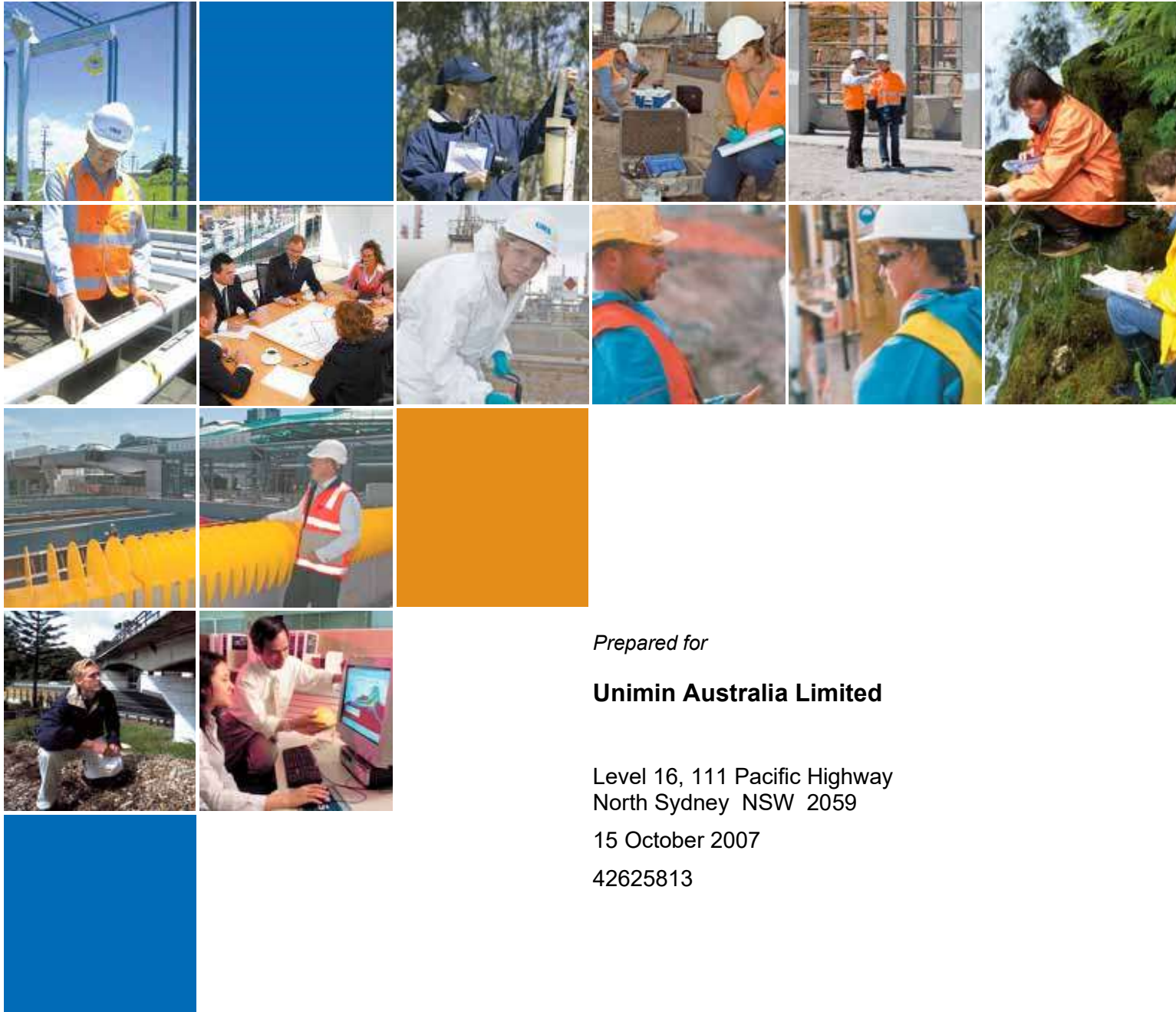


REPORT

Environmental Studies Report for Vance Mining Lease (ML1108), North Stradbroke Island, Queensland



Prepared for

Unimin Australia Limited

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15 October 2007

42625813

URS

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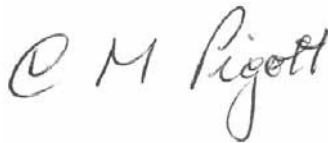


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B.	EPA Response to Draft ESR August 2005
C.	Proposal for Additional Studies
D.	EPA Stage 1 Approval for ML 1108
E.	Ecological Report (2005)

Tables, Figures, Plates, Drawings Appendices

- F. Flora Report (2006)
- G. Fauna Report (2006)
- H. Unimin Australia Stakeholder Consultation Report
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Executive Summary

Background

Unimin Australia Limited (Unimin) and its precursors have been mining on North Stradbroke Island for over 35 years to supply glass grade silica sand to local, interstate and international glass works. Current operational leases include Mining Lease (ML) 7064 and 1124 and a small section of ML1108 (Vance Lease Stage 1).

Unimin proposes to continue sand mining activities currently being undertaken in the Stage 1 area of ML1108, and expand its operations across the entire lease. Under the provisions of the Queensland Environmental Protection Act 1994, the Queensland Environmental Protection Agency (EPA) has issued Unimin an Environmental Authority (EA MIM900220203) to undertake sand mining and processing activities on North Stradbroke Island (refer Appendix A). As required by Condition A4-3(a) of the EA, an Environmental Studies Report (ESR) has to be completed by Unimin before mining operations are conducted. An ESR (this report) has been developed by Unimin to satisfy this condition of the EA.

Summary of ESR Findings

A series of environmental studies has been undertaken on ML1108 between 2005 and 2007. Initial studies in 2005 focussed on a review of existing environmental data for the area plus limited field based investigations. Phase two studies undertaken between 2006 and 2007 comprised more detailed field studies, with Unimin developing a scope of work in close consultation with EPA. The following table provides a summary of study findings including baseline environmental assessment findings, potential impacts and proposed mitigation measures.

Table ES-1: Summary of ESR Findings

Study	Baseline Results	Potential Impacts	Mitigation Measures
Terrestrial Flora	134 taxa representing 46 families. No incidence of weed species were found occurring at any survey sites No commercially/recreationally significant species identified; Three culturally significant species were identified; Two species of state conservation significance under the NC act were identified; Four vegetation communities were identified including one "Of concern" Regional Ecosystem (RE 12.2.13) under the State VM act; Two RAMSAR areas are designated by the Commonwealth outside of the mining area. However these areas were ground truthed and in actuality terrestrial woodland communities.	Removal of up to 378 ha of vegetation including 4.6 ha of the 'Of concern' RE 12.2.13; Clearing areas that contain two species of state conservation significance and three species of cultural significance; Some potential for introduction of weed species associated with mining activity. Some potential for dust impacts	Creation of conservation areas/mining exclusion zones around sensitive areas and vegetation communities; Staged clearing with relatively small areas of lease impacted by mining activity at any one time; Continual progressive revegetation of cleared areas; Monitoring of rehabilitation against success targets.; Propagation of the two species of state conservation significance and three species of cultural significance within rehabilitation; Weed management including staff education and machinery wash down.

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Study	Baseline Results	Potential Impacts	Mitigation Measures
Terrestrial Fauna	92 native species and five introduced species identified; Six species of conservation significance recorded; No endangered or critically endangered species recorded in areas to be mined; Wet heath and riparian vegetation identified as the most significant fauna habitat on the lease.	Potential loss of nesting and foraging habitat for significant fauna species; Disruption of fauna movement corridors; Disturbance to fauna from operational activities such as increased noise and human activity.	Establish 100 m buffers on either side of Cooroon Cooroonpah Creek protecting habitat for species such as the Wallum Sedge Frog; Development of an amphibian monitoring plan No mining operations in Ramsar areas Protect habitat corridors for fauna movement; Protection of open forest/woodland and casuarinas; Progressive rehabilitation using endemic species;
Cultural Heritage	Eight archaeological sites located in three areas; Australian Heritage Database indicates no listings of national indigenous significance;	No predicted impacts.	Development and implementation of a Cultural Heritage Management Plan (CHMP).
Geomorphology and Soils	Predominantly Pleistocene sand dune deposits present; Five land units identified; Uniform soils across lease dominated by white silica sands that have high porosity, low fines content and contain low levels of most plant nutrients. Usable topsoil resources confined to surficial horizon material (approx. 0.4 m deep)	No significant features registered on Australian Heritage Database are present on the lease.	Topsoil management measures. Erosion and sediment control measures.

Executive Summary

Study	Baseline Results	Potential Impacts	Mitigation Measures
Groundwater	Groundwater elevations range from approx. 8m to 44m AHD; Regional flow in a west to north direction, with a groundwater divide identified close to SE boundary of lease; Very high infiltration rates (23m/day); Groundwater is primarily recharged by rainfall infiltration; Perched aquifer only identified along Cooroon Cooroonpah Ck; Groundwater discharge principally occurs into freshwater streams/swamps; Groundwater quality includes low pH, low conductivity and low dissolved metals; Nearby water bodies such as Swallow Lagoon and Brown Lake are perched and don't appear to be influenced by the regional groundwater table.	Groundwater contamination from accidental discharge of fuel;	Appropriate location of fuel storage and handling areas; No mining operations within 100m of Cooroon Cooroonpah Creek. No mining below the water table. Groundwater monitoring program
Surface Water	Minimal surface runoff (rare occurrence); Cooran Cooroonpah Creek is major drainage line on lease and is considered to be representative of a lowland freshwater stream in South-East Queensland (eg. low pH, low conductivity, low turbidity and metal concentrations);	Increased runoff from vegetation clearing (unlikely); Disturbance of sediment or contamination (low probability); Changes to site drainage.	No mining operations within 100m of Cooroon Cooroonpah Creek; Appropriate location of fuel storage and handling areas; Surface water monitoring program
Dust	Major sources include bulldozing operations at the mine face and heavy vehicle movements; Closest sensitive receptors are at Boronia Ct (Myora Springs Estate) and Illawong St in Dunwich; Existing dust concentrations and deposition rates well below Queensland guidelines.	Predicted dust concentration and deposition rates below Queensland guidelines.	No significant mitigation measures proposed.
Noise	Major sources include bulldozers, loaders and haul trucks; Existing noise emissions are within licence conditions and indicate low background and intrusive levels.	Predicted noise emissions within licence conditions.	Siting of mobile plant behind walls of extraction site for long term noise protection.
Road Transport	Road network well under capacity.	No additional traffic impact to existing road infrastructure; No road deterioration.	Tazi Road as a potential future lease access and haulage route.

Executive Summary

Study	Baseline Results	Potential Impacts	Mitigation Measures
Socio-Economics	Demographics of immediate area reflective of Great Stradbroke Island demographics.	No predicted changes to demographics.	No mitigation measures proposed.
Community Consultation	Community consultation undertaken for development of ToR and review of initial Draft ESR. Initial Draft ESR was limited in site specific environmental baseline studies	Site specific impacts of mining operations may not have been fully identified/assessed	Project ToR and scope amended to reflect community concerns where appropriate and new more detailed studies undertaken

Proposed Environmental Management Controls

Unimin has developed a Plan of Operations for its 1-3 Year Mine Plan area in ML1108. This outlines the proposed mitigation measures to be adopted to minimise environmental impacts. This plan will be amended to cover the entire lease as required to incorporate any additional controls as identified in the ESR.

Section 1

Introduction

1.1 Background

Unimin Australia Limited (Unimin) and its precursors have been mining on North Stradbroke Island for over 35 years to supply glass grade silica sand to local, interstate, and international glass works. Current operational leases include Mining Lease (ML) 7064 and 1124 and a small section of ML1108 (Vance Lease Stage 1).

The proposed project involves the continuation of sand mining activities currently being undertaken in the Stage 1 area of ML1108. ML1108 is situated approximately 4km north-east of the township of Dunwich, North Stradbroke Island, Queensland (refer Figure 1.1). This lease is held by Unimin and it is proposed to be mined for silica sand and heavy minerals (as a bi-product). Continuation of the mining process currently underway on ML 7064 into ML 1108 will enable the infrastructure to remain in its current location (on ML 1124), allowing Unimin to minimise the impact to the environment/community of any infrastructure relocation.

Under the provisions of the Queensland Environmental Protection Act 1994, the Queensland Environmental Protection Agency (EPA) has issued Unimin an Environmental Authority (EA MIM900220203) to undertake sand mining and processing activities on North Stradbroke Island (refer Appendix A). As required by Condition A4-3(a) of the EA, an Environmental Studies Report (ESR) has to be completed by Unimin before mining operations are conducted. An ESR (this report) has been developed by Unimin to satisfy this condition of the EA.

1.2 Previous Studies Undertaken

A draft ESR was developed and submitted to EPA in August 2005. EPA and local stakeholders provided a series of comments to Unimin on this draft ESR on 27 September 2005 (refer Appendix B). In response to these comments, Unimin in consultation with EPA scoped a series of additional studies (refer Appendix C for details of scope).

An ESR for a Stage 1 (3 year mine plan area) in ML1108 was submitted to the EPA in October 2006. EPA subsequently reviewed and approved the Stage 1 ESR in December 2006 (refer Appendix D). This allowed Unimin to commence mining operations on a small section of ML1108 prior to submitting this ESR for the entire Vance lease.

1.3 Format of this Environmental Studies Report

This environmental studies report consolidates the results of the August 2005 draft ESR, October 2006 Stage 1 ESR and subsequent specialist studies into a single report. A summary of all specialist studies undertaken between 2005 and present have been incorporated into this report, with a copy of all separate specialist studies included as appendices. Accordingly, this report can be read as a stand alone document.

This ESR provides an initial description of the proposed mining activities. It also presents the findings of a number of environmentally related studies including terrestrial flora, terrestrial fauna, cultural heritage, soils and geomorphology, groundwater, surface water, air (dust), noise, transport and socio-economics. A summary of the study methodologies (section 3), study results (section 4), description of potential impacts and mitigation measures (section 5) and conclusions (section 6) has been provided.

Section 2

Description of Mining Activity

The project involves the conduct of sand mining activities on ML 1108. As an overview, dune sand shall be excavated from a shallow pit at the rate of up to 1 million tonnes per year. The sand will be processed using existing facilities on ML1124 by gravity means to remove impurities, producing high purity silica sand used mainly for glass manufacture. Heavy minerals will also be separated during the process as a bi-product and will be sold in bulk to external mineral sand companies.

2.1 Mining

Within the proposed mine path, vegetation shall be cleared weekly using a bulldozer in increments of approximately 30 metres in front of the active mine face. This approach minimises the amount of disturbed land at any one time while providing adequate mining access to sand resources. The topsoil will then be stripped to a depth of approximately 30-40 cm. Both the vegetation and topsoil will be stockpiled for use in rehabilitation. No burning of cleared vegetation shall occur on site.

Mining will be carried out by excavating the leached A2 horizon of sand to its base, identified by the hard (indurate) layer. As it is a dry mining operation, no mining below the water table shall occur. The sand will be excavated using a front end loader (FEL) and loaded into a feed hopper via a grizzly, which removes large objects such as tree roots. Water shall be added to the sand in a pump box forming slurry, so the material can be pumped. The sand slurry will then enter a trommel where more organic and oversized material is removed before the slurry is pumped back to ML 1124 for processing.

Water used in this process shall be sourced from ML 1124 where it will be pumped from recirculated process water dams. About 80L/sec of water will be used in the process to mine approximately 200 tonne/hour of plant feed, which can include up to 0.75 tonnes/hour in heavy minerals.

High concentration mineral sand will occasionally be targeted in certain areas. This will involve moving the feed hopper to the target location and commencing operations as above.

Exploration drilling and analysis has and will continue to be undertaken to determine the quality and quantity of the dune sand resource during the project. This information will be used to ensure all viable resources are targeted within the mine path. A 3 year mine plan of operations (refer Appendix E) has been developed which outlines Unimin's approach to mining the Stage 1 3 year mine plan area. This plan will be updated to cover the entire lease following completion of the lease exploration drilling program. Figure 2.1 provides an outline of the lease mine footprint. This figure should be considered indicative at present, with the final lease mining footprint subject to the findings of the exploration drilling program.

2.2 Processing

Processing of the slurry pumped from the mine face will occur at the existing processing plant located on ML 1124 (Figure 1.1). **No processing beneficiation activities will be undertaken on ML 1108.**

At the processing plant, the sand will undergo gravity separation through a series of spirals to remove heavy minerals, fine silica and clays. The silica sand product will then be stockpiled by radial stackers. Heavy mineral product will be concentrated and stockpiled separately.

Reject material consisting of the fine silica and clay will be pumped away with process wash water and settled in sedimentation dams on ML1124. Once settled, the solids will be used as backfill for rehabilitation and the water recycled back into the plant.

Final product will then be taken to Dunwich wharf by truck and barged to the Port of Brisbane. From here it will either be distributed to local/interstate markets or loaded onto ships for export.

Section 3

Environmental Studies Methodology

A series of studies has been undertaken to address the EPA's required scope of work. These have included:

- Terrestrial flora;
- Terrestrial fauna;
- Cultural heritage;
- Geomorphology and soils;
- Ground water;
- Surface water;
- Dust;
- Noise;
- Road transport;
- Socio-economics; and
- Community Consultation.

A summary of the methodology employed for the studies is provided below. Full details of the methodology are contained within the individual technical reports (refer to the appendix section of this ESR).

3.1 Terrestrial Flora

An initial flora survey was undertaken by URS Australia Pty Ltd (URS) on the Vance lease (ML 1108) on 13 January 2005. The primary objective of the initial survey was to ground truth 1:100,000 regional ecosystem mapping version 5.0 (EPA, 2005) and investigate areas of vegetation categorised as 'Category B' areas at the time of survey. A detailed description of survey effort and sampling methodology employed for the 2005 survey is provided in Appendix E.

A secondary flora survey was undertaken over a seven day period between 6 and 12 of March 2006. This survey was undertaken in accordance with an agreed methodology established in consultation with the Queensland Herbarium, as a supplementary program to the initial flora studies undertaken, to account for the unseasonably dry conditions encountered in the 2005 survey, and to establish permanent reference sites for rehabilitation benchmarks.

The 2006 survey methodology employed 15 secondary transects to record floristic and structural data of vegetation associations found on the ML 1108 lease area. In addition five permanent representative primary transects were established to record benchmark data within each of the vegetation communities. This was additional to the data recorded at the 10 secondary transects used for the initial site assessment undertaken in January 2005. Figure 3.1 provides details on survey transect locations. A detailed description of survey effort and sampling methodology employed for the 2006 survey is provided in Appendix F.

A 2006 secondary spring flora survey was also undertaken to account for seasonal variability and identify any flowering species not identified in the two previous summer survey programs. This survey was carried out on 28 September 2006 and comprised a one-day vehicle based survey as detailed in Appendix F.

Potential impacts to flora from the proposed mining operations have been assessed and a number of potential management and mitigation measures have been identified (refer Section's 5.1 and 5.2).

Section 3

Environmental Studies Methodology

3.2 Terrestrial Fauna

An initial preliminary terrestrial fauna survey of the primary habitat in ML 1108 was undertaken in January 2005. Full details of the methodology and survey effort employed for the 2005 fauna survey are provided in Appendix E. The 2005 survey was then followed by a comprehensive vertebrate terrestrial fauna survey undertaken by Ecological Management Services (EMS) Pty Ltd between 7 and 17 March 2006 (Appendix G), in accordance with methods developed in consultation with the Queensland Parks and Wildlife Service in November 2005.

The 2006 survey employed sampling at six systematic survey sites in the various primary habitats of ML 1108 (Figure 3.2), while general observations from other sites and areas were also compiled. Observational records from Swallow Lagoon (located to the south-west of ML 1108) were compiled during a one-hour inspection of this site. Standard biological survey techniques were used during field surveys, including a number of live capture/release trapping techniques, standard and general observational and habitat searches, as well as methods to indirectly detect the presence of terrestrial fauna. The survey focussed on terrestrial vertebrate taxa, however a number of freshwater sites were also sampled for aquatic and semi-aquatic species along Cooroon Cooroonpah Creek within the study area.

The survey design was based on the methodology used for the Queensland Systematic Vertebrate Fauna Survey Project in the South East Queensland Bioregion (CRA Queensland/RFA Steering Committee 1997). Site-specific survey methodologies were also employed to comply with the requested methodology outlined by the Queensland EPA (G Lundie-Jenkins pers. comm., November 2005). Table 2.1 of the EMS Report in Appendix G provides a summary of the standard methods and survey effort undertaken for this study.

Potential impacts to fauna from the proposed mining operations have been assessed and a number of potential management and mitigation measures identified (refer Section's 5.3 and 5.4).

3.3 Cultural Heritage

Unimin contracted the Minjerribah-Moorgumpin Elders-in-Council Aboriginal Corporation as the Cultural Heritage Body for North Stradbroke Island to undertake a cultural heritage study for the entire project area. Mr Shane Coghill and the University of Queensland Archaeological Service Unit were subcontracted as cultural heritage assessors to assist the Elders-in-Council with particular aspects of the project (Prangnell *et al.*, 2005). The study complies with Part 6 of the Aboriginal Cultural Heritage Act 2003.

A detailed review of previous cultural heritage studies for North Stradbroke Island was undertaken as part of the project. To assess specific cultural heritage aspects of the Vance Lease area, a total of 37.42 km of transects were surveyed in the first half of 2005. This equated to a survey area of some 374 ha, or approximately 55% of the lease area.

To ensure the protection of cultural heritage aspects of the lease area, Unimin in consultation with the Elders-in-Council has developed a Cultural Heritage Management Plan (CHMP) for the project. The CHMP details the measures and activities to be undertaken to manage Aboriginal Cultural Heritage in the lease area.

3.4 Geomorphology and Soils

A terrain analysis was carried out by GJR Holdings Pty Ltd to characterise the general terrain features in terms of geology, geomorphology and soil conditions within the lease area. The analysis generally followed the guidelines for Environmental Management of Exploration and Mining in Queensland in accordance with the requirements of the Queensland Department of Natural Resources and Mines (NRM - 1995), now administered by the EPA.

Preliminary terrain mapping based on air photo interpretation and a review of existing information (e.g. government databases, previous reports, maps) was carried out to provide a basis for the field investigation and soil sampling operations.

Section 3

Environmental Studies Methodology

Phase one of the field study was carried out in March 2005. A total of 16 sites were investigated in the field, with soil sampling being carried out using hand (sand) augers to a depth where either groundwater or hard indurated sand layers were encountered, or to a depth of three metres, whichever was shallower.

Phase two involved hydro-geological drilling investigations, undertaken in August to October 2006. A further five sites were also sampled to provide additional soils information as well as samples for laboratory soil chemical analyses for land rehabilitation purposes. Refer to Figure 3.3 for sample location details.

A total of about 150 soil samples were obtained for soil characterisation, indicative testing, and for soil profile classification purposes. Soil sampling and soil testing were generally carried out in accordance with the guidelines recommended by Gunn et al (1988) and McDonald et al (1990).

Indicative (in-house) testing was carried out on all soil samples collected. This involved testing of pH (1:5 H₂O) and Electrical Conductivity (EC 1:5 H₂O), together with descriptions of soil colour, texture, consistency and presence of organic matter, determined by field methods described by McDonald et al (1990). Representative samples were also selected for soil chemical analyses by SGS Agritech in Toowoomba. Soil descriptions and the results of the indicative testing are included in the full report (refer Appendix I) and are summarised in Section 4 of this ESR.

Potential impacts to soils from the proposed mining operations have been assessed and a number of potential management and mitigation measures identified (refer Section 5.6).

3.5 Groundwater

A hydrogeology study was undertaken to characterise the groundwater conditions within the mining lease. An initial study was carried out in February 2005 to examine baseline conditions. A follow up study was conducted in 2006, with groundwater monitoring wells being installed on site as part of the study. Data measurements from these wells have been collected since November 2006. Water quality samples were also collected from the monitoring wells and at Brown Lake and Swallow Lagoon. The first round of sampling was conducted in November 2006 (dry season conditions) and the second round conducted in April 2007 (wet season conditions). Slug tests to determine aquifer hydraulic conductivity were conducted on two bores, and 11 soil infiltrometer tests to determine infiltration rate were completed in November 2006. A hydrogeological model has been developed from previous reporting and field results. Refer to Figure 3.4 for groundwater sample location details and Appendix J for a copy of the entire groundwater report.

Potential impacts to groundwater from the proposed mining operations have been assessed and a number of potential management and mitigation measures identified (refer Section 5.7).

3.6 Surface Water

A surface water investigation has been undertaken to characterise the hydrological environment in the vicinity of the proposed mining area and identify potential impacts on surface water (refer Appendix K). Site investigations were undertaken on ML 1108 and adjacent leases between February 2005 and July 2007. Site investigations included measuring water level loggers, carrying out ground surveys, conduct of infiltrometer tests and water quality sampling. Refer Figure 3.5 for surface water sample location details.

Baseline surface water conditions in the immediate area of ML 1108 have been established and have included:

- Estimates of flow routes within the lease area from available topographic information and site walkover inspections;
- Estimates of the occurrence and temporal patterns of surface water in the Cooroon Cooroonpah Creek using shallow piezometer and ground survey data;
- Estimates of current surface water quality both within and downstream of Vance lease, based on Unimin monitoring data; and

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- Comparison of the existing surface water conditions with baseline conditions for groundwater in the area.

A review of proposed mining activities has been undertaken in order to identify potential impacts to surface waters. Based on these potential impacts, possible management and mitigation options have been developed to minimise these impacts on surface waters and the overall hydrologic environment (refer Section 5.8).

3.7 Dust

A quantitative dust assessment of proposed mining activities on ML1108 and the current mining operation on North Stradbroke Island has been undertaken by URS (refer Appendix L). Data on dust emissions from the mine's operations and processes were provided by Unimin. Emissions were calculated using emissions factors taken from the National Pollutant Inventory (NPI) Emission Estimation Techniques Handbook for Mineral Sand Mining and Processing and the NPI Emission Estimation Techniques Handbook for Mining. These manuals give emissions factor calculations for various activities associated with mining processes and have been derived from measurements undertaken in the past. In most cases, default emissions factors have been used in the estimation of emissions in this assessment with some exceptions where the emission factor was considered unrealistic.

A number of dust monitoring stations were established around the mining lease including adjacent to residential dwellings (refer Figure 3.6). All locations were evaluated for Total Suspended Particulate (TSP) Concentration, PM₁₀ concentration and TSP deposition. Background concentrations were sourced from EPA measurements at the Wynnum monitoring site, while deposition background results were derived from onsite deposition monitoring data.

The Ausplume dispersion model (TAPM) was used with meteorology results derived from TAPM to provide predicted dust concentration and deposition results for the mining operations conducted by Unimin. The model included all sources of dust from the mining operations but did not include dust from vehicle exhausts.

The calculated dust emissions were compared against the requirements set out in the Environment Protection Act 1994 (EP Act), the Environmental Protection Regulation 1998 (EP Regulation) and the Environmental Protection (Air) Policy 1997 (EPP (Air)). Dust emissions were also compared against the Redlands Shire Council Planning Scheme Policy which defines the same limits as the Queensland EPP (Air).

Based on dust assessment work undertaken possible management and mitigation options have been developed to minimise impacts (refer Section 5.9).

3.8 Noise

A noise impact assessment has been prepared by Belleng VDM Pty Ltd (refer Appendix M). The assessment was prepared to determine the level of existing noise impacts at the site and to assess potential noise impact from proposed mining operations on ML1108.

The assessment identified noise sources and the likely impact of these noise sources on the surrounds. The assessment identified that the closest noise sensitive places to the existing and proposed mining operations were residences in Boronia Court at "Myora Springs" and Illawong Street on the eastern outskirts of Dunwich township. Noise monitoring of existing operations was undertaken at these two locations (refer Figure 3.7). Noise measurements were undertaken continuously over a period of 7-days from 24th May 2006 to 30th May 2006. In addition to the long-term noise logging, attended short-term (T=10 minutes) noise measurements were carried out to determine the LA1,adj,T and LA10,adj,T noise levels at these two locations.

The industrial module of the SoundPLAN acoustic modelling software was used to calculate the operational noise impacts from proposed mining activities on the sensitive noise receiver locations. The calculations were carried out as per the procedures specified in the International Standard ISO9613. The

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model was established with a conservative assumption, that all plant and equipment at the mine lease ML1108 are located at the nearest (south-western) corner of the lease at an elevation of between 133m AHD to 140m AHD.

Based on the outcome of the modelling results, the report has made recommendations to mitigate potential noise intrusion on sensitive receptors (refer Section 5.10).

3.9 Road Transport

Burchill VDM Pty Ltd was commissioned to prepare a Road & Traffic Impact Assessment (R&TIA) for the proposed activities (refer Appendix N for a copy of the full report). The R&TIA assessed the existing road infrastructure in the immediate vicinity of the proposed expansion of current sand mining operations. It then examined impacts on the local road network and possible traffic implications from the proposed mine expansion.

Manual classified traffic surveys were carried out to establish existing traffic demands. Surveys were carried out at the two intersections in Dunwich that support mine vehicle movements – Bingle Road / Cunningham Street and Ballow Street / Junner Street. The survey was carried out on a Friday (2 June 2006) so that tourist traffic arriving for the weekend would be included in addition to local traffic. These peaks overlap mining operations.

In addition to these peak hour surveys, a two-way manual count was carried out on Tazi Road at the location of the potential southern access to ML1108. Traffic demands on East Coast Road to the south of the existing site access were taken from the Department of Main Roads (DMR) SEQ Traffic Census 2005. The surveys were taken over a one week period from 17 March 2005 to 23 March 2005 and are for twenty four hours.

For comparative purposes, the average daily value of heavy vehicles along the East Coast Road (from the DMR 2005 survey) was extrapolated to provide an approximate value of the number of heavy vehicles for the year of 2005, including the proportion of heavy vehicles from Unimin's operation.

As required by DMR (Guidelines for Assessment of Road Impacts of Development), a ten year design horizon to 2016 was considered. Annual growth on East Coast Road was calculated by comparing surveys to the south of the Unimin mining lease.

The existing haul route along the East Coast Road and a potential haul route along Tazi road were compared to identify the most appropriate route available for the mining operations (refer Figure 3.8). The R&TIA considered a range of aspects including road condition, compliance with the *Road Planning and Design Manual* (DMR), sight distances, existing traffic volumes and surrounding land use. A classified vehicle report survey including the twelve Austroads vehicle classes was carried out on behalf of DMR from 1 January 2002 to 31 December 2002 to provide an operational assessment. Further information was obtained from DMR with respect to the pavement construction and condition as contained in the extract from the ARMIS database.

Based on the outcome of the R&TIA, the report has made recommendations to mitigate potential impacts (refer Section 5.11).

3.10 Socio-Economics

A socio-economic report was prepared by URS (refer Appendix O). The report updated baseline information provided in the existing socio-economic analysis prepared by Outline Planning Consultants Pty Ltd in 1998 for mining operations on MLA7064. The original socio-economic information provided in Outline Consultants report was based on 1996 Census data. Demographic information for the URS study was based on the latest available data at the time of writing, including 2001 Census Data from the Australian Bureau of Statistics (ABS) and local population profiles from the Planning and Information Forecasting Unit (PIFU).

The geographic scope of this socio-economic study was limited to North Stradbroke Island, as per the original socio-economic study. Baseline demographic information for North Stradbroke Island is

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predominantly based on the North Stradbroke Island Demographic Profile prepared by PIFU. Data on occupation and employment by industry was based on the ABS Redland Shire Balance Statistical Local Area (SLA) Profile (SLA 305506283). This SLA includes the population on North Stradbroke Island and the surrounding Moreton Bay Islands.

The closest populated area to ML 1108 is the small settlement of Myora. This area falls into ABS collection district (CD) 3202901. This CD was used for demographic analysis of the population in the vicinity of the proposed mine lease. Details of the indigenous population for the Island have been gathered from the ABS indigenous profile for North Stradbroke Island (IARE09070).

The socio-economic report did not discuss potential impacts of the mining operation on ML1108. This was not part of the EPA's required scope of work given that this was a continuation of operations rather than an expansion.

3.11 Community Consultation

Unimin conducted a stakeholder consultation program as part of the project. The program involved:

- Identifying stakeholders;
- Informing the stakeholders about the proposed development and the ESR process;
- Involving stakeholders in environmental studies where appropriate;
- Identifying stakeholder issues and concerns with the project; and
- Identifying measures to mitigate stakeholders concerns.

The target audiences for the consultation program were identified through review of lists of government departments, and contacting community and cultural groups. Stakeholders were predominantly identified in relation to their proximity to the future mine site, potential impact from the project and likely interest in the project.

Stakeholders were provided with the first draft of the ToR in July 2004 and invited to make comments on the proposed development and the intended study which was detailed in the ToR.

Detailed submissions on the draft ToR were received from numerous stakeholders and interested parties. A second ToR was subsequently issued in August 2004 which addressed and took into account the issues raised by stakeholders. Stakeholders were again invited to make further comments on the second issue of the ToR and comments were again taken into consideration for developing the final ToR.

Opportunities to comment on the initial Draft ESR produced in 2005 were also given, with comments taken into consideration in preparing further detailed baseline environmental assessments as outlined in this report.

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Section 4 provides a summary of individual environmental studies results conducted as part of this ESR.

4.1 Terrestrial Flora

URS undertook a summer terrestrial flora survey program in 2005 and summer and spring flora survey programs in 2006 (refer Section 3.1). A copy of the full 2005 and 2006 flora survey reports are provided in Appendices E and F.

4.1.1 Species Diversity

The combined 2005 and 2006 surveys identified the presence of 134 taxa representing 99 genera and 46 families. This result represents a relatively high floral diversity typical of the ecosystems surveyed and is comparable to results of similar previous studies conducted both within the ML 1108 and its immediate vicinity.

Families represented by 3 or more genera included Cyperaceae (8), Epacridaceae (7), Euphorbiaceae (4), Fabaceae (8), Liliaceae (3), Myrtaceae (9), Poaceae (7), Proteaceae (7), and Restionaceae (4).

Genera represented by 3 or more species included *Acacia* (4), *Aristida* (3), *Eucalyptus* (3), *Hibbertia* (4), *Leptospermum* (5), *Leucopogon* (4) and *Lomandra* (4).

Incidence of weed species was low with no exotic species found to be present at any of the survey sites.

A full list of species found at both primary and secondary transects documenting the relative abundance of species at each survey site is provided in Appendix F, with the transect locations presented in Figure 3.1.

4.1.2 Spring Survey

The spring flora survey undertaken in September 2006 identified an additional five species not previously recorded during the summer surveys. These species are listed in Appendix F. None of the additional species identified are significant from a conservation, commercial or recreational standpoint. One of the species recorded, however, is considered to have cultural significance (refer Section 4.1.3).

4.1.3 Significant Species

None of the species recorded in the flora survey were identified as being significant from a commercial or recreational standpoint.

Species of cultural significance that might potentially be present within the ML1108 area included species traditionally utilised for food or medicinal purposes, tree species utilised for their bark for painting and wildflower species traditionally collected for decoration or adornment. Three species are identified by the Minjerribah Moorgumpin Elders as being of cultural significance to the traditional owners of North Stradbroke Island. Two of these species, *Boronia rosmarinifolia* (forest boronia) and *Boronia saffrolifera* (saffrole boronia), were found to be present within the low open heath habitat along the exposed ridge tops at survey sites 8, 9 and 10. *Boronia rosmarinifolia* was also found to be present in relatively low abundance within the *Eucalyptus pilularis* open forest at site 10. The third species, *Boronia falcifolia* (wallum boronia) was recorded during the spring survey within the closed wet heath at site 5.

No species of national conservation significance under the EPBC act were identified as occurring on site.

Two state conservation significant species were recorded within ML 1108 as detailed in Table 4-1 below. Both species were recorded within permanent primary transects and secondary transects, and also within targeted threatened species meander searches.

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Table 4-1 Significant Species Surveyed within the Vance lease (06-12/03/2006)

Plant Species	Common Name	Growth Form	Conservation Status ¹	Sites Recorded ²
<i>Acacia baueri</i> subsp. <i>baueri</i>	tiny wattle	Shrub	Vulnerable	P3, P4, Ts
<i>Gompholobium virgatum</i> var. <i>emarginatum</i>	wallum wedge pea	Shrub	Rare	S4, S5, S6, S7, Ts

¹ Nature Conservation (Wildlife) Regulation, 2006² P=Primary Transect, S=Secondary Transect, Ts=Targeted Search

Acacia baueri subsp. *baueri* was primarily found in relatively high abundances in the small areas of low open heath on the exposed higher elevated dunes to the south west of ML 1108. *Acacia baueri* subsp. *baueri* was also found in lower abundances in exposed areas adjacent to vehicle tracks, including the track along the Cooroon Cooroonpah Creek.

Gompholobium virgatum var. *emarginatum* was primarily found in relatively high abundances in mallee eucalypt woodland associations upslope of the Cooroon Cooroonpah Creek drainage line, and in the north-west of the approved ML 1108 3 year mine path.

4.1.4 Vegetation Communities

Four vegetation communities were described and mapped for ML 1108 on the basis of the 2006 field survey results and stereo aerial photograph interpretation. Six vegetation communities were initially described for ML 1108 based on the results of the initial 2005 vegetation survey. The subsequent reduction of communities identified in ML 1108 following the 2006 survey was a result of a more rigorous examination of the floristics of the site. These communities and their current extent within both ML 1108 and the southern coastal lowlands sub-region are summarised in Table 4-2. The extent of vegetation communities surveyed within ML 1108 is shown in Figure 3.1.

Table 4-2 Vegetation Associations Surveyed within the ML 1108 (06-12/03/2006)

Community Description		Regional Ecosystem	Total area on site (ha)	Total area in sub-region (ha) ¹
1a	Low open dry heath on Quaternary dunes and sand plains	RE 12.2.13 'Of Concern'	5.65	441
1b	Closed wet heath on seasonally waterlogged sand plains	RE 12.2.12	3.04	2,620
2a	Mallee <i>Eucalyptus</i> spp. Low woodland on Quaternary dunes and sand plains	RE 12.2.10	564.30	9,997
3a	<i>Eucalyptus</i> spp. open forest on Quaternary dunes and sand plains	RE 12.2.6	65.98	13,401

¹ Derived from RE data for the southern coastal lowland province as per Accad *et. al.* (2005)

The majority of the lease supports vegetation community 2a; Mallee *Eucalyptus* spp. low woodland (RE 12.2.10). This community was found on most landforms on the lease including the Cooroon Cooroonpah Creek drainage line, lower and upper slopes and elevated high dunes. This community is primarily dominated by a mallee form of *Eucalyptus planchoniana* (needle bark) with *Banksia aemula* (wallum banksia), however was also found to be dominated by the mallee form of *Eucalyptus racemosa* (scribbly gum) in more exposed areas close to the ridge lines on elevated dunes.

Vegetation community 1a; Low open dry heath (RE 12.2.13) persists in exposed ridge areas on the high dunes to the west of the site. This community is dominated by a number of Myrtaceae and Fabaceae heath species, however dry heath communities are being encroached by *Banksia aemula* (wallum banksia). It appears that the encroaching regeneration of *Banksia aemula* in heathland indicates early

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stages of the seral succession of Mallee *Eucalyptus* spp. low woodland, which given undisturbed conditions will eventually dominate.

Low open dry heath on Quaternary dunes and sand plains (RE 12.2.13) is currently listed as 'of concern' under the Queensland *Vegetation Management Act, 1999* (VM Act). Of the estimated original 484 ha pre-clearing extent for this community in south-east Queensland, 441 ha still remains uncleared, all within the south coastal lowland sub-region. Of the 441 ha still remaining, approximately 41 ha are currently conserved in Queensland within the Noosa National Park (Accad *et al.*, 2005). The extent of Vegetation Unit 1a present on ML 1108 (5.65 ha) represents approximately 1.3 % of the extent of this community still present within the southern coastal lowland sub-region.

The extent of vegetation community 1b; Closed wet heath (RE 12.2.12) on the lease was restricted to the ephemeral drainage line of Cooroon Cooroonpah Creek. This community was dominated by *Leptospermum liversidgei* (lemon-scented tea tree), with *Empodisma minor* (spreading rope rush) and *Baumea muelleri* (flat twigrush) also in common abundance.

Vegetation community 3a; Mixed *Eucalyptus* species open forest (RE 12.2.6) was found to be present on elevated dunes to the east and north of the site. This community was found to be co-dominated by *Eucalyptus pilularis* (needle bark) and *E. racemosa* with *Corymbia gummifera* (red bloodwood). Floristic variation was evident in examples of the community found at elevation to the very east of the site, where the community exhibited a dominance of *E. pilularis*. However *E. racemosa* and *C. gummifera* were still evident to a lesser degree in these areas.

4.1.5 Ramsar Areas

The Department of Environment and Water Resources (DEWR) National Estate Register has designated two areas on the lease, one to the east and one to the south, as Ramsar¹ protected wetland areas (Figure 3.1). Ground truthing of the vegetation communities in both these areas confirmed the vegetation to be comprised of Mallee *Eucalyptus* spp. low woodland on Quaternary dunes (RE 12.2.10) and *Eucalyptus racemosa* / *Eucalyptus pilularis* open forest on Quaternary dunes (RE 12.2.6). No wetland vegetation or significant areas of surface water were found in either of these areas. It has been assumed that these 'Ramsar' areas have been designated as such for land management purposes rather than for any intrinsic 'wetland' values.

The large extent of tall eucalypt forest on the eastern extent of the lease currently under the designation of Ramsar 'wetland' is scheduled to be annexed as part of a planned National Park (pers. com.)².

A number of secondary transects were established within the smaller of the two Ramsar designated areas to the south of the lease to obtain floristic and structural data on the vegetation types found there. A vehicle-based inspection of this area was also undertaken to further ground truth the communities. This study confirmed that the vegetation of this area comprised Mallee *Eucalyptus* spp. low woodland on Quaternary dunes (RE 12.2.10), and no wetlands were present. The only wetland vegetation found on the lease was the community of closed heath on seasonally waterlogged sand plains (RE 12.2.12) found present along the margins of the Cooroon Cooroonpah Creek drainage line (Figure 3.1).

4.2 Terrestrial Fauna

The following section presents a summary of results from the terrestrial fauna survey undertaken in 2006 (EMS, 2007).

4.2.1 Species Diversity

A total of 92 native and 5 introduced terrestrial vertebrate species were recorded during field surveys in the study area, including 7 amphibian, 17 reptile, 48 bird and 20 mammal species. Detailed descriptions

¹ Ramsar convention on the protection of internationally significant wetlands, Ramsar, Iran, 1971.

² Correspondence from Lisa Ford EPA, QPWS dated 27/09/05.

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of location and record method for all fauna taxa identified during the survey period are presented in Appendix G (EMS, 2007).

The above included 5 introduced vertebrate fauna species, including the:

- Dingo/dog (*Canis lupus dingo/Canis lupus familiaris*) - Class 2 Declared pest animal;
- Fox (*Vulpes vulpes*) - Class 2 Declared pest animal;
- Feral cat (*Felis catus*) - Class 2 Declared pest animal;
- House mouse (*Mus musculus*) - non declared animal; and
- Cane toad (*Bufo marinus*) - non-declared animal.

4.2.2 Significant Fauna Species

The majority of the species recorded or expected within the study area are widespread in eastern Australia, while a small number of species are restricted to the region or are common on the sand islands in Moreton Bay but less common on the mainland. Fauna species occurring within the study area are assigned threatened status according to Queensland and Commonwealth legislation as described in the:

- *Qld Nature Conservation (NC) Act 1992*; and
- *Commonwealth Environment Protection & Biodiversity Conservation (EPBC) Act 1999*.

In addition to the threatened species, the EPBC Act 1999 also includes a list of migratory species. These species are those that are listed under the following international agreements to which Australia is a signatory nation:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Convention on the Conservation of Migratory Species of Wild Animals - (Bonn Convention).

Under the EPBC Act 1999, Australia has an international obligation to protect significant populations and significant sites for these species.

Threatened species identified within the study area are listed in Table 4-3 and mapped in Figure 3.2. No Critically Endangered or Endangered species are known or expected to occur in the study area. Two species are classified as Vulnerable under the EPBC Act, four species are classified as Vulnerable under the Queensland NC Act, while one is classified as Rare under the Queensland NC Act. An additional species recorded adjacent to the study area is listed as Rare under the NC Act.

The conservation status of threatened species described for the study area is presented below in Table 4-3.

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Table 4-3 Status of Threatened Fauna Species

Common Name	Scientific Name	EPBC Act	Qld NC Act
Wallum Sedgefrog	<i>Litoria alongburensis</i>	Vulnerable	Vulnerable
Wallum Rocketfrog	<i>Litoria freycineti</i>		Vulnerable
Wallum Froglet	<i>Crinia tinnula</i>		Vulnerable
Cooloola Sedgefrog #	<i>Litoria cooloolensis</i>		Rare
Short-limbed Snake-skink	<i>Ophioscincus truncatus</i>		Rare
Glossy-black Cockatoo	<i>Calyptorhynchus lathami</i>		Vulnerable
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	Vulnerable	

Recorded adjacent to study area (ML 1108) only

Acid Frogs

Populations of three species of vulnerable acid frog (wallum sedgefrog, wallum rocketfrog and wallum froglet) were present on Cooroon Cooroonpah Creek within the study area. It is likely that adult frogs of these species also utilise habitats adjacent to the creek as foraging areas, particularly during wet conditions. Potential management issues identified (EMS, 2007) relate to maintenance of the water table, surface water flow and persistence of surface water (within ML 1108), particularly during periods when these frogs are breeding and for a sufficient period for larvae to mature. The maintenance of a sufficient buffer to the creek is also relevant, to maintain in-stream conditions and maintain sufficient areas of foraging habitat surrounding the creek. Discussion of potential impacts and mitigation measures is further outlined in Section 5.4

Short-limbed Snake-skink (*Ophioscincus truncatus*)

The short-limbed snake-skink (rare Qld NCA 1992) was recorded within the study area from a single specimen trapped in *E. racemosa*, *C. gummifera* open forest/woodland (S2). This species has been collected from a variety of habitats on North Stradbroke Island, including forests, woodland and heath on pale sandy soils. This species potentially occurs in a wider variety of habitats but is currently known from this one habitat type within the study area. The proposed removal of vegetation for the proposed mining area may impact an area of suitable habitat in the vicinity of the collection location. While the short-limbed snake-skink was not recorded in mallee eucalypt and *Banksia aemula* low woodland, this species also potentially occurs in this habitat type. Discussion of potential impacts and mitigation measures is further outlined in Section 5.4

Glossy Black-Cockatoo (*Calyptorhynchus lathami*)

The glossy black-cockatoo (vulnerable Qld NCA 1992) was recorded within the study area in open forest habitats (Figure 3.2) from characteristic signs of feeding on she-oaks. Observations of feeding were concentrated in two main areas of the study area. A number of signs of feeding were noted in open forest dominated by *Eucalyptus pilularis* (S5) in the east of the study area and within *Eucalyptus racemosa* open forest/woodland in the central northern part of the study area. The glossy black-cockatoo potentially uses Casuarina groves at other locations within the study area, including some potentially suitable groves on Cooroon Cooroonpah Creek and in the southern component of the study area.

Habitats supporting potential breeding sites (e.g. old growth trees with suitable hollows) are limited within the study area, however potentially suitable trees are present in *Eucalyptus pilularis* open forest and *E. racemosa* open forest/woodland (Vegetation Type 3a).

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The proposed removal of vegetation in the mining area may impact potential glossy black-cockatoo breeding sites particularly vegetation type 3a (refer Appendix F). Discussion of potential impacts and mitigation measures is outlined in Section 5.4

Grey-headed Flying-fox (*Pteropus poliocephalus*)

The grey-headed flying-fox is listed as Vulnerable under the EPBC Act. Grey-headed flying-fox occur on a seasonal basis in the main North Stradbroke Island flying-fox camp at Dunwich and it is likely that most of the bats observed within the study area are from this camp. The numbers of grey-headed flying-fox present at the Dunwich camp vary depending on seasonal changes in flowering, fruiting patterns and climatic conditions, indicating that numbers foraging within the study area are also likely to vary.

Major food sources for the grey-headed flying-fox within the study area include flowers of canopy eucalypts and corymbias in open forest and woodland habitats (*E. racemosa* open forest/woodland and *E. pilularis* open forest) and *Banksia aemula* and mallee eucalypts (mallee *Eucalyptus* spp. and *Banksia aemula* low woodland).

The initial removal of vegetation for the proposed mining path will remove a significant area of potential foraging habitat for the grey-headed flying-fox. Discussion of potential impacts and mitigation measures is outlined in Section 5.4

Koala (*Phascolarctos cinereus*)

Although surveys were conducted to target the vulnerable koala (*Phascolarctos cinereus*) (vulnerable SEQ bioregion, Qld NCA 1992), this species was not recorded in the study area during the survey period. However, the study area does support potential koala habitat consisting of *Eucalyptus pilularis* open forest and *Eucalyptus racemosa*, *C. gummifera* open-forest/woodland. A number of previous sightings of this species have been recorded to the north, south and west of the study area, the closest record being approximately 1.5 km from the study area boundary. It is likely that vegetation in the study area, particularly open forest, woodland and low woodland, provides connectivity to surrounding habitat areas.

The proposed removal of vegetation for the mining area will remove an area of suitable koala habitat, particularly to the east of Cooroon Cooroonpah Creek in the northern section of the study area (Vegetation Type 3a refer Appendix F). Discussion of potential impacts and mitigation measures is further outlined in Section 5.4

Migratory Species

No significant migratory species were recorded within the study area. A single bird species, the rainbow bee-eater (*Merops ornatus*), is listed as a migratory species under the EPBC Act 1999 (DEH 2005). This species is common and does not require specific habitat management measures. None of the habitats present within the study area are suitable for migratory wetland or shorebirds.

4.2.3 Habitat Conservation Values

Closed wet heath, Cooroon Cooroonpah Creek riparian habitat

Closed or wet heath (mapped as Vegetation Type 1b in Figure 3.1) and riparian vegetation is the most significant habitat for fauna within the study area. These ecosystems provide habitat for three threatened frog species protected under Queensland and Commonwealth legislation and support the highest diversity of native fauna species, including the highest amphibian and mammal diversity. These habitats are also significant due to the presence of open water and associated riparian vegetation and closed/wet heath. Closed wet heath and riparian habitat is one of the most restricted habitats within the study area.

Mallee *Eucalyptus* spp. and *Banksia aemula* low woodland on lowland dunes

Although low woodland on sand plains/dunes (mapped as Vegetation type 2a in Figure 3.1) support a relatively high diversity of native fauna species, including the highest reptile diversity, threatened species

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were not recorded during the survey in this habitat. This habitat provides foraging habitat for flying foxes and potential habitat for the short-limbed snake-skink.

***Eucalyptus racemosa*, *Corymbia gummifera* open forest/woodland**

Eucalyptus racemosa, *Corymbia gummifera* open forest/woodland (mapped as Vegetation type 3a in Figure 3.1) supports a moderate diversity of native fauna species relative to other habitats in the study area and provides habitat for a number of threatened fauna species, including the glossy black-cockatoo, grey-headed flying-fox and short-limbed snake-skink. Some components of this habitat within the study area support old growth forest characteristics, with senescent living and dead trees supporting hollows suitable for a range of wildlife species.

***Eucalyptus pilularis* open forest**

E. pilularis open forest (mapped as Vegetation type 3a in Figure 3.1) supported the highest diversity of birds and a moderate diversity of native fauna species during the survey period, relative to other habitats in the study area. This open forest also provides habitat for one threatened species, the glossy black-cockatoo. Some components of this habitat within the study area support old growth forest characteristics, with senescent living and dead trees supporting hollows suitable for a range of wildlife species.

***Mallee Eucalyptus* spp. and *Banksia aemula* low woodland on ridge**

Mallee *Eucalyptus* spp. and *Banksia aemula* low woodland (mapped as Vegetation type 2a in Figure 3.1), where it occurs on higher exposed dunes and ridges, supports a relatively low diversity of native fauna species. Threatened species were not recorded during the survey in this habitat type. Low woodland provides foraging habitat for flying-foxes and potential habitat for the short-limbed snake-skink.

Open or dry heath with stunted *Banksia aemula* on upland dunes

Open or dry heath on exposed high dunes and ridges (mapped as Vegetation type 1a) support the lowest diversity of native fauna species in the study area and threatened species were not recorded during the survey in this habitat type. Heath areas on high dunes are limited in area and are unlikely to support any habitat specific fauna.

4.3 Cultural Heritage

The Minjerribah-Moorgumpin Elders-in-Council Aboriginal Corporation as the Cultural Heritage Body for North Stradbroke Island have undertaken a cultural heritage study for the entire project area. A total of 37.42 km of transects were surveyed in the first half of 2005.

Eight archaeological sites were located during the survey and were associated with three areas. A summary of findings is provided below. A search of the Australian Heritage Database (formerly the Register of the National Estate) indicated no listings of national indigenous significance are present on ML1108.

Cooroon Cooroonpah Creek

Shell material was found in five locations along the track beside the creek. In addition, one stone artefact was also discovered in this area. These findings are considered of high scientific significance because they provide evidence of the passage of people along a traditional pathway across the Island.

Worked Stone

Worked stone was found on the peak of the highest dune in the southern central area of the site. This was considered of low to medium scientific interest.

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Scarred Tree

A scarred tree located in the north eastern Ramsar area is considered of little or no scientific significance as the tree itself is dead and the scar completely burnt out.

4.4 Geomorphology and Soils

The results of the geomorphology and soils study are summarised below.

4.4.1 Geology and Geomorphology

As mapped in the 1:100,000 Series Geoscience Data published by the Geological Survey of Queensland (2005), the main geological regimes that occur within the vicinity of the project area include:

- Quaternary Pleistocene Dune Sand (Qpd);
- Quaternary Holocene Sand Deposits (Qhd); and
- Triassic-Jurassic Bundamba Group Woogaroo Sub-Group (Rjbw); comprising sandstone, siltstone, shale, conglomerate and coal.

The Pleistocene sand dune deposits (Qpd) are by far the most extensive geological unit on the island and within the mining lease area (ML1108) the dunes are all of Pleistocene age.

A search of the Australian Heritage Database has identified "North Stradbroke Island (central section)" on the Register of the National Estate as a registered place. According to the register record, the area contains examples of various ages and phases of dune formation and erosion, which are significant in understanding the evolution of North Stradbroke and other sand islands. Mount Hardgrave and Swallow Lagoon, located approximately 250 metres outside the south-western corner of the lease, are the closest of these features. The footprint of proposed mining activity will not impact on these two features.

4.4.2 Landform and Land Units

The terrain within the lease area and throughout much of the central and northern part of North Stradbroke Island consists primarily of north-westerly trending sand ridges and hills with varying crestal elevations. Sand hills reach elevations in excess of 200m ASL in the vicinity of Mount Hardgrave.

In places the dune surfaces have been subject to erosion and now lack the more clearly recognisable dune shapes. The eroded upland areas exhibit a strongly undulating to low hilly surface form, with slopes mostly in the range of 10-20% on the upper slope margins. Elsewhere, narrow more sharply rounded dune ridge crests occur which have somewhat steeper marginal slopes (15-30%) increasing to 30-60% on the adjacent steep irregular planar ridge slopes to the narrow but mainly broadly depressional drainage lines.

Drainage within the lease area is via broadly depressional to locally shallowly incised drainage ways which flow generally in a north-westerly direction from the northern and central eastern sectors of the site and in a south-easterly direction from the central southern sector of the site.

Five Land Units have been identified within the site based on surface form, topographic position in the landscape, steepness of slopes, degree of dissection, drainage condition and soil type. Details of land units are provided in Appendix J.

4.4.3 Soil Types and Fertility

The soils are essentially similar throughout the entire lease area. The soil landscapes (land units) that occur within the lease are dominated by the occurrence of white silica sands that have been subject to strong weathering to depths varying locally from about 2m (mainly in the north eastern sector of the lease) to 20m or more elsewhere within the lease. With respect to the Australian Great Soil Group nomenclature - Stace et. al. (1968), the site soils are classified either as Podzols or 'Giant' Podzols.

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In terms of the Australian Soil Classification proposed by Isbell (1996), the soils have mostly been classified as Aeris Humosques Podosols on higher dune and ridge slopes or Semiaquic Humic/Alsilic Podosols in somewhat less well-drained areas and some Acidic Sapric Organosols in drainage floors and swampy areas.

The soils within the site consist almost entirely of fine-grained siliceous single-grain loose sands that have high porosity, very low silt/clay fines content and contain very low levels of most plant nutrients.

4.4.4 Topsoil Resources

Useable topsoil resources are mainly confined to the surficial (A) horizon materials, which contain seed-stock, micro-organisms and nutrients necessary for plant growth. On average, the useable topsoil resource, i.e. the (A1) soil horizon containing appreciable amounts of organic matter, fibrous roots and native seed stock, is approximately 0.4m deep on the higher dune crestal areas and ridge slopes, within the general area likely to be subject to future mining.

4.5 Groundwater

Results of the groundwater study are summarised below.

4.5.1 Hydrogeology of Vance Mining Lease

Hydrogeological information within the Vance Mining Lease is limited by a minimal amount of groundwater bores located within the lease boundaries. Only one groundwater monitoring bore with historical data is located within the lease area. Based on the existing groundwater bore on the site, the groundwater elevation of the regional aquifer in the vicinity of the lease ranges from 8m AHD to 44m AHD. Five new monitoring wells were installed as part of the 2006 investigation. Slug tests to determine aquifer hydraulic conductivity were conducted on two bores, and 11 soil infiltrometer tests to determine infiltration rate were completed on 23 November 2006.

The regional groundwater flow direction across the lease is generally between the west and north, however a groundwater divide has been identified close to the south eastern boundary of the lease. The depth to groundwater is also expected to vary considerably due to the generally hilly nature of the area. Depth to groundwater is greatest at higher elevations (such as near Mt. Hardgrave) and lower along Cooroon Cooroonpah Creek.

4.5.2 Infiltration and Groundwater Recharge

The infiltrometer testing holes all exhibited homogeneous sand with very little variation spatially or with depth. Results demonstrate that the top 500 mm of the soil profile has an average saturated permeability of approximately 23 m/d. This rapid percolation of water demonstrates that for overland flow to occur, the rainfall intensity must meet or exceed approximately 1000 mm/hr. As such surface water runoff on the lease could only happen in extremely rare circumstances.

Groundwater recharge principally occurs from direct rainfall infiltration, due to the highly permeable sandy substrate. Recent groundwater modelling shows an average recharge of 600mm to 800mm per year.

4.5.3 Groundwater Flow

The results of the slug tests yield an aquifer hydraulic conductivity of 2.26 to 6.64 m/d for the perched sand aquifer at Cooroon Cooroonpah Creek. It is noted in the study that these values are at the lower end of the range of hydraulic conductivities (1.3 to 50 m/d) determined for various groundwater models on North Stradbroke Island.

Previous studies estimate groundwater velocities through the sands near the centre of North Stradbroke Island (i.e. proximal to ML 1108) at between 4 and 7 m/day, which is typical for fine to medium grained dune sands.

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Water was only encountered in a perched aquifer on the indurated sand at Site 2 on Cooroon Cooroonpah Creek. At this site, two layers of indurated sand were encountered. The upper layer, approximately 1.5m thick, occurred at a depth of 2.5 m. The lower layer occurred at a depth of 6.3m. The recorded groundwater levels have a high degree of correlation with rainfall and with very little lag time between rainfall, indicating that there is a direct hydraulic connection between the creek and the perched aquifer. The high infiltration capacity and hydraulic conductivity of the sands allow rapid infiltration of recharge and flow of groundwater.

4.5.4 Groundwater Discharge

Groundwater discharge from ML 1108 will principally occur into freshwater streams and swamps near the coast and lateral seepage to the ocean. Cooroon Cooroonpah Creek, which drains the majority of the lease area, is primarily fed from groundwater. Most groundwater on the lease is expected to move northwards and westwards out of the area towards the northwest coast. Previous studies have found that regional groundwater does not flow into Brown Lake.

Infiltration of rainfall to the perching layer is considered the most important factor in maintaining the hydrological regime in Swallow Lagoon, immediately southeast of the lease. The extent of the perching layer could not be determined within the scope of this study, however the B-horizon encountered at Site 3 north of Swallow Lagoon did not support a perched aquifer during the period of monitoring. Due to the complexity of the development and location of the indurated B-horizon, the lagoon is expected to be filled by rainfall infiltration from its small immediate catchment, and is unlikely to be linked to any perched aquifers on-site.

The B-horizon encountered at Site 4 between ML 1108 and Brown Lake did not support a perched aquifer during the period of monitoring, and does not appear to be acting as an aquitard in this location. Due to the complexity of the development and location of the indurated B-horizon, Brown Lake is unlikely to be linked to any perched aquifers on-site.

4.5.5 Groundwater Quality

The range of water quality detected in the perched aquifer on-site and Brown Lake and Swallow Lagoon located off-site are presented in Table 4-4. The low pH values are believed to be caused by humic acids released by decomposing organic matter (e.g. tannins, ligands) and are considered to be representative of natural conditions.

As flow in the creek is also largely ephemeral, water levels fluctuate widely throughout the year with periodic wetting and drying. Periodic wetting and drying of accumulated organic matter can lead to a short-term increase in the rate of humic acid release. As the creek dries out again and water levels drop, this then causes the pH of the water to become increasingly low from seepage of acidic groundwaters at shallow depth. The low pH values in the creek are lower than those found in groundwater at depth in the vicinity of the lease area suggesting that key pH influences occur at the surface layer.

Electrical conductivity (EC) is considered to be low in comparison with the usual range found within freshwater, upland catchments. However EC can be highly variable in surface waters. The low EC of the groundwater reflects the relatively rapid and substantial recharge of fresh rainwater limiting the opportunity for evapotranspiration induced concentration of salts in rainfall, and the quartzose nature of the sand resisting leaching of minerals into the aquifer.

Concentrations of detected ions are considered to be representative of natural levels. The relative proportions of major ions are indicative of rainfall, and the low concentrations are indicative of relatively minor evapotranspiration induced concentration. Measurable concentrations of nutrients are considered to be representative of natural levels.

Concentrations of dissolved metals in the groundwater are generally low, being less than or close to the laboratory limits of detection apart from iron, manganese and zinc which typically show measurable concentrations. The presence of iron, manganese and zinc is indicative of the naturally low pH conditions of the groundwater, and reflects the process of weathering and induration of the 'giant' podsols.

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Table 4-4 Water quality of perched aquifer on-site and surface water bodies off-site

	Guideline Values	Location			
		2D	2S	Brown Lake	Swallow Lagoon
Physio-chemical Parameters					
pH	6.5 - 8.0 ^(a)	4.23 - 4.36	4.10 - 4.19	5.29	4.59 - 5.01
Electrical Conductivity (µS/cm)	626 ^(a)	111.4 - 117.8	117.0 - 131.1	118.3	61.5 - 81
Major Ions					
Calcium (mg/L)	Ne	<1 - 1	<1 - 1	<1	<1 - 1
Magnesium (mg/L)	Ne	2 - 3	2	2	1 - 2
Potassium (mg/L)	Ne	<1	<1	<1	<1
Sodium (mg/L)	Ne	15 - 16	16 - 17	17	10 - 11
Chloride (mg/L)	Ne	25 - 31	27 - 32	29	18
Sulphate (mg/L)	Ne	<1 - 5	<1 - 3	4	2 - 3
Total Alkalinity (mg/L)	Ne	<1 - 3	<1	1	<1 - 2
Metals (Dissolved)					
Arsenic (mg/L)	0.013 ^(b)	<0.001	<0.001	<0.001	<0.001
Barium (mg/L)	Ne	0.002	0.001	<0.001	<0.001
Beryllium (mg/L)	Ne	<0.001	<0.001	<0.001	<0.001
Cadmium (mg/L)	0.0002 ^(b)	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	0.001 ^(b)	<0.001	<0.001 - 0.001	<0.001	<0.001
Cobalt (mg/L)	Ne	<0.001	<0.001	<0.001	<0.001
Copper (mg/L)	0.0014 ^(b)	<0.001	<0.001	<0.001	<0.001
Ferrous Iron (mg/L)	Ne	0.27	0.41	-	0.11
Lead (mg/L)	0.0034 ^(b)	<0.001	<0.001 - 0.001	<0.001	<0.001
Manganese (mg/L)	1.9 ^(b)	0.004 - 0.008	0.002 - 0.003	0.006	0.028
Mercury (mg/L)	0.0006 ^(b)	<0.0001 - 0.0004	<0.0001 - 0.0003	<0.0001	<0.0001 - 0.0004
Nickel (mg/L)	0.011 ^(b)	<0.001	<0.001	<0.001	<0.001
Vanadium (mg/L)	Ne	<0.01	<0.01	<0.01	<0.01
Zinc (mg/L)	0.008 ^(b)	<0.005 - 0.013	0.006 - 0.011	<0.005	<0.005 - 0.009
Nutrients					
Nitrate as N (mg/L)	Ne	<0.01	<0.01	<0.01	<0.01
Nitrite as N (mg/L)	Ne	0.05 - 0.067	0.049 - 0.06	<0.01	<0.01 - 0.02
Ammonia as N (mg/L)	0.02 ^(a)	0.11 - 0.13	0.081 - 0.091	0.016	0.049 - 0.081
Total Kjeldahl Nitrogen as N (mg/L)	Ne	1.1 - 4	2.8 - 11.1	0.6	1.4 - 1.6
Total Phosphorus (mg/L)	0.05 ^(a)	<0.05 - 0.06	<0.01 - 0.13	<0.01	<0.01

Note:

(a) – Queensland Water Quality Guidelines for South East Region lowland streams and Sandy Coastal Region

(b) – ANZECC/ARMCANZ 2000 Trigger values for freshwater ecosystems - Level of protection 95% of species

Ne – not established

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4.6 Surface Water

ML1108 contributes to surface water flow in three catchments: Capembah Creek to the south, Cooroon Cooroonpah Creek in the centre of the lease and Aranarawai Creek to the north east. The majority of ML1108 (approximately 4.6km²) contributes to the catchment of Cooroon Cooroonpah Creek, which flows through the centre of the lease in a north-west direction. Downstream of the lease, Cooroon Cooroonpah Creek continues in a north-westerly direction towards swamp land adjacent to the East Coast Road and drains to marine environments in Rainbow Channel and Moreton Bay.

There are no on-site water bodies located within the mining lease except for Cooroon Cooroonpah Creek, which is an ephemeral watercourse. The overall lease area is frequently dry with no local surface ponding. There is no evidence of downstream water bodies that would rely on surface runoff to maintain water levels.

An off-site waterbody (Swallow Lagoon) is located approximately 180 m south-west of the southern boundary of the lease. This lagoon is a perched waterbody at an elevation of approximately 160 m AHD. The lagoon receives surface runoff inflow from a catchment area outside of the lease. The lagoon is protected as a RAMSAR wetland under the Environmental Protection Biodiversity Conservation (EPBC) Act 1999. Gradients within the catchment that drain to the lagoon are moderate and surface water is not therefore expected to contribute a significant quantity of recharge to Swallow Lagoon. Infiltration of rainfall is considered the most important factor in maintaining the hydrological regime in the lagoon.

4.6.1 Streamflows and Flow Regime

Surface runoff is rarely observed on North Stradbroke Island even during high, intense rainfall. Where surface flow does occur, this is mostly confined to larger creeks and gullies; some as a direct result of rainfall runoff and some from seepage of shallow groundwater springs where the watertable and surface intersect at a low angle. Due to the highly permeable nature of the underlying sands and the general steep topography of the site, most water ponds in depression areas and evaporates or quickly infiltrates after rainfall.

Cooroon Cooroonpah Creek is characterised by low water levels and flow rates and is likely to remain dry for the majority of the year. Infiltrometer testing was completed at approximately 11 sites located on the lease, including near the Creek, in upland areas, in flat lands, slopes and in areas of different vegetative covers to identify the potential for high spatial variability of soil infiltration capacity across the lease. The infiltrometer results demonstrate that the top 500 mm of the soil profile has an average saturated permeability of approximately 960 mm/hr. These infiltration test results demonstrate that direct surface water runoff on the lease would only occur in extremely rare circumstances.

4.6.2 Water Quality

Cooroon Cooroonpah Creek is considered to be representative of a lowland freshwater stream in South-East Queensland as per the Queensland Water Quality Guidelines (EPA, 2006) and Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).

pH

For all sampling locations, the median pH is outside the Queensland Water Quality Guidelines (EPA, 2006) range for lowland freshwater streams. Values are considered to be representative of naturally strong acidic conditions with a relatively narrow range of values throughout the monitoring record. The low pH values are believed to be caused by humic acids released by decomposing organic matter (e.g. tannins, lignins) and humic acids released from humus podsol soils.

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Electrical Conductivity

Electrical Conductivity (EC) is low in comparison with the Queensland Water Quality Guidelines (EPA, 2006) range for lowland freshwater streams. The recorded values are mostly below the 25th percentile of the Queensland Water Quality Guidelines (EPA, 2006) range.

Turbidity

Turbidity was below the Queensland Water Quality Guidelines (EPA, 2006) range for lowland freshwater streams, for data collected. The low turbidity is consistent with a flow regime predominantly influenced by groundwater and with minimal direct surface runoff from the catchment.

Sodium, Sulphate and Chloride

Sodium, sulphate and chloride are all common in soils, particularly in areas of former marine influence, and vary widely in terms of solubility and concentrations in surface water. It was not possible to compare concentrations of these constituents as the Queensland Water Quality Guidelines (EPA, 2006) and Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) do not include recommendations for these parameters. The concentrations detected are considered to be representative of natural levels.

Nutrients (N and P)

All analyses of oxidised nitrogen concentrations (nitrates and nitrites) were found to be less than the Queensland Water Quality Guidelines (EPA, 2006) for lowland freshwater streams, at all locations. Downstream surface water bodies in the area are not known to be eutrophic.

Iron, Manganese, Calcium, Magnesium and Potassium

Concentrations of iron at monitoring locations near the upstream extent of ML1108 were generally low (<0.3 mg/L). Monitoring at downstream locations has recorded higher concentrations (up to 0.88 mg/L). This suggests either a potential natural source of iron downstream of ML1108 (possibly due to different soil types at lower elevations), sample error due to re-suspension of bed sediments (refer Table 4-5), or possible historical releases of iron enriched water as a result of mining activity in the downstream mine leases. Iron has not been tested in samples since 2002 at any of the monitoring locations.

Manganese, calcium, magnesium and potassium were all detected at or close to the laboratory limits of reporting indicating generally low levels of these constituents.

4.7 Dust Assessment

The following section provides a summary of results from a quantitative dust assessment of the current mining operation and the proposed mining activities on ML1108. All results for dust concentration and deposition, including background levels, are well below the guidelines given by the Queensland EPA and the Redlands Shire Council. The full details of the results are available in Appendix L.

4.7.1 Current and Proposed Operations

Dust emissions occur at a number of locations on-site: at the mine face; topsoil removal and stockpiling; sand transfer points; vehicle movements over the site; recovery of sand from stockpiles and erosion from stockpiles and exposed areas on the mine. The processing operations used by Unimin are wet processes throughout the plant, and these are not considered to be dust generating sources.

The two major contributing sources of dust are from the movement of the bulldozer at the active mine face, used for scraping topsoil from the raw sand resource, and the heavy vehicle movements from the stockpiles to the front gate. The emission rate for the bulldozer was 5.2g/s of TSP and 0.9g/s of PM₁₀ emissions. Heavy vehicle movement from stockpiles to the main gate created 7.0g/s of TSP and 2.0g/s of PM₁₀ through wheel generated dust (WGD).

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4.7.2 Dust Sensitive Locations

Nine receptor locations were chosen as part of this study to assess the impact of the proposed mining operations on surrounding residential locations, the Myora Conservation Park and the mine itself. The closest residential areas or sensitive environments are at Boronia Court at "Myora Springs" and Illawong Street at the eastern outskirts of Dunwich township.

4.7.3 Dust Concentration

TSP

The study investigated concentrations of TSP at discrete receptors from Unimin operations alone, and the total concentration due to Unimin and the assumed background concentration. Table 4-5 below, taken from the dust assessment report (refer Appendix L) summarises TSP concentrations at various locations.

All receptors were well below the threshold limit of 90 $\mu\text{g}/\text{m}^3$ over a 1-year averaging period as set out in the Environmental Protection Policy 1997 (EPP (Air)). The highest annual average TSP concentrations from Unimin's operations are Boronia Court, Illawong Court and a receptor at Myora Conservation Park.

Table 4-5 TSP concentration at discrete receptors

Receptor number	Site	Annual average TSP Conc. (Unimin only), ($\mu\text{g}/\text{m}^3$)	Total annual average TSP conc. ($\mu\text{g}/\text{m}^3$)
1	Illawong Ct	1.1	17.5
2	Myora Springs estate, Boronia Ct	3.6	20.0
3	Myora Conservation Park	1.1	17.5
4	Building (due east)*	0.1	16.5
5	Building SE*	0.2	16.6
6	Building SW*	0.5	16.9
7	Building WSW 1*	0.9	17.3
8	Building WSW 2*	0.8	17.2
9	Building WSW 3*	0.7	17.1

The study notes that the background value is based from an EPA monitoring site at Wynnum and as such is not truly representative of the actual conditions around the study area.

PM₁₀

The study investigated concentrations of TSP at discrete receptors from Unimin operations alone, and the total concentration due to Unimin and the assumed background concentration. Concentrations of PM₁₀ at discrete receptors from Unimin operations alone, and the total concentration due to Unimin and the assumed background concentration are shown in Table 4-6 below.

The highest concentrations were recorded at Illawong Court and a receptor at Myora Conservation Park. All locations complied with the Environmental Protection Policy (Air) PM₁₀ limit of 150 $\mu\text{g}/\text{m}^3$ over a 24 hour averaging period and 50 $\mu\text{g}/\text{m}^3$ over a 1-year averaging period.

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Table 4-6 PM₁₀ concentration at discrete receptors

Receptor number	Site	24 Hour average PM ₁₀ Conc. (Unimin only) (µg/m ³)	Total 24 Hour average PM ₁₀ Conc. (µg/m ³)	Annual average PM ₁₀ Conc. (Unimin only) (µg/m ³)	Total Annual average PM ₁₀ Conc. (µg/m ³)
1	Illawong Ct	7.1	55.8	0.5	16.9
2	Myora Springs estate, Boronia Ct	13.2	61.9	1.7	18.1
3	Myora Conservation Park	5.7	54.4	0.6	17.0
4	Building (due east)*	1.3	50.0	0.1	16.5
5	Building SE*	2.7	51.4	0.1	16.5
6	Building SW*	4.0	52.7	0.3	16.7
7	Building WSW 1*	5.5	54.1	0.4	16.8
8	Building WSW 2*	5.3	54.0	0.4	16.8
9	Building WSW 3*	4.4	53.1	0.4	16.8

Again, it should be noted that the background value is based from an EPA monitoring site at Wynnum and as such is not truly representative of the actual conditions around the study area.

4.7.4 Dust

Table 4-7 shows the modelled results of dust deposition at the discrete receptors for the impacts due to Unimin only and the total impacts of Unimin and background dust sources. The predicted total dust levels at residential receptor locations are well below the EPA dust deposition guideline threshold (4 g/m²/month).

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Table 4-7 Dust deposition results

Receptor number	Site	Predicted dust deposition (Unimin only) (mg/m ² /day)	Predicted dust deposition (Unimin only) (g/m ² /month)	Total dust deposition (inc. Background level) (g/m ² /month)
1	Illawong Ct	10.1	0.04	2.8
2	Myora Springs estate, Boronia Ct	35.4	0.30	3.1
3	Myora Conservation Park	15.9	0.05	2.9
4	Building (due east)*	5.6	0.01	2.8
5	Building SE*	4.0	0.01	2.8
6	Building SW*	6.4	0.02	2.8
7	Building WSW 1*	7.4	0.03	2.8
8	Building WSW 2*	6.7	0.03	2.8
9	Building WSW 3*	5.7	0.02	2.8

4.8 Noise

The following section presents a summary of the results of the noise assessment for proposed operations on ML1108.

4.8.1 Current and Proposed Operations

The proposed operations and procedures on ML1108 will be a continuation of the existing operations on ML7064 and ML1124. Extraction on ML1108 will involve:

- Dry mining by a front end loader and transfer into a feed hopper;
- Primary screening through a trommel screen to remove roots and organic matter; and
- Pumping of the sand slurry off ML1108 to the main processing plant on ML7064.

No blasting, drilling or crushing activities will be undertaken on ML1108.

The mining activities on ML1108 will operate as per the current operating hours of the existing operation (Monday, Tuesday and Wednesday) with 24-hour operation on these days. The main processing plant on ML7064 will continue to operate as a 24-hour operation every Monday, Tuesday and Wednesday of each week.

In addition to the plant and equipment operating 24-hours, the day-time operations (7:00am to 6:00pm) will involve the following noise sources:

- Single tracked bulldozer engaged in vegetation clearing, and post-extraction land contouring;
- Front end loaders operating at the stockpile area; and
- Haul truck movements in and out of the stockpile area.

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There will be no increase in the number of haul trucks entering and leaving the site.

4.8.2 Noise Sensitive Locations

The nearest residences to the current and proposed operations are the residences of Boronia Court at "Myora Springs". The shortest horizontal distance from the property boundaries of these residences to the main processing plant is 1.2km.

The other residences in proximity to the current and proposed operations are the residences along Illawong Street at the eastern outskirts of Dunwich. The shortest horizontal distance from the property boundaries of these residences to the main processing plant on ML7064 is 4km.

4.8.3 Noise Impacts from Current Operation

The analysis of the long-term noise measurement data recorded at the two nearest noise sensitive places to the existing and proposed operations, revealed very low background and "intrusive" noise levels.

Results of the noise study at Boronia Court showed typical background (L_{90}) noise levels at 32dB(A) between 7am and 6pm, 28dB(A) between 6pm and 10pm and 28dB(A) between 10pm and 7am.

Noise measurements at Illawong Street showed typical background (L_{90}) noise levels at 29dB(A) between 7am and 6pm as well as 6pm to 10pm and 27dB(A) between 10pm to 7am.

The analysis of the long-term noise measurement data recorded at the two nearest noise sensitive places, when the mine is at continuous (24-hour) operation, revealed no changes in the background noise levels. The typical background noise levels, when the mine is in full operation are the same as when the mine was not operating.

The short-term (10-minute interval) noise measurements also show very low background noise levels and "intrusive noise levels" ($LA1$, and $LA10$) that are a result of typical local noise sources normally present at the investigated sites. The short-term variations in the noise levels are not influenced by the operational status of the sand mine.

The results of the noise measurements confirmed the subjectively observed absence of any "intrusive" noise that can be attributed to the current operations of the sand mine on ML 1124 and 7064.

Under the conservative modelling assumptions, the current operations at the sand mine fully comply with the licence conditions (noise criteria) during day-time and evening at Boronia Court and Illawong Street.

4.9 Road Transport

The road & traffic impact assessment (R&TIA) prepared by Burchill VDM assessed the existing road infrastructure in the immediate vicinity of the proposed operations and examined the relative impact of this on the local road network. The assessment report is provided in Appendix N and demonstrated that the continuation of mining activities into ML1108 would not have a significant impact on the existing road infrastructure in the vicinity of the subject site.

4.9.1 Current operations

Unimin currently use three semi-trailer 'tipper trucks' to transport sand to the wharf at Hospital Point, at the end of Cunningham Street, Dunwich (refer Figure 3.8). These trucks operate under a gross mass limit of 42.5 tonnes. Transport operations occur between eight and twelve hours per day, with a maximum number of six return trips made per hour. Haulage from the site operates five days a week, Monday through Friday, with the addition of an occasional half day Saturday (morning). Sundays and public holidays are not worked.

In addition to Unimin trucks, single operator contractors also purchase truck loads of sand using semi-trailers and 'truck and dog' vehicles. These trucks operate under a gross mass limit of 45 tonnes. These purchases represent an additional eight to twelve return trips per day. These single operator contractors

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use the public vehicle ferry, which departs from the wharf accessed via Junner Street, Dunwich (refer Figure 3.8).

4.9.2 Existing Road Network

The existing lease areas are currently accessed via a private road, which intersects East Coast Road at a T-intersection, approximately 1.3km north of its intersection with Gatumba Street. East Coast Road is a State Controlled road, which runs from Dunwich to Point Lookout. This road carries in the order of 2,000 vehicles per day. On average, Unimin trucks represent approximately 30% of heavy vehicle traffic along East Coast Road at this location. Bingle Road and Ballow Street (providing access to the ferry terminals in Dunwich) carry in the order of 1,800 vehicles per day.

Tazi Road, a potential alternative route for mine operations on ML1108 is controlled by Redland Shire Council. This is a lightly used road, which extends east-west from Mallon Street in Dunwich and continues across the island to its east coast. Traffic volumes on this road are less than 200 vehicles per day.

4.9.3 Existing Traffic Demands

The Bingle Road / Cunningham Street and Ballow Street / Junner Street intersections used by the mine, have been observed to operate effectively and are below intersection capacity. Surveys show a peak between 08:00 and 09:00, and between 15:30 and 16:30. These peaks overlap mining operations.

A two-way manual count carried out on Tazi Road showed that existing traffic demands at this location on this road are very low, with the highest number of vehicles counted in a single hour being nine.

4.9.4 Predicted Traffic Growth

As required by DMR (Guidelines for Assessment of Road Impacts of Development), a ten year design horizon (ie. to 2016) has been considered. The survey data shows an annual growth rate of eight percent. This is a relatively high growth rate, and traffic growth may not continue at this speed for ten years, however for the purposes of this assessment a growth rate of eight percent per annum has been applied to all background traffic volumes under consideration. The resultant volumes forecast for 2016 are provided in Figure's B-4 and B-5 in Appendix N.

4.9.5 Proposed Operations

Transfer of mining operations into ML1108 is not expected to constitute a significant increase in traffic generation. Maximum Unimin heavy vehicle volumes which could occur in a single day according to current Unimin activities are in the order of 168 heavy vehicle trips per day (84 each way). This value represents transport operations extending over a 12-hour period, at a rate of 6 Unimin trucks per hour (6 return trips), with the addition of 12 single operator contractors (12 return trips).

4.9.6 Operational Analysis

Traffic volumes across North Stradbroke Island are low, as evidenced by the surveys described earlier in this section. These low volumes allow for traffic operations at the intersections under consideration to remain well within acceptable limits as intersection capacities far exceed demands. On-site observations of the Bingle Road / Cunningham Street intersection and the Ballow Road / Junner Street intersection confirmed that they operate well below capacity.

A potential new haul route from the Vance Lease onto Tazi Road, east of Dunwich township has been reviewed as an alternative to the existing haul route. It is considered that the existing route along the East Coast Road into Dunwich remains the most suitable of the available options, with East Coast Road and Bingle Street being a main traffic route for the island.

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The proposed alternative route through Dunwich would direct the heavy vehicles through smaller streets and more residential areas (refer Figure A-3 of Appendix N) and are therefore not considered appropriate. Under the present situation, sight distances at the access point onto Tazi Road from ML1108 were not considered sufficient and road widening and rehabilitation would be required to accommodate for heavy vehicle movement. As the road presently carries few heavy vehicles, contribution of the pavement maintenance costs would likely need to be agreed with the Redland Shire Council.

4.10 Socio-Economic

This section summarises the results of the socio-economic study.

4.10.1 North Stradbroke Island

The main population centres of North Stradbroke Island include Dunwich, Amity and Point Lookout. At the time of the 2001 Census, there were a total of 2,512 persons recorded on North Stradbroke Island. This indicates a marginal increase in the number of people from the 1996 Census, when a total of 2,435 persons were recorded. There was an estimated resident population of 2196 people on North Stradbroke Island at the 2001 Census. 316 people were recorded as visitors in the 2001 Census (i.e. from elsewhere in Queensland, interstate or overseas).

Key demographic statistics are as follows:

- As at the 2001 census, 22.8% of the North Stradbroke Island resident population were aged less than 15 years and 9.4% were aged 65 and over;
- Indigenous Australians accounted for 13.3% of North Stradbroke Island's population, which is a significantly higher proportion compared to the Queensland average;
- "Couple family without children" was the most common family type on North Stradbroke Island, with 43% of families fitting this classification;
- Separate houses were the main dwelling type for the Island's population (1782 residents or 78%);
- The average population per dwelling in 2001 was 2.3 per household;
- As at the 2001 Census approximately 50% of dwellings were owned or being purchased, while approximately 38% were rented;
- Low income earners (i.e. those earning less than \$200 per week) accounted for 26.4% of all people aged 15 years and over in 2001;
- The most common occupations for employed persons were Intermediate Clerical, Sales and Service Workers (5.5%);

4.10.2 Population in the Vicinity of ML1108

The closest population to ML1108 is around Myora Estate, north of Dunwich. This area is situated in collection district (CD) 3202901, which covers an area of 156.7km². As at the 2001 Census, 139 people were recorded in this collection district.

Key demographic statistics for this area are as follows:

- At the time of the 2001 Census, 4.5% of the population were unemployed;
- Industries of employment included cultural and recreational services, government administration and defence, and mining;
- 17.5% identified themselves as Aboriginal or Torres Strait Islanders; and
- 88% of the population were born in Australia.

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4.11 Community Consultation

The following key issues were identified during the consultation process:

- Proposed methodologies of study components within the ESR;
- Need for geomorphology studies;
- Establishing an appropriate buffer zone for Swallow Lagoon;
- Details of the location of infrastructure and the proposed mine path; and
- Proposed rehabilitation process.

The following section provides a summary of issues raised, with full details available in Appendix H. Unimin's response to community issues and proposed mitigation measures are discussed in Section 5.13.

4.11.1 Proposed Methodologies

The main issue identified with the first issue of the ToR for public comment was the lack of specific information, in particular the proposed methodology for the flora/fauna studies and hydrology studies.

4.11.2 Geomorphology

Stakeholders raised concerns that the initial ESR did not include commissioning of a geomorphology study.

4.11.3 Hydrology

Swallow Lagoon was identified by stakeholders as being of great significance. Stakeholders wanted assurance that this area would not be adversely affected in any way by future operations.

4.11.4 Mining Activity

Stakeholders asked Unimin to provide details on the proposed mine path and location of infrastructure.

4.11.5 Rehabilitation

Stakeholders raised issues regarding the success rates of Unimin's rehabilitation methodologies. Stakeholders also wanted assurance of re-use of timber and topsoil in post mine rehabilitation, and the practice of transplanting the Grass Tree *Xanthorrhoea*.

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The results of desktop and field based baseline studies undertaken (refer Section 4) combined with a description of proposed mining activities (Section 2) has enabled an assessment of potential environmental impacts to be undertaken. These are described in the following section, and include details of proposed mitigation measures such as establishment of “no go” zones, adoption of appropriate operational and rehabilitation procedures and monitoring programs.

As part of any environmental monitoring program established, specific trigger levels (either quantitative and/or qualitative) will be established and documented within the site’s management plan to allow an assessment of whether Unimin’s operations are having a significant impact on site environmental values. This will enable corrective remedial actions to be undertaken if required. Any trigger levels established will (where practicable) take account of naturally occurring variations in environmental setting and may include air, water and soil contaminant concentrations; impacts to populations of significant fauna species; and successful rehabilitation of significant flora species.

5.1 Flora Impacts

5.1.1 Vegetation Removal

Figure 2.1 provides an outline of the proposed mine footprint. This figure should be considered indicative at present, with the final lease mining footprint subject to the findings of the exploration drilling program. For the purposes of this report it will be assumed the entire maximum footprint area will be cleared at some time during the operations. However, it is likely that the actual area to be cleared will be less, with steeply sloping areas and ridge tops unlikely to be suitable for mining.

Potential vegetation removal within the mine footprint will involve clearing up to approximately 378 ha of native vegetation. Table 5-1 presents a breakdown of the potential disturbance to vegetation within this area, indicating disturbance as a percentage of the communities found on the lease and as a percentage of the communities found within the sub-region.

Table 5-1 Maximum potential disturbance to vegetation communities within the proposed mining footprint

Community Description		Regional Ecosystem	Conservation Status ¹	Potential Disturbance		
				Ha	Site % ²	Sub-region % ³
1a	Low open dry heath on Quaternary dunes and sand plains	RE 12.2.13	Of concern	4.6	81.4	1.0
1b	Closed wet heath on seasonally waterlogged sand plains	RE 12.2.12	Not of concern	0	-	-
2a	Mallee <i>Eucalyptus</i> spp. Low woodland on Quaternary dunes and sand plains	RE 12.2.10	Not of concern	359	63.6	3.6
3a	<i>Eucalyptus</i> spp. open forest on Quaternary dunes and sand plains	RE 12.2.6	Not of concern	14.4	21.8	0.1

¹ As per the *Vegetation Management Act 1999*.

² Indicates % of disturbance to vegetation community within the project area.

³ Indicates % of disturbance to vegetation community within the southern coastal lowland province as per Accad *et. al.* (2003).

Vegetation Unit 2a: ‘Mallee *Eucalyptus* spp. Low woodland on Quaternary dunes and sand plains’ (‘Not of concern’ RE 12.2.10) is the community that will be mainly disturbed, with up to 359 ha to be cleared. This clearing would represent 63.6 % of the extent of this community found on site. However, when viewed in the broader context of impact to regional biodiversity, disturbance constitutes 3.6 % of this community within the sub-region. This community is not significant under state or commonwealth legislation.

The community subjected to the second highest area of clearing is Vegetation Unit 3a: *Eucalyptus* spp. open forest on Quaternary dunes and sand plains (‘Not of concern’ RE 12.2.6). This community is

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present on elevated dunes to the east and north of the site. The maximum area of this community to be cleared is 14.4 ha, which represents 21.8 % of the extent of this community found on site. However, when viewed in the broader context of impact to regional biodiversity, disturbance constitutes 0.1 % of this community within the sub-region. This community is not currently significant under state or commonwealth legislation.

5.1.2 Significant Communities

One conservation significant community will be impacted by the proposed clearing. This community is Vegetation Unit 1a: Low open dry heath on Quaternary dunes and sand plains ('Of concern' RE 12.2.13). Approximately 4.6 ha of this community occurs within the mine footprint area to be cleared. This impact represents 81.4 % of the overall area of this community found on site. However, when viewed in the broader context of impact to regional biodiversity, disturbance constitutes approximately 1% of this vegetation community found within the sub-region.

5.1.3 Significant Species

Two state conservation significant plant species were recorded within ML 1108 as detailed in Section 4.1.3.

Acacia baueri subsp. *baueri* (tiny wattle) was found in relatively high abundance, primarily in the small areas of low open heath on the exposed higher elevated dunes to the south west of ML 1108 (P3 and P4 in Figure 3.1). These areas will be protected from mining and will not be cleared. *Acacia baueri* subsp. *baueri* was also found in lower abundances in exposed areas adjacent to vehicle tracks, including the track along the Cooroon Cooroonpah Creek.

An extent of known habitat for this species outside the protected conservation areas are likely to be impacted by clearing for approved stage 1 mining operations. As such some potential impacts may be expected for this species in these areas. Mitigation of impacts for *Acacia baueri* subsp. *baueri* are outlined in Section 5.2.4

Gompholobium virgatum var. *emarginatum* (wallum wedge pea) was primarily found in relatively high abundances in mallee eucalypt woodland associations upslope of the Cooroon Cooroonpah Creek drainage line, and in the north-west of ML 1108.

An extent of known habitat for this species outside the protected conservation areas are likely to be impacted by clearing for approved stage 1 mining operations. As such some potential impacts may be expected for this species in these areas. Mitigation of impacts for *Gompholobium virgatum* var. *emarginatum* are outlined in Section 5.2.4

Species of cultural significance recorded from the site include *Boronia rosmarinifolia* (forest boronia), *Boronia saffrolifera* (safrole boronia) and *Boronia falcifolia* (wallum boronia). The former two species occur within the mine footprint and may require clearing. The latter species (*Boronia falcifolia*) is restricted to the wet heath along Cooroon Cooroonpah Creek and will be protected within the creek buffer.

Plant species of conservation significance will be included as part of any rehabilitation of disturbed areas as detailed in Section 5.2.4 to mitigate the impacts of clearing.

5.1.4 Weeds and Fire

Although the introduction of earthmoving equipment to the area has the potential to introduce new and declared weeds³, the risk of weed infestation is considered to be low due to the low edaphic nutrient cycling typical of dune vegetation communities found on site. If incidences of weed infestation are

³ Land Protection (Pest and Stock Route Management) Act, 2002.

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detected, appropriate measures will be put in place to monitor weed occurrence, and weed eradication measures will be put in place as required (Section 5.2.3). Existing fire regimes in integral vegetation communities are not considered to be affected by the proposed mining activities.

5.2 Flora Mitigation Measures

5.2.1 Conservation Areas

A number of conservation areas are proposed within ML 1108 which will exclude all mining operations. Proposed conservation areas include a 100 m exclusion buffer either side of the Cooroon Cooroonpah Creek drainage line, two areas of open heath vegetation, and the designated Ramsar 'wetland' areas at the south and east of ML 1108. The Ramsar area in the east of ML 1108 will also be potentially annexed as part of a proposed future national park (Appendix F, Section 2.5.6).

Approximately 196 ha of the vegetation within ML 1108 is to be protected within designated conservation areas. This includes approximately 67 ha of riparian vegetation within the Cooroon Cooroonpah Creek exclusion buffer and approximately 129 ha of eucalypt forest and mallee woodland within the 'Ramsar' area (Figure 3.1). An additional 64 ha of vegetation within ML 1108 occurs outside of the proposed mine footprint and so will also be retained.

Vegetation unit 1b; Closed wet heath (RE 12.2.12) is proposed to be wholly protected within the Cooroon Cooroonpah Creek exclusion buffer. Approximately 51.6 ha (78.2 %) of Vegetation Unit 3a *Eucalyptus racemosa* open forest (RE 12.2.6) and 205 ha (36.4 %) of vegetation unit 2a; Mallee *Eucalyptus spp.* low woodland (RE 12.2.10) will be protected within both the Ramsar area in the east of the site and the Cooroon Cooroonpah Creek exclusion buffer.

Areas of the "Of Concern" Vegetation Community 1b; Open dry heath community (RE 12.2.13) are located on exposed dune ridges at higher elevations. These areas are unlikely to be within the path of any mining operations due to the topography encountered. Slopes either side of the ridge line where this community is found exceed 40%, which excludes dry mining extraction under the methods currently employed. However there is potential for up to 4.6 ha of this vegetation community to be cleared. Two conservation areas are proposed in Community 1b at reference sites P3 and P4 (total area of approximately 1 ha) to ensure that the benchmark transects are protected for future reference for rehabilitation efforts (Figure 2.1).

5.2.2 Vegetation Clearing

The areas of vegetation to be cleared for the proposed mining operation will be restricted to the minimum required at any one time. Areas to be cleared will be clearly delineated prior to commencement of clearing with tape, pegs or other markers.

The preferred stripping method to be employed will ensure minimum clearing of vegetation on a weekly basis. Clearing proposed to be undertaken is estimated to be in the order of 30 m of clearing along the mine face per week (depending on depth of the deposit). This method of minimum stripping will minimise dust emissions, and will allow fauna recourse to disperse into adjacent habitat out of the mine path.

Vegetation clearing will be undertaken to ensure that isolated stands of vegetation are not created and the connectivity of habitat remains intact to allow for the dispersal of fauna. That is, clearing will be undertaken towards the direction of any adjacent contiguous vegetation that is not to be cleared to ensure connectivity of habitat is not disrupted.

Cleared shrubby vegetation will be saved to be utilised as brush matting for landform stabilisation in rehabilitation works. Cleared canopy vegetation and large woody debris such as hollow logs and branches will be stored and then reinstated as structures for faunal habitat as part of rehabilitation works.

Removal of *Xanthorrhoea johnsonii* (forest black boy) and *Xanthorrhoea latifolia* (grass tree) will be undertaken to allow for relocation of these species in rehabilitation works. Similarly, relocation may be

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undertaken for the significant *Acacia baueri*, *Gompholobium virgatum*, *Boronia rosmarinifolia* and *Boronia saffrolifera* if propagation of any these species demonstrates low success rates.

5.2.3 Weed Control

Generally weed presence in ML 1108 is relatively low. Soil disturbance and the introduction of vehicles and heavy machinery within the proposed operations footprint have the potential to introduce new and declared weeds to the site. If incidences of weed species are detected, appropriate measures will need to be implemented for eradication and continued monitoring of weed occurrence.

An effective weed control program will be implemented as an extension of the weed control program currently in place for present mining operations. The weed control program will include:

- Effective management methods to control spread of declared weed species⁴, in keeping with regional management practices or DNRM&E (or similar) pest control fact sheets;
- Ongoing monitoring of the project site to identify any new incidence of weed infestation;
- Provision of information for project staff on the identification of declared weeds;
- Dedicated machinery serviced on site and restricted to onsite use; and
- Wash down protocols for any non dedicated machinery or vehicles introduced to the site.

5.2.4 Rehabilitation of Disturbed Areas

All future proposed mine operations will be followed by a staged rehabilitation program to be undertaken behind the ongoing mine operation. Proposed rehabilitation will reform disturbed areas to previous contours with replacement of stored topsoil and will employ techniques involving direct seeding and / or tube stock to ensure a viable success rate of re-established vegetation. Revegetation will utilise endemic species of local provenance to establish floral assemblages in keeping with vegetation communities presently found on the mining lease. Rehabilitation methods will be in keeping with current best practice in accordance with the QLD EPA's rehabilitation objectives for mines (QLD EPA, 2006).

Progressive Rehabilitation

Rehabilitation will be progressively undertaken on areas that cease to be used for mining or mine-related activities within one year of becoming available. This will reduce the amount of disturbed land at any one time. Results of progressive rehabilitation will be used to refine rehabilitation methods for future mining operations.

Stored topsoil will be stockpiled to a height no greater than 3 m to ensure continued viability of the seed bank and microbial function. Rehabilitation will be undertaken with the objective to re-establish the pre-disturbance floristic and structural characteristics of the disturbed community in keeping with benchmark data obtained from permanent reference sites. Trial plots will be undertaken where necessary to assess the suitability and success rate of proposed rehabilitation methods.

Significant Species

Rehabilitation will address the requirement for re-establishment of conservation significant species and species of cultural significance. Rehabilitation of conservation significant species will utilise appropriate propagation and / or relocation techniques for successful regeneration (Section 5.2.2).

⁴ Land Protection (Pest and Stock route Management) Act, 2002

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Propagation of *Acacia baueri* has previously been achieved via standard seed raising methods following pre-treatment by soaking in boiling water or scarification. Cuttings have also been found to be successful in the propagation of this species (ASGAP, 2006).

Limited information is available on the propagation of *Gompholobium virgatum*, however anecdotal reports suggest the species can be successfully transplanted (SGAPQ, 2006). At the genus level, *Gompholobium* seeds have been shown to germinate when pre-treated with smoke under nursery or field conditions (Vigilante *et al.*, 1998).

Monitoring

Rehabilitation performance criteria will be set based on the benchmark data from the permanent primary transects, and continued monitoring undertaken to ensure that an acceptable standard of rehabilitation is met. Regular monitoring will be undertaken during the vegetation establishment period to demonstrate whether rehabilitation goals are being achieved and whether a sustainable landform has been developed.

Monitoring methodologies currently used in operation on the adjacent Unimin leases will be adopted and modified where necessary in a detailed monitoring program to be prepared for ML 1108. The monitoring program will be tailored to measure defined success criteria and undertaken regularly in order to establish the trend towards achievement of those criteria. Parameters to be monitored will potentially include, but not be restricted to:

- Erosion and landform stability;
- Ongoing physical and biological analysis of topsoil;
- Comparison of floristic and structural characteristics with data taken from reference sites; and
- Visual surveillance including the use of low level oblique or vertical aerial photography to monitor changes over time in the rehabilitation (e.g. changes in vegetation structure and landform).

In addition to rehabilitated areas, benchmark reference sites will also be monitored to allow for a meaningful comparison of the development and success of the rehabilitation against a control.

Monitoring will be conducted periodically by suitably skilled and qualified persons at locations which will be representative of the range of conditions on the rehabilitating areas. Annual monitoring data reviews will be conducted to assess trends and rehabilitation program effectiveness. Rehabilitation methods will be improved as additional knowledge develops from monitoring data results.

Maintenance

Maintenance of rehabilitated areas will be undertaken where necessary and in response to results of the monitoring program to ensure success criteria are being met, or are projected to be met at the time of mine closure. Depending on the criteria to be achieved, examples of maintenance works include re-seeding or further planting of tube stock of tree and/or shrub species to meet required revegetation parameters, and implementation of erosion protection measures to reduce erosion rates.

5.3 Fauna Impacts

Potential impacts on fauna may be associated with loss of habitat and foraging sources, disturbance to movement corridors, changes to surface water and groundwater conditions and other operational factors. A range of mitigation measures are discussed below including protection of key habitat features, appropriate rehabilitation and monitoring.

5.3.1 Habitat Loss

Vegetation removal within the proposed mining extraction area will disturb a number of habitat types, with mallee eucalypt low woodland (Vegetation unit 2a) subject to the most disturbance (Section 5.1.1). Other

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habitats subject to disturbance include smaller areas of open forest (Vegetation Unit 3a) and dune heath (Vegetation Unit 1a). Most conservation significant species were not observed within the mining area, however a number of threatened species potentially occur within ML 1108, particularly the short-limbed snake, glossy black cockatoo and the grey-headed flying fox.

The Terrestrial Fauna Study (Appendix G) notes that proposed vegetation clearing within the mining area may potentially impact glossy-black cockatoo breeding sites, particularly Vegetation Unit 3a. Mitigation measures for fauna impacts are detailed below (Section 5.4)

5.3.2 Habitat Connectivity

The mine lease (ML 1108) represents a relatively large area of intact vegetation with connectivity to adjacent tracts of intact habitat. Vegetation along the Cooroon Cooroonpah Creek and tracts of eucalypt open forest/woodland in the northern and eastern study area are likely to be of local significance as corridors for the movement of fauna species. Much of these areas are proposed to be conservation areas within the Ramsar listed area and the proposed 200 m wide buffer along Cooroon Cooroonpah Creek.

5.3.3 Hydrological Impacts

Three species of vulnerable acid frog are recorded to be present along Cooroon Cooroonpah Creek. Any significant changes to surface water flow regimes and groundwater levels, or siltation of foraging areas may have significant impacts upon these species. However, appropriate mitigation and management measures including a 200 m wide buffer along Cooroon Cooroonpah Creek should avoid impacts to these species.

Surface Water Impacts

Intense rainfall events sufficient to produce surface water runoff could potentially mobilise sediment disturbed during construction or operation of the mine which may then enter watercourses and lead to deleterious effects on aquatic habitats either on-site or downstream. The probability of this impact is considered extremely low due to the highly permeable nature of site soils which limits the potential for significant overland flow (Section 5.8.2). Additional protection, such as the installation of sediment fences downslope of all disturbed areas will ensure that the risk of sediment loss to drainage lines/watercourses is minimised.

Ground Water Impacts

The surface water flow seen along parts of the Cooroon Cooroonpah Creek drainage line is partially attributed to a perched aquifer on the layer of indurated sand along the drainage line at a depth of approximately 2.5 m (Section 4.5.2). Any disturbance to the perched aquifer along Cooroon Cooroonpah Creek may significantly impact the availability of suitable habitat for the acid frog population found along the riparian corridor. The proposed mining method is dry mining, and the nature of the mining method precludes operation in a wet environment, so for operational reasons the mining will be conducted above any water tables. Accordingly, the risk of interception of the water table (either perched or regional) is considered to be low (Section 5.7.1).

Proposed ongoing monitoring programs are outlined below for the monitoring of acid frog population parameters and habitat (Section 5.4.3), surface water quality (Section 5.8.6) and ground water levels (Section 5.7.4).

5.4 Fauna Mitigation Measures

5.4.1 Conservation of Significant Habitats and Species

Significant areas of habitat are to be conserved within a 200 m wide buffer along the full length of Cooroon Cooroonpah Creek within the mining lease (~67 ha), the Ramsar 'wetland' areas (~154 ha), two

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high dune conservation areas (~ 1 ha) and a number of areas that are outside of the proposed mining extent (~ 64 ha) (Section 5.2.1). This ensures the conservation of all primary habitat types found on site including:

- The entire extent of Closed wet heath habitat (~ 3 ha) along Cooroon Cooroonpah Creek ensuring complete maintenance of contiguous riparian connectivity across the site and preservation of habitat utilised by the highest diversity of fauna species, including conservation significant acid frog species;
- Over one third (205 ha or ~36%) of the Mallee *Eucalypt spp.* and *Banksia aemula* low woodland on site is to be conserved within both the Cooroon Cooroonpah Creek conservation buffer and the 'Ramsar' area to the east ensuring preservation of connectivity of this habitat across the site to adjoining contiguous vegetation offsite, and conserving a significant proportion of habitat supporting the highest reptile diversity on site including potential habitat for the threatened short-limbed snake-skink, and foraging habitat for grey-headed flying fox. Maintenance of the riparian corridor will allow for continued faunal movement across the site for a number of ground dwelling and arboreal species including migrating koala;
- Approximately 2 ha of *Eucalyptus racemosa*, *Corymbia gummifera* open forest / woodland that is contiguous with woodland habitat off site is situated outside the extent of proposed mining at the west of ML 1108. In addition to this, approximately 12 ha will also be conserved within the Cooroon Cooroonpah Creek conservation buffer providing for riparian connectivity of this habitat across the site and ensuring conservation of habitat utilised by a number of threatened fauna species including the glossy black-cockatoo, grey-headed flying fox and short-limbed snake-skink.
- Approximately 15 ha of *Eucalyptus pilularis* open forest is to be conserved within the 'Ramsar' area and is contiguous with extensive woodland habitat to the east of the site, and the Cooroon Cooroonpah Creek conservation buffer, providing for connectivity across the lease to offsite habitat to the north west. This will ensure conservation of habitat supporting a diversity of mammal species, old growth forest characteristics supporting a range of wildlife habitat (including glossy black-cockatoo and koala habitat) and the highest diversity of bird species found on site;
- A degree of Mallee *Eucalypt spp.* and *Banksia aemula* low woodland habitat on ridgelines that is contiguous with off site habitat will be conserved along two ridge lines present within the 'Ramsar' conservation area at the east of ML 1108. This habitat was recorded as having a relatively low diversity of fauna and did not appear to support conservation significant species, however does provide foraging habitat for flying-foxes and potential habitat for the threatened short-limbed snake-skink;
- Two conservation areas will preserve approximately 1 ha (~18 % on site) of open or dry heath with stunted *Banksia aemula* on upland dunes. This habitat is conserved for conservation value as a Regional Ecosystem, however it was found to support the lowest diversity of native fauna, no threatened species and is considered unlikely to support habitat specific fauna.

5.4.2 Rehabilitation of Disturbed Areas

A rehabilitation plan is to be implemented to ensure that ongoing progressive rehabilitation of habitat is undertaken behind the advancement of the mine face over the course of the mine life (several decades). This will reduce the amount of disturbed habitat on site at any one time. Staged rehabilitation will include revegetation of habitat to establish floral assemblages in keeping with pre-cleared vegetation communities. Known foraging species such as *Banksia aemula* and *Eucalyptus pilularis* for grey-headed flying fox, and fast growing Casuarinas for glossy black-cockatoos will be used wherever suitable growing conditions exist. Replacement of micro-habitat features such as stock piled logs and coarse woody debris, hollow bearing stags and nest boxes will also be employed to encourage faunal recruitment.

Careful planning of the staged mine path combined with ongoing progressive rehabilitation, the maintenance of the riparian corridor through the Cooroon Cooroonpah Creek buffer and conserved areas of habitat to the east, west and south of the lease will ensure that connectivity is maintained across the site allowing for the migration and post-rehabilitation recruitment of faunal assemblages.

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5.4.3 Monitoring

The mine rehabilitation plan to be implemented will also outline an ongoing monitoring program to track rehabilitation progress toward success criteria (Section 5.2.4). Monitoring will include implementation of habitat surveys within rehabilitation areas to ensure adequate establishment of foraging and shelter resources for a range of faunal groups, with particular attention paid to habitat suitable for conservation significant species such as the short-limbed snake-skink and glossy black cockatoo. In addition to ongoing habitat assessment, fauna surveys will also be undertaken after habitat establishment to gauge the level of faunal migration and recruitment taking place across the rehabilitated areas of the site.

Maintenance of rehabilitated areas will be undertaken where necessary in response to the results of the monitoring program to ensure success criteria are being met, or are projected to be met at the time of mine closure. Depending on the criteria to be achieved, examples of maintenance works include re-seeding or further planting, and introduction of habitat features such as those listed above.

In addition to the above rehabilitation monitoring program, a specific amphibian monitoring plan will be implemented to ensure correct management and monitoring of the population of acid frogs present within the wet heath habitat along Cooroon Cooroonpah Creek. This will incorporate ongoing targeted frog surveys to monitor the breeding and continued presence of the wallum froglet, wallum sedge frog and wallum rocket frog, as well as habitat monitoring to ensure the persistence of adequate microhabitat conditions for these species. Recommended ongoing monitoring of surface water and ground water quality (refer section 5.8.6 and 5.7.4) will also be undertaken in order to ascertain if there are any potential significant impacts to aquatic habitats. .

5.5 Cultural Heritage

A search of the Australian Heritage Database (formerly the Register of the National Estate) indicated no listings of national indigenous significance are present on ML 1108. Significant cultural heritage areas identified during a site walkover are located within the mining exclusion zone around Cooroon Cooroonpah Creek and will not be impacted by the proposed mine operation.

In the acknowledgement of its Cultural Heritage Duty of Care under Part 7 of the Aboriginal Cultural Heritage Act 2003 and to ensure the protection of cultural heritage aspects of the lease area, Unimin in consultation with the Elders-in-Council has developed a Cultural Heritage Management Plan (CHMP) for the project. The CHMP details the measures and activities to be undertaken to manage Aboriginal Cultural Heritage in the lease area. At the request of the Elders-in-Council the Cultural Heritage Study and CHMP have not been included with the ESR and have been provided as separate documents to the QLD EPA for their information.

5.6 Geomorphology and Soils

The footprint of proposed mining activity will not impact on those areas identified under the Australian Heritage Database as a registered place.

On average, the useable topsoil resource is approximately 0.4m thick on the higher dune crestal areas and ridge slopes within the general area proposed to be subject to future mining. A summary of proposed topsoil management measures is described below, with further details contained in the main soils and geomorphology report (refer Appendix I).

5.6.1 Topsoil Management

Stripping

Prior to the commencement of stripping, areas will be cleared of vegetation. Earthmoving plant operators will be trained and/or supervised to ensure that stripping operations are conducted in accordance with stripping plans and in-situ soil conditions. This will ensure that all suitable topsoil material resources are

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salvaged and that the quality of the stripped topsoil is not reduced through contamination with unsuitable soils.

Stockpiling

Where possible, topsoil material will be respread directly from stripped areas onto areas being rehabilitated. Where this is not possible, topsoil shall be stored in stockpiles.

Topsoil material stockpiles will be located in areas that are outside the mining disturbance area and away from drainage lines. Drainage from higher areas will be diverted around stockpiles to prevent erosion. Sediment controls will be installed, as required.

Respreading

Planning the rehabilitation of disturbed areas will include topsoil material respreading considerations including:

- Balancing required rehabilitation topsoil quantities against stored stockpile inventories;
- Planning the source of topsoil material to maximise direct respreading from stripping areas and to minimise the length of time that material is stored in stockpiles; and
- Installation of erosion control measures (silt fences, hay bales etc.) especially on the steeper slopes, to minimise erosion.

5.6.2 Soil Erosion

Following is a summary of erosion and sediment control measures proposed during the various stages of the sand mining operations:

- Vegetation clearing will be conducted progressively so that the minimum area necessary for effective operations is cleared at any one time;
- Any surface drainage or subsurface seepage is to be directed away from or around the operations areas;
- Sediment traps to remove suspended sediment prior to discharge from the operating area;
- Long-term stockpiles of topsoil and any excess cut material will be stabilised and have sediment control measures installed as required;
- Minimise disturbance to areas undergoing rehabilitation; and
- Re-established slopes will be constructed to stable slope angle (maximum 40%) and revegetated soon after construction.

5.7 Groundwater

A summary of potential impacts to groundwater and proposed mitigation measures have been identified below.

5.7.1 Interception of Groundwater within the Extraction Area

The general area of proposed sand extraction has been identified by Unimin. However, the exact locations of proposed mining pits and associated depths within this footprint have not been determined. Based on information from existing operations within adjacent lease areas (e.g. ML 7064) the silica sand is generally excavated to a depth of between 6m and 10m below original ground level.

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The risk of intercepting groundwater is likely to be greatest in the low-lying areas, such as close to Cooroon Cooroonpah Creek. However, to mitigate this risk a 100 m wide buffer zone is proposed each side of Cooroon Cooroonpah Creek, and the corresponding higher elevation of mining will reduce the risk of intercepting the groundwater table. The proposed mining method is dry mining, and the nature of the mining method precludes operation in a wet environment, so for operational reasons the mining will be conducted above any water tables and the risk of interception of the water table (either perched or regional) is considered to be low.

5.7.2 Impacts on Groundwater and Surface Water Quality

Based on the current Unimin mining operations on surrounding mining leases, the only chemicals used during the mining or processing of the sand are anionic and cationic flocculants used to coagulate fine sediments in ponds to allow the sediments to settle. The existing sediment ponds on ML 1124 will be used for settlement of the fine sediments from the ML 1108 operation and as such are not considered to present a risk on ML 1108. These sediment ponds on the adjoining leases have been constructed to minimise seepage.

Other potential contaminants on-site are associated with the machinery used for excavation and construction including diesel and other petroleum-based fuels and lubricants. The high permeability of the sands means that any liquid discharged is likely to percolate relatively rapidly through the unsaturated zone and into underlying groundwater and may have a significant impact on the relatively pristine water environment.

All reasonable steps should be taken to prevent leakage/spillage including the provision of environmental management controls for the safe operation of refuelling, maintenance and storage, plus properly constructed and bunded storage, refuelling and maintenance areas. Infrastructure should not be located within sensitive areas, such as within the 100 m buffer along Cooroon Cooroonpah Creek or the Ramsar areas.

5.7.3 Changes in Groundwater Recharge Characteristics and Groundwater Elevation

Clearing of vegetation typically leads to an increase in the groundwater elevation due to the increased infiltration beyond the root zone. In addition, the removal of local vegetation will decrease the normal rate of evapotranspiration and potentially raise the elevation of the groundwater table.

The risk of significant increase in groundwater elevation of the shallow perched or regional aquifers following clearing is considered to be low due to the rapid infiltration rate and high permeability of the aquifer material.

Progressive rehabilitation will minimise increased recharge and the 100 m buffer zone along either side of Cooroon Cooroonpah Creek will minimise any increase in groundwater elevation in the perched aquifer. The risk of any change to the groundwater regime and associated impacts on the acid frog species is considered to be low.

5.7.4 Recommended Monitoring

The groundwater report recommends Unimin install at least two groundwater monitoring bores within the lease area between active mining areas and the 100 m buffer along Cooroon Cooroonpah Creek to collect groundwater elevation and water quality information of any perched aquifer encountered. Routine monitoring of these new monitoring bores would allow continued monitoring of any potential impacts of mining activities on groundwater. A recommended groundwater monitoring programme has been suggested that includes analysis of the following parameters:

- Depth to groundwater below top of casing;
- Physio-chemical parameters (pH, EC, dissolved oxygen);

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- Major ions;
- Dissolved metals (iron and zinc); and
- Hydrocarbons (total petroleum hydrocarbons and benzene, toluene, ethylbenzene and xylene).

5.8 Surface Water

A summary of potential impacts to surface water on and in the vicinity of the mining lease and proposed mitigation measures have been identified below.

5.8.1 Increased Runoff from Vegetation Clearing

Clearing of vegetation can lead to increased runoff from reduced interception/storage and evapotranspiration and from soil compaction. Excessive increases in peak runoff could lead to an increased risk of flooding and mobilisation of sediment with a negative impact on downstream receiving waters.

The above potential impacts are considered unlikely, given the high permeability of the strata that will be exposed by clearing and excavation work. The 100m no-mining buffer zone width (measured from the high banks) either side of Cooroon Cooroonpah Creek will provide additional protection against erosion in the event of increased runoff in very high intensity rainfall events.

5.8.2 Disturbance of Sediment or Contamination

Intense rainfall events sufficient to produce surface water runoff could potentially mobilise sediment disturbed during construction or operation of the mine. Mobilised sediments could potentially enter watercourses and lead to deleterious effects on aquatic habitats either on-site or downstream. The probability of this impact is considered extremely low due to the highly permeable nature of site soils which limits the potential for significant overland flow and 100 m buffer either side of Cooroon Cooroonpah Creek. Additional protection, such as the installation of sediment fences downslope of all disturbed areas will ensure that the risk of sediment loss to drainage lines/watercourses is minimised.

5.8.3 Infilling of Watercourses/Drainage Lines

With the exception of Cooroon Cooroonpah Creek, no other distinct watercourses or drainage lines were identified within the lease area. Thus, no drainage lines or watercourses shall be infilled as part of mining operations. All operations will be undertaken on land sufficiently distant from Cooroon Cooroonpah Creek in accordance with the 100m no-mining buffer zone either side of the Creek. The potential impact of infilling of watercourses/drainage lines is therefore considered to be negligible.

5.8.4 Changes to Site Drainage

The major drainage line of Cooroon Cooroonpah Creek will be protected by a 100 m no-mining buffer zone width either side of the Creek. Other temporary changes to site drainage may be caused by regrading the local topography as sand is excavated. As the mining works are likely to be carried out on the shallower slopes, it is anticipated that mining work will be restricted to areas set back from drainage lines. It will therefore be necessary to progressively regrade and rehabilitate the disturbed area with slope and aspect similar to the pre-mining landform to prevent significant changes to flow routes. The common practices of establishing windrows of sand at the base of disturbed areas, and installation of sediment fences to limit sediment mobilisation and control drainage, will also be implemented.

Alteration of local drainage routes is unlikely to lead to significant negative impacts on a wider scale due to the rapid infiltration rates and high permeability of the underlying strata.

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5.8.5 Leakage/Spillage of Potential Contaminants

There is potential for machinery on the site to leak contaminants including diesel and other petroleum-based fuels and lubricants. The high permeability of the sands means that any liquid discharged is likely to percolate relatively rapidly through the unsaturated zone and into underlying groundwater. This may then lead to subsequent contamination of surface waters where groundwater flows into surface water bodies.

Three levels of protection are proposed to prevent/contain leakage/spillage of contaminants:

- Bunded storage areas for fuels and dangerous goods, in accordance with Australian Standards (AS 1940 and AS 3780);
- 100 m no-mining buffer zone either side of Cooroon Cooroonpah Creek; and
- Emergency spill procedures to minimise potential, extent and cleanup of leakage/spillage of contaminants.

5.8.6 Water Quality

Cooroon Cooroonpah Creek is considered to be representative of a lowland freshwater stream in South-East Queensland as per the Queensland Water Quality Guidelines (EPA, 2006) and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). Monitoring of Cooroon Cooroonpah Creek water quality conditions is recommended. In particular, further monitoring parameters including analyses for Dissolved Oxygen (as % saturation) and Chlorophyll 'a' concentrations should be considered in future monitoring to confirm the nutrient enrichment status of surface water bodies in the area.

5.9 Dust

The modelled results for dust concentration and deposition, including background levels are well below the guidelines given by the Queensland EPA and the Redlands Shire Council. No significant mitigation measures are proposed at this time.

5.10 Noise

Under conservative modelling assumptions for the operations on ML1108, the calculated noise levels at the nearest noise sensitive places are very low and full compliance with QLD EPA Environmental Authority (EA) conditions (noise criteria) is achieved at the two closest noise sensitive locations (Boronia Court and Illawong Street at Myora Springs).

The increased separation distance of the extraction site from the residences at Boronia Court is likely to result in a reduction of the noise levels at this site. Noise levels at Illawong Street are likely to increase due to increased proximity of operations and the elevation of the extraction site (mobile plant).

At Boronia Court, the modelled noise levels from the proposed operation on ML1108 are 32dB(A) between 7am and 6pm, 37dB(A) between 6pm and 10pm and 30dB(A) between 10pm and 7am.

Under conservative modelling assumptions for the proposed operations on ML1108, the calculated noise levels at the nearest noise sensitive places are very low and full compliance with EA conditions (noise criteria) is achieved at Boronia Court and Illawong Street.

Considering the elevation of the terrain along the south-western boundary of ML1108, the 2006 Noise Assessment report (refer Appendix M) recommends that the extraction plant and equipment (mobile screen plant, site generator, slurry pump and front end loader) be located in the lowest point of the extraction site. The location of the mobile plant and equipment behind the walls of the extraction site will provide a high level of noise attenuation thus ensuring long-term protection of the noise amenity at the nearest residences.

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5.11 Road Transport Assessment

Transfer of mining operations into ML1108 is not expected to constitute a significant increase in traffic generation. A review of existing traffic operations indicates that the existing road network operates well below capacity and there should not be any impact from the proposed operations along the existing haul route. There is not expected to be an acceleration of pavement deterioration from the operations on ML1108.

A potential alternative haul route from the Vance Lease onto Tazi Road, east of Dunwich township has been reviewed as an alternative to the existing haul route. This route would direct the heavy vehicles through smaller streets and more residential areas and as such is not considered a viable route at this point in time.

Use of Tazi Road would require increased pavement width, annual pavement maintenance, future rehabilitation and improvement of site distances at the entrance of the site onto Tazi Road. As the road presently carries few heavy vehicles, contribution of the pavement maintenance costs would need to be agreed with the Redland Shire Council.

5.12 Socio-economic

The scope for the socio-economic component of the ESR was limited to updating the existing socio-economic profile of the area. As such, socio-economic impacts have not been investigated in detail. However, there is not expected to be any significant socio-economic impacts to the surrounding area, as the development on ML1108 is a continuation of existing operations and does not constitute any expansion of activities.

5.13 Community Consultation

In response to key issues raised from the community consultation program (refer section 4.11), Unimin prepared mitigation measures to address stakeholders concerns.

5.13.1 Proposed Methodologies

The main issue raised with the first draft of the ToR was the lack of specific information. Therefore, the second draft provided more detailed in terms of study methodologies and references. In particular, the proposed hydrology and flora/fauna studies were required to provide additional information to explain in detail the methodologies to be employed during the project.

5.13.2 Geomorphology

Taking into consideration these concerns, Unimin commissioned a literature review of the local and island geomorphology in conjunction with a terrain analysis on the lease area. This information was to be linked with flora and fauna studies; as well as surface and groundwater hydrology studies already proposed

5.13.3 Hydrology

Stakeholders identified the significance of Swallow Lake and wanted assurance that this area would not be adversely affected in any way by future operations. Unimin will keep an appropriate buffer zone between site operations and Ramsar designated wetlands.

5.13.4 Mining Activity

Stakeholders asked Unimin to provide maps on where it would be mining and post-mine topographical maps. As this is something that could not be accurately determined until after completion of the environmental studies, Unimin could not provide this information at this time.

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Similarly with the information requested regarding infrastructure (pipelines and power etc), as mine paths are not yet known, final infrastructure locations could not be defined at this time.

5.13.5 Rehabilitation

Stakeholders questioned the success rate of the proposed and current rehabilitation methodologies. Unimin currently conducts Index of Similarities on all rehabilitated areas until a set level of similarity has been reached for two consecutive years. Stakeholders, including the EPA have reviewed Unimin's progress in this area and considered its rehabilitation to be a success. As a result, Unimin decided against having current rehabilitation practices reviewed as part of this ESR.

Stakeholders also wanted assurance of re-use of timber and topsoil in post mine rehabilitation, and the practice of transplanting the Grass Tree *Xanthorrhoea*. Unimin informed the stakeholder group that they already conduct these activities on their current leases and would continue this on the Vance Lease area.

5.13.6 Draft ESR Comments

Review of the Draft ESR in 2005 by community stakeholders and QLD EPA raised concerns with respect to the over reliance on historical data from previous studies. To address these concerns an additional program of studies was agreed to with the QLD EPA to obtain current site specific information relating to baseline conditions on ML1108.

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Unimin intend to progress their existing sand mining operations into ML1108 (Vance Lease). As part of Unimin's environmental authority approval requirements, an ESR has been developed. The following section provides a summary of the studies carried out, including baseline environmental assessment findings, identified potential impacts and proposed mitigation measures.

6.1 Terrestrial Flora

Results of the 2005 and 2006 flora survey shows that ML 1108 has relatively high floral diversity typical of the ecosystems surveyed and is comparable to results of similar previous studies conducted both within ML1 108 and its immediate locality.

Two state conservation significant species were recorded including *Acacia baueri* subsp. *baueri* (tiny wattle) and *Gompholobium vigatum* var. *emarginatum* (wallum wedge pea). Three species are identified by the Minjerribah Moorgumpin Elders as being of cultural significance to the traditional owners of North Stradbroke Island including *Boronia rosmarinifolia* (forest boronia), *Boronia saffrolifera* (safrole boronia) and *Boronia falcifolia* (wallum boronia).

Four vegetation communities were described and mapped on the basis of the 2006 field survey results, including:

- Vegetation unit 1a - Low open dry heath on Quaternary dunes and sand plains (RE 12.2.13);
- Vegetation unit 1b - Closed wet heath on seasonally waterlogged sand plains (RE 12.2.12);
- Vegetation unit 2a - Mallee *Eucalyptus* spp. Low woodland on Quaternary dunes and sand plains (RE 12.2.10); and
- Vegetation unit 3a - *Eucalyptus* spp. open forest on Quaternary dunes and sand plains (RE 12.2.6).

The majority of the lease supports vegetation unit 2a which is currently listed as 'not of concern' under the Queensland VM Act. Vegetation unit 1a is currently listed as 'of concern' under the VM Act. Approximately 6 ha is present on ML 1108.

The DEWR National Estate Register has designated two areas on the lease as Ramsar protected wetland areas. No wetland vegetation or significant areas of surface water were found in either of these areas. It is understood that these 'Ramsar' areas have been designated as such for land management purposes rather than for any intrinsic 'wetland' values.

The terrestrial flora study has identified and discussed potential impacts on the vegetation of the lease from the proposed mining operations including vegetation removal, potential weed intrusion and dust impacts. Suggested mitigation measures to minimise impacts include:

- Creating conservation areas/mining exclusion zones around sensitive areas and vegetation communities,
- Staged clearing, progressive rehabilitation and maintenance of habitat connectivity;
- Weed control including monitoring and wash down protocols; and
- Rehabilitation and continued maintenance of disturbed areas combined with ongoing monitoring to assess rehabilitation targets.

6.2 Terrestrial Fauna

A total of 92 native and 5 introduced terrestrial vertebrate species were recorded during field surveys in the study area, including 7 amphibian, 17 reptile, 48 bird and 20 mammal species.

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No Endangered or Critically Endangered species are known or expected to occur in the study area. A number of species identified on the site are classified as 'vulnerable' or 'rare' under the EPBC Act 1999, and/or the NC Act 1992, including:

- *Litoria olongburensis* (wallum sedgefrog): Vulnerable under EPBC and NC Act;
- *Litoria freycineti* (wallum rocketfrog): Vulnerable under EPBC;
- *Crinia tinnula* (wallum froglet): Vulnerable under EPBC;
- *Ophioscincus truncatus* (short-limbed snake-skink): Rare under EPBC;
- *Calyptrorhynchus lathamii* (glossy-black cockatoo): Vulnerable under EPBC; and
- *Pteropus poliocephalus* (grey-headed flying-fox): Vulnerable under NC Act

Habitat for conservation significant fauna recorded on ML 1108 includes:

- Closed wet heath, Cooroon Cooroonpah Creek riparian habitat
- Mallee *Eucalyptus* spp. and *Banksia aemula* low woodland on lowland dunes
- *Eucalyptus racemosa*, *Corymbia gummifera* open forest/woodland
- *Eucalyptus pilularis* open forest
- Mallee *Eucalyptus* spp. and *Banksia aemula* low woodland on ridge

A number of potential impacts are associated with the proposed mining activities within the study area, including:

- Vegetation removal and loss of habitat connectivity; and
- Impact on local hydrological systems (ground and surface water) on Cooroon Cooroonpah Creek.

Mitigation measures to be undertaken relating to threatened species and their habitats within ML 1108 include:

- Conducting mining activities that do not reduce surface water flows below natural flows;
- Prevent inflow of sand and silt to existing amphibian breeding sites;
- Establishing a number conservation areas of significant fauna habitat;
- Progressive rehabilitation of habitat and implementation of microhabitat features;
- Ongoing monitoring of faunal recruitment in rehabilitated areas; and
- Development of an amphibian monitoring plan for conservation significant acid frogs, implementing ongoing monitoring of habitat requirements and population parameters and incorporating ground water level and surface water quality data.

6.3 Cultural Heritage

Unimin contracted the Minjerribah-Moorgumpin Elders-in-Council Aboriginal Corporation as the Cultural Heritage Body for North Stradbroke Island to undertake a cultural heritage study for the entire project area.

Unimin in consultation with the Elders-in-Council has developed a Cultural Heritage Management Plan (CHMP) for the project and this has been provided to EPA under separate cover. The CHMP details the measures and activities to be undertaken to manage Aboriginal Cultural Heritage in the lease area. These measures include:

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- Protection of Identified Aboriginal Areas - establishing exclusion zones and restricted access areas around areas identified as significant aboriginal areas;
- Protection of Currently Unknown Cultural Heritage - establish a site inspection and monitoring regime during vegetation clearance and for the discovery of skeletal remains; and
- Rehabilitation - ensure the land is returned as much as is as reasonably practicable, to a state that provides habitats for the vegetation and fauna.

6.4 Geomorphology and Soils

The terrain within the lease area and throughout much of the central and northern part of North Stradbroke Island consists primarily of north-westerly trending sand ridges and hills with varying crestal elevations. Five Land Units have been identified within the site.

Soils are essentially similar throughout the entire lease. The soil landscapes (land units) that occur within the project area are dominated by the occurrence of white silica sands. The majority of soils on the site are classified either as Podzols or 'Giant' Podzols under the Australian Great Soil Group nomenclature - Stace et. al. (1968), and as Aeris Humosquesic Podzols on higher dune and ridge slopes or SemiaquicHumic/Arsilic Podzols under Australian Soil Classification proposed by Isbell (1996).

Useable topsoil resources are mainly confined to the surficial (A) horizon materials, which contain seed-stock, micro-organisms and nutrients necessary for plant growth. Appropriate topsoil management techniques are discussed below:

- Stripping - earthmoving operators will be trained to ensure suitable topsoil material resources are salvaged and that the quality of the stripped topsoil is not reduced through contamination with unsuitable soils.
- Respreading -Where possible, topsoil material will be respread directly from stripped areas onto areas being rehabilitated, otherwise topsoil shall be stored in stockpiles.

6.5 Groundwater

Groundwater elevations range from approximately 8m to 44m AHD. Groundwater is primarily recharged by rainfall infiltration through highly permeable quartz sands. Groundwater flow in the project area is primarily towards the north and west. Water was only encountered in a perched aquifer on the indurated sand at Site 2 on Cooroon Cooroonpah Creek. Groundwater levels in the perched aquifer identified on-site have a high degree of correlation with rainfall. The groundwater levels in monitoring wells installed along Cooroon Cooroonpah Creek indicate that there is a direct hydraulic connection between the creek and the perched aquifer.

Nearby water bodies such as Swallow Lagoon and Brown Lake are perched and don't appear to be influenced by the regional groundwater table. It is unlikely that these water bodies are linked to any perched aquifers on-site. Groundwater quality has relatively low concentrations of dissolved ions and has a low pH level.

The risk of groundwater contamination from the proposed silica mining operations on ML1108 is considered to be low. The proposed method of operation requires no chemical additives and is not expected to mine below the water table or below the indurated layer. Potential impacts to groundwater recharge and elevation are considered to be low due to the high permeability of the sands and the very low water-holding capacity of the sands above the water table.

Fuel storage and refuelling areas associated with mining operations shall advance with the mine face. These activities will require careful design, construction and operation and management practises to ensure that no fuel is allowed to discharge into the sand which is capable of rapid infiltration to the aquifers. Refuelling areas for instance should be limited to areas on impermeable pads with adequate bunding to contain any possible releases.

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It is recommended that Unimin consider installing a minimum of two groundwater monitoring bores within the lease area between the active mining areas and the 100m buffer along Cooroon Cooroonpah Creek to collect groundwater elevation and water quality information of any perched aquifer/s encountered.

Rehabilitation of mined areas is planned and should take place progressively and regularly as mined areas become available to reduce the risk of changes to the groundwater elevation and flow regime.

6.6 Surface Water

The surface water environment within the Vance Lease is characterised by minimal surface runoff, even during high, intense rainfall. The main drainage line traversing the lease is Cooroon Cooroonpah Creek, an ephemeral watercourse with intermittent flow exchange between groundwater and surface water.

The lack of surface water features and very limited potential for overland runoff flow due to very high infiltration capacity means that impacts from increased runoff, mobilisation of sediments and contamination are not considered to be significant. Site drainage is unlikely to be significantly impacted because overland flow is minimal and mining activity will not significantly alter drainage routes.

Planned rehabilitation of mined areas should be undertaken progressively as mining in specific areas is completed to reduce the risk of sedimentation and alteration of flow routes. The use of windrows and sediment fences at the edge of mining areas will also minimise these risks.

No mining or construction works should be carried out during any extreme rainfall event or within the 100m buffer zone adjacent to the creek. Potential fuel storage, refuelling and machinery maintenance areas will need to be carefully designed, built and operated with consideration of Environmental Management Systems to cover all sensitive operations.

6.7 Dust

The two major contributing sources for dust on the lease are the movement of bulldozers at the active mine face (used for scraping topsoil from the raw sand resource) and heavy vehicle movements from the stockpiles to the front gate.

Dust monitoring was undertaken at a number of off-site discrete receptors around the mine including residential locations. All locations were evaluated for Total Suspended Particulate (TSP) Concentration, PM₁₀ Concentration and TSP Deposition. Background concentrations were sourced from EPA measurements at the Wynnum monitoring site, while deposition background results were used from onsite deposition monitoring data.

All results for dust concentration and deposition, including background levels, were well below the guidelines given by the Queensland EPA and the Redlands Shire Council.

6.8 Noise

The following conclusions are based on the results of the background and operational noise measurements and consideration of the results of the noise propagation modelling for the existing and proposed Unimin operations.

Noise impacts on the closest sensitive receptors to Unimin's existing operations (along Illawong Street and Boronia Court) are very low. Full compliance with EA conditions (noise criteria) is achieved at these residential locations.

Although no noise impacts are expected from the proposed operations at ML1108, it is recommended that the extraction plant and equipment are located in the lowest point of the extraction site. The location of the mobile plant and equipment behind the walls of the extraction site will provide a high level of noise attenuation, thus ensuring long-term protection of the noise amenity at the nearest residences.

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6.9 Road Transport

The results of the road and traffic study indicate that the existing haul route along East Coast Road is considered to represent the most appropriate route between the existing Unimin access and the Wharf terminals used by Unimin. A potential alternative haul route, with a new access from ML1108 onto Tazi Road was investigated, however was not considered suitable due to poor sight distances at the access point and the existing standard of the road. If distances could be improved at the access point, and road rehabilitation works were carried out, this route may be viable in the future.

The existing intersections along the Unimin haul route have been observed to operate effectively. Surveys support on-site observations that traffic demands are well below intersection capacity. The proposed mine operation on ML1108 is not expected to generate additional traffic from the site and pavement deterioration is not expected to accelerate.

6.10 Socio-Economics

An update of demographic details from an earlier study prepared in 1998 indicates there has been a marginal decrease in the resident population. As at the 2001 Census, there were 2,196 residents, down from 2,350 residents recorded in 1996. Over 30% of the resident population were aged between 35 and 54 years of age. There were a relatively high proportion of residents aged 0-14 years (22.8%). "Couple family without children" was the most common family type on North Stradbroke Island, with 43% of families fitting this classification.

Separate houses were the predominant dwelling type for the island's population (1,782 residents or 78%), while 258 residents (11%) lived in "other" dwellings including caravans, boats and tents. The average population per dwelling in 2001 was 2.3, which was lower than the 1996 Census.

6.11 Community Consultation

Unimin carried out a community consultation program to inform the public of the proposed development, identify stakeholder issues and address these issues. Stakeholders were invited to comment on the proposed ToR and Initial Draft ESR. Key issues raised included the proposed methodology of study components; the need for a geomorphologic study; maintaining the integrity of Swallow Lagoon, rehabilitation measures, mining operations and reliance on historical, not site specific baseline studies. All issues were taken into consideration and the project has been amended to reflect community views where appropriate.

Section 7

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Section 7

References and Bibliography

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Section 8

Limitations

URS Australia Pty Ltd (URS has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Unimin Australia Limited and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated January 2006.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between July and October 2007 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

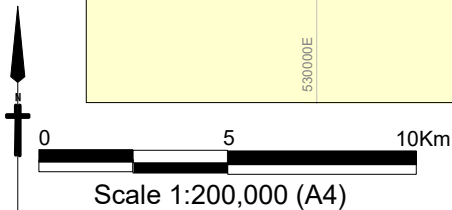
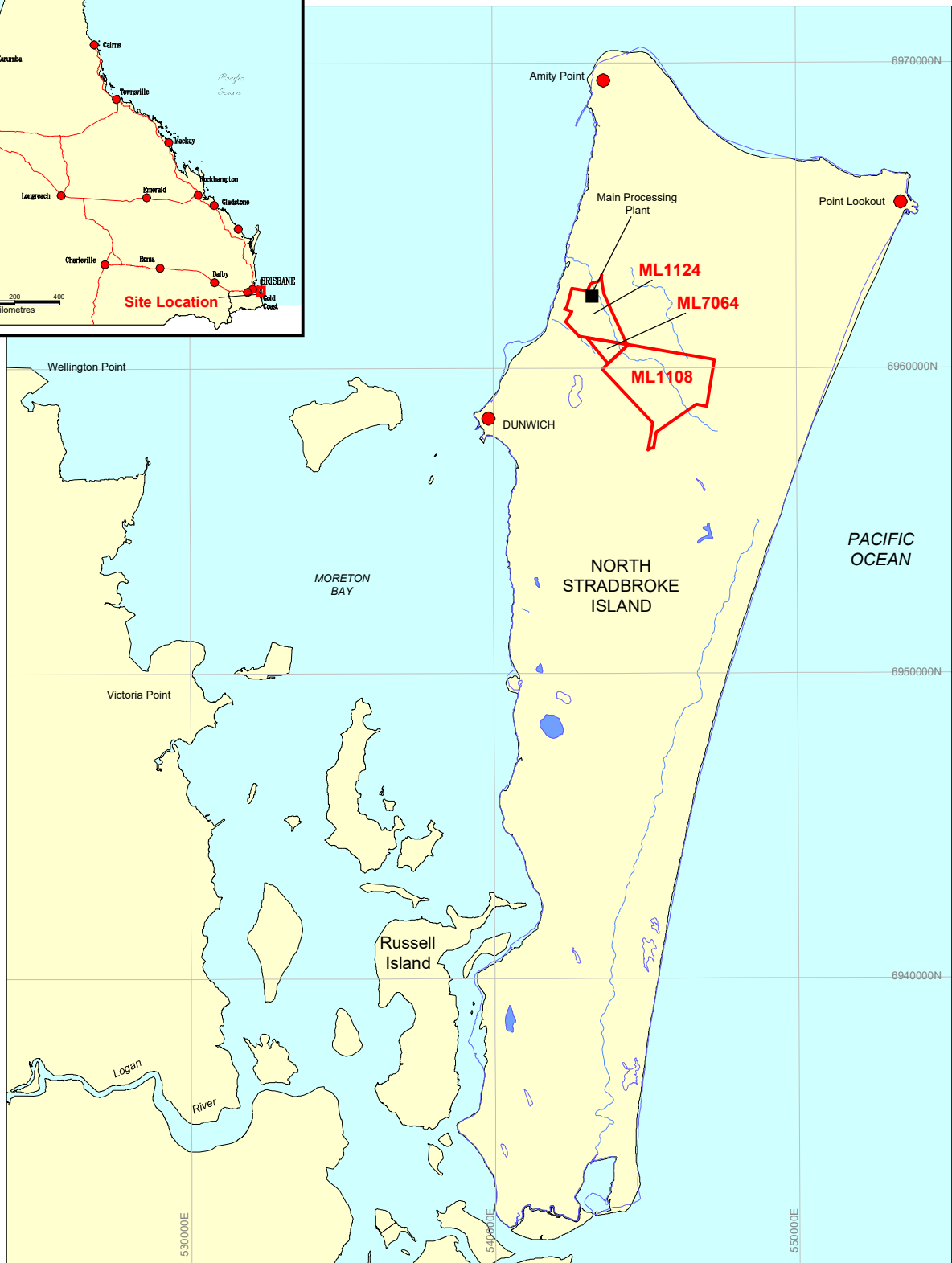
This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of contaminants in soil and groundwater are complex. Our conclusions are based upon the analytical data presented in this report and our experience. Future advances in regard to the understanding of chemicals and their behaviour, and changes in regulations affecting their management, could impact on our conclusions and recommendations regarding their potential presence on this site.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, URS must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

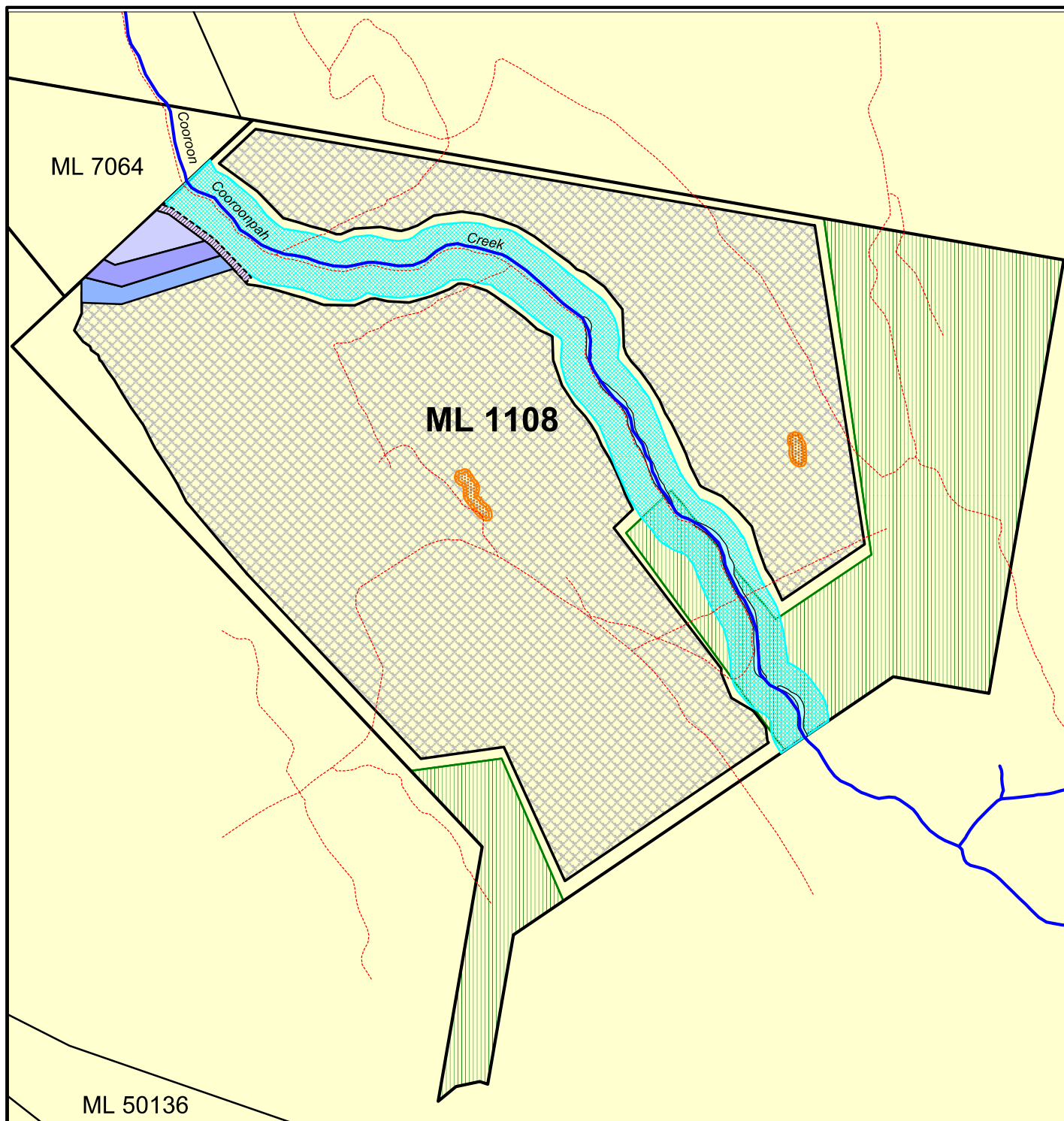
Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

Figures



Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project ENVIRONMENTAL STUDIES REPORT FOR VANCE MINING LEASE (ML1108)			Title LOCATION OF VANCE LEASE (ML1108)		
		Drawn: LL/TN	Approved: JB	Date: 11-10-2007	Figure: 1.1	Rev: A
		Job No: 4262 5813	File No: 42625813-g-061.wor			A4



LEGEND

-  Maximum Extent of Mine Footprint
-  Ramsar Area
-  Creek Buffer
-  Dry Heath Reference Sites
-  Tracks
-  Qld EPA Approved Stage 1 Mining Operations Year 1
-  Qld EPA Approved Stage 1 Mining Operations Year 2
-  Qld EPA Approved Stage 1 Mining Operations Year 3



0 500m 1000m
Scale 1:20,000 (A4)

Source: Client Supplied Aerial Photo (16-02-2005)

Client
UNIMIN AUSTRALIA LIMITED

Project
ENVIRONMENTAL STUDIES REPORT
FOR VANCE MINING LEASE (ML1108)

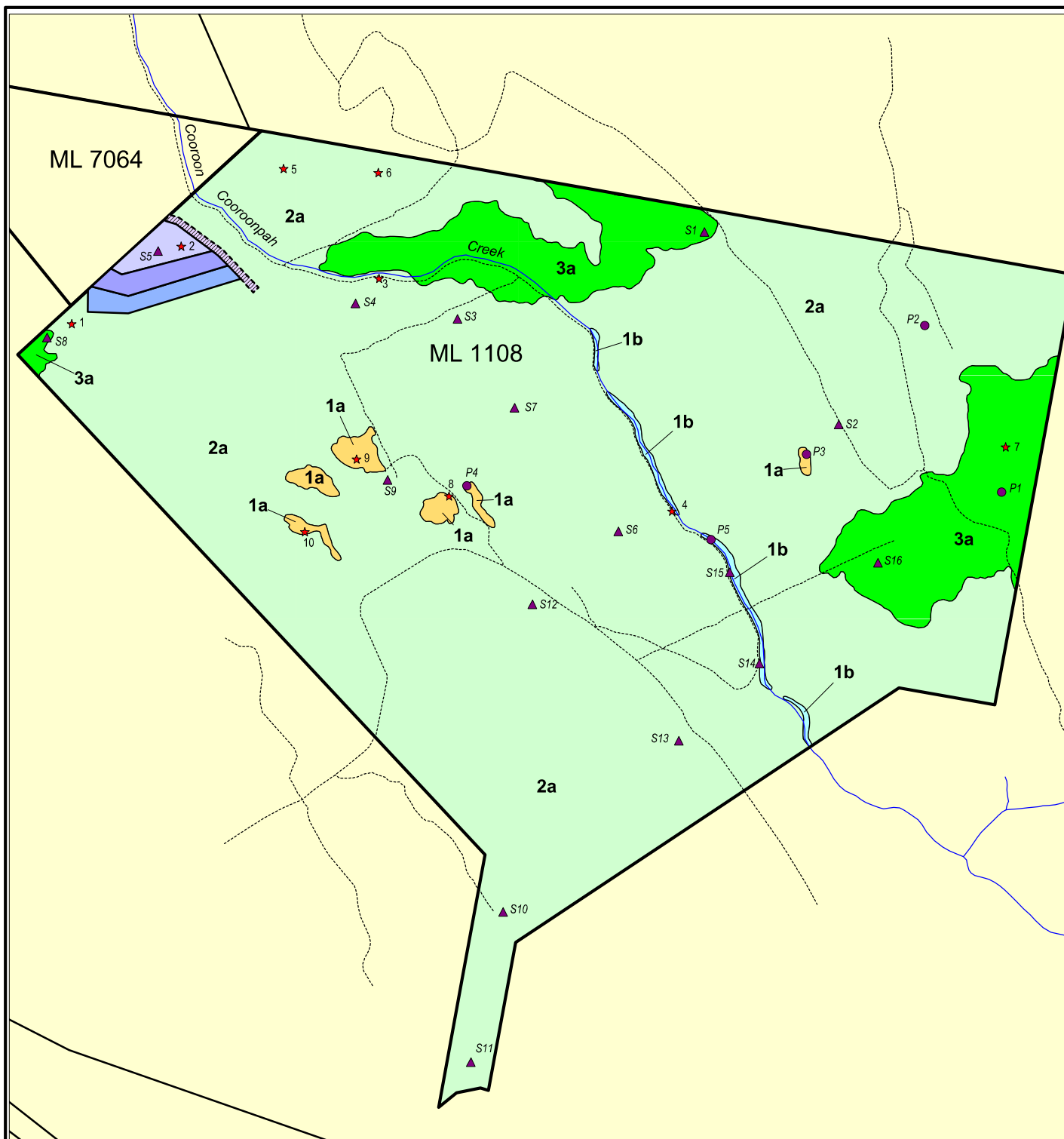
Title
MAXIMUM EXTENT OF MINE FOOTPRINT

URS

Drawn: VH/TN Approved: DS Date: 11-10-2007
Job No: **4262 5813** File No: 42625813-g-062b.wor

Figure: **2.1**

Rev: B
A4

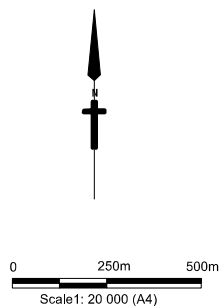


LEGEND



- 1a** Low Open dry heath on Quaternary dunes and sand plains (RE 12.2.13)
- 1b** Closed wet heath on seasonally waterlogged sand plains (RE 12.2.12)
- 2a** Mallee *Eucalyptus* spp. low woodland on Quaternary dunes and sand plains (RE 12.2.10)
- 3a** *Eucalyptus* spp. woodland on Quaternary dunes and sand plains (RE 12.2.6)

- ★ 1** 2005 Transects
- P1** 2006 Primary Transects
- ▲ S2** 2006 Secondary Transects
- Qld EPA Approved Stage 1 Mining Operations Year 1
- Qld EPA Approved Stage 1 Mining Operations Year 2
- Qld EPA Approved Stage 1 Mining Operations Year 3
- ▨** Topsoil/Battering Buffer



Source: Client Supplied Aerial Photo (16-02-2005)

Client
UNIMIN AUSTRALIA LIMITED

Project
**ENVIRONMENTAL STUDIES REPORT
FOR VANCE MINING LEASE (ML 1108)**

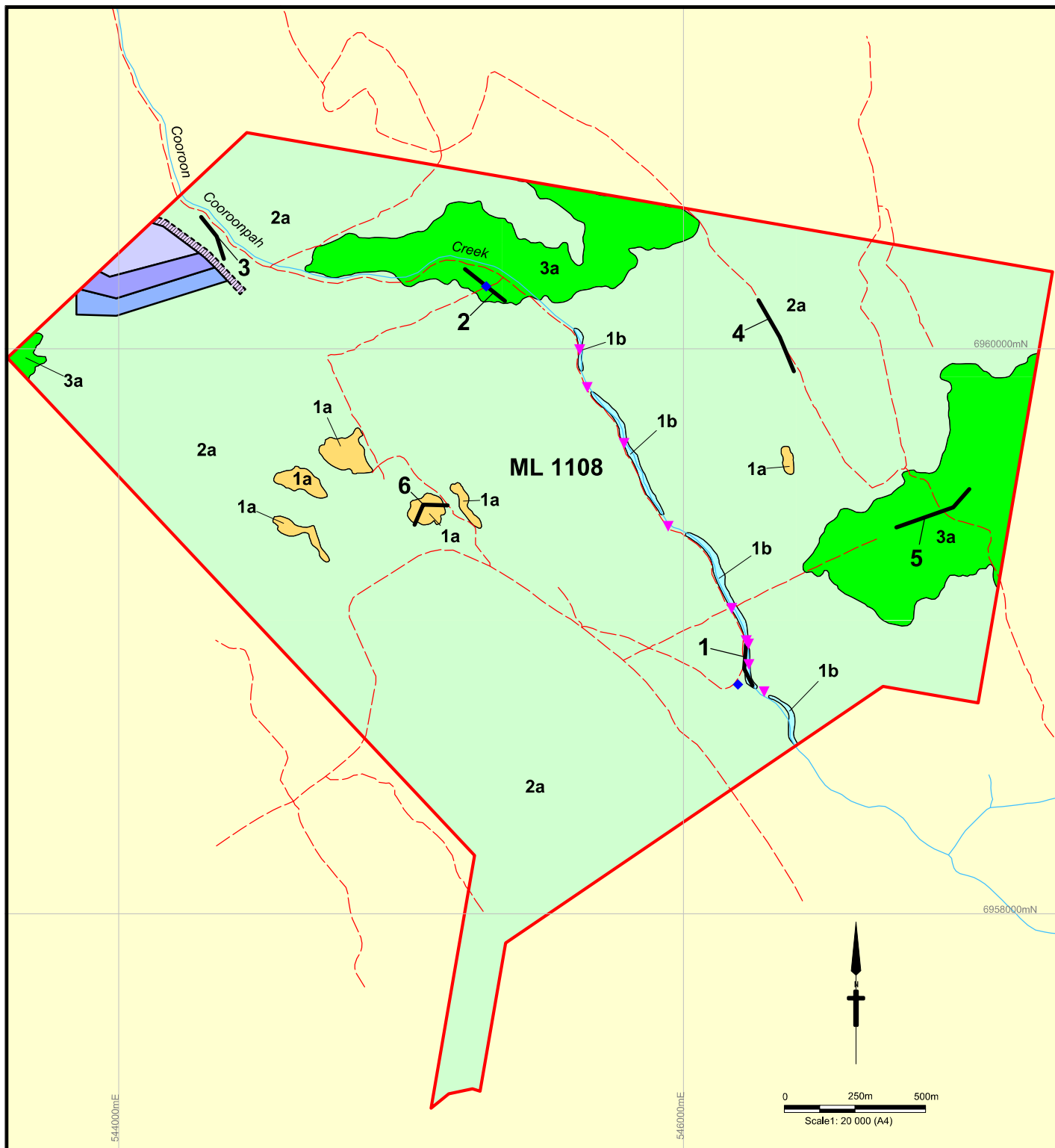
Title
**TERRESTRIAL FLORA SURVEY SITES
(2006)**

URS

Drawn: LL/TN Approved: JB Date: 11-10-2007
Job No: **4262 5813** File No: 42625813-g-063b.wor

Figure: **3.1**

Rev: B
A4



LEGEND

- ▼ *Litoria longiburensis* (Vulnerable)
- ◆ *Pteropus poliocephalus* (Vulnerable)

- 1a Low Open dry heath on Quaternary dunes and sand plains (RE 12.2.13)
- 1b Closed wet heath on seasonally waterlogged sand plains (RE 12.2.12)
- 2a Mallee *Eucalyptus* spp. low woodland on Quaternary dunes and sand plains (RE12.2.10)
- 3a *Eucalyptus* spp. woodland on Quaternary dunes and sand plains (RE12.2.6)

- Watercourse
- Track
- ML boundary
- Fauna Survey Transect
- Qld EPA Approved Stage 1 Mining Operations Year 1
- Qld EPA Approved Stage 1 Mining Operations Year 2
- Qld EPA Approved Stage 1 Mining Operations Year 3
- Topsoil/Battering Buffer

Source: Client Supplied Aerial Photo (16-02-2005)

Client
UNIMIN AUSTRALIA LIMITED

Project
ENVIRONMENTAL STUDIES REPORT
FOR VANCE MINING LEASE (ML1108)

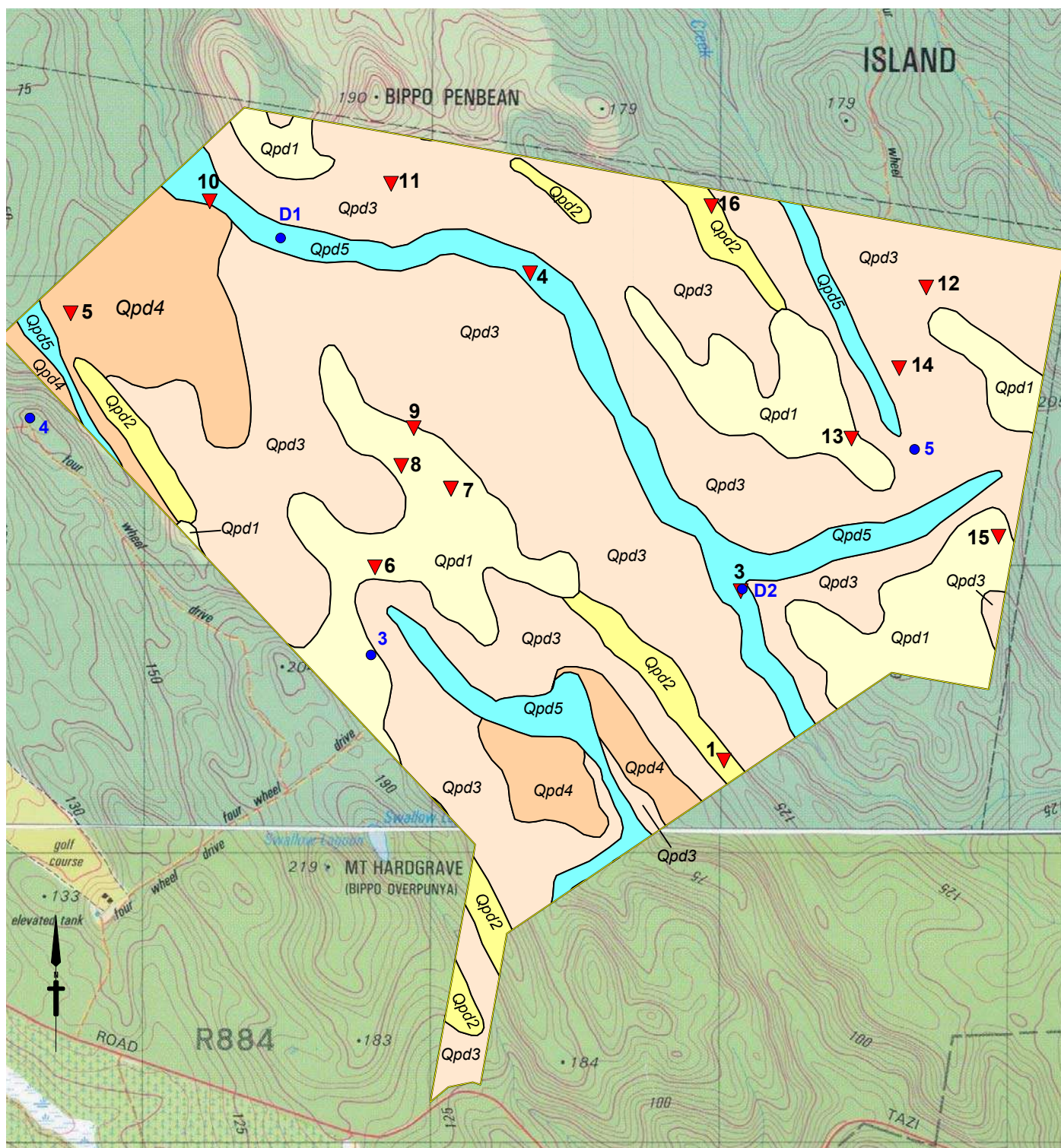
Title
TERRESTRIAL FAUNA SURVEY SITES
(2006)

URS

Drawn: LL/TN Approved: DS Date: 11-10-2007
Job No: 4262 5813 File No: 42625813-g-064b.wor

Figure: 3.2

Rev: B
A4



LEGEND

- 1 ▼ Sample Location - Phase 1
- 3 ● Sample Location - Phase 2

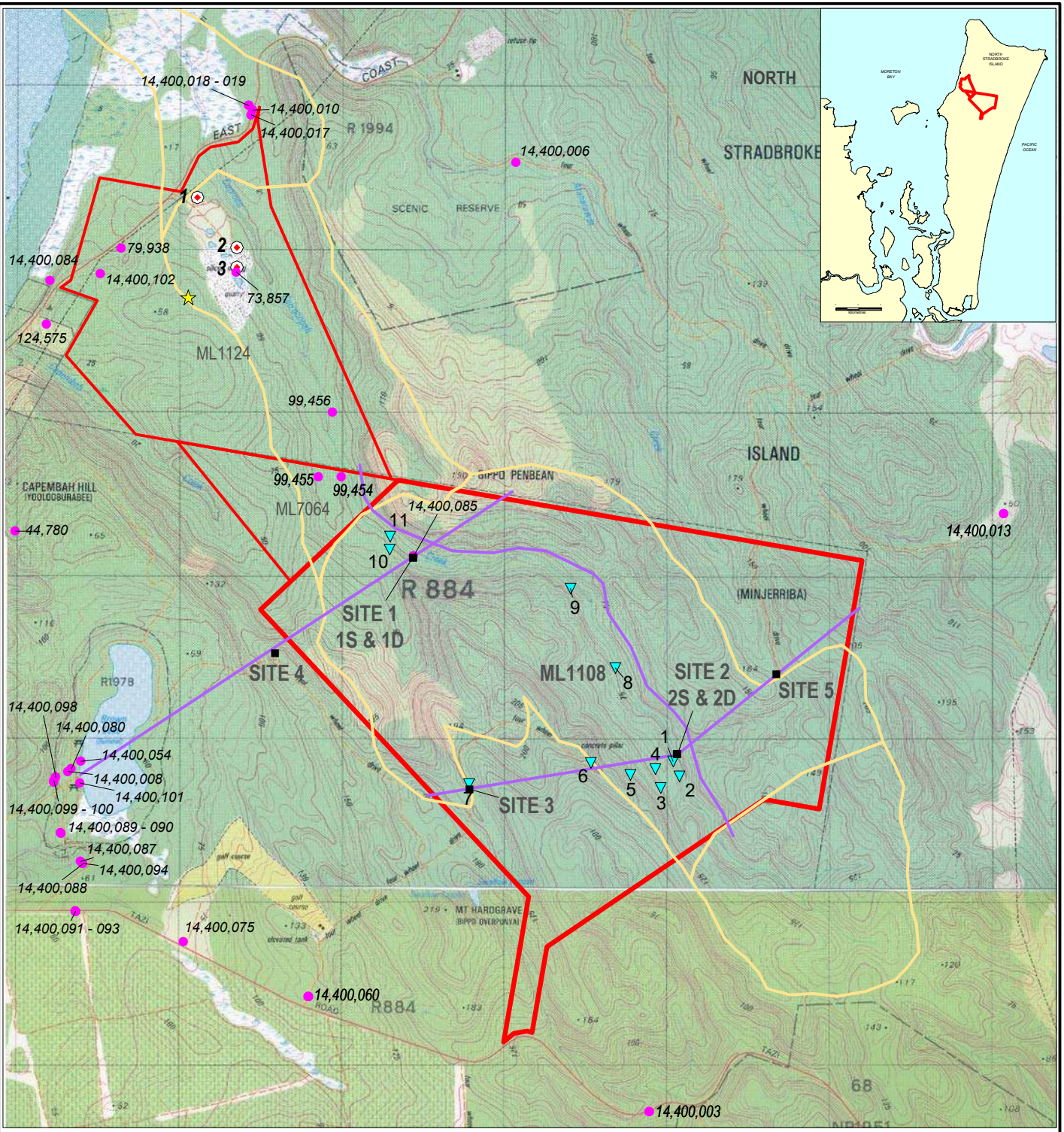
0 250m 500m
Scale 1:20 000 (A4)

LEGEND

- Qpd1** Undulating to low rounded hilly upland dune areas; slopes (10-20%), with deep Giant Podzols (Uc2.3) and locally shallower Podzols (Uc2.32) in the north-eastern sector of the site.
- Qpd2** Narrow rounded elongate sand ridge crests and upper marginal slopes (20-30%), with deep Giant Podzols (Uc2.3) and locally shallower Podzols (Uc2.32) in the north-eastern sector of the site.
- Qpd3** Steep irregular planar dune ridge slopes (30-60%), with deep Giant Podzols (Uc2.3) and locally shallower Podzols (Uc2.32) in the north-eastern sector of the site.
- Qpd4** Undulating to low hilly lowland dune areas with internal slopes (10-20%), with deep Giant Podzols (Uc2.3), with mod. highly organic and humic surficial (A1) soil horizons.
- Qpd5** Irregular planar to concave footslopes (up to 10%), drainage floors and locally seasonally swampy areas, with shallow to deep Podzols (Uc2.32), Giant Podzols (Uc2.3), and locally Humus Podzols (Uc4.3), with thick mod. to highly organic and humic surficial (A1) soil horizons.

Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project ENVIRONMENTAL STUDIES REPORT FOR VANCE MINING LEASE (ML1108)	Title SOILS AND GEOMORPHOLOGY SOIL SAMPLE LOCATIONS	
	Drawn: LL/TN Approved: JB Date: 11-10-2007	Figure: 3.3	
	Job No: 4262 5813 File No: 42625813-g-065.wor		
		Rev: A A4	



LEGEND

- Site 1 ■ URS GW Bore Locations
- 1 ▽ Infiltrometer Test Locations
- 1 ⊙ Unimin Groundwater Bores
- Cross Section Lines

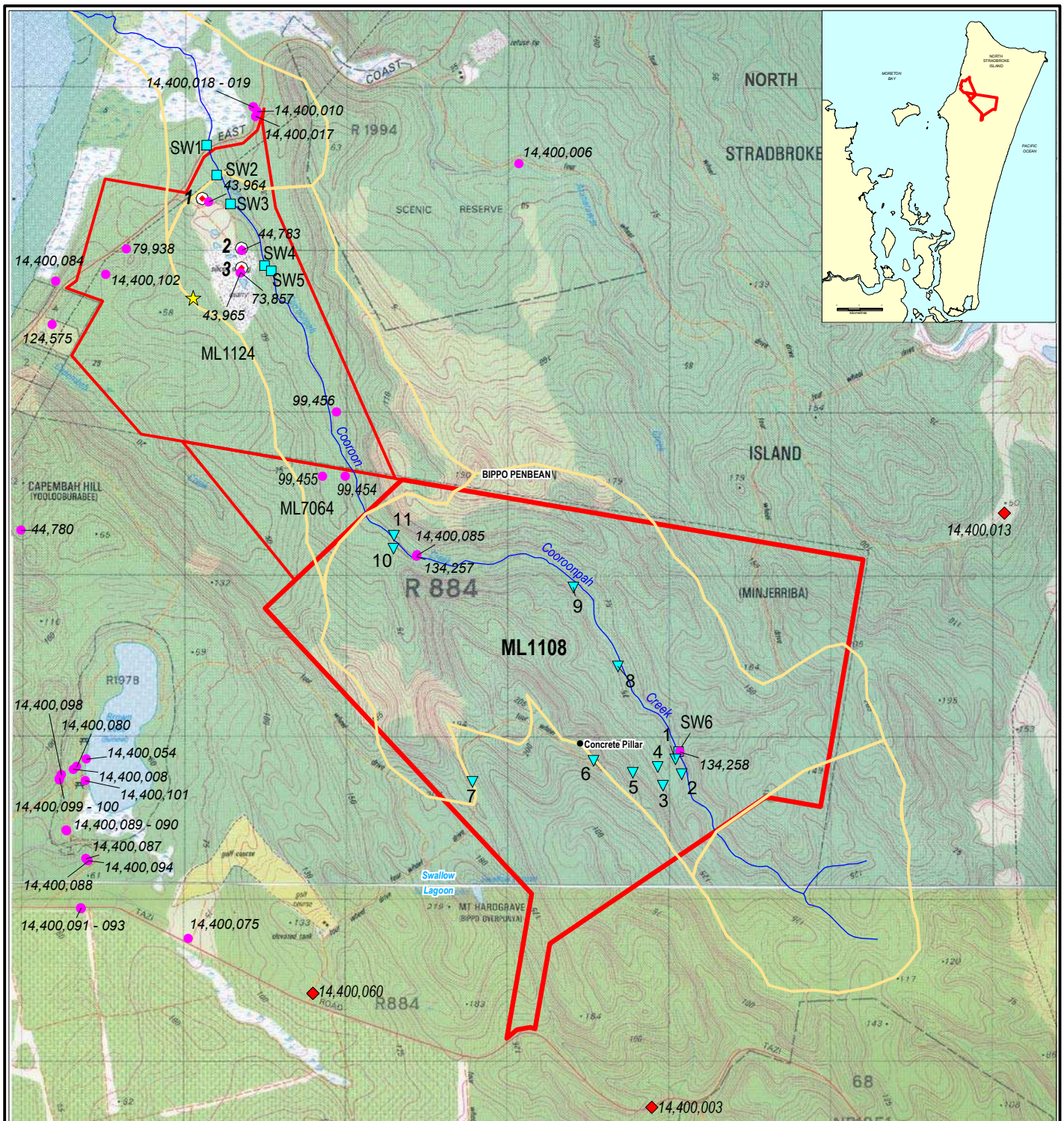
- ★ Approximate Location of Rain Station
- 73,857 ● Registered Groundwater Bores (2004 and 2007)
- Cooroon Cooroonpah Creek Catchment Boundary



0 500m 1000m
Scale 1:35 000 (A4)

Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project ENVIRONMENTAL STUDIES REPORT FOR VANCE MINING LEASE (ML1108)			Title GROUNDWATER SAMPLE LOCATION DETAILS	
	Drawn: LL/TN	Approved: JB	Date: 11-10-2007	Figure: 3.4	Rev: A
	Job No: 4262 5813	File No: 42625813-g-066.wor			A4



LEGEND

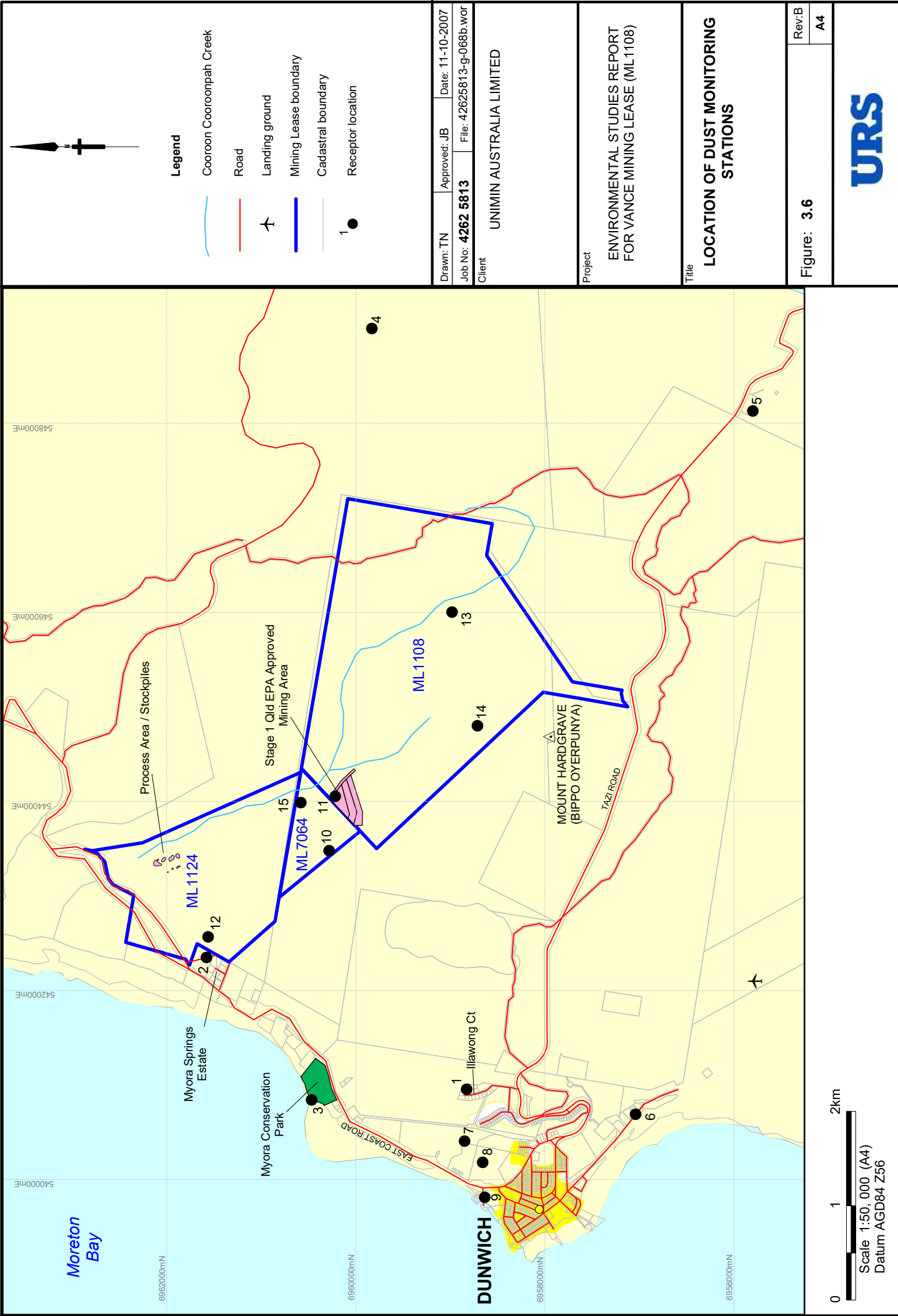
- | | |
|--|---|
| 1 ▽ Infiltrometer Test Locations | 99,454 ♦ Registered Groundwater Bores (2004) |
| 1 ⊙ Unimin Groundwater Bores | 134,258 ● Registered Groundwater Bores (2007) |
| SW1 □ Surface Water Monitoring Locations | — Cooroona Cooroona Creek Catchment Boundary |
| ★ Approximate Location of Rain Station | — Drainage |

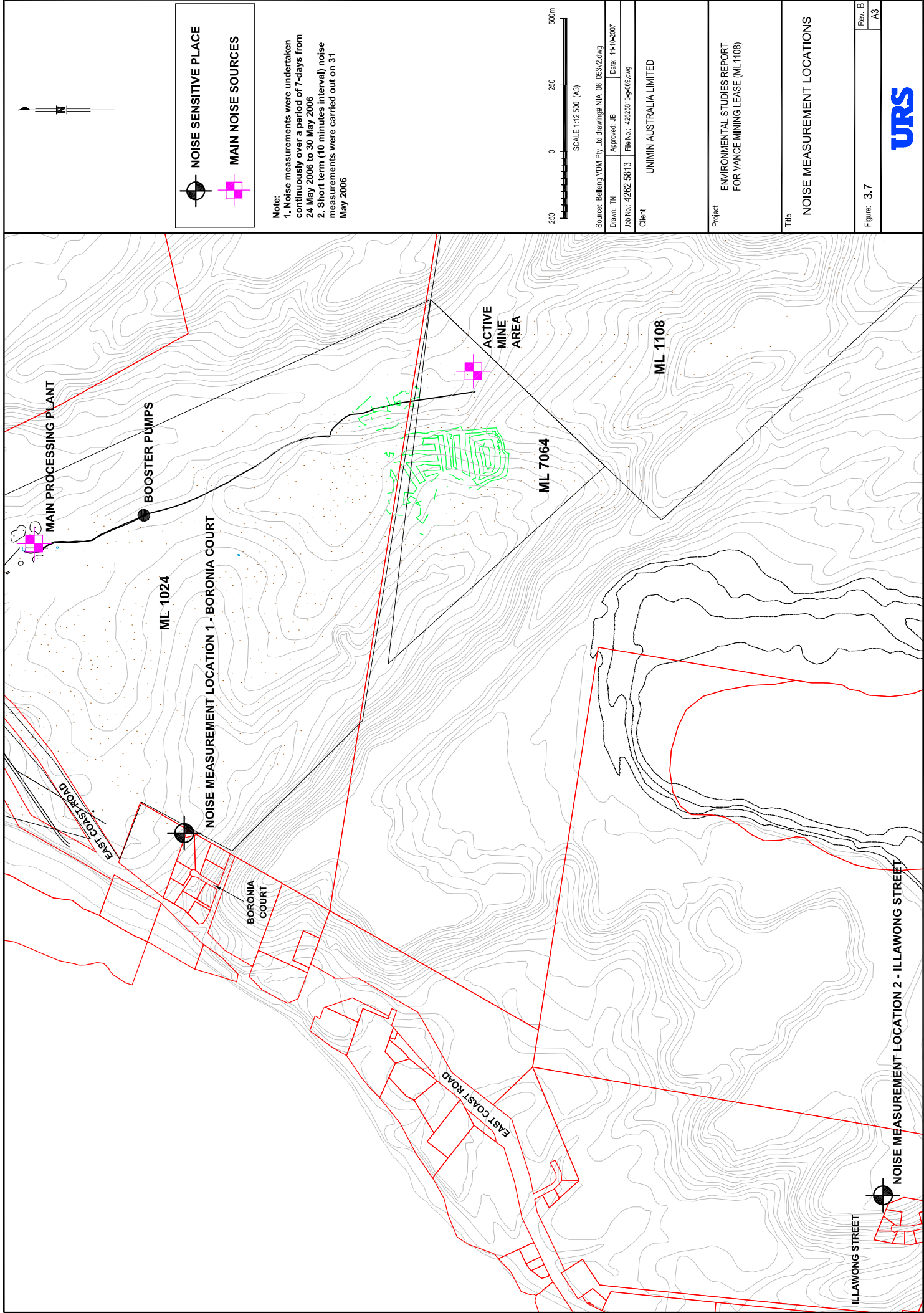


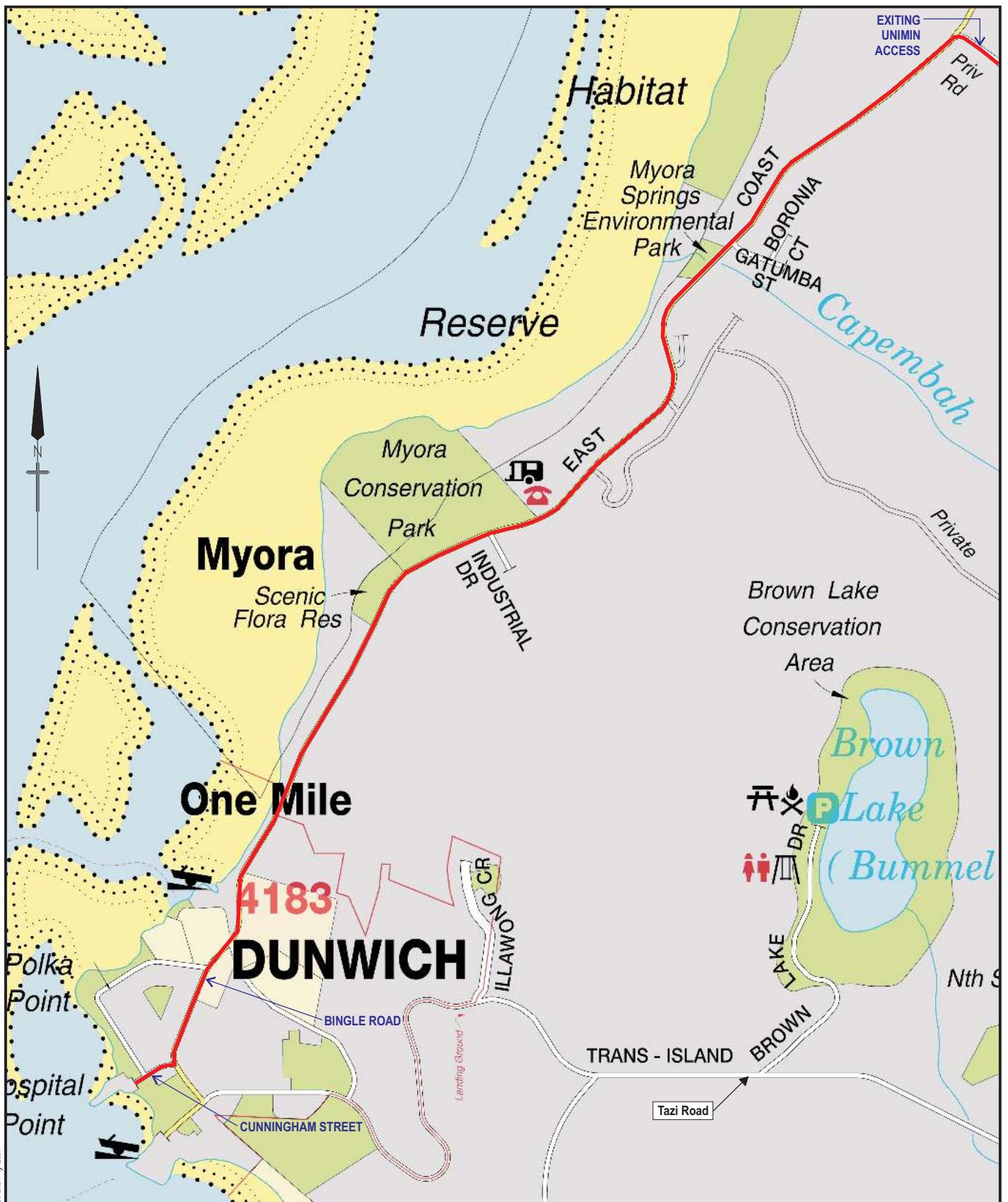
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Scale 1:35 000 (A4)

Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project ENVIRONMENTAL STUDIES REPORT FOR VANCE MINING LEASE (ML1108)	Title SURFACE WATER SAMPLE LOCATION DETAILS	
	Drawn: LL/TN	Approved: JB	Date: 11-10-2007
	Job No: 4262 5813	File No: 42625813-g-067.wor	Figure: 3.5 Rev: A A4







Source: UNIVERSAL PRESS PTY LTD AUSTRALIAN CITY STREETS VERSION 4.0

Client UNIMIN AUSTRALIA LIMITED	Project ENVIRONMENTAL STUDIES REPORT FOR VANCE MINING LEASE (ML1108)	Title EXISTING HAUL ROUTE	
URS	Drawn: TN Approved: JB Date: 11-10-2007 Job No.: 4262 5813 File No. 42625813-g-070b.cdr	Figure: 3.8 Rev. B A4	

Appendix A

Environmental Authority EA MIM900220203



Environmental Authority No. MIM900220203 (mining activities)

Section 264 (1)(a) *Environmental Protection Act 1994*

This environmental authority is granted under the Environmental Protection Act 1994 and includes conditions to minimise environmental harm caused, or likely to be caused, by the authorised mining activities. An environmental authority (mining activities) may be for mining activities authorised (under the Mineral Resources Act 1989) to occur under one of the following mining tenements: a prospecting permit; mining claim; exploration permit; mineral development licence; or mining lease. In general, a mining activity means: prospecting, exploring, mining; or processing minerals; remediation; rehabilitation; and includes facilitation and supporting activities and any action taken to prevent environmental harm.

Under the provisions of the *Environmental Protection Act 1994* this environmental authority is issued to:

Unimin Australia Limited
Level 16, 111 Pacific Highway
NORTH SYDNEY NSW 2060

in respect of carrying out activities as part of the following mining project:

Type of environmental
authority (mining activities)

Authorised mining
tenements

Location

Mining Lease

ML1108

Vance Project (4 kms north east of Dunwich, North
Stradbroke Island)

The mining activities are authorised to the following extent defined in Schedule 6 of the Environmental Protection Regulation 1998:

12(c). Mining activities, other than a standard mining activity, carried out using equipment and plant having a mineral ore throughput of 500 000t or more a year or if mineral ores mined are chemically processed to produce concentrates.

This environmental authority is subject to the conditions set out in the attached schedules.

The anniversary date of this Environmental Authority is 17 December each year.

This environmental authority takes effect from 18 August 2006.

Signed

18 August 2006

Date

Lawrie Wade
Manager
Southern Region
Delegate of Administering Authority
Environmental Protection Act 1994



This **Environmental Authority** incorporates the following schedules:

- Schedule A - General
- Schedule B - Air
- Schedule C - Water
- Schedule D - Noise
- Schedule E - Waste
- Schedule F - Land
- Schedule G - Community
- Schedule H - Definitions

Schedule A - General

Financial Assurance

- (A1-1) Provide a *financial assurance*¹ in the amount and form required by the *administering authority* prior to the commencement of the mining activities.
- (A1-2) The *financial assurance* is to remain in force until the *administering authority* is satisfied that no claim on the assurance is likely².

Maintenance of Measures, Plant and Equipment

- (A2-1) The environmental authority holder must:
- a) take all *control measures* and install plant and equipment necessary to ensure compliance with the conditions of this *environmental authority*;
 - b) maintain such *control measures*, plant and equipment in a proper condition; and
 - c) operate such *control measures*, plant and equipment in a proper manner.

Storage and Handling of Flammable or Combustible Liquids

- (A3-1) Spillage of any flammable or combustible liquids or other chemicals must be contained and rectified to prevent environmental harm (other than of trivial nature).
- (A3-2) Storage of flammable or combustible liquids must be in accordance Australian Standard 1940 - Storage and Handling of Flammable and Combustible Liquids.

Mining Operations

- (A4-1) The mining activities must not cause *environmental harm* beyond the boundary of the *authorised mining tenement*.
- (A4-2) Notwithstanding condition (A4-3), *mining activities* on the *authorised mining tenement* must not be conducted within a *category A or B environmentally sensitive area* or within Cooroon Cooroonpah Creek.

¹ NOTE: The calculation of financial assurance for condition (A1-1) must be in accordance with Guideline 17 and may include a performance discount. The financial assurance amount is defined as the maximum total rehabilitation cost for complete rehabilitation of all disturbed areas, which may vary on an annual basis due to progressive rehabilitation. The amount required for the financial assurance must be the highest Total Rehabilitation Cost calculated for any year of the Plan of Operations and calculated using the formula: Financial Assurance = Highest Total Annual Rehabilitation Cost x Percentage Required.

² NOTE: Where progressive rehabilitation is completed, progressive reductions to the financial assurance amount will be applicable where rehabilitation has been completed in accordance with the acceptance criteria prescribed by this environmental authority to the satisfaction of the administering authority.

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- (A4-3) *Mining operations can only be conducted within the authorised mining tenement if:*
- (a) an *Environmental Studies Report (ESR)* (in accordance with condition A5-3) has been completed for those operations; and
 - (b) a *planning document* for those operations has been prepared which complies with the statutory requirements and incorporates the matters set out in condition (A6-1).

Baseline Environmental Studies

- (A5-1) *Baseline environmental studies* must be conducted for areas where the *mining activities* may occur and where those activities could have an impact on or detrimentally affect the *environmental values* pertaining to such areas and the *zone of impact*.

The purpose of the *baseline environmental studies* and the *ESR* is to survey the constituents of the environment and to determine the *environmental impact(s)* including any environmental harm from the *mining activities* so that *control measures* can be identified to protect *environmental values*.

- (A5-2) The following conditions set out the process that must be followed for carrying out the *baseline environmental studies*.
- a) Terms of reference must be prepared prior to commencing the *baseline environmental studies*. The terms of reference must address the matters that are to be included in the *baseline environmental studies*.
 - b) *Stakeholders* must be consulted about a draft terms of reference. The views of *stakeholders* must be considered when finalising the terms of reference. For the purpose of this condition, the *administering authority* is a *stakeholder*.
 - c) *Baseline environmental studies* must satisfy the final terms of reference.
- (A5-3) An *Environmental Studies Report (ESR)* must be submitted to the *administering authority* at least one month prior to the commencement of *mining operations*.
- The *ESR* must:
- a) provide the results of the *baseline environmental studies*;
 - b) identify the *environmental values* and location thereof within the *authorised mining tenement* and *zone of impact*;
 - c) provide an assessment of the *environmental impact* of the *mining activities* on *environmental values*;
 - d) state *control measures* to protect *environmental values*;
 - e) state *trigger levels* for indicators³ of possible impacts on *environmental values*, the *trigger levels* being relevant to alert of potential causation of *environmental harm*;
 - f) include a proposed monitoring program;
 - g) propose buffer zone locations and dimensions to protect the *environmental values* of Cooroon Cooroonpah Creek and of *category A and B environmentally sensitive areas*; and
 - h) include the results of *stakeholder* consultation undertaken for the *baseline environmental studies* and the *ESR* including:

³ NOTE: Indicators could include water level, water quality, stability, abundance of a significant species, variance between pre and post mining landform, concentrations of a contaminant in air, water or soil, indicators of impacts on an environmental value between pre and post mining, but on the basis that they take account of naturally occurring variations in the environmental values.

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- i) a summary of the concerns and interests raised by *stakeholders*;
- ii) a summary of issues where agreement with *stakeholders* could not be reached;
- iii) ongoing *stakeholder* consultation arrangements during the mining activities; and
- iv) any identified issues which require further *stakeholder* involvement.

(A5-4) At least two months prior to submission of the *ESR* required by condition (A5-3), a draft of the *ESR* addressing the matters stated in conditions (A5-3)(a) to (h) must be submitted to the *administering authority*.

Mine Planning

- (A6-1) The following details must be included in a *planning document*, in addition to any statutory requirements of such a document:
- a) areas where *mining activities* will occur;
 - b) locations of *control measures* (where applicable);
 - c) information derived from an *ESR* of all baseline study locations and the *environmental values* thereof to be protected;
 - d) if any *environmental values* have a specific location, specify that location; and
 - e) the *control measures* provided for in an *ESR*.

Monitoring

- (A7-1) Record, compile and keep for a minimum of five years all monitoring results required by this environmental authority and make available for inspection all or any of these records upon request by the *administering authority*.
- (A7-2) Where monitoring is a requirement of this environmental authority, ensure that a competent person(s) conducts all monitoring.

END OF CONDITIONS FOR SCHEDULE A

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Schedule B - Air

Dust nuisance

- (B1-1) The release of dust or other particulate matter resulting from the mining activities must not cause an environmental nuisance at any sensitive place in the opinion of an authorised person.
- (B1-2) For the purposes of condition (B1-1), the mining activities will not cause environmental nuisance where dust or other particulate matter resulting from the activities does not exceed the following limits when measured at any sensitive place:
- (a) dust deposition of 120 milligrams per square metre per day, when monitored in accordance with Australian Standard 3580.10.1 Methods for sampling and analysis of ambient air – Determination of particulates – Deposited matter – Gravimetric method ; or
 - (b) a concentration of suspended particulate matter with an aerodynamic diameter of less than 10 micrometres (μm) (PM10) of 150 micrograms per cubic metre over a 24 hour averaging time at a sensitive place downwind, when monitored in accordance with:
 - (i) Australian Standard AS 3580.9.6 Methods for sampling and analysis of ambient air – Determination of particulate matter – PM (sub) 10 high-volume sampler with size-selective inlet - Gravimetric method; or
 - (ii) any alternative method of monitoring PM10 which may be permitted by the 'Air Quality Sampling Manual' as published from time to time by the administering authority.
- (B1-3) Dust or other particulate monitoring must be undertaken as directed by the administering authority to investigate any complaint of environmental nuisance, which complaint in the opinion of an authorised person is not frivolous, vexatious nor based on mistaken belief, and the results thereof notified to the administering authority within 14 days following completion of monitoring. Monitoring must be carried out at a site relevant to the potentially affected sensitive place and at upwind control site(s) and must include:
- (a) for a complaint alleging dust nuisance, dust deposition; and
 - (b) for a complaint alleging adverse health effects caused by dust, the concentration per cubic metre of suspended PM10 over a 24hr averaging time.
- (B1-4) If an authorised person's opinion is that environmental nuisance is being caused by dust or other particulate matter from the mining activities, the holder must:
- (a) address the complaint including the use of appropriate dispute resolution if required; or
 - (b) immediately implement abatement measures so that emission of dust or other particulate matter from the activities does not result in further environmental nuisance.

END OF CONDITIONS FOR SCHEDULE B

Schedule C - Water

- (C1-1) The mining activities must not cause environmental harm to Cooroon Cooroonpah Creek, the associated aquifer or any ecosystems dependent thereupon.

END OF CONDITIONS FOR SCHEDULE C

Schedule D - Noise

Noise nuisance

- (D1-1) Subject to condition (D1-3), noise from the mining activities must not cause an environmental nuisance at any sensitive place in the opinion of an authorised person.
- (D1-2) Noise monitoring must be undertaken as directed by the administering authority to investigate any complaint of environmental nuisance caused by noise, which complaint in the opinion of an authorised person is not frivolous, vexatious nor based on mistaken belief, and the results thereof notified to the administering authority within 14 days following completion of monitoring. For the purposes of this condition, noise monitoring must be done in accordance with the latest edition of the Environmental Protection Agency *Noise Measurement Manual* and include:
- (a) $L_{A, \text{max adj, T}}$;
 - (b) $L_{A10, \text{adj, 10 mins}}$;
 - (c) $L_{A1, \text{adj, 10 mins}}$;
 - (d) relevant background sound level;
 - (e) the level and frequency of occurrence of impulsive or tonal noise;
 - (f) atmospheric conditions including wind speed and direction; and
 - (g) location, date and time of recording.
- (D1-3) For the purposes of condition (D1-1), the mining activities will not cause environmental nuisance where noise from the activities does not exceed the limits specified in Schedule D - Table 1.
- (D1-4) If an authorised person's opinion is that environmental nuisance is being caused by noise from the mining activities, the holder must:
- (a) address the complaint including the use of appropriate dispute resolution if required; or
 - (b) immediately implement noise abatement measures so that emissions of noise from the activities does not result in further environmental nuisance.

Schedule D - Table 1 (Noise limits)

Noise level dB(A) measured as	Monday to Saturday			Sundays and public holidays		
	7am - 6pm	6pm - 10pm	10pm - 7am	9am - 6pm	6pm - 10pm	10pm - 9am
Noise measured at a 'Noise sensitive place'						
$L_{A10, \text{adj, 10 mins}}$	b/g+5	b/g+5	b/g+3	b/g+5	b/g+5	b/g+0
$L_{A1, \text{adj, 10 mins}}$	b/g+10	b/g+10	b/g+5	b/g+10	b/g+10	b/g+5
Noise measured at a 'Commercial place'						
$L_{A10, \text{adj, 10 mins}}$	b/g+10	b/g+10	b/g+5	b/g+10	b/g+10	b/g+5
$L_{A1, \text{adj, 10 mins}}$	b/g+15	b/g+15	b/g+10	b/g+15	b/g+15	b/g+10

NOTE: The method of measurement and reporting of noise levels must comply with the latest edition of the Environmental Protection Agency's Noise Manuals.

END OF CONDITIONS FOR SCHEDULE D

18/9/06

Schedule E - Waste

Waste handling

- (E1-1) All regulated waste removed from the authorised mining tenement must be by a person who holds a current authority to transport such waste under the provisions of the *Environmental Protection Act 1994*.

Waste disposal

- (E2-1) Waste generated by the *mining activities* must not be burned on the *authorised mining tenement*.

END OF CONDITIONS FOR SCHEDULE E

Schedule F - Land

Progressive Rehabilitation

- (F1-1) Progressive rehabilitation must be achieved for disturbed areas not required for the ongoing conduct of the mining activities.

Rehabilitation Outcomes

- (F2-1) The *environmental authority holder* must complete an investigation into *rehabilitation* of disturbed areas and submit a report to the *administering authority* proposing *acceptance criteria* by 30 June 2007. That report must address:
- a) post mining *land use*;
 - b) landform aspects;
 - c) landform geotechnical stability criteria;
 - d) revegetation *acceptance criteria*;
 - e) ground and surface water quality criteria;
 - f) water levels of surface water bodies and wetlands; and
 - g) post mine closure maintenance and monitoring requirements.
- (F2-2) All areas disturbed by the *mining activities* must be rehabilitated in accordance with the *acceptance criteria* prescribed in the report required by condition (F2-1) as may be modified by the *administering authority*. Where no such modification is notified by the *administering authority* to the *environmental authority holder* within six months of receipt of the report, then the *acceptance criteria* prescribed in the report will apply.

Infrastructure

- (F3-1) All infrastructure for the mining activities, including water storage structures, must be removed from the subject land prior to surrender of the environmental authority, except where otherwise agreed to in writing by the post mining land owner.

END OF CONDITIONS FOR SCHEDULE F

Schedule G – Community

Complaint response

- (G1-1) All complaints received must be recorded by the environmental authority holder including details of a complainant, reasons for a complaint, investigations undertaken, conclusions formed and actions taken. This information must be made available for inspection by the *administering authority* upon request.

END OF CONDITIONS FOR SCHEDULE G

Schedule H

Definitions

- (H1-1) Words and phrases used throughout this environmental authority are defined in Schedule H – Definitions. Where a definition for a term used in this environmental authority is sought and the term is not defined herein, the definitions in the Environmental Protection Act 1994, regulations made under that Act and Environmental Protection Policies as amended from time to time or ordinary meaning must be used.

Interpretation

"EMOS" means the Environmental Management Overview Strategy report titled "Unimin Australia Limited, North Stradbroke Island, Environmental Management Overview Strategy, ML1108" dated March 2004. Where required, interpretation of this environmental authority should be in the context of the EMOS.

Definitions

"acceptance criteria" means standards by which actions implemented to rehabilitate land are deemed to be complete (same as completion criteria).

"ambient (or total) noise" at a place, means the level of noise at the place from all sources (near and far), measured as the Leq for a relevant time interval.

"authorised mining tenement" means those mining tenements listed on page 1 of this environmental authority.

"authority" means environmental authority (mining activities) issued under the Environmental Protection Act 1994.

"baseline environmental studies" means the studies referred to in conditions (A5-1), (A5-2) hereof.

"category A or B environmentally sensitive area" has the meaning given in the *Environmental Protection Act 1994*.

"control measures" means actions that can be taken in order to prevent or minimise environmental impacts or environmental harm. Control measures can be but are not limited to planning, procedural, physical or engineering controls. Control measures has the same intent as 'risk treatment' in Australian Standard 4360 (Risk Management).

"commercial place" means a place used as an office or for business or commercial purposes, other than such a place within the authorised mining tenement.

"competent person" means a person with sufficient demonstrated skill, knowledge and qualifications required to carry out a task to a necessary standard for protection of the environment.

"environmental aspect" means an element of the mining operations or activities that can interact with the environment. A significant environmental aspect is one that can have a significant environmental impact or can cause environmental harm.

"environmental harm" has the meaning given in the *Environmental Protection Act 1994*.

John 18/8/06

"environmental impacts" means changes that occur in the environment as a result of the mining activities. Such impacts can be positive, negative or neutral.

"environmental management system" means a management system that includes organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining an environmental policy and for achieving compliance with an environmental authority and the general environmental duty prescribed by section 319 of the *Environmental Protection Act 1994*.

"environmental value" has the meaning given in the *Environmental Protection Act 1994*.

"ESR" means an environmental studies report referred to in condition (A5-3).

"expected impact" means the predicted changes to an environmental value under normal conditions by the influence of an authorised activity. Methods available for the determination of expected impact include:

- predictions based on historical data;
- knowledge based intuition;
- numerical analysis; and
- modelling.

" $L_{A\ 10, \text{adj}, 10 \text{ mins}}$ " means the A-weighted sound pressure level, adjusted for tonal character and impulsiveness of the sound, exceeded for 10% of any 10-minute measurement period, using Fast response.

" $L_{A\ 1, \text{adj}, 10 \text{ mins}}$ " means the A-weighted sound pressure level, adjusted for tonal character and impulsiveness of the sound, exceeded for 1% of any 10-minute measurement period, using Fast response

" $L_{A, \text{max adj}, 1}$ " means the average maximum A-weighted sound pressure level, adjusted for noise character, and measured over any 10 minute period using Fast response.

"land" in the "land schedule" of this document means land excluding waters and the atmosphere.

"land use" refers to description of the purpose(s) for land after cessation of mining activities thereupon.

"mining activities" has the meaning given in the *Environmental Protection Act 1994* and the *Mineral Resources Act 1989*.

"mining operations" means clearing, topsoil stripping and stockpiling, extracting, tailings placement etc., but excludes exploration activities or measures taken solely to control environmental impacts, monitoring, rehabilitation, conducting *baseline environmental studies* and gaining access to areas for these purposes.

"mining operation area(s)" means those areas identified in a planning document where mining activities or operations will occur.

"noise sensitive place" means -

- a dwelling, mobile home or caravan park, residential marina or other residential premises;
 - a motel, hotel or hostel;
 - a kindergarten, school, university or other educational institution;
 - a medical centre or hospital;
 - a protected area; and
 - a park or gardens;
- and includes the curtilage of any such place.

"noxious" means harmful or injurious to health or physical well being, other than trivial harm.

"planning document" means any document that describes a plan of *mining activities* and has a term of not more than five years. A plan of operations under section 233 of the *Environmental Protection Act* is a planning document for the purpose of this environmental authority.

"progressive rehabilitation" means rehabilitation (defined below) undertaken progressively or in stages as mining activities or operations are ongoing.

"protected area" means a protected area under the Nature Conservation Act 1992; a marine park under the Marine Parks Act 1992 or a World Heritage Area.

"rehabilitation" means the process of reshaping and revegetating land to restore it to a stable post mining state and in accordance with the acceptance criteria, and where relevant includes remediation of contaminated land.

"representative" means a sample set which covers the variance in monitoring or other data either due to natural changes or to different phases of mining activities.

"sensitive place" means;

- a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises excluding accommodation for persons engaged in the mining activities;
- a motel, hotel or hostel;
- an educational institution;
- a medical centre or hospital;
- a public park or gardens (including a protected area); and
- a commercial place;

and includes the curtilage of any such place.

"stable" means geotechnical stability of a rehabilitated landform where instability caused by settlement and subsidence has ceased.

"stakeholder" means an individual or group concerned with or affected by the conduct of mining activities in accordance with the conditions of an environmental authority.

"trigger level" means the extent or level of change in or to an environmental value that necessitates a response to prevent causation of environmental harm.

"trivial harm" means environmental harm which is not material or serious environmental harm and will not cause actual or potential loss or damage to property of an amount totalling more than \$5,000.

"waters" includes a river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water being natural or artificial watercourse, bed and bank of any waters, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, groundwater and any part thereof.

"zone of impact": means those areas, whether on or off the authorised *mining tenements* (s), where mining activities could or do result in a change in the environment. See also definition for environmental impact.

END OF CONDITIONS FOR SCHEDULE H

END OF ENVIRONMENTAL AUTHORITY

Appendix B

EPA Response to Draft ESR August 2005

Enquires David Trezise
Telephone (07) 3225 1217
Your reference
Our reference STH5052

27 September 2005

Ms K Bubb
Unimin Australia Limited
PO Box 43
Dunwich Qld 4183

Dear Katherine

Draft Environmental Studies Report - Vance Project, North Stradbroke Island

I would like to advise you that the Environmental Studies Report (ESR) for the Vance Project (Environmental Authority MIM900220203) which was submitted on 15 August 2005:

- Does not comply with the requirements of conditions (A5-1, A5-2 & A5-3) MIM900220203 for the reasons outlined in the assessment report prepared by the Environmental Protection Agency (EPA). Refer to the attached assessment report.

Further, the ESR would be enhanced by:

- Outlining the mine path and depth of proposed mining operations in the ESR; and
- Establishing the links between environmental values, hazards and identification of risk levels as intended in conditions (A6-1) and (A6-2) which requires Unimin to develop a risk management system substantially compliant with *Australian Standard for Risk Management (AS/NZS 4360:1999)* and *ISO 14001:1996 - Environmental Management Systems. Specification with guidance for use.*

Due to the areas of non-compliance with the requirements of conditions (A5-1), (A5-2) and (A5-3) identified above, the ESR must be amended and additional studies undertaken where indicated in the assessment report. An amended ESR addressing the areas of non-compliance listed in the assessment report must be submitted and be acceptable to the Agency before mining operations can commence on mining lease 1108 - Vance.

If you have any queries regarding this matter, please contact David Trezise, Chief Scientific Advisor (Mining) on telephone (07) 3225 1217.

Yours sincerely

Sinead Summerville
**A/Operations Manager - Mining and Extractive
Southern Region, EPA**

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draft\appendices\appendix b\la1 letter draft esr 27-09-2005.doc

ASSESSMENT REPORT

DRAFT ENVIRONMENTAL STUDIES REPORT FOR PROPOSED DEVELOPMENT OF VANCE MINING LEASE 1108, NORTH STRADBROKE ISLAND

Prepared by URS for Unimin Australia Limited, August 2005

BACKGROUND

Unimin is required to prepare and submit an Environmental Studies Report pursuant to the following conditions of environmental authority MIM900220203 (Vance project ML 1108):

- (A5-3) An *Environmental Studies Report (ESR)* must be submitted to the *administering authority* at least one month prior to the commencement of *mining operations* where required in accordance with condition (A4-4).

The *ESR* must:

- a) provide the results of the *baseline environmental studies*;
- b) identify *environmental values* including key *environmental values* and location(s) thereof within the *authorised mining tenements(s)* and *zone of impact* ;
- c) provide an assessment of the *environmental impact* of the *mining activities* on *environmental values*;
- d) by using the principles of the risk management system referred to in condition (A6-1) state *control strategies* to protect *environmental values* and *key environmental values*;
- e) state *trigger levels* for indicators of possible impacts on *environmental values* and *key environmental values*, the *trigger levels* being relevant to alert of potential causation of *environmental harm*; and
- f) include details of the level and nature of *stakeholder* consultation undertaken for the *baseline environmental studies* and the *ESR* including:
 - i) a summary of the concerns and interests raised by *stakeholders*;
 - ii) a summary of issues where agreement with *stakeholders* could not be reached;
 - iii) ongoing consultation arrangements during the mining activities; and
 - iv) any identified issues which require further *stakeholder* involvement.

- (A5-4) **At least two months prior to submission of the *ESR* required by condition (A5-3), a draft of the *ESR* addressing the matters stated in conditions (A5-3)(a) to (f) inclusive must be submitted to the *administering authority*.**

- (A6-1) The holder must plan and conduct the *mining activities* according to:
- a) a *risk management* system which substantially complies with the Australian Standard for Risk Management (AS/NZS 4360:1999) ; and
 - b) an *environmental management system* that substantially complies with ISO 14001:1996 (environmental management systems – specification with guidance for use).
- (A6-2) All elements of the *environmental and risk management systems*, and the implementation of those systems must be documented. As a minimum standard the documentation must include:
- a) identification and progressive assessment of the *environmental impacts* of key risk scenarios;
 - b) register(s) of *environmental aspects*, impacts and risk;
 - c) the risk evaluation criteria; and
 - d) actions taken to ameliorate *unacceptable risks*.

The draft ESR and Appendices has been reviewed and comments prepared by officers of the Environmental Protection Agency as outlined below:

Main Report – David Trezise (EPA)

Appendix A: Flora report - Kathy Stephens (Herbarium); and
Fauna report – Lisa Ford (QPWS)

Appendix B: Cultural heritage (Report still pending).

Appendix C: Groundwater report - David Trezise (EPA).

Appendix D: Surface water report - David Trezise (EPA).

Appendix E: Air quality report - David Trezise (EPA).

Appendix F: Noise report - David Trezise (EPA).

Appendix G: Road transport report - David Trezise (EPA).

Appendix H: Geomorphology and soils report - David Trezise (EPA).

Appendix I: - Socio-economic report - David Trezise (EPA).

Appendix J: Community consultation - David Trezise (EPA).

Ecological Assessment Vance Mining Lease ML 1108 North Stradbroke Island (Appendix A)

Comments by K. Stephens (Herbarium), on Flora Survey prepared by URS for Vance Mine Lease No. 1108, North Stradbroke Island.

1.1 Terms of Reference

Baseline studies appear inadequate for the purposes outlined here.

1.2 Site Description

The lease area of 630 ha will determine the sampling rate required for the flora survey. At 1:20 000 scale vegetation mapping as illustrated in figure 5, the sampling rate is 6.25 per km², which would require approximately 40 sites to adequately sample the 630ha of vegetation. These should be distributed proportionately across the lease, relative to the area of each mapping unit type.

1.3 Regional Context

1.3.1 Bioregion

Acceptable to EPA, no changes recommended.

1.3.2 Sub-region

The references (Morgan 1988, Sattler and Williams 1999) should be given in full and properly acknowledged in a references section at the end of the Flora Survey Report.

2.1 Study Aim and Objectives

The scale of the mapping of the vegetation communities is not mentioned.

2.2 Review of Existing Information.

Preliminary mapping – there is no mention of the scale of this mapping. Aerial photography of the area is mentioned but attributed to EPA. EPA does not do aerial photography. Accurate listing of photographs used for the mapping is required, with the date, source and scale of the photos. Perhaps the reference is to RE mapping done by EPA, at a scale of 1:100000. This scale would be inadequate for the lease area. The vegetation communities map is given at scale 1:20 000 which is an appropriate scale.

If using existing 1:100 000 scale mapping, they are failing to fulfil the terms of reference “to map the vegetation communities”.

The reference (EPA, 2004) is not included in any references list.

2.2.1 Data Sources

The first reference is incorrectly referred to as Queensland Museum flora database (HERBRECS) – it should be Queensland Herbarium flora database. As it is not properly referenced, there is doubt as to whether information was actually obtained from the source. Unless specifically requested HERBRECS information on rare and threatened species location is generally suppressed from species lists. Date of request for species list should be included.

No version or date given for Qld EPA 1:100 000 Regional Ecosystems mapping.

No references are given for the Flora Survey section so the information sources inadequately referenced here cannot be checked.

Checks should also have been made for species listed on the Australian Heritage Commission Register of the National Estate Database (available online). Large areas of the island are covered under 3 sections Southern, Central and Northern Sections.

Rare and threatened species recorded for all of North Stradbroke Island should have been searched for, rather than those recorded for the confined grid of the study area.

The list of data sources does not appear to have been reviewed or compiled into any database by the study. It appears to be just a list of references, not properly referenced. Some sources have been overlooked e.g. Redland Shire Mapping.

2.2.2 Regional Ecosystems

The brief description here shows a lot of confusion e.g. referral to southeast Queensland as a province. A listing of REs occurring on North Stradbroke Island from the most recent release of RE mapping would be useful. Listing of REs covering the Vance lease area could then be placed in context. Something about bioregion, land zone and vegetation type to describe a regional ecosystem is required. Some discussion of what “of concern” and “endangered” vegetation means in terms of the Vegetation Management Act.

2.2.3 Target Species

Species are not dealt with under the Vegetation Management Act, so the reference here is inappropriate. Checks should also have been made for species listed on the Australian Heritage Commission Register of the National Estate Database. Using all sources, there are over 30 significant species on North Stradbroke Island. To only consider 4 of these is inadequate and shows lack of proper research for this section.

2.2.4 Category B Regions

Acceptable to EPA, no changes recommended.

2.2.5 Ramsar Wetland Area

There is no discussion as to whether the lease is still bound by the requirements of a Ramsar listed area.

2.3 Survey Methodology

The terms of reference have a mixture of methodologies. There is no indication in the report as to which methodology was actually used. A detailed description of the methodology is required, including type of information collected at each site.

The terms of reference state approximately 1 hour will be spent at each 20m x 50m plot. To adequately measure the information they claim is “typically being recorded” including structural and floristic data including stratum descriptions, basal area, stem densities and life forms would require more than 1 hour.

2.3.1 Sampling Conditions

The flora report claims fieldwork “was conducted over 1 day” in mid summer. It also states that after each plot 15 minutes was spent on meander searches of 1.5ha. 10 hours + 10 x 15 minutes (2.5 hours), gives at least 12.5 hours in mid Summer without travelling distance between sites, or stopping for lunch or breaks, or to do the “selected secondary plots” also mentioned in the meander searches. No methodology is given for these plots, and they are not located on the map. There has to be doubt about the thoroughness of data collection. Structural and floristic data are not presented in the report.

2.3.2 Primary Plots

10 plots do not adequately sample 630ha at 1:20 000 scale, as previously mentioned. 40 would be required. It is stated that fieldwork included plant collection, but later, (2.3.5 Specimen Identification) that all plants were identified in the field. This would increase the time to do each plot considerably, as plant identification of unknown specimens is time consuming. Usually, 1 day of fieldwork requires 2 days plant identification using a microscope and keys to species.

2.3.3 Meander Searches

Reference (Cropper, 1993) in full in references list.

Mention is made here of secondary plots, but no locations, data or information about these plots is provided elsewhere in the report.

Otherwise, acceptable to EPA and no further changes recommended.

2.3.4 Incidental Observation

Where are these records in the report? A species list and vegetation description for each vegetation association should be provided.

2.3.5 Specimen Identification

That all specimens were identified in the field is disturbing. To accurately identify many species requires the use of microscopic characteristics. Field identification of many species by an experienced botanist is possible, but certainly not all species. For example accurate identification of the grass *Eriachne insularis*, which is a significant species, which reaches its southern limit on North Stradbroke Island, would require verification by microscope examination of a specimen.

2.3.6 Vegetation Community Determination.

No plant community descriptions are presented, along with their associated data e.g. floristics (species list), structure (height, crown cover, dominant species, stem counts, basal area, ground layer cover, etc) claimed to have been recorded for each plot.

Height and crown separation appear to have been estimated rather than measured, which may result in inaccuracies.

A table with the plots, their vegetation mapping units and their allocation to Regional Ecosystems would be useful here, to show the process.

2.4 Results

2.4.1 Diversity

This is acceptable to EPA, but too brief. Diversity within each community and between communities should be discussed.

2.4.2 Vegetation Communities

There are six vegetation communities listed in table 1 and map legend (figure 5), not five. To say they are described is incorrect. There are no vegetation community descriptions in the report. A one-line map unit type does not adequately describe a vegetation community. The data collected for each community should be presented, and form the basis of the description e.g. height, cover of each layer, dominant species (and relative proportions) for each layer and full species list.

The relative abundances referred to in appendix B are coded with subjective terms. These terms need to be clearly defined, in quantitative terms if possible, as operator bias is a problem with this form of categorisation in the field. Abundant = ??; Common = ?. What is the difference between Abundant and Common? Can a species be both Common and Edge plants?

The areas table (Table 1) contains good information.

2.4.3 Natural Integrity of Vegetation

Acceptable to EPA, no changes recommended.

2.4.4 Vegetation of Conservation Significance

Threatened Species

As mentioned earlier, the search should have been for over 30 species, covering both threatened species and ecologically significant species, rather than the 4 dealt with.

Species of Cultural Significance

Mention of *Eucalyptus pilularis* open forest at site 10 is inconsistent. Site 10 is in map unit 1a (dry heath). Map unit 4c (*E. pilularis*) has only site 7 in it.

Significant Communities

Perhaps also use the data from Table 1 to comment on the % in sub-region, giving regional context here.

2.5 Potential Impacts

2.5.1 Vegetation Removal

There is no mention of how the vegetation is to be cleared – all at once or progressively. There should be discussion of whether the 100% removal of RE12.3.13 will change its status under the Vegetation Management Act from ‘of concern’ to ‘endangered’. Similarly for RE12.2.10, which is the RE of the largest area to be cleared – will it change from ‘not of concern’ to ‘of concern’?

2.5.2 Weeds and Fire

There is no mention of a weed hose down area for vehicles to contain weed spread on site. Weed early detection procedures need to be spelt out here – e.g. how frequently will weed inspections occur?

2.6 Mitigation

2.6.1 Conservation Areas

Acceptable to EPA, no changes recommended.

2.6.2 Vegetation Clearance

Progressive clearing rather than broad scale clearing would be preferred, with only a operational small proportion of the site cleared at any one time, the remainder either ‘to be

cleared' or 'undergoing rehabilitation'. How the clearing will occur is not indicated here. There is no mention of seed collecting prior to clearing, or removal of *Xanthorrhoea* species for transplanting into rehabilitation areas. There is no mention of what the "adequate erosion and sedimentation mitigation measures" are. These need to be elaborated upon.

2.6.3 Rehabilitation of Disturbed Areas.

There is no indication that benchmark sites have been established for the proposed mining operation. There is a need for detailed site information on each of the vegetation communities present so that the success or otherwise of rehabilitation efforts can be measured. The most successful rehabilitation comes from topsoil that has not been stored, but placed directly from a newly cleared area to a rehabilitation area. Soil seed bank germination in this scenario is highly successful, with only limited amounts of follow up planting from nursery-raised tube stock required. The rehabilitation should ensure the same area of each community type in the same locations as prior to mining.

Additional Comments:

The Vegetation Communities Map (Figure 5) has several errors. There is an area in the southeastern portion of the site that is wrongly labelled as '3a' label in the pale green (4a, in the legend) area. Is there a '3a' polygon area that has not been pulled out in the mapping, or is it simply wrongly labelled?

The sites are not spread evenly across the project area, and many more sampling sites are required to adequately sample the area.

The map legend has several errors:

4b should read: *Eucalyptus racemosa* woodland on Quaternary dunes and sand plains (RE 12.2.6).

4c should read: *Eucalyptus pilularis* (not *racemosa* again).

There are several typographical errors and garbled sentences, which give the impression the report has been done in a rush, and not edited.

Small matters such as *Eucalyptus racemosa* being given as *Eucalyptus Racemosa*, gives the impression the report may not have been undertaken by a qualified botanist, as all graduates would know that species names are not capitalised.

The lack of information in areas of critical importance is the greatest criticism of the report.

Very little research has been done, and the scientific data underlying the survey appears inadequate, or has not been presented in the flora survey report.

In relation to the terms of reference some of the objectives have not been met. It appears that pre-existing RE mapping has been used, which may not be at a detailed enough scale for this project. Appropriate management strategies for dealing with potential impacts have not been given in any detail.

In relation to the methodology, the use of Queensland Herbarium CORVEG Proforma for data recording as specified in the terms of reference, appears not to have been undertaken. The data presented do not reflect its use.

The survey locations have been selected with emphasis on the least well-represented vegetation type (some of which is not going to be affected by operations). Unfortunately there is inadequate survey sampling of the majority of the site.

Comments by L. Ford (EPA, QPWS), on Fauna Survey prepared by URS for Vance Mine Lease No. 1108, North Stradbroke Island.

The first part of the document is an excerpt from the EPA Generic Terms of Reference for Environmental Impact Statements.

The **Blue Bold font** includes issues that I think the consultant should consider in greater detail. The ~~strikeout font~~ are things that I think are probably not relevant to this particular lease, and the **Red Bold font** are species that have not been mentioned in the ESR and should be researched.

The second part of the document is my comments on the ESR and is titled "Comments on URS Flora and Fauna Surveys for ML1108".

EPA Generic Terms of Reference for Environmental Impact Statements

1.1 Nature conservation

1.1.1 Description of environmental values

This section describes the existing environment values for nature conservation that may be affected by the proposal.

Describe the environmental values of nature conservation for the affected area in terms of:

- integrity of ecological processes, including habitats of rare and threatened species;
- conservation of resources;
- biological diversity, including habitats of rare and threatened species;
- integrity of landscapes and places including wilderness and similar natural places; and
- aquatic and terrestrial ecosystems.

A discussion should be presented on the nature conservation values of the areas likely to be affected by the proposal. The flora and fauna communities which are rare or threatened, environmentally sensitive localities including the marine environment, waterways, riparian zone, and littoral zone, rainforest remnants, old growth indigenous forests, wilderness and habitat corridors should be described. The description should include a plant species list, a vegetation map at appropriate scale and an assessment of the significance of native vegetation, from a local and regional and state perspective. The description should indicate any areas of state or regional significance identified in an approved biodiversity planning assessment (BPA) produced by the EPA (e.g. see the draft Regional Nature Conservation Strategy for SE Qld 2001-2006).

The ESR should identify issues relevant to sensitive areas, or areas, which may have, low resilience to environmental change. Areas of special sensitivity include the marine environment and wetlands, wildlife breeding or roosting areas, any significant habitat or relevant bird flight paths for migratory species, bat roosting and breeding caves including existing structures such as adits and shafts, and habitat of threatened plants, animals and

communities. The capacity of the environment to assimilate discharges/emissions should be assessed. Proposal proximity to any biologically sensitive areas should be described. Areas regarded as sensitive with respect to flora and fauna have one or more of the following features (and which should be identified, mapped, avoided or effects minimised):

- **important habitats of species listed under the *Nature Conservation Act 1992* and/or *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* as presumed extinct, endangered, vulnerable or rare;**
- ~~regional ecosystems listed as 'endangered' or 'of concern' under State legislation, and/or ecosystems listed as presumed extinct, endangered or vulnerable under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*;~~
- ~~good representative examples of remnant regional ecosystems or regional ecosystems which are poorly represented in protected areas;~~
- **sites listed under international treaties such as Ramsar wetlands and World Heritage areas;**
- **sites containing near threatened or bio-regionally significant species or essential, viable habitat for near threatened or bio-regionally significant species;**

Koala, glossy black cockatoo

- ~~sites in, or adjacent to, areas containing important resting, feeding or breeding sites for migratory species of conservation concern listed under the Convention of Migratory Species of Wild Animals, and/or bilateral agreements between Australia and Japan (JAMBA) and between Australia and China (CAMBA);~~
- ~~sites adjacent to nesting beaches, feeding, resting or calving areas of species of special interest; for example, marine turtles and cetaceans;~~
- **sites containing common species which represent a distributional limit and are of scientific value or which contains feeding, breeding, resting areas for populations of echidna, koala, platypus and other species of special cultural significance;**

Koala

- ~~sites containing high biodiversity that are of a suitable size or with connectivity to corridors/protected areas to ensure survival in the longer term; such land may contain:

 - ~~natural vegetation in good condition or other habitat in good condition (e.g. wetlands);~~
 - ~~and/or~~
 - ~~degraded vegetation or other habitats that still supports high levels of biodiversity or acts as an important corridor for maintaining high levels of biodiversity in the area;~~~~
- ~~a site containing other special ecological values, for example, high habitat diversity and areas of high endemism;~~
- ~~ecosystems which provide important ecological functions such as: wetlands of national, state and regional significance; coral reefs; riparian vegetation; important buffer to a protected area or important habitat corridor between areas;~~
- ~~sites of palaeontologic significance such as fossil sites;~~
- ~~sites of geomorphological significance, such as lava tubes or karst;~~
- **protected areas which have been proclaimed under the *Nature Conservation Act 1992* and *Marine Parks Act 1982* or are under consideration for proclamation; and/ or**

- ~~areas of major interest, or critical habitat declared under the *Nature Conservation Act 1992* or high nature conservation value areas or areas vulnerable to land degradation under the *Vegetation Management Act 1999*.~~

~~Reference should be made to both State and Commonwealth endangered species legislation and the proximity of the area to any World Heritage property.~~

~~The Queensland *Vegetation Management Act 1999* and the findings of any regional vegetation management plan should also be referenced.~~

The occurrence of pest plants and animals in the project area should be described.

Key flora and fauna indicators should be identified for future ongoing monitoring. Surveys of flora and fauna need to be conducted throughout the year to reflect seasonal variation in communities and to identify migratory species.

The EPA's guidelines for "Fauna and Flora Assessment in EIA" provide further details. The EPA should be consulted on the scope of any biological studies before they are undertaken.

1.1.1.1 Terrestrial flora

For terrestrial vegetation a map at a suitable scale should be provided, with descriptions of the units mapped. Sensitive or important vegetation types should be highlighted, including any marine littoral and subtidal zone and riparian vegetation, and their value as habitat for fauna and conservation of specific rare floral and faunal assemblages or community types. The existence of rare or threatened species should be specifically addressed. **The surveys should include species structure, assemblage, diversity and abundance. The description should contain a review of published information regarding the assessment of the significance of the vegetation to conservation, recreation, scientific, educational and historical interests.** ~~The location of any horticultural crops in the vicinity of the site should be shown.~~ **The existence of important local and regional weed species should also be discussed.**

Vegetation mapping should provide vegetation mapping for all relevant project sites including new transport infrastructure, port facilities and irrigation land if relevant. Adjacent areas may also require mapping.

The terrestrial vegetation communities within the affected areas should be described at an appropriate scale (i.e. 1:10,000) with mapping produced from aerial photographs and ground truthing, showing the following:

- location and extent of vegetation types using the EPA's regional ecosystem type descriptions in accordance with the Regional Ecosystem Description Database [REDD] available at the EPA's website;
- **location of vegetation types of conservation significance based on EPA's regional ecosystem types and occurrence of species listed as Protected Plants under the Nature Conservation (Wildlife) Regulation 1994 and subsequent amendments, as well as areas subject to the *Vegetation Management Act 1999*;**
- the current extent (bioregional and catchment) of protected vegetation types of conservation significance within the protected area estate (National Parks, Conservation Parks, Resource Reserves, Nature Refuges);

- **any plant communities of cultural, commercial or recreational significance should be identified; and**
- location and abundance of any exotic or weed species.

Within each defined (standard system) vegetation community, a minimum of three sites (numbers should be discussed with the EPA) should be surveyed for plant species, preferably in both summer and winter, as follows:

- **site data should be recorded in a form compatible with the Queensland Herbarium CORVEG database;**
- **the minimum site size should be 10 by 50 metres;**
- **a complete list of species present at each site should be recorded;**
- **the relative abundance of plant species present should be recorded;**
- **any plant species of conservation, cultural, commercial or recreational significance should be identified; and**
- **specimens of species listed as Protected Plants under the *Nature Conservation (Wildlife) Regulation 1994*, other than common species, are to be submitted to the Queensland Herbarium for identification and entry into the HERBRECS database.**

Existing information on plant species may be used instead of new survey work provided that the data is derived from surveys consistent with the above methodology. Methodology used for flora surveys should be specified in the appendices to the report.

1.1.1.2 Terrestrial fauna

The terrestrial, and riparian fauna occurring in the areas affected by the proposal should be described, noting the broad distribution patterns in relation to vegetation, topography and substrate. The description of the fauna present or likely to be present in the area should include:

- species diversity (i.e. a species list) and abundance of animals, including amphibians, birds, reptiles, mammals and bats;
- any species that are poorly known but suspected of being rare or threatened;
- **habitat requirements and sensitivity to changes, including movement corridors and barriers to movement;**
- the existence of feral or exotic animals;
- **existence of any rare, threatened or otherwise noteworthy species/communities in the study area, including discussion of range, habitat, breeding, recruitment, feeding and movement requirements, and current level of protection (e.g. any requirements of Protected Area Management Plans); and**
- use of the area by migratory birds, nomadic birds, fish and terrestrial fauna.

The ESR should indicate how well any affected communities are represented and protected elsewhere in the province where the site of the proposal occurs.

1.1.1.3 Aquatic biology

If no biota surveys/studies have previously been conducted in and downstream of the project area, the aquatic flora and fauna occurring in the areas affected by the proposal should be described, noting the patterns and distribution in the waterways and/or associated lacustrine and

marine environments. The description of the fauna and flora present or likely to be present in the area should include:

- fish species, mammals, reptiles, amphibians, crustaceans and aquatic invertebrates occurring in the waterways within the affected area, and/or those in any associated lacustrine and marine environment;
- ~~any rare or threatened marine species, particularly the dugong and its habitat;~~
- aquatic plants;
- aquatic and benthic substrate; and
- habitat downstream of the project or potentially impacted due to currents in associated lacustrine and marine environments.

1.1.2 Potential impacts and mitigation measures

This section defines and describes the objectives and practical measures for protecting or enhancing nature conservation values, describes how nominated quantitative standards and indicators may be achieved for nature conservation management, and how the achievement of the objectives will be monitored, audited and managed.

The ESR should address any actions of the project or likely impacts that require an authority under the *Nature Conservation Act 1992*, and/or would be assessable development for the purposes of the *Vegetation Management Act 1999*.

The discussion should cover all likely direct and indirect environmental harm due to the project on flora and fauna particularly sensitive areas as listed below. Terrestrial and aquatic (marine and freshwater) environments should also be covered. Also include human impacts and the control of any domestic animals introduced to the area. Strategies for protecting the Great Barrier Reef Marine Park and World Heritage Property, and any rare or threatened species should be described, and any obligations imposed by State or Commonwealth legislation or policy or international treaty obligations (i.e. JAMBA, CAMBA) should be discussed. Emphasis should be given to potential environmental harm to benthic and intertidal communities, seagrass beds and mangroves.

Strategies for collecting and preserving any significant fossils should be described.

The potential environmental harm to the ecological values of the area arising from the construction, operation and decommissioning of the project including clearing, salvaging or removal of vegetation should be described, and the indirect effects on remaining vegetation should be discussed. Short-term and long-term effects should be considered with comment on whether the impacts are reversible or irreversible. Mitigation measures and/or offsets should be proposed for adverse impacts. Any departure from no net loss of ecological values should be described.

The potential environmental harm on flora and fauna due to any alterations to the local surface and ground water environment should be discussed with specific reference to environmental impacts on riparian vegetation or other sensitive vegetation communities. **Measures to mitigate the environmental harm to habitat or the inhibition of normal movement, propagation or feeding patterns, and change to food chains should be described.**

The provision of buffer zones and movement corridors, and strategies to minimise environmental harm on migratory, nomadic and aquatic animals should be discussed. Weed management strategies are required for containing existing weed species (eg. parthenium and other declared plants) and ensuring no new declared plants are introduced to the area. Feral animal management strategies and practices should also be addressed. The study should develop strategies to ensure that the project does not contribute to increased encroachment of a feral animal species. Reference should be made to the local government authorities pest management plan when determining control strategies. The strategies for both flora and fauna should be discussed in the main body of the ESR and provided in a working form in a Pest Management Plan as part of the overall EM Plan for the project. Rehabilitation of disturbed areas should incorporate, where appropriate, provision of nest hollows and ground litter.

Comments on URS Flora and Fauna surveys for ML1108

1. General

The flora and fauna assessment standards used in the ACI Environmental Impact Statement for MLA7064 (August 1999) would be appropriate as a minimum requirement. The current study is insufficient to determine the environmental values threatened by mining for the following reasons:

1. Although rare and threatened fauna that may potentially occur on the site are listed, there are no details of how impacts on these species are to be mitigated, or how their re-introduction post-mining is to be facilitated.
2. The section on rehabilitation post-mining lacks detail, and the intent to only monitor revegetation for 2 years is far too short.
3. The areas mapped as Ramsar wetlands include the proposed national park on North Stradbroke Island.

1.1 Timing of surveys

January 2005 was the middle of a particularly dry summer in the Brisbane region. A seven-day survey of flora and fauna is unlikely to produce an accurate summary of the biodiversity of the site:

1. it was a hot and dry season which would have resulted in under-sampling of mobile fauna whose populations would have contracted to drought refuges; and
2. many flora species including the rare *Acacia baueri*, ground orchids and lilies would not have been apparent.

Flora and fauna surveys should be conducted seasonally over a year, and include a wet season, to sample the full range of biodiversity of a site. Many heath land species are not obvious unless flowering, and these areas should be sampled in spring.

2. Flora Surveys

Vegetation sampling was conducted in each vegetation association (10 sample sites). No details provided on the size of the sample plots. The EPA recommends a minimum of 20m x 50m.

Flora surveys were concentrated in very small patches of vegetation in low dry heath (3 sites), wet heath (2 sites), scribbly gum communities (2 sites) and the main vegetation community of mallee eucalypt species (RE 12.2.10) had only 3 sample sites, all located within 750m of each other. The distribution of the sampling sites did not reflect the expected impacts on RE 12.2.10, with only 3 sites in this community, and all of these sites located in one corner of the mining lease.

2.2.3 Target species – rare and threatened flora identified as being potentially present in the project area were targeted ...

The list provided in Appendix A of the flora survey by the consultant does not include *Acacia baueri*, a rare plant previously identified on the adjacent lease ML7064. Nor does it list *Schoenus scabripes* or *Blandfordia grandiflora*, both of which are rare plants that could be expected to be found in wet heath on North Stradbroke Island. *S. scabripes* requires expert assistance for identification and *B. grandiflora* would not be seen unless in flower.

2.2.5 Ramsar wetland area

This Ramsar site boundary follows the boundary of the proposed national park on North Stradbroke Island. The ESR does not make any mention of the proposed national park, or how mining activities will be conducted to minimise impacts on this proposed national park, or the nearby existing national park, Blue Lake National Park.

2.3.5 Specimen identification

No flora species identification was confirmed by the Qld Herbarium.

2.4.4 Species of cultural significance

The flora survey identified *Callitris columellaris*, large specimens of this species are significant to the Quandamooka People.

2.4.4 Significant communities

The flora survey identified a vegetation community of conservation significance RE 12.2.13 – low dry heath. The report does not make any recommendations on how to ensure that representative areas of this community are maintained through revegetation post-mining.

Section 2.5.2 Weeds and Fire

Infestation by pest plants should be minimised by using wash-down facilities for vehicles travelling between the mine site and other areas of North Stradbroke Island and the mainland. Significant weeds of low nutrient soils currently infesting North Stradbroke Island that can significantly change the vegetation community and fire regimes include *Asparagus aethiopicus*, *Schinus terebinthifolius*, *Andropogon virginicus*, *Brachiaria decumbens*, *Passiflora foetida*, *Lantana camara*, *Cenchrus echinatus* and *Eragrostis curvula*.

The ESR does not provide any clear guidelines for assessment/monitoring of weeds, which species should be looked for or what measures will be taken to control weeds in rehabilitation areas. This is of particular concern when it is stated that the proponent only intends to manage rehabilitation areas for 2 years post-mining.

Section 2.6.3 Rehabilitation of Disturbed Areas

There are no clear guidelines for topsoil management including depth of soil to be stored and storage periods.

There are no evaluation criteria to determine the success of rehabilitation. Additional rehabilitation measures that may encourage re-colonisation of the site by fauna such as replacement of tree stumps, ground litter, nesting boxes have not been mentioned.

Fauna Surveys

Fauna surveys were very restricted, with one sample site in the north-west corner of the lease sampling the creek line and its surrounds, and the other located in the north-east corner of the lease, sampling an area designated as future national park, and not planned to be mined. Sampling of fauna during this survey is likely to have significantly under-estimated fauna utilising the area. The survey period was too short, the season sub-optimal, and the survey effort very inadequate.

A similar study on North Stradbroke last year found 15 species of amphibians, 20 reptiles, 84 birds and 34 mammals – all more than twice the number of species found in this study, which indicates that this study is inadequate.

Pitfall trapping was undertaken at 2 sites with 5 x 10L buckets. The minimum recommended size for a pitfall trap is a 20L bucket, and even these will not adequately sample snakes as they can get out of them. The use of a total of 10 pitfall traps over the ecotones of 4 vegetation communities on 630ha of land is inadequate. The minimum requirement is for at least 8 x 20L buckets for three trap nights in each vegetation community.

Microchiropteran bats were recorded using an anabat detector. There was no harp trapping conducted, and the results from the anabat detector would be inconclusive at best. Additionally, the anabat detector was only used for one hour at dusk, which would not sample all bat species. It is stated that the anabat detector was used in “areas of habitat most likely to indicated the presence of microchiropteran bats”, however these areas are not recorded for verification.

It is stated that the **diurnal bird count** was undertaken at a single site during 2 thirty-minute intervals. It is then stated that the bird count was done 2 hours after dawn and 2 hours before dusk. These two statements within the same paragraph contradict each other. Bird counts should be conducted in the early and late parts of the day, in each vegetation community,

over a range of seasons. The survey period was hot and dry, and it is likely that the avifauna is significantly under-sampled by the methods used.

The **diurnal herpetofauna search** was for one hour by one person at two sites within the 630 ha mining lease. This is clearly inadequate to accurately represent the herpetofauna on the site.

The **nocturnal herpetofauna search** was for one hour by one person at two sites within the 630 ha mining lease. The optimal time for searching for herpetofauna is at night, and should be done along transects for at least 2 hours per night for 5 nights in each vegetation type.

The **nocturnal call playback** was only conducted once, during a hot, dry season, and could not be expected to adequately represent the species that utilise the mining lease. The playback session would have been done for about one hour at two survey sites. This method of survey should have been conducted over several nights along transects within each vegetation community, and over a range of seasons.

The **arboreal spotlighting** was done along a single 300m transect for one hour, plus one hour of additional spotlighting within the site. This method of survey should have been conducted over several nights along transects within each vegetation community, and over a range of seasons.

The following matters should be addressed in the ESR:

- What are the key fauna indicators of rehabilitation success?
- How will fauna be encouraged to recolonise rehabilitation areas?
- What is the value of the habitat to koalas which are vulnerable in SEQ?
- What is the value of the habitat to glossy black cockatoos?

Cultural Heritage Report (Appendix B) – Report still pending

The following Notes were extracted from Appendix J - EIS. Proposed Silica Sand Extraction. MLA 7064. North Stradbroke Island (Outline, 1998):

Section 6: Existing socio-economic and cultural environment.

“Prior to European settlement, the island was occupied by the Aboriginal people of Quandamooka”

“Aboriginal occupation of the study area (MLA 7064) goes back at least 22,000 years and there is good archaeological record for the past 6,000 years.”

“Aboriginal walking tracks...connected Dunwich to Point Lookout.”

“Myora was a traditional campsite.”

“Aborigines from North Stradbroke Island as well as other areas in southern Queensland were removed to Myora.”

Memmott & Stacey (1999) have outlined categories of customary Quandamooka places that are of high cultural heritage value to the traditional owners.”

“The archaeological and anthropological studies find that the areas surrounding Brown Lake and Capembah and Cooran Cooroonpah Creeks are integral parts of the main stories that frame the cultural landscape of the Quandamooka.”

“All water and connected waterways that constitute Brown Lake are considered to be sacred by the Quandamooka people.”

“Along the ridge to the east of Brown Lake are growing a number of sacred Cypress pines.”

Draft Report. Vance Lease North Stradbroke Island. Environmental Studies. Groundwater Environment (Appendix C)

Executive summary. “Groundwater quality is comparable to **freshwater**.” Registered bore 14400085 on ML 1108 was not sampled for water quality baseline information.

Comment [D1]:

Groundwater quality is scarce (3.3.4). Groundwater quality at Unimin bores 1, 2, & 3 on ML 1124 have pH range from 4.7 to 5.2. No data on metal content or hydrocarbons. Bores 1, 2, & 3 are downstream of Vance lease ML 1108.

Section 2 – Study methodology. Objective 5 was to achieve a plan of management & mitigation **measures**. Section 2.5 does not give any specific details of the management and mitigation measures. There are indications of these measures throughout the body of the report.

Comment [D2]: It is difficult to prepare a management plan when the location of the pits, depth of extraction site of sand processing facility on ML 1108 and site of tails pond is not known. The pond liners maybe clay (contaminant) or synthetic membrane. The latter is preferred.

Section 3 - Existing hydrology. What is the cause of groundwater stagnation (GHD, 1998) southeast of Brown Lake? Is it another perched aquifer or an extension of the Brown Lake system?

Section 3.3 - Groundwater flow diagram. If Brown Lake is a perched aquifer within a closed catchment, then why is the diagram showing the regional groundwater flow away from this Lake. The regional groundwater system occurs at a greater depth and the two systems are not connected. Again what does the groundwater stagnation area represent – perched aquifer or possible window to the regional groundwater system? If it is the latter, then is there potential to drain this feature by lowering the phreatic surface by mining activities. It should be noted that Unimin has given no indication of the depth of mining activities. This draw down may have an adverse impact on the vegetation in this area (by drying out the substrate). Why not show groundwater flows into the perched aquifers (Brown Lake and Swallow Lagoon) as non-connected systems which they are. The regional groundwater flows are more likely to be in the opposite direction (northwest trending) and not northeast trending as shown in this figure.

Section 3.3.1 – Infiltration & recharge. Given that the recharge rate will increase following clearing of ML 1108, what impact will this additional uptake of groundwater have on the perched aquifers at Brown Lake and Swallow Lagoon. At the closest point, ML 1108 is only 800m from Brown Lake reserve. Similarly, Blue Lake National Park is 1.1 km south of the lease at its nearest point.

Section 3.3.3 – Groundwater discharge. “Swallow Lagoon is likely to be perched above the regional groundwater water table”. This statement is inconsistent with section 5.1 – Baseline hydrogeological environment, which states that “ nearby water bodies, such as Swallow Lagoon and Brown Lakes are perched”.

Section 3.3.4 - Groundwater qualities at Unimin bores 1, 2, & 3 on ML 1124 have a pH range of 4.7 to 5.2. This is stated to be due to leaching of organic material from wetland areas. More advice should be sought with respect to the potential for acid sulphate soils?

Table 2: There is no data on metal content or hydrocarbons in this Table. Bores 1, 2, & 3 are downstream of Vance lease ML 1108. Why wasn't bore 1440085 (Cooroonpah Creek) sampled for groundwater quality as part of this investigation. Similarly why weren't bores 99455 and 99454 also sampled for groundwater quality. The effect of these omissions results

in there being no groundwater quality data provided from within ML 1108. As part of the base line information.

Section 4.1 – Interception of groundwater. The location and depth of the pits is not known, however the risk of intercepting the groundwater table is low. Extraction from adjacent pits occurs to a depth of 2m below the water table. This is said to be a dry mining operation. Information to support this claim of low impact should be included in the ESR. It should be noted that the risk of this occurring in Cooroon Cooroonpah Creek is high.

Section 4.2 – Contamination of groundwater & surface water. Unimin will use water-soluble flocculants to disperse sediments in tails ponds. Pond location is not known at this stage (refer to section 4.2.1). Hydrocarbons represent the other potential contaminant source, but the fuel storage & maintenance areas are not known at this stage.

Section 4.2.1 – Potential Impacts to Groundwater from Sedimentation Pond. It is not possible to assess the potential impacts of the tails pond when the proponent does not know the location of the pond at this time. However, it will be constructed to avoid flooding & overflow. What are the design parameters for this structure? Volume of tails discharged, containment capacity, lining to prevent groundwater contamination, location, free board, inspection & maintenance program, who will be the responsible person? I agree that the base and internal walls should be lined and that the dam should be constructed down gradient of the mine pit.

Section 5.2 Potential impacts. How can Unimin substantiate the statement that mining is not expected below the water table when the company is unable to provide details of the pit location or pit depth. The section should also acknowledge the use of water-soluble flocculants. There is also a mention of an indurated layer which I assume is in ML 1108, but there has been no reference to this feature in the baseline sections of the groundwater hydrogeology. What are the implications for additional perched aquifers or connections to other nearby perched aquifers such as Brown Lake (800m) and Swallow Lagoon (250m).

Section 5.3 – Recommendations. Unimin/URS should provide details as to how it was determined that four groundwater-monitoring bores are required for monitoring purposes. During the operational phase of mining bore lines should be considered to dewater any increase in groundwater flows during clearing for mining operations.

ESR - Terms of Reference. Hydrology (general)

An aim of the ESR is determination of trigger levels for relevant indicators to identify possible impacts on environmental values, those trigger levels being relevant to alert of potential causation of environmental harm (refer to condition A5-3(e) of MIM900220203). The determination of relevant parameters and trigger levels should be discussed further in the TOR.

Surface water methodology

Provide more detail on the initial surface water assessment and specify methods for determining:

- *catchment areas for relevant wetlands and creeks;*
- *potential adverse impacts to surface water flows from mining activities;*
- *interaction between groundwater and surface waters;*
- *temporal variability in surface water flows and water volumes of relevant wetlands and creeks; and*
- *temporal variability of water quality.*

**Draft Report. Vance Lease North Stradbroke Island. Surface Water Studies.
(Appendix D)**

Surface Water Environment

Section 1 – Study scope. The Agency has previously requested (refer to Appendix J, EPA correspondence, 21 September 2004) that more detail on temporal variability in water quality be included in the surface water assessment methodology. This area has not been sufficiently addressed in the objectives and methodologies outlined in this report.

Section 2.3 – Field Investigation. Field investigations were limited to a visual assessment on 28 February 2005. The investigation of baseline surface water characteristics should be primarily undertaken during field sampling to accurately assess quality and flow volumes, and to identify any seasonal variability.

Section 2.6 – Management Plan & Mitigation Measures. Objective 5 was to achieve a plan of management & mitigation measures. Section 2.6 does not provide any specific details of the management plan and/or mitigation measures to be implemented. There are indications of these measures throughout the body of the report. A summary should be included in this section.

Section 3.5 – Adjacent water bodies. Swallow Lagoon is a perched aquifer 180m southwest of ML 1108. The catchment of Swallow Lagoon extends to a drainage divide on the lease. Further, the extent of the basal indurated layer to this water body has not been described and may extend onto ML 1108. Mining activities on ML 1108 (beyond the RAMSAR area) may have potential impacts on Swallow Lagoon. Unimin will need to provide additional information on this matter.

Section 3.7 - RAMSAR Wetlands. Further advice should be sought to support the statement that the RAMSAR areas on and adjacent to ML 1108 are not wetlands and that such designation of these RAMSAR areas are for management purposes only.

Section 3.8 – Water quality. Surface waters in Cooroon Cooroonpah Creek at six sampling points above and below the current sand mining operations on ML 1124 were “strongly acidic”. The acidity is attributed to humic acids derived from decaying vegetation. The ESR has indicated that disturbance of accumulated organic matter (such as clearing prior to mining) can lead to a short-term increase in the rate of humic acid release. Management and strategies to deal with changes in pH have not been put forward in the ESR. Naturally acidic soils and peats with no past history involving iron sulfides are not acid sulphate soils, but some management of acidity is still relevant (Dear, S.E., Moore, N.G., Dobos, S.K., Watling, K.M. and Ahern, C.R., 2002: Soil Management Guidelines. In *Queensland Acid Sulfate Soil Technical Manual*. Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.).

Section 3.8.7 - Iron. Concentrations of iron were found to have increased downstream of current mining activities on ML 1124. Minerals containing iron are partially oxidized during weathering, and give rise to the familiar brown, yellow and red colours on rock and other

surfaces, and is partly dissolved as ferrous iron (Fe^2). Ferric iron (Fe^3) is reduced to ferrous iron (Fe^2) by bacterial action. The ferrous ion can be transported long distances if the solution remains reducing and slightly acidic, and if it is not admixed with other ions (carbonate, sulphide or silica) to form insoluble compounds. There are indications of environmental harm in the ESR caused by an increase in the concentration of iron in waters. Unimin must provide additional information on this matter.

Section 4.2.1 – Increased runoff. Is the requirement for a 100 m buffer to Cooroon Coroonpah Creek under a state statute, management code or policy? Is this condition mandatory and enforceable? Furthermore, the Queensland Department of Mines & Energy was amalgamated with other Departments to become the Department of Natural Resources and Mines.

Section 4.2.5 – Contaminants. “Appropriate systems and procedures” to manage contaminant releases have not been outlined in the ESR.

Section 4.2.6 – Impacts from Sedimentation Pond. The design, construction, operation and maintenance criteria for the “tails pond” have not been included in the ESR. The ESR should be amended to refer to one or both of the following EPA Codes:

- **Code of Environmental Compliance for Mining Lease Projects.** Appendix B – Criteria for dams; and
- **Environmental Code of Compliance for environmental authorities for high hazard dams containing hazardous materials.**

Environmental authority MIM900220203 does not authorise the release of process waters to groundwaters or surface waters. The following section of the ESR is inconsistent with the environmental authority:

“Water used for the slurry and in the sedimentation pond....will be discharged to groundwater or evaporated directly from the pond”.

How will this be achieved when “the sedimentation pond is unlikely to be effective as an evaporation pond to remove excess water accumulating from pumped slurry inflows”?

The potential impacts of such discharges to groundwater (contamination by flocculants and changes to water table levels and subsequent impacts on vegetation) have not been addressed in the ESR.

Reuse and recycling have not been considered in the ESR.

Air quality assessment for the proposed expansion of ACI sand extraction facility – North Stradbroke Island. (Appendix E)

Katestone Scientific Pty Ltd, 1998.

This report refers to the expansion of mining operations from ML 1124 to ML 7064. It does not include expansion onto ML 1108 – Vance. Elements of this report have been superseded by statutory changes and conditions of the environmental authority since 1998.

Unimin has not addressed the Agency's advice of 29 September 2004 that "air studies should be undertaken to assess the current performance of mining operations on ML7064 with respect to air quality impacts and how these may relate to the anticipated performance on ML1108."

Unimin should update this document to reflect the current *Environmental Protection (Air) Policy 1997* (Reprint 2C), reprinted as in force on 4 October 2004 and should refer to the "Air Quality Sampling Manual, 1997" published by the Department of Environment.

The report must be consistent with environmental authority MIM900220203, in particular the conditions of Schedule B. It should be noted that buffer distances are not specified in this environmental authority. The authority focuses on the release of dust or particulate matter from the mining activities that cause an environmental nuisance, environmental harm or serious environmental harm at any sensitive place.

The report should include a current description of sensitive places and include a location plan of such sensitive places. Figures 4 to 10 are difficult to assess in black and white as concentration greater than a specified value are represented in red.

Construction of a sand processing facility on ML 1108 is an option being considered by Unimin. The Katestone report (1998) does not make reference to this option being undertaken (refer to sections 6, 9 & conclusions).

Section 9 refers to the development of an environmental management plan for measures to minimise the frequency and severity of dust events. Measures are outlined in this report.

The conclusions are not consistent with the conditions of environmental authority MIM900220203, such as separation zones, PM10 sampling requirements and meteorology based on Eagle Farm readings. The report concludes that dust suppression techniques should be included in the environmental management plan for the mine. Has this EM Plan been completed?

IAS for Proposed Sand Extraction, MLA 7064, North Stradbroke Island, for ACI Industrial Minerals Division (Richard Heggie Associates Pty Ltd, 1998). (Appendix F)

Terms of Reference, ESR. Noise

With respect to the TOR, the EPA advised Unimin in September 2004 of the following requirements:

1. *Noise studies should be undertaken to assess the current performance of mining operations on ML7064 with respect to noise impacts and how these may relate to the anticipated performance on ML1108.*

The current performance of mining operations (noise) was not assessed.

2. *The environmental assessment should include an investigation of available strategies to minimise noise impacts.*

Strategies to minimise noise impacts were not developed.

3. *If it is anticipated that noise monitoring will be initiated, the monitoring methodology should be outlined in the TOR.*

Monitoring methodology was not discussed as to how Unimin will ensure compliance with EA condition D1-1 – “noise from the mining activity must not cause an environmental nuisance, at any sensitive or commercial place.”

Unimin’s response in the final TOR stated that:

“a noise study was completed for ML 7064, by Richard Heggie Associates, in 1998. It was summarized that there would be little impact on the environment from the mine due to the distance from the mine to the Myora residence. As the company has not received any noise complaints, and the mine will be moving further away from the residence, it is believed that this study will be applicable to Vance.”

The Heggie (1998) report was submitted unchanged as Appendix F to the ESR. It did not address the matters raised previously by the Agency.

Road Transport Report (Appendix G)

Christopher Hallam & Associates Pty Ltd, 1998: Traffic Impact Assessment of proposed extension of sand mining into lease 7064, North Stradbroke Island. ACI Industrial Minerals Division.

With respect to the TOR for the ESR, the EPA advised Unimin in September 2004 of the following requirements:

“If appropriate, comment on consideration by Unimin Australia Limited of any alternatives to the current transport method for minimising potential traffic impacts.”

Unimin responded by stating that

“As we will be transporting similar quantities from the same location, to the same destination as the current operation, this report (Hallam, 1998) will still be relevant. The proposed direction of mining on Vance will give UAL the opportunity to consider other transportation routes and methods or the delivery of sand to Dunwich. Any alternative route or method would impact areas outside 1108 so any proposal would require a separate assessment report. The ESR will contain a copy of the Road Transport Assessment (Hallam, 1998) as an appendix. Comments will be given as to the applicability of this study to the current Vance lease.”

The Hallam (1998) report found that in the short term:

*“Product sand is transported by truck via East Coast Road – Cunningham Street to a wharf...however, **it is clear that the existing transport route is far from ideal.** The current transport route passes schools and dwellings. ...ACI extraction is about 738,000 tonnes... and includes builder’s sand....about 47,000 tonnes per annum.*

“Truck movements however do have a greater noise impact than car movements and...trucks will continue to have an impact on the pavement of East Coast Road – Bingle Road.”

“Medium term planning is for a new ACI jetty to be constructed south of the CRL out loading facility and for ACI to obtain new mining leases that would enable them to develop a new transport route that bypassed Dunwich township, approaching the new jetty from Ballow Road South....south of Lang Lane.”

“The concept would allow access corridors to be established linking ACI, and possibly even the Vance lease to Tazi Road and thence to Dunwich. The public benefit of this scenario is that would take heavy truck traffic away from the Coast Road and effectively remove heavy truck transport from the township of Dunwich.”

The status of the medium-term strategy and/or construction of a new load-out jetty south of the Dunwich were not specified in the ESR. Unimin states that “it is not known whether the additional jetty is progressing and nothing is known about the additional studies.”

Traffic flow rates were assessed in November 1997, however there applicability to current traffic flows is questionable. **Figure 1 - current road network** (refer to section 2.1, Hallam, 1998) has not been included with this report.

Geomorphology and Soils. Vance Lease North Stradbroke Island Environmental Studies. GJR Holdings Pty Ltd, 20 June 2005. (Appendix H)

ESR - Terms of Reference. Geomorphology & Soils

“As part of the hydrological study (3.3.2) a conceptual geological and hydrological model will be developed for the site and surrounding areas. This will be completed as a literature review of the lease and island geomorphology.

A terrain analysis will be conducted as a basis for the characterisation of the general site terrain features in terms of existing geology, landform and soil conditions.

On a local scale, surface soils will be recorded as part of the flora field investigations at each of the field plots.

In addition to this, the National Estate database will be accessed and a review conducted in relation to the Vance project. These values may be related to issues of significance under the EPBC Act.”

Further, the EPA advised Unimin (September 2004) that:

“A primary aim of the geomorphology assessment is to establish any influence which geomorphology has on hydrology and therefore nearby sensitive creek and wetland ecosystems.

In undertaking studies of geomorphology and soils, Unimin Australia Limited must be able to demonstrate a detailed and accurate knowledge of geomorphological and hydrogeological profiles and conditions throughout areas that are likely to be impacted by the mining activities. In this respect, consideration should be given to undertaking detailed soil profiling utilising field sampling methods. If field sampling is to be undertaken, the sampling methodology should be outlined.”

Data sources – The ESR refers to the Beenleigh Geological Map Sheet (1985), which is not the most recent mapping undertaken on North Stradbroke Island. Compilation sheets for the Beenleigh map sheet are available from the Department of Natural Resources and Mines. Further, the Southeast Queensland GIS 2002 geological mapping data is available from the *Interactive Resource and Tenure Maps* at:

www.nrm.qld.gov.au/science/geoscience/tenure_maps.html

For additional information, contact the Geoscience Manager, Geological Mapping, Department of Natural Resources and Mines, 80 Meiers Road Indooroopilly, Qld 4068.

Subsurface data is limited to 16 hand auger sites to maximum depth of 3m. The ESR has not summarised mineral exploration data for the Vance project, which may have delineated the presence and extent of indurated profiles associated with perched groundwater systems. Groundwater information may also be recorded in the mineral exploration data.

In the main report (p. 2-12), Unimin states that “the thickness of the fine-grained white silica sand that is the target of mining operations typically extends to depths varying between 7m and 14m below the existing ground source. The reference source for this data has not been given in the report or in Appendix H of the ESR.

“A conceptual geological and hydrological model will be developed for the site and surrounding areas” as required by the TOR has not been outlined in this report.

It would appear that the *National Estate database* has not been accessed and a review conducted in relation to the Vance project as set out in the TOR.

Socio-Economic Report (Appendix I)

This Appendix comprises the following extracts from the *EIS. Proposed Silica Sand Extraction. MLA 7064. North Stradbroke Island (Outline, 1998)*:

- Section 6:** Existing socio-economic and cultural environment;
- Section 7:** Biophysical Impacts; and
- Section 8:** Socio Economic Impacts and Management.

“As the mine will not be expanding in terms of employment, or demands on the local community, this report will still be relevant.” (Unimin, ESR - Terms of Reference, 2004).

“Comments will be given as to the applicability of this study to the current Vance lease.”

Section 6. Existing Socio-economic and Cultural Environment.

The 1996 census was used for baseline demographics. The relevance of this data is questionable as there may be more recent data available from Australian Bureau of Statistics.

“The nearest populated area is a small rural subdivision to the west (of MLA 7064) at Myora.” This is still applicable for Vance, ML 1108.

Recreational uses on NSI include tourism, but recreational use of MLA 7064 is extremely limited.

A summary of History, Archaeology, Cultural Values have been made above in our comments to Appendix B of ESR.

Section 7 dealt with biophysical impacts to:-

- Site topography, geology;
- Hydrology;
- Flora and fauna;
- Noise impacts;
- Visual impact assessment;
- Transportation;
- Impact of agriculture;
- Land use impacts;
- Public safety and fuel storage hazard assessment;
- Air quality assessment;
- Aboriginal archaeology;
- Bushfire risk; and
- Energy considerations.

Socio Economic Impacts and Management (Section 8)

“The project (MLA 7064) allows for the continuation of an existing economic activity (namely sand mining/processing) that generally maintains existing social and economic considerations.”

Social impacts considered in the EIS were:

- Impacts on property and the potential social implications;
- Potential impact on activities (urban development & tourism);

- Potential effects on overall public amenity;
- Cultural impacts of the proposal; and
- Potential health and psychological effects of the proposal.

“Economic impacts embrace both the positive and negative effects of the proposal (MLA 7064). It is proposed in the short-term to continue to have haulage through Dunwich to service the sand-loading jetty. In the medium term, ACI’s strategy is to gain necessary approvals to relocate all of its sand processing to the “Pines” area, and to link this area to the new jetty via a new sand haulage route.” (Outline, 1998).

Although the “Pines” trade off did not occur, the assignment of ML 1108 Vance was negotiated in its place to provide Unimin with access to additional silica sand resources on NSI. As stated previously in the Hallam report (1998), *“it is clear that the existing transport route (along East Coast Road and through Dunwich) is far from ideal.”*

In view of the period of time that has elapsed since the Hallam (1998) and Outline (1998) reports were released, the EPA had expected Unimin to have advanced alternative haulage options to operational status by now.

Section 8.1.4 of the EIS proposed the following mitigation measures for socio-economic and cultural impacts:

- *Measures to avoid the impact altogether;*
- *Measures to manage likely impacts;*
- *Measures to reduce impacts; and*
- *Measures to control impacts in order to achieve certain desired outcomes.*

The following mitigation measures were outlined in the EIS for heavy traffic:

- All trucks are required to cover their loads prior to leaving ML 1124 (EIS, s.8.2.4);
- ACI’s strategy is to eventually eliminate heavy truck operations from the East Coast Road, once operations are relocated to the “Pines” (EIS, s. 8.2.4);
- Haulage vehicles will be kept well maintained (EIS, s. 8.3.7);
- Haul vehicles should maintain travelling speeds at no more than 40km/hour through Dunwich (EIS, s. 8.3.7); and
- Haul vehicles drivers should not use exhaust brakes within Dunwich township (EIS, s. 8.3.7).

It would appear that the above measures have not been implemented with regard to haulage/transport routes for product sand. Unimin should address this issue by inclusion in the ESR of an action plan to investigate and implement alternative haulage routes.

Community Consultation (Appendix J)

Stakeholder consultation was undertaken with the Friends of Stradbroke Island (FOSI), Quandamooka Land Council, Stradbroke Island Management Organisation (SIMO) and EPA.

Responses from the above stakeholder groups are attached to the draft ESR.

Appendix C

Proposal for Additional Studies

P R O P O S A L

Unimin Vance Lease Environment Studies Report (Revision B)

Prepared for

Unimin Australia Limited

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North Sydney
NSW 2059

19 January 2006

3025885



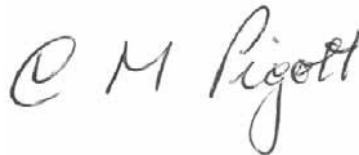
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Appendices

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Appendix B	Minutes of meeting between EPA, Unimin and URS on 10 November 2005
Appendix C	Minutes of Meeting between EPA and URS on 22 November 2005
Appendix D	Minutes of meeting between EPA and URS on 16 December 2005
Appendix E	Unimin provided map of proposed 3 year mine plan footprint
Appendix F	Agreement for the Provision of Consulting Services

URS Australia Pty Ltd (URS) is pleased to submit this revised proposal to Unimin Australia Limited (Unimin) to conduct revised environmental studies for the Vance Mining lease (ML1108) on North Stradbroke Island. This proposal has been revised at the request of Mr. Greg Watkins (Unimin Environment Manager).

Background Information

The following points provide background information on the process leading up to the preparation of this revised proposal.

- The Environmental Authority (EA) for the Vance mining lease requires Unimin to prepare an Environmental Studies Report (ESR) for their proposed mining operation.
- URS was originally commissioned to prepare this ESR for Unimin as per a Unimin supplied brief. This brief, in some areas, required URS to use existing studies done for an adjacent mining operation, rather than have URS gather new site specific baseline data. Part of the agreed scope of works was also to refer the proposed sand mining operation to the Federal Department of Environment and Heritage (DEH) for a "determination" as to whether or not the proposed mining would be a "controlled action" requiring DEH approval under the Environment Protection and Biodiversity Conservation Act (EPBC Act). This EPBC Act Referral would incorporate the ESR as the main supporting document.
- The draft ESR was prepared in response to the Final Terms of Reference (ToR) of November 2004, as agreed between Unimin and the Queensland Environmental Protection Agency (EPA) after some several months of negotiation over the contents of the ToR. The approved ToR made reference to the use of existing data.
- The Draft ESR was completed by URS and submitted to Unimin in August 2005, who in turn distributed copies to the EPA (and other relevant stakeholders) for review.
- The EPA provided a response in the form of an Assessment Report to Unimin on 27 September 2005, indicating that the Draft ESR was not, in their opinion, adequate in several areas and provided a detailed breakdown of their comments (refer Appendix A).
- The stakeholder responses received by Unimin have also been critical of several aspects of the Draft ESR.
- Unimin subsequently requested that URS provide a proposal to conduct additional studies in order to satisfy the requirements of the EPA Assessment Report and address the comments of the stakeholders. This proposal was forwarded to Unimin on 21 October 2005. Some of the EPA's comments:
 - required issues to be addressed which were **not included in the original Terms of Reference** upon which the EPA and Unimin signed off;
 - related to the assessing officers lack of familiarity with the site; and

- were valid, in terms of best practice, in that parts of the Draft ESR relied upon the extrapolation of off-site and/or now obsolete data from historical studies done for the adjacent extractive area.
- Following a review of URS' proposal Unimin requested that URS facilitate a series of meetings with key EPA personnel to clarify outstanding scope of work issues. These meetings have been held and a series of minutes developed which clarify the EPA's requirements (refer to Appendices B, C and D).
- The following revised proposal takes into account EPA's review of Unimin's Environmental Studies Report (ESR) and subsequent issue of an Assessment Report to Unimin dated 27 September 2005 plus the EPA meeting outcomes as described in Appendices B, C and D.

This proposal is based on the following assumptions:

- Unimin shall provide to URS a proposed extraction plan on a cadastral base, including infrastructure and service plans, proposed vegetation clearing pattern and post-extraction contour information. This plan shall take into account URS' recommendations on things like buffer areas etc. as detailed in the draft ESR. As a result of the outcomes of the ESR, URS may provide recommendations on the proposed vegetation clearing pattern of the mine path.
- Boreholes will be confined to existing disturbed areas only, to avoid impact to any areas of environmental significance or sensitivity.

It is proposed to conduct the required scope of work in stages as outlined below:

Stage 1: Initial Meeting with EPA to confirm scope of work (note this stage of work has been completed, with meeting outcomes documented in a series of minutes as provided in Appendices B, C and D). The invoice for this completed work will be forwarded to Unimin upon project authorisation.

Stage 2: Conduct and Reporting of Field Studies;

Stage 3: Preparation of revised ESR and EMP; and

Stage 4: Preparation of EPBC Referral.

2.1 Initial meeting with EPA (Stage 1) - completed

In consultation with Unimin's Environmental Manager a series of meetings have been held with relevant EPA personnel to clarify the proposed scope of work, with relevant URS involvement as required. Given the fact that there were still a number of unresolved issues URS considered this task as crucial to ensure all relevant parties had a clear understanding of each others expectations.

Based on the outcomes of these meetings (refer Appendices B, C and D) the scope of work for the field study has been amended to reflect a staged approach to mining, with initial environmental baseline studies focussing on the mine footprint as detailed in Attachment E.

2.2 Conduct and Reporting of Field Investigation Studies (Stage 2)

Based on the outcomes of the completed Stage 1 work the following section has been developed. This outlines the proposed field investigation studies program. This program has been developed taking into account the EPA's comments (refer to individual program sections below for specific details). Note that a URS Health and Safety Plan shall be prepared to cover all proposed field investigation programs.

2.2.1 Flora and Fauna Surveys

An additional (supplementary) flora and fauna survey is proposed to address the issues identified in the EPA/QPWS review of the ESR, and follow up scope clarification meetings.

2.2.1.1 Flora

Study Approach

A single wet season flora survey combined with a one day site visit in Spring is proposed to supplement the previous study undertaken for the Draft ESR. It is proposed that the supplementary flora survey be conducted in February/March (wet season) and September/October (Spring) 2006 to comply with EPA requirements (Appendix C).

Investigations

Literature review

A supplementary literature review will be undertaken to supplement the initial desktop review, ensuring all current data on both Federal and State listed significant species is identified for North Stradbroke Island.

Preliminary mapping

Preliminary mapping will not be required. Detailed mapping of the site's vegetation communities at a scale of 1:20,000 was undertaken for the initial survey utilising current aerial photographs taken at a scale of 1:12,000, as confirmed in recent EPA follow up meetings (Appendix C).

Transect Methodology

The methodology shall be in accordance with the agreed approach as detailed in Appendix C.

Site selection

As confirmed in the EPA meeting (refer Appendix C) and subsequent telephone conversation, nominally a total of three to four transects per vegetation community will be surveyed. In addition, a minimum of six reference sites will be established outside the mine footprint (either within the Vance lease area or, if not possible, in the adjacent national park area if suitable).

2.2.1.2 Fauna

Study Approach

A single supplementary fauna survey will be conducted in February/March 2006 as agreed with EPA (refer Appendix D).

Investigations

Literature review

A supplementary literature review will be undertaken to supplement the initial desktop review, ensuring all current data on both Federal and State listed significant species is identified for North Stradbroke Island.

Transect Methodology

The methodology shall be in accordance with the agreed approach as detailed in Appendix D. A minimum of six transects and a number of targeted active searches will be undertaken across the lease to ensure representative sampling for the entire lease area.

2.2.2 Groundwater Investigation

This revised groundwater scope is based on outcomes of a meeting between Qld EPA, URS and Unimin on 10 November 2005 (refer to Attachment B for a copy of meeting minutes). This meeting was held to seek clarification on the scale of technical investigations required to meet EPA approval of the proposed Unimin Vance Lease “Stage 1” mining activities, as outlined in the Unimin provided plan in Appendix E. With respect to groundwater, the key recommendations advised by EPA in that meeting were:

1. to substantially reduce the number of groundwater monitoring sites;
2. not to drill into the regional aquifer, and therefore not to install any new monitoring bores into the regional aquifer;
3. to utilise the one pre-existing regional aquifer bore and the Department of Natural Resources and Mines (DNRM) numerical MODFLOW groundwater model to provide detail on regional aquifer pressure heads and groundwater directions and rates of flow;
4. reduce the baseflow/perched aquifer nested piezometer sites from 3 to 1; and
5. infer perched groundwater conditions on site from 4 or 5 shallow piezometers installed into the perched aquifer during drilling.

These EPA recommendations have all reduced the scope and detail of groundwater investigations from URS’ original proposal. Although URS’ following proposed scope is based on these EPA recommendations it should be noted that, in URS’ opinion this reduction in detail, although more time efficient and cost effective is likely to result in less definitive hydrogeological interpretations. The key limitations in reducing the scope of groundwater investigations are considered to be:

1. limited understanding of the complex interaction of the perched aquifer/s and the regional aquifer;

2. limited understanding of the role of the indurated sand layer across the site. Is the layer continuous? Does thickness of the layer change between ridges and valleys? Does the rate of perched aquifer infiltration vary across site? These questions cannot be determined without nested piezometer sites.
3. limited understanding of the effects of a highly undulating topography on shallow aquifer groundwater flowpaths. Particularly the role topography has on groundwater flow in areas proximal to sensitive and environmentally significant perched lakes.
4. DNRM groundwater model is a whole-of-island model that may not reflect localised regional aquifer pressure head gradients and flowpaths. It is unknown at this stage, whether any groundwater bores proximal to the study site were used during calibration of the groundwater model. If not, then parameterisation of the model may not be favourable for site-specific requirements. Additionally, the model was built to simulate 1960 to 1999 and does not have calibrated data for post-2000. By not installing any new regional bores, it will not be possible to “challenge” the predictions of the model with field data, and therefore, any predictions derived by the model will have to be accepted.
5. To adequately fulfil the scope of work proposed in this groundwater investigation, Unimin will be required to supply accurate details of the proposed mine plan and schedule of operations on site.

The following provides a breakdown of proposed tasks to address EPA requirements:

Task Management and Organisation

- Liaise with client, EPA, DNRM and other stakeholders
- Liaise with DNRM for bore permits and other permissions:

Field Investigations

Drilling & Bore Construction

- Write drilling specifications and procure quotes from suitable drilling firms;
- Negotiate and obtain contract with successful drilling contractor, liaison with drillers, liaison with DNRM and Redlands Shire Council;
- Undertake drilling location inspection with driller to negotiate access and plan drilling program;
- Supervise drilling to investigate geological and hydrogeological layers;
- Supervise installation and development of groundwater monitoring bore network within drill holes;
- Supervise the installation of one creek monitoring site for hydrology component of the program;

- Collect soil horizon samples for geomorphology component of the program.

Baseline Groundwater Monitoring

- Design and development of groundwater monitoring program;
- Sampling of groundwater bores for laboratory analysis;
- Measurement of baseline groundwater levels both for new monitoring bore network as well as pre-existing bores outside the lease to characterise “surrounding areas”;
- Conduct falling-head permeability tests on selected monitoring bores to provide hydraulic data for conceptual groundwater model and allow interpretation of groundwater flow rates;
- Conduct double-ring infiltrometer tests to determine surface infiltration rates of the soil;
- Install pressure transducer data loggers into creek/perched aquifer monitoring site to measure continuous water levels; and
- Transfer water quality and water level data onto monitoring database.

Seasonal Groundwater Monitoring

- Sampling of groundwater bores for laboratory analysis;
- Measurement of seasonal groundwater levels both for new monitoring bore network as well as pre-existing bores outside the lease to characterise “surrounding areas”;
- Sampling of groundwater bores (within lease only) for laboratory analysis during 3 separate rounds of monitoring (3 months, 6 months and 9 months after the baseline sampling period);
- Measurement of groundwater levels for new monitoring bore network;
- Download PTDL measurements onto field laptop; and
- Transfer water quality and water level data onto monitoring database.

Data Analysis and Reporting

- Develop conceptual geological and hydrogeological models;
- Review and analyse DNRM groundwater model for Stradbroke Island;
- Assess potential groundwater contamination and assess potential impacts to perched lakes and nearby surface water bodies due to mining activities;
- Provide written report for groundwater component of the ESR.

Input to Groundwater Component of Environmental Management Plan

- Development of draft groundwater quality trigger levels in consultation with Unimin.
- Outline mitigation strategies and management options for construction and operational phases of the mine

2.2.3 Surface Water Investigation

Only limited site specific surface water data currently exists. The original Draft ESR was heavily reliant on extrapolated downstream data and inferred flow rates based on professional experience. The following scope of work aims to supplement existing information with more site specific information.

Field Investigation

In conjunction with the studies for soils and groundwater, URS will carry out the following field investigations for surface water:

- Thorough site survey to identify surface water bodies, scope out water quality monitoring locations, further investigate the RAMSAR areas and potential drainage lines across all accessible areas of the site (it is intended to carry this out in conjunction with the initial groundwater investigations);
- Infiltrometer tests to ascertain potential for sheet flow and examine runoff characteristics;
- Survey of Cooroon Cooroonpah Creek to determine size and potential flow rates within the drainage line; and
- Installation of in-situ continuous water level monitoring equipment immediately adjacent to, or within, Cooroon Cooroonpah Creek to determine number of flow events and potentially derive flow depth and hydrographic information if possible.

Data Collection and Analysis

The purpose of this work is to quantify surface water runoff as far as possible. The level of water quality data available will also be increased if possible. The primary requirement will be to further evaluate the temporal and spatial variability in water quality. Specifically, URS will:

- Design a surface water monitoring program for operation by Unimin¹ to allow collection of at least one year of surface water monitoring data on a monthly/opportunistic (following rainfall events) basis;
- Manage Unimin collected data obtained through this program on a monthly basis and advise on improvements throughout the duration of the monitoring program;
- Obtain additional data from the Bureau of Meteorology where relevant;
- Re-analyse meteorological data, potentially to give recurrence intervals for individual events and examine the potential influence on hydrology at the site;
- Derive a conceptual integrated groundwater-surface water model to help the understanding of overall water balance, temporal and spatial variability in flow and interaction with groundwater as far as the data collected will allow;
- Assess on-site and downstream water quality data to obtain information on temporal and spatial variation in water quality; and
- Create a rainfall-runoff model, calibrated with transposed gauged catchment data.

Input to Surface Water Component of Environmental Management Plan

Based on information supplied including pond and infrastructure location details, mining areas, rehabilitation program details and post-development contours, URS will prepare updated details on recommended site surface water management controls to reduce/minimise environmental impacts, including:

- Appropriate systems and procedures for managing both construction and operational phase impacts; and
- An ongoing monitoring program to further investigate surface water issues identified and compare with modelled results.

2.2.4 Soils/Geomorphology/Terrain Analysis Studies

As a result of the meeting between Unimin, URS and the EPA held on 10 November 2005, in order to address the revised requirements agreed with the EPA regarding the Geomorphological and Soils aspects of the initial ESR Report, the actions outlined below are considered to be appropriate to meet the EPA requirements.

¹ Surface water monitoring services can be provided by URS but it is assumed that Unimin will implement an expanded water quality monitoring program alongside those currently in place to include locations within Mine Lease 1108 based on URS' recommendations.

1. Subject to approval to proceed, review any additional background information relevant to the soils and geomorphology of the site and proposed mining operations. This will require Unimin to supply details of the proposed mining plan and schedule of operations for the site as a whole. In addition, any existing mineral exploration (drilling) data available for the Vance project, in particular in relation to material descriptions and the occurrence of any indurated zones and their influence on likely depth of mining, should be made available.
2. Source any background scientific papers and mining reports pertaining to geomorphological conditions on North Stradbroke Island, in particular within and in the general vicinity of the Vance lease area. Complete a review and summarise relevant information. To this end, it is proposed to engage Dr. Trevor Graham, (Specialist Coastal Geomorphologist) with GeoCoastal Australia Pty Ltd, to assist with data acquisition and review of the conceptual geological and hydrological model to be developed in consultation with the hydrogeological study group.
3. In conjunction with the proposed hydrogeological field investigation and drilling programme, obtain additional soil samples for indicative testing and soil profile characterization to supplement the existing soils data obtained and to further assist in determining the typical depth, nature and continuity of the underlying indurated (coffee rock) B horizon materials. This will include some detailed laboratory analyses of soil chemistry for soil fertility and topsoil suitability assessment and will also provide input to the land rehabilitation proposals.
4. Access and review of the most recent geological mapping data available from the Geological Survey of Queensland for North Stradbroke Island, to update the terrain analysis and (if necessary) revise land unit and soils descriptions and mapping compiled for the initial ESR study.
5. Reporting with input to the EMP for terrain and soils management.
6. Drafting/map revision(URS) and report production costs

URS has assumed that Unimin shall supply details of the proposed mining plan and schedule of operations for the site as a whole. In addition, it is assumed that Unimin shall provide URS with any existing mineral exploration (drilling) data for the Vance project, in particular in relation to material descriptions and the occurrence of any indurated zones and their influence on likely depth of mining.

2.2.5 Air Quality Investigations

The following proposed scope of work has been developed in response to the EPA's comments on the Draft ESR and includes a number of options for consideration by Unimin. In order to complete the following proposed scope of work the following information would be required from Unimin:

- Details of site operations for the Vance lease and the processing plant;
- Maps of the site operations and nearby residential areas;
- Provision of all available dust and meteorological monitoring data; and
- Provision of dust monitoring report from 1996.

Proposed Scope of Work

To revise the air quality report to satisfy the EPA and stakeholder comments (outside the ToR), the tasks have been summarised into stages. Evaluation of baseline air quality by the use of dust deposition gauges has been proposed, as the alleged impacts from the stakeholder (Greg Smith) relate to visible dust leaving the site (dust nuisance), not to adverse health effects.

Stage 1: Review/Revise Existing Information

This stage is considered mandatory and includes two tasks:

1. Summarise background air quality measurements collected by Unimin (comprising at least 2 years of data), to determine the current impacts of mine operations; and
2. Revise the initial Draft ESR's air quality report to make it applicable to the Vance lease (ML1108), including:
 - Update of dust emissions for activities on Vance lease and processing plant;
 - Update of meteorological data to get representative data for the area;
 - Dispersion modelling of the expected dust emissions from the Vance lease, including predictions of PM₁₀ concentrations and dust deposition levels at residential areas;
 - Qualitative review of the health effects of silica dust, and the potential for silica dust levels to exceed the air quality guidelines;
 - Clarification of the interpretation of ambient air quality guidelines and occupational health and safety guidelines; and
 - Update of Draft ESR to reflect current air quality legislation and conditions of the Environmental Authority for the Vance Lease.

Stage 2: Establishment and Conduct of Baseline Field Monitoring Program

The EPA has advised that new baseline air quality information will need to be collected for the subject site. The following provides an outline of the proposed program, including establishment of a dust deposition gauge monitoring network and ongoing collection of samples over the monitoring period. Note there are two options to conduct this program: URS to collect samples; or, Unimin to collect samples under URS direction. Cost estimates for both options are provided in Section 3 of this proposal.

The proposed program includes:

- Establishment of four (4) new dust gauges around the current mine to determine impacts of the current operations, and two (2) new dust gauges on the Vance lease to establish the background levels due to other sources;

- Dust gauges to be maintained monthly for a one-year period to capture seasonal variations in wind patterns and other background sources of dust;
- Monthly maintenance of dust deposition gauges (replacement of dust bottles);
- Monthly analysis of dust deposition bottles to determine total insoluble solids, reported as g/m²/month;
- Preparation of a brief six (6) monthly summary report; and
- Preparation of a concise report at the conclusion of the monitoring period to establish whether the current Unimin operations are causing any high dust deposition levels.

Baseline monitoring of airborne dust concentrations (ie 24 hour PM₁₀ concentration) has not been included in this proposal

2.2.6 Noise Assessment

The following scope of work has been developed to address the EPA's requirements. In order to complete this scope of work the following information will need to be provided by Unimin.

- The type and number of heavy machinery, including haul trucks, operating at the existing and proposed mining operations;
- Site plan (including access roads for the haul trucks delivering raw sand) of the processing plant at ML1124 as well as a plan indicating the location of the nearest residences;
- Information on any noise complaints lodged with Unimin in regards to their existing operations at ML1124 and ML7064; and
- Topographical survey plan of the wider area around the mining leases (ML1124, ML7064 and ML1108) including the nearest residential area.

The above information is required to develop a representative model (SoundPLAN) of the existing and proposed mining activities, including the relationship in terms of distance to and elevation of the nearest residential area.

Scope of Work

- Review of the plans of the existing and proposed mining operations to obtain information about the location and scope of activities undertaken on ML7064 (where the current extraction is taking place) as well as at ML1124 (where the existing processing plant is located).
- Noise measurements at the nearest residence to the existing mining operations (Myora Residence) to determine the existing noise impacts on the nearest residence (as requested by the EPA), as well as to obtain background noise measurement data for establishment of performance criteria based on background noise levels plus additional +5dB(A) due to operations at the proposed ML1108.
- Development of a noise propagation model using SoundPLAN (version 6.3) software based on Unimin supplied information on type/number of heavy machinery (including excavators, bulldozers, loaders & haul trucks) & typical sound power levels of this equipment as reported in the previous acoustic report (ML7064) or as measured by Belleng VDM Pty Ltd on similar sites.
- Noise propagation calculations over the terrain of the existing and proposed mining leases as per the topographical survey data obtained from Unimin.
- Determination of the worst-case mining operations noise impacts on the nearest residences considering the noise emissions from the existing plant at ML1124 and proposed mining operations at ML1108.
- Provision of an Acoustic Report in the format required by the EPA that will contain: details of the methodology used; tabulated noise measurement /modelling results; as well as, conclusions and recommendations.

2.2.7 Roads/Traffic Assessment

Following Unimin's discussions with the EPA on 10 October 2005, the EPA has advised that the revised assessment needs to establish a firmer link between site activities and the impact on transport issues. Further assessment of the current route with respect to current traffic levels is required and a new traffic survey should be conducted. Accordingly, a revised scope of work has been developed, including:

- Measurement of existing traffic volumes, including vehicle type;
- Correlation of traffic surveys with historical production levels;
- Projection of truck volumes;
- Builders sand volumes and truck movements to the vehicular ferry terminal;
- Investigation of pavement strength along the existing route;
- Investigation of any traffic impacts associated with the projected production traffic;
- The impacts relating to pavement structural integrity and traffic safety such as sight distances;
- Investigation of viable alternative haulage routes; and
- Conclusions and Recommendations.

2.2.8 Socio – Economic Study

The updated socio-economic component of the Revised ESR will address issues raised by the EPA in their assessment report of the Draft ESR. However this will not extend beyond the requirements of the Terms of Reference.

The EPA has accepted that the Social and Economic topics for the Revised ESR can be based on those characteristics as set out in Section 6 of the EIS for proposed silica sand extraction on MLA 7064, prepared by Outline Planning Consultants Pty Ltd in 1997 and referenced in the Draft ESR. However, the socio-economic component of the revised ESR will utilize more recent data for baseline demographic information as requested by the EPA.

Demographic information will be sourced from:

- Australian Bureau of Statistics (ABS) 2001 Census Data – the most recent Census information;
- Redland Shire Council;
- Planning and Information Forecasting Unit (PIFU); and
- Office of Economic and Statistical Research (OESR).

2.2.9 Cultural Heritage Assessment

No cultural heritage assessment work has been scoped for this task as Unimin is undertaking this in-house. However, a budget has been allocated to allow a Senior Consultant's time to edit any Unimin supplied material and input such material into the Revised ESR.

2.3 Development of Revised Environmental Studies Report (Stage 3)

This task shall include assessment, review and collation of all field study report findings into a revised Environmental Studies Report (ESR), taking into account the EPA's requirements, as will be confirmed during Stage 1 of the project. The report shall include a stand alone section on the rehabilitation measures to be adopted (with detail to include information as sourced from Unimin's 5 year mine plan). Based on the field study investigations, the environmental risks of the proposed expansion activities will be identified, and appropriate management controls developed and documented in a site specific Environmental Management Plan (EMP).

2.4 EPBC Act Referral (Stage 4)

An *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) "referral" was developed concurrently with the initial Draft ESR, with the intention of using the ESR (once finalised) as a supporting document to the final EPBC Referral. Following comments from the EPA on the Draft ESR the EPBC Referral remains incomplete.

In accordance with Unimin's request, the EPBC Act referral will be finalised using existing information compiled to date (ie. from the Draft ESR and other Unimin provided supporting information as relevant) and submitted to the Commonwealth Department of Environment and Heritage (DEH).

The original quote for the EPBC Referral was \$XXXX, of which \$XXXX was spent and \$XXXX remains.

The EPBC Referral will include a description of the project and affected areas as well as the nature and extent of the likely impacts from the proposed action. URS will compile these sections of the Referral based on existing information only (ie. from the environmental studies undertaken as part of the Draft ESR only). The Referral will assess the proposed mining operation against all relevant Matters of National Environmental Significance. Should DEH determine that additional information is required then URS shall consult with Unimin on an appropriate response. Any additional work required to be undertaken by URS shall be charged on a time and expenses basis, in accordance with URS' Standard Schedule of Rates as outlined in Table 2 (Section 3 of this proposal).

Completion of the impacts section of the Referral will require a more detailed description of the proposed mining activities.

2.5 Project Management

Effective project management is crucial to the successful delivery of this project, and hence has been assigned a discrete task. Project management will be an ongoing task throughout the course of this study and will comprise:

- Ongoing liaison with Unimin's environmental personnel (including regular progress updates);
- Liaison and communication with Unimin's mine design personnel (especially prior to the impact assessment phase);
- Coordination of site visits;
- Coordination of client and/or regulator meetings;
- Maintaining study schedules and budgets;
- Ensuring URS' internal QMS procedures are adhered to;
- Management of subcontractors; and
- Ensuring effective and regular communication of project information between study team members.

The following provides a summary of URS' cost estimate and schedule to conduct the scope of work as outlined in Section 2.

3.1 Cost Estimate

Table 1 below provides a summary cost estimate to undertake the scope of work detailed in Section 2 of this proposal.

Please note that the following cost estimate is:

- Based on a time and expenses basis, with a commitment not to exceed the following quoted cost estimate without appropriate authorisation from Unimin;
- Valid for 90 days from the date of this proposal;
- Exclusive of GST;
- Inclusive of URS' standard 7% communications fee; and
- Inclusive of the 7.5% handling charge on all contractors and expenses.

Table 1 – Summary Cost Estimate

TABLE 1 REMOVED

Any amended scope of works will be costed in accordance with URS' Schedule of Rates, as detailed in Table 2 below.

Table 2 – URS's Schedule of Rates

TABLE 2 REMOVED

3.2 Schedule

A draft work schedule is provided below. Confirmation of stage and task scheduling will be subject to discussions with Unimin. The schedule assumes client authorisation to proceed is received in January 2006, and field work can commence in February 2006.

Cost Estimate and Schedule

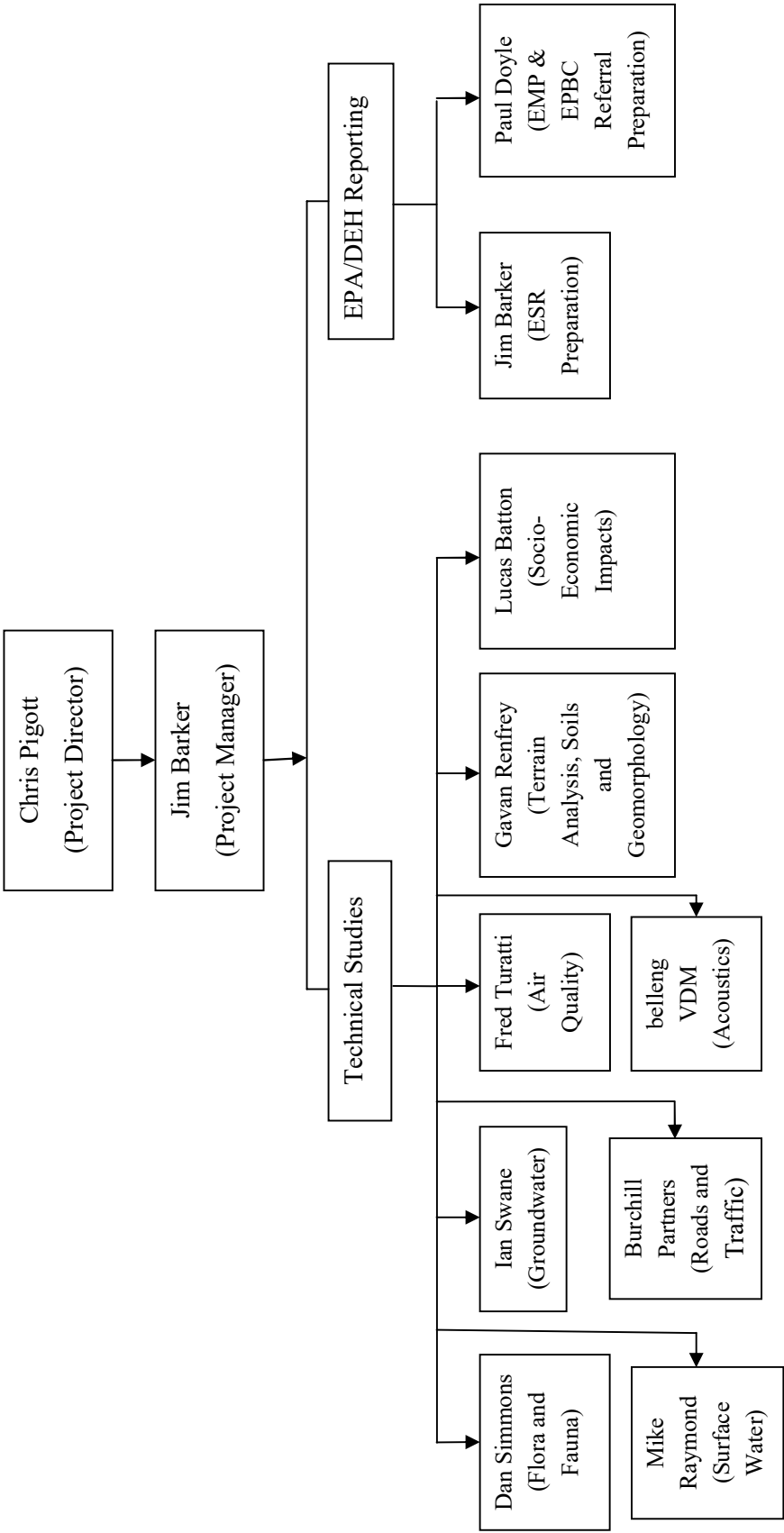
SECTION 3

Draft Work Schedule

Task	Month/Year															
	Nov 05	Dec 05	Jan 06	Feb 06	Mar 06	Apr 06	May 06	Jun 06	Jul 06	Aug 06	Sep 06	Oct 06	Nov 06	Dec 06	Jan 07	Feb 07
Unimin authorisation to proceed																
EPA meeting																
Field Studies Program																
Flora and Fauna																
Groundwater																
Surface Water																
Terrain Analysis, Soils and Geomorphology																
Air Quality																
Noise																
Socio-Economic																
Roads and Traffic																
Cultural Heritage																
Environmental Studies Report Development																
Development of draft ESR/EMP																
Unimin Review																
Finalise ESR/EMP for EPA submission																
EPA review																
Finalise ESR																
EPBC Referral																
Project Management																

URS' proposed study team is outlined in the following figure. At Unimin's request no staff details have been provided, although URS can provide these upon request.

Environmental Studies Report Project Team



URS proposes to undertake work in accordance with the standard URS/Unimin agreement, titled “Agreement for the Provision of Consulting Services” (refer Appendix F).

Appendix A

EPA Assessment of Unimin's Environment Studies Report

REMOVED

Appendix B

Minutes of meeting between EPA, Unimin and URS on 10 November 2005

REMOVED

Appendix C

Minutes of Meeting between EPA and URS on 22 November 2005

REMOVED

Appendix D

Minutes of meeting between EPA and URS on 16 December 2005

REMOVED

Appendix E

Unimin provided map of proposed 3 year mine plan footprint

REMOVED

Appendix F

Agreement for the Provision of Consulting Services

REMOVED

Appendix D

EPA Stage 1 Approval for ML 1108



**Queensland
Government**

Enquires David Trezise
Telephone (07) 3225 1217
Your reference
Our reference STH5052

Environmental Protection Agency

Incorporating the
Queensland Parks and Wildlife Service

08 December 2006

Greg Watkins
Unimin Australia Limited
Locked Bag 966
North Sydney NSW 2059

Dear Greg

Amended Draft Environmental Studies Report - Vance Project, North Stradbroke Island

I would like to advise you that the amended draft Environmental Studies Report for the Vance Project (Environmental authority MIM900220203) which was submitted on 20 October 2006 complies with the conditions of this authority.

Further, I am advised that site-specific fauna survey methodologies were employed which comply with the methodology outlined by the Environmental Protection Agency (Dr G Lundie-Jenkins, pers. comm., November 2005). Notwithstanding the above EPA requirements, you are advised that the EPA's Conservation Services – Parks Division may provide further advice with regard to the completion of the final ESR over the whole of mining lease 1108

If you have any queries regarding this matter, please contact David Trezise, Chief Scientific Advisor (Mining) on telephone (07) 3225 1217.

Yours sincerely

Mark Evans
Manager - Project Unit
Environmental Operations - Southern

Appendix E

Ecological Report (2005)

REPORT

Ecological Assessment Vance Mining Lease ML1108, North Stradbroke Is, Qld

Prepared for

Unimin Australia Limited

Locked Bag 969, North Sydney, NSW 2059

24 June 2005

42605769.05020/DRAFT ECOLOGY_24_JUNE_05.DOC



URS

environmental
and engineering
professional services

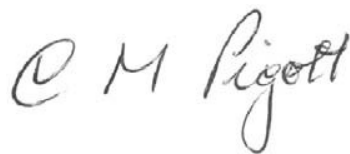
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Date: 24 June 2005
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Status: Ecology_24_June_05.doc
DRAFT

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Appendix A: Significant Species: HerbRecs, WildNet & EPBC Databases

Appendix B: Flora Species List

Appendix C: EPA Correspondence

1.1 Terms of Reference

URS Australia was commissioned by Unimin Australia Limited (UAL) to conduct baseline flora and fauna studies at the Vance Mining Lease ML1108, North Stradbroke Island. Baseline studies were conducted to identify any significant species and areas of conservation significance, potential biological impacts from the proposed mining operations, and outline appropriate management strategies identified.

1.2 Site Description

Mine lease (ML)1108, is situated on 630 ha approximately 4km north east of Dunwich on North Stradbroke Island, (Figure 1). ML 1108 is held 100% by Unimin Australia Limited, (UAL). ML 1108 is currently primarily composed of relatively undisturbed bushland. Topography of the site represents a series of high dune formations to a height of approximately 200m. Natural drainage within the site drains towards a central ephemeral drainage line, Cooroon Cooroonpah Creek traversing the approximate centre of the lease. The creek remains dry throughout the majority of the year due to the base of the creek being comprised of sand. ML 1108 is proposed to be will be mined by UAL for silica and heavy mineral sand.

1.3 Regional Context

1.3.1 Bioregion

North Stradbroke Island is situated within the southeast Queensland bioregion. The bioregions of Queensland are based on landscape patterns that reflect changes in geology and climate, as well as major changes in floral and faunal assemblages at a broad scale and are used as the fundamental framework for the planning and conservation of biodiversity. Nature conservation of the southeast Queensland bioregion has received increasing attention due to the loss of habitat that has occurred due to high population growth within the region.

1.3.2 Sub-region

The southeast Queensland bioregion contains 10 sub-regions or provinces that delineate significant differences in geology and geomorphology (Morgan, 1988). North Stradbroke Island is situated within the southern coastal lowland province. The landscape of this province is centred upon sedimentary rocks but also includes the estuarine sediments and high dunes systems of the southern off shore islands. Major vegetation types include heathland and banksia woodlands, *Melaleuca quinquenervia* forests and woodlands, mangrove forests, sedge lands and *Eucalyptus racemosa* and *E. pilularis* open forests and tall open forests (Sattler and Williams, 1999).

2.1 Study Aim and Objectives

The aim of this investigation is to map the vegetation communities of the lease area, and identify areas of conservation significance. In meeting these aims the objectives of the flora survey are to:

- Review existing terrestrial vegetation data for the local area and region;
- Provide baseline data on vegetation communities occurring in the study area;
- Identify the occurrence or expected occurrence of significant plant species (significance is in terms of rarity, habitat value and importance to indigenous people);
- Describe weed species in the study area, especially 'declared' weeds;
- Assess the value of any areas that may be disturbed by the proposed expansion for vegetation conservation; and
- Determine impact of proposed operations on the surrounding vegetation and develop appropriate management strategies.

2.2 Review of Existing Information

In order to identify the range of species and communities that may inhabit the region and area, reviews of existing data from the Queensland Herbarium and the Commonwealth Department of Environment and Heritage (DEH) databases were conducted for the area -27°34'37.8" S to -27°23'45.4" S and 153°21'35.1" E to 153°33'41.2" E. Preliminary interpretation (including assessment of historical disturbance patterns) and mapping of the vegetation communities of the project area was conducted prior to the commencement of fieldwork. Mapping techniques included vegetation community definition from aerial photography for the area (EPA, 2004).

2.2.1 Data sources

Existing data on flora of North Stradbroke Island were compiled through acquisition of the following key references:

- Queensland Museum flora database (HERBRECS);
- Qld EPA 1:100 000 Regional Ecosystems mapping;
- Environment Australia online EPBC database;
- Survey of Flora and Fauna over Mining lease 7064, near Dunwich North Stradbroke Island, Qld (Worth, G. *et al.* 1997);

-
- Vance Summary of Vegetation Surveys and Proposed Rehabilitation Procedures (CRL, 1985); and
 - Focus on Stradbroke Island: New information on North Stradbroke Island and surrounding areas, 1974-1984.

2.2.2 Regional Ecosystems

Regional Ecosystems (REs) describe the relationships between major floral species and the environment at the regional scale. They are mostly derived from linking vegetation mapping units recognised at a scale of 1:100,000 to land zones that represent major environmental variables, in particular geology, rainfall and landform. 73 REs are identified for the southeast Queensland province, and of these 24 REs are currently of conservation significance listed as either “Of concern” (17) or “Endangered” (7) under the *Vegetation Management Act, 1999*. Regional Ecosystems of relevance to the study site are discussed in Section 2.4.2.

2.2.3 Target Species

Threatened, significant or otherwise noteworthy flora¹ identified from the Qld Herbarium and DEH databases are summarised in Appendix A. From this list, an assessment of potential presence was made based on habitat present on the site. Species identified as being potentially present in the project area were targeted during the field assessment.

2.2.4 Category B Regions

At the time of the drafting of the Terms of Reference for this study, the EPA advised of several areas on the Vance mining lease that were designated as Category B environmentally sensitive areas under the *Environmental Protection Regulation, 1998*. These areas were designated Category B based on Queensland Herbarium 1:100 000 Regional Ecosystems mapping delineating as RE 12.2.13. This ecosystem is currently listed as “Of Concern” under the *Vegetation Management Act, 1999* and not “Endangered” as is the requirement for designation of Category B under the *Environmental Protection Regulation, 1998*. As the regulation states that mining activities are not allowed to occur within 1km of Category B areas it is important to note that Qld Herbarium mapping has now been revised and the above mentioned areas are no longer designated as Category B areas. The recent changes to the designation of these areas has been confirmed in correspondence from the EPA (Appendix C).

¹ Threatened species relate to species identified by Queensland State Government (*Environmental Protection Regulation, 1998 and Vegetation Management Act, 1999*) and Commonwealth (*Environment Protection & Biodiversity Conservation Act 1999*) legislation as critically endangered, endangered or vulnerable. Significant species are species that carry other legislation status or those that occur at the extent of their natural geographic range.

2.2.5 Ramsar Wetland Area

The Department of Environment and Heritage (DEH) National estate register designates an area of land within the bounds of Ramsar wetland (see Figure 4).

It is important to note that EPA 1:100,000 Regional Ecosystem mapping and the ground truthing and floral survey of the Vance lease conducted for this study reveals that in actuality there are no significant wetland areas existing on the lease. The areas delineated as Ramsar wetlands are in fact tall sclerophyll forest communities with no environmental values typically associated with that of a wetland. It is understood that this area was designated as being Ramsar for land management purposes rather than the intrinsic attributes associated with this area.

2.3 Survey Methodology

2.3.1 Sampling Conditions

Fieldwork for the floral survey was conducted over one day on the 13th January 2005. The survey involved a botanical survey and assessment of representative sites within each vegetation association found on site. During the sampling period, the weather was fine and hot with no recent rainfall. The survey was conducted under Queensland Environmental Protection Agency Scientific Purposes Permit number WISP02056304.

2.3.2 Primary Plots

Fieldwork within primary sample plots included plant collection, structural analysis and species diversity characterisation of all flora present. The locations of the data collection sites were recorded by use of a GPS. Evidence of previous disturbance, fire history, incidence of exotic species and general notes were also compiled for each sample plot. There were 10 primary sample plots within the project area spread across the vegetated cover of the lease (Figure 5).

2.3.3 Meander Searches

Following assessment of each primary plot and selected secondary plots, an area of approximately 1.5 ha surrounding each plot was searched for 15 minutes utilising the random meander technique (Cropper, 1993). Care was taken to avoid sampling in different vegetation types to those of the plots. Meander searches were employed to:

- Identify additional less abundant species not recorded within survey plots;
- confirm the representativeness of plot locations; and
- confirm boundaries and ecotonal areas between vegetation communities.

2.3.4 Incidental Observation

Additional species not previously recorded by the above techniques were identified when opportunity arose. Records were made of the vegetation associations these species were growing in.

2.3.5 Specimen Identification

Where available, fruiting and/or flowering specimens were taken to assist with identification. All plant species were identified in the field.

2.3.6 Vegetation Community Determination

Classification of vegetation type at each plot follows the established format of Walker & Hopkins (1990). This survey method provides a rapid assessment based on the structural features of each community, primarily using growth form, density and height descriptors in the classification.

Height estimates of each vegetation layer was made together with records of dominant or emergent taxa. The Crown Separation Ratio (CSR) used to determine the density of each stratum layer, was visually estimated. The CSR represents the ratio of crown width to crown separation. This procedure was used for each of the recognised upper layers in a community. Foliage Projection Cover (FPC) was used for the ground layer. Conversion of field data to a standardised forest type such as "woodland" with indications of height and dominant taxa was then undertaken using tables provided by Walker & Hopkins (1990). Vegetation communities were sorted and described on the basis of Regional Ecosystems as described by Sattler and Williams (1999).

2.4 Results

2.4.1 Diversity

The survey identified the presence of 104 taxa representing 83 genera and 39 families (Appendix B). Of these, there was a low incidence of weed species with no exotic species being found. Families represented by more than 4 species included: Cyperaceae (5); Epacridaceae (12); Fabaceae (12); Myrtaceae (15); Poaceae (9); Proteaceae (5); Restionaceae (5); and Xanthorrhoeaceae (7).

Genera represented by 2 or more species included: *Acacia* (2); *Aotus* (2); *Aristida* (3); *Allocasuarina* (2); *Boronia* (2); *Bossiaea* (2); *Cassytha* (2); *Caustis* (2); *Corymbia* (3); *Dianella* (2); *Eucalyptus* (3); *Gompholobium* (2); *Hibbertia* (2); *Leptospermum* (3); *Leucopogon* (3); *Lomandra* (5); *Monotoca* (2); *Patersonia* (2); *Pultenaea* (3); *Restio* (3); *Smilax* (3); and *Xanthorrhoea* (3).

2.4.2 Vegetation Communities

Five natural vegetation communities were described and mapped for the Vance mining lease on the basis of aerial photograph interpretation and field survey results (Figure 5). These communities and their corresponding sampling sites are summarised in Table 1. Relative abundances of all species surveyed at each sample sites are given in Appendix B.

Table 1: Vegetation Associations Surveyed at Vance (ML1108) 13/01/2005

Community Description		Regional Ecosystem	Total area on site (ha)	¹ Total area in sub-region (ha)
1a	Low open dry heath on Quaternary dunes and sand plains	RE 12.2.13	9.48	441
1b	Closed heath on seasonally waterlogged sand plains	RE 12.2.12	3.66	3,057
3a	<i>Banksia aemula</i> low woodland on Quaternary coastal dunes and sand plains	RE 12.2.9	7.00	985
4a	Mallee <i>Eucalyptus spp.</i> low woodland on Quaternary dunes and sand plains	RE 12.2.10	549.88	10,033
4b	<i>Eucalyptus Racemosa</i> woodland on Quaternary dunes and sand plains.	RE 12.2.6	32.78	13,538
4c	<i>Eucalyptus pilularis</i> Open forest on Quaternary dunes and sand plains	RE 12.2.8	36.25	1001

¹ Derived from RE data for the southern coastal lowland Province as per Accad *et. al.* (2003)

2.4.3 Natural Integrity of Vegetation

Natural integrity of vegetation associations was found to be relatively high at all sites surveyed. However, fire disturbance is a factor, having had some effect on the assemblage of species within areas frequently burnt. Most vegetation associations surveyed on site are adapted to fire disturbance. In particular, the *Banksia aemula* woodland associations are a fire adapted climax community requiring regular burns for succession.

Areas of *Eucalyptus Racemosa* woodland along the southern end of Cooroon Cooropah Creek and *Eucalyptus pilularis* open forest (Figure 4) found on the south eastern dunes, have both been subject to intense burns resulting in a reduction of species diversity and removal of some midstorey and groundcover elements. Pioneer species, such as *Dodonea triquetra*, are found to dominate ground cover in these areas as a result. These areas are still considered to have a relatively high natural integrity and ecological processes are found to be integral.

Incidence of weed species was low, with no exotic species found to be present at any of the survey sites. Vegetation communities found on Cainozoic sand substrates as is the case here, generally exhibit a low edaphic nutrient cycle and as such do not commonly support a high incidence of exotic species infestation.

2.4.4 Vegetation of Conservation Significance

Threatened Species

None of the species identified for study site (Appendix B) are listed as threatened species under the *Queensland Nature Conservation (Wildlife) Regulation* or the Commonwealth EPBC Act. A desktop search of the EPBC and HERBRECS databases (section 2.2).identified four aquatic threatened species potentially existing within the region of the study site. These are:

- *Thesium australe* (Austral Toadflax), Vulnerable EPBC Act;
- *Olearia hygrophila* (Swamp Daisy), Endangered EPBC Act & Endangered NC(W)R;
- *Phaius australis* (Lesser Swamp-orchid), Endangered EPBC Act; and
- *Phaius bernaysii* , Endangered EPBC Act.

No extent of wetland or aquatic habitat significant enough to support any of these aquatic species occurs on site, and none of these species were found to be on site during the flora survey.

Species of Cultural Significance

Two species of plant are identified by the Minjerribah Moorgumpin Elders as being of cultural significance to the traditional owners of North Stradbroke Island. Both *Boronia rosmarinifolia* (Forest Boronia) and *Boronia saffrolifera* (Saffrole Boronia) were found to be present within the low open heath habitat along the exposed ridge tops at survey sites 8, 9 & 10. *Boronia rosmarinifolia* was also found to be present in relatively low abundance within the *Eucalyptus pilularis* open forest at site 10.

Significant Communities

Vegetation unit 1a is identified as holding significant conservation status as listed under current state legislation (Table 2). The extent of Vegetation Unit 1a on site is approximately 9.48 ha which represents 1.48% surface area of total vegetation cover within the mining lease (Figure 4).

Table 2 Vegetation Communities of Conservation Significance surveyed at Vance (ML1108)

Community Description		Conservation status	Sites Sampled
1a	Low open dry heath on Quaternary dunes and sand plains (RE 12.2.13)	"Of Concern" Qld <i>Vegetation Management Act, 1999</i>	8, 9, 10

2.5 Potential Impacts

2.5.1 Vegetation Removal

Mining of the Vance lease (ML1108) is likely to involve excavation and removal of the majority of vegetation on site, excluding the areas delineated by the Ramsar designation and the 100m exclusion buffer along the Cooroon Cooroonpah Creek drainage line (Figure 4). Of the 639 ha of vegetation on the site a total area of up to 434.6 ha will be potentially impacted by vegetation removal.

Table 3 presents a breakdown of the potential disturbance to vegetation communities, indicating disturbance to each community as a percentage of the community found on the project site, and as a percentage of the community found within the sub-region.

Table 3 Potential disturbance to vegetation communities

Community Description		Regional Ecosystem	Potential disturbance		
			Ha	¹ Site %	² Sub-region %
1a	Low open dry heath on Quaternary dunes and sand plains	RE 12.2.13 'Of concern'	9.5	100	2.2
1b	Closed wet heath on seasonally waterlogged sand plains	RE 12.2.12	0.0	0	0
3a	<i>Banksia aemula</i> low woodland on Quaternary coastal dunes and sand plains	RE 12.2.9	0.7	10.5	0.008
4a	Mallee <i>Eucalyptus spp.</i> low woodland on Quaternary dunes and sand plains	RE 12.2.10	403.9	73.5	4.03
4b	<i>Eucalyptus Racemosa</i> woodland on Quaternary dunes and sand plains.	RE 12.2.6	19.8	60.3	0.15
4c	<i>Eucalyptus pilularis</i> Open forest on Quaternary dunes.	RE 12.2.8	0.7	2.05	0.07

¹ Indicates disturbed % of vegetation community within the project area.

² Indicates disturbed % of vegetation community within the southern coastal lowland province as per Accad *et. al.* (2003).

Vegetation unit 1a; Low open dry heath (RE 12.2.13) would be potentially exposed to the highest degree of disturbance when expressed as a percentage of the overall area of this community on site (100 %). However, when viewed in the broader context, overall disturbance constitutes 2.2 % percent of this vegetation community found within the sub-region.

Vegetation unit 4a; Mallee *Eucalyptus spp.* low woodland (RE 12.2.10) represents the second highest potentially disturbed community when viewed as a percentage of the overall area found on site (73.5%). When viewed in the broader context, overall disturbance constitutes 4.03% percent of this vegetation community found within the sub-region.

2.5.2 Weeds and Fire

Although the introduction of earthmoving equipment to the area has the potential to introduce new and declared weeds¹, it is not considered likely that any weed infestation will occur due to the low edaphic nutrient cycling typical of the dune vegetation communities found on site. If incidences of weed infestation are detected, appropriate measures will be put in place to monitor weed occurrence, and weed eradication measures will be put in place as required.

Existing fire regimes in integral vegetation communities are not considered to be affected by the proposed mining activities.

2.6 Mitigation

2.6.1 Conservation Areas

Of the vegetation currently present on site, approximately 204.4 ha is proposed to be conserved within both the proposed Cooroon Cooroonpah Creek 100m exclusion buffer, and the area delineated as a Ramsar site (Figure 4).

Vegetation unit 1b; Closed wet heath (RE 12.2.12) is proposed to be wholly conserved within the proposed Cooroon Cooroonpah Creek exclusion buffer, as will the majority (89.5%) of vegetation unit 3a; *Banksia aemula* low woodland (RE 12.2.9). 98% of Vegetation Unit 4c *Eucalyptus pilularis* open forest (RE 12.2.8) and 26.5% of vegetation unit 4a; Mallee *Eucalyptus spp.* low woodland (RE 12.2.10) is proposed to be conserved of the designated Ramsar area.

2.6.2 Vegetation Clearance

The areas of vegetation to be cleared for the proposed mining operation will be restricted to the minimum required. Areas to be cleared would be clearly delineated prior to commencement of clearing with tape, pegs or other markers. Particular attention would be paid when delineating clearing areas in proximity to riparian vegetation communities along the Cooroon Cooroonpah Creek drainage line. Any clearing within, or in close proximity to, riparian vegetation would employ adequate erosion and sedimentation mitigation measures to ensure that riparian vegetation is not unduly effected.

2.6.3 Rehabilitation of Disturbed Areas

The rehabilitation methods proposed to be used are those currently undertaken at the adjacent mine lease. Proposed rehabilitation of mined areas would involve reforming disturbed areas to previous contours with replacement of stored topsoil. Revegetation would utilise endemic species of local provenance.

¹ *Weeds Management Act 2001*

Rehabilitation would be undertaken with the intent to establish floral assemblages in keeping with vegetation communities presently found within the mining lease . Rehabilitation methods would be in keeping with current best practice, and would employ techniques involving direct seeding and / or tube stock to ensure a viable success rate of re-established vegetation.

3.1 Study Objectives

The objectives of the fauna study were to:

- Review existing terrestrial fauna data for the local area and region;
- Provide baseline data on fauna and habitats occurring within and near the study area with reference to existing information and results from field surveys;
- Identify the occurrence or expected occurrence of any significant wildlife species, or any sites or habitats of significance to wildlife (including significance to indigenous people);
- Describe feral animal species in the study area;
- Assess the significance of the study area for wildlife, both in a local and regional context; and
- Assess the impact of current and future operations on wildlife and develop appropriate management strategies.

3.2 Review of Existing Information

In order to identify the fauna and any significant species that inhabit the region, reviews of existing data from the EPA and the Commonwealth Department of Environment and Heritage (DEH) databases were conducted for the area -27°34'37.8" S to -27°23'45.4" S and 153°21'35.1" E to 153°33'41.2" E.

3.2.1 Data sources

Existing data on fauna of North Stradbroke Island was compiled through acquisition of a number of key references. These were:

- Queensland EPA Wildnet database (HERBRECS);
- Environment Australia online EPBC database;
- Survey of Flora and Fauna over Mining lease 7064, near Dunwich north Stradbroke Island, Qld (Worth, G. *et al.* 1997); and
- Focus on Stradbroke Island: New information on north Stradbroke Island and surrounding areas, 1974-1984.

3.2.2 Target Species

Threatened, significant or otherwise noteworthy fauna¹ identified from the Qld EPA Wildnet and DEH databases are summarised in Appendix A. From this list, an assessment of potential presence was made based on habitat present on the site. Species identified as being potentially present in the project area were targeted during the field assessment.

3.3 Survey Methodology

The fauna survey of the site was conducted within the study area between 9-15 January 2005, under Queensland Environmental Protection Agency Scientific Purposes Permit number WISP02056304 and Animal Ethics Clearance approval 'Bribie Committee 370802'.

Two survey transects were systematically sampled, while general observations from other areas were also compiled. Standard biological survey techniques were employed during field surveys, including: a number of live capture/release trapping techniques; standard and general observational and habitat searches; as well as, indirect methods to detect the presence of terrestrial fauna. The survey focussed on terrestrial vertebrate taxa, with incidental observations aimed at identification of any significant terrestrial invertebrate species.

3.3.1 Site Selection & Systematic Transects

The fauna survey was designed to sample the major habitat types present within the study area. Vegetation associations and ecosystems of the study site serve as the primary environmental variables for the selection of sample plots. Terrestrial habitats within the study area were also defined with reference to topography and soils. The distribution of fauna also depends on other factors, such as the availability of open water, fire history and availability of microhabitat and other resources. These factors were also considered when assessing fauna habitats present.

The three most prominent habitats within the mining lease targeted for fauna surveys were:

- Closed wet heath (Transect 1);
- Mallee eucalypt / Banksia dominated Woodland (Transect 1 & 2); and
- Open eucalypt forest (Transect 2).

¹ Threatened species relate to species identified by Queensland State Government (*Nature Conservation (Wildlife) Regulation, 1994*) and Commonwealth (*Environment Protection & Biodiversity Conservation Act, 1999*) legislation as critically endangered, endangered or vulnerable. Significant species are species that carry other legislation status or those that occur at the extent of their natural geographic range.

3.3.2 Standard Methods and Survey Effort

Table 4 provides a summary of the standard methods and survey effort undertaken for this study. Methodologies used in this assessment were in keeping with the Queensland State and Commonwealth Government's Vertebrate Fauna Survey in the South East Queensland Bioregion (1997).

Table 4 Summary of Survey Effort Undertaken for Fauna survey at Vance (ML1108)

Survey Method	Survey Effort
Ground Mammal Elliot Trapping	100 trap nights x 2 Transects
Arboreal Mammal Elliot Trapping	36 trap nights x 1 Transect
Pitfall Trapping	20 trap nights x 2 Transects
Microchiropteran Bat Detection	1 person hour x 2 Locations within targeted habitat
Diurnal Bird Count	1 person hour x 2 Transects
Diurnal Herpetofauna Searches	1 person hour x 2 Transects
Nocturnal Herpetofauna Searches	1 person hour x 2 Transects
Nocturnal Call Play Back	1 person hour x 2 Transects
Arboreal Spotlighting	1 person hour x 2 Transects 1 person hour x 1 Locations within targeted habitat
Targeted Active Frog Searches	2 person hours x 1 Locations within targeted habitat

Ground Mammal Elliot Trapping

25 'A' type Elliott traps were set at each systematic survey site (Total of 50 traps). Traps were spaced opportunistically at approximately 5 metre intervals. Traps were baited alternatively with peanut paste and rolled oats mixture and with salami and left open for four nights for a total of 100 trap nights. Traps were cleared early each morning, and trapped animals were temporarily marked before release by clipping a small patch of fur from the flank so that recaptures could be identified.

Arboreal Mammal Elliot Trapping

Ten "B" type Elliott traps (46 x 15.5 x 15cm) were mounted on platforms and attached to trees at a height of between 6 and 9 metres. Trees selected were of various species and girths. Traps were spaced opportunistically at approximately 20 metre intervals. Traps were baited with honey and bread mixture and scent trails of honey and water were sprayed along trunk lines above the traps to assist in luring Gliders. Traps were left open for four nights for a total of 36 trap nights. Traps were checked for captures early each morning.

Pitfall Trapping

Pit fall trap lines incorporated the use of 5 x 10 litre PVC buckets approximately 40cm deep with a drift fence (20m long x 0.4 m high). Pitfall trapping was undertaken at both systematic survey sites for a period of four nights. Pitfall traps were cleared of captures in the morning within an hour of sunrise, and early afternoon.

Microchiropteran Bat Detection

Microchiropteran bat echolocation calls were recorded using an ultrasonic bat call detector (Anabat II, Titley Electronics). Anabat detection was conducted from fixed points for an hour at dusk during the nocturnal survey. Ultrasonic detection was employed in areas of habitat most likely to indicate the presence of insectivorous Microchiropteran bats.

Diurnal Bird Count

Two thirty minute diurnal bird counts were undertaken at the single systematic site (survey plot). One count was conducted in the early morning and one in the late morning. The early morning count was conducted between dawn and two hours after dawn, and the late morning count was conducted between two and four hours after dawn. During each count, birds seen or heard while slowly traversing or stationary within the 200m transect were recorded.

Diurnal Herpetofauna Searches

One person-hour active diurnal search for herpetofauna was conducted at the survey plot within a 100 m x 50 m subplot located in the centre of the master-plot. Active searching involved recording all individuals found active or sheltering underneath or within fallen woody debris, rocks, litter and decorticated bark. Individuals, where possible, were caught for verification. Those seen, but not caught, were either recorded to genus level, or not recorded. Representative voucher specimens were not required and all animals captured were subsequently released. Frogs heard calling within the subplot during the search were recorded. Active searches were undertaken during the hottest parts of the day; between 1200 and 1400 hours when reptiles were highly active.

Nocturnal Herpetofauna Searches

One person-hour active nocturnal search for herpetofauna was undertaken at the study plot and within appropriate habitat found on site. Active searches involved the use of headlamps, and recording all individuals found active on the ground or up trees, or underneath fallen debris, rocks, litter and decorticated bark. Frogs heard calling within each subplot were recorded during this time.

Nocturnal Call Play Back

One nocturnal bird-call playback session was conducted at the centre-point of each systematic survey site. An observer stayed at the centre-point to play the calls and listened for response. Each call playback session involved an initial 10 minute listening period, where unsolicited calls from arboreal mammals and nocturnal birds were recorded, followed by the broadcasting of pre-recorded calls in the following sequence; Tawny Frogmouth (*Podargus strigoides*), Southern Boobook (*Ninox novaeseelandiae*), Barn Owl (*Tyto alba*), Powerful Owl (*Ninox strenua*) and White-throated Owllet Nightjar (*Caprimulgus mysticallis*) calls. Each call was played for three minutes, followed by a two-minute listening period. After the calls were played, the observer scanned the immediate area by spotlight for five minutes.

Arboreal Spotlighting

An arboreal spotlighting census was undertaken, which involved an observer traversing the 300 m transect with a 100 Watt spotlight for one (1) hour (*ie* one person hour), plus another hour scanning within other appropriate habitat found on site. Incidental observations were also made entering and exiting the site at night.

Targeted Active Searches

Specific searches of known microhabitats were made for reptiles and amphibians suspected of occurring within the study site. These included, for example: under decorticated bark; under logs and debris; under leaf litter at the base of trees; under bank overhangs; and around the bases of grass tussocks.

Tracks and Signs

Tracks and signs noted during the survey were inspected and identified where possible. Tracks and signs included: characteristic feeding scrapes and poke holes of echidnas and bandicoots; claw marks on trees; and tracks of larger animals.

Predator Scat Search

The site was surveyed for distinctive scats of predator species, with specific attention paid to the single systematic plot. Predator scats found either within the 200 m x 50 m survey plot or opportunistically elsewhere on site were identified *in-situ*.

Incidental Species records

Any species recorded, either within the systematic site (*ie*. within the 200 m x 50 m transect) or elsewhere on the study site, during the non-survey period, were recorded as “incidental on-site”.

Taxonomy and Nomenclature

Scientific nomenclature and common names used in this report generally follow Stanger *et al.* (1998), with the exception of recently published taxonomic revisions. Additional texts utilised for species identifications and ecological data include: Cogger (2000) for reptiles; Slater *et al* (1989) for birds; and Menkhorst & Knight (2001) for mammals.

3.4 Results**3.4.1 Conditions During Survey Period**

Seasonally the weather was typical of mid summer, with daytime maximum temperatures between 25.7 and 31.6 °C and minimums of between 21.5 and 24.5 °C. Wind speed was negligible during the survey period and the sky was clear and sunny with an average relative humidity of 74.3. An overnight rain event took place on Monday 10 of January, with a brief downpour yielding approximately 11.6mm of precipitation.

3.4.2 General Diversity

A total of 44 native and 5 introduced terrestrial vertebrate species were recorded during field surveys in the study area, including; 4 amphibian; 7 reptile; 26 bird and 12 mammal species. The trapping program resulted in the capture of one amphibian, two lizard species and 3 mammal species. 29 species were observed during targeted diurnal surveys. Eleven species were recorded during the nocturnal survey and two bat species were recorded by ultra sonic bat detection,.

3.4.3 Herpetofauna

Three native and one introduced amphibian species were recorded within the study site (Table 5). Amphibian species were associated with wetter microhabitats within the areas sampled, such as the closed heath community. A targeted nocturnal frog survey was conducted at the eastern end of the Cooroon Cooroonpah Creek drainage line, where ephemeral waters were still exhibiting some base flow. The commonest native species observed was *Littoria nasuta* (Rocket frog). The introduced *Bufo marinus* (Cane toad) was seen in all habitats during spotlight surveys. Only one species, *Bufo marinus*, was caught by pit trapping. All other records were made by spotlighting on foot.

A number of significant “Acid frog” species known to the region are especially adapted to waters of low pH and are typically found to breed in waters associated with *Melaleuca* wetlands and heathland. These are:

- Wallum sedgefrog (*Litoria olongburensis*);
- Cooloola sedgefrog (*Litoria cooloolensis*);

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- Wallum rocketfrog (*Litoria freycineti*); and
- Wallum froglet (*Crinia tinnula*).

These species were not found to be present on site during the survey and it is most likely that no habitat suitable for the presence of these species was available to these species during the survey period. Flow in of the ephemeral Cooroon Cooroonpah Creek was minimal at the time of survey, and no permanent or semi permanent water bodies typical as habitat for these species were present. It should be noted that *Crinia* species were actively calling from semi-permanent water bodies in the region of the study site during the time of survey.

Seven reptile species were identified within the study area, including representatives of seven families (Table 5). The reptile taxa identified included: one dragon (Agamidae); four skinks (Skinkidae); one monitor (Varanidae); and one elapid snake (Elapidae) species. Pitfall traps captured two skink species. Most reptile observations were made: during active searches of habitats during the day; during spotlight survey; and incidentally during the course of the trapping and bird census surveys.

Small skinks were the most obvious lizards seen during the survey and were the only reptile group caught by pit trapping. *Carlia vivax* (Rainbow skink) were common in areas of leaf litter. *Lamprolis delicata* (Grass Skink) was the most observed species.

Table 5: Herpetofauna surveyed at Vance (ML1108) 9-15/01/ 2005

Scientific Name	Common Name	Survey Site 1	Survey Site 2	Target Frog survey	Incidental	Total
Amphibians						
<i>Litoria nasuta</i>	Rocket Frog			>10 Fc		>10
<i>Litoria fallax</i>	Eastern dwarf Tree Frog			> 5 Fc		
<i>Limnodynastes peronii</i>	Striped Marsh Frog			>5 Fc		>5
<i>Bufo marinus</i> *	Cane Toad	>5 Sp 1Pt	>5 sp			>10
Reptiles						
<i>Carlia vivax</i>	Rainbow Skink	1 Pt			2 Dh	1
<i>Varanus varius</i>	Lace Monitor				1 Dh	1
<i>Diporiphora australis</i>	Tommy roundhead				1 Dh	1
<i>Lamprolis delicata</i>	Grass Skink	1 Pt	2 Dh		1 Dh	2
<i>Ctenotus robustus</i>	Striped Skink	1 Dh				1
<i>Cryptoblepharus virgatus</i>	Wall Skink		2 Dh			
<i>Cryptophis nigrescens</i>	Small Eyed Snake		1 Sp			1

Sp spotlighting; Db diurnal bird count; Dh diurnal herpetofauna search; Nh nocturnal herpetofauna search; Nc nocturnal call playback; Te terrestrial Elliot trap; Pd predator scat search; In incidental record; Pt Dry pitfall; Cg Cage trap; Hf Hair funnel; Ns Non-predator scat search; Ae arboreal Elliot trap; Ts tracks and other signs; Fc frog call recognition; Ss specific search, () recapture, * introduced.

3.4.4 Avifauna

Twenty six bird species were observed within the study area during the survey period (Table 6). Of these, 24 species were recorded during the diurnal bird counts undertaken at survey sites, while the other species were observed opportunistically throughout the study area.

The most species rich site was the Open forest habitat at Transect 2 with 16 species recorded, while 10 species were recorded from the Mallee eucalypt woodland and Wet heath habitats (Transect 1). Widely distributed generalist species such as Torresian crow (*Corvus orru*), Black-backed magpie (*Gymnorhina tibicen*) and Noisy friarbird (*Philemon corniculatus*) were recorded at both transects and incidentally, in most habitats of the study site. Birds with the highest frequency of observations were White-cheeked honeyeater (*Phylidonyris nigra*) and Noisy friarbird, with counts greater than ten individuals at transect 2. The majority of species were observed over a range of habitats in the study area. However, some species were seen only in particular habitats or sites. The stony rises habitat had 31 species, while alluvial woodland and riverine habitats had 27 and 26 species respectively. Two species, Tawny frogmouth (*Podargus strigoides*) and Bush stone-curlew (*Burhinus grallarius*) were noted during the nocturnal spotlighting survey.

Table 6 Avifauna surveyed at Vance (ML1108) 9-15/01/ 2005

Scientific Name	Common Name	Survey Site 1	Survey Site 2	Incidental	Total
Diurnal Species					
<i>Merops ornatus</i>	Rainbow bee-eater		5 Db		5
<i>Gymnorhina tibicen</i>	Australian black-backed magpie	2 Db		3	5
<i>Geopelia humeralis</i>	Bar shouldered dove	1 Db			1
<i>Coracina novaehollandiae</i>	Black-faced cuckoo-shrike	1 Db	2 Db		3
<i>Entomyzon cyanotis</i>	Blue faced honeyeater		1 Db		1
<i>Lichmera indistincta</i>	Brown honeyeater	1 Db			1
<i>Climacteris picumnus</i>	Brown tree-creeper		1 Db		1
<i>Anthochaera mellivora</i>	Brush wattle bird		1 Db		1
<i>Cracticus torquatus</i>	Grey butcherbird	3 Db			3
<i>Rhipidura fuliginosa</i>	Grey fantail		1 Db		1
<i>Dacelo novaeguineae</i>	Laughing kookaburra		1 Db	2	3
<i>Grallina cyanoleuca</i>	Magpie-lark			2	2
<i>Philemon corniculatus</i>	Noisy friarbird	2 Db	>10 Db	2	>10
<i>Centropus phasianinus</i>	Pheasant coucal	1 Db	1 Db		2
<i>Trichoglossus haematodus</i>	Rainbow lorikeet	2 Db			2
<i>Pachycephala rufiventris</i>	Rufous whistler		1 Db		1
<i>Myzomela sanguinolenta</i>	Scarlet honey eater		2 Db		2
<i>Corvus orru</i>	Torresian crow	4 Db	1 Db	3	8
<i>Hirundo neoxena</i>	Welcome swallow			2	2
<i>Haliastur (milvus) sphenurus</i>	Whistling kite			1	1
<i>Lichenostemus unicolor</i>	White-eared honeyeater	1 Db			1
<i>Phylidonyris nigra</i>	White cheeked honeyeater		>10 Db		>10
<i>Rhipidura leucophrys</i>	Willie wagtail			2	2

<i>Scientific Name</i>	Common Name	Survey Site 1	Survey Site 2	Incidental	Total
<i>Lichenostomus chrysops</i>	Yellow faced honeyeater		1 Db		1
Nocturnal Species					
<i>Burhinus grallarius</i>	Bush stone-curlew		1 Sp		1
<i>Podargus strigoides</i>	Tawny frogmouth		1 Nb		1

Sp spotlighting; Db diurnal bird count; Dh diurnal herpetofauna search; Nh nocturnal herpetofauna search; Nc nocturnal call playback; Te terrestrial Elliot trap; Pd predator scat search; In incidental record; Pt Dry pitfall; Cg Cage trap; Hf Hair funnel; Ns Non-predator scat search; Ae arboreal Elliot trap; Ts tracks and other signs; Fc frog call recognition; Ss specific search, ().recapture, * introduced.

3.4.5 Mammals

Eight native and four introduced mammal species were identified during the survey (Table 7). The diversity of small ground dwelling mammals was found to be relatively poor, with only the introduced House mouse (*Mus Musculus*) and Fawn footed melomys (*Melomys cervinipes*) represented. Numbers for the House mouse were found to be abundant, representing 92% of the captures on the ground. The Fawn footed melomys was captured twice, in wetter microhabitat found within the wet heath community. The dominance of the House mouse on the ground, in what is generally considered relatively undisturbed habitat, is reflected in other studies of the area (Worth *et. al.*, 1997). This is most likely due to an overly frequent fire regime removing groundcover elements required by native species , allowing mice to move in permanently and displace native species.

Medium-sized mammals were well represented on site by the Common ringtail possum (*Pseudocheirus peregrinus*), Northern brown bandicoot (*Isodon macrourous*) and Squirrel glider (*Petaurus norfolcensis*). The Common ringtail possum and Squirrel glider were both found to be present in the Open Eucalypt forest habitat sampled at Transect 2. The Swamp wallaby (*Wallabia bicolor*) is a common large macropod in the study area. Solitary individuals and were seen in all of the major habitat types on the site.

At least two species of microchiropteran bats were recorded by Anabat sampling. In some cases, calls cannot be differentiated to species level in the Anabat system, so one of the identifications is only to Genus level. Both microchiropteran bat species were found present in the open eucalypt forest habitat at Transect 2. The most common call type within the study area was attributed to the Northern long eared bat (*Nyctophilus bifax*).

One megachiropteran bat species, the Grey headed flying fox (*Pteropus poliocephalus*) was observed during night spotlighting activities.

An additional mammal record for the area from Worth, G. *et al.* (1997) was the Swamp rat (*Rattus Lutreolus*). While not trapped in this survey effort, the Swamp Rat would be expected to inhabit areas of the wet heath habitat of the study site.

Three introduced mammal species, other than the House mouse, were recorded within the study area by presence of their fresh tracks found in the sandy substrate of vehicle access tracks. These included House (feral) cat (*Felis catus*), the Red fox (*Vulpes vulpes*) and Domestic dogs (*Canis familiaris*).

Table 7 mammals surveyed at Vance (ML1108) 9-15/01/ 2005

Scientific Name	Common Name	Survey Site 1	Survey Site 2	Incidental	Total
Ground dwelling					
<i>Melomys cervinipes</i>	Fawn footed melomys	2 Te			2
<i>Isodon macrourus</i>	Northern brown bandicoot	1 Ts	1 Ts		
<i>Wallabia bicolor</i>	Swamp wallaby	2 Sp	1 Ts	5	8
<i>Mus musculus</i> *	House mouse	15 Te	8 Te		23
<i>Felis catus</i> *	House (feral) cat			1 Ts	1
<i>Vulpes vulpes</i> *	Red fox			1 Ts	1
<i>Canis familiaris</i> *	Domestic dog			1 Ts	1
Arboreal					
<i>Petaurus norfolcensis</i>	Squirrel glider		1 Ae		1
<i>Pseudocheirus peregrinus</i>	Common ringtail possum		3 Sp	1	4
Bats					
<i>Scotorepens spp.</i>	Broad-nosed bat species		1 Ud		1
<i>Nyctophilus bifax</i>	Northern long-eared bat		1 Ud		1
<i>Pteropus poliocephalus</i>	Grey-headed flying fox		2 Sp	2	4

Sp spotlighting; Db diurnal bird count; Dh diurnal herpetofauna search; Nh nocturnal herpetofauna search; Nc nocturnal call playback; Ud Ultrasonic detection Te terrestrial Elliot trap; Pd predator scat search; In incidental record; Pt Dry pitfall; Cg Cage trap; Hf Hair funnel; Ns Non-predator scat search; Ae arboreal Elliot trap; Ts tracks and other signs; Fc frog call recognition; Ss specific search, () recapture, * introduced.

3.5 Potential Impacts & Mitigation

3.5.1 Loss of Habitat

Loss of habitat, due to the proposed disturbance of vegetation by mining activities, will impact upon the less mobile resident species of these areas, such as the small reptiles and House mice found broadly across the site. Of the vegetation proposed to be disturbed by mining activities, the most significant areas of habitat for native fauna are considered to be represented by the wetter microhabitats found within: Vegetation unit 1b (Closed wet heath on seasonally waterlogged sand plains); and, the tall Eucalypt forest community represented by Vegetation unit 4c (Eucalyptus pilularis open forest on Quaternary dunes). Of these; 100% of Vegetation unit 1b is proposed to be conserved and 98% of Vegetation unit 4c is proposed for conservation within the Cooroon Cooroonpah Creek exclusion buffer and Ramsar areas (see section 2.6.1). Preservation of these, and the areas of other vegetation types proposed for conservation (see section 2.5.1), will provide habitat areas for the: native amphibians; small and medium ground dwelling mammals; native arboreal mammals; and bird species of the site. Revegetation of disturbed areas, utilising endemic species of local provenance in keeping with vegetation communities presently found, will facilitate the eventual recolonisation of the area with displaced faunal assemblages from areas of contiguous vegetation and core habitat areas.

3.5.2 Significant Fauna

Grey-headed flying fox (*Pteropus poliocephalus*)

Pteropus poliocephalus is listed as Vulnerable under schedule 3 of the Commonwealth Government's *Environmental Protection and Biodiversity Conservation Act 1999*. This status reflects an apparent diminishing national range, specifically along the central coast of New South Wales. However *P. poliocephalus* is not considered significant at a local or State-wide level and is not listed under the *Queensland Nature Conservation (Wildlife) Regulation 1994*. This species continues to be relatively common within southeast Queensland and is readily observed in Redland Shire.

P. poliocephalus is one of the more widely studied animals of this taxonomic group and has been found to reside in a wide variety of habitats including rainforests, mangrove, paperbark swamps, cultivated areas and wet and dry sclerophyll forests. (Churchill 1998; Hall 1995; Hall & Martin 1995; Menkhorst & Knight 2001).

Major food sources for *P. poliocephalus* consist of Native *Ficus spp.* (Figs) and blossom from eucalypts and other species of the Myrtaceae family. Orchard fruit and even the fruit and blossoms of introduced plants also account for a large portion of the diet of this species in urban areas. This bat is an important seed disperser of rainforest species such as figs and palms and most likely is a significant pollinator of eucalypts, angophoras, tea trees and banksias (Hall, 1995).

P. poliocephalus is a highly mobile species having a nightly feeding range of 20 to 50 km from its camp (Churchill, 1998). Due to the high mobility of *P. poliocephalus* and the adaptability of its diet, vegetation of the study site in isolation, is not considered critical habitat for this species. Hence, the proposed mining activities are not expected to have any significant or measurable impact upon this species. The proposed mining activities do not trigger the *Environmental Protection and Biodiversity Conservation Act 1999* in this regard.

Squirrel glider (*Petaurus norfolcensis*)

Petaurus norfolcensis (Squirrel Glider) is not currently considered significant at a State or Commonwealth perspective as per the *Queensland Nature Conservation (Wildlife) Regulation 1994* and the *Environmental Protection and Biodiversity Conservation Act 1999* respectively. This species is however listed as Significant in the adjoining municipality of Brisbane City Council (BCC) under Schedule 4 of the *BCC Natural Assets Planning Scheme Policy 2000*, with a State wide threat category of "Low Level of Threat". *P. norfolcensis* is also noted as "Potentially Vulnerable" in the Australasian Marsupials and Monotremes – Action Plan for Conservation (Kennedy 1992). Key threatening processes impacting on *P. norfolcensis* in south east Queensland include:

- Habitat loss and fragmentation due to land clearing for agriculture, development and forestry;
- Habitat degradation due to environmental weed invasion;

-
- Loss of floristic diversity resulting in diminished food resources;
 - Loss of critical habitat trees for den use; and
 - Predation from both native and feral predators.

P. norfolcensis can be found in a variety of habitat types throughout its range in eastern Australia, including; open woodland; dry sclerophyll forest; montane wet sclerophyll forest; rainforest; and swamp woodland (Menkhorst & Knight 2001; Suckling 1995; Sharpe & Goldingay 1998; Van Dyck 1995). *P. norfolcensis* is an arboreal nocturnal species that is traditionally associated with old growth hollow bearing trees (Van Dyck, 1995). Although, it is also commonly encountered in much younger forests (30 to 40 years and older) in the greater Brisbane area (*pers com.* E. Pedersen, 2003). *P. norfolcensis* usually nests in groups of between three (3) and ten (10) animals, and may at times exist in densities as high as three (3) animals per hectare (Van Dyck, 1995). The diet of Squirrel gliders consists primarily of: nectar and pollen; gum of certain eucalypts; insects; and seeds and gum produced by acacias (Menkhorst & Knight 2001; Suckling 1995; Sharpe & Goldingay 1998; Van Dyck 1995).

P. norfolcensis habitat on site is primarily encountered within the Tall *Eucalyptus pilularis* open forest community (RE 12.2.8) in the eastern portion of the Vance mining lease. 98% of this extent of habitat will be conserved within the designated Ramsar area (refer to section 2.6.1). Removal of other vegetation on site will not isolate this habitat or impede connectivity with contiguous habitat to the east of the mining lease. Any impacts to this species arising from proposed mining activities are considered to be negligible

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URS Australia Pty Ltd (URS) has prepared this report for the use of Unimin Ltd in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the agreed scope of work and for the purpose outlined in the Proposal dated 23 April 2004.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between January and July 2005 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendices

Appendix A

Significant Species:

HerbRecs, WildNet & EPBC Databases

EPA HerbRecs & DEH EPBC Database (May 2004) Significant Flora Species of Nth Stradbroke Is				
Family	Botanical Name	Common Name	NCA	EPBC
Asteraceae	<i>Olearia hygrophila</i>	Swamp Daisy	E	E
Santalaceae	<i>Thesium australe</i>	Austral Toadflax		V
Orchidaceae	<i>Phaius australis</i>	Lesser Swamp Orchid		E
Orchidaceae	<i>Phaius bernaysii</i>	Swamp Orchid		E

EPA WildNet Database (17 May 2004) Significant Fauna Species of Nth Stradbroke Island					
Class	Family	Scientific Name	Common Name	NCA	EPBC
amphibians	Hylidae	<i>Litoria olongburensis</i>	wallum sedgefrog	V	V
amphibians	Hylidae	<i>Litoria cooloolensis</i>	Cooloola sedgefrog	R	
amphibians	Hylidae	<i>Litoria freycineti</i>	wallum rocketfrog	V	
amphibians	Myobatrachidae	<i>Crinia tinnula</i>	wallum froglet	V	
birds	Procellariidae	<i>Macronectes giganteus</i>	southern giant-petrel	E	E
birds	Psittacidae	<i>Lathamus discolor</i>	swift parrot	E	E
birds	Diomedidae	<i>Diomedea exulans</i>	wandering albatross	C	V
birds	Diomedidae	<i>Phoebastria fusca</i>	sooty albatross	C	V
birds	Diomedidae	<i>Thalassarche bulleri</i>	Buller's albatross	C	V
birds	Diomedidae	<i>Thalassarche carteri</i>	Indian yellow-nosed albatross	C	V
birds	Diomedidae	<i>Thalassarche cauta</i>	shy albatross	C	V
birds	Diomedidae	<i>Thalassarche chrysostoma</i>	grey-headed albatross	C	V
birds	Procellariidae	<i>Pterodroma neglecta</i>	kermadec petrel	C	V
birds	Apodidae	<i>Collocalia spodiopygius</i>	white-rumped swiftlet	R	
birds	Burhinidae	<i>Esacus neglectus</i>	beach stone-curlew	V	
birds	Cacatuidae	<i>Calyptorhynchus lathami</i>	glossy black-cockatoo	V	
birds	Ciconiidae	<i>Ephippiorhynchus asiaticus</i>	black-necked stork	R	
birds	Haematopodidae	<i>Haematopus fuliginosus</i>	sooty oystercatcher	R	
birds	Laridae	<i>Sterna albifrons</i>	little tern	E	
birds	Phaethontidae	<i>Phaethon rubricauda</i>	red-tailed tropicbird	V	
birds	Meliphagidae	<i>Melithreptus gularis</i>	black-chinned honeyeater	R	
birds	Rallidae	<i>Rallus pectoralis</i>	Lewin's rail	R	
birds	Scolopacidae	<i>Numenius madagascariensis</i>	eastern curlew	R	
mammals	Balaenopteridae	<i>Balaenoptera musculus</i>	blue whale	C	E
mammals	Balaenopteridae	<i>Megaptera novaeangliae</i>	humpback whale	V	V
mammals	Muridae	<i>Xeromys myoides</i>	false water-rat	V	V
mammals	Pteropodidae	<i>Pteropus poliocephalus</i>	grey-headed flying-fox	C	V
mammals	Delphinidae	<i>Sousa chinensis</i>	Indo-Pacific hump-backed dolphin	R	
mammals	Dugongidae	<i>Dugong dugon</i>	dugong	V	
mammals	Phascolarctidae	<i>Phascolarctos cinereus</i>	koala (southeast Qld bioregion)	V	
reptiles	Cheloniidae	<i>Caretta caretta</i>	loggerhead turtle	E	E
reptiles	Cheloniidae	<i>Chelonia mydas</i>	green turtle	V	V
reptiles	Elapidae	<i>Acanthophis antarcticus</i>	common death adder	R	
reptiles	Scincidae	<i>Ophioscincus truncatus</i>		R	

Appendix A

Significant Species:

HerbRecs, WildNet & EPBC Databases

Key to Conservation Status

NCA: Status under the *Nature Conservation Act, 1992*.

Presumed Extinct (PE), Endangered (E), Vulnerable (V), Rare (R),
Common (C)

EPBC: Status under the *Environment Protection and Biodiversity Conservation Act, 1999*.

Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX),
Extinct in the Wild (XW), Vulnerable (V) and Threatened (includes taxa listed as CD, CE, E, EX, V and XW).

Appendix B

Flora Species List

Flora species list with relative abundances found at Survey Sites

Taxa		Survey Sites									
Family	Botanical Name	1	2	3	4	5	6	7	8	9	10
Anthericaceae	<i>Caesia parviflora</i> v <i>vittata</i>										
	<i>Laxmannia gracilis</i>			E	E	P					
	<i>Tricoryne elatior</i>									U	U
Apiaceae	<i>Platysace ericoides</i>	U	U								
	<i>Xanthosia pilosa</i>							O			
Araliaceae	<i>Astrotricha longifolia</i>			O				O			
Asclepiadaceae	<i>Marsdenia fraseri</i>							C			
Casuarinaceae	<i>Allocasuarina littoralis</i>					O	P			E	
	<i>Allocasuarina torulosa</i>				P						
Cupressaceae	<i>Callitris columellaris</i>							E			
Cyperaceae	<i>Caustis blakei</i>	E		U	E						
	<i>Caustis recurvata</i>	P	O	P	O	C	O		C	C	P
	<i>Fimbristylis dichotoma</i>				O			O			
	<i>Isolepis inundata</i>					O					
	<i>Lepidosperma laterale</i>			E			P	U			
Dennstaedtiaceae	<i>Pteridium esculentum</i>	O	O	P	E			C	O		E
Dilleniaceae	<i>Hibbertia linearis</i> v <i>linearis</i>	O	U		U	U		O	O		O
	<i>Hibbertia vestita</i>	U						O			
Elaeocarpaceae	<i>Elaeocarpus reticulatus</i>	P			P			P	U		U
Epacridaceae	<i>Brachyloma daphnoides</i>	P	U			O	O				P
	<i>Epacris pulchella</i>	P			P	O				O	
	<i>Leucopogon leptospermoides</i>	U	O	C		O			O	O	
	<i>Leucopogon margarodes</i>	O		O				P			
	<i>Leucopogon pimeleoides</i>						P		P		
	<i>Monotoca scoparia</i>	U	U	C			O	O			P
	<i>Styphelia viridis</i>					P	P				
	<i>Woollsia pungens</i>	P		O		C	E				
	<i>Poranthera microphylla</i>								P		
Euphorbiaceae	<i>Pseudanthus orientalis</i>			P					P		
	<i>Ricinocarpos pinifolius</i>	O		C	O		C				U
	<i>Aotus ericoides</i>						O				
Fabaceae	<i>Aotus lanigera</i>				P						
	<i>Bossiaea ensata</i>									O	
	<i>Bossiaea heterophylla</i>	U	U			P			P	C	
	<i>Dillwynia retorta</i> v <i>retorta</i>				O		O				
	<i>Hardenbergia violacea</i>	P			O			O			
	<i>Jacksonia stackhousii</i>									O	U
	<i>Pultenaea paleacea</i>	U	U			U					
	<i>Pultenaea retusa</i>				P			P			
	<i>Dampiera stricta</i>				E			O			
Iridaceae	<i>Patersonia glabrata</i>							C		C	
	<i>Patersonia sericea</i>	P		E		U			U	O	
Lauraceae	<i>Cassytha filiformis</i>							E			
	<i>Cassytha pubescens</i>	U									

Appendix B

Flora Species List

Menispermaceae	<i>Stephania japonica</i> v <i>discolor</i>				O					O				
Mimosaceae	<i>Acacia suaveolens</i>					E	E			P	U	U	U	
	<i>Acacia ulicifolia</i>	C	O	U	A	E	U			O	U	O	O	
Myrsinaceae	<i>Rapanea variabilis</i>									P				
Myrtaceae	<i>Angophora woodsiana</i>									P				
	<i>Austromyrtus dulcis</i>	O	O	U	P			U	C				U	
	<i>Corymbia intermedia</i>	P												
	<i>Corymbia gummifera</i>	P	C	P	O			P	O	O	P	U		
	<i>Corymbia trachyphloia</i>	O			O								C	
	<i>Eucalyptus pilularis</i>				A				A					
	<i>Eucalyptus planchoniana</i>		P		C			C						
	<i>Eucalyptus racemosa</i>	C	E	O	C			O	O	C	O	C		
	<i>Homoranthus virgatus</i>						C	C		O	O			
	<i>Leptospermum polygalifolium</i>							C						
	<i>Leptospermum semibaccatum</i>	O		O			O	E	P	E	O			
	<i>Leptospermum trinervium</i>	P	O	C	O	C	O			O	C	O		
	<i>Ochrosperma lineare</i>			O			C	O						
	<i>Syzygium oleosum</i>								C					
Olacaceae	<i>Olax retusa</i>						O				O	O		
Philesiaceae	<i>Geitonoplesium cymosum</i>					U				O				
Phormiaceae	<i>Dianella caerulea</i>									P				
	<i>Dianella longifolia</i>					O								
Poaceae	<i>Alloteropsis semialata</i>					E								
	<i>Aristida calycina</i> v <i>calycina</i>					E								
	<i>Aristida warburgii</i>									E				
	<i>Entolasia stricta</i>	O	C	E	C			D	O	O	C	O		
	<i>Eriachne pallescens</i>	P												
	<i>Imperata cylindrica</i>	U							P					
	<i>Panicum effusum</i>	P		E										
	<i>Themeda triandra</i>				P					P				
Portulacaceae	<i>Portulaca oleracea</i>	O	O	P					C				E	
Proteaceae	<i>Banksia aemula</i>	C	A	C	O	E	C	U	A	A	C			
	<i>Conospermum taxifolium</i>								U	E				
	<i>Persoonia virgata</i>	E		C					E			P		
	<i>Petrophile canescens</i>									P	P			
	<i>Strangea linearis</i>	C	U		O	O				C	A	C		
Restionaceae	<i>Leptocarpus tenax</i>					C								
	<i>Lepyrodia scariosa</i>					P								
	<i>Restio pallens</i>			O										
	<i>Restio tetraphyllus</i>			E										
Rhamnaceae	<i>Alphitonia excelsa</i>				E				E					
Rubiaceae	<i>Pomax umbellata</i>				U				U					
Rutaceae	<i>Boronia rosmarinifolia</i>								O	O	C	C		
	<i>Boronia saffrolifera</i>									O	C			
	<i>Zieria laxiflora</i>				O				C	C	C	C		
Santalaceae	<i>Leptomeria acida</i>	O								O	U	O		
	<i>Exocarpos cupressiformis</i>													

Appendix B

Flora Species List

Sapindaceae	<i>Dodonaea triquetra</i>	U			O			A			
Schizaeaceae	<i>Schizaea dichotoma</i>	O		O				O			
Smilacaceae	<i>Smilax australis</i>			P				O			
	<i>Smilax glycyphylla</i>			P				O			
Thymelaeaceae	<i>Pimelea linifolia ssp linifolia</i>	U			P	P			O	O	O
Tremandraceae	<i>Tetratheca thymifolia</i>				O						
Xanthorrhoeaceae	<i>Lomandra filiformis</i>	C						P	P		
	<i>Lomandra elongata</i>					O			O		
	<i>Lomandra longifolia</i>	C	C	E	O		U	O	O		O
	<i>Lomandra multiflora</i>							O	O		O
	<i>Xanthorrhoea johnsonii</i>	O	A	C	C	O	E	O	A	O	A
	<i>Xanthorrhoea latifolia</i>										

Key to Relative Abundance

A: Abundant
 C: Common
 O: Occasional
 U: Uncommon
 P: Present
 E: Edge

Appendix C

EPA Correspondence

URS BBN					
REG No CD-05-2416					
NAME	ACTING	DATE	COPY	SIGNATURE	DATE
Sarah B					
FILE NO					



**Queensland
Government**

Enquiries
Telephone
Your reference
Our reference

Matthew Buchanan
(07) 3224 6349

Environmental Protection Agency

Incorporating the
Queensland Parks and Wildlife Service

6 July 2005

Sarah Barnett
Environmental Scientist
URS Australia Pty. Ltd.
Level 14, 240 Queen Street, Brisbane
Queensland 4000 Australia

Dear Sarah

RE: Category B Environmentally Sensitive Areas on ML1108 - Vance

Referring to your email to me of 5 July 2005, category B environmentally sensitive areas on the Vance mining lease ML1108 are confined to those areas listed under the RAMSAR convention.

You can view all category A, B and C areas overlain on ML boundaries by accessing the EPA's maps on the web service at <http://www.epa.qld.gov.au/ecoaccess/ecomaps/>

Yours sincerely

Matthew Buchanan
Acting Operations Manager (Mining and Extractive)

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Appendix F

Flora Report (2006)

R E P O R T

Flora Assessment Vance Mining Lease ML 1108, North Stradbroke Is, Queensland

Prepared for

Unimin Australia Limited

Locked Bag 969, North Sydney, NSW 2059

15 October 2007

42625813



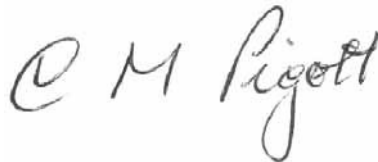
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Date: 15 October 2007
Reference: 42625813
Status: Final

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Appendices

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Appendix B	Primary Transect Field Data March 2006
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1.1 Introduction

URS Australia Pty Ltd (URS) was commissioned by Unimin Australia Limited (UAL) to conduct flora studies at the Vance Mining Lease (ML 1108), North Stradbroke Island as part of an Environmental Studies Report (ESR). Studies were conducted to identify any significant species and areas of conservation significance, provide benchmark data for the subsequent rehabilitation of proposed areas to be mined; identify potential biological impacts from the proposed mining operations and outline appropriate management strategies.

2005 Flora Studies

An initial flora survey was undertaken on the Vance lease (ML 1108) on 13 January 2005. The primary objective of the initial survey was to ground truth 1:100, 000 regional ecosystem mapping version 5.0 (EPA, 2005b) and investigate areas of vegetation categorised as ‘Category B’ areas at the time of survey. A detailed description of methodology employed for the 2005 survey is provided in Section 2.4.4.

2006 Flora Studies

A Secondary flora survey was undertaken over a seven day period between 6 and 12 of March 2006. This survey period was undertaken as a supplementary program to the initial flora studies undertaken in July 2005, to account for the unseasonably dry conditions in 2005 and obtain rehabilitation benchmark data not previously recorded. A detailed description of methodology employed for the 2006 survey is provided in Section 2.4.5. A 2006 spring survey has also been undertaken to account for seasonal variability and identify any flowering species not identified in the two previous summer survey programs. This survey was carried out on 28 September 2006 and comprised a one-day vehicle based survey as detailed in Section 2.4.5.

1.2 Site Description

ML 1108 is situated approximately 4 km north east of Dunwich on North Stradbroke Island, on 639 ha of relatively undisturbed native vegetation (Figure 1). ML 1108 is held 100% by UAL. Topography of the site represents a series of high dune formations to a height of approximately 200 m. Natural drainage within the site drains towards a central ephemeral drainage line, Cooroon Cooroonpah Creek, traversing the approximate centre of the lease from the south west corner to the north west corner. Most of the ephemeral drainage remains dry throughout the majority of the year due to the substrate of the creek being comprised of freely draining sands. Two sites designated by the Commonwealth Department of Environment and Water Resources (DEWR) as significant Ramsar ‘wetlands’ are currently found on ML 1108. These sites do not exhibit any intrinsic environmental values characteristic of a wetland (refer to section 2.5.6). ML 1108 is proposed to be dry mined by UAL for silica sand and heavy minerals (as a by product.).

1.3 Proposed Mining Activity

Proposed mining operations on ML 1108 are restricted to dry sand mining activities only. Dune sand will be extracted from a shallow pit at the rate of up to 1 million tonnes per year. Mining is proposed to extend onto ML 1108 from existing operations on the adjacent lease ML 7064. Processing of sand is proposed to be undertaken at existing facilities on ML 1124 (Figure 1). Sand shall be processed by gravity to separate impurities and heavy minerals, producing high purity silica sand primarily used for glass manufacture.

Exploration drilling and analysis has and will continue to be undertaken to determine the quality and quantity of the dune sand resource during the project. This information will be used to ensure all viable resources are targeted within the mine path. A 3 year mine plan of operations (refer Figure 2) has been developed which outlines Unimin's approach to mining the Stage 1 3 year mine plan area. This plan will be updated to cover the entire lease following completion of the lease exploration drilling program. Figure 3 provides an outline of the maximum extent of the mine footprint. This footprint should be considered indicative at present, with the final lease mining footprint subject to the findings of the exploration drilling program.

2.1 Study Aim and Objectives

The primary aim of the flora investigation is to map the vegetation communities of the lease area, identify areas of conservation significance and acquire benchmark data on the vegetation associations of the lease for future rehabilitation. In meeting these aims the objectives of the flora survey are as follows:

- Review existing vegetation data for the local area and region;
- Accurately map the vegetation communities of the site at a scale of 1:20,000;
- Provide baseline data on vegetation communities occurring in the study area;
- Identify the occurrence or expected occurrence of conservation significant plant species;
- Describe weed species in the study area;
- Assess the value of areas that may be disturbed by the proposed mining operations for vegetation conservation;
- Determine impact of proposed operations on the surrounding vegetation; and
- Develop appropriate management strategies.

2.2 Review of Existing Information

In order to identify the range of species and communities that may be present within the expansion area and local region, reviews of existing data from the Queensland Herbarium and the Commonwealth Department of Environment and Water Resources (DEWR) databases were conducted for North Stradbroke Island. The search area covered latitudes from -27°23'19.3" S to -27°44'32.2" S and longitudes from 153°21'35.1" E to 153°33'41.2" E.

2.2.1 Data Sources

Existing data on flora of the study area were compiled through acquisition of the following key references:

- Queensland EPA Herbarium 'Herbrecs' flora database;
- Queensland EPA 'Wildnet' wildlife database;
- Queensland EPA 1:100 000 Regional Ecosystems mapping ;
- Queensland EPA 'Ecomap' environmentally sensitive areas database;
- Commonwealth DEWR 'Matters of National Environmental Significance' EPBC database;

-
- Survey of Flora and Fauna over Mining Lease 7064 near Dunwich, North Stradbroke Island, Qld (Worth et al., 1997);
 - Revegetation plan as a supplement to flora and fauna studies over Mining Lease 7064 near Dunwich, North Stradbroke Island, Qld. (Worth & Andersen, 1998);
 - Vance Vegetation Surveys and Proposed Rehabilitation Procedures (CRL, 1996); and
 - Focus on Stradbroke Island: New information on North Stradbroke Island and surrounding areas, (Covacevich & Davey, 1984).

2.2.2 Target Species

Threatened, significant or otherwise noteworthy flora¹ potentially occurring in the locality were identified from previous studies, or EPA Wildnet, Qld Herbarium and the DEWR databases. From this list, an assessment of potential presence was made based on suitable habitat present on site. Species identified as being potentially present in the project area were targeted for identification during the field assessment and are listed in Appendix A.

2.3 Regional Context

2.3.1 Bioregion

North Stradbroke Island is situated within the southeast Queensland bioregion. The bioregions of Queensland are based on landscape patterns that reflect changes in geology and climate, as well as major changes in floral and faunal assemblages at a broad scale and are used as the fundamental framework for the planning and conservation of biodiversity. Nature conservation of the southeast Queensland bioregion has received increasing attention due to the loss of habitat that has occurred from high population growth within the region (Young and Dilewaard, 1999).

2.3.2 Sub-region

The southeast Queensland bioregion contains 10 sub-regions or provinces that delineate significant differences in geology and geomorphology. North Stradbroke Island is situated within the southern coastal lowland province (or sub-region). The landscape of this province is centred upon sedimentary rocks but also includes the estuarine sediments and high dunes systems of the southern off-shore islands.

¹ Threatened species relate to species identified by Queensland (*Nature Conservation (Wildlife) Regulation, 2006* under the *Nature Conservation Act, 1992*) and Commonwealth (*Environment Protection & Biodiversity Conservation Act, 1999*) legislation as critically endangered, endangered or vulnerable. Significant species are species that carry other legislation status or those that occur at the extent of their natural geographic range.

Major vegetation types include heathland and banksia woodlands, *Melaleuca quinquenervia* forests and woodlands, mangrove forests, sedge-lands and *Eucalyptus racemosa* and *E. pilularis* open forests and tall open forests (Young and Dillewaard, 1999).

2.3.3 Regional Ecosystems

Regional Ecosystems (RE's) describe the relationships between major floral species and the environment at the regional scale. They are mostly derived from linking vegetation mapping units recognised at a scale of 1:100,000 to land zones that represent major environmental variables, in particular geology, rainfall and landform. There are 72 RE's identified for the province. Of these 36 are currently of conservation significance, being listed as either "Of concern" (29) or "Endangered" (7) under the *Vegetation Management Act, 1999*. RE's of relevance to the project area are discussed in Section 2.5.4.

2.4 Survey Methodology

2.4.1 Overall Approach

The flora survey employed an assessment of floral taxa and vegetation communities in keeping with the methodology employed by the Queensland Herbarium for the survey of RE's and vegetation communities (Neldner *et al.*, 2004). Preliminary identification of the vegetation communities of the project areas was conducted prior to the commencement of fieldwork. Preliminary identification included vegetation community definition from stereo image 1:25, 000 colour aerial photography (Sunmap, 1991) and interpretation of 1:100, 000 RE mapping version 5.0 for the region (EPA, 2005b).

Preliminary community definition was used to identify locations for representative field survey sample plots to obtain floristic and structural data and to ground truth communities. Field surveys involved a botanical assessment at a number of representative sites within each vegetation community, employing a number of standard methods within primary sample plots, secondary sample plots and random meander search areas. A number of vehicle traverses of the study site were also undertaken throughout the study period to identify community boundaries and changes in landform.

Community structural formation classes were assessed according to Specht (1970). RE classification of communities was determined as per Young and Dillewaard (1999) in Sattler and Williams (1999), and in accordance with the Regional Ecosystems Description Database (REDD) (EPA, 2005a).

Final vegetation mapping was undertaken utilising field survey data and aerial photograph interpretation of stereo pair images at a scale of 1:12,000 (EPA, 2004). The field survey was conducted under Queensland Environmental Protection Agency (EPA) Scientific Purposes Permit number WISP02056304.

2.4.2 Nomenclature

Taxonomic nomenclature used for the description of floral species is according to Henderson (2002). Introduced species (as per Henderson, 2002) are signified in all text by an asterix (*). Any additional changes in taxonomic nomenclature have been incorporated as described in Jessup (2002, 2003, 2005). Field references utilised for the identification and description of floral species include; Brooker and Kleinig (1994), and Stanley and Ross (1989, 1995, 2002).

2.4.3 Specimen Identification

Where available, fruiting and/or flowering specimens were collected to assist with identification, if plant species were not identified in the field. For those species not field identified, samples were pressed and dried and positive identifications of specimens were subsequently made under laboratory conditions. All identifications were made by qualified botanist with experience identifying flora taxa of south-east Queensland coastal ecosystems.

2.4.4 2005 Sampling Methodology

Fieldwork for the initial floral survey consisted of a one-day assessment of the vegetation communities of the Vance Lease (ML 1108) on 13 January 2005. The survey utilised ten representative sample sites across the lease including a number of sites within each vegetation community (Figure 2).

Sample Plots

Sample plots utilised a 10 x 50 m transect to record floristic and structural information. Floristic analysis included plant identification of all flora present. Relative abundance was assigned for all species recorded. Plant identification and estimation of relative abundance was undertaken by an experienced taxonomic botanist with previous survey experience in south-east Queensland coastal ecosystems.

Structural analysis included recording the height class and life form of the dominant species within each strata present. The height of each strata was recorded using a hand held hypsometer. Crown Separation Ratio (CSR) of the mid and upper strata was calculated along the transect as per McDonald et al. (1998), where crown gaps (distance between crowns) were recorded using a hand held laser range finder, and crown widths (spread) were recorded using ocular estimation. Foliage Projection Cover (FPC) of the canopy and mid strata (where applicable) was calculated converting CSR to FPC using a simple equation (McDonald et al., 1998). FPC of the ground layer was determined using ocular estimation of cover within five 1 m subplots along the primary transect.

Evidence of previous disturbance, fire history, incidence of exotic species and general notes on soil type and ecological integrity were compiled for each primary sample plot. Several time encoded digital photographs were taken at each plot as a reference. Locations of data collection sites were recorded using a handheld GPS unit.

Meander Searches

Following assessment of each survey plot, an area of approximately 1.5 ha surrounding each plot was searched utilising the random meander technique (Cropper, 1993).

Care was taken to avoid sampling in different vegetation types to those of the plots. Meander searches were employed to:

- Identify any potential significant species not identified within survey plots;
- Identify additional less abundant species not recorded within survey plots;
- Confirm the representativeness of plot locations; and
- Confirm boundaries and ecotonal areas between vegetation communities.

2.4.5 2006 Sampling Methodology

A secondary flora survey was undertaken on ML 1108 over a seven day period between 6 -12 March 2006. This survey was undertaken as a supplementary program to the initial flora studies undertaken in January 2005, to account for the unseasonably dry conditions in 2005 and to obtain benchmark data for future rehabilitation efforts.

The methodology employed for the 2006 secondary survey was determined in meetings undertaken with the Queensland Herbarium in November 2005. The 2006 survey methodology employed 15 secondary transects to record floristic and structural data of vegetation associations found the ML 1108 lease area. There were five permanent representative primary transects utilised to record benchmark data within each of the vegetation communities, as reference for future rehabilitation. This was in addition to the data recorded at the 10 transects used for the initial site assessment undertaken in January 2005.

Primary Plots

Five permanent reference sites were utilised to acquire benchmark data within each of the four vegetation associations identified for the site (Figure 2). A single representative site was selected for each community within protected areas not to be disturbed by future mining operations. A second representative primary plot was selected at a different location for the dry heath community, as no areas of this community are found within designated protected areas on site (Section 3.2.1). However, the two sites selected for this community are unlikely to be disturbed as they are both located in elevated high dune ridges with gradients that are too steep to allow for any potential future dry mining operations.

Descriptive site information recorded at primary transects included; location, orientation, aspect, slope, soil type, landform, disturbance, fire history and general notes on ecological integrity. Several time-encoded digital photographs were taken at each plot as a visual reference. Locations of transects were recorded using a handheld GPS unit and permanently marked at either end of the centre line with coloured star pickets. Structural and floristic information recorded at each primary site included:

-
- Height class of each strata (T1: canopy , T2: mid, S1: shrub, S2: lower shrub, G1: ground) within the 50 x 10 m plot;
 - Crown cover of T1 and T2 strata intercepted along transect;
 - Relative abundance of all species present within the 50 x 10 m plot;
 - Stems counts for all T1 and T2 species within the 50 x 10 m plot;
 - Stems counts for all S1 and S2 species within the 50 x 2 m sub-plot;
 - Location of all stems as an x,y coordinate relative to the transect tape (for T1 and T2 species within 50 x 10 m plot, for S1 and S2 species within 50 x 2 m sub-plot);
 - Height, crown spread, and diameter at breast height (DBH) for all stems above 2 m height (for T1 and T2 species within 50 x 10 m plot, for S1 and S2 species within 50 x 2 m sub-plot);
 - Basal prism sweep and count of all T1 and T2 species; and
 - Foliage projection cover (FPC %) of all ground cover species within five 1 x 1 m quadrats along the transect tape.

Secondary Plots

There were 16 secondary plots utilised to ground truth vegetation units within the ML 1108 (Figure 2). Secondary plots were located within representative areas for each community and spread across the lease to acquire data within communities that may be effected by any future operations on the lease.

Descriptive site information recorded at secondary sites included; location, orientation, aspect, slope, soil type, landform, disturbance, fire history and general notes on ecological integrity. Several time encoded digital photographs were taken at each plot as a visual reference. Locations of transects were recorded using a handheld GPS unit and permanently marked at either end of the centre line with coloured star pickets. Structural and floristic information recorded at each primary site included:

- Height class of each strata (T1: canopy , T2: mid, S1: shrub, G1: ground) within the 50 x 10m plot;
- Crown cover of T1 and T2 strata intercepted along transect;
- Relative abundance of all species present within the 50 x 10m plot;
- Stems counts for all T1 and T2 species within the 50 x 10 m plot;
- Stems counts for all S1 and S2 species within the 50 x 2 m sub-plot;
- Basal prism sweep and count of all T1 and T2 species; and

-
- Foliage projection cover (FPC %) of all ground cover species within five 1 x 1 m quadrats along the transect tape.

Meander Searches

Following assessment of each primary and secondary plot, an area of approximately 1 ha surrounding each plot was searched utilising the random meander technique (Cropper, 1993). Care was taken to avoid sampling in different vegetation types to those of the plots. Meander searches were employed to:

- Identify additional less abundant species not recorded within survey plots;
- Identify any potential significant species not identified within the survey plot;
- Confirm the representativeness of plot locations; and
- Confirm boundaries and ecotonal areas between vegetation communities.

Targeted Search

A targeted search for significant species was undertaken within the three year mine footprint (Figure 2) targeting any rare or threatened or otherwise note-worthy species. The targeted search was undertaken within the three year footprint for a period of 3 person hours. Additional targeted surveys may be required following the delineation of the final mine footprint (Section 1.3).

Spring Survey

A 2006 spring survey was also undertaken to account for seasonal variability and identify any flowering species not identified in the two previous summer survey programs. This survey was carried out on 28 September 2006 and comprised a one-day vehicle based survey. Six sites surveyed during the summer programs were revisited (Primary Sites 1, 2, 3 and 5 and Secondary Sites 6 and 15). These sites were selected to include each of the four Regional Ecosystem mapped onsite. At each site approximately 1 hour was spent searching for additional species not previously recorded.

2.5 Survey Results

This section documents the floristic diversity and describes the vegetation communities of the project area. Detailed community descriptions and quantitative data including floristics and structure for each primary survey site are detailed in Appendix B. Quantitative data including floristics and structure for each secondary survey site is detailed in Appendix C. Additional species recorded during the spring survey are detailed in Appendix D.

2.5.1 Sampling Conditions

2005 Weather Conditions

Fieldwork for the initial flora survey was conducted on the 13 January 2005. The weather conditions experienced on the week of the survey were fine and clear with 14 mm of rain recorded. The average daily maximum temperature for the week was 27.9° C, with the average overnight low being 21.8°C.

Weather conditions during January 2005 were dry for the season as south-east Queensland was experiencing an extended drought at this time. Bureau of Meteorology daily weather observations from Point Lookout indicate that only 34.0 mm of rain was recorded in the area for January, with a total of only 157 mm of rainfall recorded for the December 2004-January 2005 period (BoM, 2006a). By comparison, climate average data for the area shows the mean rainfall for the month of January to be 158.4 mm (BoM, 2006b).

2006 Weather Conditions

Weather conditions were more typical for the season in the 2006 survey period, being generally fine with good rainfall. Bureau of Meteorology daily weather observations from Point Lookout for the survey period indicated the average daily maximum was 29.0 C and the mean minimum temperature was 22.50 C. Only 10.2 mm of rainfall was recorded during the survey period. However the wet season was occurring in the February and early March period, with high rainfall common in the weeks preceding the survey.

The week before the survey saw 104.4 mm of rainfall, with a storm event the day prior to the commencement of the survey releasing 66 mm of rain (BoM, 2006c).

2.5.2 Species Diversity

The combined 2005 and 2006 surveys identified the presence of 134 taxa representing 99 genera and 46 families. This result represents a relatively high floral diversity typical of the ecosystems surveyed and is comparable to results of similar previous studies conducted both within the ML 1108 and its immediate locality (CRL 1996, Worth et. al. 1997, URS 2005).

Families represented by 3 or more genera included *Cyperaceae* (8), *Epacridaceae* (7), *Euphorbiaceae* (4), *Fabaceae* (8), *Liliaceae* (3), *Myrtaceae* (9), *Poaceae* (7), *Proteaceae* (7), and *Restionaceae* (4).

Genera represented by 3 or more species included *Acacia* (4), *Aristida* (3), *Eucalyptus* (3), *Hibbertia* (4), *Leptospermum* (5), *Leucopogon* (4) and *Lomandra* (4).

A full list of species found at both primary and secondary transects documenting the relative abundance of species at each survey site is provided in Appendices B1.1 and C1.1 respectively.

2.5.3 Significant Species

None of the species identified in the flora survey are identified as being significant from a commercial or recreational standpoint.

Species of cultural significance that might potentially be present within ML1108 area include species traditionally utilised for food or medicinal purposes, tree species utilised for their bark for painting, and wildflower species traditionally collected for decoration or adornment. Three species are identified by the Minjerribah Moorgumpin Elders as being of cultural significance to the traditional owners of North Stradbroke Island. Two of these species, *Boronia rosmarinifolia* (forest boronia) and *Boronia saffrolifera* (safrole boronia), were found to be present within the low open heath habitat along the exposed ridge tops at survey sites 8, 9 and 10. *Boronia rosmarinifolia* was also found to be present in relatively low abundance within the *Eucalyptus pilularis* open forest at site 10. The third species, *Boronia falcifolia* (wallum boronia) was recorded within the closed wet heath at site 5. Species identified as having cultural value to the indigenous traditional owners of North Stradbroke Island will be discussed in further detail within the cultural heritage section of the ESR.

No species of national conservation significance under the EPBC act were identified as occurring on site.

Two state conservation significant species were recorded within ML 1108 as detailed in Table 1. Both species were recorded within permanent primary transects and secondary transects, and also within targeted threatened species meander searches.

Table 1 Significant Species Surveyed within the Vance lease 06-12/03/2006

Plant Species	Common Name	Growth Form	Conservation Status ¹	Sites Recorded ²
<i>Acacia baueri</i> subsp. <i>baueri</i>	tiny wattle	Shrub	Vulnerable	P3, P4, Ts
<i>Gompholobium virgatum</i> var. <i>emarginatum</i>	wallum wedge pea	Shrub	Rare	S4, S5, S6, S7, Ts

¹ Nature Conservation (Wildlife) Regulation, 2006

² P=Primary Transect, S=Secondary Transect, Ts=Targeted Search

Acacia baueri subsp. *baueri* was primarily found in relatively high abundances in the small areas of low open heath on the exposed higher elevated dunes to the south west of ML 1108. *A. baueri* was also found in lower abundances in exposed areas adjacent to vehicle tracks, including the track along the Cooroon Cooroonpah Creek within the proposed exclusion buffer (Section 3.2.1).

Gompholobium virgatum var. *emarginatum* was primarily found in relatively high abundances in mallee eucalypt woodland associations upslope of the Cooroon Cooroonpah Creek drainage line, and in the north-west of ML 1108 within the Stage 1 three year mine path.

Acacia baueri* subsp. *baueri

Acacia baueri subsp. *baueri* (tiny wattle) is a shrub that grows to 10-15 cm tall. The species flowers in June to November when it produces golden yellow ball flowers on long stalks followed by flattened seed pods (Queensland Museum, 2003). The species occurs in wet heath lands on sandy coastal plains and its

distribution extends from Fraser Island to Sydney. Much of the species habitat has been lost to development of coastal lowlands in these regions. This plant is listed as ‘Vulnerable’ under the Queensland *Nature Conservation (Wildlife) Regulation, 2006*.

Gompholobium virgatum* var. *emarginatum

Gompholobium virgatum var. *emarginatum* (wallum wedge pea) is an upright shrub that grows to 1.2m tall with smooth stems. Each leaf consists of three wedge shaped leaflets up to 1.5 cm long and 0.5 cm wide. The species flowers in late winter to spring when it produces solitary yellow pea flowers up to 1.8 cm long by 1.8 cm wide (Stanley and Ross, 1995).

The species occurs in sandy coastal areas in south-east Queensland (Stanley and Ross, 1995). Much of the species habitat has been lost to development of coastal lowlands in these regions. This plant is listed as ‘Rare’ under the Queensland *Nature Conservation (Wildlife) Regulation, 2006*.

2.5.4 Vegetation Communities

Four vegetation communities were described and mapped for ML 1108 on the basis of the 2006 field survey results and stereo aerial photograph interpretation. Six vegetation communities were initially described for ML 1108 based on the results of the initial 2005 vegetation survey. The subsequent reduction of communities identified for ML 1108 following the 2006 survey is resultant from a more rigorous examination of the floristics of the site. These communities and their current extent within both ML 1108 and the southern coastal lowlands sub-region are summarised in Table 2. The extent of vegetation communities surveyed within ML 1108 are shown on Figure 2.

Table 2: Vegetation Associations Surveyed within the ML 1108 06-12/03/2006

Community Description		Regional Ecosystem	Total area on site (ha)	¹ Total area in sub-region (ha)
1a	Low open dry heath on Quaternary dunes and sand plains	RE 12.2.13 'of concern'	5.65	441
1b	Closed wet heath on seasonally waterlogged sand plains	RE 12.2.12	3.04	2,620
2a	Mallee <i>Eucalyptus</i> spp. Low woodland on Quaternary dunes and sand plains	RE 12.2.10	564.30	9,997
3a	<i>Eucalyptus</i> spp. open forest on Quaternary dunes and sand plains	RE 12.2.6	65.98	13,401

¹ Derived from RE data for the southern coastal lowland province as per Accad *et. al.* (2005)

The majority of the site supports vegetation community 2a; Mallee *Eucalyptus* spp. low woodland (RE 12.2.10). This community is found on most landforms on the lease including the Cooroon Cooroonpah Creek drainage line, lower and upper slopes and elevated high dunes. This community is primarily dominated by mallee form of *Eucalyptus planchoniana* (needle bark) with *Banksia aemula* (wallum banksia), however was also found to be dominated by the mallee form of *Eucalyptus racemosa* (scribbly gum) in more exposed areas close to the ridge lines on elevated dunes.

Vegetation community 1a; Low open dry heath (RE 12.2.13) persists in exposed ridge areas on the high dunes to the west of the site (Figure 2). This community is dominated by a number of Myrtaceous and Fabaceae heath species, however dry heath communities are being encroached by *Banksia aemula* (wallum banksia). It appears that the encroaching regeneration of *Banksia aemula* in heathland are early stages of the seral succession of Mallee *Eucalyptus spp.* low woodland, which given undisturbed conditions will eventually dominate.

The extent of vegetation community 1b; Closed wet heath (12.2.12) on the lease was restricted to the ephemeral drainage line of Cooroon Cooroonpah Creek. This community was dominated by *Leptospermum liversidgei* (lemon-scented tea tree) with *Empodisma minor* (spreading rope rush) and *Baumea muelleri* (flat twigrush) also in common abundance.

Vegetation community 3a; Mixed *Eucalyptus species* open forest (RE 12.2.6) was found to be present on elevated dunes to the east and north of the site. This community was found to be co-dominated by *Eucalyptus pilularis* (needle bark) and *E. racemosa* with *Corymbia gummifera* (red bloodwood). Floristic variation was evident in examples of the community found at elevation to the very east of the site, where the community exhibited a dominance of *E. pilularis*. However *E. racemosa* and *C. gummifera* were still evident to a lesser degree in these areas.

Natural Integrity of Communities

The natural integrity of vegetation communities was found to be relatively high at all sites surveyed. Incidence of weed species was low with no exotic species found to be present at any of the survey sites. Vegetation communities found on Cainozoic sand substrates generally exhibit a low edaphic nutrient cycle and as such do not commonly support a high incidence of exotic species infestation.

Fire disturbance has had some effect on the assemblage of species within areas that appear to have been repeatedly burnt. Most vegetation associations surveyed on site showed some level of previous fire disturbance. In particular, areas of Mallee *Eucalyptus spp.* woodland along the southern end of Cooroon Cooroonpah Creek and *Eucalyptus pilularis* open forest found on the south eastern dunes (Figure 2) have been subject to intense burns resulting in a reduction of species diversity and removal of some mid-storey and groundcover elements. Pioneer species such as *Dodonaea triquetra* are found to dominate ground cover in these areas as a result. These areas are still considered to have relatively high in natural integrity, with low levels of exotic species intrusion evident.

2.5.5 Significant Communities

One community has conservation significance under Queensland legislation. Vegetation unit 1a; Low open dry heath on Quaternary dunes and sand plains (RE 12.2.13) is currently listed as ‘of concern’ under the Queensland *Vegetation Management Act, 1999* (VM Act).

Vegetation communities are listed as 'Of Concern' regional ecosystems under the VM Act if the remnant vegetation for the community is 10 to 30 per cent of its pre-clearing extent across the bioregion; or more than 30 per cent of its pre-clearing extent remains and the remnant extent is less than 10,000 hectares.

Of the estimated original 484 ha pre-clearing extent for this community in south-east Queensland, 441 ha still remains uncleared, all within the south coastal lowland sub-region. Of the 441 ha still remaining, approximately 41 ha is currently conserved in Queensland within the Noosa National Park (Accad et al, 2005). The extent of Vegetation Unit 1a present on ML 1108 (5.65 ha) represents approximately 1.3 % of the extent of this community still present within the southern coastal lowland sub-region.

2.5.6 Ramsar Areas

The Department of Environment and Water Resources (DEWR)) National Estate Register designates two areas on the lease, one to the east and one to the south, as Ramsar² protected wetlands (Figure 3). Ground truthing of the vegetation communities in both these areas confirms the vegetation to be comprised of Mallee *Eucalyptus* spp. low woodland on Quaternary dunes (RE 12.2.10) and *Eucalyptus racemosa* / *Eucalyptus pilularis* open forest on Quaternary dunes (RE 12.2.6). No wetland vegetation or significant areas of surface water is found in either of these areas. It is assumed that these the 'Ramsar' areas are designated as such for land management purposes rather than for any intrinsic 'wetland' values.

The large extent of tall eucalypt forest on the eastern extent of the lease currently under the designation of Ramsar 'wetland' is scheduled to be annexed as part of a planned National Park (pers. com.)³.

A number of secondary transects were established within the smaller of the two Ramsar designated areas to the south of the lease, to obtain floristic and structural data on the vegetation types found there. A drive-over inspection of this area was also undertaken to further ground truth the communities. This study confirmed that the vegetation of this area is comprised *Mallee Eucalyptus* spp. low woodland on Quaternary dunes (RE 12.2.10), and no wetlands are present. The only wetland vegetation found on the lease was the community of closed heath on seasonally waterlogged sand plains (RE 12.2.12) found present along the margins of the Cooroon Cooroonpah Creek drainage line (Figure 2).

² Ramsar convention on the protection of internationally significant wetlands, Ramsar, Iran, 1971.

³ Correspondence from Lisa Ford EPA, QPWS dated 27/09/05.

3.1 Potential Impacts

A number of potential impacts on the vegetation of the lease may result from the proposed mining operations. Impacts including vegetation removal, potential weed intrusion and dust impacts are discussed in the following sections.

3.1.1 Vegetation Removal

Figure 3 provides an outline of the potential mine footprint. This figure should be considered indicative at present, with the final lease mining footprint subject to the findings of the exploration drilling program. For the purposes of this impact assessment it will be assumed the maximum extent of the mine footprint will be cleared, however it is likely that the actual area to be cleared will be less, with steeply sloping areas and ridges tops unlikely to be suitable for mining.

Potential vegetation removal within the maximum extent of the mine footprint will involve clearing up to approximately 378 ha of native vegetation. Table 3 presents a breakdown of the potential disturbance to vegetation within the mine footprint area, indicating disturbance as a percentage of the communities found on the lease and as a percentage of the communities found within the sub-region.

Table 3 Maximum potential disturbance to vegetation communities within the proposed extent of sand extraction

Community Description		Regional Ecosystem	Conservation Status ¹	Potential Disturbance		
				Ha	Site % ²	Sub-region % ³
1a	Low open dry heath on Quaternary dunes and sand plains	RE 12.2.13	Of concern	4.6	81.4	1.0
1b	Closed wet heath on seasonally waterlogged sand plains	RE 12.2.12	Not of concern	0	-	-
2a	Mallee <i>Eucalyptus</i> spp. Low woodland on Quaternary dunes and sand plains	RE 12.2.10	Not of concern	359	63.6	3.6
3a	<i>Eucalyptus</i> spp. open forest on Quaternary dunes and sand plains	RE 12.2.6	Not of concern	14.4	21.8	0.1

¹ As per the *Vegetation Management Act 1999*.

² Indicates % of disturbance to vegetation community within the project area.

³ Indicates % of disturbance to vegetation community within the southern coastal lowland province as per Accad *et. al.* (2003).

Vegetation Unit 2a: 'Mallee *Eucalyptus* spp. Low woodland on Quaternary dunes and sand plains' ('Not of concern' RE 12.2.10) is the community to be subjected to the majority of disturbance, of which up to 359 ha will be cleared. This clearing would represent 63.6 % of the extent of this community found on site, however when viewed in the broader context of impact to regional biodiversity, disturbance constitutes 3.6 % of this community within the sub-region. This community is not significant under state or commonwealth legislation.

The community subjected to the second highest area of clearing is Vegetation Unit 3a: *Eucalyptus* spp. open forest on Quaternary dunes and sand plains ('Not of concern' RE 12.2.6) present on elevated dunes

to the east and north of the site. The maximum area of this community to be cleared is 14.4 ha which represents 21.8 % of the extent of this community found on site, however when viewed in the broader context of impact to regional biodiversity, disturbance constitutes 0.1 % of this community within the sub-region. This community is not currently significant under state or commonwealth legislation.

Significant Communities

One conservation significant community will be impacted by the proposed clearing. This community is Vegetation Unit 1a: Low open dry heath on Quaternary dunes and sand plains ('Of concern' RE 12.2.13). Approximately 4.6 ha of this community occurs within the potential mine footprint to be cleared. This impact represents 81.4 % of the overall area of this community found on site. However when viewed in the broader context of impact to regional biodiversity, disturbance constitutes 1 % of this vegetation community found within the sub-region.

Significant Species

Two state conservation significant plant species were recorded within ML 1108 as detailed in Section 2.5.3.

Acacia baueri subsp. *baueri* was found in relatively high abundances, in the small areas of low open heath on the exposed higher elevated dunes to the south west of ML 1108 (P3 and P4 in Figure 2). These areas will be protected from mining and will not be cleared. *A. baueri* subsp. *baueri* was also found in lower abundances in exposed areas adjacent to vehicle tracks, including the track along the Cooroon Cooroonpah Creek. An extent of known habitat for this species outside the protected conservation areas are likely to be impacted by clearing for approved stage 1 mining operations. As such some potential impacts may be expected for this species in these areas. Mitigation of impacts for *Acacia baueri* subsp. *baueri* are outlined in Section 3.2.5

Gompholobium virgatum var. *emarginatum* was primarily found in relatively high abundances in mallee eucalypt woodland associations upslope of the Cooroon Cooroonpah Creek drainage line, and in the north-west of ML 1108. An extent of known habitat for this species outside the protected conservation areas are likely to be impacted by clearing for approved stage 1 mining operations. As such some potential impacts may be expected for this species in these areas. Mitigation of impacts for *Gompholobium virgatum* var. *emarginatum* are outlined in Section 3.2.5

Species of cultural significance recorded from the site include *Boronia rosmarinifolia* (forest boronia), *Boronia saffrolifera* (safrole boronia) and *Boronia falcifolia* (wallum boronia). The former two species occur within the potential mine footprint and may require clearing. The latter species (*Boronia falcifolia*) is restricted to the wet heath along Cooroon Cooroonpah Creek and will be protected within the creek buffer.

Plant species of conservation significant will be included within rehabilitation of disturbed areas as detailed in Section 3.2.5 to mitigate the impacts of clearing.

3.1.2 Regional Connectivity

ML 1108 presently forms part of a wide tract of vegetation that extends relatively undisturbed, connecting core habitat in the northern and southern ends of North Stradbroke Island. Regional connectivity of habitat to the north of the site remains relatively integral with contiguous stands of native vegetation disturbed only by The East Coast Road approximately 2 km to the north. Connectivity to the south is also largely uninterrupted, however a network of four-wheel drive tracks and the surfaced Tazi Road adjacent to the southern boundary of the site interrupts connectivity of habitat to some degree.

Connectivity to the north-west of the site is currently interrupted by the East Coast Road and the current UAL sand mining operations. Connectivity to the east of the lease is also impeded by heavy mineral sand mining activities by Consolidated Rutile Limited. However, continued rehabilitation efforts will see connectivity restored to these areas of current sand mining operations.

The proposed removal of remnant vegetation of the lease does not represent a loss of any significant pathway of habitat connectivity at a regional scale, due to the relatively small size of vegetation removal proposed and the progressive rehabilitation proposed for the site.

Protected habitat is currently represented by several National Estate conservation areas that are in close proximity to ML 1108. These include; the Wild flowers Scenic Reserve approximately 500 m directly to the north of the lease, Brown Lake (Bumiera) Recreation Reserve approximately 1 km to the west of the lease and the Blue Lake National Park approximately 400 m to the south east of the lease.

3.1.3 Weeds and Fire

Although the introduction of earthmoving equipment to the area has the potential to introduce new and declared weeds⁴, the risk of weed infestation is considered to be low due to the low edaphic nutrient cycling typical of dune vegetation communities found on site. If incidences of weed infestation are detected, appropriate measures will be put in place to monitor weed occurrence, and weed eradication measures will be put in place as required (Section 3.2.4). Existing fire regimes in integral vegetation communities are not considered to be affected by the proposed mining activities.

3.1.4 Dust Impacts

Dust deposition may have potential impacts on vegetation if excessive levels are sustained over extended periods. Physical effects could potentially include blockage and damage to stomata, shading, and

⁴ Weeds Management Act 2001.

abrasion of the leaf cuticle. Reduction in the ability to photosynthesise due to physical effects may result in reduced growth rates of vegetation and decreases in floral vigour and overall community health. The potential effects of dust deposition on vegetation are determined by a number of factors including:

- The characteristics of leaf surfaces, such as surface roughness, influencing the rate of dust deposition on vegetation;
- concentration and size of dust particles in the ambient air and its associated deposition rates; and
- local meteorological conditions and the degree of penetration of dust into vegetation;
- The dominant woodland species of the vegetation communities in close proximity to the proposed mine operations typically exhibit physiological qualities that are not sensitive to dust deposition. The sclerophyllous foliage of Eucalypt and Corymbia species is generally pendulous (ie: points down), with a thick smooth cuticle that does not encourage particulate matter to remain on the surface. The dominant woodland species are also generally hardy and well adapted to adverse conditions (eg; extended dry conditions and low nutrient soils).

It is not expected that potential effects of dust deposition on vegetation within close proximity to mining operations will be significant. Any impacts to growth rate and floral vigour that may result would be diminished with the commencement of rehabilitation. It is noted that standing vegetation associations in close proximity to current mining operations do not appear to be adversely impacted from dust deposition. If dust deposition is deemed likely to be significant, control measures could be implemented to mitigate potential impacts.

3.2 Mitigation

3.2.1 Conservation Areas

A number of conservation areas are proposed for ML 1108. All mining is to be excluded from these areas. Proposed conservation areas include a 100 m exclusion buffer either side of the Cooroon Cooroonpah Creek drainage line, two areas of open heath vegetation, and the designated Ramsar 'wetland' areas at the south and east of ML 1108 (Figure 3). The Ramsar area in the east of ML 1108 will also be potentially annexed as part of a proposed future National Park (Refer to section 2.5.6).

Approximately 196 ha of the vegetation on ML 1108 is to be protected within designated conservation areas. This includes approximately 67 ha of riparian vegetation within the Cooroon Cooroonpah Creek exclusion buffer, and approximately 129 ha of eucalypt forest and mallee woodland within the 'Ramsar' area (Figure 3). An additional 64 ha of vegetation occurs outside of the proposed mine footprint and therefore will also be retained as part of the proposed mining operations.

Vegetation unit 1b; Closed wet heath (RE 12.2.12) is proposed to be wholly protected within the Cooroon Cooroonpah Creek exclusion buffer. Approximately 51.6 ha (78.2 %) of Vegetation Unit 3a *Eucalyptus racemosa* open forest (RE 12.2.6) and 205 ha (36.4 %) of vegetation unit 2a; Mallee *Eucalyptus* spp. low

woodland (RE 12.2.10) will be protected within both the Ramsar area at the east of the site and the Cooroon Cooroonpah Creek exclusion buffer.

Areas of the 'Of Concern' Vegetation Community 1b; Open dry heath community (RE 12.2.13) are located on exposed dune ridges at higher elevations. These areas are unlikely to be in the path of any mining operations due to the topography encountered here. Slopes either side of the ridge line where this community is found exceed 40 % which excludes dry mining extraction under the methods currently employed. However there is the potential for up to 4.6 ha of this vegetation community to be cleared (Section 2.5.5). Two conservation areas are proposed in Community 1b at reference sites P3 and P4 (total area of approximately 1 ha) to ensure that the benchmark transects are protected for future reference for rehabilitation efforts (Figure 2).

3.2.2 Vegetation Clearing

The areas of vegetation to be cleared for the proposed mining operation will be restricted to the minimum required. Areas to be cleared will be clearly delineated prior to commencement of clearing with tape, pegs or other markers.

The preferred stripping method to be employed will ensure minimum clearing of vegetation on a weekly basis. Clearing proposed to be undertaken is estimated to be in the order of 30 m of clearing along the mine face, per week (depending on depth of the deposit). This method of minimum stripping will minimise dust emissions, and will allow fauna recourse to disperse into adjacent habitat out of the mine path.

Clearing will be undertaken to ensure that isolated stands of vegetation are not created and the connectivity of habitat remains intact to allow for the dispersal of fauna. That is, clearing will be undertaken towards the direction of any adjacent contiguous vegetation that is not to be cleared to ensure connectivity of habitat is not disrupted.

Cleared shrubby vegetation will be saved to be utilised as brush matting for landform stabilisation in rehabilitation works. Cleared canopy vegetation such as and large woody debris such as hollow logs and branches will be stored and then reinstated as structures for faunal habitat as part of rehabilitation works.

Removal of *Xanthorrhoea johnsonii* (forest black boy) and *Xanthorrhoea latifolia* (grass tree) will be undertaken to allow for relocation of these species in rehabilitation works. Similarly relocation may be undertaken for the significant *Acacia baueri*, *Gompholobium virgatum* var. *emarginatum*, *Boronia rosmarinifolia* and *Boronia saffrolifera* (Section 2.5.3) if propagation of any these species demonstrates low success rates.

3.2.3 Topsoil Battering

A batter of stockpiled topsoil is proposed to be aligned along the north-eastern extent of the mine operations (Figure 2). The proposed batter is to be constructed down slope of the proposed operations and will serve as a 30 m buffer to exclude any undue movement of sediment down slope to the Cooroon

Cooroonpah Creek exclusion area. The topsoil batter will be constructed to a height of no greater than 3 m, and sediment fencing will be constructed down slope of the batter, as required. If stabilisation of top soil is required will brush matting from cleared vegetation may be utilised. An appropriate cover crop will be applied on the batter to help maintain soil stability, soil fauna and microbial activity.

3.2.4 Weed Control

Generally weed presence in ML 1108 is relatively low. Soil disturbance and the introduction of vehicles and heavy machinery within the proposed operations footprint has the potential to introduce new and declared weeds to the site. If incidences of weed species are detected, appropriate measures will need to be implemented for eradication and continued monitoring of weed occurrence.

An effective weed control program will be implemented for the proposed mine footprint as an extension of the weed control program currently in place for present mining operations. The weed control program will include:

- Effective management methods to control spread of declared weed species⁵, in keeping with regional management practice or DNRM&E pest control fact sheets;
- Ongoing monitoring of the project site to identify any new incidence of weed infestation; and
- Provision of information for project staff on the identification of declared weeds.
- Dedicated machinery serviced on site and restricted to onsite use; and
- Wash down protocols for any non dedicated machinery or vehicles introduced to the site.

3.2.5 Rehabilitation of Disturbed Areas

All future proposed mine operations will be followed by a staged rehabilitation program to be undertaken behind the ongoing mine operation. Proposed rehabilitation will reform disturbed areas to previous contours with replacement of stored topsoil and will employ techniques involving direct seeding, and / or tube stock to ensure a viable success rate of re-established vegetation. Revegetation will utilise endemic species of local provenance to establish floral assemblages in keeping with vegetation communities presently found on the mining lease. Rehabilitation methods will be in keeping with current best practice in accordance with the EPA's rehabilitation objectives for mines (EPA, 2006).

⁵ Land Protection (Pest and Stock Route Management) Act, 2002

Progressive Rehabilitation

Rehabilitation will be progressively undertaken on areas that cease to be used for mining or mine-related activities within one year of becoming available. This will reduce the amount of disturbed land at any one time. Results of progressive rehabilitation will be used to refine rehabilitation methods for future mining operations.

Stored topsoil will be stockpiled to a height no greater than 3 m to ensure continued viability of the seed bank and microbial function. Rehabilitation will be undertaken with the objective to re-establish the pre-disturbance floristic and structural characteristics of the disturbed community in keeping with benchmark data obtained from permanent reference sites. Trial plots and will be undertaken where necessary to assess the suitability and success rate of proposed rehabilitation methods.

Significant Species

Rehabilitation will address the requirement for re-establishment of conservation significant species and species of cultural significance. Rehabilitation of conservation significant species will utilise appropriate propagation and / or relocation techniques for successful regeneration (Section 3.2.2).

Propagation of *Acacia baueri* has previously been achieved via standard seed raising methods following pre-treatment by soaking in boiling water or scarification. Cuttings have also been found to be successful in the propagation of this species (ASGAP, 2006a).

Limited information is available on the propagation of *Gompholobium virgatum* var. *emarginatum* however anecdotal reports suggest the species can be successfully transplanted (ASGAP, 2006b). At the genus level, *Gompholobium* seeds have been shown to germinate when pre-treated with smoke under nursery or field conditions (Vigilante *et al.*, 1998).

Monitoring

Rehabilitation performance criteria will be set based on the benchmark data from the permanent primary transects, and continued monitoring undertaken to ensure that an acceptable standard of rehabilitation is met. Regular monitoring will be undertaken during the vegetation establishment period, to demonstrate whether rehabilitation goals are being achieved and whether a sustainable landform has been developed.

Monitoring methodologies currently used in operation on the adjacent lease will be adopted and modified where necessary in a detailed monitoring program to be prepared for ML 1108. The monitoring program will be tailored to measure defined success criteria and undertaken regularly in order to establish the trend towards achievement of those criteria. Parameters to be monitored will potentially include, but not restricted to:

- Erosion and landform stability;
- Ongoing physical and biological analysis of topsoil;

-
- Comparison of floristic and structural characteristics with data taken from reference sites; and
 - Visual surveillance including the use of low level oblique or vertical aerial photography to monitor changes over time in the rehabilitation (e.g. changes in vegetation structure and landform).

In addition to rehabilitated areas, benchmark reference sites will also be monitored to allow for a meaningful comparison of the development and success of the rehabilitation against a control.

Monitoring will be conducted periodically by independent, suitably skilled and qualified persons at locations which will be representative of the range of conditions on the rehabilitating areas. Annual monitoring data reviews will be conducted to assess trends and rehabilitation program effectiveness. Rehabilitation methods will be improved as additional knowledge develops from monitoring data.

Maintenance

Maintenance of rehabilitated areas will be undertaken where necessary and in response to results of the monitoring program to ensure success criteria are being met, or are projected to be met at the time of mine closure. Depending on the criteria to be achieved, examples of maintenance works include re-seeding or further planting of tube stock of tree and/or shrub species to meet required revegetation parameters, and implementation of erosion protection measures to reduce erosion rates.

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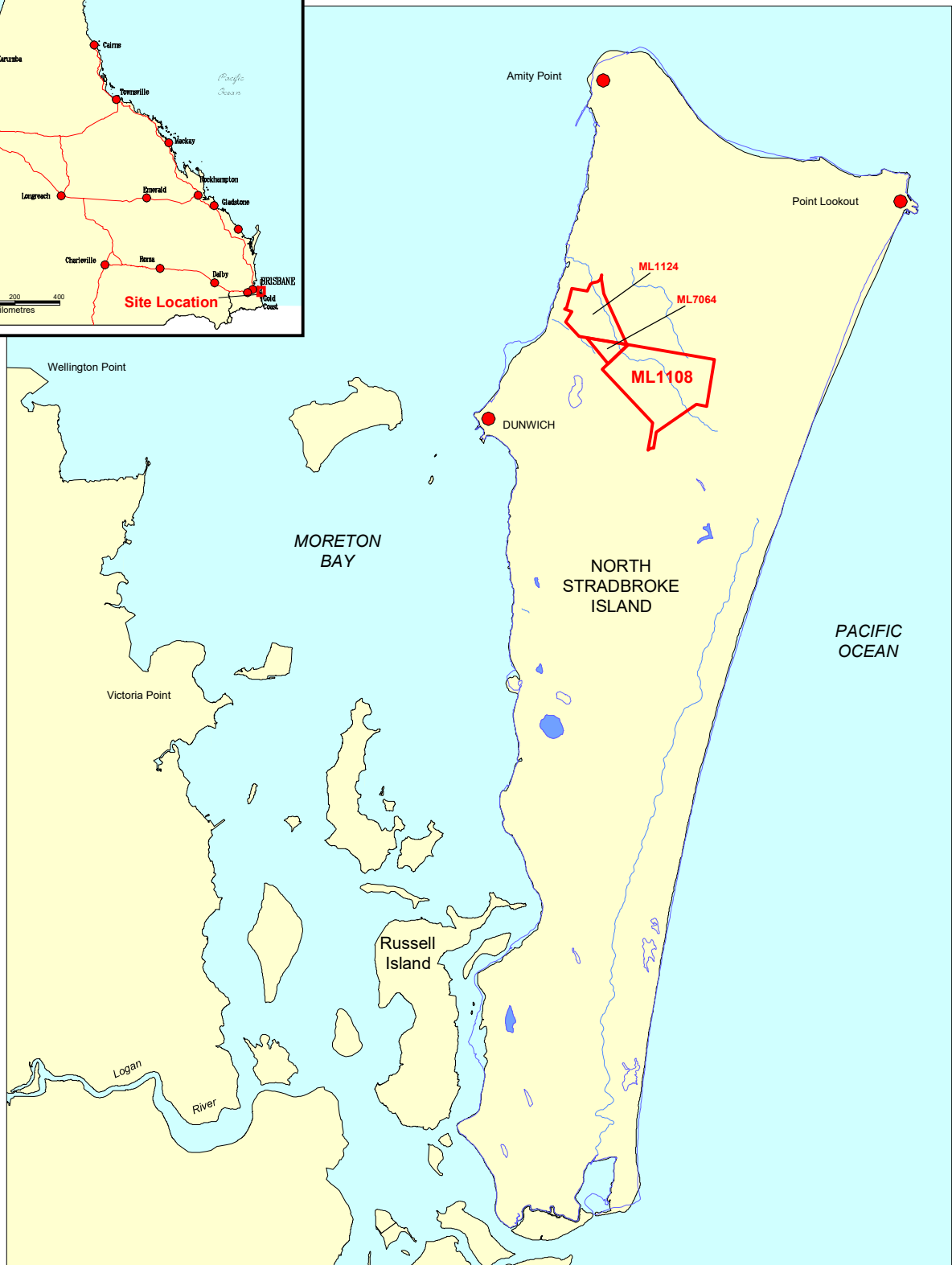
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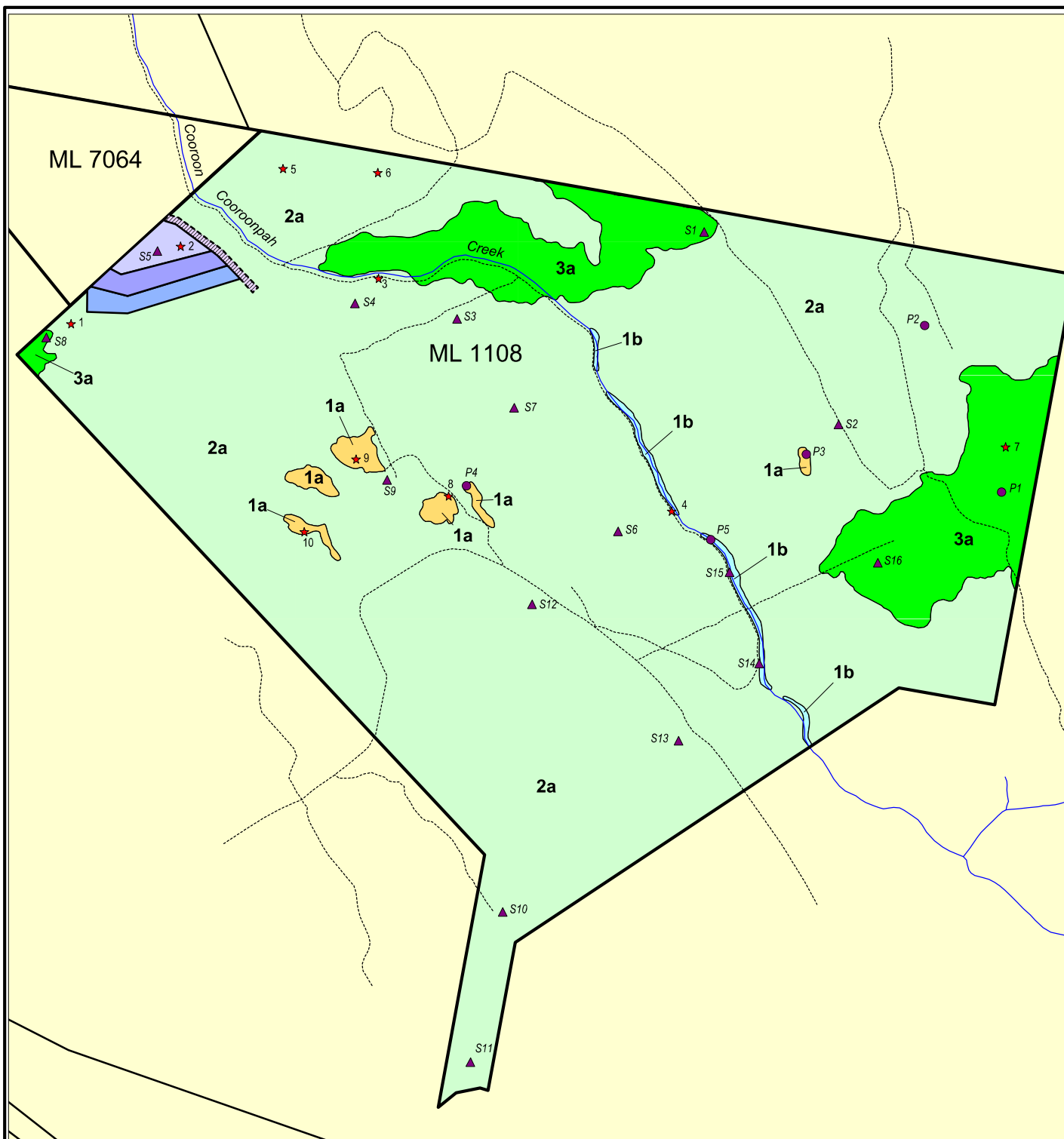
Figures



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Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project VANCE LEASE NORTH STRADBROKE ISLAND ENVIRONMENTAL STUDIES - FLORA REPORT			Title REGIONAL LOCATION	
	Drawn: LL	Approved: DS	Date: 11-10-2007		Rev: B
	Job No: 4262 5813	File No: 42625813-g-001b.wor			A4



LEGEND



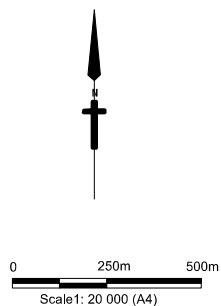
1a Low Open dry heath on Quaternary dunes and sand plains (RE 12.2.13)

1b Closed wet heath on seasonally waterlogged sand plains (RE 12.2.12)

2a Mallee *Eucalyptus* spp. low woodland on Quaternary dunes and sand plains (RE12.2.10)

3a *Eucalyptus* spp. woodland on Quaternary dunes and sand plains (RE12.2.6)

- ★ 1 2005 Transects
- P1 2006 Primary Transects
- ▲ S2 2006 Secondary Transects
- Qld EPA Approved Stage 1 Mining Operations Year 1
- Qld EPA Approved Stage 1 Mining Operations Year 2
- Qld EPA Approved Stage 1 Mining Operations Year 3
- Topsoil/Battering Buffer



Source: Client Supplied Aerial Photo (16-02-2005)

Client
UNIMIN AUSTRALIA LIMITED

Project
VANCE LEASE
NORTH STRADBROKE ISLAND
ENVIRONMENTAL STUDIES -
FLORA REPORT

Title
VEGETATION COMMUNITIES

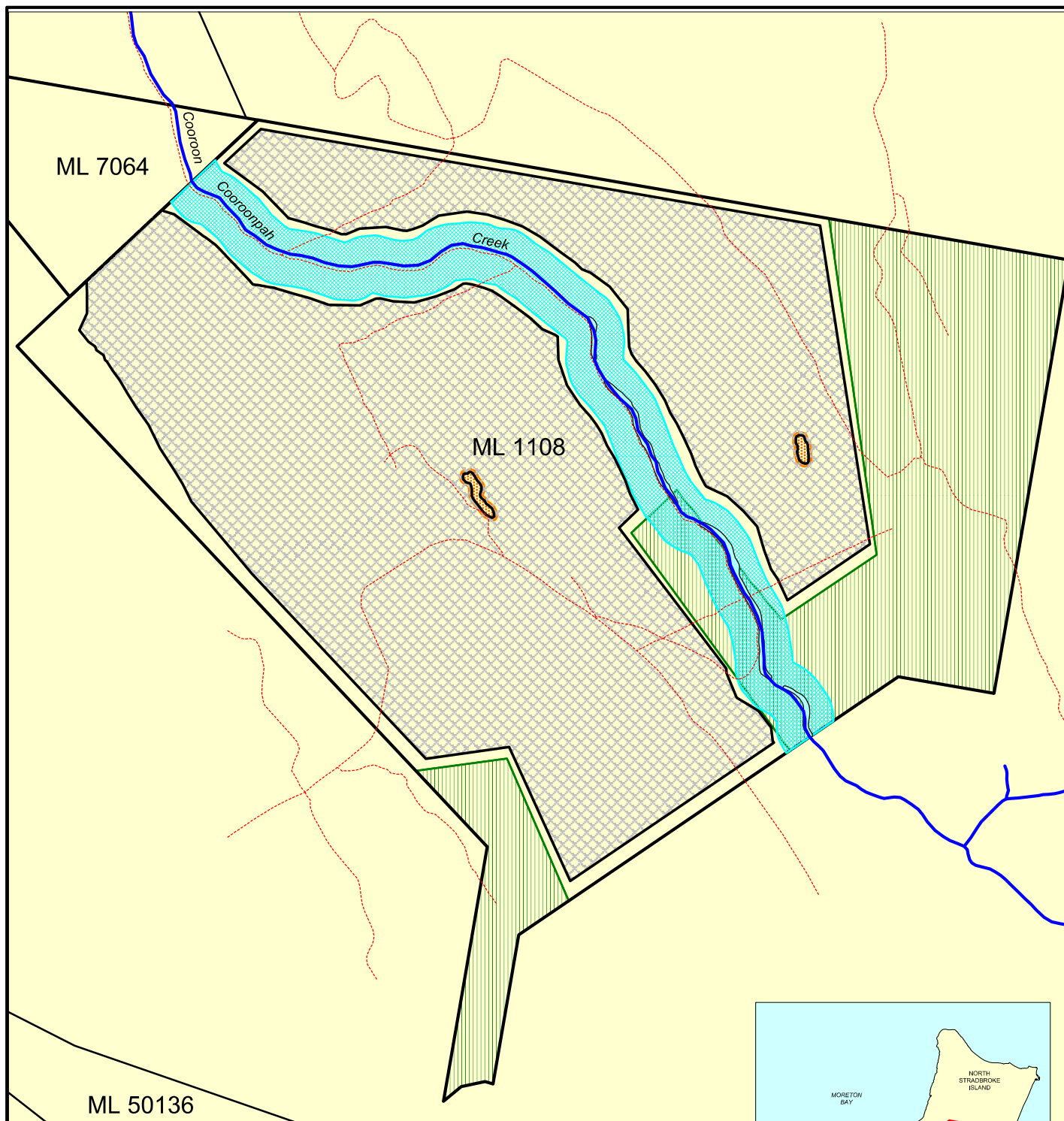
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Drawn: LL/TN Approved: DS Date: 11-10-2007

Job No: 4262 5813 File No: 42625813-g-002e.wor

Figure: 2

Rev: E
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LEGEND

-  Maximum Extent of Mine Footprint
-  Ramsar Area
-  Creek Buffer
-  Dry Heath Reference Sites
-  Tracks

Source: Client Supplied Aerial Photo (16-02-2005)

Client
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Project
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NORTH STRADBROKE ISLAND
ENVIRONMENTAL STUDIES -
FLORA REPORT

Title
**PROPOSED CONSERVATION AREAS
AND MAXIMUM EXTENT OF
MINE FOOTPRINT**

URS

Drawn: LL/TN Approved: JB Date: 11-10-2007
Job No: **4262 5813** File No: 42625813-g-004b.wor

Figure: 3

Rev: B
A4

Appendix A
Significant Species Potentially Present at
the Vance Mining Lease (ML 1108), North
Stradbroke Island

Appendix A Significant species potentially present at the Vance mining lease (ML 1108)

Scientific Name	Common Name	Conservation Status					Habitat Requirements	Previously Recorded on NSI ⁵
		AHC ¹		NCA ²	EPBC ³	ROTAP ⁴		
		Register Records	Reason Significant					
<i>Acacia baueri</i> subsp. <i>baueri</i>	tiny wattle			V			Infertile often seasonally water logged sands in coastal heath (wallum)	yes
<i>Acrostichum speciosum</i>	mangrove fern	S	occurs at higher densities than normal				Mangrove swamps or on cliff-faces by the sea	yes
<i>Arthraxon hispidus</i>				V			Damp shady places	yes
<i>Banksia spinulosa</i> var. <i>collina</i>	golden candlesticks	S, C, N	occurs on deep sand instead of sandstone				In open- forest or coastal heath in sand, loamy or shaly soils often over sandstone.	yes
<i>Blanfordia grandiflora</i>	christmas bells			R			Coastal wallum areas	yes
<i>Boronia saefrolifera</i>	saefrole boronia	S, C	northern limit				Swampy or badly drained wallum areas.	yes
<i>Calytrix tetragona</i>	fringe myrtle	S	occurs on sand instead of sandstone, northern limit in its coastal distribution, restricted shrub				Sandy or skeletal soils	yes
<i>Carex fasciculata</i>	tassel sedge	S, C, N	northern limit				In coastal districts, on creek banks and in swamps	yes

Scientific Name	Common Name	Conservation Status					Habitat Requirements	Previously Recorded on NSI ⁵
		AHC ¹		NCA ²	EPBC ³	ROTAP ⁴		
		Register Records	Reason Significant					
<i>Cryptocarya foetida</i>	stinking cryptocarya			V	V		Littoral closed- forest	yes
<i>Durringtonia paludosa</i>	durringtonia	N	Rare (3RC) ³	R			Moreton Is and Stradbroke Is within swamps in areas with permanent subsurface fresh water, associated with <i>Empodisma minus</i> in a closed-sedgeland community.	yes
<i>Eleocharis ochrostachys</i>	spikerush	S, C, N	southern limit				In near coastal swamps.	no
<i>Eriachne insularis</i>	wanderrie grass	S, C, N	southern limit				On sand, an understorey grass in open- forest.	yes
<i>Eucalyptus pilularis</i>	blackbutt	S, C	early stage of formation of rainforest (with lilly pilli understorey)				On slopes on sandy or other well drained siliceous soils, often on high sand dunes on the offshore islands.	yes
<i>Eucalyptus planchoniana</i>	planchon's stringybark	S, C	Tree of restricted range				On low ridges and gentle slopes of the offshore islands on deep sandy soils or subcoastal sandstone areas.	yes
<i>Gompholobium virgatum</i> var. <i>emarginatum</i>	notched wallum wedged pea			R			Sandy coastal areas	yes
<i>Goodenia arenicola</i>				R			Unknown, suspect headlands	yes
<i>Lepturus repens</i>		S, N	southern limit				Seacoasts, growing on sand or occasionally on rocky headlands.	yes
<i>Lycopus australis</i>	water horehound	S, C, N	northern limit				In <i>Phragmites</i> swamps on river banks	yes

Scientific Name	Common Name	Conservation Status					Habitat Requirements	Previously Recorded on NSI ⁵
		AHC ¹		NCA ²	EPBC ³	ROTAP ⁴		
		Register Records	Reason Significant					
<i>Melichrus procumbens</i>		S, C	southern limit; occurs on sand instead of sandstone and granite				Shallow soil overlying sandstone or granite.	yes
<i>Olearia hygrophila</i>	swamp daisy	N	Endangered (2E) ³ , endemic, population less than 10 plants	E	E		Known only from swampy ground on Stradbroke Island	yes
<i>Persicaria elatior</i>	smartweed			V	V		Swampy areas near Brisbane	yes
<i>Petalostigma pubescens</i>	quinine berry	S, N	southern limit in its coastal distribution				Mainly in open- forests, often on sandy soils	yes
<i>Petrophile canescens</i>	conesticks	C	Occurs on sand instead of sandstone				On consolidated sands or sandstone or rocky areas.	yes
<i>Petrophile shirleyae</i>	conesticks	S, C, N	southern limit				Coastal districts in heath areas or in wallum, on sand or sandy soils	yes
<i>Phaius australis</i>	swamp orchid			E	E	3VCa	Islands in Moreton Bay and on the mainland, in swamps	yes
<i>Phaius bernaysii</i>	swamp orchid			E	E		Islands in Moreton Bay and southern Wide Bay district, in swamps	yes
<i>Podocarpus spinulosus</i>	dwarf plum pine	C	Relict population				Stradbroke Island	yes
<i>Pterostylis nigricans</i>	brownhood orchid			R			Stradbroke Island on sandy soils under light coastal scrub.	yes
<i>Schoenus scabripes</i>	bog rush	C	Rare (3RC) ³	R			Swampy coastal areas of Moreton and Wide Bay districts	yes
<i>Syncarpia hillii</i>	a turpentine	C	Rare (3RC) ³				In higher rainfall areas	yes

Scientific Name	Common Name	Conservation Status					Habitat Requirements	Previously Recorded on NSI ⁵
		AHC ¹		NCA ²	EPBC ³	ROTAP ⁴		
		Register Records	Reason Significant					
<i>Thelypteris confluens</i>	soft swamp fern			V		3K+	Wet swampy ground	yes
<i>Thesium australe</i>	toadflax			V			Scattered throughout Moreton district, often in damp areas; root parasite	yes
<i>Todea barbara</i>	king fern	N	Largest stand on the island				Terrestrial, in swamps of the coastal heathlands, mountain gullies in rainforest, often beside streams, sometimes growing in rock crevices.	yes
<i>Xanthorrhoea fulva</i>	swamp grasstree	S	only occurrence on North Stradbroke Island				Coastal regions in swamps and wallum areas	yes
<i>Livistona/ Archontophoenix</i> rainforest	cabbage tree palm/ piccabeen palm	S	does not occur elsewhere on the island				Shaded moist areas	yes ⁶

¹ S Listed on the Australian Heritage Council (AHC) Register of the National Estate Database for the Southern Section of North Stradbroke Island

C Listed on the AHC Register of the National Estate Database for the Central Section of North Stradbroke Island

N Listed on the AHC Register of the National Estate Database for the Northern Section of North Stradbroke Island

² Status under the Queensland *Nature Conservation Act, 1992*.

PE Presumed Extinct

E Endangered

V Vulnerable

R Rare

³ Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999*:

EX Extinct

CE Critically Endangered

E Endangered

V Vulnerable

⁴ Status assigned by Briggs and Leigh (1996) *Rare or Threatened Australian Plants*:
3 Geographic range in Australia greater than 100 km

V Vulnerable

C Reserved

R Rare

E Endangered

K Poorly Known

+ Overseas occurrence

Ca The 1000 plants total can be from a single large population.

⁵ Based on HERBRECS database at December 2001 & January 2005

Appendix B

Primary Transect Field Data March 2006

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Appendix B

Primary Transect Field Data

B1.1 Master List of all Species on Primary Transects

Family	Plant Species	Common Name	¹ Growth Form	² Status	³ Relative Abundance				
					PT1	PT2	PT3	PT4	PT5
CONIFERS									
CUPRESSACEAE	<i>Callitris columellaris</i>	Bribie Island Pine	T	C					
PODOCARPACEAE	<i>Podocarpus spinulosus</i>	Yellow wood	T						
ANGIOSPERMS									
MIMOSACEAE	<i>Acacia baueri</i> ssp <i>baueri</i>	Tiny Wattle	SH	V			C	C	
MIMOSACEAE	<i>Acacia leiocalyx</i> ssp <i>leiocalyx</i>	Black Wattle	T						
MIMOSACEAE	<i>Acacia suaveolens</i>	Sweet Wattle	SH				O		
MIMOSACEAE	<i>Acacia ulicifolia</i>	Prickly Moses	SH	C	U	O		O-C	
MYRTACEAE	<i>Acmena smithii</i>	Lily Pilly	T						
CASUARINACEAE	<i>Allocasuarina littoralis</i>	Coastal She Oak	T	C					
CASUARINACEAE	<i>Allocasuarina torulosa</i>	Forest She Oak	T		O				
POACEAE	<i>Alloteropsis semialata</i>	Cockatoo Grass	H						
RHAMNACEAE	<i>Alphitonia excelsa</i>	Red Ash	T						
EUPHORBIACEAE	<i>Amperea xiphioclada</i>	Broom Spurge	SH				O		
MYRTACEAE	<i>Angophora woodsiana</i>	Wood's Apple	T						
FABACEAE	<i>Aotus ericoides</i>	Common Aotus	SH			C	A	O	
FABACEAE	<i>Aotus lanigera</i>	Pointed Aotus	SH						R
POACEAE	<i>Aristida calycina</i> c. <i>calycina</i>	Dark wiregrass	H						
POACEAE	<i>Aristida warburgii</i>	Speargrass	H						
ARALIACEAE	<i>Astrotricha longifolia</i>	Long-leaf star-hair	SH		R				
MYRTACEAE	<i>Austromyrtus dulcis</i>	Midyim	SH		O	O			
RESTIONACEAE	<i>Baloskion pallens</i>	Pale Cord Rush	H	C					
RESTIONACEAE	<i>Baloskion tetraphyllum</i>	Tassel Cord Rush	H	C					A
PROTEACEAE	<i>Banksia aemula</i>	Wallum Banksia	T	C	O	C	C	C	
PROTEACEAE	<i>Banksia spinulosa</i> v. <i>collina</i>	Golden Candlesticks	SH	C					
CYPERACEAE	<i>Baumea muelleri</i>	Flat Twigrush	H						C-A
CYPERACEAE	<i>Baumea rubiginosa</i>	Soft Twigrush	H						
RUTACEAE	<i>Boronia falcifolia</i>	Wallum Boronia	SH						C ¹
RUTACEAE	<i>Boronia rosmarinifolia</i>	Forest Boronia	SH		C	O	O		
RUTACEAE	<i>Boronia saffrolifera</i>	Ferny Boronia	SH				O-C		
FABACEAE	<i>Bossiaea ensata</i>	Leafless Bossiaea	SH				C	C	
FABACEAE	<i>Bossiaea heterophylla</i>	Variable Bossiaea	SH			U	C	O-C	
EPACRIDACEAE	<i>Brachyloma daphnoides</i>	Daphne Heath.	SH						
BURMANNIACEAE	<i>Burmannia disticha</i>	Native Stattus	H						U
ANTHERICACEAE	<i>Caesia parviflora</i>	Caesia	H						

Appendix B

Primary Transect Field Data

Family	Plant Species	Common Name	¹ Growth Form	² Status	³ Relative Abundance				
					PT1	PT2	PT3	PT4	PT5
LAURACEAE	<i>Cassytha filiformis</i>	Love vine	V		O ⁴		U		O
LAURACEAE	<i>Cassytha pubescens</i>	Dodder Vine	V		U			R	R
CYPERACEAE	<i>Caustis blakei</i>	Foxtail	H	C	R				
CYPERACEAE	<i>Caustis recurvata</i>	Curly Wig	H	C		C	C	C-A	
RESTIONACEAE	<i>Coleocarya gracilis</i>		H					O	
PROTEACEAE	<i>Conospermum taxifolium</i>	Devil's Rice	S	C			O	O	
MYRTACEAE	<i>Corymbia gummifera</i>	Red Bloodwood	T		U				
MYRTACEAE	<i>Corymbia intermedia</i>	Pink Bloodwood	T						
CYPERACEAE	<i>Cyperus polystachyos</i>	Bunchy sedge	H						
GOODENIACEAE	<i>Dampiera sylvestris</i>	Blue fan flower	SH		O				O
LILIACEAE	<i>Dianella caerulea</i>	Blue Flax Lilly	H		U				
LILIACEAE	<i>Dianella longifolia</i>	Blue Flax-lily	H						
FABACEAE	<i>Dillwynia retorta v retorta</i>	Eggs & Bacon Pea	SH				O	R	
SAPINDACEAE	<i>Dodonaea triquetra</i>	Large-leaved hop bush	SH		A				
DROSERACEAE	<i>Drosera binata</i>	Sundew	H						O
DROSERACEAE	<i>Drosera spatulata</i>	Sundew	H						C
ELAEOCARPACEAE	<i>Elaeocarpus reticulatus</i>	Blueberry Ash	T	C	R ⁴				
RESTIONACEAE	<i>Empodisma minor</i>	Spreading Rope Rush	H						A
POACEAE	<i>Entolasia stricta</i>	Wiry Panic	H		R	O	O-C	O	O-C
EPACRIDACEAE	<i>Epacris microphylla</i>	Coral Heath	C						C
EPACRIDACEAE	<i>Epacris pulchella</i>	Wallum Heath	SH			U			
POACEAE	<i>Eriachne pallescens</i>	A Wanderie Grass	H						
MYRTACEAE	<i>Eucalyptus pilularis</i>	Black Butt	T	C	C				
MYRTACEAE	<i>Eucalyptus planchoniana</i>	Needle Bark	T		R	C		U	
MYRTACEAE	<i>Eucalyptus racemosa</i>	Scribbly Gum	T		R			R	
SANTALACEAE	<i>Exocarpos cupressiformis</i>	Native Cherry	T	C					
CYPERACEAE	<i>Fimbristylis dichotoma</i>	Common Finger Rush	H						
CYPERACEAE	<i>Gahnia sieberiana</i>	Saw Sedge	H	C					
PHILESIACEAE	<i>Geitonoplesium cymosum</i>	Scrambling Lilly	V						
FABACEAE	<i>Gompholobium virgatum v emarginatum</i>	Wallum Wedge Pea	SH	R					
HALORAGACEAE	<i>Gonocarpus chinensis v verrucosus</i>	Chinese raspwort	SH		R				
HAEMODORACEAE	<i>Haemodorum tenuifolium</i>	Slender Blood-Lilly	H						
FABACEAE	<i>Hardenbergia violacea</i>	Native Sarsaparilla	V	C					
DILLENIACEAE	<i>Hibbertia acicularis</i>	Prickly Guinea Flower	SH						
DILLENIACEAE	<i>Hibbertia linearis</i>	Showy Guinea Flower	SH		C		C	A	

Appendix B

Primary Transect Field Data

Family	Plant Species	Common Name	¹ Growth Form	² Status	³ Relative Abundance				
					PT1	PT2	PT3	PT4	PT5
DILLENIACEAE	<i>Hibbertia salicifolia</i>	Willow Guinea Flower	SH						C
DILLENIACEAE	<i>Hibbertia vestita</i>	Hairy Guinea Flower	SH					R	
MYRTACEAE	<i>Homoranthus virgatus</i>	Banana Heath	SH		O			O	
RESTIONACEAE	<i>Hypolaena fastigiata</i>	Tassel Rope-rush	H					C-A	
POACEAE	<i>Imperata cylindrica</i>	Blady Grass	H		U				
CYPERACEAE	<i>Isolepis inundata</i>	Swamp Club-sedge	H						
FABACEAE	<i>Jacksonia stackhousii</i>	Wallum dogwood	SH						
LILIACEAE	<i>Laxmannia gracilis</i>	Slender Wire Lilly	H					O	
CYPERACEAE	<i>Lepidosperma laterale</i>	Variable sawsedge	H		U				
RESTIONACEAE	<i>Leptocarpus tenax</i>		H						
SANTALACEAE	<i>Leptomeria acida</i>	Native currant	SH						
MYRTACEAE	<i>Leptospermum liversidgei</i>	Lemon-scented tea tree	SH	C					A
MYRTACEAE	<i>Leptospermum polygalifolium</i>	Wild May	SH	C					
MYRTACEAE	<i>Leptospermum semibaccatum</i>	Heath May	SH				A	C-A	
MYRTACEAE	<i>Leptospermum speciosum</i>	Broad-leaved Tea Tree	SH						
MYRTACEAE	<i>Leptospermum trinervium</i>	Paperbark tea-tree	SH			A			
RESTIONACEAE	<i>Lepyrodia scariosa</i>	Scaly Rush	H			C			
EPACRIDACEAE	<i>Leucopogon ericoides</i>	Pink Beard Heath	SH						
EPACRIDACEAE	<i>Leucopogon leptospermoides</i>	Beard heath	SH			O		C	
EPACRIDACEAE	<i>Leucopogon margarodes</i>	Drab Beard-Heath	SH						
EPACRIDACEAE	<i>Leucopogon pedicellatus</i>	Heath Whitebeard	SH		O				
EPACRIDACEAE	<i>Leucopogon virgatus</i>		SH				U ⁴		
XANTHORRHOEACEAE	<i>Lomandra elongata</i>	Matt Rush	H						
XANTHORRHOEACEAE	<i>Lomandra filiformis</i>	Matt Rush	H						
XANTHORRHOEACEAE	<i>Lomandra longifolia</i>	Spinyhead Matt Rush	H		C		R		
XANTHORRHOEACEAE	<i>Lomandra multiflora</i>	Many Flowered Matt Rush	H	C					
ASCLEPIADACEAE	<i>Marsdenia fraseri</i>	Narrow-leaved Milk Vine	V						
EPACRIDACEAE	<i>Monotoca scoparia</i>	Prickly Broom Heath	SH		O	C	C	C	
MYRTACEAE	<i>Ochrosperma lineare</i>	Coast Myrtle	SH			A	C	A	C
OLACACEAE	<i>Olax retusa</i>	Olax	SH					C	
POACEAE	<i>Panicum effusum v simile</i>	Hairy panic	H						
IRIDACEAE	<i>Patersonia glabrata</i>	Leafy Purple Flag	H						
IRIDACEAE	<i>Patersonia sericea</i>	Silky Purple Flag	H	C			O	O	
PROTEACEAE	<i>Persoonia virgata</i>	Narrow-leaf Geebung	SH	C	U		O		
PROTEACEAE	<i>Petrophile canescens</i>	Conesticks	SH	C			C		
THYMELAEACEAE	<i>Pimelea linifolia</i>	Riceflower	SH	C			O	O	

Appendix B

Primary Transect Field Data

Family	Plant Species	Common Name	¹ Growth Form	² Status	³ Relative Abundance				
					PT1	PT2	PT3	PT4	PT5
APIACEAE	<i>Platysace ericoides</i>	Heath Platysace	SH						
RUBIACEAE	<i>Pomax umbellata</i>	Pomax	SH						
EUPHORBIACEAE	<i>Poranthera microphylla</i>	Small poranthera	SH						
PORTULACACEAE	<i>Portulaca oleracea</i>	Purslane	SH						
EUPHORBIACEAE	<i>Pseudanthus orientalis</i>	Sand Hill Pseudanthus	SH				A	C	
FABACEAE	<i>Pultenaea paleacea</i>	Chaffy Bush Pea	SH						
FABACEAE	<i>Pultenaea retusa</i>	Blunt Bush Pea	SH						
MYRSINACEAE	<i>Rapanea variabilis</i>	Muttonwood	T						
CYPERACEAE	<i>Rhynchospora brownii</i>	Brown's Beak-sedge	H						U
EUPHORBIACEAE	<i>Ricinocarpos pinifolius</i>	Wedding Bush	SH			O-C			
CYPERACEAE	<i>Schoenus ornithopodioides</i>	Bird's Foot Bog Rush	H				R	R	
SMILACACEAE	<i>Smilax australis</i>	Austral Smilax	V		O				
RESTIONACEAE	<i>Sporadanthus interruptus</i>		H						
EPACRIDACEAE	<i>Sprengelia sprengelioides</i>	Sprengelia	SH						C
MENISPERMACEAE	<i>Stephania japonica</i>	Snake Vine	V						
PROTEACEAE	<i>Strangea linearis</i>	Strangea	SH			U-O	C	C	
STYLIDIACEAE	<i>Stylidium debile</i>	Weak Triggerplant	H						O
EPACRIDACEAE	<i>Styphelia viridis</i>	Green-flowered Styphelia	SH	C		O			
MYRTACEAE	<i>Syzygium oleosum</i>	Blue Lillypilly	T						
TREMANDRACEAE	<i>Tetradlea thymifolia</i>	Black eyed Susan	S						
POACEAE	<i>Themeda triandra</i>	Kangaroo Grass	H						
LILIACEAE	<i>Tricoryne elatior</i>	Flat-stemmed rush-lily	H						
LENTIBULARIACEAE	<i>Utricularia dichotoma</i>	Bladderwort	H						O-C
FABACEAE	<i>Viminaria juncea</i>	Golden spray	SH				A	C	
EPACRIDACEAE	<i>Woolisia pungens</i>	Woolisia	SH			A			
XANTHORRHOEACEAE	<i>Xanthorrhoea johnsonii</i>	Forest Black-Boy	SH	C	O	U-O	O	A	
XANTHORRHOEACEAE	<i>Xanthorrhoea latifolia</i>	Grass tree	SH	C					
APIACEAE	<i>Xanthosia pilosa</i>	Woolly Xanthosia	H						
RUTACEAE	<i>Zieria laxiflora</i>		SH		O				
PTERIDOPHYTES - FERNS									
BLECHNACEAE	<i>Blechnum indicum</i>	Bungwahl	F	C					
DENNSTAEDTIACEAE	<i>Pteridium esculentum</i>	Common Bracken Fern	F	C	C	R			
SCHIZAEACEAE	<i>Schizaea bifida</i>	Forked Comb Fern	F						
SELLAGINELLACEAE	<i>Selaginella uliginosa</i>	Swamp selaginella	F						O ⁴

¹ Growth Form:
Tree T
Shrub SH

³ Relative Abundance:
1-10 plants RARE R
11-20 plants UNCOMMON U

Appendix B

Primary Transect Field Data

Herb	H	21- 30 plants	OCCASIONAL	O
Vine	V	31 - 50 plants	COMMON	C
Fern	F	> 51 plants	ABUNDANT	A

² **Conservation Status:**

Vulnerable species (Schedule 3 - *Nature Conservation Act, 1992*) **V**

Rare species (Schedule 4 - *Nature Conservation Act, 1992*) **R**

Common species (Schedule 5 *Nature Conservation Act, 1992*) **C**

⁴ **Spring Survey**

These species were recorded during the spring survey (September 2006). Relative abundances are qualitative estimates only.

Appendix B

Primary Transect Field Data

B1.2 Reference Site P1: Vegetation Community 3a; *Eucalyptus* spp. open forest (RE 12.2.6)

Reference Site 1 (P1) was located within a tall mixed Eucalypt open forest community to the east of the study site within the area currently protected under ‘Ramsar’ designation (Figure 1). The transect was aligned along the north-south of the contour, upslope of the main vehicle access track to this part of the lease. The regional ecosystem most analogous to this community is RE 11.2.6: *Eucalyptus racemosa*, *Corymbia intermedia*, *C. gummifera*, *Angophora leiocarpa* and *E. pilularis* shrubby or grassy woodland to open-forest on Quaternary coastal dunes and beaches. This community was found to be mainly located on elevated dunes to the east and north of the site.

The community was generally found to be co-dominated dominated in the canopy by *Eucalyptus Pilularis* (needle bark) and *E. racemosa* to a height of 25m. *Corymbia gummifera* (red bloodwood) was usually present, however floristic variation was evident across the lease with *E. Pilularis*, *E. racemosa* and *C. gummifera* all exhibiting dominance in the canopy at various locations. Disturbance was minimal at this site, with some fire disturbance evident within the past 2-5 years. Detailed structural and floristic data for this site is presented below.



Plate B.1: Example of mixed tall Eucalypt forest at Reference Site 1 (08/03/06)

Appendix B

Primary Transect Field Data

Transect information

Primary Transect 1	08/03/06	
Community	Mixed Sclerophyll Open Forest	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	North end of transect (0 m)	South end of transect (50 m)
	0547095 mE 6959495 mN	0547045 mE 6959449 mN
Transect Bearing	194 ⁰ S	
Aspect	290 ⁰ W	
Slope	23 ⁰ (43 %)	
Soil (A Horizon)	Grey sandy loam	
Disturbance	Intense burn within 2–5 yrs	

Structure

P1: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	18-25	40	Mid dense
Mid (T2)	8-10		Very sparse
Shrub (S1)	1-3		Dense
Ground (G)	<1	9	sparse

¹ After Walker and Hopkins, 1990

Basal Count

P1: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	2
<i>Eucalyptus pilularis</i>	12
<i>Eucalyptus racemosa</i>	1

Canopy, mid and shrub Layer Transect Data

Ref Site P1: T1 & T2 50x10 m Plot						
Species	Strata	Height (m)	DBH (cm)	Crown (m)	x (m)	y (m)
<i>Banksia aemula</i>	mid	8	25	2.50	15.00	6.00
<i>Eucalyptus pilularis</i>	canopy	25	43	8.00	21.70	3.50
<i>Eucalyptus racemosa</i>	canopy	15	35	5.00	40.90	5.00
<i>Banksia aemula</i> (dead)	mid	3	24	0.00	36.40	2.50
<i>Banksia aemula</i>	mid	10	21	2.00	40.10	2.00
<i>Corymbia gummifera</i>	canopy	15	36	10.00	47.60	2.50

Appendix B

Primary Transect Field Data

Ref Site P1:						
T1 & T2 50x10 m Plot						
<i>Allocasuarina torulosa</i> (dead)	canopy	15	35	0.00	46.50	-2.00
<i>Eucalyptus pilularis</i>	canopy	15	65	4.00	45.70	-5.00
<i>Banksia aemula</i> (dead)	mid	3.5	25	0.00	36.60	-2.00
<i>Eucalyptus pilularis</i>	canopy	20	55	10.00	36.30	-4.00
<i>Eucalyptus pilularis</i>	canopy	20	55	10.00	29.60	-2.00
<i>Eucalyptus pilularis</i> (dead)	canopy	15	65	0.00	15.30	-0.50
<i>Eucalyptus pilularis</i>	canopy	20	75	12.00	6.60	-1.50
S1 50x2 m Sub plot						
<i>Dodonaea triquetra</i>	shrub	1.4	0.5	0.70	2.90	2.00
<i>Xanthorrhoea johnsonii</i>	shrub	1.8	30	1.40	6.30	2.40
<i>Xanthorrhoea johnsonii</i>	shrub	1.6	30	0.90	8.20	2.50
<i>Dodonaea triquetra</i>	shrub	1.7	0.5	0.70	8.20	4.10
<i>Dodonaea triquetra</i>	shrub	2	0.5	0.80	12.40	4.00
<i>Dodonaea triquetra</i>	shrub	1.6	0.5	0.30	12.40	20.00
<i>Xanthorrhoea johnsonii</i>	shrub	3.8	30	2.00	12.40	5.80
<i>Dodonaea triquetra</i>	shrub	1.4	0.5	0.10	0.00	5.30
<i>Xanthorrhoea johnsonii</i>	shrub	1.6	20	1.10	10.40	0.90
<i>Dodonaea triquetra</i>	shrub	1.6	0.5	0.30	12.40	0.20
<i>Dodonaea triquetra</i>	shrub	1.8	0.5	0.35	13.10	-0.70
<i>Dodonaea triquetra</i>	shrub	1.5	0.5	0.20	17.80	-0.60
<i>Banksia aemula</i>	shrub	1.8	2	0.40	22.70	-1.00
<i>Dodonaea triquetra</i>	shrub	1.6	0.5	0.30	23.50	0.70
<i>Dodonaea triquetra</i>	shrub	1.4	0.5	0.20	24.30	0.00
<i>Dodonaea triquetra</i>	shrub	1.8	0.5	0.50	22.30	0.00
<i>Dodonaea triquetra</i>	shrub	1.7	0.5	0.50	29.50	0.60
<i>Dodonaea triquetra</i>	shrub	2.1	0.5	0.80	40.60	0.00
<i>Dodonaea triquetra</i>	shrub	1.8	0.5	0.40	44.50	0.00
<i>Xanthorrhoea johnsonii</i>	shrub	1.3	30	1.70	45.40	0.00
<i>Xanthorrhoea johnsonii</i>	shrub	1.3	30	1.60	47.00	1.10
<i>Dodonaea triquetra</i>	shrub	2.1	0.5	0.80	48.10	0.10
<i>Pteridium esculentum</i>	shrub	1.3	0.5	0.90	48.60	-0.40
<i>Dodonaea triquetra</i>	shrub	1.4	0.5	0.20	48.80	0.00

Ground layer quadrat data

P1: Quadrat 1		
1x1 m sub plot Intersecting transect at 0 m		
Species	Count	Cover (%)
<i>Lomandra longifolia</i>	2	2.00%
<i>Pteridium esculentum</i>	2	2.00%
<i>Monotoca scoparia</i>	1	1.00%
Total plant cover		5.00%
Leaf Litter		95.00%

Appendix B

Primary Transect Field Data

P1: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Species	Count	Cover (%)
<i>Lomandra longifolia</i>	2	2.00%
<i>Boronia rosmarinifolia</i>	1	1.00%
<i>Xanthorrhoea johnsonii</i>	1	1.00%
Total plant cover		4.00%
Leaf litter		96.00%

P1: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Imperata cylindrica</i>	4	4.00%
<i>Banksia aemula</i>	1	1.00%
<i>Dodonaea triquetra</i>	1	1.00%
<i>Eucalyptus pilularis</i>	1	1.00%
<i>Smilax australis</i>	1	1.00%
Total plant cover		8.00%
Leaf litter		92.00%

P1: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Dampiera sylvestre</i>	5	5.00%
<i>Lomandra longifolia</i>	4	4.00%
<i>Boronia rosmarinifolia</i>	2	2.00%
<i>Imperata cylindrica</i>	2	2.00%
<i>Dianella caerulea</i>	1	1.00%
<i>Lepidosperma laterale</i>	1	1.00%
<i>Monotoca scoparia</i>	1	1.00%
Total plant cover		16.00%
Leaf Litter		84.00%

P1: Quadrat 5 1 x 1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Cassytha pubescens</i>	2	2.00%
<i>Dodonaea triquetra</i>	2	2.00%
<i>Lomandra longifolia</i>	2	2.00%
<i>Dampiera sylvestre</i>	1	1.00%
<i>Hibbertia linearis</i>	1	1.00%
<i>Pteridium esculentum</i>	1	1.00%
Total plant cover		9.00%
Leaf Litter		91.00%

Appendix B

Primary Transect Field Data

B1.3 Reference Site P2: Vegetation Community 2a; Mallee *Eucalyptus* spp. low woodland (12.2.10).

Reference Site P2 is located within a Mallee *Eucalyptus* spp. low woodland community at the north east of the study site within the area currently protected under a 'Ramsar' designation. The transect was aligned on the north south contour, approximately 80 m down slope of the of the communication tower maintenance track (Figure 2).

The regional ecosystem most analogous to this community is RE 11.2.10 Mallee *Eucalyptus* spp. low woodland on Quaternary dunes and sand plains. This community is found on most landforms of the lease including the Cooroon Cooroonpah Creek drainage line, lower and upper slopes and elevated high dunes. This community is primarily dominated by mallee form of *Eucalyptus planchoniana* (needle bark) with *Banksia aemula* (wallum banksia), however was also found to be dominated by the mallee form of *Eucalyptus racemosa* (scribbly gum) in more exposed areas close to the ridge lines on elevated dunes. Detailed structural and floristic data for this site is presented below.



Plate B.2: Example of Mallee woodland community at Reference Site 2 (08/03/06)

Appendix B

Primary Transect Field Data

Transect information

Primary Transect 2	08/03/06	
Community	Mallee woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	South end of transect (0 m)	North end of transect (50 m)
	0546784mE 6960083mN	0546765mE 6960129mN
Transect Bearing	340 ⁰ N	
Aspect	245 ⁰ W	
Slope	24 ⁰ (45 %)	
Soil (A Horizon)	Grey sandy loam, med organic content	
Disturbance	No signs of fire within 5 yrs	

Structure

P2: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	8-10	20- 25	Mid dense
Shrub (S1)	2-3	70	Dense
Ground (G)	<1	98	Very dense

¹After (Walker and Hopkins, 1990)

Basal Count

P2: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	2
<i>Eucalyptus planchoniana</i>	13

Canopy, mid and shrub Layer Transect Data

Reference Site P2: Canopy and Mid 10x50 m Plot						
Species	Strata	Height (m)	DBH (cm)	Crown (m)	x (m)	y (m)
<i>Eucalyptus planchoniana</i>	C	3	6	2.50	10.40	-2.00
<i>Eucalyptus planchoniana</i>	C	3.5	5	1.00	11.60	-0.50
<i>Eucalyptus planchoniana</i>	C	3.5	4	1.00	11.90	-1.30
<i>Banksia aemula</i>	C	3	5	1.00	13.00	-3.00
<i>Banksia aemula</i>	C	3.5	8	1.00	13.80	-3.20
<i>Eucalyptus planchoniana</i>	C	5	5	1.50	15.50	-1.40
<i>Eucalyptus planchoniana</i>	C	5	5	1.00	16.10	-3.00
<i>Eucalyptus planchoniana</i>	C	5	7	1.00	16.70	-1.20

Appendix B

Primary Transect Field Data

Reference Site P2: Canopy and Mid 10x50 m Plot						
<i>Eucalyptus planchoniana</i>	C	5	5	1.00	17.10	-3.00
<i>Eucalyptus planchoniana</i>	C	4	4	1.00	18.10	-1.50
<i>Eucalyptus planchoniana</i>	C	5	10	3.00	24.10	-1.00
<i>Eucalyptus planchoniana</i>	C	5	10	2.00	26.40	-2.00
<i>Eucalyptus planchoniana</i>	C	5	8	3.00	28.80	-1.00
<i>Banksia aemula</i>	M	2.5	20	3.00	38.50	-2.50
<i>Banksia aemula</i>	M	2	10	2.00	40.40	0.00
<i>Banksia aemula</i>	M	2	10	2.00	41.10	-1.00
<i>Banksia aemula</i>	C	5	30	3.00	45.40	-1.00
<i>Eucalyptus planchoniana</i>	C	5	8	2.00	45.90	-3.50
<i>Banksia aemula</i>	M	2	15	2.00	47.40	-1.00
<i>Eucalyptus planchoniana</i>	C	4	6	1.00	48.30	-3.00
<i>Banksia aemula</i>	M	2	10	1.00	49.50	3.00
<i>Eucalyptus planchoniana</i>	C	3.5	3	1.00	48.00	0.80
<i>Banksia aemula</i>	M	3	10	1.00	44.20	1.50
<i>Banksia aemula</i>	M	3	15	1.50	38.40	3.00
<i>Banksia aemula</i>	M	3	15	2.00	32.70	0.00
<i>Banksia aemula</i>	C	4	30	3.00	31.40	2.00
<i>Eucalyptus planchoniana</i>	C	5	10	1.00	29.00	0.20
<i>Eucalyptus planchoniana</i>	C	6	15	1.50	28.30	1.00
<i>Eucalyptus planchoniana</i>	C	6	10	1.00	28.90	4.00
<i>Eucalyptus planchoniana</i>	C	7	15	2.00	28.50	5.00
<i>Eucalyptus planchoniana</i>	C	7	15	2.00	29.00	5.00
<i>Eucalyptus planchoniana</i>	C	5	10	1.00	27.20	0.10
<i>Eucalyptus planchoniana</i>	C	4.5	6	1.00	26.40	1.30
<i>Banksia aemula</i>	M	3	20	3.00	26.10	5.00
<i>Banksia aemula</i>	M	4	15	3.00	23.10	2.00
<i>Eucalyptus planchoniana</i>	C	8	20	5.00	19.80	5.00
<i>Banksia aemula</i>	M	3	20	3.00	19.10	1.00
<i>Banksia aemula</i>	M	3	15	3.00	12.90	0.50
<i>Eucalyptus planchoniana</i>	C	6.5	10	5.00	11.60	5.00
<i>Eucalyptus planchoniana</i>	C	6	10	3.00	6.90	4.00
Shrub 2x50 m Sub plot						
<i>Leptospermum trinervium</i>	S				1.70	-0.30
<i>Woollsia pungens</i>	S				1.00	-0.70
<i>Leptospermum trinervium</i>	S	2	2	0.60	2.50	-0.60
<i>Monotoca scoparia</i>	S				2.90	1.20
<i>Leptospermum trinervium</i>	S				3.20	0.40
<i>Woollsia pungens</i>	S				5.30	0.80
<i>Ochrosperma lineare</i>	S				5.10	0.60
<i>Woollsia pungens</i>	S				4.90	-0.10
<i>Woollsia pungens</i>	S				6.10	0.10
<i>Ochrosperma lineare</i>	S				5.20	0.30
<i>Strangea linearis</i>	S				5.70	1.00
<i>Banksia aemula</i>	S	2.2	3	1.30	6.30	-1.00
<i>Ochrosperma lineare</i>	S				6.80	0.00
<i>Woollsia pungens</i>	S				7.30	0.00
<i>Monotoca scoparia</i>	S				6.90	0.70

Appendix B

Primary Transect Field Data

Reference Site P2: Canopy and Mid 10x50 m Plot						
<i>Woollsia pungens</i>	S				7.40	0.9
<i>Woollsia pungens</i>	S				7.90	0.60
<i>Monotoca scoparia</i>	S				7.60	-0.20
<i>Woollsia pungens</i>	S				8.30	0.70
<i>Ochrosperma lineare</i>	S				8.60	0.00
<i>Ochrosperma lineare</i>	S				8.70	0.40
<i>Ochrosperma lineare</i>	S				8.90	0.60
<i>Ochrosperma lineare</i>	S				9.10	0.40
<i>Ochrosperma lineare</i>	S				9.10	-0.80
<i>Monotoca scoparia</i>	S	2.2	3	1.00	9.50	-1.00
<i>Ochrosperma lineare</i>	S				10.00	0.00
<i>Ochrosperma lineare</i>	S				10.00	0.00
<i>Ochrosperma lineare</i>	S				10.00	0.30
<i>Ochrosperma lineare</i>	S				10.00	0.50
<i>Ochrosperma lineare</i>	S				10.00	0.80
<i>Ochrosperma lineare</i>	S				9.70	0.80
<i>Ricinocarpos pinifolius</i>	S				9.70	1.00

Key:

Canopy **C (T1)**

Mid **M (T2)**

Shrub **S (S1)**

Ground layer quadrat data

P2 Quadrat 1 1x1 m sub plot Intersecting transect at 0 m	
Species	Cover (%)
<i>Leptospermum trinervium</i>	25.00%
<i>Lepyrodi scariosa</i>	20.00%
<i>Monotoca scoparia</i>	15.00%
<i>Ochrosperma lineare</i>	10.00%
<i>Woollsia pungens</i>	10.00%
<i>Caustis recurvata</i>	5.00%
<i>Boronia rosmarinifolia</i>	5.00%
<i>Aotus ericoides</i>	3.00%
<i>Ricinocarpos pinifolius</i>	1.00%
Total plant coverage	94.00%
Bare sand	6.00%

P2 Quadrat 2 1x1 m sub plot Intersecting transect at 10 m	
Species	Percentage
<i>Ochrosperma lineare</i>	85.00%
<i>Woollsia pungens</i>	5.00%
<i>Lepyrodi scariosa</i>	5.00%
<i>Monotoca scoparia</i>	3.00%
<i>Ricinocarpos pinifolius</i>	2.00%

Appendix B

Primary Transect Field Data

P2 Quadrat 2 1x1 m sub plot Intersecting transect at 10 m	
Total plant coverage	100.00%
Bare sand	0.00%

P2 Quadrat 3 1x1 m sub plot Intersecting transect at 20 m	
Species	Percentage
<i>Ochrosperma lineare</i>	80.00%
<i>Woollsia pungens</i>	10.00%
<i>Ricinocarpos pinifolius</i>	5.00%
<i>Epacris pulchella</i>	2.00%
<i>Acacia ulicifolia</i>	1.00%
<i>Caustis recurvata</i>	1.00%
<i>Lepyrodia scariosa</i>	1.00%
Total plant coverage	100.00%
Bare sand	0.00%

P2 Quadrat 4 1x1 m sub plot Intersecting transect at 30 m	
Species	Percentage
<i>Ochrosperma lineare</i>	80.00%
<i>Ricinocarpos pinifolius</i>	18.00%
<i>Bossia heterophylla</i>	1.00%
<i>Lepyrodia scariosa</i>	1.00%
Total plant coverage	100.00%
Bare sand	0.00%

P2 Quadrat 5 1x1 m sub plot Intersecting transect at 40 m	
Species	Percentage
<i>Banksia aemula</i>	85.00%
<i>Leptospermum trinervium</i>	8.00%
<i>Ochrosperma lineare</i>	3.00%
<i>Boronia rosmarinifolia</i>	1.00%
<i>Epacris pulchella</i>	1.00%
<i>Lepyrodia scariosa</i>	1.00%
<i>Woollsia pungens</i>	1.00%
Total plant coverage	100.00%
Bare sand	0.00%

Appendix B

Primary Transect Field Data

B1.4 Reference Site P3: Vegetation Community 1a; Low open dry heath (RE 12.2.13)

Reference Site P3 is located at the east of the site in a relatively small extent (approximately 0.34 ha) of low open dry heathland. The transect is located approximately 200 m down slope, to the south west of the Mount Bippo Penbean wheel drive vehicle access track (Figure 2).

The regional ecosystem most analogous to this community is RE 11.2.10 Mallee *Eucalyptus spp.* low woodland on Quaternary dunes and sand plains. As well as being present at Transect P3, extents of this community are present in exposed ridge areas on the high dunes to the west of the site. This community is dominated by a number of Myrtaceous and Fabaceae heath species. However *Banksia aemula* (wallum banksia) is growing around the edges and as isolated scattered examples throughout the heath community. Detailed structural and floristic data for this site is presented below.



Figure B.3: Example of Dry heath vegetation at Primary Transect 3 (09/03/06)

Appendix B

Primary Transect Field Data

Transect information

Primary Transect 3	09/03/06	
Community	Open dry heath	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	North end of transect (0 m)	South end of transect (50 m)
	0546375mE 6959630mN	0546369mE 6959810mN
Transect Bearing	190 ⁰ S	
Aspect	180 ⁰ S	
Slope	30 ⁰ (57%)	
Soil (A Horizon)	Grey sandy loam, leached with low organic content	
Disturbance	Med intensity burn within previous 2 yrs	

Structure

P3: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Emergent (S1)	1.5-3.0	n/a	Isolated plants
Canopy (S2)	>1.0	59	Mid-dense
Mid (S3)	0.70-1.0		Mid-dense
Ground (G)	<0.70	60	Mid-dense

¹ After Walker and Hopkins, 1990

Basal Count

P3: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	1

Canopy, mid and shrub Layer Transect Data

Reference Site P3: S1 10x50 m plot						
Species	Strata	Height (m)	DBH (cm)	Crown (m)	x (m)	y (m)
<i>Banksia aemula</i>	E	1.8	10	1.60	7.00	-1.90
<i>Banksia aemula</i>	E	2.2	15	3.00	11.10	5.00
<i>Banksia aemula</i>	E	1.6	8	1.00	25.30	-3.00
<i>Banksia aemula</i>	E	3.2	25	3.00	43.40	5.00
S2 & S3 2x50 m sub plot						
<i>Leptospermum semibaccatum</i>	C				3.60	0.00
<i>Leptospermum semibaccatum</i>	C				8.40	-1.50

Appendix B

Primary Transect Field Data

Reference Site P3: S1 10x50 m plot						
<i>Leptospermum semibaccatum</i>	C				10.90	0.60
<i>Strangea linearis</i>	M				2.50	0.70
<i>Aotus ericoides</i>	M				5.10	-0.80
<i>Aotus ericoides</i>	M				6.00	0.00
<i>Xanthorrhoea johnsonii</i>	M				5.90	-0.80
<i>Petrophile canescens</i>	M				8.20	-0.60
<i>Hibbertia linearis</i>	M				11.60	0.50
<i>Leptospermum semibaccatum</i>	C				17.60	0.30
<i>Banksia aemula</i>	C				17.90	-0.10
<i>Aotus ericoides</i>	M				21.10	0.80
<i>Leptospermum semibaccatum</i>	M				23.40	0.90
<i>Leptospermum semibaccatum</i>	M				23.00	-0.50
<i>Aotus ericoides</i>	M				24.30	-0.90
<i>Aotus ericoides</i>	M				25.00	0.00
<i>Leptospermum semibaccatum</i>	M				26.30	0.40
<i>Leptospermum semibaccatum</i>	M				27.00	1.00
<i>Leptospermum semibaccatum</i>	C				29.20	0.60
<i>Leptospermum semibaccatum</i>	M				31.20	0.90
<i>Leptospermum semibaccatum</i>	M				32.10	1.00
<i>Petrophile canescens</i>	C				32.90	-1.00
<i>Banksia aemula</i>	M				34.40	0.90
<i>Petrophile canescens</i>	M				34.90	-1.00
<i>Leptospermum semibaccatum</i>	M				37.10	0.00
<i>Leptospermum semibaccatum</i>	C				38.90	0.60
<i>Leptospermum semibaccatum</i>	M				39.70	0.60
<i>Leptospermum semibaccatum</i>	M				40.30	0.00
<i>Leptospermum semibaccatum</i>	M				40.30	-0.40
<i>Leptospermum semibaccatum</i>	C				41.80	0.70
<i>Leptospermum semibaccatum</i>	C				42.10	0
<i>Aotus ericoides</i>	M				41.90	-0.60
<i>Xanthorrhoea johnsonii</i>	M				42.60	0.40
<i>Leptospermum semibaccatum</i>	C				42.50	-0.80
<i>Leptospermum semibaccatum</i>	M				43.50	-0.60
<i>Leptospermum semibaccatum</i>	C				46.90	0.00
<i>Leptospermum semibaccatum</i>	M				47.50	0.20
<i>Leptospermum semibaccatum</i>	C				48.10	0.70
<i>Xanthorrhoea johnsonii</i>	M				48.40	0.90
<i>Leptospermum semibaccatum</i>	M				48.30	-0.60
<i>Banksia aemula</i>	C				49.20	-0.70

Key:

Emergent **E (S1)**

Canopy **C (S2)**

Mid **M (S3)**

Appendix B

Primary Transect Field Data

Ground layer quadrat data

P3 Quadrat 1 1x1 m sub plot Intersecting transect at 0 m	
Species	Cover (%)
<i>Aotus ericoides</i>	30.00%
<i>Ochrosperma lineare</i>	6.00%
<i>Hibbertia linearis</i>	5.00%
<i>Caustis recurvata</i>	2.00%
<i>Viminaria juncea</i>	2.00%
<i>Acacia baueri</i>	1.00%
<i>Acacia suaveolens</i>	1.00%
<i>Cassytha filiformis</i>	1.00%
<i>Monotoca scoparia</i>	1.00%
<i>Pseudanthus orientalis</i>	1.00%
Total plant coverage	50.00%
Bare sand	50.00%

P3 Quadrat 2 1x1 m sub plot Intersecting transect at 10 m	
Species	Percentage
<i>Leptospermum semibaccatum</i>	50.00%
<i>Caustis recurvata</i>	5.00%
<i>Ochrosperma lineare</i>	5.00%
<i>Aotus ericoides</i>	3.00%
<i>Pseudanthus orientalis</i>	2.00%
<i>Viminaria juncea</i>	2.00%
<i>Banksia aemula</i>	1.00%
<i>Bossiaea heterophylla</i>	1.00%
<i>Patersonia sericea</i>	1.00%
Total plant coverage	70.00%
Bare sand	30.00%

P3 Quadrat 3 1x1 m sub plot Intersecting transect at 20 m	
Species	Percentage
<i>Bossiaea heterophylla</i>	20.00%
<i>Viminaria juncea</i>	10.00%
<i>Aotus ericoides</i>	10.00%
<i>Acacia baueri</i>	1.00%
<i>Acacia suaveolens</i>	1.00%
<i>Boronia saffrolifera</i>	1.00%
<i>Bossiaea ensata</i>	1.00%
<i>Caustis recurvata</i>	1.00%
<i>Monotoca scoparia</i>	1.00%

Appendix B

Primary Transect Field Data

P3 Quadrat 3 1x1 m sub plot Intersecting transect at 20 m	
<i>Ochrosperma lineare</i>	1.00%
<i>Patersonia sericea</i>	1.00%
<i>Persoonia virgata</i>	1.00%
<i>Pseudanthus orientalis</i>	1.00%
Total plant coverage	50.00%
Bare sand	50.00%

P3 Quadrat 4 1x1 m sub plot Intersecting transect at 30 m	
Species	Percentage
<i>Monotoca scoparia</i>	30.00%
<i>Acacia baueri</i>	10.00%
<i>Aotus ericoides</i>	10.00%
<i>Leptospermum semibaccatum</i>	10.00%
<i>Caustis recurvata</i>	3.00%
<i>Boronia saffrolifera</i>	2.00%
<i>Pseudanthus orientalis</i>	2.00%
<i>Bossiaea ensata</i>	1.00%
<i>Ochrosperma lineare</i>	1.00%
<i>Viminaria juncea</i>	1.00%
Total plant coverage	70.00%
Bare sand	30.00%

P3 Quadrat 5 1x1 m sub plot Intersecting transect at 40 m	
Species	Percentage
<i>Leptospermum semibaccatum</i>	30.00%
<i>Monotoca scoparia</i>	10.00%
<i>Bossiaea ensata</i>	5.00%
<i>Viminaria juncea</i>	3.00%
<i>Boronia rosmarinifolia</i>	1.00%
<i>Caustis recurvata</i>	1.00%
<i>Conospermum taxifolium</i>	1.00%
<i>Entolasia stricta</i>	1.00%
<i>Ochrosperma lineare</i>	1.00%
<i>Patersonia sericea</i>	1.00%
<i>Persoonia virgata</i>	1.00%
<i>Pseudanthus orientalis</i>	1.00%
Total plant coverage	56.00%
Bare sand	44.00%

Appendix B

Primary Transect Field Data

B1.5 Reference Site P4: Vegetation Community 1a; Low open dry heath (RE 12.2.13)

Reference Site P4 is located on an exposed ridge line on elevated dunes (at approximately 180 m elevation) near the centre of ML 1108. The community here is a relatively small extent (approximately 0.54 ha) of low open dry heathland. The transect is located adjacent to the main four-wheel drive access track in this part of the lease (Figure 2).

The regional ecosystem most analogous to this community is RE 11.2.10 Mallee *Eucalyptus* spp. low woodland on Quaternary dunes and sand plains. As well as being present at Transect P3 and P4, extents of this community are present in exposed ridge areas on the high dunes to the west of the site. This community is dominated by a number of Myrtaceous and Fabaceae heath species. However *Banksia aemula* (wallum banksia) is growing around the edges and as isolated scattered examples throughout the heath community. Detailed structural and floristic data for this site is presented below



Figure B.4: Example of Dry heath vegetation at Primary Transect 4 (11/03/06)

Appendix B

Primary Transect Field Data

Transect information

Primary Transect 4	11/03/06	
Community	Open dry heath	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	North end of transect (0 m)	South end of transect (50 m)
	0545185mE 6959512mN	
Transect Bearing	130 ⁰ S	
Aspect	60 ⁰ NE	
Slope	23 ⁰ (42 %)	
Soil (A Horizon)	White sandy loam, leached with very low organic content	
Disturbance	Med intensity burn within previous 2 yrs	

Structure

P4: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Emergent (S1)	1-2.5		Isolated plants
Canopy (S2)	>1.0	65	Mid-dense
Mid (S3)	0.70-1.0	70	Mid-dense
Ground (G)	<0.70	38	Mid Dense

¹ After Walker and Hopkins, 1990

Basal Count

P4: Basal prism sweep (BAF 1:1) Transect intersect at 25 m		
Species	Count	Basal Area
<i>Banksia aemula</i>	3	

Canopy, mid and shrub Layer Transect Data

Ref Site P4: S1 10x50 m Plot						
Species	Strata	Height (m)	DBH (cm)	Crown (m)	x (m)	y (m)
<i>Banksia aemula</i>	C	1.8	4	1.20	46.30	4.50
<i>Banksia aemula</i>	C	1.6	2	1.60	37.80	1.50
<i>Banksia aemula</i>	C	1.8	8	1.70	32.00	4.00
<i>Banksia aemula</i>	C	2	3	1.60	23.70	3.50
<i>Banksia aemula</i>	C	2.1	6	1.80	17.40	2.00

Appendix B

Primary Transect Field Data

S2 2x50 m sub plot						
<i>Xanthorrhoea johnsonii</i>	M				3.70	-1.00
<i>Xanthorrhoea johnsonii</i>	M				5.90	0.00
<i>Monotoca scoparia</i>	M				6.30	0.40
<i>Xanthorrhoea johnsonii</i>	M				8.00	-0.30
<i>Banksia aemula</i>	M				11.10	-0.80
<i>Banksia aemula</i>	M				12.80	-0.70
<i>Strangea linearis</i>	M				14.50	0.20
<i>Banksia aemula</i>	M				15.50	0.00
<i>Xanthorrhoea johnsonii</i>	M				17.10	0.00
<i>Strangea linearis</i>	M				18.40	-0.30
<i>Banksia aemula</i>	M				21.50	0.00
<i>Xanthorrhoea johnsonii</i>	M				23.10	0.00
<i>Leucopogon leptospermoides</i>	M				26.50	0.00
<i>Banksia aemula</i>	M				27.00	-0.60
<i>Banksia aemula</i>	M				27.20	0.90
<i>Xanthorrhoea johnsonii</i>	M				32.80	0.20
<i>Xanthorrhoea johnsonii</i>	M				35.40	-0.40
<i>Leptospermum semibaccatum</i>	M				36.30	0.70
<i>Conospermum taxifolium</i>	M				44.50	-0.30
<i>Banksia aemula</i>	M				47.90	1.00

Key:

Canopy **C (S1)**

Mid **M (S2)**

Ground layer quadrat data

P4 Quadrat 1 1x1 m sub plot Intersecting transect at 0 m	
Species	Percentage
<i>Hypolaena fastigiata</i>	10.00%
<i>Ochrosperma lineare</i>	10.00%
<i>Hibbertia linearis</i>	3.00%
<i>Leucopogon leptospermoides</i>	3.00%
<i>Monotoca scoparia</i>	3.00%
<i>Pseudanthus orientalis</i>	3.00%
<i>Bossiaea ensata</i>	2.00%
<i>Olax retusa</i>	2.00%
<i>Acacia baueri</i>	1.00%
<i>Bossiaea heterophylla</i>	1.00%
<i>Laxmannia gracilis</i>	1.00%
<i>Pimelea linifolia</i>	1.00%
Total plant coverage	40.00%
Bare sand	60.00%

Appendix B

Primary Transect Field Data

PT4 Quadrat 2 1x1 m sub plot Intersecting transect at 10 m	
Species	Percentage
<i>Bossiaea heterophylla</i>	10.00%
<i>Hypolaena fastigiata</i>	8.00%
<i>Caustis recurvata</i>	5.00%
<i>Acacia baueri</i>	1.00%
<i>Aotus ericoides</i>	1.00%
<i>Laxmannia gracilis</i>	1.00%
<i>Leucopogon leptospermoides</i>	1.00%
<i>Monotoca scoparia</i>	1.00%
<i>Olax retusa</i>	1.00%
<i>Schoenus ornithopodioides</i>	1.00%
Total plant coverage	30.00%
Bare sand	70.00%

P4 Quadrat 3 1x1 m sub plot Intersecting transect at 20 m	
Species	Percentage
<i>Monotoca scoparia</i>	20.00%
<i>Bossiaea heterophylla</i>	10.00%
<i>Hypolaena fastigiata</i>	5.00%
<i>Leucopogon leptospermoides</i>	5.00%
<i>Ochrosperma lineare</i>	5.00%
<i>Acacia baueri</i>	1.00%
<i>Bossiaea ensata</i>	1.00%
<i>Coleocarya gracilis</i>	1.00%
<i>Pimelea linifolia</i>	1.00%
<i>Xanthorrhoea johnsonii</i>	1.00%
Total plant coverage	50.00%
Bare sand	50.00%

P4 Quadrat 4 1x1 m sub plot Intersecting transect at 30 m	
Species	Percentage
<i>Monotoca scoparia</i>	20.00%
<i>Ochrosperma lineare</i>	8.00%
<i>Entolasia stricta</i>	5.00%
<i>Hypolaena fastigiata</i>	2.00%
<i>Acacia baueri</i>	1.00%
<i>Caustis recurvata</i>	1.00%
<i>Olax retusa</i>	1.00%
<i>Pseudanthus orientalis</i>	1.00%
<i>Viminaria juncea</i>	1.00%
Total plant coverage	40.00%
Bare sand	60.00%

Appendix B

Primary Transect Field Data

P4 Quadrat 5 1x1 m sub plot Intersecting transect at 40 m	
Species	Percentage
<i>Xanthorrhoea johnsonii</i>	10.00%
<i>Olax retusa</i>	5.00%
<i>Bossiaea ensata</i>	4.00%
<i>Acacia baueri</i>	4.00%
<i>Acacia ulicifolia</i>	2.00%
<i>Caustis recurvata</i>	2.00%
<i>Dillwynia retorta v retorta</i>	1.00%
<i>Hypolaena fastigiata</i>	1.00%
<i>Leptospermum semibaccatum</i>	1.00%
Total plant coverage	30.00%
Bare sand	70.00%

Appendix B

Primary Transect Field Data

B1.6 Reference Site P5: Vegetation Unit 1b; Closed wet heath (RE 12.2.12)

The extent of Closed wet heath on the lease was restricted to the ephemeral drainage line of Cooroon Cooroonpah Creek covering an area of approximately 3 ha (Figure 2). This community was dominated by *Leptospermum liversidgei* (lemon-scented tea tree) with *Empodisma minor* (spreading rope rush) and *Baumea muelleri* (flat twigrush) also in common abundance. The regional ecosystem most analogous to this community is RE 11.2.13 Low open dry heath on Quaternary dunes and sand plains. Detailed structural and floristic data for this site is presented below



Figure B.5: Example of Closed wet heath vegetation at Primary Transect 5 (11/03/06)

Appendix B

Primary Transect Field Data

Transect Information

Primary Transect 5	11/03/06	
Community	Closed wet heath	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	North end of transect (0 m)	South end of transect (50 m)
	0546005mE 6959353mN	0546043mE 6959327mN
Transect Bearing	130 ⁰ SE	
Aspect	220 ⁰ SW	
Slope	2 ⁰	
Soil (A Horizon)	Alluvial sediment	
Disturbance	Not burnt within previous 2 yrs	

Structure

P5: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Emergent (T1)	>2		Isolated plants
Canopy (S1)	1-2	90	dense
Mid (S2)	0.70-1.0	90	dense
Ground (G)	<0.70	100	dense

¹ Walker and Hopkins, 1990

Basal Count

P5: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	1
<i>Eucalyptus racemosa</i>	1

Canopy, mid and shrub Layer Transect Data

Ref Site P5: T1 10x50 m transect						
Species	Strata	Height (m)	DBH (cm)	Crown (m)	x (m)	y (m)
<i>Banksia aemula</i>	E					
<i>Eucalyptus racemosa</i>	E					
S1 & S2 50x2 m sub plot						
<i>Leptospermum liversidgei</i>	C				1.00	0.70
<i>Aotus lanigera</i>	C				1.20	0.00
<i>Sprengelia sprengelioides</i>	C				1.60	0.10
<i>Sprengelia sprengelioides</i>	C				2.20	0.10

Appendix B

Primary Transect Field Data

Ref Site P5:						
T1 10x50 m transect						
<i>Sprengelia sprengelioides</i>	C				2.30	0.10
<i>Leptospermum liversidgei</i>	C				2.00	0.30
<i>Leptospermum liversidgei</i>	C				2.10	1.00
<i>Ochrosperma lineare</i>	C				2.80	0.50
<i>Sprengelia sprengelioides</i>	C				3.00	0.20
<i>Sprengelia sprengelioides</i>	M				3.60	0.70
<i>Aotus lanigera</i>	M				3.70	0.00
<i>Leptospermum liversidgei</i>	C				5.00	0.80
<i>Aotus lanigera</i>	C				5.50	0.10
<i>Leptospermum liversidgei</i>	C				5.20	1.00
<i>Sprengelia sprengelioides</i>	C				5.40	1.00
<i>Leptospermum liversidgei</i>	C				3.70	2.00
<i>Leptospermum liversidgei</i>	C				5.80	0.40
<i>Leptospermum liversidgei</i>	C				6.40	0.50
<i>Aotus lanigera</i>	C				6.10	0.00
<i>Sprengelia sprengelioides</i>	C				7.30	0.00
<i>Leptospermum liversidgei</i>	C				7.40	0.20
<i>Leptospermum liversidgei</i>	C				7.70	1.50
<i>Leptospermum liversidgei</i>	C				8.00	0.50
<i>Sprengelia sprengelioides</i>	C				8.60	0.60
<i>Leptospermum liversidgei</i>	C				8.60	1.00
<i>Ochrosperma lineare</i>	C				9.00	0.30
<i>Aotus lanigera</i>	M				9.10	0.00
<i>Ochrosperma lineare</i>	C				9.30	0.30
<i>Aotus lanigera</i>	C				9.80	1.20
<i>Leptospermum liversidgei</i>	C				9.40	2.00
<i>Leptospermum liversidgei</i>	C				10.50	1.00
<i>Leptospermum liversidgei</i>	C				10.50	2.00
<i>Leptospermum liversidgei</i>	C				10.90	1.50
<i>Sprengelia sprengelioides</i>	C				10.90	0.30
<i>Ochrosperma lineare</i>	C				11.20	0.20
<i>Ochrosperma lineare</i>	C				11.70	1.00
<i>Leptospermum liversidgei</i>	C				13.40	2.00
<i>Ochrosperma lineare</i>	C				13.70	0.00
<i>Ochrosperma lineare</i>	C				14.30	0.00
<i>Leptospermum liversidgei</i>	C				15.80	1.00
<i>Leptospermum liversidgei</i>	C				16.00	2.00
<i>Leptospermum liversidgei</i>	C				16.70	2.00
<i>Leptospermum liversidgei</i>	C				16.90	1.00
<i>Leptospermum liversidgei</i>	C				17.10	1.50
<i>Leptospermum liversidgei</i>	C				17.60	1.50
<i>Leptospermum liversidgei</i>	C				18.00	2.00
<i>Leptospermum liversidgei</i>	C				18.20	1.00
<i>Leptospermum liversidgei</i>	C				18.40	1.00
<i>Leptospermum liversidgei</i>	C				18.60	1.50
<i>Ochrosperma lineare</i>	C				14.00	0.00
<i>Ochrosperma lineare</i>	C				19.60	0.00
<i>Leptospermum liversidgei</i>	C				19.50	1.50
<i>Leptospermum liversidgei</i>	C				19.90	2.00
<i>Aotus lanigera</i>	M				20.10	0.00
<i>Ochrosperma lineare</i>	C				20.60	0.00
<i>Ochrosperma lineare</i>	C				20.80	0.30
<i>Ochrosperma lineare</i>	C				20.80	0.50
<i>Ochrosperma lineare</i>	C				20.90	0.00
<i>Ochrosperma lineare</i>	C				21.50	0.30
<i>Sprengelia sprengelioides</i>	C				21.90	0.30

Appendix B

Primary Transect Field Data

Ref Site P5:						
T1 10x50 m transect						
<i>Aotus lanigera</i>	M				22.50	0.00
<i>Sprengelia sprengelioides</i>	C				22.30	0.30
<i>Leptospermum liversidgei</i>	C				22.20	0.80
<i>Sprengelia sprengelioides</i>	C				22.00	0.30
<i>Leptospermum liversidgei</i>	C				21.70	1.50
<i>Leptospermum liversidgei</i>	C				21.70	2.00
<i>Leptospermum liversidgei</i>	C				22.60	1.00
<i>Ochrosperma lineare</i>	C				23.10	1.50
<i>Ochrosperma lineare</i>	C				23.10	1.40
<i>Leptospermum liversidgei</i>	C				23.30	2.00
<i>Leptospermum liversidgei</i>	C				23.00	1.00
<i>Aotus lanigera</i>	M				24.30	0.50
<i>Leptospermum liversidgei</i>	C				24.10	1.50
<i>Leptospermum liversidgei</i>	C				24.80	2.00
<i>Leptospermum liversidgei</i>	C				24.90	2.00
<i>Leptospermum liversidgei</i>	C				24.90	1.00
<i>Leptospermum liversidgei</i>	C				24.90	0.30
<i>Leptospermum liversidgei</i>	C				25.00	0.2

Key:

Emergent **E (T1)**

Canopy **C (S1)**

Mid **M (S2)**

P5 Quadrat 1 1x1 m sub plot Intersecting transect at 0 m	
Plant Species	Percentage
<i>Leptospermum liversidgei</i>	40.00%
<i>Empodisma minor</i>	30.00%
<i>Baloskion tetraphyllum</i>	25.00%
<i>Sprengelia sprengelioides</i>	3.00%
<i>Aotus lanigera</i>	1.00%
<i>Leptospermum speciosum</i>	1.00%
Total plant coverage	100.00%

P5 Quadrat 2 1x1 m sub plot Intersecting transect at 10 m	
Plant Species	Percentage
<i>Baloskion tetraphyllum</i>	70.00%
<i>Empodisma minor</i>	15.00%
<i>Entolasia stricta</i>	10.00%
<i>Epacris micropophylla</i>	3.00%
<i>Aotus lanigera</i>	1.00%
<i>Leptospermum polygalifolium</i>	1.00%
Total plant coverage	100.00%

Appendix B

Primary Transect Field Data

P5 Quadrat 3 1x1 m sub plot Intersecting transect at 20 m	
Plant Species	Percentage
<i>Leptospermum liversidgei</i>	60.00%
<i>Baloskion tetraphyllum</i>	20.00%
<i>Empodisma minor</i>	15.00%
<i>Ochrosperma lineare</i>	3.00%
<i>Aotus lanigera</i>	2.00%
Total plant coverage	100.00%

P5 Quadrat 4 1x1 m sub plot Intersecting transect at 30 m	
Plant Species	Percentage
<i>Baloskion tetraphyllum</i>	80.00%
<i>Empodisma minor</i>	10.00%
<i>Leptospermum liversidgei</i>	5.00%
<i>Entolasia stricta</i>	2.00%
<i>Sprengelia sprengelioides</i>	2.00%
<i>Stylidium debile</i>	1.00%
Total plant coverage	100.00%

P5 Quadrat 5 1x1 m sub plot Intersecting transect at 30 m	
Plant Species	Percentage
<i>Baloskion tetraphyllum</i>	80.00%
<i>Leptospermum liversidgei</i>	10.00%
<i>Empodisma minor</i>	5.00%
<i>Ochrosperma lineare</i>	4.00%
<i>Cassytha pubescens</i>	1.00%
Total plant coverage	100.00%

Appendix C

Secondary Transect Field Data

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Appendix C

Secondary Transect Field Data

C1.1 Master list of species found on secondary transects

Secondary Transect: Relative abundance of all species (50x10m Quadrat)																				
Family	Plant Species	Common Name	Growth Form	Status	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11	ST12	ST13	ST14	ST15	ST16
CONIFERS																				
CUPRESSACEAE	<i>Callitris columellaris</i>	Bribie Island Pine	T	C					U-O									R		
PODOCARPACEAE	<i>Podocarpus spinulosus</i>	Yellow wood	T			R										C	O			C
ANGIOSPERMS																				
MIMOSACEAE	<i>Acacia baueri</i> ssp <i>baueri</i>	Tiny Wattle	SH	V																
MIMOSACEAE	<i>Acacia leiocalyx</i> ssp <i>leiocalyx</i>	Black Wattle	T		U															
MIMOSACEAE	<i>Acacia suaveolens</i>	Sweet Wattle	SH			C			U	O	O-C		C	U	U		A	C		R
MIMOSACEAE	<i>Acacia ulicifolia</i>	Prickly Moses	SH	C	U	C	C	A	A	C	A	A	O	A	O		U	O		R
MYRTACEAE	<i>Acmena smithii</i>	Lily Pilly	T																	C
CASUARINACEAE	<i>Allocasuarina littoralis</i>	Coastal She Oak	T	C						U						U				
CASUARINACEAE	<i>Allocasuarina torulosa</i>	Forest She Oak	T		O		O													O-C
POACEAE	<i>Alloteropsis semialata</i>	Cockatoo Grass	H																	
RHAMNACEAE	<i>Alphitonia excelsa</i>	Red Ash	T		R															
EUPHORBIACEAE	<i>Amperea xiphoclada</i>	Broom Spurge	SH			C				R	U-O		R	O-C			O			
MYRTACEAE	<i>Angophora woodsiana</i>	Wood's Apple	T																	
FABACEAE	<i>Aotus ericoides</i>	Common Aotus	SH			U			O	O		O	C	C		O	O	U		
FABACEAE	<i>Aotus lanigera</i>	Pointed Aotus	SH												O-C				R	
POACEAE	<i>Aristida calycina</i> c. <i>calycina</i>	Dark wiregrass	H																	
POACEAE	<i>Aristida warburgii</i>	Speargrass	H																	
ARALIACEAE	<i>Astrotricha longifolia</i>	Long-leaf star-hair	SH																	
MYRTACEAE	<i>Austromyrtus dulcis</i>	Midyim	SH		O	U	O	O		O		U-O			U	O	O	R		C

Appendix C

Secondary Transect Field Data

Secondary Transect: Relative abundance of all species (50x10m Quadrat)																				
Family	Plant Species	Common Name	Growth Form	Status	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11	ST12	ST13	ST14	ST15	ST16
RESTIONACEAE	<i>Balaskion pallens</i>	Pale Cord Rush	H	C				O												
RESTIONACEAE	<i>Balaskion tetraphyllum</i>	Tassel Cord Rush	H	C															C	
PROTEACEAE	<i>Banksia aemula</i>	Wallum Banksia	T	C	O-C	C	O-C	C	C	C	C	O-C	C	C	C	C	C	C		R
PROTEACEAE	<i>Banksia spinulosa v. collina</i>	Golden Candlesticks	SH	C	C															
CYPERACEAE	<i>Baumea muelleri</i>	Flat Twigrush	H																C	
CYPERACEAE	<i>Baumea rubiginosa</i>	Soft Twigrush	H																	
RUTACEAE	<i>Boronia rosmarinifolia</i>	Forest Boronia	SH		O	O	O	O-C	O	O	O-C	O-C	R	R	O-C		U	O-C		
RUTACEAE	<i>Boronia saffolifera</i>	Ferny Boronia	SH			U							R	R	U	U	O	R		
FABACEAE	<i>Bossiaea ensata</i>	Leafless Bossiaea	SH			U	R			O						U	R			
FABACEAE	<i>Bossiaea heterophylla</i>	Variable Bossiaea	SH					O	U	O	O-C		O			U				
EPACRIDACEAE	<i>Brachyloma daphnoides</i>	Daphne Heath.	SH																	
BURMANNIACEAE	<i>Burmannia disticha</i>	Native Status	H																	
COLCHICACEAE	<i>Burchardia umbellata</i>	Milk Maids	H																U ¹	
ANTHERICACEAE	<i>Caesia parviflora</i>	Caesia	H																	
LAURACEAE	<i>Cassytha filiformis</i>	Love vine	V																U	
LAURACEAE	<i>Cassytha pubescens</i>	Dodder Vine	V			U						O-C			U	U		R	U	
CYPERACEAE	<i>Cautis blakei</i>	Foxtail	H	C	C-A		O	O												O
CYPERACEAE	<i>Cautis recurvata</i>	Curly Wig	H	C		C			C	A	C	U	C	C	C	C	C	C		
RESTIONACEAE	<i>Coleocarya gracilis</i>		H							O-C	R-U									
PROTEACEAE	<i>Conospermum taxifolium</i>	Devil's Rice	S	C							U		U		U		R	U		
MYRTACEAE	<i>Corymbia gummitifera</i>	Red Bloodwood	T		C				O			C				C	C			U-O
MYRTACEAE	<i>Corymbia intermedia</i>	Pink Bloodwood	T				C	C												
CYPERACEAE	<i>Cyperus polystachyos</i>	Bunchy sedge	H																	
GOODENIACEAE	<i>Dampiera sylvestris</i>	Blue fan flower	SH		U															

Appendix C

Secondary Transect Field Data

Secondary Transect: Relative abundance of all species (50x10m Quadrat)																				
Family	Plant Species	Common Name	Growth Form	Status	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11	ST12	ST13	ST14	ST15	ST16
LILIACEAE	<i>Dianella caerulea</i>	Blue Flax Lily	H		O															
LILIACEAE	<i>Dianella longifolia</i>	Blue Flax-lily	H																	
FABACEAE	<i>Dillwynia retorta</i> v <i>retorta</i>	Eggs & Bacon Pea	SH		C				O				C	C	U	O-C	O	O		R
SAPINDACEAE	<i>Dodonaea triquetra</i>	Large-leaved hop bush	SH		A		U					A								A
DROSERACEAE	<i>Drosera binata</i>	Sundew	H																R	
DROSERACEAE	<i>Drosera spathulata</i>	Sundew	H																C	
ELAEOCARPACEAE	<i>Elaeocarpus reticulatus</i>	Blueberry Ash	T	C														R		U-O
RESTIONACEAE	<i>Empodisma minor</i>	Spreading Rope Rush	H																A	
POACEAE	<i>Entolasia stricta</i>	Wiry Panic	H		O-C	C	O	O	O	O-C	C	C	C	C	O-C	C	C	C	A	O
EPACRIDACEAE	<i>Epacris microphylla</i>	Coral Heath	C																C	
EPACRIDACEAE	<i>Epacris pulchella</i>	Wallum Heath	SH						R						U	C				
POACEAE	<i>Eriachne pallescens</i>	A Wanderie Grass	H				C	O												
MYRTACEAE	<i>Eucalyptus pilularis</i>	Black Butt	T	C	C															C
MYRTACEAE	<i>Eucalyptus planchoniana</i>	Needle Bark	T				C	C-A	C	C	C		C	C	C	C	C	C		C
MYRTACEAE	<i>Eucalyptus racemosa</i>	Scribbly Gum	T		C	C	C					C				C				
SANTALACEAE	<i>Exocarpos cupressiformis</i>	Native Cherry	T	C																
CYPERACEAE	<i>Fimbristylis dichotoma</i>	Common Finger Rush	H																	
CYPERACEAE	<i>Gahnia sieberiana</i>	Saw Sedge	H	C															O	
PHILESIACEAE	<i>Geitonoplesium cymosum</i>	Scrambling Lily	V																	
FABACEAE	<i>Gompholobium virgatum</i> v <i>emarginatum</i>	Wallum Wedge Pea	SH	R				U	C-A	U-O	O-C									
HALORAGACEAE	<i>Gonocarpus chinensis</i>	Chinese raspsort	SH																	
HAEMODORACEAE	<i>Haemodorum verrucosus</i>	Slender Blood-Lily	H																	
FABACEAE	<i>Hardenbergia violacea</i>	Native Sarsaparilla	V	C			R					R		U						R
DILLENIACEAE	<i>Hibbertia acicularis</i>	Prickly Guinea	SH																	

Appendix C

Secondary Transect Field Data

Secondary Transect: Relative abundance of all species (50x10m Quadrat)																				
Family	Plant Species	Common Name	Growth Form	Status	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11	ST12	ST13	ST14	ST15	ST16
		Flower																		
DILLENIACEAE	<i>Hibbertia linearis</i>	Showy Guinea Flower	SH			C-A	O	O	O	C	C	U	O	C	A		R	C		O
DILLENIACEAE	<i>Hibbertia salicifolia</i>	Willow Guinea Flower	SH																O-C	
DILLENIACEAE	<i>Hibbertia vestita</i>	Hairy Guinea Flower	SH	U																R
MYRTACEAE	<i>Homoranthus virgatus</i>	Banana Heath	SH					U						O	A		U			
RESTIONACEAE	<i>Hypolaena fastigiata</i>	Tassel Rope-rush	H																	
POACEAE	<i>Imperata cylindrica</i>	Blady Grass	H																	
CYPERACEAE	<i>Isolepis inundata</i>	Swamp Club-sedge	H																	
FABACEAE	<i>Jacksonia stackhousii</i>	Wallum dogwood	SH																	
LILIACEAE	<i>Laxmannia gracilis</i>	Slender Wire Lilly	H						O				C				R			
CYPERACEAE	<i>Lepidosperma laterale</i>	Variable saw'sedge	H	O												U				U-O
RESTIONACEAE	<i>Leptocarpus tenax</i>		H																	
SANTALACEAE	<i>Leptomeria acida</i>	Native currant	SH																	
MYRTACEAE	<i>Leptospermum liversidgei</i>	Lemon-scented tea tree	SH	C															A	
MYRTACEAE	<i>Leptospermum polygalifolium</i>	Wild May	SH	C		C							O	C	O	U		O		
MYRTACEAE	<i>Leptospermum semibaccatum</i>	Heath May	SH										U			O	U			
MYRTACEAE	<i>Leptospermum speciosum</i>	Broad-leaved Tea Tree	SH																	
MYRTACEAE	<i>Leptospermum trinervium</i>	Paperbark tea-tree	SH					O	O	O-C	O-C	U								
RESTIONACEAE	<i>Lepyrodia scariosa</i>	Scaly Rush	H				R								R	C				
EPACRIDACEAE	<i>Leucopogon deformis</i>		SH							U ¹										
EPACRIDACEAE	<i>Leucopogon ericoides</i>	Pink Beard Heath	SH														U			
EPACRIDACEAE	<i>Leucopogon leptospermoides</i>	Beard heath	SH		O			C	C	O	C	O	C	O		O	U			

Appendix C

Secondary Transect Field Data

Secondary Transect: Relative abundance of all species (50x10m Quadrat)																				
Family	Plant Species	Common Name	Growth Form	Status	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11	ST12	ST13	ST14	ST15	ST16
EPACRIDACEAE	<i>Leucopogon margarodes</i>	Drab Beard-Heath	SH							R						O				
EPACRIDACEAE	<i>Leucopogon pedicellatus</i>	Heath Whitebeard	SH		U		R								O	U				U-O
XANTHORRHOACEAE	<i>Lomandra elongata</i>	Matt Rush	H																	
XANTHORRHOACEAE	<i>Lomandra filiformis</i>	Matt Rush	H																	
XANTHORRHOACEAE	<i>Lomandra longifolia</i>	Spinyhead Matt Rush	H		O	C	A			U-O		C-A		U-O	U-O	U	R	O		O
XANTHORRHOACEAE	<i>Lomandra multiflora</i>	Many Flowered Matt Rush	H		O-C															
ASCLEPIADACEAE	<i>Marsdenia fraseri</i>	Narrow-leaved Milk Vine	V																	R
EPACRIDACEAE	<i>Monotoca scoparia</i>	Prickly Broom Heath	SH		A		C	O	O	C		U	O	R	U	C	O	R		U-O
MYRTACEAE	<i>Ochrosperma lineare</i>	Coast Myrtle	SH					O		C-A	C		C		O	C	U	U	C-A	
OLACACEAE	<i>Olax retusa</i>	Olax	SH			U											R	R		
POACEAE	<i>Panicum effusum v simile</i>	Hairy panic	H																	
IRIDACEAE	<i>Patersonia glabrata</i>	Leafy Purple Flag	H																	
IRIDACEAE	<i>Patersonia sericea</i>	Silky Purple Flag	H		C	R		R		R							R	R		
PROTEACEAE	<i>Persoonia virgata</i>	Narrow-leaf Geebung	SH		C								U	R-U	U	U	U			
PROTEACEAE	<i>Petrophile canescens</i>	Conesticks	SH		C											U				
THYMELAEACEAE	<i>Pimelea linifolia</i>	Riceflower	SH		C	U			O	R-U	O	U	U				U	R		
APIACEAE	<i>Platysace ericoides</i>	Heath Platysace	SH			O														
RUBIACEAE	<i>Pomax umbellata</i>	Pomax	SH																	
EUPHORBIACEAE	<i>Poranthera microphylla</i>	Small poranthera	SH																	
PORTULACACEAE	<i>Portulaca oleracea</i>	Purslane	SH																	
EUPHORBIACEAE	<i>Pseudanthus orientalis</i>	Sand Hill Pseudanthus	SH						R								U			
FABACEAE	<i>Pultenaea paleacea</i>	Chafty Bush Pea	SH																	
FABACEAE	<i>Pultenaea retusa</i>	Blunt Bush Pea	SH																	

Appendix C

Secondary Transect Field Data

Secondary Transect: Relative abundance of all species (50x10m Quadrat)																				
Family	Plant Species	Common Name	Growth Form	Status	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11	ST12	ST13	ST14	ST15	ST16
MYRSINACEAE	<i>Rapanea variabilis</i>	Muttonwood	T																	
CYPERACEAE	<i>Rhynchospora brownii</i>	Brown's Beak-sedge	H																U	
EUPHORBIACEAE	<i>Ricinocarpus pinifolius</i>	Wedding Bush	SH			C	O	O	O	C	O	O	O	A	C	O	O	C		
CYPERACEAE	<i>Schoenus ornithopodioides</i>	Bird's Foot Bog Rush	H					R												
SMILACACEAE	<i>Smilax australis</i>	Austral Smilax	V																	C
RESTIONACEAE	<i>Sporadanthus interruptus</i>		H																O	
EPACRIDACEAE	<i>Sprengelia sprengeloides</i>	Sprengelia	SH																C	
MENISPERMACEAE	<i>Stephania japonica</i>	Snake Vine	V																	
PROTEACEAE	<i>Strangea linearis</i>	Strangea	SH			O		O-C	C	C	C	R-U			O	O	O	O		
STYLIDIACEAE	<i>Stylidium debile</i>	Weak Triggerplant	H																	
EPACRIDACEAE	<i>Styphelia viridis</i>	Green-flowered Styphelia	SH	C																
MYRTACEAE	<i>Syzygium oleosum</i>	Blue Lillypilly	T																	
TREMANDRACEAE	<i>Tetratheca thymifolia</i>	Black eyed Susan	S				R	R												
POACEAE	<i>Themeda triandra</i>	Kangaroo Grass	H							O ¹										
LILIACEAE	<i>Tricoryne elatior</i>	Flat-stemmed rush-lily	H																	
LENTIBULARIACEAE	<i>Utricularia dichotoma</i>	Bladderwort	H																O	
FABACEAE	<i>Viminaria juncea</i>	Golden spray	SH										O			R	O	U		
EPACRIDACEAE	<i>Woolisia pungens</i>	Woolisia	SH							R					U	C				
XANTHORRHOACEAE	<i>Xanthorrhoea johnsonii</i>	Forest Black-Boy	SH	C	U	O	O-C	A	A	A	A	A	A	C	O	O	A	A		O
XANTHORRHOACEAE	<i>Xanthorrhoea latifolia</i>	Grass tree	SH	C																
APIACEAE	<i>Xanthosia pilosa</i>	Woolly Xanthosia	H																	U
RUTACEAE	<i>Zieria laxiflora</i>		SH		U			O	U	O	C	U		U	C		U	C		R
PTERIDOPHYTES - FERNS																				

Appendix C

Secondary Transect Field Data

Secondary Transect: Relative abundance of all species (50x10m Quadrat)																				
Family	Plant Species	Common Name	Growth Form	Status	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11	ST12	ST13	ST14	ST15	ST16
BLECHNACEAE	<i>Blechnum indicum</i>	Bungwahl	F	C																
DENNSTAEDTIACEAE	<i>Pteridium esculentum</i>	Common Bracken Fern	F	C	U-O		O					C		O-C						O
SCHIZAEACEAE	<i>Schizaea bifida</i>	Forked Comb Fern	F			R								R						

Key

Growth Form:

Tree T
Shrub SH
Herb H
Vine V
Fern F

Conservation Status:

Vulnerable species (Schedule 3 - Nature Conservation Act, 1992) V
Rare species (Schedule 4 - Nature Conservation Act, 1992) R
Common species (Schedule 5 Nature Conservation Act, 1992) C

Relative Abundance:

1-10 plants RARE R
11-20 plants UNCOMMON U
21- 30 plants OCCASIONAL O
31 - 50 plants COMMON C
> 51 plants ABUNDANT A

¹ Spring Survey

These species were recorded during the spring survey (September 2006). Relative abundances are qualitative estimates only.

Appendix C

Secondary Transect Field Data

C1.2 Secondary Site 1



Figure A.1: Example of Mixed Eucalypt community at Secondary Transect 1 (08/03/06)

Transect information

Secondary Transect S1	08/03/06	
Community	Mixed Eucalypt Open Forest	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	North end of transect (0 m)	South end of transect (50 m)
	0545940 mE 6960188 mN	0549111 mE 6960182 mN
Transect Bearing	210 ⁰ S	
Aspect	280 ⁰ W	
Slope	26 ⁰ (49 %)	
Soil (A Horizon)	Yellow sandy with medium organic matter	
Disturbance	No evidence of recent fire disturbance	

Appendix C

Secondary Transect Field Data

Structure

S1: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	20-25	35 %	Mid dense
Mid (T2)	10-12		Very sparse
Shrub (S1)	1-4		Dense
Ground (G)	<1	9	sparse

¹ After Walker and Hopkins, 1990

Basal area count

S1: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Allocasuarina torulosa</i>	1
<i>Banksia aemula</i>	1
<i>Corymbia gummifera</i>	2
<i>Eucalyptus pilularis</i>	1
<i>Eucalyptus racemosa</i>	2

Canopy, mid and shrub stem counts

Secondary Site 1: T1 & T2 50x10 m Plot		
Species	Strata	Count
<i>Allocasuarina torulosa</i>	canopy	1
<i>Banksia aemula</i>	mid	4
<i>Corymbia gummifera</i>	canopy	8
<i>Eucalyptus pilularis</i>	canopy	7
<i>Eucalyptus racemosa</i>	canopy	1
S1 50x2 m Sub plot		
<i>Acacia leiocalyx ssp leiocalyx</i>	Shrub	1
<i>Banksia aemula</i>	Shrub	1
<i>Banksia spinulosa v. collina</i>	Shrub	3
<i>Dodonaea triquetra</i>	Shrub	3
<i>Monotoca scoparia</i>	Shrub	16
<i>Persoonia virgata</i>	Shrub	4
<i>Petrophile canescens</i>	Shrub	7

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S1: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>	1	1.0
<i>Caustis blakei</i>	1	1.0
<i>Dianella caerulea</i>	1	1.0
<i>Dodonaea triquetra</i>	1	1.0
<i>Petrophile canescens</i>	3	3.0
Total plant coverage		12.00%
Leaf Litter		87.00%

S1: Quadrat 2 1 x 1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Austromyrtus dulcis</i>	4	4.0
<i>Banksia spinulosa</i> v. <i>collina</i>	1	1.0
<i>Caustis blakei</i>	5	5.0
<i>Dodonaea triquetra</i>	1	1.0
<i>Xanthorrhoea johnsonii</i>	1	1.0
Total plant coverage		12.00%
Leaf Litter		87.00%

S1: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Caustis blakei</i>	5	5.0
<i>Dodonaea triquetra</i>	4	4.0
<i>Lomandra longifolia</i>	1	1.0
<i>Persoonia virgata</i>	1	1.0
<i>Petrophile canescens</i>	1	1.0
Total plant coverage		12.0
Leaf Litter		88.0

S1: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Banksia aemula</i>	1	1.0
<i>Caustis blakei</i>	2	2.0
<i>Lomandra longifolia</i>	4	4.0
<i>Monotoca scoparia</i>	2	2.0
<i>Persoonia virgata</i>	1	1.0
Total plant coverage		10.0
Leaf Litter		90.0

S1: Quadrat 5 1 x 1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Banksia aemula</i>	1	1.00%
<i>Boronia rosmarinifolia</i>	1	1.00%
<i>Caustis blakei</i>	1	1.00%
<i>Dampiera sylvestris</i>	4	4.00%
<i>Dodonaea triquetra</i>	3	3.00%
<i>Lomandra multiflora</i>	2	2.00%
<i>Monotoca scoparia</i>	1	1.00%
<i>Petrophile canescens</i>	2	2.00%
<i>Xanthorrhoea johnsonii</i>	1	1.00%
Total plant coverage		16.00%
Leaf Litter		84.00%

Appendix C

Secondary Transect Field Data

C1.3 Secondary Site 2



Figure A.2: Example of Mallee woodland community at Secondary Transect 2 (08/03/06)

Transect information

Secondary Transect S2	08/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	South end of transect (0 m)	North end of transect (50 m)
	0546486 mE 6959737 mN	0546492 mE 6959687 mN
Transect Bearing	360 ⁰ N	
Aspect	280 ⁰ W	
Slope	21 ⁰ (38 %)	
Soil (A Horizon)	Bleached sand, low organic content	
Disturbance	Intense fire has burn taller mallee spp. within previous 2 yrs	

Appendix C

Secondary Transect Field Data

Structure

S2: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	8-10	20	Sparse
Shrub (S1)	2-6		Sparse
Ground (G)	<1		Dense

¹ After Walker and Hopkins, 1990

Basal area count

S2: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	7
<i>Eucalyptus racemosa</i>	2

Canopy, mid and shrub stem counts

Secondary Site 2: T1 & T2 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	5
<i>Eucalyptus racemosa</i>	canopy	13
S1 50x2 m Sub plot		
<i>Acacia ulicifolia</i>	Shrub	2
<i>Banksia aemula</i>	Shrub	1
<i>Eucalyptus racemosa</i>	Shrub	2
<i>Hibertia linearis</i>	Shrub	21
<i>Leptospermum polyglauifolium</i>	Shrub	16
<i>Ricinocarpus pinifolia</i>	Shrub	28
<i>Xanthorrhoea johnsonii</i>	Shrub	2

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S2: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>	1	1.0
<i>Amperea xiphoclada</i>	7	7.0
<i>Caustis recurvata</i>	1	1.0
<i>Dillwynia retorta</i> v <i>retorta</i>	1	1.0
<i>Entolasia stricta</i>	1	1.0
<i>Hibbertia linearis</i>	1	1.0
<i>Lomandra longifolia</i>	3	3.0
<i>Podocarpus spinulosus</i>	1	1.0
<i>Ricinocarpos pinifolius</i>	2	2.0
<i>Zieria laxiflora</i>	2	2.0
Total plant coverage		20.0
Bare Sand		80.0

S2: Quadrat 2 1 x 1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Ricinocarpos pinifolius</i>	4	4.0
<i>Acacia suaveolens</i>	3	3.0
<i>Caustis recurvata</i>	1	1.0
<i>Dillwynia retorta</i> v <i>retorta</i>	1	1.0
<i>Ricinocarpos pinifolius</i>	4	4.0
Total plant coverage		9.0
Leaf Litter		91.0

S2: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Numbers	Percentage
<i>Acacia ulicifolia</i>	1	1.0
<i>Caustis recurvata</i>	3	3.0
<i>Dillwynia retorta</i> v <i>retorta</i>	7	7.0
<i>Hibbertia linearis</i>	1	1.0
<i>Ochrosperma lineare</i>	1	1.0
<i>Olax retusa</i>	1	1.0
<i>Platysace ericoides</i>	2	2.0
Total plant coverage		17.0
Leaf Litter		3.0
Bare Sand		80.0

S2: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Numbers	Percentage
<i>Caustis recurvata</i>	8	8.0
<i>Eucalyptus racemosa</i>	1	1.0
<i>Lomandra longifolia</i>	3	3.0
<i>Platysace ericoides</i>	1	1.0
<i>Ricinocarpos pinifolius</i>	1	1.0
Total plant coverage		14.0
Leaf Litter		32.0
Bare Sand		84.0

S2: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Numbers	Percentage
<i>Acacia ulicifolia</i>	2	2.0
<i>Entolasia stricta</i>	2	2.0
<i>Hibbertia linearis</i>	2	2.0
<i>Ricinocarpos pinifolius</i>	2	2.0
<i>Acacia suaveolens</i>	1	1.0
<i>Banksia aemula</i>	1	1.0
<i>Boronia rosmarinifolia</i>	1	1.0
<i>Bossiaea heterophylla</i>	1	1.0
<i>Caustis recurvata</i>	1	1.0
<i>Dillwynia retorta</i> v <i>retorta</i>	1	1.0
<i>Leucopogon leptospermoides</i>	1	1.0
Total plant coverage		16.0
Leaf Litter		4.0
Bare Sand		80.0

Appendix C

Secondary Transect Field Data

C1.4 Secondary Site 3



Figure A.3: Example of Mallee woodland community at Secondary Transect 3 (09/03/06)

Transect information

Secondary Transect 3	09/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	East end of transect (0 m)	west end of transect (50 m)
	0545146 mE 6960103 mN	
Transect Bearing	250 ⁰ W	
Aspect	350 ⁰ N	
Slope	22 ⁰ (40 %)	
Soil (A Horizon)	Yellow sand, some organic content	
Disturbance	Signs of Fire within previous 2 yrs	

Appendix C

Secondary Transect Field Data

Structure

S3: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	15-18 m	48	Mid-dense
Mid (S1)	8-10 m		Mid-dense
Shrub (S1)	1-3		Sparse
Ground (G)	< 1 m		Sparse

¹ After Walker and Hopkins, 1990

Basal area count

S3: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Allocasuarina torulosa</i>	2
<i>Banksia aemula</i>	5
<i>Corymbia intermedia</i>	4
<i>Eucalyptus planchoniana</i>	1
<i>Eucalyptus racemosa</i>	3

Canopy, mid and shrub stem counts

Secondary Site 3: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Allocasuarina torulosa</i>	canopy	1
<i>Banksia aemula</i>	mid	10
<i>Corymbia intermedia</i>	canopy	6
<i>Corymbia intermedia</i>	mid	2
<i>Eucalyptus planchoniana</i>	canopy	10
<i>Eucalyptus planchoniana</i>	mid	4
<i>Eucalyptus racemosa</i>	canopy	4
<i>Eucalyptus racemosa</i>	mid	4
S2 50x2 m Sub plot		
<i>Acacia ulicifolia</i>	Shrub	8
<i>Dodonaea triquetra</i>	Shrub	5
<i>Hibbertia linearis</i>	Shrub	4
<i>Leucopogon pedicellatus</i>	Shrub	1
<i>Ricinocarpos pinifolius</i>	Shrub	6

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S3: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Boronia rosmarinifolia</i>	1	1.0
<i>Lomandra longifolia</i>	5	5.0
Total plant coverage		6.0
Leaf Litter		20.0
Bare Sand		74.0

S3: Quadrat 2 1 x 1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Lomandra longifolia</i>	3	3.0
Total plant coverage		3.0
Leaf Litter		97.0
Bare Sand		0.0

S3: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Boronia rosmarinifolia</i>	1	1.0
<i>Lomandra longifolia</i>	6	6.0
Total plant coverage		7.0
Leaf Litter		3.0
Bare Sand		90.0

S3: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Caustis blakei</i>	1	1.0
<i>Entolasia stricta</i>	2	2.0
<i>Lomandra longifolia</i>	5	5.0
<i>Monotoca scoparia</i>	1	1.0
<i>Ricinocarpos pinifolius</i>	1	1.0
Total plant coverage		10.0
Leaf Litter		90.0
Bare Sand		0.0

S3: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Lomandra longifolia</i>	6	6.0
<i>Entolasia stricta</i>	2	2.0
<i>Austromyrtus dulcis</i>	1	1.0
<i>Caustis blakei</i>	1	1.0
<i>Ricinocarpos pinifolius</i>	1	1.0
Total plant coverage		1.0
Leaf Litter		89.0
Bare Sand		0.0

Appendix C

Secondary Transect Field Data

C1.5 Secondary Site 4



Figure A.4: Example of Mallee woodland community at Secondary Transect 4 (09/03/06)

Transect information

Secondary Transect 4	09/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	West end of transect (0 m)	East end of transect (50 m)
	0544788 mE 6960156 mN	0544833 mE 6960150 mN
Transect Bearing	110 ⁰ E	
Aspect	350 ⁰ N	
Slope	25 ⁰ (47 %)	
Soil (A Horizon)	White sand, some organic content	
Disturbance	Signs of Fire within previous 2 yrs	

Appendix C

Secondary Transect Field Data

Structure

S4: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	15-18 m	40	Mid-dense
Mid (T2)	8-10 m		Mid-dense
Shrub (S1)	1-3		Dense
Ground (G)	< 1 m		Sparse

¹ After Walker and Hopkins, 1990

Basal area count

S4: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	5
<i>Corymbia intermedia</i>	7
<i>Eucalyptus planchoniana</i>	2

Canopy, mid and shrub stem counts

Secondary Site 4: T1 & T2 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	3
<i>Banksia aemula</i>	mid	7
<i>Corymbia intermedia</i>	canopy	2
<i>Eucalyptus planchoniana</i>	mid	15
S1 50x2 m Sub plot		
<i>Acacia ulicifolia</i>	Shrub	13
<i>Banksia aemula</i>	Shrub	3
<i>Boronia rosmarinifolia</i>	Shrub	2
<i>Hibbertia linearis</i>	Shrub	3
<i>Ricinocarpos pinifolius</i>	Shrub	4
<i>Strangea linearis</i>	Shrub	3
<i>Xanthorrhoea johnsonii</i>	Shrub	18

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S4: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		4.0
<i>Caustis blakei</i>		1.0
<i>Leucopogon leptospermoides</i>		4.0
<i>Monotoca scoparia</i>		1.0
Total plant coverage		10.0
Leaf Litter		88.0
Bare Sand		2.0

S4: Quadrat 2 1 x 1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		20.0
<i>Baloskion pallens</i>		3.0
<i>Banksia aemula</i>		2.0
<i>Bossiaea heterophylla</i>		5.0
<i>Caustis blakei</i>		5.0
<i>Gompholobium virgatum v emarginatum</i>		5.0
<i>Leucopogon leptospermoides</i>		10.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S4: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Banksia aemula</i>	9	9.0
<i>Entolasia stricta</i>	1	1.0
Total plant coverage		10.0
Leaf Litter		70.0
Bare Sand		20.0

S4: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		2.0
<i>Banksia aemula</i>		2.0
<i>Bossiaea heterophylla</i>		2.0
<i>Caustis blakei</i>		2.0
<i>Eriachne pallescens</i>		1.0
<i>Schoenus ornithopodioides</i>		1.0
Total plant coverage		10.0
Leaf Litter		90.0
Bare Sand		0.0

S4: Quadrat 5 1 x 1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Xanthorrhoea johnsonii</i>		10.0
<i>Acacia ulicifolia</i>		2.0
<i>Bossiaea heterophylla</i>		1.0
<i>Caustis blakei</i>		1.0
Total plant coverage		14.0
Leaf Litter		86.0
Bare Sand		0.0

Appendix C

Secondary Transect Field Data

C1.6 Secondary Site 5



Figure A.5: Example of Mallee woodland community at Secondary Transect 5 (09/03/06)

Transect information

Secondary Transect 5	09/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	North end of transect (0 m)	South end of transect (50 m)
	0544094 mE 6960103 mN	
Transect Bearing	160° S	
Aspect	70° E	
Slope	15° (22 %)	
Soil (A Horizon)	Sandy loam, some organic content	
Disturbance	Signs of Fire within previous 2-5 yrs	

Appendix C

Secondary Transect Field Data

Structure

S5: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	8-10 m	30	Mid-dense
Mid (S1)	3-5 m		Mid-dense
Shrub (S2)	1-3		Dense
Ground (G)	< 1 m		Sparse

¹ After Walker and Hopkins, 1990

Basal area count

S5: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	6
<i>Eucalyptus planchoniana</i>	6

Canopy, mid and shrub stem counts

Secondary Site 5: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	mid	14
<i>Corymbia intermedia</i>	canopy	1
<i>Eucalyptus planchoniana</i>	canopy	27
<i>Leptospermum trinervium</i>	mid	9
S2 50x2 m Sub plot		
<i>Acacia ulicifolia</i>	shrub	7
<i>Banksia aemula</i>	shrub	7
<i>Eucalyptus planchoniana</i>	shrub	2
<i>Gompholobium virgatum v emarginatum</i>	shrub	8
<i>Leptospermum trinervium</i>	shrub	4
<i>Leucopogon leptospermoides</i>	shrub	2
<i>Xanthorrhoea johnsonii</i>	shrub	10
<i>Zieria laxiflora</i>	shrub	1

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S5: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		20.0
<i>Leucopogon leptospermoides</i>		20.0
<i>Gompholobium virgatum</i> v <i>emarginatum</i>		5.0
<i>Pimelea linifolia</i>		3.0
<i>Caustis recurvata</i>		2.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S5: Quadrat 2 1 x 1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Leptospermum trinervium</i>		30.0
<i>Acacia ulicifolia</i>		5.0
<i>Entolasia stricta</i>		5.0
<i>Leucopogon leptospermoides</i>		5.0
<i>Caustis recurvata</i>		4.0
<i>Laxmannia gracilis</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S5: Quadrat 3 1x1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Xanthorrhoea johnsonii</i>		45.0
<i>Acacia ulicifolia</i>		5.0
Total plant coverage		50.0
Leaf Litter		50.0
Bare Sand		0.0

S5: Quadrat 4 1x1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		30.0
<i>Xanthorrhoea johnsonii</i>		10.0
Total plant coverage		40.0
Leaf Litter		20.0
Bare Sand		40.0

S5: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Strangea linearis</i>		50.0
<i>Acacia ulicifolia</i>		15.0
<i>Aotus ericoides</i>		5.0
Total plant coverage		70.0
Leaf Litter		20.0
Bare Sand		10.0

Appendix C

Secondary Transect Field Data

C1.7 42625813 Secondary Site 6



Figure A.6: Example of Mallee woodland community at Secondary Transect 6 (10/03/06)

Transect information

Secondary Transect 6	10/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	South end of transect (0 m)	North end of transect (50 m)
	0545717 mE 6959354 mN	
Transect Bearing	320° N	
Aspect	48° NE	
Slope	29° (55 %)	
Soil (A Horizon)	Sandy loam, some organic content	
Disturbance	Signs of Fire within previous 2 yrs	

Appendix C

Secondary Transect Field Data

Structure

S6: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	8-10 m	35	Mid-dense
Mid (S1)	3-5 m		Sparse
Shrub (S2)	1-3		Mid-dense
Ground (G)	< 1 m		Sparse

¹ After Walker and Hopkins, 1990

Basal area count

S6: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	3
<i>Eucalyptus planchoniana</i>	3

Canopy, mid and shrub stem counts

Secondary Site 6: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Allocasuarina torulosa</i>	mid	
<i>Banksia aemula</i>	canopy	7
<i>Banksia aemula</i>	mid	11
<i>Corymbia intermedia</i>	canopy	2
<i>Corymbia intermedia</i>	mid	1
<i>Eucalyptus planchoniana</i>	canopy	40
<i>Eucalyptus planchoniana</i>	mid	27
S2 50x2 m Sub plot		
<i>Acacia suaveolens</i>	shrub	1
<i>Acacia ulicifolia</i>	shrub	6
<i>Allocasuarina littoralis</i>	shrub	2
<i>Banksia aemula</i>	shrub	5
<i>Callitris columellaris</i>	shrub	7
<i>Eucalyptus planchoniana</i>	shrub	4
<i>Gompholobium virgatum v emarginatum</i>	shrub	2
<i>Hibbertia linearis</i>	shrub	2
<i>Leptospermum trinervium</i>	shrub	3
<i>Leucopogon leptospermoides</i>	shrub	1
<i>Monotoca scoparia</i>	shrub	15
<i>Ricinocarpos pinifolius</i>	shrub	5
<i>Woollsia pungens</i>	shrub	2

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S6: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acacia suaveolens</i>		1.0
<i>Acacia ulicifolia</i>		2.0
<i>Caustis recurvata</i>		2.0
<i>Entolasia stricta</i>		2.0
<i>Leucopogon leptospermoides</i>		10.0
<i>Pimelea linifolia</i>		1.0
<i>Zieria laxiflora</i>		2.0
Total plant coverage		20.0
Leaf Litter		70.0
Bare Sand		10.0

S6: Quadrat 2 1 x 1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		20.0
<i>Bossiaea heterophylla</i>		1.0
<i>Caustis recurvata</i>		50.0
<i>Dillwynia retorta v retorta</i>		2.0
<i>Entolasia stricta</i>		2.0
<i>Hibbertia linearis</i>		2.0
<i>Ricinocarpos pinifolius</i>		2.0
<i>Zieria laxiflora</i>		1.0
Total plant coverage		80.0
Leaf Litter		10.0
Bare Sand		10.0

S6: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		10.0
<i>Bossiaea heterophylla</i>		1.0
<i>Caustis recurvata</i>		2.0
<i>Dillwynia retorta v retorta</i>		5.0
<i>Entolasia stricta</i>		2.0
<i>Xanthorrhoea johnsonii</i>		30.0
Total plant coverage		50.0
Leaf Litter		45.0
Bare Sand		5.0

S6: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		10.0
<i>Bossiaea heterophylla</i>		1.0
<i>Caustis recurvata</i>		2.0
<i>Dillwynia retorta v retorta</i>		5.0
<i>Entolasia stricta</i>		2.0
<i>Ricinocarpos pinifolius</i>		1.0
<i>Xanthorrhoea johnsonii</i>		30.0
<i>Zieria laxiflora</i>		1.0
Total plant coverage		52.0
Leaf Litter		0.0
Bare Sand		48.0

S6: Quadrat 5 1 x 1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Caustis recurvata</i>		10.0
<i>Coleocarya gracilis</i>		30.0
<i>Dillwynia retorta v retorta</i>		3.0
<i>Leptospermum trinervium</i>		10.0
<i>Leucopogon margarodes</i>		10.0
<i>Woolfsia pungens</i>		2.0
<i>Xanthorrhoea johnsonii</i>		5.0
Total plant coverage		70.0
Leaf Litter		0.0
Bare Sand		30.0

Appendix C

Secondary Transect Field Data

C1.8 Secondary Site 7



Figure A.7: Example of Mallee woodland community at Secondary Transect 7 (10/03/06)

Transect information

Secondary Transect 7	10/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	North-west end of transect (0 m)	South-east end of transect (50 m)
	0545390 mE 6959790 mN	
Transect Bearing	150° SE	
Aspect	60° NE	
Slope	19° (35 %)	
Soil (A Horizon)	Sandy loam, some organic content	
Disturbance	Fire disturbance not as evident as most sites	

Appendix C

Secondary Transect Field Data

Structure

S7: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	5-8 m	30	Mid-dense
Mid (S1)	2-4 m		Sparse
Shrub (S2)	1-3 m		Mid-dense
Ground (G)	< 1 m		Sparse

¹ After Walker and Hopkins, 1990

Basal area count

S7: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	6
<i>Eucalyptus planchoniana</i>	6

Canopy, mid and shrub stem counts

Secondary Site 7: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	7
<i>Banksia aemula</i>	mid	11
<i>Eucalyptus planchoniana</i>	canopy	40
<i>Eucalyptus planchoniana</i>	mid	27
S2 50x2 m Sub plot		
<i>Acacia suaveolens</i>	shrub	1
<i>Conospermum taxifolium</i>	shrub	2
<i>Gompholobium virgatum v emarginatum</i>	shrub	2
<i>Hibbertia linearis</i>	shrub	3
<i>Leptospermum trinervium</i>	shrub	2
<i>Ricinocarpos pinifolius</i>	shrub	1
<i>Xanthorrhoea johnsonii</i>	shrub	6

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S7: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		5.0
<i>Amperea xiphoclada</i>		1.0
<i>Caustis recurvata</i>		10.0
<i>Entolasia stricta</i>		1.0
<i>Gompholobium virgatum v emarginatum</i>		1.0
<i>Hibbertia linearis</i>		1.0
<i>Leucopogon leptospermoides</i>		30.0
<i>Xanthorrhoea johnsonii</i>		20.0
<i>Zieria laxiflora</i>		1.0
Total plant coverage		20.0
Leaf Litter		30.0
Bare Sand		50.0

S7: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		10.0
<i>Bossiaea heterophylla</i>		1.0
<i>Caustis recurvata</i>		2.0
<i>Dillwynia retorta v retorta</i>		5.0
<i>Entolasia stricta</i>		2.0
<i>Xanthorrhoea johnsonii</i>		30.0
Total plant coverage		70.0
Leaf Litter		10.0
Bare Sand		20.0

S7: Quadrat 5 1 x 1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Aotus ericoides</i>		5.0
<i>Banksia aemula</i>		5.0
<i>Bossiaea heterophylla</i>		2.0
<i>Caustis recurvata</i>		5.0
<i>Hibbertia linearis</i>		5.0
<i>Leucopogon leptospermoides</i>		25.0
<i>Ochrosperma lineare</i>		2.0
<i>Pimelea linifolia</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0

S7: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		1.0
<i>Banksia aemula</i>		1.0
<i>Boronia rosmarinifolia</i>		1.0
<i>Caustis recurvata</i>		1.0
<i>Entolasia stricta</i>		1.0
<i>Hibbertia linearis</i>		1.0
<i>Leptospermum trinervium</i>		9.0
<i>Xanthorrhoea johnsonii</i>		70.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S7: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		10.0
<i>Bossiaea heterophylla</i>		1.0
<i>Caustis recurvata</i>		2.0
<i>Dillwynia retorta v retorta</i>		5.0
<i>Entolasia stricta</i>		2.0
<i>Ricinocarpos pinifolius</i>		1.0
<i>Xanthorrhoea johnsonii</i>		30.0
<i>Zieria laxiflora</i>		1.0
Total plant coverage		85.0
Leaf Litter		15.0
Bare Sand		0.0

Appendix C

Secondary Transect Field Data

Bare Sand		50.0
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C1.9 Secondary Site 8



Figure A.8: Example of mixed eucalypt open forest community at Secondary Transect 8 (10/03/06)

Transect information

Secondary Transect 8	10/03/06	
Community	Mixed <i>Eucalypt spp.</i> open forest	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	South-east end of transect (0 m)	North end of transect (50 m)
		0545418 mE 6959094 mN
Transect Bearing	170 ⁰ S	
Aspect	250 ⁰ w	
Slope	6 ⁰ (11 %)	
Soil (A Horizon)	Sandy loam, some organic content	

Appendix C

Secondary Transect Field Data

Disturbance	Evidence of intense fire 2-3 yrs previous. Epicormic evident budding on <i>C. gummifera</i>
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Structure

S8: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	20-25 m	68	Mid-dense
Mid (T2)	8-12 m		Mid-dense
Shrub (S2)	2-5 m		Mid-dense
Ground (G)	< 1 m		Mid-dense

¹ After Walker and Hopkins, 1990

Basal area count

S8: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	3
<i>Corymbia gummifera</i>	5
<i>Eucalyptus racemosa</i>	3

Canopy, mid and shrub stem counts

Secondary Site 8: T1 & T2 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	mid	8 (2 dead)
<i>Corymbia gummifera</i>	canopy	3
<i>Corymbia gummifera</i>	mid	1
<i>Eucalyptus racemosa</i>	canopy	3
<i>Eucalyptus racemosa</i>	mid	4
<i>Leptospermum trinervium</i>	mid	1
S1 50x2 m Sub plot		
<i>Acacia ulicifolia</i>	shrub	7
<i>Aotus ericoides</i>	shrub	2
<i>Banksia aemula</i>	shrub	1
<i>Corymbia gummifera</i>	shrub	3
<i>Dodonaea triquetra</i>	shrub	57
<i>Eucalyptus racemosa</i>	shrub	2
<i>Leptospermum trinervium</i>	shrub	1
<i>Pimelea linifolia</i>	shrub	1
<i>Ricinocarpos pinifolius</i>	shrub	2

Appendix C

Secondary Transect Field Data

<i>Xanthorrhoea johnsonii</i>	shrub	4
<i>Zieria laxiflora</i>	shrub	1

Ground layer quadrat data

S8: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Xanthorrhoea johnsonii</i>		40.0
<i>Pteridium esculentum</i>		30.0
<i>Dodonaea triquetra</i>		10.0
Total plant coverage		80.0
Leaf Litter		10.0
Bare Sand		10.0

S8: Quadrat 2 1 x 1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Dodonaea triquetra</i>		3.0
<i>Lomandra longifolia</i>		1.0
<i>Pteridium esculentum</i>		1.0
Total plant coverage		5.0
Leaf Litter		95.0
Bare Sand		0.0

S8: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Dodonaea triquetra</i>		2.0
<i>Acacia ulicifolia</i>		1.0
<i>Lomandra longifolia</i>		1.0
<i>Pteridium esculentum</i>		1.0
Total plant coverage		5.0
Leaf Litter		95.0
Bare Sand		0.0

S8: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Xanthorrhoea johnsonii</i>		3.0
<i>Pteridium esculentum</i>		1.0
<i>Dodonaea triquetra</i>		1.0
Total plant coverage		5.0
Leaf Litter		90.0
Bare Sand		5.0

S7: Quadrat 5 1 x 1 m Sub plot Intersecting transect at 40 m		
Plant Species	Numbers	Percentage
<i>Dodonaea triquetra</i>		2.0
<i>Acacia ulicifolia</i>		2.0
<i>Lomandra longifolia</i>		1.0
Total plant coverage		5.0
Leaf Litter		90.0
Bare Sand		5.0

Appendix C

Secondary Transect Field Data

C1.10 Secondary Site 9



Figure A.9: Example of mixed eucalypt open forest community at Secondary Transect 9 (10/03/06)

Transect information

Secondary Transect 9	10/03/06	
Community	Low Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	east end of transect (0 m)	west end of transect (50 m)
	0544906 mE 6959532 mN	
Transect Bearing	112 ⁰ E	
Aspect	220 ⁰ SSW	
Slope	24 ⁰ (45 %)	
Soil (A Horizon)	Sandy loam, some organic content	
Disturbance	Intense fire within 2 years previously	

Appendix C

Secondary Transect Field Data

Structure

S9: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (S1)	3-5 m	28	Mid-dense
Mid (S2)	1-3 m		Mid-dense
Shrub (S3)	1-2 m		Mid-dense
Ground (G)	< 1 m		Mid-dense

¹ After Walker and Hopkins, 1990

Basal area count

S9: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	5
<i>Eucalyptus planchoniana</i>	3

Canopy, mid and shrub stem counts

Secondary Site 9: S1 & S2 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	7 (4 dead)
<i>Banksia aemula</i>	mid	6
<i>Eucalyptus planchoniana</i>	canopy	14
<i>Eucalyptus planchoniana</i>	mid	9
S3 50x2 m Sub plot		
<i>Acacia suaveolens</i>	shrub	12
<i>Xanthorrhoea johnsonii</i>	shrub	7
<i>Leptospermum polygalifolium</i>	shrub	6
<i>Acacia ulicifolia</i>	shrub	1
<i>Banksia aemula</i>	shrub	1
<i>Leptospermum semibaccatum</i>	shrub	1

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S9: Quadrat 1 1 x 1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Amperea xiphioclada</i>		1.0
<i>Aotus ericoides</i>		1.0
<i>Caustis recurvata</i>		15.0
<i>Ochrosperma lineare</i>		1.0
<i>Xanthorrhoea johnsonii</i>		60.0
Total plant coverage		80.0
Leaf Litter		0.0
Bare Sand		20.0

S9: Quadrat 2 1 x 1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Dillwynia retorta v retorta</i>		40.0
<i>Entolasia stricta</i>		5.0
<i>Acacia suaveolens</i>		2.0
<i>Viminaria juncea</i>		2.0
<i>Hypolaena fastigiata</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S9: Quadrat 3 1 x 1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Leptospermum semibaccatum</i>		15.0
<i>Leucopogon leptospermoides</i>		15.0
<i>Caustis recurvata</i>		10.0
<i>Ochrosperma lineare</i>		5.0
<i>Bossiaea heterophylla</i>		1.0
<i>Hibbertia linearis</i>		1.0
<i>Laxmannia gracilis</i>		1.0
<i>Monotoca scoparia</i>		1.0
<i>Viminaria juncea</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S9: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Leucopogon leptospermoides</i>		30.0
<i>Acacia ulicifolia</i>		15.0
<i>Hibbertia linearis</i>		10.0
<i>Caustis recurvata</i>		5.0
<i>Dillwynia retorta v retorta</i>		5.0
<i>Ochrosperma lineare</i>		3.0
<i>Entolasia stricta</i>		2.0
Total plant coverage		70.0
Leaf Litter		0.0
Bare Sand		30.0

S9: Quadrat 5 1 x 1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Leptospermum polygalifolium</i>		40.0
<i>Caustis recurvata</i>		5.0
<i>Ochrosperma lineare</i>		1.0
<i>Laxmannia gracilis</i>		1.0
<i>Leucopogon leptospermoides</i>		1.0
<i>Pimelea linifolia</i>		1.0
<i>Conospermum taxifolium</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

Appendix C

Secondary Transect Field Data

C1.11 Secondary Site 10



Figure A.10: Example of mixed eucalypt open forest community at Secondary Transect 10 (10/03/06)

Transect information

Secondary Transect 10	10/03/06	
Community	Low Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	north end of transect (0 m)	south end of transect (50 m)
	0545325 mE 6958004 mN	
Transect Bearing	160° SSE	
Aspect	70° E	
Slope	25° (45 %)	
Soil (A Horizon)	Sandy loam, some organic content	
Disturbance	Fire within 2-3 years previously	

Appendix C

Secondary Transect Field Data

Structure

S10: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	8-10 m	18	Sparse
Mid (S1)	5-8 m		Sparse
Shrub (S2)	3-5 m		Mid-dense
Ground (G)	< 1 m		Mid-dense

¹ After Walker and Hopkins, 1990

Basal area count

S10: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	5
<i>Eucalyptus planchoniana</i>	3

Canopy, mid and shrub stem counts

Secondary Site 10: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	5
<i>Banksia aemula</i>	mid	1 (4 dead)
<i>Eucalyptus planchoniana</i>	canopy	5 (7 dead)
<i>Eucalyptus planchoniana</i>	mid	21
S2 50x2 m Sub plot		
<i>Acacia suaveolens</i>	shrub	1
<i>Acacia ulicifolia</i>	shrub	17
<i>Banksia aemula</i>	shrub	4
<i>Eucalyptus planchoniana</i>	shrub	8
<i>Hibbertia linearis</i>	shrub	4
<i>Leptospermum polygalifolium</i>	shrub	7
<i>Ricinoscarpos pinifolius</i>	shrub	26
<i>Zieria laxiflora</i>	shrub	3

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S10: Quadrat 1 1x1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Leptospermum polygalifolium</i>		20.0
<i>Pteridium esculentum</i>		20.0
<i>Acacia ulicifolia</i>		18.0
<i>Lomandra longifolia</i>		10.0
<i>Amperea xiphoclada</i>		5.0
<i>Entolasia stricta</i>		5.0
<i>Hardenbergia violacea</i>		1.0
<i>Hibbertia linearis</i>		1.0
Total plant coverage		80.0
Leaf Litter		0.0
Bare Sand		20.0

S10: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Caustis recurvata</i>		20.0
<i>Acacia ulicifolia</i>		10.0
<i>Hibbertia linearis</i>		10.0
<i>Entolasia stricta</i>		4.0
<i>Lomandra longifolia</i>		3.0
<i>Ricinocarpos pinifolius</i>		2.0
<i>Schizaea bifida</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S10: Quadrat 3 1x1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Leptospermum semibaccatum</i>		15.0
<i>Leucopogon leptospermoides</i>		15.0
<i>Caustis recurvata</i>		10.0
<i>Ochrosperma lineare</i>		5.0
<i>Bossiaea heterophylla</i>		1.0
<i>Hibbertia linearis</i>		1.0
<i>Laxmannia gracilis</i>		1.0
<i>Monotoca scoparia</i>		1.0
<i>Viminaria juncea</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S10: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Leucopogon leptospermoides</i>		30.0
<i>Acacia ulicifolia</i>		15.0
<i>Hibbertia linearis</i>		10.0
<i>Caustis recurvata</i>		5.0
<i>Dillwynia retorta v retorta</i>		5.0
<i>Ochrosperma lineare</i>		3.0
<i>Entolasia stricta</i>		2.0
Total plant coverage		70.0
Leaf Litter		0.0
Bare Sand		30.0

S10: Quadrat 5 1 x 1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Leptospermum polygalifolium</i>		40.0
<i>Caustis recurvata</i>		5.0
<i>Ochrosperma lineare</i>		1.0
<i>Laxmannia gracilis</i>		1.0
<i>Leucopogon leptospermoides</i>		1.0
<i>Pimelea linifolia</i>		1.0
<i>Conospermum taxifolium</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

Appendix C

Secondary Transect Field Data

C1.12 Secondary Site 11



Figure A.11: Example of mixed eucalypt open forest community at Secondary Transect 11 (10/03/06)

Transect information

Secondary Transect 11	10/03/06	
Community	Low Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	North-east end of transect (0 m)	South-west end of transect (50 m)
	0545217 mE 6957474 mN	
Transect Bearing	235 ⁰ SW	
Aspect	180 ⁰ S	
Slope	20 ⁰ (36 %)	
Soil (A Horizon)	Sandy loam, some organic content	
Disturbance	Fire within 2-3 years previously	

Appendix C

Secondary Transect Field Data

Structure

S11: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	12-15 m	56	Mid-dense
Mid (S1)	3-5 m		Mid-dense
Shrub (S2)	1-3 m		Dense
Ground (G)	< 1 m		Mid-dense

¹ After Walker and Hopkins, 1990

Basal area count

S11: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	3
<i>Eucalyptus planchoniana</i>	8

Canopy, mid and shrub stem counts

Secondary Site 11: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	11
<i>Banksia aemula</i>	mid	17
<i>Eucalyptus planchoniana</i>	canopy	24
<i>Eucalyptus planchoniana</i>	mid	30
S2 50x2 m Sub plot		
<i>Hibbertia linearis</i>	shrub	17
<i>Homoranthus virgatus</i>	shrub	12
<i>Zieria laxiflora</i>	shrub	9
<i>Ricinocarpos pinifolius</i>	shrub	7
<i>Conospermum taxifolium</i>	shrub	2
<i>Leucopogon pedicellatus</i>	shrub	2
<i>Monotoca scoparia</i>	shrub	2
<i>Boronia rosmarinifolia</i>	shrub	1
<i>Boronia saefrolifera</i>	shrub	1
<i>Leptospermum polygalifolium</i>	shrub	1
<i>Ochrosperma lineare</i>	shrub	1

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S11: Quadrat 1 1x1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Boronia rosmarinifolia</i>		1.0
<i>Xanthorrhoea johnsonii</i>		1.0
<i>Hibbertia linearis</i>		1.0
Total plant coverage		3.0
Leaf Litter		0.0
Bare Sand		97.0

S11: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Austromyrtus dulcis</i>		1.0
<i>Leucopogon pedicellatus</i>		1.0
<i>Lomandra longifolia</i>		1.0
<i>Strangea linearis</i>		1.0
Total plant coverage		4.0
Leaf Litter		96.0
Bare Sand		0.0

S11: Quadrat 3 1x1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Xanthorrhoea johnsonii</i>		30.0
<i>Schoenus ornithopodioides</i>		10.0
<i>Caustis recurvata</i>		5.0
<i>Dillwynia retorta v retorta</i>		2.0
<i>Hibbertia linearis</i>		2.0
<i>Zieria laxiflora</i>		1.0
Total plant coverage		50.0
Leaf Litter		50.0
Bare Sand		0.0

S11: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Homoranthus virgatus</i>		10.0
<i>Caustis recurvata</i>		5.0
<i>Entolasia stricta</i>		5.0
<i>Hibbertia linearis</i>		5.0
<i>Ochrosperma lineare</i>		5.0
<i>Ricinocarpos pinifolius</i>		3.0
<i>Zieria laxiflora</i>		2.0
Total plant coverage		35.0
Leaf Litter		65.0
Bare Sand		0.0

S11: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Ochrosperma lineare</i>		20.0
<i>Caustis recurvata</i>		10.0
<i>Homoranthus virgatus</i>		10.0
<i>Epacris pulchella</i>		5.0
<i>Leucopogon leptospermoides</i>		5.0
<i>Monotoca scoparia</i>		5.0
<i>Zieria laxiflora</i>		5.0
Total plant coverage		60.0
Leaf Litter		20.0
Bare Sand		20.0

Appendix C

Secondary Transect Field Data

C1.13 Secondary Site 12



Figure A.12: Example of mixed eucalypt open forest community at Secondary Transect 12 (11/03/06)

Transect information

Secondary Transect 12	11/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	east end of transect (0 m)	west end of transect (50 m)
	0545418 mE 6959094 mN	0545371 mE 6959097 mN
Transect Bearing	100 ⁰ E	
Aspect	180 ⁰ S	
Slope	9 ⁰ (17 %)	
Soil (A Horizon)	Sandy grey loam, med -high organic content	
Disturbance	Doesn't appear burnt within 5 -8 yrs years previously	

Appendix C

Secondary Transect Field Data

Structure

S12: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	5-6 m	38	Mid-dense
Mid (S1)	4-5 m		Mid-dense
Shrub (S2)	2-3 m		Dense
Ground (G)	< 1 m		Mid-dense

¹ After Walker and Hopkins, 1990

Basal area count

S12: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	3
<i>Eucalyptus racemosa</i>	3
<i>Eucalyptus planchoniana</i>	5

Canopy, mid and shrub stem counts

Secondary Site 12: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	7
<i>Banksia aemula</i>	mid	7
<i>Corymbia gummifera</i>	canopy	2
<i>Corymbia gummifera</i>	mid	12
<i>Eucalyptus racemosa</i>	canopy	5
<i>Eucalyptus racemosa</i>	mid	4
<i>Eucalyptus planchoniana</i>	canopy	24
<i>Eucalyptus planchoniana</i>	mid	13
S2 50x2 m Sub plot		
<i>Epacris pulchella</i>	shrub	41
<i>Monotoca scoparia</i>	shrub	20
<i>Podocarpus spinulosus</i>	shrub	13
<i>Ochrosperma lineare</i>	shrub	8
<i>Leucopogon pedicellatus</i>	shrub	7
<i>Dillwynia retorta v retorta</i>	shrub	6
<i>Woollsia pungens</i>	shrub	3
<i>Allocasuarina littoralis</i>	shrub	2
<i>Aotus ericoides</i>	shrub	2
<i>Leucopogon margarodes</i>	shrub	2
<i>Banksia aemula</i>	shrub	1
<i>Eucalyptus racemosa</i>	shrub	1
<i>Leptospermum polygalifolium</i>	shrub	1

Appendix C

Secondary Transect Field Data

<i>Persoonia virgata</i>	shrub	1
<i>Ricinocarpos pinifolius</i>	shrub	1

Ground layer quadrat data

S12: Quadrat 1 1x1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Caustis recurvata</i>		2.0
<i>Dillwynia retorta</i> v <i>retorta</i>		1.0
<i>Lepidosperma laterale</i>		1.0
<i>Podocarpus spinulosus</i>		15.0
<i>Woollisia pungens</i>		1.0
Total plant coverage		20.0
Leaf Litter		80.0
Bare Sand		0.0

S12: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Austromyrtus dulcis</i>		2.0
<i>Entolasia stricta</i>		1.0
<i>Leucopogon margarodes</i>		1.0
<i>Podocarpus spinulosus</i>		15.0
Total plant coverage		20.0
Leaf Litter		80.0
Bare Sand		0.0

S12: Quadrat 3 1x1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Caustis recurvata</i>		3.0
<i>Dillwynia retorta</i> v <i>retorta</i>		5.0
<i>Lepyrodia scariosa</i>		20.0
<i>Monotoca scoparia</i>		5.0
<i>Ochrosperma lineare</i>		25.0
<i>Woollisia pungens</i>		20.0
Total plant coverage		80.0
Leaf Litter		20.0
Bare Sand		0.0

S12: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Banksia aemula</i>		10.0
<i>Entolasia stricta</i>		5.0
<i>Caustis recurvata</i>		3.0
<i>Epacris pulchella</i>		1.0
<i>Eucalyptus planchoniana</i>		1.0
Total plant coverage		20.0
Leaf Litter		80.0
Bare Sand		0.0

S12: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Bossiaea heterophylla</i>		1.0
<i>Dillwynia retorta</i> v <i>retorta</i>		1.0
<i>Eucalyptus planchoniana</i>		1.0
<i>Lepidosperma laterale</i>		1.0
<i>Lepyrodia scariosa</i>		50.0
<i>Monotoca scoparia</i>		1.0
<i>Ochrosperma lineare</i>		20.0
<i>Woollisia pungens</i>		5.0
Total plant coverage		80.0
Leaf Litter		20.0
Bare Sand		0.0

Appendix C

Secondary Transect Field Data

C1.14 Secondary Site 13



Figure A.13: Example of mixed eucalypt open forest community at Secondary Transect 13 (11/03/06)

Transect information

Secondary Transect 13	11/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	Soutj-east end of transect (0 m)	north-west end of transect (50 m)
	0545936 mE 6958614 mN	
Transect Bearing	240° NW	
Aspect	230° SW	
Slope	15° (23 %)	
Soil (A Horizon)	Sandy grey loam, med -high organic content	
Disturbance	Fire disturbance within previous 2-yrs	

Appendix C

Secondary Transect Field Data

Structure

S13: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	8-10 m	24	Sparse
Mid (S1)	5-6 m		Dense
Shrub (S2)	1-3 m		Dense
Ground (G)	< 1 m		Mid-dense

¹ After Walker and Hopkins, 1990

Basal area count

S13: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	2
<i>Eucalyptus planchoniana</i>	6

Canopy, mid and shrub stem counts

Secondary Site 13: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	3
<i>Banksia aemula</i>	mid	11
<i>Eucalyptus planchoniana</i>	canopy	33
<i>Eucalyptus planchoniana</i>	mid	38
S2 50x2 m Sub plot		
<i>Acacia suaveolens</i>	shrub	20
<i>Boronia saffrolifera</i>	shrub	1
<i>Eucalyptus planchoniana</i>	shrub	1
<i>Zieria laxiflora</i>	shrub	1
<i>Boronia rosmarinifolia</i>	shrub	1
<i>Leucopogon leptospermoides</i>	shrub	1

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S13: Quadrat 1 1x1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		10.0
<i>Amperea xiphoclada</i>		1.0
<i>Austromyrtus dulcis</i>		1.0
<i>Caustis recurvata</i>		1.0
<i>Dillwynia retorta</i> v <i>retorta</i>		1.0
<i>Entolasia stricta</i>		5.0
<i>Xanthorrhoea johnsonii</i>		20.0
<i>Zieria laxiflora</i>		1.0
Total plant coverage		40.0
Leaf Litter		0.0
Bare Sand		60.0

S13: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		2.0
<i>Austromyrtus dulcis</i>		5.0
<i>Banksia aemula</i>		20.0
<i>Caustis recurvata</i>		10.0
<i>Entolasia stricta</i>		3.0
<i>Xanthorrhoea johnsonii</i>		20.0
Total plant coverage		60.0
Leaf Litter		15.0
Bare Sand		25.0

S13: Quadrat 3 1x1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Acacia suaveolens</i>		5.0
<i>Caustis recurvata</i>		15.0
Total plant coverage		20.0
Leaf Litter		0.0
Bare Sand		80.0

S13: Quadrat 4 1x1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Acacia suaveolens</i>		5.0
<i>Caustis recurvata</i>		2.0
<i>Dillwynia retorta</i> v <i>retorta</i>		3.0
<i>Xanthorrhoea johnsonii</i>		50.0
Total plant coverage		60.0
Leaf Litter		0.0
Bare Sand		40.0

S13: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Acacia suaveolens</i>		1.0
<i>Aotus ericoides</i>		1.0
<i>Banksia aemula</i>		1.0
<i>Boronia saffrolifera</i>		6.0
<i>Leptospermum semibaccatum</i>		20.0
<i>Viminaria juncea</i>		1.0
<i>Xanthorrhoea johnsonii</i>		10.0
Total plant coverage		40.0
Leaf Litter		0.0
Bare Sand		60.0

Appendix C

Secondary Transect Field Data

C1.15 Secondary Site 14



Figure A.14: Example of mixed eucalypt open forest community at Secondary Transect 14 (11/03/06)

Transect information

Secondary Transect 14	11/03/06	
Community	Mallee <i>Eucalypt</i> spp. woodland	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	north end of transect (0 m)	south end of transect (50 m)
	0546216 mE 6958889 mN	
Transect Bearing	330 ⁰ N	
Aspect	250 ⁰ W	
Slope	12 ⁰ (21 %)	
Soil (A Horizon)	Sandy grey loam, med -high organic content	
Disturbance	Fire disturbance within previous 2-yrs	

Appendix C

Secondary Transect Field Data

Structure

S14: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	8-10 m	28	Sparse
Mid (S1)	5-8 m		Mid-dense
Shrub (S2)	1-3 m		Sparse
Ground (G)	< 1 m		Sparse

¹ After Walker and Hopkins, 1990

Basal area count

S14: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	2
<i>Eucalyptus planchoniana</i>	3

Canopy, mid and shrub stem counts

Secondary Site 14: T1 & S1 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	13
<i>Eucalyptus planchoniana</i>	canopy	8
<i>Eucalyptus planchoniana</i>	mid	27
S2 50x2 m Sub plot		
<i>Acacia suaveolens</i>	shrub	18
<i>Hibbertia linearis</i>	shrub	13
<i>Zieria laxiflora</i>	shrub	13
<i>Conospermum taxifolium</i>	shrub	9
<i>Ricinocarpos pinifolius</i>	shrub	8
<i>Xanthorrhoea johnsonii</i>	shrub	8
<i>Acacia ulicifolia</i>	shrub	4
<i>Eucalyptus planchoniana</i>	shrub	4
<i>Banksia aemula</i>	shrub	3
<i>Callitris columellaris</i>	shrub	2
<i>Dillwynia retorta v retorta</i>	shrub	1
<i>Elaeocarpus reticulatus</i>	shrub	1
<i>Monotoca scoparia</i>	shrub	1
<i>Strangea linearis</i>	shrub	1

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S14: Quadrat 1 1x1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acacia suaveolens</i>		2.0
<i>Boronia rosmarinifolia</i>		5.0
<i>Caustis recurvata</i>		2.0
<i>Dillwynia retorta</i> v <i>retorta</i>		1.0
<i>Entolasia stricta</i>		20.0
Total plant coverage		30.0
Leaf Litter		50.0
Bare Sand		20.0

S14: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Acacia suaveolens</i>		1.0
<i>Boronia rosmarinifolia</i>		1.0
<i>Caustis recurvata</i>		10.0
<i>Dillwynia retorta</i> v <i>retorta</i>		1.0
<i>Monotoca scoparia</i>		1.0
<i>Patersonia sericea</i>		1.0
<i>Xanthorrhoea johnsonii</i>		15.0
Total plant coverage		30.0
Leaf Litter		60.0
Bare Sand		10.0

S14: Quadrat 3 1x1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		5.0
<i>Cassytha pubescens</i>		1.0
<i>Caustis recurvata</i>		2.0
<i>Dillwynia retorta</i> v <i>retorta</i>		1.0
<i>Entolasia stricta</i>		15.0
<i>Hibbertia linearis</i>		1.0
<i>Leptospermum polygalifolium</i>		2.0
<i>Ricinocarpos pinifolius</i>		2.0
<i>Xanthorrhoea johnsonii</i>		30.0
<i>Zieria laxiflora</i>		1.0
Total plant coverage		60.0
Leaf Litter		0.0
Bare Sand		40.0

S14: Quadrat 4 1 x 1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		5.0
<i>Boronia rosmarinifolia</i>		2.0
<i>Caustis recurvata</i>		1.0
<i>Conospermum taxifolium</i>		10.0
<i>Leucopogon leptospermoides</i>		10.0
<i>Viminaria juncea</i>		1.0
<i>Xanthorrhoea johnsonii</i>		20.0
<i>Zieria laxiflora</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

S14: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Xanthorrhoea johnsonii</i>		25.0
<i>Acacia ulicifolia</i>		10.0
<i>Acacia suaveolens</i>		5.0
<i>Zieria laxiflora</i>		5.0
<i>Entolasia stricta</i>		2.0
<i>Caustis recurvata</i>		1.0
<i>Dillwynia retorta</i> v <i>retorta</i>		1.0
<i>Lomandra longifolia</i>		1.0
Total plant coverage		50.0
Leaf Litter		0.0
Bare Sand		50.0

Appendix C

Secondary Transect Field Data

C1.16 Secondary Site 15



Figure A.15: Example of wet heath community at Secondary Transect 15 (11/03/06)

Transect information

Secondary Transect 15	11/03/06	
Community	Wet heath	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	north end of transect (0 m)	south end of transect (50 m)
	0546109 mE 6959212 mN	
Transect Bearing	340 ⁰ N	
Aspect	0 ⁰	
Slope	0 ⁰	
Soil (A Horizon)	Alluvial sand	
Disturbance	Fire disturbance on margins	

Appendix C

Secondary Transect Field Data

Structure

S15: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (S1)	2-3 m		Sparse
Mid(S2)	1-2 m		Mid-dense
Shrub (S3)	> 0.7 m		Dense
Ground (G)	< 1 m		Dense

¹ After Walker and Hopkins, 1990

Basal area count

S15: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Banksia aemula</i>	1

Canopy, mid and shrub stem counts

Secondary Site 15: S1 50x10 m Plot		
Species	Strata	Count
<i>Banksia aemula</i>	canopy	5
<i>Gahnia sieberiana</i>	canopy	6
<i>Leptospermum liversidgei</i>	canopy	15
S2 & S3 50x2 m Sub plot		
<i>Aotus lanigera</i>	shrub	1
<i>Epacris microphylla</i>	shrub	5
<i>Gahnia sieberiana</i>	shrub	4
<i>Leptospermum liversidgei</i>	shrub	18
<i>Ochrosperma lineare</i>	shrub	12
<i>Sprengelia sprengelioides</i>	shrub	10

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S15: Quadrat 1 1x1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Baloskion tetraphyllum</i>		5.0
<i>Cassytha pubescens</i>		1.0
<i>Empodisma minor</i>		35.0
<i>Entolasia stricta</i>		1.0
<i>Epacris microphylla</i>		4.0
<i>Leptospermum liversidgei</i>		30.0
<i>Ochrosperma lineare</i>		20.0
<i>Sprengelia sprengelioides</i>		4.0
Total plant coverage		100.0
Leaf Litter		0.0
Bare Sand		0.0

S15: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Baumea muelleri</i>		2.0
<i>Cassytha filiformis</i>		1.0
<i>Empodisma minor</i>		80.0
<i>Hibbertia salicifolia</i>		2.0
<i>Leptospermum liversidgei</i>		5.0
<i>Sprengelia sprengelioides</i>		10.0
Total plant coverage		100.0
Leaf Litter		0.0
Bare Sand		0.0

S15: Quadrat 3 1x1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Baumea muelleri</i>		3.0
<i>Cassytha pubescens</i>		1.0
<i>Empodisma minor</i>		25.0
<i>Entolasia stricta</i>		15.0
<i>Leptospermum liversidgei</i>		50.0
<i>Rhynchospora brownii</i>		2.0
<i>Sprengelia sprengelioides</i>		4.0
Total plant coverage		100.0
Leaf Litter		0.0
Bare Sand		0.0

S15: Quadrat 4 1x1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Baumea muelleri</i>		24.0
<i>Empodisma minor</i>		40.0
<i>Entolasia stricta</i>		10.0
<i>Epacris microphylla</i>		1.0
<i>Leptospermum liversidgei</i>		10.0
<i>Ochrosperma lineare</i>		10.0
<i>Sprengelia sprengelioides</i>		5.0
Total plant coverage		100.0
Leaf Litter		0.0
Bare Sand		0.0

S15: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Baumea muelleri</i>		5.0
<i>Boronia rosmarinifolia</i>		5.0
<i>Empodisma minor</i>		60.0
<i>Hibbertia salicifolia</i>		1.0
<i>Leptospermum liversidgei</i>		20.0
<i>Rhynchospora brownii</i>		3.0
<i>Sprengelia sprengelioides</i>		5.0
<i>Utricularia dichotoma</i>		1.0
Total plant coverage		10.0
Leaf Litter		0.0
Bare Sand		0.0

Appendix C

Secondary Transect Field Data

C1.17 Secondary Site 16



Figure A.16: Example mixed eucalypt open forest at Secondary Transect 16 (12/03/06)

Transect information

Secondary Transect 16	12/03/06	
Community	Wet heath	
Location UTM WGS '84 (GPS accuracy +/- 5 m)	north end of transect (0 m)	south end of transect (50 m)
	0546628 mE 6959248 mN	
Transect Bearing	360 ⁰ N	
Aspect	340 ⁰ N ⁰	
Slope	12 ⁰ (21 %)	
Soil (A Horizon)	Sand loam	
Disturbance	Evidence of intense burn 3-5 yrs previous	

Appendix C

Secondary Transect Field Data

Structure

S15: Structure			
Strata	Height (m)	FPC (%)	Cover Classification ¹
Canopy (T1)	25-30 m	42	Mid-dense
Mid(T2)	10-15 m		Mid-dense
Shrub (S1)	1-3 m		Sparse
Ground (G)	< 1 m		Dense

¹ After Walker and Hopkins, 1990

Basal area count

S15: Basal prism sweep (BAF 1:1) Transect intersect at 25 m	
Species	Count
<i>Allocasuarina torulosa</i>	1
<i>Corymbia gummifera</i>	4
<i>Eucalyptus pilularis</i>	12
<i>Eucalyptus planchoniana</i>	3

Canopy, mid and shrub stem counts

Secondary Site 15: T1 & T2 50x10 m Plot		
Species	Strata	Count
<i>Allocasuarina torulosa</i>	mid	3
<i>Corymbia gummifera</i>	canopy	2
<i>Eucalyptus pilularis</i>	canopy	13
<i>Eucalyptus pilularis</i>	mid	2
<i>Eucalyptus planchoniana</i>	canopy	5
<i>Eucalyptus planchoniana</i>	mid	2
S2 & S3 50x2 m Sub plot		
<i>Aotus lanigera</i>	shrub	1
<i>Epacris microphylla</i>	shrub	5
<i>Gahnia sieberiana</i>	shrub	4
<i>Leptospermum liversidgei</i>	shrub	18
<i>Ochrosperma lineare</i>	shrub	12
<i>Sprengelia sprengelioides</i>	shrub	10

Appendix C

Secondary Transect Field Data

Ground layer quadrat data

S16: Quadrat 1 1x1 m Sub plot Intersecting transect at 0 m		
Plant Species	Count	Cover (%)
<i>Acmena smithii</i>		20.0
<i>Caustis blakei</i>		6.0
<i>Monotoca scoparia</i>		2.0
<i>Smilax australis</i>		2.0
Total plant coverage		30.0
Leaf Litter		60.0
Bare Sand		0.0

S16: Quadrat 2 1x1 m Sub plot Intersecting transect at 10 m		
Plant Species	Count	Cover (%)
<i>Acacia suaveolens</i>		1.0
<i>Acmena smithii</i>		30.0
<i>Dodonaea triquetra</i>		20.0
<i>Lomandra longifolia</i>		8.0
<i>Smilax australis</i>		10.0
<i>Xanthosia pilosa</i>		1.0
Total plant coverage		70.0
Leaf Litter		30.0
Bare Sand		0.0

S16: Quadrat 3 1x1 m Sub plot Intersecting transect at 20 m		
Plant Species	Count	Cover (%)
<i>Acacia ulicifolia</i>		2.0
<i>Allocasuarina torulosa</i>		5.0
<i>Austromyrtus dulcis</i>		3.0
<i>Dodonaea triquetra</i>		4.0
<i>Hibbertia linearis</i>		2.0
<i>Lepidosperma laterale</i>		30.0
<i>Marsdenia fraseri</i>		1.0
<i>Smilax australis</i>		3.0
Total plant coverage		50.0
Leaf Litter		50.0
Bare Sand		0.0

S16: Quadrat 4 1x1 m Sub plot Intersecting transect at 30 m		
Plant Species	Count	Cover (%)
<i>Austromyrtus dulcis</i>		1.0
<i>Dodonaea triquetra</i>		1.0
<i>Podocarpus spinulosus</i>		15.0
<i>Pteridium esculentum</i>		3.0
Total plant coverage		20.0
Leaf Litter		80.0
Bare Sand		0.0

S16: Quadrat 5 1x1 m Sub plot Intersecting transect at 40 m		
Plant Species	Count	Cover (%)
<i>Austromyrtus dulcis</i>		12.0
<i>Boronia rosmarinifolia</i>		1.0
<i>Dodonaea triquetra</i>		3.0
<i>Entolasia stricta</i>		1.0
<i>Eucalyptus pilularis</i>		10.0
<i>Lomandra longifolia</i>		2.0
<i>Smilax australis</i>		1.0
Total plant coverage		30.0
Leaf Litter		70.0
Bare Sand		0.0

Appendix D

Spring Survey Field Data September 2006

Appendix D

Spring Survey Results

D 1.1 Additional species found during spring survey

Family	Plant Species	Common Name	Growth Form	Status	Vegetation Community	Site Recorded	Relative Abundance
ANGIOSPERMS							
RUTACEAE	<i>Boronia falcifolia</i>	Wallum Boronia	SH		1b	PT5	C
COLCHICACEAE	<i>Burchardia umbellata</i>	Milk Maids	H		1b	ST15	U
EPACRIDACEAE	<i>Leucopogon deformis</i>		SH		2a	ST6	U
EPACRIDACEAE	<i>Leucopogon virgatus</i>		SH		1a	PT3	U
PTERIDOPHYTES - FERNS							
SELLAGINELLACEAE	<i>Selaginella uliginosa</i>	Swamp selaginella	F		1b	PT5	O

Key

Growth Form:

Tree **T**
 Shrub **SH**
 Herb **H**
 Vine **V**
 Fern **F**

Conservation Status:

Vulnerable species (Schedule 3 - *Nature Conservation Act, 1992*) **V**
 Rare species (Schedule 4 - *Nature Conservation Act, 1992*) **R**
 Common species (Schedule 5 *Nature Conservation Act, 1992*) **C**

Site Recorded:

PT – Primary Transect
 ST – Secondary Transect

Relative Abundance:

1-10 plants RARE **R**
 11-20 plants UNCOMMON **U**
 21- 30 plants OCCASIONAL **O**
 31 - 50 plants COMMON **C**
 > 51 plants ABUNDANT **A**

These species were recorded during the spring survey (September 2006) and relative abundances are qualitative estimates only.

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Appendix G

Fauna Report (2006)

**VANCE MINING LEASE ML1108
NORTH STRADBROKE ISLAND, QUEENSLAND**

FAUNA ASSESSMENT



**Prepared For
URS Australia Pty Ltd
Unimin Australia Limited**

**Final Report Revision 1
24 August 2006**



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ECOLOGICAL MANAGEMENT SERVICES

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VANCE MINING LEASE ML1108 NORTH STRADBROKE ISLAND, QUEENSLAND FAUNA ASSESSMENT

1.0 INTRODUCTION

Ecological Management Services Pty Ltd has been commissioned by URS Australia Pty Ltd (URS) to prepare a report documenting the terrestrial and aquatic vertebrate fauna of the Unimin Australia Limited (UAL) ML 1108 on North Stradbroke Island. Baseline studies were conducted to identify any significant fauna species and areas of significant habitat and identify the potential impacts on fauna and habitats associated with the proposed mine impact areas.

The objective of the survey was to document the terrestrial vertebrate fauna (amphibians, reptiles, mammals and birds) of the area, with particular reference to the occurrence of threatened species. This report details the results of the fauna studies, including a fauna field sampling program conducted in March 2006, a review of existing fauna data and information on the status of significant species occurring on North Stradbroke Island.

2.0 SCOPE AND METHODOLOGY

2.1 Study Objectives

The objectives of the fauna study were to:

- Review existing terrestrial fauna data for the local area and North Stradbroke Island;
- Provide baseline data on fauna and habitats occurring within and near the study area with reference to existing information and results from field surveys;
- Identify the occurrence or expected occurrence of any significant wildlife species, or any sites or habitats of significance to wildlife; and
- Describe feral animal species in the study area.

2.2 Study Area

The ML 1108 (referred to as the study area in this report) consists of an area of 639 ha approximately 4km north east of Dunwich on North Stradbroke Island. The vegetation within study area is relatively undisturbed and intact. The topography of the study area represents a

series of high dune formations to a height of approximately 200m intersected by lower gullies and drainage lines. Cooroon Cooroonpah Creek is the main drainage line within the study area, traversing the study area from the south-east to north-west. The study area (ML 1108) is proposed to be dry mined by UAL for silica sand and heavy minerals (as a by-product).

2.3 Data Acquisition

Existing data on fauna of North Stradbroke Island was reviewed from a number of sources. These included:

- Queensland EPA Wildnet database (EPA 2006a);
- Terrestrial vertebrate records from the Queensland Museum (Queensland 2006);
- Fauna species list for Blue Lake National Park (EPA 2006b);
- Department of the Environment & Heritage (2006) online EPBC database (EPBC Protected Matters Report, 1 March 2006);
- An initial survey of the fauna of ML 1108 undertaken by URS (2005b); and
- Survey of Flora and Fauna Over Mining Lease 7064, near Dunwich North Stradbroke Island, Qld (Worth *et al.* 1997).

2.4 Field Survey Methods

The fauna survey of the study area was undertaken between 7 – 17 March 2006 inclusive. Six survey sites were systematically sampled, while general observations from other sites and areas were also compiled. Observational records from Swallow Lagoon (located to the south-west of ML 1108) were compiled during a one-hour inspection of this site. Standard biological survey techniques were used during field surveys, including a number of live capture/release trapping techniques, standard and general observational and habitat searches, as well as methods to indirectly detect the presence of terrestrial fauna. The survey focussed on terrestrial vertebrate taxa, however a number of freshwater sites were sampled for aquatic and semi-aquatic species along Cooroon Cooroonpah Creek within the study area.

The survey design was based on the methodology used for the Queensland Systematic Vertebrate Fauna Survey Project in the South East Queensland Bioregion (CRA Queensland/RFA Steering Committee 1997). Site-specific survey methodologies were also employed to comply with the requested methodology outlined by the Queensland EPA (G Lundie-Jenkins pers. comm., November 2005). Table 2.1 provides a summary of the standard methods and survey effort undertaken for this study.

Table 2.1 Summary of Survey Effort

Survey Method	Survey Effort	Total Survey Effort
Diurnal Bird Count	5 x 20 minute counts x 6 Sites	10 hours
Diurnal Searches	3 x 20 minute searches x 6 Sites	6 hours
Nocturnal Searches	3 x 20 minute searches x 6 Sites	6 hours
Nocturnal Call Play Back	1 call playback session x 6 Sites	6 sessions
Spotlighting	1 person hour x 6 Sites	6 hours
Ultrasonic microbat detection	1 overnight x 6 Sites + 2 nights targeted anabat detection at Cooroon Cooroonpah Creek where high levels of bat activity were observed	8 nights (total 96 hours)
Ground Mammal Elliot Trapping	25 traps/100 trap nights x 6 Transects	600 trap nights
Arboreal Mammal Trapping	5 traps/20 trap nights x 5 Transects * * Arboreal trapping was not conducted at one open heath site, as this habitat type did not support suitable trees.	100 trap nights
Pitfall Trapping	5 traps/20 trap nights x 6 sites	120 trap nights
Wire Cage Traps	2 traps/ 8 trap nights x 6 Transects	48 trap nights
Hair Funnels	6 funnels per site x 6 nights x 6 Transects	216 hair funnel nights
Non-standard Methods		
Harp trapping	2 harp trap nights at 3 sites	6 harp trap nights
Targeted Koala Survey: Diurnal Searches, Spotlighting, Call Playback, Signs & Scats	Targeted survey in open forest and woodland habitats	
Targeted Glossy-black cockatoo survey: Diurnal searches, bird survey	Targeted survey in suitable habitat	
Targeted Amphibian nocturnal searches, bankside observations, dip netting	Targeted survey at Cooroon Cooroonpah Creek	3 nights
Aquatic Fauna: Fish, turtle and crustacea trapping using Gansell and Opera house traps, bankside observations, dip netting	2 x Gansell and 2 x Opera house fish traps @ 5 aquatic sites on Cooroon Cooroonpah Creek	10 hours trapping per site
Vehicle spotlighting	No standard effort	
Predator and non-predator scat collection	No standard effort	
Sand pads for detecting animal tracks (on existing tracks)	No standard effort	

2.4.1 Standard methods used at systematic sites

At each standard systematic survey site, the following standard methods were conducted;

Diurnal Bird Counts

Five 20 minute/2 ha timed area (1 hour 40 mins per site) diurnal bird counts were undertaken at each systematic site within representative habitat. Timed/area searches involved walking through a habitat area for 20 minutes actively pursuing calling birds and recording all bird species seen or heard within the broad habitat type. Bird counts were conducted between dawn and 0900 hours, with a minimum of one additional count in the late morning or late afternoon at each site.

Diurnal Searches

One person-hour (3 x 20 minute searches) active diurnal search was conducted at each systematic site. Active searching involved recording all individuals (small mammals, reptiles, amphibians) found active or sheltering underneath or within fallen woody debris, rocks, litter and decorticated bark. Frogs heard calling during the search were also recorded. Active searches were undertaken between 1000 and 1400 hours when reptiles were active.

Nocturnal Searches

One person-hour (3 x 20 minute searches) active nocturnal search was undertaken at each systematic site. Active searches involved the use of Petzl Zoom headlamps and low watt spotlights, and recording all individuals (small mammals, reptiles, amphibians) found active on the ground or up trees, or underneath fallen debris, rocks, litter and decorticated bark. Frogs heard calling at each site were also recorded during this time.

Nocturnal Call Play Back

One nocturnal call playback session was conducted at the centre point of each systematic survey site. One observer stayed at the centre point to play the calls, while a second observer moved to the 150 m point of the transect to listen for responses. Each call playback session involved an initial 10-minute listening period, where any calls from arboreal mammals and nocturnal birds were recorded. This was followed by the broadcasting of pre-recorded calls of arboreal mammals including the sugar glider, squirrel glider and koala and the following birds; Australian owl-nightjar (*Aegotheles cristatus*), white-throated nightjar (*Eurostopodus mystacalis*), southern boobook (*Ninox novaeseelandiae*), barn owl (*Tyto alba*), grass owl (*Tyto capensis*) and powerful owl (*Ninox strenua*). Each call was played for three minutes, followed by a two-minute listening period. After the calls were played, each observer scanned by spotlight the immediate area for five minutes.

Spotlighting

Spotlighting census involved an observer within the study area with a 50-Watt spotlight for one person-hour per site at six sites (6 hours). Incidental observations were also made while driving along tracks and entering and exiting the study area at night.

Ultrasonic Microbat Call Detection

Ultrasonic microbat call detection was used to sample microchiropteran bats. The ultrasonic detection was conducted at each systematic site for one night of remote sampling using ANABAT II, commencing at dusk. Two additional nights of sampling were conducted adjacent to Cooroon Cooroonpah Creek where high levels of bat activity were observed (total 8 nights remote detection, 96 remote monitoring hours). Additional incidental hand held recordings were collected during the spotlight survey. Recorded calls were analysed by Paul Barden, Ecological Management Services.

Elliott Trapping for Small Mammals

At each systematic site 25 traps (22 Elliot 'A' type & 3 Elliot 'B' type) were set approximately eight metres apart along a 200 m transect. Traps were baited with a peanut butter and oat mixture and left open for four nights. Traps were cleared early each morning and trapped animals were temporarily marked so that recaptures could be identified.

Arboreal Mammal Trapping

Arboreal trapping was conducted at five systematic sites. Arboreal trapping was not conducted at one systematic site (S6 open heath), as this habitat type did not support suitable trees. Five arboreal traps were mounted on platforms and attached to trees. Trees selected were of various species and girths. Traps were spaced opportunistically at approximately 30 metre intervals. Traps were baited with honey and oat mixture and scent trails of honey and water were sprayed above the traps to assist in luring gliders. Traps were left open for four nights and checked for captures early each morning.

Pitfall Trapping

Pitfall traps were used to capture frog, reptile and small mammal species that are cryptic and difficult to detect, such as burrowing frogs and fossorial skinks. Pitfall traps were used at all six systematic sites. Five pitfall lines consisting of four 10 litre buckets and one 20 litre bucket, with a 10 m drift fence for each pitfall line were set at the six systematic sites. Pitfall lines were left open for four nights, and were checked early each morning and late afternoon/early evening for captures, which were identified and released.

Wire Cage Trapping

At each systematic site, 2 wire cage traps were set along a 200 m transect. Traps were baited and left open for four nights. Traps were checked early each morning and late afternoon.

Hair Funnels for Small to Medium-sized Mammals

Six ground and tree based hair funnels (Faunatech) were set approximately 30 m apart along the 200 m transect at six systematic sites. The tubes were baited with a peanut butter and oat mixture and left on site for six nights. All hair samples obtained were sent to B. Triggs, Victoria, for analysis. Samples were identified and classified into the reliability categories, definite and probable.

2.4.2 Non standard methods used within the survey area

Harp Trapping for Microbats

Collapsible harp traps were used to capture low flying microchiropteran and small megachiropterans. Where possible harp traps were set on systematic sites. However harp trapping was not undertaken at some sites due to an absence of suitable flyways. Harp traps were left open for two nights at each trap site (2 harp trap nights at 3 sites).

Aquatic Fauna Survey

Aquatic fauna was sampled at five sites where open water was present on Cooroon Cooroonpah Creek. Methods used at each of these sites include diurnal and nocturnal bankside observations; Gansell and opera house fish traps and dip netting (Table 2.1). Targeted species included freshwater fishes, amphibians and semi-aquatic vertebrates. Bait traps were set on an opportunistic basis and left open for at least one night. They were set in the deeper sections of the creek, adjacent to any available cover. The traps were suspended, with the upper part of the trap out of the water, so that captured animals could breathe, or were placed in shallow water where no securing point was available. Traps were checked early each morning for captures which were then identified and released.

Vehicle Spotlighting

Vehicle spotlighting was conducted along tracks in the study area and while driving between survey sites at night to obtain incidental records.

Predator Scat Search

Predator scats from dogs *Canis familiaris* and foxes *Vulpes vulpes* found at sites and opportunistically elsewhere in the study area were collected for identification through analysis of grooming hairs by B. Triggs. Remains of prey species were identified where possible, from hairs and bones in the scat. As with the identification of hair-tube samples, scat samples were classified as definite or probable depending upon the reliability of the identification.

Non-Predator Scat Collection, Tracks & Signs

Searches were conducted for non-predator scats, particularly for the target species, koala *Phascolarctos cinereus*. Suitable koala food trees were searched along transects for koalas, signs of use and scats. Scats collected within the study area were collected for identification through analysis of grooming hairs by B. Triggs. Tracks and signs noted during the survey were inspected and identified.

Sand Pads

Sand pads were prepared at each site on existing sand tracks by sweeping an area of sand along a track (approximately 5m x 3m). Tracks were read each morning and pads reset each evening for a minimum of three nights per site.

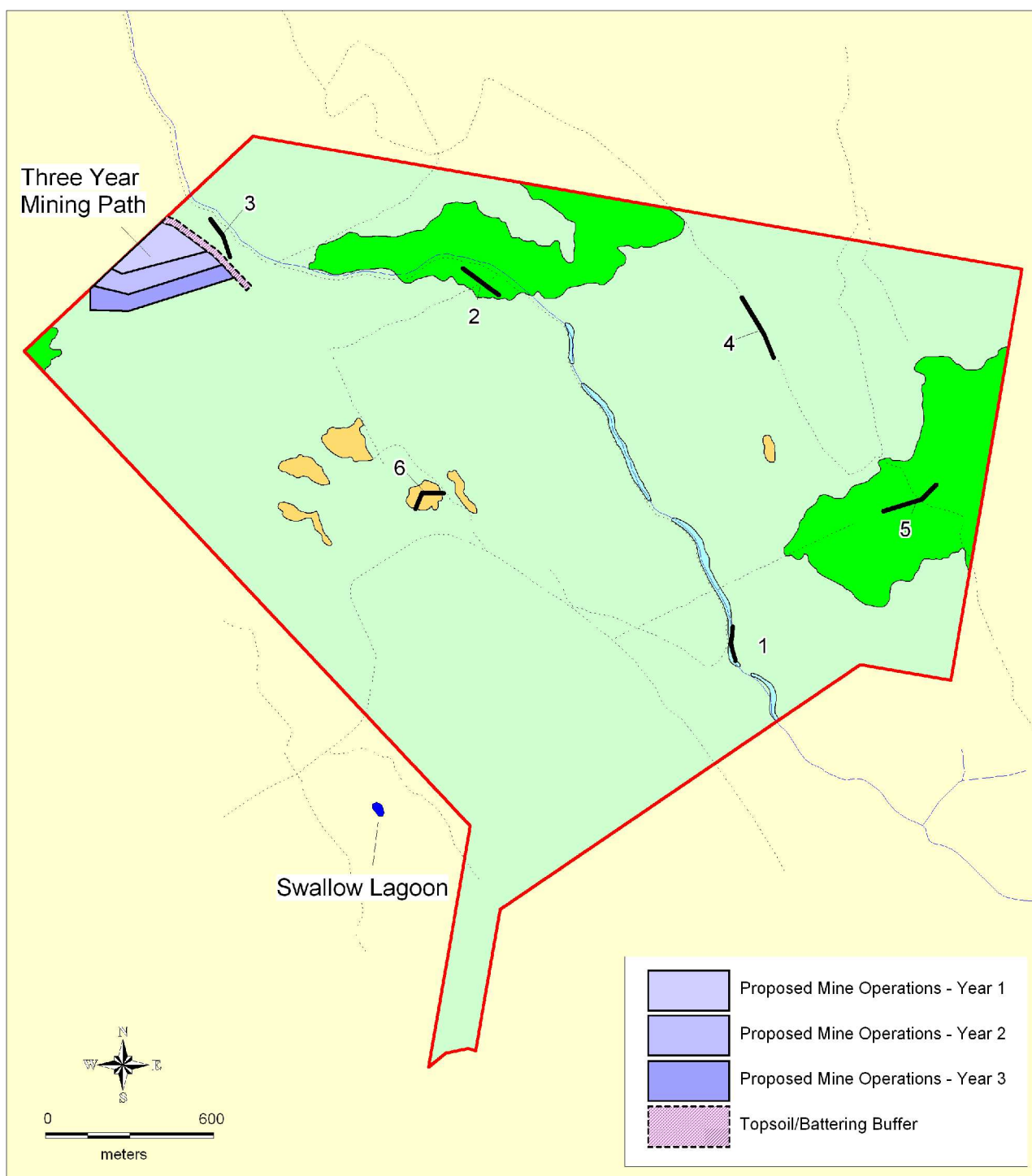
3.0 SITE SELECTION AND HABITATS

The vegetation of the study area is described in a separate flora report (URS 2006). The fauna survey was designed to sample representative habitat types and regional ecosystems present within the study area. At the time of the fauna survey the revised vegetation mapping (URS 2006) was not available. Consequently, terrestrial fauna habitats and survey sites within the study area were selected following consideration of the habitats/regional ecosystems (EPA 2005), draft vegetation mapping (URS 2005a), topography/gradient and preliminary proposed impact areas provided at the time of the field survey by URS. Other factors affecting the distribution of fauna were considered when assessing the fauna habitats present including the proximity to creeks and standing water.

Six systematic sample sites were selected to survey representative habitats within the study area (Figure 1, Table 3.1).

Table 3.1 Fauna Survey Site Locality and Broad Habitat Data

Site No	Location	Dominant Canopy Species	Broad Habitat/Land Unit	Vegetation Type (URS 2006)
1	Cooroon Cooroonpah Creek. Ramsar Area	Closed wet heath ± stunted emergent shrubs/low trees.	Closed or wet heath associated with Cooroon Cooroonpah Creek (Plate 1). Occurs on seasonally waterlogged sand plains. Drainage floor and locally seasonally swampy areas.	1b
2	South of Cooroon Cooroonpah Creek	Eucalyptus racemosa, Corymbia gummifera.	Open forest/woodland (Plate 2). Occurs on Quaternary coastal dunes. Steep irregular planar dune ridge slopes.	3a
3	South -west of Cooroon Cooroonpah Creek. Vicinity of the proposed impact area.	Banksia aemula and mallee forms of Corymbia gummifera, Eucalyptus racemosa.	Low woodland (Plate 3). Occurs on Quaternary coastal dunes and sand plains. Undulating to low hilly lowland dune areas.	2a
4	Ridgeline in the north-eastern component of the study area	Mallee Eucalyptus planchoniana, Banksia aemula mallee forms of Corymbia gummifera and Eucalyptus racemosa.	Low woodland on a high dune ridge (Plate 4). Occurs on Quaternary coastal dunes. Sand ridge crest and upland dune areas.	2a
5	Eastern component of the study area. Ramsar Area.	Eucalyptus pilularis, Eucalyptus planchoniana, Corymbia gummifera.	Open forest (Plate 5). Occurs on Quaternary coastal dunes. Irregular planar to concave foot slopes.	3a
6	Central component of the study area.	Open or dry heath, stunted Banksia aemula and E. racemosa.	Open or dry heath (Plate 6). Occurs on Quaternary coastal dunes. Undulating to low rounded hilly upland dune areas.	1a



Legend

- Cooroon Cooroonpah Creek
- Access Tracks
- ML 1108 Vance Mining Lease Boundary
- Fauna Survey Transect

Vegetation Communities (URS 2006)

- 1a Low open dry heath on Quaternary dunes and sand plains
- 1b Closed wet heath on seasonally waterlogged sand plains
- 2a Mallee Eucalyptus spp. low woodland on Quaternary dunes and sand plains
- 3a Eucalyptus spp. open forest/woodland on Quaternary dunes and sand plains

Figure 1

Fauna Survey Site Transects

Project:
Unimin Vance Mining Lease 1108
North Stradbroke Island
Fauna Report



Source: Draft Vegetation
Map URS 2006
Client: URS

22 August 2006

3.1 Climate

The following climatic data was recorded at the Point Lookout Station by the Bureau of Meteorology (BOM 2006). Seasonally the weather was characteristic of the late warm season, with minimum temperatures ranging between 22°C and 23°C and maximum temperatures ranging between 28°C and 30°C. A significant rainfall event occurred prior to the commencement of the field survey with 153.7 mm of rainfall recorded between the 1 – 6 March (BOM 2006). During this period high rainfall (140.2 mm) was recorded between the 3 and 5 March 2006 and 10.2 mm of rain was recorded on Monday 6 March 2006 immediately prior to the field survey. The field survey was conducted between the 7 and 17 March 2006 and only 0.2 mm of rainfall was recorded at the Point Lookout Station during the survey period.

4.0 FAUNA SURVEY RESULTS

4.1 Sampling Results

A total of 92 native and 5 introduced terrestrial vertebrate species were recorded during field surveys in the study area, including 7 amphibian, 17 reptile, 48 bird and 20 mammal species.

4.2 Amphibians

Seven native and one introduced amphibian species were observed within the study area (Table 4.1) and an additional native species was recorded at Swallow Lagoon adjacent to ML 1108. Amphibian species were generally associated with wetter microhabitats within the areas sampled, particularly along Cooroon Cooroonpah Creek. However two native amphibian species, the northern banjo frog (*Limnodynastes terraereginae*) and sandy gungun (*Uperoleia fusca*), were also recorded in dry habitats well removed from watercourses. Both of these species were captured in pitfall traps on a high dune ridge in open heath.

The native species most frequently observed or identified from vocalisations were the wallum froglet (*Crinia tinnula*), wallum sedgefrog (*Litoria olongburensis*) and northern banjo frog. Males of a variety of species were vocalising along Cooroon Cooroonpah Creek during the survey, including three vulnerable species (EPBC Act 1999, Queensland Nature Conservation Act 1992) (refer to Section 5.2). Tadpoles belonging to a number of species were also present in the creek, including *Limnodynastes terraereginae*, *Litoria fallax*, *Litoria olongburensis* and *Crinia tinnula*.

Table 4.1 Amphibians

Common Name	Scientific Name	1	2	3	4	5	6	SL	Total
Wallum Froglet	<i>Crinia tinnula</i>	~20NS	5NS						25
Northern Banjo Frog	<i>Limnodynastes terraereginae</i>	3PF, NS1	2PF				1PF		1
Sandy Gungun	<i>Uperoleia fusca</i>						1PF		
Cooloola Sedgefrog#	<i>Litoria cooloolensis</i>							X	
Striped Rocketfrog	<i>Litoria nasuta</i>	1NS							1
Wallum Rocketfrog	<i>Litoria freycineti</i>		X					X	
Wallum Sedgefrog	<i>Litoria olongburensis</i>	~10NS							10
Eastern Sedgefrog	<i>Litoria fallax</i>	X	X	X					
Cane Toad *	<i>Bufo marinus</i>	1PF, TR	1PF, 2NS, TR	4NS, TR		1NS, TR	TR		7
Total Species = 9		6	5	2	0	1	2	2	

NS = Recorded during nocturnal survey/spotlighting; X = incidental observation at site; Numbers in columns = no of amphibians observed/collected/heard during timed nocturnal and amphibian searches for the study area; PF = Pitfall trap capture; SL = observation records from Swallow Lagoon adjacent (south-west) of ML 1108. * = Exotic species; # Recorded adjacent to study area (ML 1108) only

4.3 Reptiles

Seventeen reptile species were identified within the study area (Table 4.2). The reptile taxa identified included one flap-footed lizard (Pygopodidae), one agamid (Agamidae), one monitor (Varanidae), ten skink (Skincidae) and four elapid snake (Elapidae) species. Pitfall traps captured a number of skink species and the agamid species (*Diporiphora australis*). Most reptile observations were made during active reptile searches of habitats during the day and incidentally during the course of the trapping and bird census surveys. The richest habitat for reptiles was mallee *Eucalyptus* spp. and *Banksia aemula* low woodland on sand plains (Site 3) with high numbers also present in mallee *Eucalyptus* spp. and *Banksia aemula* low woodland on a high dune ridge (S4) and *Eucalyptus racemosa*, *C. gummifera* open forest to woodland (S2).

Small skinks were the most commonly observed reptiles within the study area. The arcane striped skink (*Ctenotus arcanus*) was the most frequently observed and captured species, and was common in all of the habitats sampled across the study area. Less common species (recorded from a single or small number of observations) included the fire-tailed skink (*Morethia taeniopleura*), short-limbed snake-skink (*Ophioscincus truncatus*), *Calyptotis scutirostrum*, *Lampropholis guichenoti* and major skink (*Egernia major*). One skink species, the short-limbed snake-skink (*Ophioscincus truncatus*), is listed as rare in the Queensland *Nature Conservation Act 1992* (refer to Section 5.2). A single specimen was captured in a pitfall trap in *Eucalyptus racemosa*, *C. gummifera* open forest to woodland.

Four snake species were recorded in the surveys. One species, the eastern small-eyed snake (*Cryptophis nigrescens*) was located during timed reptile searches. A lesser black whipsnake (*Demansia vestigiata*) was located after being killed by a bush thick-knee (*Burhinus grallarius*) on the access track adjacent to site 3. The only venomous snake species recorded was a red-bellied black snake (*Pseudechis porphyriacus*), which was observed on the margins of Cooroon Cooroonpah Creek.

Table 4.2 Reptiles

Common Name	Scientific Name	1	2	3	4	5	6	Total
Burton's Snake-lizard	<i>Lialis burtonis</i>			X				
Tommy Roundhead	<i>Diporiphora australis</i>			2PF, 1			2PF, 3	4
Lace Monitor	<i>Varanus varius</i>				X		TR~	
Burrowing Skink	<i>Calyptotis scutirostrum</i>		2					2
Lively Skink	<i>Carlia vivax</i>			1			1	2
Fence Skink	<i>Cryptoblepharus virgatus</i>		X			X		
Copper-tailed Skink	<i>Ctenotus taeniolatus</i>			X	1		1PF, 2	3
Arcane Striped Skink	<i>Ctenotus arcanus</i>	2PF, 3	1PF, 2	3PF, 1	8	1	2PF, 4	19
Major Skink	<i>Egernia frerei</i>					1		1
Eastern Grass Skink	<i>Lampropholis delicata</i>		1		1PF	1		2
Skink	<i>Lampropholis guichenoti</i>				2PF			
Fire-tailed Skink	<i>Morethia taeniopleura</i>		1		1			2
Short-limbed Snake-skink	<i>Ophioscincus truncatus</i>		1PF					
Yellow-faced Whip Snake	<i>Demansia psammophis</i>			X				
Black Whip Snake	<i>Demansia vestigiata</i>			X				
Red-bellied Black Snake	<i>Pseudechis porphyriacus</i>	X						
Eastern Small-eyed Snake	<i>Cryptophis nigrescens</i>	1						1
Total Species = 17		3	6	7	6	4	4	

X = incidental observation at site; Numbers in columns = no of reptiles observed/collected during timed reptile searches;
PF = Pitfall trap capture; TR~ = Tracks and sign probable ID

4.4 Birds

Forty-eight bird species were observed within the study area during the survey period (Table 4.3). Of these, 34 species were recorded during the timed census counts at the six main study sites, while the other species were observed opportunistically throughout the study area.

Results of bird census counts are included in Table 4.3. The most species rich site was site 5 (*E. pilularis* open forest with dense vegetation in gully lines), with 23 species recorded. A number of small forest bird species, including the spectacled monarch (*Monarcha trivirgatus*), grey fantail (*Rhipidura fuliginosa*) and eastern yellow robin (*Eopsaltria australis*), were only recorded at this habitat. Sites supporting heath and *Banksia aemula* woodland along Cooroon Cooroonpah Creek and at lower altitude also supported high number of species, with 20 species recorded at site 1 and 22 species at site 3. Numbers of bird species may have been elevated due to the presence of open water in or near these habitats. The most species poor habitats for birds were open or dry heath on hilly upland dune areas (S6) and Mallee eucalypt spp. and *Banksia aemula* woodland on sand ridges and upland dune areas (S4).

The most frequently recorded and widespread species included (in order of frequency of reporting in timed bird surveys) the noisy friarbird (*Philemon corniculatus*), white-cheeked honeyeater (*Phylidonyris nigra*), brown honeyeater (*Lichmera indistincta*), rainbow lorikeet

(*Trichoglossus haematodus*), grey butcherbird (*Cracticus torquatus*) and bar-shouldered dove (*Geopelia humeralis*). Uncommon species recorded from single observations include the spectacled monarch (*Monarcha trivirgatus*), little shrike-thrush (*Colluricincla megarrhyncha*), brown cuckoo-dove (*Macropygia amboinensis*) and bush stone-curlew (*Burhinus grallarius*).

One species recorded during the survey, the glossy black-cockatoo (*Calyptorhynchus lathami*), is listed as vulnerable in the Queensland *Nature Conservation Act 1992*. Signs indicating that this species was feeding on casuarinas were identified in a number of open forest habitats, including *Eucalyptus racemosa*, *C. gummifera* open forest/woodland and *Eucalyptus pilularis* open forest. Casuarina groves suitable for this species are also present in other habitats.

Table 4.3 Avifauna

Common Name	Scientific Name	1	2	3	4	5	6	SL	Total
Brown Quail	<i>Coturnix ypsilophora</i>	X			1		4		5
Pacific Black Duck	<i>Anas superciliosa</i>							X	
Australian Wood Duck	<i>Chenonetta jubata</i>							X	
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>							X	
Whistling Kite	<i>Haliastur sphenurus</i>			X					
Brahminy Kite	<i>Haliastur indus</i>		1						1
Brown Goshawk	<i>Accipiter fasciatus</i>			1					1
Brown Falcon	<i>Falco berigora</i>			X					
Bush Stone-curlew	<i>Burhinus grallarius</i>			1NS, TR					1
Brown Cuckoo-dove	<i>Macropygia amboinensis</i>	1							1
Common Bronzewing	<i>Phaps chalcoptera</i>	6		2					8
Peaceful Dove	<i>Geopelia striata</i>	2							2
Bar-shouldered Dove	<i>Geopelia humeralis</i>	6	2	5	1		6		20
Glossy Black-Cockatoo	<i>Calyptorhynchus lathami</i>					X			
Galah	<i>Cacatua roseicapilla</i>		2						2
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>	10	5	2	2	20	8	X	47
Scaly-breasted Lorikeet	<i>Trichoglossus chlorolepidotus</i>					2			2
Pheasant Coucal	<i>Centropus phasianinus</i>	X		2					2
Southern Boobook	<i>Ninox novaeseelandiae</i>					1NS			1
Tawny Frogmouth	<i>Podargus strigoides</i>			1		1NS			1
White-throated Nightjar	<i>Eurostopodus mystacalis</i>	1NS	1NS		2NS	1NS	1NS		6
Australian Owlet Nightjar	<i>Aegotheles cristatus</i>	1NS	2NS	2NS					5
White-throated Needletail	<i>Hirundapus caudacutus</i>				X		2		2
Laughing Kookaburra	<i>Dacelo novaeguineae</i>	1		1		2	1	X	5
Rainbow Bee-eater	<i>Merops ornatus</i>	5	5	1	2	2		X	15
Dollarbird	<i>Eurystomus orientalis</i>						X		
Striated Pardalote	<i>Pardalotus striatus</i>			1				X	1
Brush Wattlebird	<i>Anthochaera chrysoptera</i>	6	2		1	2		X	11
Noisy Friarbird	<i>Philemon corniculatus</i>	16	12	22	11	26	7	X	94
Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>					1			1
White-throated Honeyeater	<i>Melithreptus albogularis</i>					19			19
Brown Honeyeater	<i>Lichmera indistincta</i>	5	2	5	17	13	7	X	49
White-cheeked Honeyeater	<i>Phylidonyris nigra</i>	9	4	13	17	7	13	X	63
Scarlet Honeyeater	<i>Myzomela sanguinolenta</i>		X						
Eastern Yellow Robin	<i>Eopsaltria australis</i>					2			2
Rufous Whistler	<i>Pachycephala rufiventris</i>	2			2	1			5
Little Shrike-thrush	<i>Colluricincla megarrhyncha</i>					1			1
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	2		1	5	1			9
Spectacled Monarch	<i>Monarcha trivirgatus</i>					1			1
Grey Fantail	<i>Rhipidura fuliginosa</i>					X			
Spangled Drongo	<i>Dicrurus bracteatus</i>		1	X					1
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>			2		X			2
Grey Butcherbird	<i>Cracticus torquatus</i>	4	12	6	4	6	4		36
Pied Butcherbird	<i>Cracticus nigrogularis</i>			1					1
Torresian Crow	<i>Corvus orru</i>	2	2		2		4		10
Mistletoebird	<i>Dicaeum hirundinaceum</i>					2	1	X	3
Welcome Swallow	<i>Hirundo neoxena</i>				X				
Tree Martin	<i>Hirundo nigricans</i>	X		1	X		2		3
Total Species = 48		20	15	22	16	23	14	12	

NS = Recorded during nocturnal survey/spotlighting; X = incidental observation at site; Numbers in columns = no of birds observed during timed diurnal bird counts and timed nocturnal survey/spotlighting; SL = observation records from Swallow Lagoon adjacent to ML 1108 (south-west).

4.5 Mammals

Twenty native and four introduced mammal species were identified during the survey (Table 4.4). The introduced house mouse (*Mus musculus*) was the most common and abundant species in the study area and was recorded at all systematic survey sites. The grassland melomys (*Melomys burtoni*) was the most abundant native ground dwelling mammal and was recorded at four sites in the study area. The grassland melomys was recorded in closed/wet heath (S1) and *Eucalyptus racemosa*, *C. gummifera* woodland to open-forest (S2), mallee *Eucalypt* spp. and *Banksia aemula* low woodland on sand ridges (S4) and *Eucalyptus pilularis* open forest (S5). The fawn-footed melomys (*Melomys cervinipes*) was recorded in one habitat, *Eucalyptus racemosa*, *C. gummifera* open-forest/woodland (S2). The swamp rat (*Rattus lutreolus*) was captured in one habitat consisting of a wetter microhabitat within a wet/closed heath community associated with Cooroon Cooroonpah Creek (S1). The richest habitat for mammals was the closed/wet heath associated with Cooroon Cooroonpah Creek (15 native species).

Three arboreal mammal species, the squirrel glider (*Petaurus norfolcensis*), sugar glider (*Petaurus breviceps*) and feathertail glider (*Acrobates pygmaeus*), were recorded during the survey. Although specific surveys were conducted to target the vulnerable koala (*Phascolarctos cinereus*), the koala was not recorded in the study area during the survey period. However the study area does support potential koala habitat consisting of *Eucalyptus pilularis* open forest and *Eucalyptus racemosa*, *C. gummifera* open forest/woodland. The koala occurs on North Stradbroke Island (Queensland Museum 2006; EPA 2006a) and existing records have been located in a number of regional ecosystem types outside the study area, including regional ecosystems 12.2.6, 12.2.8 and 12.2.10. A number of previous sightings of this species have been recorded to the north, south and west of the study area, the closest being approximately 1.5 km from the study area boundary. It is likely that vegetation in the study area, particularly open forest, woodland and low woodland, provides connectivity to surrounding habitat areas for this species.

The swamp wallaby (*Wallabia bicolor*) is the most common large macropod in the study area. Individuals were recorded in a variety of habitats, including wet and dry heath, low woodland and open forest/woodland. Eastern grey kangaroos (*Macropus giganteus*) were observed adjacent to, but not within the study area.

Large numbers of flying-fox were feeding in flowering canopy trees across the study area during the survey period. It is likely that the majority of these bats originate from the camp at

Dunwich. During the survey period this camp was dominated by a large percentage of little red flying-fox (*Pteropus scapulatus*), smaller numbers of black flying-fox (*Pteropus alecto*) and small numbers of grey-headed flying-fox (*Pteropus poliocephalus*). These camp numbers reflect the proportions of flying-fox species observed on the site, with the little red flying-fox comprising 70.8% of flying-fox observed during timed spotlight counts, black flying-fox comprising 26.9% of flying-fox observed during timed spotlight counts and grey-headed flying-fox accounting for 2.3% of flying-fox observed during timed spotlight counts. The composition of the Dunwich camp changes throughout the year, with a larger percentage of grey-headed flying-fox and black flying-fox present at times (B. Kerr pers. comm., QPWS), indicating that the percentages of each species feeding in the study area are also likely to change depending on seasonal conditions and flowering of canopy trees.

During the survey period the highest numbers of flying-foxes were feeding on flowering canopy eucalypt and corymbia species in open forest habitats with *E. racemosa* or *E. pilularis* as the dominant canopy species, with 13.8 flying-fox observed per 20 minute spotlight period. Lower numbers were also feeding on flowering mallee Eucalypt spp and *Banksia aemula* low woodland (8.6 flying-fox observed per 20 minute spotlight period). Open forest habitats supporting winter flowering eucalypts are likely to be important flying-fox feeding sites during late winter/spring.

Nine species of microchiropteran bats were recorded by echolocation call detection (Anabat), however some of the identifications are tentative due to overlapping call characteristics for some species that potentially occur within the study area. The most common and widespread bat species detected within the study area were the white-striped freetail-bat (*Tadarida australis*) and little bentwing bat (*Miniopterus australis*). The hoary wattled bat (*Chalinolobus nigrogriseus*) was also relatively common across a range of habitat types. The chocolate wattled bat (*Chalinolobus morio*) was identified from a small number of short call sequences recorded at one site. Three species, including the eastern freetail bat (*Mormopterus* sp 2), eastern broad-nosed bat (*Scotorepens orion*) and central-eastern broad-nosed bat (*Scotorepens* sp [Parnaby 1992]) were possibly detected within the study area, however their presence cannot be confirmed due to limited calls being recorded or due to overlapping call parameters. The highest number of bat species (up to nine taxa) was recorded at site 1 (closed wet heath/riparian vegetation along Cooroon Cooroonpah Creek). Numbers of microbat species at this site were possibly increased due to the presence of open water. No bats were captured in harp traps during the survey.

One species recorded during the survey, the grey-headed flying-fox, is listed as vulnerable in the Commonwealth EPBC Act 1999. This species was observed in low numbers at a number of sites within the study area, where it was observed feeding on canopy eucalypts in open forest, isolated tall eucalypts along Cooroon Cooroonpah Creek and flowering *Banksia*

aemula in mallee *Eucalypt* spp. and *Banksia aemula* low woodland. Numbers of this species within the study area are likely to increase during periods when increased numbers of grey-headed fling-fox are seasonally present in the Dunwich camp.

Table 4.4 Mammals

Common Name	Scientific Name	1	2	3	4	5	6	Total
Bandicoot sp	<i>Perameles</i> or <i>Isoodon</i> sp				TR		TR	
Sugar Glider	<i>Petaurus breviceps</i>				S			
Squirrel Glider	<i>Petaurus norfolcensis</i>		1NS		1NS	2NS		4
Feathertail Glider	<i>Acrobates pygmaeus</i>		2NS					2
Swamp Wallaby	<i>Wallabia bicolor</i>	TR	X, S, TR	S, TR	X, TR	S	X, S, TR	
Black Flying-fox	<i>Pteropus alecto</i>	5NS	4NS	3NS	4NS	20NS		36
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	2NS	1NS			X		3
Little Red Flying-fox	<i>Pteropus scapulatus</i>	8NS	50NS	9NS	20NS	8NS		95
Eastern Freetail-bat	<i>Mormopterus</i> sp 2	X		X				
White-striped Freetail-bat	<i>Tadarida australis</i>	X	X	X	X		X	
Little Bentwing-bat	<i>Miniopterus australis</i>	X	X	X		X	X	
Unidentified Long-eared Bat	<i>Nyctophilus</i> sp	X			X	X		
Gould's Wattled Bat	<i>Chalinolobus gouldii</i>	X~		X			X~	
Chocolate Wattled Bat	<i>Chalinolobus morio</i>	X~						
Hoary Wattled Bat	<i>Chalinolobus nigrogriseus</i>	X	X	X		X	X	
Eastern Broad-nosed bat	<i>Scotorepens orion</i>	X		X				
Central-eastern Broad-nosed Bat	<i>Scotorepens</i> sp (Parnaby 1992)	X~	X	X	X~	X	X~	
Fawn-footed Melomys	<i>Melomys cervinipes</i>		2E, H					2
Grassland Melomys	<i>Melomys burtoni</i>	8E, H	2E, H		4E, H	5E, H		19
House Mouse *	<i>Mus musculus</i>	8E, H	6E, H	13 E, 1PF, H	4E, 1PF	7E, H	H	40
Swamp Rat	<i>Rattus lutreolus</i>	3E, H						3
Dingo/Dog *	<i>Canis lupus dingo/familiaris</i>	TR, H	S, TR,	X, H	X		X, H	
Red Fox *	<i>Vulpes vulpes</i>	TR	X, TR	X, TR	S, TR		X, S~, TR	
Cat *	<i>Felis Catus</i>	H~						
Total Species =	24	19	15	13	13	10	10	

NS = Recorded during nocturnal survey/spotlighting; X = incidental observation at site; PF = Pitfall trap capture; E = Elliot trap capture; H = hair funnel definite ID, H~ = hair funnel probable ID; S = Scat analysis; S~ = Scat analysis probable ID; TR = Tracks and sign; X~ = Possible identification, not confirmed. * = Exotic species.

4.6 Aquatic Fauna

Aquatic surveys within Cooroon Cooroonpah Creek (fish traps, bankside observations etc.) did not record any freshwater fishes or semi-aquatic vertebrate species. The larvae (tadpoles) of a number of amphibian species were collected in traps and dip nets, including *Litoria fallax*, *Crinia tinnula*, *Litoria olongburensis* and *Limnodynastes terraereginae*. The only other species observed or captured in the study area were freshwater crayfish (*Cherax robustus* and *Cherax dispar*).

4.7 Introduced Species

Five introduced vertebrate fauna species were recorded during field surveys within the study area:

- Dingo/dog (*Canis lupus dingo/Canis lupus familiaris*) - Class 2 Declared pest animal;
- Fox (*Vulpes vulpes*) - Class 2 Declared pest animal;
- Feral cat (*Felis catus*) - Class 2 Declared pest animal;
- House mouse (*Mus musculus*) - non declared animal; and
- Cane toad (*Bufo marinus*) - non-declared animal.

Some of these animals (dingo/dog, fox, feral cat) have been declared as Class 2 Declared pest animals under the *Queensland's Land Protection (Pest and Stock Route Management) Act 2002*. These class 2 animals are established in Queensland and have or could have a substantial adverse economic, environmental or social impact and require control by the landowner (DNRMW 2006). Two of these exotic animals are non-declared animals (house mouse and cane toad).

The red fox (*Vulpes vulpes*) was recorded at most sites throughout the study area. The feral dog/dingo was recorded at a number of sites. The feral cat was recorded at one site in the study area in wet/closed heath (S1).

The house mouse (*Mus musculus*) was common in the study area and was recorded in all habitats sampled. The house mouse was the most abundant in mallee *Eucalypt spp.* and *Banksia aemula* low woodland on sand plains (S3), in the vicinity of the proposed impact area.

The cane toad (*Bufo marinus*) is a feral amphibian species that was relatively common in the study area. Most sightings were associated with Cooroon Cooroonpah Creek, however the cane toad was present in most of the habitats sampled.

5.0 SIGNIFICANT SPECIES, SITES AND HABITATS

5.1 Overview

The majority of the species recorded or expected within the study area are widespread in eastern Australia, while a small number of species are restricted to the region or are common on the sand islands in Moreton Bay but less common on the mainland. Fauna species occurring within the study area are assigned threatened status according to Queensland and Commonwealth legislation are described in the:

- Qld *Nature Conservation Act 1992*; and
- Commonwealth *Environment Protection & Biodiversity Conservation Act 1999*.

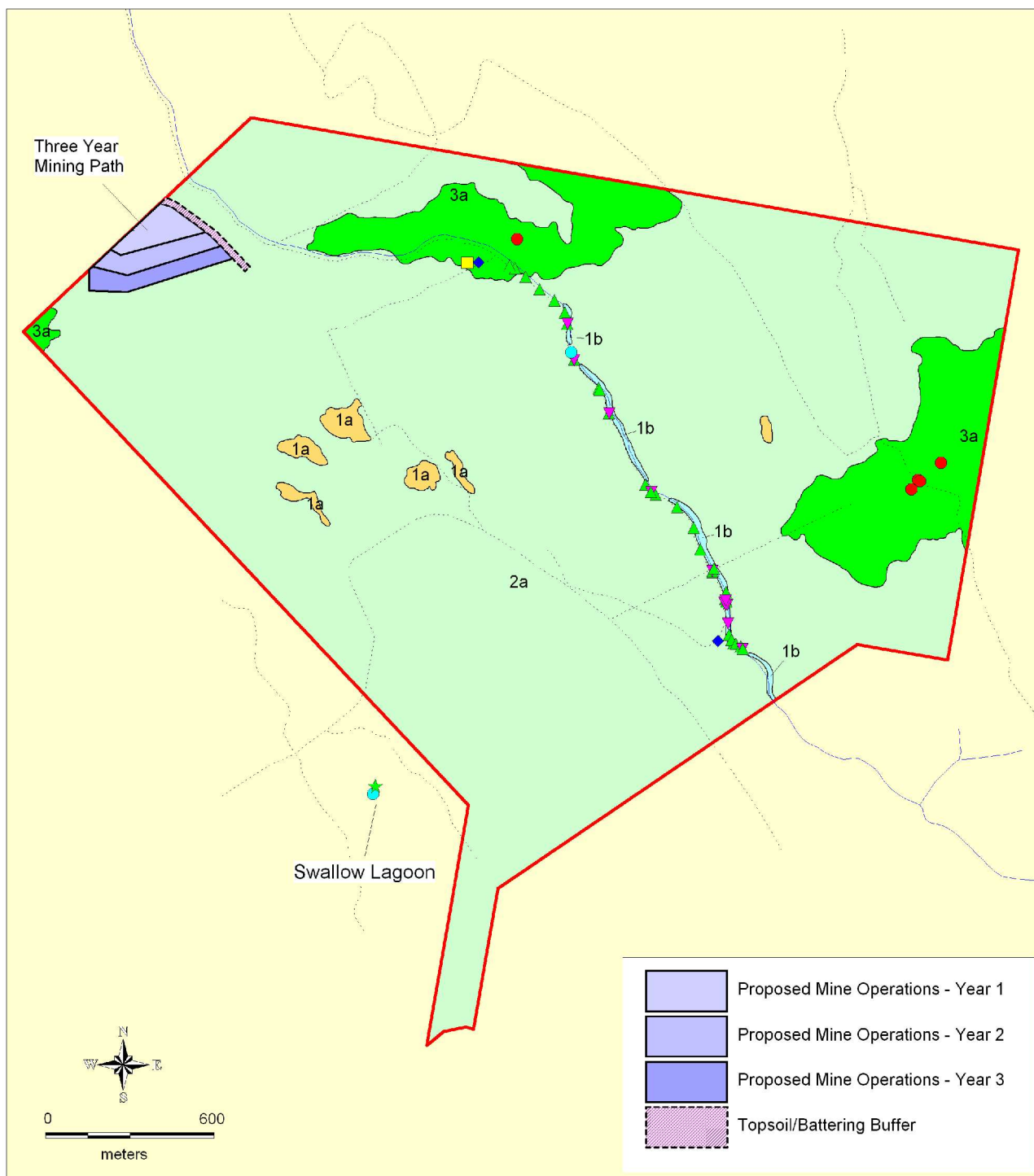
In addition to the threatened species, the *EPBC Act 1999* also includes a list of migratory species. These species are those that are listed under the following international agreements to which Australia is a signatory nation:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Convention on the Conservation of Migratory Species of Wild Animals - (Bonn Convention).

Under the *EPBC Act 1999*, Australia has an international obligation to protect significant populations and significant sites for these species.

5.2 Threatened Species

Threatened species known to occur within the study area are listed in Table 5.1 and mapped in Figure 2. No Endangered or Critically Endangered species are known or expected to occur in the study area. Two species are classified as Vulnerable under the *EPBC Act 1999*, four species are classified as Vulnerable under the Queensland *Nature Conservation Act 1992*, while one is classified as Rare under the Queensland *Nature Conservation Act 1992*. An additional species recorded adjacent to the study area is listed as Rare under the Queensland *Nature Conservation Act 1992*.



Legend

- Cooroon Cooroonpah Creek
Access Tracks
ML 1108 Vance Mining Lease Boundary

Vulnerable & Rare Fauna Species

- *Calyptrorhynchus lathamii* (Vulnerable)
- ▲ *Crinia tinnula* (Vulnerable)
- ★ *Litoria cooloolensis* (Rare)
- *Litoria freycineti* (Vulnerable)
- ▼ *Litoria olongburensis* (Vulnerable)
- *Ophioscincus truncatus* (Rare)
- ◆ *Pteropus poliocephalus* (Vulnerable)

Figure 2

Vulnerable and Rare Fauna Species

Project:
Unimin Vance Mining Lease 1108
North Stradbroke Island
Fauna Report

Source: Draft Vegetation
Mapping URS 2006
Client: URS



22 August 2006

The conservation status of threatened species in the study area is described below.

Table 5.1 Status of Threatened Fauna Species

Common Name	Scientific Name	EPBC 1999	Qld NCA1992
Wallum Sedgefrog	<i>Litoria olongburensis</i>	Vulnerable	Vulnerable
Wallum Rocketfrog	<i>Litoria freycineti</i>		Vulnerable
Wallum Froglet	<i>Crinia tinnula</i>		Vulnerable
Cooloola Sedgefrog #	<i>Litoria cooloolensis</i>		Rare
Short-limbed Snake-skink	<i>Ophioscincus truncatus</i>		Rare
Glossy-black Cockatoo	<i>Calyptorhynchus lathami</i>		Vulnerable
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	Vulnerable	

Recorded adjacent to study area (ML 1108) only

5.2.1 Acid Frogs

Populations of three species of vulnerable acid frog (wallum sedgefrog, wallum rocketfrog and wallum froglet) are present on Cooroon Cooroonpah Creek within the study area. It is likely that adult frogs of these species also utilise habitats adjacent to the creek as foraging areas, particularly during wet conditions. Significant management issues relating to proposed mining activities include the maintenance of the water table, surface water flow and persistence of surface water (within ML 1108), particularly during periods when these frogs are breeding and for a sufficient period for larvae to mature. The maintenance of a sufficient buffer to the creek is also relevant, to maintain instream conditions, prevent inflows of sand/silt that may reduce viability of breeding sites and maintain sufficient areas of foraging habitat surrounding the creek.

The proposed removal of vegetation for the three-year mining path (as defined by Unimin) would not have a direct impact on acid frog habitat. The populations of acid frogs identified within the study area are upstream of the three-year mining path impact area, however additional populations potentially occur on Cooroon Cooroonpah Creek below ML 1108.

Wallum Sedgefrog (*Litoria olongburensis*)

The wallum sedgefrog (vulnerable, EPBC Act 1999, vulnerable Qld NCA 1992) was recorded at all sites where surface water was present along Cooroon Cooroonpah Creek, from the area upstream of site 1 to the vicinity of site 2, primarily in closed/wet heath. Adult male frogs were vocalising along the length of the creek during the survey period.

Wallum Rocketfrog (*Litoria freycineti*)

The wallum rocketfrog (vulnerable Qld NCA 1992) was recorded at one site on Cooroon Cooroonpah Creek (upstream of site 2) and from Swallow Lagoon. At the Cooroon Cooroonpah Creek site, males were vocalising in the vicinity of the creek in closed/wet heath.

This species is likely to occur in habitats along the creek supporting surface water and adjacent habitats.

Wallum Froglet (*Crinia tinnula*)

The wallum froglet (vulnerable *Qld NCA 1992*) was recorded at all sites where surface water was present along Cooroon Cooroonpah Creek, from the area upstream of site 1 to the vicinity of site 2, primarily in closed/wet heath, *Banksia aemula* low woodland and *E. racemosa* open forest with a heath ground cover associated with the creek. Adult male frogs were vocalising along the length of the creek during the survey period and larvae (tadpoles) were present at a number of sites.

Cooloola Sedgefrog (*Litoria cooloolensis*)

The Cooloola sedgefrog (rare *Qld NCA 1992*) was not recorded within the study area and it is unlikely that any of the habitats along Cooroon Cooroonpah Creek are suitable for this species. However the Cooloola sedgefrog was recorded at Swallow Lagoon to the south-west of the study area outside ML 1108. Most of the known localities for this species on North Stradbroke Island are associated with deeper perched lake and lagoon habitats, including Blue Lake, Brown Lake, Tortoise Lagoon, Blue Lake, Swallow Lagoon and Welsby Lagoon.

5.2.2 Short-limbed Snake-skink (*Ophioscincus truncatus*)

The short-limbed snake-skink (rare *Qld NCA 1992*) was recorded within the study area from a single specimen trapped in *E. racemosa*, *C. gummifera* open forest/woodland (S2). This species has been collected from a variety of habitats on North Stradbroke Island, including forests, woodland and heath on pale sandy soils (Wilson 2005). This species potentially occurs in a wider variety of habitats but is currently known from this one habitat type within the study area. The proposed removal of vegetation for the three-year mining path (as defined by Unimin) does not have a direct impact on the ML 1108 collection site of the short-limbed snake-skink. The short-limbed snake-skink was not recorded in the vicinity of the three-year mining path, however this habitat mallee eucalypt and *Banksia aemula* low woodland (2a in URS 2006) is potentially suitable for this species.

5.2.3 Glossy Black-Cockatoo (*Calyptorhynchus lathami*)

The glossy black-cockatoo (vulnerable *Qld NCA 1992*) was recorded within the study area in open forest habitats (Figure 2) from characteristic signs of feeding on she-oaks. Observations of feeding were concentrated in two main areas of the study area. A number of signs of feeding were located in open forest dominated by *Eucalyptus pilularis* (S5) in the east of the study area. The majority of this habitat is within the RAMSAR listed area and is not within the area proposed for mining for the three-year mining path. A number of feeding signs were also located within *E. racemosa* open forest/woodland in the central northern component of the

study area. The glossy black-cockatoo potentially uses Casuarina groves at other locations within the study area, with some potentially suitable groves present on Cooroon Cooroonpah Creek and in the southern component of the study area. Habitats supporting potential breeding sites (eg old growth trees with suitable hollows) are limited within the study area, however potentially suitable trees are present in *Eucalyptus pilularis* open forest and *E. racemosa* open forest/woodland (3a in URS 2006). The proposed removal of vegetation for the three-year mining path (as defined by Unimin) is unlikely to have a direct impact on glossy black-cockatoo habitat, as no foraging habitat (casuarinas) or nesting sites (large mature eucalypts with hollows) were observed in this area.

5.2.4 Grey-headed Flying-fox (*Pteropus poliocephalus*)

The grey-headed flying-fox is listed as Vulnerable under the Commonwealth Government's *Environmental Protection and Biodiversity Conservation Act 1999*. The national grey-headed flying-fox population declined by 30% between 1989 and 1999 and ongoing habitat clearance, particularly along coastal areas in northern NSW, is the main threat to this species (DEH 2003).

Grey-headed flying-fox occur on a seasonal basis in the main North Stradbroke Island flying-fox camp at Dunwich and it is likely that most of the bats observed within the study area are from this camp. Numbers of grey-headed flying-fox present at the Dunwich camp vary depending on seasonal changes in flowering, fruiting patterns and climatic conditions, indicating that numbers foraging within the study area are also likely to vary.

Major food sources for the grey-headed flying-fox within the study area include flowers of canopy eucalypts and corymbias in open forest and woodland habitats (*E. racemosa* open forest/woodland and *E. pilularis* open forest) and *Banksia aemula* and mallee eucalypts (mallee *Eucalypt* spp. and *Banksia aemula* low woodland). In areas of coastal SEQ/northern NSW blossom shortages typically occur through a combination of spatial and temporal patchiness in flowering and due to the clearing of those species that occurred on soils preferred for agriculture (Law *et al.* 2000). These shortages commonly occur from late winter to spring (Law *et al.* 2000) and some of the habitats within the study area support numbers of canopy trees that flower reliably in this period (eg *Eucalyptus pilularis*).

The proposed removal of vegetation for the three-year mining path (as defined by Unimin) will remove approximately nine hectares (URS 2006) of potential foraging habitat for the grey-headed flying-fox. This area represents a small percentage of mallee eucalypt and *Banksia aemula* low woodland (2a in URS 2006) within ML 1108. Numbers of other flying-fox species observed foraging within mallee eucalypt and *Banksia aemula* low woodland (2a in URS 2006) were generally lower than those observed in taller open forest types (3a in URS 2006).

Within mallee eucalypt and *Banksia aemula* low woodland the main canopy trees utilised by other flying-fox species was *Banksia aemula* and it is likely that mallee eucalypts would also be used when they are in flower.

5.2.5 Koala (*Phascolarctos cinereus*)

Although surveys were conducted to target the vulnerable koala (*Phascolarctos cinereus*) (vulnerable SEQ bioregion, *Qld NCA 1992*), this species was not recorded in the study area during the survey period. However the study area does support potential koala habitat consisting of *Eucalyptus pilularis* open forest and *Eucalyptus racemosa*, *C. gummifera* open-forest/woodland. The koala occurs on North Stradbroke Island (Queensland Museum 2006; EPA 2006a) and existing records have been located in a number of regional ecosystem types outside the study area, including regional ecosystems 12.2.6, 12.2.8 and 12.2.10. A number of previous sightings of this species have been recorded to the north, south and west of the study area, the closest record being approximately 1.5 km from the study area boundary. It is likely that vegetation in the study area, particularly open forest, woodland and low woodland, provides connectivity to surrounding habitat areas.

The proposed removal of vegetation for the three-year mining path (as defined by Unimin) will remove approximately nine hectares (URS 2006) of mallee eucalypt vegetation (2a in URS 2006). This represents a small percentage of similar habitat within ML 1108. Habitat in this impact area is likely to be of lower significance as koala habitat when compared to taller open forest/woodland within ML 1108 (eg 3a in URS 2006). Although vegetation in the proposed impact area may provide habitat connectivity to areas west of the study area, the proposed buffer along Cooroon Cooroonpah Creek may also provide connectivity value to these areas.

5.3 Migratory Species

No significant migratory species were recorded within the study area. A single bird species, the rainbow bee-eater (*Merops ornatus*), is listed as a migratory species under the *EPBC Act 1999* (DEH 2005). This species is common and does not require specific habitat management measures. None of the habitats present within the study area are suitable for migratory wetland or shorebirds.

5.4 Habitat Conservation Values

5.4.1 Closed wet heath, Cooroon Cooroonpah Creek riparian habitat

Closed or wet heath (mapped as 1b in URS 2006) and riparian vegetation is the most significant habitat for fauna within the study area. These ecosystems provide habitat for three threatened frog species protected under Queensland and Commonwealth legislation and

support the highest diversity of native fauna species, including the highest amphibian and mammal diversity. These habitats are also significant due to the presence of open water and associated riparian vegetation and closed/wet heath. Closed wet heath and riparian habitat is one of the most restricted habitats within the study area.

5.4.2 Mallee *Eucalyptus* spp. and *Banksia aemula* low woodland on lowland dunes

Although low woodland on sand plains/dunes (mapped as 2a in URS 2006) support a relatively high diversity of native fauna species, including the highest reptile diversity, threatened species were not recorded during the survey in this habitat. This habitat provides foraging habitat for flying foxes and potential habitat for the short-limbed snake-skink.

5.4.3 *Eucalyptus racemosa*, *Corymbia gummifera* open forest/woodland

Eucalyptus racemosa, *Corymbia gummifera* open forest/woodland (mapped as 3a in URS 2006) supports a moderate diversity of native fauna species relative to other habitats in the study area and provides habitat for a number of threatened fauna species, including the glossy black-cockatoo, grey-headed flying-fox and short-limbed snake-skink. Some components of this habitat within the study area support old growth forest characteristics, with senescent living and dead trees supporting hollows suitable for a range of wildlife species.

5.4.4 *Eucalyptus pilularis* open forest

E. pilularis open forest (mapped as 3a in URS 2006) supported the highest diversity of birds and a moderate diversity of native fauna species during the survey period, relative to other habitats in the study area. This open forest also provides habitat for one threatened species, the glossy black-cockatoo. Some components of this habitat within the study area support old growth forest characteristics, with senescent living and dead trees supporting hollows suitable for a range of wildlife species.

5.4.5 Mallee *Eucalyptus* spp. & *Banksia aemula* low woodland on ridge

Mallee *Eucalyptus* spp. and *Banksia aemula* low woodland (mapped as 2a in URS 2006), where it occurs on higher exposed dunes and ridges, supports a relatively low diversity of native fauna species. Threatened species were not recorded during the survey in this habitat type. Low woodland provides foraging habitat for flying-foxes and potential habitat for the short-limbed snake-skink.

5.4.6 Open or dry heath with stunted *Banksia aemula* on upland dunes

Open or dry heath on exposed high dunes and ridges (mapped as 1a in URS 2006) support the lowest diversity of native fauna species in the study area and threatened species were not recorded during the survey in this habitat type. Heath areas on high dunes are limited in area and are unlikely to support any habitat specific fauna.

6.0 OVERVIEW: FAUNA IMPACTS AND MANAGEMENT

6.1 Potential Impacts

Proposed operations within ML 1108 are limited to the removal of dune sand, with processing undertaken on the adjacent lease area ML 1124 (URS 2006). Current proposed mining activities within ML 1108 (stage 1) include a 3 year mining path located in the north-western sector of the study area (URS 2006). A number of potential impacts are associated with the proposed mining activities within the study area, including vegetation removal, other impacts associated with mining activities (eg noise, dust, weeds etc) (URS 2006), habitat connectivity and potential impacts on local hydrological systems (ground and surface water) on Cooroon Cooroonpah Creek.

6.1.1 Vegetation Removal

Proposed removal of vegetation within the three year mining path will require the removal of approximately 9.5 ha of vegetation (URS 2006). The vegetation in this area is dominated by Mallee eucalypt species low woodland, a community that is the most common and widespread within the study area, covering 564 ha (URS 2006). During the current survey threatened fauna species were not observed within or adjacent to the three-year mining path, however a number of species potentially occur in this habitat, particularly the short-limbed snake-skink and the grey-headed flying-fox.

During the survey period Mallee eucalypt low woodland appeared to be of lesser significance as foraging habitat for flying-foxes than more developed taller woodland and open forest within the study area. The widespread nature of Mallee eucalypt habitat within the study area and the relatively small area encompassed by the three-year mining path indicates that impacts of vegetation clearing will be minimised. Further proposed mining beyond the three year mine path would require specific impact assessment and design of appropriate mitigation measures.

6.1.2 Habitat Connectivity

The study area represents a relatively large area of intact vegetation, with connectivity to adjacent tracts of intact habitat. Habitats within the study area may provide connectivity between a number of conservation areas surrounding the study area, including Wildflowers Scenic Reserve to the north, Brown Lake Recreation Area to the west and Blue Lake National Park to the south-east (URS 2006). Within the study area, vegetation along the Cooroon Cooroonpah Creek and tracts of eucalypt open forest/woodland in the northern and eastern study area are likely to be of local significance as corridors for the movement of fauna species. These areas are partially protected by proposed conservation areas within the Ramsar listed area and the proposed 200m wide buffer along Cooroon Cooroonpah Creek.

The proposed three year mining path does not impact areas or sites that are locally significant in terms of habitat connectivity and wildlife movements within the local landscape. Mining proposed for additional areas of the study area should consider the implications for functioning wildlife movement corridors, particularly along the Cooroon Cooroonpah Creek corridor and the northern and eastern open forest/woodland habitats.

6.1.3 Operational Mining Impacts

Operational mining impacts potentially associated with the proposed mining operation include weed invasion, altered fire regimes, generation of noise and dust, and other factors that may influence wildlife, such as the presence of lighting and increased human activity in the area surrounding the mining area. Measures aimed at minimising the impact of weed infestations are discussed by URS (2006). Minimising operational impacts associated with noise, dust and lighting adjacent to the mining area should be considered during the design of infrastructure and operational stages of the project. The three-year mining path is located within an area that is currently adjacent to existing mining areas, and this area is already subject to levels of impact (eg noise). In terms of the three-year mining path, impacts on local wildlife are likely to be restricted to the relatively limited mining area and adjacent areas.

Existing fire regimes are not expected to be altered by the proposed mining operations (URS 2006), however consideration should be given to prevention of unplanned fires during the clearing and operational phases.

6.1.4 Hydrological Impacts

Populations of three species of vulnerable acid frog are present on Cooroon Cooroonpah Creek within the study area, indicating that mitigation of potential impacts on aquatic habitats within the study area will remain a significant management issue. The major issues relate to the:

- Maintenance of sufficient buffers on Cooroon Cooroonpah Creek;
- Prevention of erosion and sedimentation in and adjacent to the creek; and
- Prevention of impacts due to alteration of the water table and maintenance of surface water habitats and flows, particularly during amphibian breeding periods.

Impacts on the aquatic habitats on Cooroon Cooroonpah Creek associated with the three year mining path are likely to be low, as the proposed mining site is downstream of the most significant amphibian habitats within the study area and includes an established buffer between the lower extent of the creek within ML 1108. However, any potential impacts on water table levels will require ongoing monitoring and assessment and measures to prevent downstream impacts (eg through sedimentation) are required. Further proposed mining beyond the three year mining path would require additional assessment of potential impacts

on Cooroon Cooroonpah Creek and associated habitats and the design of mitigation measures specific to those proposed impact areas.

6.2 MITIGATION MEASURES

6.2.1 Conservation of Significant Habitats and Species

Specific management recommendations relating to threatened species and their habitats within the entire study area (ML 1108) include:

Acid Frogs (Vulnerable):

- Conduct mining activities in such a way that the impact of Unimin's activities on surface and groundwater flows within the study area do not reduce surface water flows below natural flows, in order to avoid impacts on breeding sites, particularly during critical breeding periods.
- Prevent inflow of sand and silt to existing amphibian breeding sites.
- Establish sufficient creek and habitat buffers with the width determined following assessment of potential hydrological impacts.
- Establish monitoring of surface and groundwater flows to determine any detrimental impacts on the amphibian population.
- Maintain sufficient areas of habitat surrounding the creek to enable viable amphibian populations to persist.
- Maintain sufficient areas of habitat surrounding the creek to allow for natural filtration of water and sedimentation from surrounding areas.
- Develop a threatened amphibian management and monitoring program.

Short-limbed Snake-skink (Rare):

- Consider protection of a larger area of *E. racemosa* open forest/woodland to the east of Cooroon Cooroonpah Creek. This area also supports glossy black-cockatoo habitat, grey-headed flying-fox feeding habitat and potential koala habitat.

Glossy Black-Cockatoo (Vulnerable):

- Protect significant groves of casuarinas within the study area. The main area where glossy black-cockatoos were detected during the survey should remain protected as these habitats are not located in the proposed mining footprint and are located in the Ramsar area.
- Protect areas of open forest with old growth habitat features (eg large hollow trees suitable as nesting sites).
- Manage fire within the study area to protect groves of Casuarina.

- Widening of the Cooroon Cooroonpah Creek buffer area to include open forest habitat along the creek may also protect additional feeding sites.
- Include Casuarina's sourced from local endemic stock in rehabilitation areas.

Grey-headed Flying-fox (Vulnerable):

- Protect foraging habitats, particularly open forest habitats that include late winter flowering canopy trees. Some of these areas are already protected in the Ramsar area.
- Include trees endemic to the study area that are known to be used as flying-fox foraging sources in rehabilitation areas (eg *Banksia aemula*, *Eucalyptus planchoniana*), with consideration to providing a proportion of species that flower across a variety of seasons.

Koala (Vulnerable SEQ):

- Protect open forest types within the study area.
- Provide corridors for movement throughout the study area by retaining open forest/woodland in the study area and corridors between open forest/woodland habitats in the study area.
- Further consideration should be given to the design of these corridors between potential open forest/woodland habitats in an east west orientation, encompassing the retention of Eucalypt low woodland where possible.

6.2.2 Maintenance of Habitat Connectivity

- Protect riparian vegetation in a broad corridor along Cooroon Cooroonpah Creek.
- Protect open forest types, providing habitat linkages to the north and east of the study area.

6.2.3 Protection of Riparian and Instream Habitats

- Manage surface and groundwater to maintain surface water flows.
- Prevent the inflow of sand and silt to existing amphibian breeding sites.
- Establish sufficient creek and habitat buffers.
- Maintain sufficient areas of habitat surrounding the creek.

6.2.4 Rehabilitation of Disturbed Areas

URS (2006) provides recommendations for rehabilitation within the proposed mine area of ML 1108. The following recommendations should be considered in relation to the proposed rehabilitation measures:

- Develop guidelines for protection of areas outside mining and associated infrastructure areas.

- Rehabilitation of disturbed areas should include consideration of the requirements of fauna that will potentially recolonise these areas. Measures could include stockpiling of deadwood and woody debris following clearing, for later return to the rehabilitation area to provide fauna microhabitat and increase the rate of faunal return.
- A system of habitat linkages and buffer areas for significant habitats should be developed, to assist in the retention of fauna biodiversity and threatened species within the study area.

6.2.5 Monitoring

- Conduct terrestrial fauna monitoring in rehabilitation areas and control sites, to determine the success of rehabilitation measures.
- Monitor aquatic habitats and fauna and develop a management plan for threatened frogs in the study area and adjacent areas.
- Establish monitoring of surface and groundwater flows in relation to fauna and threatened species.
- Monitor significant habitats or sites in buffer areas to determine impacts.

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PLATES



Plate 1: Site 1 Closed wet heath Cooroon Cooroonpah Creek



Plate 2: Site 2 *E. racemosa*, *C. gummifera* Open Forest



Plate 3: Site 3 Mallee Eucalypt and *Banksia aemula* low woodland on lowland dunes



Plate 4: Site 4 Mallee Eucalypt and *Banksia aemula* low woodland on ridge



Plate 5: Site 5 *Eucalyptus pilularis* open forest



Plate 6: Site 6 Open or dry heath with stunted *Banksia aemula* on upland dunes



Plate 7: *Ctenotus arcanus*, the most abundant reptile encountered within the study area



Plate 8: Short-limbed Snake-skink (*Ophioscincus truncatus*) (rare, NCA 1992)



Plate 9: Wallum sedgefrog (*Litoria olongburensis*) (Vulnerable, EPBC Act 1999) on Cooroon Cooroonpah Creek within the study area



Plate 10: Wallum rocketfrog (*Litoria freycineti*) (vulnerable, NCA 1992) at site 7



Plate 11: The introduced House mouse (*Mus musculus*), the most commonly trapped rodent within the study area

Appendix H

Unimin Australia Stakeholder Consultation Report



Unimin Australia Limited

Stakeholder Consultation Report

Prepared for ML 1108 (Vance) Environmental Studies Report

June 2006

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1. Introduction

North Stradbroke Island is of significance to quite a diverse group of people. The Vance Lease, the subject of this Environmental Studies Report (ESR), is of cultural significance to the local indigenous community. Cooroon Cooroonpah Creek also traverses the lease and Swallow Lagoon, Queensland's highest perched lake is situated south west of the lease boundary. Thus, scientifically and historically, these areas are of significance to interested groups.

2. Objectives of the Consultation

In accordance with the Environmental Protection Act 1994, a stakeholder consultation program was conducted to ensure participation of all recognised interested groups in the ESR process.

The objectives of this stakeholder consultation program were to:

- Inform the stakeholders about the ESR process and opportunities for them to be involved;
- Provide the stakeholders with adequate opportunity to be involved in the preparation of the ESR;
- Involve the stakeholders in the associated environmental studies that form part of the ESR and establish a mutually beneficial flow of information between the parties;
- Identify stakeholder issues and concerns with the project;
- Identify measures to mitigate perceived and actual issues that cause stakeholder concern; and
- Facilitate a transparent and fair process where mutual trust can be developed.

3. Stakeholder Groups

The target audiences for the consultation program were identified through review of lists of government departments, community and cultural groups.

Based on the review above, appropriate interested groups/stakeholders were selected to be involved in the consultation program based on their proximity to the future mine site; general interest in Unimin's activities; and North Stradbroke Island in general.

Stakeholders that were invited to participate in the consultation program included:

- Environmental Protection Agency (EPA);
- Friends of Stradbroke Island (FOSI);
- Stradbroke Island Management Organisation (SIMO);

- Quandamooka Land Council (QLC);
- the residents of Myora;
- Redland Shire Council;
- Department of Natural Resources Mines and Energy (DNRME).

The Minjerribah Moorgumpin Elders Council received a copy of the final documentation once they were assigned as the Cultural Heritage Registered Body of North Stradbroke Island. Thus, the Terms of Reference (ToR) did not focus on cultural heritage issues. Instead, this consultation was conducted according to the Aboriginal Cultural Heritage Act 2003 with the Minjerribah Moorgumpin Elders in Council. Refer to the Project Cultural Heritage Management Report for further details on indigenous stakeholder consultation.

4. Consultation Process

As a result of the proactive consultation process initiated by Unimin it was decided to conduct the consultation with stakeholders using the drafts of the ToR document for the ESR. Thus, stakeholders were encouraged to respond or contact Unimin with any questions or concerns at an early stage.

The first draft of the ToR was issued to all stakeholders on the 7 July 2004. This ToR included basic ideas of what Unimin planned on including within the ESR and was designed to gauge stakeholders' expectations of the project. The stakeholders were allocated one month to provide comments on the draft ToR.

Detailed submissions on the draft ToR were received from FOSI, SIMO and the QLC stakeholders. Unimin responded to these submissions on 25th August 2004, addressing all issues raised with draft ToR.

A second draft of the ToR was subsequently produced based on the submissions above and issued at this time. Stakeholders were again encouraged to contact Unimin with further concerns or questions by the 8th September 2004.

The EPA submitted comments on this document by email on the 29th August 2004 and was the only stakeholder to make a submission on the second draft. The EPA's comments were responded to verbally and as before, any appropriate changes were made to the ToR.

The final ToR was issued in November 2004 to all stakeholders.

5. Key Issues Raised During ToR Consultation

5.1 Methodologies and Reporting

The main issue raised with the first draft of the ToR was the lack of specific information. Therefore, the second draft provided more detailed in terms of study methodologies and references. In particular the proposed hydrology and flora/fauna studies were required to provide additional information to explain in detail the methodologies to be employed during the project.

5.2 Geomorphology

Unimin's initial decision was not to complete a geomorphology study on the lease. This approach caused some concern with the consultation group and was the one issue raised by all stakeholders who responded to the first draft.

Taking into consideration these concerns, Unimin commissioned a literature review of the local and island geomorphology, in conjunction with a terrain analysis on the lease area. This information was to be linked with flora and fauna studies; as well as surface and groundwater hydrology studies already proposed.

5.3 Hydrology

Swallow Lagoon, being the highest perched lake in Queensland is of great significance to the stakeholders. This area being classified as Ramsar wetland is protected under the *Environmental Protection Biodiversity Conservation Act 1999* (EPBC). Stakeholders wanted assurance that this area would not be adversely affected in any way by future operations.

Unimin informed the stakeholders that an appropriate buffer zone would be established between site operations and Ramsar designated wetlands.

5.4 Mining Activity

Stakeholders asked Unimin to provide maps on where it would be mining and post-mine topographical maps. As this is something that could not be accurately determined until after completion of the environmental studies, Unimin could not provide this information at this time.

Similarly with the information requested regarding infrastructure (pipelines and power etc), as mine paths are not yet known, final infrastructure locations could not be defined at this time.

5.5 Rehabilitation

Rehabilitation was another issue raised by stakeholders. The main issue was the success rates of our current rehabilitation methodologies.

Unimin conducts Index of Similarities on all rehabilitated areas until a set level of similarity has been reached for two consecutive years. Stakeholders, including the EPA have reviewed Unimin's progress in this area and considered our rehabilitation to be a success. As a result, Unimin decided against having current rehabilitation practices reviewed as part of this ESR.

Stakeholders also wanted assurance of re-use of timber and topsoil in post mine rehabilitation, and the practice of transplanting the Grass Tree *Xanthorrhoea*. Unimin informed the stakeholder group that they already conduct these activities on their current leases and would continue this on the Vance Lease area.

Table 1. Summary of Issues Identified During ToR Consultation

Stakeholder	Infrastructure	Flora / Fauna	Hydrology	Geomorphology	Mine	Rehabilitation	Socio-Economic	UAL CRL inter-relationship	Cultural Heritage	Air	Noise	Transport
EPA		✓	✓	✓					✓		✓	✓
FOSI	✓	✓	✓	✓	✓	✓						
QLC			✓	✓	✓			✓	✓			
SIMO		✓	✓	✓	✓	✓	✓					

6. Key Issues Raised During Review of Draft ESR

The stakeholders were provided with copies of the Draft ESR in the second half of 2005 to give them an opportunity for further comment and feedback on the proposed project.

Formal responses were received from the EPA, SIMO, FOSI and one Myora resident. Key issues raised in these responses included:

- Over reliance on data/information from old or existing reports (particularly air, noise, transport, socioeconomic);
- Limited number of transect/survey areas for the flora and fauna studies; and
- Only desk top hydrogeological, hydrological and geomorphological assessments were undertaken. No field sampling was completed.

In subsequent meetings held between Unimin and the EPA, agreement was reached to undertake additional investigation programs on ML1108 to provide further information to address the above stakeholder concerns.

7. Conclusion

Stakeholder consultation was conducted prior to undertaking the ESR using the ToR for the project. Two drafts of the ToR were provided to stakeholders for comment prior to the final being approved and distributed.

Responses to the ToR were received from the EPA, FOSI, SIMO and QLC interested groups. Their concerns, comments and suggestions were incorporated, where appropriate, into the final ToR for the project. The main issues raised during the consultation process are summarised above in Table 1.

Additional opportunity to comment and review the Draft ESR was provided to the stakeholders. Further investigations were commissioned by Unimin to address the issues raised at this time.

The proactive approach to stakeholder consultation undertaken by Unimin with respect to this project has ensured that mutual trust has been established between the parties. This should result in a positive legacy for future interaction between Unimin and its stakeholders for current and future operations.

APPENDIX A - EPA ASSESSMENT REPORT

DRAFT ENVIRONMENTAL STUDIES REPORT FOR PROPOSED DEVELOPMENT OF VANCE MINING LEASE 1108, NORTH STRADBROKE ISLAND

Prepared by URS for Unimin Australia Limited, August 2005

BACKGROUND

Unimin is required to prepare and submit an Environmental Studies Report pursuant to the following conditions of environmental authority MIM900220203 (Vance project ML 1108):

- (A5-3) An *Environmental Studies Report (ESR)* must be submitted to the *administering authority* at least one month prior to the commencement of *mining operations* where required in accordance with condition (A4-4).

The *ESR* must:

- a) provide the results of the *baseline environmental studies*;
- b) identify *environmental values* including *key environmental values* and location(s) thereof within the *authorised mining tenements(s)* and *zone of impact* ;
- c) provide an assessment of the *environmental impact* of the *mining activities* on *environmental values*;
- d) by using the principles of the risk management system referred to in condition (A6-1) state *control strategies* to protect *environmental values* and *key environmental values*;
- e) state *trigger levels* for indicators of possible impacts on *environmental values* and *key environmental values*, the *trigger levels* being relevant to alert of potential causation of *environmental harm*; and
- f) include details of the level and nature of *stakeholder* consultation undertaken for the *baseline environmental studies* and the *ESR* including:
 - i) a summary of the concerns and interests raised by *stakeholders*;
 - ii) a summary of issues where agreement with *stakeholders* could not be reached;
 - iii) ongoing consultation arrangements during the mining activities; and
 - iv) any identified issues which require further *stakeholder* involvement.

- (A5-4) **At least two months prior to submission of the *ESR* required by condition (A5-3), a draft of the *ESR* addressing the matters stated in conditions (A5-3)(a) to (f) inclusive must be submitted to the *administering authority*.**

- (A6-1) The holder must plan and conduct the *mining activities* according to:
- a) a *risk management* system which substantially complies with the Australian Standard for Risk Management (AS/NZS 4360:1999) ; and
 - b) an *environmental management system* that substantially complies with ISO 14001:1996 (environmental management systems – specification with guidance for use).
- (A6-2) All elements of the *environmental and risk management systems*, and the implementation of those systems must be documented. As a minimum standard the documentation must include:
- a) identification and progressive assessment of the *environmental impacts* of key risk scenarios;
 - b) register(s) of *environmental aspects*, impacts and risk;
 - c) the risk evaluation criteria; and
 - d) actions taken to ameliorate *unacceptable risks*.

The draft ESR and Appendices has been reviewed and comments prepared by officers of the Environmental Protection Agency as outlined below:

Main Report – David Trezise (EPA)

Appendix A: Flora report - Kathy Stephens (Herbarium); and
Fauna report – Lisa Ford (QPWS)

Appendix B: Cultural heritage (Report still pending).

Appendix C: Groundwater report - David Trezise (EPA).

Appendix D: Surface water report - David Trezise (EPA).

Appendix E: Air quality report - David Trezise (EPA).

Appendix F: Noise report - David Trezise (EPA).

Appendix G: Road transport report - David Trezise (EPA).

Appendix H: Geomorphology and soils report - David Trezise (EPA).

Appendix I: - Socio-economic report - David Trezise (EPA).

Appendix J: Community consultation - David Trezise (EPA).

Ecological Assessment Vance Mining Lease ML 1108 North Stradbroke Island (Appendix A)

Comments by K. Stephens (Herbarium), on Flora Survey prepared by URS for Vance Mine Lease No. 1108, North Stradbroke Island.

1.1 Terms of Reference

Baseline studies appear inadequate for the purposes outlined here.

1.2 Site Description

The lease area of 630 ha will determine the sampling rate required for the flora survey. At 1:20 000 scale vegetation mapping as illustrated in figure 5, the sampling rate is 6.25 per km², which would require approximately 40 sites to adequately sample the 630ha of vegetation. These should be distributed proportionately across the lease, relative to the area of each mapping unit type.

1.3 Regional Context

1.3.1 Bioregion

Acceptable to EPA, no changes recommended.

1.3.2 Sub-region

The references (Morgan 1988, Sattler and Williams 1999) should be given in full and properly acknowledged in a references section at the end of the Flora Survey Report.

2.1 Study Aim and Objectives

The scale of the mapping of the vegetation communities is not mentioned.

2.2 Review of Existing Information.

Preliminary mapping – there is no mention of the scale of this mapping. Aerial photography of the area is mentioned but attributed to EPA. EPA does not do aerial photography. Accurate listing of photographs used for the mapping is required, with the date, source and scale of the photos. Perhaps the reference is to RE mapping done by EPA, at a scale of 1:100000. This scale would be inadequate for the lease area. The vegetation communities map is given at scale 1:20 000 which is an appropriate scale.

If using existing 1:100 000 scale mapping, they are failing to fulfil the terms of reference “to map the vegetation communities”.

The reference (EPA, 2004) is not included in any references list.

2.2.1 Data Sources

The first reference is incorrectly referred to as Queensland Museum flora database (HERBRECS) – it should be Queensland Herbarium flora database. As it is not properly referenced, there is doubt as to whether information was actually obtained from the source. Unless specifically requested HERBRECS information on rare and threatened species location is generally suppressed from species lists. Date of request for species list should be included.

No version or date given for Qld EPA 1:100 000 Regional Ecosystems mapping.

No references are given for the Flora Survey section so the information sources inadequately referenced here cannot be checked.

Checks should also have been made for species listed on the Australian Heritage Commission Register of the National Estate Database (available online). Large areas of the island are covered under 3 sections Southern, Central and Northern Sections.

Rare and threatened species recorded for all of North Stradbroke Island should have been searched for, rather than those recorded for the confined grid of the study area.

The list of data sources does not appear to have been reviewed or compiled into any database by the study. It appears to be just a list of references, not properly referenced. Some sources have been overlooked e.g. Redland Shire Mapping.

2.2.2 Regional Ecosystems

The brief description here shows a lot of confusion e.g. referral to southeast Queensland as a province. A listing of REs occurring on North Stradbroke Island from the most recent release of RE mapping would be useful. Listing of REs covering the Vance lease area could then be placed in context. Something about bioregion, land zone and vegetation type to describe a regional ecosystem is required. Some discussion of what “of concern” and “endangered” vegetation means in terms of the Vegetation Management Act.

2.2.3 Target Species

Species are not dealt with under the Vegetation Management Act, so the reference here is inappropriate. Checks should also have been made for species listed on the Australian Heritage Commission Register of the National Estate Database. Using all sources, there are over 30 significant species on North Stradbroke Island. To only consider 4 of these is inadequate and shows lack of proper research for this section.

2.2.4 Category B Regions

Acceptable to EPA, no changes recommended.

2.2.5 Ramsar Wetland Area

There is no discussion as to whether the lease is still bound by the requirements of a Ramsar listed area.

2.3 Survey Methodology

The terms of reference have a mixture of methodologies. There is no indication in the report as to which methodology was actually used. A detailed description of the methodology is required, including type of information collected at each site.

The terms of reference state approximately 1 hour will be spent at each 20m x 50m plot. To adequately measure the information they claim is “typically being recorded” including structural and floristic data including stratum descriptions, basal area, stem densities and life forms would require more than 1 hour.

2.3.1 Sampling Conditions

The flora report claims fieldwork “was conducted over 1 day” in mid summer. It also states that after each plot 15 minutes was spent on meander searches of 1.5ha. 10 hours + 10 x 15 minutes (2.5 hours), gives at least 12.5 hours in mid Summer without travelling distance between sites, or stopping for lunch or breaks, or to do the “selected secondary plots” also mentioned in the meander searches. No methodology is given for these plots, and they are not located on the map. There has to be doubt about the thoroughness of data collection. Structural and floristic data are not presented in the report.

2.3.2 Primary Plots

10 plots do not adequately sample 630ha at 1:20 000 scale, as previously mentioned. 40 would be required. It is stated that fieldwork included plant collection, but later, (2.3.5 Specimen Identification) that all plants were identified in the field. This would increase the time to do each plot considerably, as plant identification of unknown specimens is time consuming. Usually, 1 day of fieldwork requires 2 days plant identification using a microscope and keys to species.

2.3.3 Meander Searches

Reference (Cropper, 1993) in full in references list.

Mention is made here of secondary plots, but no locations, data or information about these plots is provided elsewhere in the report.

Otherwise, acceptable to EPA and no further changes recommended.

2.3.4 Incidental Observation

Where are these records in the report? A species list and vegetation description for each vegetation association should be provided.

2.3.5 Specimen Identification

That all specimens were identified in the field is disturbing. To accurately identify many species requires the use of microscopic characteristics. Field identification of many species by an experienced botanist is possible, but certainly not all species. For example accurate identification of the grass *Eriachne insularis*, which is a significant species, which reaches its southern limit on North Stradbroke Island, would require verification by microscope examination of a specimen.

2.3.6 Vegetation Community Determination.

No plant community descriptions are presented, along with their associated data e.g. floristics (species list), structure (height, crown cover, dominant species, stem counts, basal area, ground layer cover, etc) claimed to have been recorded for each plot.

Height and crown separation appear to have been estimated rather than measured, which may result in inaccuracies.

A table with the plots, their vegetation mapping units and their allocation to Regional Ecosystems would be useful here, to show the process.

2.4 Results

2.4.1 Diversity

This is acceptable to EPA, but too brief. Diversity within each community and between communities should be discussed.

2.4.2 Vegetation Communities

There are six vegetation communities listed in table 1 and map legend (figure 5), not five. To say they are described is incorrect. There are no vegetation community descriptions in the report. A one-line map unit type does not adequately describe a vegetation community. The data collected for each community should be presented, and form the basis of the description e.g. height, cover of each layer, dominant species (and relative proportions) for each layer and full species list.

The relative abundances referred to in appendix B are coded with subjective terms. These terms need to be clearly defined, in quantitative terms if possible, as operator bias is a problem with this form of categorisation in the field. Abundant = ??; Common = ?. What is the difference between Abundant and Common? Can a species be both Common and Edge plants?

The areas table (Table 1) contains good information.

2.4.3 Natural Integrity of Vegetation

Acceptable to EPA, no changes recommended.

2.4.4 Vegetation of Conservation Significance

Threatened Species

As mentioned earlier, the search should have been for over 30 species, covering both threatened species and ecologically significant species, rather than the 4 dealt with.

Species of Cultural Significance

Mention of *Eucalyptus pilularis* open forest at site 10 is inconsistent. Site 10 is in map unit 1a (dry heath). Map unit 4c (*E. pilularis*) has only site 7 in it.

Significant Communities

Perhaps also use the data from Table 1 to comment on the % in sub-region, giving regional context here.

2.5 Potential Impacts

2.5.1 Vegetation Removal

There is no mention of how the vegetation is to be cleared – all at once or progressively. There should be discussion of whether the 100% removal of RE12.3.13 will change its status under the Vegetation Management Act from ‘of concern’ to ‘endangered’. Similarly for RE12.2.10, which is the RE of the largest area to be cleared – will it change from ‘not of concern’ to ‘of concern’?

2.5.2 Weeds and Fire

There is no mention of a weed hose down area for vehicles to contain weed spread on site. Weed early detection procedures need to be spelt out here – e.g. how frequently will weed inspections occur?

2.6 Mitigation

2.6.1 Conservation Areas

Acceptable to EPA, no changes recommended.

2.6.2 Vegetation Clearance

Progressive clearing rather than broad scale clearing would be preferred, with only a operational small proportion of the site cleared at any one time, the remainder either ‘to be

cleared' or 'undergoing rehabilitation'. How the clearing will occur is not indicated here. There is no mention of seed collecting prior to clearing, or removal of *Xanthorrhoea* species for transplanting into rehabilitation areas. There is no mention of what the "adequate erosion and sedimentation mitigation measures" are. These need to be elaborated upon.

2.6.3 Rehabilitation of Disturbed Areas.

There is no indication that benchmark sites have been established for the proposed mining operation. There is a need for detailed site information on each of the vegetation communities present so that the success or otherwise of rehabilitation efforts can be measured. The most successful rehabilitation comes from topsoil that has not been stored, but placed directly from a newly cleared area to a rehabilitation area. Soil seed bank germination in this scenario is highly successful, with only limited amounts of follow up planting from nursery-raised tube stock required. The rehabilitation should ensure the same area of each community type in the same locations as prior to mining.

Additional Comments:

The Vegetation Communities Map (Figure 5) has several errors. There is an area in the southeastern portion of the site that is wrongly labelled as '3a' label in the pale green (4a, in the legend) area. Is there a '3a' polygon area that has not been pulled out in the mapping, or is it simply wrongly labelled?

The sites are not spread evenly across the project area, and many more sampling sites are required to adequately sample the area.

The map legend has several errors:

4b should read: *Eucalyptus racemosa* woodland on Quaternary dunes and sand plains (RE 12.2.6).

4c should read: *Eucalyptus pilularis* (not *racemosa* again).

There are several typographical errors and garbled sentences, which give the impression the report has been done in a rush, and not edited.

Small matters such as *Eucalyptus racemosa* being given as *Eucalyptus Racemosa*, gives the impression the report may not have been undertaken by a qualified botanist, as all graduates would know that species names are not capitalised.

The lack of information in areas of critical importance is the greatest criticism of the report.

Very little research has been done, and the scientific data underlying the survey appears inadequate, or has not been presented in the flora survey report.

In relation to the terms of reference some of the objectives have not been met. It appears that pre-existing RE mapping has been used, which may not be at a detailed enough scale for this project. Appropriate management strategies for dealing with potential impacts have not been given in any detail.

In relation to the methodology, the use of Queensland Herbarium CORVEG Proforma for data recording as specified in the terms of reference, appears not to have been undertaken. The data presented do not reflect its use.

The survey locations have been selected with emphasis on the least well-represented vegetation type (some of which is not going to be affected by operations). Unfortunately there is inadequate survey sampling of the majority of the site.

Comments by L. Ford (EPA, QPWS), on Fauna Survey prepared by URS for Vance Mine Lease No. 1108, North Stradbroke Island.

The first part of the document is an excerpt from the EPA Generic Terms of Reference for Environmental Impact Statements.

The **Blue Bold font** includes issues that I think the consultant should consider in greater detail. The ~~strikeout font~~ are things that I think are probably not relevant to this particular lease, and the **Red Bold font** are species that have not been mentioned in the ESR and should be researched.

The second part of the document is my comments on the ESR and is titled "Comments on URS Flora and Fauna Surveys for ML1108".

EPA Generic Terms of Reference for Environmental Impact Statements

Nature conservation

Description of environmental values

This section describes the existing environment values for nature conservation that may be affected by the proposal.

Describe the environmental values of nature conservation for the affected area in terms of:

- integrity of ecological processes, including habitats of rare and threatened species;
- conservation of resources;
- biological diversity, including habitats of rare and threatened species;
- integrity of landscapes and places including wilderness and similar natural places; and
- aquatic and terrestrial ecosystems.

A discussion should be presented on the nature conservation values of the areas likely to be affected by the proposal. The flora and fauna communities which are rare or threatened, environmentally sensitive localities including the marine environment, waterways, riparian zone, and littoral zone, rainforest remnants, old growth indigenous forests, wilderness and habitat corridors should be described. The description should include a plant species list, a vegetation map at appropriate scale and an assessment of the significance of native vegetation, from a local and regional and state perspective. The description should indicate any areas of state or regional significance identified in an approved biodiversity planning assessment (BPA) produced by the EPA (e.g. see the draft Regional Nature Conservation Strategy for SE Qld 2001-2006).

The ESR should identify issues relevant to sensitive areas, or areas, which may have, low resilience to environmental change. Areas of special sensitivity include the marine environment and wetlands, wildlife breeding or roosting areas, any significant habitat or relevant bird flight paths for migratory species, bat roosting and breeding caves including existing structures such as adits and shafts, and habitat of threatened plants, animals and

communities. The capacity of the environment to assimilate discharges/emissions should be assessed. Proposal proximity to any biologically sensitive areas should be described. Areas regarded as sensitive with respect to flora and fauna have one or more of the following features (and which should be identified, mapped, avoided or effects minimised):

- important habitats of species listed under the *Nature Conservation Act 1992* and/or *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* as presumed extinct, endangered, vulnerable or rare;
- ~~regional ecosystems listed as 'endangered' or 'of concern' under State legislation, and/or ecosystems listed as presumed extinct, endangered or vulnerable under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*;~~
- ~~good representative examples of remnant regional ecosystems or regional ecosystems which are poorly represented in protected areas;~~
- sites listed under international treaties such as Ramsar wetlands and World Heritage areas;
- sites containing near threatened or bio-regionally significant species or essential, viable habitat for near threatened or bio-regionally significant species;

Koala, glossy black cockatoo

- ~~sites in, or adjacent to, areas containing important resting, feeding or breeding sites for migratory species of conservation concern listed under the Convention of Migratory Species of Wild Animals, and/or bilateral agreements between Australia and Japan (JAMBA) and between Australia and China (CAMBA);~~
- ~~sites adjacent to nesting beaches, feeding, resting or calving areas of species of special interest; for example, marine turtles and cetaceans;~~
- sites containing common species which represent a distributional limit and are of scientific value or which contains feeding, breeding, resting areas for populations of echidna, koala, platypus and other species of special cultural significance;

Koala

- ~~sites containing high biodiversity that are of a suitable size or with connectivity to corridors/protected areas to ensure survival in the longer term; such land may contain:

 - natural vegetation in good condition or other habitat in good condition (e.g. wetlands); and/or
 - degraded vegetation or other habitats that still supports high levels of biodiversity or acts as an important corridor for maintaining high levels of biodiversity in the area;~~
- ~~a site containing other special ecological values, for example, high habitat diversity and areas of high endemism;~~
- ~~ecosystems which provide important ecological functions such as: wetlands of national, state and regional significance; coral reefs; riparian vegetation; important buffer to a protected area or important habitat corridor between areas;~~
- ~~sites of palaeontologic significance such as fossil sites;~~
- ~~sites of geomorphological significance, such as lava tubes or karst;~~
- protected areas which have been proclaimed under the *Nature Conservation Act 1992* and *Marine Parks Act 1982* **or are under consideration for proclamation**; and/ or

- ~~areas of major interest, or critical habitat declared under the *Nature Conservation Act 1992* or high nature conservation value areas or areas vulnerable to land degradation under the *Vegetation Management Act 1999*.~~

Reference should be made to both State and Commonwealth endangered species legislation and the proximity of the area to any World Heritage property.

The Queensland *Vegetation Management Act 1999* and the findings of any regional vegetation management plan should also be referenced.

The occurrence of pest plants and animals in the project area should be described.

Key flora and fauna indicators should be identified for future ongoing monitoring. Surveys of flora and fauna need to be conducted throughout the year to reflect seasonal variation in communities and to identify migratory species.

The EPA's guidelines for "Fauna and Flora Assessment in EIA" provide further details. The EPA should be consulted on the scope of any biological studies before they are undertaken.

Terrestrial flora

For terrestrial vegetation a map at a suitable scale should be provided, with descriptions of the units mapped. Sensitive or important vegetation types should be highlighted, including any marine littoral and subtidal zone and riparian vegetation, and their value as habitat for fauna and conservation of specific rare floral and faunal assemblages or community types. The existence of rare or threatened species should be specifically addressed. **The surveys should include species structure, assemblage, diversity and abundance. The description should contain a review of published information regarding the assessment of the significance of the vegetation to conservation, recreation, scientific, educational and historical interests.** The location of any horticultural crops in the vicinity of the site should be shown. **The existence of important local and regional weed species should also be discussed.**

Vegetation mapping should provide vegetation mapping for all relevant project sites including new transport infrastructure, port facilities and irrigation land if relevant. Adjacent areas may also require mapping.

The terrestrial vegetation communities within the affected areas should be described at an appropriate scale (i.e. 1:10,000) with mapping produced from aerial photographs and ground truthing, showing the following:

- location and extent of vegetation types using the EPA's regional ecosystem type descriptions in accordance with the Regional Ecosystem Description Database [REDD] available at the EPA's website;
- **location of vegetation types of conservation significance based on EPA's regional ecosystem types and occurrence of species listed as Protected Plants under the Nature Conservation (Wildlife) Regulation 1994 and subsequent amendments, as well as areas subject to the *Vegetation Management Act 1999*;**
- the current extent (bioregional and catchment) of protected vegetation types of conservation significance within the protected area estate (National Parks, Conservation Parks, Resource Reserves, Nature Refuges);

- **any plant communities of cultural, commercial or recreational significance should be identified; and**
- location and abundance of any exotic or weed species.

Within each defined (standard system) vegetation community, a minimum of three sites (numbers should be discussed with the EPA) should be surveyed for plant species, preferably in both summer and winter, as follows:

- site data should be recorded in a form compatible with the Queensland Herbarium CORVEG database;
- the minimum site size should be 10 by 50 metres;
- a complete list of species present at each site should be recorded;
- the relative abundance of plant species present should be recorded;
- any plant species of conservation, cultural, commercial or recreational significance should be identified; and
- specimens of species listed as Protected Plants under the *Nature Conservation (Wildlife) Regulation 1994*, other than common species, are to be submitted to the Queensland Herbarium for identification and entry into the HERBRECS database.

Existing information on plant species may be used instead of new survey work provided that the data is derived from surveys consistent with the above methodology. Methodology used for flora surveys should be specified in the appendices to the report.

Terrestrial fauna

The terrestrial, and riparian fauna occurring in the areas affected by the proposal should be described, noting the broad distribution patterns in relation to vegetation, topography and substrate. The description of the fauna present or likely to be present in the area should include:

- species diversity (i.e. a species list) and abundance of animals, including amphibians, birds, reptiles, mammals and bats;
- any species that are poorly known but suspected of being rare or threatened;
- **habitat requirements and sensitivity to changes, including movement corridors and barriers to movement;**
- the existence of feral or exotic animals;
- **existence of any rare, threatened or otherwise noteworthy species/communities in the study area, including discussion of range, habitat, breeding, recruitment, feeding and movement requirements, and current level of protection (e.g. any requirements of Protected Area Management Plans); and**
- use of the area by migratory birds, nomadic birds, fish and terrestrial fauna.

The ESR should indicate how well any affected communities are represented and protected elsewhere in the province where the site of the proposal occurs.

Aquatic biology

If no biota surveys/studies have previously been conducted in and downstream of the project area, the aquatic flora and fauna occurring in the areas affected by the proposal should be

described, noting the patterns and distribution in the waterways and/or associated lacustrine and marine environments. The description of the fauna and flora present or likely to be present in the area should include:

- fish species, mammals, reptiles, amphibians, crustaceans and aquatic invertebrates occurring in the waterways within the affected area, and/or those in any associated lacustrine and marine environment;
- ~~any rare or threatened marine species, particularly the dugong and its habitat;~~
- aquatic plants;
- aquatic and benthic substrate; and
- habitat downstream of the project or potentially impacted due to currents in associated lacustrine and marine environments.

Potential impacts and mitigation measures

This section defines and describes the objectives and practical measures for protecting or enhancing nature conservation values, describes how nominated quantitative standards and indicators may be achieved for nature conservation management, and how the achievement of the objectives will be monitored, audited and managed.

The ESR should address any actions of the project or likely impacts that require an authority under the *Nature Conservation Act 1992*, and/or would be assessable development for the purposes of the *Vegetation Management Act 1999*.

The discussion should cover all likely direct and indirect environmental harm due to the project on flora and fauna particularly sensitive areas as listed below. Terrestrial and aquatic (marine and freshwater) environments should also be covered. Also include human impacts and the control of any domestic animals introduced to the area. Strategies for protecting the Great Barrier Reef Marine Park and World Heritage Property, and any rare or threatened species should be described, and any obligations imposed by State or Commonwealth legislation or policy or international treaty obligations (i.e. JAMBA, CAMBA) should be discussed. Emphasis should be given to potential environmental harm to benthic and intertidal communities, seagrass beds and mangroves.

Strategies for collecting and preserving any significant fossils should be described.

The potential environmental harm to the ecological values of the area arising from the construction, operation and decommissioning of the project including clearing, salvaging or removal of vegetation should be described, and the indirect effects on remaining vegetation should be discussed. Short-term and long-term effects should be considered with comment on whether the impacts are reversible or irreversible. Mitigation measures and/or offsets should be proposed for adverse impacts. Any departure from no net loss of ecological values should be described.

The potential environmental harm on flora and fauna due to any alterations to the local surface and ground water environment should be discussed with specific reference to environmental impacts on riparian vegetation or other sensitive vegetation communities. **Measures to**

mitigate the environmental harm to habitat or the inhibition of normal movement, propagation or feeding patterns, and change to food chains should be described.

The provision of buffer zones and movement corridors, and strategies to minimise environmental harm on migratory, nomadic and aquatic animals should be discussed. Weed management strategies are required for containing existing weed species (eg. parthenium and other declared plants) and ensuring no new declared plants are introduced to the area. Feral animal management strategies and practices should also be addressed. The study should develop strategies to ensure that the project does not contribute to increased encroachment of a feral animal species. Reference should be made to the local government authorities pest management plan when determining control strategies. The strategies for both flora and fauna should be discussed in the main body of the ESR and provided in a working form in a Pest Management Plan as part of the overall EM Plan for the project.

Rehabilitation of disturbed areas should incorporate, where appropriate, provision of nest hollows and ground litter.

Comments on URS Flora and Fauna surveys for ML1108

1. General

The flora and fauna assessment standards used in the ACI Environmental Impact Statement for MLA7064 (August 1999) would be appropriate as a minimum requirement.

The current study is insufficient to determine the environmental values threatened by mining for the following reasons:

1. Although rare and threatened fauna that may potentially occur on the site are listed, there are no details of how impacts on these species are to be mitigated, or how their re-introduction post-mining is to be facilitated.
2. The section on rehabilitation post-mining lacks detail, and the intent to only monitor revegetation for 2 years is far too short.
3. The areas mapped as Ramsar wetlands include the proposed national park on North Stradbroke Island.

1.1 Timing of surveys

January 2005 was the middle of a particularly dry summer in the Brisbane region.

A seven-day survey of flora and fauna is unlikely to produce an accurate summary of the biodiversity of the site:

1. it was a hot and dry season which would have resulted in under-sampling of mobile fauna whose populations would have contracted to drought refuges; and
2. many flora species including the rare *Acacia baueri*, ground orchids and lilies would not have been apparent.

Flora and fauna surveys should be conducted seasonally over a year, and include a wet season, to sample the full range of biodiversity of a site. Many heath land species are not obvious unless flowering, and these areas should be sampled in spring.

2. Flora Surveys

Vegetation sampling was conducted in each vegetation association (10 sample sites). No details provided on the size of the sample plots. The EPA recommends a minimum of 20m x 50m.

Flora surveys were concentrated in very small patches of vegetation in low dry heath (3 sites), wet heath (2 sites), scribbly gum communities (2 sites) and the main vegetation community of mallee eucalypt species (RE 12.2.10) had only 3 sample sites, all located within 750m of each other. The distribution of the sampling sites did not reflect the expected impacts on RE 12.2.10, with only 3 sites in this community, and all of these sites located in one corner of the mining lease.

2.2.3 Target species – rare and threatened flora identified as being potentially present in the project area were targeted ...

The list provided in Appendix A of the flora survey by the consultant does not include *Acacia baueri*, a rare plant previously identified on the adjacent lease ML7064. Nor does it list *Schoenus scabripes* or *Blandfordia grandiflora*, both of which are rare plants that could be expected to be found in wet heath on North Stradbroke Island. *S. scabripes* requires expert assistance for identification and *B. grandiflora* would not be seen unless in flower.

2.2.5 Ramsar wetland area

This Ramsar site boundary follows the boundary of the proposed national park on North Stradbroke Island. The ESR does not make any mention of the proposed national park, or how mining activities will be conducted to minimise impacts on this proposed national park, or the nearby existing national park, Blue Lake National Park.

2.3.5 Specimen identification

No flora species identification was confirmed by the Qld Herbarium.

2.4.4 Species of cultural significance

The flora survey identified *Callitris columellaris*, large specimens of this species are significant to the Quandamooka People.

2.4.4 Significant communities

The flora survey identified a vegetation community of conservation significance RE 12.2.13 – low dry heath. The report does not make any recommendations on how to ensure that representative areas of this community are maintained through revegetation post-mining.

Section 2.5.2 Weeds and Fire

Infestation by pest plants should be minimised by using wash-down facilities for vehicles travelling between the mine site and other areas of North Stradbroke Island and the mainland. Significant weeds of low nutrient soils currently infesting North Stradbroke Island that can

significantly change the vegetation community and fire regimes include *Asparagus aethiopicus*, *Schinus terebinthifolius*, *Andropogon virginicus*, *Brachiaria decumbens*, *Passiflora foetida*, *Lantana camara*, *Cenchrus echinatus* and *Eragrostis curvula*.

The ESR does not provide any clear guidelines for assessment/monitoring of weeds, which species should be looked for or what measures will be taken to control weeds in rehabilitation areas. This is of particular concern when it is stated that the proponent only intends to manage rehabilitation areas for 2 years post-mining.

Section 2.6.3 Rehabilitation of Disturbed Areas

There are no clear guidelines for topsoil management including depth of soil to be stored and storage periods.

There are no evaluation criteria to determine the success of rehabilitation. Additional rehabilitation measures that may encourage re-colonisation of the site by fauna such as replacement of tree stumps, ground litter, nesting boxes have not been mentioned.

Fauna Surveys

Fauna surveys were very restricted, with one sample site in the north-west corner of the lease sampling the creek line and its surrounds, and the other located in the north-east corner of the lease, sampling an area designated as future national park, and not planned to be mined. Sampling of fauna during this survey is likely to have significantly under-estimated fauna utilising the area. The survey period was too short, the season sub-optimal, and the survey effort very inadequate.

A similar study on North Stradbroke last year found 15 species of amphibians, 20 reptiles, 84 birds and 34 mammals – all more than twice the number of species found in this study, which indicates that this study is inadequate.

Pitfall trapping was undertaken at 2 sites with 5 x 10L buckets. The minimum recommended size for a pitfall trap is a 20L bucket, and even these will not adequately sample snakes as they can get out of them. The use of a total of 10 pitfall traps over the ecotones of 4 vegetation communities on 630ha of land is inadequate. The minimum requirement is for at least 8 x 20L buckets for three trap nights in each vegetation community.

Microchiropteran bats were recorded using an anabat detector. There was no harp trapping conducted, and the results from the anabat detector would be inconclusive at best. Additionally, the anabat detector was only used for one hour at dusk, which would not sample all bat species. It is stated that the anabat detector was used in “areas of habitat most likely to indicated the presence of microchiropteran bats”, however these areas are not recorded for verification.

It is stated that the **diurnal bird count** was undertaken at a single site during 2 thirty-minute intervals. It is then stated that the bird count was done 2 hours after dawn and 2 hours before

dusk. These two statements within the same paragraph contradict each other. Bird counts should be conducted in the early and late parts of the day, in each vegetation community, over a range of seasons. The survey period was hot and dry, and it is likely that the avifauna is significantly under-sampled by the methods used.

The **diurnal herpetofauna search** was for one hour by one person at two sites within the 630 ha mining lease. This is clearly inadequate to accurately represent the herpetofauna on the site.

The **nocturnal herpetofauna search** was for one hour by one person at two sites within the 630 ha mining lease. The optimal time for searching for herpetofauna is at night, and should be done along transects for at least 2 hours per night for 5 nights in each vegetation type.

The **nocturnal call playback** was only conducted once, during a hot, dry season, and could not be expected to adequately represent the species that utilise the mining lease. The playback session would have been done for about one hour at two survey sites. This method of survey should have been conducted over several nights along transects within each vegetation community, and over a range of seasons.

The **arboreal spotlighting** was done along a single 300m transect for one hour, plus one hour of additional spotlighting within the site. This method of survey should have been conducted over several nights along transects within each vegetation community, and over a range of seasons.

The following matters should be addressed in the ESR:

- What are the key fauna indicators of rehabilitation success?
- How will fauna be encouraged to recolonise rehabilitation areas?
- What is the value of the habitat to koalas which are vulnerable in SEQ?
- What is the value of the habitat to glossy black cockatoos?

Cultural Heritage Report (Appendix B) – Report still pending

The following Notes were extracted from Appendix J - EIS. Proposed Silica Sand Extraction. MLA 7064. North Stradbroke Island (Outline, 1998):

Section 6: Existing socio-economic and cultural environment.

“Prior to European settlement, the island was occupied by the Aboriginal people of Quandamooka”

“Aboriginal occupation of the study area (MLA 7064) goes back at least 22,000 years and there is good archaeological record for the past 6,000 years.”

“Aboriginal walking tracks...connected Dunwich to Point Lookout.”

“Myora was a traditional campsite.”

“Aborigines from North Stradbroke Island as well as other areas in southern Queensland were removed to Myora.”

Memmott & Stacey (1999) have outlined categories of customary Quandamooka places that are of high cultural heritage value to the traditional owners.”

“The archaeological and anthropological studies find that the areas surrounding Brown Lake and Capembah and Cooran Cooroonpah Creeks are integral parts of the main stories that frame the cultural landscape of the Quandamooka.”

“All water and connected waterways that constitute Brown Lake are considered to be sacred by the Quandamooka people.”

“Along the ridge to the east of Brown Lake are growing a number of sacred Cypress pines.”

**Draft Report. Vance Lease North Stradbroke Island. Environmental Studies.
Groundwater Environment (Appendix C)**

Executive summary. “Groundwater quality is comparable to **freshwater**.” Registered bore 14400085 on ML 1108 was not sampled for water quality baseline information.

Section 2 – Study methodology. Objective 5 was to achieve a plan of management & mitigation **measures**. Section 2.5 does not give any specific details of the management and mitigation measures. There are indications of these measures throughout the body of the report.

Section 3 - Existing hydrology. What is the cause of groundwater stagnation (GHD, 1998) southeast of Brown Lake? Is it another perched aquifer or an extension of the Brown Lake system?

Section 3.3 - Groundwater flow diagram. If Brown Lake is a perched aquifer within a closed catchment, then why is the diagram showing the regional groundwater flow away from this Lake. The regional groundwater system occurs at a greater depth and the two systems are not connected. Again what does the groundwater stagnation area represent – perched aquifer or possible window to the regional groundwater system? If it is the latter, then is there potential to drain this feature by lowering the phreatic surface by mining activities. It should be noted that Unimin has given no indication of the depth of mining activities. This draw down may have an adverse impact on the vegetation in this area (by drying out the substrate). Why not show groundwater flows into the perched aquifers (Brown Lake and Swallow Lagoon) as non-connected systems which they are. The regional groundwater flows are more likely to be in the opposite direction (northwest trending) and not northeast trending as shown in this figure.

Section 3.3.1 – Infiltration & recharge. Given that the recharge rate will increase following clearing of ML 1108, what impact will this additional uptake of groundwater have on the perched aquifers at Brown Lake and Swallow Lagoon. At the closest point, ML 1108 is only 800m from Brown Lake reserve. Similarly, Blue Lake National Park is 1.1 km south of the lease at its nearest point.

Section 3.3.3 – Groundwater discharge. “Swallow Lagoon is likely to be perched above the regional groundwater water table”. This statement is inconsistent with section 5.1 – Baseline hydrogeological environment, which states that “ nearby water bodies, such as Swallow Lagoon and Brown Lakes are perched”.

Section 3.3.4 - Groundwater qualities at Unimin bores 1, 2, & 3 on ML 1124 have a pH range of 4.7 to 5.2. This is stated to be due to leaching of organic material from wetland areas. More advice should be sought with respect to the potential for acid sulphate soils?

Table 2: There is no data on metal content or hydrocarbons in this Table. Bores 1, 2, & 3 are downstream of Vance lease ML 1108. Why wasn't bore 1440085 (Cooroonpah Creek) sampled for groundwater quality as part of this investigation. Similarly why weren't bores 99455 and 99454 also sampled for groundwater quality. The effect of these omissions results

Comment [D1]:

Groundwater quality is scarce (3.3.4).
Groundwater quality at Unimin bores 1, 2, & 3 on ML 1124 have pH range from 4.7 to 5.2
No data on metal content or hydrocarbons. Bores 1, 2, & 3 are downstream of Vance lease ML 1108.

Comment [D2]:

It is difficult to prepare a management plan when the location of the pits, depth of extraction site of sand processing facility on ML 1108 and site of tails pond is not known. The pond liners maybe clay (contaminant) or synthetic membrane. The latter is preferred.

in there being no groundwater quality data provided from within ML 1108. As part of the base line information.

Section 4.1 – Interception of groundwater. The location and depth of the pits is not known, however the risk of intercepting the groundwater table is low. Extraction from adjacent pits occurs to a depth of 2m below the water table. This is said to be a dry mining operation. Information to support this claim of low impact should be included in the ESR. It should be noted that the risk of this occurring in Cooroon Cooroonpah Creek is high.

Section 4.2 – Contamination of groundwater & surface water. Unimin will use water-soluble flocculants to disperse sediments in tails ponds. Pond location is not known at this stage (refer to section 4.2.1). Hydrocarbons represent the other potential contaminant source, but the fuel storage & maintenance areas are not known at this stage.

Section 4.2.1 – Potential Impacts to Groundwater from Sedimentation Pond. It is not possible to assess the potential impacts of the tails pond when the proponent does not know the location of the pond at this time. However, it will be constructed to avoid flooding & overflow. What are the design parameters for this structure? Volume of tails discharged, containment capacity, lining to prevent groundwater contamination, location, free board, inspection & maintenance program, who will be the responsible person? I agree that the base and internal walls should be lined and that the dam should be constructed down gradient of the mine pit.

Section 5.2 Potential impacts. How can Unimin substantiate the statement that mining is not expected below the water table when the company is unable to provide details of the pit location or pit depth. The section should also acknowledge the use of water-soluble flocculants. There is also a mention of an indurated layer which I assume is in ML 1108, but there has been no reference to this feature in the baseline sections of the groundwater hydrogeology. What are the implications for additional perched aquifers or connections to other nearby perched aquifers such as Brown Lake (800m) and Swallow Lagoon (250m).

Section 5.3 – Recommendations. Unimin/URS should provide details as to how it was determined that four groundwater-monitoring bores are required for monitoring purposes. During the operational phase of mining bore lines should be considered to dewater any increase in groundwater flows during clearing for mining operations.

ESR - Terms of Reference. Hydrology (general)

An aim of the ESR is determination of trigger levels for relevant indicators to identify possible impacts on environmental values, those trigger levels being relevant to alert of potential causation of environmental harm (refer to condition A5-3(e) of MIM900220203). The determination of relevant parameters and trigger levels should be discussed further in the TOR.

Surface water methodology

Provide more detail on the initial surface water assessment and specify methods for determining:

- *catchment areas for relevant wetlands and creeks;*
- *potential adverse impacts to surface water flows from mining activities;*
- *interaction between groundwater and surface waters;*
- *temporal variability in surface water flows and water volumes of relevant wetlands and creeks; and*
- *temporal variability of water quality.*

**Draft Report. Vance Lease North Stradbroke Island. Surface Water Studies.
(Appendix D)**

Surface Water Environment

Section 1 – Study scope. The Agency has previously requested (refer to Appendix J, EPA correspondence, 21 September 2004) that more detail on temporal variability in water quality be included in the surface water assessment methodology. This area has not been sufficiently addressed in the objectives and methodologies outlined in this report.

Section 2.3 – Field Investigation. Field investigations were limited to a visual assessment on 28 February 2005. The investigation of baseline surface water characteristics should be primarily undertaken during field sampling to accurately assess quality and flow volumes, and to identify any seasonal variability.

Section 2.6 – Management Plan & Mitigation Measures. Objective 5 was to achieve a plan of management & mitigation measures. Section 2.6 does not provide any specific details of the management plan and/or mitigation measures to be implemented. There are indications of these measures throughout the body of the report. A summary should be included in this section.

Section 3.5 – Adjacent water bodies. Swallow Lagoon is a perched aquifer 180m southwest of ML 1108. The catchment of Swallow Lagoon extends to a drainage divide on the lease. Further, the extent of the basal indurated layer to this water body has not been described and may extend onto ML 1108. Mining activities on ML 1108 (beyond the RAMSAR area) may have potential impacts on Swallow Lagoon. Unimin will need to provide additional information on this matter.

Section 3.7 - RAMSAR Wetlands. Further advice should be sought to support the statement that the RAMSAR areas on and adjacent to ML 1108 are not wetlands and that such designation of these RAMSAR areas are for management purposes only.

Section 3.8 – Water quality. Surface waters in Cooroon Cooroonpah Creek at six sampling points above and below the current sand mining operations on ML 1124 were “strongly acidic”. The acidity is attributed to humic acids derived from decaying vegetation. The ESR has indicated that disturbance of accumulated organic matter (such as clearing prior to mining) can lead to a short-term increase in the rate of humic acid release. Management and strategies to deal with changes in pH have not been put forward in the ESR. Naturally acidic soils and peats with no past history involving iron sulfides are not acid sulphate soils, but some management of acidity is still relevant (Dear, S.E., Moore, N.G., Dobos, S.K., Watling, K.M. and Ahern, C.R., 2002: Soil Management Guidelines. In *Queensland Acid Sulfate Soil Technical Manual*. Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.).

Section 3.8.7 - Iron. Concentrations of iron were found to have increased downstream of current mining activities on ML 1124. Minerals containing iron are partially oxidized during weathering, and give rise to the familiar brown, yellow and red colours on rock and other

surfaces, and is partly dissolved as ferrous iron (Fe^2). Ferric iron (Fe^3) is reduced to ferrous iron (Fe^2) by bacterial action. The ferrous ion can be transported long distances if the solution remains reducing and slightly acidic, and if it is not admixed with other ions (carbonate, sulphide or silica) to form insoluble compounds. There are indications of environmental harm in the ESR caused by an increase in the concentration of iron in waters. Unimin must provide additional information on this matter.

Section 4.2.1 – Increased runoff. Is the requirement for a 100 m buffer to Cooroon Coroonpah Creek under a state statute, management code or policy? Is this condition mandatory and enforceable? Furthermore, the Queensland Department of Mines & Energy was amalgamated with other Departments to become the Department of Natural Resources and Mines.

Section 4.2.5 – Contaminants. “Appropriate systems and procedures” to manage contaminant releases have not been outlined in the ESR.

Section 4.2.6 – Impacts from Sedimentation Pond. The design, construction, operation and maintenance criteria for the “tails pond” have not been included in the ESR. The ESR should be amended to refer to one or both of the following EPA Codes:

- **Code of Environmental Compliance for Mining Lease Projects.** Appendix B – Criteria for dams; and
- **Environmental Code of Compliance for environmental authorities for high hazard dams containing hazardous materials.**

Environmental authority MIM900220203 does not authorise the release of process waters to groundwaters or surface waters. The following section of the ESR is inconsistent with the environmental authority:

“Water used for the slurry and in the sedimentation pond....will be discharged to groundwater or evaporated directly from the pond”.

How will this be achieved when “the sedimentation pond is unlikely to be effective as an evaporation pond to remove excess water accumulating from pumped slurry inflows”?

The potential impacts of such discharges to groundwater (contamination by flocculants and changes to water table levels and subsequent impacts on vegetation) have not been addressed in the ESR.

Reuse and recycling have not been considered in the ESR.

Air quality assessment for the proposed expansion of ACI sand extraction facility – North Stradbroke Island. (Appendix E)

Katestone Scientific Pty Ltd, 1998.

This report refers to the expansion of mining operations from ML 1124 to ML 7064. It does not include expansion onto ML 1108 – Vance. Elements of this report have been superseded by statutory changes and conditions of the environmental authority since 1998.

Unimin has not addressed the Agency’s advice of 29 September 2004 that “air studies should be undertaken to assess the current performance of mining operations on ML7064 with respect to air quality impacts and how these may relate to the anticipated performance on ML1108.”

Unimin should update this document to reflect the current *Environmental Protection (Air) Policy 1997* (Reprint 2C), reprinted as in force on 4 October 2004 and should refer to the “Air Quality Sampling Manual, 1997” published by the Department of Environment.

The report must be consistent with environmental authority MIM900220203, in particular the conditions of Schedule B. It should be noted that buffer distances are not specified in this environmental authority. The authority focuses on the release of dust or particulate matter from the mining activities that cause an environmental nuisance, environmental harm or serious environmental harm at any sensitive place.

The report should include a current description of sensitive places and include a location plan of such sensitive places. Figures 4 to 10 are difficult to assess in black and white as concentration greater than a specified value are represented in red.

Construction of a sand processing facility on ML 1108 is an option being considered by Unimin. The Katestone report (1998) does not make reference to this option being undertaken (refer to sections 6, 9 & conclusions).

Section 9 refers to the development of an environmental management plan for measures to minimise the frequency and severity of dust events. Measures are outlined in this report.

The conclusions are not consistent with the conditions of environmental authority MIM900220203, such as separation zones, PM10 sampling requirements and meteorology based on Eagle Farm readings. The report concludes that dust suppression techniques should be included in the environmental management plan for the mine. Has this EM Plan been completed?

IAS for Proposed Sand Extraction, MLA 7064, North Stradbroke Island, for ACI Industrial Minerals Division (Richard Heggie Associates Pty Ltd, 1998). (Appendix F)

Terms of Reference, ESR. Noise

With respect to the TOR, the EPA advised Unimin in September 2004 of the following requirements:

1. *Noise studies should be undertaken to assess the current performance of mining operations on ML7064 with respect to noise impacts and how these may relate to the anticipated performance on ML1108.*

The current performance of mining operations (noise) was not assessed.

2. *The environmental assessment should include an investigation of available strategies to minimise noise impacts.*

Strategies to minimise noise impacts were not developed.

3. *If it is anticipated that noise monitoring will be initiated, the monitoring methodology should be outlined in the TOR.*

Monitoring methodology was not discussed as to how Unimin will ensure compliance with EA condition D1-1 – “noise from the mining activity must not cause an environmental nuisance, at any sensitive or commercial place.”

Unimin’s response in the final TOR stated that:

“a noise study was completed for ML 7064, by Richard Heggie Associates, in 1998. It was summarized that there would be little impact on the environment from the mine due to the distance from the mine to the Myora residence. As the company has not received any noise complaints, and the mine will be moving further away from the residence, it is believed that this study will be applicable to Vance.”

The Heggie (1998) report was submitted unchanged as Appendix F to the ESR. It did not address the matters raised previously by the Agency.

Road Transport Report (Appendix G)

Christopher Hallam & Associates Pty Ltd, 1998: Traffic Impact Assessment of proposed extension of sand mining into lease 7064, North Stradbroke Island. ACI Industrial Minerals Division.

With respect to the TOR for the ESR, the EPA advised Unimin in September 2004 of the following requirements:

“If appropriate, comment on consideration by Unimin Australia Limited of any alternatives to the current transport method for minimising potential traffic impacts.”

Unimin responded by stating that

“As we will be transporting similar quantities from the same location, to the same destination as the current operation, this report (Hallam, 1998) will still be relevant. The proposed direction of mining on Vance will give UAL the opportunity to consider other transportation routes and methods or the delivery of sand to Dunwich. Any alternative route or method would impact areas outside 1108 so any proposal would require a separate assessment report. The ESR will contain a copy of the Road Transport Assessment (Hallam, 1998) as an appendix. Comments will be given as to the applicability of this study to the current Vance lease.”

The Hallam (1998) report found that in the short term:

*“Product sand is transported by truck via East Coast Road – Cunningham Street to a wharf...however, **it is clear that the existing transport route is far from ideal.** The current transport route passes schools and dwellings. ...ACI extraction is about 738,000 tonnes... and includes builder’s sand....about 47,000 tonnes per annum.*

“Truck movements however do have a greater noise impact than car movements and...trucks will continue to have an impact on the pavement of East Coast Road – Bingle Road.”

“Medium term planning is for a new ACI jetty to be constructed south of the CRL out loading facility and for ACI to obtain new mining leases that would enable them to develop a new transport route that bypassed Dunwich township, approaching the new jetty from Ballow Road South....south of Lang Lane.”

“The concept would allow access corridors to be established linking ACI, and possibly even the Vance lease to Tazi Road and thence to Dunwich. The public benefit of this scenario is that would take heavy truck traffic away from the Coast Road and effectively remove heavy truck transport from the township of Dunwich.”

The status of the medium-term strategy and/or construction of a new load-out jetty south of the Dunwich were not specified in the ESR. Unimin states that “it is not known whether the additional jetty is progressing and nothing is known about the additional studies.”

Traffic flow rates were assessed in November 1997, however there applicability to current traffic flows is questionable. **Figure 1 - current road network** (refer to section 2.1, Hallam, 1998) has not been included with this report.

Geomorphology and Soils. Vance Lease North Stradbroke Island Environmental Studies. GJR Holdings Pty Ltd, 20 June 2005. (Appendix H)

ESR - Terms of Reference. Geomorphology & Soils

“As part of the hydrological study (3.3.2) a conceptual geological and hydrological model will be developed for the site and surrounding areas. This will be completed as a literature review of the lease and island geomorphology.

A terrain analysis will be conducted as a basis for the characterisation of the general site terrain features in terms of existing geology, landform and soil conditions.

On a local scale, surface soils will be recorded as part of the flora field investigations at each of the field plots.

In addition to this, the National Estate database will be accessed and a review conducted in relation to the Vance project. These values may be related to issues of significance under the EPBC Act.”

Further, the EPA advised Unimin (September 2004) that:

“A primary aim of the geomorphology assessment is to establish any influence which geomorphology has on hydrology and therefore nearby sensitive creek and wetland ecosystems.

In undertaking studies of geomorphology and soils, Unimin Australia Limited must be able to demonstrate a detailed and accurate knowledge of geomorphological and hydrogeological profiles and conditions throughout areas that are likely to be impacted by the mining activities. In this respect, consideration should be given to undertaking detailed soil profiling utilising field sampling methods. If field sampling is to be undertaken, the sampling methodology should be outlined.”

Data sources – The ESR refers to the Beenleigh Geological Map Sheet (1985), which is not the most recent mapping undertaken on North Stradbroke Island. Compilation sheets for the Beenleigh map sheet are available from the Department of Natural Resources and Mines. Further, the Southeast Queensland GIS 2002 geological mapping data is available from the *Interactive Resource and Tenure Maps* at:

www.nrm.qld.gov.au/science/geoscience/tenure_maps.html

For additional information, contact the Geoscience Manager, Geological Mapping, Department of Natural Resources and Mines, 80 Meiers Road Indooroopilly, Qld 4068.

Subsurface data is limited to 16 hand auger sites to maximum depth of 3m. The ESR has not summarised mineral exploration data for the Vance project, which may have delineated the presence and extent of indurated profiles associated with perched groundwater systems. Groundwater information may also be recorded in the mineral exploration data.

In the main report (p. 2-12), Unimin states that “the thickness of the fine-grained white silica sand that is the target of mining operations typically extends to depths varying between 7m and 14m below the existing ground source. The reference source for this data has not been given in the report or in Appendix H of the ESR.

“A conceptual geological and hydrological model will be developed for the site and surrounding areas” as required by the TOR has not been outlined in this report.

It would appear that the *National Estate database* has not been accessed and a review conducted in relation to the Vance project as set out in the TOR.

Socio-Economic Report (Appendix I)

This Appendix comprises the following extracts from the *EIS. Proposed Silica Sand Extraction. MLA 7064. North Stradbroke Island (Outline, 1998)*:

- Section 6:** Existing socio-economic and cultural environment;
- Section 7:** Biophysical Impacts; and
- Section 8:** Socio Economic Impacts and Management.

“As the mine will not be expanding in terms of employment, or demands on the local community, this report will still be relevant.” (Unimin, ESR - Terms of Reference, 2004).

“Comments will be given as to the applicability of this study to the current Vance lease.”

Section 6. Existing Socio-economic and Cultural Environment.

The 1996 census was used for baseline demographics. The relevance of this data is questionable as there may be more recent data available from Australian Bureau of Statistics.

“The nearest populated area is a small rural subdivision to the west (of MLA 7064) at Myora.” This is still applicable for Vance, ML 1108.

Recreational uses on NSI include tourism, but recreational use of MLA 7064 is extremely limited.

A summary of History, Archaeology, Cultural Values have been made above in our comments to Appendix B of ESR.

Section 7 dealt with biophysical impacts to:-

- Site topography, geology;
- Hydrology;
- Flora and fauna;
- Noise impacts;
- Visual impact assessment;
- Transportation;
- Impact of agriculture;
- Land use impacts;
- Public safety and fuel storage hazard assessment;
- Air quality assessment;
- Aboriginal archaeology;
- Bushfire risk; and
- Energy considerations.

Socio Economic Impacts and Management (Section 8)

“The project (MLA 7064) allows for the continuation of an existing economic activity (namely sand mining/processing) that generally maintains existing social and economic considerations.”

Social impacts considered in the EIS were:

- Impacts on property and the potential social implications;
- Potential impact on activities (urban development & tourism);
- Potential effects on overall public amenity;
- Cultural impacts of the proposal; and
- Potential health and psychological effects of the proposal.

“Economic impacts embrace both the positive and negative effects of the proposal (MLA 7064). It is proposed in the short-term to continue to have haulage through Dunwich to service the sand-loading jetty. In the medium term, ACI’s strategy is to gain necessary approvals to relocate all of its sand processing to the “Pines” area, and to link this area to the new jetty via a new sand haulage route.” (Outline, 1998).

Although the “Pines” trade off did not occur, the assignment of ML 1108 Vance was negotiated in its place to provide Unimin with access to additional silica sand resources on NSI. As stated previously in the Hallam report (1998), *“it is clear that the existing transport route (along East Coast Road and through Dunwich) is far from ideal.”*

In view of the period of time that has elapsed since the Hallam (1998) and Outline (1998) reports were released, the EPA had expected Unimin to have advanced alternative haulage options to operational status by now.

Section 8.1.4 of the EIS proposed the following mitigation measures for socio-economic and cultural impacts:

- *Measures to avoid the impact altogether;*
- *Measures to manage likely impacts;*
- *Measures to reduce impacts; and*
- *Measures to control impacts in order to achieve certain desired outcomes.*

The following mitigation measures were outlined in the EIS for heavy traffic:

- All trucks are required to cover their loads prior to leaving ML 1124 (EIS, s.8.2.4);
- ACI’s strategy is to eventually eliminate heavy truck operations from the East Coast Road, once operations are relocated to the “Pines” (EIS, s. 8.2.4);
- Haulage vehicles will be kept well maintained (EIS, s. 8.3.7);
- Haul vehicles should maintain travelling speeds at no more than 40km/hour through Dunwich (EIS, s. 8.3.7); and
- Haul vehicles drivers should not use exhaust brakes within Dunwich township (EIS, s. 8.3.7).

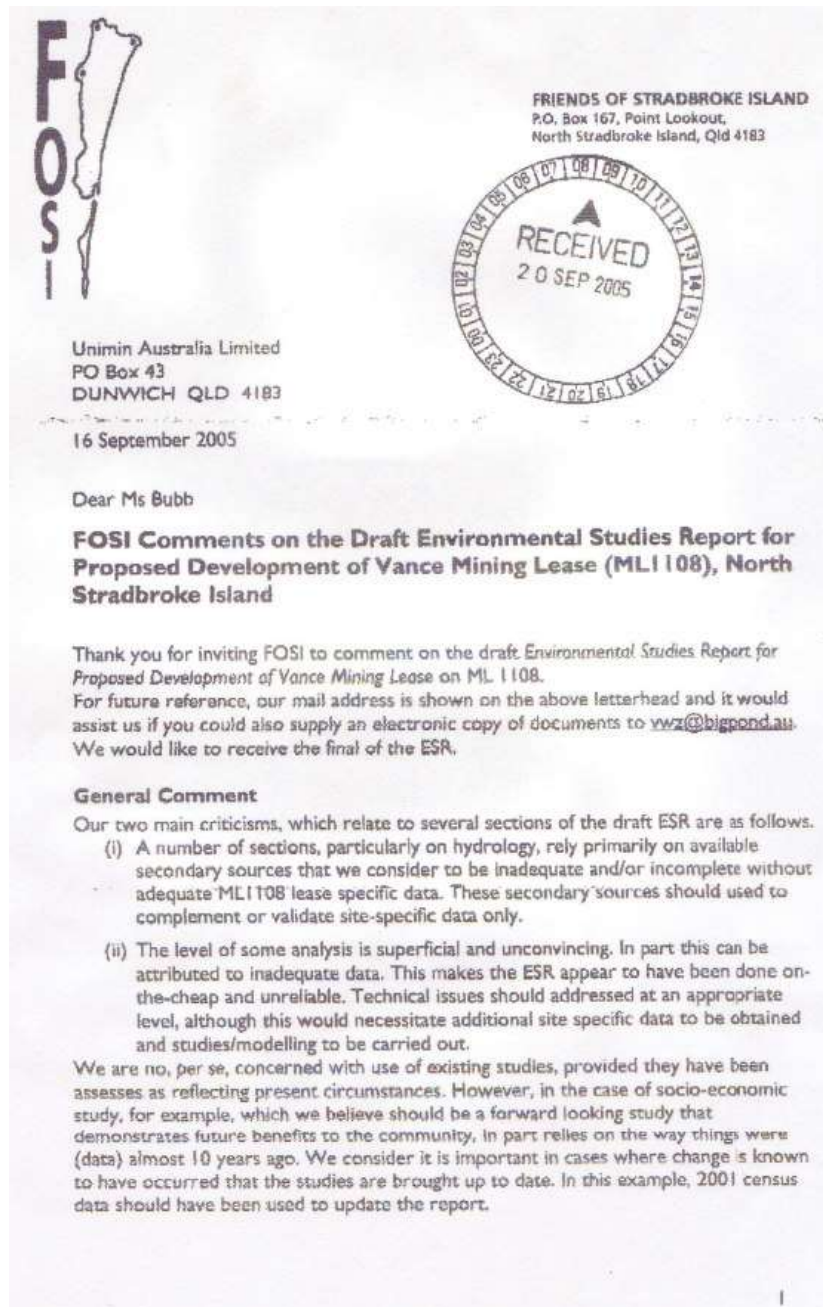
It would appear that the above measures have not been implemented with regard to haulage/transport routes for product sand. Unimin should address this issue by inclusion in the ESR of an action plan to investigate and implement alternative haulage routes.

Community Consultation (Appendix J)

Stakeholder consultation was undertaken with the Friends of Stradbroke Island (FOSI), Quandamooka Land Council, Stradbroke Island Management Organisation (SIMO) and EPA.

Responses from the above stakeholder groups are attached to the draft ESR.

APPENDIX B



SPECIFIC COMMENTS

SECTION 2.8 – SOCIO-ECONOMIC

Use of old data

The socio-economic summary is based on a previous 1999 report for lease ML7064, part of which is based on data from 1996 census. The summary states that "there may be extrapolations applicable for the current proposed expansion" but fails to identify the parts of the report that have become dated and make a case why it is not necessary to update the study to reflect current circumstances. **We recommend** that socio-economic data should be brought up date and where significant changes have occurred since the previous study was carried out the data reanalysed and the changes explained. 2001 census data should be used. For example, in 2.8.1 the report states that 182 people were directly engaged in the mining industry on the island. We understand that CRL employs well over 200 people, so the figure given may not be accurate. Also recently a greater proportion of mining staff have moved to reside on the mainland, and this greatly diminishes any economic benefit to the island.

Use of tracks on MLI 108

We can confirm that many of our members regularly use the tracks on MLI 108 as walking tracks to access Bippen Penbean, Mount Hardgrave and the Brown Lake circuit. These are some of the islands most important walking tracks, each running through a number of different ecosystems, and providing simultaneous views of ocean and the Bay from their high points. **We recommend** the study properly address any loss of tracks to tourism; possibility of maintaining the walking tracks during mining period; and and reinstatement of tracks post-mining.

APPENDIX A – FLORA AND FAUNA REPORT

Rehabilitation of ridges

We note that low open dry heath (1a) provides cover to existing ridges paralleling the south-western boundary of MLI 108. This indicates that ridges along this line are likely to offer a poor microclimate for revegetation. **We recommend** the study explicitly determine whether there are specific issues or difficulties that will need to be address during revegetation of ridges paralleling the south-western boundary.

APPENDIX C – GROUNDWATER REPORT

Inadequate determination of groundwater table (section 3.3)

The study is based on just one borehole (14400085) on MLI 108, and relies on extrapolation from limited data from 8 bores that are nearest to the lease. Except for bores 99455 and 99454, which lie on adjacent Unimin mining lease ML7064 few hundred metres from MLI 108, we estimate that the remaining bores are between 0.9 and 1.5 km from the boundary of MLI 108. The study has failed to provide a credible argument or evidence that the groundwater level it determines is reliable. We consider that the data provided limits reliable ground water determination to the north-west corner of the lease only.

The study fails to set out the methodology it used to determine the groundwater level on MLI 108. Therefore, it appears to have been just based on an inspection of the bore data. If this was the case then this should be stated, and an argument provided on why this method is sufficiently reliable: we do not believe that it is, and the ground water should be (computer) modelled, as done by other resource based operations on the island.

The unreliability of the work presented appears clear from the range of groundwater level given for MLI 108 - "from 27 mAHD to 86 mAHD". We do not believe that this is

correct. The 86 mAHd reading, is noted as "(perched?)" in the Table 1. Given that this is the one of only few data points provided by this study; and that it is the one responsible for inferring the maximum groundwater level; and its level is substantially different from the other levels; the nature of this data point should have been properly resolved: either

- the area under bore 14400060 is perched, which eliminates this data point for groundwater level determination, or
- bore 14400060 is accepted as giving an accurate underlying groundwater level and an explanation should be provided to explain why the groundwater level has a high point at this location and why this high point extends over 1 km onto the MLI 108 but falls to 36 mAHd at bore 14400075 only 0.5 km from bore 14400060.

We conclude that groundwater level determination is shoddy work. **We recommend** that the groundwater levels on MLI 108 need to be determined with higher degree of confidence, using more bore data distributed within MLI 108.

Flow diagram (p.3-4)

Brown Lake is a window to perched aquifer, with an estimates 1.5 x 1.5 km plan area (DNRM, whole-of-island ground water model). As such it only contributes to the groundwater table through over-spill, during extended periods of heavy rainfall.

Therefore, we conclude that the flow regime shown under Brown Lake in the flow diagram, which shows the lake acting as a water source, is wrong.

A groundwater model for North Stradbroke Island has been developed by DNRM, and **we recommend** that Unimin should use/adapt the model to determine the groundwater flow on and around MLI 108.

No systematic methodology for identification of potential impacts (section 4)

The study does not use a systematic process to identify potential events that would adversely affect groundwater. **We recommend** that a proper systematic process should be gone through to provide sufficient confidence that a complete set of events has been identified.

APPENDIX D – SURFACE WATER REPORT

Failure to address intermittent flow characteristic to and of Cooroon Cooroonpah Creek

Flora and fauna surrounding Cooroon Cooroonpah Creek is adapted to its intermittent flow characteristic. The study has not addressed the potential for mining to alter this intermittent flow pattern(s) to the Creek during and after mining. In particular, it has formally established whether or not the pre-existing surface flow regime from outside the buffer zone to the Creek will be altered during mining and, if so, what impact is this likely to have, what measures need to be put in place to prevent this happening. Section 4.2.4 states that "it is anticipated that mining work will be restricted to areas set back from drainage lines". This is too vague. **We recommend** that any ground water flows to the Creek, which provide critical intermittent recharge, be identified and presented in the report, and measures for maintaining them during and after mining established.

The report should make it a requirement that all the identified drainage lines will be avoided during mining. If this cannot be done then it should propose means by which the appropriate level of intermittent recharge should be maintained during mining.

No systematic methodology for identification of potential impacts (section 4)

The study does not use a systematic process to identify potential events that would adversely affect surface water and its flow. **We recommend** that a formal systematic

process should be gone through to identify potential impact events, and presented in the report, to provide sufficient confidence that a complete set of events has been identified. For example, failure of the slurry line has not been addressed.

Reliance on the Buffer Zone to attenuate impact on Cooroon Cooroonpah Creek

The report relies substantially on the buffer zone to mitigate (control) potential impacts from mining operations on the Creek (e.g., in sections 4.2.3 and 4.2.2). We understand that licensing of the mining operation will require that no harm is done to any area that is not being mined. This means that the whole buffer zone area will be required to be protected and, therefore, cannot be used to mitigate impact from mine operations. **We recommend** that all parts of the study report where the buffer zone is relied on to mitigate mining related incidents are reworked to establish alternative mitigating measures.

Subjective assessment of impacts (section 4)

Assessment of each potential impact is opinion-based and done at a fairly superficial level. This indicates that the author(s) of the report have not carried out sufficient technical work to fully understand the potential impacts, their likelihood and potential consequence, and how this potential should be treated.

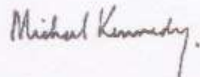
For example, in dealing with runoff in section 4.2.1, the study concludes that "the significance of this potential impact is considered to be low". If "considered" means conclusion drawn from the material presented then we considered that the conclusion drawn is plainly wrong. The study states that:

- overland flow would only occur during prolonged and extreme rainfall;
- these types of events are relatively infrequent with low probability of occurrence in any year.

"Prolonged and extreme rainfall" and "low probability" are technical issues that should have been dealt with in specific terms, which they are not. Given that these events have been "observed", it seems that the frequency of such events is more likely to be in the range of one in 3 to 8 years, and not say one in 20-50 years. The bottom line is that heavy rain events are likely to occur several times during the life of the mine, and the mining operation has to be prepared for these events at all times. The recent (July, 2005) tailings dam failure at CRL's Ibis/Enterprise mine underlines the need to treat this issue properly. Anecdotal information is that some of Unimin roads at its current mine turned into rivers during these rains.

We recommend that all issues requiring technical (engineering) assessment be reworked at an appropriate technical level, using appropriate methodologies, by appropriately trained people. The buffer zone should not be relied on for mitigation: Mitigation measures need to be built into the mining operation to protect the buffer zone.

Yours sincerely



Michael Kennedy
President, FOSI

cc Sinead Summerville, Environmental Protection Agency

APPENDIX C

Katherine Bubb
QSE Co-ordinator
Unimin Australia Limited

9.9.05

Dear Katherine,

Re: Draft Report – Environmental Studies Report for Proposed Development of Vance Mining Lease, North Stradbroke Island

Thank you for the opportunity to comment on this Report. Please accept the following comments.

Description of the Mining Activity

SIMO believes the most important condition for maximizing successful revegetation, drainage to water catchments and minimizing wind erosion in post mine re-contoured landform is the orientation and aspect of the topography.

Topsoil Spreading

CRL have had success with double stripping of the topsoil, trials have indicated improved revegetation results. UNIMIN should be looking at incorporating this method to advance success rates.

Erosion Prevention and Repair

What are the Open Area figures for existing mine and predicted for Vance? What measures are taken by UNIMIN to minimize Open Area? What management plans for revegetation if the drought conditions, as predicted, continue into the future?

Direct Planting and Seedlings

UNIMIN must establish with community and EPA what are acceptable landform and rehabilitation conditions to be met for relinquishment.

Flora Survey

A map should be provided overlaying vegetation communities with topography. To understand the relationship of topography and micro- ecosystems within valleys and high dunes. Thereby making the mapping of post-mine revegetation an easier and hopefully more successful task.

2.4.4 Threatened Species

States “*No extent of wetland or aquatic habitat significant enough to support any of these aquatic species occurs on site.*” Did the Surveyors talk to longterm workers of UNIMIN to seek anecdotal evidence of wetlands in pre-drought conditions?

The one area (1a) which is listed as ‘of concern’ will be 100% disturbed. We find this unacceptable. If mine paths have not been formulated as is indicated in this Report, then we need to see risk assessments for avoiding these areas.

2.6.2 Vegetation Clearance

Again no figures are provided for Open Area, both now and the future. States minimum required, what is the maximum allowed?

2.6.3 Rehabilitation

Refer to comments regarding importance of orientation in Description of Mining Activity.

3.4.3 Herpetofauna

Should be noted we are in the middle of one of the worst droughts in recent history. With such a small survey time of 1-2 days such broad statements on waterbodies should not be made.

3.2 Aquifer System on North Stradbroke Island.

Where is the data to back up this statement – “*The infiltration capacity of the dune sand deposits is considered to be high and little runoff has been observed on the island...*” Where are these observation points? Where is the monitoring data from Myora Springs, Swan Bay, coastal swamps, township stormwater drains, headland cliffs, Blue Lake overflow etc. The reference to Laycock 1975 does not substantiate this statement as all his observations on surface water and recharge rates are assumptions with large error factors.

3.3.1 Infiltration and Groundwater Recharge

The infiltration rate / recharge rate is over a very large range of estimation. SIMO has always found these figures to be unsubstantiated and require further monitoring studies to have complete confidence in studies such as this Report when reusing the same ancient figures.

3.3.3 Groundwater Discharge

Swallow Lagoon is apparently the highest perched lake in Queensland. The use of ‘approximations and estimations’ when referring to its presence and protection are not good enough.

Water quality studies must be done before mining to form a data base for future reference.

4.2.1

Even though seepage water from the sediment pond is unlikely to be contaminated, it may contain different water qualities to groundwater and Swallow Lagoon. SIMO believes the potential impacts to groundwater are one of the most important issues of this Report. It is therefore unacceptable this Report is based on ‘limited data’.

The recommendation of installation of at least 4 monitoring bores should be made a condition by the EPA.

3.3 Catchments, Drainage and Topography

It is an important fact that the southern side of the Lease drains down towards Tortoise Lagoon. Any re-contouring of landforms on this side must mirror pre-mine topography so as not to interfere with this drainage system into the Blue Lake National Park.

3.4 On –site Waterbodies

The statement “*No downstream water bodies are thought to be reliant on surface runoff*” we find misleading. The coast swamps rely on water runoff from these areas.

3.6 Streamflow and Flow Regime.

Once again a sweeping statement which we would like to have substantiated – “*Little significant surface runoff is observed on NSI even during high intense rainfall*”

3.8.1 Surface Water Monitoring Sites

Still no mention of the significance of the longterm drought we are experiencing.

4.1 Summary of Mining Operations

Landform orientation is the most important factor in post mine re contouring to determine successful outcomes for revegetation, erosion minimization and drainage.

Double stripping of topsoil should be required.

No mention is made of timber stockpiling for fauna habitat. What is the percentage of timber burnt?

4.2.4 Changes to Site Drainage

SIMO does not agree with the statement – “*Alteration of local drainage route is unlikely to lead to significant negative impacts on a wide scale due to the rapid infiltration and high permeability of underlying strata*”

We would like to see a risk assessment on the potential impacts to the drainage area to Tortoise Lagoon and Swallow Lagoon.

How is the measure of 100m calculated as a suitable buffer around the creek?

4.2.6 Impacts from Sedimentation Pond and Associated Infrastructure.

SIMO would like to see exactly where the pond will be.

Existing Socio Economic and Cultural Environment

Use of 1996 Census material is misleading and is now incorrect some ten years down the track. The permanent population has remained quite constant, but the number tourists have increased and the number of mining workers living on the island has reduced dramatically with the take over of CRL by Iluka.

8.3.9

Has UNIMIN been granted a Lease in the Pines area?

The statement that UNIMIN can relinquish its Amity Lease once its operations are relocated to the Pines area amounts to UNIMIN holding out the Amity Lease as a bribe to the government. The future of the Amity Lease if relinquished is not automatically a National Park. If relinquishment will be of “great benefit to island residents and visitors alike” why not do it now?

8.4 Economics of the Project.

What is the number of UNIMIN workers and how many live on the Island?

How much does one hectare of pristine land cost to mine and revegetate? How does this compare to its value in its pristine state as a sustainable tourism opportunity in the future?

Conclusion

SIMO is not impressed with the scope of the surveys and the lack of original work in most of the Reports. Surface water and water quality monitoring has to be upgraded and data used to complete the picture with no ‘assumptions’ used regarding drainage to Swallow Lagoon.

Post mine landforming is too vague and must be given approved criteria by EPA and community to what will be an acceptable final result- both for ecological sustainability and future eco-tourism potential. There is no mention of goals to be achieved by UNIMIN in regard to postmine landform and revegetation success.

Open Area figures are not included both for present situation and predicted future areas in Vance or what measures are taken by the company to deal with prolonged drought conditions in relation to rehabilitation techniques.

All Reports do not take into account the prolonged drought conditions and predicted future dry seasons.

This Report does not invite confidence in the ability of UNIMIN to carry out an acceptable sand extraction operation at Vance, which will guarantee the future of the complex drainage systems on a sand island, which is the key to ecological sustainability.

Yours Sincerely,

Jennie Truman
President Stradbroke Island Management Organisation

cc. Environmental Protection Agency

APPENDIX D

Greg Smith
 Lot 5 Boronia Court
 Myora Springs Estate
 Dunwich Qld 4183

Unimin Australia Limited
 PO Box 43
 Dunwich Qld 4183

8 September 2005

Dear Ms Bubb,

Thank you for the opportunity to comment on your ESR for the Vance lease ML 1108. I am employed by Consolidated Rutile Limited and am a proponent of the resource industry. Please note however that I am writing this letter from the standpoint of a private citizen and interested stakeholder who maintains the viewpoint that all mining activities should be conducted responsibly and transparently.

After reviewing the draft report, I would suggest that this study falls short of adequately addressing issues and concerns.

A summary of concerns and questions is as follows

:

1. Flora

One of the aims of the study was to identify any significant flora. I could not ascertain whether there are any significant species present from your report and suspect there are significant species present.

2. Fauna

One of the aims of the study was to identify any significant fauna. Given that a total of 6 days was spend on site, a lack of seasonality would restrict the number of different animals identified.

3. Significant Areas

There is little mention of the Ramsar areas or Swallow Lagoon / Brown Lake which are either near or on the lease. If damage was sustained in these sensitive areas, fallout from stakeholders would be "dramatic". Given the potential (severe) consequences of damage to these areas, common sense dictates that efforts should be made to conduct proper surveys, collect baseline data and continually monitor.

4. Road Transport

There is no mention of additional trucks in a traffic report which was done 8 years ago and the quoted mining rate of 1 million tonne per year suggests that there will be an increase in truck movements from that currently. I would have thought that a more recent review was warranted given the heavy traffic from Yarraman mine site and growth of the Island over the last 8 years. I did not note any estimate for mine life (other than a 5 year mine plan) which must be a consideration when reviewing potential traffic issues.

5. Air Quality

The 1998 report tabled is at least honest in admitting to a qualitative, not quantitative review! I am not convinced that the air quality does not present a risk to Myora residents.

A summary of concerns and questions which support this statement include:

- . Long term residents at Myora tell me that the samplers were positioned under trees which would affect the accuracy of the results.
- . On any given day with a 51:: blowing approximately 25 knots, a dust cloud from the mine site is clearly visible from the Rainbow Channel.
- . On occasions of > 30 knot winds, a dust storm is clearly visible along the main road opposite the entrance or down wind of your site.
- . I soon learnt to close windows at Myora when the wind is blowing at any strength due to dust which can only be described as excessive.
- Why did Unimin not release the details of the 1996 analysis which 'found no marked increase in dust levels when the wind was blowing towards residences'. Please do.
- . The 24 hour average of 50 micro *grams*/m³ with an exceedance rate of 5 times per year for < 10 micron particles does not differentiate between free quartz (cancer causing) or insoluble solids. Current industry standards quote a limit of 100 micrograms/m³ for PM 10 free quartz over 8 hours. Considering Unimin is a silica sand mine, I find it hard to believe that a worker cannot be exposed to any more than 500 (5 x 100) in a working week but is ok for a member of the public to breathe in 350 (7 x 50) at home. Please clarify.
- . The report was particularly poor with modelling based on old techniques and data from a weather station isolated many kilometres away. More applicable sources would have been CRL, RSC, Cape Moreton or perhaps your own station.
- . I am unclear about the term 'averaging 3 months worth of data' as it doesn't indicate when there would be an issue or how often (number of exceedances).
- . The Vance deposit is further away from the estate suggesting less dust however the report doesn't show that.
- . There was little mention of dust control strategies, the effect of the Processing area, its contribution or the size of open area near it.

6. Geomorphology

There is no mention of changes to indurated catchments of the Cooroon-Cooroonpah Creek where the 100m buffer is arbitrary if the catchment is damaged. The mining discussion suggests that no indurated layers will be disturbed but it's not clear if any layers have been mapped or identified

7. General

There is no discussion on how the area will appear after the removal of a large hill. The terms of reference for this study are not clear ie whether the stakeholders are approving work. Unimin are responding to concerns or if the study itself lacks rigor. Either way there are numerous requests for information or further studies to be undertaken in the consultation section, particularly from the EPA, which have not been answered

My understanding with safety and environmental issues is that legal compliance is a minimum and level effort should be made to achieve best practice. I'm not in a position to know whether this ESR complies with legislative requirements but I don't believe the study addresses stakeholder concerns.

Yours Faithfully.

A handwritten signature in dark ink, appearing to read "Greg Smith". The signature is written in a cursive, slightly slanted style.

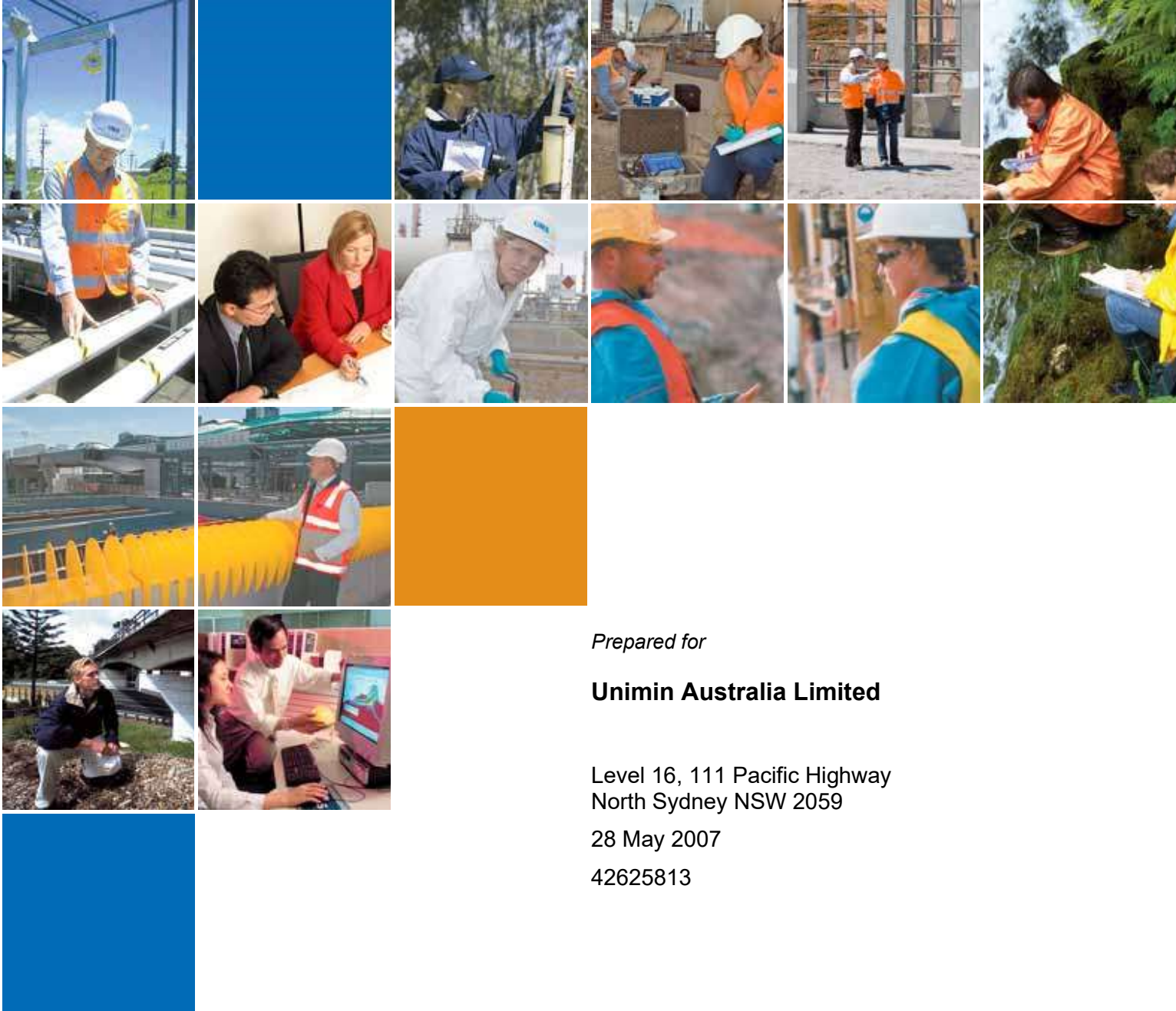
Greg Smith.

Appendix I

Soils and Geomorphology Report (2007)

REPORT

Unimin Vance Mining Lease (ML1108) Soils and Geomorphology Report



Prepared for

Unimin Australia Limited

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28 May 2007

42625813

URS

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Date: 28 May 2007
Reference: 42625813.50005 Final Report
Status: Final

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Section 1

Introduction

1.1 The Project Area

URS Australia Pty Ltd (URS) was commissioned by Unimin Australia Limited (Unimin) to undertake a geomorphology and soils study to characterise the terrain conditions within Mine Lease Area ML 1108 (Vance) as part of the environmental studies being undertaken to facilitate planning and environmental impact assessment for a proposed mine expansion programme. The operations will involve excavation and removal of silica sand to its base level followed by re-contouring and rehabilitation of the lowered land surface by replacement of topsoil and subsequent revegetation.

The Vance Mining Lease 1108 includes a land area of approximately 630 ha, approximately 4 km east of Dunwich on North Stradbroke Island as shown in **Figure 1**.

1.2 Scope of Work

The objectives of the study were to carry out a terrain analysis as a basis for the characterisation of the general terrain features in terms of geology, geomorphology and soil conditions within the lease area, generally following the guidelines for Environmental Management of Exploration and Mining in Queensland in accordance with the requirements of the Queensland Department Natural Resources and Mines (NRM - 1995), now administered by the Environmental Protection Agency (EPA).

Aspects of the study have included:

- Preliminary terrain mapping based on air photo interpretation to provide a basis for the field investigation and soil sampling operations;
- Review of existing information (eg. government databases, previous reports, maps); and
- Conducting a soil survey to classify the soil types occurring on the site and to assess their properties in terms of topsoil suitability and topsoil stripping depths for rehabilitation purposes.

Section 2

Methodology

2.1 Terrain Classification and Mapping

Land units have been identified from air photo interpretation with reference to geological, geomorphic, topographic and soil information data sources included in **Section 2.2**. As mapped, a land unit comprises a discrete or recurring area of the terrain that is considered to have a unique combination of physical attributes in terms of geology, surface slope and form, and soil/substrate conditions. Accordingly, soil/landform characteristics determined at one location may be extrapolated to other occurrences of the land unit identified through the terrain classification process.

A map showing the occurrence and distribution of the land units identified within the lease area is included as **Figure 2**. Descriptions of the land units are included in **Table 1**.

2.2 Data Sources

The following data and reference sources were used to help describe and evaluate characteristics of the physical environment within the project area:

- Queensland Government (NR&M) colour aerial photography (QAP5931) Brisbane Run 14, flown 21-02-02 at a nominal scale of 1:25,000;
- Project area topographic base map, with 5m contour intervals shown;
- Geological Survey of Queensland, 1:100,000 Geological Series Queensland, Beenleigh Sheet 9542 (1985);
- Commonwealth Department of Environment and Water (DEW) Australian Heritage Database Register of National Estate;
- Summary details of vegetation and proposed rehabilitation procedures prepared by P Foot; Senior Environmental Officer - Consolidated Rutile Limited (CRL - 1990);
- Paper by Thompson and Ward, CSIRO Division of Soils Brisbane – Soil Landscapes of North Stradbroke Island, published in the Proceedings of the Royal Society of Queensland (1975); and
- Review of the Geomorphology of ML1108, North Stradbroke Island, Queensland, by Geo-Coastal Australia (December 2006);

2.3 Fieldwork

During the initial phase (Phase 1) of the project, a field reconnaissance of the lease area was carried out in March 2005.

The purpose of the reconnaissance field survey was:

- To provide ground truthing for the preliminary land unit mapping determined from air photo interpretation; and,
- Subject to site accessibility, to select representative locations for soil sampling operations to be undertaken initially by Unimin site staff, under instructions from URS personnel.

In Phase 1 a total of 16 sites (V1-V16) were investigated in the field, with soil sampling being carried out using hand (sand) augers to a depth where either groundwater or hard indurated sand layers were encountered, or to a depth of 3.0m, whichever was shallower. Subsequently as part of the Phase 2 hydro-geological drilling investigations undertaken in August to October 2006, a further 5 sites (D1, D2 and Sites 3-5) were also sampled to provide additional soils information as well as samples for laboratory soil chemical analyses for land rehabilitation purposes.

Section 2

Methodology

Given the essentially uniform nature of the soil/landscape systems that occur within the general site area, the frequency of site observations, soil sampling and soil testing carried out are generally in accordance with the guidelines recommended by Gunn *et al* (1988) and McDonald *et al* (1990).

A total of about 150 soil samples were obtained for soil characterisation, indicative testing, and for soil profile classification purposes. In general, samples were recovered from the surficial and immediate subsoil horizons and subsequently at 0.5m depth intervals or at distinct horizon changes throughout the profile found at each sampling location. The site inspection/soil sampling locations investigated are shown in **Figure 2**.

2.4 Soil Characterisation

Indicative (in-house) testing was carried out on all soil samples collected. This involved testing of pH (1:5 H₂O) and Electrical Conductivity (EC 1:5 H₂O), together with descriptions of soil colour, texture, consistence and presence of organic matter, determined by field methods described by McDonald *et al* (1990). Soil descriptions and the results of the indicative testing are included in **Appendix A.1**. From the samples recovered during the Stage 2 drilling investigation, in addition to the indicative testing carried out, representative samples were also selected for soil chemical analyses by SGS Agritech in Toowoomba. Individual Test Certificates together with a summary of the results of the laboratory testing are included in **Appendix A.2**.

Section 3

Description of the Environment

3.1 Geology and Geomorphology

As mapped in the 1:100,000 Series Geoscience Data published by the Geological Survey of Queensland (2005), the main geological regimes that occur within the vicinity of the project area include:

- Quaternary Pleistocene Dune Sand (Qpd);
- Quaternary Holocene Sand Deposits (Qhd); and
- Triassic-Jurassic Bundamba Group Woogaroo Sub-Group (RJbw); comprising sandstone, siltstone, shale conglomerate and coal.

In a regional context, the geology of North Stradbroke Island is characterised by Quaternary Holocene and Pleistocene sands overlying Triassic and Jurassic bedrock, comprising quartzose sandstone, siltstone, shale conglomerate, coal, basalt and breccia. On the northern part of the island bedrock outcrop is limited to coastal areas near Dunwich and Point Lookout.

The Pleistocene sand dune deposits (Qpd) are by far the most extensive geological unit on the island. These sands represent the successive overlay of a number of major episodic aeolian events interspaced by periods of stability that have occurred through much of the Quaternary and is continuing today (Thompson & Ward, 1975; Benussi, 1975). At least three and possibly 4 stages of dune development have been recognised by Cranfield (*QDME; pers. comm*) who recently reviewed the geology of North Stradbroke Island classifying the dunes using a similar system to that used for the mapping of Moreton Island. The system identifies various dune sequences (most recent to oldest) within the Holocene (Qhd1 to Qhd3) and Pleistocene (Qpd1 to 3 and Qpde).

Ward (1977) and Ward & Grimes (1987) have identified nine sand blowing events with intervening periods of strandplain development. The resulting formation is a massive transgressive dune field with north-west trending ridge lines. The dunes are moderately densely vegetated and are underlain by a weathered bedrock surface, the elevation of which ranges from above sea level on the western side of the island near Dunwich, to approximately 90 metres below sea level on the eastern side of the island. Vegetated dune sand deposits (Qhd) post-dating the Holocene emergence occur on the eastern coast of the island. These deposits are relatively low in height and consist of fine to medium-grained quartz sand deposited mainly by wind action.

Within the mining lease area (ML1108) the dunes are all of Pleistocene age and Cranfield's mapping of them is illustrated in **Figure 3**. These older sand dune deposits (Qpd) predate the Holocene emergence and consist of fine to medium-grained quartz sand with minor peaty layers, ironstone bands, and carbonaceous indurated sand-rock zones (coffee rock). Coffee rock exhibiting varying degrees of induration could be expected to have formed in relation to each stage of dune development.

A search of the Commonwealth Department of Environment and Water's (DEW) Australian Heritage Database has identified "North Stradbroke Island (central section)" on the Register of the National Estate as a registered place. According to the register record the area contains examples of various ages and phases of dune formation and erosion, which are significant in understanding the evolution of North Stradbroke and other sand islands. The Vance Lease ML1108 occupies this "Central Section" of North Stradbroke Island. A number of significant geomorphological features have been identified on the register as occurring in the central section including:

- Mount Hardgrave, the highest dune on North Stradbroke Island;
- Swallow Lagoon, likely to be the most elevated water body in the Queensland sandmass system;
- Brown Lake, a large perched lake;
- Blue Lake, a water table window lake formed by sand dams; and
- Tortoise Lagoon, a perched lake prior to 1976 that has since receded into a swamp.

Section 3

Description of the Environment

None of the above features occur on the Vance lease, with the closest features being Mount Hardgrave and Swallow Lagoon, located approximately 250 metres outside the south-western corner of the lease.

The footprint of proposed mining activity will not impact on these two features. Potential groundwater impacts are addressed in the Groundwater Assessment report (refer Appendix D of the ESR).

A review of the geomorphology of North Stradbroke Island, the dune forming processes and implications for hydrogeology with respect to ML 1108 is included as **Appendix B**.

3.2 Landform

The terrain within the lease area and throughout much of the central and northern part of North Stradbroke Island consists primarily of north-westerly trending sand ridges and hills with varying crestal elevations which have resulted from the superimposition of different generations of transgressive dune stacking. These sand hills reach elevations in excess of 200m ASL in the vicinity of Mount Hardgrave. In places the dune surfaces have been subject to erosion and now lack the more clearly recognisable dune shapes that are evident at lower elevations towards the eastern side of the Island. The eroded upland areas exhibit a strongly undulating to low hilly surface form, with slopes mostly in the range of 10-20% on the upper slope margins. Elsewhere, narrow more sharply rounded dune ridge crests occur which have somewhat steeper marginal slopes (15-30%) increasing to 30-60% on the adjacent steep irregular planar ridge slopes to the narrow but mainly broadly depressional drainage lines.

In general, the more elevated upland areas and the more exposed higher parts of some north-east facing dune slopes have been subject to moderately severe surface sheet erosion by wind and the remnant vegetation is sparse to moderately dense. On the more protected south-west facing slopes and elsewhere on the mid to lower dune slopes and in drainageways, the vegetative cover is dense to very dense and the effects of erosion appear significantly lower.

Drainage within the lease area is via broadly depressional to locally shallowly incised drainageways which flow generally in a north-westerly direction from the northern and central eastern sectors of the site and in a south-easterly direction from the central southern sector of the site.

3.3 Land Units

Five Land Units have been identified within the site based on surface form, topographic position in the landscape, steepness of slopes, degree of dissection, drainage condition and soil type. As mapped, the land units identified have provided the basis for the description of the environment and for the identification of soil types that occur within the project area. A general description of the land units identified is given in **Table 1**. The occurrence and distribution of land units is shown in **Figure 2**.

Section 3**Description of the Environment****TABLE 1: Description of Land Units**

Land Unit	Landform	Soil Type
Qpd 1	Broad, strongly undulating to low hilly upland areas, with broadly rounded upper marginal slopes mainly in the range 10-20%.	Mainly deep (giant) podzol soils with mod. highly organic and humic surficial (A1) soil horizons, over white fine sandy (A2) subsoil horizons, locally underlain by shallow red to yellowish brown ferruginous gravelly sand subsoil (B) horizons in the north eastern sector of the lease area.
Qpd 2	Mostly narrow and moderately sharply rounded dune ridge crests and upper marginal slopes 20-30%.	Mainly deep (giant) podzol soils with thick mod. highly organic and humic surficial (A1) soil horizons underlain by white fine sandy (A2) subsoil horizons; local areas with shallow B horizons, as for Qpd1.
Qpd 3	Steep irregular planar dune ridge slopes (30-60%).	Mainly deep (giant) podzol soils with thick mod. highly organic and humic surficial (A1) soil horizons underlain by white fine sandy (A2) subsoil horizons; local areas with shallow B horizons, as for Qpd1.
Qpd 4	Undulating to low hilly lowlands with broadly rounded crestal areas and low rises with internal and marginal slopes mostly in the range 10-20%.	Deep (giant) podzol soils with thick mod. highly organic and humic surficial (A1) soil horizons, over white fine sandy (A2) subsoil horizons mostly extending below 3m depth.
Qpd 5	Irregular planar to concave colluvial footslopes and broadly depressional drainage floors, with marginal slopes up to about 10%, locally with seasonally high groundwater levels and local swampy areas within drainageways.	Shallow to deep podzols, giant podzols and peaty/organic sand soils with highly organic and humic surficial (A1) soil horizons, locally with white fine sandy (A2) subsoil over organic rich subsoil (B) horizons; local occurrences of shallow groundwater.

Section 4

Soils

4.1 Soil Types

The soils in the project area are essentially similar throughout the entire site and have been identified based on the examination of 16 site/soil profiles, details of which are included in **Appendix A.1**. In order to fully characterise the soils, they have been classified in terms of four commonly used systems of soil identification, namely:

- The common Australian soil group name, generally following Stace *et al.* (1968) and Northcote *et al.* (1975);
- The Principal Profile Form based on Northcote (1971);
- The Australian Soil Classification by Isbell (1996); and
- The Australian Engineering Soil Classification (AS 1726-1993).

The soil landscapes (land units) that occur within the project area are dominated by the occurrence of white silica sands that have been subject to strong weathering to depths varying locally from about 2m (mainly in the north eastern sector of the site) to 20m or more elsewhere within the site. However in general, the thickness of the fine-grained white silica sand that is the target of the mining operations typically varies between about 7-14m. The surficial (A1) horizons are generally grey or dark grey and white speckled in colour and contain moderately high amounts of organic matter, including charcoal, fibrous roots and seed stock. These A1 horizons are usually between 0.3-0.6m thick and grade into the underlying pale grey or white sandy (A2) horizons, which in turn are underlain (at varying depths) by ferric and/or black organic-rich subsoil (B) horizons. In most cases, except for sites V12-14 and V16, all in the north eastern sector of the site, the hand auger holes (generally about 3.0m deep), were not sufficiently deep to intersect the B horizon materials.

In terms of the more common soil classification systems currently in use, the site soils may be classified as follows:

- With respect to the Australian Great Soil Group nomenclature - Stace *et al.* (1968), the site soils are classified either as *Podzols*, where the depth to the B horizon is relatively shallow (<2-3m), and as '*Giant*' *Podzols* on the crestal areas and slopes of the high eroded old dune systems. Some *Organic/Peaty Sands* occur in drainage floors and swampy areas.
- In terms of the Principal Profile Form (PPF) classification developed by Northcote (1971), the soils comprise mainly *Uc2.3*, *Uc2.31-2.32-2.34* in the hilly and higher sand dune areas and *Uc5.11* in some poorly drained areas.
- In terms of the Australian Soil Classification proposed by Isbell (1996), the soils have mostly been classified as *Aeric Humosquesic Podosols* on higher dune and ridge slopes or *SemiaquicHumic/Alsilic Podosols* in somewhat less well-drained areas and some *Acidic Sapric Organosols* in drainage floors and swampy areas.

Engineering soil classifications are applicable to individual soil layers or horizons and these are included together with the soil descriptions and indicative testing results in **Appendix A.1**.

4.2 Soil Fertility

The soils within the site consist almost entirely of fine-grained siliceous single-grain loose sands that have high porosity, very low silt/clay fines content and contain very low levels of most plant nutrients. In the initial (Stage 1) report, reference was made to analytical data available for 3 topsoil samples (tested by SGS Quantum) obtained from a giant podzol soil profile on the Vance lease as part of a vegetation survey conducted by E Smyth (1990). This data indicated the materials were very strongly acidic and nutrient poor with very low levels of nitrogen and phosphorus, low levels of potassium and deficiencies in calcium compared to magnesium, as well as very low levels of trace elements, (copper, zinc, manganese, iron

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and boron). Levels of organic matter were also low and there is likely to be little variation in nutrient status over the majority of the site.

Subsequent additional laboratory analyses have been carried as part of the current (Stage 2) investigations, the results of which are summarised in **Appendix A.2**. These data further confirm the strongly acidic and nutrient poor status of the materials that are likely to be disturbed by the mining process. Accordingly, whilst the recovery of the existing topsoil resources within the site which has been found to be beneficial for rehabilitation purposes, the use of a broad-spectrum general 'start-up' fertiliser (such as Fertico), introduced with the initial cover crop and native seed application, is likely to be necessary to promote the initial plant establishment in the rehabilitation process.

Some comments with respect to the interpretation of the soil chemistry and soil fertility attributes of the soils within the project area are included in **Appendix A.3**.

4.3 Topsoil Resources

The current practice adopted for the existing sand mining operations when entering a new area, is to clear the existing vegetation, strip and stockpile or where possible immediately reuse the existing topsoil layer for the ongoing rehabilitation programme. Larger vegetation is temporarily wind-rowed for later replacement as habitat on the re-contoured land surface and smaller shrubby vegetation is incorporated with the topsoil stripping process.

Reference to the soil descriptions included in **Appendix A.1** indicates that useable topsoil resources are mainly confined to the surficial (A) horizon materials, which contain seed-stock, micro-organisms and nutrients necessary for plant growth. Soil microbial activity, organic matter content and other parameters affecting soil fertility, tend to decrease with depth. On average, the useable topsoil resource, i.e. the (A1) soil horizon containing appreciable amounts of organic matter, fibrous roots and native seed stock, is approximately 0.4m deep on the higher dune crestral areas and ridge slopes, within the general area likely to be subject to future mining. Somewhat deeper occurrences (0.5-0.6m+) were found on the foot slopes and along drainage lines, and some shallower variants (<0.3m) occur in the north eastern sector of the site in the RAMSAR Region, but neither of these situations will be subject to mining.

4.4 Topsoil Management

More detailed topsoil resource assessments will be carried out in advance of mining in new areas, progressively over the life of the sand mining operations. These assessments will involve review of existing soils data and additional soil sampling and testing to determine actual soil stripping depths to facilitate volume calculations prior to clearing of the areas to be disturbed. Monitoring of soil type variability will be undertaken during the ongoing operational phases of the project to ensure that the maximum quantity and quality of useable topsoil resources is recovered.

4.4.1 Stripping

Prior to the commencement of stripping, areas will be cleared of vegetation. Earthmoving plant operators will be trained and/or supervised to ensure that stripping operations are conducted in accordance with stripping plans and *in situ* soil conditions. This will ensure that all suitable topsoil material resources are salvaged and that the quality of the stripped topsoil is not reduced through contamination with unsuitable soils.

4.4.2 Stockpiling

Where possible, topsoil material will be respread directly from stripped areas onto areas being rehabilitated. Where this is not possible, topsoil shall be stored in stockpiles.

Topsoil material stockpiles will be located in areas that are outside the mining disturbance area and away from drainage lines. Drainage from higher areas will be diverted around stockpiles to prevent erosion. Sediment controls will be installed down gradient of the stockpiles to collect any washed sediment. If the

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stockpile is to be retained for a period of more than 6 months, the stockpile should be sown with local grass seed stock and legumes in order to keep the soil healthy and maintain biological activity. Topsoil stockpiles will be clearly sign-posted for easy identification and to avoid any inadvertent losses. Establishment of weeds on the stockpiles will also be monitored and controlled.

4.4.3 Respreading

Planning the rehabilitation of disturbed areas will include topsoil material respreading considerations including:

- Balancing required rehabilitation topsoil quantities against stored stockpile inventories;
- Planning the source of topsoil material to maximise direct respreading from stripping areas and to minimise the length of time that material is stored in stockpiles; and
- Installation of erosion control measures (silt fences, hay bales etc.) especially on the steeper slopes, to minimise erosion.

If topsoil has been stored for a considerable period of time (6-12 months or more), when removed from the stockpiles, care will be taken to optimise the quality of the material to be respread. To achieve this, the upper and lower sections of the stockpiles will be mixed during the recovery process to ensure that seed stock and micro-fauna content is consistent throughout the material being replaced.

In accordance with current practice, topsoil material will be respread in even layers approximately 0.3m thick.

The mine rehabilitation strategy will include the following measures that are designed to minimise the loss of topsoil material respread on rehabilitated areas:

- Surface regrading across the contour to encourage rainfall infiltration and minimise runoff;
- Reseeding soon after respreading to establish revegetation cover as early as possible;
- Replacement of wind-rowed vegetation for surface protection and creation of faunal habitat;
- Installation of contour banks if appropriate, to limit slope lengths and surface runoff velocity; and
- Installation of silt fences and/or hay bales where appropriate, to restrict runoff in drainage paths and contain sediment loss on the steeper slopes.

4.5 Soil Erosion

Based on interpretation of the (Feb. 2002) aerial photography, together with general observations made during the site reconnaissance, soil erosion in the form of surface sheet/wind erosion is occurring within the project area in particular along the central northern boundary, in the north eastern sector and in the central western and southern sectors of the project area. This appears to be partly related to the presence of property tracks and mining exploration tracks in these areas.

The following proposed erosion and sediment control measures will be implemented during the various stages of the sand mining operations.

- Vegetation clearing will be conducted progressively so that the minimum area necessary for effective operations is cleared at any time.
- Given the deep and predominantly sandy nature of the soils, surface runoff is likely to be minimal other than during severe storm events. However, any surface drainage or subsurface seepage accumulation originating from upslope of the mining areas will be directed away from or around the operations areas.

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- Runoff from bare earthworks areas within the mining areas will be directed via constructed drains to the base of the active pit or through sediment traps to remove suspended sediment prior to discharge from the site.
- Long-term stockpiles of topsoil and any excess cut material will be planted with grass seed and will have drainage diversion and sediment control measures introduced to contain sediment loss.
- Re-established slopes will be constructed to stable slope angle (maximum 40%) and revegetated soon after construction.
- Temporary access tracks will be landscaped and revegetated as soon as possible after mining operations are completed in each area.
- If appropriate, rehabilitated slopes will have contour mounds installed to minimise slope lengths and runoff velocities.
- Where appropriate, in areas undergoing rehabilitation brush matting or chipped/mulched vegetative matter will be used to minimise surface disturbance due to the effects of wind erosion and/or possible surface runoff.
- A maintenance program will be implemented to ensure the proper functioning of drainage and sediment control structures.

Section 5**Glossary*****Aeolian Deposits***

Sediments deposited after transport by wind

Aquiclude

A body of relatively impermeable rock that is capable of absorbing water slowly but does not transmit it rapidly enough to supply a well or spring.

Aquitard

A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer; a leaky confining bed.

Concatenation of depositional circumstances

A union of depositional circumstances in a series, chain or unbroken sequence.

Illuviated

Accumulated – the deposition in the lower soil (usually the B horizon) of soluble or suspended materials transported from an upper horizon (usually the A horizon) by the process of eluviation.

Strandplain

A prograded shore built seaward by waves and currents, and continuous for some distance along the coast. It is characterised by subparallel beach ridges and swales, in places with associated dunes.

Section 6

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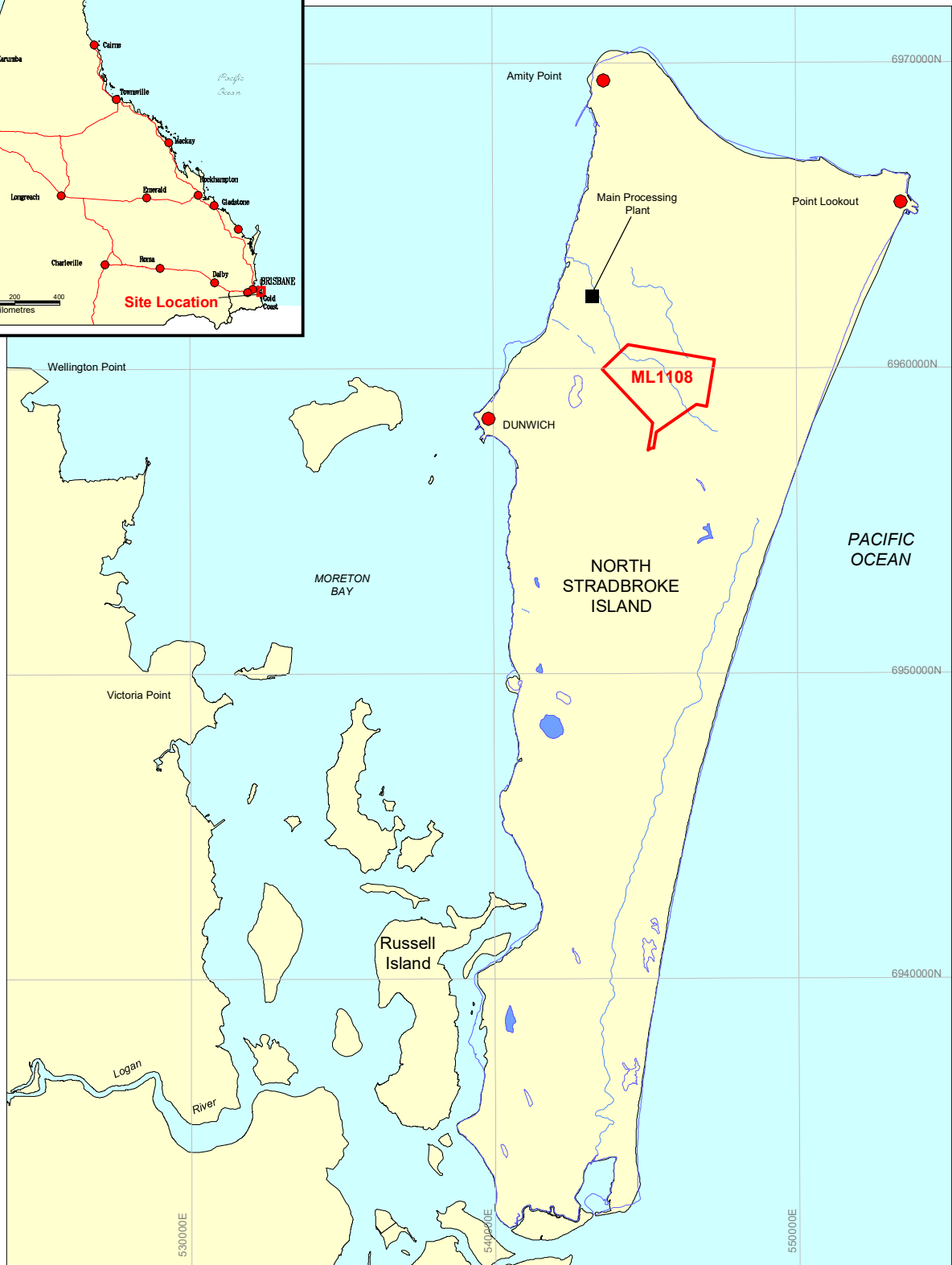
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Note: See Appendix B for additional Reference sources.

Figures



0 2.5 5Km
Scale 1:200,000 (A4)

Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client
UNIMIN AUSTRALIA LIMITED

Project
**VANCE LEASE
NORTH STRADBROKE ISLAND
ENVIRONMENTAL STUDIES
GEOMORPHOLOGY AND SOILS REPORT**

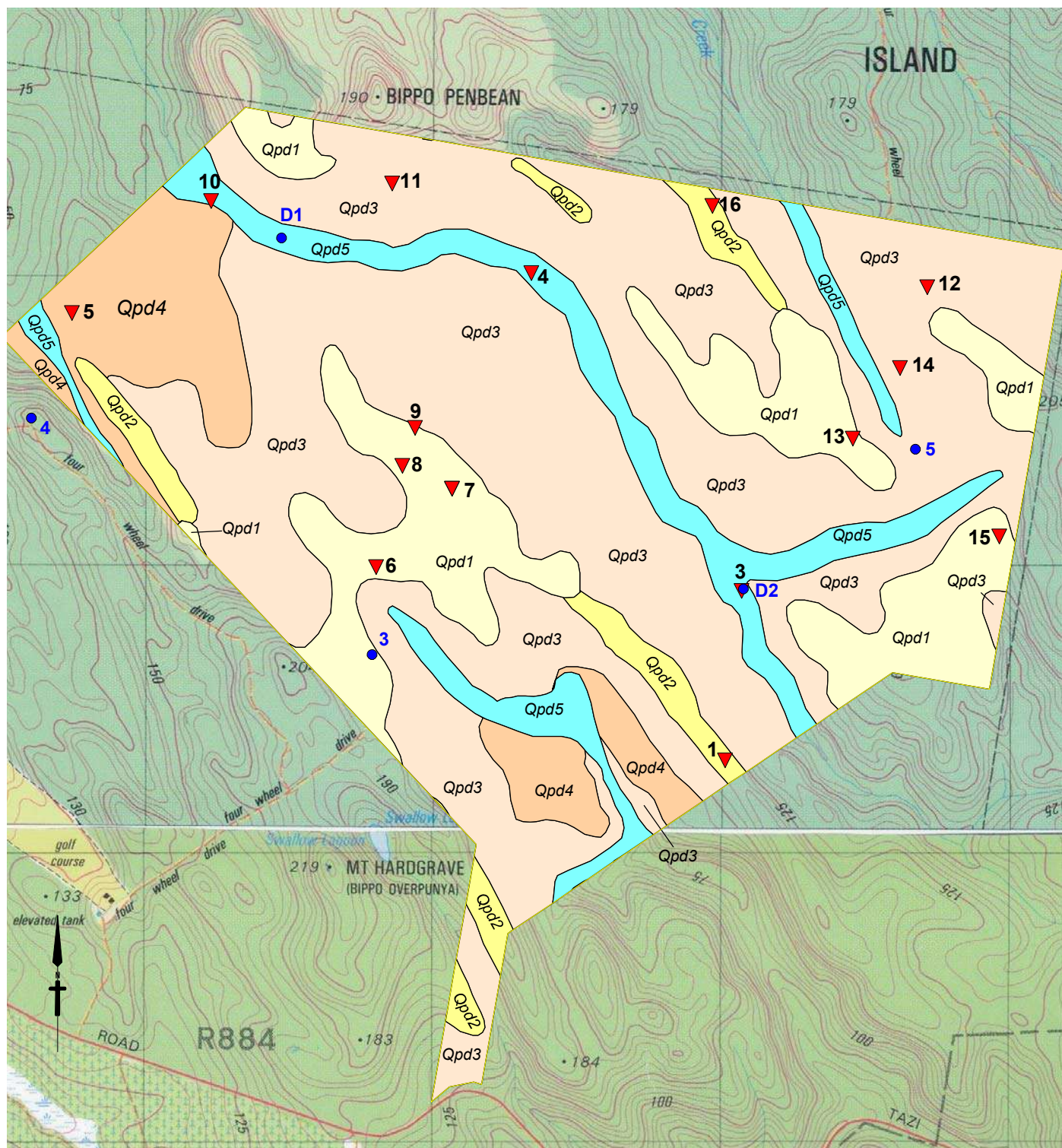
Title
LOCALITY PLAN

URS

Drawn: LL/VH Approved: JB Date: 30-05-2007
Job No: **4262 5813** File No: 42625813-g-018wor

Figure: **1**

Rev: A
A4



LEGEND

- 1 ▼ Sample Location - Phase 1
- 3 ● Sample Location - Phase 2

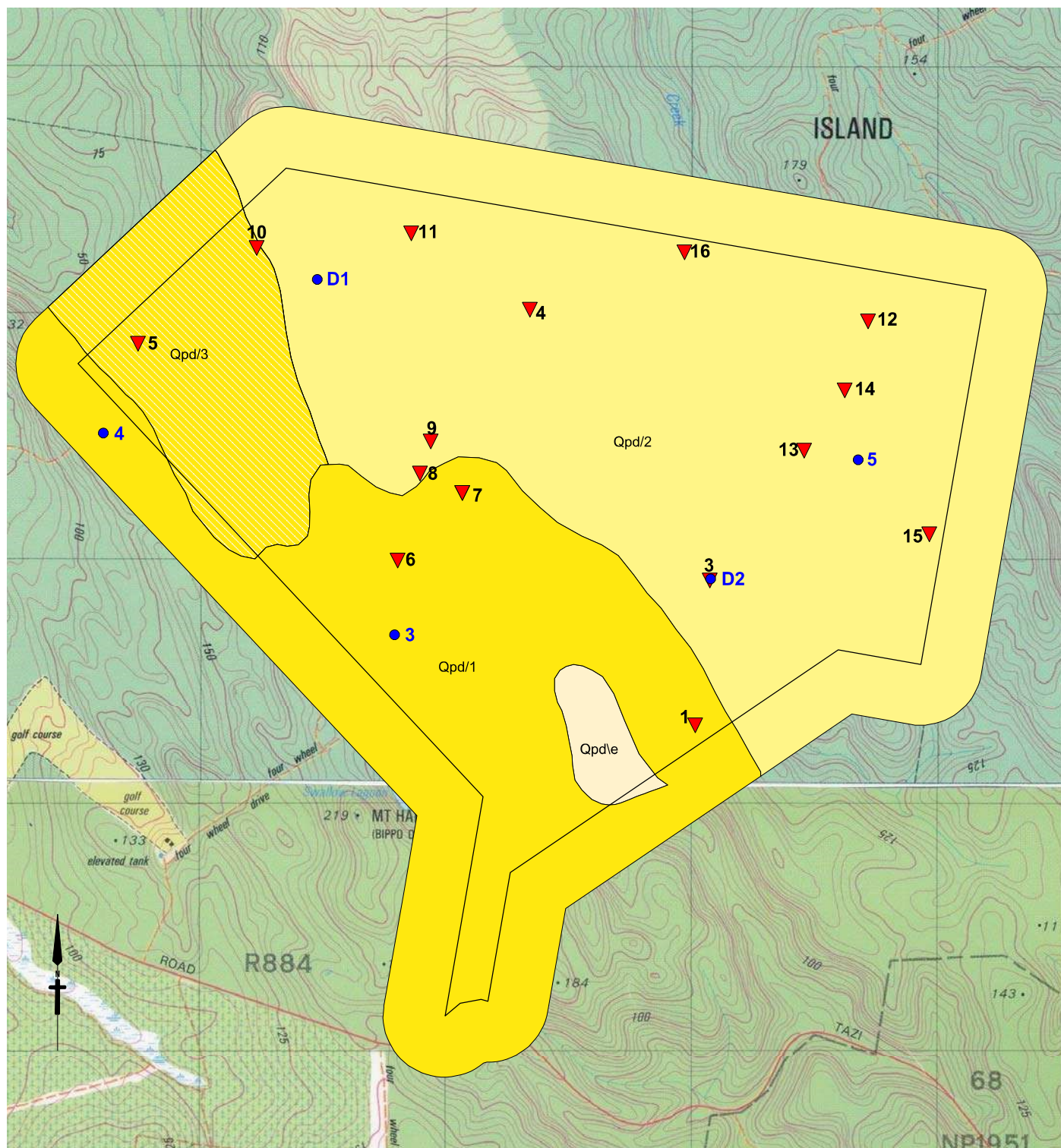
0 250m 500m
Scale 1:20 000 (A4)

LEGEND

- Qpd1** Undulating to low rounded hilly upland dune areas; slopes (10-20%), with deep Giant Podzols (Uc2.3) and locally shallower Podzols (Uc2.32) in the north-eastern sector of the site.
- Qpd2** Narrow rounded elongate sand ridge crests and upper marginal slopes (20-30%), with deep Giant Podzols (Uc2.3) and locally shallower Podzols (Uc2.32) in the north-eastern sector of the site.
- Qpd3** Steep irregular planar dune ridge slopes (30-60%), with deep Giant Podzols (Uc2.3) and locally shallower Podzols (Uc2.32) in the north-eastern sector of the site.
- Qpd4** Undulating to low hilly lowland dune areas with internal slopes (10-20%), with deep Giant Podzols (Uc2.3), with mod. highly organic and humic surficial (A1) soil horizons.
- Qpd5** Irregular planar to concave footslopes (up to 10%), drainage floors and locally seasonally swampy areas, with shallow to deep Podzols (Uc2.32), Giant Podzols (Uc2.3), and locally Humus Podzols (Uc4.3), with thick mod. to highly organic and humic surficial (A1) soil horizons.

Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project VANCE LEASE NORTH STRADBROKE ISLAND ENVIRONMENTAL STUDIES GEOMORPHOLOGY AND SOILS REPORT		Title LAND UNITS	
	Drawn: LL	Approved: JB	Date: 30-05-2007	Figure: 2
	Job No: 4262 5813	File No: 42625813-g-019.wor		Rev: A A4



LEGEND

- 1 ▼ Sample Location - Phase 1
- 3 ● Sample Location - Phase 2

0 250m 500m
Scale 1:20 000 (A4)

LEGEND

- Qpd/1 Pleistocene Dunes, parabolic, quartz sand (youngest)
- Qpd/2 Pleistocene Dunes, parabolic, quartz sand
- Qpd/3 Pleistocene Dunes, parabolic, quartz sand
- Qpd/e Pleistocene Dunes, parabolic, quartz sand (oldest)

Geology by L Cranfield (DME)

Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project VANCE LEASE NORTH STRADBROKE ISLAND ENVIRONMENTAL STUDIES GEOMORPHOLOGY AND SOILS REPORT		Title GEOLOGICAL REGIMES	
	Drawn: LL	Approved: JB	Date: 30-05-2007	
	Job No: 4262 5813	File No: 42625813-g-021.wor		Figure: 3 Rev: A A4

Appendix A

Appendix A.1 - Soil Characterisation and Indicative Testing

Appendix A1 – Soil Characterisation and Indicative Testing Results

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
V1-0-0.1	Qpd2	A1	Sand (SP) fine-grained, grey (5Y5/1), low to moderate organics and some fibrous roots, single-grain loose, moist.	4.0	0.0	Giant Podzol – Uc2.3, with a thick organic/humic A1 horizon; Aerlic/Semiaquic Podosol
0.1-0.2		A1	Sand (SP) as above with moderate amounts of fibrous roots	-	-	
0.2-0.3		A1	Sand (SP) as above low organics and fibrous roots content, just moist.	4.0	0.0	
0.3-0.4		A1	Sand (SP) as above grey (2.5Y5/1), low organics and moderate fibrous roots.			
0.4-0.5		A1-A2	Sand (SP) fine-grained grey (2.5Y 6/1)	4.0	0.0	
0.5-1.0		A2	Sand (SP) fine-grained, white (2.5Y8/1) nil or very low organics or fibrous roots, single and grain loose, just moist.	4.3	0.0	
1.0-1.5		A2	Sand (SP) as above, white (2.5Y8/1)	4.5	0.0	
1.5-2.0		A2	Sand (SP) as above, dry.	4.5	0.0	
2.0-2.5		A2	Sand (SP) as above	4.6	0.0	
2.5-3.0		A2	Sand (SP) continuing as above	4.7	0.0	
V2-0-0.1	Qpd3	A1	Sand (SP) fine-grained, grey (2.3Y6/1) low organics, moderate fibrous roots content, single-grain, loose, moist	4.6	0.0	On edge of track – topsoil removed; Giant Podzol – Uc2.3, with a thick organic/humic A1 horizon; Humose Aerlic/Semiaquic Podosol
0.1-0.2		A1	Sand (SP) as above, moist	-	-	
0.2-0.3		A1	Sand (SP) as above, most	4.1	0.0	
0.3-0.4		A1	Sand (SP) as above, most	-	-	
0.4-0.5		A1	Sand (SP) fine-grained, grey (5Y6/1) nil to very low organics, single grain, loose	4.1	0.0	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
0.5-1.0		A2	Sand (SP) fine-grained, light grey (5Y7/1), single grain, loose, dry	4.2	0.0	
1.0-2.0		A2	Sand (SP) fine-grained, white (2.5Y8/1) single-grain, loose, dry, powdery	4.3	0.0	Too powdery to dig below 2.0m
V3-0-0.1	Qpd5	A11	Sand (SP) fine-grained, grey (5Y5/1), dry, single-grain loose some fibrous roots	4.6	0.0	Giant Podzol – Uc2.3, with a thick organic/humic A1 horizon; Aerlic/Semiaquic Podosol
0.1-0.2		A11	Sand (SP) as above, grey (2.5Y5/1) few fibrous roots	-	-	
0.2-0.3		A12	Sand (SP) fine-grained, with some organic matter, grey (2.5Y5/1), some small weakly cohesive lumps, a few fibrous roots	3.9	0.01	Extremely acidic
0.3-0.4		A12	Sand (SP) fine-grained, dark grey (2.5Y4/1-5/1) loose, single-grain	-	-	
0.4-0.5		A12	Sand (SP) as above, grey (2.5Y5/1) with some charcoal fragments	4.0	0.0	
0.5-1.0		A12	Sand (SP) as above, grey (5Y5/1)	3.6	0.0	Extremely acidic
1.0-1.5		A2	Sand (SP) fine-grained, light grey (2.5Y7/1), single-grain loose, most	3.8	0.0	Extremely acidic
1.5-2.0		A2	Sand (SP) as above, light grey (5Y7/1), wet	3.8	0.0	Struck water (hole terminated)
V4-0-0.1	Qpd5	A11	Sand (SP) fine-grained, grey 2.5Y5/1) with organic matter and fibrous roots, single-grain loose, moist	4.5	0.0	Giant Podzol – Uc2.3, with a thick organic/humic A1 horizon; Humose Aerlic/Semiaquic Podosol
0.1-0.2		A11	Sand (SP) fine-grained as above with fibrous roots and charcoal pieces	-	-	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
0.2-0.3		A12	Sand (SP) fine-grained dark grey (5Y5/1) single-grain, loose, dry with fine to coarse fibrous roots	4.1	0.0	
0.3-0.4		A12	Sand (SP) as above, dark grey (5Y5/1) some fibrous roots	-	-	
0.4-0.5		A13	Sand (SP) fine-grained as above, grey (5Y5/1), few fibrous roots	4.0	0.0	
0.5-1.0		A21	Sand (SP) fine-grained light grey (2.5Y7/1), single-grain, loose, trace of fibrous roots	3.9	0.0	
1.0-1.5		A21	Sand (SP) fine-grained as above light grey (2.5Y7/1)	4.0	0.0	
1.5-2.0		A22	Sand (SP) fine-grained white (2.5Y8/1), loose single-grain, moist	4.6	0.0	
2.0-2.5		A22	Sand (SP) fine-grained, as above white 2.5Y8/1)	4.6	0.0	
2.5-3.0		A22	Sand (SP) fine-grained, as above white (2.5Y8/1)	4.6	0.0	White sand continues
V5 0-0.1	Qpd4	A1	Sand (SP) fine-grained dark grey (2.5Y4/1), high organics and fibrous roots content, single-grain, loose, moist	4.2	0.01	Giant Podzol – Uc2.3, with a mod. thin organic/humic A1 horizon; Humose Aeric/Semiaquic Podosol
0.1-0.2		A1	Sand (SP) fine-grained, dark grey (2.5Y4/1) as above, very moist	-	-	
0.2-0.3		A1	Sand (SP) as above very dark grey (2.5Y3/1)	3.9	0.0	
0.3-0.4		A21	Sand (SP) fine-grained, grey (2.5Y5/1) low amounts of organics and fibrous roots, single-grain, loose very moist	-	-	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
0.4-0.5		A21	Sand (SP) as above, grey (2.5Y6/1)	4.0	0.0	
0.5-1.0		A22	Sand (SP) fine-grained, light grey to white (2.5Y7/1-8/1) very low organics, single-grain, loose, moist	4.1	0.0	
1.0-1.5		A22	Sand (SP) fine grained, white (2.5Y8/1) very low organics, single-grain, loose, moist	4.3	0.0	
1.5-2.0		A22	Sand (SP) as above, white (2.5Y8/1), just moist	4.7	0.0	
2.0-2.5		A22	Sand (SP) as above white 2.5Y8/1)	-	-	
2.5-3.0		A22	Sand (SP) as above, nil or very low organics, just moist	4.5	0.0	
V6-0-0.1	Qpd1	A1	Sand (SP) fine-grained, grey (2.5Y5/1) with black speckles of organic matter and some to moderate fibrous roots	4.6	0.0	Giant Podzol – Uc2.3, with a thin weak organic/humic A1 horizon; Aeric/Semi-aquic Podosol
0.1-0.2		A1	Sand (SP) as above, very moist	-	-	
0.2-0.3		A1	Sand (SP) as above with moderate amount of fibrous roots, moist	4.4	0.0	
0.3-0.4		A2	Sand (SP) fine-grained light grey (5Y7/1) with a few black inclusions or organic matter and some fibrous roots, single grain loose, moist	4.3	0.0	
0.5-0.6		A2	Sand (SP) fine-grained, light grey to white (2.5Y7/1-8/1), with a few fine fibrous roots, single grain, loose, moist	4.4	0.01	
0.5-1.0		A2	Sand (SP) fine-grained white (2.5Y8/1), nil to very low organics, no fibrous roots, single-grain loose, moist	4.4	0.0	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
1.0-1.5		A2	Sand (SP) as above			
1.5-2.0		A2	Sand (SP) as above	4.1	0.0	
2.0-3.0		A2	Sand (SP) continuing as above	4.3	0.0	
V7 0-0.2	Qpd1	A11	Sand (SP) fine-grained, grey (2.5Y6/1) with black inclusions of organics and some fibrous roots, single-grain, loose, moist	4.4	0.0	Giant Podzol – Uc2.3, with a weakly organic/humic A1 horizon; Aerlic/Semiaquic Podosol
0.2-0.4		A12	Sand (SP) fine-grained, grey (2.5Y5/1) with moderate amounts of organics and fibrous roots, single-grain loose	4.0	0.0	
0.4-0.5		A1-A2	Sand (SP) fine-grained as above but with inclusions of lighter grey sand, single-grain loose, moist	4.1	0.0	
0.5-1.0		A2	Sand (SP) fine-grained light grey (5Y7/1), nil or very low organics, single-grain and loose	4.0	0.0	
1.0-1.5		A2	Sand (SP) continuing as above light grey to white (5Y7/1-8/1)	4.3	0.0	No recovery beyond 1.5m – too powdery and dry
V8 0-0.2	Qpd1-Qpd3	A1	Sand (SP) fine-grained, grey (2.5Y5/1-6/1) with black specks of organics and a few fibrous roots, single-grain, loose, moist	4.6	0.0	Giant Podzol – Uc2.3, with a thin weakly organic/humic A1 horizon partly removed by erosion; Aerlic/Semiaquic Podosol.
0.2-0.4		A1-A2	Sand (SP) as above, grey to light grey (2.5Y6/1-7/1) low organics and no fibrous roots, single-grain, loose	4.1	0.0	
0.4-0.5		A21	Sand (SP) fine-grained, light grey (2.5Y7/1) very low organics, trace of fibrous roots, single-grain, loose just moist	4.0	0.0	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
0.5-1.0		A21	Sand (SP) as above	4.1	0.0	
1.0-2.0		A22	Sand (SP) fine-grained, light grey to white (5Y7/1-8/1) nil to very low organics, no fibrous roots, single grain, loose, must moist	4.1	0.0	
2.0-3.0		A22	Sand (SP) fine-grained, white 2.5Y8/1) as above, continuing	4.3	0.0	
V9 0-0.2	Qpd1	A12	Sand (SP) fine-grained grey (2.5Y5/1) with moderate to high organics and fibrous roots, single-grain, loose, some weakly cohesive lumps	4.1	0.0	Crestal area in low banksia shrubland; Giant Podzol – Uc2.3; Humose Aeric/Semiaquic Podosol
0.2-0.4		A1	Sand (SP) fine-grained grey (2.5Y5.1) as above but with moderate amount of organics and fibrous roots	3.8	0.0	
0.4-0.5		A1-A2	Sand (SP) as above but with lighter grey (2.5Y6/1) sand inclusions and moderate levels of fibrous root matter	3.6	0.0	
0.5-1.5		A2	Sand (SP) fine-grained light grey (2.5Y7/1), nil to very low organics and no fibrous roots, single-grain, loose, just moist	3.9	0.0	
1.5-2.5		A2	Sand (SP) fine-grained, white (2.5Y8/1), nil to very low organics, no fibrous roots, single grain, loose.	4.1	0.0	
2.5-3.0		A2	Sand (SP) as above, very fine-grained, powdery loose and dry	4.2	0.0	
V10 – 0.01	Qpd5	A1	Sand (SP) fine-grained grey (2.5Y5/1) with high weakly cohesive lumps of organic matter content and fibrous roots	4.5	0.07	Giant Podzol – Uc2.3, with a mod. thick, highly organic/humic A1 horizon; Humose Aeric/Semiaquic Podosol
0.1-0.2		A1	Sand (SP) as above with high organic matter content			

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
0.2-0.3		A1	Sand (SP) fine-grained, dark grey to grey (2.5Y4/1-5/1), with low to moderate amounts of organic matter and fibrous roots, dry	4.1	0.03	Effective limit of useful organic matter content
0.3-0.4		A1	Sand (SP) as above, grey (2.5Y5/1)			
0.4-0.5		A21	Sand (SP) fine-grained, grey (5Y5/1) loose, single-grain some fibrous roots and low amounts of organic matters, dry	4.2	0.0	
0.5-1.0		A21	Sand (SP) fine-grained light grey 5Y7/1), few inclusions of organic matter, moist	4.3	0.0	
1.0-1.5		A22	Sand (SP) fine-grained white 2.5Y8/1), must moist	4.1	0.0	
1.5-2.0		A22	Sand (SP) as above	4.4	0.01	
2.0-2.5		A22	Sand (SP) as above, moist	4.4	0.0	
2.5-3.0		A22	Sand (SP) continuing as above	4.5	0.0	
V11-0-0.1	Qpd3	A1	Sand (SP) fine-grained, grey 2.5Y5/1) with high amounts of organic matter and fibrous roots, some weakly cohesive lumps	4.2	0.0	Giant Podzol – Uc2.3, with a thick highly organic/humic A1 horizon; Humose Aeric/Semiaquic Podosol
0.1-0.2		A1	Sand (SP) fine-grained as above, loose, single grain	-	-	
0.2-0.3		A1	Sand (SP) fine-grained, dark grey (2.5Y4/1), loose, single-grain, medium levels of organics, seed stock and fibrous roots	3.6	0.03	
0.3-0.4		A1	Sand (SP) as above	-	-	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
0.4-0.5		A1	Sand (SP) fine-grained, grey (2.5Y5/1) with low to moderate levels of organics and fibrous roots	3.9	0.0	
0.5-1.0		A21	Sand (SP) fine-grained, light grey (5Y6/1-7/1), single-grain loose, very low amounts of organics, moist	3.9	0.0	
1.0-1.5		A21	Sand (SP) fine-grained, light grey (5Y7/1), single-grain, loose moist	4.0	0.0	
1.5-2.0		A22	Sand (SP) fine-grained, white (2.5Y8/1) single-grain, loose, moist	4.3	0.01	
2.0-2.5		A22	Sand (SP) as above	4.2	0.0	
2.5-3.0		A22	Sand (SP) continuing as above	4.2	0.0	
V12 0-0.2	Qpd3	A11	Sand (SP) fine-grained, dark grey to grey (2.5Y4/1-5/1) with black specks of organics and moderate fibrous root content, single-grain tending to weak cohesive humic lumps	4.6	0.0	Podzol – Uc2.32, with a thick organic/humic A1 horizon; Humose Aeric/Semiaquic Podosol
0.2-0.4		A11	Sand (SP) as above with low to moderate fibrous root matter, grey (2.5Y5/1)	3.8	0.0	
0.4-1.0		A12	Sand (SP) as above, grey (2.5Y6/1) with low organics and nil to very low fibrous roots	3.9-4.0	0.0	Water added to hole to assist recovery
1.0-1.5		A2	Sand (SP) fine-grained, light grey 2.5Y7/1), very low organics, no fibrous roots, single-grain loose	4.9	0.0	
1.5-2.0		A2	Sand (SP) as above continuing but with some yellowish red staining	4.8	0.0	Possibly approaching indurated ferruginous layer

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
V13-0-0.1	Qpd1	A1-2	Sand (SP) fine-grained, grey (2.5Y6/1), with low amounts of organics and fibrous roots, single-grain, loose, most	5.0	0.0	Podzol – Uc2.32, with a thin weakly organic/humic A1 horizon. Vegetation absent in this area, moderate surface sheet/wind erosion; Sesquic Semiaquic Podosol
0.1-0.2		A1-2	Sand (SP) fine-grained, grey (2.5Y6/1), as above most	4.7	0.0	Low content of fibrous roots
0.2-0.3		A2	Sand (SP) as above grey (10YR6/1) but with 10% of soft-firm ferruginous (Fe) concretions, and low organics and fibrous roots	4.8	0.0	Rounded Fe concretions (10-15mm)
0.3-0.4		A-B	Loamy sand (SP-SC) with 40-50% rounded Fe concretions (5-20mm), yellowish red, (5YR4/6)	4.5	0.01	Unable to dig with land auger below 0.4m
V14 0-0.2	Qpd3	A1	Sand (SP) fine-grained, grey (2.5Y6/1) with black flecks of organics and low fibrous roots content, single-grain, loose	4.3	0.0	Podzol – Uc2.32, with a thin weakly organic/humic A1 horizon; Sesquic Semiaquic Podosol
0.2-0.4		A21	Sand (SP) fine-grained, light grey to white (2.5Y7/1-8/1), few fibrous roots	-	-	
0.4-1.0		A22	Sand (SP) fine-grained, white 2.5Y8/1 nil to very low organics or fibrous root matter, single-grain, loose	4.7	0.0	
1.0-1.5		A22	Sand (SP) as above, white (2.5Y6/1) with some brownish yellow staining	4.4	0.0	
1.5-2.25		B1	Sand (SP) fine-grained, brownish yellow (10YR6/6) with a trace of silty or clayey fines	4.5	0.0	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
2.25-2.75		B2	Gravelly Loamy Sand (SP-SM) dark yellowish brown (10YR4/6) sand is fine-grained with approx 5-10% silt/clayey fines and 25-30% ferruginous gravel (5.15mm)	4.7	0.0	Upper level of the (B) horizon substrate, very hard unable to penetrate below 2.75m.
V15 0.0-1	Qpd1	A1	Sand (SP) fine-grained, grey (2.5Y5/1) with black flecks of organics and high fibrous roots content, single-grain loose	4.3	0.0	Giant Podzol – Uc2.3, with a thick organic/humic A1 horizon; Aeric/Semi-aquic Podosol
0.1-0.4		A1	Sand (SP) fine-grained, very dark grey (2.5Y3/1) with high organics and low fibrous root material, single-grain loose	3.7	0.04	
0.4-0.5		A1	Sand (SP) fine-grained, dark grey 2.5Y4/1 as above but with a few charcoal inclusions	3.7	0.0	
0.5-1.0		A1-A2	Sand (SP) fine-grained, grey (2.5Y5/1) low organics and nil to low fibrous root matter, single-grain loose	3.8	0.0	
1.0-2.0		A2	Sand (SP) fine-grained, light-grey (2.5Y7/1) nil to very low organic, single-grain loose, just moist	4.1	0.0	
2.0-3.0		A2	Sand (SP) as above, continuing	3.9	0.0	
V16 0-0.2	Qpd2	A1	Sand (SP) fine-grained, grey (2.5Y5/1) with low to moderate organics and charcoal inclusions, some fibrous roots, single-grain, loose, dry	4.1	0.0	
0.2-0.4		A1-A2	Sand (SP) fine-grained, grey to light grey (2.5Y6/1-7/1), low organics, a few fibrous roots, single-grain, loose	4.1	0.0	Podzol – Uc2.34, with a thin weakly organic/humic A1 horizon; Aeric/Semi-aquic Podosol
0.4-0.5		A2	Sand (SP) fine-grained, grey to light grey (2.5Y6/1-7/1), low organics a few fibrous roots, single-grain, loose	4.1	0.0	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
0.5-1.0		A2	Sand (SP) as above with slight yellow brown staining	4.4	0.0	
1.0-1.5		B	Gravelly sand (GP-SP) sands fine-grained yellowish brown (10YR5/4) with approximately 30% sub-rounded ferruginous gravel (to 20mm)	4.0	0.0	Very hard unable to penetrate beyond 1.5m.
1D/ 0-0.5	Qpd5	A1	Sand (SP) fine-grained, dark grey (2.5Y4/1) with low to moderate levels of organics, some fibrous roots, moist single-grain, loose	3.7	0.6	Lower slope adjacent to drainage Giant Podzol – Uc2.3; Semiaquic Humic/Alislic Podzol; (Lab.sample) (Lab. sample)
0.5-1.0		A2	Sand (SP) fine-grained, white (2.5Y8/1) moist single-grain loose	4.6	0.0	(Lab.sample)
1.0-1.5			Sand (SP) fine-grained, white (2.5Y8/1), continuing as above	4.5	0.0	(Lab.sample)
1.5-2.0			Sand (SP) fine to medium-grained, white (2.5Y8/1) moist single-grain loose	4.4	0.0	
2.0-2.5+			Sand (SP) fine to medium-grained, white (2.5Y8/1), continuing as above	4.0	0.0	A2 horizon continues to a depth of 10.1m
10.1		B	Indurated sand (Coffee Rock)	-	-	Indurated sand layer
2D/ 0-0.5	Qpd5	A	Sand (SP) fine-grained, very dark grey (10YR3/1), high organic content, moist, single-grain loose to slightly cohesive	3.2	0.0	Floor of drainageway; sandy organic soil O-Uc5.11; Acidic Sapric Organosol
0.5-1.0			Sand (SP) fine-grained, very dark grey (10YR3/1) as above	3.2	0.0	(Lab. sample)
1.0-1.5		B1	Sand (SP) fine-grained, very dark grey to black (2.5Y2.5/1), very high organic content moist, single-grain loose to slightly cohesive fines content	3.2	0.0	(Lab. sample)
1.5-2.0			Sand (SP) fine-grained, very dark grey (2.5Y3/1), high organic content very moist, single-grain loose to slightly cohesive fines content	3.3	0.0	(Lab. sample)
2.0-2.5		B2	Silty and Light Clayey Sand (SM-SP), sand is fine-grained, very dark grey (2.5Y3/1), highly organic, saturated (completely decomposed organic matter), slightly cohesive to single-grain, loose	3.4	0.0	Indurated sand (coffee rock) encountered at 2.6m

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
3/ 0-0.3	Qpd1	A1-A2	Sand (SP) fine-grained light grey to white (2.5Y7/1-8/1), trace of organics, some fibrous roots, dry, single-grain, loose	4.0	0.0	Undulating low hilly lands; Giant Podzol – (Uc2.31); Semiaquic Humic/Aisilic Podosol; (Lab.sample)
0.3-1.0		A2	Sand (SP) fine-grained, white (2.5Y8/1), just moist, single-grain loose	4.3	0.0	(Lab. Sample)
1.0-1.5			Sand (SP) fine-grained, white (2.5Y8/1), as above	4.5	0.0	(Lab. Sample)
1.5-2.0			Sand (SP) fine-grained, white (2.5Y8/1), as above	4.5	0.0	(Lab. Sample)
2.0-2.5			Sand (SP) fine-grained, white (2.5Y8/1), as above, continuing	4.7	0.0	
2.5-11.0		B	Orange-brown sand with thin lenses of indurated sand	-	-	Coffee rock.
11.0+			Dark brown indurated sand			
4/ 0-0.15	Qpd4	A1-A2	Sand (SP) fine-grained, light grey (2.5Y7/1m) to white (2.5Y8/1d), trace of organics and plant debris, dry, single-grain, loose	4.2	0.0	Undulating lowlands and low rounded rises; Giant Podzol (Uc2.31); Aerice Humosequic Podosol; (Lab.sample)
0.15-0.4			Sand (SP) fine-grained, as above, with a slight increase in organics and plant debris, dry, single-grain, loose	4.2	0.0	(Lab.sample)
0.4-0.9		A2	Sand (SP) fine-grained, light grey (2.5Y7/1), moist, nil to very slight organics content, single-grain, non-cohesive, loose	4.4	0.0	(Lab.sample)
0.9-1.6			Sand (SP) fine-grained, light grey (2.5Y7/1), as above, slightly more moist	4.6	0.0	
1.6-2.2			Sand (SP) fine-grained, light grey to white (2.5Y7/1-8/1), nil to very low organics, moist, single-grain, loose	4.6	0.0	(Lab.sample)
2.2-2.6			Sand (SP) fine-grained, light grey to white (2.5Y7/1-8/1), continuing as above	4.7	0.0	
11.0-14.0		B	Fine to medium-grained brown sand (SP)	-	-	
14.0+			Weakly cemented Coffee Rock, dark brown.	-	-	

Site ID and Sample Depth (m)	Land Unit	Soil Horizon	Soil Description	Soil pH (1:5 H ₂ O)	EC (1:5 H ₂ O) (mS/cm)	Comments/Soil Classification
5/ 0-0.3	Qpd3	A1	Sand (SP) fine-grained, grey (2.5Y5/1) with moderate amounts of organics and fibrous roots, just moist, single grain, loose	3.6	0.0	Steep planar dune ridge slopes; Giant Podzol (Uc2.31); Aeric Humosequic Podosol; (Lab.sample)
0.3-0.7			Sand (SP) fine-grained, grey (2.5Y5/1), as above with low to moderate amounts of organic matter	3.5	0.0	(Lab.sample)
0.7-1.4		A21	Sand (SP) fine-grained, light grey to white (2.5Y7/1), low organics, some plant debris, moist, single-grain, loose	3.5	0.0	(Lab.sample)
1.4-2.0			Sand (SP) fine-grained, white (2.5Y8/1), moist, nil to very low organics, single grain, loose	3.9	0.0	(Lab.sample)
2.0-4.0		A22	Sand (SP) fine-grained, white (2.5Y8/1), low organics, some plant debris, very moist single-grain, loose	4.0	0.0	
4.0+		B	Sand (SP) fine-grained, grey-brown with light grey and white sand inclusions	-	-	Coffee rock encountered at 23.0m

Appendix A

**Appendix A.2 - Summary of Laboratory Test
Results and Test Certificates**

Appendix A.2 – Summary of Laboratory Test Results and Test Certificates

Analysis	Site No.	1D/	1D/	1D/	2D/	2D/	2D/	2D/	3/	3/	3/
	Depth (m)	0-0.5	0.5-1.0	1.0-1.5	0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	0-0.3	0.3-1.0	1.0-1.5
	Land Unit	Qpd5			Qpd5				Qpd1		
pH (1:5 H ₂ O)	Unit-	4.7	5.5	5.5	4.6	4.6	4.6	4.5	5.3	5.6	5.6
EC (1:5 H ₂ O)	dS/m	0.02	<0.01	<0.01	0.02	0.01	0.02	0.02	0.01	<0.01	<0.01
Chloride (Cl)	mg/kg	20	21	18	18	21	26	19	18	18	21
Nitrate Nitrogen	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phosphorus (P)	mg/kg	8	1	1	6	3	4	5	1	2	1
Organic Matter	%	1.4	<0.1	<0.1	0.8	0.9	1.1	1.4	<0.1	<0.1	<0.1
Sulfur (S)	mg/kg	2.8	<1.0	<1.0	2.8	2.2	5.3	8.0	<1	<1	<1
Calcium (Ca)	mg/kg	43.0	3.0	5.7	34.0	29.0	67.0	46.0	14.0	4.5	5.4
Potassium (K)	mg/kg	27.0	<1.0	20.0	19.0	13.0	<1	14.0	13.0	6.8	9.2
Magnesium (Mg)	mg/kg	20.0	6.8	2.6	32.0	30.0	46.0	76.0	15.0	6.0	3.4
Sodium (Na)	mg/kg	<1	<1	<1	14.0	11.0	11.0	<1	<1	<1	15.0
Aluminium (Al)	mg/kg	7.1	0.7	1.8	13.0	13.0	14.0	30.0	1.4	0.0	0.0
CEC - (ECEC)	meq/100g	0.54	0.09	0.12	0.69	0.62	0.92	1.24	0.25	0.09	0.15
Ex. Sodium	meq/100g	<0.1	<0.1	<0.1	0.06	0.05	0.05	<0.1	<0.1	<0.1	0.07
Ex. Potassium	meq/100g	0.07	<0.1	0.05	0.05	0.03	<0.01	0.04	0.03	0.02	0.02
Ex. Calcium	meq/100g	0.22	0.02	0.03	0.17	0.15	0.33	0.23	0.07	0.02	0.03
Ex. Magnesium	meq/100g	0.17	0.06	0.02	0.27	0.25	0.38	0.64	0.13	0.05	0.03
Ex. Aluminium	meq/100g	0.08	0.01	0.02	0.14	0.14	0.16	0.33	0.02	0.0	0.0
Ex. Sodium (ESP)	%	<0.1	<0.1	<0.1	8.7	8.1	5.4	<0.1	<0.1	<0.1	48.7
Ex. Potassium %	%	13.0	<0.1	41.7	7.2	4.8	<0.1	3.2	12.0	22.2	13.3
Ex. Calcium %	%	40.7	22.2	25.0	24.6	24.2	35.9	18.5	28.0	22.2	20.0
Ex. Magnesium %	%	31.5	66.7	16.7	39.1	40.3	41.3	51.6	52.0	55.6	20.0
Ex. Aluminium %	%	14.8	11.1	16.7	20.3	22.6	17.4	26.6	8.0	0.0	0.0
Ca/Mg	Ratio	1.3	0.3	1.5	0.6	0.6	0.9	0.4	0.5	0.4	1.0
Copper (Cu)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Iron (Fe)	mg/kg	35.0	4.0	5.0	25.0	17.0	16.0	13.0	6.0	2.0	2.0
Manganese (Mn)	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Zinc (Zn)	mg/kg	0.6	0.2	0.5	0.3	0.3	0.2	0.3	0.2	<0.1	0.2
Boron (B)	mg/kg	<0.5	<0.1	<0.1	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

[illegible]



This is to certify that the undermentioned sample was analysed and this certificate was issued at SGS Agritech, 214 McDougall St., Toowoomba QLD 4350.
Phone: 0011+61+7+46330599. NATA accredited laboratory 2120.

CTW.2605730

Certificate of Analysis

Client: U.R.S.
Sample Date: 5/12/2006
Report Date: 21/12/2006

Submitted by: GJR Holdings P/L
Markings: Site ID / 0-0.5
Laboratory No: 2006018835

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		4.7	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	8	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	27	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	2.8	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	43	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	20	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	7	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.6	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	35	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	1.4	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.02	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	20	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.54		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.07	13.0 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.22	40.7 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.17	31.5 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.08	14.8 %	SOL044A
Ca/Mg Ratio		1.3		SOL044A

(< = Less than)

Page 1 of 1
TOOWOOMBA

For and on behalf of
SGS Australia Pty Ltd

The results apply only to the sample analysed. The sample on which the test was performed was not collected by or on behalf of SGS Agritech. This certificate is discrete and can only be reproduced in full.



This is to certify that the undermentioned sample was analysed and this certificate was issued at SGS Agritech, 214 McDougall St., Toowoomba QLD 4350.
Phone: 0011+61+7+46330599. NATA accredited laboratory 2120.

CTW.2605730

Certificate of Analysis

Client: U.R.S.
Sample Date: 5/12/2006
Report Date: 21/12/2006

Submitted by: GJR Holdings P/L
Markings: Site 1D / 0.5-1.0
Laboratory No: 2006018836

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.5	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	<1	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	3	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	7	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	1	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.2	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	4	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	<0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	21	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.09		SOL044A
EXCHANGE SODIUM	meq/100g	<0.01	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	<0.01	<0.1 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.02	22.2 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.06	66.7 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.01	11.1 %	SOL044A
Ca/Mg Ratio		0.3		SOL044A

(< = Less than)

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CTW.2605730

Certificate of Analysis

Client: U.R.S.
Sample Date: 5/12/2006
Report Date: 21/12/2006

Submitted by: GJR Holdings P/L
Markings: Site 1D / 1.0-1.5
Laboratory No: 2006018837

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.5	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	20	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	6	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	3	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	2	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.5	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	5	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.1	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	<0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	18	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.12		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.05	41.7 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.03	25.0 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.02	16.7 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.02	16.7 %	SOL044A
Ca/Mg Ratio		1.5		SOL044A

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CTW.2605730

Certificate of Analysis

Client: U.R.S.
Sample Date: 5/12/2006
Report Date: 21/12/2006

Submitted by: GJR Holdings P/L
Markings: Site 2D / 0-0.5
Laboratory No: 2006018838

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		4.6	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	6	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	19	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	2.8	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	34	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	32	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	13	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.3	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	25	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	0.6	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	0.8	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.02	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	14	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	18	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.69		SOL044A
EXCHANGE SODIUM	meq/100g	0.06	8.7 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.05	7.2 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.17	24.6 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.27	39.1 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.14	20.3 %	SOL044A
Ca/Mg Ratio		0.6		SOL044A

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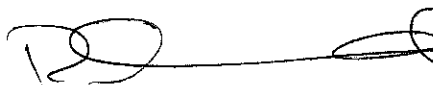
Certificate of Analysis

Client: U.R.S. Submitted by: GJR Holdings P/L
Sample Date: 5/12/2006 Markings: Site 2D / 0.5-1.0
Report Date: 21/12/2006 Laboratory No: 2006018839

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		4.6	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	3	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	13	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	2.2	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	29	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	30	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	13	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.3	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	17	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	0.9	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	11	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	21	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.62		SOL044A
EXCHANGE SODIUM	meq/100g	0.05	8.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.03	4.8 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.15	24.2 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.25	40.3 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.14	22.6 %	SOL044A
Ca/Mg Ratio		0.6		SOL044A

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Client: U.R.S.		Submitted by: GJR Holdings P/L			
Sample Date: 5/12/2006		Markings: Site 2D / 1.0-1.5			
Report Date: 21/12/2006		Laboratory No: 2006018840			
Analysis	Unit	Result	Method	Reference	
ACIDITY					
pH		4.6	1:5 Soil/Water	SOL003/SOL001/1	
MAJOR ELEMENTS					
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030	
PHOSPHORUS	P mg/kg	4	Bicarbonate extract	SOL005/001/4	
POTASSIUM	K mg/kg	<1	Ammonium acetate	SOL044	
SECONDARY ELEMENTS					
SULPHUR	S mg/kg	5.3	KCl-40	SOL001/6-2	
CALCIUM	Ca mg/kg	67	Ammonium acetate	SOL044	
MAGNESIUM	Mg mg/kg	46	Ammonium acetate	SOL044	
ALUMINIUM	Al mg/kg	14	Potassium Chloride Extract	SOL002/1-2	
TRACE ELEMENTS					
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12	
ZINC	Zn mg/kg	0.2	DTPA Extract	SOL001/9/10/11/12	
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12	
IRON	Fe mg/kg	16	DTPA Extract	SOL001/9/10/11/12	
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13	
ORGANIC MATTER	%	1.1	WALKLEY-BLACK	SOL002/1	
SALINITY					
CONDUCTIVITY	dS/m	0.02	1:5 Soil/Water	SOL007/SOL002/2	
SODIUM	Na mg/kg	11	Ammonium acetate	SOL044	
CHLORIDE	Cl mg/kg	26	Aqueous extract	SAL003	
CALCULATIONS					
CATION EXCHANGE	meq/100g	0.92		SOL044A	
EXCHANGE SODIUM	meq/100g	0.05	5.4 %	SOL044A	
EXCHANGE POTASSIUM	meq/100g	<0.1	<0.1 %	SOL044A	
EXCHANGE CALCIUM	meq/100g	0.33	35.9 %	SOL044A	
EXCHANGE MAGNESIUM	meq/100g	0.38	41.3 %	SOL044A	
EXCHANGE ALUMINIUM	meq/100g	0.16	17.4 %	SOL044A	
Ca/Mg Ratio		0.9		SOL044A	

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Certificate of Analysis

Client: U.R.S. Submitted by: GJR Holdings P/L
Sample Date: 5/12/2006 Markings: Site 2D / 1.5-2.0
Report Date: 21/12/2006 Laboratory No: 2006018841

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		4.5	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	5	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	14	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	8.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	46	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	76	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	30	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.3	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	13	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	1.4	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.02	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	19	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	1.24		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.04	3.2 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.23	18.5 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.64	51.6 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.33	26.6 %	SOL044A
Ca/Mg Ratio		0.4		SOL044A

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Certificate of Analysis

Client: U.R.S. Submitted by: GJR Holdings P/L
Sample Date: 5/12/2006 Markings: Site 3 / 0-0.3
Report Date: 21/12/2006 Laboratory No: 2006018842

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.3	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	13	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	14	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	15	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	1	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.2	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	6	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.6	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	18	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.25		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.03	12.0 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.07	28.0 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.13	52.0 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.02	8.0 %	SOL044A
Ca/Mg Ratio		0.5		SOL044A

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Certificate of Analysis

Client: U.R.S.
Sample Date: 5/12/2006
Report Date: 21/12/2006

Submitted by: GJR Holdings P/L
Markings: Site 3 / 0.3-1.0
Laboratory No: 2006018843

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.6	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	2	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	7	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	5	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	6	Ammonium acetate	SOL044
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	2	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	<0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	18	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.09		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.02	22.2 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.02	22.2 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.05	55.6 %	SOL044A
Ca/Mg Ratio		0.4		SOL044A

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CTW.2605730

Certificate of Analysis

Client: U.R.S. Submitted by: GJR Holdings P/L
Sample Date: 5/12/2006 Markings: Site 3 / 1.0-1.5
Report Date: 21/12/2006 Laboratory No: 2006018844

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.6	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	9	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	5	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	3	Ammonium acetate	SOL044
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.2	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	2	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	<0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	15	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	21	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.15		SOL044A
EXCHANGE SODIUM	meq/100g	0.07	46.7 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.02	13.3 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.03	20.0 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.03	20.0 %	SOL044A
Ca/Mg Ratio		1.0		SOL044A

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Certificate of Analysis

Client: U.R.S. Submitted by: GJR Holdings P/L
Sample Date: 5/12/2006 Markings: Site 4 / 0-0.15
Report Date: 21/12/2006 Laboratory No: 2006018845

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.2	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	<1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	5	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	10	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	6	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	1	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.3	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	2	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	16	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.12		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.01	8.3 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.05	41.7 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.05	41.7 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.01	8.3 %	SOL044A
Ca/Mg Ratio		1.0		SOL044A

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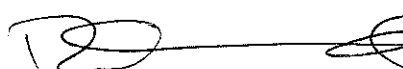
CTW.2605730

Certificate of Analysis

Client: U.R.S.		Submitted by: GJR Holdings P/L		
Sample Date: 5/12/2006		Markings: Site 4 / 0.15-0.4		
Report Date: 21/12/2006		Laboratory No: 2006018846		
Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.1	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	4	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	14	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	8	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	3	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.2	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	2	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	8	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	15	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.21		SOL044A
EXCHANGE SODIUM	meq/100g	0.03	14.3 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	0.01	4.8 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.07	33.3 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.06	28.6 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.04	19.0 %	SOL044A
Ca/Mg Ratio		1.2		SOL044A

(< = Less than)

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Certificate of Analysis

Client: U.R.S.
Sample Date: 5/12/2006
Report Date: 21/12/2006

Submitted by: GJR Holdings P/L
Markings: Site 4 / 0.4-0.9
Laboratory No: 2006018847

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.5	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	<1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	<1	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	12	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	6	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	<0.5	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	1	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	<0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	17	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.11		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.06	54.5 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.05	45.5 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	<0.1	<0.1 %	SOL044A
Ca/Mg Ratio		1.2		SOL044A

(< = Less than)

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Certificate of Analysis

Client: U.R.S.		Submitted by: GJR Holdings P/L		
Sample Date: 5/12/2006		Markings: Site 5 / 0-0.3		
Report Date: 21/12/2006		Laboratory No: 2006018848		
Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		4.7	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	4	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	<1	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	130	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	57	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	8	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.2	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	19	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	1.6	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	24	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	1.21		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.64	52.9 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.48	39.7 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.09	7.4 %	SOL044A
Ca/Mg Ratio		1.3		SOL044A

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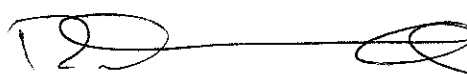
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Certificate of Analysis

Client: U.R.S.		Submitted by: GJR Holdings P/L			
Sample Date: 5/12/2006		Markings: Site 5 / 0.3-0.7			
Report Date: 21/12/2006		Laboratory No: 2006018849			
Analysis	Unit	Result	Method	Reference	
ACIDITY					
pH		4.6	1:5 Soil/Water		SOL003/SOL001/1
MAJOR ELEMENTS					
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract		SOL030
PHOSPHORUS	P mg/kg	3	Bicarbonate extract		SOL005/001/4
POTASSIUM	K mg/kg	<1	Ammonium acetate		SOL044
SECONDARY ELEMENTS					
SULPHUR	S mg/kg	<1.0	KCl-40		SOL001/6-2
CALCIUM	Ca mg/kg	40	Ammonium acetate		SOL044
MAGNESIUM	Mg mg/kg	28	Ammonium acetate		SOL044
ALUMINIUM	Al mg/kg	5	Potassium Chloride Extract		SOL002/1-2
TRACE ELEMENTS					
COPPER	Cu mg/kg	<0.1	DTPA Extract		SOL001/9/10/11/12
ZINC	Zn mg/kg	0.2	DTPA Extract		SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract		SOL001/9/10/11/12
IRON	Fe mg/kg	6	DTPA Extract		SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract		SOL001/13
ORGANIC MATTER	%	0.6	WALKLEY-BLACK		SOL002/1
SALINITY					
CONDUCTIVITY	dS/m	0.01	1:5 Soil/Water		SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate		SOL044
CHLORIDE	Cl mg/kg	24	Aqueous extract		SAL003
CALCULATIONS					
CATION EXCHANGE	meq/100g	0.49			SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %		SOL044A
EXCHANGE POTASSIUM	meq/100g	0.00	<0.1 %		SOL044A
EXCHANGE CALCIUM	meq/100g	0.20	40.8 %		SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.24	49.0 %		SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.05	10.2 %		SOL044A
Ca/Mg Ratio		0.8			SOL044A

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Certificate of Analysis

Client: U.R.S. Submitted by: GJR Holdings P/L
Sample Date: 5/12/2006 Markings: Site 5 / 0.7-1.4
Report Date: 21/12/2006 Laboratory No: 2006018850

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		4.7	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	<1	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	6	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	7	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	1	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.2	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	2	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	19	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.10		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.03	30.0 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.06	60.0 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.01	10.0 %	SOL044A
Ca/Mg Ratio		0.5		SOL044A

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Certificate of Analysis

Client: U.R.S. Submitted by: GJR Holdings P/L
Sample Date: 5/12/2006 Markings: Site 5 / 1.4-2.0
Report Date: 21/12/2006 Laboratory No: 2006018851

Analysis	Unit	Result	Method	Reference
ACIDITY				
pH		5.1	1:5 Soil/Water	SOL003/SOL001/1
MAJOR ELEMENTS				
NITROGEN (NITRATE)	N mg/kg	<1	Aqueous extract	SOL030
PHOSPHORUS	P mg/kg	1	Bicarbonate extract	SOL005/001/4
POTASSIUM	K mg/kg	<1	Ammonium acetate	SOL044
SECONDARY ELEMENTS				
SULPHUR	S mg/kg	<1.0	KCl-40	SOL001/6-2
CALCIUM	Ca mg/kg	3	Ammonium acetate	SOL044
MAGNESIUM	Mg mg/kg	3	Ammonium acetate	SOL044
ALUMINIUM	Al mg/kg	1	Potassium Chloride Extract	SOL002/1-2
TRACE ELEMENTS				
COPPER	Cu mg/kg	<0.1	DTPA Extract	SOL001/9/10/11/12
ZINC	Zn mg/kg	0.2	DTPA Extract	SOL001/9/10/11/12
MANGANESE	Mn mg/kg	<1	DTPA Extract	SOL001/9/10/11/12
IRON	Fe mg/kg	1	DTPA Extract	SOL001/9/10/11/12
BORON	B mg/kg	<0.5	CaCl2 Extract	SOL001/13
ORGANIC MATTER	%	<0.1	WALKLEY-BLACK	SOL002/1
SALINITY				
CONDUCTIVITY	dS/m	<0.01	1:5 Soil/Water	SOL007/SOL002/2
SODIUM	Na mg/kg	<1	Ammonium acetate	SOL044
CHLORIDE	Cl mg/kg	17	Aqueous extract	SAL003
CALCULATIONS				
CATION EXCHANGE	meq/100g	0.06		SOL044A
EXCHANGE SODIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE POTASSIUM	meq/100g	<0.1	<0.1 %	SOL044A
EXCHANGE CALCIUM	meq/100g	0.02	33.3 %	SOL044A
EXCHANGE MAGNESIUM	meq/100g	0.03	50.0 %	SOL044A
EXCHANGE ALUMINIUM	meq/100g	0.01	16.7 %	SOL044A
Ca/Mg Ratio		0.7		SOL044A

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Appendix A

**Appendix A.3 - Guide to the Interpretation of
Soil Chemical/Fertility Levels**

Appendix A.3 – Guide to Interpretation of Soil Chemical/Fertility Properties

The following information and comments are included to provide a general guide and to assist in relation to the interpretation of general soil chemical and soil fertility attributes and should be read in conjunction with the results of the indicative testing in **Appendices A.1** and the summary of laboratory analytical results included in **Appendix A.2**.

Levels of Major Soil Nutrients

With respect to topsoil suitability and existing general levels of soil fertility, depending on soil texture and plant available moisture capacity, some of the more important soil chemical requirements relate to the general levels of soil available nitrogen, phosphorus, potassium and organic matter content. With respect to the surficial soil horizons, the general levels of soil nutrients relevant for normal plant growth are as follows:

Soil Nutrient Level Ratings						
Analyte	Unit	Very Low	Low	Medium	High	Very High
Nitrogen (NO ₃)	mg/kg	<5	5-15	15-25	25-50	>50
Phosphorus (P)	mg/kg	<5	5-10	10-17	18-25	25
Potassium (Ex. K)	me/100g	<0.2	0.2-0.3	0.3-0.7	0.7-2.0	>2.0
Organic Matter (OM)	%	<1.0	1.0-2.0	2.0-3.0	3.0-5.0	>5.0

A summary of the results of these analyses is as follows:

- Levels of nitrate nitrogen were very low in all samples analysed.
- Levels of phosphorus were mostly very low. Two sites (D1 and D2) had slightly higher but still low P levels in the surficial soil horizons.
- Levels of available (exchangeable) potassium (Ex. K) were very low in all samples analysed.
- Levels of organic matter (OM) content were mostly very low with the exception of the surficial soil horizon at site 1D and in the deeper subsoil horizons at site 2D.

Soil pH (1:5 H₂O)

Soil pH is a measure of the acidity or alkalinity of a soil. It characterises the chemical environment of the soil and provides a guide to likely mineral deficiencies and toxicities for plant growth. According to Bruce and Rayment (1982), the general interpretation for soil pH (1:5 H₂O) is as follows:

Soil pH (1:5 H ₂ O)	Soil Acidity/Alkalinity
8.5 or higher	Strongly or very strongly alkaline
7.5 to 8.4	Mildly to moderately alkaline
6.5 to 7.4	Neutral
6.4 to 5.5	Moderately to slightly acidic
5.4 to 4.5	Strongly to very strongly acidic
<4.5	Extremely acidic

The preferred range for most plants varies between pH 6.0 to 8.0 depending on the plant species.

Within the project area, all samples tested recorded pH levels within the extremely to strongly acidic range (pH 3.5-5.5).

Salinity – Electrical Conductivity (EC-1:5 H₂O)

Salinity relates to the presence of water soluble salts, mainly sodium, calcium and magnesium, which may be in the form of chlorides, sulfates or carbonates. High levels of salinity can severely affect plant growth and as a consequence increase the soil erosion potential. Salinity levels based on the laboratory determined EC (1:5 H₂O) expressed as mS/cm (dS/m), vary depending on the soil texture and have been rated in Hazelton and Murphy (1992). The approximate ranges are as follows:

Salinity Level	Electrical Conductivity – (1:5 H ₂ O)		
	Sand	Loam	Medium to Heavy Clays
Non saline	<0.10 mS/cm	<0.20 mS/cm	<0.30 mS/cm
Slightly saline	0.10-0.25 mS/cm	0.20-0.40 mS/cm	0.30-0.55 mS/cm
Moderately saline	0.25-0.47 mS/cm	0.40-0.80 mS/cm	0.56-1.15 mS/cm
Highly saline	0.48-0.95 mS/cm	0.81-1.60 mS/cm	1.16-2.30 mS/cm
Extremely saline	>0.95 mS/cm	>1.60 mS/cm	>2.30 mS/cm

All soils tested from within the project area were non-saline with EC values <0.10 mS/cm.

Chloride (Cl) – (1:5 H₂O)

A rating of chloride levels with respect to potential effects for plant growth (Bruce & Rayment – 1982) is provided below.

Chloride Concentration	Rating
<100 mg/kg (<0.01%)	Very low
100-300 mg/kg (0.01-0.03%)	Low
300-600 mg/kg (0.03-0.06%)	Medium
600-2000 mg/kg (0.06-0.20%)	High
>2000 mg/kg (>0.2%)	Unsustainable for all but very salt tolerant species

The results of the laboratory analyses indicate that all samples tested had very low Chloride levels throughout the profile depth analysed.

Cation Exchange Capacity (CEC) and Exchangeable Cations

Cation Exchange Capacity reflects the capacity of the soil to hold and exchange cations. It is a major controlling agent of stability of soil structure and nutrient availability for plant growth. Units are expressed as milli-equivalents per 100 g of soil (meq/100 g). Ratings for CEC range from <6 meq/100 g (very low), 6-12 meq/100 g (low), 12-25 meq/100 g (moderate), 25-40 meq/100 g (high) and >40 meq/100 g (very high).

The five most abundant cations present in soils are calcium (Ca²⁺), magnesium (Mg), potassium (K), sodium (Na) and in strongly acid soils, aluminium (Al). The cations manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn) are usually present in small amounts that do not contribute significantly to the total cation compliment. It is common practice therefore to measure the concentrations of only the

four or five most abundant cations. CEC may be measured directly, or the sum of the four major cations (Ca, Mg, Na, K) may be determined to give an approximate value of CEC termed - Effective CEC (ECEC). The individual major cations may then be expressed as a percentage of the CEC or ECEC. Hazelton and Murphy (1992) rate the levels of the basic cations as follows:

Basic Cation Concentrations (meq/100 g)					
Cation	Very Low	Low	Moderate	High	Very High
Calcium	0-2	2-5	5-10	10-20	>20
Magnesium	0-0.3	0.3-1.0	1-3	3-8	>8
Sodium	0-0.1	0.1-0.3	0.3-0.7	0.7-2.0	>2.0
Potassium	0-0.2	0.2-0.3	0.3-0.7	0.7-2.0	>2.0
Aluminium	<0.05	0.05-0.07	0.07-0.1	0.1	>0.1

A more meaningful relationship relevant to plant performance and growth is the relative proportions of the various exchangeable cations expressed as a percentage of the Effective Cation Exchange Capacity (ECEC). A guide to the desirable range of each of the major cations for healthy plant growth is as follows;

Ex. Cation/ECEC	%
Calcium (Ca)	65-80
Magnesium (Mg)	10-15
Potassium (K)	1-5
Sodium (Na)	0-1
Aluminium (Al)	<5

In this regard, given the predominantly sandy nature of the soils and that the effective CEC's for all samples tested were in the very low range (max. 1.2 meq/100g), overall the level of Ex. Ca percentage is low; Ex. Mg is generally very high; Ex. K is high in the organic rich surficial soil layers with the exception of Site 5 which had very low levels of Ex. K. Exchangeable Sodium percentage (ESP) is mostly very low, with the exception of the organic rich sands found at Site 2D and in the deeper subsoil layers at Site 3 and Site 4. Soils with an ESP of 6% or greater are considered to be sodic soils. Given that the soils tested are all strongly acidic, levels of Ex. Al are mostly very high.

Sodicity

Sodicity is the level of exchangeable sodium in the soil and is determined using the exchangeable sodium percentage (ESP) which is the amount of exchangeable sodium expressed as a percentage of the effective cation exchange capacity (ECEC). General ratings for sodicity established by Northcote and Skene (1972) are as follows:

ESP%	Rating
<6	Non-Sodic
6-14	Sodic
14-25	Strongly Sodic
>25	Very Strongly Sodic

Where the soil fines content is appreciable, sodic soils may exhibit the following problems:

- Very severe surface crusting;
- Likely dispersion on wetting;
- Very low infiltration and hydraulic conductivity;
- Very hard dense subsoils;
- High susceptibility to severe gully erosion;
- High susceptibility to tunnel erosion.

Based on the results of laboratory analyses summarised in **Appendix A.2**, the majority of the samples tested were non-sodic, with the exception of the samples from Site 2D which indicate the presence of sodic soil conditions. The immediate subsoil layer at Site 4 and the deeper subsoil layers at Site 3 indicate the presence of strongly to extremely sodic conditions respectively.

Ca/Mg Ratio

Levels of Exchangeable Calcium to Exchangeable Magnesium expressed as a (Ca/Mg) ratio, with values of <2.0 (in particular those close to or <1.0) in soils with an appreciable silt/clay fines content, are likely to be subject to clay dispersion resulting in the development of poor soil structural conditions and hard impermeable sub-soil conditions due to clay illuviation. ,

The results of laboratory analyses summarised in **Appendix A.2**, indicate the Ca/Mg ratio for all samples tested was mostly <1.0 and in places between 1.0-1.5. However this attribute may not be particularly relevant in the case of deep dune sand soil profiles which typically have very low fines content.

Organic Matter

Organic matter (OM%) is derived from the breakdown of plants and animal matter and is largely responsible for much of the physical and chemical fertility of the soil. Organic matter content is normally only measured in the topsoil horizon and is usually calculated from the levels of organic carbon (OC%) determined. As reported in Hazelton and Murphy (1992), levels of organic matter content have been ranked as shown in the tabulation below:

Organic Matter	Ranking	Soil Structure
<0.3%	Extremely low	Typical of subsoil levels or severely degraded or eroded surface soils
0.3-1.2%	Very Low to Low	Indicative of very poor to poor structural condition and structural stability.
1.2-1.7%	Moderate	Indicative of average to good structural condition and structural stability
1.7-2.9	High	Good structural condition and stability
>2.9%	High or very high	Indicative of good structural condition and high structural stability; soils may be water repellent.

Micronutrients

Micronutrients or trace elements are found in low concentrations in most soils and the availability is crop or plant species specific and pH dependent. As a general guide, levels of micronutrients have been evaluated by Baker (1991) as follows.

Micronutrient (mg/kg)	Very Low	Low	Medium	High	Very High
Copper (Cu)	<0.1	0.1-0.3	0.3-5	5-15	>15
Iron (Fe)	<40	40-80	80-200	200-500	>500
Zinc (Zn) - pH>7	<0.3	0.3-0.8	0.8-5	5-15	>15
Zinc (Zn) – pH<7	<0.2	0.2-0.5	0.5-5	5-15	>15
Manganese (Mn)	<1	1-2	2-50	50-500	>500
Boron (B)	<0.5	0.5-1	1-2	2-5	>5

Based on the results of the laboratory analyses summarised in **Appendix A.2**, levels of the micronutrients Cu, Fe, Mn and B were all very low, whilst Zn levels were mainly in the low to moderate range.

Appendix B

**Appendix B - Geomorphology Review - ML1108;
North Stradbroke Island, Queensland**

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GEOMORPHOLOGY REVIEW – ML 1108, NORTH STRADBROKE ISLAND, QUEENSLAND

INTRODUCTION

BACKGROUND

GeoCoastal (Australia) was commissioned by URS (Australia) Pty Ltd to conduct a review of data and published material available regarding the geomorphology of Mining Lease 1108 on North Stradbroke Island.

OBJECTIVES

Sources of information accessed and reviewed are as follows:

- Any additional relevant background information on the soils and geomorphology of the site,
- Mineral exploration (drilling) data,
- Occurrence and nature of indurated (coffee rock) zones and their influence on the likely depth of mining,
- Background scientific papers or articles,
- The most recent geological mapping data for North Stradbroke Island available from the Geological Survey of Queensland.

GEOMORPHOLOGY REVIEW – ML 1108, NORTH STRADBROKE ISLAND, QUEENSLAND

DUNE GEOMORPHOLOGY

BACKGROUND GEOLOGY

North Stradbroke Island consists of unconsolidated Quaternary sands overlying Triassic and Jurassic bedrock that varies in elevation between sea level in some locations on the western side of the island to >90m on the eastern side of the island (Laycock, 1975). These sands represent the successive overlay of a number of major episodic aeolian events interspaced by periods of stability that have occurred through much of the Quaternary and is continuing today (Thompson & Ward, 1975; Benussi, 1975). Ward (1977) and Ward & Grimes (1987) identify nine sand blowing events with intervening periods of strandplain development. The resulting formation is a massive transgressive dune field with north-west trending ridge lines.

DUNE MORPHOLOGY AND FORMATION

Morphology

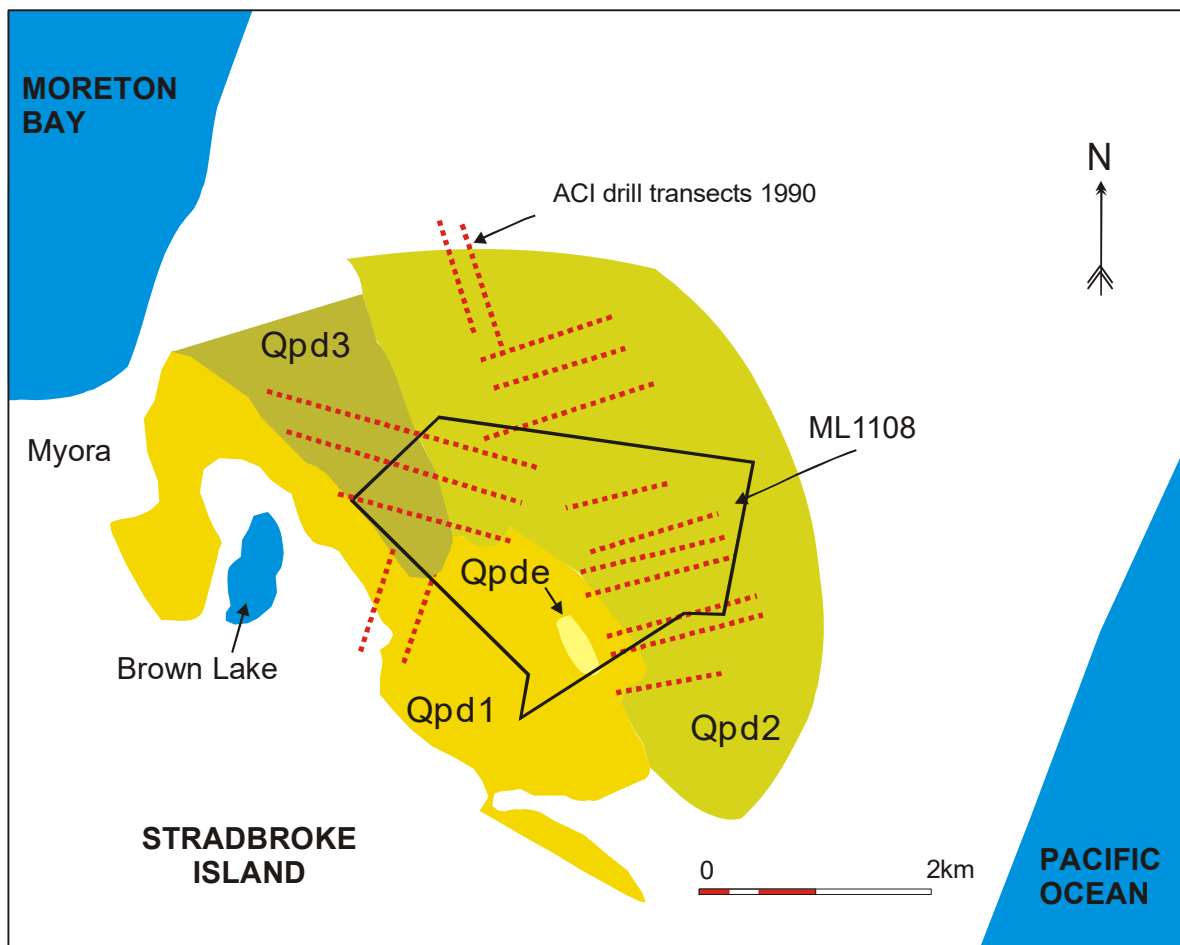
A number of authors have identified the complex stratigraphy of the North Stradbroke Island dunes resulting from the superimposition of generations of transgressive-dune stacking, and while the mechanisms for their formation are relatively simple to explain, the driving forces and timing of these major phases of dune sand accumulations is more complex, and the subject of ongoing debate.

Ward (2006) observes that the:

‘... relation of the dunes to the stranded foredunes of the coastal plains is a morphostratigraphic one, in which a time sequence is displayed, rather than a simple geographic one in which parabolic dunes form in some places and coastal foredunes in others according to accidents of local exposure. Thus, the parabolic dunes lie on prior strandplains, and on previously formed dunes, and the strandplains rest against the wave-cliffed margins of earlier dunes.’ (p.363)

At least three and possibly four stages of dune development have been recognised by Cranfield (*QDME; pers. comm*) who recently reviewed the geology of Stradbroke Island classifying the dunes using a similar system to that used by Grimes who mapped Moreton Island. This system identifies the various dune sequences within the Pleistocene (Qpd1 to Qpd3) and Holocene (Qhd1 to Qhd3). Within the mining lease area (ML1108) the dunes are all of Pleistocene age and Cranfield’s mapping of them is

illustrated in Figure1. Coffee rock exhibiting varying degrees of induration could be expected to have formed in relation to each stage of dune development.



LEGEND

- Qpd1 Pleistocene Dunes, parabolic, quartz sand (youngest)
- Qpd2 Pleistocene Dunes, parabolic, quartz sand
- Qpd3 Pleistocene Dunes, parabolic, quartz sand
- Qpde Pleistocene Dunes, parabolic, quartz sand (oldest)

Geology: L Cranfield Department of Mines and Energy

PROJECT: Review of Geomorphology - ML 1108, North Stradbroke Island, Queensland

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FIGURE 1:
ML 1108 illustrating ACI drilling
transects (1990) & dune classification
by Cranfield (Pers. Comm.).

Factors influencing dune formation

Debate about when in the cycle of sea level rise and fall major dune mobilisation phases occur, and the influence of other extraneous factors such as sediment reserves on the inner shelf, and offshore gradients is ongoing. A review of different theories was given by Pye and Bowman (1984). Succinctly summarised they are as follows:

- i. during sea level retreat ('regression') - large quantities of sand are exposed on the continental shelf to winds
- ii. during sea level advance ('transgression') - continuous coastal erosion destabilises and mobilises sand making it available for aeolian transport
- iii. during sea level highstand ('stillstand') – this period is generally considered the least likely period for major dune mobilisation because excess longshore transported sand is generally reworked into prograding beach-ridge barriers within this depositional setting and there is evidence of continuous dune deposition extending from beneath highstand sea levels. However, the superimposition of a number of high sea level stabilisations at levels within a close range may be a major contributing factor to the development of large stacked dune sequences (Graham & Larsen, 2003). Periods where sea level is marginally lower than the previous highstand, such as presently witnessed in the Holocene, would lead to the collection and storage of longshore transported sand into substantial strandplain ridge deposition, whereas subsequent marginally more elevated highstands would result in erosive realignment and remobilisation of this inner shelf and ridge sand transgressive dunes as sea level approached its new maximum. This superimposition of similar elevation highstands is feasible mechanism on a tectonically stable continental margin such as eastern Australia. Ward & Grimes (1987) propose that major dune building ceased shortly after the cessation of Holocene sea level rise c.a. 6,700 ¹⁴C yrs B.P.

Ward (2006) completes the list of possible sea level phases by proposing that active dune building began during the glacial periods (low sea level) when wind strengths were high and persisted as the sea level rose during the interglacial. He points to the earlier observation of Ward and Grimes (1987) that the continuation of dune sand below the highstand water level in support of his contention that the major dune building phases must have occurred during lowered sea level periods.

Other influences not directly sea level related may contribute to dune mobilisation such as fire or extended dry periods leading to destruction of vegetative cover and destabilisation initiating mobilisation (Lees *et. al.*, 1993). Regional bedrock physiography causing a shoreline arc to develop at a strongly oblique orientation to the prevailing wind direction may be a strong determinant on the propensity for transgressive dunes to initiate. However, these agents are not considered the major forcing functions.

Although generally favouring one explanation, most authors agree that these complex dune bodies may be the concatenation of a variety of depositional circumstances.

DUNE STRATIGRAPHY AND IMPLICATIONS FOR HYDROGEOLOGY

As each new transgressive dune advances across the island former dunes are reworked, modified and overlapped. This results in a very complex series of ridges and swales. The lateral juxtaposition of the Pleistocene dunes allows older dunes to be distinguished from younger dunes, although the degraded nature of the dunes can make individual dune identification difficult.

Soil development has been used to differentiate the dune units (Thompson, 1981). Between dune forming events the dunes were exposed to pedogenic processes over extended periods of time resulting in the development of deep podsols. Typically they produce a thick A horizon consisting of bleached white sand commonly overlying a humicrete (coffee rock) B horizon (Thompson and Ward, 1975). These humicrete layers typically form in the zone of watertable fluctuation, where humic substances from the accumulating surface litter, and iron from the upper soil leached through the profile are illuviated. Farmer *et. al.* (1983) propose that this humic B-horizon development is largely the result of coprecipitation between organic-rich surface waters and aluminium from groundwater.

Because these humicrete layers form in response to perched water tables in individual dunes, their ultimate geometry and degree of maturity is variable in response to erosive truncation and stacking of different generations of dune migrations punctuated by varying intervals of stabilisation. Cranfield (*pers. comm.*) indicated that he found up to three layers of coffee rock exposed at a single location (exposed during mining operations in other areas) when mapping Stradbroke Island. Drilling for the monitoring wells (URS, refer elsewhere this report) within ML1108 intersected coffee rock of varying degrees of induration at depths as shallow as 2.5m down to depths of 23m. In wells 2, 3 and 4 two layers of coffee rock were intersected indicating multiple episodes of dune building activity.

ACI drilled part of the area of ML1108 for silica sand in 1990 (approximate drill transects shown on Figure 1). ACI were only interested in the surficial leached sand layer and ceased drilling immediately brown sand was intersected. The brown sand was described as soft, and has been interpreted as the top of a humicrete horizon. The depth to this horizon varied from less than 2m to greater than 10m across the site.

The resultant stratigraphic architecture within these dune bodies is a complex series of gently convex humicrete layers which converge in some orientations, and are discontinuous in other orientations where they have been truncated by subsequent erosive events. This complexity, when combined with variable induration rendering these layers a mixture of aquitard and aquiclude properties, provides a challenging hydrogeological environment to model. This is consistent with the findings of McMahon (1963) who investigated the leases to the immediate east of the present subject area:

‘These first water-bearing sequences represent the location of elevated water-tables which are extremely irregular both in their areal extent and in the depth at which they are first encountered below the surface.’

GLOSSARY

Aquiclude

A body of relatively impermeable rock that is capable of absorbing water slowly but does not transmit it rapidly enough to supply a well or spring.

Aquitard

A *confining* bed that retards but does not prevent the flow of water to or from an adjacent aquifer; a *leaky confining bed*.

Concatenation of depositional circumstances

A union of depositional circumstances in a series, chain, or unbroken sequence.

Illuviated

Accumulated – the deposition in the lower soil of soluble or suspended materials transported from an upper horizon by the process of eluviation.

Strandplain

A prograded shore built seaward by waves and currents, and continuous for some distance along the coast. It is characterised by subparallel beach ridges and swales, in places with associated dunes.

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Appendix J

Groundwater Study (2007)

Revised Groundwater Investigations
Vance Lease ML 1108
North Stradbroke Island, QLD



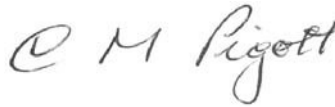
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Status: Final

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Section 1

Introduction

1.1 Introduction

URS Australia Pty Ltd (URS) has been commissioned by Unimin Australia Limited (Unimin) to provide consulting services associated with the proposed expansion of an existing silica and mineral sand mine on to 'Vance' Mining Lease 1108 (ML 1108), located on North Stradbroke Island, in Moreton Bay, Queensland (**Figure 1**). These consulting services were required as an integral component of the Environmental Studies Report for the proposed expansion of the Unimin North Stradbroke (UNS) Mine Project.

This report specifically comprises the groundwater component (hydrogeology) of the hydrological study and is an update from the previous work conducted by URS and reported as the "Environmental Studies Report for Proposed Stage 1 Development of Vance Mining Lease (ML1108), North Stradbroke Island, QLD" dated October 2006.

1.2 Project Description

ML 1108 is situated approximately 4 km north east of Dunwich on North Stradbroke Island, on 639 ha of land comprising relatively undisturbed native vegetation. ML 1108 is held 100% by Unimin. Topography of the site represents a series of high dune formations to a height of approximately 200 m. Natural drainage within the site is towards a central ephemeral drainage line, Cooroon Cooroonpah Creek, traversing the approximate centre of the lease from the south east to the north west.

ML 1108 is proposed to be dry mined by Unimin for silica sand and heavy minerals (as a by product.). Dune sand will be extracted from a shallow pit at the rate of up to 1 million tonnes per year. The operations will involve excavation and removal of silica sand to its base level followed by re-contouring and rehabilitation of the lowered land surface by replacement of topsoil and subsequent revegetation. Mining is proposed to extend onto ML 1108 from existing operations on the adjacent lease ML 7064. Processing of sand is proposed to be undertaken at existing facilities on ML 1124 (**Figure 1**). Sand shall be processed by gravity to separate impurities and heavy minerals, producing high purity silica sand primarily used for glass manufacture. Continuation of the mining process currently underway on ML 7064 into ML 1108 will enable the infrastructure to remain in its current location (on ML 1124), allowing Unimin to minimise the impact to the environment/community of any infrastructure relocation.

1.3 Study Scope

The overall aim of this project was to undertake a hydrogeology study to characterise the groundwater conditions within the mining lease as part of the environmental studies being undertaken to facilitate approvals for the proposed mine expansion programme.

To achieve this aim, the objectives of the hydrogeological investigations conducted were as follows:

- To establish the baseline conditions with respect to groundwater levels and water quality at, and in the immediate vicinity of, the Vance Mining Lease (the Site);
- To determine the potential impacts of the Vance Mining Lease mining operations on the sensitive environments at, and in the vicinity of, the site; and
- To provide the groundwater hydrology component of the Environmental Studies Report to the standard necessary to fulfil the requirements of Environmental Authority No. MIM900220203, specifically Schedule C - Water.

Section 2

Study Methodology

The objectives outlined in the study scope (**Section 1.3**) have been achieved through five primary tasks:

- 1) Review of existing groundwater information;
- 2) Field investigation;
- 3) Establishment of baseline groundwater conditions;
- 4) Identification and assessment of potential impacts to groundwater; and
- 5) Plan of management and mitigation measures.

2.1 Review of Existing Groundwater Environment

A detailed data search and literature review was undertaken upon commencement of the project. The following relevant data and information have been reviewed and used in this groundwater assessment:

- Queensland Department of Natural Resources and Water (DNRW) Groundwater Database (accessed 25 February 2005 and 11 July 2007) for the area bound by 27.38 degrees south / 153.38 degrees east and 27.62 degrees south / 153.55 degrees east, and for the area bound by 27.42 degrees south / 153.39 degrees east and 27.51 degrees south / 153.49 degrees east respectively.
- Consolidated Rutile Ltd (CRL) drill logs for exploration conducted within the lease boundary for the period 1972 to 1990.
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2.2 Field Investigation

URS completed an initial field investigation of the Vance Mining Lease and surrounding area on 28 February 2005. Accompanied by Unimin environmental personnel, the Vance Mining Lease and adjacent leases (ML1124 and ML7064) were viewed with respect to topography, geology, drainage and vegetation

Section 2

Study Methodology

cover. Principally, the investigation included an inspection of Cooroon Cooroonpah Creek, Swallow Lagoon and likely drainage patterns throughout the Vance Mining Lease and immediately adjacent areas.

URS undertook two rounds of monitoring well installation as follows:

- On 28-29 June 2006 two sets of nested monitoring wells, designated as well pair 1S and 1D and well pair 2S and 2D were installed adjacent to Cooroon Cooroonpah Creek. Each set of nested monitoring wells is comprised of a shallow well to monitor base flow in the creek and a deeper well to monitor the perched aquifer on the shallowest competent indurated sand ('coffee' rock) layer. The locations of these nested monitoring wells are shown on **Figure 2**.
- On 17-18 October 2006 three monitoring wells were installed on the high ridge lines towards the boundaries of the lease. These monitoring wells were installed to the top of the shallowest competent indurated sand ('coffee' rock) layer encountered. Two of these monitoring wells were installed near the site boundaries towards the sensitive surface water environments of Swallow Lagoon and Brown Lake. The third monitoring well was installed to the north of Cooroon Cooroonpah Creek to provide a cross-section across the creek valley. The locations of these monitoring wells are shown on **Figure 2**.

Automated water level loggers were installed in the monitoring wells and data measurements have been collected at hourly intervals since November 2006. URS completed two rounds of water quality sampling from the five monitoring well sites, Brown Lake and Swallow Lagoon. The first round of sampling was conducted on 22 November 2006, and the second round was conducted on 3 April 2007. Slug tests to determine aquifer hydraulic conductivity were conducted on two bores, and 11 soil infiltrometer tests to determine infiltration rate were completed on 23 November 2006.

2.3 Establishment of Baseline Groundwater Conditions

Based on the data/literature review and the field investigations, the baseline groundwater conditions in the immediate vicinity of the Vance Mining Lease have been established by:

- Estimating the current groundwater elevation over the Vance Mining Lease based on current groundwater elevation, geological and topographic data;
- Estimating the current groundwater flow directions across the Vance Mining Lease based on current groundwater elevation, geological and topographic data;
- Estimating the current groundwater quality over the Vance Mining Lease based on current groundwater quality data, site geology and current land use; and
- Deriving a conceptual hydrogeological model of the Vance Mining Lease and immediately adjacent areas.

2.4 Identification and Assessment of Potential Impacts to Groundwater

The proposed mine plan, method of mining and associated infrastructure have been assessed with respect to the conceptual hydrogeological model for the Vance Mining Lease. Potential impacts to groundwater from the proposed mining operations have been identified and are discussed in detail in **Section 4**.

2.5 Plan of Management and Mitigation Measures

Based on the potential impacts the mining operation on the Vance Mining Lease may have to groundwater, a number of potential management and mitigation measures have been identified to minimise the potential impact to groundwater and the overall hydrologic environment.

Section 3

Existing Hydrogeological Environment

North Stradbroke Island contains the largest groundwater resource of the four large sand islands of Moreton Bay (South and North Stradbroke Islands, Moreton Island and Bribie Island), and contains a number of major wetlands, lakes and small perennial streams. Many of the lake and wetland features of the island, such as Brown Lake and Swallow Lagoon, are considered to be perched above the main aquifer system whilst others, such as Blue Lake are window lakes in the regional ground water aquifer. The largest wetland of the island is Eighteen Mile Swamp, located on the south eastern coast of the island.

Detailed and extensive hydrogeological investigations were undertaken by the Geological Survey of Queensland on North Stradbroke Island during the late 1960s and early 1970s, as reported by Laycock (1975). These investigations included geophysical studies, drilling and logging of exploration and observation bores, survey and levelling studies, measurements of water levels, pumping tests and laboratory tests. An island-wide groundwater numerical model for the purposes of groundwater management was developed by the then Queensland Department of Natural Resources and Mines, as reported by Chen (2001). Reference is made to Laycock's 1975 report and Chen's 2001 report for a detailed description of these investigations and their findings and outcomes. The existing hydrogeological environment discussed herein is based on geological, hydrogeological and topographic data listed in **Section 2.1** and the results of the field investigations undertaken by URS.

3.1 Geology of North Stradbroke Island

The geology of North Stradbroke Island is characterised by Holocene and Pleistocene (Quaternary) sands overlying Triassic and Jurassic bedrock, comprising quartzose sandstone, siltstone, shale conglomerate, coal, basalt and breccia. On the northern part of the island, bedrock outcroppings are limited to coastal areas near Dunwich and Point Lookout.

The Quaternary deposits are by far the most extensive geological units on the island. The oldest deposits are the dune sands, predating the Holocene emergence (a regional sea-level fall approximately 6500 years before present) and consisting of fine to medium grained quartz sand with minor peaty layers, ironstone bands, and carbonaceous sand/rock. These dunes are vegetated and form dominant northwesterly trending ridges. The dune sands occur above a weathered bedrock surface, whose elevation ranges from above sea level on parts of the western side of the island to approximately 90 metres below sea level on the eastern side of the island. These deposits have accumulated by intense and perhaps prolonged wind action (Laycock, 1975).

Vegetated dune sand post-dating the Holocene emergence occurs on the eastern coast of the island. These deposits are relatively low in height and consist of fine to medium grained quartz sand deposited by wind action. The existing fresh water swamps in the coastal areas are thought to have formed during the same period as these deposits.

Later Cainozoic deposits include the beach sand ridges stabilised by vegetation and occurring on the northern coast, and the non-vegetated, dynamic present day deposits undergoing active deposition on the coast line, including the sands of the beach, beach sand ridges and dune sands. These units are comprised of fine to medium grained quartz sands.

3.1.1 Geology of Unimin Vance Lease

Within the mining lease area the dunes are all of Pleistocene age. These older sand dune deposits predate the Holocene emergence and consist of fine to medium grained quartz sand with minor peaty layers, ironstone bands, and carbonaceous indurated sand-rock zones ('coffee' rock). As each new transgressive dune advances across the island, former dunes are reworked, modified and overlapped. This results in a very complex series of ridges and swales. Between dune forming events the dunes were exposed to pedogenic processes over extended periods of time resulting in the development of deep 'giant' podsol. These 'giant' podsol soils consist of an organic and humic surficial soil horizon (A1) over a white fine sandy quartzose subsoil horizon (A2), underlain by quartz sand with organic material and iron oxide precipitations (B-horizon) as described in the soils and geomorphology work conducted by URS

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and reported as “Unimin Vance Mining Lease (ML1108) Soils and Geomorphology Report” dated May 2007.

Drilling at five sites was conducted during this study, the logs of which are shown in **Appendix A**. The aim of this drilling program was to investigate the extent and nature of perched groundwater on-site, therefore drilling was conducted only through to the upper indurated sand (‘coffee’ rock) B-horizon which typically behaves as an aquitard. The results of this drilling, together with the soils and geomorphology study conducted by URS (2007), found that the near surface geology within the project area is dominated by the occurrence of white silica sands that have been subject to strong weathering to depths varying locally from about 2m (mainly in the north eastern sector of the site) to 20m or more elsewhere within the site. However in general, the thickness of the fine-grained white silica sand that is the target of the mining operations typically varies between about 7-14m. The surficial A1-horizons are generally grey or dark grey and white speckled in colour and contain moderately high amounts of organic matter, including charcoal, fibrous roots and seed stock. These A1-horizons are usually between 0.3-0.6m thick and grade into the underlying pale grey or white sandy A2-horizons, which in turn are underlain (at varying depths) by ferric and/or black organic-rich subsoil B-horizons.

This geologic profile can occur over wide ranging depths because of dune movement. The indurated sand (‘coffee’ rock) layers typically form in the zone of watertable fluctuation, where humic substances from the accumulating surface litter, and iron from the upper soil leached through the profile are illuviated. Because these indurated sand (‘coffee’ rock) layers form in response to perched water tables in individual dunes, their ultimate geometry and degree of maturity is variable in response to erosive truncation and stacking of different generations of dune migrations punctuated by varying intervals of stabilisation. Drilling for the monitoring wells within the Vance Mining Lease intersected indurated sand (‘coffee’ rock) of varying degrees of induration at depths as shallow as 2.5m down to depths of 23m. In wells 2, 3 and 4 two layers of indurated sand (‘coffee’ rock) were intersected indicating multiple episodes of dune building activity.

ACI Industrial Minerals Division Pty Ltd (ACI) and Consolidated Rutile Ltd (CRL) drilled parts of the area of the Vance Mining Lease for silica sand and mineral sand exploration respectively (approximate drill transects shown on **Figure 3**). ACI were only interested in the surficial leached sand layer and ceased drilling immediately brown sand was intersected. The brown sand was described as soft, and has been interpreted as the top of the B-horizon. The depth to this horizon varied from less than 2m to greater than 10m across the site.

The resultant stratigraphic architecture within these dune bodies is a complex series of gently convex indurated sand (‘coffee’ rock) layers which converge in some orientations, and are discontinuous in other orientations where they have been truncated by subsequent erosive events.

3.2 Aquifer System on North Stradbroke Island

Groundwater occurs on North Stradbroke Island mainly as a lenticular body of freshwater within the intergranular spaces of the sand deposits that constitute the bulk of the island. This freshwater body is not considered to be ‘floating’ as a lens on top of a seawater body, but has been built up on top of the low permeability weathered bedrock due to infiltration and percolation of rainwater and the relatively shallow depth of the aquifer base. The seawater has formed a relatively short landward trending wedge around the perimeter of North Stradbroke Island with its position being determined by the rate of lateral seepage.

The regional aquifer is recharged by the infiltration of incident rainfall. The infiltration capacity of the dune sand deposits is considered to be high and little runoff is observed on the island, even during periods of high, intense rainfall. A reasonable correlation exists between the cumulative rainfall residual curve for Point Lookout and groundwater levels. Some of the rainfall water infiltrating and percolating into the sand is held near the surface and may be lost by evaporation, with the excess water migrating downwards to the water table. Where there is no intervening perching layer, rainfall directly recharges the regional sand aquifer. Where a perching layer is encountered the perched groundwater system is recharged. The perched groundwater can then flow to perched lakes, streams and wetlands or can further percolate downwards to the underlying regional sand aquifer system (Laycock, 1975).

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The mean annual rainfall of North Stradbroke Island is generally higher than the adjacent mainland. There is a wet and dry season on NSI with two thirds of the average rainfall occurring during the period December through May. Mean rainfall for key locations on the island is as follows:

- North Stradbroke Island (Dunwich) 1,662 mm/a;
- North Stradbroke Island (Point Lookout) 1,706 mm/a; and
- North Stradbroke Island (Unmin ML1124) 1,678 mm/a.

The permeability of the sand mass and rainfall recharge to the regional aquifer has created an elongated groundwater mound in the northern part of North Stradbroke Island. Laycock (1975) indicated that this mound reached a maximum elevation of approximately 60 m AHD in the central north of the island in the vicinity of the area between Mt Corrie and Cooroon Cooroonpah Creek. Data collection and review by Chen (2001) indicated that the mound elevation probably did not exceed 50 m AHD with the misinterpretation due to erroneous data or the use of perched aquifer data. **Figure 4** and **Figure 5** reproduce groundwater elevation contours for the island produced by Chen (2001) for 1970 and 2000 respectively. Regional groundwater flow is from the central areas of the island towards the coast and towards existing creeks, streams, lakes and swamps within the island. The regional groundwater table intersects the ground surface in some topographically low-lying areas, creating freshwater lakes (such as Blue Lake, the Yarraman Drainage System and Eighteen Mile Swamp). In more recent times, this regional groundwater flow system has locally been altered due to past and current sand mining operations and groundwater extraction for water supply purposes by the Redlands Shire Council.

Irregular areas of perched aquifers occur in some parts of the island, where the vertical percolation is impeded by the occurrence of fine organic or silty material, or by indurated sand ('coffee' rock) layers with low vertical permeability. Where perched aquifers intersect topographically low-lying areas, freshwater lakes may be formed, as is the case at Brown Lake.

Discharge of groundwater from the regional sand mass on the island occurs by lateral seepage to the ocean or by flow to surface water features fringing the island such as the coastal creeks and swamps. The largest of these watercourses is Freshwater Creek which discharges through Eighteen Mile Swamp and ultimately to Swan Lagoon at the southern end of the island. On the western side of the island Laycock (1975) noted that stream flows occur to the north of Dunwich in Aranarawai Creek, Cooroon Cooroonpah Creek, Campebah Creek, Myora Springs, Yerrol Creek, and One Mile Creek.

3.3 Hydrogeology of Vance Mining Lease ML1108

Hydrogeological information within the Vance Mining Lease was limited by a distinct lack of groundwater bores located within the lease boundaries. Only one groundwater monitoring bore with historical data is located within the Vance Mining Lease area (DNRW registered bore 14400085), which is located adjacent to Cooroon Cooroonpah Creek southwest of Bippo Penbean (**Figure 2**). The groundwater elevation in this bore has been regularly monitored (by DNRW personnel) since 1992 and has varied from approximately 31 to 36 m AHD. Water table elevations recorded from bores in the vicinity of the lease area (**Figure 2**) are shown in **Table 3-1**.

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Table 3-1 Groundwater elevation from bores located within the vicinity of the Site

Bore ID	Aquifer	Observation Period	Approximate Surface Elevation (mAHD)	Approximate Groundwater Elevation (mAHD)	Approximate Depth to Groundwater (m)
14400085 ^(a)	Regional ^(b)	1992 - 2007	45	31 - 36	10 - 14
14400075 ^(a)	Regional ^(b)	1990 - 2007	71	30 - 36	35 - 41
14400013 ^(a)	Regional ^(b)	1968 - 1974	57	30 - 36	21 - 27
14400017 ^(a)	Regional ^(b)	1968 - 2007	16	8 - 10	6 - 8
14400003 ^(a)	Regional ^(b)	1965 - 2005	67	27 - 32	35 - 40
14400008A ^(a)	Regional ^(b)	1968 - 1981	60	33 - 44	15 - 26
1D ^(c)	Perched	2006 - 2007	46	Dry	Dry
2D ^(c)	Perched	2006 - 2007	71	70 - 71	0 - 1
3 ^(c)	Perched	2006 - 2007	171	Dry	Dry
4 ^(c)	Perched	2006 - 2007	151	Dry	Dry
5 ^(c)	Perched	2006 - 2007	143	Dry	Dry
14400080 ^(a)	Perched ^(b)	1990 - 2007	60	54 - 57	2 - 5
14400060 ^(a)	Perched ^(b)	1978 - 1985	113	76 - 86	27 - 36
14400008B ^(a)	Perched ^(b)	1968 - 2007	60	55 - 59	1 - 5
99455 ^(a)	Unknown	1975 - 1984	45	33 - 36	8 - 12
99454 ^(a)	Unknown	1971 - 1984	45	33 - 37	8 - 12
99456 ^(a)	Unknown	1971 - 1984	40	29 - 32	8 - 11

Note:

(a) – DNRW database bore identification number

(b) – After Chen (2001)

(c) – URS monitoring bore identification number

Based on the data in **Table 3-1**, the groundwater elevation of the regional aquifer in the vicinity of the Vance Mining Lease ranges from 8 mAHD to 44 mAHD. This correlates satisfactorily with the groundwater model developed by Chen (2001) as shown in **Figure 4** and **Figure 5**.

The regional groundwater flow direction across the Vance Mining Lease is generally between the west and north, however a groundwater divide has been identified (Gilbert & Sutherland, 1999; and Chen, 2001) close to the southeastern boundary of the Vance Mining Lease. This divide is located along the top of the groundwater mound in the regional aquifer, and groundwater on the western side of the divide will generally flow towards the west and groundwater on the eastern side of the mound will generally flow to the east (**Figure 4** and **Figure 5**). In addition, a groundwater stagnation point southeast of Brown Lake was identified by Gilbert & Sutherland (1999). This groundwater stagnation point is likely to be due to Brown Lake being locally perched (i.e. elevated above the regional groundwater table). Brown Lake is likely to discharge to the regional aquifer by overspilling of the confining layer by the perched aquifer and downward percolation through the semi-confining layer which may cause a local mounding of the regional groundwater system below Brown Lake, and locally modify the generally westward groundwater flow direction in the area. Since regional groundwater does not feed into Brown Lake, the water level in Brown Lake regularly fluctuates in response to rainfall alone (Chen, 2001).

Generally, the regional groundwater table subtly mirrors the local topography; generally deeper on hilltops and shallower in valley floors and close to watercourses. Within the Vance Mining Lease the depth to groundwater is also expected to vary considerably due to the generally hilly nature of the area. This is evident from groundwater elevation data (**Table 3-1**), where the depth to groundwater is greatest at higher elevations (such as near Mt. Hardgrave) and lower along Cooroonpah Creek.

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As described in the **Section 3.1.1**, the B-horizon consists of quartz sand variably cemented by iron oxide and organic material precipitates. Because the B-horizon forms in response to weathering of the sand dunes, their ultimate geometry and degree of maturity is variable in response to erosive truncation and stacking of different generations of dune migrations punctuated by varying intervals of stabilisation. The resultant stratigraphic architecture within these dune bodies is a complex series of gently convex indurated sand ('coffee' rock) layers which converge in some orientations, and are discontinuous in other orientations where they have been truncated by subsequent erosive events. The B-horizon has undergone varying degrees of induration, from minor organic infilling to hard impermeable cementing. This variable induration of the B-horizon yields variable hydrogeological properties. The structural complexity, when combined with varying degrees of induration, provides a challenging hydrogeological environment to model. This is consistent with the findings of McMahon (1963) who investigated the leases to the immediate east of the Vance Mining Lease area:

'These first water-bearing sequences represent the location of elevated water-tables which are extremely irregular both in their areal extent and in the depth at which they are first encountered below the surface.'

Drilling for the monitoring wells within the Vance Mining Lease intersected indurated sand ('coffee' rock) of varying degrees of induration at depths as shallow as 2.5m down to depths of 23m. In wells 2, 3 and 4 two layers of indurated sand ('coffee' rock) were intersected indicating multiple episodes of dune building activity.

A conceptual hydrogeological model of the area of the Vance Mining Lease has been constructed (**Figure 6**).

3.3.1 Infiltration and groundwater recharge

Soil permeability in the surficial units were measured using infiltrometer testing completed at 11 sites located on Vance Mining Lease. The location of each testing location is provided in **Figure 2**. Due to the typically high spatial variability of soil permeability, testing locations were located near Cooroon Cooroonpah Creek, in upland areas, in flat lands, slopes and in areas of different vegetative covers. The infiltrometer testing holes all exhibited homogeneous sand with very little variation spatially or with depth. The infiltrometer testing was completed using the method of Oosterbaan and Nijland (1994).

The infiltrometer test results, as presented in **Appendix B**, demonstrate that the top 500 mm of ground surface (the A1 horizon) has an average saturated permeability of approximately 23 m/day. This high permeability demonstrates that for overland flow to occur on the Vance Mining Lease, the rainfall intensity must meet or exceed approximately 1000 mm/hr. As discussed in the surface water report prepared by URS titled "Vance Lease North Stradbroke Island Surface Water Studies", dated July 2007, this result demonstrates that direct surface water runoff on the Vance Mining Lease should only happen in extremely rare circumstances.

Groundwater recharge principally occurs from direct rainfall infiltration. Some of the rain is lost by overland flow, some is lost by evapotranspiration, and the rest is recharge to the groundwater system due to the highly permeable sandy substrate. This is evidenced by the correlation between the residual rainfall mass curve for the site and the hydrograph of the DNRW monitoring bore 1400085 as shown in **Figure 7**. Rainfall recharge studies previously conducted by others have estimated the infiltration rate to be between 400 mm/yr and 800 mm/yr, or 23 to 47% of average rainfall is recharged to the regional aquifer (Laycock, 1975). The results of Chen's (2001) sensitivity analysis of the groundwater model indicated that a better performing model was obtained with average recharge of 600 to 800 mm/yr compared to 400 mm/yr.

3.3.2 Groundwater Flow

Slug tests were conducted on groundwater monitoring wells 2S and 2D to determine aquifer hydraulic properties at depths of 2 m and 6 m respectively. The results of the slug tests, as presented in **Appendix C**, yield an aquifer hydraulic conductivity of 2.26 to 6.64 m/d for the perched sand aquifer at Cooroon

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Cooroonpah Creek. These values are at the lower end of the range of hydraulic conductivities (1.3 to 50 m/d) determined for various groundwater models on North Stradbroke Island (Chen, 2001).

Groundwater velocities through the sands near the centre of North Stradbroke Island (i.e. proximal to the Vance Mining Lease) have been estimated at between 4 and 7 m/day (Coffey & Partners, 1989; URS, 2000), which is typical for fine to medium grained dune sands.

Water was only encountered in a perched aquifer on the indurated sand at site 2 on Cooroon Cooroonpah Creek. At this site, two layers of indurated sand were encountered. The upper layer, approximately 1.5m thick, occurred at a depth of 2.5m. The lower layer occurred at a depth of 6.3m. A shallow monitoring well was installed in the upper sand layer to gauge flow in the creek and a monitoring well was installed in the deeper perched aquifer. The groundwater levels, as recorded in pressure transducers installed in both monitoring wells, have a high degree of correlation with rainfall and with very little lag time between rainfall, the appearance in the shallow and the arrival in the deeper zone as shown in **Figure 8 and Figure 9**. The groundwater level in the deeper monitoring well has a slightly subdued and delayed response (of approximately 2 to 5 hours) to rainfall compared to the shallow monitoring well. The close correlation between groundwater levels and response to rainfall in these shallow aquifers indicates that there is a direct hydraulic connection between the creek and the perched aquifer. The high infiltration capacity and hydraulic conductivity of the sands allow rapid infiltration of recharge and flow of groundwater. When infiltration encounters indurated areas of the B-horizon at higher elevations, it flows along the indurated layer to lower elevations. If the degree of induration is low, the infiltrated water will percolate further down to recharge the regional aquifer. In the upper reaches of Cooroon Cooroonpah Creek, the B-horizon is sufficiently indurated and close to the surface that infiltration travels down to the creek line and expresses at the surface in the creek causing surface flow during wetter periods. Further downstream at site 1 the B-horizon occurs at greater depth, and there may be areas of lesser induration between the two sites, so that the perched aquifer overflows recharging the regional aquifer. This is supported by the absence of areas of closed wet heath downstream on the Vance Mining Lease, and that the indurated B-horizon at site 1 was dry at the times of monitoring.

3.3.3 Groundwater Discharge

Groundwater discharge from the Vance Mining Lease will principally occur into freshwater streams and swamps near the coast and lateral seepage to the ocean. Cooroon Cooroonpah Creek, which drains the majority of the lease area, is primarily fed from groundwater. Most groundwater on the Vance Mining Lease is expected to move northwards and westwards out of the area towards the northwest coast. Work undertaken by GHD (1998) (as reported in Gilbert & Sutherland, 1998) found that regional groundwater does not flow into Brown Lake.

Swallow Lagoon, immediately southeast of the Vance Lease, is also perched above the regional water table. The lagoon level on 28 February 2005 was approximately 151 mAHD. The base of the lagoon is estimated at approximately 146 mAHD, which is approximately 100 m higher than the expected regional water table elevation. This lagoon is a perched water body considered to have formed where vertical percolation has been impeded by fine organic or silty material or by indurated sand, isolated from the underlying regional aquifer. The lagoon is located in a limited catchment area entirely outside the lease area and is protected as a RAMSAR wetland under the Federal Environmental Protection Biodiversity Conservation (EPBC) Act 1999. Gradients within the catchment that drain to the lagoon are moderate and surface water is not therefore expected to contribute a significant quantity of recharge to Swallow Lake. Infiltration of rainfall to the perching layer is considered the most important factor in maintaining the hydrological regime in the lagoon. The extent of the perching layer could not be determined within the scope of this study, however the B-horizon encountered at site 3 north of Swallow Lagoon did not support a perched aquifer during the period of monitoring. Due to the complexity of the development and location of the indurated B-horizon, the lagoon is expected to be filled by rainfall infiltration from its small immediate catchment, and is unlikely to be linked to any perched aquifers on-site.

The B-horizon encountered at site 4 between the Vance Mining Lease and Brown Lake did not support a perched aquifer during the period of monitoring, and does not appear to be acting as an aquitard in this location. Due to the complexity of the development and location of the indurated B-horizon, Brown Lake is unlikely to be linked to any perched aquifers on-site.

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3.3.4 Groundwater Quality

Groundwater quality information in the area of the Vance Mining Lease is scarce, due to the lack of groundwater bores in the area and the limited representative water quality information available from those bores. The range of water quality detected in the perched aquifer on-site and Brown Lake and Swallow Lagoon located off-site are presented in **Table 3-2**, with the full analytical results included in **Appendix D**. Information available from the DNRW Groundwater Database and from Unimin's sampling of groundwater bores adjacent to the Vance Mining Lease (**Table 3-3**) are comparable to the results obtained on-site.

Current Australian guidelines indicate that groundwater quality is assessed on the basis of its intended beneficial human use and, where applicable, the discharge receiving environment. Based on groundwater gauging data, it is estimated that groundwater expresses at the surface in Cooroon Cooroonpah Creek and flows in a westerly direction towards freshwater creeks and swamps on the coast. Based on the presence of these identified sensitive receptors, the following groundwater guideline levels are considered applicable:

- Guideline levels for slightly to moderately disturbed freshwater ecosystems for the protection of 95% of species, as specified in the "Australian and New Zealand Guidelines for Fresh and Marine Water Quality", (ANZECC/ARMCANZ, October 2000); and
- Guideline levels for South East Region lowland streams and Sandy Coastal Region, as specified in the "Queensland Water Quality Guidelines", (Queensland Environmental Protection Agency, March 2006).

The assessment of groundwater quality using surface water guideline values has an inherent level of conservatism due to the assumptions made regarding the behaviour and fate of the analytes detected in groundwater and the subsequent effects in the surface water ecosystem. Exceedence of a guideline value does not indicate that an impact has occurred or is likely to occur, but may warrant further investigation.

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Table 3-2 Water quality of perched aquifer on-site and surface water bodies off-site

	Guideline Values	Location			
		2D	2S	Brown Lake	Swallow Lagoon
Physio-chemical Parameters					
pH	6.5 - 8.0 ^(a)	4.23 - 4.36	4.10 - 4.19	5.29	4.59 - 5.01
Electrical Conductivity (µS/cm)	626 ^(a)	111.4 - 117.8	117.0 - 131.1	118.3	61.5 - 81
Major Ions					
Calcium (mg/L)	ne	<1 - 1	<1 - 1	<1	<1 - 1
Magnesium (mg/L)	ne	2 - 3	2	2	1 - 2
Potassium (mg/L)	ne	<1	<1	<1	<1
Sodium (mg/L)	ne	15 - 16	16 - 17	17	10 - 11
Chloride (mg/L)	ne	25 - 31	27 - 32	29	18
Sulphate (mg/L)	ne	<1 - 5	<1 - 3	4	2 - 3
Total Alkalinity (mg/L)	ne	<1 - 3	<1	1	<1 - 2
Metals (Dissolved)					
Arsenic (mg/L)	0.013 ^(b)	<0.001	<0.001	<0.001	<0.001
Barium (mg/L)	ne	0.002	0.001	<0.001	<0.001
Beryllium (mg/L)	ne	<0.001	<0.001	<0.001	<0.001
Cadmium (mg/L)	0.0002 ^(b)	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	0.001 ^(b)	<0.001	<0.001 - 0.001	<0.001	<0.001
Cobalt (mg/L)	ne	<0.001	<0.001	<0.001	<0.001
Copper (mg/L)	0.0014 ^(b)	<0.001	<0.001	<0.001	<0.001
Ferrous Iron (mg/L)	ne	0.27	0.41	-	0.11
Lead (mg/L)	0.0034 ^(b)	<0.001	<0.001 - 0.001	<0.001	<0.001
Manganese (mg/L)	1.9 ^(b)	0.004 - 0.008	0.002 - 0.003	0.006	0.028
Mercury (mg/L)	0.0006 ^(b)	<0.0001 - 0.0004	<0.0001 - 0.0003	<0.0001	<0.0001 - 0.0004
Nickel (mg/L)	0.011 ^(b)	<0.001	<0.001	<0.001	<0.001
Vanadium (mg/L)	ne	<0.01	<0.01	<0.01	<0.01
Zinc (mg/L)	0.008 ^(b)	<0.005 - 0.013	0.006 - 0.011	<0.005	<0.005 - 0.009
Nutrients					
Nitrate as N (mg/L)	ne	<0.01	<0.01	<0.01	<0.01
Nitrite as N (mg/L)	ne	0.05 - 0.067	0.049 - 0.06	<0.01	<0.01 - 0.02
Ammonia as N (mg/L)	0.02 ^(a)	0.11 - 0.13	0.081 - 0.091	0.016	0.049 - 0.081
Total Kjeldahl Nitrogen as N (mg/L)	ne	1.1 - 4	2.8 - 11.1	0.6	1.4 - 1.6
Total Phosphorus (mg/L)	0.05 ^(a)	<0.05 - 0.06	<0.01 - 0.13	<0.01	<0.01

Note:

(a) – Queensland Water Quality Guidelines for South East Region lowland streams and Sandy Coastal Region

(b) – ANZECC/ARMCANZ 2000 Trigger values for freshwater ecosystems - Level of protection 95% of species

ne – not established

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Table 3-3 Groundwater quality of regional aquifer down gradient and adjacent to Site

	Guideline Values	43964	44783	73857	14400017	14400075	14400003
Physio-chemical Properties							
pH	6.5 - 8.0^(a)	4.79 (4.62-5.33) 24	4.68 (4.57-4.87) 10	5.08 (4.88-5.38) 22	6.5 (6.5-7) 6	5.9 (5.8-6.1) 8	8.6 (7.2-9.6) 5
Electrical Conductivity (µS/cm)	626^(a)	75 (73-79) 24	77 (71-83) 10	77 (74-82) 22	108 (91-126) 6	108 (87-121) 8	119 (112-140) 5
Major Ions							
Calcium (mg/L)	ne	0.5 (0.5-0.5) 18	0.5 (0.5-0.5) 10	0.5 (0.5-0.5) 16	1 (1-1.2) 6	1.7 (1.1-2.7) 8	0.9 (0.6-1.1) 5
Magnesium (mg/L)	ne	1 (1-1) 7	1 (1-1) 7	1 (1-1) 7	1.3 (1.2-1.6) 6	1.6 (0.9-2.0) 8	0.1 (0.1-0.2) 5
Potassium (mg/L)	ne	0.5 (0.5-0.5) 7	0.5 (0.5-0.5) 7	0.5 (0.5-0.5) 7	1.1 (0.8-1.7) 6	0.9 (0.8-1.2) 8	1.5 (1.3-2.0) 5
Sodium (mg/L)	ne	12 (11-12) 25	11 (11-13) 10	12 (11-13) 23	11.6 (11.3-12.1) 6	12.7 (12.1-15.5) 8	21.6 (21.2-25.9) 5
Chloride (mg/L)	ne	17 (13-20) 26	16 (13-20) 11	18 (13-21) 22	18.1 (18-18.3) 6	22.8 (19.5-24.6) 8	13.9 (12.8-18.1) 5
Sulphate (mg/L)	ne	2 (2-2.0) 25	2 (2-2.2) 10	2 (2-3) 23	0 (0-1.9) 6	1 (0.8-6.8) 8	0.7 (0.5-2.0) 5
Total Alkalinity (mg/L)	ne				12 (5-26) 6	7.5 (3.8-11.2) 8	33 (29-42.6) 5
Metals (Dissolved)							
Iron (mg/L)	ne	0.09 (0.07-0.14) 6	0.18 (0.14-0.22) 7	0.31 (0.21-0.33) 6	0 (0-0) 6	0.08 (0-0.50) 8	0.01 (0-0.02) 5
Manganese (mg/L)	1.9^(b)	0.005 (0.005-0.026) 7	0.005 (0.005-0.017) 7	0.005 (0.005-0.005) 7	0.05 (0.01-0.21) 6	0.07 (0.04-0.1) 8	0 (0-0.02) 5
Zinc (mg/L)	0.008^(b)				0.03 (0.02-0.04) 2	0.26 (0.16-0.66) 3	0.12 (0.12-0.12) 1
Nutrients							
Nitrate as N (mg/L)	ne	0.275 (0.246-0.322) 24	0.230 (0.128-0.268) 9	0.100 (0.034-0.110) 23	1.6 (0.5-5.9) 6	0.4 (0-0.6) 8	0 (0-0.5) 5
Total Phosphorus (mg/L)	0.05^(a)	0.01 (0.006-0.020) 17	0.005 (0.005-0.052) 9	0.015 (0.005-0.060) 16			

Note:

(a) – Queensland Water Quality Guidelines for South East Region lowland streams and Sandy Coastal Region

(b) – ANZECC/ARMCANZ 2000 Trigger values for freshwater ecosystems - Level of protection 95% of species

2 First value shown is the median
(2-2.0) 20th to 80th percentile range shown in brackets
25 Last value shown is the number of samples
ne – not established

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Existing Hydrogeological Environment

The pH is considered to be representative of naturally acidic conditions with a relatively narrow range of values throughout the monitoring record. The low pH values are believed to be caused by humic acids released by decomposing organic matter (e.g. tannins, ligands) and are considered to be representative of natural conditions. No potentially acid sulphate soils have been identified on the Vance Lease. Aquatic species on the island, such as the three acid frogs (Wallum Sedgefrog, Rocketfrog and Froglet), are known to be sensitive to changes in pH, preferring more acid conditions (EMS, 2006). The area surrounding the Cooroon Cooroonpah Creek drainage line is characterised by thick vegetation of closed heath and low banksia woodland. As flow in the creek is also largely ephemeral, water levels fluctuate widely throughout the year with periodic wetting and drying. Periodic wetting and drying of accumulated organic matter can lead to a short-term increase in the rate of humic acid release. As the creek dries out again and water levels drop, this then causes the pH of the water to become increasingly low from seepage of acidic groundwaters at shallow depth. The low pH values in the creek are lower than those found in groundwater at depth in the vicinity of the lease area suggesting that key pH influences occur at the surface layer. The Vance Mining Lease has been identified as a potential habitat for the three acid frog species listed as Vulnerable under the Queensland Nature Conservation Act (NCA) 1992 and/or the EPBC Act. Preferred acid frog habitat includes wetter parts of the site, such as areas adjacent to the Creek. It has been identified that the acid frogs prefer acid swamp conditions (generally pH less than 5.5). The water quality data suggest the Creek could provide adequate habitat for the acid frog species during certain flow conditions.

Electrical conductivity (EC) is considered to be low in comparison with the usual range found within freshwater, upland catchments. However EC can be highly variable in surface waters. The low EC of the groundwater reflects the relatively rapid and substantial recharge of fresh rainwater limiting the opportunity for evapo-transpiration induced concentration of salts in rainfall, and the quartzose nature of the sand resisting leaching of minerals into the aquifer.

The relative proportions of major ions are indicative of rainfall, and the low concentrations are indicative of relatively minor evapo-transpiration induced concentration. It was not possible to compare concentrations of these constituents with screening criteria as no relevant state or national guidelines have been published. However the concentrations detected are considered to be representative of natural levels.

Concentrations of dissolved metals in the groundwater are generally low, less than or close to the laboratory limits of detection apart from iron, manganese and zinc which typically show measurable concentrations. The presence of iron, manganese and zinc is indicative of the naturally low pH conditions of the groundwater, and reflects the process of weathering and induration of the 'giant' podsoils. There are no screening criteria under either the State or ANZECC/ARMCANZ 2000 guidelines for iron. The concentration of zinc is often greater than the ANZECC/ARMCANZ 2000 guidelines for freshwater aquatic ecosystems, however the concentrations are considered to be representative of natural levels.

Measurable concentrations of nutrients are typically detected in the perched and regional groundwater within and surrounding the Vance Mining Lease. The nutrients are contributed to the groundwater by biogenic processes, such as the decomposition of organic matter, and the concentrations are considered to be representative of natural levels.

Section 4

Potential Impacts to Groundwater from Proposed Mining Activities

The proposed mining operation on the Vance Mining Lease is to selectively quarry shallow sand for the purposes of extracting clean silica sand. Mining will be carried out by excavating the leached A2-horizon of sand to its base, identified as the coloured sand of the top of the B-horizon. As it is a dry mining operation, no mining below the regional or perched water table shall occur. The sand will be excavated using a front end loader (FEL) and loaded into a feed hopper via a grizzly, which removes large objects such as tree roots. Water shall be added to the sand in a pump box forming a slurry, so the material can be pumped. The sand will then enter a trommel where more organic and oversized material is removed before the slurry is pumped back to Mine Lease Area 1124 (ML 1124) for processing. Water used in this process shall be sourced from groundwater bores on ML 1124 where it will be pumped and recirculated through process water dams. No processing beneficiation activities will be undertaken on ML 1108.

Relatively little infrastructure is anticipated to be installed on the Vance Mining Lease but would likely include power lines, pumps, pipelines, fuel storage, unsealed roads, and portable mine equipment. The installation works are likely to involve similar processes to mining (i.e. use of machinery to clear vegetation, shallow excavation of topsoil and sand).

Mined areas will be progressively rehabilitated to minimise the disturbance area and will consist of the following stages:

- Re-contouring using a bulldozer to replicate the pre-mining landform but with a reduced elevation by up to 15 metres;
- Spreading topsoil (salvaged immediately after stripping) over re-contoured ground to a depth approximating pre-mining conditions;
- Seeding with a hybrid cover crop and native seed;
- Wind guard- and silt-fencing to reduce erosion from wind and water; and
- Direct planting of native seedlings propagated in the site nursery on an adjacent lease area.

In conducting the proposed mining operation, the following potential impacts to groundwater on and in the vicinity of the Vance Mining Lease have been identified:

- Interception of groundwater within the extraction area;
- Impacts on groundwater and surface water quality, such as from discharge or seepage of slurry water from pipes/plant and leakage/spillage of chemicals associated with mechanical construction equipment; and
- Increases in groundwater elevation due to increased groundwater recharge following clearing of vegetation.

4.1 Interception of Groundwater Within the Extraction Area

The depth to the regional groundwater on the Vance Mining Lease ranges from approximately 10 to 14 m below ground level beside Cooroon Cooroonpah Creek, however the depth to regional groundwater is expected to be greater than 20 m at higher elevations (**Table 3-1**). The presence of and depth to perched groundwater will be variable across the site depending on the degree of induration of the B-horizon, the depth of development of the 'giant' podsols, and the elevation. It is known that perched groundwater expresses at the surface in the areas of closed heath in the upstream reach of Cooroon Cooroonpah Creek.

With the exception of the approved 3 year mine path, the exact locations of proposed mining pits and associated depths within the lease area have not been determined. However, within nearby lease areas (e.g. ML 7064) the silica sand is generally excavated to a depth of between 6 and 10 m below original ground level. Therefore, generally, the risk of interception of the regional groundwater table is considered to be low. The risk of intercepting groundwater is likely to be greatest in the low-lying areas, such as close to Cooroon Cooroonpah Creek. A 100 m wide buffer zone is proposed each side of Cooroon

Section 4

Potential Impacts to Groundwater from Proposed Mining Activities

Cooroonpah Creek, and the corresponding higher elevation of mining will reduce the risk of intercepting the perched groundwater table. The proposed mining method is dry mining, and the nature of the mining method precludes operation in a wet environment, so for operational reasons the mining will be conducted above any water tables and the risk of interception of the water table is considered to be low.

4.2 Impacts on Groundwater Quality

Based on the current Unimin mining operations at ML1124 and ML7064, the only chemicals used during the mining or processing of the sand are anionic and cationic flocculants (FLOPAM AN905 PWG and FLOQUAT FL4440) used to coagulate fine sediments in ponds to allow the sediments to settle. The flocculants are water-soluble and non-hazardous, however should not be allowed to impact surface water or groundwater systems. A sediment pond will not be constructed on the Vance Lease, however the existing sediment ponds on ML1124 will be used for settlement of the fine sediments.

Other potential contaminants on-site are associated with the machinery used for excavation and construction. These include diesel and other petroleum-based fuels and lubricants. The terms of the lease include provision for the installation of fuel storage, and roads are to be unsealed. Detailed locations of infrastructure has not been determined to date, as this will vary with the chosen mine path. However, all reasonable steps should be taken to prevent leakage/spillage including the provision of environmental management controls for the safe operation of refuelling, maintenance and storage, plus properly constructed and bunded storage, refuelling and maintenance areas. Furthermore, all such infrastructure must not be located within the 100 m buffer along Cooroon Cooroonpah Creek or located within an area designated as a RAMSAR site. The high permeability of the sands means that any liquid discharged is likely to percolate relatively rapidly through the unsaturated zone and into underlying groundwater. This may then lead to subsequent impact of surface waters where groundwater flows into surface water bodies. Any significant leakage/spillage must be immediately reported and appropriate emergency clean-up operations implemented as soon as practicable. This may include excavation and disposal of impacted sands and treatment systems for groundwater.

Given the relatively undisturbed nature of local water bodies, any discharge of liquids from leakage/spillage may have a significant impact on the relatively pristine water environment. However, potential chemicals of concern are considered to be present on-site in only minimal quantities and, as long as appropriate systems and procedures are set-up and operated, the significance of this impact is considered to be low.

4.3 Changes in Groundwater Recharge Characteristics and Groundwater Elevation

Clearing of vegetation typically leads to an increase in the groundwater elevation due to the increased infiltration beyond the root zone. In addition, the removal of local vegetation will decrease the normal amounts of evapotranspiration and the elevation of the shallow groundwater may appear to rise. In the Vance Mining Lease, the risk of significant increase in groundwater elevation of the shallow perched or regional aquifers following clearing however, is considered to be low due to the rapid infiltration rate and high permeability of the aquifer material.

After mining, the extracted sand material will not be present to perform any storage function, however progressive rehabilitation concurrent with mining will re-establish similar levels of evapo-transpiration to pre-mining levels, and the effects of any increased recharge will be minimal because of the very high hydraulic conductivity of the sands (4 to 7 m/day) and very low water-holding capacity of the sands. The extent of the 100 m buffer zone along Cooroon Cooroonpah Creek will minimise any increase in groundwater elevation in the perched aquifer, and so the risk of any change to the groundwater regime and associated impacts on the acid frog species is considered to be low.

From a groundwater perspective, the continued use of the sedimentation pond on the adjacent lease is unlikely to create any significant hydraulic problems within the Vance Mining Lease as the pond is constructed to minimise seepage. If significant seepage from the pond occurs, a groundwater mound may develop beneath the pond. Despite this apparent risk, the very high permeability of the dune sands

Section 4**Potential Impacts to Groundwater from
Proposed Mining Activities**

would likely allow slow seepage from the pond to equilibrate with the water table without significant changes in groundwater elevation.

Section 5

Conclusions and Management Measures

5.1 Conclusions

The primary objectives of this report were to:

- Outline the baseline hydrogeological conditions in the vicinity of the Vance Mining Lease; and
- Identify any potential impacts to groundwater from the proposed mining activities on Vance lease.

Prior to this study, few groundwater bores existed in the vicinity of the Vance Mining Lease. Therefore, baseline hydrogeological conditions and potential impacts to groundwater from the proposed mining operation are based on a limited dataset. Data gathered from the Vance Mining Lease and surrounding area and information relating to the hydrogeology of North Stradbroke Island generally has provided a sufficient basis for characterising the hydrogeological environment in the vicinity of the proposed mining area and to identify potential impacts on groundwater in the vicinity of the lease.

5.1.1 Baseline Hydrogeological Environment

Groundwater elevations of the regional aquifer in the vicinity of the Vance Mining Lease are topographically controlled, subtly mirroring the local topography; generally deeper on hilltops and shallower in valley floors and close to watercourses. Groundwater elevations range from approximately 8 to 44 mAHD. Groundwater is recharged primarily by rainfall infiltration through highly permeable quartz sands. Groundwater elevations have historically fluctuated depending upon the amount of rainfall over the island. Groundwater elevations over the Vance Mining Lease do not appear to have been impacted significantly by dewatering from other mines or water resources projects on the northern half of the island.

Groundwater flow direction in the project area, within the regional aquifer is primarily towards the north and west, however the southeastern boundary of the lease area may be proximal to a northeast-southwest groundwater divide.

Perched aquifers may develop on the B-horizon of the weathering profile if the sands are sufficiently indurated. Because the B-horizon forms in response to weathering of the sand dunes, their ultimate geometry and degree of maturity is variable in response to erosive truncation and stacking of different generations of dune migrations punctuated by varying intervals of stabilisation. The resultant stratigraphic architecture within these dune bodies is a complex series of gently convex indurated sand layers which converge in some orientations, and are discontinuous in other orientations where they have been truncated by subsequent erosive events. The B-horizon has undergone varying degrees of induration, from minor organic infilling to hard impermeable cementing. This variable induration of the B-horizon yields variable hydrogeological properties. Water was only encountered in a perched aquifer on the indurated sand at site 2 on Cooroon Cooroonpah Creek. The B-horizon at the four other sites investigated on the mining lease did not support perched aquifers. The groundwater levels in the perched aquifer identified on-site has a high degree of correlation with rainfall. The groundwater level in monitoring wells installed along Cooroon Cooroonpah Creek indicates that there is a direct hydraulic connection between the creek and the perched aquifer. The high infiltration capacity and hydraulic conductivity of the sands allow rapid infiltration of recharge and flow of groundwater. When infiltration encounters indurated areas of the B-horizon at higher elevations, it flows along the indurated layer to lower elevations. If the degree of induration is low, the infiltrated water will percolate further down to recharge the regional aquifer. In the upper reaches of Cooroon Cooroonpah Creek, the B-horizon is sufficiently indurated and close to the surface that infiltration travels down to the creek line and expresses at the surface in the creek causing surface flow during wetter periods. Further downstream at site 1 the B-horizon occurs at greater depth, and there may be areas of lesser induration between the two sites, so that the perched aquifer overflows, subsequently recharging the regional aquifer, so that a perched aquifer is not sustained at site 1.

Nearby water bodies, such as Swallow Lagoon and Brown Lake are perched (i.e. above the water table) and do not appear to be influenced by the regional groundwater table. Due to the complexity of the development and location of the indurated B-horizon, Brown Lake and Swallow Lagoon are unlikely to be linked to any perched aquifers on-site.

Section 5

Conclusions and Management Measures

The groundwater quality is comparable to rainwater in that it has relatively low concentrations of dissolved ions. It has low pH believed to be caused by humic acids released by decomposing organic matter (e.g. tannins, ligands) and is considered to be representative of natural conditions.

5.1.2 Potential Impacts to Groundwater due to Mining

The method of sand mining proposed by Unimin for the Vance Mining Lease requires no chemical additives and is not expected to mine below the water table and below the indurated layer, where the greatest concentration of heavy minerals is typically found.

Potential fuel storage, refuelling and machinery maintenance areas have yet to be defined, however these activities will require careful design, construction and operation and management practises to ensure that no fuel is allowed to discharge into the sand which is capable of rapid infiltration to the aquifers. Refueling areas for instance should be limited to areas with adequate controls to contain any possible releases.

The potential impacts to groundwater resulting from shallow sand mining on Vance Mining Lease with respect to groundwater recharge and groundwater elevation are also considered to be very low. This is due to the very high permeability (high hydraulic conductivity) of the sands, the very low water-holding capacity of the sands above the water table and the expectation, based on current and historic groundwater elevations, that the mining activities will not intersect the regional water table.

Therefore, the risk of groundwater contamination from the proposed silica mining operations on Vance Mining Lease ML1108 is considered to be very low.

5.2 Management Measures

Unimin should consider installing a minimum of two additional groundwater monitoring bores within the lease area between mining areas and the 100 m buffer along Cooroon Cooroonpah Creek to collect groundwater elevation and water quality information of any perched aquifer encountered. Routine monitoring of these new monitoring bores, together with the monitoring bores installed for the purposes of this study and DNRW bore 14400085, would allow continued monitoring of any potential impacts of mining on groundwater for the Vance Mining Lease. The installation of the new bores is recommended to be undertaken to allow Unimin to accurately monitor the groundwater environment within the Vance Mining Lease during construction and operation. The monitoring bore locations should be selected by a hydrogeologist and should be located in areas close to where Unimin plans to excavate. Monitoring bores should be installed under the supervision of a hydrogeologist or other suitably qualified environmental professional.

The monitoring programme should be conducted for the following parameters:

- Depth to groundwater below top of casing;
- Physio-chemical parameters (pH, EC, dissolved oxygen);
- Major ions;
- Dissolved metals (iron and zinc); and
- Hydrocarbons (total petroleum hydrocarbons and benzene, toluene, ethylbenzene and xylene).

This monitoring for depth to groundwater and physio-chemical parameters should be conducted bi-monthly, with the other chemical sampling undertaken quarterly, with assessment and review conducted annually by a suitably qualified environmental professional. The monitoring for hydrocarbons should be conducted for two monitoring events before mining commences, and then may be undertaken annually unless a hydrocarbon spill is known to have occurred on-site, in which case the monitoring frequency will be determined in consultation with the Queensland EPA until the spill has been remediated to the satisfaction of the Queensland EPA.

Section 5

Conclusions and Management Measures

The results of the monitoring should be compared to the baseline values and the ANZECC/ARMCANZ (2000) water quality guidelines and the Queensland EPA (2006) Queensland Water Quality Guidelines.

As well as monitoring groundwater and surface water quality, monitoring of aquatic habitats and fauna should be conducted, and a management plan for the threatened acid frogs in the area should be developed.

Potential fuel storage, refuelling and machinery maintenance areas will need to be carefully designed, built and operated with consideration of Environmental Management Controls to cover all sensitive operations.

Rehabilitation of mined areas is planned and should take place progressively and regularly as mined areas become available to reduce the risk of changes to the groundwater elevation and flow regime. No mining operations should be carried out within the 100 m buffer zone either side of Cooroon Cooroonpah Creek.

Section 6

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Section 7

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Unimin Australia Limited and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the URS Proposal.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was initially prepared in October 2006 and, following a change in mine plan, updated in July 2007 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

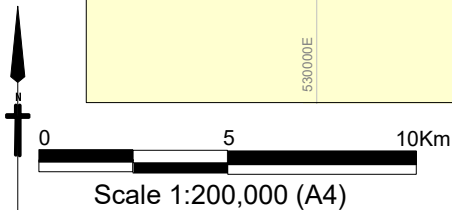
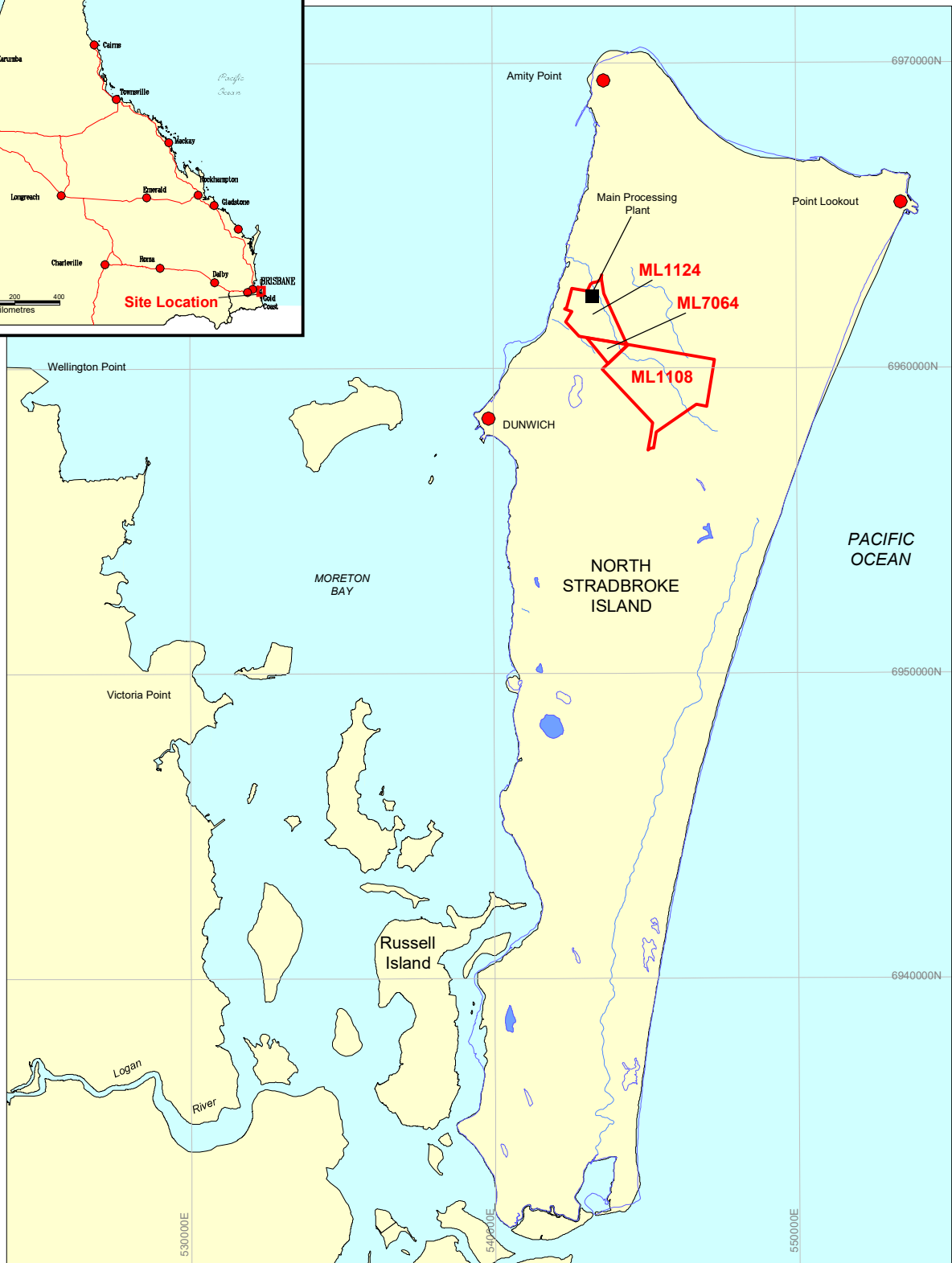
This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of contaminants in soil and groundwater are complex. Our conclusions are based upon the analytical data presented in this report and our experience. Future advances in regard to the understanding of chemicals and their behaviour, and changes in regulations affecting their management, could impact on our conclusions and recommendations regarding their potential presence on this site.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, URS must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

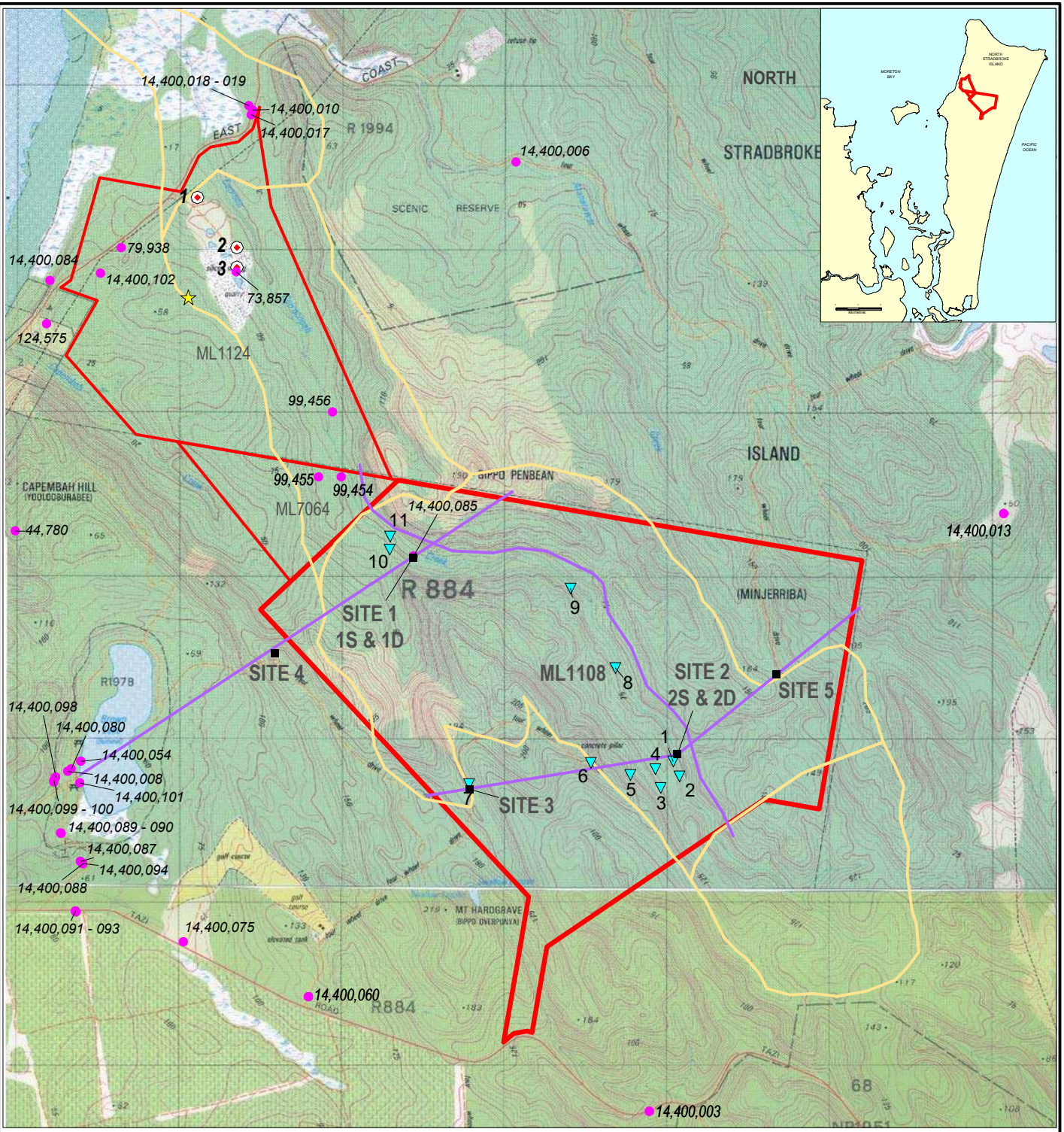
Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

Figures



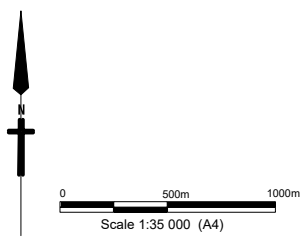
Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project GROUNDWATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND			Title LOCATION OF VANCE LEASE (ML1108)	
	Drawn: LL/TN	Approved: SD	Date: 22-08-2007		Rev: B
	Job No: 4262 5813		File No: 42625813-g-051.wor		A4



LEGEND

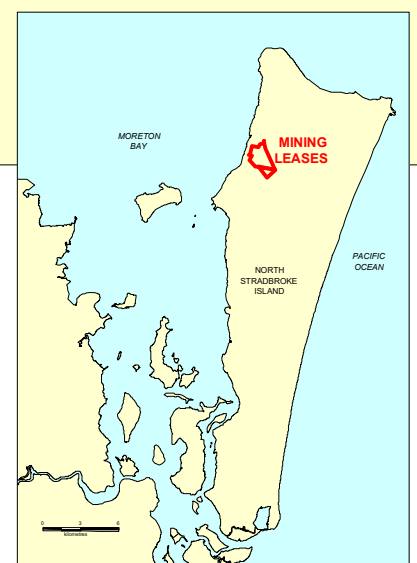
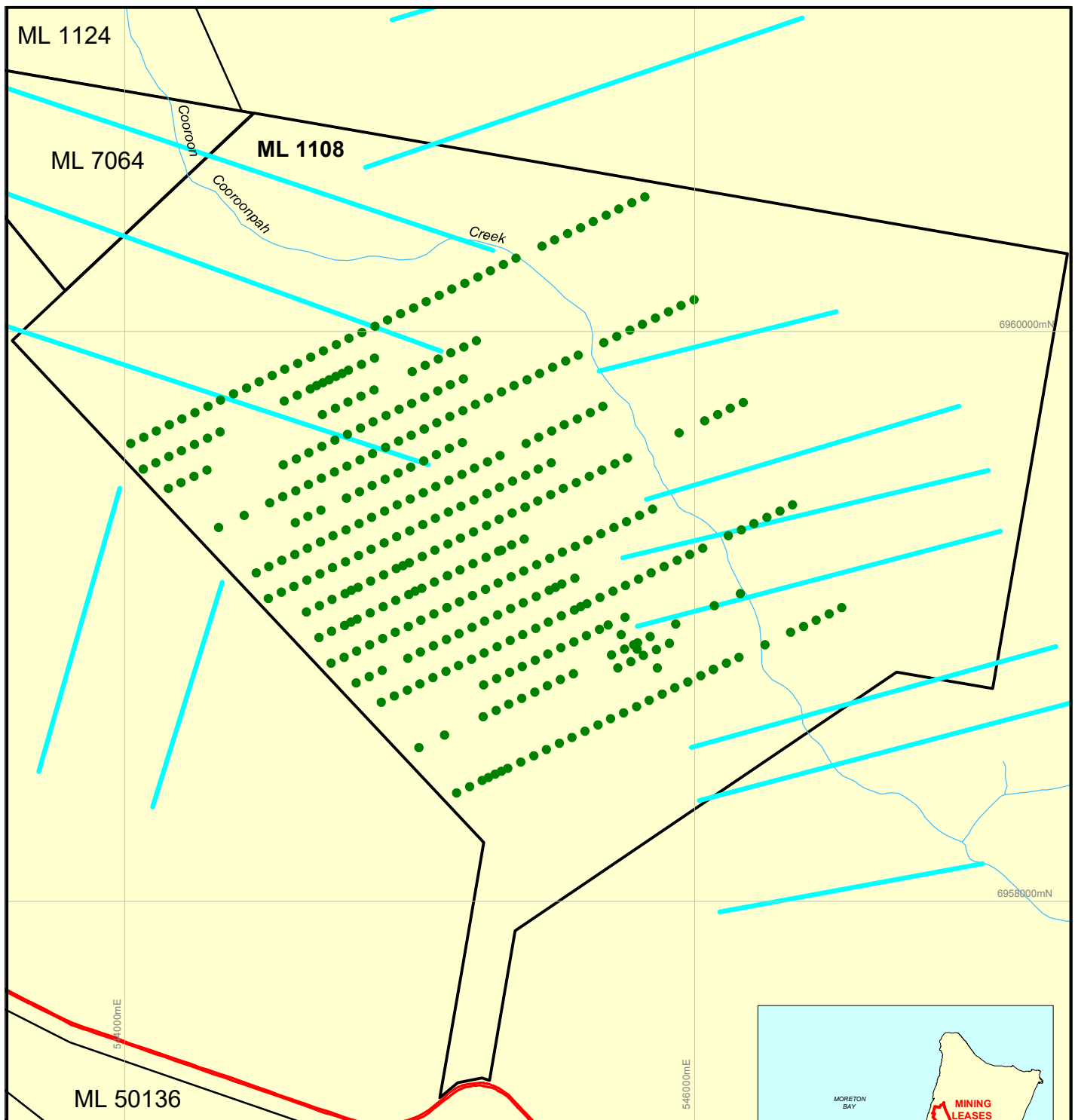
- Site 1 ■ URS SW Bore Locations
- 1 ▽ Infiltration Test Locations
- 1 ⊙ Unimin Groundwater Bores
- Cross Section Lines
- ★ Approximate Location of Rain Station
- 73,857 ● Registered Groundwater Bores 2004 and 2007)
- Cooroon Cooroonpah Creek Catchment Boundary



Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project GROUNDWATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND			Title GROUNDWATER BORES AND INFILTROMETER TEST LOCATIONS		
	Drawn: LL/TN Approved: SD Date: 22-08-2007			Figure: 2		Rev: B
						A4
URS	Job No: 4262 5813	File No: 42625813-g-052b.wor				

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LEGEND

-  Watercourse
-  Road
-  CRL Borehole Locations
-  ACI Drill Transects



0 250m 500m
Scale 1: 20 000 (A4)

Source: Client Supplied Bore data (July 2007)

Client
UNIMIN AUSTRALIA LIMITED

Project
**GROUNDWATER REPORT OF VANCE MINING
LEASE NORTH STRADBROKE ISLAND**

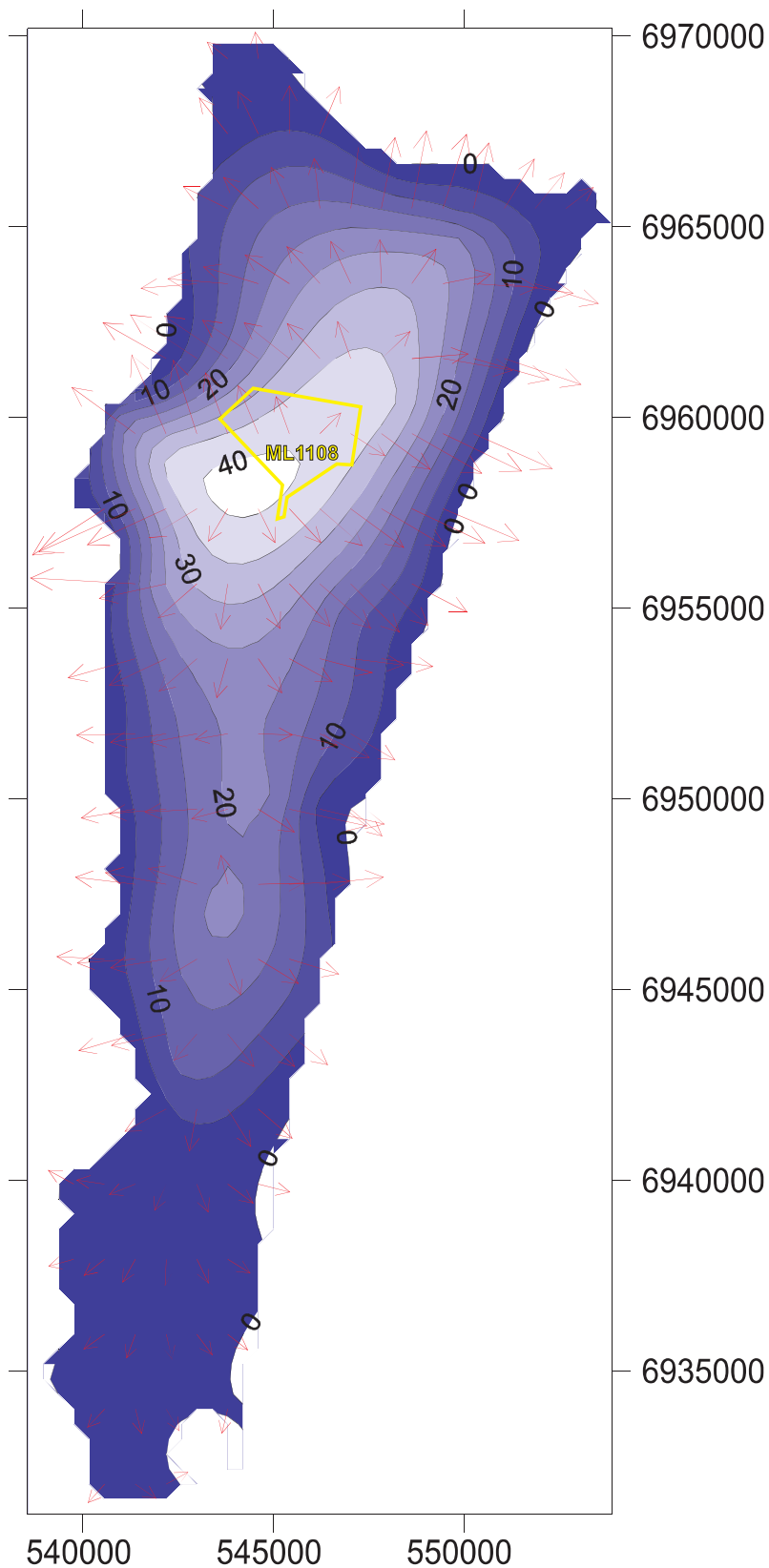
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**LOCATIONS OF ACI AND
CRL EXPLORATION BORES**

URS

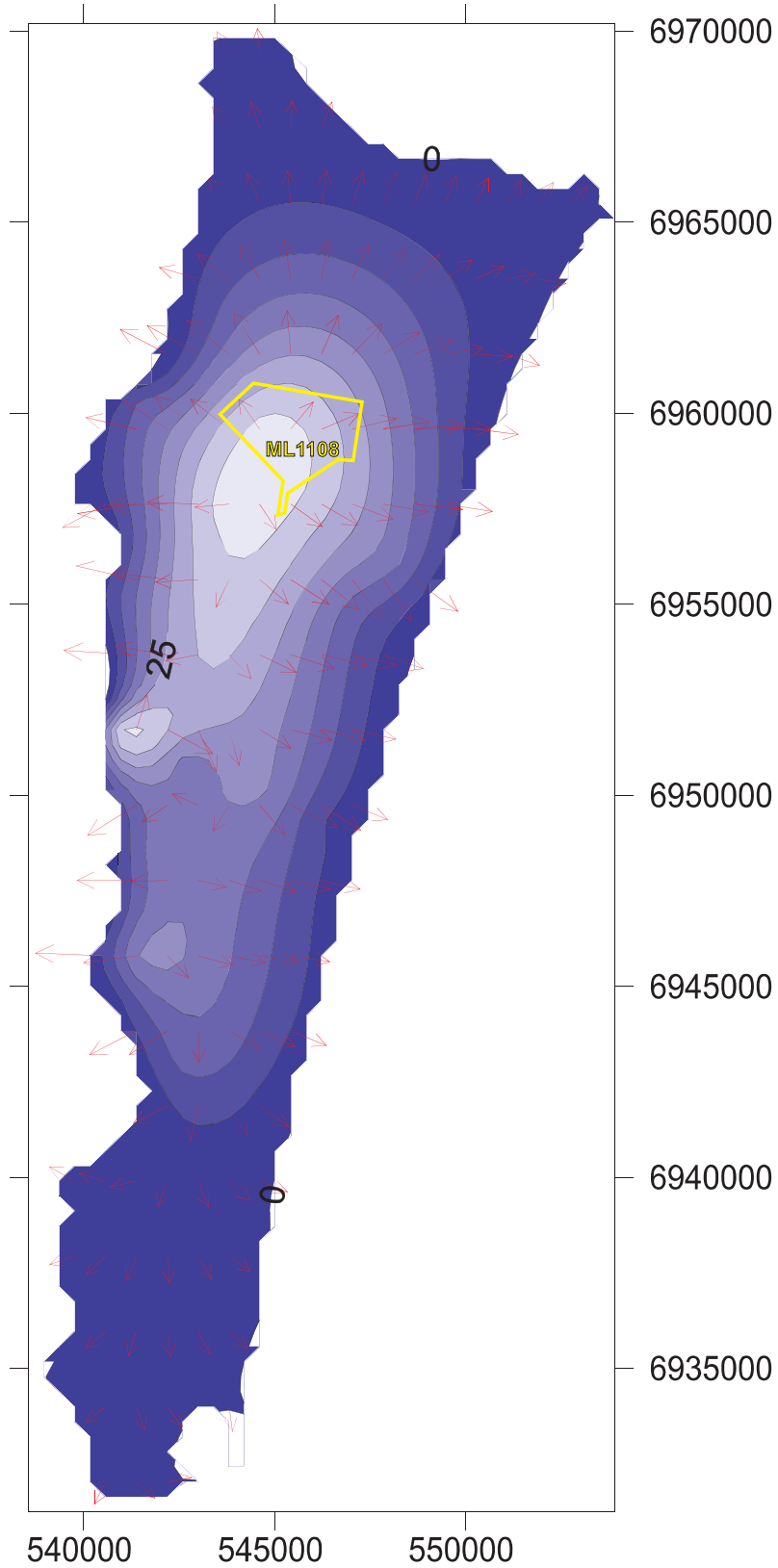
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Figure: 3

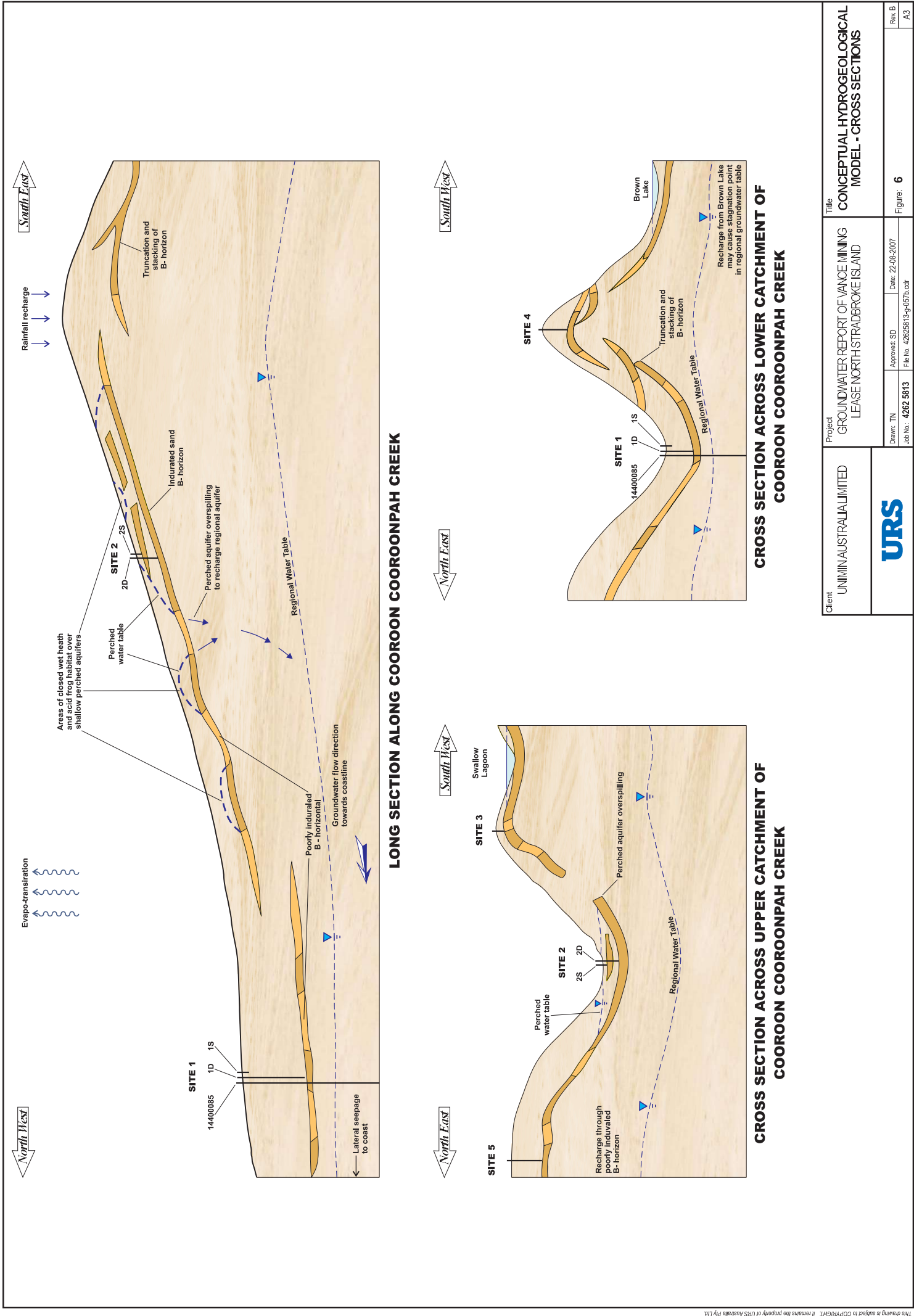
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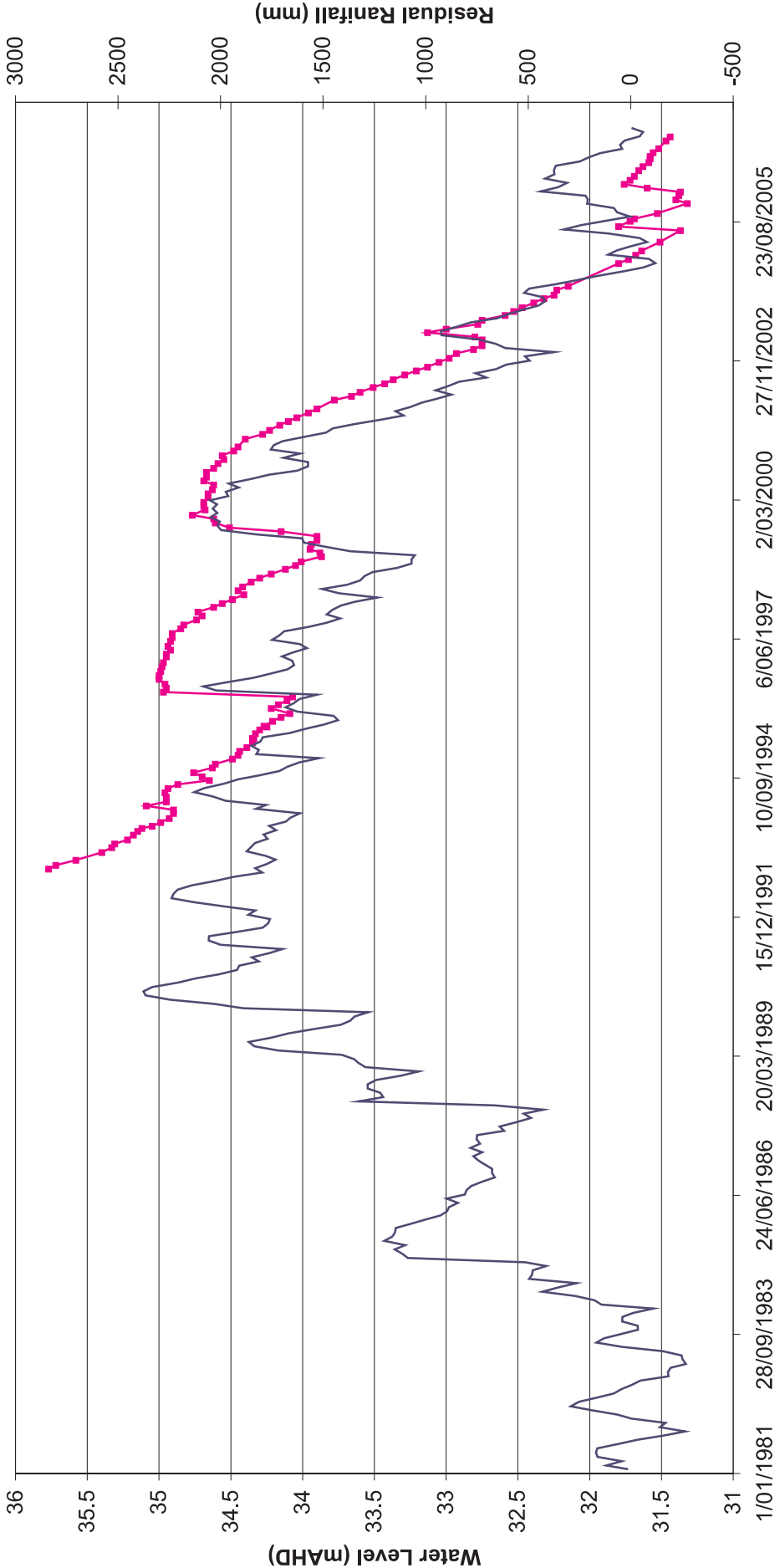
Client UNIMIN AUSTRALIA LIMITED	Project GROUNDWATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND			Title GROUNDWATER ELEVATION CONTOURS (mAHD) FOR NORTH STRADBROKE ISLAND FOR 1970 AFTER CHEN (2001)	
	Drawn: TN Job No.: 4262 5813	Approved: SD File No. 42625813-g-054b.cdr	Date: 22-08-2007	Figure: 4	Rev. B A4



Client UNIMIN AUSTRALIA LIMITED	Project GROUNDWATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND	Title GROUNDWATER ELEVATION CONTOURS (mAHd) FOR NORTH STRADBROKE ISLAND FOR 2000 AFTER CHEN (2001)		
	Drawn: TN Job No.: 4262 5813	Approved: SD File No. 42625813-g-056b.cdr	Date: 22-08-2007	Figure: 5 Rev. B A4



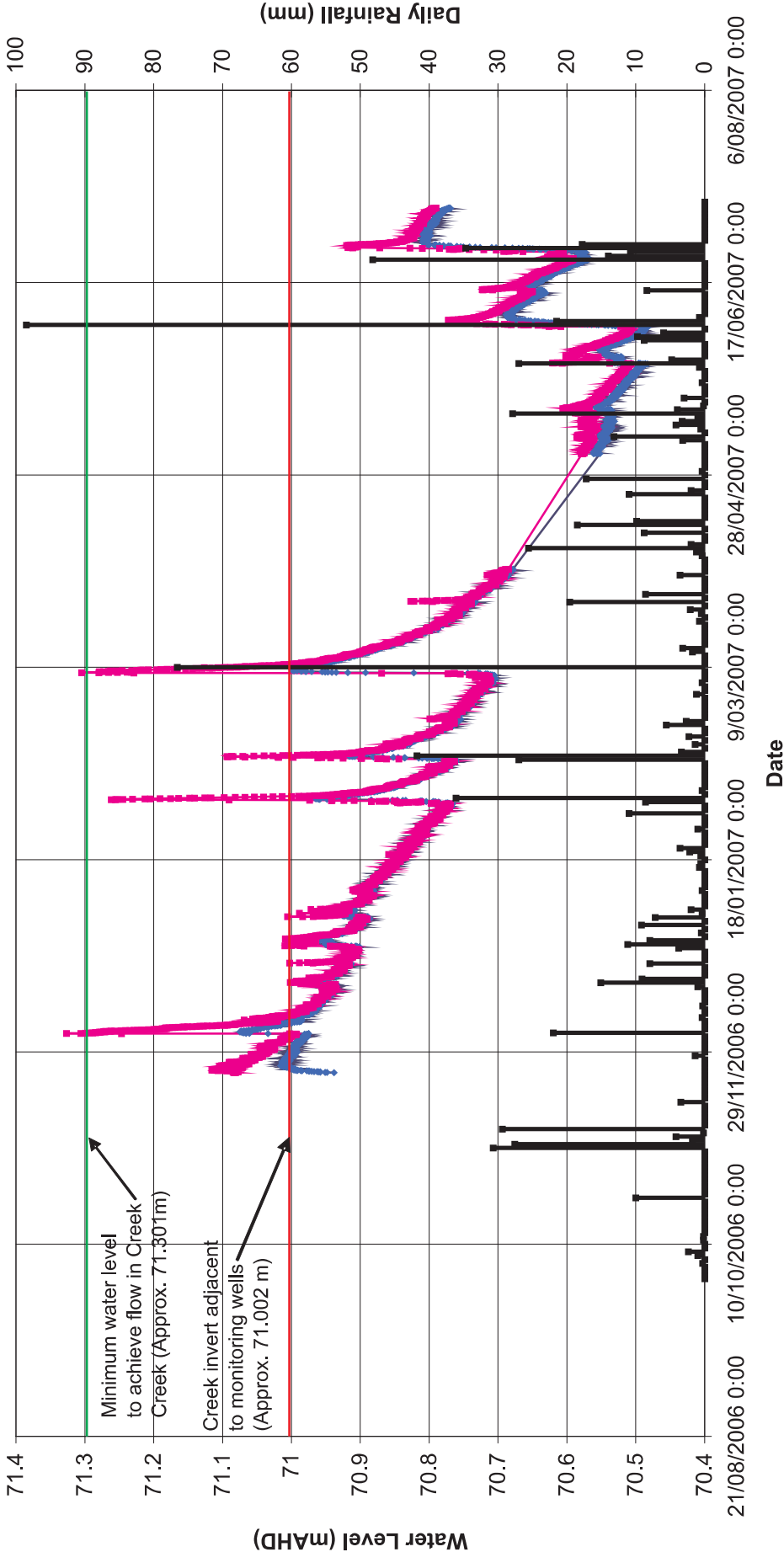
Water Level and Residual Rainfall Mass Curve, UNIMIN North Stradbroke



Date

Client UNIMIN AUSTRALIA LIMITED	Project			Title	
	GROUNDWATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND			SITE RESIDUAL RAINFALL MASS CURVE AND HYDROGRAPH FOR BORE 14400085	
	Drawn: TN	Approved: SD	Date: 22-08-2007	Figure: 7	
	Job No.: 4262 5813	File No. 42625813-g-058b.cdr		Rev. B	A4

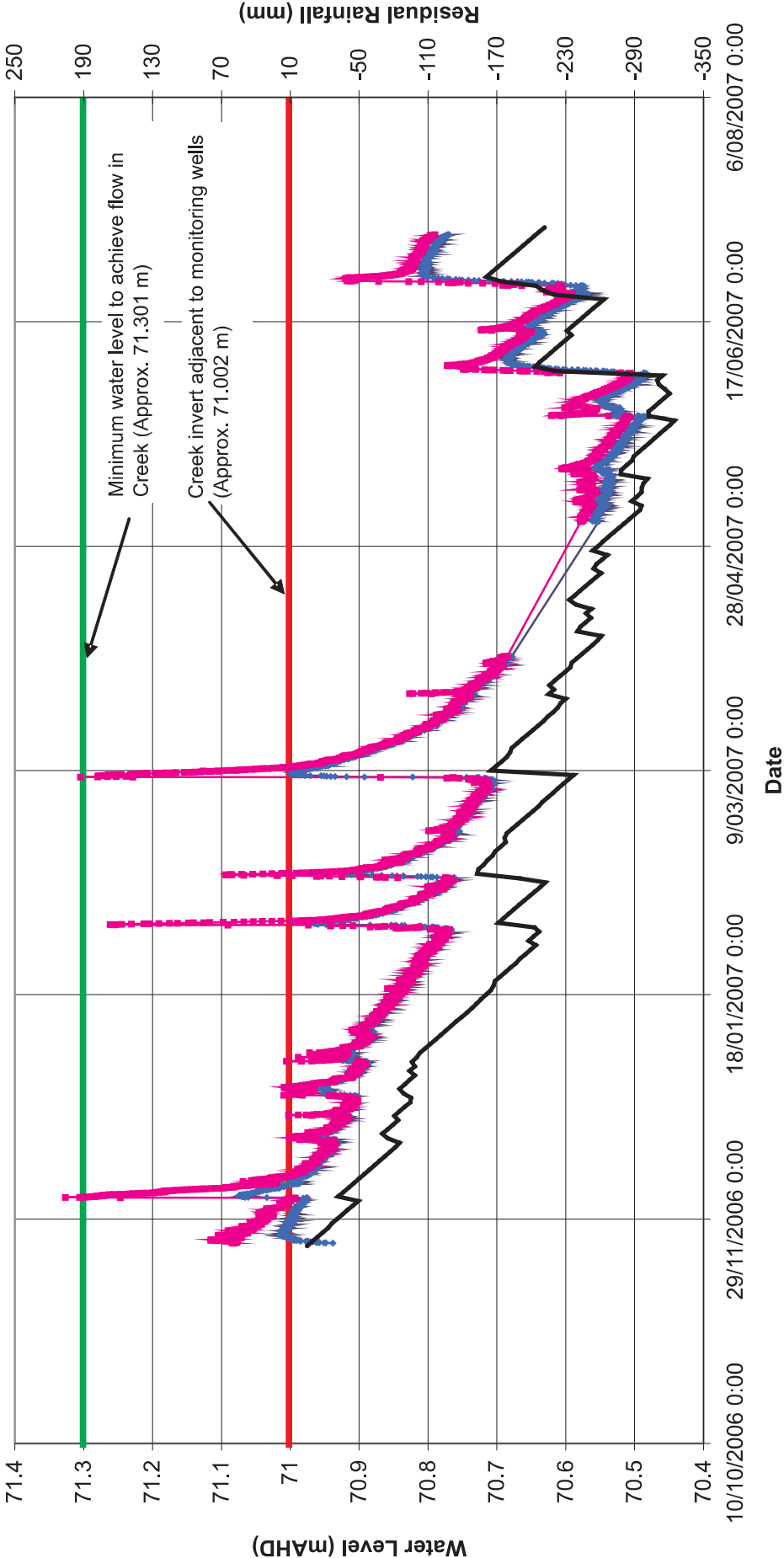
Water Level and Daily Rainfall, Cooroon Cooroonpah Creek Perched Aquifer, UNIMIN North
Stradbroke



—◆— Deep Bore —■— Shallow Bore ■ Rainfall

Client UNIMIN AUSTRALIA LIMITED	Project GROUNDWATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND		Title SITE RAINFALL AND HYDROGRAPH FOR PERCHED AQUIFER AT COORON COORONPAH CREEK	
	Drawn: TN	Approved: SD	Date: 22-08-2007	
	Job No.: 4262 5813	File No. 42625813-g-059b.cdr		Figure: 8
URS			Rev. B	A4

Water Level and Residual Rainfall Mass Curve, Cooroon Cooroonpah Creek Perched Aquifer, UNIMIN North Stradbroke



Client UNIMIN AUSTRALIA LIMITED	Project GROUNDWATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND		Title SITE RESIDUAL RAINFALL MASS CURVE AND HYDROGRAPH FOR PERCHED AQUIFER AT COOROON COOROONPAH CREEK	
	Drawn: TN	Approved: SD	Date: 22-08-2007	
Job No.: 4262 5813			Figure: 9	Rev. B
URS				A4

Appendix A

Drillhole Lithological Logs

URS Australia Pty Ltd		Monitoring Well 3	
URS Australia Pty. Ltd. Level 14, 240 Queen Street, Brisbane, QLD, 4001		Phone +61732432111 Fax +61732432199	Project No.: 42625813
Drilling Contractor: Drillsure		Project Reference: Unimin EIS	
Drilling Method: Rotary Mud	Logged By: ABS	Relative Level: 171.26 mAHD	Client: Unimin Australia Ltd
	Checked By: SD	Coordinates: 544897.6 mE	
	Date Started: 18-10-06	6958865.91 mN	
Date Finished: 18-10-06		Permit No:	

SAMPLING DETAILS			WELL CONSTRUCTION DETAILS		DESCRIPTION OF STRATA										
Sample Type	Sampling and Observations	PID (ppm)	Lockable Stand Pipe Lockable Envirocap Bentonite seal around 50mm uPVC Class 12 casing 2mm gravel pack Slotted 50mm uPVC Class 12 screen, slot size 0.7mm End cap		Depth (m)	Legend	Lithology	Consistency	Structure	Grain Size	Shape	Sorting	Plasticity	Moisture	Classification
					0		Fine, white sand Fine to medium, white-yellow-bright orange sand			F F-M		W W		D SM	SW SW
					1		Fine to medium, orange-brown sand			F-M		W		M	SW
					2		Brown coffee rock Fine to medium, orange-brown sand			F-M F-M		W W			SM SW
					3										
					4										
					5										
					6										
					7										
					8										
					9										
					10										
					11		Medium, dark brown coffee rock			M		W			SM
					12										
					13										
					14										
					15										
					16										
					17										
					18										
					19										
					20										
					21										
					22										
					23										
					24										
REMARKS:															

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URS Australia Pty. Ltd.
Level 14, 240 Queen Street, Brisbane, QLD, 4001Phone +61732432111
Fax +61732432199

Project No.:

42625813

Project Reference:

Unimin EIS

Drilling Contractor: Drillsure

Drilling Method:

Rotary Mud

Logged By: ABS

Checked By: SD

Date Started: 17-10-06

Date Finished: 17-10-06

Relative Level: 151.70 mAHD
Coordinates: 543696.45 mE
6959698.57 mN

Permit No:

Client:

Unimin Australia Ltd

SAMPLING DETAILS

WELL CONSTRUCTION DETAILS

DESCRIPTION OF STRATA

Sample Type	Sampling and Observations	PID (ppm)	Lockable Stand Pipe	Lockable Envirocap	Depth (m)	Legend	Lithology	Consistency	Structure	Grain Size	Shape	Sorting	Plasticity	Moisture	Classification
					0		Fine, white sand			F		W			SW
					1										
					2										
					3										
					4										
					5										
					6										
					7										
					8										
					9										
					10										
					11		Medium to fine, brown sand			F-M		W			SW
					12										
					13										
					14	x	Dark brown coffee rock, uncemented			F-M		W			SM
					15		Medium to fine, brown sand			F-M		W			SW
					16										
					17										
					18										
					19										
					20										
					21	x	Dark brown coffee rock			F-M		W			SM
					22	x									
					23										
					24										

Bentonite seal around 50mm uPVC Class 12 casing

2mm gravel pack

Slotted 50mm uPVC Class 12 screen, slot size 0.7mm

End cap

REMARKS:

Unimin EIS

42625813

Unimin Australia Ltd

Permit No:

SAMPLING DETAILS			WELL CONSTRUCTION DETAILS		DESCRIPTION OF STRATA										
Sample Type	Sampling and Observations	PID (ppm)	Lockable Stand Pipe	Lockable Envirocap	Depth (m)	Legend	Lithology	Consistency	Structure	Grain Size	Shape	Sorting	Plasticity	Moisture	Classification
					0		Fine, black-dark grey sand			F		W		D	SW
					1		Medium, white-light grey sand			M		W		SM	SW
					2										
					3		Medium, grey-brown sand			M		W		SM	SW
					4										
					5										
					6		Medium, white-light grey sand			M		W			SW
					7										
					8										
					9										
					10										
					11										
					12										
					13										
					14										
					15										
					16										
					17										
					18										
					19										
					20										
					21										
					22										
					23										
					24		Fine, dark brown coffee rock			F		W			SM
					25										
					26										

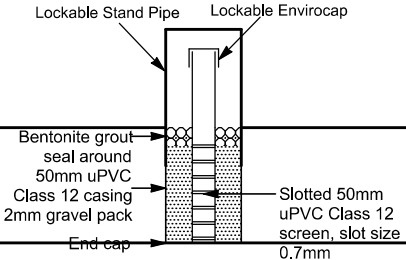
REMARKS:

URS Australia Pty Ltd			Monitoring Well 1D		
URS Australia Pty. Ltd. Level 14, 240 Queen Street, Brisbane, QLD, 4001		Phone +61732432111 Fax +61732432199		Project No.: 42625813	Project Reference: Unimin EIS
Drilling Contractor: GeoDrill					
Drilling Method: Rotary Mud	Logged By: AW	Relative Level: 46.23 mAHD		Client: Unimin Australia Ltd	
	Checked By: SD	Coordinates: 544546.6 mE 6960288.22 mN			
	Date Started: 29-8-06	Permit No:			
Date Finished: 29-8-06					

SAMPLING DETAILS			WELL CONSTRUCTION DETAILS		Depth (m)	DESCRIPTION OF STRATA									
Sample Type	Sampling and Observations	PID (ppm)	Lockable Stand Pipe	Lockable Envirocap		Legend	Lithology	Consistency	Structure	Grain Size	Shape	Sorting	Plasticity	Moisture	Classification
						0	Organic rich dark grey black sand			F					SW
						1	White clean sand			F					SW
						2									
						3									
						4									
						5									
						6									
						7									
						8									
						9									
						10									
						11	Indurated sand (coffee rock)			F					SM
						12									
						13									
						14									
						15									
						16									
						17									
						18									
						19									
						20									
						21									
						22									
						23									
						24									
REMARKS:															

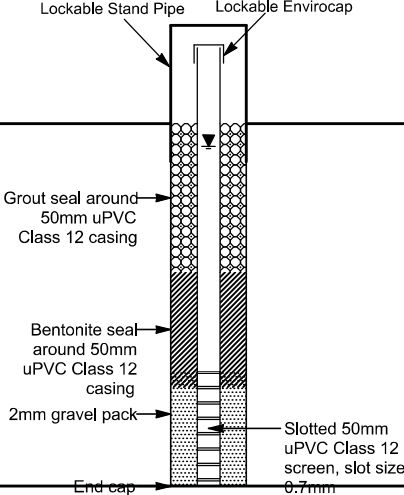
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URS Australia Pty Ltd			Monitoring Well 1S		Sheet 1 of 1
URS Australia Pty. Ltd. Level 14, 240 Queen Street, Brisbane, QLD, 4001		Phone +61732432111 Fax +61732432199	Project No.: 42625813		Project Reference: Unimin EIS
Drilling Contractor: GeoDrill					
Drilling Method: Rotary Mud		Logged By: AW Checked By: SD Date Started: 28-2-06 Date Finished: 28-2-06	Relative Level: 46.14 mAHD Coordinates: 544547.13 mE 6960289.06 mN Permit No:		Client: Unimin Australia Ltd

SAMPLING DETAILS			WELL CONSTRUCTION DETAILS		Depth (m)	DESCRIPTION OF STRATA									
Sample Type	Sampling and Observations	PID (ppm)				Legend	Lithology	Consistency	Structure	Grain Size	Shape	Sorting	Plasticity	Moisture	Classification
					0		Organic rich dark grey black sand			Fine					SW
					1		White clean sand			Fine					SW
					2										
					3										
					4										
					5										
					6										
					7										
					8										
					9										
					10										
					11										
					12										
					13										
					14										
					15										
					16										
					17										
					18										
					19										
					20										
					21										
					22										
					23										
					24										
REMARKS:															

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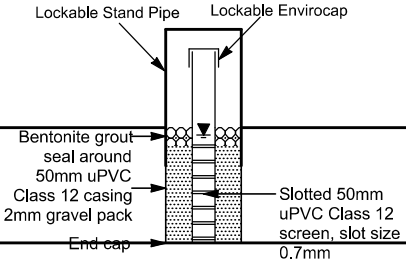
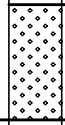
URS Australia Pty Ltd			Monitoring Well 2D		
URS Australia Pty. Ltd. Level 14, 240 Queen Street, Brisbane, QLD, 4001		Phone +61732432111 Fax +61732432199		Project No.: 42625813	Project Reference: Unimin EIS
Drilling Contractor: GeoDrill					
Drilling Method: Rotary Mud	Logged By:	AW	Relative Level:	71.85 mAHD	
	Checked By:	SD	Coordinates:	546171.74 mE	
	Date Started:	29-6-06		6959078.99 mN	
	Date Finished:	29-6-06	Permit No:		
					Client: Unimin Australia Ltd

SAMPLING DETAILS				WELL CONSTRUCTION DETAILS		Depth (m)	DESCRIPTION OF STRATA									
Sample Type	Sampling and Observations	PID (ppm)			Legend		Lithology	Consistency	Structure	Grain Size	Shape	Sorting	Plasticity	Moisture	Classification	
					0		Organic rich dark grey black sand			F					SW	
					1											
					2											
					3		Indurated sand (coffee rock)			F					SM	
					4											
					5		White grey sand			F					SW	
					6											
					7		Indurated sand (coffee rock)			F					SM	
					8											
					9											
					10											
					11											
					12											
					13											
					14											
					15											
					16											
					17											
					18											
					19											
					20											
					21											
					22											
					23											
					24											

REMARKS:

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URS Australia Pty Ltd			Monitoring Well 2S		Sheet 1 of 1
URS Australia Pty. Ltd. Level 14, 240 Queen Street, Brisbane, QLD, 4001		Phone +61732432111 Fax +61732432199	Project No.: 42625813		Project Reference: Unimin EIS
Drilling Contractor: GeoDrill					
Drilling Method: Rotary Mud		Logged By: AW Checked By: SD Date Started: 29-6-06 Date Finished: 29-6-06	Relative Level: 71.87 mAHD Coordinates: 546172.42 mE 6959079.62 mN Permit No:		Client: Unimin Australia Ltd

SAMPLING DETAILS			WELL CONSTRUCTION DETAILS		Depth (m)	DESCRIPTION OF STRATA										
Sample Type	Sampling and Observations	PID (ppm)				Legend	Lithology	Consistency	Structure	Grain Size	Shape	Sorting	Plasticity	Moisture	Classification	
					0		Organic rich dark grey black sand			F						SW
					1											
					2											
					3											
					4											
					5											
					6											
					7											
					8											
					9											
					10											
					11											
					12											
					13											
					14											
					15											
					16											
					17											
					18											
					19											
					20											
					21											
					22											
					23											
					24											
REMARKS:																

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Appendix B

Infiltrometer Test Results

Unimin Vance Lease Infiltrometer Test Results

Site 1		
K (m/d)	18.56711	
Time (s)	h (m)	h+0.5r (m)
1	0.292	0.307
2	0.273	0.288
3	0.286	0.301
4	0.275	0.29
5	0.277	0.292
6	0.268	0.283
7	0.26	0.275
8	0.262	0.277
9	0.266	0.281
10	0.263	0.278
11	0.254	0.269
12	0.252	0.267
13	0.25	0.265
14	0.239	0.254
15	0.244	0.259
16	0.241	0.256
17	0.239	0.254
18	0.235	0.25
19	0.232	0.247
20	0.229	0.244
21	0.227	0.242
22	0.224	0.239
23	0.219	0.234
24	0.218	0.233
25	0.202	0.217
26	0.209	0.224
27	0.21	0.225
28	0.205	0.22
29	0.202	0.217
30	0.199	0.214
31	0.198	0.213
32	0.192	0.207
33	0.19	0.205
34	0.189	0.204
35	0.184	0.199
36	0.182	0.197
37	0.177	0.192
38	0.176	0.191
39	0.175	0.19
40	0.172	0.187
41	0.167	0.182
42	0.164	0.179
43	0.165	0.18
44	0.163	0.178
45	0.159	0.174
46	0.156	0.171
47	0.154	0.169
48	0.152	0.167
49	0.151	0.166
50	0.147	0.162
51	0.145	0.16
52	0.143	0.158
53	0.139	0.154
54	0.139	0.154
55	0.136	0.151
56	0.134	0.149
57	0.131	0.146
58	0.13	0.145
59	0.129	0.144
60	0.125	0.14
61	0.123	0.138
62	0.121	0.136
63	0.12	0.135
64	0.119	0.134
65	0.117	0.132
66	0.115	0.13
67	0.112	0.127
68	0.111	0.126
69	0.109	0.124
70	0.108	0.123
71	0.107	0.122
72	0.103	0.118
73	0.102	0.117
74	0.101	0.116
75	0.101	0.116
76	0.074	0.089
77	0.075	0.09
78	0.091	0.106
79	0.081	0.096
80	0.072	0.087

Site 2		
K (m/d)	17.0198	
Time (s)	h (m)	h+0.5r (m)
1	0.581	0.596
2	0.56	0.575
3	0.548	0.563
4	0.537	0.552
5	0.523	0.538
6	0.51	0.525
7	0.497	0.512
8	0.488	0.503
9	0.476	0.491
10	0.466	0.481
11	0.458	0.473
12	0.449	0.464
13	0.44	0.455
14	0.433	0.448
15	0.423	0.438
16	0.415	0.43
17	0.408	0.423
18	0.4	0.415
19	0.395	0.41
20	0.388	0.403
21	0.381	0.396
22	0.377	0.392
23	0.369	0.384
24	0.365	0.38
25	0.359	0.374
26	0.353	0.368
27	0.35	0.365
28	0.345	0.36
29	0.34	0.355
30	0.336	0.351
31	0.331	0.346
32	0.327	0.342
33	0.324	0.339
34	0.316	0.331
35	0.313	0.328
36	0.31	0.325
37	0.306	0.321
38	0.301	0.316
39	0.296	0.311
40	0.292	0.307
41	0.291	0.306
42	0.287	0.302
43	0.281	0.296
44	0.276	0.291
45	0.274	0.289
46	0.27	0.285
47	0.266	0.281
48	0.262	0.277
49	0.257	0.272
50	0.256	0.271
51	0.253	0.268
52	0.247	0.262
53	0.245	0.26
54	0.243	0.258
55	0.239	0.254
56	0.236	0.251
57	0.232	0.247
58	0.227	0.242
59	0.227	0.242
60	0.224	0.239
61	0.22	0.235
62	0.215	0.23
63	0.215	0.23
64	0.211	0.226
65	0.208	0.223
66	0.206	0.221
67	0.202	0.217
68	0.198	0.213
69	0.196	0.211
70	0.196	0.211
71	0.192	0.207
72	0.187	0.202
73	0.184	0.199
74	0.182	0.197
75	0.178	0.193
76	0.177	0.192
77	0.173	0.188
78	0.172	0.187
79	0.168	0.183
80	0.165	0.18

Site 3		
K (m/d)	12.72472	
Time (s)	h (m)	h+0.5r (m)
1	0.596	0.611
2	0.589	0.604
3	0.589	0.604
4	0.585	0.6
5	0.567	0.582
6	0.556	0.571
7	0.548	0.563
8	0.541	0.556
9	0.533	0.548
10	0.525	0.54
11	0.515	0.53
12	0.508	0.523
13	0.501	0.516
14	0.493	0.508
15	0.486	0.501
16	0.478	0.493
17	0.473	0.488
18	0.465	0.48
19	0.46	0.475
20	0.455	0.47
21	0.448	0.463
22	0.442	0.457
23	0.436	0.451
24	0.43	0.445
25	0.424	0.439
26	0.419	0.434
27	0.411	0.426
28	0.407	0.422
29	0.401	0.416
30	0.396	0.411
31	0.391	0.406
32	0.386	0.401
33	0.383	0.398
34	0.379	0.394
35	0.375	0.39
36	0.373	0.388
37	0.367	0.382
38	0.363	0.378
39	0.359	0.374
40	0.356	0.371
41	0.351	0.366
42	0.347	0.362
43	0.345	0.36
44	0.342	0.357
45	0.34	0.355
46	0.335	0.35
47	0.332	0.347
48	0.329	0.344
49	0.327	0.342
50	0.322	0.337
51	0.319	0.334
52	0.315	0.33
53	0.312	0.327
54	0.309	0.324
55	0.308	0.323
56	0.305	0.32
57	0.303	0.318
58	0.299	0.314
59	0.293	0.308
60	0.291	0.306
61	0.289	0.304
62	0.286	0.301
63	0.282	0.297
64	0.279	0.294
65	0.278	0.293
66	0.272	0.287
67	0.27	0.285
68	0.269	0.284
69	0.266	0.281
70	0.263	0.278
71	0.259	0.274
72	0.258	0.273
73	0.255	0.27
74	0.252	0.267
75	0.25	0.265
76	0.247	0.262
77	0.245	0.26
78	0.243	0.258
79	0.24	0.255
80	0.235	0.25

Site 4		
K (m/d)	17.9462	
Time (s)	h (m)	h+0.5r (m)
1	0.481	0.496
2	0.475	0.49
3	0.471	0.486
4	0.46	0.475
5	0.446	0.461
6	0.433	0.448
7	0.418	0.433
8	0.405	0.42
9	0.393	0.408
10	0.38	0.395
11	0.367	0.382
12	0.355	0.37
13	0.342	0.357
14	0.332	0.347
15	0.321	0.336
16	0.313	0.328
17	0.303	0.318
18	0.295	0.31
19	0.283	0.298
20	0.279	0.294
21	0.272	0.287
22	0.263	0.278
23	0.259	0.274
24	0.252	0.267
25	0.247	0.262
26	0.241	0.256
27	0.235	0.25
28	0.233	0.248
29	0.227	0.242
30	0.222	0.237
31	0.216	0.231
32	0.213	0.228
33	0.209	0.224
34	0.207	0.222
35	0.201	0.216
36	0.198	0.213
37	0.197	0.212
38	0.19	0.205
39	0.188	0.203
40	0.184	0.199
41	0.18	0.195
42	0.176	0.191
43	0.173	0.188
44	0.171	0.186
45	0.167	0.182
46	0.166	0.181
47	0.16	0.175
48	0.161	0.176
49	0.158	0.173
50	0.155	0.17
51	0.151	0.166
52	0.15	0.165
53	0.147	0.162
54	0.146	0.161
55	0.143	0.158
56	0.14	0.155
57	0.138	0.153
58	0.137	0.152
59	0.134	0.149
60	0.131	0.146
61	0.13	0.145
62	0.127	0.142
63	0.126	0.141
64	0.125	0.14
65	0.124	0.139
66	0.121	0.136
67	0.117	0.132
68	0.118	0.133
69	0.118	0.133
70	0.115	0.13
71	0.113	0.128
72	0.109	0.124
73	0.11	0.125
74	0.108	0.123
75	0.107	0.122
76	0.105	0.12
77	0.102	0.117
78	0.101	0.116
79	0.099	0.114
80	0.098	0.113

Unimin Vance Lease Infiltrometer Test Results

Site 1		
K (m/d)	18.56711	
Time (s)	h (m)	h+0.5r (m)

Site 2		
K (m/d)	17.0198	
Time (s)	h (m)	h+0.5r (m)
81	0.163	0.178
82	0.158	0.173
83	0.157	0.172
84	0.153	0.168
85	0.151	0.166
86	0.148	0.163
87	0.146	0.161
88	0.143	0.158
89	0.139	0.154
90	0.137	0.152
91	0.135	0.15
92	0.132	0.147
93	0.13	0.145
94	0.126	0.141
95	0.125	0.14
96	0.122	0.137
97	0.121	0.136
98	0.117	0.132
99	0.114	0.129
100	0.113	0.128
101	0.11	0.125
102	0.106	0.121
103	0.105	0.12
104	0.102	0.117
105	0.1	0.115
106	0.098	0.113
107	0.095	0.11
108	0.095	0.11
109	0.091	0.106
110	0.088	0.103
111	0.087	0.102
112	0.084	0.099
113	0.083	0.098
114	0.081	0.096
115	0.078	0.093
116	0.075	0.09
117	0.074	0.089
118	0.073	0.088
119	0.071	0.086
120	0.069	0.084
121	0.066	0.081
122	0.066	0.081
123	0.064	0.079
124	0.061	0.076
125	0.059	0.074
126	0.057	0.072
127	0.054	0.069
128	0.055	0.07
129	0.053	0.068
130	0.053	0.068
131	0.049	0.064
132	0.05	0.065
133	0.048	0.063
134	0.045	0.06
135	0.04	0.055
136	0.039	0.054
137	0.037	0.052
138	0.036	0.051
139	0.036	0.051
140	0.034	0.049
141	0.035	0.05
142	0.033	0.048
143	0.031	0.046
144	0.028	0.043
145	0.027	0.042
146	0.028	0.043
147	0.027	0.042
148	0.027	0.042
149	0.025	0.04
150	0.02	0.035
151	0.022	0.037
152	0.02	0.035
153	0.019	0.034
154	0.017	0.032
155	0.015	0.03
156	0.015	0.03
157	0.014	0.029
158	0.013	0.028
159	0.012	0.027
160	0.01	0.025
161	0.009	0.024
162	0.003	0.018

Site 3		
K (m/d)	12.72472	
Time (s)	h (m)	h+0.5r (m)
81	0.235	0.25
82	0.232	0.247
83	0.23	0.245
84	0.228	0.243
85	0.225	0.24
86	0.223	0.238
87	0.221	0.236
88	0.218	0.233
89	0.216	0.231
90	0.212	0.227
91	0.21	0.225
92	0.207	0.222
93	0.208	0.223
94	0.205	0.22
95	0.203	0.218
96	0.2	0.215
97	0.198	0.213
98	0.197	0.212
99	0.193	0.208
100	0.191	0.206
101	0.188	0.203
102	0.184	0.199
103	0.184	0.199
104	0.181	0.196
105	0.179	0.194
106	0.178	0.193
107	0.175	0.19
108	0.173	0.188
109	0.171	0.186
110	0.169	0.184
111	0.166	0.181
112	0.164	0.179
113	0.162	0.177
114	0.16	0.175
115	0.157	0.172
116	0.156	0.171
117	0.153	0.168
118	0.152	0.167
119	0.147	0.162
120	0.147	0.162
121	0.145	0.16
122	0.143	0.158
123	0.141	0.156
124	0.139	0.154
125	0.136	0.151
126	0.136	0.151
127	0.132	0.147
128	0.131	0.146
129	0.129	0.144
130	0.127	0.142
131	0.125	0.14
132	0.123	0.138
133	0.119	0.134
134	0.12	0.135
135	0.116	0.131
136	0.116	0.131
137	0.115	0.13
138	0.112	0.127
139	0.111	0.126
140	0.109	0.124
141	0.107	0.122
142	0.104	0.119
143	0.102	0.117
144	0.102	0.117
145	0.097	0.112
146	0.097	0.112
147	0.096	0.111
148	0.095	0.11
149	0.092	0.107
150	0.091	0.106
151	0.089	0.104
152	0.089	0.104
153	0.085	0.1
154	0.086	0.101
155	0.083	0.098
156	0.081	0.096
157	0.079	0.094
158	0.079	0.094
159	0.077	0.092
160	0.075	0.09
161	0.072	0.087
162	0.071	0.086
163	0.07	0.085

Site 4		
K (m/d)	17.9462	
Time (s)	h (m)	h+0.5r (m)
81	0.097	0.112
82	0.094	0.109
83	0.094	0.109
84	0.092	0.107
85	0.092	0.107
86	0.091	0.106
87	0.089	0.104
88	0.088	0.103
89	0.085	0.1
90	0.084	0.099
91	0.083	0.098
92	0.083	0.098
93	0.08	0.095
94	0.079	0.094
95	0.076	0.091
96	0.077	0.092
97	0.074	0.089
98	0.075	0.09
99	0.071	0.086
100	0.07	0.085
101	0.069	0.084
102	0.071	0.086
103	0.067	0.082
104	0.067	0.082
105	0.066	0.081
106	0.063	0.078
107	0.063	0.078
108	0.062	0.077
109	0.061	0.076
110	0.06	0.075
111	0.059	0.074
112	0.059	0.074
113	0.057	0.072
114	0.055	0.07
115	0.054	0.069
116	0.054	0.069
117	0.053	0.068
118	0.052	0.067
119	0.049	0.064
120	0.048	0.063
121	0.05	0.065

Unimin Vance Lease Infiltrometer Test Results

Site 1		
K (m/d)	18.56711	
Time (s)	h (m)	h+0.5r (m)

Site 2		
K (m/d)	17.0198	
Time (s)	h (m)	h+0.5r (m)

Site 3		
K (m/d)	12.72472	
Time (s)	h (m)	h+0.5r (m)
164	0.067	0.082
165	0.066	0.081
166	0.066	0.081
167	0.065	0.08
168	0.063	0.078
169	0.062	0.077
170	0.06	0.075
171	0.059	0.074
172	0.056	0.071
173	0.056	0.071
174	0.055	0.07
175	0.054	0.069
176	0.053	0.068
177	0.052	0.067
178	0.051	0.066
179	0.05	0.065
180	0.046	0.061
181	0.047	0.062
182	0.046	0.061
183	0.046	0.061
184	0.042	0.057
185	0.043	0.058
186	0.043	0.058
187	0.042	0.057
188	0.04	0.055
189	0.04	0.055
190	0.037	0.052
191	0.035	0.05
192	0.036	0.051
193	0.033	0.048
194	0.035	0.05
195	0.033	0.048
196	0.032	0.047
197	0.031	0.046
198	0.03	0.045
199	0.03	0.045
200	0.027	0.042
201	0.028	0.043
202	0.028	0.043
203	0.027	0.042
204	0.026	0.041
205	0.022	0.037
206	0.023	0.038
207	0.022	0.037
208	0.02	0.035
209	0.02	0.035
210	0.018	0.033
211	0.018	0.033
212	0.017	0.032
213	0.016	0.031
214	0.014	0.029
215	0.014	0.029
216	0.014	0.029
217	0.011	0.026
218	0.011	0.026
219	0.009	0.024
220	0.008	0.023
221	0.003	0.018
222	0.001	0.016

Site 4		
K (m/d)	17.9462	
Time (s)	h (m)	h+0.5r (m)

Unimin Vance Lease Infiltrometer Test Results

Site 5		
K (m/d)	13.26296	
Time (s)	h (m)	h+0.5r (m)
1	0.495	0.51
2	0.493	0.508
3	0.494	0.509
4	0.489	0.504
5	0.479	0.494
6	0.473	0.488
7	0.463	0.478
8	0.457	0.472
9	0.447	0.462
10	0.439	0.454
11	0.431	0.446
12	0.423	0.438
13	0.414	0.429
14	0.405	0.42
15	0.396	0.411
16	0.389	0.404
17	0.38	0.395
18	0.37	0.385
19	0.361	0.376
20	0.354	0.369
21	0.346	0.361
22	0.34	0.355
23	0.332	0.347
24	0.327	0.342
25	0.319	0.334
26	0.313	0.328
27	0.309	0.324
28	0.3	0.315
29	0.294	0.309
30	0.29	0.305
31	0.285	0.3
32	0.28	0.295
33	0.277	0.292
34	0.273	0.288
35	0.268	0.283
36	0.261	0.276
37	0.259	0.274
38	0.254	0.269
39	0.25	0.265
40	0.248	0.263
41	0.245	0.26
42	0.241	0.256
43	0.237	0.252
44	0.232	0.247
45	0.231	0.246
46	0.229	0.244
47	0.225	0.24
48	0.223	0.238
49	0.218	0.233
50	0.217	0.232
51	0.214	0.229
52	0.211	0.226
53	0.21	0.225
54	0.207	0.222
55	0.204	0.219
56	0.2	0.215
57	0.2	0.215
58	0.196	0.211
59	0.197	0.212
60	0.194	0.209
61	0.191	0.206
62	0.188	0.203
63	0.188	0.203
64	0.186	0.201
65	0.184	0.199
66	0.18	0.195
67	0.177	0.192
68	0.176	0.191
69	0.176	0.191
70	0.174	0.189
71	0.17	0.185
72	0.168	0.183
73	0.168	0.183
74	0.166	0.181
75	0.162	0.177
76	0.161	0.176
77	0.159	0.174
78	0.158	0.173
79	0.155	0.17
80	0.154	0.169

Site 6		
K (m/d)	46.09941	
Time (s)	h (m)	h+0.5r (m)
1	0.462	0.477
2	0.45	0.465
3	0.436	0.451
4	0.415	0.43
5	0.393	0.408
6	0.366	0.381
7	0.343	0.358
8	0.321	0.336
9	0.303	0.318
10	0.283	0.298
11	0.265	0.28
12	0.251	0.266
13	0.238	0.253
14	0.226	0.241
15	0.214	0.229
16	0.204	0.219
17	0.194	0.209
18	0.184	0.199
19	0.175	0.19
20	0.166	0.181
21	0.158	0.173
22	0.148	0.163
23	0.142	0.157
24	0.134	0.149
25	0.127	0.142
26	0.121	0.136
27	0.116	0.131
28	0.111	0.126
29	0.105	0.12
30	0.1	0.115
31	0.098	0.113
32	0.092	0.107
33	0.086	0.101
34	0.084	0.099
35	0.081	0.096
36	0.077	0.092
37	0.072	0.087
38	0.071	0.086
39	0.068	0.083
40	0.065	0.08
41	0.062	0.077
42	0.057	0.072
43	0.055	0.07
44	0.055	0.07
45	0.05	0.065
46	0.049	0.064
47	0.047	0.062
48	0.045	0.06
49	0.042	0.057
50	0.041	0.056
51	0.039	0.054
52	0.036	0.051
53	0.035	0.05
54	0.031	0.046
55	0.031	0.046
56	0.029	0.044
57	0.025	0.04
58	0.026	0.041
59	0.024	0.039
60	0.021	0.036
61	0.022	0.037
62	0.02	0.035
63	0.015	0.03
64	0.015	0.03
65	0.011	0.026
66	0.011	0.026
67	0.009	0.024
68	0.007	0.022
69	0.004	0.019

Site 7		
K (m/d)	39.42534	
Time (s)	h (m)	h+0.5r (m)
1	0.5	0.515
2	0.499	0.514
3	0.489	0.504
4	0.494	0.509
5	0.426	0.441
6	0.386	0.401
7	0.352	0.367
8	0.324	0.339
9	0.3	0.315
10	0.282	0.297
11	0.263	0.278
12	0.248	0.263
13	0.234	0.249
14	0.222	0.237
15	0.209	0.224
16	0.199	0.214
17	0.187	0.202
18	0.177	0.192
19	0.168	0.183
20	0.162	0.177
21	0.153	0.168
22	0.143	0.158
23	0.139	0.154
24	0.132	0.147
25	0.129	0.144
26	0.122	0.137
27	0.118	0.133
28	0.114	0.129
29	0.109	0.124
30	0.105	0.12
31	0.1	0.115
32	0.098	0.113
33	0.094	0.109
34	0.09	0.105
35	0.086	0.101
36	0.084	0.099
37	0.083	0.098
38	0.079	0.094
39	0.078	0.093
40	0.074	0.089
41	0.072	0.087
42	0.07	0.085
43	0.066	0.081
44	0.064	0.079
45	0.062	0.077
46	0.061	0.076
47	0.058	0.073
48	0.056	0.071
49	0.053	0.068
50	0.053	0.068
51	0.052	0.067
52	0.049	0.064
53	0.048	0.063
54	0.046	0.061
55	0.044	0.059
56	0.043	0.058
57	0.041	0.056
58	0.041	0.056
59	0.038	0.053
60	0.036	0.051
61	0.035	0.05
62	0.034	0.049
63	0.031	0.046
64	0.032	0.047
65	0.031	0.046
66	0.028	0.043
67	0.027	0.042
68	0.023	0.038
69	0.004	0.019

Site 8		
K (m/d)	25.92952	
Time (s)	h (m)	h+0.5r (m)
1	0.505	0.52
2	0.478	0.493
3	0.444	0.459
4	0.415	0.43
5	0.388	0.403
6	0.365	0.38
7	0.348	0.363
8	0.329	0.344
9	0.312	0.327
10	0.301	0.316
11	0.289	0.304
12	0.278	0.293
13	0.269	0.284
14	0.255	0.27
15	0.245	0.26
16	0.238	0.253
17	0.232	0.247
18	0.224	0.239
19	0.214	0.229
20	0.208	0.223
21	0.203	0.218
22	0.198	0.213
23	0.191	0.206
24	0.184	0.199
25	0.177	0.192
26	0.173	0.188
27	0.167	0.182
28	0.163	0.178
29	0.158	0.173
30	0.155	0.17
31	0.149	0.164
32	0.146	0.161
33	0.142	0.157
34	0.138	0.153
35	0.134	0.149
36	0.132	0.147
37	0.128	0.143
38	0.126	0.141
39	0.124	0.139
40	0.118	0.133
41	0.117	0.132
42	0.112	0.127
43	0.112	0.127
44	0.108	0.123
45	0.107	0.122
46	0.103	0.118
47	0.1	0.115
48	0.098	0.113
49	0.095	0.11
50	0.095	0.11
51	0.093	0.108
52	0.091	0.106
53	0.086	0.101
54	0.086	0.101
55	0.085	0.1
56	0.082	0.097
57	0.08	0.095
58	0.079	0.094
59	0.078	0.093
60	0.074	0.089
61	0.073	0.088
62	0.072	0.087
63	0.069	0.084
64	0.067	0.082
65	0.063	0.078
66	0.018	0.033
67	0.004	0.019
68	0.029	0.044
69	0.048	0.063
70	0.047	0.062
71	0.043	0.058
72	0.041	0.056
73	0.039	0.054
74	0.011	0.026
75	0.006	0.021
76	0.002	0.017
77	0.002	0.017

Unimin Vance Lease Infiltrometer Test Results

Site 5		
K (m/d)	13.26296	
Time (s)	h (m)	h+0.5r (m)
81	0.152	0.167
82	0.152	0.167
83	0.149	0.164
84	0.147	0.162
85	0.146	0.161
86	0.144	0.159
87	0.142	0.157
88	0.139	0.154
89	0.138	0.153
90	0.139	0.154
91	0.137	0.152
92	0.134	0.149
93	0.134	0.149
94	0.133	0.148
95	0.131	0.146
96	0.13	0.145
97	0.127	0.142
98	0.128	0.143
99	0.126	0.141
100	0.124	0.139
101	0.124	0.139
102	0.121	0.136
103	0.121	0.136
104	0.121	0.136
105	0.119	0.134
106	0.119	0.134
107	0.116	0.131
108	0.113	0.128
109	0.111	0.126
110	0.113	0.128
111	0.112	0.127
112	0.108	0.123
113	0.109	0.124
114	0.105	0.12
115	0.107	0.122
116	0.104	0.119
117	0.101	0.116
118	0.101	0.116
119	0.1	0.115
120	0.099	0.114
121	0.099	0.114
122	0.096	0.111
123	0.096	0.111
124	0.094	0.109
125	0.094	0.109
126	0.093	0.108
127	0.091	0.106
128	0.092	0.107
129	0.092	0.107
130	0.089	0.104
131	0.087	0.102
132	0.087	0.102
133	0.085	0.1
134	0.085	0.1
135	0.083	0.098
136	0.082	0.097
137	0.081	0.096
138	0.08	0.095
139	0.075	0.09
140	0.007	0.022
141	0.004	0.019
142	0.01	0.025

Site 6		
K (m/d)	46.09941	
Time (s)	h (m)	h+0.5r (m)

Site 7		
K (m/d)	39.42534	
Time (s)	h (m)	h+0.5r (m)

Site 8		
K (m/d)	25.92952	
Time (s)	h (m)	h+0.5r (m)

Unimin Vance Lease Infiltrometer Test Results

Site 5		
K (m/d)	13.26296	
Time (s)	h (m)	h+0.5r (m)

Site 6		
K (m/d)	46.09941	
Time (s)	h (m)	h+0.5r (m)

Site 7		
K (m/d)	39.42534	
Time (s)	h (m)	h+0.5r (m)

Site 8		
K (m/d)	25.92952	
Time (s)	h (m)	h+0.5r (m)

Unimin Vance Lease Infiltrometer Test Results

Site 9		
K (m/d)	24.16928	
Time (s)	h (m)	h+0.5r (m)
1	0.509	0.524
2	0.494	0.509
3	0.48	0.495
4	0.454	0.469
5	0.432	0.447
6	0.415	0.43
7	0.398	0.413
8	0.38	0.395
9	0.366	0.381
10	0.354	0.369
11	0.342	0.357
12	0.33	0.345
13	0.32	0.335
14	0.31	0.325
15	0.302	0.317
16	0.293	0.308
17	0.283	0.298
18	0.277	0.292
19	0.269	0.284
20	0.263	0.278
21	0.256	0.271
22	0.247	0.262
23	0.243	0.258
24	0.236	0.251
25	0.232	0.247
26	0.225	0.24
27	0.221	0.236
28	0.216	0.231
29	0.21	0.225
30	0.207	0.222
31	0.2	0.215
32	0.197	0.212
33	0.195	0.21
34	0.19	0.205
35	0.185	0.2
36	0.182	0.197
37	0.175	0.19
38	0.172	0.187
39	0.168	0.183
40	0.166	0.181
41	0.162	0.177
42	0.157	0.172
43	0.154	0.169
44	0.15	0.165
45	0.147	0.162
46	0.146	0.161
47	0.141	0.156
48	0.14	0.155
49	0.137	0.152
50	0.132	0.147
51	0.13	0.145
52	0.128	0.143
53	0.125	0.14
54	0.121	0.136
55	0.118	0.133
56	0.115	0.13
57	0.113	0.128
58	0.112	0.127
59	0.111	0.126
60	0.106	0.121
61	0.103	0.118
62	0.101	0.116
63	0.098	0.113
64	0.098	0.113
65	0.096	0.111
66	0.094	0.109
67	0.091	0.106
68	0.091	0.106
69	0.088	0.103
70	0.087	0.102
71	0.084	0.099
72	0.082	0.097
73	0.08	0.095
74	0.077	0.092
75	0.076	0.091
76	0.075	0.09

Site 10		
K (m/d)	21.6324	
Time (s)	h (m)	h+0.5r (m)
1	0.51	0.525
2	0.496	0.511
3	0.481	0.496
4	0.463	0.478
5	0.444	0.459
6	0.428	0.443
7	0.412	0.427
8	0.401	0.416
9	0.387	0.402
10	0.373	0.388
11	0.365	0.38
12	0.355	0.37
13	0.345	0.36
14	0.336	0.351
15	0.326	0.341
16	0.321	0.336
17	0.312	0.327
18	0.304	0.319
19	0.299	0.314
20	0.291	0.306
21	0.284	0.299
22	0.278	0.293
23	0.273	0.288
24	0.266	0.281
25	0.261	0.276
26	0.256	0.271
27	0.249	0.264
28	0.247	0.262
29	0.239	0.254
30	0.236	0.251
31	0.232	0.247
32	0.23	0.245
33	0.224	0.239
34	0.217	0.232
35	0.217	0.232
36	0.212	0.227
37	0.21	0.225
38	0.207	0.222
39	0.201	0.216
40	0.198	0.213
41	0.193	0.208
42	0.192	0.207
43	0.187	0.202
44	0.184	0.199
45	0.18	0.195
46	0.179	0.194
47	0.173	0.188
48	0.172	0.187
49	0.167	0.182
50	0.166	0.181
51	0.163	0.178
52	0.16	0.175
53	0.157	0.172
54	0.155	0.17
55	0.15	0.165
56	0.148	0.163
57	0.146	0.161
58	0.141	0.156
59	0.141	0.156
60	0.138	0.153
61	0.133	0.148
62	0.134	0.149
63	0.131	0.146
64	0.127	0.142
65	0.126	0.141
66	0.125	0.14
67	0.12	0.135
68	0.118	0.133
69	0.116	0.131
70	0.115	0.13
71	0.112	0.127
72	0.111	0.126
73	0.108	0.123
74	0.104	0.119
75	0.105	0.12
76	0.103	0.118
77	0.099	0.114
78	0.098	0.113
79	0.097	0.112
80	0.096	0.111

Site 11		
K (m/d)	16.6405	
Time (s)	h (m)	h+0.5r (m)
1	0.515	0.53
2	0.502	0.517
3	0.496	0.511
4	0.487	0.502
5	0.471	0.486
6	0.454	0.469
7	0.44	0.455
8	0.426	0.441
9	0.417	0.432
10	0.406	0.421
11	0.396	0.411
12	0.386	0.401
13	0.375	0.39
14	0.365	0.38
15	0.359	0.374
16	0.348	0.363
17	0.341	0.356
18	0.333	0.348
19	0.327	0.342
20	0.322	0.337
21	0.314	0.329
22	0.306	0.321
23	0.303	0.318
24	0.297	0.312
25	0.292	0.307
26	0.285	0.3
27	0.279	0.294
28	0.274	0.289
29	0.269	0.284
30	0.265	0.28
31	0.259	0.274
32	0.255	0.27
33	0.252	0.267
34	0.246	0.261
35	0.243	0.258
36	0.238	0.253
37	0.235	0.25
38	0.231	0.246
39	0.227	0.242
40	0.224	0.239
41	0.221	0.236
42	0.217	0.232
43	0.215	0.23
44	0.209	0.224
45	0.208	0.223
46	0.205	0.22
47	0.202	0.217
48	0.2	0.215
49	0.197	0.212
50	0.195	0.21
51	0.191	0.206
52	0.189	0.204
53	0.189	0.204
54	0.184	0.199
55	0.181	0.196
56	0.178	0.193
57	0.176	0.191
58	0.173	0.188
59	0.172	0.187
60	0.168	0.183
61	0.165	0.18
62	0.163	0.178
63	0.162	0.177
64	0.158	0.173
65	0.156	0.171
66	0.155	0.17
67	0.152	0.167
68	0.149	0.164
69	0.147	0.162
70	0.145	0.16
71	0.145	0.16
72	0.14	0.155
73	0.14	0.155
74	0.137	0.152
75	0.136	0.151
76	0.132	0.147
77	0.133	0.148
78	0.128	0.143
79	0.128	0.143
80	0.124	0.139

Unimin Vance Lease Infiltrometer Test Results

Site 9		
K (m/d)	24.16928	
Time (s)	h (m)	h+0.5r (m)

Site 10		
K (m/d)	21.6324	
Time (s)	h (m)	h+0.5r (m)
81	0.094	0.109
82	0.089	0.104
83	0.09	0.105
84	0.088	0.103
85	0.086	0.101
86	0.085	0.1
87	0.083	0.098
88	0.081	0.096
89	0.077	0.092
90	0.078	0.093
91	0.076	0.091
92	0.073	0.088
93	0.074	0.089
94	0.07	0.085
95	0.07	0.085
96	0.068	0.083
97	0.066	0.081
98	0.064	0.079
99	0.062	0.077
100	0.061	0.076
101	0.061	0.076
102	0.058	0.073
103	0.059	0.074
104	0.055	0.07
105	0.056	0.071
106	0.056	0.071
107	0.051	0.066
108	0.052	0.067
109	0.05	0.065
110	0.049	0.064
111	0.048	0.063
112	0.046	0.061
113	0.046	0.061
114	0.044	0.059
115	0.041	0.056
116	0.042	0.057
117	0.038	0.053
118	0.038	0.053
119	0.038	0.053
120	0.037	0.052
121	0.035	0.05
122	0.033	0.048
123	0.032	0.047
124	0.03	0.045
125	0.028	0.043
126	0.026	0.041
127	0.028	0.043
128	0.027	0.042
129	0.023	0.038
130	0.023	0.038
131	0.023	0.038

Site 11		
K (m/d)	16.6405	
Time (s)	h (m)	h+0.5r (m)
81	0.125	0.14
82	0.123	0.138
83	0.118	0.133
84	0.12	0.135
85	0.116	0.131
86	0.116	0.131
87	0.115	0.13
88	0.11	0.125
89	0.111	0.126
90	0.107	0.122
91	0.108	0.123
92	0.107	0.122
93	0.104	0.119
94	0.103	0.118
95	0.102	0.117
96	0.098	0.113
97	0.07	0.085

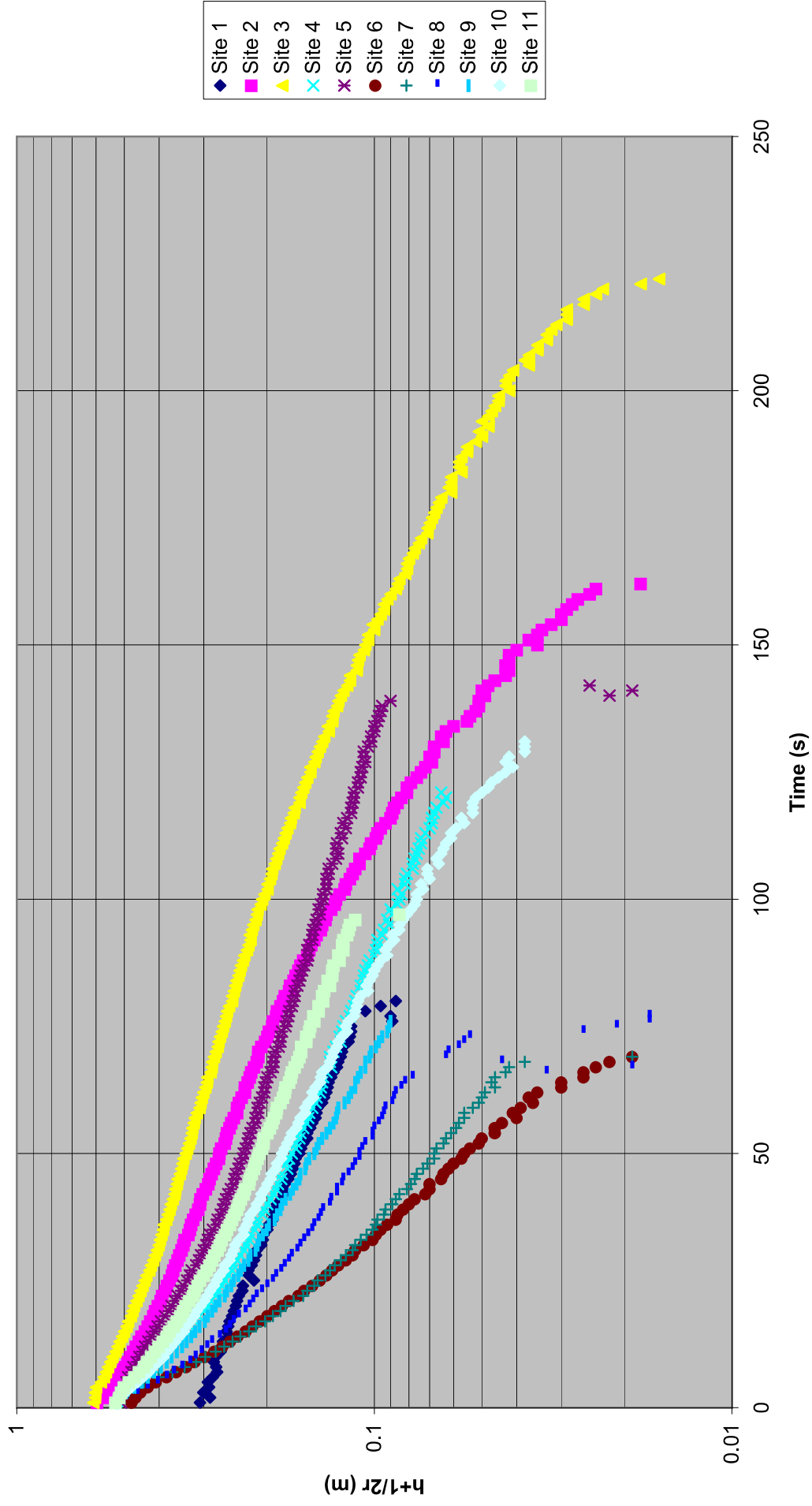
Unimin Vance Lease Infiltrrometer Test Results

Site 9		
K (m/d)	24.16928	
Time (s)	h (m)	h+0.5r (m)

Site 10		
K (m/d)	21.6324	
Time (s)	h (m)	h+0.5r (m)

Site 11		
K (m/d)	16.6405	
Time (s)	h (m)	h+0.5r (m)

Unimin Vance Lease Infiltrometer Test Plots



Appendix C

Slug Test Results

 URS Australia Pty Ltd Level 14 240 Queen Street Brisbane QLD 4000				Slug Test - Water Level Data		Page 1 of 2
				Project: Unimin Environmental Studies		
				Number: 42625813		
				Client: Unimin Australia Limited		
Location: Vance Lease, North Stradbroke			Slug Test: 2D Slug Test		Test Well: 2D	
Test conducted by: S. Denner			Test date: 23/11/2006			
Water level at t=0 [m]: 0.87			Static water level [m]: 0.00		Water level change at t=0 [m]: 0.87	
	Time [s]	Water Level [m]	WL Change [m]			
1	1	0.858	0.858			
2	2	0.652	0.652			
3	3	0.563	0.563			
4	4	0.484	0.484			
5	5	0.42	0.42			
6	6	0.367	0.367			
7	7	0.321	0.321			
8	8	0.281	0.281			
9	9	0.25	0.25			
10	10	0.223	0.223			
11	11	0.199	0.199			
12	12	0.177	0.177			
13	13	0.159	0.159			
14	14	0.142	0.142			
15	15	0.128	0.128			
16	16	0.116	0.116			
17	17	0.107	0.107			
18	18	0.099	0.099			
19	19	0.091	0.091			
20	20	0.084	0.084			
21	21	0.074	0.074			
22	22	0.075	0.075			
23	23	0.07	0.07			
24	24	0.066	0.066			
25	25	0.061	0.061			
26	26	0.057	0.057			
27	27	0.054	0.054			
28	28	0.051	0.051			
29	29	0.05	0.05			
30	30	0.045	0.045			
31	31	0.043	0.043			
32	32	0.037	0.037			
33	33	0.037	0.037			
34	34	0.035	0.035			
35	35	0.033	0.033			
36	36	0.03	0.03			
37	37	0.029	0.029			
38	38	0.024	0.024			
39	39	0.023	0.023			
40	40	0.022	0.022			
41	41	0.022	0.022			
42	42	0.022	0.022			
43	43	0.019	0.019			
44	44	0.016	0.016			
45	45	0.017	0.017			
46	46	0.015	0.015			
47	47	0.015	0.015			
48	48	0.014	0.014			
49	49	0.012	0.012			
50	50	0.012	0.012			
51	51	0.012	0.012			



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Level 14
240 Queen Street
Brisbane QLD 4000

Slug Test - Water Level Data	Page 2 of 2
Project: Unimin Environmental Studies	
Number: 42625813	
Client: Unimin Australia Limited	

	Time [s]	Water Level [m]	WL Change [m]
52	52	0.011	0.011
53	53	0.01	0.01
54	54	0.009	0.009
55	55	0.01	0.01
56	56	0.009	0.009
57	57	0.01	0.01
58	58	0.011	0.011
59	59	0.009	0.009
60	60	0.009	0.009
61	61	0.007	0.007
62	62	0.007	0.007
63	63	0.007	0.007
64	64	0.005	0.005
65	65	0.007	0.007
66	66	0.006	0.006
67	67	0.006	0.006
68	68	0.006	0.006
69	69	0.006	0.006
70	70	0.005	0.005
71	71	0.005	0.005
72	72	0.005	0.005
73	73	0.005	0.005
74	74	0.007	0.007
75	75	0.007	0.007
76	76	0.007	0.007
77	77	0.004	0.004
78	78	0.005	0.005
79	79	0.005	0.005
80	80	0.006	0.006
81	81	0.005	0.005
82	82	0.006	0.006
83	83	0.006	0.006
84	84	0.005	0.005
85	85	0.003	0.003
86	86	0.005	0.005
87	87	0.005	0.005
88	88	0.003	0.003
89	89	0.005	0.005



URS Australia Pty Ltd
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Brisbane QLD 4000

Slug Test Analysis Report

Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2D Slug Test

Test Well: 2D

Test conducted by: S. Denner

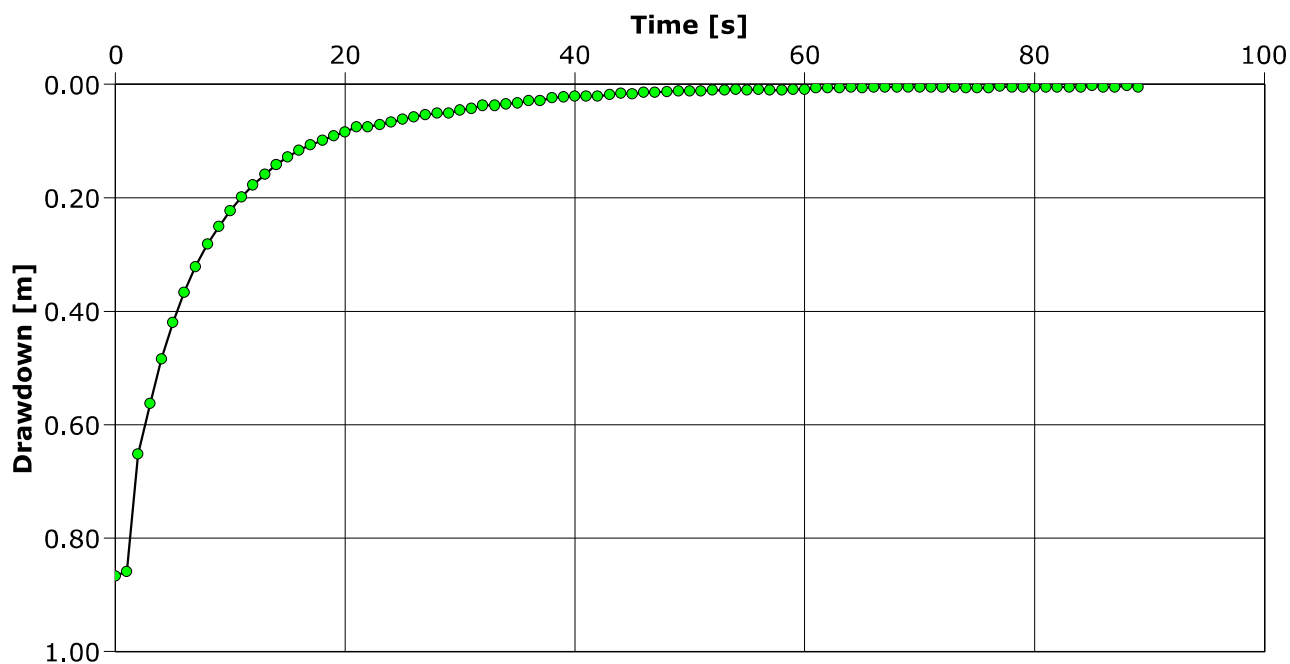
Test date: 23/11/2006

Analysis performed by: S. Denner

Time vs. Change in WL

Date: 28/11/2006

Aquifer Thickness: 2.00 m





URS Australia Pty Ltd
Level 14
240 Queen Street
Brisbane QLD 4000

Slug Test Analysis Report

Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2D Slug Test

Test Well: 2D

Test conducted by: S. Denner

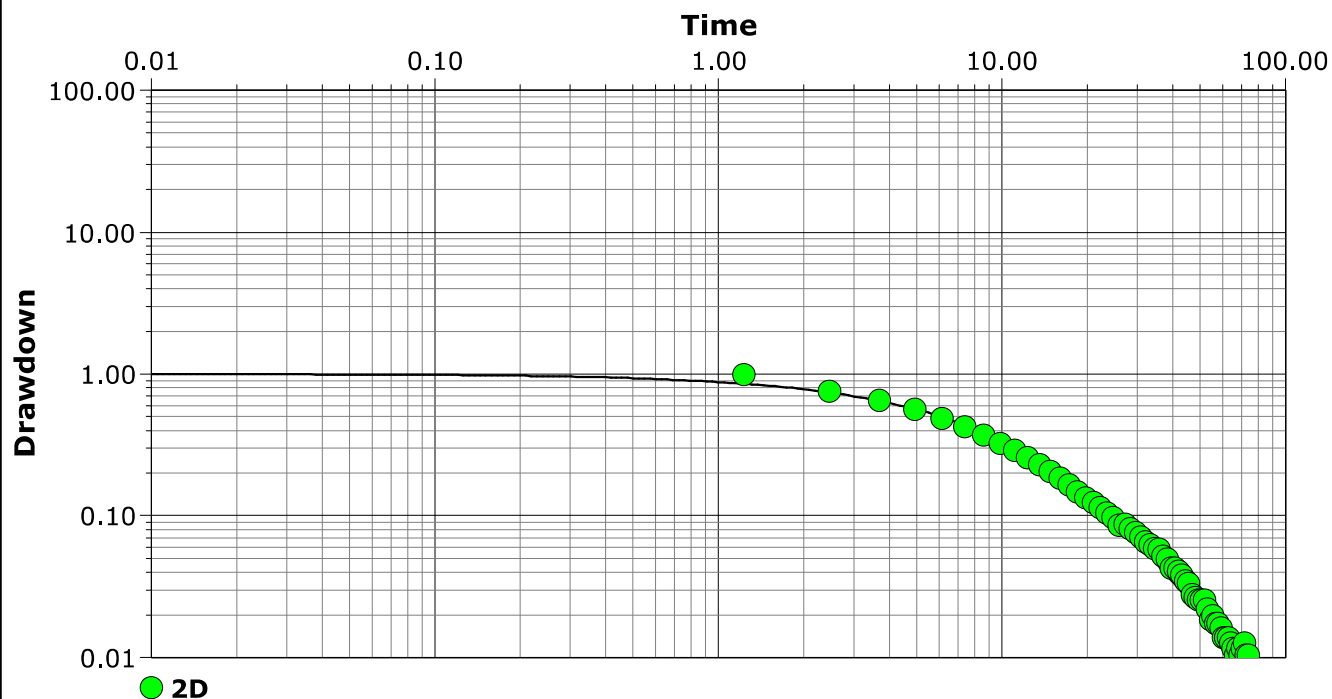
Test date: 23/11/2006

Analysis performed by: S. Denner

Cooper-Bredehoft

Date: 28/11/2006

Aquifer Thickness: 2.00 m



Calculation after Cooper-Bredehoft-Papadopolos

Observation well	Transmissivity [m ² /d]	K [m/d]	Well-bore storage coefficient
2D	3.60×10^1	1.80×10^1	2.55×10^{-8}



URS Australia Pty Ltd
Level 14
240 Queen Street
Brisbane QLD 4000

Slug Test Analysis Report

Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2D Slug Test

Test Well: 2D

Test conducted by: S. Denner

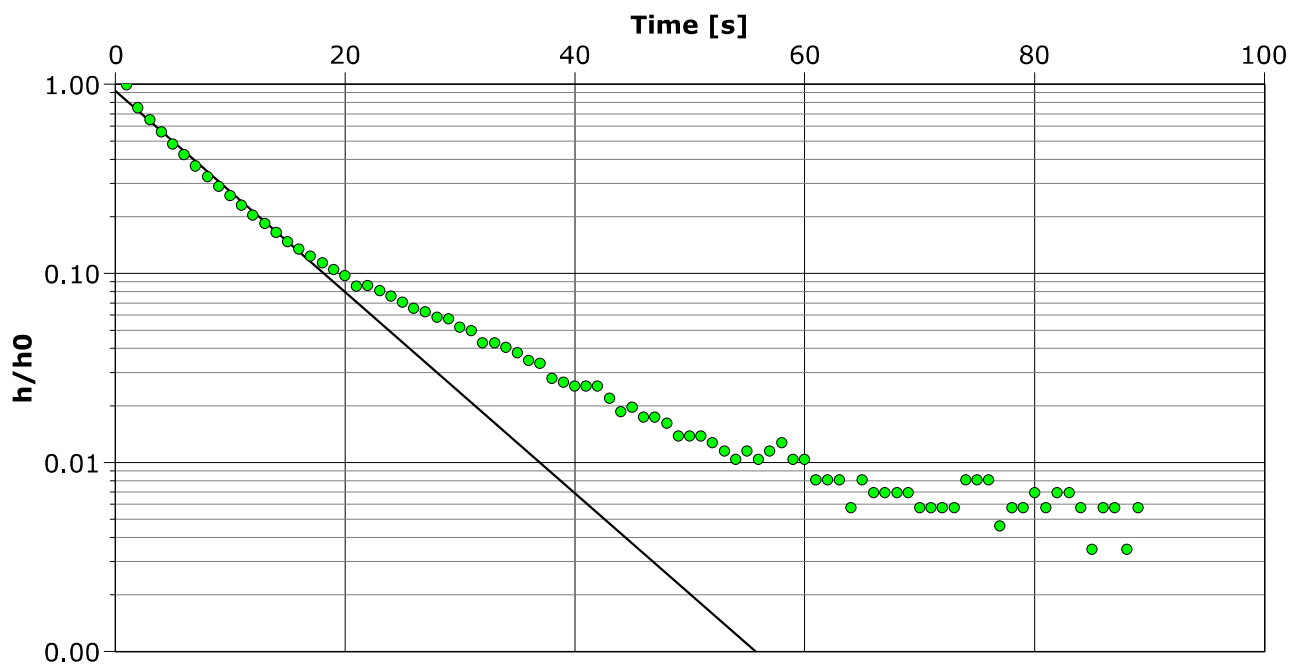
Test date: 23/11/2006

Analysis performed by: S. Denner

Hvorslev

Date: 28/11/2006

Aquifer Thickness: 2.00 m



Calculation after Hvorslev

Observation well

K
[m/d]

2D

6.64×10^0



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Slug Test Analysis Report

Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2D Slug Test

Test Well: 2D

Test conducted by: S. Denner

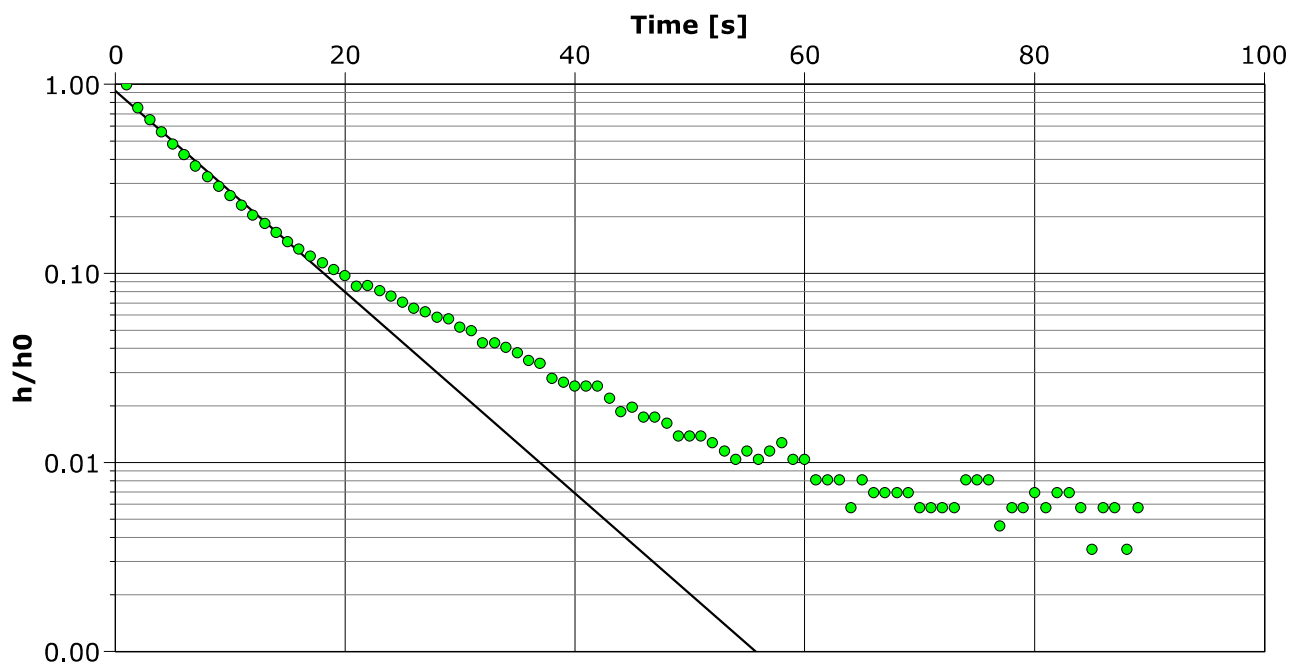
Test date: 23/11/2006

Analysis performed by: S. Denner

Bouwer-Rice

Date: 28/11/2006

Aquifer Thickness: 2.00 m



Calculation after Bouwer & Rice

Observation well

K
[m/d]

2D

5.06×10^0



Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2D Slug Test

Test Well: 2D

Test conducted by: S. Denner

Test date: 23/11/2006

Aquifer Thickness: 2.00 m

	Analysis Name	Analysis performed by	Date	Method name	Well	T [m ² /d]	K [m/d]	S
1	Cooper-Bredehoft	S. Denner	28/11/2006	Cooper-Bredehoft-Pa	2Ddopulos	3.60×10^1	1.80×10^1	2.55×10^{-8}
2	Hvorslev	S. Denner	28/11/2006	Hvorslev	2D		6.64×10^0	
3	Bouwer-Rice	S. Denner	28/11/2006	Bouwer & Rice	2D		5.06×10^0	
Average						3.60×10^1	9.91×10^0	2.55×10^{-8}

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 URS Australia Pty Ltd Level 14 240 Queen Street Brisbane QLD 4000				Slug Test - Water Level Data		Page 1 of 4
				Project: Unimin Environmental Studies		
				Number: 42625813		
				Client: Unimin Australia Limited		
Location: Vance Lease, North Stradbroke			Slug Test: 2S Slug Test		Test Well: 2S	
Test conducted by: S. Denner			Test date: 23/11/2006			
Water level at t=0 [m]: 0.73			Static water level [m]: 0.00		Water level change at t=0 [m]: 0.73	
	Time [s]	Water Level [m]	WL Change [m]			
1	1	0.733	0.733			
2	2	0.69	0.69			
3	3	0.641	0.641			
4	4	0.597	0.597			
5	5	0.556	0.556			
6	6	0.522	0.522			
7	7	0.489	0.489			
8	8	0.458	0.458			
9	9	0.43	0.43			
10	10	0.406	0.406			
11	11	0.381	0.381			
12	12	0.361	0.361			
13	13	0.339	0.339			
14	14	0.321	0.321			
15	15	0.305	0.305			
16	16	0.287	0.287			
17	17	0.272	0.272			
18	18	0.257	0.257			
19	19	0.244	0.244			
20	20	0.232	0.232			
21	21	0.22	0.22			
22	22	0.209	0.209			
23	23	0.199	0.199			
24	24	0.187	0.187			
25	25	0.178	0.178			
26	26	0.168	0.168			
27	27	0.16	0.16			
28	28	0.153	0.153			
29	29	0.148	0.148			
30	30	0.14	0.14			
31	31	0.135	0.135			
32	32	0.127	0.127			
33	33	0.121	0.121			
34	34	0.117	0.117			
35	35	0.111	0.111			
36	36	0.106	0.106			
37	37	0.101	0.101			
38	38	0.097	0.097			
39	39	0.094	0.094			
40	40	0.091	0.091			
41	41	0.087	0.087			
42	42	0.082	0.082			
43	43	0.08	0.08			
44	44	0.076	0.076			
45	45	0.073	0.073			
46	46	0.071	0.071			
47	47	0.069	0.069			
48	48	0.066	0.066			
49	49	0.063	0.063			
50	50	0.06	0.06			
51	51	0.059	0.059			



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Slug Test - Water Level Data

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Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

	Time [s]	Water Level [m]	WL Change [m]
52	52	0.057	0.057
53	53	0.053	0.053
54	54	0.054	0.054
55	55	0.054	0.054
56	56	0.054	0.054
57	57	0.05	0.05
58	58	0.048	0.048
59	59	0.045	0.045
60	60	0.045	0.045
61	61	0.044	0.044
62	62	0.041	0.041
63	63	0.042	0.042
64	64	0.039	0.039
65	65	0.04	0.04
66	66	0.034	0.034
67	67	0.034	0.034
68	68	0.037	0.037
69	69	0.038	0.038
70	70	0.034	0.034
71	71	0.034	0.034
72	72	0.032	0.032
73	73	0.03	0.03
74	74	0.03	0.03
75	75	0.032	0.032
76	76	0.031	0.031
77	77	0.03	0.03
78	78	0.027	0.027
79	79	0.029	0.029
80	80	0.027	0.027
81	81	0.027	0.027
82	82	0.027	0.027
83	83	0.024	0.024
84	84	0.026	0.026
85	85	0.025	0.025
86	86	0.024	0.024
87	87	0.023	0.023
88	88	0.023	0.023
89	89	0.023	0.023
90	90	0.02	0.02
91	91	0.022	0.022
92	92	0.021	0.021
93	93	0.02	0.02
94	94	0.02	0.02
95	95	0.019	0.019
96	96	0.02	0.02
97	97	0.016	0.016
98	98	0.018	0.018
99	99	0.015	0.015
100	100	0.016	0.016
101	101	0.015	0.015
102	102	0.017	0.017
103	103	0.016	0.016
104	104	0.017	0.017
105	105	0.017	0.017
106	106	0.016	0.016
107	107	0.014	0.014



URS Australia Pty Ltd
Level 14
240 Queen Street
Brisbane QLD 4000

Slug Test - Water Level Data	Page 3 of 4
Project: Unimin Environmental Studies	
Number: 42625813	
Client: Unimin Australia Limited	

	Time [s]	Water Level [m]	WL Change [m]
108	108	0.015	0.015
109	109	0.016	0.016
110	110	0.013	0.013
111	111	0.012	0.012
112	112	0.011	0.011
113	113	0.015	0.015
114	114	0.014	0.014
115	115	0.012	0.012
116	116	0.012	0.012
117	117	0.011	0.011
118	118	0.013	0.013
119	119	0.008	0.008
120	120	0.011	0.011
121	121	0.011	0.011
122	122	0.012	0.012
123	123	0.01	0.01
124	124	0.01	0.01
125	125	0.01	0.01
126	126	0.009	0.009
127	127	0.007	0.007
128	128	0.01	0.01
129	129	0.009	0.009
130	130	0.01	0.01
131	131	0.01	0.01
132	132	0.007	0.007
133	133	0.008	0.008
134	134	0.007	0.007
135	135	0.006	0.006
136	136	0.008	0.008
137	137	0.007	0.007
138	138	0.007	0.007
139	139	0.008	0.008
140	140	0.007	0.007
141	141	0.006	0.006
142	142	0.006	0.006
143	143	0.004	0.004
144	144	0.007	0.007
145	145	0.006	0.006
146	146	0.006	0.006
147	147	0.005	0.005
148	148	0.005	0.005
149	149	0.007	0.007
150	150	0.004	0.004
151	151	0.005	0.005
152	152	0.003	0.003
153	153	0.004	0.004
154	154	0.005	0.005
155	155	0.004	0.004
156	156	0.005	0.005
157	157	0.005	0.005
158	158	0.005	0.005
159	159	0.005	0.005
160	160	0.002	0.002
161	161	0.002	0.002
162	162	0.004	0.004
163	163	0.005	0.005



URS Australia Pty Ltd
Level 14
240 Queen Street
Brisbane QLD 4000

Slug Test - Water Level Data	Page 4 of 4
Project: Unimin Environmental Studies	
Number: 42625813	
Client: Unimin Australia Limited	

	Time [s]	Water Level [m]	WL Change [m]
164	164	0.004	0.004
165	165	0.003	0.003
166	166	0.007	0.007
167	167	0.005	0.005
168	168	0.005	0.005
169	169	0.004	0.004
170	170	0.004	0.004
171	171	0.004	0.004
172	172	0.004	0.004
173	173	0.006	0.006
174	174	0.004	0.004
175	175	0.003	0.003
176	176	0.005	0.005
177	177	0.005	0.005
178	178	0.003	0.003
179	179	0.002	0.002
180	180	0.004	0.004
181	181	0.004	0.004
182	182	0.003	0.003
183	183	0.002	0.002
184	184	0.004	0.004
185	185	0.003	0.003
186	186	0.003	0.003
187	187	0.003	0.003
188	188	0.002	0.002
189	189	0.003	0.003
190	190	0.004	0.004
191	191	0.003	0.003
192	192	0.003	0.003
193	193	0.001	0.001
194	194	0.004	0.004
195	195	0.003	0.003
196	196	0.003	0.003
197	197	0.002	0.002
198	198	0.002	0.002
199	199	0.002	0.002
200	200	0.003	0.003
201	201	0.002	0.002
202	202	0.002	0.002
203	203	0.002	0.002
204	204	0.003	0.003
205	205	0.003	0.003
206	206	0.004	0.004
207	207	0.003	0.003
208	208	0.002	0.002
209	209	0.001	0.001
210	210	0.002	0.002
211	211	0.002	0.002
212	212	0.002	0.002
213	213	0.004	0.004
214	214	0.002	0.002
215	215	0.00	0.00



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240 Queen Street
Brisbane QLD 4000

Slug Test Analysis Report

Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2S Slug Test

Test Well: 2S

Test conducted by: S. Denner

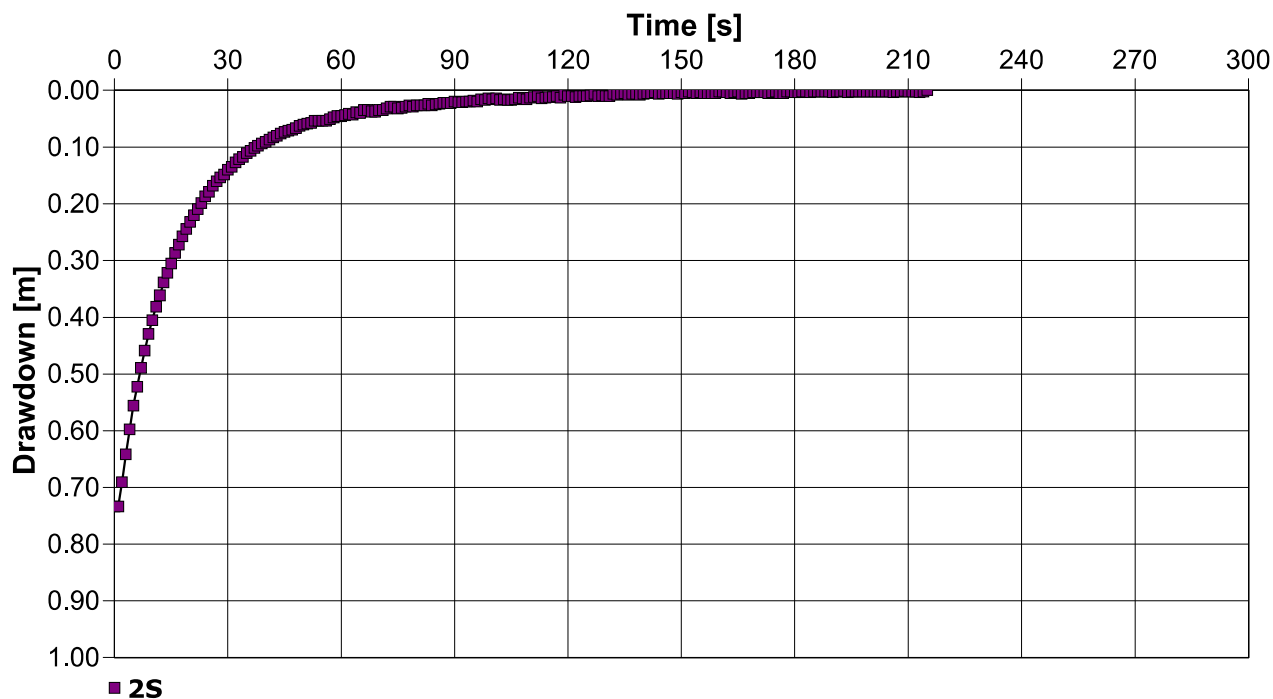
Test date: 23/11/2006

Analysis performed by: S. Denner

Time vs. Change in WL

Date: 28/11/2006

Aquifer Thickness: 2.60 m





URS Australia Pty Ltd
Level 14
240 Queen Street
Brisbane QLD 4000

Slug Test Analysis Report

Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2S Slug Test

Test Well: 2S

Test conducted by: S. Denner

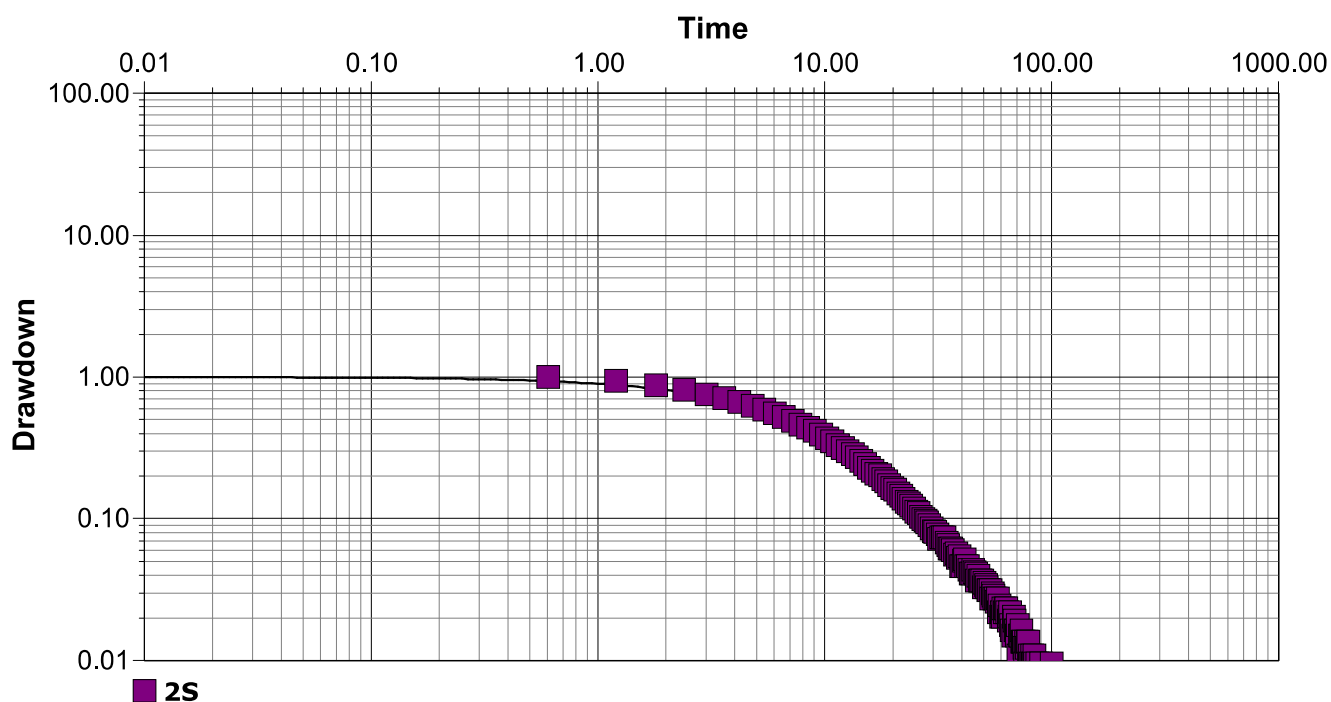
Test date: 23/11/2006

Analysis performed by: S. Denner

Cooper-Bredehoeft

Date: 28/11/2006

Aquifer Thickness: 2.60 m



Calculation after Cooper-Bredehoeft-Papadopoulos

Observation well	Transmissivity [m ² /d]	K [m/d]	Well-bore storage coefficient
2S	1.76×10^{-1}	6.76×10^0	1.41×10^{-9}



URS Australia Pty Ltd
Level 14
240 Queen Street
Brisbane QLD 4000

Slug Test Analysis Report

Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2S Slug Test

Test Well: 2S

Test conducted by: S. Denner

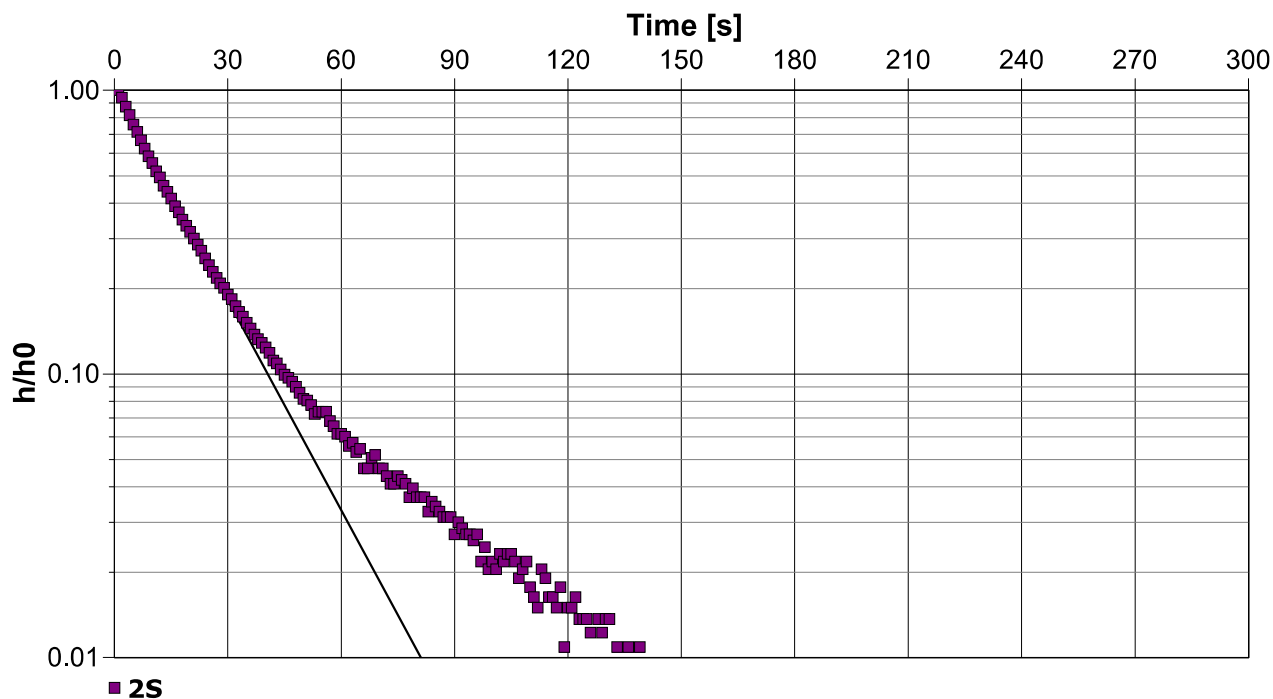
Test date: 23/11/2006

Analysis performed by: S. Denner

Hvorslev

Date: 28/11/2006

Aquifer Thickness: 2.60 m



Calculation after Hvorslev

Observation well

K
[m/d]

2S

3.46×10^0



URS Australia Pty Ltd
Level 14
240 Queen Street
Brisbane QLD 4000

Slug Test Analysis Report

Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2S Slug Test

Test Well: 2S

Test conducted by: S. Denner

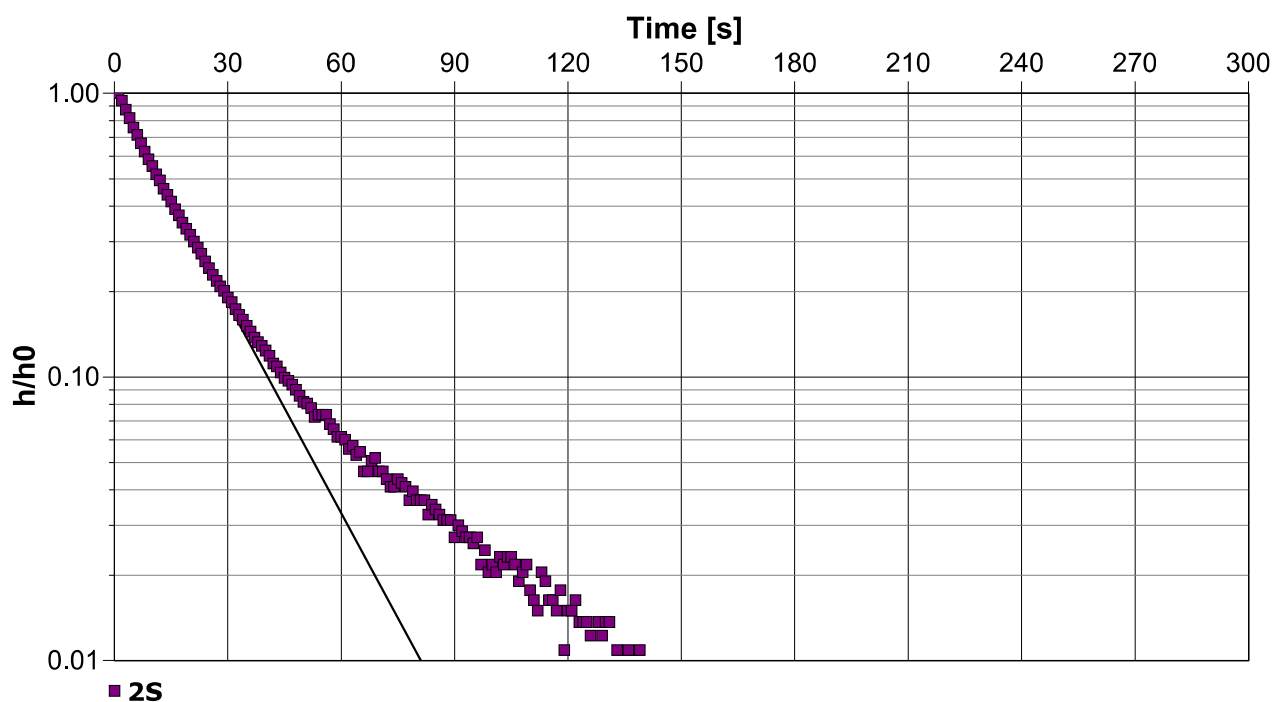
Test date: 23/11/2006

Analysis performed by: S. Denner

Bouwer-Rice

Date: 28/11/2006

Aquifer Thickness: 2.60 m



Calculation after Bouwer & Rice

Observation well

K
[m/d]

2S

2.26×10^0



Project: Unimin Environmental Studies

Number: 42625813

Client: Unimin Australia Limited

Location: Vance Lease, North Stradbroke

Slug Test: 2S Slug Test

Test Well: 2S

Test conducted by: S. Denner

Test date: 23/11/2006

Aquifer Thickness: 2.60 m

	Analysis Name	Analysis performed by	Date	Method name	Well	T [m ² /d]	K [m/d]	S
1	Cooper-Bredehoeft	S. Denner	28/11/2006	Cooper-Bredehoeft-Pa	2Sdopulos	1.76×10^1	6.76×10^0	1.41×10^{-9}
2	Hvorslev	S. Denner	28/11/2006	Hvorslev	2S		3.46×10^0	
3	Bouwer-Rice	S. Denner	28/11/2006	Bouwer & Rice	2S		2.26×10^0	
Average						1.76×10^1	4.16×10^0	1.41×10^{-9}

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Appendix D

Laboratory Analytical Reports

CUSTODY DOCUMENTATION

Pty Ltd

Level 14, 240 Queen Street, Brisbane

Stephen Denner

SAMPLER: S Denner

MOBILE: 0419 777 303

PHONE 3243 2189

EMAIL REPORT TO: stephen_denner@urscorp.com

EMAIL INVOICE TO: natasha_gavin@urscorp.com

Australian Laboratory Services Pty Ltd



SITE:

P.O. NO.:

RESULTS REQUIRED (Date): Standard Turnaround

QUOTE NO.: EB20050096

FOR LABORATORY USE ONLY

COOLER SEAL (circle appropriate)

Intact Yes No N/A

SAMPLE TEMPERATURE

CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water)

ALS ID	SAMPLE ID	MATRIX	DATE	TIME	CONTAINER INFORMATION
			Type / Code	Total bottles	
1	2S	Water	22/11/2006	2pm	4
2	2D	Water	22/11/2006	3pm	4
3	SL	Water	23/11/2006	9am	4

Major Ions

Nitrate, nitrite, ammonia, TKN

Total P

(Dissolved)

Ferrous Iron (Dissolved)

Notes:

EC ~ 120uS/cm, pH ~ 6.1

EC ~ 120uS/cm, pH ~ 6.1

EC ~ 60uS/cm, pH ~ 6.1

Telephone : +61 (07) 3243 7222

ALS Environmental

Brisbane

Work Order

EB0611786

Barcode

RECEIVED BY

NAME

DATE

TIME

OF

NAME

DATE

TIME

OF

NAME

DATE

TIME

OF

NAME

DATE

TIME

OF

NAME

DATE

TIME

OF

NAME

DATE

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulphuric Preserved Amber Glass; H = HCl Preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulphuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

AUSTRALIAN LABORATORY SERVICES P/L



ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Comprehensive report

Client Details

Client : URS AUSTRALIA PTY LTD (QLD)
Contact : MR STEPHEN DENNER
Address : GPO BOX 302 BRISBANE QLD AUSTRALIA 4001

Project : 42625813
Order number : - Not provided -
C-O-C Number : - Not provided -
Site : - Not provided -
Sampler : Stephen Denner

E-mail : stephen_denner@urscorp.com
Telephone : 07 3243 2111
Facsimile : 07 3243 2199

Laboratory Details

Laboratory : ALS Environmental Brisbane
Manager : Michael Heery
Address : 32 Shand Street Stafford QLD Australia 4053

Quote number : EB20050096
Work order : EB0611786

E-mail : services.brisbane@alsenviro.com
Telephone : +61 (07) 3243 7222
Facsimile : +61 (07) 3243 7259

Dates

Date Samples Received : 24 Nov 2006
Scheduled Reporting Date : **4 Dec 2006**
SRA Issue Date : 26 Nov 2006
Client Requested Date : 4 Dec 2006

Delivery Details

Mode of Delivery : Carrier.
No. of coolers/boxes : 1 LARGE
Security Seal : Intact.
Temperature : 21.8 C
No. of samples - Received : 3
- Analysed : 3

Comments

- Samples received in appropriately pretreated and preserved containers.
 - Breaches in recommended extraction / analysis holding times may occur.
 - The recommended holding time for Fe²⁺ and/or Cr⁶⁺ analysis is 24 hours from the time of sampling.
-
- Please direct any turn around / technical queries to the laboratory contact designated above.
 - Sample Disposal - Aqueous (14 days), Solid (90 days) from date of completion of work order.
 - Please direct any queries related to sample condition / numbering / breakages to Janine Hew.
 - Analytical work for this work order will be conducted at ALSE Brisbane.
 - When the sampling time is not supplied on the COC documentation, ALSE defaults the sampling time to that of the COC 'relinquishment' time (if supplied). If this also is not supplied, ALSE defaults the sampling time to the 'time of receipt at Laboratory'.

Disclaimer : This document contains privileged and confidential information intended only for the use of the addressee. If you are not the addressee, you are hereby notified that you must not disseminate, copy or take action of its contents. If you have received this document in error, please notify ALS immediately.

SAMPLE RECEIPT NOTIFICATION (SRN) - continued

Client : URS AUSTRALIA PTY LTD (QLD)
Project : 42625813

Work Order : EB0611786
ALS Quote Reference : EB20050096



Summary of Sample(s) / Container(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as moisture and preparation tasks, that form an implicit part of that package.

ALS Sample ID.	Client Sample ID - Sample Date	Requested Analysis									
		EG051F - WATER Ferrous Iron - Filtered	EK055A - WATER Ammonia as N	EK058 - WATER Nitrate as N (Incl. Nitrite as N)	EK061 - WATER Total Kjeldahl Nitrogen as N (TKN)	EK067 - WATER Total Phosphorus as P	EN055 - WATER Ionic Balance	Major Anions - WATER Cl, SO ₄ , Alkalinity PCT	Major Cations - WATER Ca, Mg, Na, K	W-03 - WATER 13 Metals (NEPM Suite)	
EB0611786-001	2S - 22 Nov 2006	●	●	●	●	●	●	●	●	●	
EB0611786-002	2D - 22 Nov 2006	●	●	●	●	●	●	●	●	●	
EB0611786-003	SL - 23 Nov 2006	●	●	●	●	●	●	●	●	●	
Total(s) :		3	3	3	3	3	3	3	3	3	

SAMPLE RECEIPT NOTIFICATION (SRN) - continued

Client : URS AUSTRALIA PTY LTD (QLD)
Project : 42625813

Work Order : EB0611786
ALS Quote Reference : EB20050096



Requested Reports

- **ALL RESULTS BRISBANE**

- A4 - Quality Control Report - NEPM format	Email	brisbane@urscorp.com
- A4 - Certificate of Analysis - NEPM format	Email	brisbane@urscorp.com
- A4 - Interpretive Quality Control Report - NEPM format	Email	brisbane@urscorp.com
- MRED Export Format	Email	brisbane@urscorp.com
- A4 - Sample Receipt Notification - Comprehensive format	Email	brisbane@urscorp.com
- Chain of Custody Acknowledgement	Email	brisbane@urscorp.com

- **MR STEPHEN DENNER**

- A4 - Quality Control Report - NEPM format	Email	stephen_denner@urscorp.com
- A4 - Certificate of Analysis - NEPM format	Email	stephen_denner@urscorp.com
- A4 - Interpretive Quality Control Report - NEPM format	Email	stephen_denner@urscorp.com
- MRED Export Format	Email	stephen_denner@urscorp.com
- A4 - Sample Receipt Notification - Comprehensive format	Email	stephen_denner@urscorp.com
- Chain of Custody Acknowledgement	Email	stephen_denner@urscorp.com

- **NATASHA GAVIN**

- Invoice	Email	natasha_gavin@urscorp.com
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Sample Container(s) / Preservation Non-Compliance Log

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exist.**

CERTIFICATE OF ANALYSIS

Client	: URS AUSTRALIA PTY LTD (QLD)	Laboratory	: ALS Environmental Brisbane	Page	: 1 of 5
Contact	: MR STEPHEN DENNER	Contact	: Michael Heery	Work Order	: EB0611786
Address	: GPO BOX 302 BRISBANE QLD AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053		
E-mail	: stephen_denner@urscorp.com	E-mail	: services.brisbane@alsenviro.com		
Telephone	: 07 3243 2111	Telephone	: +61 (07) 3243 7222		
Facsimile	: 07 3243 2199	Facsimile	: +61 (07) 3243 7259		
Project	: 42625813	Quote number	: EN/001/05		
Order number	: - Not provided -	Date received	: 24 Nov 2006		
C-O-C number	: - Not provided -	Date issued	: 4 Dec 2006		
Site	: - Not provided -	No. of samples	: - Received		: 3
			Analysed		: 3

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NATA Accredited Laboratory
825

This document is issued in
accordance with NATA's
accreditation requirements.

Accredited for compliance with
ISO/IEC 17025.



WORLD RECOGNISED
ACCREDITATION

This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signature	Position	Department
Kim McCabe	Senior Inorganic Chemist	Inorganics - NATA 825 (818 - Brisbane)

Page Number : 2 of 5
Client : URS AUSTRALIA PTY LTD (QLD)
Work Order : EB0611786

Comments

This report for the ALSE reference EB0611786 supersedes any previous reports with this reference. Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- **Analytical Results for Samples Submitted**
- **Surrogate Recovery Data**

The analytical procedures used by ALS Environmental have been developed from established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insufficient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits). Where LOR of reported result differ from standard LOR, this may be due to high moisture, reduced sample amount or matrix interference. When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes. Abbreviations: CAS number = Chemical Abstract Services number, LOR = Limit of Reporting. * Indicates failed Surrogate Recoveries.



ALS Environmental

Page Number : 3 of 5
Client : URS AUSTRALIA PTY LTD (QLD)
Work Order : EB0611786

Analytical Results

Analytical Results							
Sample Matrix Type / Description : Sample Date / Time :		Client Sample ID :		2S WATER 22 Nov 2006 14:00 EB0611786-001	2D WATER 22 Nov 2006 15:00 EB0611786-002	SL WATER 23 Nov 2006 9:00 EB0611786-003	
Laboratory Sample ID :	CAS number	LOR	Units				
ED037P: Alkalinity by PC Titrator							
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	<1	
Total Alkalinity as CaCO3		1	mg/L	<1	<1	<1	
ED040F: Dissolved Major Anions							
Sulphate as SO4 2-	14808-79-8	1	mg/L	<1	<1	2	
ED045P: Chloride by PC Titrator							
Chloride	16887-00-6	1	mg/L	32	31	18	
ED093F: Dissolved Major Cations							
Calcium	7440-70-2	1	mg/L	1	<1	<1	
Magnesium	7439-95-4	1	mg/L	2	2	1	
Sodium	7440-23-5	1	mg/L	17	16	10	
Potassium	7440-09-7	1	mg/L	<1	<1	<1	
EG020F: Dissolved Metals by ICP-MS							
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	
Barium	7440-39-3	0.001	mg/L	0.001	0.002	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	
Lead	7439-92-1	0.001	mg/L	0.001	<0.001	<0.001	
Manganese	7439-96-5	0.001	mg/L	0.003	0.004	0.028	
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	
Zinc	7440-66-6	0.005	mg/L	0.011	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS							
Mercury	7439-97-6	0.0001	mg/L	0.0003	0.0004	0.0004	
EG051: Ferrous Iron							
Ferrous Iron		0.05	mg/L	0.41	0.27	0.11	
EK055: Ammonia as N							
Ammonia as N	7664-41-7	0.010	mg/L	0.091	0.130	0.081	
EK057: Nitrite as N							
Nitrite as N		0.010	mg/L	0.060	0.067	0.020	
EK058: Nitrate as N							
Nitrate as N	14797-55-8	0.010	mg/L	<0.010	<0.010	<0.010	



Analytical Results

Analytical Results				
Client Sample ID :		Sample Matrix Type / Description :		
Sample Date / Time :		Sample Date / Time :		
Laboratory Sample ID :		Laboratory Sample ID :		
Analyte	CAS number	LOR	Units	
EK059 : Nitrite plus Nitrate as N (NOx)				
Nitrite + Nitrate as N		0.010	mg/L	
EK061 : Total Kjeldahl Nitrogen (TKN)				
Total Kjeldahl Nitrogen as N		0.1	mg/L	
EK067 : Total Phosphorus as P				
Total Phosphorus as P		0.01	mg/L	
EN055: Ionic Balance				
Total Anions		0.01	meq/L	
Total Cations		0.01	meq/L	

Page Number

: 5 of 5

Client

: URS AUSTRALIA PTY LTD (QLD)

Work Order

: EB0611786



ALS Environmental

Surrogate Control Limits

- No surrogates present on this report.

QUALITY CONTROL REPORT

Client	: URS AUSTRALIA PTY LTD (QLD)	Laboratory	: ALS Environmental Brisbane	Page	: 1 of 9
Contact	: MR STEPHEN DENNER	Contact	: Michael Heery		
Address	: GPO BOX 302 BRISBANE QLD AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053	Work order	: EB0611786
Project	: 42625813	Quote number	: EN/001/05	Amendment No.	:
Order number	: - Not provided -			Date received	: 24 Nov 2006
C-O-C number	: - Not provided -			Date issued	: 4 Dec 2006
Site	: - Not provided -				
E-mail	: stephen_denner@urscorp.com	E-mail	: services.brisbane@alsenviro.com	No. of samples	
Telephone	: 07 3243 2111	Telephone	: +61 (07) 3243 7222	Received	: 3
Facsimile	: 07 3243 2199	Facsimile	: +61 (07) 3243 7259	Analysed	: 3

This final report for the ALSE work order reference EB0611786 supersedes any previous reports with this reference. Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Laboratory Duplicates (DUP); Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Samples (LCS); Recovery and Acceptance Limits
- Matrix Spikes (MS); Recovery and Acceptance Limits

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This document is issued in accordance with NATA's accreditation requirements.

Accredited for compliance with ISO/IEC 17025

This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory
Kim McCabe

Department
Inorganics - NATA 825 (818 - Brisbane)

Quality Control Report - Laboratory Duplicates (DUP)

The quality control term **Laboratory Duplicate** refers to an intralaboratory split sample randomly selected from the sample batch. Laboratory duplicates provide information on method precision and sample heterogeneity.
 - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. **Abbreviations: LOR = Limit of Reporting, RPD = Relative Percent Difference.**
 * Indicates failed QC. The permitted ranges for the RPD of Laboratory Duplicates (relative percent deviation) are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting:- Result < 10 times LOR, no limit - Result between 10 and 20 times LOR, 0% - 50% - Result > 20 times LOR, 0% - 20%

Matrix Type: WATER

Laboratory Duplicates (DUP) Report

Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD
ED037P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 314603)						
EB0611693-001	Anonymous	Hydroxide Alkalinity as CaCO3	1 mg/L	mg/L	mg/L	%
		Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	146	148	1.4
		Total Alkalinity as CaCO3	1 mg/L	146	148	1.4
EB0611807-143	Anonymous	Hydroxide Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	21	20	4.9
		Total Alkalinity as CaCO3	1 mg/L	21	20	4.9
ED040F: Dissolved Major Anions						
ED040F: Dissolved Major Anions - (QC Lot: 313456)						
EB0611696-002	Anonymous	Sulphate as SO4 2-	1 mg/L	mg/L	mg/L	%
EB0611729-004	Anonymous	Sulphate as SO4 2-	1 mg/L	501	512	2.1
ED045P: Chloride by PC Titrator						
ED045P: Chloride by PC Titrator - (QC Lot: 315307)						
EB0611779-006	Anonymous	Chloride	1 mg/L	mg/L	mg/L	%
EB0611779-015	Anonymous	Chloride	1 mg/L	1400	1390	0.4
ED093F: Dissolved Major Cations						
ED093F: Dissolved Major Cations - (QC Lot: 313457)						
EB0611759-001	Anonymous	Calcium	1 mg/L	mg/L	mg/L	%
		Magnesium	1 mg/L	70	72	2.3
		Sodium	1 mg/L	54	54	0.0
		Potassium	1 mg/L	299	309	3.2
EG020F: Dissolved Metals by ICP-MS						
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 315314)						
EB0611808-030	Anonymous	Arsenic	0.001 mg/L	mg/L	mg/L	%
				<0.001	<0.001	0.0



Matrix Type: WATER				Laboratory Duplicates (DUP) Report			
Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD	
EG020F: Dissolved Metals by ICP-MS - continued							
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 315314) - continued							
EB0611808-030	Anonymous	Beryllium	0.001 mg/L	<0.001	mg/L	%	
		Barium	0.001 mg/L	0.008	0.008	0.0	
		Cadmium	0.0001 mg/L	<0.0001	<0.0001	0.0	
		Chromium	0.001 mg/L	<0.001	<0.001	0.0	
		Cobalt	0.001 mg/L	<0.001	<0.001	0.0	
		Copper	0.001 mg/L	<0.001	<0.001	0.0	
		Lead	0.001 mg/L	<0.001	<0.001	0.0	
		Manganese	0.001 mg/L	<0.001	<0.001	0.0	
		Nickel	0.001 mg/L	<0.001	<0.001	0.0	
		Vanadium	0.01 mg/L	<0.01	<0.01	0.0	
		Zinc	0.005 mg/L	<0.005	<0.005	0.0	
		Arsenic	0.001 mg/L	0.002	0.002	0.0	
		Beryllium	0.001 mg/L	0.004	0.004	0.0	
		Barium	0.001 mg/L	0.030	0.031	0.0	
		Cadmium	0.0001 mg/L	0.0040	0.0042	3.8	
		Chromium	0.001 mg/L	<0.001	<0.001	0.0	
EB0611808-036	Anonymous	Cobalt	0.001 mg/L	0.062	0.062	0.0	
		Copper	0.001 mg/L	0.027	0.027	0.0	
		Lead	0.001 mg/L	0.015	0.015	0.0	
		Manganese	0.001 mg/L	19.8	20.1	1.3	
		Nickel	0.001 mg/L	0.107	0.110	2.8	
		Vanadium	0.01 mg/L	<0.01	<0.01	0.0	
		Zinc	0.005 mg/L	2.26	2.25	0.6	
		EG035F: Dissolved Mercury by FIMS					
		EG035F: Dissolved Mercury by FIMS - (QC Lot: 313768)					
		EB0611666-001	Anonymous	Mercury	0.0001 mg/L	mg/L	%
EB0611731-002	Anonymous	Mercury	0.0001 mg/L	<0.0001	128		
EG051: Ferrous Iron							
EG051: Ferrous Iron - (QC Lot: 313620)							
				mg/L	mg/L	%	



Matrix Type: WATER				Laboratory Duplicates (DUP) Report			
Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD	
EG051: Ferrous Iron - continued							
EG051: Ferrous Iron - (QC Lot: 313620) - continued							
EB0611779-011	Anonymous	Ferrous Iron	0.05 mg/L	mg/L	mg/L	%	
EB0611786-003	SL	Ferrous Iron	0.05 mg/L	45.3	44.9	0.9	
				0.11	0.13	16.7	
EK055: Ammonia as N							
EK055: Ammonia as N - (QC Lot: 313127)							
EB0611778-026	Anonymous	Ammonia as N	0.010 mg/L	mg/L	mg/L	%	
				6610	6500	1.7	
EK057: Nitrite as N							
EK057: Nitrite as N - (QC Lot: 313125)							
EB0611778-006	Anonymous	Nitrite as N	0.010 mg/L	mg/L	mg/L	%	
EB0611778-015	Anonymous	Nitrite as N	0.010 mg/L	0.036	0.039	8.6	
				0.014	0.014	0.0	
EK059: Nitrite plus Nitrate as N (NOx)							
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 313126)							
EB0611778-026	Anonymous	Nitrite + Nitrate as N	0.010 mg/L	mg/L	mg/L	%	
				131	133	1.4	
EK061: Total Kjeldahl Nitrogen (TKN)							
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 314450)							
EB0611720-001	Anonymous	Total Kjeldahl Nitrogen as N	0.1 mg/L	mg/L	mg/L	%	
EB0611770-001	Anonymous	Total Kjeldahl Nitrogen as N	0.1 mg/L	3.0	2.7	8.9	
				0.4	0.4	0.0	
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 314452)							
EB0611786-003	SL	Total Kjeldahl Nitrogen as N	0.1 mg/L	mg/L	mg/L	%	
EB0611832-003	Anonymous	Total Kjeldahl Nitrogen as N	0.1 mg/L	1.4	1.4	0.0	
				1.3	1.3	0.0	
EK067: Total Phosphorus as P							
EK067: Total Phosphorus as P - (QC Lot: 314451)							
EB0611720-001	Anonymous	Total Phosphorus as P	0.01 mg/L	mg/L	mg/L	%	
EB0611770-001	Anonymous	Total Phosphorus as P	0.01 mg/L	5.70	5.94	4.0	
				0.21	0.22	0.0	

Quality Control Report - Method Blank (MB) and Laboratory Control Samples (LCS)

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC type is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a known, interference free matrix spiked with target analytes or certified reference material. The purpose of this QC type is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of actual laboratory data. Flagged outliers on control limits for inorganics tests may be within the NEPM specified data quality objective of recoveries in the range of 70 to 130%. Where this occurs, no corrective action is taken. Abbreviations: LOR = Limit of reporting.

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

Analyte name		LOR	Method blank result	Actual Results		Recovery Limits	
			Spike concentration	Spike Recovery	Dynamic Recovery Limits		
				LCS	Low	High	
ED037P: Alkalinity by PC Titrator							
ED037P: Alkalinity by PC Titrator - (QC Lot: 314603)			mg/L	%	%	%	
Total Alkalinity as CaCO3		1 mg/L	----	500	93.0	70	130
ED040F: Dissolved Major Anions							
ED040F: Dissolved Major Anions - (QC Lot: 313456)			mg/L	%	%	%	
Sulphate as SO4 2-		1 mg/L	<1	1	-----	-----	-----
ED045P: Chloride by PC Titrator							
ED045P: Chloride by PC Titrator - (QC Lot: 315307)			mg/L	%	%	%	
Chloride		1 mg/L	<1				
		1 mg/L	-----	1000	100	70	130
ED093F: Dissolved Major Cations							
ED093F: Dissolved Major Cations - (QC Lot: 313457)			mg/L	%	%	%	
Calcium		1 mg/L	<1	-----	-----	-----	-----
Magnesium		1 mg/L	<1	-----	-----	-----	-----
Potassium		1 mg/L	<1	-----	-----	-----	-----
Sodium		1 mg/L	<1	-----	-----	-----	-----
EG020F: Dissolved Metals by ICP-MS							
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 315314)			mg/L	%	%	%	
Arsenic		0.001 mg/L	-----	0.1000	98.3	70	130
		0.001 mg/L	<0.001	-----	-----	-----	-----
Barium		0.001 mg/L	<0.001	-----	-----	-----	-----
Beryllium		0.001 mg/L	<0.001	-----	-----	-----	-----
		0.001 mg/L	-----	0.100	107	70	130
Cadmium		0.0001 mg/L	-----	0.1000	98.6	70	130
		0.0001 mg/L	<0.0001	-----	-----	-----	-----



Matrix Type: WATER									
Method Blank (MB) and Laboratory Control Samples (LCS) Report									
Analyte name		LOR	Method blank result	Actual Results		Recovery Limits			
				Spike concentration	Spike Recovery	Dynamic Recovery Limits			
LCS									
EG020F: Dissolved Metals by ICP-MS - continued									
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 315314) - continued									
Chromium	0.001 mg/L	mg/L	mg/L	%	%	%	%	%	%
	0.001 mg/L	<0.001	0.1000	98.6	70	130			
	0.001 mg/L								
Cobalt	0.001 mg/L		0.1000	100	70	130			
	0.001 mg/L	<0.001							
	0.001 mg/L		0.200	101	70	130			
Copper	0.001 mg/L	<0.001							
	0.001 mg/L	<0.001							
	0.001 mg/L		0.1000	103	70	130			
Lead	0.001 mg/L	<0.001							
	0.001 mg/L	<0.001							
	0.001 mg/L		0.1000	101	70	130			
Manganese	0.001 mg/L	<0.001							
	0.001 mg/L								
	0.001 mg/L	<0.001							
Nickel	0.001 mg/L	<0.001							
	0.001 mg/L		0.1000	102	70	130			
	0.01 mg/L		0.1000	97.3	70	130			
Vanadium	0.01 mg/L	<0.01							
	0.01 mg/L								
	0.005 mg/L		0.200	103	70	130			
Zinc	0.005 mg/L	<0.005							
	0.005 mg/L								
EG035F: Dissolved Mercury by FIMS									
EG035F: Dissolved Mercury by FIMS - (QC Lot: 313768)									
Mercury	0.0001 mg/L	mg/L	mg/L	%	%	%	%	%	%
	0.0001 mg/L		0.010	100	70	130			
		<0.0001							
EG051: Ferrous Iron									
EG051: Ferrous Iron - (QC Lot: 313620)									
Ferrous Iron	0.05 mg/L	mg/L	mg/L	%	%	%	%	%	%
	0.05 mg/L		2.00	99.5	70	130			
		<0.05							
EK055: Ammonia as N									
EK055: Ammonia as N - (QC Lot: 313127)									
Ammonia as N	0.01 mg/L	mg/L	mg/L	%	%	%	%	%	%
	0.010 mg/L		1	104	70	130			
		<0.010							
EK057: Nitrite as N									



Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

Analyte name		Method blank result	Actual Results		Recovery Limits		
LOR			Spike concentration	Spike Recovery	Dynamic Recovery Limits		
			LCS		Low	High	
EK057: Nitrite as N - continued							
EK057: Nitrite as N - (QC Lot: 313125)		mg/L		%	%	%	
Nitrite as N	0.010 mg/L	<0.010					
	0.01 mg/L		0.5	118	70	130	
EK057: Nitrite as N - (QC Lot: 313128)		mg/L		%	%	%	
Nitrite as N	0.01 mg/L		0.5	117	70	130	
	0.010 mg/L	<0.010					
EK059: Nitrite plus Nitrate as N (NOx)							
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 313126)		mg/L		%	%	%	
Nitrite + Nitrate as N	0.010 mg/L	<0.010					
	0.01 mg/L		0.5	110	70	130	
EK061: Total Kjeldahl Nitrogen (TKN)							
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 314450)		mg/L		%	%	%	
Total Kjeldahl Nitrogen as N	0.1 mg/L		10	106	70	130	
	0.1 mg/L	<0.1					
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 314452)		mg/L		%	%	%	
Total Kjeldahl Nitrogen as N	0.1 mg/L		10	112	70	130	
	0.1 mg/L	<0.1					
EK067: Total Phosphorus as P							
EK067: Total Phosphorus as P - (QC Lot: 314451)		mg/L		%	%	%	
Total Phosphorus as P	0.01 mg/L		4.42	84.5	70	130	
	0.01 mg/L	<0.01					



Quality Control Report - Matrix Spikes (MS)

The quality control term **Matrix Spike (MS)** refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC type is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). 'Ideal' recovery ranges stated may be waived in the event of sample matrix interferences. - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. Abbreviations: **LOR** = Limit of Reporting, **RPD** = Relative Percent Difference.

* Indicates failed QC

Matrix Type: WATER

Matrix Spike (MS) Report

Analyte name	Laboratory Sample ID	Client Sample ID	LOR	Spike Concentration	Actual Results		Recovery Limits	
					Sample Result	Spike Recovery MS	Low	High
ED045P: Chloride by PC Titrator								
ED045P: Chloride by PC Titrator - (QC Lot: 315307)								
Chloride	EB0611779-007	Anonymous	1 mg/L	mg/L	400	mg/L	%	%
EG020F: Dissolved Metals by ICP-MS								
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 315314)								
Arsenic	EB0611786-002	2D	0.001 mg/L	mg/L	0.100	mg/L	%	%
Beryllium			0.001 mg/L	0.100	<0.001	101	70	130
Barium			0.001 mg/L	0.100	<0.001	103	70	130
Cadmium			0.001 mg/L	0.100	0.002	98.7	70	130
Chromium			0.0001 mg/L	0.100	<0.0001	97.1	70	130
Cobalt			0.001 mg/L	0.100	<0.001	98.6	70	130
Copper			0.001 mg/L	0.100	<0.001	107	70	130
Lead			0.001 mg/L	0.100	<0.001	104	70	130
Manganese			0.001 mg/L	0.100	<0.001	101	70	130
Nickel			0.001 mg/L	0.100	0.004	102	70	130
Vanadium	0.001 mg/L	0.100	0.001 mg/L	101	70	130		
Zinc	0.005 mg/L	0.100	0.01 mg/L	<0.01	101	70	130	
EG035F: Dissolved Mercury by FIMS								
EG035F: Dissolved Mercury by FIMS - (QC Lot: 313768)								
Mercury	EB0611666-001	Anonymous	0.0001 mg/L	mg/L	0.01	mg/L	%	%
EG051: Ferrous Iron								
EG051: Ferrous Iron - (QC Lot: 313620)								
Ferrous Iron	EB0611779-011	Anonymous	0.05 mg/L	mg/L	20	mg/L	%	%
EK055: Ammonia as N								
EK055: Ammonia as N - (QC Lot: 313127)								
Ammonia as N	EB0611778-028	Anonymous	0.01 mg/L	mg/L	4	mg/L	%	%
					5.62		109	70
								130



ALS Environmental

Matrix Type: WATER

Matrix Spike (MS) Report

Analyte name	Laboratory Sample ID	Client Sample ID	LOR	Spike Concentration	Actual Results		Recovery Limits	
					Sample Result	Spike Recovery	Static Limits	High
EK057: Nitrite as N								
EK057: Nitrite as N - (QC Lot: 313125)								
Nitrite as N	EB0611778-008	Anonymous	0.01 mg/L	0.4 mg/L	mg/L	%	%	%
EK057: Nitrite as N - (QC Lot: 313128)								
Nitrite as N	EB0611778-028	Anonymous	0.01 mg/L	0.4 mg/L	mg/L	%	75.0	130
EK059: Nitrite plus Nitrate as N (NOx)								
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 313126)								
Nitrite + Nitrate as N	EB0611778-025	Anonymous	0.01 mg/L	2000 mg/L	mg/L	%	117	130
EK061: Total Kjeldahl Nitrogen (TKN)								
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 314450)								
Total Kjeldahl Nitrogen as N	EB0611759-001	Anonymous	0.1 mg/L	5 mg/L	mg/L	%	129	130
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 314452)								
Total Kjeldahl Nitrogen as N	EB0611811-001	Anonymous	0.1 mg/L	5 mg/L	mg/L	%	130	130
EK067: Total Phosphorus as P								
EK067: Total Phosphorus as P - (QC Lot: 314451)								
Total Phosphorus as P	EB0611759-001	Anonymous	0.01 mg/L	1 mg/L	mg/L	%	97.9	130

Report version : QC_NA 3.03

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INTERPRETIVE QUALITY CONTROL REPORT

Client	: URS AUSTRALIA PTY LTD (QLD)	Laboratory	: ALS Environmental Brisbane	Page	: 1 of 7
Contact	: MR STEPHEN DENNER	Contact	: Michael Heery		
Address	: GPO BOX 302 BRISBANE QLD AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053	Work order	: EB0611786
Project	: 42625813	Quote number	: EN/001/05	Amendment No.	:
Order number	: - Not provided -			Date received	: 24 Nov 2006
C-O-C number	: - Not provided -			Date issued	: 4 Dec 2006
Site	: - Not provided -				
E-mail	: stephen_denner@urscorp.com	E-mail	: services.brisbane@alsenviro.com	No. of samples	
Telephone	: 07 3243 2111	Telephone	: +61 (07) 3243 7222	Received	: 3
Facsimile	: 07 3243 2199	Facsimile	: +61 (07) 3243 7259	Analysed	: 3

This Interpretive Quality Control Report was issued on 4 Dec 2006 for the ALS work order reference EB0611786 and supersedes any previous reports with this reference.

This report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Type Frequency Compliance
- Summary of all Quality Control Outliers
- Brief Method Summaries

Interpretive Quality Control Report - Analysis Holding Time

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the sample aliquot was taken. Elapsed time to analysis represents time from sampling where no extraction / digestion is involved or time from extraction / digestion where this is present. For composite samples, sampling date/time is taken as that of the oldest sample contributing to that composite. Sample date/time for laboratory produced leaches are taken from the completion date/time of the leaching process. Outliers for holding time are based on USEPA SW846, APHA, AS and NEPM (1999). Failed outliers, refer to the 'Summary of Outliers'.

Matrix Type: WATER			Analysis Holding Time and Preservation				
Method Container / Client Sample ID(s)	Date Sampled	Extraction / Preparation		Analysis			
		Date extracted	Due for extraction	Date analysed	Due for analysis		
ED037-P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural 2S,	2D	22 Nov 2006			29 Nov 2006	6 Dec 2006	
Clear Plastic Bottle - Natural SL		23 Nov 2006			29 Nov 2006	7 Dec 2006	
ED040F: Major Anions - Filtered							
Clear Plastic Bottle - Natural 2S,	2D	22 Nov 2006			27 Nov 2006	20 Dec 2006	
Clear Plastic Bottle - Natural SL		23 Nov 2006			27 Nov 2006	21 Dec 2006	
ED045-P: Chloride by PC Titrator							
Clear Plastic Bottle - Natural 2S,	2D	22 Nov 2006			30 Nov 2006	20 Dec 2006	
Clear Plastic Bottle - Natural SL		23 Nov 2006			30 Nov 2006	21 Dec 2006	
ED093F: Major Cations - Filtered							
Clear Plastic Bottle - Natural 2S,	2D	22 Nov 2006			27 Nov 2006	20 Dec 2006	
Clear Plastic Bottle - Natural SL		23 Nov 2006			27 Nov 2006	21 Dec 2006	
EG020A-F: Dissolved Metals by ICP-MS - Suite A							
Clear Plastic Bottle - Nitric Acid; Filtered 2S,	2D	22 Nov 2006			30 Nov 2006	21 May 2007	
Clear Plastic Bottle - Nitric Acid; Filtered SL		23 Nov 2006			30 Nov 2006	22 May 2007	
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Filtered 2S,	2D	22 Nov 2006			28 Nov 2006	20 Dec 2006	
Clear Plastic Bottle - Nitric Acid; Filtered SL		23 Nov 2006			28 Nov 2006	21 Dec 2006	
EG051F: Ferrous Iron - Filtered							
Clear Plastic Bottle - HCl 2S,	2D	22 Nov 2006			24 Nov 2006	23 Nov 2006	
Clear Plastic Bottle - HCl SL		23 Nov 2006			24 Nov 2006	24 Nov 2006	
						Fail by 1 day	
						Pass	



Client : URS AUSTRALIA PTY LTD (QLD) Work Order : EB0611786 Page Number : 3 of 7
Project : 42625813 ALS Quote Reference : EN/001/05 Issue Date : 4 Dec 2006

Matrix Type: WATER

Analysis Holding Time and Preservation

Method	Date Sampled	Extraction / Preparation			Analysis	
Container / Client Sample ID(s)		Date extracted	Due for extraction	Pass?	Date analysed	Due for analysis
EK055A: Ammonia as N						
Clear Plastic Bottle - Sulphuric Acid 2S,	2D	-----	-----	-----	24 Nov 2006	20 Dec 2006
Clear Plastic Bottle - Sulphuric Acid SL	23 Nov 2006	-----	-----	-----	24 Nov 2006	21 Dec 2006
EK057: Nitrite as N						
Clear Plastic Bottle - Natural 2S,	2D	-----	-----	-----	24 Nov 2006	24 Nov 2006
Clear Plastic Bottle - Natural SL	23 Nov 2006	-----	-----	-----	24 Nov 2006	25 Nov 2006
EK059: Nitrite and Nitrate as N (NOx)						
Clear Plastic Bottle - Sulphuric Acid 2S,	2D	-----	-----	-----	24 Nov 2006	20 Dec 2006
Clear Plastic Bottle - Sulphuric Acid SL	23 Nov 2006	-----	-----	-----	24 Nov 2006	21 Dec 2006
EK061: Total Kjeldahl Nitrogen as N						
Clear Plastic Bottle - Sulphuric Acid 2S,	2D	29 Nov 2006	20 Dec 2006	Pass	29 Nov 2006	20 Dec 2006
Clear Plastic Bottle - Sulphuric Acid SL	23 Nov 2006	29 Nov 2006	21 Dec 2006	Pass	29 Nov 2006	21 Dec 2006
EK067: Total Phosphorus as P						
Clear Plastic Bottle - Sulphuric Acid 2S,	2D	29 Nov 2006	20 Dec 2006	Pass	29 Nov 2006	20 Dec 2006
Clear Plastic Bottle - Sulphuric Acid SL	23 Nov 2006	29 Nov 2006	21 Dec 2006	Pass	29 Nov 2006	21 Dec 2006

Interpretive Quality Control Report - Frequency of Quality Control Samples

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which this work order was processed. Actual rate should be greater than or equal to the expected rate.

Matrix Type: WATER Frequency of Quality Control Samples

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification
Method		QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)						
ED037-P: Alkalinity by PC Titrator		2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
ED040F: Major Anions - Filtered		2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
ED045-P: Chloride by PC Titrator		2	14	14.3	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
ED093F: Major Cations - Filtered		1	9	11.1	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG020A-F: Dissolved Metals by ICP-MS - Suite A		2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG035F: Dissolved Mercury by FIMS		2	19	10.5	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG051F: Ferrous Iron - Filtered		2	10	20.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK055A: Ammonia as N		1	4	25.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK057: Nitrite as N		2	21	9.5	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK059: Nitrite and Nitrate as N (NOx)		1	7	14.3	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK061: Total Kjeldahl Nitrogen as N		4	40	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK067: Total Phosphorus as P		2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
Laboratory Control Samples (LCS)						
ED037-P: Alkalinity by PC Titrator		1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
ED045-P: Chloride by PC Titrator		1	14	7.1	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG020A-F: Dissolved Metals by ICP-MS - Suite A		1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG035F: Dissolved Mercury by FIMS		1	19	5.3	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG051F: Ferrous Iron - Filtered		1	10	10.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK055A: Ammonia as N		1	4	25.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK057: Nitrite as N		2	21	9.5	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK059: Nitrite and Nitrate as N (NOx)		1	7	14.3	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK061: Total Kjeldahl Nitrogen as N		2	40	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK067: Total Phosphorus as P		1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
Method Blanks (MB)						
ED040F: Major Anions - Filtered		1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
ED045-P: Chloride by PC Titrator		1	14	7.1	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
ED093F: Major Cations - Filtered		1	9	11.1	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG020A-F: Dissolved Metals by ICP-MS - Suite A		1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG035F: Dissolved Mercury by FIMS		1	19	5.3	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EG051F: Ferrous Iron - Filtered		1	10	10.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK055A: Ammonia as N		1	4	25.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK057: Nitrite as N		2	21	9.5	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK059: Nitrite and Nitrate as N (NOx)		1	7	14.3	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK061: Total Kjeldahl Nitrogen as N		2	40	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement
EK067: Total Phosphorus as P		1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement



Matrix Type: WATER Frequency of Quality Control Samples

Quality Control Sample Type Method	Count		Rate (%)		Quality Control Specification	
	QC	Regular	Actual	Expected		
Matrix Spikes (MS)						
ED045-P: Chloride by PC Titrator	1	14	7.1	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EG020A-F: Dissolved Metals by ICP-MS - Suite A	1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EG035F: Dissolved Mercury by FIMS	1	19	5.3	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EG051F: Ferrous Iron - Filtered	1	10	10.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK055A: Ammonia as N	1	4	25.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK057: Nitrite as N	2	21	9.5	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK059: Nitrite and Nitrate as N (NOx)	1	7	14.3	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK061: Total Kjeldahl Nitrogen as N	2	40	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK067: Total Phosphorus as P	1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement

Interpretive Quality Control Report - Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged on the 'Quality Control Report'. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). Flagged outliers on control limits for inorganics tests may be within the NEPM specified data quality objective of recoveries in the range of 70 to 130%. Where this occurs, no corrective action is taken. - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot.

Non-surrogates

- For all matrices, no RPD recovery outliers occur for the duplicate analysis.
- For all matrices, no method blank result outliers occur.
- For all matrices, no laboratory spike recoveries breaches occur.
- For all matrices, no matrix spike recoveries breaches occur.

Surrogates

- For all matrices, no surrogate recovery outliers occur.

Outliers : Analysis Holding Time

The following report highlights outliers within this 'Interpretive Quality Control Report - Analysis Holding Time'.

Method Container / Client Sample ID(s)	Date Sampled	Extraction / Preparation		Analysis	
		Date extracted	Due for extraction	Date analysed	Due for analysis
EG051F: Ferrous Iron - Filtered					
Clear Plastic Bottle - HCl					
2S,					
2D	22 Nov 2006	----	----	24 Nov 2006	23 Nov 2006
					Fail by 1 day

Outliers : Frequency of Quality Control Samples

The following report highlights outliers within this 'Interpretive Quality Control Report - Frequency of Quality Control Samples'.

- No frequency outliers occur.

Method Reference Summary

The analytical procedures used by ALS Environmental are based on established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house procedure are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

Matrix Type: WATER

Method Reference Summary

Preparation Methods

EK061/EK067 : TKN/TP Digestion - APHA 20th ed., 4500 Norg - D; APHA 20th ed., 4500 P - H. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Analytical Methods

ED037-P : Alkalinity by PC Titrator - APHA 21st ed., 2320 B This procedure determines alkalinity by both manual measurement and automated measurement (e.g. PC Titrator) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

ED040F : Major Anions - Filtered - APHA 21st ed., 3120 Sulphur and Silicon content is determined by ICP/AES and reported as Sulphate after conversion by gravimetric factor.

ED045-P : Chloride by PC Titrator - APHA 20th ed., 4500 Cl - B. Automated Silver Nitrate titration.

ED093F : Major Cations - Filtered - APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EG020A-F : Dissolved Metals by ICP-MS - Suite A - (APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

EG035F : Dissolved Mercury by FIMS - AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl₂)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EG051F : Ferrous Iron - Filtered - APHA 21st ed., 3500 Fe-B. A colorimetric determination based on the reaction between phenanthroline and ferrous iron at pH 3.2-3.3 to form an orange-red complex that is measured against a five-point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK055A : Ammonia as N - APHA 20th ed., 4500 NH₃+H Ammonia is determined by direct colorimetry by FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK057 : Nitrite as N - APHA 20th ed., 4500 NO₃- I. Nitrite is determined by direct colorimetry by FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK058 : Nitrate as N - APHA 20th ed., 4500 NO₃-I Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by FIA. Nitrite is determined separately by direct colorimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK059 : Nitrite and Nitrate as N (NO_x) - APHA 20th ed., 4500 NO₃- I. Combined oxidised Nitrogen (NO₂+NO₃) is determined by Cadmium Reduction and direct colorimetry by FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK061 : Total Kjeldahl Nitrogen as N - APHA 20th ed., 4500-Norg-D 100mL water samples are digested using a traditional Kjeldahl digestion followed by determination by FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK067 : Total Phosphorus as P - APHA 20th ed., 4500 P-H This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EN055 : Ionic Balance - APHA 20th Ed. 1030F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

CHAIN OF CUSTODY DOCUMENTATION



CLIENT: UNIMIN	SAMPLER: AW
ADDRESS / OFFICE:	MOBILE: 0448 853 004
PROJECT MANAGER (PM): JB	PHONE: 07 3243 2146
PROJECT ID: 42625813	EMAIL REPORT TO: stephen denner@urscorp.co (underscore between stephen and denner)
SITE:	EMAIL INVOICE TO: (if different to report)
P.O. NO.:	

RESULTS REQUIRED (Date):		QUOTE NO.:				
FOR LABORATORY USE ONLY						
COOLER SEAL (circle appropriate)						
☒ In Use ☐ No ☐ N/A						
SAMPLE TEMPERATURE 71						
☒ CHILLED ☐ Yes ☐ No						
SAMPLE INFORMATION (note: S = Soil, W=Water)		CONTAINER INFORMATION				
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles
1	2D	Water	3/4/07	1pm	P, N, SP	3
2	2S		3/4/07	2pm	P, N, SP	3
3	SWALLOW LAGOON		3/4/07	4pm	P, N, SP	3
4	BROWN LAKE		3/4/07	5pm	P, N, SP	3
5	QC01		3/4/07	2pm	P, N, SP	3
6	QC02		3/4/07	1pm	P, N, SP	3

RELINQUISHED BY:		RECEIVED BY:	
Name: Andrew Wilson	Date: 4/4/07	Name: [Signature]	Date: 4/4/07
Of: VRS	Time:	Of: ACS	Time: 11:00
Name:	Date:	Name:	Date:
Of:	Time:	Of:	Time:

METHOD OF SHIPMENT	
Con' Note No:	
Transport Co:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulphuric Preserved Amber Glass; H = HCl Preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Solids; B = Unpreserved Bag.



ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Comprehensive report

Client Details

Client : URS AUSTRALIA PTY LTD (QLD)
Contact : MR STEPHEN DENNER
Address : GPO BOX 302 BRISBANE QLD AUSTRALIA 4001

Project : 42625813
Order number : - Not provided -
C-O-C Number : - Not provided -
Site : - Not provided -
Sampler : AW

E-mail : stephen_denner@urscorp.com
Telephone : 32432111
Facsimile : 32432199

Laboratory Details

Laboratory : Environmental Division Brisbane
Manager : Tim Kilmister
Address : 32 Shand Street Stafford QLD Australia 4053

Quote number : EB20050096
Work order : EB0703720

E-mail : Services.Brisbane@alsenviro.com
Telephone : 61-7-3243 7222
Facsimile : 61-7-3243 7259

Dates

Date Samples Received : 4 Apr 2007
Scheduled Reporting Date : **20 Apr 2007**

SRA Issue Date :
Client Requested Date : 20 Apr 2007

Delivery Details

Mode of Delivery : Client Drop off.
No. of coolers/boxes : 1 LARGE, 1 SMALL
Security Seal : Intact.

Temperature : 7.1 C - Ice bricks present
No. of samples - Received 6
- Analysed 6

Comments

- Samples received in appropriately pretreated and preserved containers.
 - Sample(s) have been received within recommended holding times.
-
- Please direct any turn around / technical queries to the laboratory contact designated above.
 - Sample Disposal - Aqueous (14 days), Solid (90 days) from date of completion of work order.
 - Please direct any queries related to sample condition / numbering / breakages to Janine Hew.
 - Analytical work for this work order will be conducted at ALSE Brisbane.
 - When the sampling time is not supplied on the COC documentation, ALSE defaults the sampling time to that of the COC 'relinquishment' time (if supplied). If this also is not supplied, ALSE defaults the sampling time to the 'time of receipt at Laboratory'.

Disclaimer : This document contains privileged and confidential information intended only for the use of the addressee. If you are not the addressee, you are hereby notified that you must not disseminate, copy or take action of its contents. If you have received this document in error, please notify ALS immediately.

SAMPLE RECEIPT NOTIFICATION (SRN) - continued

Client : URS AUSTRALIA PTY LTD (QLD)
Project : 42625813

Work Order : EB0703720
ALS Quote Reference : EB20050096



Summary of Sample(s) / Container(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as moisture and preparation tasks, that form an implicit part of that package.

ALS Sample ID.	Client Sample ID - Sample Date	Requested Analysis									
		EK055A - WATER Ammonia as N	EK058 - WATER Nitrate as N (Incl. Nitrite as N)	EK062 - WATER Total Nitrogen as N (TKN + NOx)	EK067 - WATER Total Phosphorus as P	EN055 - WATER Ionic Balance	Major Anions - WATER Cl, SO4, Alkalinity PCT	Major Cations - WATER Ca, Mg, Na, K	W-03 - WATER 13 Metals (NEPM Suite)		
EB0703720-001	2 D - 3 Apr 2007	●	●	●	●	●	●	●	●		
EB0703720-002	2 S - 3 Apr 2007	●	●	●	●	●	●	●	●		
EB0703720-003	SWALLOW LAGOON - 3 Apr 2007	●	●	●	●	●	●	●	●		
EB0703720-004	BROWN LAKE - 3 Apr 2007	●	●	●	●	●	●	●	●		
EB0703720-005	QC01 - 3 Apr 2007	●	●	●	●	●	●	●	●		
EB0703720-006	QC02 - 3 Apr 2007	●	●	●	●	●	●	●	●		
Total(s) :		6	6	6	6	6	6	6	6		

SAMPLE RECEIPT NOTIFICATION (SRN) - continued

Client : URS AUSTRALIA PTY LTD (QLD)
Project : 42625813

Work Order : EB0703720
ALS Quote Reference : EB20050096



Requested Reports

- **MR STEPHEN DENNER**

- A4 - AU Certificate of Analysis - NEPM format	Email	stephen_denner@urscorp.com
- A4 - AU Interpretive Quality Control Report - NEPM format	Email	stephen_denner@urscorp.com
- A4 - AU Quality Control Report - NEPM format	Email	stephen_denner@urscorp.com
- EDI Format - MRED	Email	stephen_denner@urscorp.com
- Default - Chain of Custody	Email	stephen_denner@urscorp.com
- A4 - AU Sample Receipt Notification - Comprehensive format	Email	stephen_denner@urscorp.com

- **NATASHA GAVIN**

- A4 - AU Tax Invoice	Email	natasha_gavin@urscorp.com
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Sample Container(s) / Preservation Non-Compliance Log

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exist.**

CERTIFICATE OF ANALYSIS

Client	: URS AUSTRALIA PTY LTD (QLD)	Laboratory	: Environmental Division Brisbane	Page	: 1 of 7
Contact	: MR STEPHEN DENNER	Contact	: Tim Kilmister	Work Order	: EB0703720
Address	: GPO BOX 302 BRISBANE QLD AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053		
E-mail	: stephen_denner@urscorp.com	E-mail	: Services.Brisbane@alsenviro.com		
Telephone	: 32432111	Telephone	: 61-7-3243 7222		
Facsimile	: 32432199	Facsimile	: 61-7-3243 7259		
Project	: 42625813	Quote number	: EN/001/07	Date received	: 4 Apr 2007
Order number	: - Not provided -			Date issued	: 20 Apr 2007
C-O-C number	: - Not provided -			No. of samples	: - Received : 6
Site	: - Not provided -				: - Analysed : 6

ALSE - Excellence in Analytical Testing

 NATA Accredited Laboratory 825 This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025.		This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.	
Signature	Position	Signature	Position
Kim McCabe	Senior Inorganic Chemist		Inorganics - NATA 825 (818 - Brisbane)
Stephen Hislop	Senior Inorganic Chemist		Inorganics - NATA 825 (818 - Brisbane)

Page Number : 2 of 7
Client : URS AUSTRALIA PTY LTD (QLD)
Work Order : EB0703720

Comments

This report for the ALSE reference EB0703720 supersedes any previous reports with this reference. Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Analytical Results for Samples Submitted
- Surrogate Recovery Data

The analytical procedures used by ALS Environmental have been developed from established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insufficient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits). Where LOR of reported result differ from standard LOR, this may be due to high moisture, reduced sample amount or matrix interference. When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes. Abbreviations: CAS number = Chemical Abstract Services number, LOR = Limit of Reporting. * Indicates failed Surrogate Recoveries.

Specific comments for Work Order **EB0703720**

EK067 : EB0703720:SAMPLE 6 : LOR Raised due to the presence of suspended solids
Ionic balances are within acceptable limits as detailed in the 20th Ed. APHA "Standard Methods for the Examination of Water and Wastewater".



ALS Environmental

Page Number : 3 of 7
Client : URS AUSTRALIA PTY LTD (QLD)
Work Order : EB0703720

Analytical Results

Analyte		CAS number	LOR	Units	2 D WATER 3 Apr 2007 13:00 EB0703720-001	2 S WATER 3 Apr 2007 14:00 EB0703720-002	SWALLOW LAGOON WATER 3 Apr 2007 16:00 EB0703720-003	BROWN LAKE WATER 3 Apr 2007 17:00 EB0703720-004	QC01 WATER 3 Apr 2007 14:00 EB0703720-005
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO ₃		DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃		3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃		71-52-3	1	mg/L	3	<1	2	1	2
Total Alkalinity as CaCO ₃			1	mg/L	3	<1	2	1	2
ED040F: Dissolved Major Anions									
Sulphate as SO ₄ 2-		14808-79-8	1	mg/L	5	3	3	4	<1
ED045P: Chloride by PC Titrator									
Chloride		16887-00-6	1	mg/L	25	27	18	29	<1
ED093F: Dissolved Major Cations									
Calcium		7440-70-2	1	mg/L	1	<1	1	<1	<1
Magnesium		7439-95-4	1	mg/L	3	2	2	2	<1
Sodium		7440-23-5	1	mg/L	15	16	11	17	<1
Potassium		7440-09-7	1	mg/L	<1	<1	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS									
Arsenic		7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium		7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium		7440-39-3	0.001	mg/L	0.002	0.001	<0.001	<0.001	<0.001
Cadmium		7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium		7440-47-3	0.001	mg/L	<0.001	0.001	<0.001	<0.001	<0.001
Cobalt		7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper		7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead		7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese		7439-96-5	0.001	mg/L	0.008	0.002	0.028	0.006	<0.001
Nickel		7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium		7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc		7440-66-6	0.005	mg/L	0.013	0.006	0.009	<0.005	<0.005
EG035F: Dissolved Mercury by FIMS									
Mercury		7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK055: Ammonia as N									
Ammonia as N		7664-41-7	0.010	mg/L	0.111	0.081	0.049	0.016	0.017
EK057: Nitrite as N									
Nitrite as N			0.010	mg/L	0.050	0.049	<0.010	<0.010	<0.010
EK058: Nitrate as N									
Nitrate as N		14797-55-8	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010
EK059: Nitrite plus Nitrate as N (NO_x)									
Nitrite + Nitrate as N			0.010	mg/L	0.016	0.016	<0.010	<0.010	<0.010



ALS Environmental

Analytical Results

Analyte	CAS number	Client Sample ID :		2 D	2 S	SWALLOW LAGOON	BROWN LAKE	QC01
		Sample Matrix	Type / Description :					
			Sample Date / Time :					
			Laboratory Sample ID :					
		LOR	Units					
EK061: Total Kjeldahl Nitrogen (TKN)								
Total Kjeldahl Nitrogen as N		0.1	mg/L	1.1	11.1	1.6	0.6	0.2
EK067: Total Phosphorus as P								
Total Phosphorus as P		0.01	mg/L	0.06	0.13	<0.01	<0.01	<0.01
EN055: Ionic Balance								
Total Anions		0.01	meq/L	0.87	0.82	0.62	0.93	0.04
Total Cations		0.01	meq/L	0.92	0.87	0.65	0.91	<0.01



ALS Environmental

Page Number : 5 of 7
Client : URS AUSTRALIA PTY LTD (QLD)
Work Order : EB0703720

Analytical Results

Analyte		CAS number	Client Sample ID : Sample Matrix Type / Description : Sample Date / Time : Laboratory Sample ID :		QC02 WATER 3 Apr 2007 13:00 EB0703720-006				
ED037P: Alkalinity by PC Titrator			LOR	Units					
Hydroxide Alkalinity as CaCO ₃		DMO-210-001	1	mg/L	<1				
Carbonate Alkalinity as CaCO ₃		3812-32-6	1	mg/L	<1				
Bicarbonate Alkalinity as CaCO ₃		71-52-3	1	mg/L	<1				
Total Alkalinity as CaCO ₃			1	mg/L	<1				
ED040F: Dissolved Major Anions									
Sulphate as SO ₄ 2-		14808-79-8	1	mg/L	2				
ED045P: Chloride by PC Titrator									
Chloride		16887-00-6	1	mg/L	25				
ED093F: Dissolved Major Cations									
Calcium		7440-70-2	1	mg/L	<1				
Magnesium		7439-95-4	1	mg/L	2				
Sodium		7440-23-5	1	mg/L	15				
Potassium		7440-09-7	1	mg/L	<1				
EG020F: Dissolved Metals by ICP-MS									
Arsenic		7440-38-2	0.001	mg/L	<0.001				
Beryllium		7440-41-7	0.001	mg/L	<0.001				
Barium		7440-39-3	0.001	mg/L	0.002				
Cadmium		7440-43-9	0.0001	mg/L	<0.0001				
Chromium		7440-47-3	0.001	mg/L	<0.001				
Cobalt		7440-48-4	0.001	mg/L	<0.001				
Copper		7440-50-8	0.001	mg/L	<0.001				
Lead		7439-92-1	0.001	mg/L	<0.001				
Manganese		7439-96-5	0.001	mg/L	0.008				
Nickel		7440-02-0	0.001	mg/L	<0.001				
Vanadium		7440-62-2	0.01	mg/L	<0.01				
Zinc		7440-66-6	0.005	mg/L	0.006				
EG035F: Dissolved Mercury by FIMS									
Mercury		7439-97-6	0.0001	mg/L	<0.0001				
EK055: Ammonia as N									
Ammonia as N		7664-41-7	0.010	mg/L	0.110				
EK057: Nitrite as N									
Nitrite as N			0.010	mg/L	0.052				
EK058: Nitrate as N									
Nitrate as N		14797-55-8	0.010	mg/L	<0.010				
EK059: Nitrite plus Nitrate as N (NO _x)									
Nitrite + Nitrate as N			0.010	mg/L	0.020				

Page Number : 6 of 7

Client : URS AUSTRALIA PTY LTD (QLD)

Work Order : EB0703720



ALS Environmental

Analytical Results

Client Sample ID :			QC02		
Sample Matrix Type / Description :			WATER		
Sample Date / Time :			3 Apr 2007		
Laboratory Sample ID :			EB0703720-006		
Analyte	CAS number	LOR	Units		
EK061: Total Kjeldahl Nitrogen (TKN)					
Total Kjeldahl Nitrogen as N		0.1	mg/L	4.0	
EK067: Total Phosphorus as P					
Total Phosphorus as P		0.01	mg/L	<0.05	
EN055: Ionic Balance					
Total Anions		0.01	meq/L	0.74	
Total Cations		0.01	meq/L	0.83	

Page Number

: 7 of 7

Client

: URS AUSTRALIA PTY LTD (QLD)

Work Order

: EB0703720



ALS Environmental

Surrogate Control Limits

- No surrogates present on this report.

QUALITY CONTROL REPORT

Client	: URS AUSTRALIA PTY LTD (QLD)	Laboratory	: Environmental Division Brisbane	Page	: 1 of 10
Contact	: MR STEPHEN DENNER	Contact	: Tim Kilmister		
Address	: GPO BOX 302 BRISBANE QLD AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053	Work order	: EB0703720
Project	: 42625813	Quote number	: EN/001/07	Amendment No.	:
Order number	: - Not provided -			Date received	: 4 Apr 2007
C-O-C number	: - Not provided -			Date issued	: 20 Apr 2007
Site	: - Not provided -				
E-mail	: stephen_denner@urscorp.com	E-mail	: Services.Brisbane@alsenviro.com	No. of samples	
Telephone	: 32432111	Telephone	: 61-7-3243 7222	Received	: 6
Facsimile	: 32432199	Facsimile	: 61-7-3243 7259	Analysed	: 6

This final report for the ALSE work order reference EB0703720 supersedes any previous reports with this reference. Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Laboratory Duplicates (DUP); Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Samples (LCS); Recovery and Acceptance Limits
- Matrix Spikes (MS); Recovery and Acceptance Limits

Work order specific comments

EK067 : EB0703720: SAMPLE 6 : LOR Raised due to the presence of suspended solids

Ionic balances are within acceptable limits as detailed in the 20th Ed. APHA "Standard Methods for the Examination of Water and Wastewater".

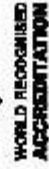
ALSE - Excellence in Analytical Testing



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This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Department
Kim McCabe	Inorganics - NATA 825 (818 - Brisbane)
Stephen Hislop	Inorganics - NATA 825 (818 - Brisbane)

Quality Control Report - Laboratory Duplicates (DUP)

The quality control term **Laboratory Duplicate** refers to an intralaboratory split sample randomly selected from the sample batch. Laboratory duplicates provide information on method precision and sample heterogeneity.
 - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. **Abbreviations: LOR = Limit of Reporting, RPD = Relative Percent Difference.**
 * Indicates failed QC. The permitted ranges for the RPD of Laboratory Duplicates (relative percent deviation) are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting:- Result < 10 times LOR, no limit - Result between 10 and 20 times LOR, 0% - 50% - Result > 20 times LOR, 0% - 20%

Matrix Type: WATER

Laboratory Duplicates (DUP) Report

Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD
ED037P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 391247)						
EB0703720-001	2 D	Hydroxide Alkalinity as CaCO3	1 mg/L	mg/L	mg/L	%
		Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	3	1	100
		Total Alkalinity as CaCO3	1 mg/L	3	1	100
EB0703730-004	Anonymous	Hydroxide Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	106	106	0.0
		Total Alkalinity as CaCO3	1 mg/L	106	106	0.0
ED040F: Dissolved Major Anions						
ED040F: Dissolved Major Anions - (QC Lot: 386222)						
EB0703689-001	Anonymous	Sulphate as SO4 2-	1 mg/L	mg/L	mg/L	%
EB0703689-010	Anonymous	Sulphate as SO4 2-	1 mg/L	468	464	0.7
ED040F: Dissolved Major Anions - (QC Lot: 386225)						
EB0703720-003	SWALLOW LAGOON	Sulphate as SO4 2-	1 mg/L	190	187	1.5
ED045P: Chloride by PC Titrator						
ED045P: Chloride by PC Titrator - (QC Lot: 391248)						
EB0703720-001	2 D	Chloride	1 mg/L	mg/L	mg/L	%
EB0703730-004	Anonymous	Chloride	1 mg/L	25	25	0.0
ED093F: Dissolved Major Cations						
ED093F: Dissolved Major Cations - (QC Lot: 386223)						
EB0703689-001	Anonymous	Calcium	1 mg/L	mg/L	mg/L	%
EB0703689-010	Anonymous	Magnesium	1 mg/L	35	35	0.0
		Sodium	1 mg/L	38	39	0.0
		Potassium	1 mg/L	592	591	0.0
EB0703689-010	Anonymous	Calcium	1 mg/L	6	6	0.0
		Calcium	1 mg/L	29	29	0.0



Matrix Type: WATER				Laboratory Duplicates (DUP) Report			
Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD	
ED093F: Dissolved Major Cations - continued							
ED093F: Dissolved Major Cations - (QC Lot: 386223) - continued							
EB0703689-010	Anonymous	Magnesium	1 mg/L	35	35	0.0	
		Sodium	1 mg/L	460	452	1.6	
		Potassium	1 mg/L	6	6	0.0	
ED093F: Dissolved Major Cations - (QC Lot: 386227)							
EB0703720-003	SWALLOW LAGOON	Calcium	1 mg/L	1	1	0.0	
		Magnesium	1 mg/L	2	2	0.0	
		Sodium	1 mg/L	11	10	0.0	
EB0703726-002	Anonymous	Potassium	1 mg/L	<1	<1	0.0	
		Calcium	1 mg/L	25	26	0.0	
		Magnesium	1 mg/L	12	12	0.0	
		Sodium	1 mg/L	22	24	9.3	
		Potassium	1 mg/L	5	5	0.0	
EG020F: Dissolved Metals by ICP-MS							
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 386544)							
EB0703671-001	Anonymous	Arsenic	0.001 mg/L	0.001	<0.001	0.0	
		Beryllium	0.001 mg/L	<0.001	<0.001	0.0	
		Barium	0.001 mg/L	0.181	0.182	0.0	
		Cadmium	0.0001 mg/L	<0.0001	<0.0001	0.0	
		Chromium	0.001 mg/L	0.004	0.004	0.0	
		Cobalt	0.001 mg/L	<0.001	<0.001	0.0	
		Copper	0.001 mg/L	<0.001	<0.001	0.0	
		Lead	0.001 mg/L	<0.001	<0.001	0.0	
		Manganese	0.001 mg/L	0.136	0.136	0.0	
		Nickel	0.001 mg/L	0.001	0.001	0.0	
		Vanadium	0.01 mg/L	<0.01	<0.01	0.0	
		Zinc	0.005 mg/L	<0.005	<0.005	0.0	
		Arsenic	0.001 mg/L	<0.001	<0.001	0.0	
		Beryllium	0.001 mg/L	<0.001	<0.001	0.0	
Barium	0.001 mg/L	<0.001	<0.001	0.0			
EB0703720-004							



Matrix Type: WATER Laboratory Duplicates (DUP) Report

Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD
EG020F: Dissolved Metals by ICP-MS - continued						
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 386544) - continued						
EB0703720-004	BROWN LAKE	Cadmium	0.0001 mg/L	mg/L <0.0001	mg/L <0.0001	% 0.0
		Chromium	0.001 mg/L	<0.001	<0.001	0.0
		Cobalt	0.001 mg/L	<0.001	<0.001	0.0
		Copper	0.001 mg/L	<0.001	<0.001	0.0
		Lead	0.001 mg/L	<0.001	<0.001	0.0
		Manganese	0.001 mg/L	0.006	0.006	0.0
		Nickel	0.001 mg/L	<0.001	<0.001	0.0
		Vanadium	0.01 mg/L	<0.01	<0.01	0.0
		Zinc	0.005 mg/L	<0.005	<0.005	0.0
EG035F: Dissolved Mercury by FIMS						
EG035F: Dissolved Mercury by FIMS - (QC Lot: 389179)						
EB0703676-010	Anonymous	Mercury	0.0001 mg/L	mg/L <0.0001	mg/L <0.0001	% 0.0
EB0703720-005	QC01	Mercury	0.0001 mg/L	<0.0001	<0.0001	0.0
EK055: Ammonia as N						
EK055: Ammonia as N - (QC Lot: 386154)						
EB0703648-005	Anonymous	Ammonia as N	0.010 mg/L	mg/L 2.02	mg/L 1.96	% 3.2
EB0703648-007	Anonymous	Ammonia as N	0.010 mg/L	0.136	0.141	3.6
EK057: Nitrite as N						
EK057: Nitrite as N - (QC Lot: 386156)						
EB0703648-005	Anonymous	Nitrite as N	0.010 mg/L	mg/L <0.010	mg/L <0.010	% 0.0
EB0703701-002	Anonymous	Nitrite as N	0.010 mg/L	<0.010	<0.010	0.0
EK059: Nitrite plus Nitrate as N (NOx)						
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 386157)						
EB0703701-002	Anonymous	Nitrite + Nitrate as N	0.010 mg/L	mg/L <0.010	mg/L <0.010	% 0.0
EB0703704-001	Anonymous	Nitrite + Nitrate as N	0.010 mg/L	0.514	0.524	1.9
EK061: Total Kjeldahl Nitrogen (TKN)						
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 388444)						
EB0703491-001	Anonymous	Total Kjeldahl Nitrogen as N	0.1 mg/L	mg/L 0.1	mg/L 0.2	% 67.8
EB0703750-004	Anonymous	Total Kjeldahl Nitrogen as N	0.1 mg/L	7.5	7.1	4.9



Matrix Type: WATER				Laboratory Duplicates (DUP) Report			
Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD	
EK067: Total Phosphorus as P							
EK067: Total Phosphorus as P - (QC Lot: 388445)							
EB0703491-001	Anonymous	Total Phosphorus as P	0.01 mg/L	mg/L	mg/L	%	
EB0703750-004	Anonymous	Total Phosphorus as P	0.01 mg/L	0.04	0.05	25.8	
				9.38	9.74	3.8	

Quality Control Report - Method Blank (MB) and Laboratory Control Samples (LCS)

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC type is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a known, interference free matrix spiked with target analytes or certified reference material. The purpose of this QC type is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of actual laboratory data. Flagged outliers on control limits for inorganics tests may be within the NEPM specified data quality objective of recoveries in the range of 70 to 130%. Where this occurs, no corrective action is taken. Abbreviations: LOR = Limit of reporting.

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

Analyte name		LOR	Method blank result	Actual Results		Recovery Limits	
			Spike concentration	Spike Recovery	Low	High	
			LCS				
ED037P: Alkalinity by PC Titrator							
ED037P: Alkalinity by PC Titrator - (QC Lot: 391247)			mg/L	mg/L	%	%	%
Total Alkalinity as CaCO3			---	200	95.0	70	130
ED040F: Dissolved Major Anions							
ED040F: Dissolved Major Anions - (QC Lot: 386222)			mg/L	mg/L	%	%	%
Sulphate as SO4 2-			<1	1	---	---	---
ED040F: Dissolved Major Anions - (QC Lot: 386225)			mg/L	mg/L	%	%	%
Sulphate as SO4 2-			<1	1	---	---	---
ED045P: Chloride by PC Titrator							
ED045P: Chloride by PC Titrator - (QC Lot: 391248)			mg/L	mg/L	%	%	%
Chloride			<1	---	---	---	---
			1 mg/L	1000	102	70	130
ED093F: Dissolved Major Cations							
ED093F: Dissolved Major Cations - (QC Lot: 386223)			mg/L	mg/L	%	%	%
Calcium			<1	---	---	---	---
Magnesium			<1	---	---	---	---
Potassium			<1	---	---	---	---
Sodium			<1	---	---	---	---
ED093F: Dissolved Major Cations - (QC Lot: 386227)			mg/L	mg/L	%	%	%
Calcium			<1	---	---	---	---
Magnesium			<1	---	---	---	---
Potassium			<1	---	---	---	---
Sodium			<1	---	---	---	---
EG020F: Dissolved Metals by ICP-MS							
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 386544)			mg/L	mg/L	%	%	%



Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

Analyte name		LOR	Method blank result	Actual Results		Recovery Limits	
				Spike concentration	Spike Recovery LCS	Low	High
EG020F: Dissolved Metals by ICP-MS - continued							
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 386544) - continued							
Arsenic	0.001 mg/L	mg/L	mg/L	%	%	%	
	0.001 mg/L		0.1000	86.0	70	130	
	0.001 mg/L	<0.001					
Barium	0.001 mg/L						
	0.001 mg/L		0.100	81.5	70	130	
	0.001 mg/L	<0.001					
Cadmium	0.0001 mg/L	mg/L	mg/L				
	0.0001 mg/L	<0.0001					
	0.0001 mg/L		0.1000	94.8	70	130	
Chromium	0.001 mg/L	mg/L	mg/L				
	0.001 mg/L		0.1000	91.9	70	130	
	0.001 mg/L	<0.001					
Cobalt	0.001 mg/L	mg/L	mg/L				
	0.001 mg/L		0.1000	91.8	70	130	
	0.001 mg/L	<0.001					
Copper	0.001 mg/L	mg/L	mg/L				
	0.001 mg/L		0.200	93.2	70	130	
	0.001 mg/L		0.1000	93.0	70	130	
Lead	0.001 mg/L	mg/L	mg/L				
	0.001 mg/L	<0.001					
	0.001 mg/L	<0.001					
Manganese	0.001 mg/L	mg/L	mg/L				
	0.001 mg/L		0.1000	90.8	70	130	
	0.001 mg/L	<0.001					
Nickel	0.001 mg/L	mg/L	mg/L				
	0.001 mg/L		0.1000	96.7	70	130	
	0.01 mg/L	<0.01					
Vanadium	0.01 mg/L	mg/L	mg/L				
	0.01 mg/L		0.1000	84.7	70	130	
	0.005 mg/L	<0.005					
Zinc	0.005 mg/L	mg/L	mg/L				
	0.005 mg/L		0.200	92.0	70	130	
	0.005 mg/L						
EG035F: Dissolved Mercury by FIMS							
EG035F: Dissolved Mercury by FIMS - (QC Lot: 389179)							
Mercury	0.0001 mg/L	mg/L	mg/L	%	%	%	
	0.0001 mg/L		0.010	76.2	70	130	
	0.0001 mg/L	<0.0001					
EK055: Ammonia as N							
EK055: Ammonia as N - (QC Lot: 386154)							
	mg/L	mg/L	mg/L	%	%	%	



Matrix Type: WATER Method Blank (MB) and Laboratory Control Samples (LCS) Report

Analyte name		LOR		Method blank result	Actual Results		Recovery Limits	
					Spike concentration	Spike Recovery LCS	Low	High
EK055: Ammonia as N - continued								
EK055: Ammonia as N - (QC Lot: 386154) - continued				mg/L			%	%
Ammonia as N		0.010 mg/L		<0.010				
		0.01 mg/L			1		106	130
EK057: Nitrite as N								
EK057: Nitrite as N - (QC Lot: 386156)				mg/L			%	%
Nitrite as N		0.01 mg/L			0.5		116	130
		0.010 mg/L		<0.010				
EK059: Nitrite plus Nitrate as N (NOx)								
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 386157)				mg/L			%	%
Nitrite + Nitrate as N		0.01 mg/L			0.5		105	130
		0.010 mg/L		<0.010				
EK061: Total Kjeldahl Nitrogen (TKN)								
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 388444)				mg/L			%	%
Total Kjeldahl Nitrogen as N		0.1 mg/L			10		97.0	130
		0.1 mg/L		<0.1				
EK067: Total Phosphorus as P								
EK067: Total Phosphorus as P - (QC Lot: 388445)				mg/L			%	%
Total Phosphorus as P		0.01 mg/L			4.42		84.4	130
		0.01 mg/L		<0.01				



Quality Control Report - Matrix Spikes (MS)

The quality control term **Matrix Spike (MS)** refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC type is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). 'Ideal' recovery ranges stated may be waived in the event of sample matrix interferences. - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. Abbreviations: **LOR** = Limit of Reporting, **RPD** = Relative Percent Difference.

* Indicates failed QC

Matrix Type: WATER

Matrix Spike (MS) Report

					Actual Results		Recovery Limits	
					Sample Result	Spike Recovery MS	Low	High
Analyte name	Laboratory Sample ID	Client Sample ID	LOR	Spike Concentration				
ED045P: Chloride by PC Titrator								
ED045P: Chloride by PC Titrator - (QC Lot: 391248)								
Chloride	EB0703720-002	2 S	1 mg/L	mg/L	mg/L	%	%	%
				490	27	104	70	130
EG020F: Dissolved Metals by ICP-MS								
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 386544)								
Arsenic	EB0703671-002	Anonymous	0.001 mg/L	mg/L	mg/L	%	%	%
Beryllium			0.001 mg/L	0.100	<0.001	107	70	130
Barium			0.001 mg/L	0.100	<0.001	102	70	130
Cadmium			0.001 mg/L	0.100	0.317	108	70	130
Chromium			0.0001 mg/L	0.100	<0.0001	102	70	130
Cobalt			0.001 mg/L	0.100	<0.001	98.5	70	130
Copper			0.001 mg/L	0.100	<0.001	110	70	130
Lead			0.001 mg/L	0.100	<0.001	102	70	130
Manganese			0.001 mg/L	0.100	<0.001	105	70	130
Nickel			0.001 mg/L	0.100	0.058	82.5	70	130
Vanadium	EB0703671-002	Anonymous	0.001 mg/L	0.100	<0.001	109	70	130
Zinc			0.01 mg/L	0.100	<0.01	103	70	130
			0.005 mg/L	0.100	<0.005	112	70	130
EG035F: Dissolved Mercury by FIMS								
EG035F: Dissolved Mercury by FIMS - (QC Lot: 389179)								
Mercury	EB0703676-010	Anonymous	0.0001 mg/L	mg/L	mg/L	%	%	%
				0.01	<0.0001	76.0	70	130
EK055: Ammonia as N								
EK055: Ammonia as N - (QC Lot: 386154)								
Ammonia as N	EB0703648-004	Anonymous	0.01 mg/L	mg/L	mg/L	%	%	%
				0.4	0.587	116	70	130
EK057: Nitrite as N								
EK057: Nitrite as N - (QC Lot: 386156)								
Nitrite as N	EB0703648-004	Anonymous	0.01 mg/L	mg/L	mg/L	%	%	%
				2	0.912	116	70	130

Matrix Type: WATER					Matrix Spike (MS) Report				
Analyte name	Laboratory Sample ID	Client Sample ID	LOR	Spike Concentration	Actual Results		Recovery Limits		
					Sample Result	Spike Recovery	Static Limits	High	
EK059: Nitrite plus Nitrate as N (NOx)									
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 386157)					mg/L	%	%	%	
Nitrite + Nitrate as N	EB0703700-002	Anonymous	0.01 mg/L	0.4	<0.010	107	70	130	
EK061: Total Kjeldahl Nitrogen (TKN)									
EK061: Total Kjeldahl Nitrogen (TKN) - (QC Lot: 388444)					mg/L	%	%	%	
Total Kjeldahl Nitrogen as N	EB0703491-002	Anonymous	0.1 mg/L	5	<0.1	120	70	130	
EK067: Total Phosphorus as P									
EK067: Total Phosphorus as P - (QC Lot: 388445)					mg/L	%	%	%	
Total Phosphorus as P	EB0703491-002	Anonymous	0.01 mg/L	1	0.04	97.4	70	130	

INTERPRETIVE QUALITY CONTROL REPORT

Client	: URS AUSTRALIA PTY LTD (QLD)	Laboratory	: Environmental Division Brisbane	Page	: 1 of 7
Contact	: MR STEPHEN DENNER	Contact	: Tim Kilmister		
Address	: GPO BOX 302 BRISBANE QLD AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053	Work order	: EB0703720
Project	: 42625813	Quote number	: EN/001/07	Amendment No.	:
Order number	: - Not provided -			Date received	: 4 Apr 2007
C-O-C number	: - Not provided -			Date issued	: 20 Apr 2007
Site	: - Not provided -				
E-mail	: stephen_denner@urscorp.com	E-mail	: Services.Brisbane@alsenviro.com	No. of samples	
Telephone	: 32432111	Telephone	: 61-7-3243 7222	Received	: 6
Facsimile	: 32432199	Facsimile	: 61-7-3243 7259	Analysed	: 6

This Interpretive Quality Control Report was issued on 20 Apr 2007 for the ALS work order reference EB0703720 and supersedes any previous reports with this reference.

This report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Type Frequency Compliance
- Summary of all Quality Control Outliers
- Brief Method Summaries

Interpretive Quality Control Report - Analysis Holding Time

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the sample aliquot was taken. Elapsed time to analysis represents time from sampling where no extraction / digestion is involved or time from extraction / digestion where this is present. For composite samples, sampling date/time is taken as that of the oldest sample contributing to that composite. Sample date/time for laboratory produced leaches are taken from the completion date/time of the leaching process. Outliers for holding time are based on USEPA SW846, APHA, AS and NEPM (1999). Failed outliers, refer to the 'Summary of Outliers'.

Matrix Type: WATER

Analysis Holding Time and Preservation

Method		Date Sampled	Extraction / Preparation		Analysis			
Container / Client Sample ID(s)			Date extracted	Due for extraction	Pass?	Date analysed	Due for analysis	Pass?
ED037-P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural 2 D, SWALLOW LAGOON, QC01,	2 S, BROWN LAKE, QC02	3 Apr 2007	-----	-----	-----	16 Apr 2007	17 Apr 2007	Pass
ED040F: Major Anions - Filtered								
Clear Plastic Bottle - Natural 2 D, SWALLOW LAGOON, QC01,	2 S, BROWN LAKE, QC02	3 Apr 2007	-----	-----	-----	5 Apr 2007	1 May 2007	Pass
ED045-P: Chloride by PC Titrator								
Clear Plastic Bottle - Natural 2 D, SWALLOW LAGOON, QC01,	2 S, BROWN LAKE, QC02	3 Apr 2007	-----	-----	-----	16 Apr 2007	1 May 2007	Pass
ED093F: Major Cations - Filtered								
Clear Plastic Bottle - Natural 2 D, SWALLOW LAGOON, QC01,	2 S, BROWN LAKE, QC02	3 Apr 2007	-----	-----	-----	5 Apr 2007	1 May 2007	Pass
EG020A-F: Dissolved Metals by ICP-MS - Suite A								
Clear Plastic Bottle - Nitric Acid; Filtered 2 D, SWALLOW LAGOON, QC01,	2 S, BROWN LAKE, QC02	3 Apr 2007	-----	-----	-----	5 Apr 2007	30 Sep 2007	Pass
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Nitric Acid; Filtered 2 D, SWALLOW LAGOON, QC01,	2 S, BROWN LAKE, QC02	3 Apr 2007	-----	-----	-----	12 Apr 2007	1 May 2007	Pass
EK055A: Ammonia as N								
Clear Plastic Bottle - Sulphuric Acid 2 D, SWALLOW LAGOON, QC01,	2 S, BROWN LAKE, QC02	3 Apr 2007	-----	-----	-----	5 Apr 2007	1 May 2007	Pass
EK057: Nitrite as N								



Matrix Type: WATER

Analysis Holding Time and Preservation

Method Container / Client Sample ID(s)	Date Sampled	Extraction / Preparation		Analysis	
		Date extracted	Due for extraction	Date analysed	Due for analysis
EK057: Nitrite as N - continued					
Clear Plastic Bottle - Natural 2 D, SWALLOW LAGOON, QC01, QC02	3 Apr 2007	----	----	5 Apr 2007	5 Apr 2007
Pass					
EK059: Nitrite and Nitrate as N (NOx)					
Clear Plastic Bottle - Sulphuric Acid 2 D, SWALLOW LAGOON, QC01, QC02	3 Apr 2007	----	----	5 Apr 2007	1 May 2007
Pass					
EK061: Total Kjeldahl Nitrogen as N					
Clear Plastic Bottle - Sulphuric Acid 2 D, SWALLOW LAGOON, QC01, QC02	3 Apr 2007	12 Apr 2007	1 May 2007	12 Apr 2007	1 May 2007
Pass					
EK067: Total Phosphorus as P					
Clear Plastic Bottle - Sulphuric Acid 2 D, SWALLOW LAGOON, QC01, QC02	3 Apr 2007	12 Apr 2007	1 May 2007	12 Apr 2007	1 May 2007
Pass					

Interpretive Quality Control Report - Frequency of Quality Control Samples

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which this work order was processed. Actual rate should be greater than or equal to the expected rate.

Matrix Type: WATER			Frequency of Quality Control Samples			
Quality Control Sample Type		Quality Control Specification				
Method	Count		Rate (%)			
	QC	Regular	Actual	Expected		
Laboratory Duplicates (DUP)						
ED037-P: Alkalinity by PC Titrator	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
ED040F: Major Anions - Filtered	3	29	10.3	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
ED045-P: Chloride by PC Titrator	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
ED093F: Major Cations - Filtered	4	31	12.9	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EG020A-F: Dissolved Metals by ICP-MS - Suite A	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EG035F: Dissolved Mercury by FIMS	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK055A: Ammonia as N	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK057: Nitrite as N	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK059: Nitrite and Nitrate as N (NOx)	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK061: Total Kjeldahl Nitrogen as N	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK067: Total Phosphorus as P	2	20	10.0	10.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
Laboratory Control Samples (LCS)						
ED037-P: Alkalinity by PC Titrator	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
ED045-P: Chloride by PC Titrator	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EG020A-F: Dissolved Metals by ICP-MS - Suite A	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EG035F: Dissolved Mercury by FIMS	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK055A: Ammonia as N	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK057: Nitrite as N	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK059: Nitrite and Nitrate as N (NOx)	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK061: Total Kjeldahl Nitrogen as N	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK067: Total Phosphorus as P	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
Method Blanks (MB)						
ED040F: Major Anions - Filtered	2	29	6.9	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
ED045-P: Chloride by PC Titrator	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
ED093F: Major Cations - Filtered	2	31	6.5	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EG020A-F: Dissolved Metals by ICP-MS - Suite A	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EG035F: Dissolved Mercury by FIMS	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK055A: Ammonia as N	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK057: Nitrite as N	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK059: Nitrite and Nitrate as N (NOx)	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK061: Total Kjeldahl Nitrogen as N	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	
EK067: Total Phosphorus as P	1	20	5.0	5.0	NEPM 1999 Schedule B(3) and ALSE QCS3 requirement	



Matrix Type: WATER				Frequency of Quality Control Samples			
Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Method		QC	Regular	Actual	Expected		
Matrix Spikes (MS)							
ED045-P: Chloride by PC Titrator		1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EG020A-F: Dissolved Metals by ICP-MS - Suite A		1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EG035F: Dissolved Mercury by FIMS		1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK055A: Ammonia as N		1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK057: Nitrite as N		1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK059: Nitrite and Nitrate as N (NOx)		1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK061: Total Kjeldahl Nitrogen as N		1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement
EK067: Total Phosphorus as P		1	20	5.0	5.0	NEPM 1999	Schedule B(3) and ALSE QCS3 requirement

Client : URS AUSTRALIA PTY LTD (QLD)
Project : 42625813

Work Order : EB0703720
ALS Quote Reference : EN/001/07

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Issue Date : 20 Apr 2007



Interpretive Quality Control Report - Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged on the 'Quality Control Report'. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). Flagged outliers on control limits for inorganics tests may be within the NEPM specified data quality objective of recoveries in the range of 70 to 130%. Where this occurs, no corrective action is taken. - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot.

Non-surrogates

- For all matrices, no RPD recovery outliers occur for the duplicate analysis.
- For all matrices, no method blank result outliers occur.
- For all matrices, no laboratory spike recoveries breaches occur.
- For all matrices, no matrix spike recoveries breaches occur.

Surrogates

- For all matrices, no surrogate recovery outliers occur.

Outliers : Analysis Holding Time

The following report highlights outliers within this 'Interpretive Quality Control Report - Analysis Holding Time'.

- No holding time outliers occur.

Outliers : Frequency of Quality Control Samples

The following report highlights outliers within this 'Interpretive Quality Control Report - Frequency of Quality Control Samples'.

- No frequency outliers occur.

Method Reference Summary

The analytical procedures used by ALS Environmental are based on established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house procedure are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

Matrix Type: WATER

Method Reference Summary

Preparation Methods

EK061/EK067 : TKN/TP Digestion - APHA 21st ed., 4500 Norg - D; APHA 21st ed., 4500 P - H. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Analytical Methods

ED037-P : Alkalinity by PC Titrator - APHA 21st ed., 2320 B This procedure determines alkalinity by both manual measurement and automated measurement (e.g. PC Titrator) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

ED040F : Major Anions - Filtered - APHA 21st ed., 3120 Sulphur and Silicon content is determined by ICP/AES and reported as Sulphate after conversion by gravimetric factor.

ED045-P : Chloride by PC Titrator - APHA 21st ed., 4500 Cl - B. Automated Silver Nitrate titration.

ED093F : Major Cations - Filtered - APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EG020A-F : Dissolved Metals by ICP-MS - Suite A - (APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

EG035F : Dissolved Mercury by FIMS - AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl₂)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK055A : Ammonia as N - APHA 21st ed., 4500 NH₃+H Ammonia is determined by direct colorimetry by FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK057 : Nitrite as N - APHA 21st ed., 4500 NO₃- I. Nitrite is determined by direct colorimetry by FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK058 : Nitrate as N - APHA 21st ed., 4500 NO₃-I Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by FIA. Nitrite is determined separately by direct colorimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK059 : Nitrite and Nitrate as N (NO_x) - APHA 21st ed., 4500 NO₃- I. Combined oxidised Nitrogen (NO₂+NO₃) is determined by Cadmium Reduction and direct colorimetry by FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK061 : Total Kjeldahl Nitrogen as N - APHA 21st ed., 4500-Norg-D 100mL water samples are digested using a traditional Kjeldahl digestion followed by determination by FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK062 : Total Nitrogen as N (TKN + Nox) - APHA 21st ed., 4500 N org / NO₃. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EK067 : Total Phosphorus as P - APHA 21st ed., 4500 P-H This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

EN055 : Ionic Balance - APHA 21st Ed. 1030F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

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Appendix K

Surface Water Study (2007)

REPORT

Vance Lease North Stradbroke Island Surface Water Studies



Prepared for

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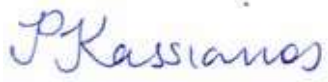
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Section 1

Introduction and Study Scope

Unimin Australia Limited (Unimin) own and operate a Silica Sand mine (Mining Lease 7064 and 1124), on North Stradbroke Island, approximately 4km north-east of Dunwich, in Queensland. Unimin are approved to operate within a designated 3 year mine path on adjacent ML1108 (Vance Lease) and propose to extend mining operations to the remainder of the lease area.

URS Australia Pty Ltd (URS) was commissioned by Unimin to undertake environmental studies for the Vance Lease. This report specifically comprises the surface water component of the hydrological study and is an update from the previous work conducted by URS and reported as the "Vance Lease North Stradbroke Island Surface Water Studies" dated October 2006.

The objectives of the hydrological investigation, were as outlined in URS' proposal dated December 2005. The aim was to obtain more site specific data and minimise the reliance on downstream data. In order to meet these objectives the following tasks have been undertaken:

- Site investigations to identify water bodies, water quality monitoring locations, RAMSAR (Wetlands of International Importance under the Ramsar Convention, 1971) areas and potential drainage lines across all accessible areas of the site;
- Infiltrometer tests to ascertain potential for sheet flow and examine runoff characteristics;
- Survey of Cooroon Cooroonpah Creek to determine size and potential flow rates within the drainage line; and
- Installation of in-situ continuous water level monitoring equipment immediately adjacent to, or within, Cooroon Cooroonpah Creek to determine number of flow events and potentially derive flow depth and hydrographic information.

The methodology and individual tasks associated with the above objectives are documented in the following sections.

Section 2

Study Methodology

2.1 General

The objectives outlined in the previous section have been achieved through five primary tasks:

- 1) Review of existing hydrological data;
- 2) Site investigation;
- 3) Establishment of baseline conditions;
- 4) Identification and assessment of potential hydrological impacts; and
- 5) Plan of management and mitigation options.

2.2 Review of Existing Hydrological Data

A data search and literature review was undertaken and the following relevant references and information have been incorporated into this investigation:

- Hydrology of North Stradbroke Island, Department of Natural Resources and Water, March 2006.
- North Stradbroke Island – The development and management of water supplies for Redland Shire and mining purposes, Department of Natural Resources and Water, March 2006.
- Groundwater Impact Assessment, Mining Lease ML1132, North Stradbroke Island, URS, March 2001.
- Amity 1:25,000 Topographic Map 9543-22 Edition 2 (1986). Department of Mapping and Surveying (Qld).
- Dunwich 1:25,000 Topographic Map 9542-11 Edition 2 (1986). Department of Mapping and Surveying (Qld).
- North Stradbroke Island Hydrogeological Report, Geological Survey of Queensland, Queensland Department of Mines, 1975.
- Unimin surface water monitoring data from January 1999 to June 2007.
- Australian Bureau of Meteorology evaporation data, Brisbane Aero: 1986-2000 (Station Number 40223) and 2000-2004 (Station Number 40842).

Section 2

Study Methodology

2.3 Site Investigations

Site investigations were undertaken on the Vance lease ML 1108 and adjacent leases between February 2005 and July 2007. During these site investigations, the following tasks were undertaken:

- Seven boreholes were drilled on the Vance Lease and including four wells adjacent to the Cooroon Cooroonpah Creek.
- Automated water level loggers were placed in wells and data measurements have been collected since November 2006.
- Ground survey was completed of several cross sections along the Cooroon Cooroonpah Creek.
- Approximately 11 infiltrometer tests were completed in the upland areas of the Vance Lease.
- Rounds of water quality sampling in the shallow wells and in several other locations including Brown Lake and the Shallow Lagoon.
- Photographs were taken to aid in the assessment of the current condition of the site including vegetation coverage.

2.4 Establishment of Baseline Surface Water Conditions

Based on the data reviewed, site investigations and discussions with Unimin staff, baseline surface water conditions in the immediate vicinity of the Vance lease area have been established with:

- Estimates of flow routes within the lease area from available topographic information and the site walkover;
- Estimates of the occurrence and temporal patterns of surface water in the Cooroon Cooroonpah Creek using shallow piezometer and ground survey data;
- Estimates of current surface water quality both within and downstream of Vance lease, based on Unimin monitoring data; and,
- Comparison of the existing surface water conditions with baseline conditions for groundwater in the area.

2.5 Identification and Assessment of Potential Impacts to Surface Water

Proposals for the potential mining lease, methods to be employed through construction, operation and rehabilitation stages and infrastructure/equipment to be installed/used have been assessed in terms of impacts to the surface water environment.

Section 2**Study Methodology****2.6 Plan of Management and Mitigation Measures**

Based on the potential impacts of the mining lease on surface water, possible management and mitigation options have been explored to minimise these impacts on surface waters and the overall hydrologic environment.

These measures are documented throughout this report and are summarised below:

- A 100 m buffer width (measured from the high banks) will be maintained either side of Cooroon Cooroonpah Creek between the Creek and mining operations (i.e. 200m wide buffer zone), as recommended in the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995).
- No mining operations will be undertaken below the ground water table.
- Sediment fences and windrows will be implemented downslope of all disturbed areas.
- No mining or clearing work will be carried out during extreme rainfall.
- Progressive regrading and rehabilitation of disturbed areas will be undertaken.
- Bunded storage areas for fuels and dangerous goods will be constructed in accordance with Australian Standards (AS 1940 and AS 3780).
- Emergency spill procedures will be developed to minimise potential, limit the extent and cleanup of leakage/spillage of contaminants.

Section 3

Existing Surface Water Environment

3.1 Site Location

Vance Lease is located on North Stradbroke Island, a large sand island in Moreton Bay, off the coast of South East Queensland. The site is located approximately 4 km north-east of Dunwich, a small township on the western coast of North Stradbroke Island. Vance Lease adjoins current mining operations undertaken by Unimin on mining leases ML 7064 and ML 1124, northwest of Vance Lease, refer to Figure 1, Appendix A.

3.2 Catchments, Drainage and Topography

Vance Lease is approximately 6.3 km² in area, comprising of dunal sands covered in undisturbed bushland. Topography within the lease area is characterised by undulating landforms. Elevations across the site range from 50 mAHD to 200 mAHD. The central portion of the site, close to the concrete pillar, and Bippo Penbean, elevated topography to the north of the lease area, are characterised by steep terrain with peak elevations between 190-200 mAHD, refer to Figure 2, Appendix A.

Vance Lease contributes to three catchments: Capembah Creek to the south, Cooroon Cooroonpah Creek in the centre and Aranarawai Creek to the north east. The majority of Vance Lease (approximately 4.6km²) contributes to the catchment of Cooroon Cooroonpah Creek, which flows through the centre of the lease in a north-west direction. Downstream of Vance Lease, Cooroon Cooroonpah Creek continues in a north-westerly direction towards swamp land adjacent to the East Coast Road and drains to marine environments in Rainbow Channel and Moreton Bay.

Cooroon Cooroonpah Creek and catchment areas are shown on Figure 2, Appendix A. Contour and feature survey information for the site and surrounds were sourced from 1:25,000 topographic maps (Department of Mapping and Surveying, 1986).

3.3 On-Site Waterbodies

There are no on-site waterbodies located within the mining lease except for Cooroon Cooroonpah Creek, which is an ephemeral watercourse. The overall lease area is frequently dry with no local surface ponding. There is no evidence of downstream water bodies that would rely on surface runoff to maintain water levels.

3.4 Adjacent Waterbodies

An off-site waterbody named Swallow Lagoon is located approximately 180 m south-west of the southern boundary of Vance lease. This lagoon is a perched waterbody at an elevation of approximately 160 mAHD, considered to have formed where vertical percolation has been impeded by fine organic or silty material or by indurated sand, isolated from the underlying aquifer.

The lagoon receives surface runoff inflow from a catchment area outside of Vance Lease. The lagoon is protected as a RAMSAR wetland under the Environmental Protection Biodiversity Conservation (EPBC) Act 1999. Gradients within the catchment that drain to the lagoon are moderate and surface water is not therefore expected to contribute a significant quantity of recharge to Swallow Lagoon. Infiltration of rainfall is considered the most important factor in maintaining the hydrological regime in the lagoon (see Appendix J - Groundwater Report of the Environmental Studies Report for the Proposed Stage 1 Development of Vance Mining Lease (ML1108) for further details).

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3.5 Streamflows and Flow Regime

Surface runoff is rarely observed on North Stradbroke Island even during high, intense rainfall. Where surface flow does occur, this is mostly confined to larger creeks and gullies, some as a direct result of rainfall runoff and some from seepage of shallow groundwater springs where the watertable and surface intersect at a low angle. Due to the highly permeable nature of the underlying sands and the general steep topography of the site, most water ponds in depression areas and evaporates or quickly infiltrates after rainfall.

Cooroon Cooroonpah Creek is characterised by low water levels and flow rates and is likely to remain dry for the majority of the year. Laycock (1975) stated that some of the rainfall water infiltrating and percolating into the sand is held near the surface and may be lost to evaporation, with excess water migrating downwards towards the water table. All surface water features on the island demonstrate a strong degree of interaction with groundwater at some level with groundwater flowing towards surface water bodies and following the course of creeks and streams to the coast. With the exception of measurements near Brown Lake, groundwater elevations have been observed to be generally at more than 8 m below ground level within the vicinity of the lease area (see Appendix J - Groundwater Report of the Environmental Studies Report for the Proposed Stage 1 Development of Vance Mining Lease (ML1108) for further details). It is, however, expected that groundwater elevations fluctuate by approximately 1 m based on piezometer measurements collected on-site.

3.6 RAMSAR Wetlands

Two portions of the lease area are designated as RAMSAR regions under the EPBC Act 1999 in the eastern half and towards the south. A more detailed summary of RAMSAR regions is contained within the Appendix E - Ecological Report of the Environmental Studies Report for the Proposed Stage 1 Development of Vance Mining Lease (ML1108).

3.7 Rainfall and Evaporation Data

3.7.1 Annual Rainfall Statistics

The climate of the Moreton Bay area can be classified as sub-tropical. Mean annual rainfall, from data gathered by Unimin on Stradbroke Island over the period 1981-2006 is 1,678 mm. Rainfall occurs throughout the year with the highest monthly totals generally occurring between December and May (**Table 3-1**Error! Reference source not found.).

Section 3**Existing Surface Water Environment****Table 3-1 North Stradbroke Monthly Rainfall Statistics 1981 - 2006 (mm)**

	Mean	Median (50th percentile)	Dry (10th percentile)	Wet (90th percentile)
January	130	116	55	195
February	192	155	60	399
March	193	162	55	349
April	216	173	85	374
May	193	177	59	309
June	146	128	41	289
July	112	88	29	256
August	77	68	21	143
September	56	47	10	126
October	87	76	21	175
November	114	110	52	174
December	162	141	69	296
Annual Rainfall (mm)	1678	1617	1308	2215

3.7.2 Rainfall Intensity-Frequency-Duration Relationship

Site-specific rainfall intensity, frequency, and duration (IFD) data derived with the procedures and parameters described in Australian Rainfall and Runoff, 1987 using AUS-IFD software (Ver. 2 is presented in **Figure 3-1**. The IFD curve shows that the:

- 1 hour storm duration, 2 year Annual Recurrence Interval (ARI) has a rainfall intensity of approximately 48 mm/hr.
- 1 hour, 100 year ARI peak rainfall intensity is approximately 300 mm/hr.

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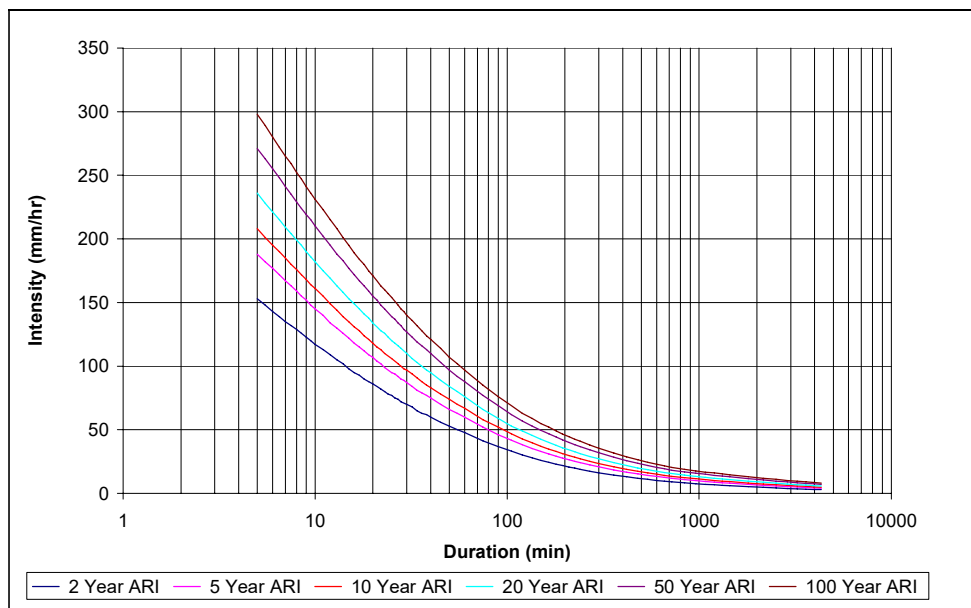


Figure 3-1 IFD Curve Generated for Unimin Mine Vance Lease

3.7.3 Evaporation Data

Evaporation data was not available for North Stradbroke Island. However, data gathered by the Bureau of Meteorology at Brisbane Airport (station numbers 40223 and 40842) was analysed for evaporation and is presented in **Table 3-2**. Mean annual evaporation (over the period 1986 to 2007) at this location is 1,976 mm.

Section 3**Existing Surface Water Environment****Table 3-2 Brisbane Aero Evaporation Statistics 1986 - 2007 (mm)**

	Mean	Median (50th percentile)	Dry (10th percentile)	Wet (90th percentile)
January	229	228	212	252
February	199	204	159	226
March	179	185	148	210
April	137	138	113	156
May	101	103	91	112
June	90	91	76	102
July	98	96	87	110
August	128	123	112	156
September	172	170	142	207
October	196	197	179	215
November	218	214	196	243
December	231	230	215	247
Annual Evaporation (mm)	1976	1979	1731	2237

3.8 Site Investigations

Several site investigations were performed between February 2005 and July 2007 by URS personnel. These investigations were undertaken during both wet weather and prolonged dry conditions.

The site investigations were undertaken to establish the existing characteristics of the Cooroon Cooroonpah Creek within Vance Lease. The characteristics of interest are creek alignment, pools, erosion and sedimentation and vegetation. The following sections describe representative sites along Cooroon Cooroonpah Creek and in upland areas of Cooroon Cooroonpah Creek.

3.8.1 Cooroon Cooroonpah Creek Site 1

This site is located at a crossroads between 4WD tracks traversing Vance lease and adjacent to where groundwater boreholes 1D and 1S, as shown on Figure 2, Appendix A. The approximate coordinates of this location are E544546; N6960288 (MGA Zone 56, GDA 94). Very little water has been identified at this location on any of the site inspections conducted. On one occasion flowing water was observed at Site 2; however, Site 1 remained dry.

A ground survey cross-section was completed at Site 1 as shown in Figure 3, Appendix A. The survey indicates a poorly defined low flow channel.

Section 3**Existing Surface Water Environment****Table 3-3 Geomorphologic Assessment of Cooroon Cooroonpah Creek Site 1**

Depth of channel:	No clear channel – significantly overgrown but less than 0.2 m.
Width of channel:	As above. Channel likely to be between 1-2 m.
Slope of banks:	Less than 20°.
Stability of banks:	Moderate. Banks largely covered with dense vegetation but underlain by sand.
Substrate:	Poorly graded sand.
Water:	None present during any site visit.
Debris and tree roots:	A large amount of vegetation present, within and adjacent to the channel. Some felled trees upstream of the site inspection area.
Overbanks:	Some trees, mainly shrubs and grasses.

Plate 3-1 Cooroon Cooroonpah Creek Site 1

Section 3**Existing Surface Water Environment****3.8.2 Cooroon Cooroonpah Creek Site 2**

This site is located at an upstream crossroads between 4WD tracks approximately 2.5 km upstream of Site 1 and adjacent to where groundwater boreholes 2D and 2S are installed. The approximate coordinates of this location are E546172; N6959080 (MGA Zone 56, GDA 94). The location of Site 2 is shown on Figure 2, Appendix A. Water has been intermittently identified at the site. Photos presented below show the creek at the maximum extent observed during site inspections after a period of prolonged wet weather.

A ground survey cross-section was completed across the Creek as shown in Figure 4, Appendix A. The field survey shows an area that was ponded upstream of the 4WD road which is slightly raised by approximately 300 mm.

Table 3-4 Geomorphologic Assessment of Cooroon Cooroonpah Creek Site 2

Depth of channel:	Between 0.2 m and 0.5 m
Width of channel:	2-4 m at stream channel.
Slope of banks:	Generally 20°-45°.
Stability of banks:	Moderate. Most areas covered with vegetation (shrubs, grasses and some trees), however the substrate is sand and some banks that are not vegetated are subject to erosion. There are some signs of incised channels upstream.
Substrate:	Sand.
Water:	Water has been intermittently present during site visits. When the site is wet the water generally seems stagnate.
Debris and tree roots:	Some minor debris within the channel but no log jams.
Overbanks:	Some trees, mainly shrubs and grasses.

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Plate 3-2 Cooroon Cooroonpah Creek Site 2 with stagnate water present



Plate 3-3 Defined low flow channel in Cooroon Cooroonpah Creek approximately 200 m upstream from Site 2



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3.8.3 Upland Area Site

The upland areas of Cooroon Cooroonpah Creek catchment are densely vegetated. The substrate across the entire site is sand and no surface water features have been observed during any of the site inspections. There does not appear to be any localised rills or gullies caused from overland flow on the upstream areas. The sand appears to be dry, poorly graded material with few fines.

Plate 3-4 Vegetation at higher elevations in the catchment



Plate 3-5 Density of vegetation around the catchment



Section 3**Existing Surface Water Environment****Plate 3-6 Example of vegetation in wooded area near Creek****3.9 Water Quality of Surface Water and Shallow Groundwater****3.9.1 Water Quality Objectives**

The creek is considered to be representative of a lowland freshwater stream in South-East Queensland as per the Queensland Water Quality Guidelines (EPA, 2006) and Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000)

Water quality objectives for management and protection of the aquatic ecosystems Environmental Values of Cooroon Cooroonpah Creek are:

- pH 6.5 – 8.0 (EPA, 2006)
- EC – 626 $\mu\text{S}/\text{cm}$ (EPA, 2006)
- Turbidity 50 NTU (EPA, 2006)
- Total Nitrogen 0.5 mg/L (EPA, 2006)
- Total Phosphorus 0.05 mg/L (EPA, 2006)
- Manganese 1.9 mg/L (ANZECC, 2000)

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The Queensland Water Quality Guidelines (EPA, 2006) have been used to define the water quality objectives for Dissolved Oxygen, pH, turbidity and some nutrients (Total Nitrogen, Total Phosphorous etc.) but do not cover toxicants including heavy metals.

It should be noted that the EPA-2006 criteria for pH may not be appropriate for this site, as it is known that acid frogs have been observed at and near the site, these amphibious species are reported to rely on low pH water for breeding.

The 95% protection level has been adopted from the Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000)

The Qld EPA 2006 and ANZECC 2000 guidelines do include specific and reliable recommendations for Electrical Conductivity (EC); and therefore the 75th percentile value for the sandy coastal zone has been adopted for comparison against the median EC results (in accordance with EPA 2006 recommendations).

It is envisaged that on-going data collection from water quality monitoring on Vance Lease can be used in the future to develop site-specific water quality objectives for Cooroon Cooroonpah Creek.

3.9.2 Water Quality Monitoring

Investigations of creek water quality, prior to the development of Unimin's Silica Sand mine of ML 1124 and ML 7064, downstream of Vance Lease are not available. As part of the current mining operations on ML 1124 and ML 7064, Unimin have implemented a water quality monitoring program to assess the water quality of the Cooroon Cooroonpah Creek upstream and downstream of the current mining operations.

The monitoring plan requires collection of water quality samples in the monitoring wells and surface water locations every three months and at the surface water monitoring locations when the mine receives more than 25 mm of rainfall in 24 hours. Seven monitoring sites were established although only one of these (SW6) is located within Vance Lease. Site SW7 was located upstream of the proposed mine area but, over the first year of monitoring, two samples were analysed at this location for selected constituents and monitoring was discontinued due to lack of water.

The Environmental Management Overview Strategy (EMOS) and Plan of Operations for Unimin's current mining operations (ML 1124 and ML 7064) were reviewed and updated in 2002. Analysis for iron, manganese, calcium, magnesium and potassium was discontinued after June 2002 as this was no longer required. Data collected by Unimin staff between January 1999 and June 2007 is limited due to lack of ponded water and flow in Cooroon Cooroonpah Creek. Continuous records of regular sampling are not available for all locations.

The GPS co-ordinates (WGS84) and descriptions for the remaining six Unimin water quality monitoring sites along Cooroon Cooroonpah Creek are summarised in Table 3-5 and presented Figure 2, Appendix A.

Section 3**Existing Surface Water Environment****Table 3-5 Surface Water Quality Monitoring Sites**

Sampling Location Number	GPS Coordinates (WGS84)		Description
	Easting	Northing	
SW1	0543240	6962829	Brown coloured water with high concentration of tannins observed in water. Sampling site densely vegetated.
SW2	0543303	6962647	Sampling discontinued in June 2002 due to resuspension of sediment during sampling making sampling unrepresentative of water conditions.
SW3	0543388	6962468	Very low flow observed during site visit. Sampling site densely vegetated.
SW4	0543598	6962087	No water observed. Sampling site densely vegetated.
SW5	0543641	6962053	Sampling site heavily overgrown. No water observed.
SW6	0546166	6959084	No water observed. Samples only taken after rainfall or when water is otherwise present.

The available data was reviewed and analysed for the purposes of describing baseline surface water quality conditions.

In addition to the Unimin water quality monitoring, URS collected water quality data from the shallow monitoring wells (2S and 2D) on two occasions (see Appendix J - Groundwater Report of the Environmental Studies Report for the Proposed Stage 1 Development of Vance Mining Lease (ML1108) for further details).

3.9.3 Water Quality Data

Analysis of key water statistics and trends has been undertaken to determine median statistics of key parameters, and the 20th to 80th percentile range. The results of this analysis are presented in Table 3-6.

Section 3**Existing Surface Water Environment****Table 3-6 Median and 20th to 80th Percentile Range of Surface Water Quality in
Cooroon Cooroonpah Creek (1999 to 2007)**

Parameter	Water Quality Objective (Source)	LOR	SW1	SW2	SW3	SW4	SW5	SW6
pH	6.5*-8.2 (QLD)	0.01	4.8¹ (4.5–5.2) ² 53 samples	4.5¹ (4.3–4.8) ² 24 samples	4.8¹ (4.4–5.1) ² 53 samples	4.2¹ (3.9–4.3) ² 35 samples	4.2¹ (4.2–4.3) ² 17 samples	4.0¹ (3.9–4.3) ² 31 samples
EC (µS/cm)	626 (QLD)	1	98 (89–110) 52 samples	94 (82–102) 23 samples	91 (82–99) 52 samples	112 (95–159) 36 samples	92 (90–97) 17 samples	119 (106–128) 30 samples
Turbidity (NTU)	50 (QLD)	0.1	4.0 (2.7–9.1) 52 samples	12 (4.6–83.0) 23 samples	6.6 (2.8–24.0) 52 samples	1.2 (0.7–2.4) 35 samples	1.9 (0.7–3.1) 17 samples	1.2 (0.4–2.7) 30 samples
Sodium (mg/L)	NC	1	14 (12–16) 52 samples	12 (11–13) 23 samples	12 (12–15) 52 samples	13 (11–18) 35 samples	11 (10–12) 17 samples	14 (12–16) 30 samples
Sulphate (SO ₄) (mg/L)	NC	1	3 (2–4) 52 samples	2 (2–3) 23 samples	3 (2–4) 52 samples	4 (2–8) 36 samples	2 (2–3) 17 samples	3 (1–4) 30 samples
Chloride (mg/L)	NC	1	21 (16–25) 53 samples	19 (17–24) 23 samples	18 (14–23) 53 samples	19 (15–28) 36 samples	16 (13–19) 17 samples	21 (18–27) 31 samples
Nitrate and Nitrite (N mg/L)	0.5–Total N (QLD)	0.01	0.01 (0.01– 0.02) 51 samples	0.01 (0.01– 0.02) 22 samples	0.01 (0.01– 0.02) 51 samples	0.01 (0.01– 0.03) 34 samples	0.01 (0.01– 0.01) 16 samples	0.01 (0.01– 0.03) 29 samples
Phosphorus (P mg/L)	0.05 (QLD)	0.01	0.02 (0.01– 0.07) 39 samples	0.05 (0.01– 0.27) 22 samples	0.02 (0.01– 0.16) 40 samples	0.01 (0.01– 0.04) 29 samples	0.02 (0.01– 0.11) 15 samples	0.02 (0.01– 0.06) 20 samples
Iron (mg/L)	ID	0.01	0.67 (0.46– 0.81) 24 samples	0.88 (0.68– 1.05) 24 samples	0.55 (0.43– 0.96) 24 samples	0.30 (0.16– 0.40) 21 samples	0.30 (0.19– 0.40) 17 samples	0.17 (0.10– 0.20) 12 samples

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Parameter	Water Quality Objective (Source)	LOR	SW1	SW2	SW3	SW4	SW5	SW6
Manganese (mg/L)	1.9 (ANZECC)	0.01	0.01 (0.01–0.02) 23 samples	0.01 (0.01–0.01) 23 samples	0.01 (0.01–0.01) 23 samples	0.01 (0.01–0.01) 20 samples	0.01 (0.01–0.01) 17 samples	0.01 (0.01–0.01) 13 samples
Calcium (mg/L)	NC	1	0.5 (0.5–0.6) 25 samples	0.5 (0.5–0.5) 23 samples	0.5 (0.5–0.5) 25 samples	0.5 (0.5–0.5) 20 samples	0.5 (0.5–0.5) 17 samples	0.5 (0.5–0.5) 14 samples
Magnesium (mg/L)	NC	1	1 (1–1) 23 samples	1 (1–2) 23 samples	1 (1–1) 23 samples	1 (1–2) 20 samples	1 (1–2) 18 samples	1 (1–2) 13 samples
Potassium (mg/L)	NC	1	0.5 (0.5–0.5) 23 samples	0.5 (0.5–0.5) 23 samples	0.5 (0.5–0.5) 23 samples	0.5 (0.5–0.5) 203 samples	0.5 (0.5–0.5) 17 samples	0.5 (0.5–0.5) 13 samples

Notes:

- 1) QLD = Queensland Water Quality Guidelines, LOR = Limits of Reporting, NC = No Criterion, ID = Insufficient Data.
- 2) Median values shown in **bold**.
- 3) 20th to 80th percentile range shown in brackets, with 25th to 75th percentile shown for EC.
- 4) Exceedance of the guideline criteria shown as shaded cells.
- 5) Where concentrations of constituents have been detected below the laboratory LOR, a value equivalent to the LOR divided by two has been used for the calculation of median and the 20th to 80th percentile range statistics.

3.9.4 pH

For all sampling locations, the median pH is outside the Queensland Water Quality Guidelines (EPA, 2006) range for lowland freshwater streams, refer Figure 3-2.

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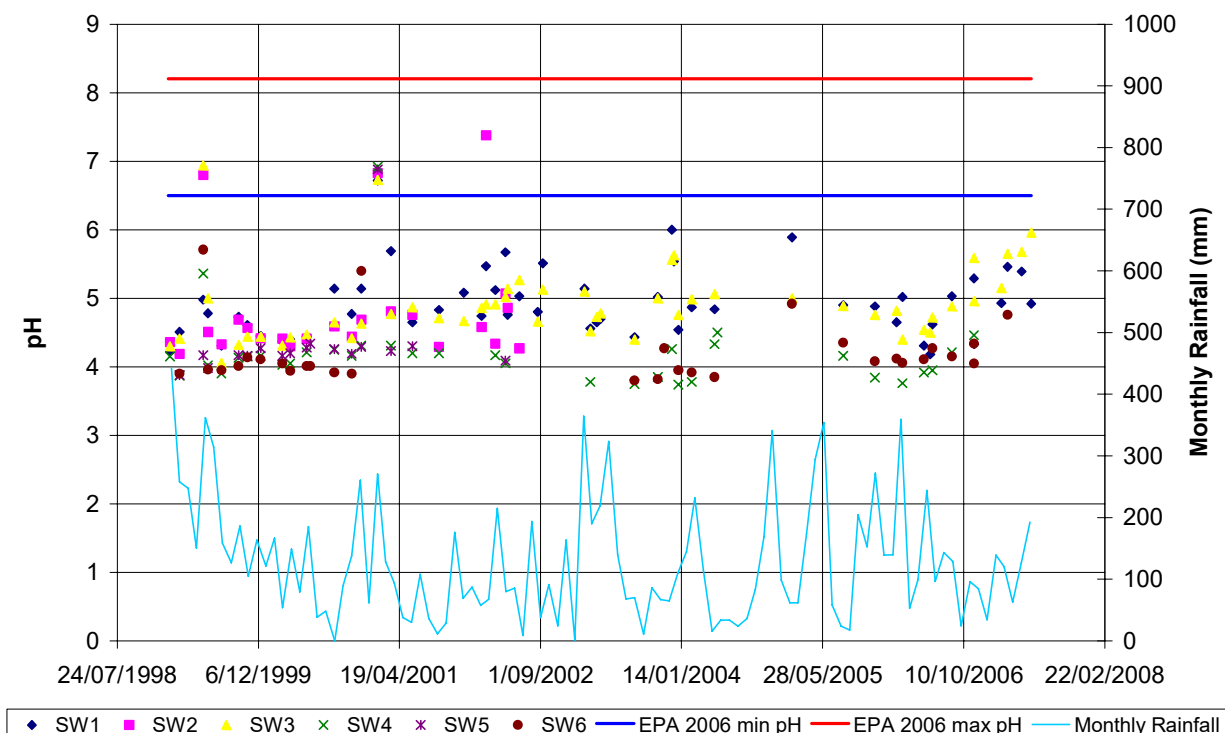


Figure 3-2 Surface Water pH data collected from 1999 to 2007

Values are considered to be representative of naturally strong acidic conditions with a relatively narrow range of values throughout the monitoring record. The low pH values are believed to be caused by the following:

- Humic acids released by decomposing organic matter (e.g. tannins, lignins). The area surrounding the Cooroon Cooroonpah Creek drainage line is characterised by dense vegetation of heath and low banksia woodland. As flow in the creek is also largely ephemeral, water levels fluctuate throughout the year with periodic wetting and drying. Periodic disturbance of accumulated organic matter can lead to a short-term increase in the rate of humic acid release. As the creek subsequently dries and water levels recede, pH decreases due to influences from seepage of acidic groundwaters at shallow depth.
- Humic acids released from humus podsol soils as the groundwater levels rise to the surface and discharge to the stream.

No acid sulphate soils have been identified on the Vance Lease.

Aquatic species local to the island are known to be sensitive to changes in pH, preferring more acid conditions (see Appendix F – Flora Report and Appendix G – Fauna Report of the Environmental Studies Report for the Proposed Stage 1 Development of Vance Mining Lease (ML1108) for further details) see Flora and Fauna Section). The Vance Lease has been identified as a potential habitat for the Wallum Froglet, a species listed as Vulnerable under the Queensland *Nature Conservation (Wildlife) Regulation – 2006*. Preferred Wallum Froglet habitat includes wetter parts of the site, such as areas adjacent to the Creek. It has been identified that the Wallum Froglet prefers acid swamp conditions (generally pH less than 5.5) for breeding (Straughan et al, 1966; Ingram et al, 1975; Barker et al, 1995). The pH data suggest the Cooroon Cooroonpah Creek provides adequate habitat for the Wallum Froglet, (pH 3.5 to 5.5). The lower limit WQO for pH in EPA 2006 guidelines should not be applied for these conditions.

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The proposed management strategy to protect against adverse impacts on pH include:

- A 100 m buffer width (measured from the high banks) will be maintained either side of Cooroon Cooroonpah Creek between the Creek and mining operations (i.e. 200m wide buffer zone), as recommended in the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995).
 - This buffer protects the dominant areas of humus podsols soils and associated accumulated organic matter across the release and will minimise the potential for adverse increases in the disturbance and release of humic acids.
- Protection of the groundwater aquifers (as no mining will be undertaken below the water table).

The groundwater levels will continue to rise to the surface as it currently does, generating periodic acidic surface water which are considered natural.

3.9.5 Electrical Conductivity

Electrical Conductivity (EC) is low in comparison with the Queensland Water Quality Guidelines (EPA, 2006) range for lowland freshwater streams. The recorded values are mostly below the 25th percentile of the Queensland Water Quality Guidelines (EPA, 2006) range. Figure 3-3 presents the EC surface water data collected from 1999 to 2007 and the monthly rainfall totals. Comparison between the EC trends and monthly rainfall shows no correlation in temporal variability.

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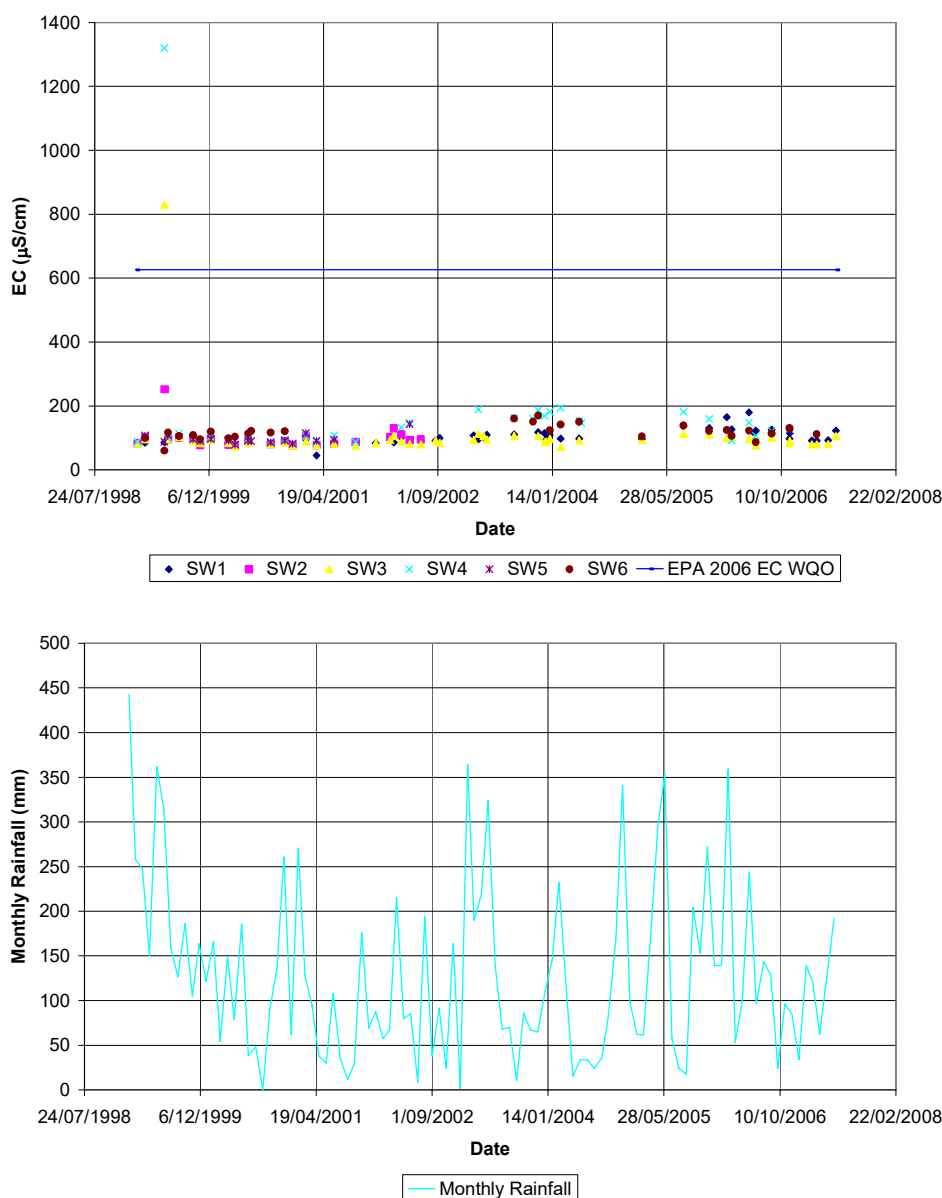


Figure 3-3 EC data collected from 1999 to 2007 and Monthly Rainfall Totals

3.9.6 Turbidity

Turbidity was below the Queensland Water Quality Guidelines (EPA, 2006) range for lowland freshwater streams, for data collected at locations SW4 to SW6. The low turbidity is consistent with a flow regime predominantly influenced by groundwater and with minimal direct surface runoff from the catchment. Turbidity results and monthly rainfall totals are presented in Figure 3-4 and show little seasonal or temporal correlation. Two high turbidity readings were recorded in February 2002 at site SW2; however, there was no rainfall or other indication that would produce high readings.

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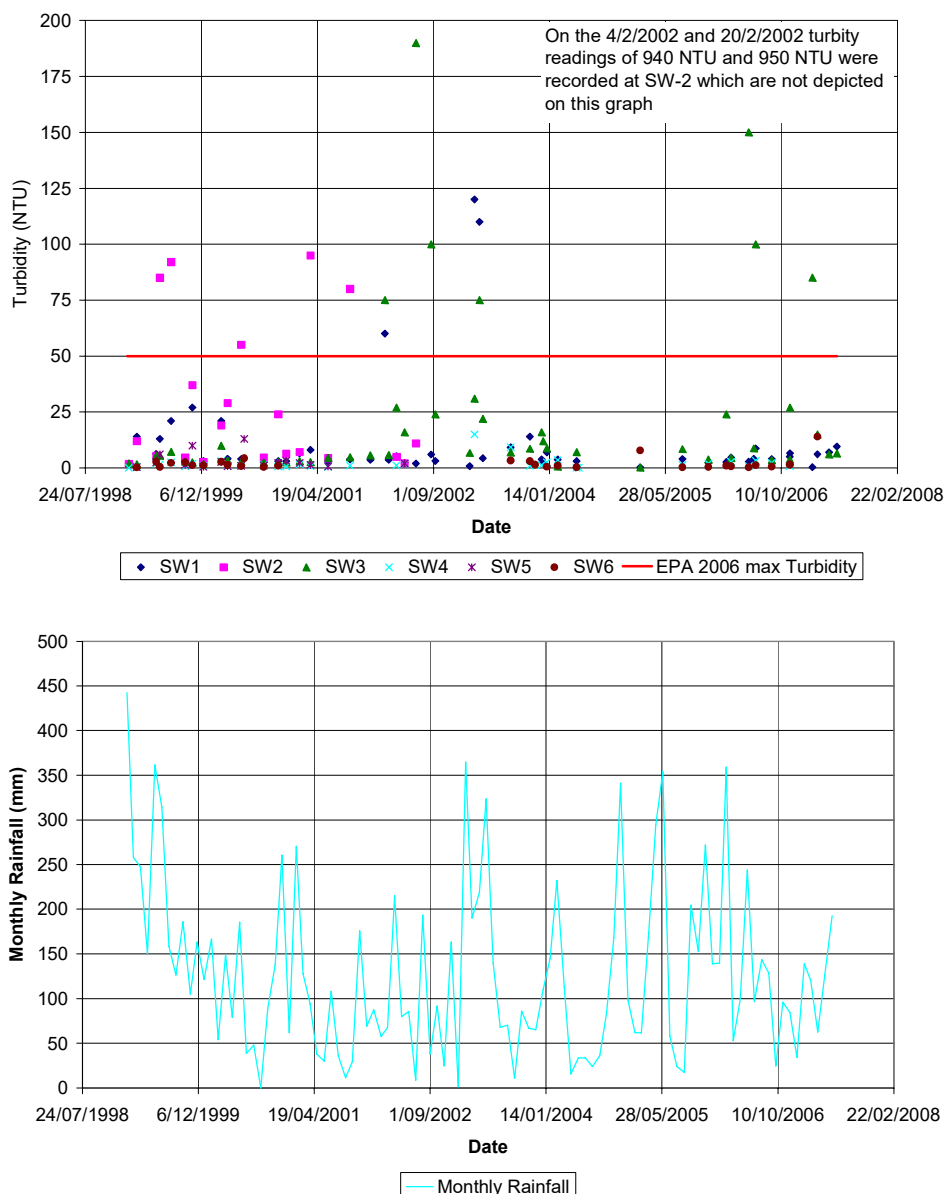


Figure 3-4 Turbidity data collected from 1999 to 2007 and Monthly Rainfall Totals

3.9.7 Sodium, Sulphate and Chloride

Sodium, sulphate and chloride are all common in soils, particularly in areas of former marine influence, and vary widely in terms of solubility and concentrations in surface water. It was not possible to compare concentrations of these constituents as the Queensland Water Quality Guidelines (EPA, 2006) and Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000), do not include recommendations for these parameters. The concentrations detected are considered to be representative of natural levels.

Section 3**Existing Surface Water Environment****3.9.8 Nutrients (N and P)**

All analyses of oxidised nitrogen concentrations (nitrates and nitrites) were found to be less than the Queensland Water Quality Guidelines (EPA, 2006) guidelines for lowland freshwater streams, at all locations. Total phosphorus results and monthly rainfall totals are presented in Figure 3-5. Downstream surface water bodies in the area are not known to be eutrophic. Further monitoring parameters including analyses for Dissolved Oxygen (as % saturation) and Chlorophyll 'a' concentrations should be considered in future monitoring to confirm the nutrient enrichment status of surface water bodies in the area.

High phosphorus concentrations were historically recorded at Site 2 around 1998 to 2001 and this site has not been monitored since that period. The discontinuation of monitoring at this site was due to difficulties in sampling due to re-suspension of bed sediments which probably also influenced the high phosphorus results.

Comparison between the phosphorus trends and monthly rainfall shows no temporal variability.

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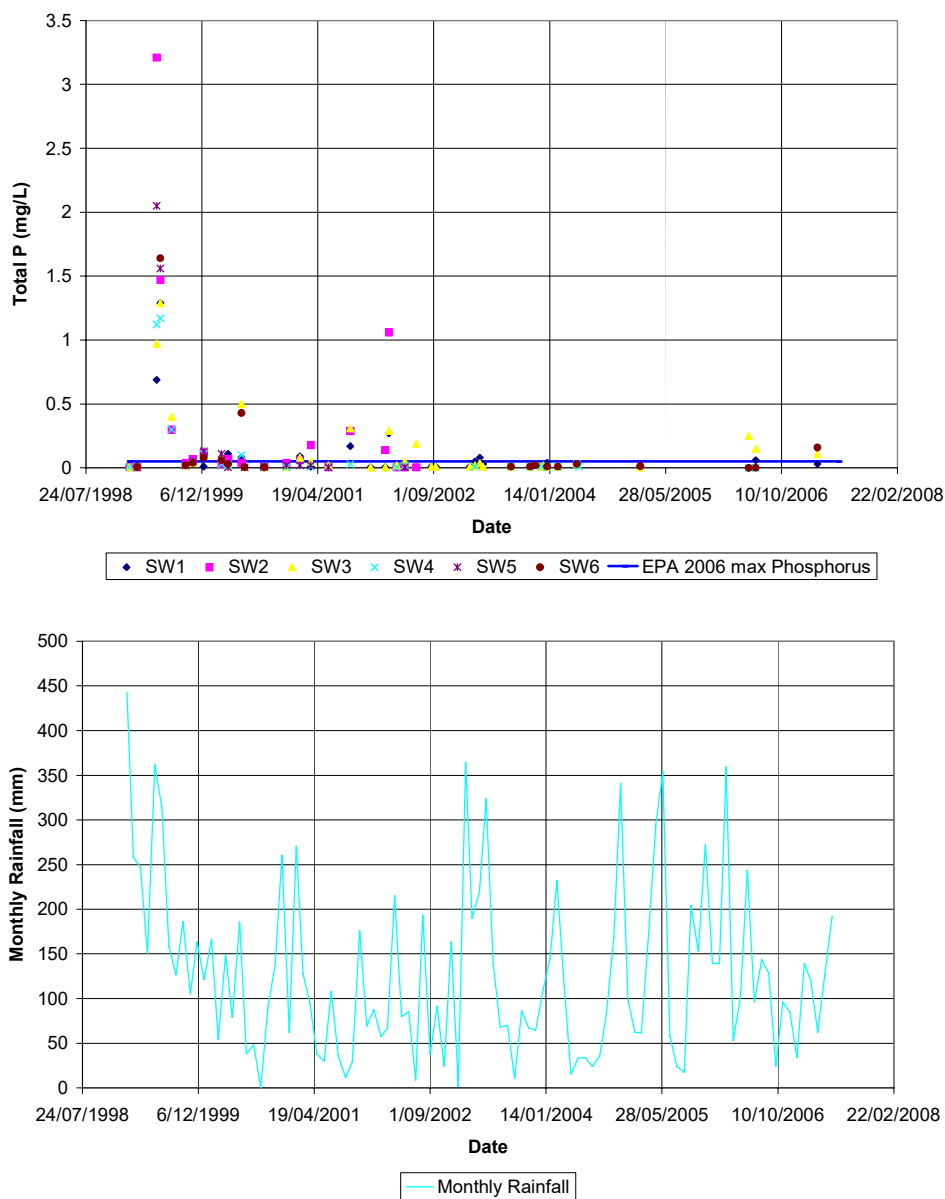


Figure 3-5 Total Phosphorus data collected from 1999 to 2007 and Monthly Rainfall Totals

Section 3**Existing Surface Water Environment****3.9.9 Iron, Manganese, Calcium, Magnesium and Potassium**

Concentrations of iron at monitoring locations (SW4 – 1.5 km downstream of ML1108, and SW6 – near the upstream extent of ML1108) are generally low (<0.3 mg/L). Monitoring at downstream locations SW1 to SW3 (some 2.5 km downstream of the ML1108 lease boundary), have recorded higher concentrations (up to 0.88 mg/L at SW2). This suggests either a potential natural source of iron downstream of ML1108 (possibly due to different soil types at lower elevations), sample error due to resuspension of bed sediments (refer Table 3-5), or possible historical releases of iron enriched water as a result of mining activity in the downstream mine leases. There are no screening criteria for iron in the Queensland Water Quality Guidelines (EPA, 2006) and Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). Iron has not been tested in samples since 2002 at any of the monitoring locations.

Manganese, calcium, magnesium and potassium were all detected at or close to the laboratory limits of reporting indicating generally low levels of these constituents.

3.10 Surface Water – Groundwater Interaction**3.10.1 Introduction**

Surface water and groundwater relationships are a complex due to the variable topography over the relatively small catchment area. The Vance Lease geology consists of high permeability sand cover with intermittent layers of low permeability indurated sand (coffee rock). It is believed that the layers of coffee rock limit surface water from seeping into the deeper groundwater aquifers and produce shallow perched aquifers throughout the site.

Field work and analysis was conducted to quantify the saturated permeability of the soils representing the surficial aquifer on the Vance Lease.

3.10.2 Infiltrometer Testing

Infiltrometer testing was completed at approximately 11 sites located on the Vance Lease. The approximate location of each testing location is provided in Figure 2, Appendix A. Test locations were located near the Creek, in upland areas, in flat lands, slopes and in areas of different vegetative covers to identify the potential for high spatial variability of soil infiltration capacity across the lease. The infiltrometer test holes all exhibited homogeneous sand with very little variation spatially or with depth. Tests were completed over one to four hour periods. The infiltrometer testing was completed using "Determining the Saturated Hydraulic Conductivity" (Oosterbaan and Nijland, 1994).

The infiltrometer results demonstrate that the top 500 mm of ground surface has an average saturated permeability of approximately 960 mm/hr. This capacity for rapid percolation of water through the soil demonstrates that for overland flow to occur on the Vance Lease, the rainfall intensity would need to exceed approximately 1000 mm/hr. Based on the IFD curves presented in Section 3.8, the 100 year ARI, 5-minute storm intensity is approximately 300 mm/hr. This infiltration test results demonstrate that direct surface water runoff on the Vance Lease property would only occur in extremely rare circumstances. Summary results of the infiltrometer testing are provided in

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Table 3-7.

Section 3**Existing Surface Water Environment****Table 3-7 Summary of Infiltrometer Testing Completed on Vance Lease**

	Saturated Hydraulic Conductivity	
	(m/d)	(mm/hr)
Average	23	960
Median	19	774
90 th Percentile	26	1080
10 th Percentile	17	693

3.10.3 Hydrologic Monitoring***Piezometers***

Boreholes to monitor groundwater (piezometers) have been installed at a number of locations around the lease area (Sites 1-5, see Figure 2, Appendix A). The geology of the area is mostly sand with some discontinuous indurated layers of coffee rock and deeper low permeability bedrock. The hydrogeology is therefore complex with local shallow and deep aquifers occurring irregularly across the entire area.

Monitoring Wells

Monitoring wells were located adjacent to Cooroon Cooroonpah Creek at sites 1 and 2 as shown on Figure 2, Appendix A. A shallow well and deep well were installed at each site. The following points provide brief descriptions of the monitoring wells (more detail is provided in Appendix J - Groundwater Report of the Environmental Studies Report for the Proposed Stage 1 Development of Vance Mining Lease (ML1108)):

- Monitoring Well 1S - 2.0 m deep well located in white clean sand and indurated sand;
- Monitoring Well 1D - 10.1 m deep well located in white clean sand and coffee rock at the base of the well;
- Monitoring Well 2S – 2.0 m deep well located in organically rich dark grey-black sand; and
- Monitoring Well 2D – 6.3 m deep well with the top 2.5 m located in organically rich dark grey-black sand, coffee rock at depths between 2.5 m and 4.3 m, white grey sand at depths below 4.3 m to the bottom of the well.

Site 1

Water was not been encountered in the wells located at site 1 since the wells were established in November 2006.

Site 2

Water was observed in Cooroon Cooroonpah Creek at Site 2 and in the monitoring wells since their installation. When the boreholes were being installed (and also when the site was visited in June 2006), there was water present in the creek adjacent to 2S and 2D, but no water was observed more than 100 m downstream of Site 2. This suggests that on the occasions surface water flow occurs in the upper reach of Cooroon Cooroonpah Creek) on ML1108, and does not continue as surface flow along the creek where water flows beneath the ground surface. Refer Figure 5, Appendix A.

Section 3

Existing Surface Water Environment

It is likely that the layer of shallow coffee rock at approximately 2.5 m below ground at site 2 acts as a groundwater barrier and maintains shallow groundwater levels near the surface. Pressure transducers with automated level loggers were placed in the wells located at site 2 in November 2006 to record water levels on an hourly basis.

The results from the data loggers show that the water levels in the shallow and deep wells follow a similar trend. Increases in water level in the deep well tend to lag those in the shallow well in both timing and intensity. This is expected as there is a greater depth of soil to the deeper well that attenuates groundwater level responses to rainfall events.

Based on the ground survey, the lowest point in the creek bed adjacent to the monitoring wells at site 2 is at an elevation of 71.0 mAHD; however, downstream of where the 4WD track crosses Cooroon Cooroonpah Creek, the water level must exceed an elevation of approximately 71.3 mAHD to produce surface water flow along the creek. The 195 days of monitoring presented in Figure 3-6, shows that the shallow groundwater level increased to produce a stagnate surface pool of water on approximately four occasions for a total of approximately 19 days. The surface pool water level was sufficiently high to produce flow in Cooroon Cooroonpah Creek on two occasions for a total of approximately 8 hours. On these occasions, the depth of flow in Cooroon Cooroonpah Creek did not exceed approximately 0.05 m and this depth is not sufficient to enable reliable estimation of the discharge occurring in the creek.

The two occasions that produced flow in Cooroon Cooroonpah Creek occurred under different circumstances. The first flow event (on December 4, 2006) occurred after a moderate rainfall event (22 mm). The second event (between March 7 and 8, 2007) occurred after a significant rainfall event (the largest throughout the monitoring period of 88 mm rainfall recorded on-site, and 77 mm rainfall recorded at Point Lookout). The smaller storm in early December 2006 had preceding conditions that appeared to be more consistently wet and groundwater levels were higher. The creek can therefore also be considered conditionally ephemeral with surface flow dependent on either very large individual rainfall events, or elevated groundwater levels followed by modest rainfall events.

There was a steady decrease in water levels in the wells during late March 2007 when low of rainfall occurred (362 mm recorded compared to the combined average of 677 mm for these months). Larger rainfall events occurred in June 2007 (280 mm recorded compared to an average June rainfall of 146 mm); however, the rainfall did not increase the groundwater levels sufficiently for surface water to exhibit in Cooroon Cooroonpah Creek. The Creek was inspected on July 8, 2007 and no surface water was visible on the Vance Lease.

Furthermore, the daily rainfall data gathered from Point Lookout, North Stradbroke Island (BOM station 040209), was plotted with respect to the shallow groundwater level data. The rainfall data was normalised as residual rainfall by subtracting the long-term daily rainfall from the cumulative data set (approximately 4.6 mm of rainfall per day based on Unimin gauge). Visually, the residual rainfall data closely emulates the groundwater levels indicating a strong relationship between groundwater levels and rainfall occurrence as presented on **Figure 3-6**.

From the monitoring and assessments, two key characteristics have been identified for surface flow in the creek. The first is that surface flow only occurs when shallow groundwater levels rise to intersect the ground surface. The second characteristic is that overland runoff from the catchment could occur when very rainfall intensities are sufficient to shed water as runoff rather than infiltrating to shallow groundwater.

The infiltrometer tests, rainfall IFD data, and observations that surface flow does not occur lower down in the catchment, suggests that overland surface runoff would rarely occur and is unlikely to be a significant influence on overall Cooroon Cooroonpah Creek catchment hydrology. Very localised areas of surface runoff could also occur from small limited areas in the creek bed where fines have accumulated or shallow / exposed coffee rock may inhibit infiltration and could produce some surface runoff during high storm intensities. Such areas considered to be limited and would not significantly influence the overall catchment hydrology.

Section 3

Existing Surface Water Environment

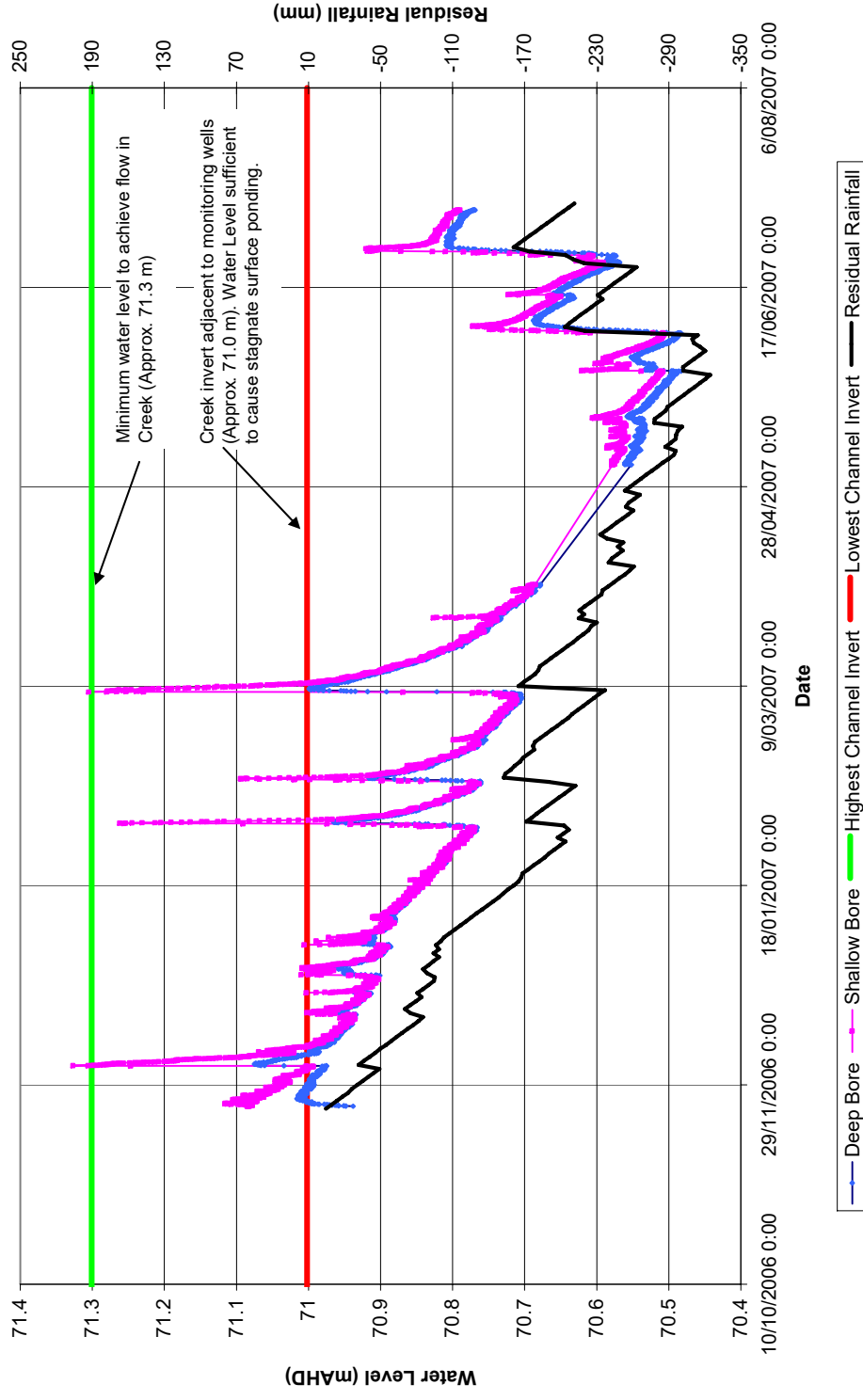


Figure 3-6 Residual Rainfall and Shallow Groundwater Levels on the Vance Lease

Section 4**Potential Impacts to Surface Water from
Proposed Mining Activities****4.1 Summary of Mining Operations**

Mining operations within the lease area will involve excavation of shallow sand for the purpose of extracting clean silica sand. The operations will comprise the following activities:

- Clearing vegetation;
- Excavating and stockpiling of topsoil;
- Excavating clean, white sand using rubber-tyred excavators (front-end loaders) to the top of the indurated layer (groundwater will not be intercepted); and,
- Mixing excavated sand with water into slurry to be pumped via a pipe to either the existing processing plant at ML1124.

Relatively little infrastructure is anticipated to be installed on the Vance lease but would likely include power lines, fuel storage, unsealed roads, and portable mine equipment. The installation works are likely to involve similar processes to mining (i.e. use of machinery to clear vegetation, shallow excavation of topsoil and sand).

Mined areas will be progressively rehabilitated to minimise the disturbance area and will consist of the following stages:

- Re-contouring using a bulldozer to replicate the pre-mining landform but with a elevation reduced by up to 15 metres;
- Spreading topsoil (previously salvaged during stripping operations) over re-contoured ground to a depth approximating pre-mining conditions;
- Seeding with a hybrid cover crop and native seed;
- Wind guard- and silt-fencing to reduce erosion from wind and water; and,
- Direct planting of native seedlings sourced from propagation in the site nursery on an adjacent lease area.

4.2 Potential Impacts

The mining activities may potentially impact surface water as summarised below:

- Clearing vegetation leading to a decrease in interception/storage of rainfall and subsequent potential to increase runoff;
- Disturbance and mobilisation of sediment, shallow soil or groundwater contamination during clearing, ground preparation and excavation works leading to potential deterioration of surface water quality;
- Inadvertent infilling of watercourses/drainage lines leading to potential loss of storage and/or ecological habitats and shallow waterlogging;
- Changes to site drainage patterns; and/or
- Leakage/spillage of chemicals associated with mechanical construction equipment (e.g. fuels and lubricants).

Section 4**Potential Impacts to Surface Water from
Proposed Mining Activities****4.2.1 Increased Runoff from Vegetation Clearing**

Clearing vegetation can lead to increased runoff from reduced interception/storage and evapotranspiration and from soil compaction. Excessive increases in peak runoff could lead to an increased risk of flooding and mobilisation of sediment with a negative impact on downstream receiving waters.

The above potential impacts are considered unlikely, given the high permeability of the strata that will be exposed by clearing and excavation work, which means that runoff is likely to infiltrate rapidly to groundwater and overland flow occurs only in the most extreme circumstances. These types of events are relatively infrequent with a very low probability of occurrence in any year.

Furthermore, the recommended 100 m no-mining buffer width (measured from the high banks) to Cooroon Cooroonpah Creek (i.e. 200m wide buffer zone) will provide additional protection against erosion in the event of increased runoff in very high intensity rainfall events. The potential impact of increased runoff from vegetation clearing is therefore considered to be low.

Only areas immediately in front of the active mine face are cleared at any one time, thus minimising areas exposed to runoff from clearing.

4.2.2 Disturbance of Sediment or Contamination

Intense rainfall events sufficient to produce surface water runoff could potentially mobilise sediment disturbed during construction or operation of the mine which may then enter watercourses and lead to deleterious effects on aquatic habitats either on-site or downstream. The probability of this impact is considered extremely low because the soil is highly permeable and limits the potential for significant overland flow. Sediment in surface runoff is therefore likely to remain close to the source of ground disturbance.

Additional protection will be provided with the installation of sediment fences downslope of all disturbed areas to ensure that the risk of sediment loss to drainage lines/watercourses is minimised. Cooroon Cooroonpah Creek is not considered large enough to carry significant sediment loads further downstream and for the majority of the year is likely to be dry. Sediment exposed or generated during construction and/or operation, may also be blown by wind into surface water bodies and may potentially dry up wet areas. The 100 m no-mining buffer width (measured from the high banks) to Cooroon Cooroonpah Creek (i.e. 200m wide buffer zone) is considered adequate for reducing the risk of wind-blown sediments from entering this watercourse.

There is no history of the site being used for potentially contaminating purposes and the risk of in-situ contamination being present is considered negligible.

No mining or clearing work will be carried out during extreme rainfall in order to minimise risks from sediments and contamination mobilisation. Hence the potential impact of disturbance of sediments and contamination is considered to be low.

4.2.3 Infilling of Watercourses/Drainage Lines

All operations to be carried out on Vance Lease will be undertaken on land sufficiently distant from Cooroon Cooroonpah Creek in accordance with the 100 m no-mining buffer width to Cooroon Cooroonpah Creek (i.e. 200m wide buffer zone). The potential impact of infilling of watercourses/drainage lines is therefore considered to be negligible.

Section 4**Potential Impacts to Surface Water from
Proposed Mining Activities****4.2.4 Changes to Site Drainage**

The major drainage line of Cooroon Cooroonpah Creek will be protected by a 100 m no-mining buffer width to Cooroon Cooroonpah Creek (i.e. 200m wide buffer zone). Other temporary changes to site drainage may be caused by regrading the local topography as sand is excavated. As the mining works are likely to be carried out on the shallower slopes, it is anticipated that mining work will be restricted to areas set back from drainage lines. It will therefore be necessary to progressively regrade and rehabilitate the disturbed area with slope and aspect similar to the pre-mining landform to prevent significant changes to flow routes. The common practices of establishing windrows of sand at the base of disturbed areas, and installation of sediment fences to limit sediment mobilisation and control drainage, will also be implemented.

Alteration of local drainage routes is unlikely to lead to significant negative impacts on a wider scale due to the rapid infiltration rates and high permeability of the underlying strata. Even if water is temporarily redirected from its original course at the surface, this should not affect the overall water balance of the area as the majority of water movement occurs below surface via groundwater flow. The groundwater flow is unlikely to be impacted, because mining will not occur below groundwater levels. The potential impact of changes to site drainage is therefore considered to be low.

4.2.5 Leakage/Spillage of Potential Contaminants

Mined sand is processed to extract silica and fine sediment by products. This process includes pumping sand in slurry form to sedimentation ponds. Current Unimin mining operations (ML1124 and ML7064) use anionic and cationic flocculants (FLOPAM AN905 PWG and FLOQUAT FL4440) to coagulate fine sediments in the ponds and allow them to settle. These flocculants are water soluble and non-hazardous but should be prevented from entering natural watercourses. A sediment pond will not be constructed on the Vance Lease and the mine sand will be processed at the existing adjacent lease.

Other potential contaminants for the lease area to be developed are associated with the machinery used for excavation and construction. These include diesel and other petroleum-based fuels and lubricants. The high permeability of the sands means that any liquid contamination is likely to percolate relatively rapidly through the unsaturated zone and into underlying groundwater. This may then lead to subsequent contamination of surface waters where groundwater flows into surface water bodies. Three levels of protection are proposed to prevent/contain leakage/spillage of contaminants:

- Bunded storage areas for fuels and dangerous goods, in accordance with Australian Standards (AS 1940 and AS 3780);
- 100 m no-mining buffer width to Cooroon Cooroonpah Creek (i.e. 200m wide buffer zone);
- Emergency spill procedures to minimise potential, extent and cleanup of leakage/spillage of contaminants.

Given the relatively undisturbed nature of the catchment, any contamination from leakage/spillage could potentially cause a significant impact on the water environment. The potential contaminants will only be present on-site in minimal quantities and, providing that appropriate systems and procedures are implemented, the significance of this impact is considered to be low.

Section 5**Conclusions and Recommendations****5.1 General**

The surface water environment within the Vance Lease is characterised by minimal significant surface runoff, even during high, intense rainfall. The main drainage line through Vance Lease is Cooroon Cooroonpah Creek, an ephemeral watercourse with intermittent flow exchange between groundwater and surface water.

Site investigations and monitoring data gathered from the site and surrounding area and information relating to the hydrology of North Stradbroke Island generally has provided a sufficient basis for characterising the hydrological environment in the vicinity of the proposed mining area and to identify potential impacts on surface water.

5.2 Baseline Hydrological Environment

Rainfall for the local area is characteristic of the sub-tropical climate of south-east Queensland. The majority of rainfall infiltrates to groundwater with surface runoff occurring only after heavy prolonged rainfall events. Surface water is generally as a result of shallow groundwater rising to ground levels as opposed to rainfall runoff of the ground surface. Groundwater hydrology is therefore considered to be the dominating influence on the hydrology of the creek. Local topography dictates that if runoff does occur it would be directed towards Cooroon Cooroonpah Creek, which runs through the middle of the site in a generally north-westerly direction.

No surface runoff from the site contributes to Swallow Lagoon to the south or the designated RAMSAR wetland sites within Vance lease. Water quality assessment for the site was limited by discontinuous monitoring record but is indicative of generally natural conditions. The turbidity is low due to low flow rates and unlikely or rare occur of overland surface runoff. The pH of surface waters are lower than recommended water quality objectives in Qld EPA guidelines but are consistent with the natural source and evapoconcentration of humic acids derived from periodic wet / dry cycles and releases from decomposing organic matter and humus podsols. The records of acid frog presence in and near the creek is consistent with the low pH being a natural influence.

5.3 Potential Impacts to Surface Water

The lack of surface water features and very limited potential for overland runoff flow due to very high infiltration capacity means that impacts from increased runoff, mobilisation of sediments and contamination are not considered to be significant. The protection of a 100 m no-mining buffer width to Cooroon Cooroonpah Creek (i.e. 200m buffer zone) will also ensure protection of the creek against surface water impacts including protection against excessive disturbance of humic acids which occur in the soils within the buffer zone. The key mitigation measure to avoid mining below groundwater level will also ensure that the groundwater hydrology is preserved which is a key influence on the surface water hydrology.

Site drainage is unlikely to be significantly impacted because overland flow is minimal and mining activity will not significantly alter drainage routes.

Fuel storage, refuelling and machinery maintenance areas may be present on-site and present a risk from spillage/leakage which can be mitigated with good storage, handling, and refuelling practices.

Section 5**Conclusions and Recommendations****5.4 Recommendations**

Monitoring of Cooroon Cooroonpah Creek both on the Vance Lease and downstream should continue throughout the duration of the mining activity to ascertain any change from baseline conditions. The monitoring programme should be expanded to include Dissolved Oxygen and Chlorophyll 'a' to provide a better indication of the trophic status of surface water bodies where nutrient concentrations alone are inconclusive. Planned rehabilitation of mined areas should be undertaken progressively as mining in specific areas is completed to reduce the risk of sedimentation and alteration of flow routes. The use of windrows and sediment fences at the edge of mining areas will also minimise these risks.

No mining operations should be carried out during any extreme rainfall event or within 100 m buffer width of the Cooroon Cooroonpah Creek (i.e. 200m buffer zone).

Potential fuel storage, refuelling and machinery maintenance areas will need to be carefully designed, built and operated with consideration of Environmental Management Systems to cover all sensitive operations.

A plan showing locations where mining operations should not be carried out is presented in Figure 6, Appendix A.

Section 6

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Section 7

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Unimin Australia Limited and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 23 April 2004 and 19 January 2006.

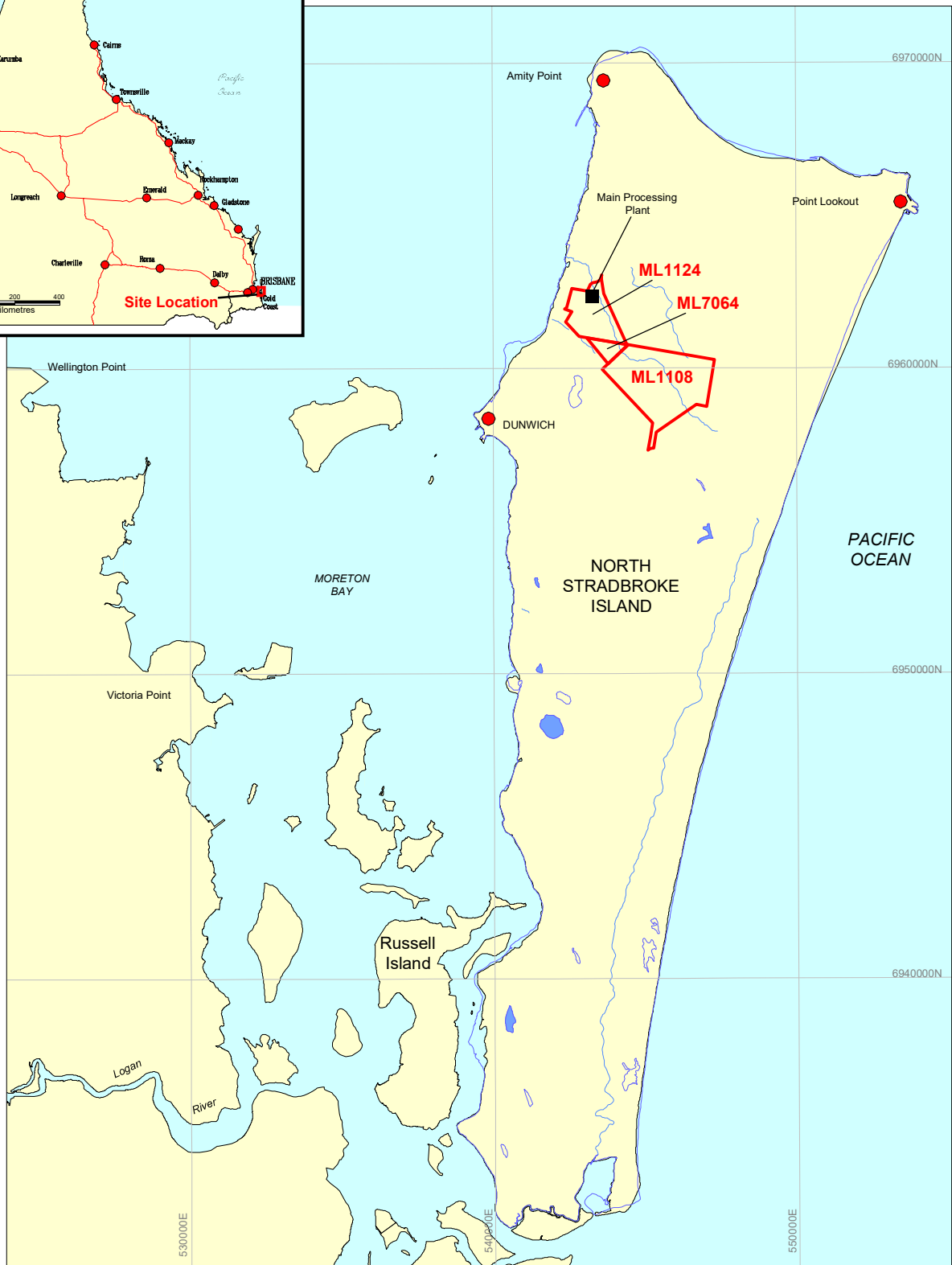
The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 28 February – 31 May 2005, and February 2006 to August 2007 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A

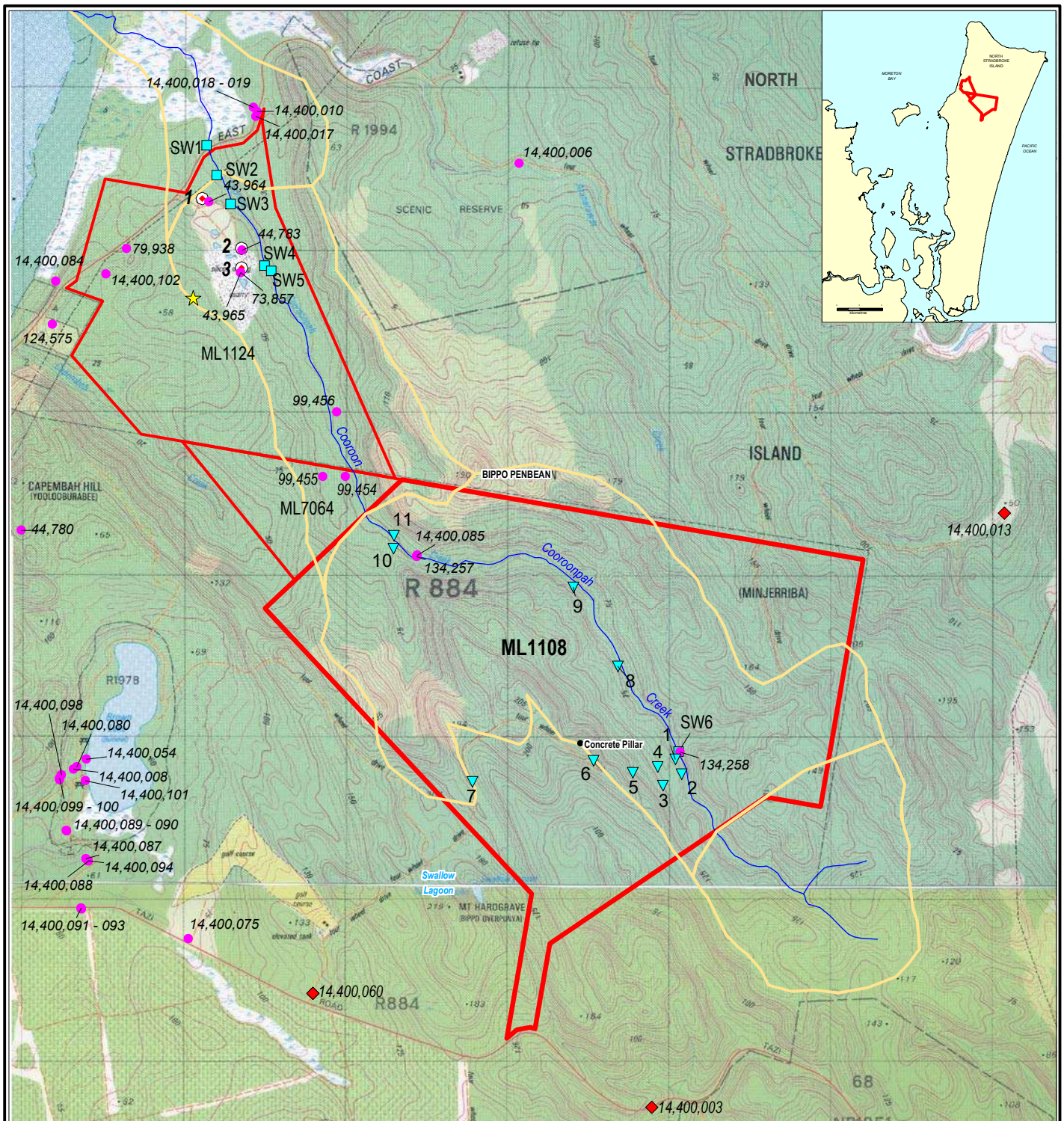
Figures



Scale 1:200,000 (A4)

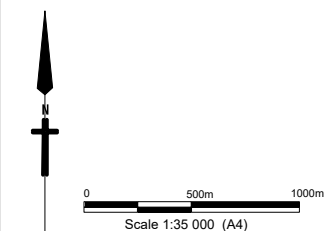
Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

Client UNIMIN AUSTRALIA LIMITED	Project SURFACE WATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND			Title LOCATION OF VANCE LEASE (ML1108)	
	Drawn: LL/TN	Approved: JD	Date: 24-08-2007		Rev: B
	Job No: 4262 5813		File No: 42625813-g-041b.wor		A4



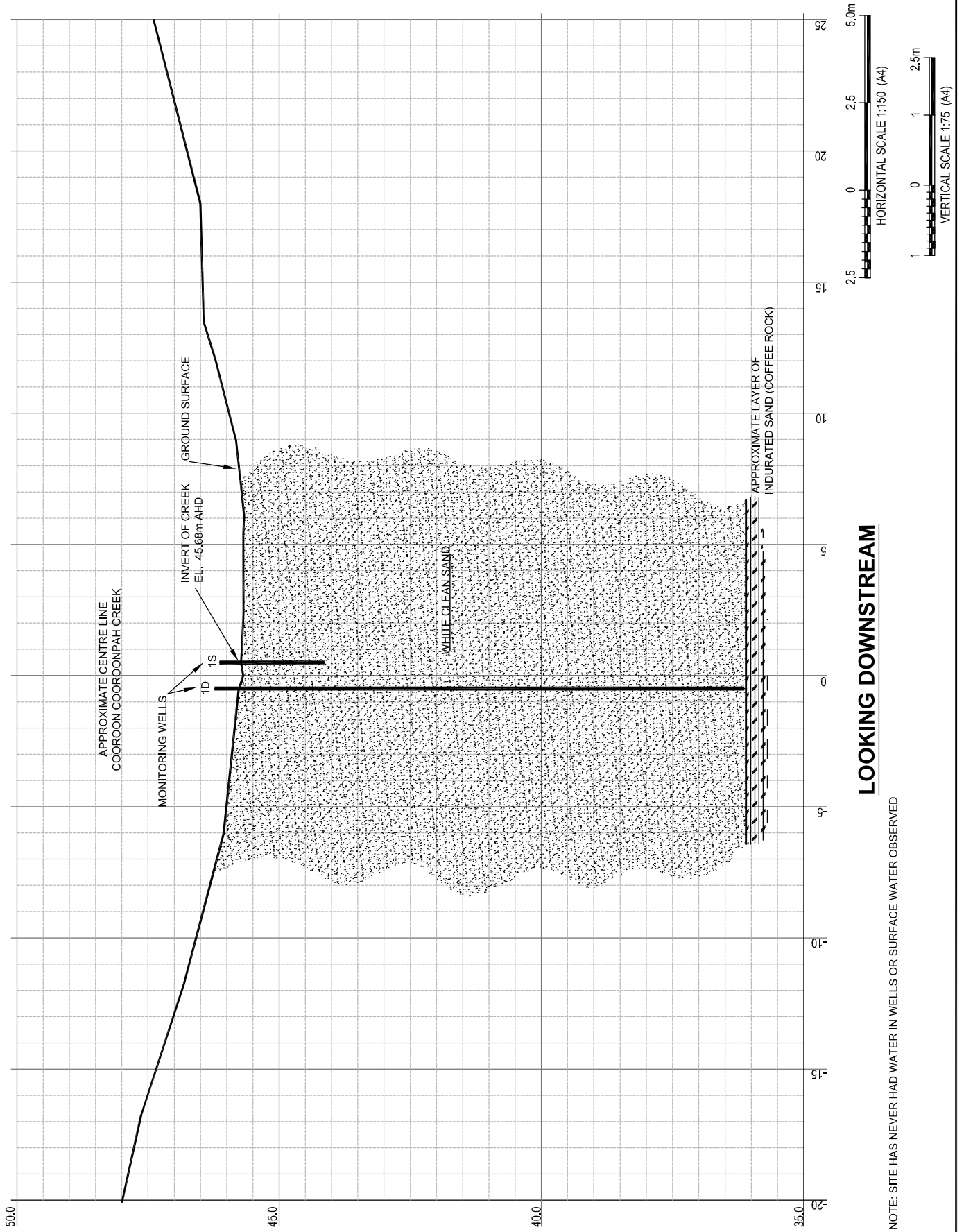
LEGEND

- | | |
|--|---|
| 1 ▽ Infiltrometer Test Locations | 99,454 ♦ Registered Groundwater Bores (2004) |
| 1 ⊙ Unimin Groundwater Bores | 134,258 ● Registered Groundwater Bores (2007) |
| SW1 ■ Surface Water Monitoring Locations | — Cooroon Cooroonpah Creek Catchment Boundary |
| ★ Approximate Location of Rain Station | — Drainage |



Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

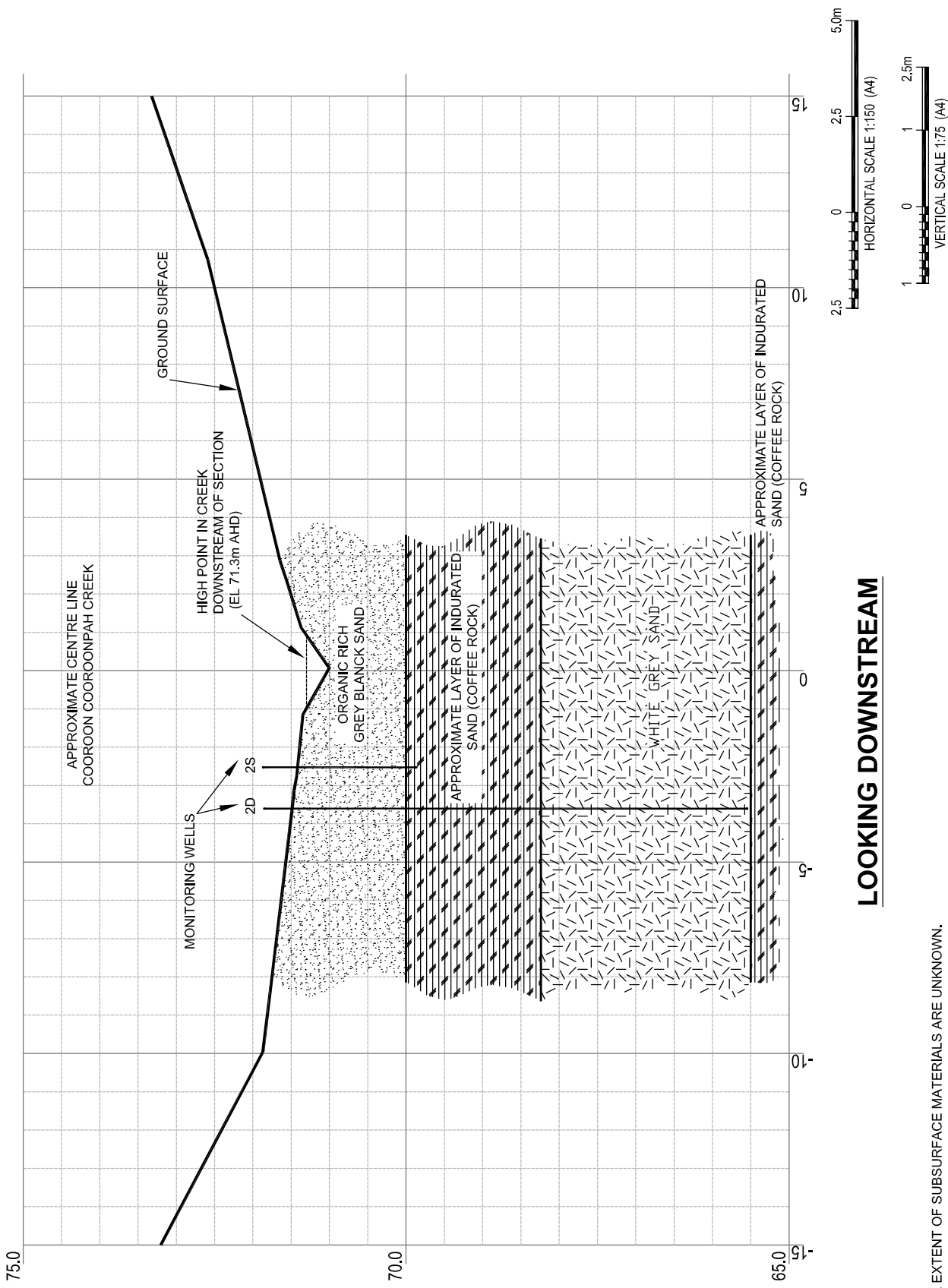
Client UNIMIN AUSTRALIA LIMITED	Project SURFACE WATER REPORT OF VANCE MINING LEASE NORTH STRADBROKE ISLAND			Title GROUNDWATER BORES AND SURFACE WATER MONITORING LOCATIONS	
	Drawn: LL/TN	Approved: JD	Date: 24-08-2007	Figure: 2	
	Job No: 4262 5813	File No: 42625813-g-042b.wor			Rev: B A4



NOTE: SITE HAS NEVER HAD WATER IN WELLS OR SURFACE WATER OBSERVED

Client UNIMIN AUSTRALIA LIMITED	Project SURFACE WATER INVESTIGATION VANCE MINING LEASE (ML1108) NORTH STRADBROKE ISLAND			Title SITE 1 CROSS SECTION AND BOREHOLES		
				Figure: 3		Rev. B
Job No.: 4262 5813			File No.: 42625813-g-043b.dwg			A4

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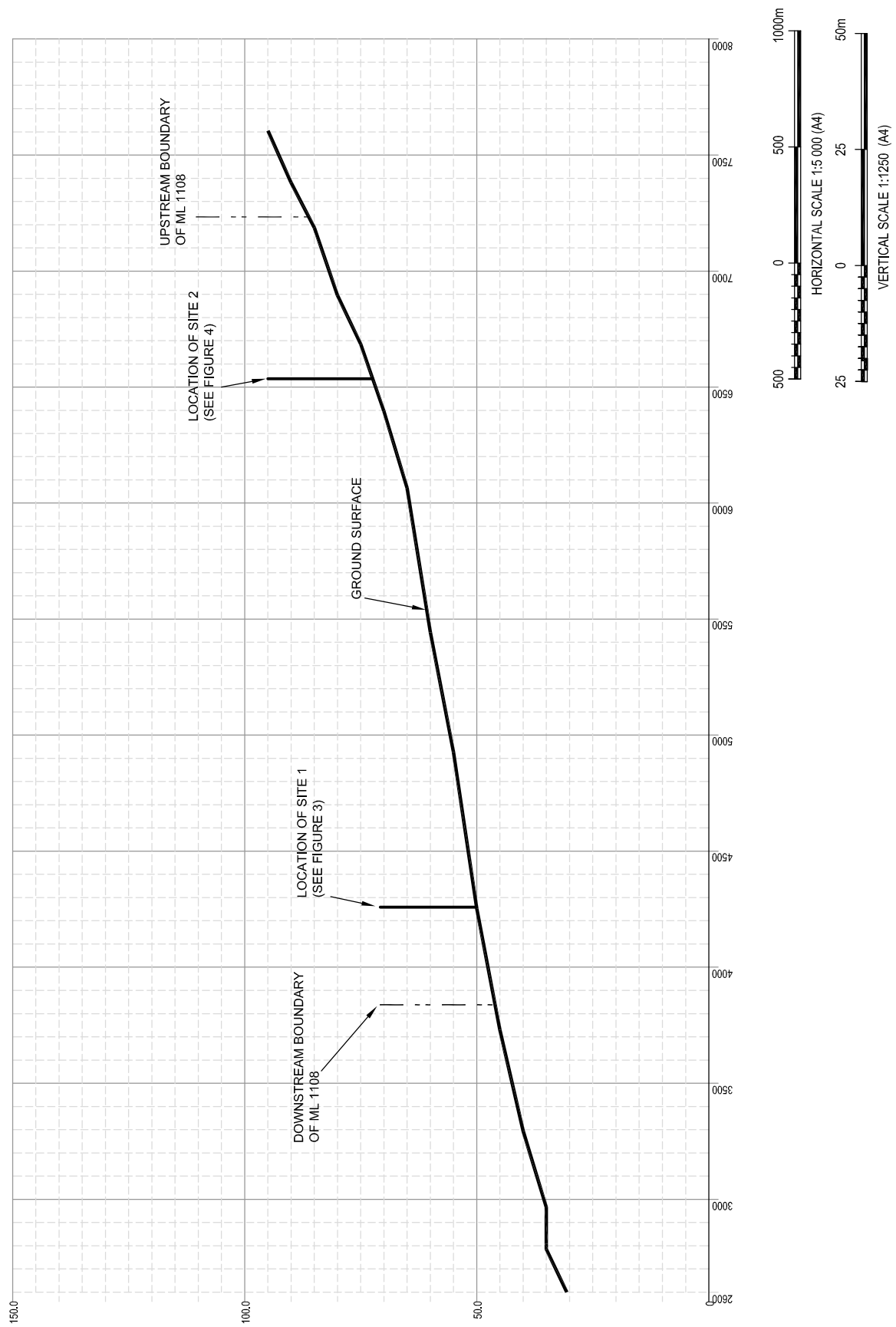


LOOKING DOWNSTREAM

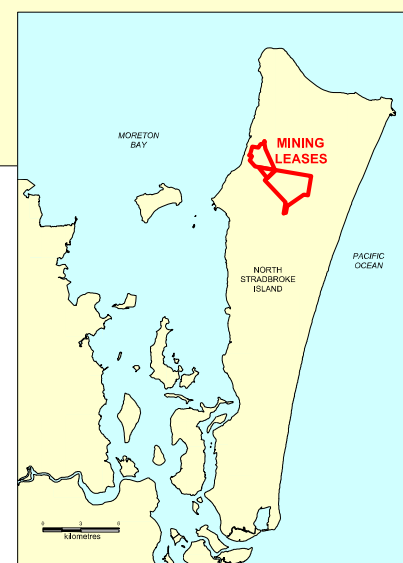
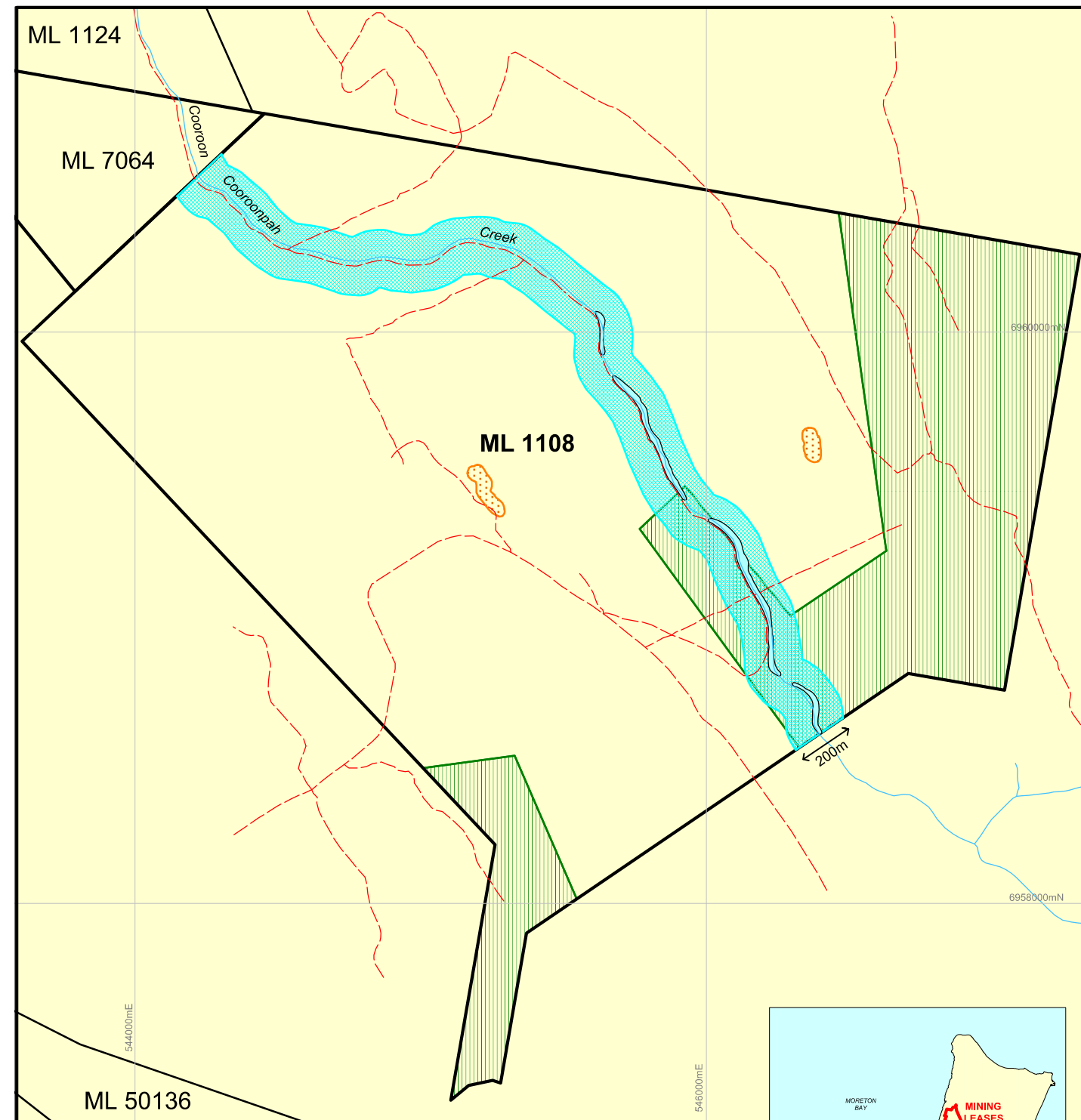
NOTE: SPATIAL EXTENT OF SUBSURFACE MATERIALS ARE UNKNOWN.

Client UNIMIN AUSTRALIA LIMITED		Project SURFACE WATER INVESTIGATION VANCE MINING LEASE (ML1108) NORTH STRADBROKE ISLAND		Title SITE 2 CROSS SECTION AND BOREHOLES	
		Drawn: LL/TN	Approved: JD	Date: 24-08-2007	Figure: 4
		Job No.: 4262 5813	File No.: 42625813-g-044b.dwg		Rev. B A4

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Client UNIMIN AUSTRALIA LIMITED	Project SURFACE WATER INVESTIGATION VANCE MINING LEASE (ML1108) NORTH STRADBROKE ISLAND			Title COOROONPAH CREEK LONG SECTION AND ADJACENT BOREHOLES	
				Figure: 5	
Job No.: 4262 5813			File No.: 42625813-g-045b.dwg		A4



LEGEND

- Watercourse
- Tracks
- Ramsar Area
- Creek Buffer (200m)
- Dry Heath Reference Sites



0 250m 500m
Scale 1: 20 000 (A4)

Source: Client Supplied Aerial Photo (16-02-2005)

Client
UNIMIN AUSTRALIA LIMITED

Project
**SURFACE WATER REPORT OF VANCE MINING
LEASE NORTH STRADBROKE ISLAND**

Title
**PROPOSED CONSERVATION AREAS
ML1108**

URS

Drawn: LL/TN Approved: JD Date: 24-08-2007
Job No: **4262 5813** File No: 42625813-g-046b.wor

Figure: **6**

Rev: B
A4

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Appendix L

Dust Assessment (2007)

REPORT

Dust Assessment of Unimin Mining Activities at North Stradbroke Island



Prepared for

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1 August 2007

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Date: 1 August 2007
Reference: Dust Assessment Report
Status: Final

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Executive Summary

This report sets out the estimation methodology, parameters and results for a dust dispersion modelling assessment conducted for Unimin Australia Limited (Unimin) in regards to its proposed mining activities on ML1108 and the current mining operation on North Stradbroke Island.

An estimation of emissions of Total Suspended Particulate and PM₁₀ dust has been carried out using emission factors from industry sources and information supplied by the site. Background data provided by the dust deposition monitoring program currently underway on site has been incorporated into the calculation. The emission rate for the site has been estimated to be 65 kg/hour for total particulate, and 19 kg/hour for PM₁₀, assuming simultaneous operation of all equipment on site.

Site-specific meteorological data was generated through the use of The Air Pollution Model (TAPM). Dust concentration and deposition were modelled using Ausplume to provide concentration and deposition contours. Deposition rates and concentrations were calculated at a number of discrete receptors including built up areas near the mining leases and other localities specified by Unimin.

All concentration and deposition predictions at receptors outside the mine lease boundary are well below regulatory guideline values.

Section 1

Introduction

Unimin Australia Limited (Unimin) has commissioned URS Australia Pty Ltd (URS) to prepare a dust assessment for sanding mining operations on ML7064, ML1124 and ML1108 (Vance Lease) on North Stradbroke Island. As part of the Environmental Studies Report (ESR) required for the Vance Lease, a dust assessment of mining activities is to be prepared, in addition to a review of any air quality related studies completed in the past.

A dust assessment was conducted for earlier mining activities in 1998 by Katestone Scientific. That assessment was considered by the Queensland EPA for the current mining plan and found to be insufficient for the new mine and as such, has not been used.

For the purposes of the new assessment and in response to the Queensland EPA review, an updated emissions inventory and more current meteorological data were needed and have been acquired as part of the scope of this project. The models used were the most recent available release of each and guideline values for comparison are taken from the most recent updates to the legislation.

An ongoing program of baseline dust deposition measurement has been established for current operations. The results for this program for 1 year of operation have been included in the air quality assessment as appropriate.

This report sets out the regulatory and operational background to the dust assessment and presents an overview of dust estimation techniques used. Dust concentrations for both Total Suspended Particulates (TSP) and PM₁₀ (particles with an aerodynamic diameter of less than 10 micron) were modelled using the Ausplume air quality model and the results are presented and compared with regulatory guidelines. Dust deposition was also modelled and compared with Queensland guidelines for dustfall.

Section 2

Proposed Operation and Emission Estimation

2.1 Current and Proposed Operations

Unimin Australia Limited (Unimin) and its precursors have been sand mining on North Stradbroke Island for over 35 years to supply local, interstate and international glass works. Currently, mining is undertaken on Mining Lease (ML) 7064 and has recently extended into a designated “3 year mine plan area” on ML1108 in accordance with EPA approval.

The proposed operations will involve the conduct of sand mining activities only on ML 1108. No processing of sand will occur, this being undertaken using existing facilities on the adjacent ML1124. Dune sand will be extracted from a shallow pit at the rate of up to 1 million tonnes per year and transported via a slurry pipeline to the processing facility. Processing will be undertaken using gravity means to remove impurities, producing high purity silica sand used mainly for glass manufacture. Heavy minerals will be separated during the process as a by-product. The heavy minerals product (not silica) is sold in bulk to external mineral sands companies.

This report is concerned with dust generated by the actions and processes on the mining leases where the operations take place. The processing operations used by Unimin are wet processes throughout the plant, and these are not considered to be dust generating sources. Operations involving handling of dry sand, a source of airborne dust, are: at the entry to the primary grizzly screen; and after it has been dried on the stockpiles.

2.1.1 Mine Location

The Unimin operation on North Stradbroke Island is located on Mining Leases ML 1108, ML 1124 and ML 7064 approximately 3.5 km Northwest of Dunwich. The processing plant and clean sand stockpile area is located in the northwest corner of ML 1124 and is situated approximately 4.8 km from Dunwich and 1.3 km from Myora Springs estate – considered the nearest built-up area. Unimin has recently (with EPA approval) expanded into the north western section of ML1108. Figures 2-1 and 2-2 show the locations of the mine on the island and the location of major plant items on the mining leases.

2.1.2 Operating Times and Parameters

Mining operations are conducted on a Monday, Tuesday and Wednesday, 24 hours per day. Topsoil is removed by dozer and stockpiled to a batter between the mine site and the Cooroon-Cooroonpah creek buffer. Sand is won from the active mine site by front-end loader and is delivered via a slurry pipeline to the primary processing plant. This operation runs for approximately 65 hours per week.

Processing, stockpiling and delivery operations are conducted 5 days per week from 8 am until 6 pm (for approximately 2,500 hours per year). Sand is delivered wet to stockpiles and allowed to dry before loading onto trucks using front-end loaders. Reject material is pumped wet to two reject dams located close to the processing plant on ML1124 with some damp oversize material used to re-contour the site near the processing plant and in rehabilitating areas.

The Vance lease is expected to yield approximately 413,000 tonnes of processed sand per year with non-spec material sent to the reject dams expected to be 45,000 tonnes per year.

2.1.3 Discrete Receptors

There are a number of discrete receptors surrounding Unimin mining leases on North Stradbroke Island which may be affected by the mining activities. The closest residential areas or sensitive environments are Myora Springs estate, the Myora Conservation area and Illawong Court in the Dunwich township. In addition, a number of sites located about the mine have been identified on supplied maps. These discrete receptors have been included in this dust assessment. Table 2-1 shows the significant discrete receptors and locations used in the modelling, as well as the location of baseline dust deposition monitors on site. Figure 2-2 shows the locations of the discrete receptors on the island.

Section 2

Proposed Operation and Emission Estimation

Table 2-1 Discrete receptor locations

Site identified	Receptor number used in models	Location (m East)	Location (m North)
Illawong Ct	1	541056	6959014
Myora Springs estate, Boronia Ct	2	542350	6961576
Myora Conservation Park	3	540846	6960465
Building (due east)*	4	549103	6960016
Building SE*	5	548236	6955986
Building SW*	6	540792	6957226
Building WSW 1*	7	540508	6959035
Building WSW 2*	8	540286	6958844
Building WSW 3*	9	539916	6958820
Deposition monitoring site 1	10	543480	6960279
Deposition monitoring site 2	11	544055	6960216
Deposition monitoring site 3	12	542567	6961559
Deposition monitoring site 4	13	546001	6958979
Deposition monitoring site 5	14	544799	6958711
Deposition monitoring site 6	15	543988	6960578

* directions of buildings refer to direction from active mine face.

Site coordinates are based on the AGD84 datum. All Deposition monitoring sites are within the boundaries of the Unimin mining leases.

2.2 Emissions Summary

Emissions from the operation occur at a number of locations on-site: at the mine face; topsoil removal and stockpiling; sand transfer points; vehicle movements over the site; recovery of sand from stockpiles and erosion from stockpiles and exposed areas on the mine. As noted above, dust is not generated by the processing plant itself and it should also be noted that the delivery trucks are covered before leaving site and therefore do not generate significant dust from sand contained within the transported load. All dust generation points are outlined below in Tables 2-2 to 2-5, and are described further in this section. Emissions of pollutants other than particulate matter, such as nitrogen dioxide and sulphur dioxide from vehicles, are considered to be negligible and have not been addressed in this assessment.

Section 2

Proposed Operation and Emission Estimation

2.2.1 Emissions Assumptions

All dust emissions are calculated using emissions factors taken from the NPI Emission Estimation Techniques Handbook for Mineral Sand Mining and Processing¹ and the NPI Emission Estimation Techniques Handbook for Mining². These manuals give emissions factor calculations for various activities associated with mining processes and have been derived from measurements undertaken in the past. In most cases, default emissions factors have been used in the estimation of emissions in this assessment with some exceptions where the emission factor was considered unrealistic. For estimation of Heavy vehicle (delivery truck), Light vehicle (on-site mine vehicles) and bulldozer emissions, the calculated emission factor was based on a 4 % silt content for all sands and a moisture content of 4%.

Detailed bulk density and particle size information is available for the product sand for the size grades important for product specifications, between 1 mm and 53 micron (μm). However, total suspended particulates are considered to have an aerodynamic diameter of 50 micron and less, and detailed particle sizing and density is not available in this range. It is assumed for this assessment that average values for particle sizes are used, namely for TSP a mix of 15 and 5 micron particles. PM_{10} is considered to be all 5 micron particles.

2.2.2 Vehicle Activity Emissions

The mine runs a small fleet of vehicles in its operations on site. The actions of these vehicles generate dust through movement over sand roads and active mining areas and through the unconfined transfer of mined sand (a front end loader dropping sand to a hopper for example). Calculated and default emission factors have been used to calculate the emission rate of dust from the activities of the vehicles.

This dust assessment is for activities confined to the mining lease boundaries. Delivery truck distances driven are therefore only the distance from the stockpiles to the gate of the mine. As noted above, the trucks are covered and do not emit dust from their load while travelling. The light vehicles used are assumed to be light trucks and the distance travelled per year is assumed to all occur on-site.

Wheel generated dust (WGD) emissions for the trucks and light vehicles have been calculated using emission factors and appropriate sources have been distributed along the main roads on the site.

The vehicle fleet emission points are outlined in Table 2-2 below with the estimated emission rates.

¹ National Pollutant Inventory, *Emission Estimation Technique Manual for Mineral Sand Mining and Processing*, Version 1, April 2001

² National Pollutant Inventory, *Emission Estimation Technique Manual for Mining*, Version 2.3, 5 December 2001

Section 2

Proposed Operation and Emission Estimation

Table 2-2 Vehicle fleet used at Unimin North Stradbroke

Vehicle	Total hrs driven per year	Total km driven on site per year	Emission source	Emission rate TSP (g/s)	Emission rate PM ₁₀ (g/s)
Mining					
Front end Loader (FEL1)	3250	40000	WGD from raw sand active mine	1.0	0.5
			Sand drop to grizzly screen (primary plant)	0.2	0.07
D9 Dozer	100	500	Vehicle movement over topsoil	5.2	0.9
Processing					
Front End Loader (FEL2)	2500	2500	WGD on stockpiles	1.1	0.6
Front End Loader (FEL3)	2500	2500			
Front End Loader (FEL4)	2500	40			
Front End Loader (FEL5)	2500	1100			
28 tonne Tipper truck	2500	16143*	WGD on road from stockpiles to main gate	7.0	2.0
28 tonne Tipper truck	2500				
28 tonne Tipper truck	2500				
Light vehicle	2500	20000	WGD from movement over site	2.7	1.0
Light vehicle		25000			
Light vehicle		30000			

* only the distance from stockpiles to gate is used as noted above.

The bulldozer operation has a very high emission rate compared to that of other activities. The dozer is in operation approximately two hours per week to clear the topsoil from the sand resource. The emission rate for this source has been averaged over the day to ensure a more realistic picture of emissions as the operation of this vehicle may be timed to avoid adverse weather conditions.

2.2.3 Stockpile and Exposed Area Emissions

There are a number of stockpiles of processed sand on the site. These are located at the north-east corner of ML1124 near the processing plant and close to the exit from the site for sand delivery trucks. Sand is delivered to the stockpiles wet and therefore dust is not generated by this activity. Dust generation from the stockpiles occurs when the sand dries and is eroded by wind. Specific information about stockpile size and contents is constantly changing due to production and movement of the processed sand – therefore all stockpiles are treated as a constant emission source with the same sand type, diameter and average height. Stockpile information supplied by Unimin and estimated dust emission rates are shown in Table 2-3 below.

Section 2

Proposed Operation and Emission Estimation

Table 2-3 Processed sand stockpiles

Stockpile	Size (tonnes)	Height	Area	Emission rate TSP (g/s)	Emission Rate PM ₁₀ (g/s)
Processed sand 1	4000	12 m average height	30-40 m average diameter	0.09	0.05
Processed sand 2	4000				
Processed sand 3	4000				
Processed sand 4	4000				
Heavy sand 5	5000				
Non Spec. sand 6	2000				
Non Spec. sand 7	2000				
Non Spec. sand 8	2000				

Reject dams used on site are treated as a dust emission source when dry through the action of wind erosion. Information on the reject dams supplied by Unimin and the estimated emission rates are given in Table 2-4 below.

Table 2-4 Reject dam information

Dam	Area (ha)	Dry area (%)	Emission rate TSP (g/s)	Emission Rate PM ₁₀ (g/s)
Dam 1	0.6	100	0.12	0.06
Dam 2	1.2	40		

The other major sources of wind erosion generated dust are the exposed topsoil stockpiles and exposed active mining area. Topsoil is removed by dozer each week from the active mine cut area. The topsoil is amassed to the batter on the east of the mining area and re-contoured every six months. This stockpile is treated as a single wind erosion dust source as it is dry and assumed to be evenly spread.

The active mine cut area is treated as a wind erosion source. It is assumed that active rehabilitation and self-revegetation of the previously mined area is undertaken at the same rate as the sand is mined from the active site – this means that the area exposed does not change substantially over the life of the mine in the time frame considered by this assessment. The area chosen for this emission source is equal to the largest exposed active mining area from the projected mine plan (that area expected to be mined in 2009) as this is more conservative. Table 2-5 shows the emission information relating to the topsoil stockpiles and active mine area exposure.

Table 2-5 Exposed area dust emission sources

Source	Size	Area (ha)	Emission rate TSP (g/s)	Emission Rate PM ₁₀ (g/s)
Exposed Mine Cut area	100 m mine face	3.4	0.38	0.19
Topsoil stockpile	6000 tonnes	0.1	0.01	0.005

Section 3

Air Quality Guidelines

The pollutants of concern from sand mining operations such as the Unimin mine are primarily particulate matter. For air quality impacts, ground level concentrations of Total Suspended Particulate (TSP) and Particulate matter less than 10 microns (PM₁₀) are evaluated and compared against relevant air quality guidelines. Dust Deposition can also create nuisance dust issues and is also compared against air quality guidelines.

This report has evaluated air quality impacts at residential locations in close proximity to the operational leases only to assess potential health impacts of the mine operations. On-site dust levels are managed through Occupational Health and Safety legislation for the protection of workers health, and have not been evaluated in this assessment.

3.1 Queensland

3.1.1 Concentration

In Queensland, air quality is managed under the Environment Protection Act 1994 (*the Act*), the Environmental Protection Regulation 1998 ³ (*the Regulation*) and the Environmental Protection (Air) Policy 1997 ⁴ (*the Policy*).

The Act provides for long-term protection for the environment in Queensland in a manner that is consistent with the principles of ecologically sustainable development. The primary purpose of the Policy is to achieve the objectives of the Act in relation to Queensland's air environment. This objective is achieved by the Policy through:

- Identification of environmental values to be enhanced or protected;
- Specification of air quality indicators and goals to protect environmental values; and
- Provision of a framework for making consistent and fair decisions about managing the air environment and involving the community in achieving air quality goals that best protect Queensland's air environment.

Schedule 1 of the Policy, referred to as the EPP (Air) in this report, specifies the air quality indicators and goals that are to be achieved. The Schedule is divided into:

Part 1 – Indicators and goals relevant to the aesthetic enjoyment of places and visual and local amenity;

Part 2 - Indicators and goals relevant to biological integrity; and

Part 3 – Other indicators and goals.

The goals in Part 3 are set for the protection of human health. EPP (Air) goals in Parts 1 and 3 are taken to be applicable to residential locations, while Part 2 goals are taken to be applicable to sensitive vegetation.

The Queensland EPP (Air) gives guidelines as follows:

³ Queensland Government, *Environmental Protection Regulation* 1998, Office of the Queensland Parliamentary Counsel.

⁴ Queensland Government, *Environmental Protection (Air) Policy* 1997, Office of the Queensland Parliamentary Counsel

Section 3

Air Quality Guidelines

- For Particulates as PM₁₀: 150 µg/m³ over a 24 hour averaging period and 50 µg/m³ over a 1-year averaging period.
- For Particulates as Total Suspended Particulates (TSP): 90 µg/m³ over a 1-year averaging period.

3.1.2 Deposition

The Queensland EPA has adopted a guideline for dust deposition of 4 g/m²/month to ensure adequate protection from nuisance levels of dustfall. This level was derived from ambient monitoring of dust conducted in the Hunter Valley, NSW in the 1980's. The former NSW State Pollution Control Commission set the level to avoid a loss of amenity in residential areas, based on the levels of dust fallout that cause complaints. The current guideline level adopted in NSW ⁵ is that the maximum total dust deposition level should not exceed 4 g/m²/month, and that the maximum increase in deposited dust is 2 g/m²/month.

3.2 Redlands Shire Council

The Redlands Shire Council Planning Scheme Policy defines the same limits as the Queensland EPP (Air) for ambient PM₁₀ and TSP concentration. In addition, the Redlands Shire Council has adopted an air quality dustfall standard of 133 mg/m²/day for dust deposition. This is equivalent to the value used by the Queensland EPA.

⁵ NSW Department of Environment and Conservation, *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, August 2005.

Section 4

Background Air Quality

4.1 Dust Concentration

There are no background TSP or PM₁₀ measurements available for North Stradbroke Island as there are no publicly maintained monitoring stations for which data is available.

PM₁₀ concentration measurements from various other sites around Brisbane are available from the Queensland EPA. The closest site to North Stradbroke Island is that at Wynnum – an industry operated site. The annual average background PM₁₀ concentration at this site over the year from December 2005 to November 2006 is approximately 16.4 µg/m³. The highest 24-hour average background concentration at this site was 48.7 µg/m³, occurring in November 2006. The background values used from the Wynnum site are likely to overestimate the results for North Stradbroke Island.

TSP concentration data are not available at these sites, therefore an annual average background concentration equal to that of PM₁₀ has been used.

4.2 Dust Deposition

Unimin is currently conducting a dust deposition monitoring program around its operations on the island. Six monitoring sites were set up at various locations inside the mining lease boundary to measure monthly dustfall. Samples are analysed monthly for dust deposition (total insoluble solids). The program has run from May 2006.

The six monitors are sited to capture data based on their location. Sites 1, 2 and 6 are sited near operational mining areas to give data on mining impacts. Sites 4 and 5 are located in the Vance Lease at some distance from all mining activities to capture background levels of dustfall. Site 3 is situated close to the mine lease boundary near the Myora Springs Estate residential area to monitor dustfall affecting residents.

The average results over one year of monitoring (25 May 2006 to 28 May 2007) from sites 3, 4 and 5 have been used to give a background dust deposition level for the mine as Sites 4 and 5 are upwind of the mine site in the prevailing wind direction and Site 3 is some distance from active operations. The background average obtained thus is 2.8 g/m²/month. This figure has been used with modelling predictions to give the modelled results. It should be noted that the predicted data from the model agrees with the measured dustfall at the background monitoring sites.

Section 5

Dust modelling

5.1 Meteorology

Meteorological data used for previous studies had been sourced from the weather monitoring station at Eagle Farm, near the Brisbane airport. This was considered unsuitable for the updated dust assessment as the station is too far away from the operational leases. Site specific meteorological data was generated through the use of The Air Pollution Model.

5.1.1 The Air Pollution Model (TAPM)

Meteorological modelling was conducted to compile a meteorological file generated on a semi regional basis by using the CSIRO model, The Air Pollution Model (TAPM)⁶.

TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical coordinate for three-dimensional simulations. It includes parameterisations for cloud/rain micro-physical processes, turbulence closure, urban/vegetative canopy and soil, and radiative fluxes.

TAPM, with the use of the input databases provided by CSIRO, was used to generate a meteorological dataset for the year 2005 (the most current data available) based on actual synoptic data.

The following TAPM settings and input files were used to generate the meteorological file for the Unimin Vance site for the year 2005:

- Grid centre coordinates 27°29'00" latitude, 153°27'30" longitude (local coordinates of 545,278 mE, 6,959,935 mN);
- Five nested grid domains of 25 × 25 grid cells at 30 km, 10 km, 3 km, 1 km and 300m grid spacing;
- Twenty-five vertical grid levels from 10 to 8,000 m;
- Terrain, vegetation and soil type data at 1 km grid spacing from the US Geological Survey, Earth Resources Observation System (EROS) Data Centre Distributed Active Archive Centre (EDC DAAC) and Geoscience Australia for terrain information;
- Sea surface temperature data at 100 km grid intervals from the US National Centre for Atmospheric Research (NCAR);
- Six hourly synoptic scale meteorology from the Bureau of Meteorology on a 75 to 100 km grid. This data is derived from the LAPS (Local Analysis Prediction System) or GASP (Global assimilation and Prediction model) analysis; and
- Deep soil volumetric moisture content set at the default of 0.15 m³/m³.

5.1.2 Wind Data

Wind data generated by TAPM were used to compile wind roses for the site.

Figure 5-1 shows the wind data generated for the year 2005 for all hours of the day. The predominant wind direction is from the south east and winds are generally less than 8 m/s or 16 knots. "Calms" refers to the percentage of time where winds were less than 0.5 m/s.

⁶ Hurley, Peter (2005). *The Air Pollution Model (TAPM) Version 3. Part 1: Technical Description* CSIRO Atmospheric Research Technical Paper No. 71.

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Dust modelling

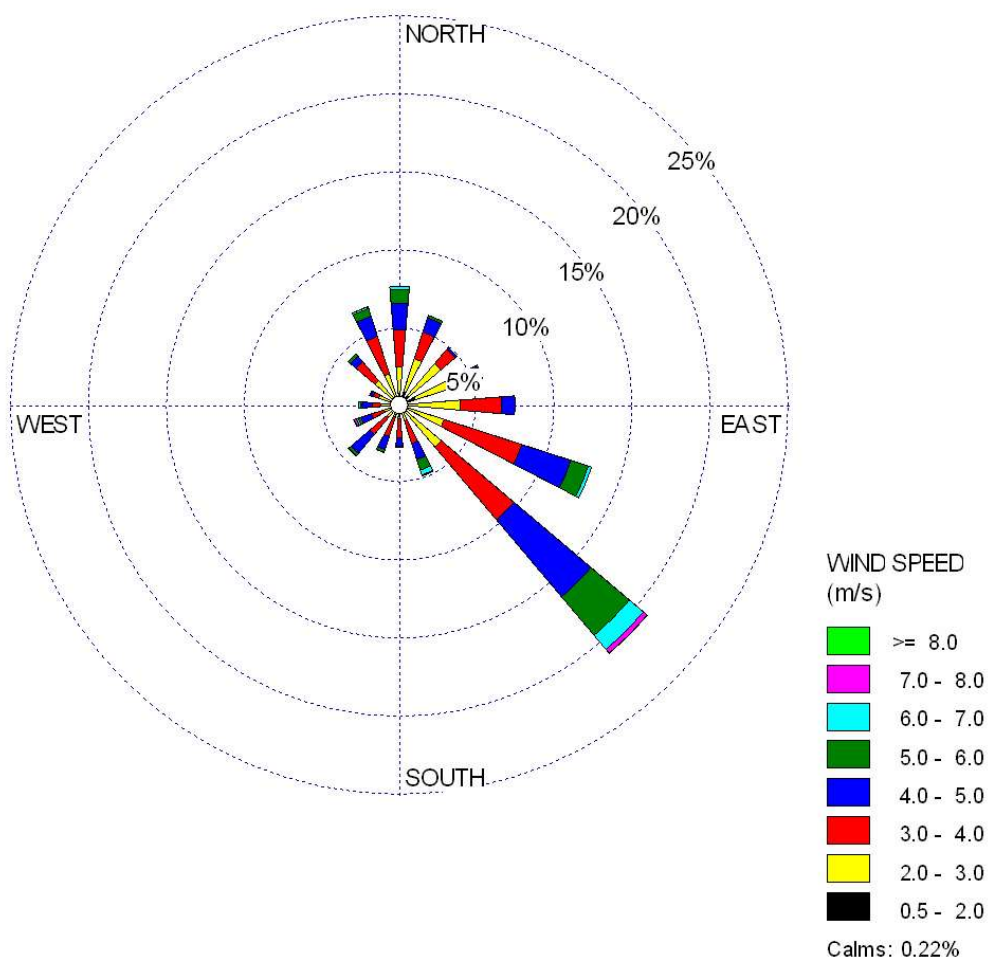


Figure 5-1 Wind rose for the Vance site, all hours, annual, 2005

Figure 5-2 shows the wind data for the site showing the changes in wind direction for seasonal variation. The prevailing wind for summer (a), autumn (b) and winter (c) is predominantly from the South East. The prevailing wind for the spring (d) is from the north and north-west.

Section 5

Dust modelling

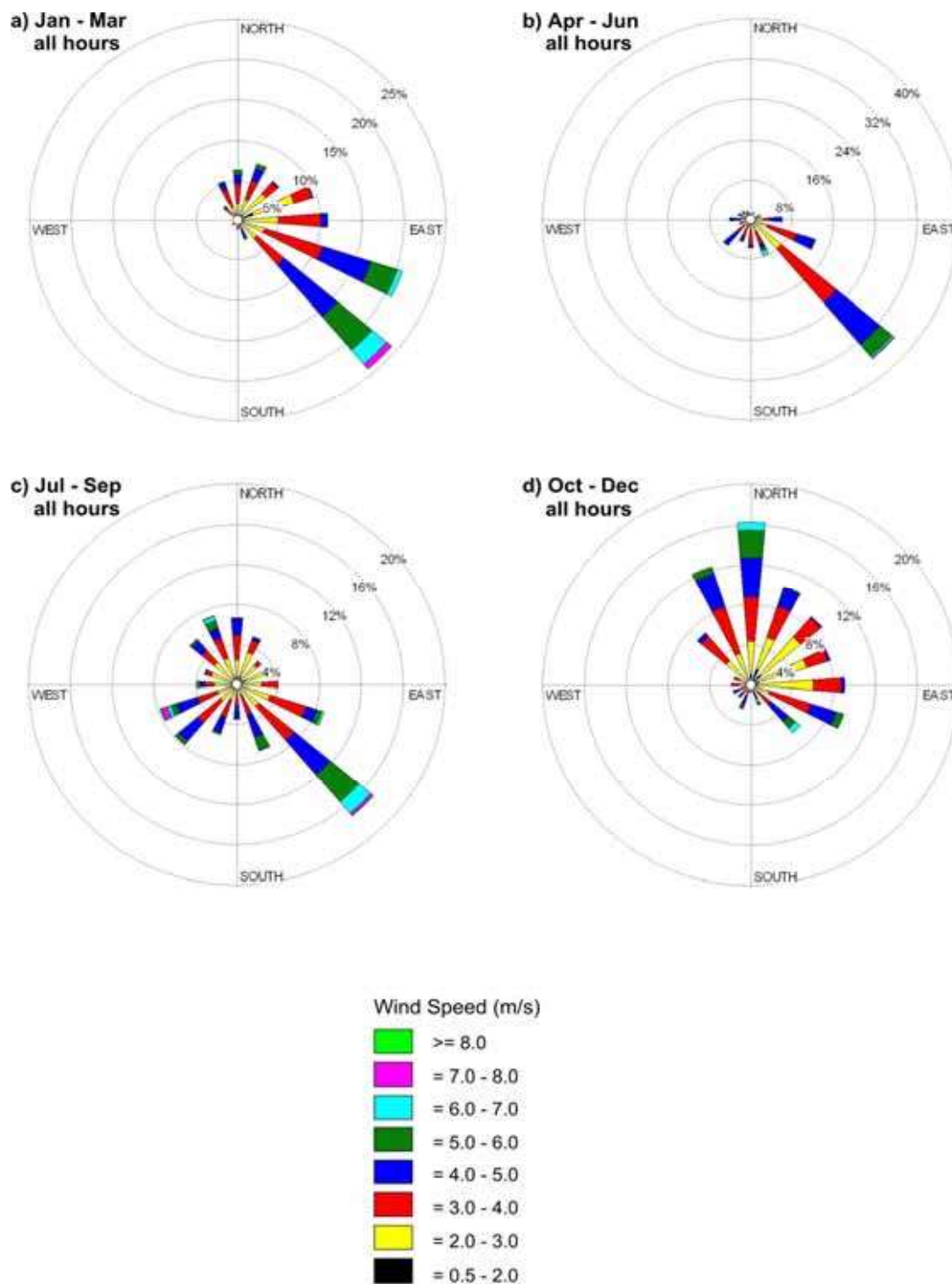


Figure 5-2 Wind rose for the Vance site, all hours, by season, 2005

Section 5

Dust modelling

5.2 Dust Dispersion Modelling

Modelling of the proposed emissions of dust was undertaken using the Ausplume⁷ (Version 6.0) model, developed by the EPA of Victoria. This model has been used widely throughout Australia and is constantly updated.

Ausplume is a steady state, Gaussian model capable of predicting dust concentration and deposition including the effects of depletion on the plume. Ausplume was used to model the deposition and concentration of Total Suspended Particulate matter (TSP) and downwind concentration of Particulate Matter of less than 10 micron aerodynamic diameter (PM₁₀). Modelling runs were setup as follows:

- PM₁₀ concentration was modelled for the site for both 24 hour and annual averaging periods.
- Total suspended particulate (TSP) was modelled for the site on an annual averaging period basis.
- Dust deposition was modelled on an annual averaging period and calculated to provide a monthly deposition rate for comparison with regulatory guidelines and collected data from the monitoring program. Monthly deposition data cannot be directly calculated in Ausplume.
- The proportion of TSP and PM₁₀ for each source was determined by the relevant NPI emission factors.
- TSP was modelled with the assumption of two particle sizes – 15 micron and 5 micron with particle density of 2.23 g/cm³. PM₁₀ was modelled using one particle size of 5 micron, and a density of 2.23 g/cm³.

A total peak dust generation rate for TSP of 18.1 grams per second (65 kg/hour) was calculated for the site. A total peak dust generation rate for PM₁₀ of 5.4 grams per second was calculated for the site.

Default options were selected for most of the parameters that are used in the Ausplume model. The parameters selected in the model setup are as follows:

- Grid spacing of 500 m, over a model domain of 8 km in the east-west direction by 8 km in the north-south direction.
- Discrete receptors were entered separately to represent the closest residential locations, buildings considered significant from Unimin supplied data, and the sites used for dust deposition monitoring.
- Pasquill-Gifford dispersion curves used for horizontal and vertical dispersion curves.
- Default plume rise and wind speed categories used.
- Irwin rural wind profile exponents used.
- Surface roughness of 0.4 m selected for the site to represent rolling hills.
- Operating hours of 8 am to 6 pm were used for vehicle emission sources at the processing area only (i.e. the front end loaders, light trucks and heavy trucks). All other emissions are assumed to occur 24 hours per day.

⁷ Ausplume Version 6.0, Gaussian Plume Dispersion Model, developed by and available from EPA Victoria, <http://www.epa.vic.gov.au/air/epa/pub391.asp>.

Section 6

Results and Discussion

6.1 Dust Concentration

The two major contributing sources for dust are the movement of the bulldozer at the active mine face, used for scraping topsoil from the raw sand resource, and the heavy vehicle movements from the stockpiles to the front gate. The influence of these sources is evident in the concentration contours shown in the figures noted below – in all cases the highest results are concentrated on those two areas.

There are concerns from local residents that the sand mine contains a proportion of silica and free quartz which may be present in dust emitted from the site. Currently the Australian Safety and Compensation Council (formerly the National Occupational Health and Safety Council) has not endorsed a national standard for industrial air concentrations of crystalline silica (including free quartz) as the standard is under review⁸. It should also be noted that the ambient air guidelines in the EPP (Air) are for general dust (less than 1% silica) and are not comparable to occupational health and safety guidelines.

6.1.1 TSP

Total suspended particulate (TSP) has a defined guideline of 90 µg/m³ for an annual averaging period under the Queensland EPP (Air). Table 6-1 shows the concentration of TSP at the discrete receptors for the predicted impacts due to Unimin operations alone, and the total concentration due to Unimin and the assumed background concentration. Figure 6-1 shows the concentration contours for TSP due to Unimin operations alone. It should be noted that the background value of 16.4 µg/m³ for an annual averaging period is for EPA monitoring site at Wynnum, and is not strictly valid at the Vance site.

Table 6-1 TSP concentration at discrete receptors

Receptor number	Site	Annual average TSP Conc. (Unimin only), (µg/m ³)	Total annual average TSP conc. (µg/m ³)
1	Illawong Ct	1.1	17.5
2	Myora Springs estate, Boronia Ct	3.6	20.0
3	Myora Conservation Park	1.1	17.5
4	Building (due east)*	0.1	16.5
5	Building SE*	0.2	16.6
6	Building SW*	0.5	16.9
7	Building WSW 1*	0.9	17.3
8	Building WSW 2*	0.8	17.2
9	Building WSW 3*	0.7	17.1

* directions of buildings refer to direction from active mine face.

The total TSP concentrations are well below guidelines at the off site discrete receptor locations.

⁸ Guidance Note on the Interpretation of Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:3008(1995)] 3rd Edition (Updated for Amendments). Available: <http://www.ascc.gov.au/ascc/AboutUs/Publications/NationalStandards/GuidanceNoteontheInterpretationofExposureStandardsforAtmosphericContaminantsintheOccupationalEnviron.htm>

Section 6

Results and Discussion

6.1.2 PM₁₀

Particulate matter with an aerodynamic diameter of less than 10 micron (PM₁₀) has a guideline of 50 µg/m³ for an annual averaging period and a guideline of 150 µg/m³ for a 24 hour averaging period. Table 6-2 shows the PM₁₀ concentration at the discrete receptors for each averaging period, presenting the impacts due to Unimin only as well as the total impact of Unimin operations and other background dust sources. It should be noted that the background values of 48.7 µg/m³ for a 24 hour averaging period and 16.4 µg/m³ for an annual averaging period are for EPA monitoring site at Wynnum, and are not strictly valid at the Vance site. Figure 6-2 shows the PM₁₀ concentration contours for an averaging period of 24 hours, and Figure 6-3 shows PM₁₀ concentration contours for an annual averaging period for dust impacts due to the Unimin operations only.

Table 6-2 PM₁₀ concentration at discrete receptors

Receptor number	Site	24 Hour average PM₁₀ Conc. (Unimin only) (µg/m³)	Total 24 Hour average PM₁₀ Conc. (µg/m³)	Annual average PM₁₀ Conc. (Unimin only) (µg/m³)	Total Annual average PM₁₀ Conc. (µg/m³)
1	Illawong Ct	7.1	55.8	0.5	16.9
2	Myora Springs estate, Boronia Ct	13.2	61.9	1.7	18.1
3	Myora Conservation Park	5.7	54.4	0.6	17.0
4	Building (due east)*	1.3	50.0	0.1	16.5
5	Building SE*	2.7	51.4	0.1	16.5
6	Building SW*	4.0	52.7	0.3	16.7
7	Building WSW 1*	5.5	54.1	0.4	16.8
8	Building WSW 2*	5.3	54.0	0.4	16.8
9	Building WSW 3*	4.4	53.1	0.4	16.8

* directions of buildings refer to direction from active mine face.

The PM₁₀ concentrations due to Unimin and background dust sources are below the guidelines at the off-site discrete receptor locations.

6.2 Dust Deposition

Interim dust deposition results for the monitoring program currently underway on site are available for comparison to modelled results. These data have been used to estimate a background dust level for the site of 2.8 g/m²/month, independent of mining activity undertaken by Unimin. The modelled dust deposition rates due to Unimin have been added to the background level for comparison to the EPA guideline of 4 g/m²/month.

The monthly deposition data from baseline monitoring is consistent with that of the modelled data for sites at a reasonable distance (sites 3, 4 and 5) from the major dust sources as identified in the emissions

Section 6

Results and Discussion

estimation study. Monitoring sites that are located very close to the active mine site (sites 1, 2 and 6) have a larger variance between modelled and measured values.

Table 6-3 shows the modelled results of dust deposition at the discrete receptors for the impacts due to Unimin only and the total impacts of Unimin and background dust sources. The predicted total dust levels at residential receptor locations are well below the EPA dust deposition guideline. Figure 6-4 shows the monthly average deposition contours predicted by the model, including the background levels measured during the monitoring program (2.8 g/m²/month).

Table 6-3 Dust deposition results

Receptor number	Site	Predicted dust deposition (Unimin only) (mg/m²/day)	Predicted dust deposition (Unimin only) (g/m²/month)	Total dust deposition (inc. Background level) (g/m²/month)
1	Illawong Ct	10.1	0.04	2.8
2	Myora Springs estate, Boronia Ct	35.4	0.30	3.1
3	Myora Conservation Park	15.9	0.05	2.9
4	Building (due east)*	5.6	0.01	2.8
5	Building SE*	4.0	0.01	2.8
6	Building SW*	6.4	0.02	2.8
7	Building WSW 1*	7.4	0.03	2.8
8	Building WSW 2*	6.7	0.03	2.8
9	Building WSW 3*	5.7	0.02	2.8

* directions of buildings refer to direction from active mine face.

Table 6-4 shows the predicted dust deposition results and the measured results from one year of dust deposition monitoring at the on-site monitoring locations. The results show that the model is reasonably accurate to determine dust deposition levels at receptors located further from the mine operations (Sites 3, 4 and 5). It must be noted that the predictions have been made with future dust emission sources while the measured data is for current and previous sources.

Section 6

Results and Discussion

Table 6-4 Model predictions and measured results for on-site receptors

Site	Predicted result (g/m ² /month)	Predicted result (inc. Background level) (g/m ² /month)	Average measured result (g/m ² /month)**
Deposition monitoring site 1	1.0	3.8	28.2
Deposition monitoring site 2	17.8	20.6	4.9
Deposition monitoring site 3	0.4	3.2	5.0
Deposition monitoring site 4	0.04	2.8	1.5
Deposition monitoring site 5	0.1	2.9	1.8
Deposition monitoring site 6	3.7	6.5	1.7

**Average results are for 12 months monitoring. Averages include data outliers.

Section 7

Conclusions

Unimin Australia Ltd. commissioned URS Australia Pty. Ltd. to provide a quantitative dust assessment of proposed mining activities on ML1108 and the current mining operation on North Stradbroke Island.

Dust emissions from the site were evaluated using information provided by Unimin and emission estimation techniques given by the National Pollutant Inventory.

The Ausplume dispersion model was used with meteorology derived from TAPM to provide predicted dust concentration and deposition results for the mining operations conducted by Unimin. The model included all sources of dust from the mining operations but did not include dust from vehicle exhausts.

A number of off-site discrete receptors were used around the mine including residential locations. All locations were evaluated for Total Suspended Particulate (TSP) Concentration, PM₁₀ Concentration and TSP Deposition. Background concentrations were sourced from EPA measurements at the Wynnum monitoring site, while deposition background results were used from onsite deposition monitoring data.

All results for dust concentration and deposition, including background levels, are well below the guidelines given by the Queensland EPA and the Redlands Shire Council.

Section 8

Limitations

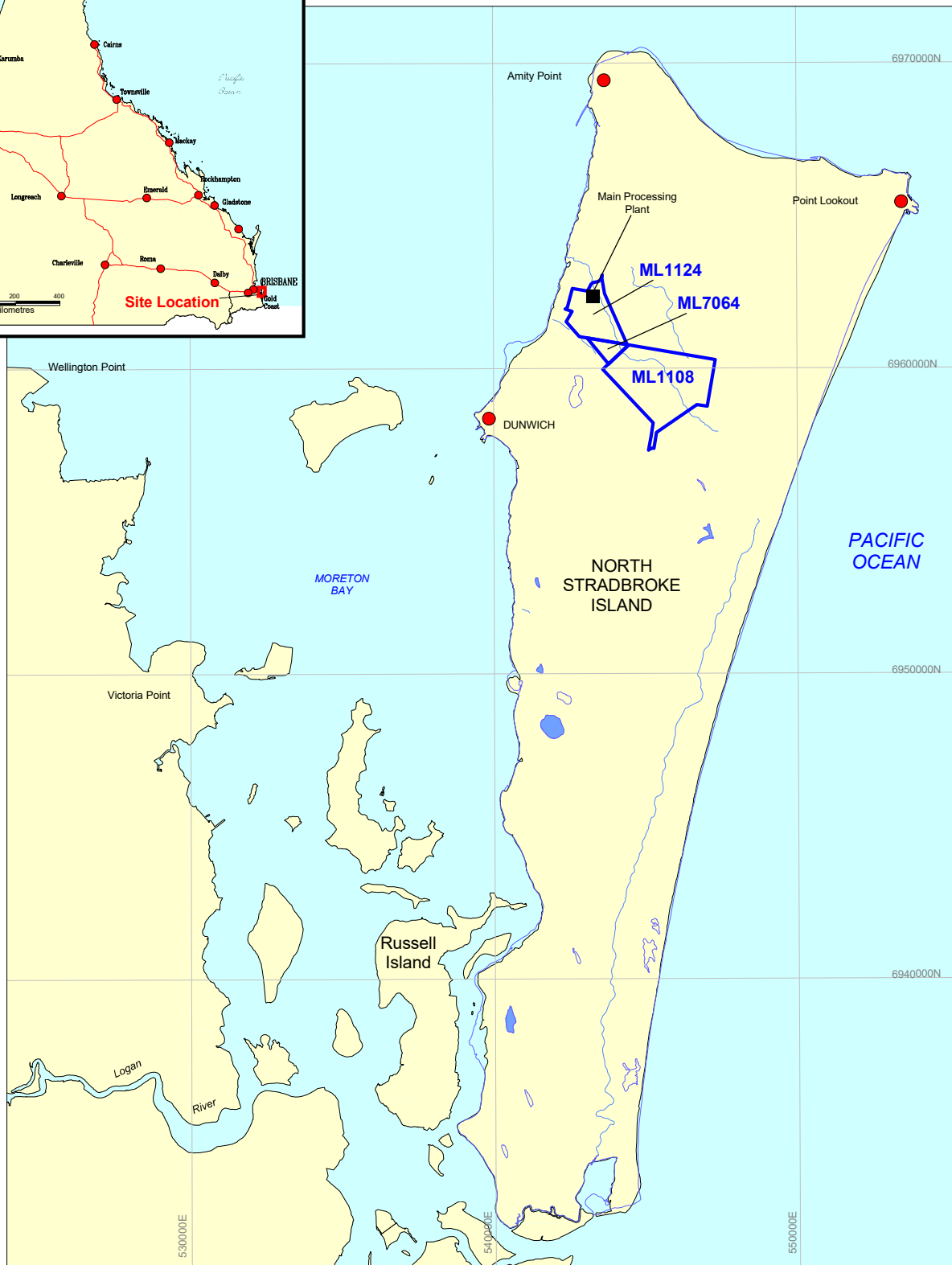
URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Unimin Australia Ltd. and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 19 January 2006.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between December 2006 and June 2007 and is based on the information supplied and reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

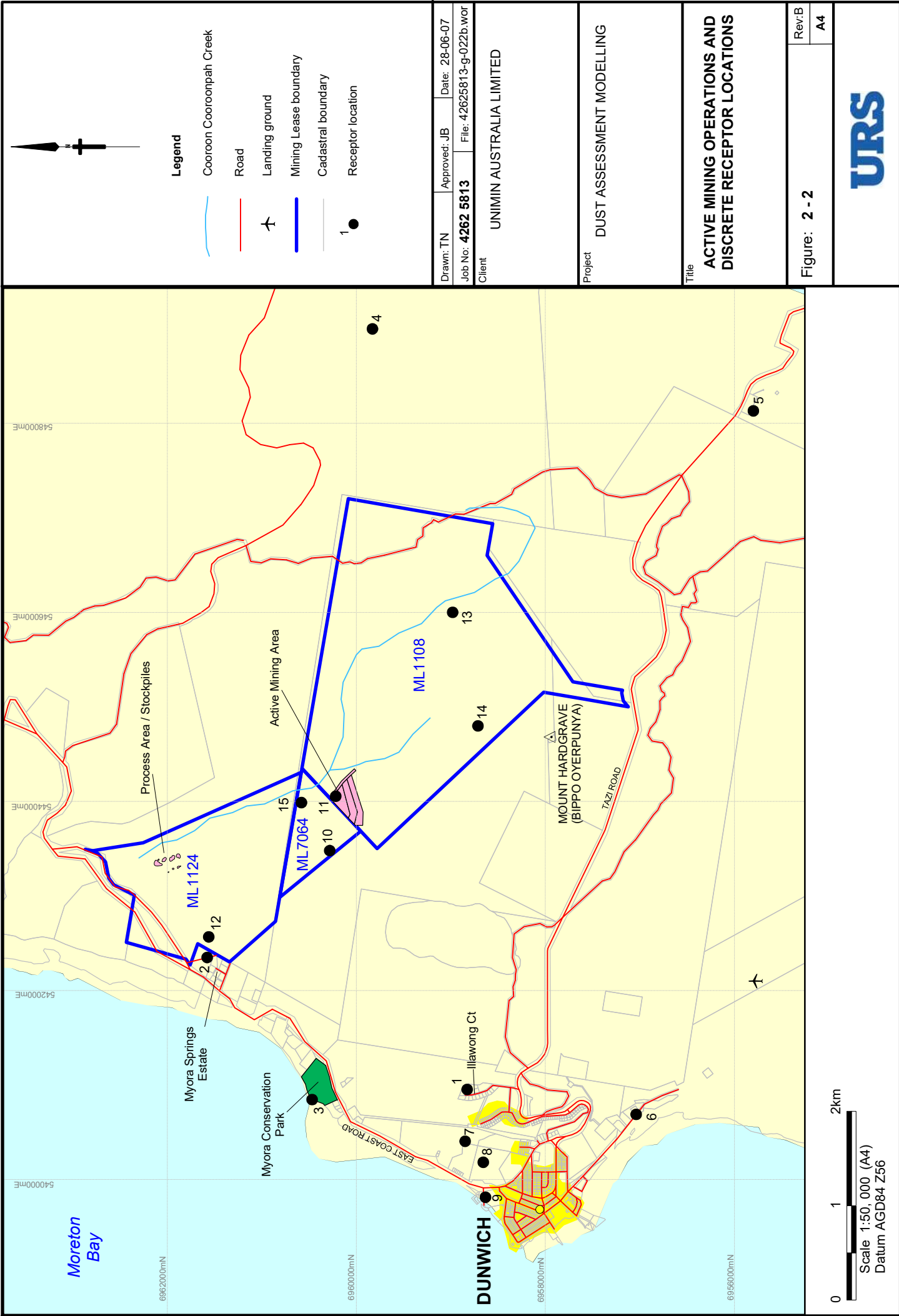
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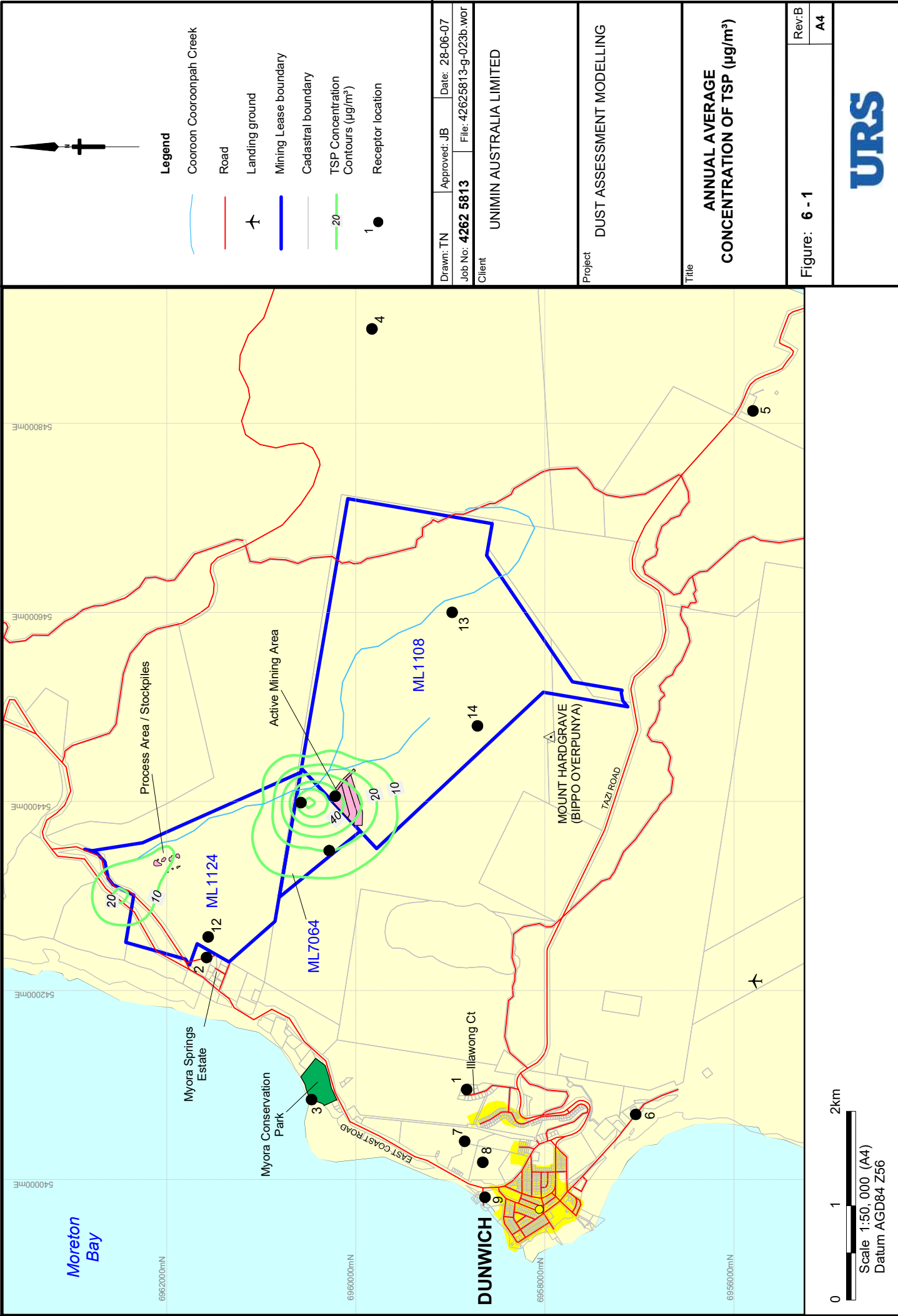


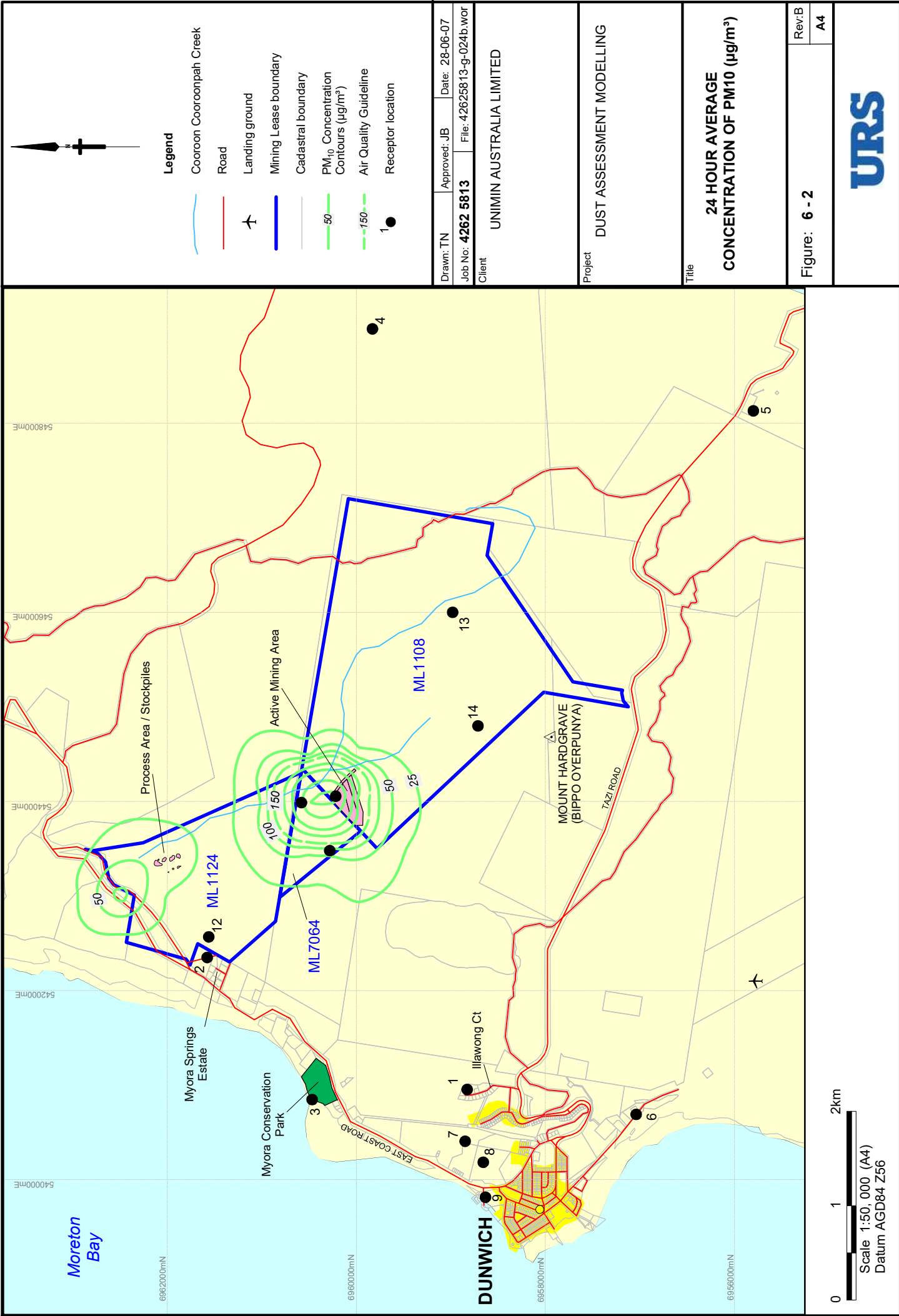
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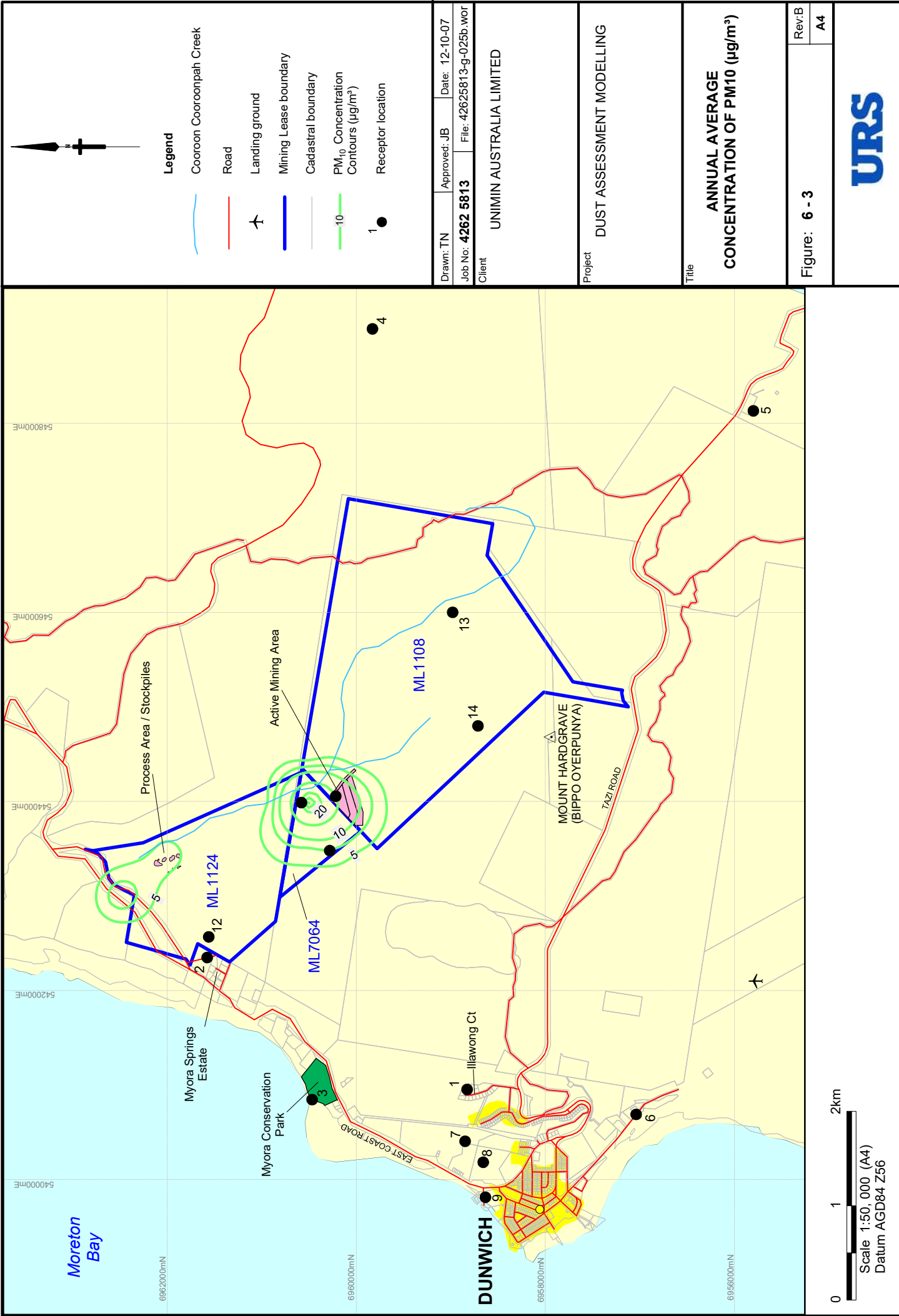
Source: AMITY 9543-22 & DUNWICH 9542-11 - 1:25000 Topographic Map

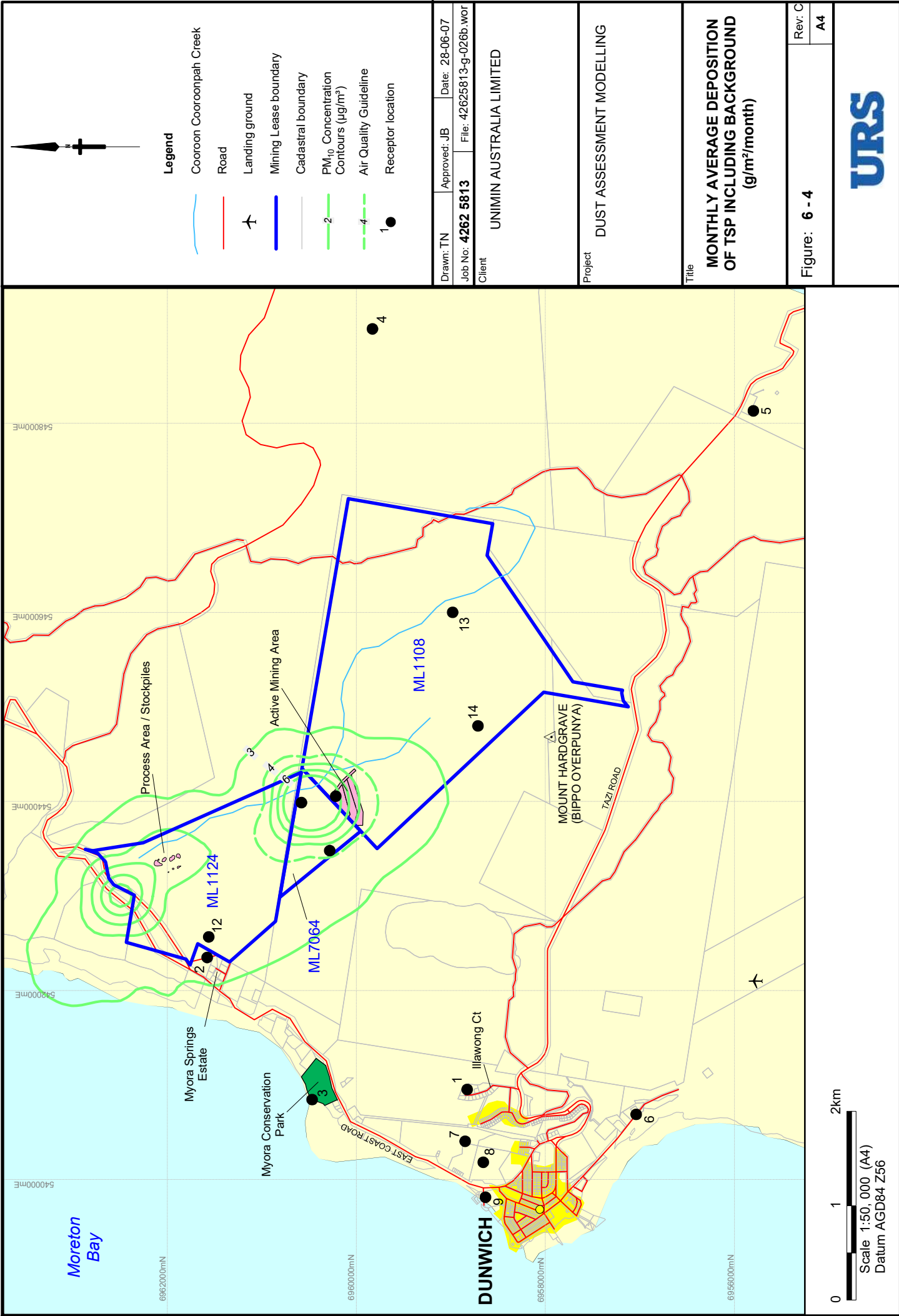
Client UNIMIN AUSTRALIA LIMITED	Project DUST ASSESSMENT MODELLING	Title LOCATION OF UNIMIN LEASES (ML1108, ML1124 and ML7064)	
	Drawn: TN	Approved: JB	Date: 28-06-2007
	Job No: 4262 5813	File No: 42625813-g-017b.wor	Figure: 2 - 1 Rev: B A4











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Appendix M

Noise Assessment Report (2006)

Unimin Australia Limited

**Mining Lease 7064, 1124 and 1108 (Vance Lease)
North Stradbroke Island**

Noise Impact Assessment

**Issue No. 1
8 August 2006**

Prepared For

Unimin Australia Limited

Prepared By

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Report Details:

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Author(s):	Noise Impact Assessment S Temelkoski & E O'Callaghan
Status:	Issue No.1
Client:	Unimin Australia Limited
Client Contact:	Mr. Jim Barker (URS Australia Pty Ltd)
Synopsis:	The report assesses the potential noise impacts associated with the proposed mine operation of ML1108 (Vance Lease) at the Unimin Sand Mine at North Stradbroke Island.

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1.0 Introduction

1.1 Background

Belleng VDM Pty Ltd was engaged by *URS Australia Pty Ltd* on behalf of *Unimin Limited Australia* (Unimin) to investigate the potential noise impacts associated with the proposed mining operations on ML1108 (Vance Lease) at the Unimin sand mine at North Stradbroke Island.

This noise impact assessment forms part of an overall environmental baseline study of the Vance Lease, being conducted by Unimin in accordance with its Environmental Authority (MIM900220203) for the lease.

1.2 Study Objectives

Study objectives are as follows:

- ñ Measurement of the existing background noise levels at the nearest noise sensitive places to the mine lease ML1108 (Vance Lease) to determine the existing noise amenity before the commencement of operations at ML1108.
- ñ Review of the plans of the existing and proposed mining operations to obtain information about the location and scope of activities undertaken at the existing mine leases (ML7064, where the current extraction is taking place and at ML1124, where the existing processing plant is located) and mine lease ML1108.
- ñ Assessment of the potential noise impact from ML1108 considering the maximum extent of operational boundaries, the hours of operation, the type and number of plant and equipment (including permanent processing plant, mobile plant, booster pumps, compressors, bulldozers, front end loaders and haul tracks) and site topography. The noise assessment is carried out on the basis of:
 - i. Determination of the existing noise amenity at the nearest noise sensitive places to the current operations at Unimin sand mine considering the background levels at the nearest noise sensitive places and the “intrusive noise” (present 1% and 10% of measurement interval) associated with typical noise sources present on site; and
 - ii. Determination of the operational noise impacts from proposed mining on ML1108 by detailed noise propagation modelling using SoundPLAN software.

2.0 Existing and Proposed Operations

2.1 Site Location

Unimin and its precursors have been operating the sand mine at North Stradbroke Island for 36 years. The processed sand is supplied to the local, interstate, and international glass works.

ML1108 is situated approximately 4 kilometres north east of Dunwich. Unimin proposes to continue the existing mining operations on ML7064 into the immediately adjacent ML1108. The current environment of ML1108 is relatively undisturbed bushland.

The site location of the existing leases is presented in Figures 2.1 and 2.2 below.

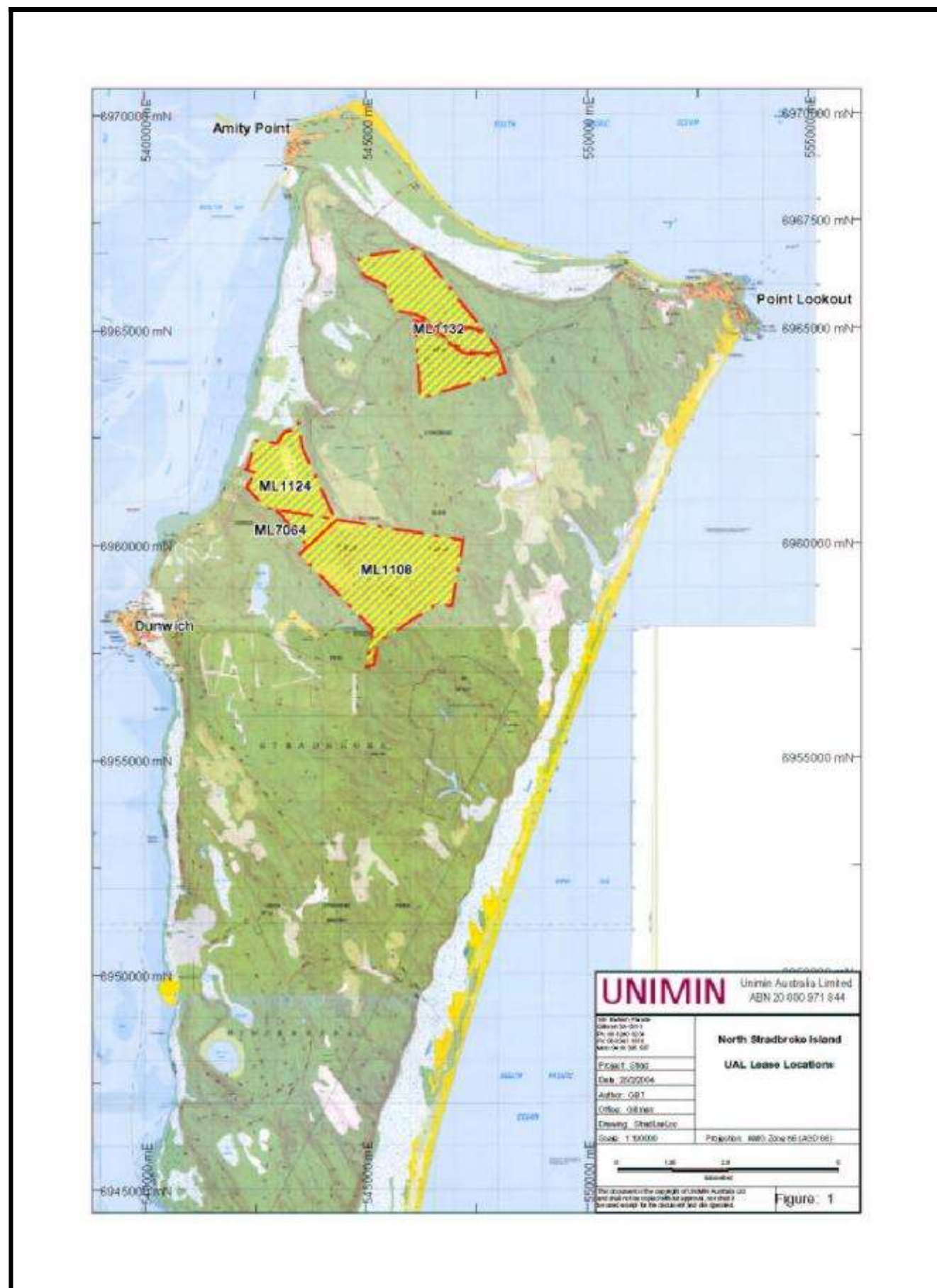
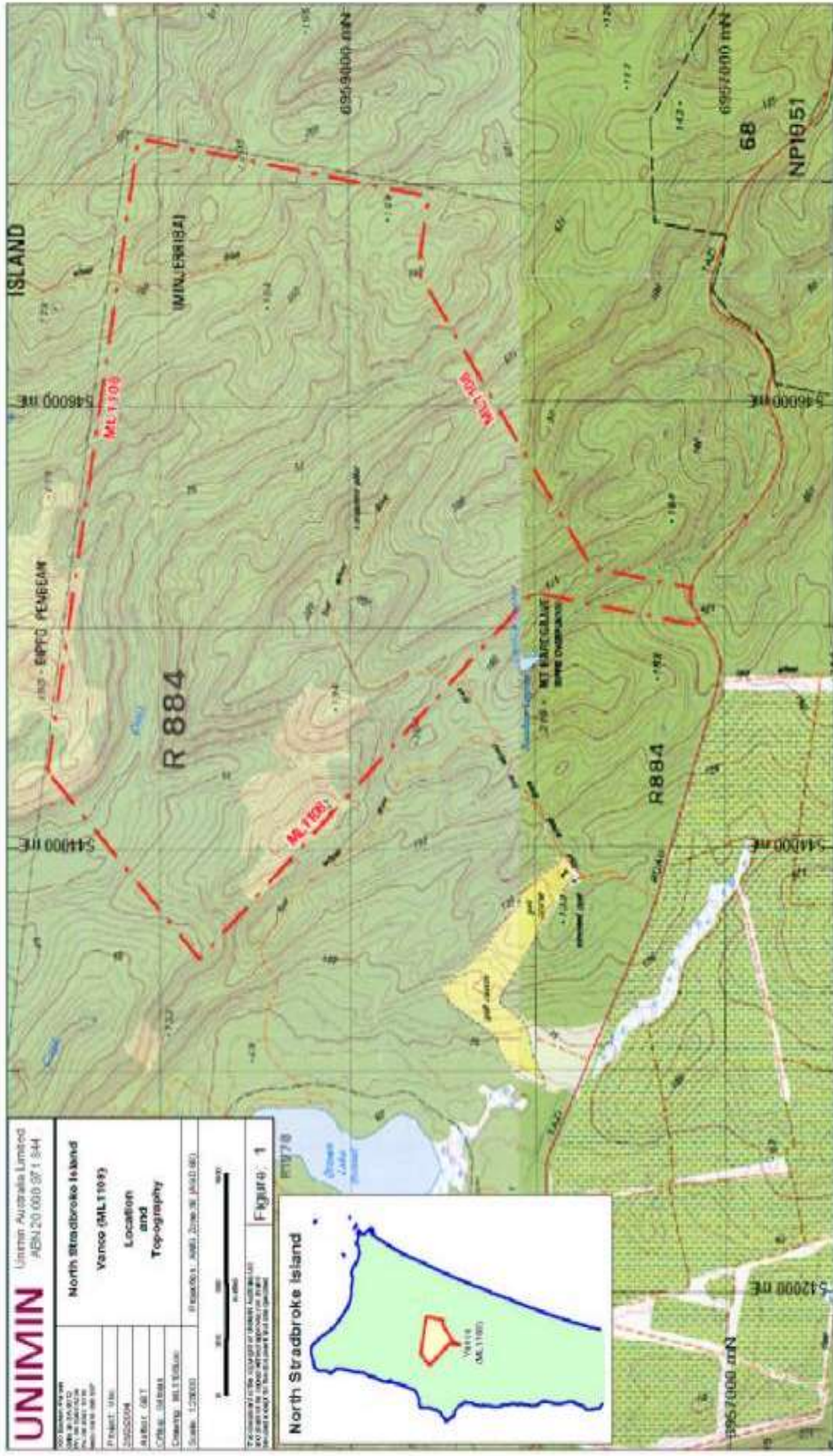


Figure 2.1 Unimin Lease Locations



2.2 Process Description

The high quality dune sand (unbounded sand) has been extracted from the sand deposits on Stradbroke Island for more than 35 years. The sand is mined in an open cut process that comprises of the following:

Dry mining by a front end loader and transfer into a feed hopper;
Primary screening through a trommel screen to remove roots and organic matter; and
Pumping of the sand slurry to the main processing plant.

Photographs of the dry mining process and the primary screening plant are presented in Appendix A (Photos 1 and 2).

The main processing plant is located on ML1124 (refer Figure 2.1). Gravity separation is used to remove heavy minerals that are concentrated, stockpiled and sold separately. The impurities (fine silica and clay) are pumped into settling dams on ML1124, while the purified sand is pumped as slurry to the stockpile area according to the grain size and purity. The main processing plant and the stockpile area is presented in Appendix A (Photos 3 and 4).

There will be no processing operations at the mine lease ML1108. It is proposed that the sand mining processes currently undertaken at mine lease ML7064 are continued. The existing processing plant and equipment will remain within ML1124, thus reducing potential impacts due to relocation.

The resource to be extracted from ML1108 is high quality dune sand. Drilling and analysis will be undertaken to determine the quality and quantity of this resource and the best mining practices to ensure environmental feasibility. A five year mine plan will be developed specifying the staging of the extraction processes and:

The starting point of the extraction process;
Progress schedule; and
Depth of mining and the quality of the resource.

It is envisaged that up to one million tonnes per year of sand will be extracted and the above information will be used to develop the Plan of Operations for the site.

2.3 Noise Sources

The Unimin sand mine at North Stradbroke Island is in its 36th year of operation. Currently, the sandmine operates 3 days per week (Monday, Tuesday and Wednesday). The extraction activities (at existing lease ML7064) are conducted continuously (24-hour operation) during the three days of operation in each week. The main processing plant also operates continuously (24-hour operation) every Monday, Tuesday and Wednesday of each week.

The mining activities on ML1108 will operate as per the current operating hours of the existing lease. The 24-hour operations will involve the following noise sources:

Single front end loader at the extraction site;
Primary screen to remove roots and organic matter;
Pumping of the sand slurry to the main processing plant; and
Booster pumps along the slurry pipe network (maximum of three pumps in operation).

In addition to the plant and equipment operating 24-hours, the day-time operations (7:00am to 6:00pm) will involve the following noise sources:

Single tracked bulldozer engaged in vegetation clearing, and post-extraction land contouring;
Front end loaders operating at the stockpile area; and
Haul truck movements in and out of the stockpile area.

The sand mine operations are carried out by dry mining of fine sand that is available for loading via front end loaders directly from the extraction face. There is no need for blasting or drilling to uncover or dislodge the resource. The mined sand is very fine and there is no need for crushing of the extracted resource.

No blasting, drilling or crushing activities will be undertaken on ML1108.

The operations on ML1108 will be a continuation of the existing operations carried out at the currently active lease ML7064. There will be no increase in production or increase in the number of haul trucks entering and leaving the site.

2.4 Noise Sensitive Places

ML1108 is situated to the north-east of the township of Dunwich and to the south-east of the recently established residential subdivision "*Myora Springs*". The nearest residences to the current and proposed operations are the residences of Boronia Court at "*Myora Springs*". The shortest horizontal distance from the property boundaries of these residences to the main processing plant is 1.2km

The other residences in proximity to the current and proposed operations are the residences along Illawong Street at the eastern outskirts of Dunwich. The shortest horizontal distance from the property boundaries of these residences to the main processing plant is 4km.

The locations of the nearest noise sensitive places relative to current operations and those proposed on ML1108 are presented in Figure 2.3 below.

3.0 Noise Impact Assessment (Current Situation)

3.1 Noise Criteria (Noise Limits)

The noise criteria (noise limits) applicable to the mining operations on ML1108 are specified in Table 1 of Schedule D–Noise of the *Environmental Authority No. MIM900220203*. The noise criteria are presented in Table 3.1 below.

Table 3.1 Noise Criteria (Noise Limits)

Noise Level dB(A) (Measured as)	Monday to Saturday			Sundays and public holidays		
	7am-6pm	6pm-10pm	10pm-7am	9am-6pm	6pm-10pm	10pm-9am
Noise Measured at “Noise Sensitive Place”*						
L_{A10}, adj., 10 mins	b/g+5	b/g+5	b/g+3	b/g+5	b/g+5	b/g+0
L_{A1}, adj., 10 mins	b/g+10	b/g+10	b/g+5	b/g+10	b/g+10	b/g+5
Noise Measured at “Commercial Place”*						
L_{A10}, adj., 10 mins	b/g+10	b/g+10	b/g+5	b/g+10	b/g+10	b/g+5
L_{A1}, adj., 10 mins	b/g+15	b/g+15	b/g+10	b/g+15	b/g+15	b/g+10

*Table 1 of Schedule D–Noise Environmental Authority No. MIM900220203 issued by the Environmental Protection Agency.

b/g = background noise level measured in the absence of the investigated noise source.

3.2 Noise Measurement Locations

Belleng VDM Pty Ltd carried out noise monitoring at two locations representative of the nearest noise sensitive places to the existing and proposed mining operations. The noise measurements were undertaken continuously over a period of 7-days from 24th May 2006 (Wednesday) to 30th May 2006 (Tuesday). The noise measurement locations are presented in Figure 3.1 below and in Appendix A (Photo 5 and 6).

Considering that the main extraction activities are undertaken over 24-hours for three days of the week, the noise measurement data recorded on Wednesday (24th May 2006), Monday (29th May 2006) and Tuesday (30th May 2006) is considered representative of the impact of the existing mining operations on the nearest residential areas.

The noise measurement data recorded on Thursday (25th May 2006), Friday (26th May 2006), Saturday (27th May 2006) and Sunday (28th May 2006) is considered representative of the existing background noise levels in the absence of noise emissions from the mine site.

In addition to the long-term noise logging, attended short-term (T=10 minutes) noise measurements were carried out to determine the L_{A1,adj,T} and L_{A10,adj,T} noise levels at the two long-term noise measurement locations.

The short-term noise measurements were carried out on 31st May 2006 (Wednesday), during day-time. The measurements were carried out under the following mine operating conditions:

ñ Boronia Court	(12:52pm – 1:02pm)	Mine Inoperative (Power Failure)
ñ Boronia Court	(4:17pm – 4:27pm)	Mine in Full Operation
ñ Illawong Street	(11:54am – 12:04pm)	Mine Inoperative (Power Failure)
ñ Illawong Street	(3:55pm – 4:05pm)	Mine in Full Operation

3.3 Equipment Used

Noise levels were measured using the following equipment.

- ñ Australian Research Laboratory Noise Loggers AL 315 (2 Units)
- ñ Sound Level Meter (with 1/3 band analyser) SVAN 947 (Serial Number: 5243)
- ñ Sound Level Calibrator RION NC - 73

The noise measurement instruments used conform to ASIEC61672.1-2004 and the measurements were undertaken in general accordance with Environmental Protection Agency *Noise Measurement Manual* and AS1055.1–1997 and AS1055.2–1997.

The noise measurement instruments were calibrated before and after the noise measurements. The maximum calibration drift recorded was <0.1 dB(A).

The prevailing meteorological conditions during the noise measurements were fine with light to moderate south-easterly wind.

3.4 Background Noise Measurement Results

3.4.1 Boronia Court – “Myora Springs”

The results of the background noise measurements (daytime) are presented in Table 3.2 below and in graphical form in Appendix B.

Table 3.2 Boronia Court - Background Noise Measurement Results – Daytime

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Boronia Court	25 May 2006 Thursday (7:00am to 6:00pm)	L ₁₀ ¹	43
		L ₉₀ ²	32
		L ₁ ³	49
Boronia Court	26 May 2006 Friday (7:00am to 6:00pm)	L ₁₀	42
		L ₉₀	31
		L ₁	50
Boronia Court	27 May 2006 Saturday (7:00am to 6:00pm)	L ₁₀	43
		L ₉₀	32
		L ₁	52
Boronia Court	28 May 2006 Sunday (7:00am to 6:00pm)	L ₁₀	41
		L ₉₀	31
		L ₁	51
Typical Background Noise Levels		L ₁₀	42
		L ₉₀	32
		L ₁	51

¹ “Intrusive Noise Level” is the A-weighted sound pressure level equalled or exceeded for 10% of the time interval of the noise measurement.

² “Background Noise Level” is the A-weighted sound pressure level equalled or exceeded for 90% of the time interval of the noise measurement.

³ “Intrusive Noise Level” is the A-weighted sound pressure level equalled or exceeded for 1% of the time interval of the noise measurement (Referred to as an “average maximum noise level”).

The results of the background noise measurements (evening) are presented in Table 3.3 below and in graphical form in Appendix B.

Table 3.3 Boronia Court - Background Noise Measurement Results – Evening

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Boronia Court	25 May 2006 Thursday (6:00pm to 10:00pm)	L ₁₀	35
		L ₉₀	28
		L ₁	41
Boronia Court	26 May 2006 Friday (6:00pm to 10:00pm)	L ₁₀	35
		L ₉₀	27
		L ₁	40
Boronia Court	27 May 2006 Saturday (6:00pm to 10:00pm)	L ₁₀	38
		L ₉₀	29
		L ₁	45
Boronia Court	27 May 2006 Sunday (6:00pm to 10:00pm)	L ₁₀	35
		L ₉₀	29
		L ₁	42
Typical Background Noise Levels		L ₁₀	36
		L ₉₀	28
		L ₁	42

The results of the background noise measurements (night-time) are presented in Table 3.4 below and in graphical form in Appendix B.

Table 3.4 Boronia Court - Background Noise Measurement Results – Night-time

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Boronia Court	25 May 2006 Thursday (10:00pm to 7:00am)	L ₁₀	32
		L ₉₀	29
		L ₁	37
Boronia Court	26 May 2006 Friday (10:00pm to 7:00am)	L ₁₀	31
		L ₉₀	28
		L ₁	35
Boronia Court	27 May 2006 Saturday (10:00pm to 7:00am)	L ₁₀	31
		L ₉₀	28
		L ₁	37
Boronia Court	27 May 2006 Sunday (10:00pm to 7:00am)	L ₁₀	31
		L ₉₀	28
		L ₁	36
Typical Background Noise Levels		L ₁₀	31
		L ₉₀	28
		L ₁	36

3.4.2 Illawong Street – Dunwich

The results of the background noise measurements (daytime) are presented in Table 3.5 below and in graphical form in Appendix B.

Table 3.5 Illawong Street - Background Noise Measurement Results – Daytime

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Illawong Street	25 May 2006 Thursday (7:00am to 6:00pm)	L ₁₀	37
		L ₉₀	29
		L ₁	48
Illawong Street	26 May 2006 Friday (7:00am to 6:00pm)	L ₁₀	41
		L ₉₀	30
		L ₁	51
Illawong Street	27 May 2006 Saturday (7:00am to 6:00pm)	L ₁₀	39
		L ₉₀	28
		L ₁	49
Illawong Street	28 May 2006 Sunday (7:00am to 6:00pm)	L ₁₀	40
		L ₉₀	29
		L ₁	51
Typical Background Noise Levels		L ₁₀	39
		L ₉₀	29
		L ₁	50

The results of the background noise measurements (evening) are presented in Table 3.6 below and in graphical form in Appendix B.

Table 3.6 Illawong Street - Background Noise Measurement Results – Evening

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Illawong Street	25 May 2006 Thursday (6:00pm to 10:00pm)	L ₁₀	33
		L ₉₀	28
		L ₁	42
Illawong Street	26 May 2006 Friday (6:00pm to 10:00pm)	L ₁₀	35
		L ₉₀	31
		L ₁	41
Illawong Street	27 May 2006 Saturday (6:00pm to 10:00pm)	L ₁₀	33
		L ₉₀	28
		L ₁	44
Illawong Street	27 May 2006 Sunday (6:00pm to 10:00pm)	L ₁₀	34
		L ₉₀	27
		L ₁	44
Typical Background Noise Levels		L ₁₀	34
		L ₉₀	29
		L ₁	43

The results of the background noise measurements (night-time) are presented in Table 3.7 below and in graphical form in Appendix B.

Table 3.7 Illawong Street - Background Noise Measurement Results – Night-time

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Illawong Street	25 May 2006 Thursday (10:00pm to 7:00am)	L ₁₀	32
		L ₉₀	27
		L ₁	42
Illawong Street	26 May 2006 Friday (10:00pm to 7:00am)	L ₁₀	32
		L ₉₀	27
		L ₁	41
Illawong Street	27 May 2006 Saturday (10:00pm to 7:00am)	L ₁₀	31
		L ₉₀	26
		L ₁	41
Illawong Street	27 May 2006 Sunday (10:00pm to 7:00am)	L ₁₀	32
		L ₉₀	27
		L ₁	41
Typical Background Noise Levels		L ₁₀	32
		L ₉₀	27
		L ₁	41

3.5 Operational Noise Measurement Results

3.5.1 Boronia Court – “Myora Springs”

The results of the noise measurements (daytime) when the sand mine is at full operation (24-hour operation) are presented in Table 3.8 below and in graphical form in Appendix B.

Table 3.8 Boronia Court – Operational Noise Results – Daytime

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Boronia Court	24 May 2006 Wednesday (7:00am to 6:00pm)	L ₁₀	42
		L ₉₀	32
		L ₁	49
Boronia Court	29 May 2006 Monday (7:00am to 6:00pm)	L ₁₀	40
		L ₉₀	30
		L ₁	48
Boronia Court	30 May 2006 Tuesday (7:00am to 6:00pm)	L ₁₀	41
		L ₉₀	31
		L ₁	48
Typical Operational Noise Levels		L ₁₀	41
		L ₉₀	31
		L ₁	48

The results of the noise measurements (evening) when the sand mine is at full operation (24-hour operation) are presented in Table 3.9 below and in graphical form in Appendix B.

Table 3.9 Boronia Court – Operational Noise – Evening

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Boronia Court	24 May 2006 Wednesday (6:00pm to 10:00pm)	L ₁₀	37
		L ₉₀	30
		L ₁	42
Boronia Court	29 May 2006 Monday (6:00pm to 10:00pm)	L ₁₀	32
		L ₉₀	27
		L ₁	41
Boronia Court	30 May 2006 Tuesday (6:00pm to 10:00pm)	L ₁₀	35
		L ₉₀	27
		L ₁	42
Typical Operational Noise Levels		L ₁₀	35
		L ₉₀	28
		L ₁	42

The results of the noise measurements (night-time) when the sand mine is at full operation (24-hour operation) are presented in Table 3.10 below and in graphical form in Appendix B.

Table 3.10 Boronia Court – Operational Noise – Night-time

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Boronia Court	24 May 2006 Wednesday (10:00pm to 7:00am)	L ₁₀	32
		L ₉₀	28
		L ₁	38
Boronia Court	29 May 2006 Monday (10:00pm to 7:00am)	L ₁₀	31
		L ₉₀	28
		L ₁	36
Boronia Court	30 May 2006 Tuesday (10:00pm to 7:00am)	L ₁₀	31
		L ₉₀	28
		L ₁	37
Typical Operational Noise Levels		L ₁₀	31
		L ₉₀	28
		L ₁	37

3.5.2 Illawong Street – Dunwich

The results of the noise measurements (day-time) when the sand mine is at full operation (24-hour operation) are presented in Table 3.11 below and in graphical form in Appendix B.

Table 3.11 Illawong Street – Operational Noise – Daytime

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Illawong Street	24 May 2006 Wednesday (7:00am to 6:00pm)	L ₁₀ ⁴	38
		L ₉₀ ⁵	29
		L ₁ ⁶	49
Illawong Street	29 May 2006 Monday (7:00am to 6:00pm)	L ₁₀	39
		L ₉₀	29
		L ₁	50
Illawong Street	30 May 2006 Tuesday (7:00am to 6:00pm)	L ₁₀	37
		L ₉₀	28
		L ₁	48
Typical Operational Noise Levels		L ₁₀	39
		L ₉₀	29
		L ₁	49

The results of the noise measurements (evening) when the sand mine is at full operation (24-hour operation) are presented in Table 3.12 below and in graphical form in Appendix B.

Table 3.12 Illawong Street – Operational Noise – Evening

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Illawong Street	24 May 2006 Wednesday (6:00pm to 10:00pm)	L ₁₀	35
		L ₉₀	30
		L ₁	43
Illawong Street	29 May 2006 Monday (6:00pm to 10:00pm)	L ₁₀	33
		L ₉₀	29
		L ₁	43
Illawong Street	30 May 2006 Tuesday (6:00pm to 10:00pm)	L ₁₀	31
		L ₉₀	27
		L ₁	41
Typical Operational Noise Levels		L ₁₀	33
		L ₉₀	29
		L ₁	42

⁴ "Intrusive Noise Level" is the A-weighted sound pressure level equalled or exceeded for 10% of the time interval of the noise measurement.

⁵ "Background Noise Level" is the A-weighted sound pressure level equalled or exceeded for 90% of the time interval of the noise measurement.

⁶ "Equivalent Continuous A-weighted Sound Pressure Level" is the A-weighted sound pressure level of a continuous steady sound that within a specified interval has the same mean square sound pressure as a sound whose level varies with time.

The results of the noise measurements (night-time) when the sand mine is at full operation (24-hour operation) are presented in Table 3.13 below and in graphical form in Appendix B.

Table 3.13 Illawong Street – Operational Noise – Night-time

Description	Date/Time	L _T	Average Sound Pressure Level dB(A)
Illawong Street	24 May 2006 Wednesday (10:00pm to 7:00am)	L ₁₀	30
		L ₉₀	26
		L ₁	39
Illawong Street	29 May 2006 Monday (10:00pm to 7:00am)	L ₁₀	30
		L ₉₀	26
		L ₁	41
Illawong Street	30 May 2006 Tuesday (10:00pm to 7:00am)	L ₁₀	30
		L ₉₀	26
		L ₁	41
Typical Operational Noise Levels		L ₁₀	30
		L ₉₀	26
		L ₁	40

3.6 Attended Noise Measurements

3.6.1 Boronia Court – “Myora Springs”

The results of the attended noise measurements (daytime) are presented in Table 3.14 below and in Appendix C.

Table 3.14 Boronia Court – Attended Noise Measurements – Daytime

Description	Date/Time	L _T	Sound Pressure Level dB(A)	Observed Noise Sources*
Boronia Court (Mine Non-operational)	31 May 2006 Wednesday (12:52pm -1:02pm)	L ₁₀	39	Birds chirping, brief distant dog barking, traffic on East Coast Road.
		L ₉₀	28	
		L ₁	53	
Boronia Court (Mine at Full Operation)	31 May 2006 Wednesday (4:17pm – 4:27pm)	L ₁₀	45	Birds chirping, brief distant dog barking, traffic on East Coast Road and local traffic on Boronia Court.
		L ₉₀	29	
		L ₁	61	

*No noise that can be associated with the mine operations could be heard above the noise sources typical for the area.

3.6.2 Illawong Street

The results of the attended noise measurements (daytime) are presented in Table 3.15 below and in Appendix C.

Table 3.15 Illawong Street – Attended Noise Measurements – Daytime

Description	Date/Time	L _T	Sound Pressure Level dB(A)	Observed Noise Sources*
Illawong Street (Mine Non-operational)	31 May 2006 Wednesday (11:54am -12:04pm)	L ₁₀ L ₉₀ L ₁	34 26 45	Birds chirping, brief distant dog barking, single vehicle movement on Illawong Street.
Illawong Street (Mine at Full Operation)	31 May 2006 Wednesday (3:55pm – 4:05pm)	L ₁₀ L ₉₀ L ₁	40 30 48	Birds chirping, brief distant dog barking, distant plane flyover, high-pitched shrieks of lorikeets.

*No noise that can be associated with the mine operations could be heard above the noise sources typical for the area.

3.7 Discussions

The analysis of the long-term noise measurement data recorded at the two nearest noise sensitive places to the existing and proposed mine lease, revealed very low background noise levels. The noise levels measured are similar to the amenity in typical rural areas of Queensland unaffected by transportation, commercial or industrial noise emissions.

In addition to the background noise levels (present 90% of the measurement period), the noise levels that are present for short duration (1% and 10% of the time) are also included. The short duration noise levels (sometimes called “intrusive noise”) are the result of emissions from either natural or man made sources that are typical of the noise measurement locations.

The background and the “intrusive” noise levels are part of the overall noise amenity at the nearest noise sensitive places. In this case the overall noise amenity at the two measurement locations can be defined as “*areas with negligible transportation*” (AS1055.3 – 1997). It is important to note that the description “*areas with negligible transportation*” is one of four noise categories (R1 to R4) defined in AS1055.3-1997. Only noise categories R3 and R4 (with night-time background noise levels higher than 40dB(A)_{L_{A90,T}}) are considered to have an overall noise amenity influenced by commerce or industry. The short-term variations in the noise levels due to existing natural and man made sources, typical of the area, do not result in adverse noise amenity.

The description of the existing noise amenity in terms of background and existing “intrusive” noise is important because of the further comparisons with the noise levels when the sand mine is operating continuously (day, evening and night-time), and with the noise limits imposed in the *Environmental Authority No. MIM900220203*.

The analysis of the long-term noise measurement data recorded at the two nearest noise sensitive places, when the mine is at continuous (24-hour) operation, revealed no changes in the background noise levels. The typical background noise levels, when the mine is in full operation are the same as when the mine was not operating. Over the long-term

monitoring period, the noise levels that are present for short duration (1% and 10% of the time) also show no signs of influence by the noise emissions from the mine operations.

The short-term (10-minute interval) noise measurements also show very low background noise levels and “intrusive noise levels” (L_{A1} , and L_{A10}) that are a result of typical local noise sources normally present at the investigated sites. Typical noise sources present at the two nearest noise sensitive places are birds, dogs, traffic on East Coast Road, local car movements and plane flyover from the local airport. The short-term variations in the noise levels are not influenced by the operational status of the sand mine.

The graphical presentation of the noise measurement data reveals that the typical noise sources, normally associated with the investigated sites, contribute to the variations in the “intrusive noise levels” (L_{A1} , and L_{A10}). The variations in the noise levels (particularly the short-term events) are evident from the presented graphs of noise measurement data in Appendix B.

Overall throughout the continuous noise measurement period of 7-days (24th May to 30th May 2006), the typical noise amenity at the two nearest noise sensitive places remained quiet. The results of the noise measurements confirmed the subjectively observed absence of any “intrusive” noise that can be attributed to the current operations of the sand mine.

The relatively low noise emissions from the sand mine operations (discussed further in this report), the significant distance of 4 kilometres, as well as the terrain, contribute to a high level of noise attenuation and absence of noise impact from the current operations at mine leases ML1124 and ML7064.

4.0 Noise Impact Assessment (ML1108 Proposed Operations)

4.1 Computer Modelling Method

The industrial module of the SoundPLAN acoustic modelling software was used to calculate the noise at the receiver locations. The calculations were carried out as per the procedures specified in the International Standard ISO9613. The calculation method for a single frequency is as follows:

$$L_s = [L_w + D_i + K_0] - [D_s + \Sigma D]$$

Where:

- L_s sound pressure for a single frequency
- L_w sound power
- D_i directivity of the source
- K_0 spherical model
- D_s spreading
- ΣD different contributing factors

The noise propagation losses, in addition to spreading, are calculated as a combination of screening, volume absorption (foliage, buildings) and the ground attenuation. In a large scale model dominated by distance, where the ground attenuation dominates the effect of the screening is zero dB. Where the screening effect by natural or man made obstacles along the noise propagation path are bigger than the ground absorption, the ground absorption is ignored.

Under the ISO9613 calculation method the noise level at the receiver is calculated in terms of A-weighted equivalent sound pressure level (L_{Aeq}). To convert the noise propagation results from L_{Aeq} into L_{A10} noise levels, the following adjusting factor was used:

$$L_{A10} = L_{Aeq} + 3dB(A)$$

The noise propagation results were obtained as tabulated results as well as noise contours at 10m intervals and with an angle increment of 5°. The receivers were located at an elevation of 1.5m above ground level in free-field conditions as per the location of the long-term noise measurement locations. Conservative assumptions were made about the operational conditions at the sand mine, as follows:

- ñ All noise sources at the mine site operate continuously for 24-hours;
- ñ Considering the significant distance from the sources to the receivers all sources were considered continuously operated point sources;
- ñ There are no noise control measures implemented on site or at the receivers;
- ñ The noise emissions from the sources that are associated with dominant noise at certain frequencies, such as booster pumps and the site generator, were adjusted for tonality by addition of 5dB(A);
- ñ Current situation was modeled as per the survey plan of the existing operations obtained from Unimin;
- ñ The mine lease ML1108 operations were modelled considering that the main processing plant and the booster pumps will remain at their current location (within ML1124); and
- ñ All plant and equipment proposed for ML1108 are located at the nearest (south-western) corner of the lease at an elevation as per the current topographical survey.

4.2 Sound Power Levels of the Main Noise Sources

Belleng VDM Pty Ltd carried out field measurements of the sound pressure levels (noise survey) at proximity to the main noise sources at the sand mine on the 31st May 2006. Attended noise measurements were carried out on the following noise sources using a Svantek 947 Sound Level Meter:

- ñ Main processing plant;
- ñ Primary screening plant;
- ñ Front end loader at the extraction face;
- ñ Front end loader at the stockpile area;
- ñ Bulldozer used for clearing of vegetation prior to extraction;
- ñ Booster pumps; and
- ñ Site Generator.

The noise measurements were carried out as per the procedures from AS1217.7-1985.

Typical noise emissions (sound power levels) of the above noise sources were considered in the calculations. The maximum noise levels (L_{Amax}) from the dominant noise sources are presented in Table 4.1 below.

Table 4.1 Measured Sound Pressure Level of Noise Sources

Description	Dist (m)	dB(A)	Octave Band Centre Frequency (Hz)							
			63	125	250	500	1k	2k	4k	8k
Booster Pump - Raw Feed (Sand) - 110kW	1	87	66	69	67	68	69	81	83	70
Booster Pump 2 from the Pond - 110kW	1	86	76	79	82	84	82	79	73	67
Booster Pump 1 from the Pond - 75kW	1	84	73	85	85	81	79	76	70	60
Booster Pump - Water Feed - 37kW	1	88	66	70	68	75	75	85	81	66
D9L Loader, raising and lowering bucket/plough	5	86	78	88	82	82	82	80	74	64
Main Processing Plant - Eastern Façade setback 5m	5	74	71	70	69	70	69	67	64	58
Main Processing Plant - Northern Façade setback 5m	5	74	65	68	73	69	70	67	63	56
Main Processing Plant - Southern Façade setback 5m	5	74	72	72	72	68	69	67	65	61
Main Processing Plant - Western Façade setback 5m	5	71	68	67	74	68	65	63	60	56
"Second Wash" Pump	1	83	74	75	85	81	79	72	67	61
Mack 410hp Semi, with a full load, taking off	4	75	81	73	69	70	69	69	67	60
Mobile Generator (with Mobile plant) with both doors open	2	89	87	93	84	85	84	83	78	73
Raw feed Plant Pump (mobile Plant) Fully Operational	2	81	81	77	75	77	77	74	71	63
Rotating separator - Fully Operational	2	76	84	75	73	71	71	70	68	64

4.3 Noise Propagation Modelling Results

4.3.1 Current Situation

The current situation as per operations at ML1124 and ML7064 was modelled considering the Digital Terrain Model (DTM) developed for the whole of North Stradbroke Island based on survey information obtained from Queensland Department of Natural Resources, Mines and Water (NRM&W) and the survey plan of the existing operations obtained from Unimin.

The noise propagation modelling results are presented in Table 4.2 below and in Appendix C.

Table 4.2 Noise Modelling Results (Current Situation)

Location	Calculated $L_{10,adj}$ (24-hour)* dB(A)	Criteria (Day-time/Evening) $L_{10,adj}$ (10-min)* dB(A)	Criteria (Night-time) $L_{10,adj}$ (10-min)* dB(A)
Boronia Court	32	37	31
Illawong Street	25	34	30

*Free-field conditions.

Under the conservative modelling assumptions, the current operations at the sand mine fully comply with the licence conditions (noise criteria) during day-time and evening at Boronia Court. Slight exceedance of the noise criteria by 1dB(A) is possible during night-time at this location. The exceedance of the criteria is only of a theoretical nature, as the calculated noise levels of 31dB(A) $L_{10,adj}$ are indistinguishable from the naturally occurring noise levels at the investigated site.

Full compliance with the license conditions (noise criteria) during day-time, evening and night-time is achieved at Illawong Street. This is expected considering the separation distance of 4km between Illawong Street and the mine.

4.3.2 Proposed Operations at ML1108

The proposed operations on ML1108 will be a continuation of the existing operations carried out on ML7064. There will be no increase in production or increase in the number of haul trucks entering and leaving the site.

Considering the site topography, worst-case noise propagation modelling was carried out to determine the potential noise impact from the operations at ML1108. The model was established with a conservative assumption, that all plant and equipment at the mine lease ML1108 are located at the nearest (south-western) corner of the lease at an elevation of between 133m AHD to 140m AHD.

The noise propagation modelling results are presented in Table 4.3 below and in Appendix C.

Table 4.3 Noise Modelling Results (ML1108 Operations)

Location	Calculated $L_{10,adj}$ (24-hour)* dB(A)	Criteria (Day-time/Evening) $L_{10,adj}$ (10-min)* dB(A)	Criteria (Night-time) $L_{10,adj}$ (10-min)* dB(A)
Boronia Court	31	37	31
Illawong Street	27	34	30

*Free-field conditions.

The increased separation distance of the extraction site from the residences at Boronia Court results in a reduction of the noise levels at this site. Considering the increased elevation of the extraction site (mobile plant) and the reduced distance from Illawong Street, the calculated noise levels at this location have increased.

Under conservative modelling assumptions for the proposed operations on ML1108, the calculated noise levels at the nearest noise sensitive places are very low and full compliance with license conditions (noise criteria) is achieved at Boronia Court and Illawong Street.

The contours of the calculated noise levels, as per current operations at the sand mine and as per proposed operations at ML1108, are presented as an overlay over the topographical and cadastral map of Stradbroke Island in Appendix C.

Considering the elevation of the terrain along the south-western boundary of ML1108 it is recommended that the extraction plant and equipment (mobile screen plant, site generator, slurry pump and front end loader) are located in the lowest point of the extraction site. The location of the mobile plant and equipment behind the walls of the extraction site will provide a high level of noise attenuation thus ensuring long-term protection of the noise amenity at the nearest residences.

5.0 Conclusions

Based on the results of the background and operational noise measurements and consideration of the results of the noise propagation modelling for the existing and proposed Unimin operations, the following conclusions are made:

- ñ Throughout the continuous noise measurement period of 7-days (24th May to 30th May 2006), the typical noise amenity at the two nearest noise sensitive places remained quiet. The overall noise amenity at the two measurement locations can be defined as “*areas with negligible transportation*” (AS1055.3 – 1997). The short-term variations in the noise levels due to existing natural and man made sources, typical of the area, do not result in adverse noise amenity.
- ñ The analysis of the long-term noise measurement data recorded when the mine is at continuous (24-hour) operation reveals no changes in the background noise levels. The typical background noise levels, when the mine is in full operation are the same as when the mine is not operating. Over the long-term monitoring period, the noise levels that are present for short durations (1% and 10% of the time) also show no signs of influence by the noise emissions from the mine operations.
- ñ The results of the noise measurements confirmed the subjectively observed absence of any “intrusive” noise that can be attributed to the current operations of the sand mine. The relatively low noise emissions from the sand mine operations, the significant distance 4 kilometres, as well as the terrain, contribute to a high level of noise attenuation and absence of noise impact from the current operations at mine leases ML1124 and ML7064.
- ñ Under the conservative modelling assumptions, the current operations at the sand mine fully comply with the licence conditions (noise criteria) during day-time and evening at Boronia Court. Slight exceedance of the noise criteria by 1dB(A) is possible during night-time at this location. The exceedance of the criteria is only of a theoretical nature, as the calculated noise levels of 31dB(A)_{L_{10,adj}} are indistinguishable from the naturally occurring noise levels at the investigated site.
- ñ Full compliance with the licence conditions (noise criteria) during day-time, evening and night-time is achieved at Illawong Street. This is expected considering the separation distance of 4km between Illawong Street and the mine.
- ñ Under conservative modelling assumptions for the operations at the ML1108, the calculated noise levels at the nearest noise sensitive places are very low and full compliance with licence conditions (noise criteria) is achieved at Boronia Court and Illawong Street.
- ñ Although no noise impacts are expected from the proposed operations at ML1108, it is recommended that the extraction plant and equipment are located in the lowest point of the extraction site. The location of the mobile plant and equipment behind the walls of the extraction site will provide a high level of noise attenuation, thus ensuring long-term protection of the noise amenity at the nearest residences.

6.0 References

- ñ Australian Standard ASIEC61672.1-2004 (*Electroacoustics - Sound Level Meters – Specifications*)
- ñ Australian Standard AS1055. 1-1997 (*Acoustics - Description and Measurement of Environmental Noise Part 1: General Procedures*)
- ñ Australian Standard AS1055. 2-1997 (*Acoustics - Description and Measurement of Environmental Noise Part 2: Application to Specific Situations*)
- ñ Australian Standard AS1055. 3-1997 (*Acoustics - Description and Measurement of Environmental Noise Part 3: Acquisition of data pertinent to land use*)
- ñ Australian Standard AS1217.7-1985 (*Acoustics – Determination of sound power levels of noise sources – Part 7. Survey Method*)
- ñ Queensland EPA, 2000 *Noise Measurement Manual – For Use in Testing for Compliance with the Environmental Protection Act 1994*
- ñ Queensland EPA, *Environmental Authority No. MIM900220203 (mining activities)*

7.0 Appendices

Appendix A Site Photos

Appendix B Graphs of the Noise Levels Measured

Appendix C SoundPLAN Calculation Results

Appendix A

Site Photos



Photo 1. Dry Mining Site



Photo 2. Primary Screening Plant



Photo 3. Main Processing Plant



Photo 4. Loading of Haul Truck at the Stockpile Area



Photo 5. Position of Logger No: 1 of Boronia Court ("Myora Springs")



Photo 6. Position of Logger No: 2 of Illawong Street (Dunwich)

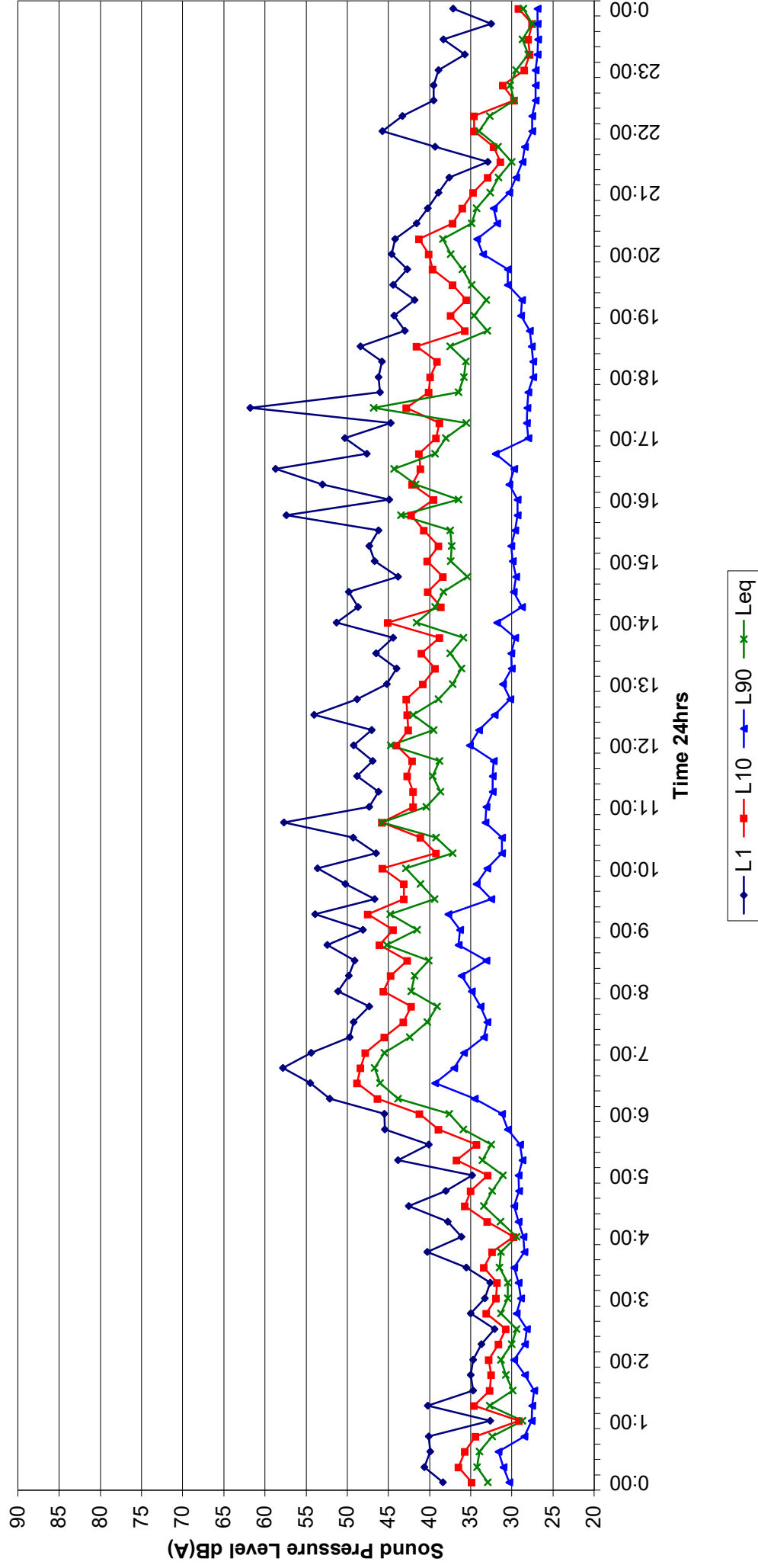
Appendix B

Graphs of the Noise Levels Measured

Unimin Sand Mine North Stradbroke Island - Mine in Full Operation

Logger 1 - Boronia Court

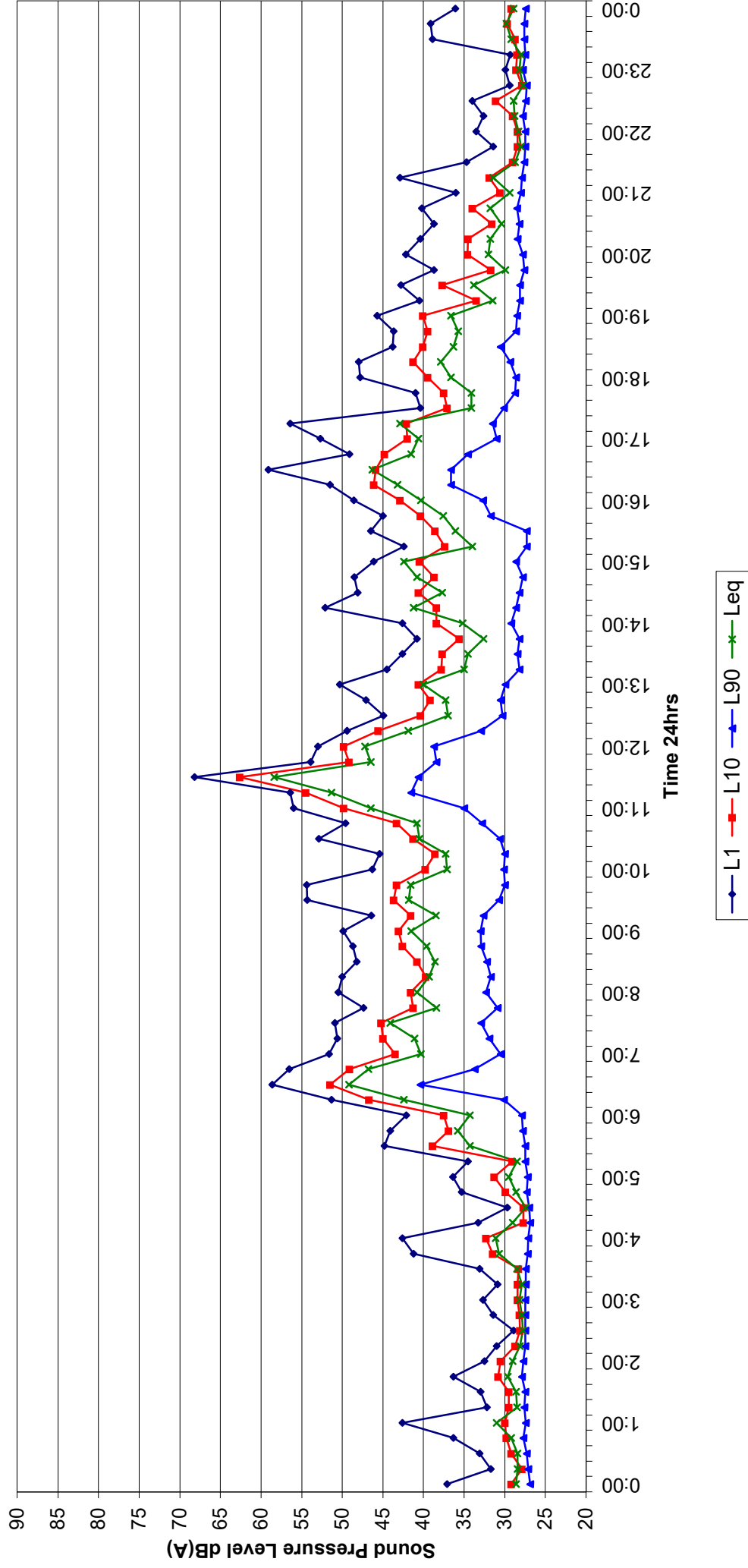
Wednesday 24/05/2006



Unimin Sand Mine North Stradbroke Island - Background Noise

Logger 1 - Boronia Court

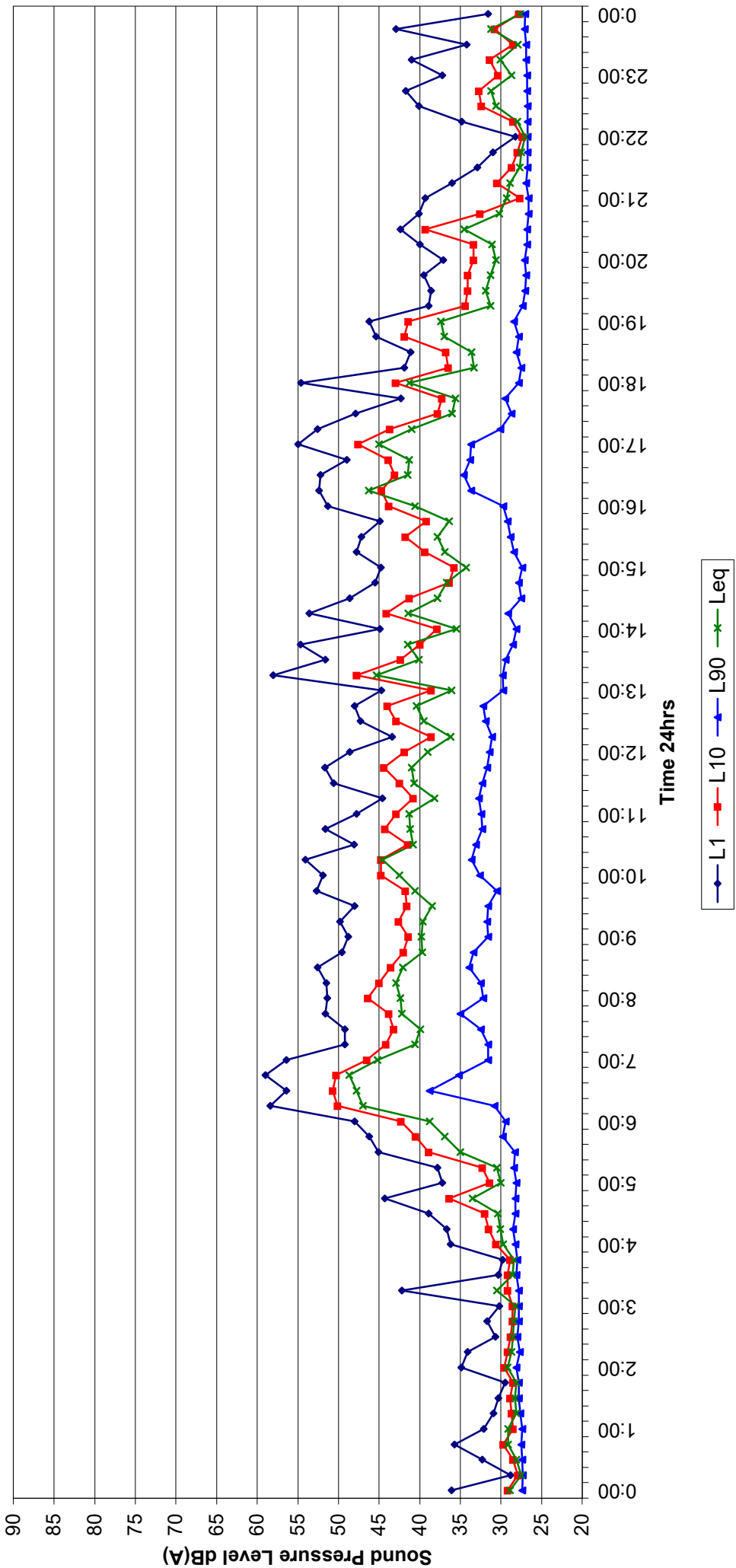
Thursday 25/05/2006



Unimin Sand Mine North Stradbroke Island - Background Noise

Logger 1 - Boronia Court

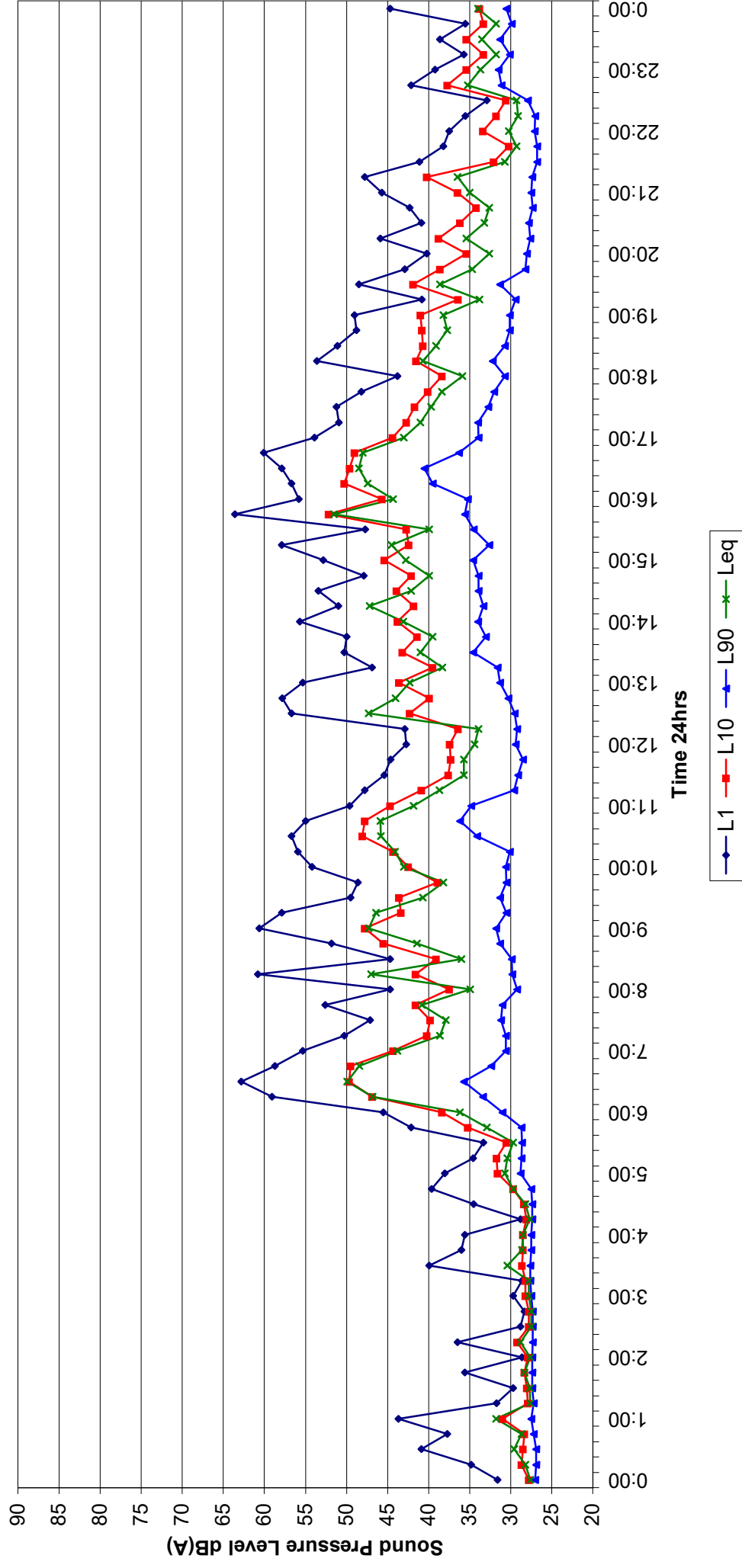
Friday 26/05/2006



Unimin Sand Mine North Stradbroke Island - Background Noise

Logger 1 - Boronia Court

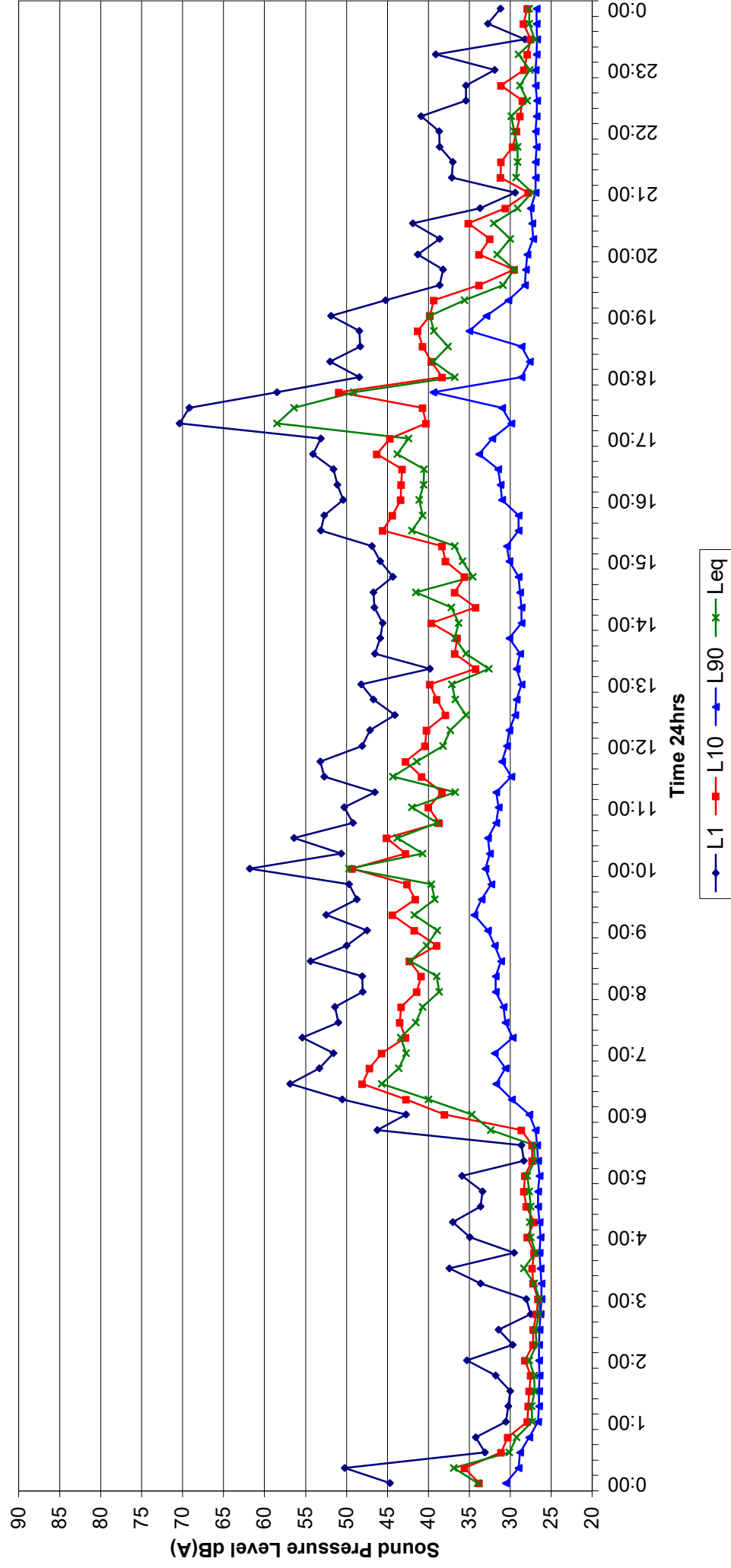
Saturday 27/05/2006



Unimin Sand Mine North Stradbroke Island - Background Noise

Logger 1 - Boronia Court

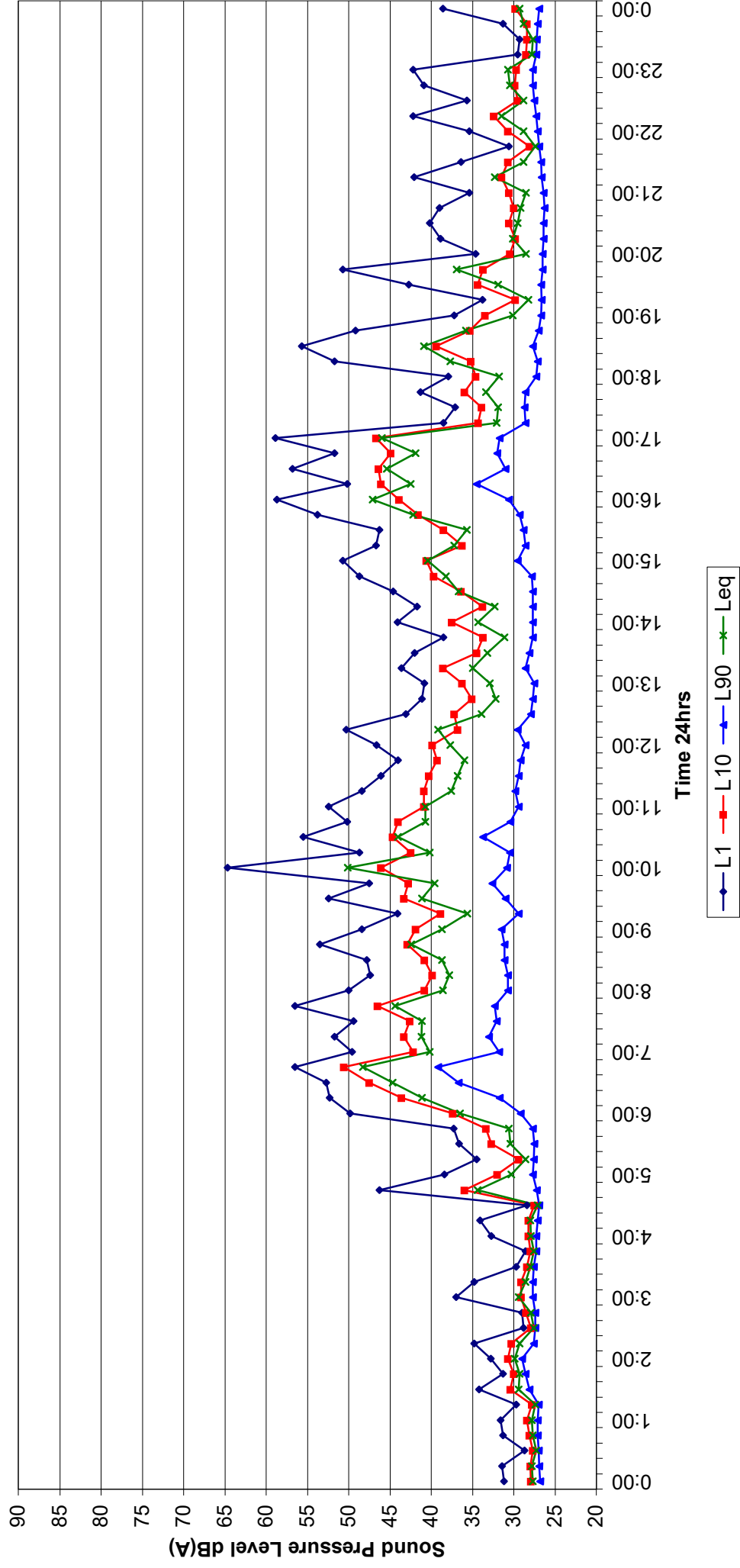
Sunday 28/05/2006



Unimin Sand Mine North Stradbroke Island - Mine in Full Operation

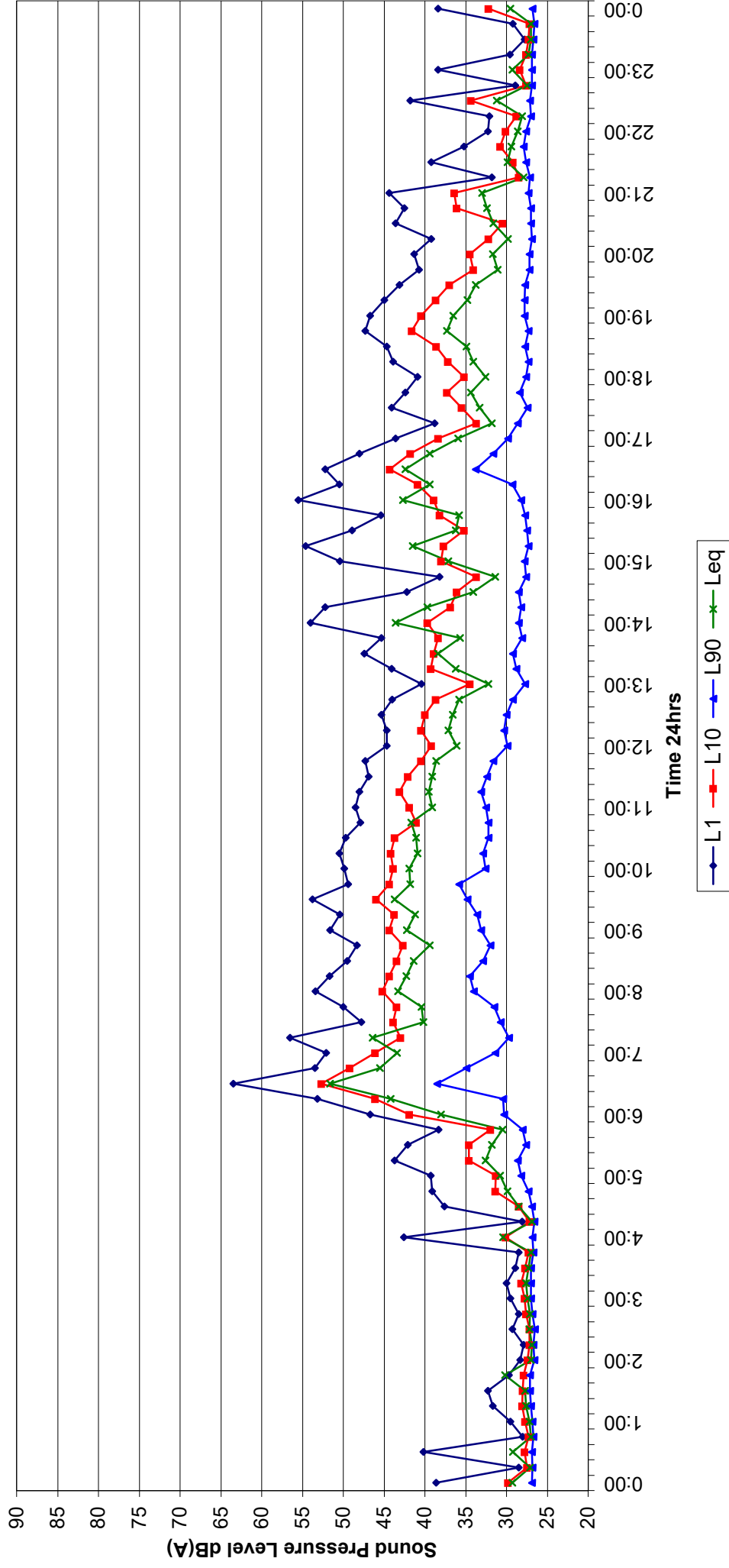
Logger 1 - Boronia Court

Monday 29/05/2006



Unimin Sand Mine North Stradbroke Island - Mine in Full Operation

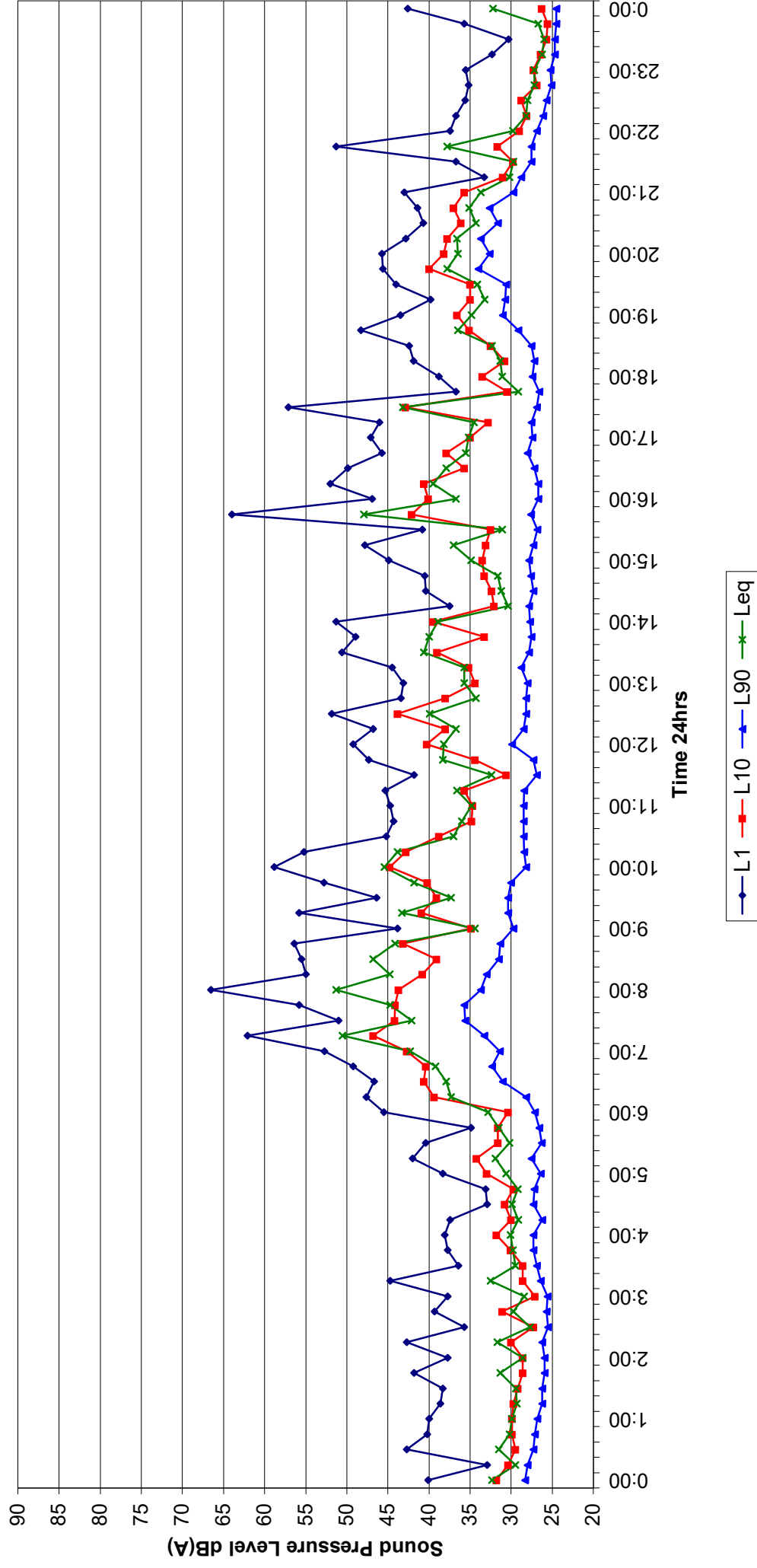
Logger 1 - Boronia Court
Tuesday 30/05/2006



Unimin Sand Mine North Stradbroke Island - Mine in Full Operation

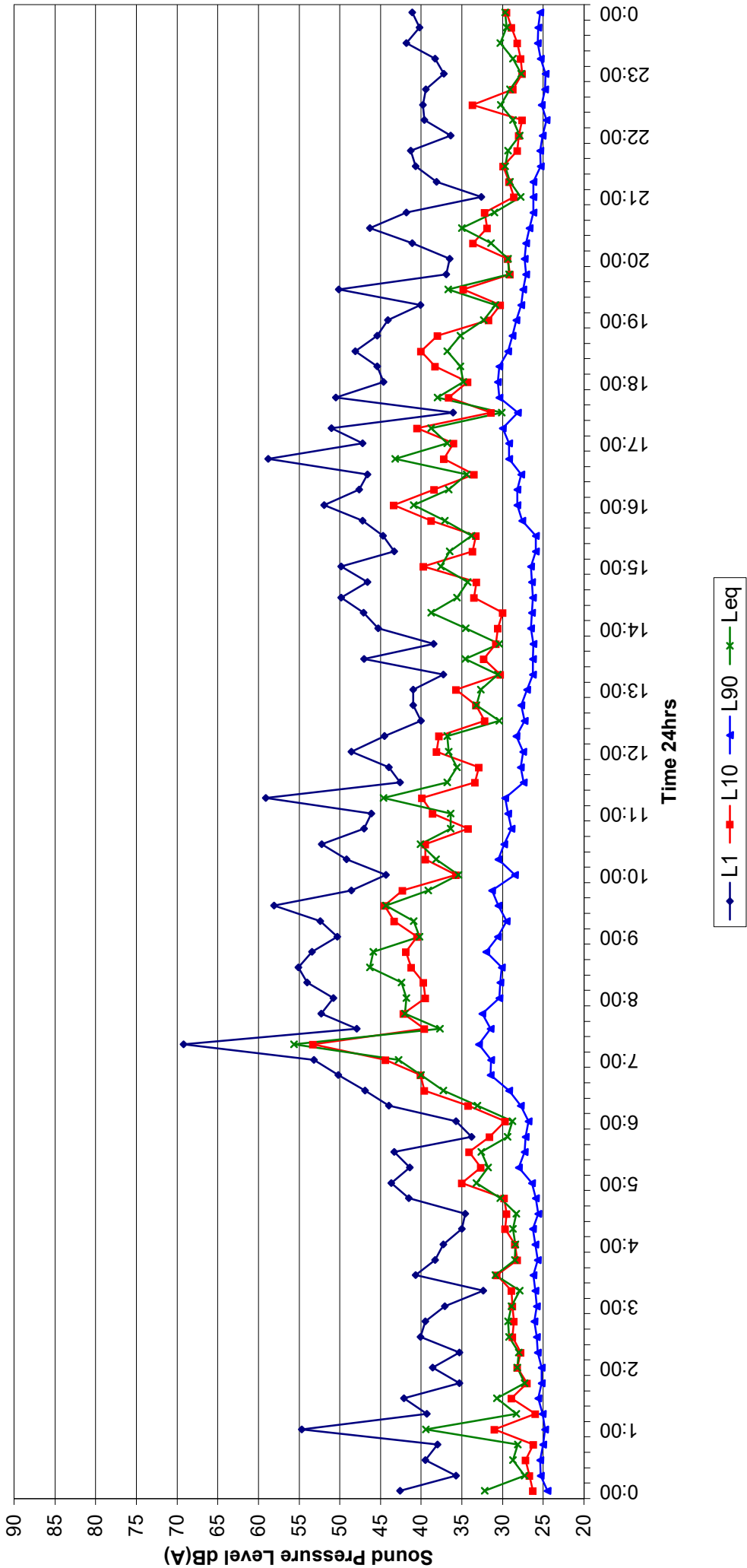
Logger 2 - Illawong Street

Wednesday 24/05/2006



Unimin Sand Mine North Stradbroke Island - Background Noise

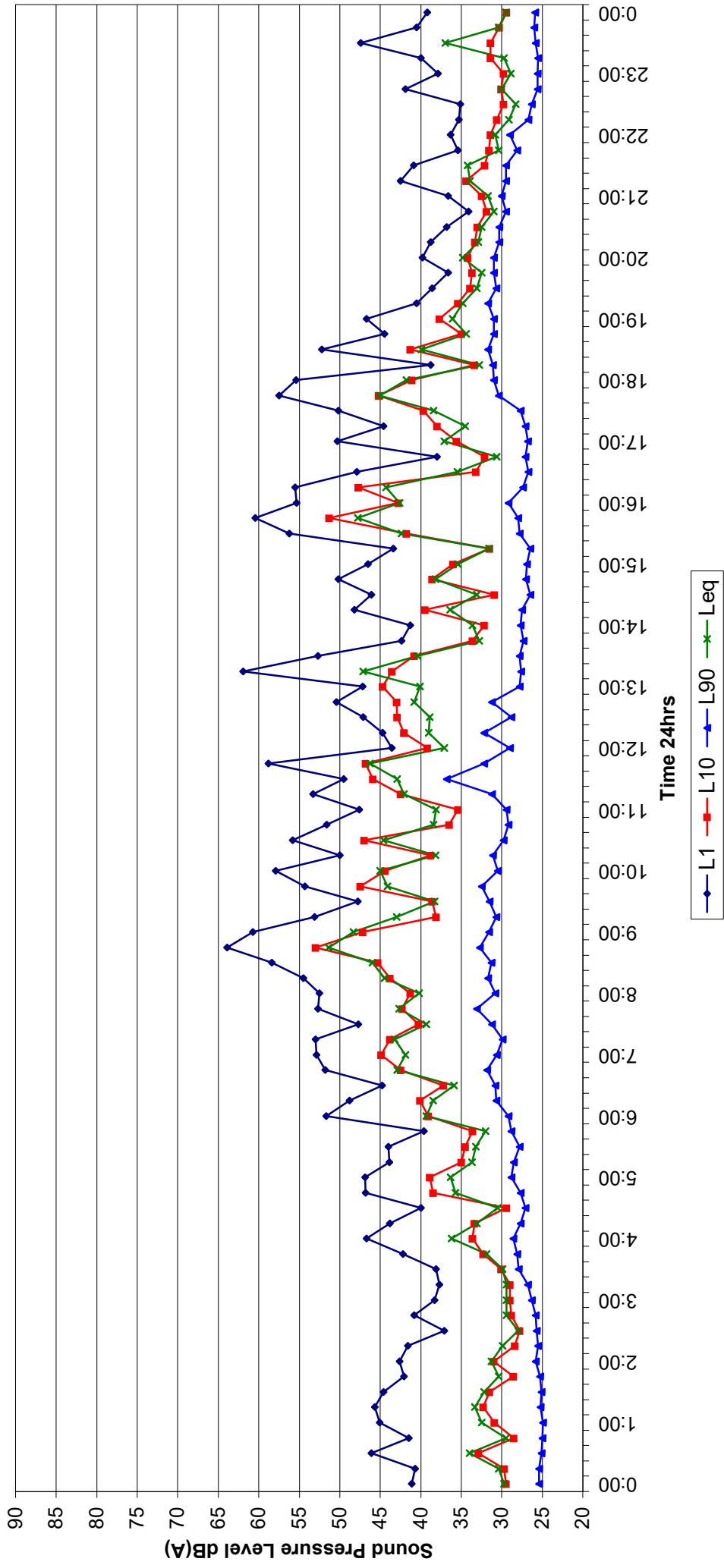
Logger 2 - Illawong Street
Thursday 25/05/2006



Unimin Sand Mine North Stradbroke Island - Background Noise

Logger 2 - Illawong Street

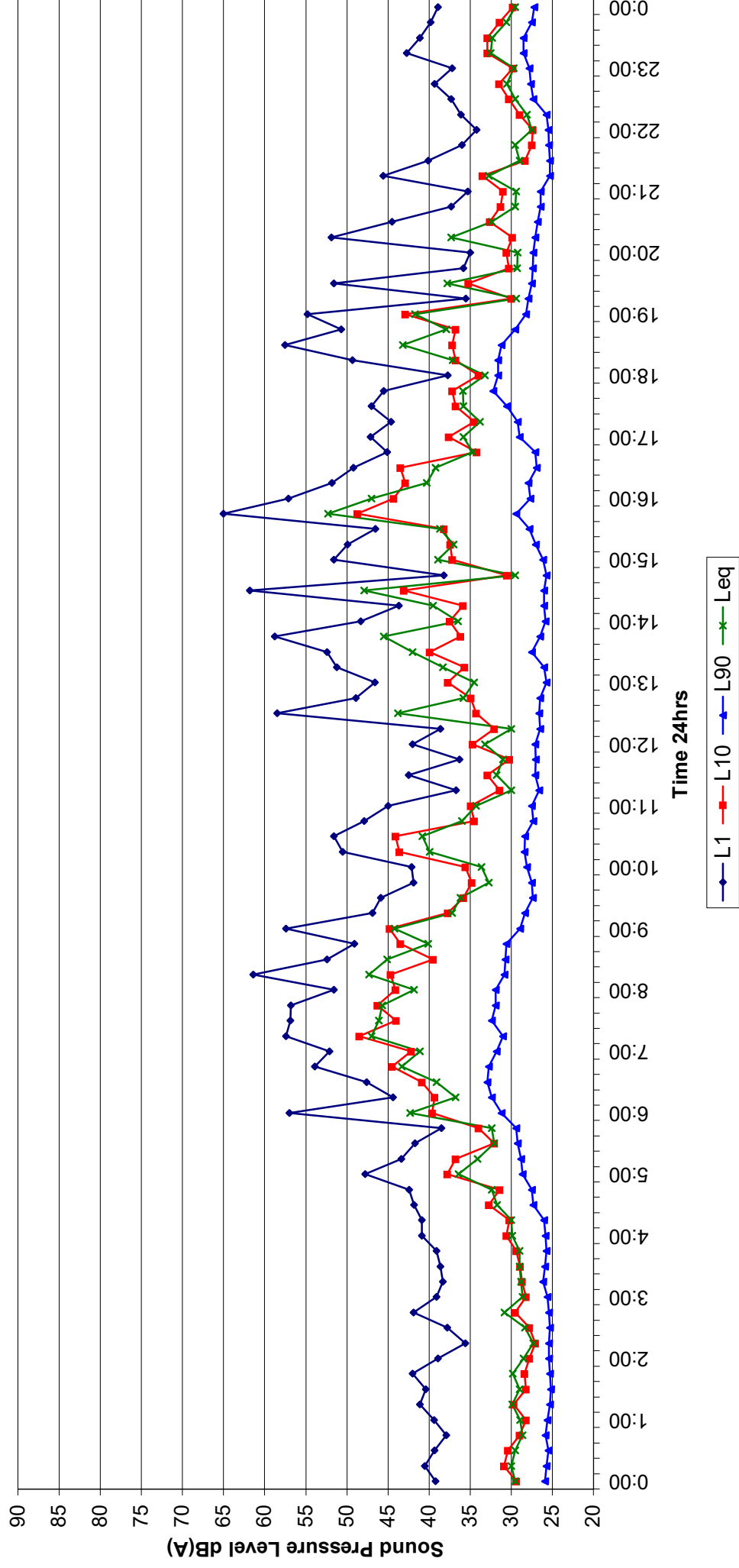
Friday 26/05/2006



Unimin Sand Mine North Stradbroke Island - Background Noise

Logger 2 - Illawong Street

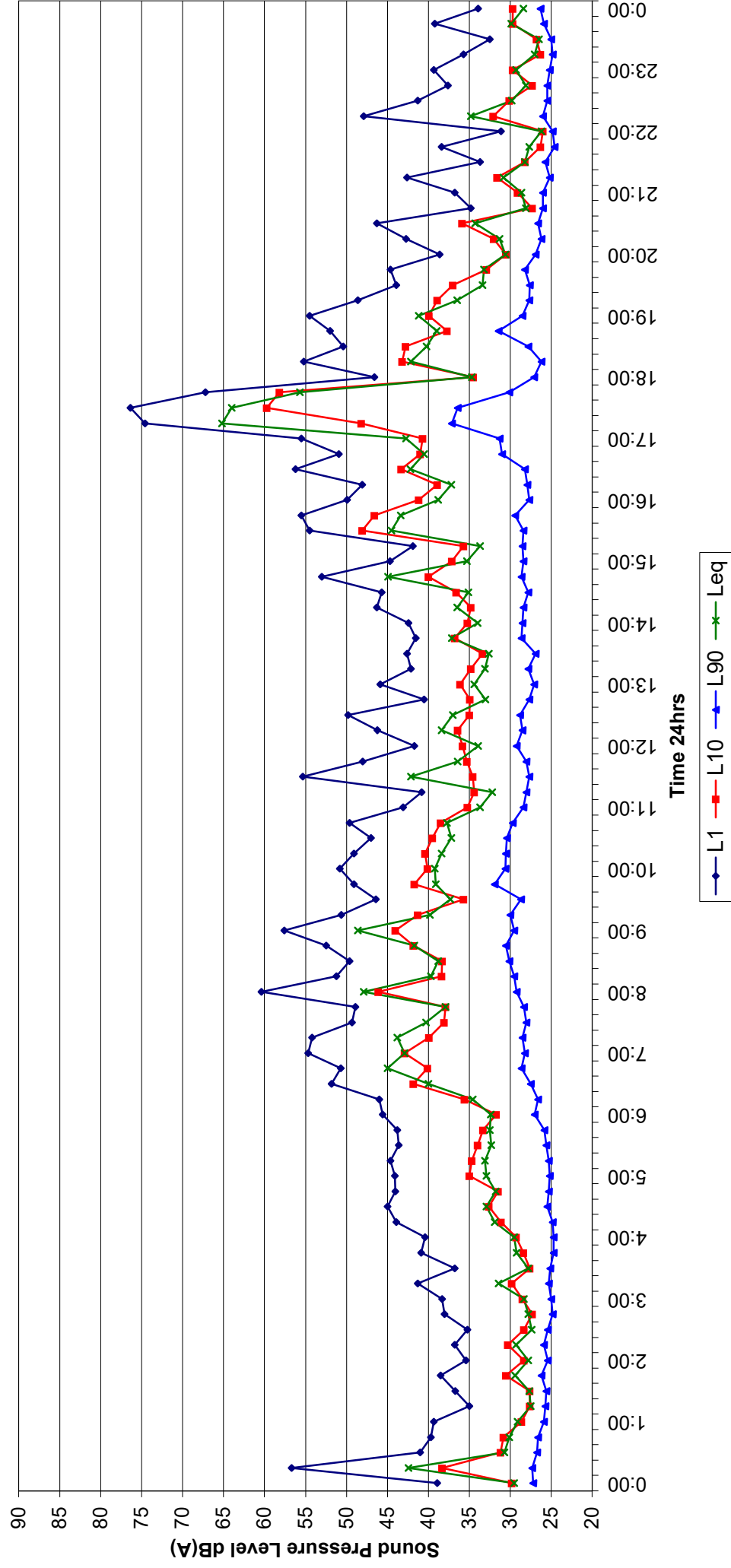
Saturday 27/05/2006



Unimin Sand Mine North Stradbroke Island - Background Noise

Logger 2 - Illawong Street

Sunday 28/05/2006

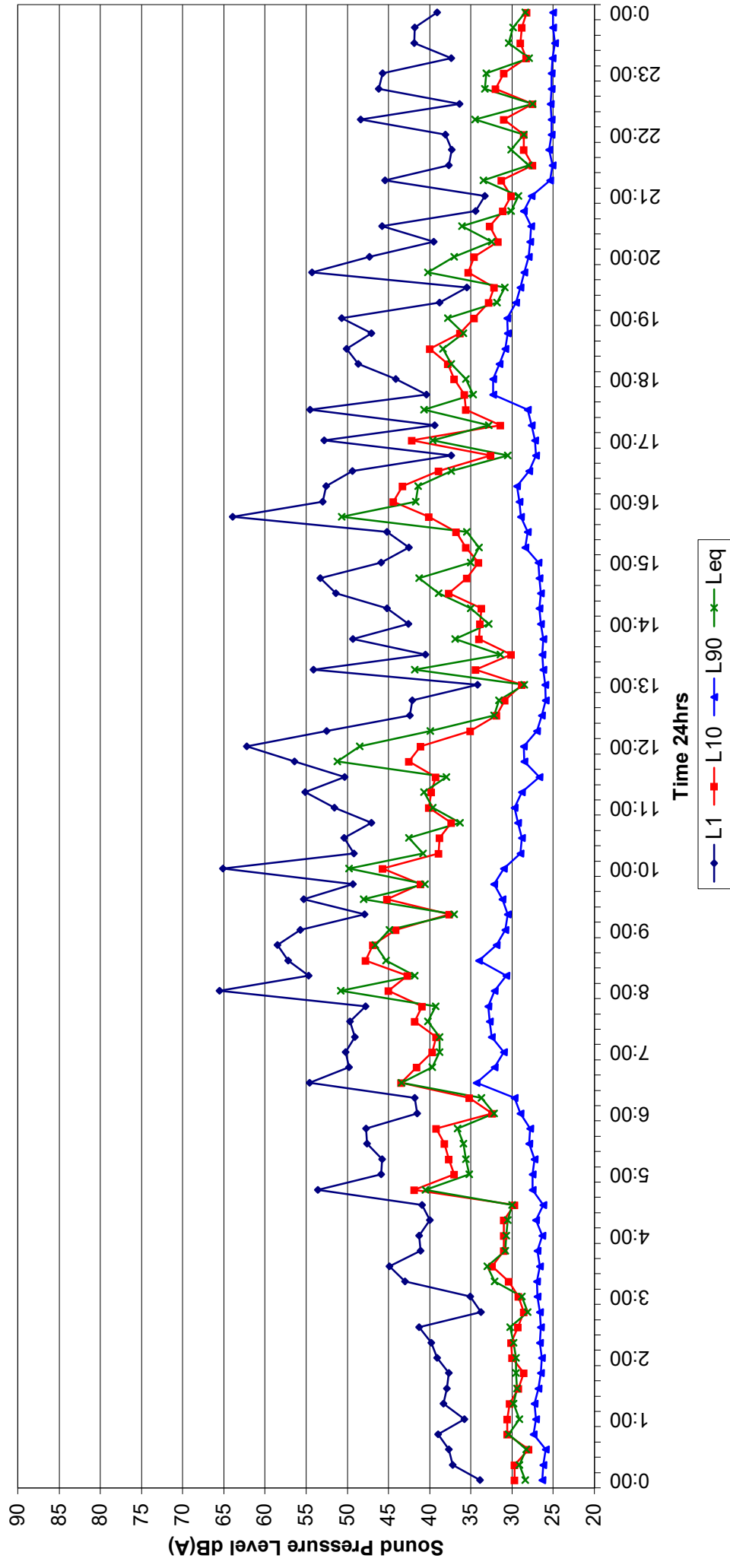


Unimin Sand Mine North Stradbroke Island - Mine in Full Operation

Logger 2 - Illawong Street

Monday

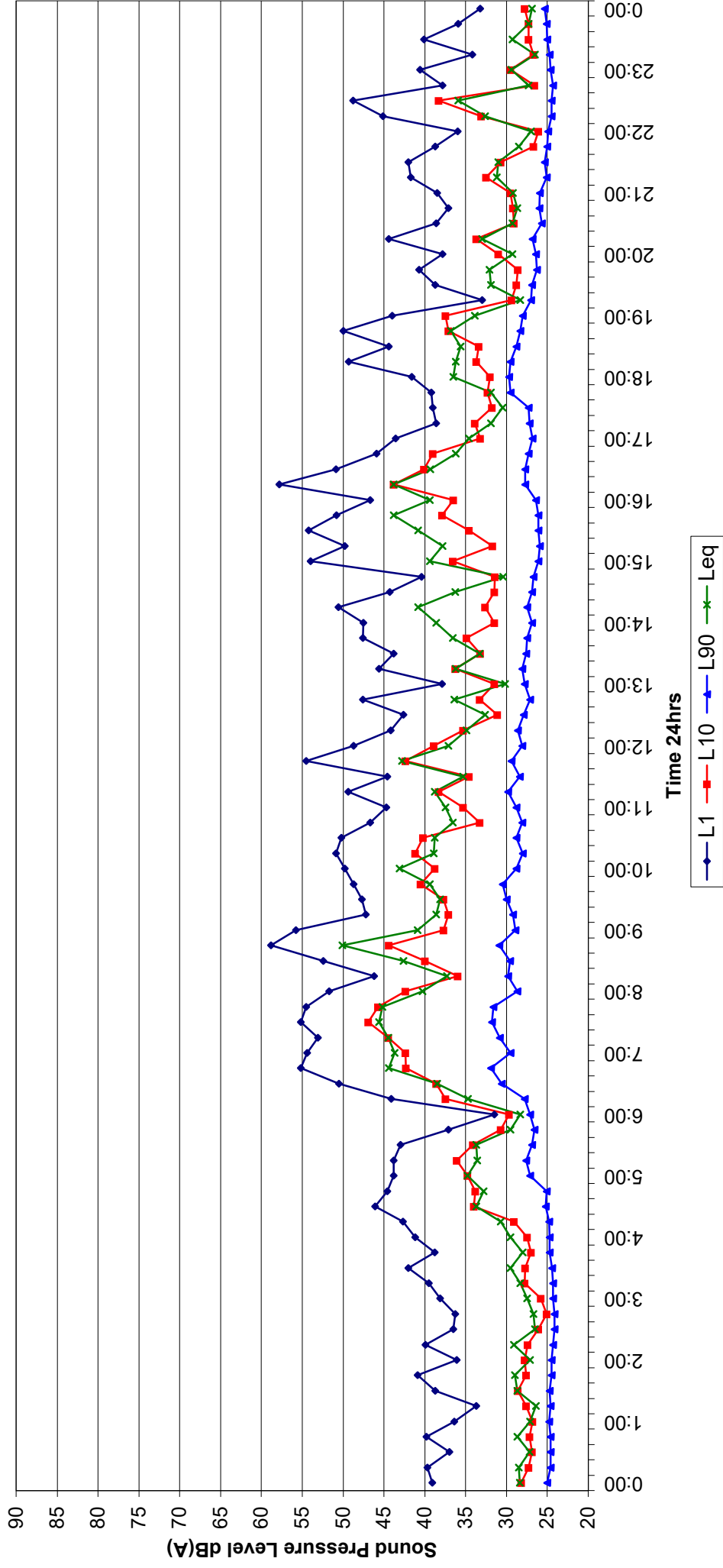
29/05/2006



Unimin Sand Mine North Stradbroke Island - Mine in Full Operation

Logger 2 - Illawong Street

Tuesday 30/05/2006



Appendix C

SoundPLAN Calculation Results

Unimin Sand Mine - Noise Propagation Modelling
Current Situation

Receiver	L10,adj(24-hour)
	dB(A)
Boronia Court	32.4
Illawong Court	24.5

31/07/2006 2:46 PM		Page 1
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Appendix C
Current Operations
Unimin Sand Mine
No Noise Control
L10,adj(24-hour) 1.8m AGL

Noise level
L10,adj(24-hour)
in dB(A)

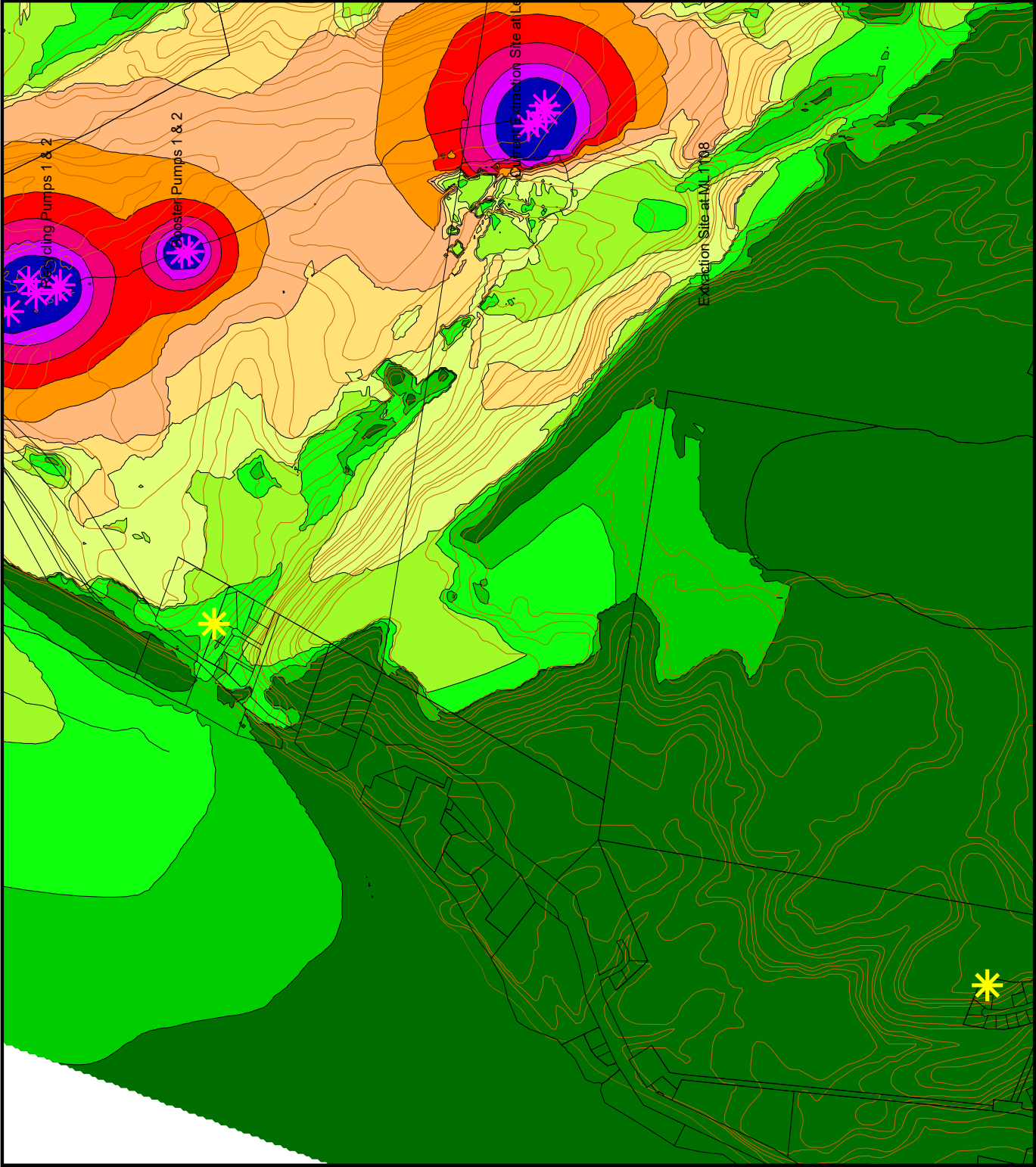


Grid Spacing = 5m
Increment Angle = 1

Signs and symbols

- Point source
- Elevation line
- Point receiver

Scale 1:20000



Appendix C
ML1108
Unimin Sand Mine
No Noise Control
L10,adj(24-hour) 1.8m AGL

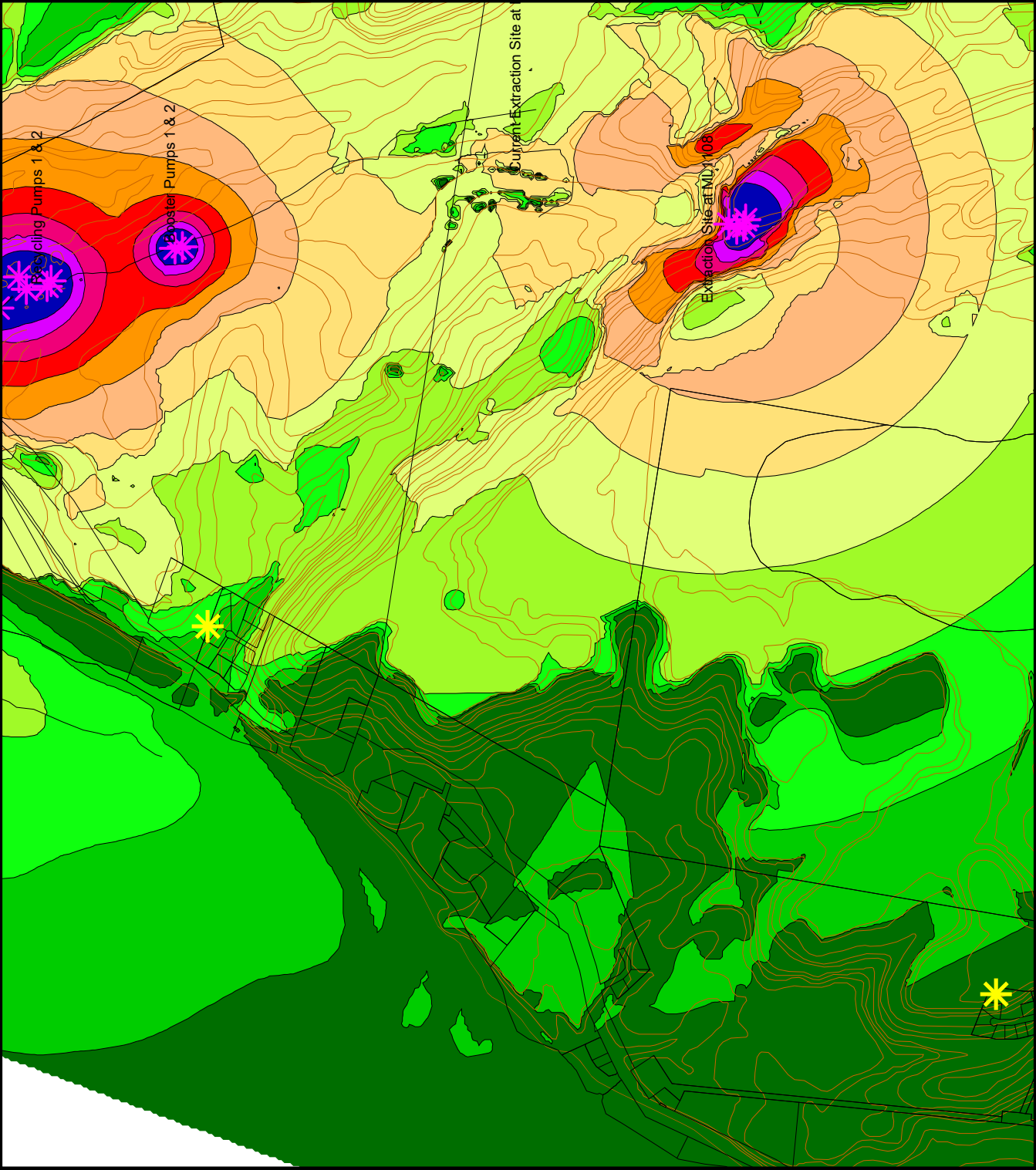
Noise level
L10,adj(24-hour)
in dB(A)



Grid Spacing = 5m
Angle Increment = 1

Signs and symbols
Point source
Elevation line
Point receiver

Scale 1:20000



Appendix N

Road and Transport Impact Assessment (2006)

ROAD & TRAFFIC IMPACT ASSESSMENT

**UNIMIN VANCE LEASE (ML1108)
NORTH STRADBROKE ISLAND,
QUEENSLAND**

August 2006

**Job No: C3577
Report No: 4190-3**

Prepared for: Unimin Australia Limited

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Job No. C3577

Report No. 4190-3
Original Date of Issue August 2006

Project Leader Dale Kleimeyer

REPORT DETAILS

Title: Road & Traffic Impact Assessment
Unimin Vance Lease (ML1108), North Stradbroke Island, Queensland

Author(s): Mr Dale Kleimeyer – Principal, Civil Engineering
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Client: Unimin Australia Limited

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Client Reference: 42625813.50009

Synopsis: This report considers the potential road pavement and traffic impacts of the proposal to expand mining operations into the Vance Lease (ML1108) on North Stradbroke Island, Queensland

REVISION/CHECKING HISTORY

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4190-3	02-08-06		MOA		MOA			

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APPENDIX B – Traffic Flow Figures

1.0 INTRODUCTION

Burchill VDM Pty Ltd are retained by Unimin Australia Limited to advise on the road infrastructure and traffic implications of the proposal to extend mining operations, which are currently underway on Mine Lease (ML) 7064, into ML1108 (Vance Lease) on North Stradbroke Island, Queensland.

This Road & Traffic Impact Assessment (R&TIA) assesses the existing road infrastructure in the immediate vicinity of the proposed expansion of current sand mining operations and examines the relative impacts of this proposal on the local road network.

This report demonstrates that the expansion of mining activities into the Vance Lease area would not have a material impact on the existing road infrastructure in the vicinity of the subject site.

2.0 SITE LOCATION AND EXISTING CONDITIONS

SUBJECT SITE

Unimin Australia Limited (UAL) has operated a commercial sand mining venture for the past 36 years on North Stradbroke Island. Their product is predominately utilised in high grade glass manufacture and is supplied to local, interstate and international glass works.

UAL's existing sand mining operations are currently carried out on ML1124 and ML7064. These lease areas are located approximately 4km north-east of the township of Dunwich. The lease area where the existing mining operations will expand to is located to the south-east of lease area ML7064 and is known as the Vance Lease (ML1108). The proposed expansion site is currently undisturbed bushland.

The existing lease areas are currently accessed via a private road, which intersects East Coast Road at a T-intersection, approximately 1.3km north of its intersection with Gatumba Street.

The site location is illustrated in **Figure 2.1**, with the location of the existing access road illustrated in **Figure 2.2**.

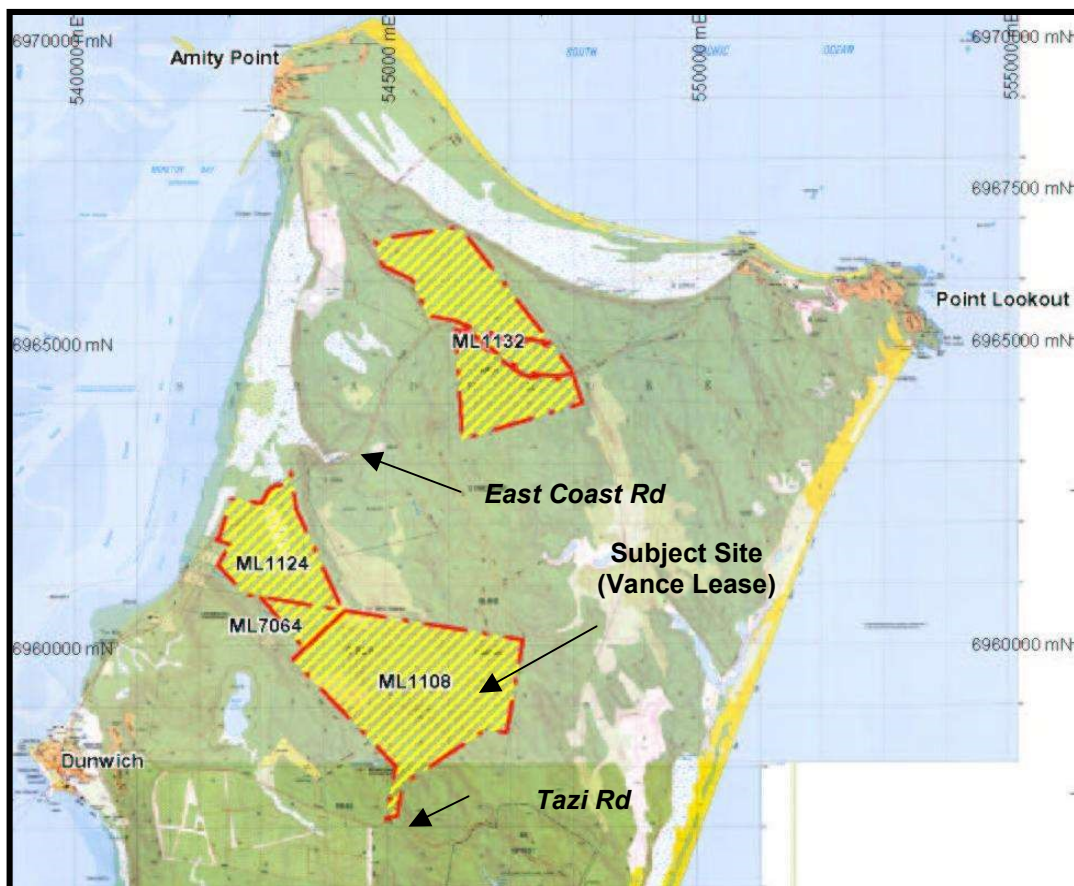


Figure 2.1 – Site Location

The Vance Lease area (ML1108) (refer Figure 2.1) has a short section, which abuts Tazi Road. The potential to access the site at this location is considered in this assessment.

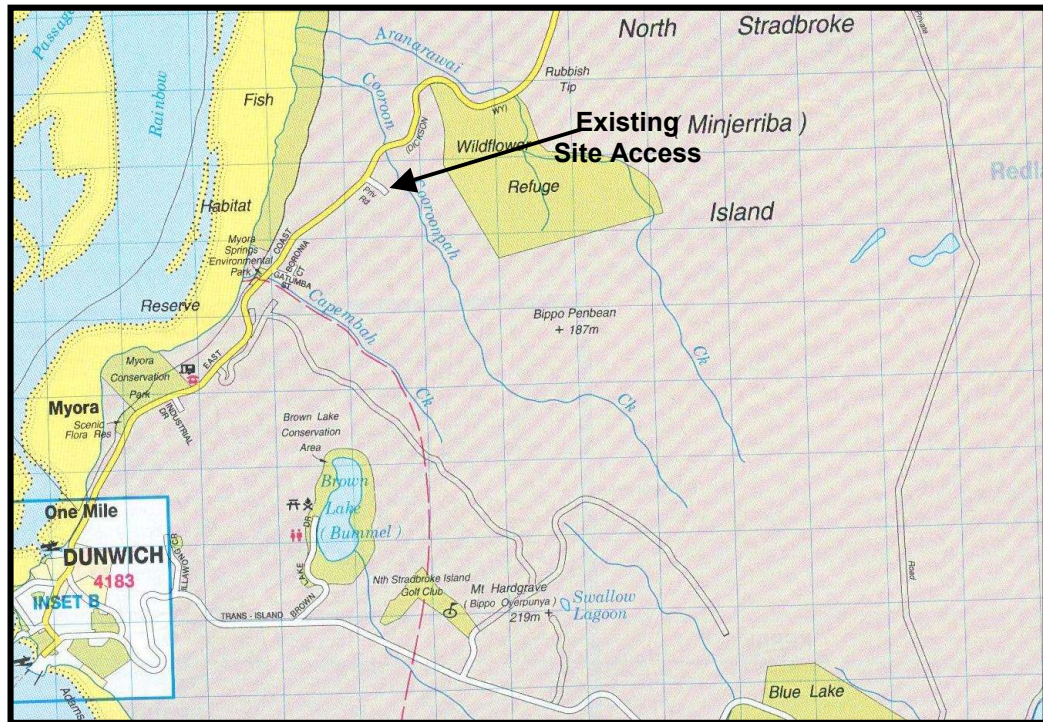


Figure 2.2 – UAL Site Access Location

SURROUNDING LAND USES

Stradbroke Island has three townships:

- 1) Dunwich, which lies to the south-west of the subject site;
- 2) Amity Point, which lies to the north of the subject site; and
- 3) Point Lookout, which lies to the north-east of the subject site.

There are scattered dwellings outside of these townships. The island is also a popular tourist destination. The total island population is in the order of 3,500, with numbers substantially increasing during holiday periods.

The island's educational facilities are both located in Dunwich, with Dunwich Primary School fronting Bingle Street, and Dunwich High School fronting East Coast Road, just north of the primary school.

Vehicle ferries and water taxis operate between Dunwich and Cleveland on the mainland, departing from the wharf at Junner Street.

In addition to the existing UAL mine, there are two other sand mines operating on North Stradbroke Island.

EXISTING ROAD NETWORK

East Coast Road is a State Controlled road, which runs from Dunwich to Point Lookout. This road carries in the order of 2,000 vehicles per day. Within the township of Dunwich, East Coast Road becomes Bingle Road, then Ballow Street, turning into Junner Street and providing access to the jetty where the vehicular ferries and water taxis dock. Bingle Road and Ballow Street carry in the order of 1,800 vehicles per day.

East Coast Road has a seal width of at least 9 metres. Warning signs relating to heavy vehicle use of the road have been erected along this road. In the township of Dunwich, both the Bingle Road / Cunningham Street and the Ballow Street / Junner Street intersections are well linemarked.

Tazi Road falls under the control of Redland Shire Council. This is a lightly used road, which extends east-west from Mallon Street in Dunwich and continues across the island. Traffic volumes on this road are less than 200 vehicles per day. This road has a seal width of approximately 6.2m metres.

3.0 PROPOSED DEVELOPMENT

UAL currently extract sand from ML7064, with processing activities being carried out on ML1124, immediately adjacent.

It is proposed to expand and continue sand mining operations into the Vance Lease area identified as ML1108. Processing of the raw material will still be carried out using the infrastructure in place on ML1124.

MINING PROCESSES

The current sand mining activities of UAL extract up to 1 million tonnes of sand per year from their current mining leases on North Stradbroke Island. The sand is processed to remove impurities, leaving behind high purity silica sand that is predominately used in glass manufacturing.

The current sand mining operations are carried out using open cut excavations. The silica sand is dry mined using a front end loader. The sand is passed through a trommel screen to remove roots and other organic matter. The sand is then pumped in slurry form to the processing plant.

At the processing plant (on ML1124), heavy minerals are removed through gravity separation. The heavy mineral product is sold separately. The discarded material, which consists of fine silica and clay, is pumped away using wash water, then released into a system of settling dams.

Processing activities are intended to remain on ML1124, with ML1108 to be used strictly for extraction activities.

4.0 TRIP GENERATION & DISTRIBUTION

TRIP GENERATION

UAL currently use three semi-trailer 'tipper trucks' (tri-axle prime movers hauling tri-axle trailers) to transport sand to the wharf at Hospital Point (at the end of Cunningham Street, Dunwich). These trucks operate under a gross mass limit of 42.5 tonne. Transport operations occur between eight and twelve hours per day, with a maximum number of six return trips made per hour. The sand mine operates five days a week, Monday through Friday, with the addition of an occasional half day Saturday (morning). Sundays and public holidays are not worked.

In addition to UAL trucks, single operator contractors also purchase truck loads of sand using semi-trailers and 'truck and dog' (ie truck-trailer) vehicles. These trucks operate under a gross mass limit of 45 tonnes. These purchases represent an additional eight to twelve return trips per day. These single operator contractors use the public vehicle ferry, which departs from the wharf accessed via Junner Street, Dunwich.

Transfer of mining operations into the Vance Lease is not expected to constitute a significant increase in traffic generation. Maximum UAL heavy vehicle volumes which could occur in a single day according to current UAL activities are in the order of 168 heavy vehicle trips per day (84 each way). This value represents transport operations extending over a 12-hour period, at a rate of 6 UAL trucks per hour (6 return trips), with the addition of 12 single operator contractors (12 return trips).

DEVELOPMENT TRIP DISTRIBUTION

Two trip distribution scenarios have been considered:

- (i) All trips travel via the existing access point on East Coast Road (see **Figure A1**, Appendix A for haul route illustration); and
- (ii) All trips travel via a new access point from the Vance Lease onto Tazi Road (see **Figure A2**, Appendix A for haul route illustration).

The existing haul route between the mine and the wharf starts on East Coast Road at the mine access, travelling south to Dunwich, remaining on East Coast Road as it becomes Bingle Road, then turning west into Cunningham Street, which provides access to the barge facilities. Vehicles bound for the public vehicle ferry would follow Bingle Road as it becomes Ballow Street, then turn west onto Junner Street.

If the haul route were to operate from Tazi Road, the route would progress westwards on this road, continuing west as it becomes Mallon Street, turning north at the Mallon Street intersection with Ballow Road, then west onto Cunningham Street. Vehicles bound for the public vehicle ferry would cross over Ballow Street from Mallon Street to Junner Street.

5.0 OPERATIONAL ASSESSMENT

EXISTING TRAFFIC DEMANDS

The two intersections in Dunwich that support mine vehicle movements are Bingle Road / Cunningham Street and Ballow Street / Junner Street. In order to establish existing traffic demands at these intersections, manual classified traffic surveys were commissioned.

The surveys were carried out on a Friday (2 June 2006) so that tourist traffic arriving for the weekend would be included in addition to local traffic. The surveys show a peak between 08:00 and 09:00, and between 15:30 and 16:30. These peaks overlap mining operations.

In addition to these peak hour surveys, a two-way manual count was carried out on Tazi Road at the location of the potential access to the Vance Lease area (ML1108). This survey revealed that existing traffic demands at this location on this road are very low, with the highest number of vehicles counted in a single hour being nine.

The relevant survey data is presented in Appendix B, Figures B1, B2 and B3.

Traffic demands on East Coast Road to the south of the existing site access were taken from the Department of Main Roads (DMR) SEQ Traffic Census 2005. The surveys were taken over a one week period from 17 March 2005 to 23 March 2005 and are for twenty four hours. These surveys are provided in Appendix A. The volume of trucks exiting the UAL site during this same period has been obtained from mine records. On average UAL trucks represent approximately 30% of heavy vehicle traffic along East Coast Road at this location. This information is summarised in Table 5.1.

Table 5.1 – UAL proportion of Heavy Vehicle Demands – East Coast Road

Date	Total Surveyed Traffic Volume	Surveyed Commercial Vehicles (2 way)	UAL Trucks (2 way)	UAL Trucks% of Surveyed Commercial Vehicles
17/03/2005	2,070	276	116	42%
18/03/2005	2,326	311	102	33%
19/03/2005	1,824	244	76	31%
20/03/2005	1,765	236	0	0%
21/03/2005	2,115	282	104	37%
22/03/2005	2,003	268	96	36%
23/03/2005	2,183	292	88	30%
7 Day Average	2,041	273	83	30%

For comparative purposes, the average daily value of heavy vehicles along this road (from the DMR 2005 survey) has been extrapolated to an annual value by multiplying the daily average (273 commercial vehicles) by 365 days, providing an approximate value of 99,483 heavy vehicles for the year of 2005. During this same

year, UAL extracted a total of 366,021 tonnes of sand, which equates to 13556 truck loads or 27,112 return trips. Thus for the year of 2005, UAL operations contributed 27% of commercial vehicle traffic on East Coast Road to the south of the mine access.

DESIGN HORIZON

As required by DMR (*Guidelines for Assessment of Road Impacts of Development*), a ten year design horizon has been considered, that is to 2016. Annual growth on East Coast Road has been calculated by comparing surveys to the south of the UAL access from 2002 and 2005 (surveys sourced from DMR SEQ Traffic Census). The survey data shows an annual growth rate of eight percent. This is a relatively high growth rate, and traffic growth may not continue at this speed for ten years, however for the purposes of this assessment, a growth rate of eight percent per annum has been applied to all background traffic volumes under consideration.

The resultant volumes forecast for 2016 are illustrated in Figures B4, B5 and B6.

OPERATIONAL ANALYSIS - TRAFFIC

Traffic volumes across North Stradbroke Island are low, as evidenced by the surveys described earlier in this section. These low volumes allow for traffic operations at the intersections under consideration to remain well within acceptable limits as intersection capacities far exceed demands.

On-site observations of the Bingle Road / Cunningham Street intersection and the Ballow Road / Junner Street intersection confirmed that they operate well below capacity.

The existing access to the UAL mining operations allows excellent sight distances to approaching vehicles, well in excess of the 140 m required for the 70 km/hr speed limit operating on East Coast Road. These sight distances are illustrated in **Figures 5.1 and 5.2.**



Figure 5.1 – Sight lines from UAL Access - north

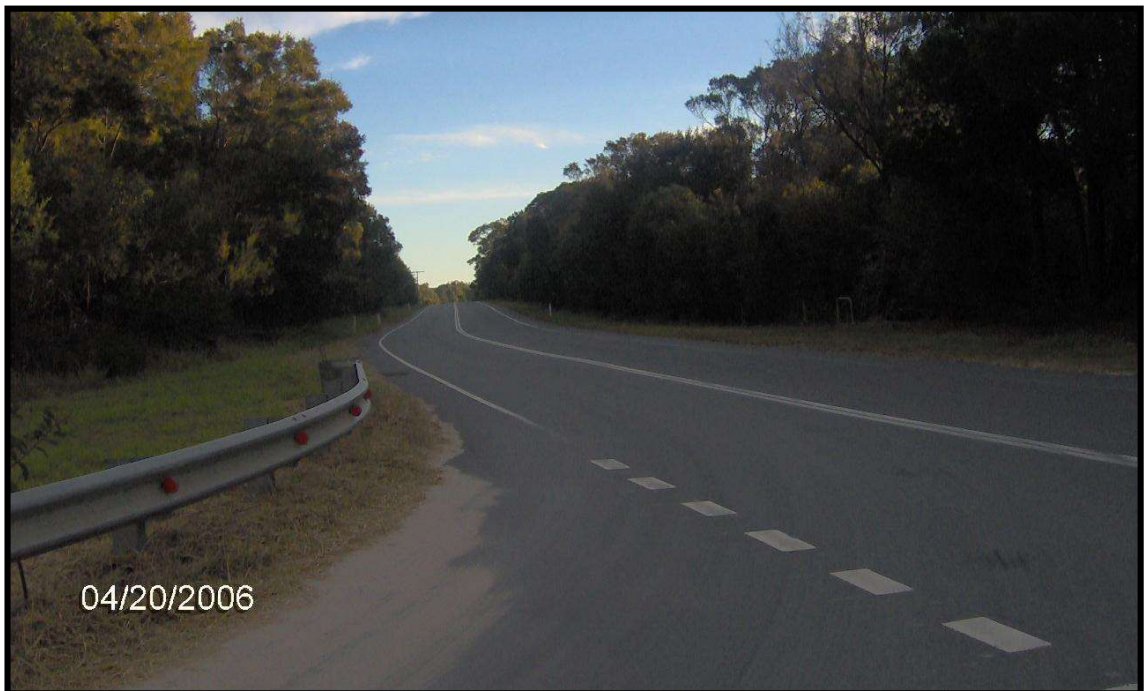


Figure 5.2 – Sight lines from UAL Access - south

Existing Haul Route – East Coast Road

The existing haul route is exclusively along a State Controlled road, with the exception of the short length travelled on Cunningham Street to reach the sand barge. Whilst it is acknowledged that this route is not ideal, passing two schools, and travelling through Dunwich township, the route remains the most suitable of

the available options, with East Coast Road and Bingle Street being a main traffic route for the island. Alternative routes through Dunwich would direct the heavy vehicles through smaller streets and more residential areas and are therefore not considered appropriate.

The crossing facility on Bingle Street for the primary school is operated using a crossing 'warden' during the morning drop-off and afternoon pick-up periods. This provides a safe means for children to cross this road. A school zone with a 40km/hr speed limit operates outside the school in the morning and afternoon. On-site observations of driver behaviour showed an excellent adherence to this reduced speed limit. Heavy vehicles, including those associated with UAL operations, were observed to travel in accord with the speed limit and crossing arrangements.

It is therefore considered that the existing haul route between the UAL access and the wharfs is the most appropriate route available between these points.

Southern Access – Tazi Road

As a small portion of the Vance Lease area (ML1108) adjoins Tazi Road, the potential for providing a direct access onto this road has been considered.

Tazi Road has a 60km/hr signed speed limit, however vehicles using this road have been observed to travel in excess of this speed. The road has a 6.2 metre seal width and there is no line marking. The potential access point is located on a curve, with the eastern approach being slightly downhill. Sight lines at this location are in the order of 100m, which falls slightly below the recommended minimum Safe Intersection Sight Distance of 113m for a 60km/h design speed.

The sight lines are impeded by low growing vegetation on the southern side of the road, as shown in Figures 5.3 and 5.4. If this vegetation were to be removed, appropriate sightlines from the access point may be achieved.

As discussed previously, existing traffic volumes on this road are very low, being less than 200 vehicles per day. Based on current mining operations, traffic associated with UAL activities would be in the order of 6 return semi-trailer trips per hour. This is one entry and one exit movement every 10 minutes. As a result, it is considered that this would not pose a capacity issue for this proposed access.



Figure 5.3 – Sight lines from Vance Lease - west

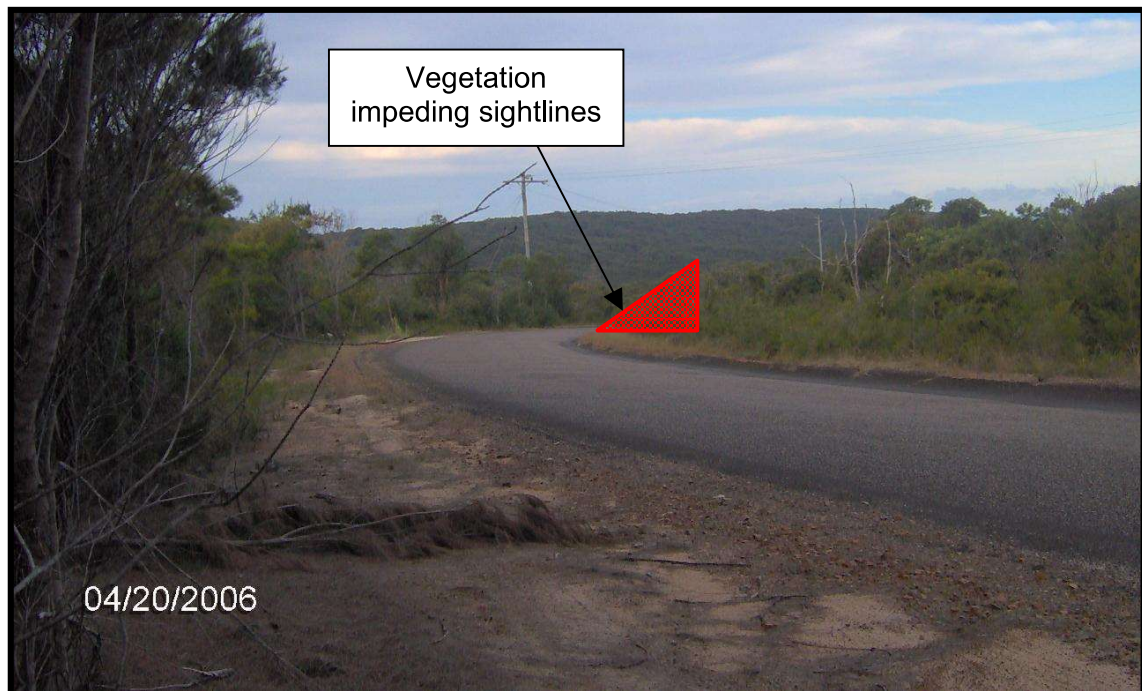


Figure 5.4 – Sight lines from Vance Lease - east

OPERATIONAL ASSESSMENT – ROADS

Existing Haul Route – East Coast Road

A classified vehicle report survey including the twelve Austroads vehicles classes was carried out on behalf of DMR from 1 January 2002 to 31 December 2002. This survey is attached in Appendix A.

At the location of the survey (south of Myora Road, Dunwich) the AADT recorded was 1697 vehicles with 13.6% commercial vehicles (CV). A more recent survey was carried out in this location in 2005, as described under the Existing Traffic Demands subheading. The proportion of commercial vehicles was also in the order of 13% at this time. These traffic volumes surveyed in 2005 have been factored at an annual growth rate of 8% (the derivation of this growth rate is described under the '**DESIGN HORIZON**' subheading) to estimate 2006 traffic demands as shown in the following Table.5.2.

Table 5.2 Existing Haul Route – Traffic Volumes

Road	DMR #	Section	2006 AADT [^]	2006 Daily CV [^]
East Coast Rd	1000	UAL Access to Bingle Rd	2,204	294
Bingle Rd	1000	East Coast Rd to Ballow St	1,470	175
Cunningham St		Bingle Rd to Wharf	740	195
*Ballow St	1000	Bingle St to Junner St	1,835	60
*Junner St	1000	Bingle St to Wharf	1,325	225

[^] *estimated from available data*

* *route only used by private contractors, not UAL trucks*

The survey figures include the UAL trucks, which average 83 vehicles per day or approximately 30% of the total number of commercial vehicles counted in the survey.

Further information was obtained from DMR with respect to the pavement construction and condition as contained in the extract from the ARMIS database in Appendix A and summarized as follows:

- ñ the total pavement depth including subgrade averages 350mm; and
- ñ the roughness ranges from 20 to 90 counts per kilometre, and rutting is from 1mm to 12mm.

Rutting is a measure of pavement deformation due to continuous wheel loads, measured perpendicular to the road centre line. Using a 'Rutmeter', measurements are taken to determine pavement profile.

Roughness is a measure of the riding qualities of pavement surfaces. Using instrumentation that sums the vertical movements in one direction over any specified interval.

The pavement depth of 350mm over a sand subgrade of CBR 15 equates to a pavement's life of 4.7×10^6 Equivalent Standard Axles (ESA's). The roughness

and rutting show that the pavement has not reached terminal values. The maximum desirable terminal value for roughness is 175 counts per kilometre, however actual values may approach 230 counts per kilometre.

Southern Access – Tazi Road

Information has been received from the Redland Shire Council regarding the Tazi Road, adjacent to the proposed southern access and has been summarised as follows:

- ñ the road was built by a mining company;
- ñ maintenance is carried out by Redland Shire Council;
- ñ pavement depth is 200mm;
- ñ the road is surfaced with bitumen chip seal; and
- ñ the surface width is 6.2 metres.

No information was available with regard to CBR, rutting or corrugations.

The traffic survey carried out on 29 June 2006 recorded a total of 16 light vehicles over a 2½ hour period from 11.30 am to 2.00 pm - 9 vehicles on the east approach and 7 vehicles on the western approach. The following Table 5.3 details the potential number of commercial vehicles using the road as a result of the development.

Table 5.3 Potential Haul Route using Tazi Rd – Traffic Volumes

Road	DMR #	Section	2006 AADT [^]	2006 Daily CV [^]
Tazi Rd		UAL (new) Access to Mallon St	200	10
Mallon St		Mining Co. Rd to Ballow St	1,235	135
Ballow St	1000	Mallon St to Bingle St	1,835	60
Cunningham St		Ballow St to Wharf	740	195
*Junner St	1000	Bingle St to Wharf	1,325	225

[^] *estimated from available data*

* *route only used by private contractors, not UAL trucks*

The impacts associated with use of the road for haulage of up to 168 commercial vehicles per day is two-fold.

The minimum passing width for commercial vehicles of 168 vehicles per day requires a sealed pavement width of 7.0 metres with half metre wide shoulders to provide a total carriageway width of 8.0 metres. (Reference: Queensland Department of Main Roads - *Road Planning and Design Manual*). With the existing pavement width of 6.2 metres, pavement widening to the minimum requirement noted above is recommended, should this access route be utilised. The recommended pavement width also allows tourist traffic to avoid the haulage vehicles.

Currently, the road does not carry any heavy vehicles as shown by the survey. The pavement depth of 200mm on a sand subgrade of CBR 15 provides for an

estimated number of repetitions 0.3×10^6 ESA. The maximum daily vehicles of 168 equates to a theoretical pavement life expectancy of approximately 3 years.

However, due to the thickness of pavement and depending on the standard of the original construction and quality of materials, it is possible that isolated sections of the pavement could suffer damage earlier than 3 years and require rehabilitation. Such measures would include pavement thickening and resurfacing. Specifically this would apply to the westbound lane carrying the loaded vehicles.

6.0 SUMMARY AND CONCLUSIONS

UAL propose to expand its current mining operations into the Vance Lease area (ML1108). Processing activities will remain at their existing location on ML1124. This assessment has revealed that expansion into the Vance Lease area is not likely to result in additional traffic generation on North Stradbroke Island.

Traffic Impacts

The existing haul route has been reviewed, and is considered to represent the most appropriate route between the existing UAL access and the Cunningham Street Wharf. The potential for an alternate haul route, with a new access from the Vance Lease onto Tazi Road has been reviewed. Providing appropriate sight distances could be provided at the access point, and road rehabilitation were carried out, this route is considered viable in the future.

The existing intersections along the UAL haul route have been observed to operate effectively. Surveys support on-site observations that traffic demands are well below intersection capacity.

Pavement Impacts and Mitigation Measures

The East Coast Road is currently supporting haulage vehicles from UAL and other mining operations on the Island. Estimates show that the proportion of UAL haulage vehicles is in the order of 30% of the total number of the commercial vehicles using the road.

UAL operations have been occurring along East Coast Road for 36 years. Moving mining operations onto the Vance Lease (ML1108) is not expected to represent a material increase in traffic generation from the site and pavement deterioration is not expected to accelerate.

The impact of the proposal to use Tazi Road relates to a requirement for increased pavement width, annual pavement maintenance and future rehabilitation. As the road presently carries few heavy vehicles, contribution of the pavement maintenance costs would need to be agreed with the Redland Shire Council.

DALE KLEIMEYER
Principal Civil Engineering

APPENDIX A

Traffic & Pavement Information

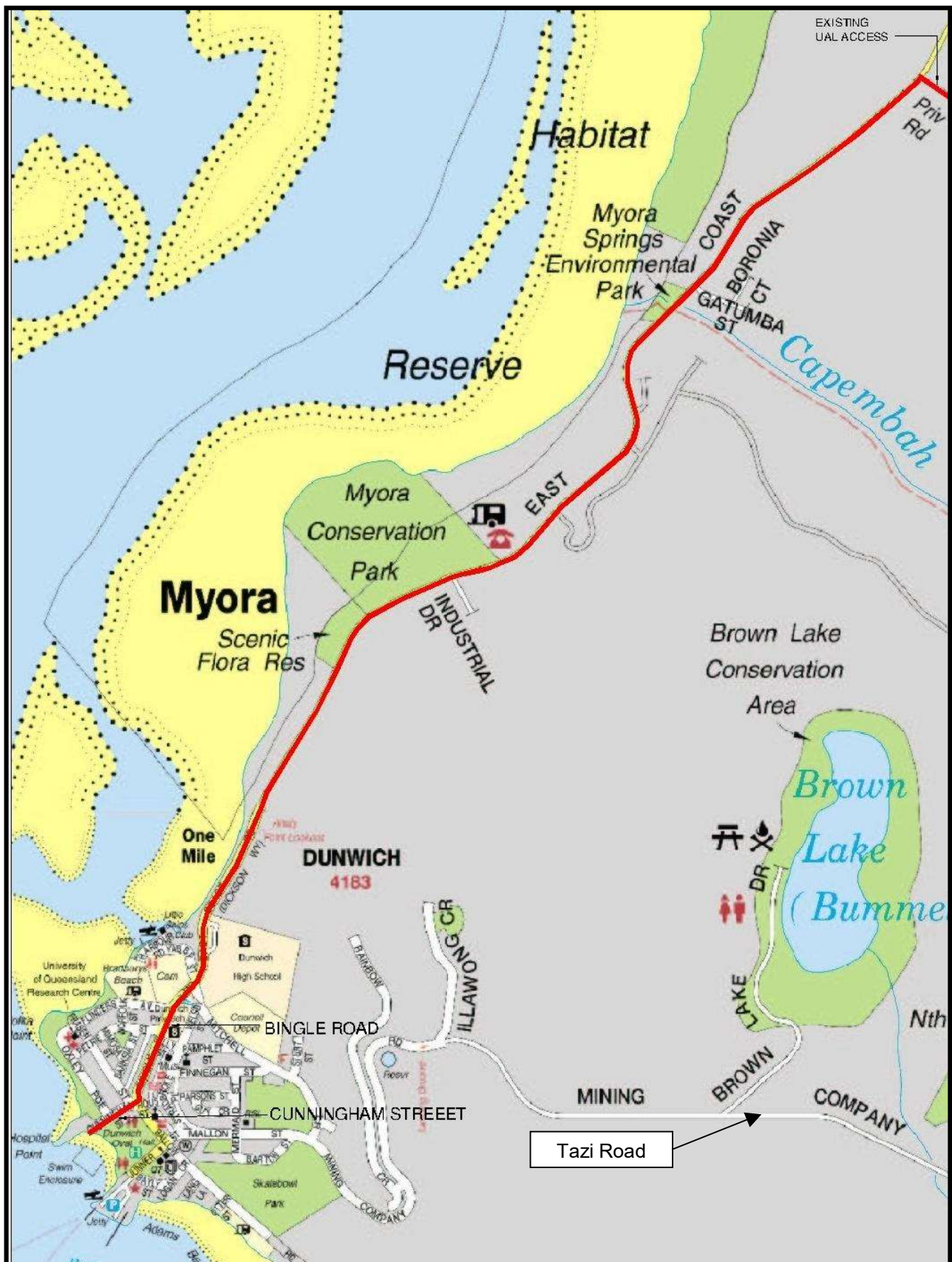


Figure A1 – Existing Haul Route

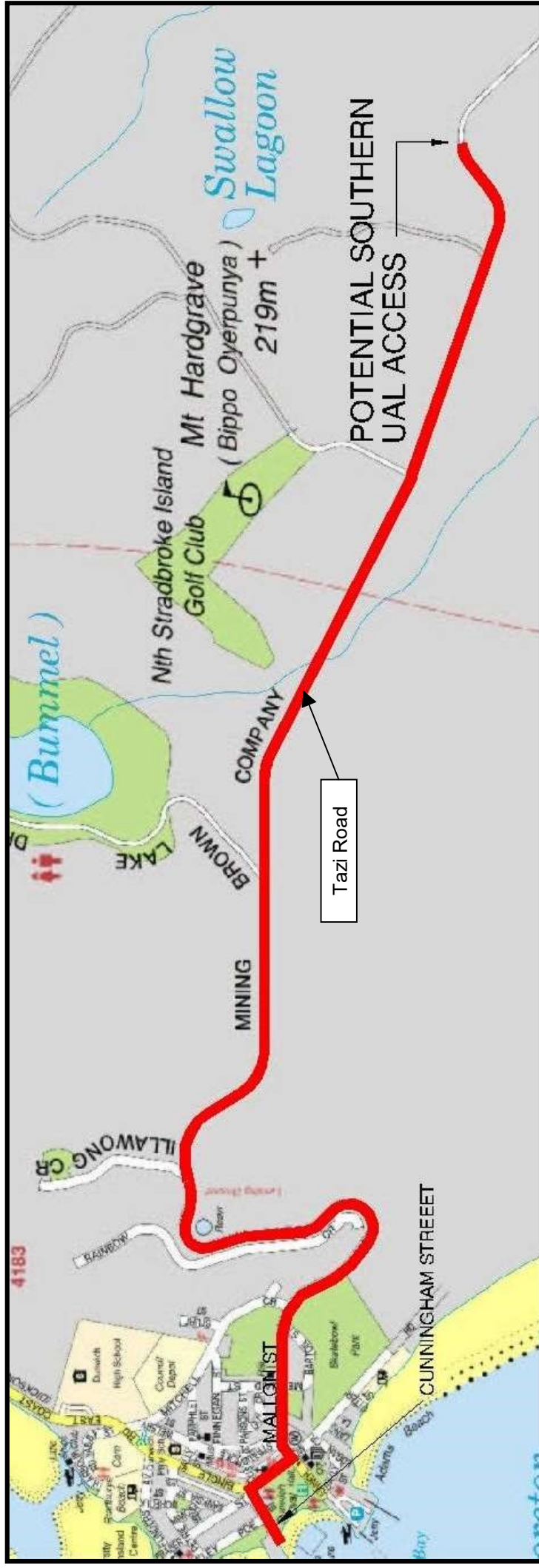


Figure A2 – Potential Southern Haul Route

Table A1

Road	Total Vehicles			Commercial Vehicles		
	AM	PM	~ AADT	AM	PM	~ Daily
Bingle Road	146	148	1470	23	12	175
Ballow Street	158	209	1835	28	11	195
Cunningham Street	68	80	740	9	3	60
Junner Street	113	152	1325	31	14	225
Mallon Street	99	148	1235	21	6	135
Tazi Road	-	-	200	-	-	10

District 13 METROPOLITAN DISTRICT (MR)

Road Section 1000 EAST COAST ROAD

Site 131646 Sth of Myora Res- Dunwich

Site Stream All Site Streams

From 01-JAN-2002 To 31-DEC-2002

Hour	Austroads Class												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
00-01	1	0	0	0	0	0	0	0	0	0	0	0	1
01-02	1	0	0	0	0	0	0	0	0	0	0	0	1
02-03	1	0	0	0	0	0	0	0	0	0	0	0	1
03-04	1	0	0	0	0	0	0	0	0	0	0	0	1
04-05	3	0	0	0	0	0	0	0	0	0	0	0	3
05-06	25	1	1	0	0	0	0	0	1	0	0	0	28
06-07	69	1	8	1	0	0	0	1	9	1	0	0	90
07-08	81	2	6	3	0	0	1	1	12	0	0	0	106
08-09	121	3	8	2	1	1	0	0	9	0	0	0	145
09-10	117	4	7	2	0	1	0	0	11	0	0	0	142
10-11	110	4	4	1	0	1	1	2	12	0	0	0	135
11-12	131	4	6	2	0	1	0	1	16	0	0	0	161
12-13	103	3	6	1	0	1	0	1	11	0	0	0	126
13-14	98	3	5	2	0	1	0	0	7	0	0	0	116
14-15	117	3	5	1	0	0	0	0	5	0	0	0	131
15-16	128	2	11	0	0	0	0	0	2	0	0	0	143
16-17	106	2	6	0	0	0	0	0	3	0	0	0	117
17-18	98	2	4	0	0	0	0	1	5	0	0	0	110
18-19	50	1	4	0	0	0	0	1	6	0	0	0	62
19-20	32	1	3	0	0	0	0	0	1	0	0	0	37
20-21	17	0	0	0	0	0	0	0	0	0	0	0	17
21-22	12	0	1	0	0	0	0	0	0	0	0	0	13
22-23	7	0	0	0	0	0	0	0	0	0	0	0	7
23-24	4	0	0	0	0	0	0	0	0	0	0	0	4
Total	1433	36	85	15	1	6	2	8	110	1	0	0	1697
Class%	84.3	2.1	5.0	0.9	0.1	0.4	0.1	0.5	6.5	0.1	0.0	0.0	

Light %	86.4	
Heavy %		13.6
Short %	86.4	
Truck or Bus %		6.0
Art. Veh. %		7.5
Rd. Train %		0.1

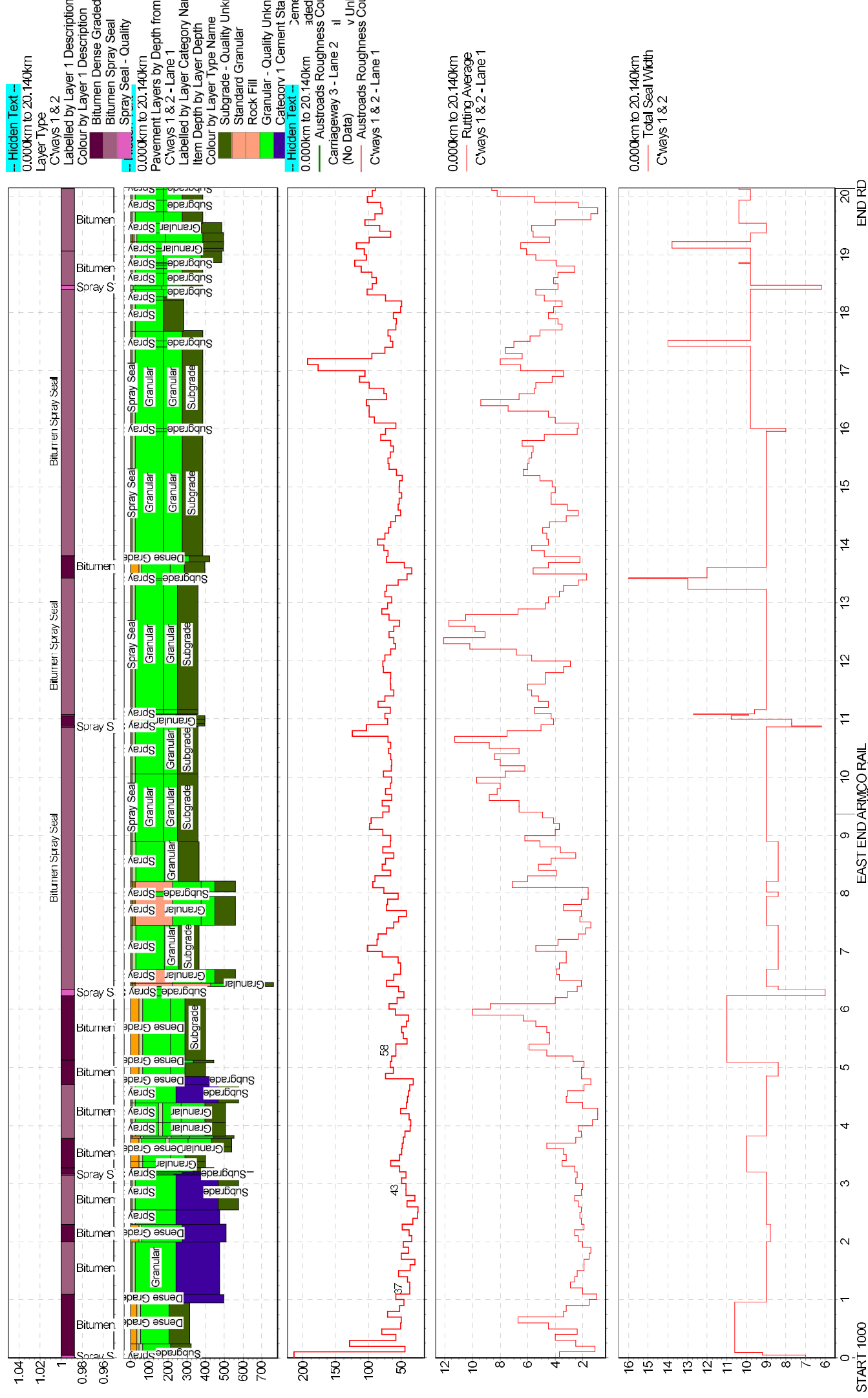
Estimated AADT:
Average % CV: 12.98%

[illegible]

Estimated AADT:
Average % CV: 13.73%

[illegible]

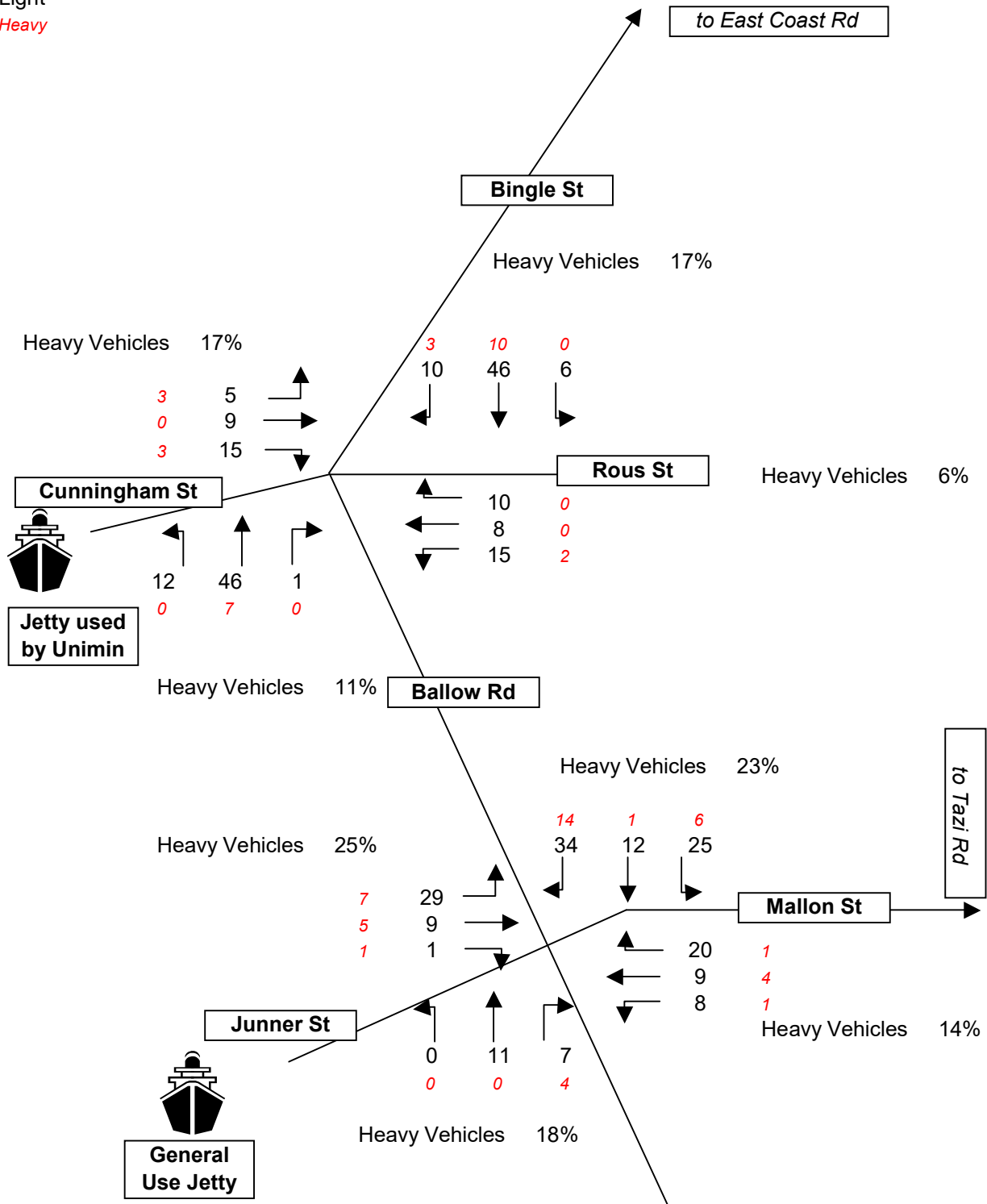
Road Section 1000 - EAST COAST ROAD (20.1 km) from METROPOLITAN DISTRICT (MR) refreshed on 28 Jun 2006



APPENDIX B

Traffic Flow Figures

Light
Heavy



Unimin Vance Lease

Figure B1

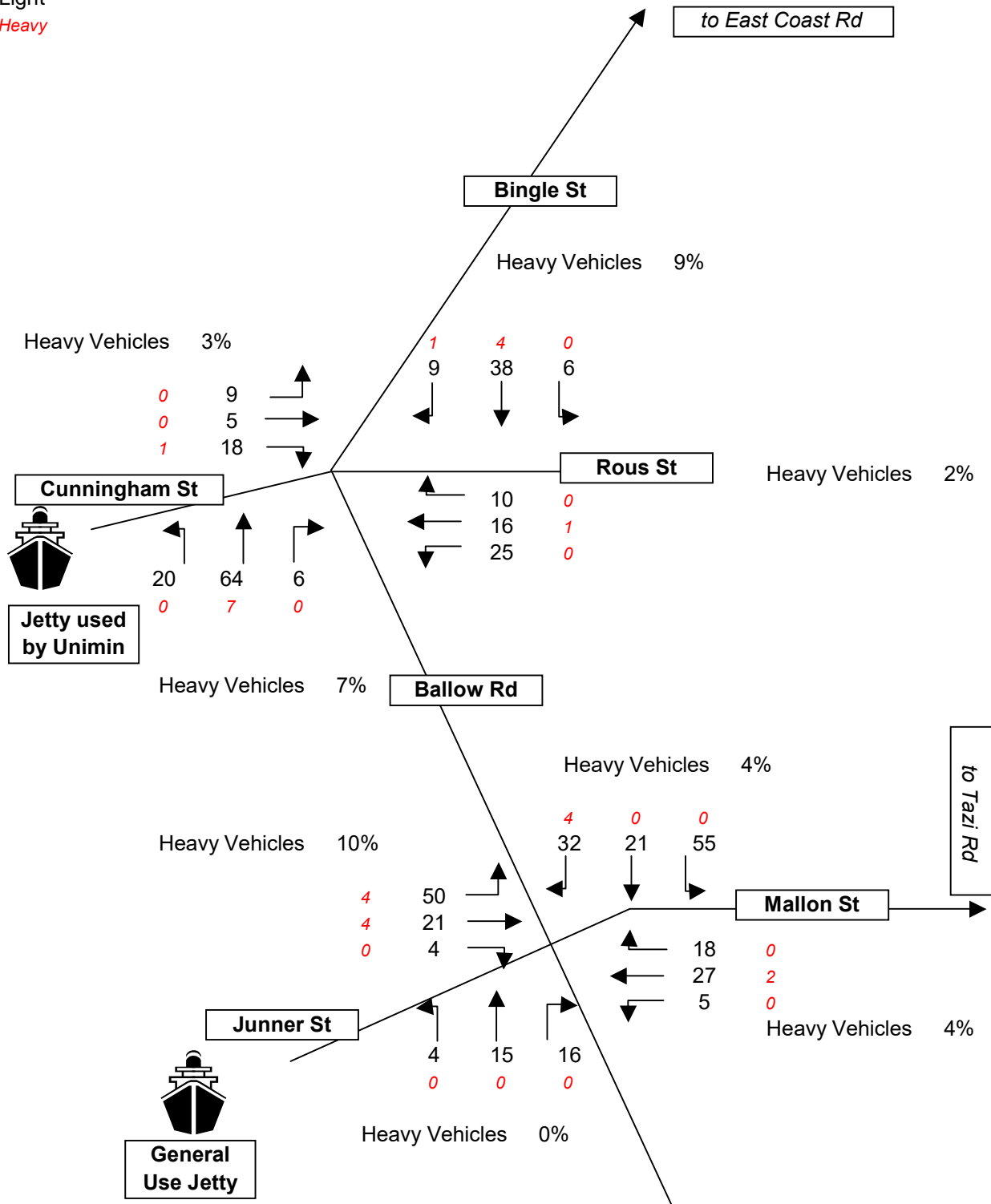
Surveyed Traffic Demands 2006

Morning Peak Period

Friday 08:00-09:00

BURCHILL VDM

Light
Heavy

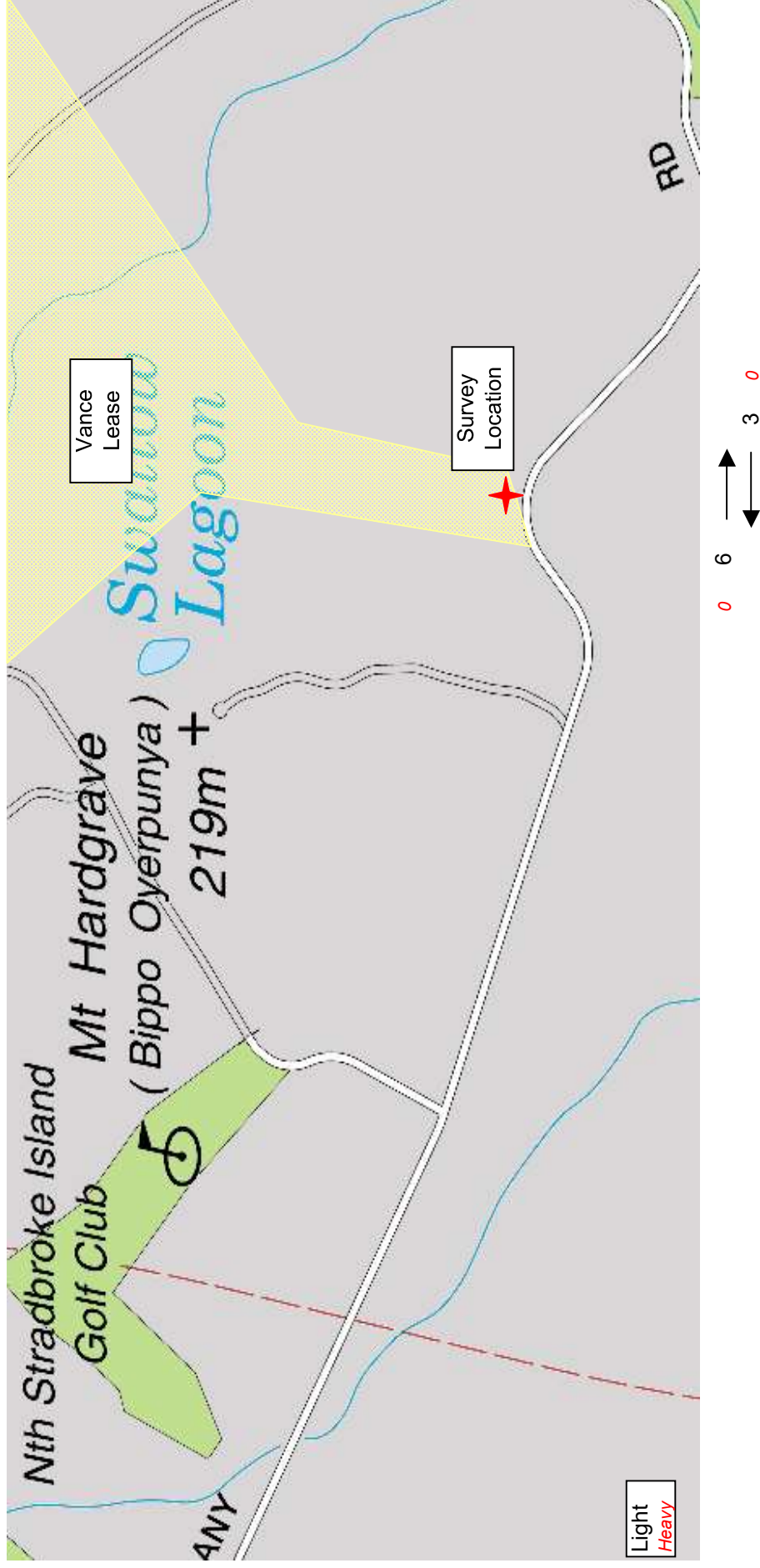


Unimin Vance Lease

Figure B2

Surveyed Traffic Demands 2006
Evening Peak Period
Friday 15:30-16:30

BURCHILL VDM



Unimin Vance Lease

Figure B3

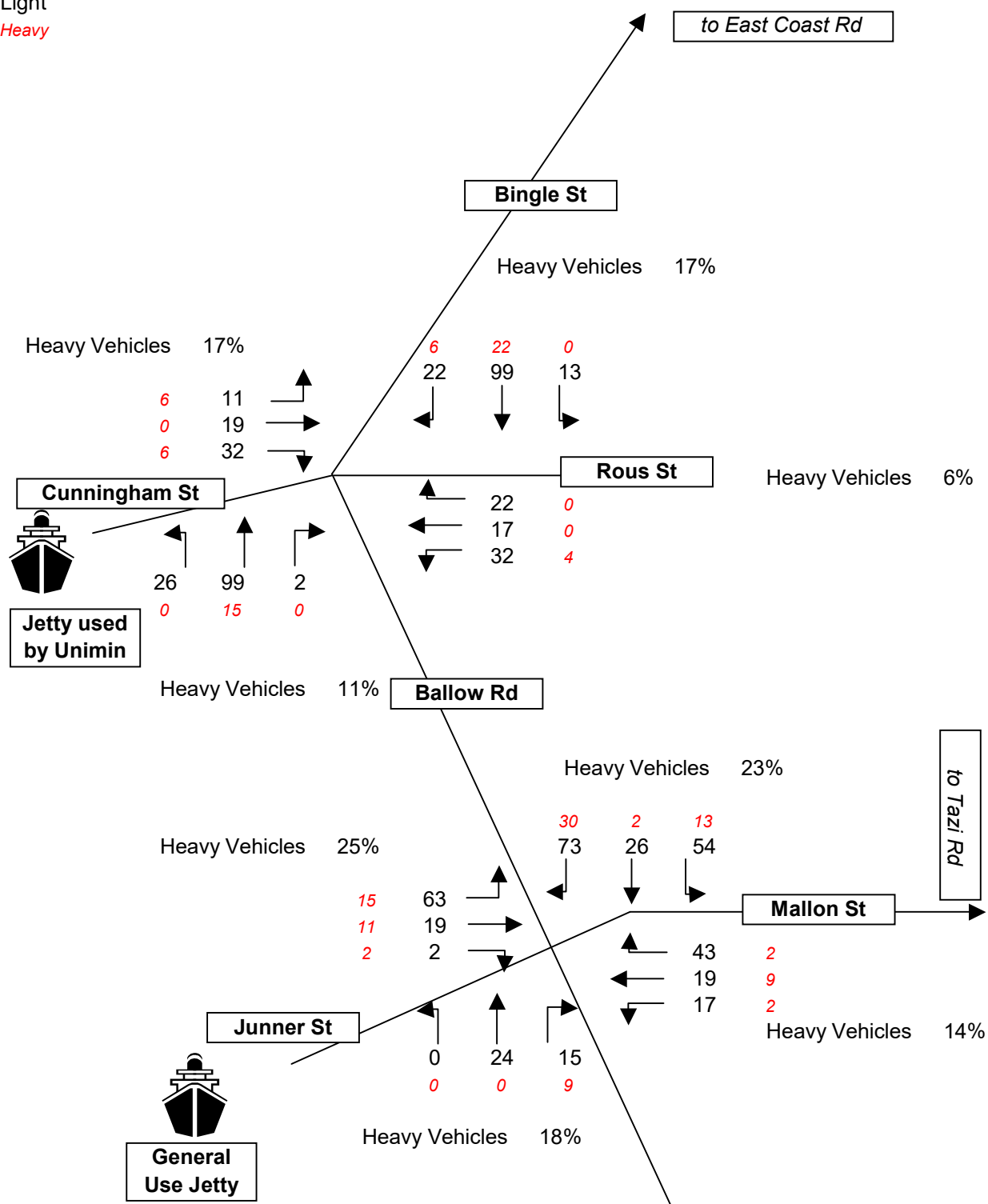
Surveyed Traffic Demands 2006

Tazi Road

Friday, Peak Hour Surveyed: 12:00-13:00

BURCHILL VDM

Light
Heavy



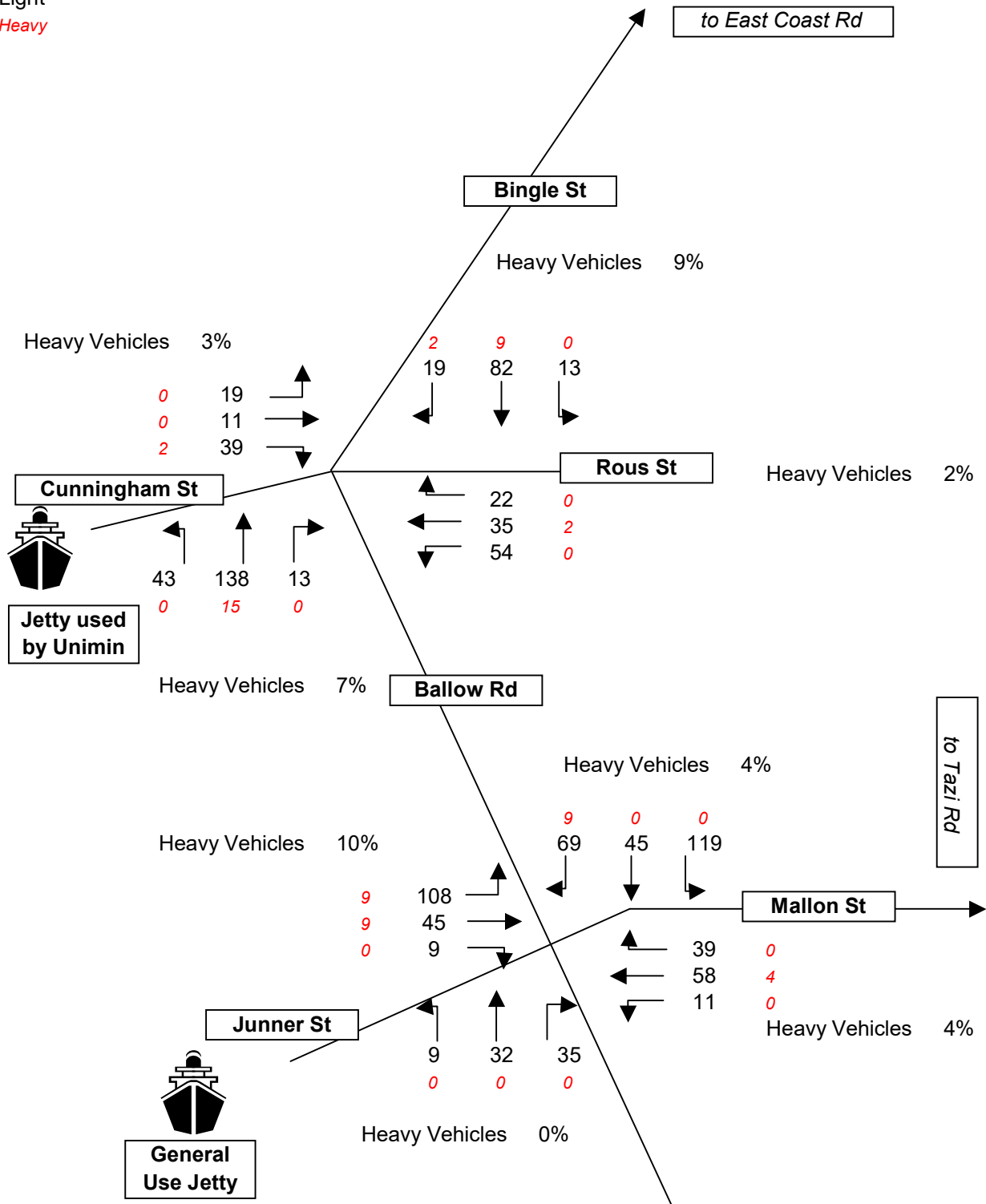
Unimin Vance Lease

Figure B4

Forecast Traffic Demands 2016
Morning Peak Period

BURCHILL VDM

Light
Heavy



Unimin Vance Lease

Figure B5

Forecast Traffic Demands 2016
Evening Peak Period

BURCHILL VDM



Unimin Vance Lease

Figure B6

Forecast Traffic Demands 2016

Tazi Road

Peak Hour Surveyed: 12:00-13:00

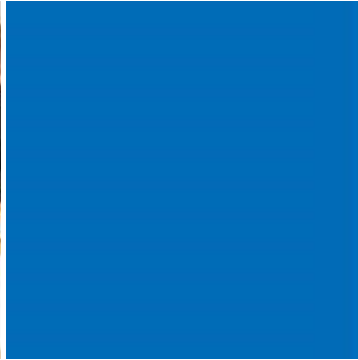
BURCHILL VDM

Appendix O

Socio-Economic Study

REPORT

Update on Socio-Economic Considerations – Vance Lease ML 1108



Prepared for

Unimin Australia Limited

20 March 2007

42625813

URS

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Date: 20 March 2007
Reference: Socio Economic Report
Status: Final

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Section 1

Introduction

This report has been compiled in response to the Environmental Protection Agency's (EPA's) comments on the draft Environmental Studies Report (ESR) for the Unimin Australia Limited (Unimin) Vance Lease, prepared by URS Australia Pty Ltd (URS). At EPA's request, this report provides additional socio-economic information to what was initially provided in the Environmental Impact Statement (EIS) for the Proposed Silica Sand Extraction project on MLA7064, North Stradbroke Island. This EIS included a socio-economic component, as prepared by Outline Planning Consultants Pty Ltd in 1998.

This report is intended to complement Outline Consultants original socio-economic report by providing:

- Updated baseline demographic information; and
- Details of alternative haulage options for ML1108.

1.1 Methodology

The EPA has accepted that the Social and Economic topics for the Vance Lease ESR can be based on those characteristics set out in Section 6 of the EIS, prepared for the proposed silica sand extraction project by Outline Planning Consultants Pty Ltd. However, EPA also indicated that the socio-economic component of the ESR must incorporate more recent data for baseline demographic information.

1.1.1 Baseline Demographic Data

The original socio-economic information provided in Outline Consultants report was based on 1996 Census data. Updated demographic information used for this report has been sourced from:

- Australian Bureau of Statistics (ABS) 2001 Census Data – the most recent Census information available;
- Australian Bureau of Statistics (ABS) 2001 Indigenous Profile – North Stradbroke Island (IARE09070);
- Redland Shire Council; and
- The following Queensland government state information bodies:
 - Queensland Planning and Information Forecasting Unit (PIFU); and
 - Queensland Office of Economic and Statistical Research (OESR).

The geographic scope of this socio-economic study has been limited to North Stradbroke Island, as per the original socio-economic study.

Baseline demographic information for North Stradbroke Island is predominantly based on the North Stradbroke Island Demographic Profile prepared by PIFU. Data on occupation and employment by industry is based on the Redland Shire Balance Statistical Local Area (SLA)

Section 1

Introduction

Profile (SLA 305506283). This SLA includes the population on North Stradbroke Island and the surrounding Moreton Bay Islands.

Details of the indigenous population for the Island have been gathered from the ABS indigenous profile for North Stradbroke Island (IARE09070).

The proposed mining activities on ML1108 are located in a sparsely populated section of North Stradbroke Island. Based on information contained in the original socio-economic report, the nearest populated area is the small settlement of Myora. This area falls into ABS collection district (CD) 3202901. This CD has been used for demographic analysis of the population in the vicinity of the proposed mine lease.

1.1.2 Details of alternative haulage options

Details of alternative haulage route options have been derived from the Road and Traffic Impact Assessment Report, which was prepared for Unimin by Burchill VDM in August 2006. A summary of key aspects of this report is provided in Section 3.

Section 2

Baseline Demographic Information

2.1 North Stradbroke Island

At the time of the 2001 Census, there were a total of 2,512 persons recorded on North Stradbroke Island. This indicates a marginal increase in the number of people from the 1996 Census, when a total of 2,435 persons were recorded. The estimated resident population of North Stradbroke Island as at the 2001 Census was 2,196 people, representing a decrease of 154 people, or 1.3% per annum since 1996. 316 people were recorded as visitors in the 2001 Census (ie. from elsewhere in Queensland, interstate or overseas).

The main population centres of North Stradbroke Island include Dunwich, Amity and Point Lookout.

As at the 2001 census, 22.8% of the North Stradbroke Island resident population were aged less than 15 years and 9.4% were aged 65 and over. Table 1 details the age structure of the North Stradbroke Island resident population.

Table 1: Age Structure

Age (Years)	Estimated Resident Population (%)
0-14	22.8
15-24	9.7
25-34	10.8
35-44	16.1
45-54	16.7
55-64	14.5
65-74	6.4
75-84	2.5
85+	0.5

(Source: PIFU, 2002)

80.4% of people recorded on North Stradbroke Island at the Census were born in Australia. The highest ranking birthplace countries of people born overseas were the United Kingdom (3.2%) and New Zealand (2.4%).

Indigenous Australians accounted for 13.3% of North Stradbroke Island's population, which is a significantly higher proportion compared to the Queensland average, where 3.1% of the population is indigenous. 31.2% of the island's indigenous population were less than 14 years of age. Less than 1% of recorded indigenous people on the island spoke Aboriginal or Torres Strait Island languages.

"Couple family without children" was the most common family type on North Stradbroke Island, with 43% of families fitting this classification. This family type has increased from a recorded 38.9% during the 1996 Census. Couple families with children decreased from 41.7% of all

Section 2

Baseline Demographic Information

families in 1996 to 36.4% in 2001. One parent families increased from 17.3% of all families in 1996 to 19.5% in 2001. Table 2 provides details of family type.

Table 2: Family Type (2001 Census)

Family Type	(%)
Couple Family with Children	36.4
Couple Family without Children	43.0
One Parent Family	19.5
Other Family	1.1
Total Families (persons)	544

On North Stradbroke Island, 12.9% of residents were recorded as living alone in 2001. Husbands and wives accounted for 45.8% of the Island's population.

Separate houses were the predominant dwelling type for the Island's population (1782 residents or 78%), while 258 residents (11%) lived in "other" dwellings including caravans, boats and tents. The average population per dwelling in 2001 was 2.3 per household, which was lower than the 1996 Census. On North Stradbroke Island almost 40% of dwellings were unoccupied at the time of the Census, reflecting the abundance of short term/holiday accommodation in the area. As at the 2001 Census approximately 50% of dwellings were owned or being purchased, while approximately 38% were rented. The median rent on the island as at the 2001 Census was between \$100 and \$150 per week.

North Stradbroke Island recorded a higher rate of low income earners compared to the Queensland average. Low income earners (ie. those earning less than \$200 per week) accounted for 26.4% of all people aged 15 years and over in 2001. High income earners (earning more than \$1,500.00 per week) accounted for 2.2% of all people aged 15 years and over in 2001.

As discussed in Section 1.1, details of occupation and employment by industry specifically for North Stradbroke Island are not available, with data being based on Redland Shire Balance Statistical Local Area demographics, which cover a number of Moreton Bay Islands (refer section 1.1 for further details). In Redland Shire Balance SLA, the most common occupations for employed persons were Intermediate Clerical, Sales and Service Workers (5.5%), Tradespersons and Related Workers (5.2%) and Associate Professionals (5.1%). The least common occupation was Advanced Clerical and Service Workers (1.1%). In Redland Shire Balance, the most popular industries of employment were Accommodation, Cafes and Restaurants (3.6%), Metal Ore Mining (3.1%), Business Services (2.3%), Education (2.3%) and Construction Trade Services (2.1%).

Section 2**Baseline Demographic Information****2.2 Population in the Vicinity of ML1108**

The closest population to the Vance Mining Lease ML1108 is around Myora Estate, north of Dunwich. This area is situated in collection district (CD) 3202901, which covers an area of 156.7km². As at the 2001 Census, 139 people were recorded in this collection district, representing a decrease in the population of the area since the 1996 Census, when 177 people were recorded. 31 persons (17.5%) identified themselves as Aboriginal or Torres Strait Islanders. 88% of the population were born in Australia.

At the time of the 2001 Census, 4.5% of the population were unemployed, which is significantly lower than the 1996 Census, where the original socio-economic study reported unemployment at 17.6%. Of those employed as at 2001, 55% were employed full time. 2001 Census data indicated that industries of employment included:

- cultural and recreational services;
- government administration and defence;
- mining;
- agriculture; and
- forestry and fishing.

Section 3

Alternative Haulage Route Options

A Road and Traffic Impact Assessment (R&TIA) report was prepared by Burchill VDM in August 2006. The R&TIA report assessed the existing road infrastructure in the area around the proposed mining lease and the impact on the local road network.

The R&TIA report found that the proposed operation in the Vance Lease ML1108 area is unlikely to result in additional traffic generation on North Stradbroke Island. The existing haul route is considered by the consultant to represent the most appropriate route between the existing mine site access and the Cunningham Street Wharf. Alternate routes were considered, but were found to direct heavy vehicles through smaller streets and more residential areas, and thus were not considered appropriate.

A future alternative haulage route with a new access from the southern end of ML1108 onto Tazi Road was considered viable provided appropriate sight distance could be provided at the access point, and road rehabilitation work was carried out. Use of Tazi Road would require increased pavement width, annual pavement maintenance and future rehabilitation. Full details of traffic impacts and the alternative route are provided in Appendix H of the ESR document.

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