyclopoid copepods. One or two species, probably just one. Marked sexual dimorphism, but there are some specimens larger than the average.
Ha. Cop.:	Harpacticoid copepods. One, two or three species, but very few specimens so lumped together in the table.
Ostra.:	Ostracoda. Two species, sp.1 (most common form) and sp.2 (similar to sp.1 but flatter 'bean' shape).
Oligo.:	Oligochaeta. Identified by Adrian Pinder. E= Enchytraeidae (and cannot identify further); P=Phreodrilidae (cannot identify further but possibly all of the same species); T=Tubificidae (mature, but a marine form and Adrian is not familiar with marine tubificids).
Turb.:	Turbellaria. Specimens were solidly oblique causing difficulty to determine morphological detail.
Acar.:	Acarina. Only two specimens that appear to be of same species.
Insecta:	Insecta. The stygofaunal specimen is significant, and it seems to belong to the order Diplura. That is, it is a member of the Hexapoda, and not a true insect. However, it has an extra head appendage and if it is a dipluran, then would seem to belong to a new family. I am engaging an entomological colleague in a friendly debate on the issue. The other specimen is a beetle (soil or surface fauna) that most probably fell into the bore.
DTW:	Depth to water (m)
Line:	Drag line length (m)

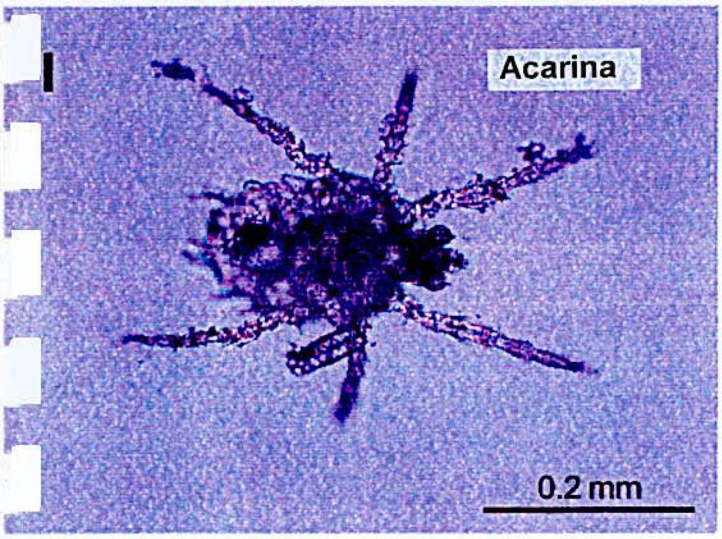
Table 1: Cape Preston Stygofauna Sampling

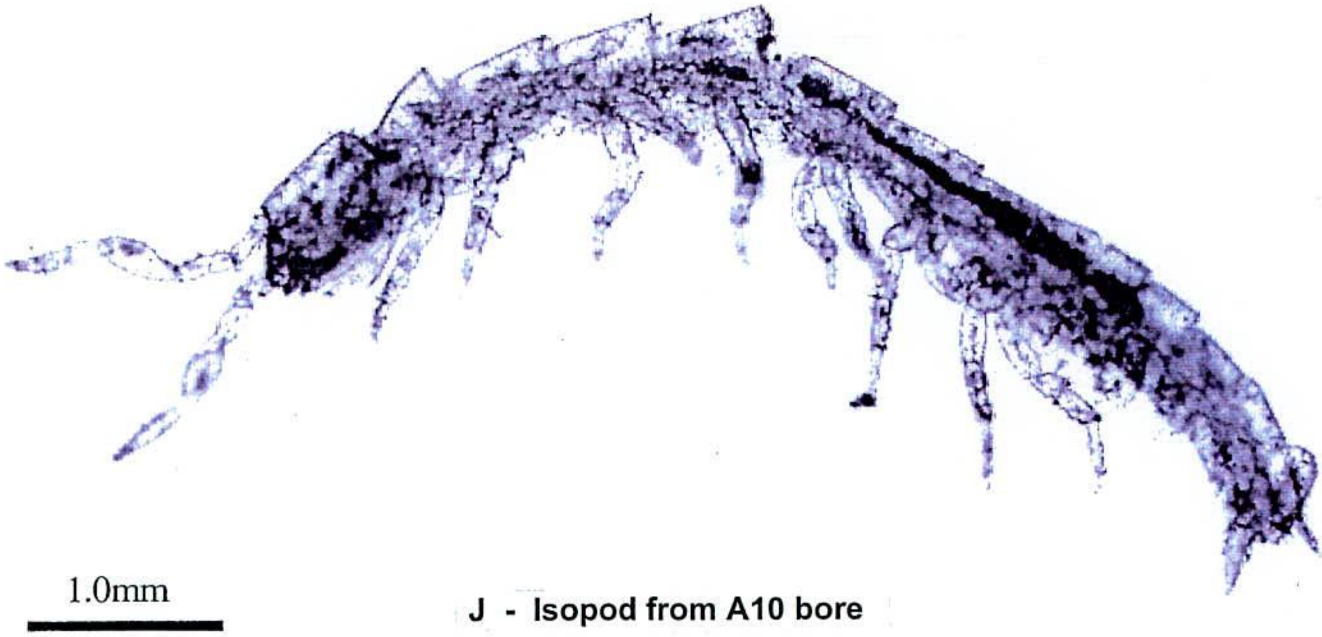
Site	Drag #	Date	Amphi.	Therm.	Iso.	Cy. Cop.	Ha. Cop.	Ostra.	Oligo.	Turb.	Acar.	Insecta	DTW	Line
A4	D1	27-Mar-01							1(E)				32.3	72 - 112
A4	D2	27-Mar-01							1(E)					
A4	D3	27-Mar-01							1(E)					
A5	D1	27-Mar-01							1(P)				33.8	90 - 100
A7	D1	27-Mar-01											28.5	65 - 80
A7	D2	27-Mar-01							1(P)					
A7	D3	27-Mar-01				3	1		1(P)					
A8	D1	27-Mar-01				11							21.7	60
A8	D2	27-Mar-01				2								
A9	D1	27-Mar-01				49							20.4	30
A9	D2	27-Mar-01				26								
A9	D3	27-Mar-01				22								
A10	D1	27-Mar-01			2	1							27.3	80
A10	D2	27-Mar-01			4				1(E)					
A10	D3	27-Mar-01			13									
A16	D3	26-Mar-01				3							27.8	-
A17	D1	26-Mar-01				8							25.2	30
A17	D2	26-Mar-01				12								
B1	D1	28-Mar-01				2							7	10
B1	D2	28-Mar-01				2								
B1	D3	28-Mar-01				5								
B2	D1	29-Mar-01	2(sp.2)	8		13							6.4	13
B2	D2	29-Mar-01		1		22								
B2	D3	29-Mar-01		4		17								
B2	D4	29-Mar-01	1(sp.2)	4		14		1(sp.1)						
B7	D1	29-Mar-01	1(sp.2)										6.4	17
B8	D1	29-Mar-01										1(Beetle)	6.5	20
B8	D2	29-Mar-01										1(Diplura)		
B10	D1	29-Mar-01	1(sp.2)			5							6	12
B10	D2	29-Mar-01				6								
M0	D1	30-Mar-01				2		1(sp.2)					5	13
M0	D2	30-Mar-01				3								
M0	D3	30-Mar-01				3								
M1	D1	31-Mar-01	1(sp.2)			11					1		6	13
M1	D2	31-Mar-01				7								
M1	D3	31-Mar-01				10								
M2B	D1 LS	29-Mar-01	4(sp.2)	4		9			1(?); 2(P)				6.2	16
M2B	D2	29-Mar-01	2(sp.2)	3		3								
M2B	D3	29-Mar-01	5(sp.2)			1		2(sp.1)		2				
M3A	D1	29-Mar-01				1							6.5	23
M3A	D2	29-Mar-01	1(sp.2)											
M4A	D1	30-Mar-01				2							6	14 - 19
M4P	D1	30-Mar-01	1ex(sp.2)	8			1	3(sp.1)					5.6	11
M4P	D2	30-Mar-01		7			1		1(T)					
M5	D1	30-Mar-01				5							7.7	16
M5	D2	30-Mar-01					2				1			
M6A	D1	30-Mar-01	1(sp3);1(sp.4)			2							5.6	-
M8A	D1	30-Mar-01		10		56	1						6	15
M8A	D2	30-Mar-01		2		27								
M8A	D3	30-Mar-01		2		7								
M10	D1	31-Mar-01	1(sp.5)										6.6	17
M10	D2	31-Mar-01	2(sp.2)											
M10	D3	31-Mar-01		1		1								
M11	D1	31-Mar-01	2.5(sp.2)	2		16							6.5	20
M11	D2	31-Mar-01	5(sp.2)	6		10	1							
M11	D3	31-Mar-01	6(sp.2)	1		10								
M33P	D1	30-Mar-01		1		3	1	4(sp.1)					8.4	18
M33P	D2	30-Mar-01				3	5							
M34A	D1	30-Mar-01		12				1(sp.1)					7.3	14
M34A	D2	30-Mar-01		2				1(sp.1)						
M34B	D1	30-Mar-01	1(sp.2);1(sp.4)										7.9	10


- Amphipod (*Nedsia*, sp. 2)
2mm
B - Amphipod (sp. 4)
1mm
- Amphipod (sp. 5)
1mm
D - Amphipod (sp. 3)
2mm
E
Thermosbaenacea
1mm
F - Ostracoda
0.5 mm

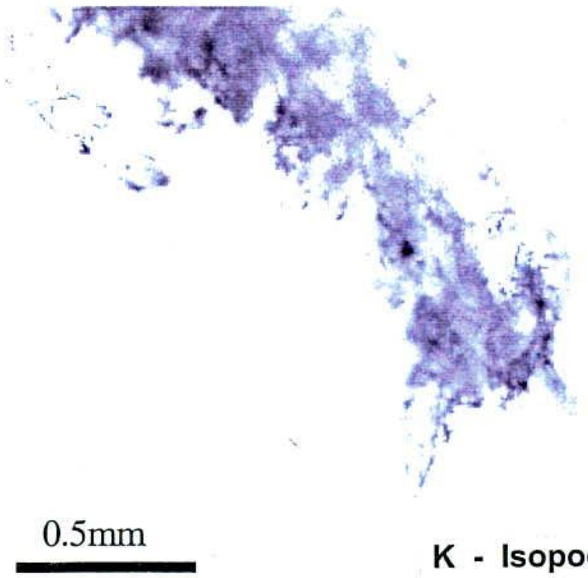

G - Cycloid Copepod
0.2 mm


H
Cycloid Copepod
0.2 mm

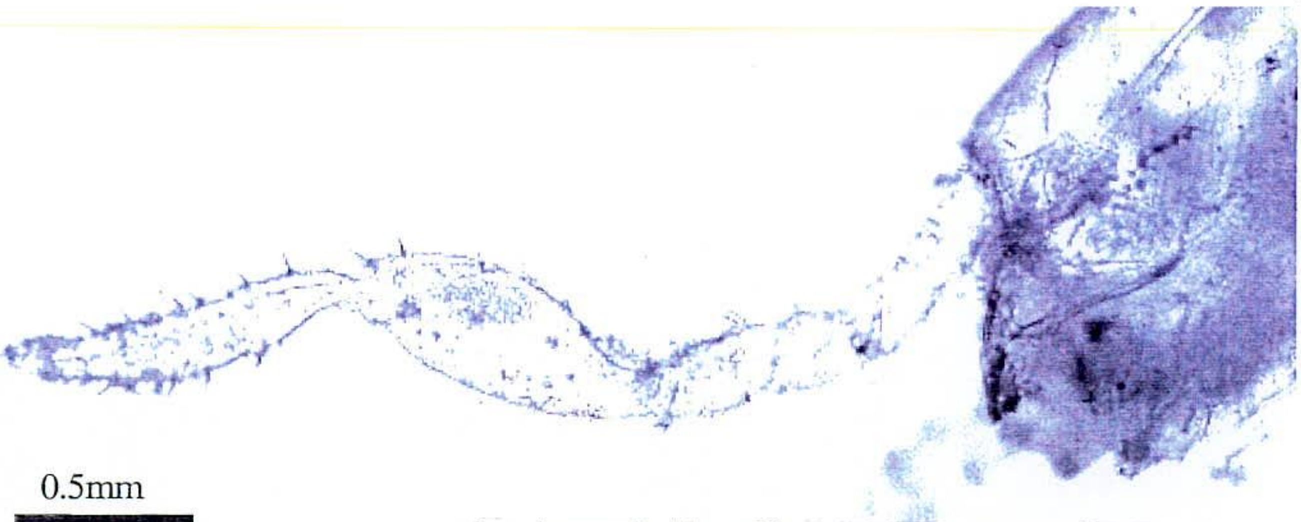

I
Acarina
0.2 mm



J - Isopod from A10 bore



K - Isopod: Magnified view of uropods and pleopods



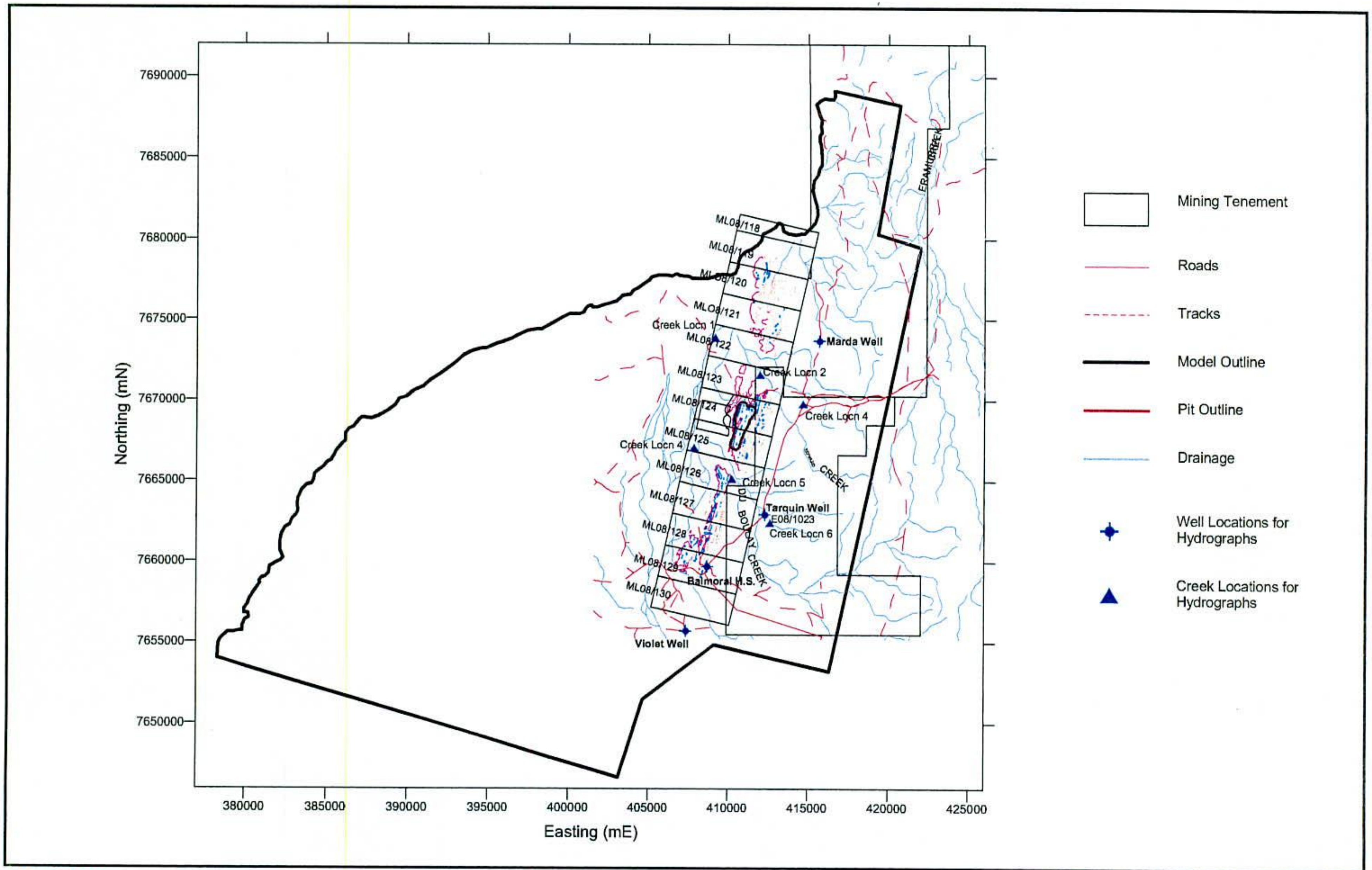
L - Isopod: Magnified view of head section

Appendix B

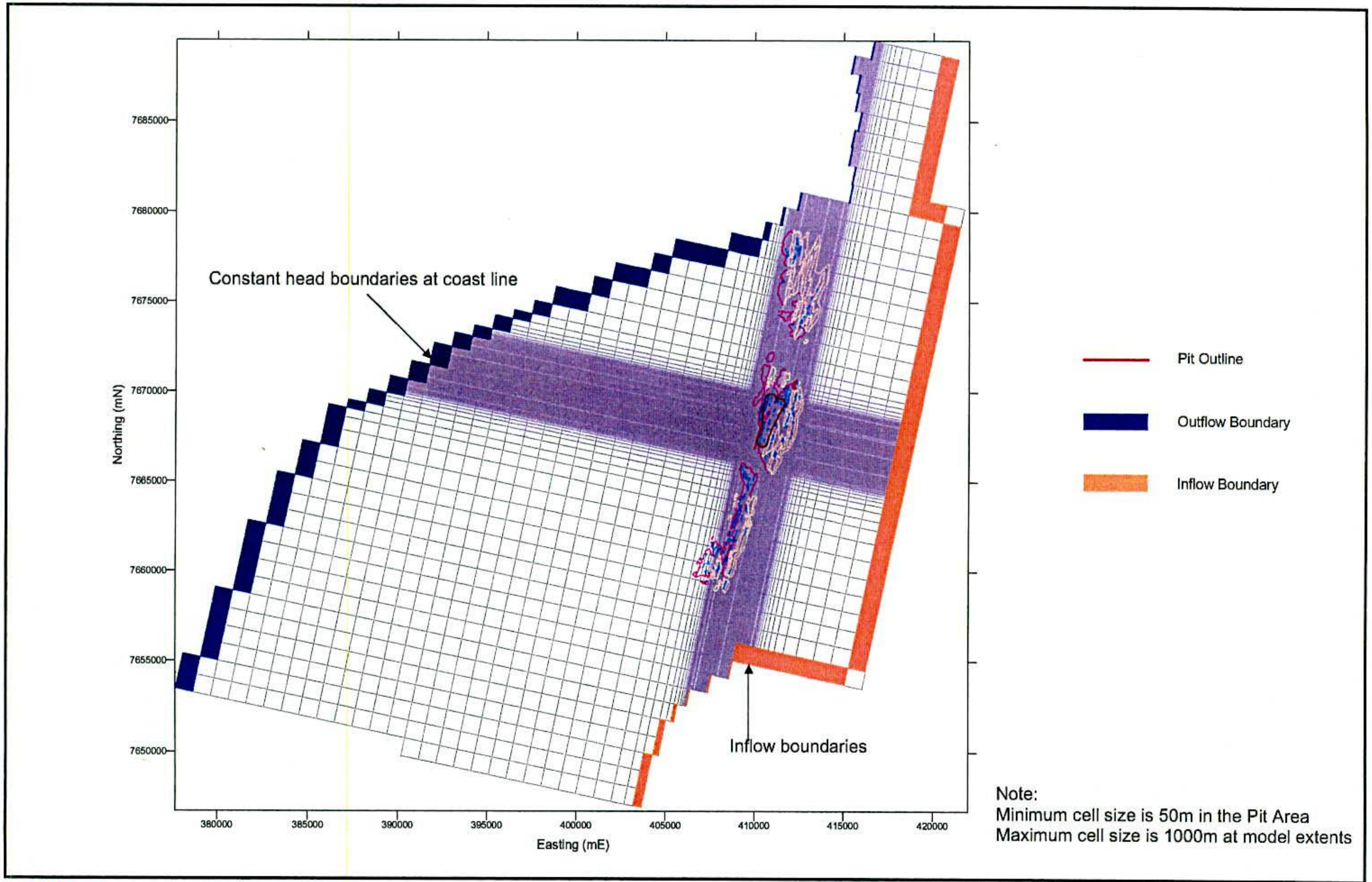
Austeel Iron Ore Project,
Prediction of Groundwater Level Drawdown,
Figures 1 – 16.

Aquaterra Pty Ltd, August 2001.

FIGURES



Location Plan
Figure 1



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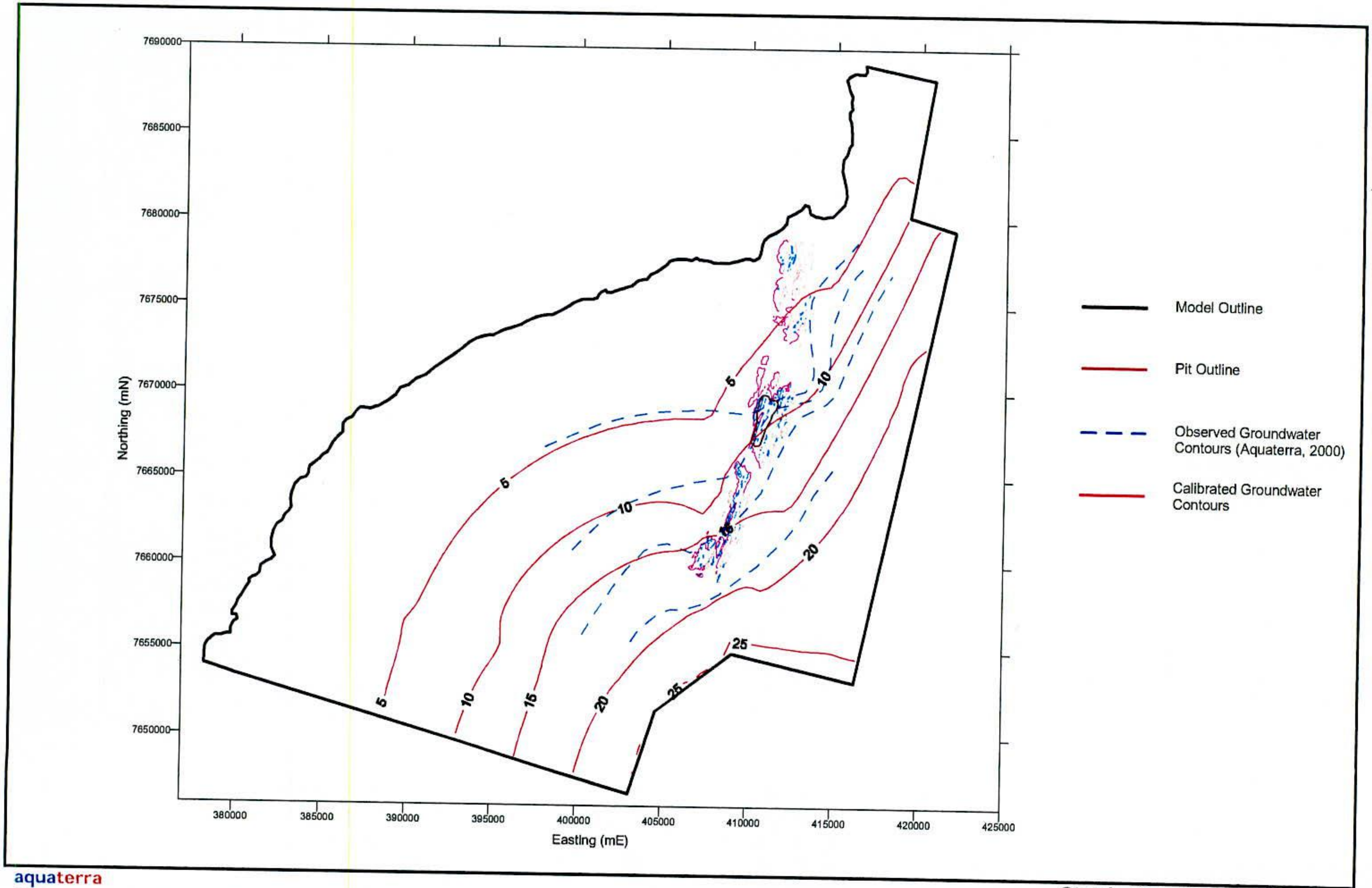
Finite Difference Grid
Figure 2



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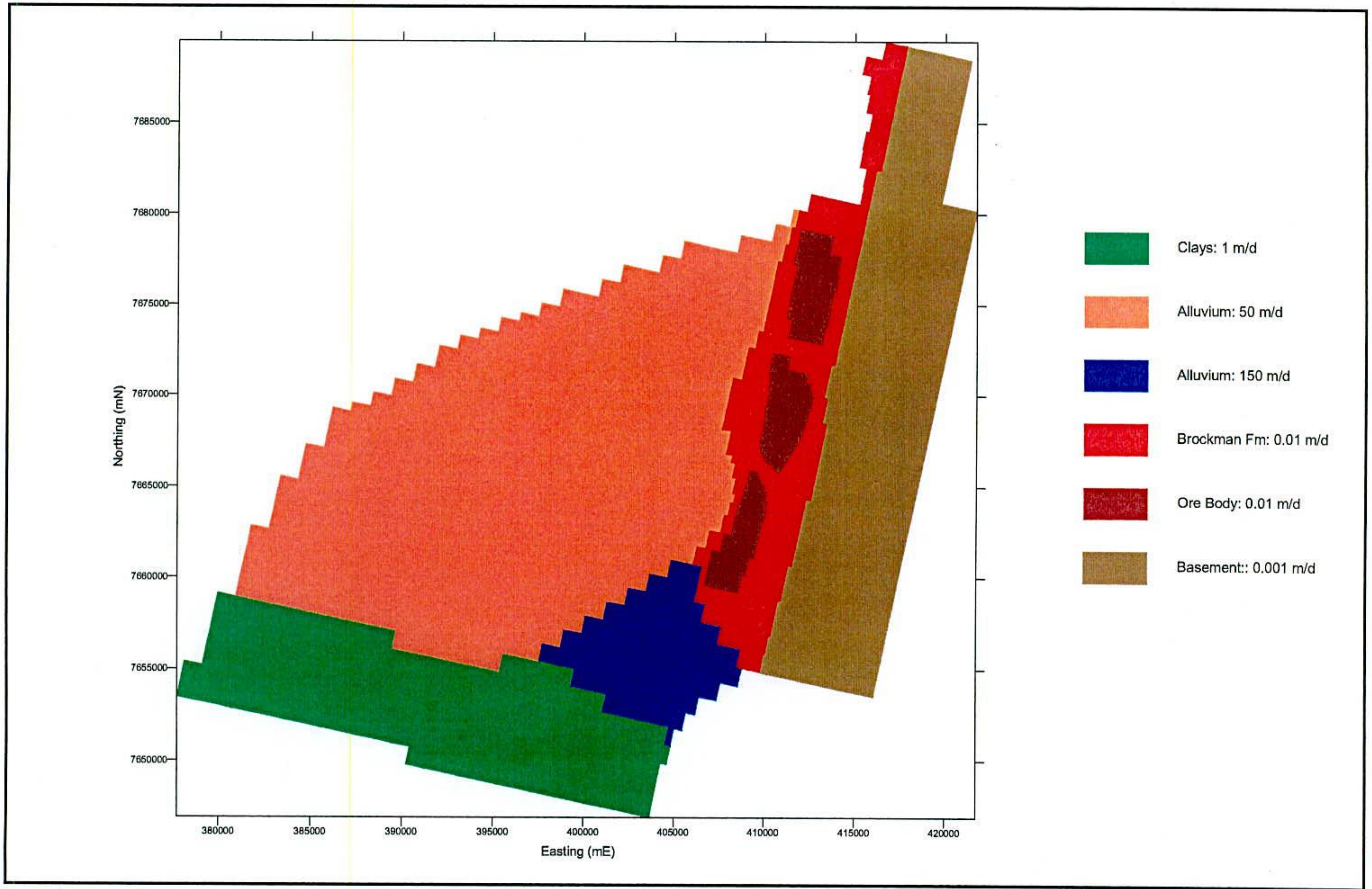
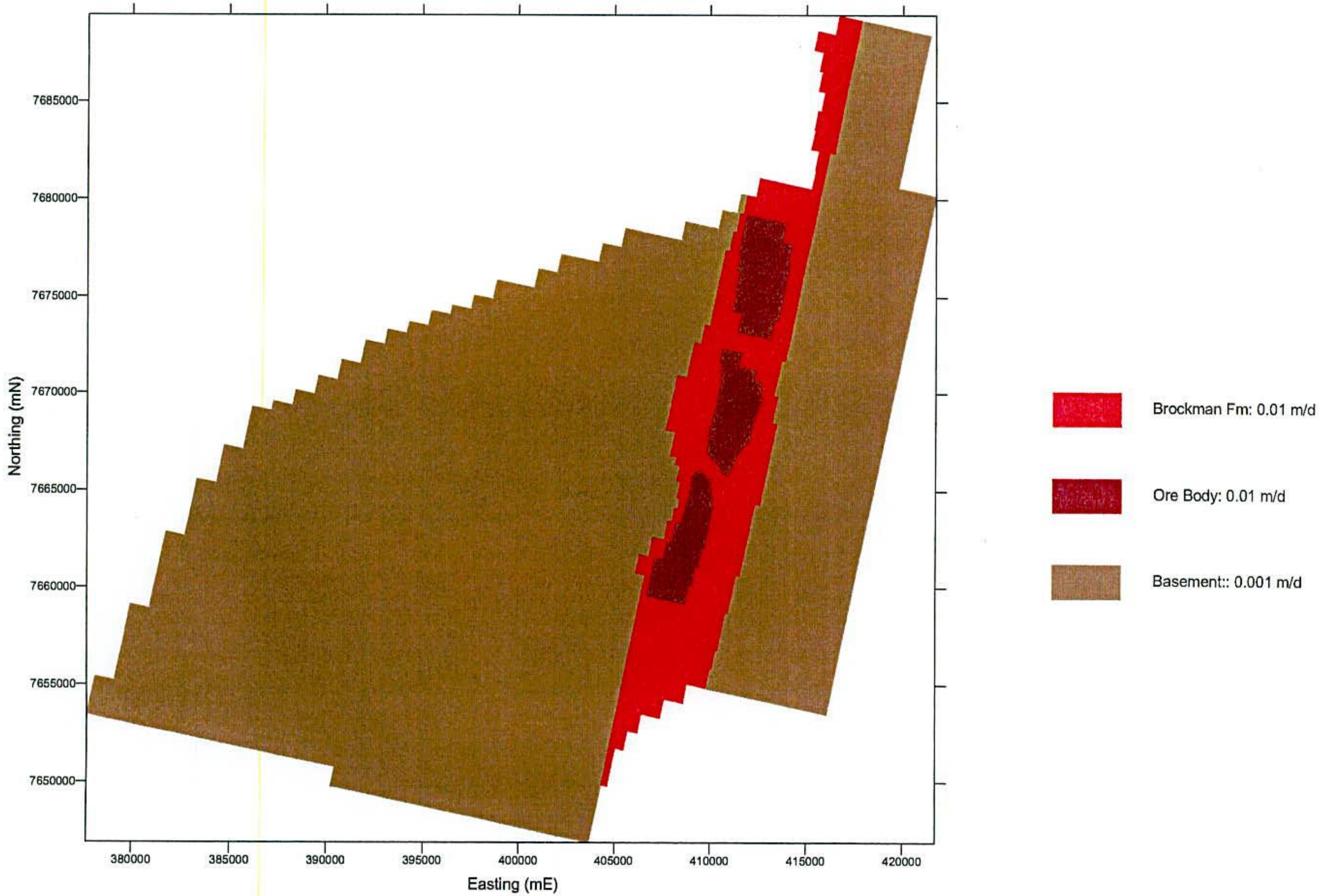
Steady State Model Calibration
Figure 4



Hydraulic Conductivity Distribution – Layer 1
Figure 5



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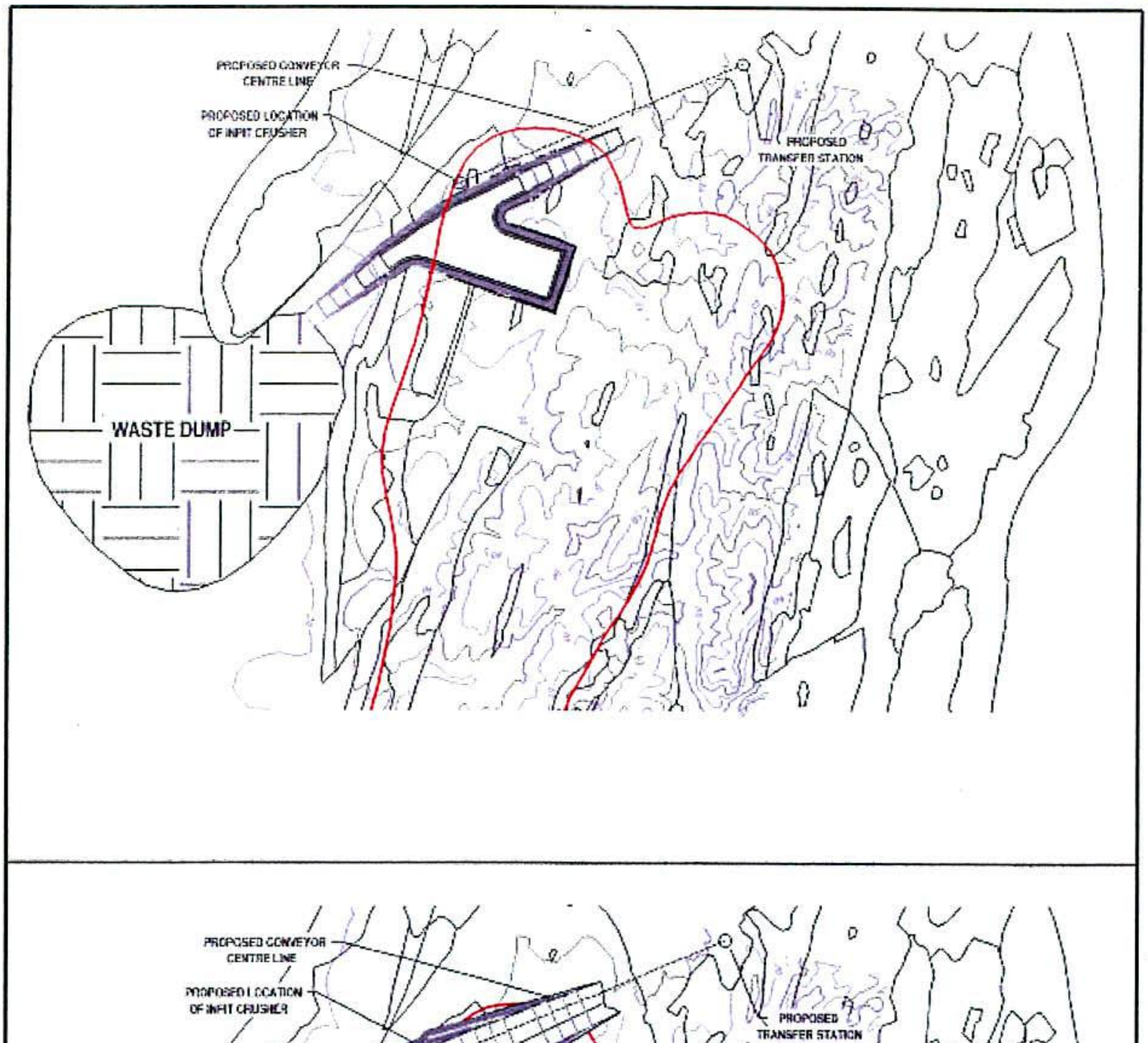
Hydraulic Conductivity Distribution – Layer 2
Figure 6



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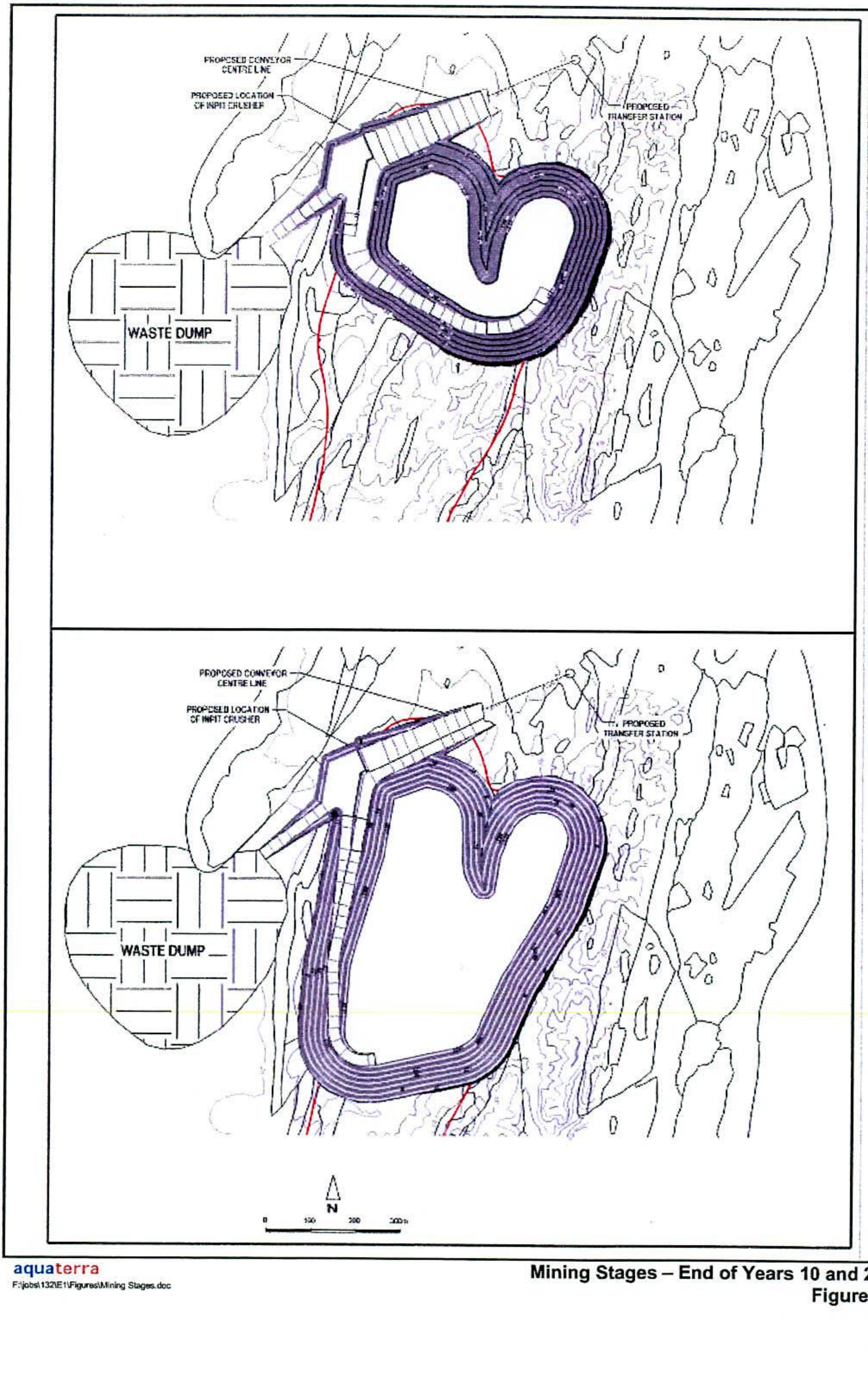
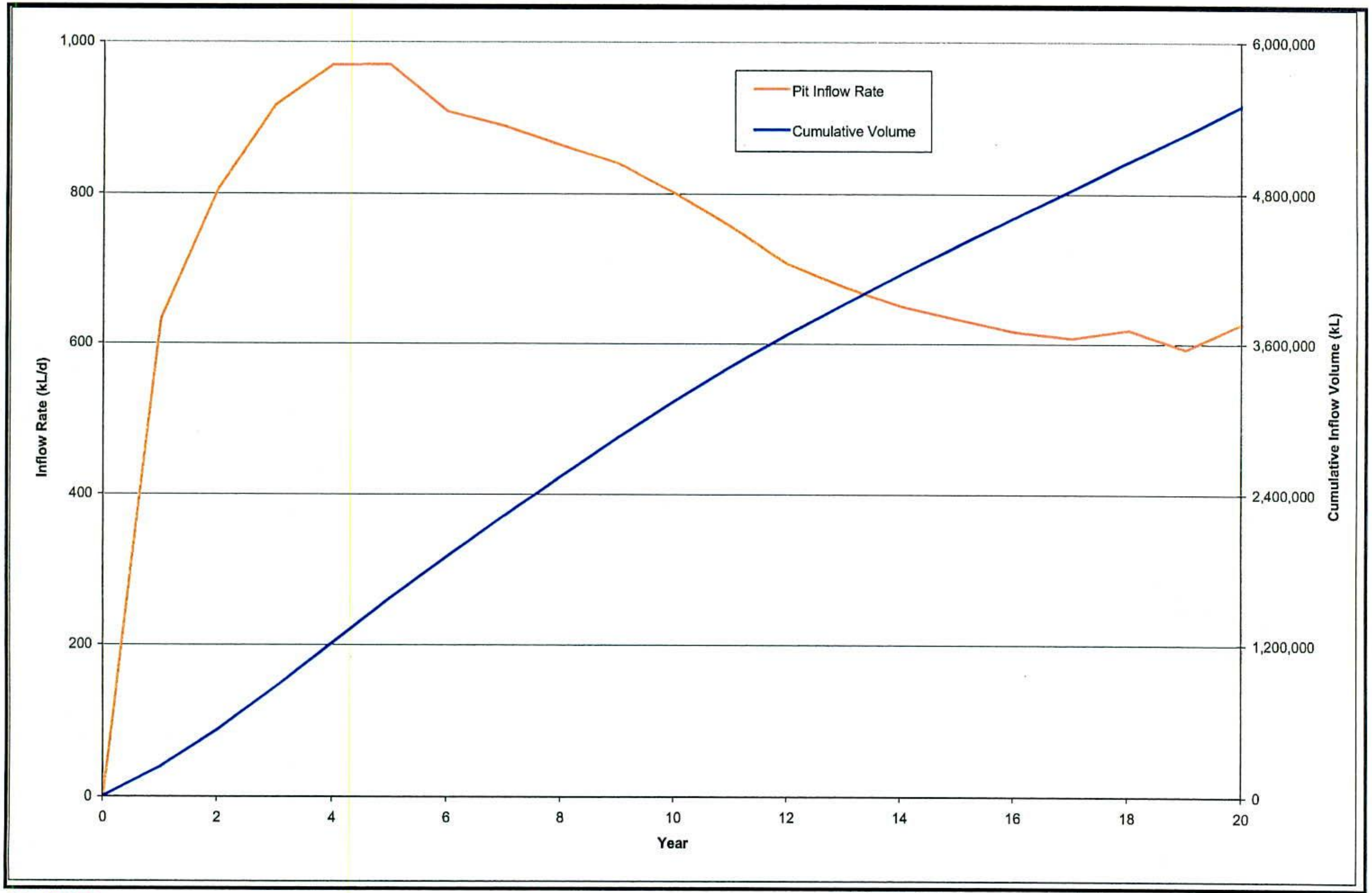
Mining Stages – Prestrip and End of Year 5
Figure 7



Mining Stages – End of Years 10 and 20
Figure 8



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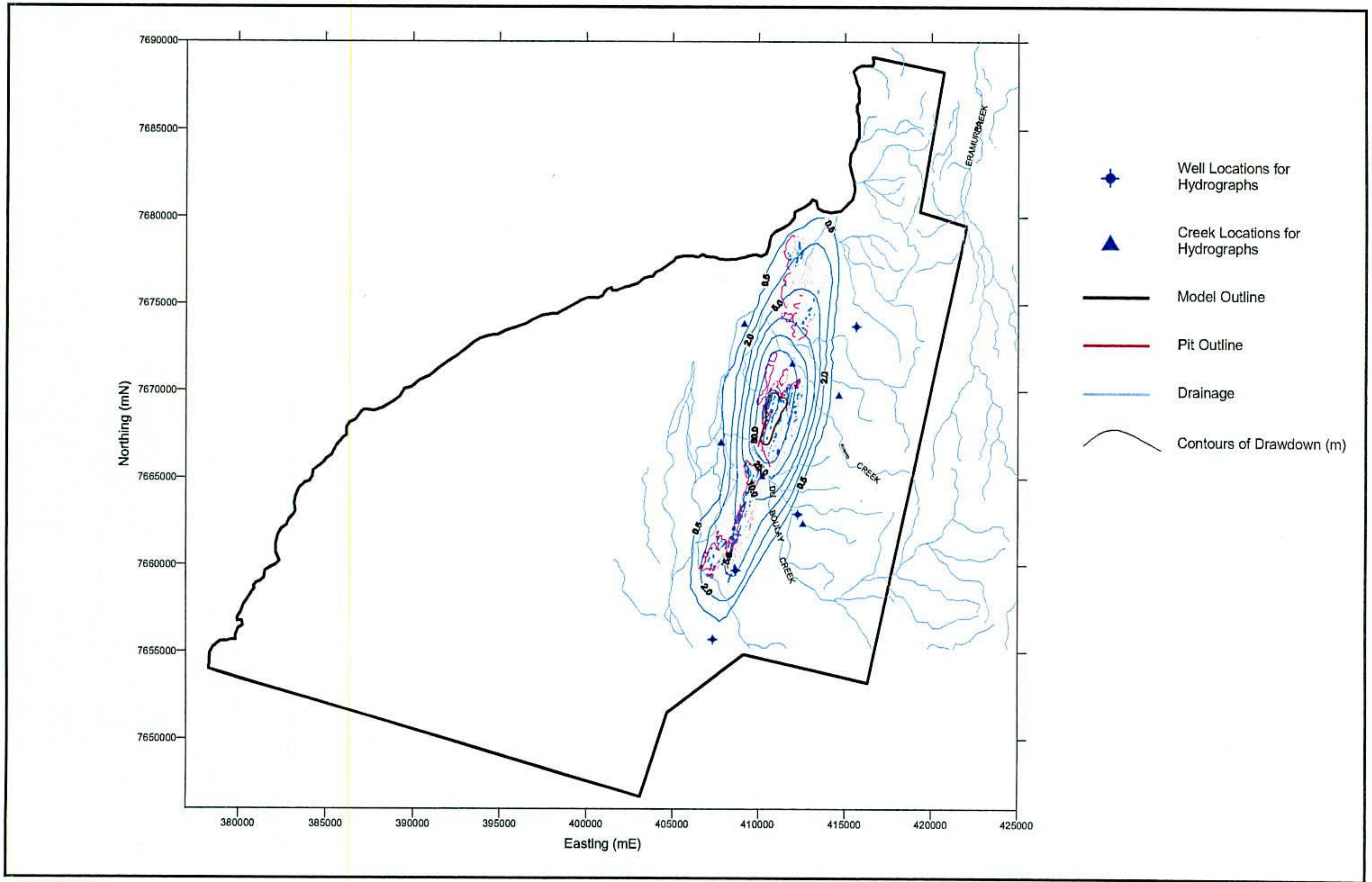
Predicted Groundwater Inflow and Cumulative Volume

Figure 9



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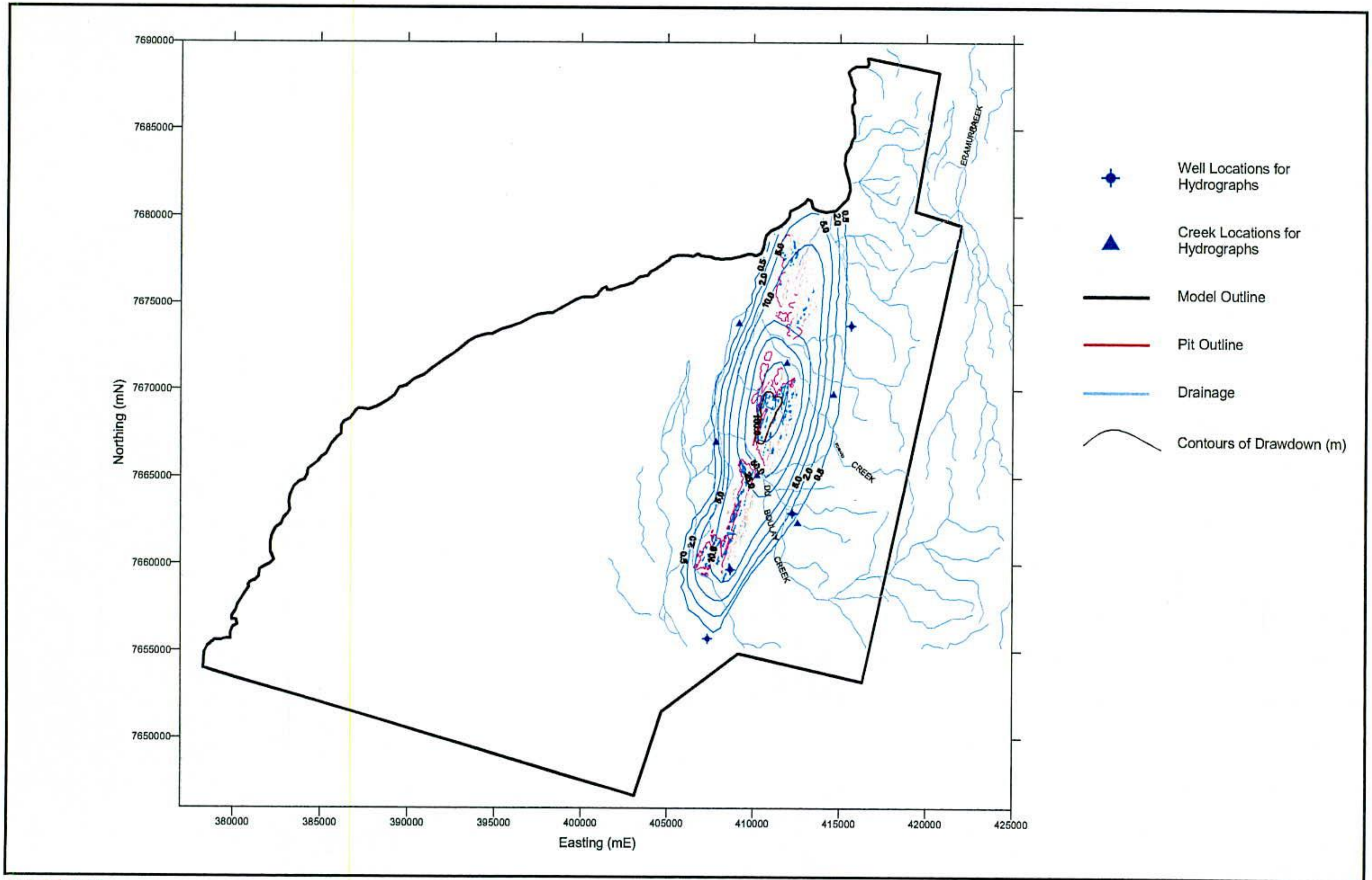
Predicted Drawdown – Year 5

Figure 10



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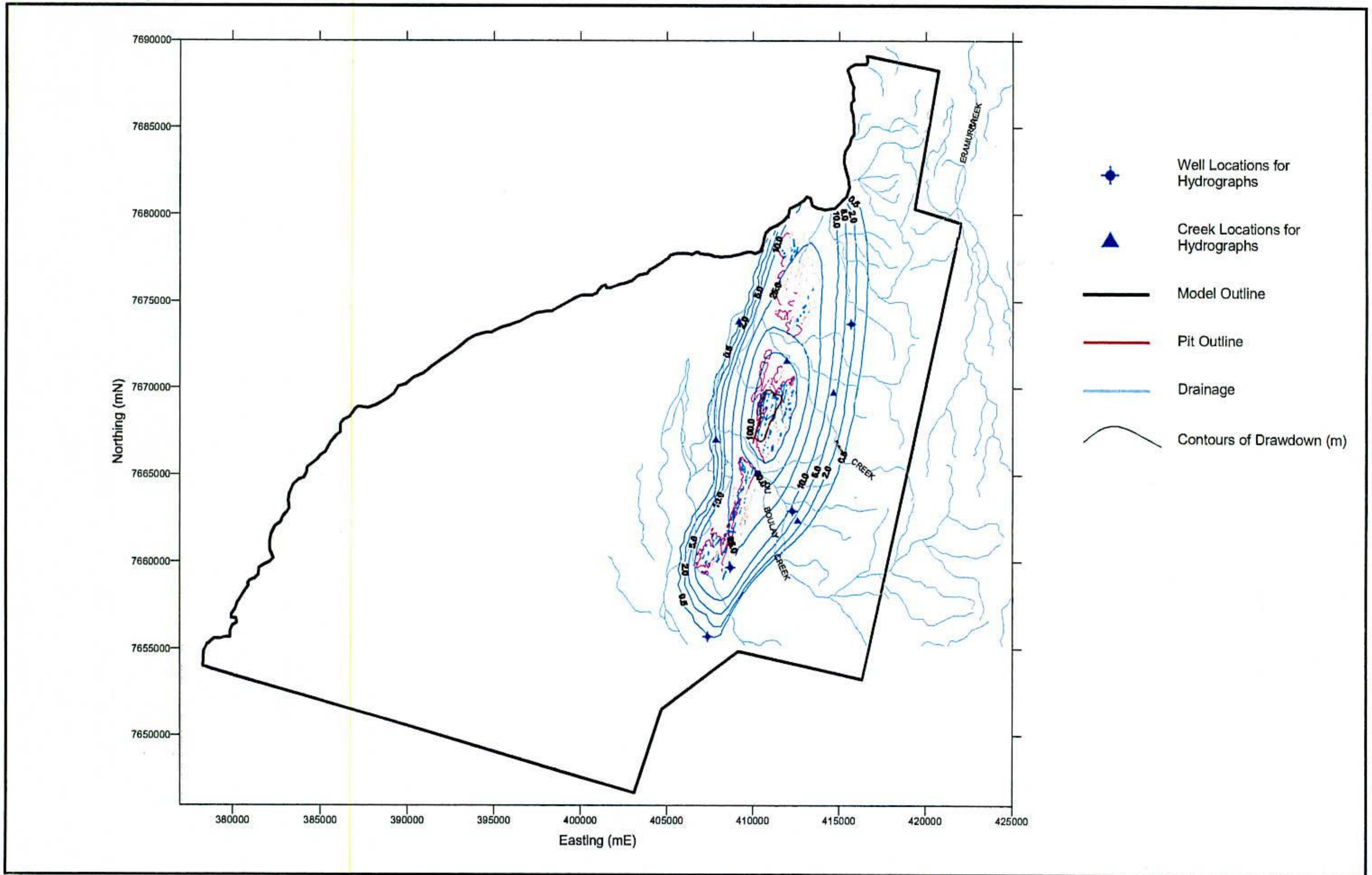
Predicted Drawdown – Year 10
Figure 11



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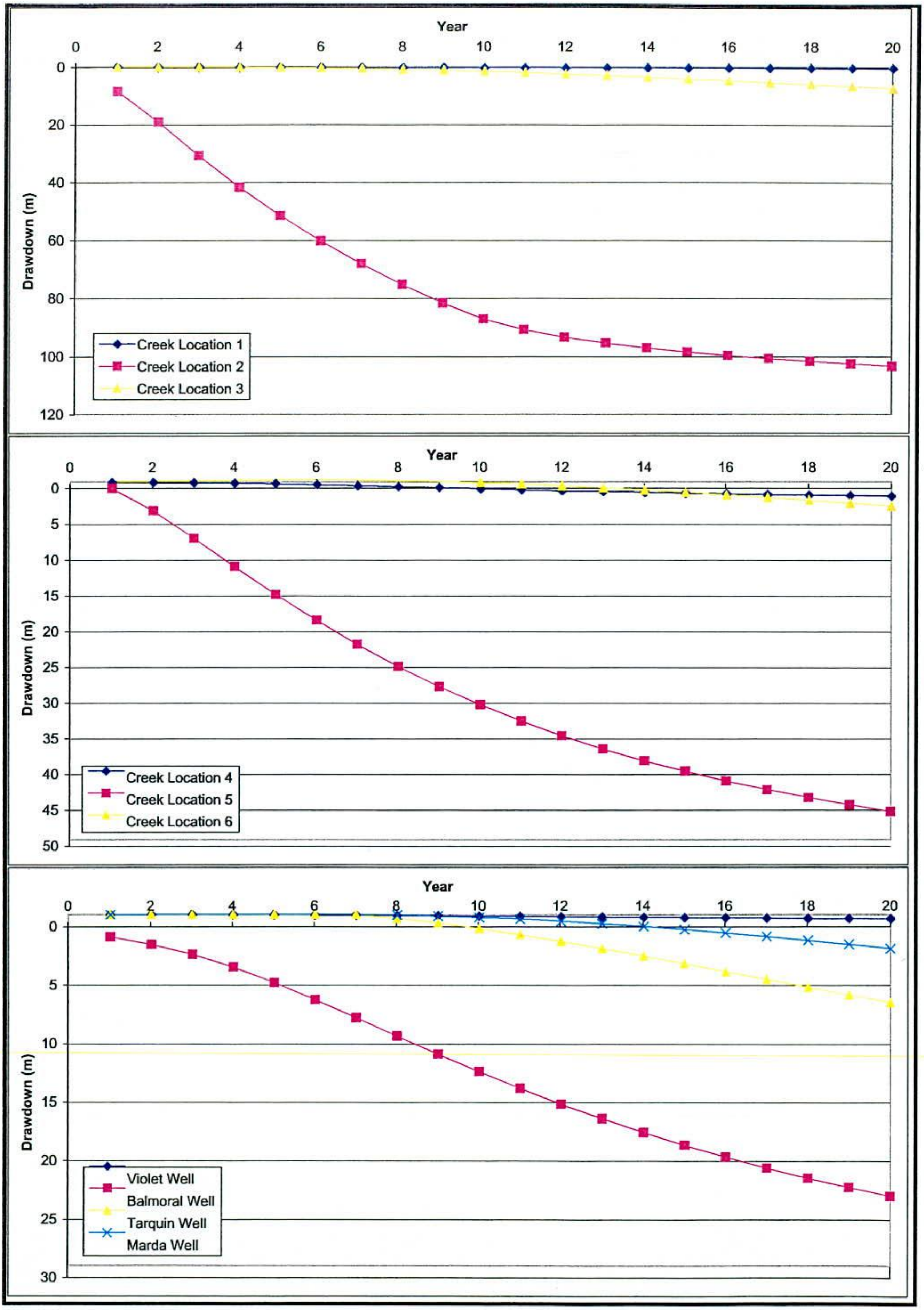
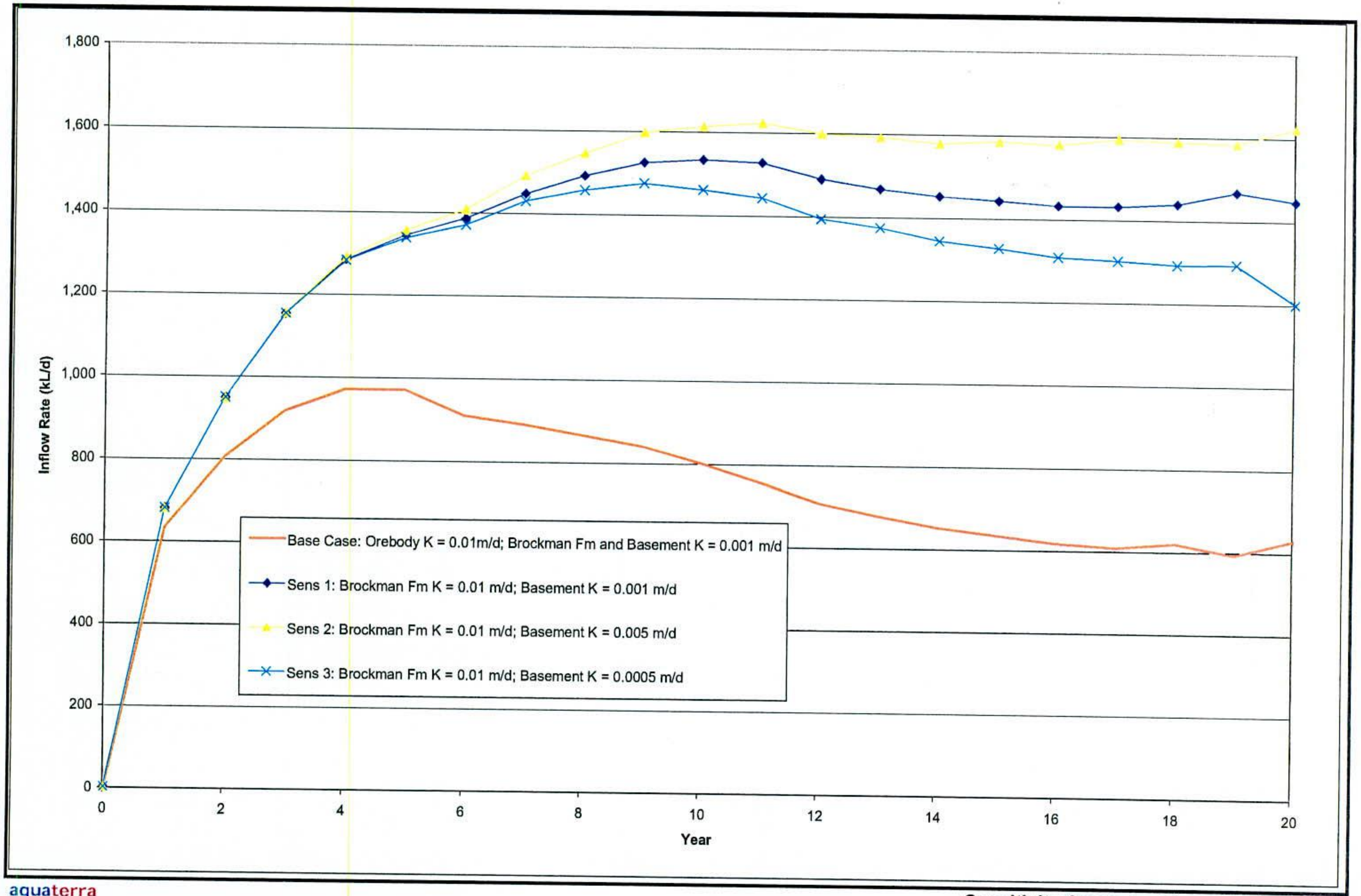
Predicted Drawdown – Year 20
Figure 12



Predicted Drawdown: Wells and Drainage Paths

Figure 13

[redacted]



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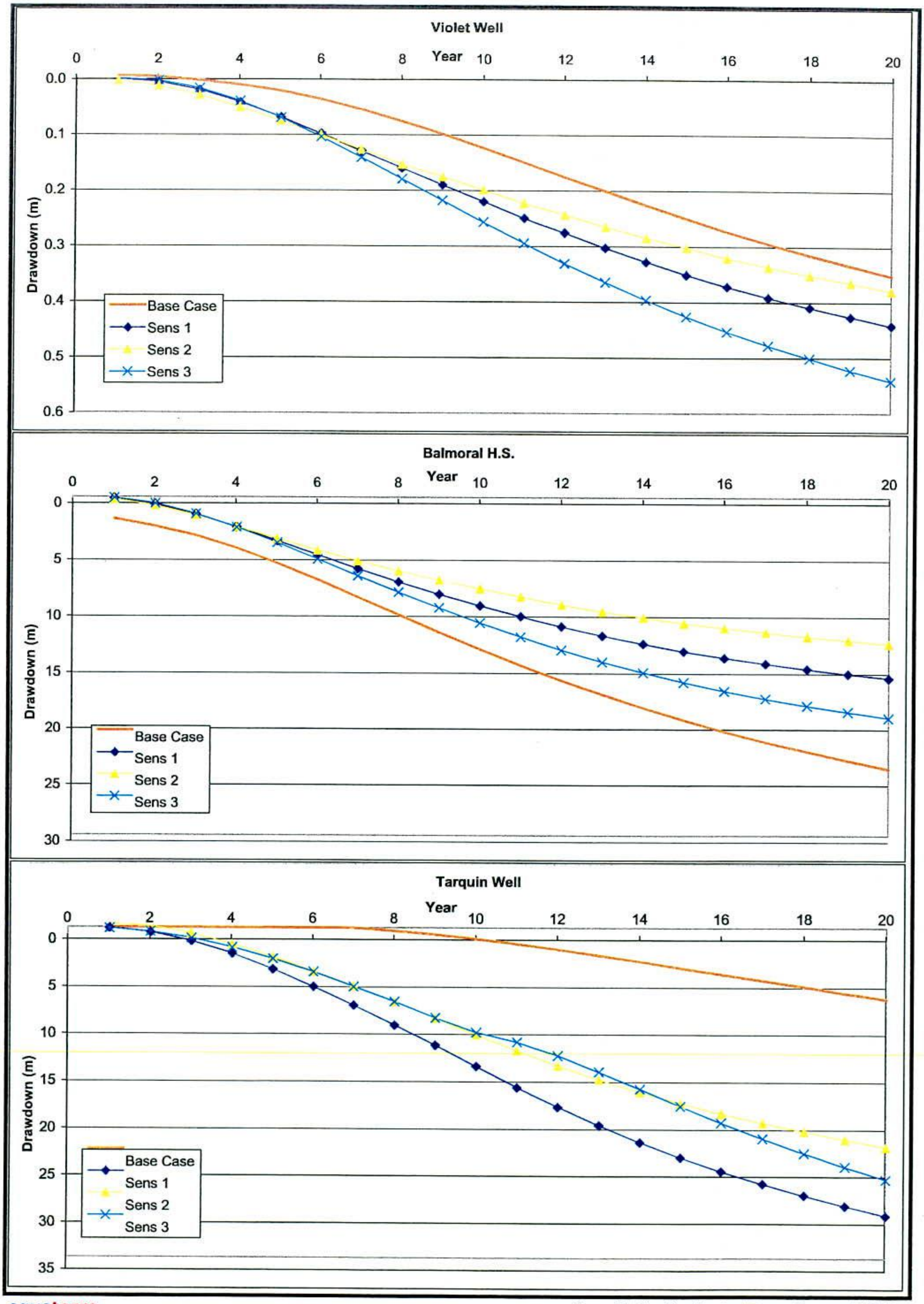
F:\templates\projman\[Cost 2000_2001d.xls]Budget

Sensitivity Analysis - Groundwater Inflow

Figure 14



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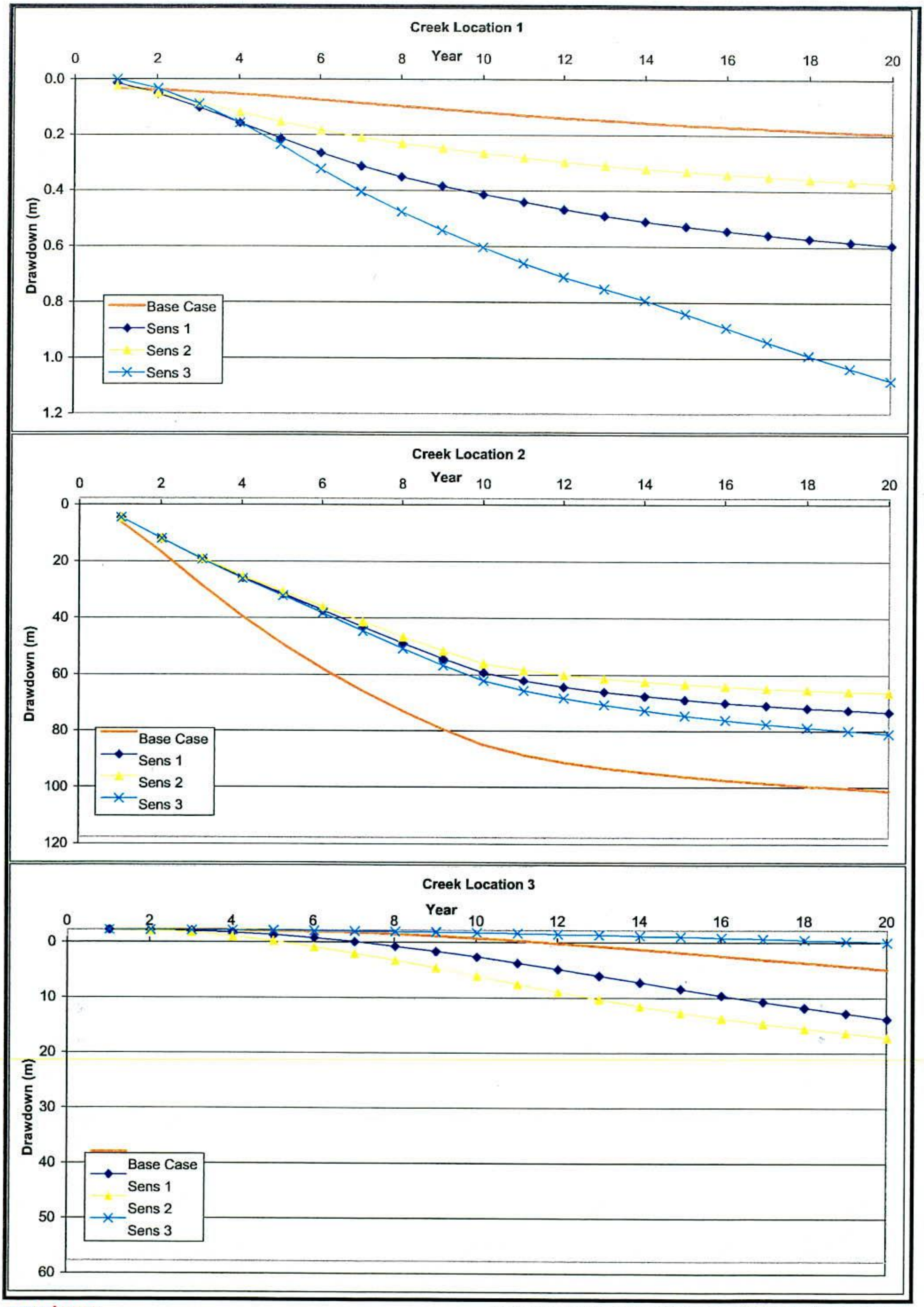
F:\jobs\132\E1\Modelling\[Dewatering Volumes.xls]Drawdown - Sens (1)

Sensitivity Analysis: Drawdown at Wells

Figure 15



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Sensitivity Analysis: Drawdown at Drainage Paths

F:\jobs\132\E1\Modelling\[Dewatering Volumes.xls]Drawdown - Sens (2)

Figure 16

Appendix C

Austeel Project, Yearly Projections of CO_{2-e} Emissions

Table 1: Yearly Projections of CO2-e Emissions

Year	Overburden & Waste (Mt)	Natural Gas Usage (TJ)	Process Gas & Electricity Generation (10^3 t)	Upstream Gas Production (10^3 t)	**Natural Gas Full Fuel Cycle (10^3 t)**	ANFO Blasting (10^3 t)	Mobile Equipment (10^3 t)	Vegetation Clearing (10^3 t)	Domestic Wastewater (10^3 t)	**Total Emissions (10^3 t)**
1	0	0	0	0	**0**	0	143	2	0.11	**145**
2	0	0	0	0	**0**	0	143	3	0.11	**146**
3	34	22,363	1,159	194	**1,353**	1	224	5	0.11	**1,583**
4	59.6	89,450	4,637	774	**5,411**	2	143	5	0.02	**5,562**
5	59.6	89,450	4,637	774	**5,411**	2	143	6	0.02	**5,562**
6	59.6	89,450	4,637	774	**5,411**	2	143	6	0.02	**5,563**
7	59.2	89,450	4,637	774	**5,411**	2	142	7	0.02	**5,562**
8	57.6	89,450	4,637	774	**5,411**	2	138	7	0.02	**5,559**
9	57.6	89,450	4,637	774	**5,411**	2	138	7	0.02	**5,559**
10	57.6	89,450	4,637	774	**5,411**	2	138	8	0.02	**5,560**
11	57.6	89,450	4,637	774	**5,411**	2	138	8	0.02	**5,560**
12	57.2	89,450	4,637	774	**5,411**	2	137	7	0.02	**5,558**
13	57.6	89,450	4,637	774	**5,411**	2	138	6	0.02	**5,558**
14	57.6	89,450	4,637	774	**5,411**	2	138	5	0.02	**5,557**
15	54	89,450	4,637	774	**5,411**	2	129	5	0.02	**5,548**
16	54	89,450	4,637	774	**5,411**	2	129	5	0.02	**5,548**
17	53.6	89,450	4,637	774	**5,411**	2	128	5	0.02	**5,547**
18	54	89,450	4,637	774	**5,411**	2	129	5	0.02	**5,548**
19	54	89,450	4,637	774	**5,411**	2	129	5	0.02	**5,548**
20	54	89,450	4,637	774	**5,411**	2	129	5	0.02	**5,548**
21	54	89,450	4,637	774	**5,411**	2	129	5	0.02	**5,548**
22	54	89,450	4,637	774	**5,411**	2	129	5	0.02	**5,548**

Appendix D

Atmospheric Emissions Modelling

SINCLAIR KNIGHT MERZ

FACSIMILE

To:	Halpern Glick Maunsell	**From:**	Jon Harper
Attention:	Filipe Dos Santos	**Project No:**	WV02263
Fax No:		**Date:**	15 February, 2002
Copies:		**No of Pages:**	1 of 10
Subject:	AQ Modelling Austeel		

Filipe,

As requested in your e-mail (dated 29th January 2002) please find attached the results and conclusion summary of the re-modelling of the Austeel air emissions. These results are based on:

- A second Pellet Plant with emissions identical to the first Plant;
- DRI emissions remaining the same; and
- Two additional gas turbines at the power station.

Yours sincerely

Jon Harper
Environmental Scientist

Phone: (08) 9268 9650
Facsimile: (08) 9268 9625
E-mail: jharper@skm.com.au

Halpern Glick Maunsell
AQ Modelling Austeel
15 February, 2002

1. Introduction

This report has been prepared by Sinclair Knight Merz to assess the air quality impacts of a second pellet plant and two additional gas turbines for Austeel Pty Ltd proposed Hot Briquetted Iron (HBI) project at Cape Preston.

2. Modelling Methodology

2.1 Methodology

To ensure that the modelling conformed to the previous air quality modelling conducted by Sinclair Knight Merz the same meteorological file was used (Karratha – September 1998 to August 1999). The same ISCPRIME input files were also used with the following changes:

- An additional pellet plant was added with emissions identical to the original; and
- Two additional gas turbines were added to the power station with emissions identical to the original two.

2.2 Locations

For the purpose of this modelling exercise the additional pellet plant was created adjacent to and as a mirror of the existing proposed pellet plant. The additional gas turbines were located in line with the existing proposed turbines.

3. Results – ISCPRIME

3.1 NO_2 Levels

The updated maximum one hour and one year average concentration predictions for NO_2 are presented in **Figures 3.1** and **3.2** and summarised in **Table 3.1**. These results indicate that the maximum concentrations will occur on elevated terrain seven kilometres to the east and that there will be no exceedances of the NEPM standard. As these standards are only applicable beyond the Austeel lease and buffer area the concentrations of NO_2 beyond these parameters will be even lower. This indicates that NO_2 concentrations from the proposed development, even with the increased emissions will not be an issue.

Unlike the previous Austeel modelling, which was based on the assumption that at ground level 50% of NO_x is NO_2, these results are based on DEP monitoring from Dampier which was used in the assessment of the proposed Burrup Fertiliser plant (SKM, 2001). This assessment determined a conservative estimate of the conversion of NO to NO_2 to be determined by:

$$[NO_2] = 14.39 + 0.30x[NO_x] \quad NO_x > 20.56$$
$$[NO_2] = [NO_x] \quad NO_x < 20.56$$

where NO_x and NO_2 are in $\mu g/m^3$

Table 3-1 Updated predicted maximum ground level concentrations from ISCPRIME

Pollutant	NEPM standard ppm ($\mu g/m^3$)	Averaging Period	Highest predicted GLC ($\mu g/m^3$)	Percentage of NEPM Standard (%)	Number of exceedances
NO_2	0.12 (246) 0.03 (62)	1-hour 1-year	185 5.6	75.2 9.1	0 0
SO_2	0.20 (572) 0.08 (228) 0.02 (57)	1-hour 1-day 1-year	55.3 6.7 0.5	9.7 3.0 0.9	0 0 0
PM10	50 $\mu g/m^3$	1-day	57.7	115.3	2

Note: NEPM standard has been converted to $\mu g/m^3$ at 0° and 101.3 kPA.

3.2 Sulphur dioxide

The updated maximum one hour, maximum 24 hour and maximum one year average concentration predictions for SO_2 are presented in **Figures 3.3** to **3.5** and summarised in **Table 3.1**. As with the previous modelled results these indicate that the modelled SO_2 levels are well within the NEPM standards.

3.3 PM10

The updated maximum 24-hour predicted average concentrations of PM10 are presented in **Figure 3.6** and summarised in **Table 3.1**. The modelling results predict two exceedances of the NEPM standard, both of which occur within 500m of the plant. The concentration of PM10 outside the lease boundary, where the NEPM standards apply, will be lower and therefore compliant with the standards.

4. Conclusions

Remodelling has been conducted on the likely local air quality impacts of additional operating plants at the Austeel proposed HBI plant. The impact of an additional pellet plant and two additional gas turbines has been modelled with the USEPA air dispersion software ISCPRIME and Karratha meteorological data.

Although the local impacts of NO_2 and SO_2 have increased slightly with the addition of a second pellet plant and two additional gas turbines they are still well within the maximum concentrations allowed by the NEPM standards. There are two exceedances of particulate matter (PM10) both of which occur near the plant area though concentrations drop to 50% of the NEPM standard within 1.5 kilometres of the plant.

As in the previous report (SKM, 2000) it is concluded that the local impact from these pollutants will be minimal.

Halpern Glick Maunsell
AQ Modelling Austeel
15 February, 2002

Table 3-1 Updated predicted maximum ground level concentrations from ISCPRIME

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Halpern Glick Maunsell
AQ Modelling Austeel
15 February, 2002

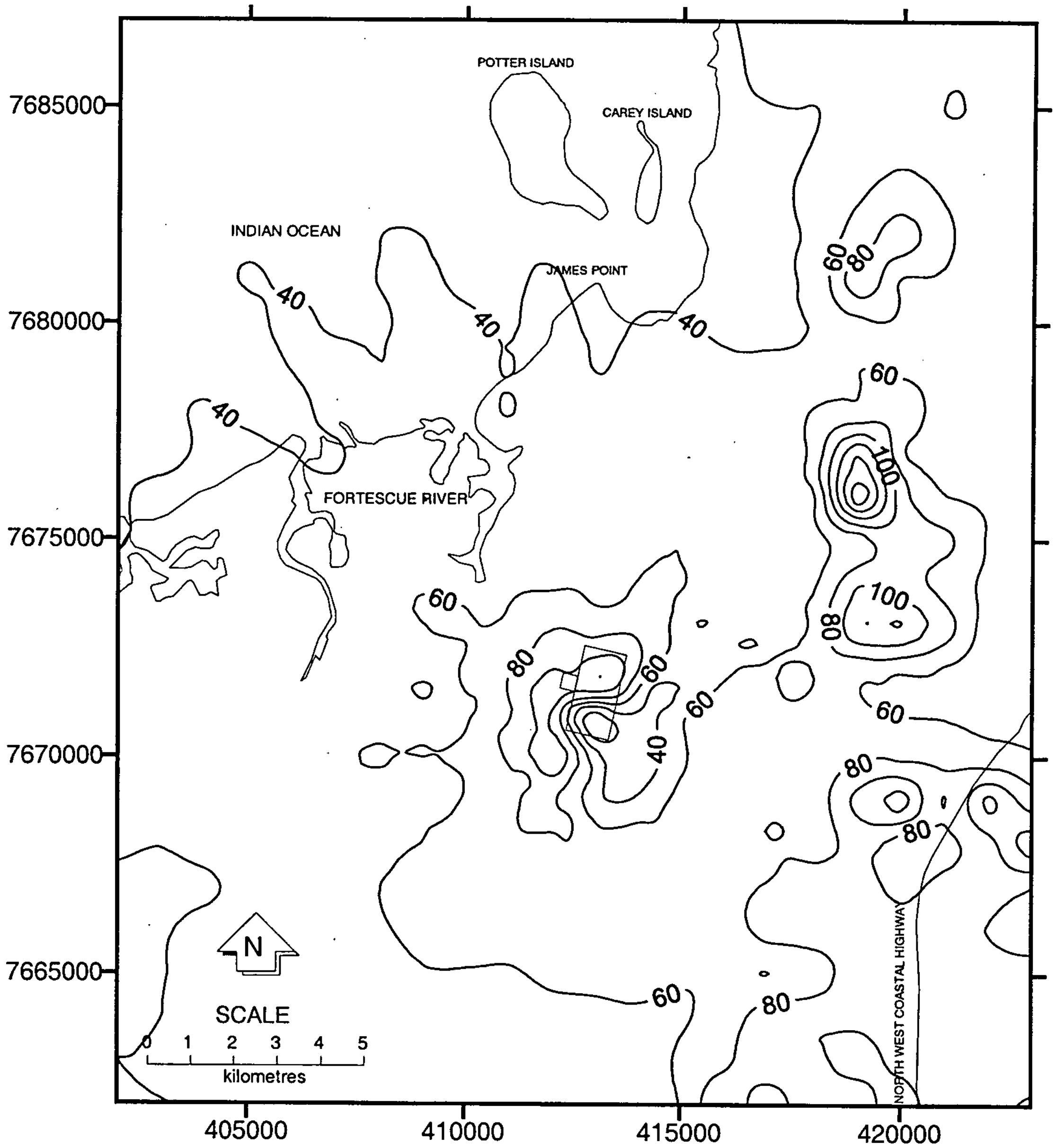

Figure 3-1 Predicted maximum 1 hour average ground level concentrations of NO_2 ($\mu g/m^3$) from ISCPRIME.

Halpern Glick Maunsell
AQ Modelling Austeel
15 February, 2002

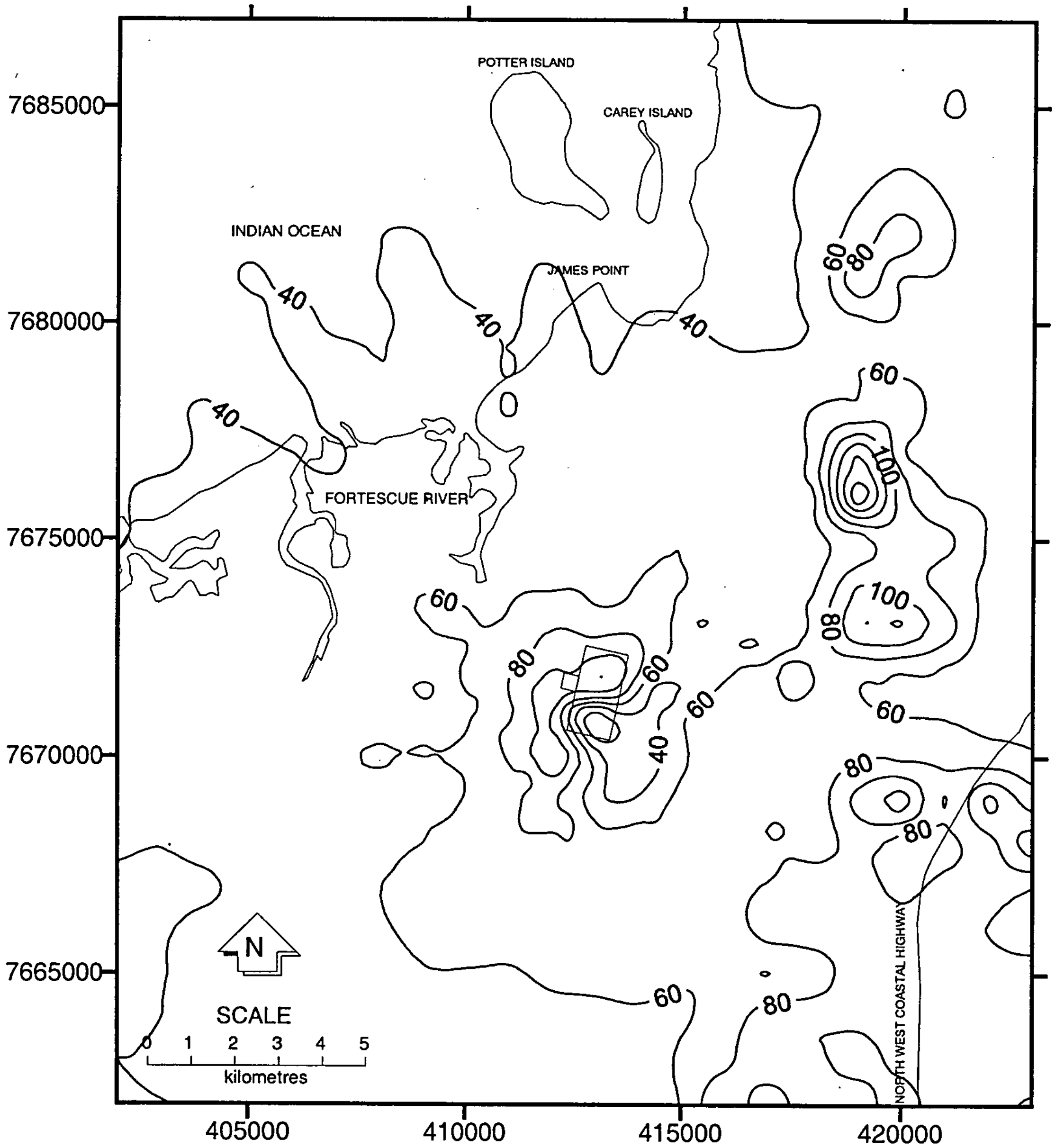

Figure 3-1 Predicted maximum 1 hour average ground level concentrations of NO_2 ($\mu g/m^3$) from ISCPRIME.

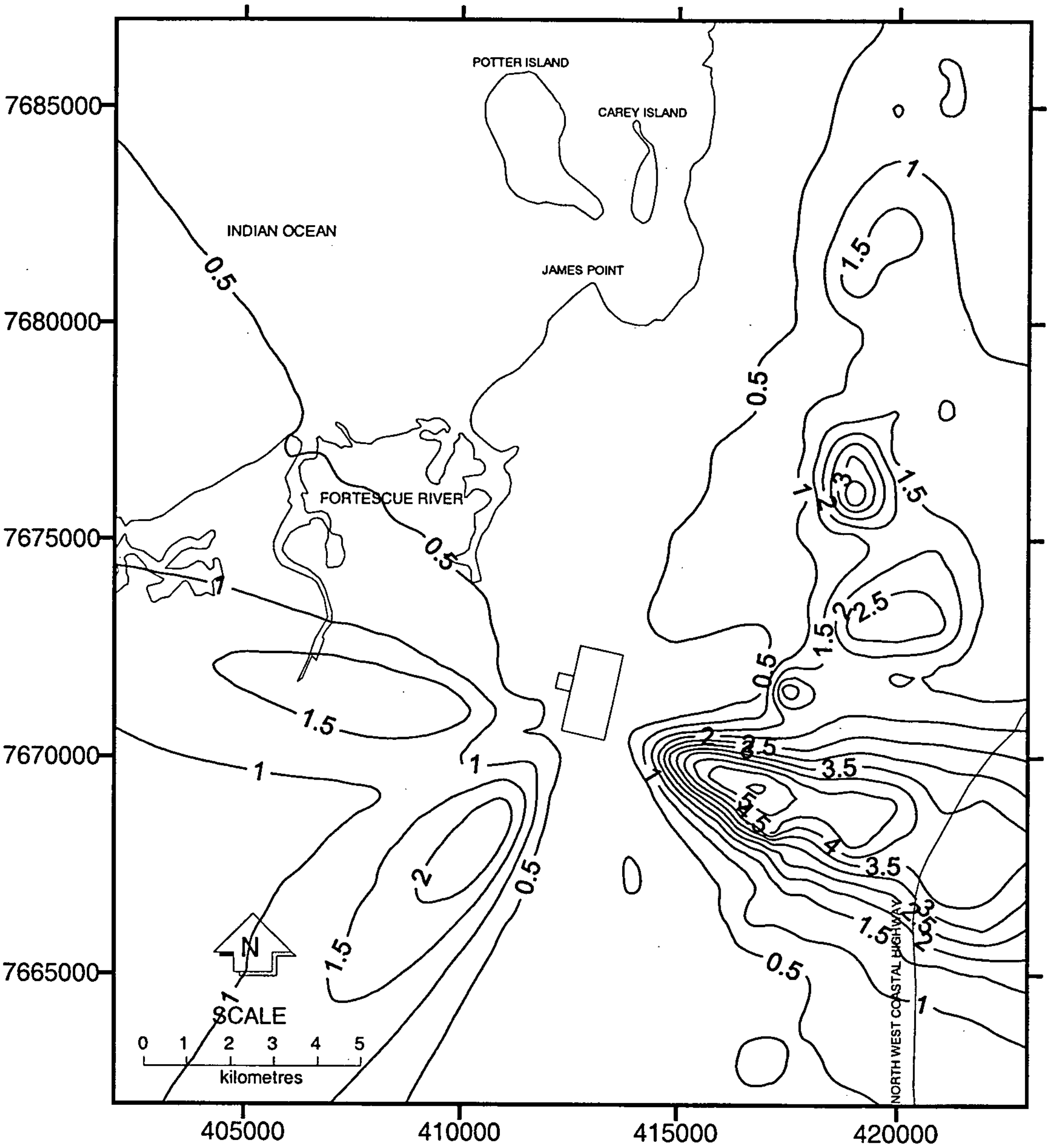

Figure 3-2 Predicted annual average ground level concentration of NO_2 ($\mu g/m^3$) from ISCPRIME

Halpern Glick Maunsell
AQ Modelling Austeel
15 February, 2002

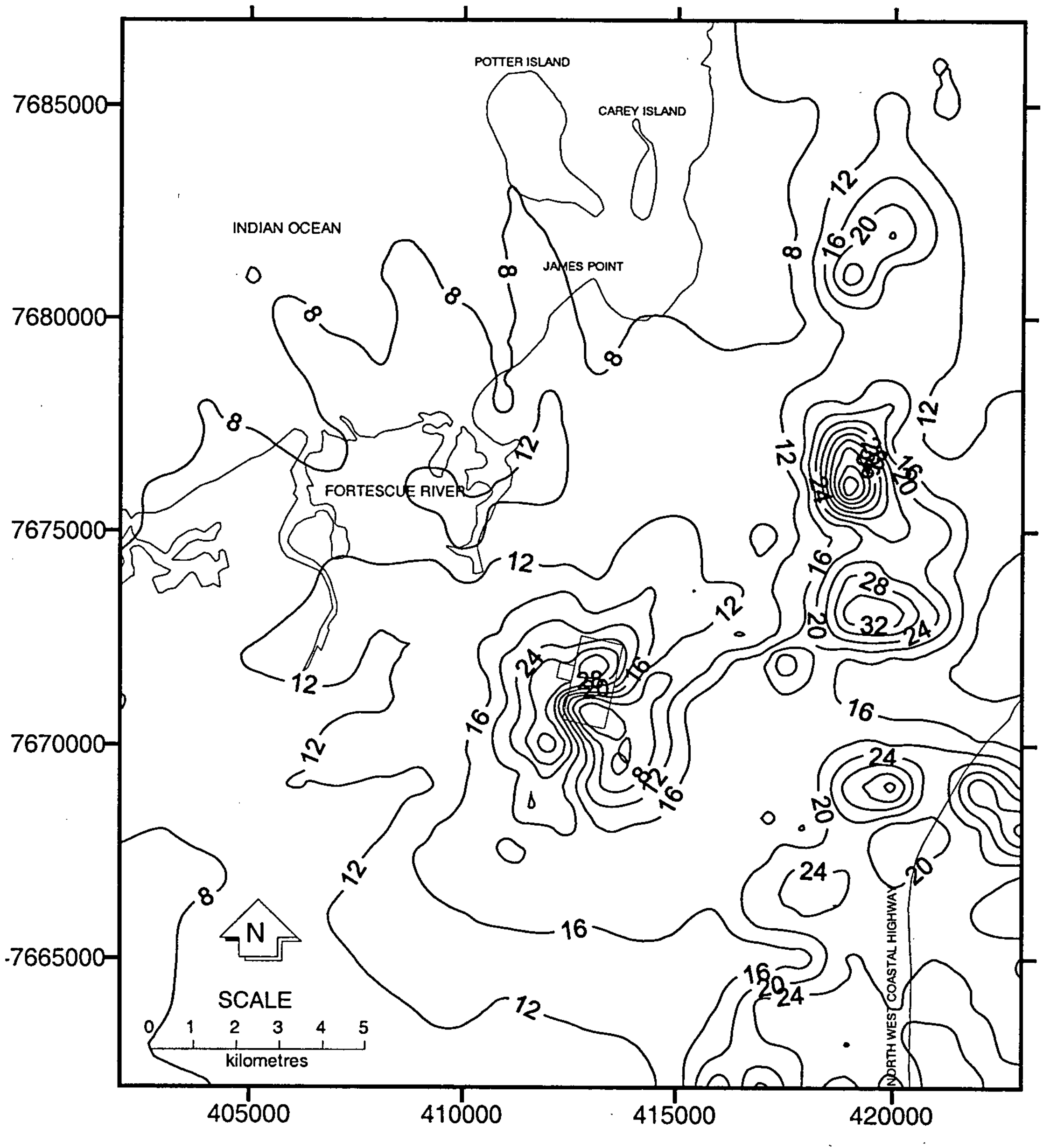

Figure 3-3 Predicted maximum 1 hour average ground level concentration of SO_2 ($\mu g/m^3$) from ISCPRIME.

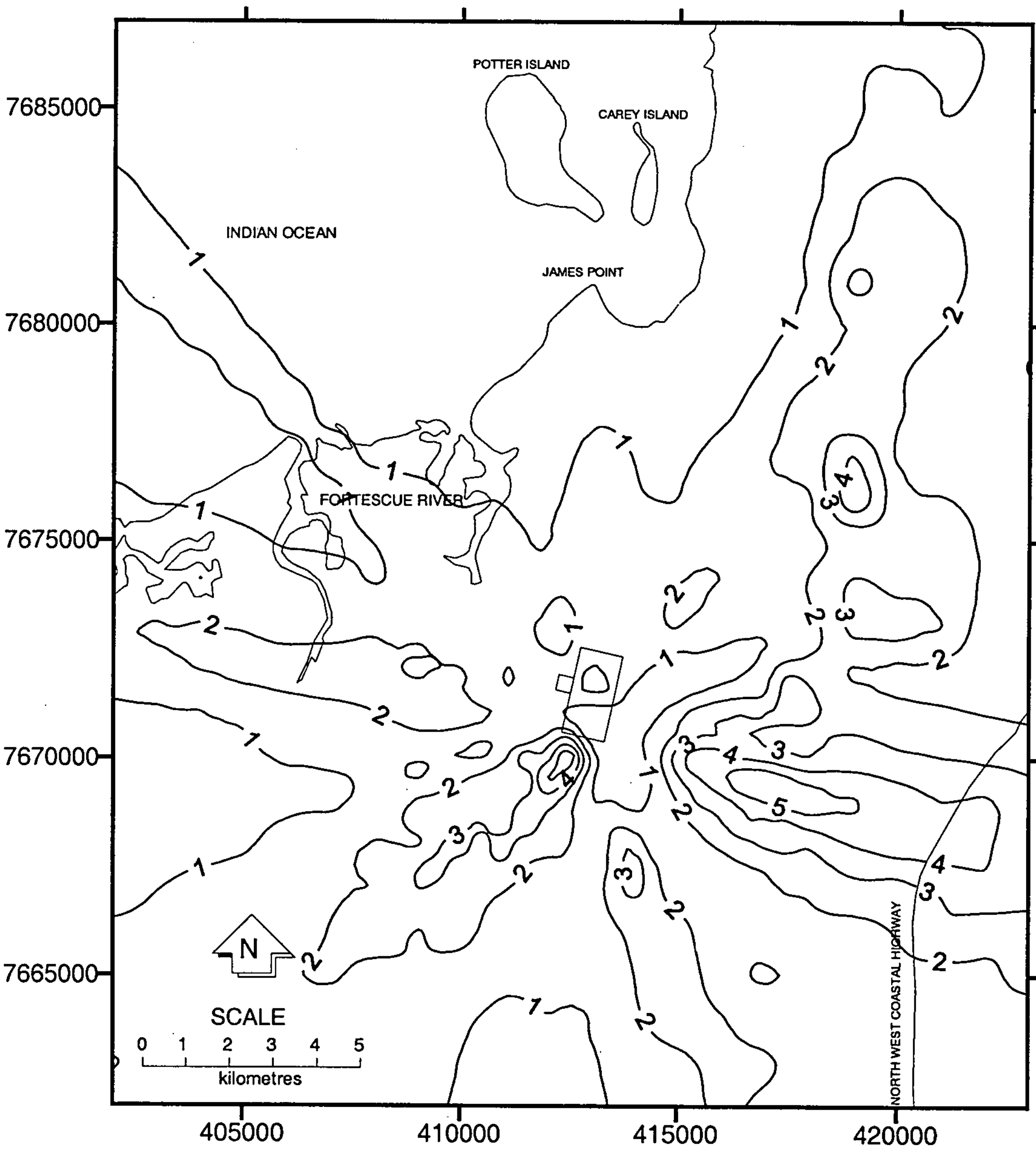

Figure 3-4 Predicted maximum 24 hour average ground level concentration of SO_2 ($\mu g/m^3$) from ISCPRIME.

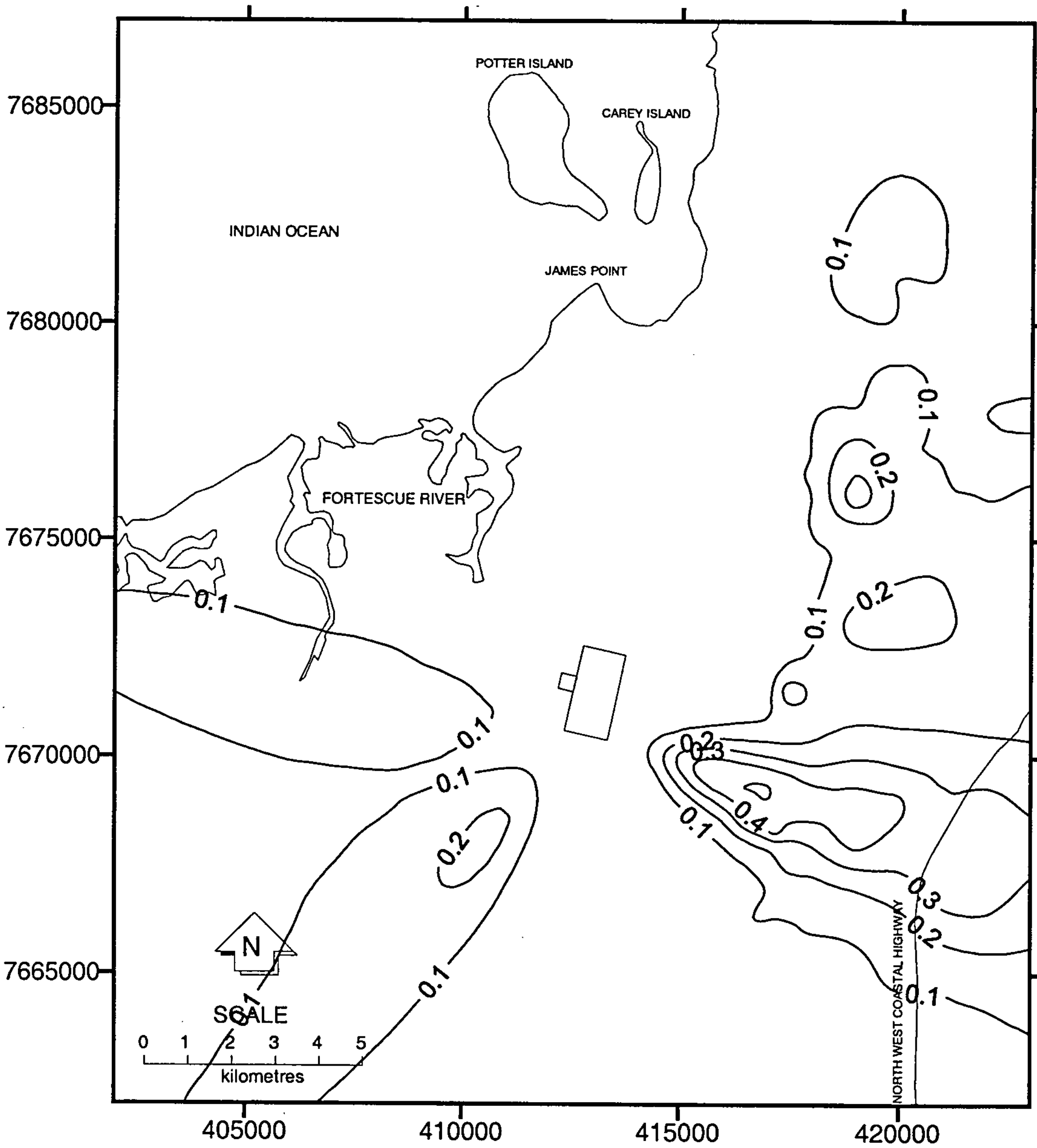

Figure 3-5 Predicted annual average ground level concentration of SO_2 ($\mu g/m^3$) from ISCPRIME.

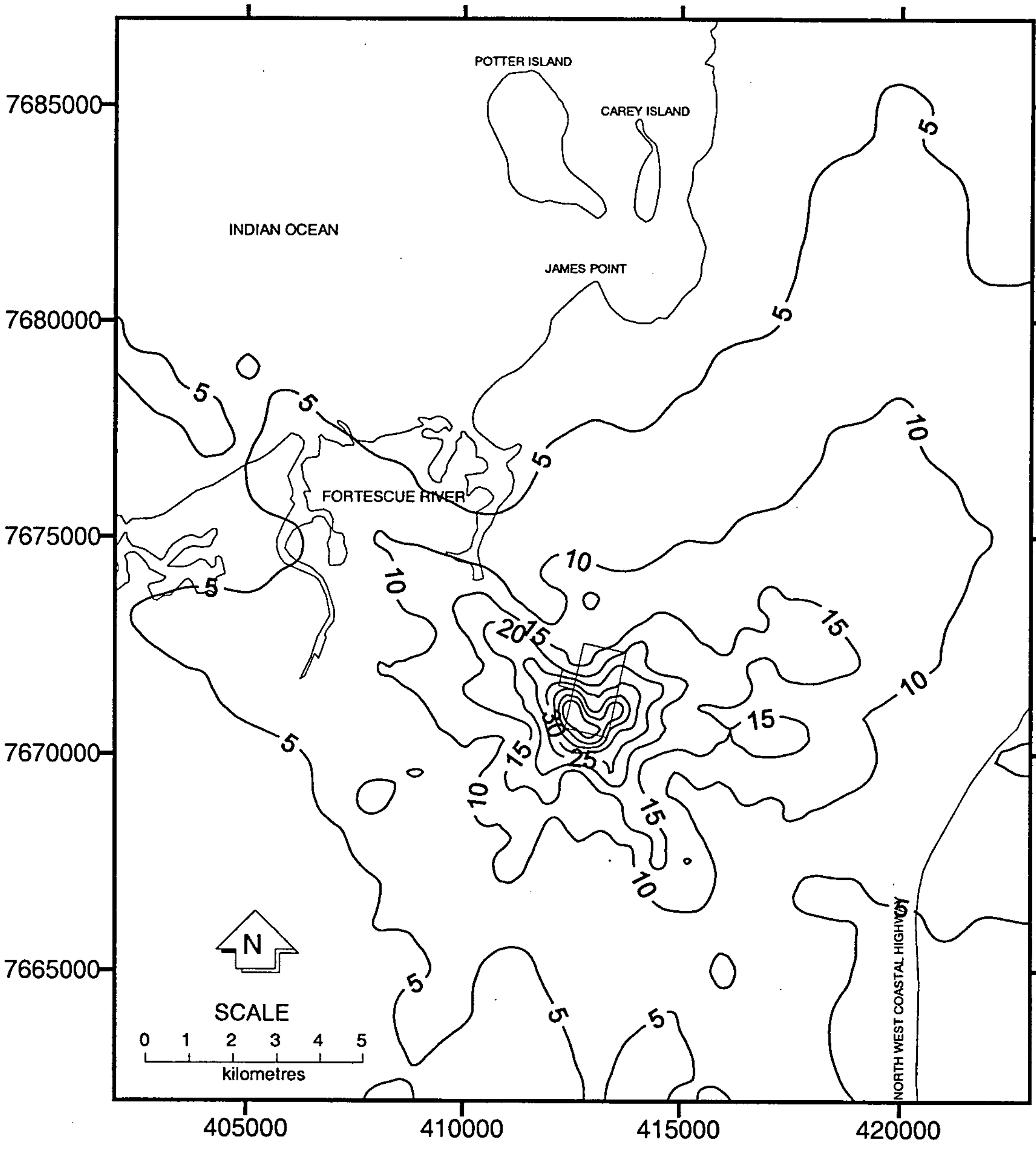

Figure 3-6 Predicted maximum 24 hour ground level concentration of PM10 ($\mu g/m^3$) from ISCPRIME.

Summary of Emission Parameters for the Austeel Project

Stack No.	Description	Easting (m)	Northing (m)	Stack Height (m)	Diameter (m)	Volume (wet) (kg/s)	Volume (wet) (Nm^3/hr)	Emission Temp (C)	Volume atxit exit Temp (m^3/s)	Velocit (m/s)	SO_2 (mg/Nm^3)	NOx (mg/Nm^3)	Dust (mg/Nm^3)	Volume (dry) (Nm^3/s)	SO_2 (g/s)	NOx (g/s)	Dust (g/s)	NO2/NOX (%)
Pellet Plant																		
A1	Main stack A	412,761	7,670,800	60	**8.25**		2,288,000	140	**961**	18	40	400	50	**578.4**	**23.13**	**231.34**	**28.92**	10
A2	Feed dedusting	412,825	7,670,782	20	**1.00**		46,800	58	**16**	20	0	0	50	**11.8**	**0.00**	**0.00**	**0.59**	
A3	Discharge dedusting A	412,837	7,670,955	20	**1.38**		93,600	40	**30**	20	0	0	50	**23.7**	**0.00**	**0.00**	**1.18**	
A3	Discharge dedusting B	412,837	7,670,955	20	**1.38**		93,600	40	**30**	20	0	0	50	**23.7**	**0.00**	**0.00**	**1.18**	
A4	Screen dedusting	412,867	7,670,971	20	**1.38**		93,600	40	**30**	20	0	0	50	**23.7**	**0.00**	**0.00**	**1.18**	
B1	Main stack B	412,761	7,670,800	60	**8.25**		2,288,000	140	**961**	18	40	400	50	**578.4**	**23.13**	**231.34**	**28.92**	10
B2	Feed dedusting	412,825	7,670,782	20	**1.00**		46,800	58	**16**	20	0	0	50	**11.8**	**0.00**	**0.00**	**0.59**	
B3	Discharge dedusting A	412,837	7,670,955	20	**1.38**		93,600	40	**30**	20	0	0	50	**23.7**	**0.00**	**0.00**	**1.18**	
B3	Discharge dedusting B	412,837	7,670,955	20	**1.38**		93,600	40	**30**	20	0	0	50	**23.7**	**0.00**	**0.00**	**1.18**	
B4	Screen dedusting	412,867	7,670,971	20	**1.38**		93,600	40	**30**	20	0	0	50	**23.7**	**0.00**	**0.00**	**1.18**	
DRI Plant																		
5.1	Main stack	412,768	7,671,120	60	**5.84**		688,000	340	**429**	16	7	165	20	**173.9**	**1.22**	**28.70**	**3.48**	50
5.2	Main stack	412,845	7,671,103	60	**5.84**		688,000	340	**429**	16	7	165	20	**173.9**	**1.22**	**28.70**	**3.48**	50
5.3	Main stack	412,952	7,671,079	60	**5.84**		688,000	340	**429**	16	7	165	20	**173.9**	**1.22**	**28.70**	**3.48**	50
6.1	Hot DRI dedusting	412,771	7,671,264	65	**1.58**		120,000	50	**39**	20	0	0	40	**30.3**	**0.00**	**0.00**	**1.21**	
6.2	Hot DRI dedusting	412,849	7,671,246	65	**1.58**		120,000	50	**39**	20	0	0	40	**30.3**	**0.00**	**0.00**	**1.21**	
6.3	Hot DRI dedusting	412,955	7,671,223	65	**1.58**		120,000	50	**39**	20	0	0	40	**30.3**	**0.00**	**0.00**	**1.21**	
7	Oxide handling dedust:	412,879	7,671,223	65	**1.02**		50,000	50	**16**	20	0	0	40	**12.6**	**0.00**	**0.00**	**0.51**	
8	Briquetting dedusting	412,992	7,671,200	65	**1.02**		50,000	50	**16**	20	0	0	40	**12.6**	**0.00**	**0.00**	**0.51**	
9	Passivation bin dedus1	412,966	7,670,992	25	**1.02**		50,000	50	**16**	20	0	0	40	**12.6**	**0.00**	**0.00**	**0.51**	
Power Station																		
1	Unit 1	412,420	7,671,700	40	5.80	519.2	**1,473,082**	540	**1219**	**46.12**	0	51.3	0	**379.4**	**0.00**	**19.47**	**0.00**	10
2	Unit 2	412,420	7,671,700	40	5.80	519.2	**1,473,082**	540	**1219**	**46.12**	0	51.3	0	**379.4**	**0.00**	**19.47**	**0.00**	10
3	Unit 3	412,420	7,671,700	40	5.80	519.2	**1,473,082**	540	**1219**	**46.12**	0	51.3	0	**379.4**	**0.00**	**19.47**	**0.00**	10
4	Unit 4	412,448	7,671,700	40	5.80	519.2	**1,473,082**	540	**1219**	**46.12**	0	51.3	0	**379.4**	**0.00**	**19.47**	**0.00**	10
													Total		**49.92**	**626.64**	**81.71**	

Notes
1. Normal is at 1 atmosphere and 0 degrees
2. Emission volumes for plant are wet at 0 deg C. Emission concentrations given as dry at 0 deg and 1 atmosphere
3 Emssion volume wet for plant converted to emission volume dry assuming 9% water vapour (Lurgi, 28/8/00), Gas Turbines have 7.27% water vapour.
4. Emission parameters except from the power station are from Lurgi fax of 12/7/00 to Ian McCardle of HGM.
5. Stack locations are obatined from site daigrams
6. Bolded are derived parameters from supplied data (unbolded)
7. NOX expressed as NO2 from power station is <25ppm,dry,15% O2
8. Emission parameters for power station are from (Siemans, 2000) letter of 19/7/00 to Ian McCardle of HGM. Gas turbines are open cycle V94.2 gas turbines with DLN burners

Appendix E

Brine Dispersion Modelling

INITIAL MIXING OF BRINE AT CAPE PRESTON

Prepared for:

HGM

Prepared by:

D.A. LORD & ASSOCIATES PTY LTD

FEBRUARY 2002

REPORT NO. 01/248/1

CONTENTS

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 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 3.1.

Table 3.1 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.

[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.

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 3.1. 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 Discharges. 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.