VOLUME 2: PUBLIC ENVIRONMENTAL REVIEW

PROPOSED RELOCATION OF THE VOYAGER QUARRY

LAND CLEARING AND QUARRY EXPANSION, AVON LOC 1881, LOT 14 HORTON ROAD, THE LAKES

(EPA Assessment Number 1413)

January 2003

BGC

URS

PUBLIC ENVIRONMENTAL REVIEW
(Volume 2)

Land Clearing and Quarry Expansion, Avon Loc 1881, Lot 14 Horton Road, The Lakes

(EPA Assessment Number 1413)

Prepared for

BGC (Australia) Pty Ltd
Lot 4 Stirling Crescent
HAZELMERE WA 6055

January 2003

URS Australia Pty Ltd
Level 3, Hyatt Centre, 20 Terrace Road
East Perth Western Australia 6004
Tel.: (08) 9221 1630; Fax: (08) 9221 1639
E-mail: perth@urscorp.com
ABN 46 000 691 690

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INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. If you are able to, electronic submissions emailed to the DEP/EPA Project Assessment Officer would be most welcome.

BGC (Australia) Pty Ltd proposes to expand its existing hard rock quarry near The Lakes. In accordance with the *Environmental Protection Act* 1986, a PER has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of eight weeks from 6 January, closing on 3 March 2003.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?
A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?
If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission
You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the PER:
- clearly state your point of view;
- indicate the source of your information or argument if this is applicable; and
- suggest recommendations, safeguards or alternatives.

Points to keep in mind
By keeping the following points in mind, you will make it easier for your submission to be analysed:
- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the PER;
- if you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:
- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: **3 March 2003**.

Submissions should ideally be emailed to

ben.von.perger@environ.wa.gov.au
OR addressed to:

The Environmental Protection Authority
PO Box K822
PERTH WA 6842
Attention: Ben von Perger

[Westralia Square
141 St George's Terrace
PERTH WA 6000

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1. INTRODUCTION

1.1 THE PROPOSAL

The Voyager Quarry is located on Great Southern Highway approximately 47 km southwest of the town of Northam and 16 km east of the town of Mundaring, Western Australia (Figure 1.1). BGC (Australia) Pty Ltd (the Proponent) has been operating the quarry since 1990 to provide crushed granite for the manufacture of concrete, road base and other building products. The Voyager Quarry plant has a nominal rated throughput of approximately 900,000 tonnes per annum (tpa) which provides 35-40% of the crushed rock required by building and construction industries in the Perth Metropolitan Region and surrounding areas.

The current Voyager Quarry comprises an open pit (Plate 1), a crushing plant (Plates 2-3), noise attenuation bunds, product stockpiles, a workshop and office facilities. Access to the site is via a sealed road from Great Southern Highway. The layout of these project components is provided in Figures 1.2 and 1.3.

Plate 1 Existing Voyager Quarry pit

Plate 2 Primary crusher and stockpiles

Plate 3 Secondary and tertiary crushers and screens

The existing quarry has an expected project life of six years. To ensure a continuous supply of crushed rock to current and future markets, the Proponent proposes to develop a second open pit to the west of the existing pit, within Lot 14 Horton Road, The Lakes. The crushing plant, which is currently located to the east of the existing quarry (Figures 1.2 and 1.3), will

be decommissioned and a new plant will be constructed below ground level within the new pit. The layout of the proposed quarry is provided in Figures 1.2 and 1.3.

The existing quarry, crushing plant and supporting infrastructure are located on land leased by the Proponent from the owner of the Voyager Farm. The proposed quarry will be located on land owned by the Proponent (Figure 1.4) and hereafter will be referred to as the Project Area.

Approximately 1-2 Mt of gravel and approximately 12 Mt of clay will be excavated from the proposed Project Area over the four to five year construction period for the proposed open pit. Quarrying of the granite located beneath the gravel and clay is expected to occur over a 50 year period, based on current reserves. During this period, approximately 50 Mt of granite will be excavated from the Project Area.

1.2 THE PROPONENT

The Proponent of this Project is:

BGC (Australia) Pty Ltd
Lot 4 Stirling Crescent
HAZELMERE WA 6055

ABN 62005736005

For further information contact:

Frank Italiano, General Manager Quarries/Asphalt
Tel: (08) 9442 2387
Fax: (08) 9442 2389
Email: frank@bgc-quarries.com.au

BGC Quarries is part of the construction division of the Buckeridge Group of Companies (BGC [Australia] Pty Ltd), a privately owned Western Australian company involved in the building, construction and mining industries on a national and international scale.

BGC (Australia) Pty Ltd is a Quality Endorsed Company with a Quality System developed in accordance with ISO 9002.

1.3 PURPOSE AND STRUCTURE OF THE PER

The proposed quarry relocation is being assessed under Part IV of the *Environmental Protection Act* 1986 (as amended) as a Public Environmental Review (PER). The objectives of the PER are to:

- place the proposed quarry relocation in the context of the local and regional environment and a historical perspective;
- adequately describe all components of the proposal;
- provide the basis of the Proponent's environmental management programme, which shows that the environmental impacts resulting from the proposal (including any cumulative impacts) can be managed in an acceptable manner;

- communicate clearly with the public (including government agencies), so that the Environmental Protection Authority (EPA) can obtain informed public comment to assist in providing advice to the Minister for the Environment and Heritage; and
- clearly set out the reasons why the proposal should be considered by the EPA to be environmentally acceptable.

The PER comprises three volumes:

- Volume 1: Executive Summary.
- Volume 2: Public Environmental Review.
- Volume 3: Appendices.

Volume 2 of the PER (this document) is structured as follows:

Section 1	Introduction	Provides background information relevant to the environmental assessment of the proposed quarry relocation.
Section 2	Project Justification	Provides information on the site selection process, identifies the environmental and social benefits of the proposed quarry relocation, and outlines the consequences of the proposed quarry relocation not proceeding.
Section 3	Project Description	Describes the key characteristics of the proposed quarry relocation. The Proponent's current operations at the Voyager Quarry are also described to provide context to the assessment of the proposed quarry relocation.
Section 4	Existing Environment	Describes the physical, biological and social characteristics and values of the Project Area.
Section 5	Community and Government Consultation	Describes the community and government consultation programme conducted during the preparation of this PER and the consultation programme proposed as part of proposal implementation.
Section 6	Environmental Effects Summary	Identifies the key environmental issues that could arise as a result of proposal implementation, and a summary of the ability of the Project to satisfy the EPA's objectives for each issue.
Section 7	Environmental Issues and Management	Identifies the environmental and social impacts associated with the proposed quarry relocation and the proposed environmental management of these impacts.
Section 8	Summary of Environmental Management Commitments	Summarises the Proponent's environmental management commitments.

Section 9	Conclusion	Provides a concluding statement of the potential environmental costs and benefits of the proposed quarry relocation, and a case outlining why the proposal should be allowed to proceed.
Section 10	Acknowledgements	Acknowledges the study team, organisations and other people who have contributed to this report.
Section 11	References	Provides a list of references cited in this PER.
Section 12	Abbreviations	Lists the abbreviations used in this PER.

1.4 LAND TENURE

The proposed Project Area is located on Lot 14 Horton Road, which is owned by the Proponent. Lot 14 is located in the Shire of Northam and adjacent to the Shire of Mundaring (Figure 1.4). The zoning classification for the Project Area is Rural Zone 3. The Rural Zone 3 classification means that Council will not support further subdivision of the land, except where this may be necessary for the protection of the natural and rural environment or the acquisition of additional reserves.

1.5 RESPONSIBLE AUTHORITIES

The main agencies involved in the environmental assessment and management of the proposed quarry relocation are:

- The EPA, which is an independent statutory authority and the key provider of independent environmental advice to Government. The EPA's objectives are to protect the environment and to prevent, control and abate pollution.

- The Department of Environmental Protection (DEP), which administers the *Environmental Protection Act* 1986 on behalf of the Minister for the Environment and Heritage and is responsible for considering and initiating measures for the conservation, protection and management of the environment, and for the prevention, control and abatement of pollution. The DEP, the Water and Rivers Commission (WRC) and the Swan River Trust are in the process of amalgamating to form the Department of Environment, Water and Catchment Protection.

- The WRC, which administers the *Water and Rivers Commission Act* 1995 and other relevant legislation (such as the *Waterways Conservation Act* 1976 and parts of the *Rights in Water and Irrigation Act* 1914) to ensure that the State's water resources are managed to support sustainable development and conservation of the environment for the long-term benefit of the community.

- Department of Conservation and Land Management (CALM), which manages lands and waters for the conservation of biodiversity at ecosystem, species and genetic levels. CALM administers the *Conservation and Land Management Act* 1950 and assists the Conservation Commission, the Marine Parks and Reserves Authority, and the Marine Parks and Reserves Scientific Advisory Committee carry out their statutory functions. CALM also works closely with the Forest Products Commission.

- Department of Indigenous Affairs, which administers the *Aboriginal Heritage Act* 1972 and supports the Aboriginal Lands Trust.

- Shire of Northam, which issues the Voyager Quarry's Extractive Industries Licence. This local government body also regulates land zonings within the Shire of Northam in conjunction with the Ministry for Planning.

- Department of Agriculture, which includes the Soil and Land Conservation Commission and administers the *Soil and Land Conservation Act* 1945.

1.6 RELEVANT LEGISLATION, POLICIES AND GUIDELINES

The Proponent's proposal for the relocation of the Voyager Quarry is being assessed under Part IV of the *Environmental Protection Act* 1986 (as amended). If the Project is approved, the Minister for the Environment and Heritage will issue a statement that lists the environmental conditions that will apply to the Project when implemented.

In addition to obtaining approval from the Minister for the Environment and Heritage, the Proponent will also need to comply with a range of legislation and regulations administered by State and Federal Government agencies. Relevant legislation includes those Acts and Regulations listed in Table 1.1.

Table 1.1 also lists a range of policies and guidelines applicable to the expansion of the Voyager Quarry.

Table 1.1
Regulatory Framework

Aspect	Title	Applicability
Commonwealth Legislation	*Environment Protection and Biodiversity Conservation Act* 1999	The proposed quarry relocation was referred to Environment Australia under this Act due to potential impacts on listed threatened species and migratory species protected under international agreements (see Section 1.7.2 for details).
National Policies and Strategies	1996 National Strategy for the Conservation of Australia's Biological Diversity	Applies to the clearing of remnant vegetation as principles and objectives of the National Strategy aim to conserve biological diversity.
	1992 National Strategy for Ecologically Sustainable Development	Provides guidelines for the use of natural resources in an ecologically sustainable manner.
	Australian and New Zealand Environmental and Conservation Council (ANZECC) National Framework for the Management and Monitoring of Australia's Native Vegetation 1999	Provides guidelines for the management and monitoring of native vegetation.
	Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000)	Provides a water quality management framework, including the key steps for developing water quality guidelines and water quality objectives.
	The National Environment Protection Measure (NEPM) for Air Quality.	A set of national air quality standards to apply in all States and Territories. These standards have been set by the National Environment Protection Council (NEPC). The levels specified in the NEPM provide a benchmark and assist in the protection against air pollution.
State Legislation	*Environmental Protection Act* 1986 (as amended)	The proposed quarry relocation is being formally assessed under Part IV of this Act. Any Works Approvals or Licences required for the project are issued under Part V of the Act.
	Environmental Protection (Noise) Regulations 1997	Represents the prescribed standards for noise under the *Environmental Protection Act 1986*. Acceptable noise levels for different times of the day are specified.
	Mining Act 1978	Provides occupational health standards applicable to the operation of the quarry.
	Rights in Water and Irrigation Act 1914	Applies to the management of water resources and the equitable and efficient use of water resources.
	Aboriginal Heritage Act 1972	Relates to the protection and preservation of Aboriginal sites.
	Wildlife Conservation Act 1950	Applies to the protection of wildlife in Western Australia.

Table 1.1 (continued)

Aspect	Title	Applicability
State Legislation (continued)	*Soil and Land Conservation Act* 1945	Applies to the clearing of native vegetation and disturbance of soil in Western Australia.
State Policies and Strategies	Memorandum of Understanding (MOU) for the Protection of Remnant Vegetation on Private Land in the Agricultural Region of Western Australia 1997	Applies to proposals to clear more than one hectare of native vegetation on rural zoned land in southern Western Australia, south or west of the eastern boundaries of the main agricultural areas. There is a general presumption against clearing in areas: • less than 20% of the original vegetation remaining in the main agricultural areas of the shire; • less than 20% of the original vegetation remaining on the property; • a controlled catchment or water reserve proclaimed under the *Country Area Water Supply Act* 1947; or • a special policy area (such as the Peel-Harvey Catchment). The onus is on the landholder to demonstrate that land degradation and loss of biodiversity will not occur.
EPA Position Statements	*Environmental Protection of Native Vegetation in Western Australia. Clearing of Native Vegetation, with Particular Reference to the Agricultural Area*. EPA Position Statement No. 2 (EPA, 2000)	Applies to proposals to clear remnant native vegetation in Western Australia as it aims to protect biodiversity. Key criteria applied include: • the "threshold level" below which species loss appears to accelerate exponentially at the ecosystem level is regarded as being at a level of 30% of the pre-clearing of the vegetation type; and • a level of 10% of the original extent is regarded as being a level representing "endangered" and should be avoided.
	Terrestrial Biological Surveys as an Element of Biodiversity Protection. EPA Position Statement No. 3 (EPA, 2002)	Highlights the significance of biodiversity and the need to develop and implement best practice in terrestrial biological surveys.
	EPA Bulletin 966 on Clearing of Native Vegetation (EPA, 1999a)	Applies to the clearing of native vegetation within the agricultural region of Western Australia.
	Final Report of the Native Vegetation Working Group (Native Vegetation Working Group, 2000)	Provides strategies for the management of native vegetation in Western Australia.

Table 1.1 (continued)

Aspect	Title	Applicability
EPA Guidance for the Assessment of Environmental Factors	Environmental Noise (Draft Guidance Statement No. 8) (EPA, 1998a)	Provides guidance about the assessment of noise emissions to proponents submitting proposals for environmental impact assessment. This Guidance Statement assists proponents in determining whether or not noise emissions will require detailed analysis. The Statement also provides guidelines for the derivation and presentation of technical information for assessment of noise impacts.
EPA Guidance for the Assessment of Environmental Factors (cont.)	Management of Surface Run-off from Industrial and Commercial Sites (Draft Guidance Statement No. 26) (EPA, 1999b)	Provides guidance for the protection of water resources from stormwater runoff carrying pollutants. This Guidance Statement also addresses groundwater and surface water contamination caused by stormwater runoff from industrial sites. The EPA's position on stormwater discharges to the environment is also presented in the Statement.
	Assessment of Aboriginal Heritage (Draft Guidance Statement No. 41) (EPA, 2001)	This Guidance Statement considers 'Aboriginal heritage' as a relevant environmental factor in circumstances where they are linked directly to physical and biological attributes of the environment, and when the protection and management of those attributes are threatened as a result of a proposed development. The Statement provides information which the EPA will consider when assessing proposals where Aboriginal Heritage is a relevant environmental factor.
Government Guidelines	Environmental Management of Quarries: Development, Operation and Rehabilitation Guidelines (Department of Minerals and Energy [DME], 1994)	Provides a practical guide for the environmental management of quarries so that adequate standards of environmental performance are achieved.
Industry Guidelines	Strategic Framework for Mine Closure (Australian and New Zealand Minerals and Energy Council [ANZMEC] and Minerals Council Australia [MCA], 2000)	Provides a set of objectives and principles designed to facilitate a broadly consistent framework for mine closure across Australia.
	Mine Closure Guideline for Minerals Operations in Western Australia (The Chamber of Minerals and Energy of Western Australia Inc, 1999)	Provides a framework for closing a range of minerals industry operations to ensure a company does not leave itself, subsequent land owners or the State with unacceptable ongoing liability.

1.7 ENVIRONMENTAL ASSESSMENT PROCESS

1.7.1 Assessment under the WA *Environmental Protection Act*

The environmental assessment process in WA is designed to provide information to the EPA, DEP and other regulatory authorities, as well as the public, about proposed developments with the potential to impact on the natural and social environment. The main stages of this process are illustrated in Figures 1.5 and 1.6.

The proposed quarry relocation was referred to the WA EPA by the Commissioner for Soil and Land Conservation on 19 December 2001 and the EPA elected to formally assess the proposal as a PER. The level of assessment was advertised in the *West Australian* newspaper on 24 December 2001 and was subject to a two-week public appeals period. A number of appeals against the level of assessment were submitted to the Appeals Convenor and were considered by the Minister for the Environment and Heritage. On 1 May 2002, the Minister dismissed the appeals and confirmed that the proposal would be assessed as a PER.

Guidelines for the preparation of this PER have been issued by the EPA and are provided in Appendix A. The environmental factors that the EPA, in consultation with key regulatory authorities, believes should be addressed in the PER are listed in Part A of these Guidelines.

The PER is a public document and will be subject to an eight-week public review period. During this time, government agencies, private organisations, community groups and the public are invited to make submissions to the EPA. The EPA will then assess the proposed quarry relocation with consideration of:

- issues raised by the public during the public review period;
- the Proponent's response to the issues raised by the public;
- specialist advice from government agencies;
- the EPA's own research; and
- research undertaken by other specialist agencies or parties, if required.

Following its assessment of the proposed project, the EPA will prepare and submit its report and recommendations to the Minister for the Environment and Heritage. This document will comprise the EPA's report on the environmental acceptability of the proposal and its recommendations regarding the environmental conditions that should apply if the proposed quarry relocation is to proceed. The EPA will publish its report and the public may appeal to the Minister against the content of the report or its recommendations.

The decision on whether the proposed quarry relocation may proceed will be made by the Minister for the Environment and Heritage. Only after the Minister has set the environmental conditions of approval may regulatory authorities issue other environmental approvals.

1.7.2 Assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act*

Under the *Environment Protection and Biodiversity Conservation Act* 1999 (the EPBC Act), an action requires approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a matter of National Environmental Significance (NES). The matters of NES are:

- World Heritage properties;
- Ramsar wetlands of international importance;
- listed threatened species and communities;
- migratory species protected under international agreements;
- nuclear actions; and
- the Commonwealth marine environment.

The proposed quarry relocation was referred to Environment Australia on 22 February 2002 due to the potential for impacts on the following species:

- Sticky Hemigenia (*Hemigenia viscida*), a plant species listed as Vulnerable under the EPBC Act;
- Carnaby's Black Cockatoo (*Calyptorhynchus latirostris),* which is listed as Endangered under the EPBC Act;
- Baudin's Black Cockatoo (*Calyptorhynchus baudinii)* which is listed as Vulnerable under the EPBC Act;
- the Chuditch (*Dasyurus geoffroii*), which is listed as vulnerable under the EPBC Act; and
- the Fork-tailed Swift (*Apus pacificus*) and Rainbow Bee-eater (*Merops ornatus*), which are migratory bird species protected by international agreements.

Information on the potential for environmental impacts on these species is provided in Section 7.8 of this PER.

The referral was published on Environment Australia's web page on 25 February 2002 (Reference number 2002/587). The public then had two weeks to comment on whether the proposed quarry relocation should be a "controlled action" (i.e. whether the proposal is likely to have a significant impact on a matter protected under the EPBC Act and therefore should require environmental assessment and approval).

Following the close of the public comment period on 11 March 2002, the Approvals and Legislation Division of Environment Australia considered the referral and any public comments, and determined that the action is not a controlled action. Therefore, approval is not required under the EPBC Act.

2. PROJECT JUSTIFICATION

2.1 EVALUATION OF ALTERNATIVE SITES

2.1.1 Historical Perspective on the Development of the Existing Quarry

In the 1980s, BGC conducted an extensive search for a quarry site to source the requirements of home building companies. BGC spent three years and considerable expense researching and evaluating sites suitable for quarrying within reasonable proximity to the City of Perth. These sites are listed in Table 2.1. All sites were constrained by various factors (as indicated in Table 2.1) but, following exhaustive analysis and extensive discussion with relevant authorities, the company selected the Hardinge Road site in Orange Grove (south of the Bickley Reservoir) as its preferred location.

The proposal had been assessed under the Mines Department approval process and had been upheld by the Warden's Court against an objection. Despite the proposal having received relevant approvals, the Minister for Mines refused final permission in 1986. Consequently, further extensive discussions were conducted with the local Government authority (the City of Swan) and various State Government departments. The department representatives emphasised the difficulties in getting approvals for sites located in the metropolitan area and it was strongly suggested that a search should be made outside the metropolitan area and distant from any urban development. In response to BGC's concerns about haulage difficulties and high transport costs, the departments indicated that, in the medium to long term, all quarries would eventually have to relocate outside the metropolitan area. BGC currently carries a substantial cost penalty per tonne when compared with competitors' quarries in the metropolitan area (Figure 2.1).

Following the refusal by the Minister for Mines to issue approval to develop the Hardinge Road site, BGC proposed that a quarry be developed at Koobeja (Lot 1889) to the south-east of the existing Voyager Quarry (Figure 1.1). Koobeja was not considered in the initial site selection process as it was considered to be too distant from the metropolitan area. However, the site was discovered after exhaustive field trips were undertaken to locate outcrops of suitable granite rock.

The proposal to develop a quarry at Koobeja was initiated in 1990 and was to be the subject of a Consultative Environmental Review. However, the proposal lapsed as there were concerns regarding the site being located within the Mundaring Weir Catchment Area. Subsequently, extensive discussions were held with the EPA, who suggested that the site should be located:

- outside of the Perth Metropolitan Area; and
- outside of the Mundaring Weir Catchment Area.

The current location of the Voyager Quarry was identified as meeting the above criteria. BGC negotiated with the land holder of the Voyager Farm and obtained a lease agreement to establish a quarry on a portion of the farm. Following the issue of a Works Approval by the EPA, and an Extractive Industries Licence from the Shire of Northam, the Voyager Quarry became fully operational in 1991.

Table 2.1
Review of Regional Site Options

Site	Environmental and Social Constraints							
	Proximity to Urban Development	**Excessive Transport Costs**	**Potential for Visual Impacts on the Darling Scarp**	**Road Upgrade or Construction Requirements**	**Cost of Establishing Infrastructure (excluding roads)**	**Water Issues**	**Proximity to National Parks**	**Potential Difficulty in Obtaining Relevant Approvals**
Copley Road, Middle Swan	✓			✓	✓			✓
Pearce Farm, Bullsbrook		✓	✓	✓	✓			
Hardinge Road, Orange Grove	✓					✓	✓	
Waterway Farm, Bedfordale	✓					✓	✓	✓
Kiln Road, Cardup	✓	✓		✓	✓			✓
Shale Road, Whitby	✓	✓		✓	✓	✓	✓	✓
Burgess Road, Gidgegannup	✓			✓				✓ (see Note 1)

Note: 1. The Gidgegannup site was mainly constrained by the truck size that could use Toodyay Road.

2.1.2 Site Selection Process for Proposal

The Voyager Quarry has reached a depth of 50 m. Although there are granite resources at greater depth, it is expected that these will not be economic to mine. To ensure a continuous supply of crushed rock to current and future markets, the Proponent therefore has two options:

1. to relocate the quarrying operations to another site away from the existing Voyager Quarry; or
2. to expand or relocate in the vicinity of the existing Voyager Quarry (i.e. to the north, south, west and/or east of its existing operations).

As part of its site selection process, BGC reviewed the regional site options listed in Table 2.1 but concluded that it would not be feasible to develop a new quarry at any of these sites. The company therefore considered the expansion or relocation of the existing quarry to the north, south, west and/or east of its existing operations (Table 2.2). The criteria used for the evaluation of local options in Table 2.2 were based on criteria developed by Archer (1980) for the assessment of potential aggregate resource sites in the vicinity of the Darling Scarp, and are described below:

- **Condition of the site:** Assess the present condition of the site according to the condition of the vegetation, degree of existing clearing, existence of lines of communication and infrastructure, previous quarrying activity and present land uses. The presence of existing support infrastructure and the compatibility of the development with the surrounding land uses are desirable.
- **Significance of the site:** Determine the existence of significant vegetation and native fauna. Assess the site in terms of social and cultural significance, including the reservation of the site and adjacent areas for any public purpose, including water catchment and state forest. The establishment of a quarry at sites where there are significant cultural associations, vegetation or fauna is unfavourable.
- **Noise and ground vibration buffer zones:** Assess the proximity of the operation to residential areas. A buffer distance of 0.5 km is desirable to minimise the noise and ground vibration impacts on residential areas.
- **Visibility:** Assess the visibility of the operation from the Swan Coastal Plain, residential areas, roads and public areas. Sites that are not visible from the coastal plain and which have limited visibility from potential viewing points are favourable.
- **Accessibility:** Assess the access route for the site for heavy trucks, in terms of the presence of major arterial roads to service the site. The suitability of the existing roads for heavy traffic usage should be investigated.
- **Proximity to markets:** Determine the distance to the market using the most direct route, as cost of transport is a critical factor.
- **Size of reserves:** The reserves of the quarry should be sufficient to sustain a 25 – 30 year operation period. Sites that have a lifespan that exceeds 25 years at the proposed production rate are considered to have sufficient reserves.
- **Overburden ratio:** The nature, distribution and thickness of the overburden should be assessed to determine the economic viability of the reserve. Sites that have shallow overburden are more favourable for the development of quarries.
- **Quality of the reserves:** Assess the quality of the reserve, based on the lithology and the presence of shears. The presence of large volumes of even-grained granitic rocks is desirable.
- **Area for plant:** Relatively level terrain near the quarry is required to accommodate the crushing plant, stockpiles and offices.

Each criterion was assessed on a scale of 0 – 3 (0 being the lowest level of suitability and 3 being the highest level of suitability). The results from the site selection process are provided in Table 2.2.

Table 2.2
Review of Local Options

Criteria	North of the Existing Quarry	South of the Existing Quarry	East of the Existing Quarry	West of the Existing Quarry
Condition of the Site	Cleared farmland with potential to connect to existing lines of communication 3	Cleared farmland with potential to connect to existing lines of communication 3	Cleared farmland with potential to connect to existing lines of communication 3	Remnant vegetation present. There is potential to connect to existing lines of communication 2
Significance of the Site	Cleared area with a drainage line 2	Cleared area 3	Cleared area with a drainage line 2	Presence of uncleared vegetation and a significant plant species 1
Noise and Ground Vibration Buffer Zones	Buffer distance is greater than 0.5 km to the nearest residence 3	Buffer distance is greater than 0.5 km to nearest residence 3	Buffer distance is greater than 0.5 km to the nearest residence, but there is no vegetation for noise attenuation 1	Buffer distance is greater than 0.5 km to the nearest residence 3
Visibility	Likely to be visible by residences to the north of the quarry 0	Likely to be visible by residences to the north and from Great Southern Highway 0	Likely to be visible by residences to the east of the quarry 0	Remnant vegetation provides an effective screen for the quarry from most vantage points 2
Accessibility	Construction or extension of the access road would be required 1	Use existing access road 3	Extension of existing access road would be required 2	Use of existing access road 3
Proximity to Markets	Close to the Perth metropolitan market 3	Close to the Perth metropolitan market 3	Close to the Perth metropolitan market 3	Close to the Perth metropolitan market 3
Size of Reserves	Limited reserves for long-term operation 0	Limited reserves for long-term operation 1	Limited reserves for long-term operation 0	Large reserves sufficient for long term operation 3
Overburden Ratio	Very large amount of overburden as reserve dips to the north 0	Moderate depth of overburden material 2	Moderate depth of overburden material 2	Moderate depth of overburden material 2
Quality of the Reserves	High quality material 3	High quality material 3	High quality material 3	High quality material 3
Area for Plant	Relocation of plant and stockpiles 1	Use of existing plant, however relocation of stockpiles required 2	Relocation of plant and stockpiles 1	Opportunity to establish plant in the new quarry pit to reduce noise impacts 3
Total	**16**	**23**	**17**	**25**

Of the local options, the least viable options were to expand or relocate the quarry operations to the north and east of the existing operations. The main constraint for the north option relates to an economic factor, as the granite reserve dips to the north and would be uneconomical to extract due to a large amount of overburden material. The south option was a favourable option, but the owner of the Voyager Farm is reluctant to allow further

development of the quarry on the farm and has indicated that BGC's lease will not be renewed when it expires in six years time. This constraint also affects the north and east options.

The most viable option based on the environmental and economic factors is the west option. The major factors contributing to the opportunity for expansion or relocation to the west are related to the fact that the Proponent owns the property (Lot 14) and there is remnant vegetation present to act as a buffer between the property and neighbouring properties. The vegetation would be effective in screening the operations from residences to the west of the site and users of Horton Road. The reserves to the west of the existing quarry are economical to extract and sufficient for long term operations. The granite reserve is classified as a key extraction area by the Western Australian Planning Commission (2000a) and the site is considered to be of regional significance. The site is viewed as being essential to the region and strategically located in relation to transport links and manufacturing plants.

2.2 PROJECT NEED

The proposed relocation of the Voyager Quarry will be important to ensure a continuous supply of crushed rock to current and future markets and to ensure the long term viability of BGC Quarries. Currently one million tonnes of granite each year are extracted from the Voyager Quarry, which provides 35-40% of the crushed rock required by building and construction industry in the Perth Metropolitan Region and surrounding areas.

BGC is associated with a group of companies that constructs approximately 5,000 houses per annum. History has shown that independent suppliers have had great difficulty in securing reliable and economical sources of crushed rock. The logistical difficulty of establishing a new quarry limits competition and governs supply and price.

The Basic Raw Materials Planning Policy Statement identifies that the availability of basic raw material resources located close to Perth is declining as otherwise suitable sites are constrained by planning and environmental factors (Western Australian Planning Commission, 2000b). The policy statement recognises the importance of ensuring that the extraction of basic raw materials occurs with minimum detriment to the local amenity and environment. The following policy areas are identified in the policy statement:

- **Priority Resource Locations** – locations of regionally significant resources which should be recognised for future basic raw materials extraction and not be constrained by incompatible uses or development.
- **Key Extraction Areas** – areas of recognised regional resources providing for the long term supply of basic raw materials. These areas should be protected in relevant town planning schemes.
- **Extraction Areas** – existing extractive industries operating under the *Mining Act* 1978, the *Local Government Act* 1996, a regional planning scheme or a town planning scheme. They should be protected in the short term but will eventually be replaced by other uses or reserves.

The Project Area is identified under the Basic Raw Materials Planning Policy as a Key Extraction Area.

Within the Perth Metropolitan Region, there are currently ten quarries supplying hard rock resources. These are located in the Shire of Northam, Shire of Toodyay, City of Swan, City of Gosnells and Shire of Serpentine-Jarrahdale.

According to the study conducted by Landvision (1996a), the total known volume of resources is greater than 1.5 billion tonnes, providing a supply for over 400 years at current rates of extraction. However, most of these resources are located at the Toodyay Quarry and the Voyager Quarry. It was reported by Landvision (1996a) that if these quarries ceased operations, the remaining resources would only be sufficient for less than ten years based on the market demand.

Aggregate demand is directly related to the activities in the construction industry, particularly housing construction (Landvision, 1996a). In Western Australia, the seasonally adjusted estimates for the total dwellings approved in the fourth quarter of 2001 were more than 40% higher than the estimates for the same quarter in 2000 (Australian Bureau of Statistics, 2002). If similar trends are recorded in the future, there will be a steadily increasing demand for crushed rock. Long term demand is expected to grow with population growth while accommodating short term peaks and troughs. As such, there is a clear need for further capacity within the hard rock industry, particularly considering there would be a loss of 35-40% of the capacity if the Voyager Quarry operation was not continued into the future.

2.3 PROJECT BENEFITS

2.3.1 Environmental and Social Benefits

Since the establishment of the Voyager Quarry Project in 1990, the Proponent has contributed to the local community through a number of initiatives including:

- funding for community projects;
- financial support for community sporting clubs; and
- sponsorship of local recreation facilities.

BGC plays a significant role in the West Australian community. As well as providing employment for thousands of people, BGC is committed to supporting programmes and initiatives which benefit the whole community. BGC's ongoing sponsorship programme makes a major contribution to supporting the future of Western Australia, providing support for junior development programmes, medical research, surf life saving, sporting clubs and community projects.

Numerous projects throughout the State have utilised material obtained from the existing Voyager Quarry. These include:

- ~5,000 houses per annum;
- Great Eastern Highway Northam By-pass;
- re-surfacing of Great Eastern Highway, Greenmount;
- all road works in City of Gosnells;
- supply of road-base aggregate for 20 shires in the wheatbelt;
- Armadale hospital;
- CSIRO building, Floreat;
- University of Western Australia Oral Health Centre;
- Curtin University of Technology Physiotherapy and Business buildings; and
- Institute of Child Health Research Centre.

The proposed quarry relocation is important to the long-term viability of the Proponent's operations at the Voyager Quarry. There is a range of environmental and social benefits that would also result from the implementation of the proposed expansion including:

- development and implementation of an Environmental Management System (EMS) focused on continual improvement of environmental performance;
- reduction in the sources of dust and noise by upgrading and housing the plant, and locating it below ground level within the proposed quarry pit;
- revegetation projects;
- community involvement in the management of native vegetation to be left intact;
- establishment of a Community Liaison Group to facilitate two-way communication about the site operations; and
- continued employment for approximately 22 permanent BGC employees and up to 300 people employed in related delivery and processing services.

2.3.2 State Benefits

The development of the Project will result in a number of significant benefits for the State, including:

- continued supply of crushed rock for the West Australian construction industry. The establishment of the proposed quarry and plant prior to the cessation of operations in the current Voyager Quarry will enable an efficient transfer of operations and ensure that there is continuity in the supply of crushed rock for the Perth metropolitan market;
- reduced pressure to develop new quarries or expand existing quarries in the Darling Scarp area;
- the continued supply of raw materials, bituminous materials or finished concrete products being sold directly or indirectly to Western Australian Government agencies. These include the Main Roads Western Australia, Shires, Westrail, Department of Defence, Building Management Authority and Homeswest;
- maintenance of low cost supplies of hard rock to the Perth metropolitan market, as the proposed quarry site is easily accessible and relatively close to the metropolitan area;
- maintenance of competition in the Perth metropolitan market; and
- revenue for the Local and State governments in the form of royalties, taxes and other charges.

2.4 CONSEQUENCES OF NOT PROCEEDING

The consequences of not proceeding with the proposed quarry relocation include loss of benefits to:

- the State (through the loss of royalties and taxes, and a source of construction materials);
- the local community (through the loss of financial support for local businesses and income for the Shire);
- the Perth metropolitan community (through increased costs of building and housing material, and delays in building and project completion); and
- BGC owners and employees (through a loss of jobs and profits).

As indicated previously, the existing Voyager Quarry currently supplies approximately 900,000 t of granite per annum which provides 35-40% of the crushed rock required by the building and construction industries in the Perth Metropolitan Region and surrounding areas. There will be market implications should the proposal not proceed, as there will be a shortage of crushed rock to meet the demand in the Perth Metropolitan Region. This will result in a price increase for the product, which will also lead to increased costs for housing.

The "no project" option increases the pressure for existing quarries to expand to provide the quantities of crushed rock that is required for the Perth metropolitan region. The expansion of quarry operations on the Darling Scarp, which are more visible from the Swan Coastal Plain, will reduce the visual amenity of the Scarp.

The presence of BGC in The Lakes area has resulted in social benefits within the local community with the company supporting local businesses, sporting clubs and community projects. Therefore, if the Proposal does not proceed and BGC is forced to withdraw from The Lakes area, there will be a loss of social and financial opportunities within the local community.

Currently, the existing Voyager Quarry employs over 20 personnel with up to 300 people employed in related delivery and processing services. There are likely to be repercussions on the personnel directly and indirectly related with the operations of the existing quarry. Should the Project not proceed, there will be a loss of jobs within BGC.

The above consequences of not proceeding with the proposed quarry relocation are by no means trivial and are likely to have widespread ramifications that could adversely impact the Perth Metropolitan Region and elsewhere within WA.

3. PROJECT DESCRIPTION

This section describes the proposed quarry relocation. A description of the existing Voyager Quarry operations is provided as background information and to provide context to the assessment of the proposed quarry relocation.

3.1 OVERVIEW

The Voyager Quarry site currently comprises the following components:

- an open-pit granite quarry which is 600 m long, 350 m wide and 50 m deep;
- a crushing and screening plant which is licenced by the DEP for a nominal rated throughput 900,000 tonnes per annum (tpa) of crushed rock;
- internal access and haul roads;
- product stockpile areas;
- topsoil stockpiles;
- a water supply dam;
- workshop and fuel storage areas; and
- offices, amenities and weigh-bridge.

The layout of these facilities is illustrated in Figures 1.2 and 1.3.

The Proponent proposes to expand the quarrying operations into primarily uncleared land to the west of the existing quarry. Construction of the proposed quarry will require excavation of 1-2 Mt of gravel and approximately 12 Mt of clay from the footprint of the new quarry area, which will be used for manufacturing of asphalt, blocks and bricks or stockpiled off-site for backfilling the proposed pit. This excavation will take up to five years to complete.

The crushing plant, which is currently located to the east of the existing quarry (Figures 1.2 and 1.3), will be decommissioned and a new plant will be constructed at the south end of the proposed quarry pit and west of the site's existing access road (Figure 1.2).

Quarrying of the granite is proposed to commence between 2005 and 2008 (depending on the time taken to excavate the existing gravel and clay) and is expected to continue for up to 50 years, based on current rates of extraction. During this period, approximately 50 Mt of granite will be excavated from the proposed quarry site. The conventional drilling and blasting, loading and hauling, crushing and screening methods used in the existing Voyager Quarry will be used in the operation of the proposed quarry (Figure 3.1).

Construction of the proposed quarry pit will need to start within the next 12 months, as there are only reserves in the existing pit for operations to continue for another six years. This will allow for an efficient transition of operations from the existing pit to the proposed pit.

The key characteristics of the proposed quarry are summarised, and compared to those of the existing quarry, in Table 3.1.

Table 3.1
Key Characteristics

Characteristic	Existing Project	Proposed Project (once the proposed quarry relocation has been implemented)
Project Life	Currently six years of existing quarry life remaining.	Approximately 50 years.
Land Tenure	Current Project Area leased from private landowner.	Proposed Project Area owned by the Proponent.
Rate of Extraction	Approximately 6,000 – 10,000 t/day	Approximately 6,000 - 10,000 t/day
Extraction Method	Extraction from an open-pit using conventional drilling, blasting, loading and hauling techniques.	Extraction from an open-pit using conventional drilling, blasting, loading and hauling techniques.
Location of Crushing and Screening Operations	East of the existing quarry pit on ground surface.	Within the proposed quarry pit, 30 m below ground surface.
Crushing and Screening Equipment	More than 10 years old.	New improved technology will be used. Primary crusher will be housed within noise reduction structure.
Final Quarry Dimensions	600 m long 350 m wide 50 m deep	900 m long 450 m wide 50 m deep
Footprint of Quarry	55 ha	61 ha
Footprint of All Disturbance	55 ha	85 ha
Quarry Operation Hours	0700 – 0400 hours Monday to Friday, 0700 – 1300 hours Saturday	0700 – 0400 hours Monday to Friday, 0700 – 1300 hours Saturday
List of Major Components	• Quarry • Product stockpiles • Topsoil stockpiles • Water storage dam • Infrastructure (processing plant, administration buildings, workshop, roads)	• Quarry • Product stockpiles • Topsoil stockpiles • Water storage dam • Infrastructure (processing plant, administration buildings, workshop, roads)
Water Storage Dam Capacity	100,000 kL	150,000 kL
Water Supply Source	Surface runoff and groundwater seepage.	Surface runoff and groundwater seepage.
Average Daily Water Requirements	Approximately 377 kL (summer) Approximately 77 kL (winter)	Approximately 377 kL (summer) Approximately 77 kL (winter)
Maximum Annual Water Requirement	Approximately 94,250 kL	Approximately 94,250 kL

3.2 CONSTRUCTION

3.2.1 Construction Activities

Development of the proposed quarry operations will involve the following sequence of activities (Figure 3.2):

- Stripping of vegetation and topsoil, which will be stockpiled for the rehabilitation of the existing quarry site and/or disturbances associated with proposed quarry relocation. Any surplus topsoil will be made available for rehabilitation of off-site areas to ensure that the viability of the seed bank is maximised. The clearing of vegetation will be conducted progressively over a five year period, with the initial clearing expected to be undertaken over a period of approximately two months.

- Excavation of 1-2 Mt of gravel, which forms a layer approximately 1 m thick across the quarry footprint. The gravel will be used for the manufacture of various products including asphalt, blocks and bricks. The gravel extraction process will be conducted over the five year construction period.

- Excavation of approximately 12 Mt of clay, which forms a 10 - 20 m thick layer across the proposed quarry footprint. The clay may be used to backfill the existing pit or be sold as product. The excavation of clay will be undertaken over the fiver year construction period.

- Removal of the overburden material, which will take approximately four to five years.

- Construction of a new crushing and screening plant at the south end of the proposed quarry and west of the access road. This will be undertaken over a one year period. Some infrastructure from the existing plant will be used in the construction of the new plant.

- Construction of a new administration building, weighbridge and workshop.

3.2.2 Pit Design

The proposed quarry pit will be designed according to results of site-specific geotechnical and hydrogeological investigations. The design will also take into consideration slope stability and the operation of surface machinery.

It is expected that the expanded open-pit granite quarry will be 900 m long and 450 m wide. When quarrying is completed, the depth of the pit will be approximately 50 m below the current land surface. Bench heights within the quarry will be 15 m.

3.2.3 Plant Construction

A new crushing and screening plant that will utilise primarily new technology will be constructed within the proposed quarry pit. Some infrastructure for this plant will be sourced from the existing plant. The remainder of the existing plant will be decommissioned and sold or salvaged as scrap material.

The new primary crusher will be housed within a structure to minimise the noise impact on the surrounds. Use of new technology will improve the efficiency of the plant.

3.3 OPERATIONS

3.3.1 General

The existing Voyager Quarry utilises a conventional three-phase process to produce crushed rock aggregate, as follows:

- drill and blast;
- load and haul; and
- crush and screen.

The same process will be utilised in the proposed quarry operations. These methods are described below. A process flow chart is provided as Figure 3.1.

3.3.2 Drilling and Blasting

The drill and blast phase commences with the marking out of a predetermined drill pattern on a selected area within the quarry. An average-sized blast consists of approximately 80 to 100 holes. The holes are 102 mm in diameter and are generally 16 m deep (to allow for a 15 m bench height and 1 m for sub-drilling into the floor to provide an even finish on the quarry floor).

A hydraulic drill rig is used to drill the blast holes, which are drilled at a rate of approximately 20 holes per ten-hour shift. On completion of drilling, the depth of the holes is checked and the holes are loaded with explosives. After the safety checks have been completed, the blast is initiated by a shot-firer.

The explosives are purchased in bulk from a supplier and delivered to the site on a designated day.

The Shire of Northam's by-laws relating to extractive industries state that blasting operations are only to be conducted between the hours of 0600 and 1800 on Monday to Saturday, inclusive. However, the Proponent complies with the more stringent *Environmental Protection (Noise) Regulations* 1997, which specify that blasting should be conducted between 0700 and 1800 on any day except Sundays and Public Holidays.

Blasting was previously conducted approximately once per week, but has recently been extended to once per fortnight in order to reduce noise and ground vibration impacts on nearby residents. Blasting generally occurs in the middle of the day (1300 hours) and is preceded by a three minute long siren blast.

BGC operates a Blast Notification Service for residents within a 3 km radius of the Voyager Quarry. Landowners registered for the services are notified by BGC in advance of upcoming blasting activities.

3.3.3 Loading and Hauling

Following blasting, the blast area is inspected to ensure that all explosives have been fired. The blasted material is then loaded onto 85 t dump trucks by an excavator and hauled from the quarry pit to the primary jaw crusher. Two dump trucks are used to cart 30 loads each during a ten-hour shift.

The optimum size of rock to be fed into the primary jaw crusher is <1 m. Any blasted material that is too large for the primary jaw crusher is carted to a separate designated area within the pit to be further broken down by a hydraulic rock breaker. When the oversized rock has been broken down, it is reloaded and carted back to the primary jaw crusher for crushing.

3.3.4 Crushing and Screening

The crushing operation commences at the primary jaw crusher, where the blasted rock is broken down from <1 m to <200 mm at a rate of approximately 600-700 t per hour. The crushed rock is then screened to separate out any <20 mm material. This material is stacked for use in making road base product.

Material larger than 20 mm in diameter is passed through a gyratory cone crusher and stacked on a tertiary crushing plant stockpile. This stockpile of material is then fed into a tertiary circuit comprising two gyratory crushers and three vibrating screens. After passing through the two crushers, the material is screened into eight products, as listed below:

- 40 mm ballast – railways foundations;
- 20 mm – concrete and blocks;
- 14 mm – concrete, blocks, asphalt and road sealing;
- 10 mm - concrete, blocks, asphalt and road sealing;
- 7 mm - concrete, blocks, asphalt and road sealing;
- 5 mm - concrete, blocks, asphalt and road sealing;
- Dust - concrete, blocks, asphalt and road sealing; and
- Roadbase – road construction and other foundations.

The rate of end-product production is between 250 t and 300 t per hour. When the stockpile areas under the product stackers are full, it is carted to the product stockpile areas using a front-end loader and dump trucks. The products are then transported from site using various road truck configurations.

3.3.5 Pit Dewatering

Large scale pit dewatering operations will not be required for the proposed quarry expansion as the floor of the proposed quarry pit will generally be above the groundwater table. As with the existing operations, surface water runoff and groundwater seepage will be collected at the base of the quarry, pumped to the water storage dam and used in the crushing plant for product washing and around the quarry site for dust suppression.

3.3.6 Water Supply and Usage

The Voyager Quarry utilises approximately 376.6 kL/day of water for processing and dust suppression in summer and approximately 77.4 kL/day in winter. A breakdown of the water usage for different activities at the site is presented in Table 3.2. The water is sourced from direct rainfall, surface water runoff from the site and water collected in a sump in the existing quarry. Water used in the production of washed material is recycled into the dam, located to the east of the existing quarry.

Table 3.2
Average Daily Water Usage

Activity	Water Usage	Total Daily Water Usage (kL)
Water Cart	10 loads per day @ 32 kL/load (summer) 2 loads per day @ 32 kL/load (winter)	320 (summer) 64 (winter)
Spray Bar	-	5
Stockpile Sprinklers	8 sprinklers @ 10 minutes x 3 times per day (pump rate of 1.8 kL/minute)	43.2 (summer) 0 (winter)
Wash Plant	80 kL (90% wash water return)	8
Plant Wash Down	4 hours @ 1 kL/hour (90% water return)	0.4
Total		**376.6 kL (summer)** **77.4 kL (winter)**

The relocated quarry will have similar water requirements to the current operations with no significant increase in the potable and plant water requirements. The total daily water requirements for the relocated site will be the same as the existing operations. Water from the storage dam will be used for dust suppression on haul roads, stockpile sprinklers, plant wash down and conveyor suppression. Water is not required for drilling. Potable water is brought in from external sources.

It is anticipated that a new water storage dam will be constructed in the southeast corner of the proposed quarry. The exact location of the dam is yet to be determined.

3.4 SUPPORT FACILITIES

Support facilities for the existing operations are located to the east of the quarry (Figures 1.2 and 1.3). These facilities consist of an administration building, weigh bridge and workshop. These facilities will be decommissioned and removed following the cessation of operations at the existing quarry.

The proposed quarry operations will be supported by a new administration building, weigh bridge and workshop. The proposed location of these facilities is provided on Figures 1.2 and 1.3.

All supporting infrastructure (such as buildings and workshops) will be removed from the Project Area once they are no longer required or at completion of quarrying operations.

3.5 HOURS OF OPERATION

Site quarrying operations are currently conducted from 0700 to 0400 hours from Monday to Friday, and from 0700 to 1200 hours on Saturdays. The pit and primary crusher operation has been reduced to 0700 to 2200 hours Monday to Friday and 0700 to 1200 hours on Saturdays. The tertiary crushing and screening operation runs from 0700 to 0400 hours Monday to Friday and from 0700 to 1200 hours on Saturdays.

It is currently proposed that similar operating hours apply to the proposed quarry operations.

3.6 WORKFORCE

The Voyager Quarry currently employs 22 personnel, with up to 300 people in related delivery and processing services, such as at the concrete plants.

The workforce required for the construction of the proposed quarry relocation will be primarily sourced from within BGC (Australia) Pty Ltd. However, it is likely that there will be an increase in the number of contractors on the site. It is expected that up to 50 people will be employed during construction of the proposed quarry operations, with at least 20 people employed once the relocated project is fully operational.

3.7 ENVIRONMENTAL MANAGEMENT AND MONITORING

3.7.1 Environmental Licensing

The Voyager Quarry currently holds DEP Licence Number 5356/6 which was issued under Part V of the *Environmental Protection Act* 1986 (as amended). BGC complies with the conditions set out in its licence and has received a number of visits from DEP licencing officers during 2002.

The Shire of Northam has issued an Extractive Industries Licence (Licence Number 6) for the existing operations. According to the Shire of Northam by-laws relating to extractive industries, Clause 16 permits blasting between 0600 and 1800 hours, Monday to Saturday inclusive. However, blasting at the existing quarry is conducted between 0700 and 1800 hours (in accordance with the *Environmental Protection [Noise] Regulations* 1997) usually once per fortnight during the middle of a working day.

Clause 17 of the Shire of Northam's extractive industries by-laws relates to dust. This clause states that, when dust arising from the operations is allowed to escape the premises, the Council may require the licensee to provide the most effective means to remove or prevent it from endangering any person or creating nuisance or damage to natural vegetation.

Clause 17A of Shire of Northam's by-laws relating to extractive industries, requires that a licensee not stockpile any material that is likely to escape into any stream, watercourse or drain, that is not wholly situated within land owned or occupied by the licensee, unless he erects a wall of such height as to be capable of retaining that material.

3.7.2 Environmental Monitoring

Since January 1993, BGC has undertaken ground vibration (peak particle velocity mm/s) and airblast monitoring (db linear peak) of every blast (Figures 3.3 and 3.4) in accordance with DEP licence conditions. In addition, the following additional monitoring exercises have been conducted:

- In 1994, BGC commissioned Airblast Technology Pty Ltd (ABT) to measure noise levels at the site boundary and check for compliance with the DEP licence conditions.

- In January 2002, ABT Engineering was commissioned to record and assess noise levels in the immediate vicinity of the quarry during early evening hours (i.e. between 1825 and 2122 hours) whilst crushing and screening operations were undertaken.

- In March 2002, ABT was commissioned to provide additional independently recorded noise levels in the early evening.

- In March 2002, two groundwater monitoring bores were drilled to the west of the existing quarry. The groundwater levels in monitoring bores are measured on a weekly basis.

- In May 2002, BGC commenced its water monitoring programme which involved the collection of water samples from the quarry pit and quarry processing dam on a monthly basis. Samples are sent to laboratory for analysis of Total Dissolved Solids (TDS) and Total Suspended Solids (TSS).

- Since August 2002, BGC has been videotaping every blast conducted in the existing qurry. Each tape is reviewed to assess whether flyrock is being contained within the site.

- In September 2002, BGC commissioned new data loggers to record noise onto digital tapes. These data loggers also record wind speed and direction. Data are forwarded to the DEP on a quarterly basis.

3.7.3 Complaints Register

During operation of the Voyager Quarry, BGC has received complaints directly from the local community and indirectly through the Shire of Northam. The number of complaints received by the Shire of Northam since 1991 in relation to the existing quarry operation is provided in Table 3.3.

Table 3.3
Number of Environmental Complaints Received by the Shire of Northam
(as at October 2002)

Period	Number of Complaints
1991	1
1992-1999	0
2000	2
2001 – up to 14 December 2001	0
15 – 31 December 2001	8
January – October 2002	47
Total	**58**

Between 1991 and December 2001, the Shire of Northam registered a total of three complaints regarding the Voyager Quarry. Subsequent to the clearing of vegetation within Lots 11 and 14, which occurred on 15 December 2001, 55 complaints were made to the Shire of Northam regarding various aspects of the quarry operations. The key issues raised in the complaints related to noise, dust and the clearing conducted by BGC within the Project Area in mid-December 2001 (Table 3.4).

Table 3.4
Summary of the Complaints Received by the Shire of Northam
(as at October 2002)

Nature of Complaint	Number of Times Issues Raised [1]
Hours of Operation	3
Blasting Without Notice	2
Noise	39
Dust	11
Clearing	9
Salinity	2
Adverse Effect on Catchments	2
Excessive Traffic	1
Agricultural Concerns	1
Property Values	3
Lifestyle	1
Other Concerns	16

Note: 1 Some complaints raised more than one issue, therefore the number of complaints identified in Table 3.3 does not equal the number of times that an issue has been raised as identified in Table 3.4.

BGC maintains a Neighbour Complaints Register on which the following details are recorded:

- the date and time that the complaint was received;
- who the complainant was (if identified);
- the BGC representative recording the complaint;
- description of the complaint;
- the action required by BGC;
- whether follow-up was undertaken by BGC; and
- sign off by the Quarry Manager.

A total of 30 complaints had been recorded on the register up to October 2002 (Table 3.5). Of these, most related to noise (Table 3.6).

Table 3.5
Number of Environmental Complaints Received by BGC
(as at October 2002)

Period	Number of Complaints
1991 – 15 December 2001	1
16 December 2001 – October 2002	29
Total	**30**

Table 3.6
Summary of the Complaints Received by BGC (as at October 2002)

Nature of Complaint	Number of Times Issues Raised [1]
Noise	27
Dust	1
Light Overspill	1
Ground Vibration	2
Blasting	1
Other Concerns	1

Note: 1 Some complaints raised more than one issue, therefore the number of complaints identified in Table 3.5 does not equal the number of times that an issue has been raised as identified in Table 3.6.

3.7.4 Recent Improvements to BGC Operations

In response to complaints received since 15 December 2001, BGC has implemented the following improvements to its operations:

- sealing of the access road to reduce dust emissions;
- replacing existing earthmoving machines with new and larger excavators, loaders and dump trucks to reduce the number of machinery movements and thereby reduce dust and noise emissions;
- reducing the frequency of blasting operations from weekly to fortnightly to halve noise and vibration emissions;
- videotaping of all blasting operations to confirm that flyrock has fallen into the pit as planned.
- increased noise monitoring of blasting operations to confirm that noise levels are within defined limits;
- construction of rubber backed frames and earthen bund walls around the primary crusher to significantly reduce noise;
- modified nightshift activities to reduce noise; and
- reduced operating hours of the primary crusher from 21 to 15 hours between the hours of 0700 and 2200.

In addition, the Proponent will enclose the primary crushing plant, and replace the existing drilling machinery with new, quieter "down hole" drilling technology.

Furthermore, the Proponent has offered to establish a community liaison group to regularly meet and discuss quarry operations. However, no residents have taken up the offer to date

3.7.5 Environmental Management

An environmental policy exists for BGC Contracting, which is a subsidiary of BGC (Australia) Pty Ltd. The policy will be applied to the proposed quarry expansion project to ensure that a high standard of environmental management is achieved for the Project.

The environmental policy is provided below.

BGC Contracting - Environment Policy

BGC Contracting recognises the fundamental requirement to conduct its operations in an environmentally responsible manner.

In order to achieve our Clients' environmental objectives an Environmental Management System based upon ISO 14001 shall be implemented and performance will be monitored through site inspection and formal project audit protocols.

Management makes the commitment to:

- Foster the prevention of pollution and comply with statutory environmental legislation.
- Put in place sound management systems that meet or exceed the Clients specified environmental targets and objectives for the project.
- Ensure that the views of all stakeholders are considered when developing project systems.
- Integrate environmental issues into site induction's, training and ongoing workplace communication procedures.
- Evaluate and regularly review subcontractor and supplier environmental performance.
- Encourage continual improvement in environmental performance through the establishment of planning, training, monitoring, inspection and reporting systems.

Employees have the shared responsibility to:

- Work in compliance with the project environmental conditions as communicated through the site induction and ongoing communications from BGC Contracting management and the Client.
- Support their respective managers and supervisors in the continual improvement of project environmental performance.
- Communicate any environmental incidents to management.

Through realisation of these commitments and responsibilities the impact of our operations upon the environment will be minimised for the benefit of future generations.

BGC is currently preparing an EMS for its quarry operations based on the information already available from BGC Contracting. The EMS will be integrated into the site's existing certified quality management system and will address all quarrying activities and associated environmental issues.

COMMITMENT

Prior to the commencement of operations, the Proponent will develop an Environmental Management System that will address the environmental issues associated with the proposed quarrying activities.

3.7.6 Training

Prior to commencing work at the quarry, all employees and contractors are required to complete an environmental, health and safety induction programme. The environmental component of the induction is designed to increase the environmental awareness of employees and ensure they understand their environmental responsibilities.

COMMITMENT

The Proponent will ensure that all employees and contractors have completed the site's environmental, health and safety induction programme.

3.7.7 Benchmarking BGC's Existing Operations at the Voyager Quarry

A benchmarking exercise was conducted to compare the management practices implemented at the existing Voyager Quarry and three other similarly sized hard rock quarries. The aim of the exercise was to investigate whether the management practices implemented at the Voyager Quarry are comparable to those implemented at other hard rock quarry operations. The hard rock quarries included in this benchmarking exercise were:

- Pioneer – Red Hill Quarry;
- CSR Readymix – Martin Quarry; and
- Boral Quarries – Maddington Quarry.

Information on the following aspects were obtained:

- operating hours;
- nearest residences;
- dust management;
- potential impacts on visual amenity;
- management of noise; and
- water supply and management.

A summary of the management measures employed at each site is provided as Table 3.7. The information used to prepare this table was obtained from publicly available reports, particularly the environmental impact assessment documents for each of the quarries. Each quarry operator was then contacted and asked to verify the information presented for its site. The operators were also invited to add comments regarding the management of the various factors listed above, particularly if changes or improvements in environmental management had been made since the documents were produced. At the time that this PER was produced, only verification of the information for the Martin Quarry had been received.

Based on the readily available information, it appears that the management practices of the Voyager Quarry are comparable to, and in some cases more rigorous than, those of the other quarries reviewed during the benchmarking exercise.

The operating hours for the Voyager Quarry are longer than those for the other quarries, which are predominately daylight operations. However, the Red Hill and Maddington quarries do extend their hours of operation on occasion to meet any increased product demands.

The nearest residence to the Martin Quarry is located 1 km from the site, which is similar to the distance between the Voyager Quarry and its nearest residence (1.1 km). The nearest residence to the Maddington Quarry is 1.7 km, whilst the nearest residence to the Red Hill Quarry is located approximately 3 km from the site.

The results of the benchmarking exercise indicate that the Voyager Quarry implements similar procedures for the management of dust. The use of water for dust suppression is a common practice across the four sites.

Water supplies for the four quarries predominantly consist collected surface water. Most of the quarries also use groundwater abstracted from bores to augment their supplies. Scheme water is used at the Red Hill Quarry to supplement its water requirements in dry periods.

The Voyager, Red Hill and Maddington quarries implement similar surface water management strategies. The management measures include the use of some form of sediment retention structures, such as a sediment trap. Runoff water is diverted into sedimentation basins and storage dams using diversion banks and bunds.

The Voyager Quarry's noise management practices are comparable to those for the Red Hill, Martin and Maddington quarries, if not slightly more extensive. The main difference is that the Voyager Quarry uses data loggers to monitor noise on a continual basis. This instruments also record wind speed and wind direction. The collection of this data provides information about whether the operations comply with the *Environmental Protection (Noise) Regulation 1997* and is submitted to the DEP on a quarterly basis.

The Red Hill, Martin and Maddington quarries are located on the Darling Scarp and are visible from various locations on the Swan Coastal Plain. The Voyager Quarry is not located on the Darling Scarp and is not visible from any public viewing points. Consequently, of the four quarries assessed as part of this benchmarking exercise, the Voyager Quarry has the lowest level of visual impact. However, it is recognised that CSR Readymix implements a number of management strategies to reduce the visual of the Martin Quarry.

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Table 3.7
Management Measures Implemented at Similarly Sized Hard Rock Quarries

Factor	Pioneer Red Hill Quarry[1]	CSR Readymix Martin Quarry[2]	Boral Quarries Maddington Quarry[3, 4]	BGC Existing Voyager Quarry
Operating Hours	The hours of operation are 0600 to 1700 hours. On some occasions, the plant is started earlier and sometimes operated at night.	The hours of operation are 0600 to 1800 hours, Monday to Saturday.	The operations are conducted during daylight hours, six days a week. On occasion, operations are extended for limited periods to meet very high demand for hard rock materials.	The hours of operation are as follows: • Quarrying and primary crusher: 0700 to 2200 hours Monday to Friday, 0700 to 1200 hours Saturday. • Tertiary crusher: 0700 to 0400 hours Monday to Friday, 0700 to 1200 hours Saturday.
Nearest Residence	The nearest residence is located approximately 3 km away.	The nearest residence is located approximately 1 km away.	The nearest residence is located 1.7 km from the blast area.	The nearest residence is located approximately 1.1 km to the west of the quarry pit.
Dust	The dust control measures implemented at the site include: • sealing of roads, where practical; • watering of roads; • watering of stockpiles; • wetting material during the transfer operations in the processing plant; • spraying loads leaving site; • restriction of blasting to periods when prevailing winds are away from residential areas; • use of an enclosed conveyor for transporting rock from the secondary to the tertiary crusher; • enclosure of all crushing and screening plants; and • improved design of stockpiles and despatch facilities.	The dust control measures implemented at the site include: • sealing of all permanent roads; • selectively watering roads using a 50 kL Cat 773 watercart; • atomisation of water in plant areas, using mist sprays at all transfer points; • using a water cannon under automatic control for some stockpile areas; • using covered conveyor belts and dust extraction equipment; • establishment of extensive forest plantation at the base of stockpiles; and • conducting environmental dust monitoring at the site boundary.	The dust control measures implemented at the site include: • sealing the main entry road; • sealing of all permanent roads; • watering of areas prepared for quarrying; • watering of benches and pit floors; • using automatic sprinklers on the aggregate stockpile area; • not overloading trucks, reducing the amount of spillage occurring; • watering of loads or covering loads; • using wet drilling practices for the quarrying operations; • using dust suppression systems in the crushing plant; • enclosure of screens, crushers, conveyors and transfer points; • using dust extractors in enclosed areas eg. cyclones, wet scrubbers and fabric filters; • using stabilising treatments such as hydromulch for the early stages of rehabilitation of overburden stockpiles; • surrounding stockpiles with limited planting for windbreak protection; • restricting blasting to times when the prevailing winds are in a favourable direction; • monitoring of dust emissions from stockpiles; and • restricting vehicle speeds.	The dust control measures implemented at the site include: • sealing of the main access road; • watering of roads; • watering of benches and pit floors; • watering of stockpiles using automatic sprinklers; • watering of shotrock in the pit before it is loaded and hauled to the crushing plant; • using wet drilling practices for the quarrying operations; • using water sprays throughout the plant and at all transfer points; • watering and covering loads when transporting material off-site; • not overloading trucks, reducing spillage; • implementing speed limit restrictions; • use of new Komatsu WA600-3 wheel loader, which has a larger bucket size, reducing the amount of vehicle movement necessary; • use of new Komatsu HD785 dump trucks, which reduces the amount of vehicle movement necessary; • enclosure or part enclosure of the primary crusher; • consideration of atmospheric conditions prior to blasting; and • visually monitoring the level of particulate emissions and using dust suppression techniques when necessary.
Visual Amenity	The site is located on the face of the Darling Scarp.	The site is located on the face of the Darling Scarp. There are a number of locations where the quarry is visible from public viewpoints, however rehabilitation and revegetation has occurred on the top four benches, reducing the visual impact. A forest plantation close to Tonkin Highway provides screening. Also, the structure housing the crusher and screens are coloured green to minimise visual impact.	The site is generally not visible locally due to the low elevation of the scarp, however the quarry is visible to passing traffic on Tonkin Highway.	The site is not visible to the public as the operation is an open pit. The operations may be visible from the nearest residence to the north of quarry. In general, the quarry is screened by the surrounding topography and remnant vegetation to the west, east and south.

Table 3.7 (continued)

Factor	Pioneer Red Hill Quarry[1]	CSR Readymix Martin Quarry[2]	Boral Quarries Maddington Quarry[3, 4]	BGC Existing Voyager Quarry
Noise	The noise management measures implemented at the site include: • enclosure of all crushing and screening plants; • use of rubber or polypropylene components in the plant; and • buffer zone of 3 km from residential properties.	The noise management measures implemented at the site include: • establishment of a forest plantation to act as a noise buffer; • enclosing the crusher and screens to help suppress noise emissions from the source; • minimising airblast emissions by conducting blasting once per month; and • monitoring every airblast, including conducting spot-checks at neighbourhood locations.	The noise management measures implemented at the site include: • locating the crushing plant at the base of the quarry; • avoiding blasting when temperature inversion conditions are present, if possible; • reduction in the maximum instantaneous charge; • better placement of holes and downhole surveying allowing correct burden and spacing of holes; • re-drilling of unsatisfactory holes; • restricted operating hours; • noise monitoring by an independent specialist; • full enclosure of the plant; • use of rubber or polypropylene components in the plant; • noise attenuation barriers located as close as possible to the noise source within the buffer zone; and • noise barriers are constructed from excess overburden and water materials produced by quarrying.	The noise management measures implemented at the site include: • enclosure or part enclosure of the primary crusher; • reducing primary crusher operating hours from to 0700-0400 hours to 0700-2200 hours; • streamlining nightshift activities to reduce vehicle noise; • implementing speed limit restrictions; • no use of horns at night except in emergencies; • limiting sirens to short bursts; • keeping the primary crusher hopper full; • grading of all unsealed roads regularly to ensure the smooth travelling of vehicles; • establishing frames around the primary crusher and rubber padding attached to reduce noise emissions; • use of new Komatsu WA600-3 wheel loader, which has a larger bucket size, reducing the amount of vehicle movement necessary; • use of new Komatsu HD785 dump trucks, reducing the amount of vehicle movement necessary; • establishment of bund walls on the north and south sides of the primary crushing plant to reduce noise emissions; and • monitoring of noise on a continual basis using new loggers, which record noise onto digital tapes. Data is forwarded to the DEP quarterly.
Water Supply and Management	The process water for the site is sourced from: • the storage basin in the quarry pit in Pioneer 1; • scheme water, which is used to supplement the water in the pit in dry periods; • the reservoir to the south-west of the quarry; and • water recycled from the sedimentation basin. The following water management measures are implemented on site: • flow from the quarry areas via the streams in the vicinity of the quarry is diverted into a sedimentation basin downstream of the quarry pit; • runoff from any disturbed areas outside the quarry pit is diverted into the sedimentation basin by using bunds; and • water leaving the quarry site is treated to a quality which is comparable to that of water draining from undisturbed areas.	The process water for the site is sourced from: • surface water stored in a holding dam at the base of the quarry; and • a borefield on the property, which supplements the water supplies from the dam. The following water management measures are implemented on site: • using settling ponds at site boundaries to retain silt on-site from runoff water.	The process water for the site is sourced from: • surface water stored in the main storage dam or reservoir at the base of the 'old' quarry; and • the abstraction of groundwater from a deep bore at the site to supplement supplies in the reservoir. The following water management measures are implemented on site: • using silt traps and settling ponds; • maintenance of settling ponds in summer; • maintenance of water flow in the ephemeral eastern and southern streamlines; • ensuring that the flow and water quality in the southern streamline is not affected by the quarry; • controlling stormwater to prevent erosion; • using drainage measures to protect the excavation of disturbed areas; • using diversion banks constructed during the process of vegetation clearing to prevent erosion of the undisturbed ground surface; and • monitoring the water quality of overflow water prior to discharge to the eastern and southern streamlines.	The process water for the site is sourced from: • the surface water storage dam located to the east of the quarry; and • groundwater seepage collected in the sump located at the base of the quarry pit. The following water management measures are implemented on site: • conducting monthly water quality analyses of the water from the storage dam and quarry sump; • measuring groundwater levels on a weekly basis for two bores located to the west of the quarry; • using a sediment trap on the northeast corner of the quarry site; • having a sealed (concrete) area for workshop; • using an oil separator in the workshop area; • bunds direct runoff water from the plant and quarry areas into the pit, surface water storage dam or sediment trap; • recycling of excess process water from the wash down area in the plant.

Notes:
1. Dames & Moore (1990) Herne Hill Quarry Relocation Public Environmental Review. Prepared for Pioneer, July 1990.
2. Brian O'Brien (1982) Environmental Review and Management Programme for Long-Term Planning of Readymix Land-Use at Gosnells. Prepared for The Readymix Group, May 1982.
3. Feilman Planning Consultants and Halpern Glick Maunsell (1990) Long Term Development of Maddington Quarry Public Environmental Review. Prepared for Boral Resources, June 1990.
4. Halpern Glick Maunsell (1992) Environmental Management Plan for Maddington Quarry. Prepared for Boral Quarries, December 1992.

3.8 DECOMMISSIONING, REHABILITATION AND CLOSURE

3.8.1 Decommissioning Plan for the Existing Voyager Quarry

Following the cessation of operations at the existing Voyager Quarry, BGC will rehabilitate the site to the landowner's requirements. This is likely to involve:

- the removal and disposal of any plant, equipment and infrastructure not used in the construction of processing facilities required for the proposed quarry relocation;
- removal of any remaining stockpile material;
- site rehabilitation and revegetation; and
- monitoring the progress of rehabilitation against completion criteria.

The post-operation land use for the existing quarry void has not yet been determined by the landowner.

The main access road from Great Southern Highway will be maintained for use in the proposed quarry operations.

3.8.2 Closure and Rehabilitation of the Proposed Quarry Operations

The Proponent recognises that appropriate planning and adequate provisioning for rehabilitation and closure is essential to ensure that the process occurs in an orderly, cost-effective and timely manner. The closure plan for the proposed quarry will be based on the objectives and principles presented in the guidelines developed by ANZMEC and MCA (2000) and The Chamber of Minerals and Energy of Western Australia (1999). The closure plan will meet the objectives presented in the guidelines for the following areas:

- stakeholder involvement;
- planning;
- financial provisioning;
- implementation of the plan;
- standards for indicating successful completion; and
- relinquishment.

BGC has developed a draft closure strategy to ensure that the closure of the Project is conducted in an environmentally and socially acceptable manner. The draft closure strategy is presented below.

BGC
Draft Closure Strategy

The desired closure outcome is to prevent adverse long-term environmental impacts and to create self-sustaining natural ecosystems or land uses, which are acceptable to the community and other stakeholders. In conducting our activities, during planning, construction, operational, decommissioning and closure phases, we will aim to:

- Conduct comprehensive consultation with all stakeholders during the closure decision-making process;
- Ensure effective planning is undertaken so that closure occurs in an orderly, cost-effective and timely manner;
- Ensure that the company accounts have adequately reflected the cost of closure and financial provisions are set aside;
- Ensure there is clear accountability and adequate resources for the implementation of the closure plan;
- Establish a set of acceptable criteria and indicators, which will demonstrate the successful completion of the closure project;
- Achieve successful completion where the agreed completion criteria have been met to the satisfaction of the Responsible Authority; and
- Ensure that the community is not left with a liability.

3.8.3 Void Closure and Rehabilitation

Quarry operations generally cease as a result of one or more of the following reasons:

- no more resources remain in the quarry;
- operating conditions at the quarry significantly constrain, or prevent, quarrying;
- the viability of the operations are adversely affected by changes in market conditions; or
- resources can no longer be extracted in a profitable manner.

A closure and rehabilitation plan will be prepared for the quarry and will describe:

- the closure option selected for the pit;
- how the closure and decommissioning will be implemented;
- the rehabilitation objectives and completion criteria relevant to the closure options; and
- the monitoring programme that will be implemented to determine progress made towards achieving the rehabilitation objectives.

This plan will be submitted to the regulatory authorities and other relevant stakeholders for review prior to site closure.

The post-operational land use for the proposed Project Area has not yet been selected. Following the cessation of operations, the quarry could:

1. be left empty;
2. be allowed to fill with water; or
3. be filled with non-putrescible waste materials, such as waste rock.

The post-operational land use will depend on which of these three scenarios is selected. Examples of potential options for future use of the void are given in Table 3.8.

A decision tree for the assessment of closure options for the quarry has been developed with consideration of the work by Mallet and Mark (1996) and is presented in Figure 3.5. The proposed use of the decision tree is discussed below.

The first step in the decision tree is to assess whether the quarry contains any more hard rock (granite) or whether it is ready for the closure process to be implemented. In the event that resources are still available within the confines of the quarry, it will be left open and the long-term configuration will be determined. This will include a geotechnical assessment of the quarry to determine stability and an assessment of economic viability. If the quarry is inactive and the resource remaining in the quarry can be extracted in a cost-effective manner in the future, government approval will be sought to leave the quarry open beyond the 50 year life proposed in this PER.

Following the cessation of quarrying operations and confirmation that resources have been exhausted, options for post-operational land use need to be assessed. Three closure scenarios are presented in Figure 3.6. The assessment of these options is considered in the decision tree presented as Figure 3.5. The water storage option could be considered for the quarry as water may accumulate naturally or be diverted into the void. In considering this option, the final void water quality needs to be assessed in terms of salinity, pH, nutrient and metal concentrations, and turbidity. The limnological and hydrological characteristics of the void also need to be taken into account to determine if the void water will be suitable for consumptive or non-consumptive uses. The possible water uses at the quarry site include stock water supply, agricultural water supply and recreation, depending on water quality and environmental sustainability.

Alternatively, the void may be used for the storage of inert waste such as stockpiled overburden material and inert municipal waste. In considering this option, the availability of wastes needs to be assessed and ranked in order of economic value. The quarry void must be suitable for the containment of the waste and this is dependent on the characteristics of the waste material and geology/geotechnics of the quarry. Other important factors to consider in the assessment of this option are the economical aspects (cost-benefit analysis) and surrounding land uses.

Any stockpiled waste rock from the quarrying operations will be disposed of to the quarry. After these materials have been placed in the void, the final surface will be lower than the surrounding level. The option for the Proponent to accept clean fill from other nearby operations or the local councils will therefore also be considered. The final land surface will need to be re-contoured after surface drainage has been taken into account. Surface treatments, such as topsoil respreading, ripping and seeding, may be required to promote revegetation on the land surface. The revegetation options for the final land surface may include agriculture (pastures or crops) and remnant vegetation. This is dependent on the characteristics of the surface material and whether the conditions are favourable for the establishment of these plants. The economic feasibility of these options also needs to be considered in determining the best revegetation option.

According to the decision tree presented as Figure 3.5, the land use options for the quarry void need to be arranged in order of preference. An environmental, social and economic cost-benefit analysis for the option will be conducted, where costs, risks, liabilities, benefits (public perception, environmental and economic) and regulatory acceptance are considered. Provided that the environmental and social benefits for selecting the preferred option outweigh the costs, then relevant government approvals will be sought for the preferred closure option.

COMMITMENT

Prior to closure of the Project, the Proponent will review its planning for the closure, decommissioning and rehabilitation of the Project. This review will address, but will not necessarily be limited to, the following:

- the removal of infrastructure;
- the rehabilitation of disturbed areas in the Project Area;
- the development of a closure solution for the quarry pit, which is acceptable to regulatory authorities; and
- the identification and remediation of contaminated areas (if any exist at that time).

Table 3.8
Options for Post-Operation Quarry Use

Option	Assessment Criteria					Suitability as Post-Operation Void Use
	Safety and Stability	Practicality of Implementation	Environmental Sustainability	Cost Effectiveness	Acceptability to Stakeholders	
Leave as a void	Granite is a competent rock that is able to stand at vertical or near vertical angles for significant periods of time, depending on the intensity of fracturing. However, some slumping or slippage may occur. Would require establishment of an abandonment bund.	Practical, depending on a range of issues including the nature of any water body that may form in the void and slope stability.	May be environmentally sustainable depending on issues such as the nature of any water body that may form in the void.	Costs may be incurred for any monitoring and maintenance requirements.	May be acceptable to stakeholders if there is no impact outside of the Project Area.	Low-medium
Water Supply for Human Consumption	As above.	Impractical if water quality is not suitable for human consumption.	Could be sustainable depending on rate of inflow and abstraction.	Costs would depend on water supply design and implementation, and need to be assessed.	May be acceptable to stakeholders if there is no impact outside of the Project Area.	Low-medium
Water Supply for Watering of Stock	As above.	Most likely suitable for the watering of stock, provided salinity does not increase significantly.	Could be sustainable depending on rate of inflow and abstraction.	Costs would depend on water supply design and implementation, and need to be assessed.	May be acceptable to stakeholders if there is no impact outside of the Project Area.	Low-medium
Water Supply for Crop Irrigation	As above.	Practicality of this option will depend on a range of factors including distance between the supply and the crop and the salinity of the water.	Not environmentally sustainable if abstraction exceeds inflow. Irrigation may contribute to salinisation of the catchment, which would not be acceptable.	Cost of installing an irrigation system not quantified. Cost of rehabilitating any land that becomes salt-affected due to irrigation could be significant.	Increase in land salinisation in the catchment would not be acceptable to stakeholders. If no risk of salination, then may be acceptable to stakeholders.	Low-medium.

Table 3.8 (continued)

Option	Assessment Criteria					Suitability as Post-Operation Void Use
	Safety and Stability	Practicality of Implementation	Environmental Sustainability	Cost Effectiveness	Acceptability to Stakeholders	
Recreational Use	Will depend on a range of issues such as the nature of any water body that forms in the void, surface stability of the quarry walls, ease of access to the void and the type of recreational activities proposed at the site.	Pit walls may be suitable for rock climbing or abseiling. If a water body forms in the void, it may be suitable for swimming. The bushland around the void could be used for picnicking, camping, bush walking and bird watching.	Environmentally sustainable depending on the way in which such as land use is developed and managed. This option may provide an opportunity to reduce any recreational pressure on The Lakes.	Could be a cost-effective option. Will depend on extent of reshaping of quarry slopes.	May be acceptable to stakeholders. Opportunities for community or commercial benefits are envisaged.	Medium
Waste Storage for Waste Rock (Overburden)	Containment of inert waste material would assist in reducing the risk of surface slumping or slippage.	Practical, depending on potential sources of fill material.	Environmentally sustainable, provided the final land surface is re-contoured appropriately and a stable vegetative cover is established on the surface.	Cost-effective depending on potential sources of fill material.	Possibly acceptable to stakeholders provided that the material is not contaminated with putrescible waste.	High
Waste Supply for Municipal Waste	Containment of municipal waste material would assist in reducing the risk of surface slumping or slippage.	Practical for the local councils to utilise the space in the void, instead of constructing new landfills.	The permeability of the walls may need to be assessed to determine whether the material could be properly contained.	Could be a cost-effective option. Will depend on the suitability of the quarry void for the containment of municipal waste or if liners or other membranes are required.	Not considered to be an appropriate option by stakeholders.	Low
Aquaculture	Will depend on a range of issues such as the nature of any water body that forms in the void, surface stability of the quarry walls, and ease of access to the void.	Currently cannot be quantified, but would depend on a range of factors including water depth, turbidity, salinity and temperature stratification.	Environmentally sustainable depending on the way in which such a land use is developed and managed.	Not able to be quantified.	This option may be acceptable to stakeholders, but would need to be assessed.	Medium

4. EXISTING ENVIRONMENT

4.1 CLIMATE

The Project Area is located within a Mediterranean semi-desert climatic region and experiences cool, wet winters and mild, dry summers. The weather stations closest to the Project Area are located at Bickley, Northam, Chidlow and Mundaring (Table 4.1).

The mean monthly rainfall varies from site to site, with Northam recording the lowest mean (432 mm). Chidlow receives more than twice the average monthly rainfall of Northam (893 mm), whilst Mundaring and Bickley both receive a mean monthly rainfall of more than 1,000 mm (see Table 4.1).

The closest stations recording temperature are Bickley and Northam (Table 4.1). The average maximum temperature at Bickley ranges from 15°C in July to 30.6°C in February. The average minimum temperature at Bickley ranges from 7.2°C in July to 15.6°C in February. At Northam, the average maximum temperature ranges from 16.8°C in July to 34.1°C in January, and the average minimum temperature ranges from 5.4°C in July to 17.1°C in January and February. The long term rainfall and temperature averages for Bickley have been presented graphically in Figure 4.1.

Evaporation data collected from the Northam weather station are provided in Table 4.1. Evaporation can reach over 260 mm/month in January, with December and February also recording high daily evaporation rates. Evaporation rates are lowest in winter, when average monthly rainfall is high.

Wind data for the site are limited, with the nearest recording station located at Bickley. The Bickley station is located approximately 30 km southwest of the proposed quarry site and it is anticipated that a similar wind regime would occur, however the wind regime at the Project Area will be influenced by the surrounding topography. The prevailing wind in the morning throughout the year, recorded at the Bickley station, is an easterly wind (Figure 4.2). By mid-afternoon, the prevailing wind is usually a westerly which, in spring and summer, changes to a south-westerly in the late evening. During autumn and winter, the prevailing wind in the late evening is usually an easterly.

Table 4.1
Data from Weather Stations Near the Project Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bickley (Temperature 8 years data, Rainfall 33 years data)													
Mean Daily Maximum Temperature (°C)	30.4	30.6	27.6	24.0	19.2	16.0	15.0	15.8	17.5	21.2	24.6	28.1	22.5
Mean Daily Minimum Temperature (°C)	15.2	15.6	14.3	12.8	10.2	8.2	7.2	7.5	8.4	9.2	11.6	13.4	11.1
Mean Monthly Rainfall (mm)	18.3	20.7	25.7	53.3	135.0	213.1	221.3	170.6	118.1	67.6	40.4	12.7	1,087.9
Northam (Temperature 99 years data, Rainfall 125 years data, Evaporation 5 years data)													
Mean Daily Maximum Temperature (°C)	34.1	33.6	30.6	26.1	21.0	17.8	16.8	17.8	20.5	23.8	28.3	32.1	25.2
Mean Daily Minimum Temperature (°C)	17.1	17.1	15.4	12.0	8.5	6.5	5.4	5.7	7.0	9.0	12.4	15.4	10.9
Mean Monthly Rainfall (mm)	9.6	12.9	19.0	23.2	56.7	81.9	83.9	61.5	36.6	24.9	12.0	9.1	432.4
Mean Daily Evaporation (mm)	8.5	8.1	5.7	4.0	2.0	1.6	1.5	1.9	2.8	4.6	6.4	8.2	4.5
Chidlow (Rainfall 111 years data)													
Mean Monthly Rainfall (mm)	12.2	16.7	19.3	41.3	112.9	179.0	184.5	141.4	89.3	56.4	25.7	13.7	893.3
Mundaring (Rainfall 114 years data)													
Mean Monthly Rainfall (mm)	12.3	16.5	22.6	50.8	139.1	213.4	216.3	171.1	110.6	70.2	31.4	16.9	1,072.8

4.2 GEOLOGY, LANDFORMS AND SOILS

The Project Area is located in the mid-western section of the Southwestern Province of the Yilgarn Block, within the Western Shield. The Darling Scarp and Darling Fault, which delineates the western boundary of the Yilgarn Block (Biggs and Wilde, 1980), lie east of the Project Area. The Archaen rocks of the Yilgarn Block within the study area predominantly consist of granite, gneiss, migmatite and intruded dolerite dykes (King and Wells, 1990).

The stratigraphy of the area is dominated by Archaean granite (Figures 4.3a, 4.3b and 4.4), which is coarse and even-grained, and has been dated at approximately 2,600 million years. The exposed granite has minor variations. Minor jointing mainly occurs in a regular northeast–southwest direction. A simplified stratigraphic profile for this area comprises:

- hard caprock, laterite and gravel (0 – 2 m);
- weathered granite, gravel and clay material with some granite chips (2 – 5 m);
- fractured granite, abundance of quartz and granite chips (5 – 18 m); and
- fresh granite, with granite fragments (>18 m).

Small north to northwesterly trending quartz-dolerite dykes, which were formed as a result of movements associated with the Darling Fault, occur throughout the area. The dykes are expected to date between 450 and 750 million years (Williams, 1975).

A land system is defined as an area or group of areas throughout which there is a recurring pattern of topography, soils and vegetation (Christian and Stewart, 1953). The proposed site for the relocated quarry is situated in the Darling System and the landforms and soils of this system were characterised by Churchward and McArthur (1980) and revised by King and Wells (1990). The soil types in the Project Area are typical of the 'lateritic uplands', with a small portion on the eastern section of the Project Area located in a 'minor valley'.

The land units within the Project Area are listed below (Churchward and McArthur, 1980; King and Wells, 1990) and illustrated in Figure 4.5:

- **Yalanbee:** Gently undulating landscape, inclined crests and upper slopes dominated by moderately deep fine gravels; some duricrust on ridges. The Yalanbee land unit has moderately well drained yellow duplex soils and yellow and brown massive earths. The topsoil is classified as a sand to sandy loam with respect to the texture, and the subsoil is sand to clayey sand. These soils have high surface permeability and low runoff potentials. Runoff tends to occur mainly as a result of baseflow seepage in lower areas of the landscape, or as overland flow in saturated areas.

- **Pindalup:** Valleys on the central part of the plateau; gravelly duplex soils on the slopes, some rock outcrop, grey sands, yellow duplex soils and yellow and brown massive earths in broad floors. These tend to have a lower permeability than the soils in the Yalanbee land unit. The topsoil has a sand to sandy loam texture, which has a moderately slow permeability.

- **Cooke:** Level to gently inclined hillcrests; hills rising above general plateau level; mainly dominated by granite outcrop, very shallow yellow duplex soils and yellow and brown massive earths. The permeability of the soils in the Cooke land unit is moderately low.

Other land units near the Project Area include Goonaping and Murray. Goonaping is located south-east of the Project Area. This land unit is associated with shallow valleys located on level to gently inclined upland flats (Churchward and McArthur, 1980; King and Wells, 1990). The typical soil type for the Goonaping land unit is grey sand. The Murray land unit

is located directly to the north of the Project Area. The Murray land unit comprises of deeply incised valleys, which have red and yellow soils on the slopes (Churchward and McArthur, 1980).

4.3 SURFACE WATER

A description of the surface hydrology of the proposed Project Area is provided in Appendix G and the key characteristics are described below.

The proposed quarry relocation site is located near the top of the local catchment divide (Figure 4.6). The site is located in the southeast corner of the Wooroloo Brook catchment, which in turn forms part of the Swan-Avon catchment. The site is located in a proposed Priority 3 Drinking Water Source Area and the catchment is proclaimed under the *Rights in Water and Irrigation Act* 1914.

Runoff from the proposed quarry site reaches the Avon River via Wooroloo Brook. Wooroloo Brook is a major contributing catchment to the Swan-Avon system, with a catchment area of around 266 km^2 (26,600 ha). The confluence of Wooroloo Brook with the Avon River marks the change in name from the Avon to the Swan River. The area of the quarry and infrastructure (approximately 85 ha) is extremely small compared to the area of the Wooroloo Brook (0.32%) and the wider Swan-Avon catchments.

The proposed quarry site is located on the western side of a small valley. Surface drainage in the valley is from the south to the north. The average topographic gradient of the slope at the site is around 7% and the general direction of flow on the valley slope is towards the northeast. Elevation in the quarry area site varies from 300 to 350 m AHD. The sub-catchments in the vicinity of the Project Area are shown on Figure 4.7, and Table 4.2 summarises the characteristics of the catchments.

Table 4.2
Summary of Catchments

Catchment	Area (ha)	Hydrologic Characteristics
1 - Existing quarry and plant area	55	Pit void and plant area. Close to 100% runoff. Surface water is collected and reused for processing.
2 - Proposed quarry and plant area	85	Proposed pit void and plant area. At full development will have close to 100% runoff. Surface water will be collected and reused for processing.
3 – Pasture land downstream of existing quarry	117	Existing cleared pasture land; contains the eastern and western streams.
4 – Pasture land upstream of existing quarry	80	Existing cleared pasture land; contains the start of the eastern stream.
5 – Forest south of proposed quarry	22	Existing forest. No defined streamlines. Low runoff.
6 – Forest north of proposed quarry	63	Existing forest. Few defined streamlines. Low runoff.
Total	**422**	

Source: URS (2002a). See Appendix G.

There are no substantial drainage lines, wetlands or sensitive water bodies in the proposed quarry area, which is located approximately 7 km south of Wooroloo Brook. A small stream passes to the east of the site (the "eastern stream"), joining with a small stream from the west (the "western stream") about 750 m north of the existing quarry site. The streams have incised channels 0.5-2 m wide and 0.5-1 m deep in a broad valley. A dam on the "eastern stream" is used as a water supply for the existing quarry. The streams are ephemeral, flowing mainly during winter as a result of seepage from local groundwater or surface runoff.

Runoff from the catchments was simulated using SWAT (Soil Water Assessment Tool, Arnold *et al*., 1994), which is a catchment scale, continuous runoff model. SWAT simulates soil water of the top 1 - 2 m of the soil profile, vegetation growth, infiltration and movement of runoff in overland flow and channels using a daily time step. The catchment is represented with a series of sub-basins based on catchment drainage and varying land use/soils/vegetation. Characteristics of the catchment and observed weather data are used in the model.

The water balance varied markedly with land use and land condition. Table 4.3 summarises the predicted water balance for the existing land uses in the immediate area of the proposed quarry.

Table 4.3
Predicted Water Balance for the Existing Land Uses

Land Use	Proportion of Rainfall (%)			
	Runoff	Seepage to Groundwater	Evapotranspiration	Extraction for Process Use
Forest	3	7	90	-
Pasture	5	17	78	-
Seepage areas in pasture	35	0	65	-
Existing quarry and plant area	33	3	50	14

Source: URS (2002a). See Appendix G.

The surface water balance for forested areas (Catchment 2 in Table 4.2, which includes the site proposed for quarry relocation), is dominated by evapotranspiration and percolation. Only about 3% of average annual rainfall was predicted to become stream flow from this area, as soils are highly permeable. Runoff occurs mainly from low-lying areas and streamlines that become saturated during periods of rainfall or groundwater discharge. Evapotranspiration (transpiration by vegetation plus evaporation from the soil surface or vegetation) was predicted to constitute 90% of the rainfall water balance. Percolation below the vegetation root zone was predicted to account for 7% of rainfall, consistent with values reported in the literature for similar soils, vegetation and rainfall.

Runoff from the cleared pasture land to the south, north and east of the site (Catchments 3 and 4) is likely to be higher than from the forested areas – about 5% of average annual rainfall in grassed areas and up to 35% in bare scalded areas. Clearing and establishment of pasture is predicted to increase seepage to groundwater from 7% to 17%. This additional seepage is the cause of rising groundwater levels in the area. Evapotranspiration was predicted to have fallen to 78% of average annual rainfall, mainly because the pasture did not transpire as much water as forest.

Virtually all rainfall falling in the existing pit and plant areas (Catchment 1) becomes runoff. Runoff in the pit is collected in a sump; part of the runoff from the plant area is collected in the dam to the east of the plant area. Water collected in these storages is used for dust suppression and processing on the quarry site. Water in excess of requirements is released into the "eastern stream".

Most runoff was predicted to occur between May and August (Figure 4.8). The amount of runoff varies from year to year (Figure 4.9) and in the past five years has been well below average. Coefficient of variation in annual runoff was predicted to be 58%, which is moderate compared with other parts of Australia.

There are several obvious areas of salinisation in the pasture land downstream of the existing quarry site (URS, 2002a). Vegetation in these areas is sparse, runoff rates are high, and the areas are erosionally unstable. Disturbance and trampling by stock exacerbate the erosion and lead to increased streamflow turbidity. Observations of salinity in the streams, storages and bores over a period of time clearly show that seepage from surrounding agricultural land is the main source of salt load in the local catchment. This seepage is a result of rising watertables caused by clearing of vegetation for agriculture and is not related to the existing quarry operations. Controlled discharge from the current quarry has increased streamflows, but the salinity of the discharge water is low, leading to an overall lowering of salinity levels in the streams near the quarry.

4.4 GROUNDWATER

4.4.1 General

The proposed quarry site occurs in the Darling Scarp Province of Western Australia. The province has reliable rainfall and is characterised by streams that deeply incise the laterite profile into underlying granite bedrock. Small amounts of potable groundwater are available from bores and wells that intersect fractures within the granite bedrock, but generally yield less than 15 kilolitres/day. Those sited in valleys or on some hill slopes may give larger supplies, but the groundwater salinity is generally higher (Wilde and Low, 1978).

Kirchner (2002) describes three types of aquifers present in the Wooroloo Brook Catchment, as follows:

- a semi-confined aquifer;
- superficial aquifers; and
- perched aquifers.

Only the semi-confined aquifer has been found in the proposed quarry area. This aquifer is expected to be widespread in the catchment area.

The salinity of groundwater in the upper parts of the Wooroloo Brook Catchment varies from less than 1,000 to more than 7,000 mg/L total dissolved solids (TDS). There is an increase in salinity from west to east across the catchment (Figure 4.10).

The proposed quarry occurs in the very upper-most reaches of the Wooroloo Brook Catchment, immediately adjacent to the catchment divide. Groundwater yield to bores is therefore very small and groundwater salinities are between 1,200 and 3,700 mg/L TDS. According to the ANZECC Guidelines (2000) water with this salinity could be suitable for consumption by stock provided there were no deleterious elements. The TDS exceeds the 500 mg/L limit recommended for consumption by humans.

Due to low bore yields and generally poor groundwater quality, the area containing the existing and proposed quarry is not within a proclaimed groundwater area under the *Rights in Water and Irrigation Act* 1914. A licence is therefore not required to extract groundwater in this area.

The small groundwater seep into existing quarry operations is used for suppression of dust, washing the crushed rock product and washing the plant and equipment. The groundwater is sourced from the quarry sump.

Quarry water is pumped directly to the sprinklers and water cart. Artesian groundwater flows from the top of each bore to a small dam upstream and adjacent to the quarry dam. Overflow from this dam spills into the quarry dam. The quarry dam is located immediately east of the plant and is used as a source of water supply for the remainder of the operations. As well as receiving groundwater from the artesian bores, the quarry dam receives surface water runoff from the upstream catchment and is topped up when needed by the quarry dewatering pump. The quarry dam was lined with clay during construction.

Plate 4 Existing quarry dam located east of the processing plant

4.4.2 Quarry Water

The existing quarry is 61 m deep as measured from the highest original topographic elevation to the deepest excavated point. The highest elevation was 315 m above the Australian Height Datum (AHD) while the deepest excavated point is at a relative level (RL) of 254 m above AHD. At the base of the quarry is a water pond (sump) approximately 16 m deep. The water surface in the quarry sump (Plate 5) is at a RL of 270 m above AHD.

Groundwater flows towards the existing quarry through fractures in the granite and dolerite. When inspected in March 2002 a small flow of groundwater was seen entering the east wall of the quarry through fractured granite. At this time, groundwater was entering the quarry at a RL of 292 m above AHD. Other inflows have been observed by site personnel over the past 18 months but these had gradually dried up. Site personnel have also reported that the flows gradually and progressively dried up at lower and lower levels within the quarry. Evidence for these past groundwater inflows could be seen in the following geological entities:

- Steeply dipping zones of fractured granite.
- Edge of dolerite dyke intrusions.
- Horizontal fractures caused by pressure unloading in the granite.
- The contact between the fresh and weathered granite.

The pit was re-examined in July 2002 after a period of winter rainfall to determine if any further inflows had developed. A further 23 inflows were visible, mainly along the southern end of the quarry between RL 307 and 309 mAHD. This inflow was discharging from the contact between the fresh and weathered granite at the base of the saprolite zone and was estimated to have a cumulative inflow rate of 0.1 L/sec. Another inflow was observed at RL

282 mAHD emanating from a horizontal fracture at an estimated flow rate of between 0.08 and 0.1 L/sec. The total visible inflow to the quarry was approximately 0.25 L/sec.

The groundwater flowing into the quarry comprises natural groundwater from the regional aquifer and rainfall recharge that exits the aquifer at the quarry face. The water in the sump is composed of this groundwater and any rainwater falling directly into the quarry.

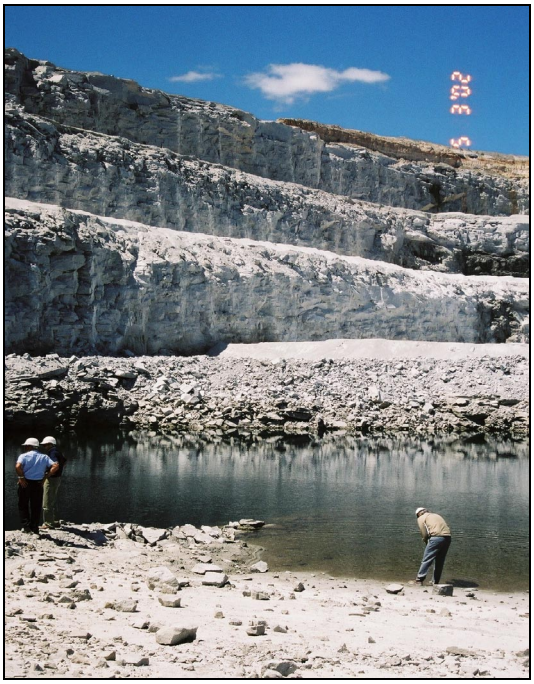

Plate 5 Quarry sump located at the base of the existing Voyager Quarry pit

4.4.3 Bore Water

In 1996, two bores were installed approximately 500 m east of the centre of the existing quarry and immediately upstream of the quarry dam. The bores were drilled to 26 m depth. Based on observations in March 2002 of damp soils and abundant green grass, the location appears to be a natural soak. The artesian bores are not currently equipped for pumping as they flow naturally to the surface and then overland to the small dam upstream of the quarry dam. The bores are therefore, by definition, artesian bores.

In March 2002, two vertical groundwater monitoring bores were drilled in the area of the proposed quarry relocation. One was drilled to 60 m in the centre of the proposed quarry (BGC1) and the other was drilled to 50 m on the western edge (BGC2). The groundwater level in the central bore (BGC1) was 54 m below ground surface. No groundwater was intersected by the western bore (BGC2). No measurable groundwater flows were found in either bore. Fracturing was noted in the top 18 m of each bore, but these fractures were dry. This main fractured zone corresponded to the saprolitic zone of the weathered granite profile, a zone which was expected to exist over the entire quarry site. The groundwater yield from BGC1 came from a very minor fracture intersected at an undetermined depth.

It was concluded that a significant unsaturated zone occurs in the area of the proposed quarry as the main fractured zone intersected in the top 18 m depth was dry. The lack of significant groundwater yield from the two bores does not discount the possibility for some groundwater to be present in steeply-dipping fractures within un-weathered granite in other parts of the proposed quarry. Generally, these types of fractures do not yield significant quantities of

groundwater. There is also a possibility that the main fractured zone could intercept rainfall recharge after a period of high rainfall activity.

A search of the WRC water bore database, AQUABASE revealed several bores in the district, the closest of which is 1.5 km from the proposed quarry. The information from these bores is summarised in Table 4.4.

Table 4.4
Bore Information Obtained Using AQUABASE

AQUABASE Bore Identifier	Bore Information
20039023, 20039024 and 20039025	Depths 17 - 20 m.
20039087	Depth 9.7 m; Cased with 100 mm PVC.
20039094	Depth 16.2 m; Cased with 100 mm PVC; Used for domestic and livestock water supply.
20039095 and 20039096	Depths 18 m; Cased with 100 mm PVC; Salinity 1,440 to 5,250 mg/L TDS. Groundwater level 6.0 m.
20039106, 20039107 and 20039108	No information.
20039112 and 20039113	Depths 10.7 m; Cased with 100 mm PVC. Used for domestic water supply and irrigation.

The information on the AQUABASE bores is limited, particularly in respect to groundwater levels and groundwater salinity.

A bore census of private bores on six properties in the vicinity of the Project Area was conducted in September and November 2002 by URS. The results from the census are presented in Table 4.5. The bore census has provided baseline information on groundwater levels and salinity.

Water Quality

The TDS of groundwater in the quarry sump and quarry dam was measured from water samples collected in January 2002 and analysed in a laboratory. The TDS of groundwater was also measured in the field in March 2002 using an electrical conductivity meter. Results are provided as Table 4.6.

Groundwater emanating from the quarry face in July 2002 had EC values ranging from 693 µS/cm to 1,812 µS/cm (which converts to TDS values of approximately 464 to 1,214 mg/L). The lower values were probably derived from recent rainfall recharge.

Groundwater from the fracture intersected by the BGC1 bore had a TDS content of 3,700 mg/L.

The quality of groundwater abstracted from the existing quarry and from the two artesian bores is typical for this area.

Table 4.5
Bore Census Results

Bore ID	Location	Water Depth (WD)[1]	WD Reference Point	Bore Depth (m)	Sample Number	Sampling Method	Field Readings				Comments
							EC (µS/cm)[2]	TDS (mg/L)[3]	pH	Temp (°C)	
Bore 1	Lot 7 Cable Road - Windmill head-frame over bore fitted with centrifugal pump approx. 50 m E of house on rise.	9.09	Top of inner PVC casing	19	BGC-WS-01	Tap on pressure pump. Pump ran for 5 mins	4039	2167	5.73	18.4	Bore previously not operated for a week. Used for domestic household purposes.
					Not sampled	Bore rested 45 mins & pumped again for 5 mins	4890	2632	5.19	18.5	
						Pump ran for 10 mins	3347	1767	5.15	18.3	
					BGC-WS-04	Pump ran for 15 mins	4552	2439	5.03	19.0	
Bore 2	Lot 7 Cable Road - Approx. 300 m E of farmhouse, in valley.	0.35	Top-most part of inner PVC casing	13.8	BGC-WS-02	Bailed from 1 m below water level.	690	343	6.19	17.5	Bore not used. Abundant surface water with EC 535 µS/cm & pH 6.24 around top of bore.
					Not sampled	Bailed from 5 m below water level	691	343	6.06	17.5	
Bore 3	Lot 7 Cable Road - Approx. 200 m NE of house in valley.	4.52	Top-most inner PVC casing	21	BGC-WS-03	Bailed from 1 m below water level.	277	134	4.74	19.1	Bore not used.
					Not sampled	Bailed from 20 m depth	276	134	4.20	19.6	
Bore 4	Lot 3 Cable Road - Approx. 50 m east of house.	2.03	Top of inner PVC casing		Not enough room in hole to take a water sample. Bore not operating. Main dam 110 m N of house had near surface water sample EC 1562 µS/cm, pH 6.49 & temp. 16.6°C..						Pump not operated since last summer.
Bore 5a	Lot 5 Horton Road – Approx. 20 m east of house. Bore 5a is a bore & coincident hand dug well.	16.91	Top of concrete costean	Bore - 23 Well - 10	BGC-WS-05	Bailed from 1m below water level.	1140	574	6.47	18.7	Metal sheeting over top of well. Bore plugged at base of well.
Bore 5b	Lot 5 Horton Road – Bore 5b is approx. 1 m from 5a.	No WD measured as adjacent to Bore 5a.		27	Not sampled	Pumped using installed air driven pump.	1123	568	6.81	16.2	Bore capped. Approx. 600 L pumped about 2 days ago. Bore used for domestic household.
Bore 6	Lot 5 Horton Road – Approx. 10 m SE of shed.	The owner of the bore said water level was at 13 m most of the time.		21	Not sampled	Pumped for few minutes only	629	310	5.67	19.7	Bore approx. 10 years old. Rain water drained to bore when excess available. Approx. 200 L drained last week. Bore used for garden.
					BGC-WS-06	Pumped at 8.7 L/min for 1 hr.	229	111	5.54	18.2	

Table 4.5 (continued)

Bore ID	Location	Water Depth (WD)[1]	WD Reference Point	Bore Depth (m)	Sample Number	Sampling Method	Field Readings				Comments
							EC (µS/cm)[2]	TDS (mg/L)[3]	pH	Temp (°C)	
Bore 7	Lot 5 Horton Road – Approx. 250 m S of house adjacent Horton Rd.	13.15	Top of inner PVC casing	27	BGC-WS-07	Pumped with air driven pump a few minutes.	3350	1772	5.42	18.3	Bore drilled Jan'02. Pump set about 17 to 18 m depth. The owner of the bore said saline (3000 mg/L) seep intersected above main aquifer. Main aquifer was fresher (1500mg/L)
Bore 8	Lot 5 Horton Road – Western end of property near dam.	3.14	Top-most inner PVC casing	18	BGC-WS-08	Pumped with air driven pump a few minutes.	1291	654	5.00	19.3	Rag & rock covering bore. Was the house supply bore. The owner of the bore said WD is approx. 6 m in summer.
Bore 9	Lot 4 Horton Road – Centre of SE paddock.	2.40	Ground	8	BGC-WS-09	Bailed from 1 m below water level.	150	72.5	5.24	17.5	No casing, surface water enters top of bore.
Bore 10	Lot 27658 Wariin Road – West of top dams	No water depth measurements or sampling possible as inoperable shaft driven pump located over bore.									Bore drilled 10-13 years ago. Pump not used for 2 years. House water obtained from new, large #2 dam.
Bore 11	Lot 27655 Wariin Road – Windmill SW corner of property	2.47	Top of inner steel casing	Not known	BGC-WS-10	From tank overflow approx. 100 m N of bore.	9005	5030	5.82	17.4	Bore used for sheep watering. 20-25 years old. Only bore on property.
Bore 12	Lot 200 Carter Road	2.09	Top of inner PVC casing	20	BGC-WS-11	Bailed from top of water column.	376	168	5.23	18.7	Bore used for domestic garden and stock watering.
Bore 13	Lot 6 Cable Road	0.70	Top of concrete costain	6	BGC-WS-12	Bailed from 5m depth	2740	1297	5.18	18.3	Bore used for stock watering.

Notes:
1. All water depths are rest levels unless stated otherwise.
2. EC not temperature compensated.
3. NaCl salinity calculated by probe.

Table 4.6
Water Quality in the Quarry Dam in January and March 2002

Sample Location	Sample Date	Water Temp (C°)	Electrical Conductivity @ 25C° (µS/cm)	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	Comments
Quarry Sump	17/1/02			1,200	<5	AEL Report 62385
	5/3/02	26.7	1,325	888*		Measured near surface of pond
Artesian Bore 1	5/3/02	21.0	1,470	985*		Northern bore
Artesian Bore 2	5/3/02	20.6	1,935	1,296*		Southern bore
Quarry Dam	17/1/02			1,800	19	AEL Report 62385
	5/3/02	26.7	2,500	1,675*		-

Note: * indicates that these TDS values were calculated using the factor of 0.67 as an approximate conversion from EC to TDS.

4.5 VEGETATION AND FLORA

4.5.1 Vegetation

A vegetation survey of the Project Area was conducted in January 2002 by Mattiske Consulting Pty Ltd. The objectives, methodology and results of this survey are described in Appendix B.

In total, 11 site-vegetation types were defined and mapped for the survey area. These plant communities are described in Table 4.7. A vegetation map is provided as Figure 4.11.

All of the site-vegetation types present in the proposed Project Area are represented in the wider conservation estate (Mattiske Consulting Pty Ltd, 2002). However, as only sections of the south-west forest region have been mapped at the scale of site-vegetation type level, it is not feasible to place percentages on representation.

Vegetation types are considered significant when they are restricted in distribution, and/or support populations of significant flora. The site-vegetation type G (open to closed heath of Proteaceae) is locally significant as it is associated with localised outcropping supporting a range of species and taxa, including the Priority 4 species, *Hemigenia viscida.* Although local variations are noted in composition, this site-vegetation type is well represented in the conservation estate (Heddle *et al.,* 1980).

Further discussion of the local and regional significance of the vegetation of the Project Area is presented in Table 4.7 and Appendix B.

COMMITMENT

The Proponent will monitor vegetation condition within the Project Area during the construction and operational phases of the Project, as recommended by Environment Australia. The monitoring programme will encompass both woodland and heath communities.

Table 4.7
Local and Regional Significance of Vegetation Types in the Project Area

Code	Vegetation Type	Known Occurrence	
		Locally (Project Area and Surrounds)	**Regionally (Southwest WA)**
D	Open woodland of *Eucalyptus marginata* subsp. *thalassica – Corymbia calophylla* on lower slopes with mixed low understorey species, including *Baeckea camphorosmae, Daviesia preissii* and *Mesomelaena tetragona*.	Restricted in occurrence in the general Project Area as the majority of lower valley slopes have already been cleared for agriculture in adjacent properties.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest of WA. However, dieback free areas of this vegetation type are significant in a regional context.
H	Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with scattered understorey, including *Hibbertia acerosa, Dryandra lindleyana, Xanthorrhoea gracilis, Calothamnus sanguineus, Conospermum stoechadis* and *Lepidosperma squamatum.*	Relatively widespread in Project Area and surrounds due to suitability of soil conditions.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest of WA.
HS	Open Forest to Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with scattered understorey, including *Dryandra sessilis*, *Dryandra lindleyana, Leucopogon nutans* and *Lepidosperma squamatum.*	Relatively restricted in the Project Area and surrounds, due in part to the lack of lateritic gravel soils in which it favours.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest.
HG	Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with low dense understorey, including *Dryandra armata, Hakea undulata, Hakea stenocarpa, Hakea incrassata, Pericalymma ellipticum, Grevillea bipinnatifida* and *Lepidosperma squamatum.*	Relatively widespread in the Project Area and surrounds.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest.
P	Open Forest to Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with scattered understorey, including *Leucopogon nutans* and *Lepidosperma squamatum.*	Relatively widespread in the Project Area and surrounds.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest.
PS	Open Forest to Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with scattered understorey, including *Dryandra sessilis*, *Leucopogon nutans* and *Lepidosperma squamatum.*	Relatively widespread in the Project Area and surrounds.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest.

Table 4.7 (continued)

Code	Vegetation Type	Known Occurrence	
		Locally (Project Area and Surrounds)	**Regionally (southwest WA)**
PG	Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with low dense understorey, including *Dryandra armata, Hakea undulata, Grevillea bipinnatifida, Leucopogon nutans* and *Lepidosperma squamatum.*	Relatively widespread in the Project Area and surrounds.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest.
Y	Woodland of *Eucalyptus wandoo* with scattered understorey, including *Gastrolobium calycinum, Mesomelaena tetragona, Daviesia rhombifolia* and *Xanthorrhoea gracilis*.	Relatively restricted in the Project Area and surrounds as the majority of this vegetation type has been cleared historically for agricultural activities.	Not restricted. Occurs in other conservation areas, both within the eastern and northern parts of the Jarrah forest of southwest WA.
YG	Woodland of *Eucalyptus wandoo* with low dense understorey, including *Synaphea petiolaris, Dryandra squarrosa* subsp. *squarrosa, Hibbertia acerosa* and *Dryandra lindleyana.*	Relatively restricted in the Project Area and surrounds as the majority of this vegetation type has been cleared historically for agricultural activities.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest of southwest WA
MG	Open Woodland of *Eucalyptus wandoo* with dense understorey, including *Hakea incrassata, Allocasuarina microstachya, Dryandra armata, Hakea undulata* and *Allocasuarina humilis*.	Relatively restricted in the Project Area and surrounds as the majority of this vegetation type has been cleared historically for agricultural activities	Occurs in conservation areas, both within the eastern, western escarpment and northern parts of the Jarrah Forest.
G	Open to Closed Heath of Proteaceae - Myrtaceae species, including *Hakea incrassata, Hakea stenocarpa, Dryandra armata, Hakea undulata, Melaleuca scabra, Calothamnus quadrifidus, Dryandra squarrosa* subsp. *squarrosa* and *Beaufortia macrostemon.*	Scattered occurrence throughout the Project Area. *Hemigenia viscida* (Priority 4 species) occurs in this vegetation type in the Project Area.	Restricted in distribution within the northern Jarrah forest, but is well represented in conservation estates (e.g. near Mt Cooke and Mt Windsor).

4.5.2 Flora

Two flora surveys were conducted in the Project Area in 2002. The first survey was undertaken in January 2002 by Mattiske Consulting Pty Ltd, and recorded 200 vascular plant taxa (including seven introduced taxa) from 39 plant families and 102 genera. Mattiske Consulting Pty Ltd conducted a follow-up flora survey in Spring 2002 to identify any additional species not recorded during the January 2002 survey. During this survey, an additional 23 vascular plant taxa were recorded, which included orchids and trigger plants. Therefore, a total of 223 vascular plant taxa from 42 plant families and 112 genera have been recorded within the survey area (refer to Appendix B).

No Declared Rare Flora (DRF) species gazetted under the *Wildlife Conservation Act* 1950 were recorded within the Project Area during the surveys. However, a species listed as Priority 4 (Rare Flora) on the State Declared Rare and Priority Flora List and as Vulnerable under the EPBC Act was recorded in the Project Area. This species, *Hemigenia viscida,* was recorded in four of the 17 areas of heath present in the Project Area (Mattiske Consulting Pty Ltd, 2002) (Figure 4.12). Almost 95% of *Hemigenia viscida* plants (1,612 plants) were recorded in one heath community (H5) (Figure 4.12).

A survey to identify other locations or potential locations for *Hemigenia viscida* populations beyond the immediate Project Area was conducted by Mattiske Consulting Pty Ltd in February 2002 (Figure 4.13). This was undertaken through an interpretation of aerial photographs and follow-up ground-truthing. The survey identified a population of at least 110 plants in a heath community on Mundaring Shire land to the west of Horton Road, and south of a Mundaring Shire gravel quarry pit. No plants were located in nearby State Forest areas.

In Western Australia, *Hemigenia viscida* has also been recorded previously on the eastern edge of the jarrah forest and in pockets in the Wheatbelt region (Appendix B).

Seven introduced plant species have been recorded in the Project Area. The species are *Briza maxima* (Blowfly Grass), *Lagarus ovatus* (Hare's Tail Grass), *Ehrharta longifolia* (Annual Veldt Grass), *Chamaecytisus palmensis* (Tree Lucerne), *Anagalis arvensis* (Pimpernel), *Conyza bonariensis* (Flaxleaf Fleabane) and *Pseudognaphalium luteoalbum* (Jersey Cudweed). All of these weeds are widespread in the south-west of Western Australia, particularly on disturbed areas (Hussey *et al.,* 1997).

4.5.3 Dieback

A field survey was conducted by Glevan Dieback Consultancy Services in December 2001 to assess the presence of *Phytophthora* spp. in the Project Area (Appendix C). *Phytophthora* spp. are soil-borne pathogens which affect a wide range of plant species of the south west of Western Australia. An area of *Phytophthora cinnamomi* infestation was identified, running parallel to Great Southern Highway for approximately 1.65 km (Glevan, 2001). It was suggested that the introduction of the pathogen may have occurred during initial road construction and that the infestation has had an impact on the plant communities, particularly on the species, *Banksia grandis*. The remainder of the area assessed during the study was deemed to be free of the symptoms associated with the *Phytophthora* sp. pathogen (Glevan, 2001)

4.6 VERTEBRATE FAUNA

4.6.1 Vertebrate Fauna Species

A desktop vertebrate fauna review and brief site inspection undertaken by Ninox Wildlife Consulting in January 2002 identified that 80 bird species, 17 native mammal species (including seven bat species), nine frog species and 31 reptile species may occur in the area (refer to Appendix D). Most of these species have widespread distributions throughout the South-west forested area and are not restricted to individual habitats.

Three species listed under the EPBC Act 1999 are known or expected to occur within the general Project Area. These are:

- Carnaby's Black Cockatoo, *Calyptorhynchus latirostri* (which is listed as Endangered under the EPBC Act and as Threatened under the State *Wildlife Conservation Act*);
- Baudin's Black Cockatoo, *Calyptorhynchus baudinii* (which is listed as Vulnerable under the EPBC Act and as Threatened under the State *Wildlife Conservation Act*);
- the Chuditch, *Dasyurus geoffroii* (which is listed as Vulnerable under the EPBC Act and as Threatened under the State *Wildlife Conservation Act*); and
- the Fork-tailed Swift (*Apus pacificus*) and the Rainbow Bee-eater (*Merops ornatus*), which are listed under the EPBC Act as they are protected under international agreements for migratory birds.

Both Black Cockatoo species are likely to occur only periodically within the proposed Project Area when particular food resources are available or when climatic conditions are favourable. The relative lack of large trees with suitable nesting hollows would limit the number of pairs of birds, mainly Carnaby's Black Cockatoo, that could breed in the proposed quarry site. In addition, the Baudin's Black Cockatoo is unlikely to breed in the Project Area as preferred forest types occur further to the south.

If present, the Chuditch is likely to occur within the general area, using both native vegetation and adjacent cleared land to obtain food resources. As Chuditch are relatively mobile they would be able to move away from impacted area and attempt to locate food elsewhere. Depending on the numbers of Chuditch in suitable habitat within the surrounding area, some territorial competition may occur. However, populations would be expected to stabilise once conflicts are resolved. Some deaths may take place as displaced animals move across roads to find new habitat.

The Fork-tailed Swift does not breed in Australia, but the Rainbow Bee-eater is highly likely to breed in the proposed quarry area. However, the overall impact of the proposed activities on these species is expected to be low (Ninox Wildlife Consulting, 2002).

Species gazetted under Schedule 4 ('In Need of Special Protection') of the *Wildlife Conservation Act* 1950 which could potentially occur within the Project Area include:

- Peregrine Falcon (*Falco peregrinus*): This species occurs throughout Australia in most habitats with a preference for timbered water courses. There is high probability of occurrence throughout the general Project Area as Peregrine Falcons are known to readily use ledges within quarried areas for roosting and possibly nesting. They are also able to forage widely for food can coexist with human disturbance.

- Carpet Python (*Morelia spilota imbricata*): This species occurs in forest, woodlands, heath and granite outcrops throughout south-western Australia including the western portion of the wheatbelt. There is a moderate probability the Carpet Python may be found

within the Project Area, particularly in heaths where the higher concentration of birds would provide a major food resource.

The following vertebrate species listed as Priority 3 ('Taxa with several, poorly known populations, some on conservation lands') on CALM's Priority Fauna list may occur within the proposed Project Area:

- Wambenger/Brush-tailed Phascogale (*Phascogale tapoatafa*). This species may be found in most forest types in the south-west of the State. Howev;er, there is a high probability that this species of mammal occurs within the study area.

- Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*). This large cockatoo would almost certainly occur periodically within the Project Area, particularly when a preferred food resource such as Marri nuts is available. However, the relative lack of large trees with suitable nesting hollows is likely to limit the number of individuals that could be resident during breeding season.

The following species listed on CALM's Priority database as Priority 4 taxa ('Taxa in need of monitoring') may also occur within the Project Area:

- Western Brush Wallaby (*Macropus irma*): Scats of this wallaby were observed in heath, Jarrah and Jarrah-Sheoak communities during field surveys. Hence, it is likely that this species occurs throughout the Project Area, particularly wherever dense vegetation is present.

- Western False Pipistrelle (*Falsistrellus mckenziei*): This species is more common further south. It is unlikely that this bat will occur in the Project Area as the area is outside the known distribution for this species. Extensive surveys conducted in the Darling Range by Alcoa and Worsley have not found this species and there are no historic records of this species in the Darling Range.

- Crested Shrike-tit (*Falcunculus frontatus*): Due to the limited areas of preferred Wandoo woodland habitat in the Project Area, there is only a moderate probability of this species occurring.

- Dell's Skink (*Ctenotos delli*): This skink occurs in the Darling Range from Darlington and Mundaring South nearly to Collie. It is patchily distributed in its geographic range and may occur within the Project Area.

The Honey Possum (*Tarsipes rostratus*) is another species that may occur in the Project Area, which could be considered locally significant in the Darling Range (Ninox Wildlife Consulting, 2002). The species was originally thought to occur only in the sandplain heaths of South-west coastal and sub-coastal Western Australia where it is relatively common. However, since 1981 small populations of the Honey Possum have been found in heath patches within the forested Darling Range. This species was also found to occur in some reserves in the wheatbelt during the late 1970s.

The numbat (*Myrmecobius fasciatus)* is highly unlikely to occur within the Project Area despite its historical distribution in the region. At present, only a few isolated numbat populations remain in south-western Australia (Friend, 1998). Numbats bred in captivity have been released at sites throughout the south-west of WA to improve the conservational status of the species. The numbat release site closest to the Project Area is approximately 20-30 km south (J.A. Friend, pers. comm., 2002). However, it is unlikely that the released numbats have moved from the release site to the Project Area due to the size of habitat in the Project Area

(J.A. Friend, pers. comm., 2002). A busy highway separates both areas and lack of shelter and/or refuge logs and the small area of preferred wandoo habitat in the Project Area indicate it is unlikely that a resident population occurs within the Project Area.

Introduced fauna species are also expected to occur in the Project Area. These include the Black Rat (*Rattus rattus*), House Mouse (*Mus musculus*), Red Fox (*Vulpes vulpes*), Feral Cat (*Felis catus*), Rabbit (*Oryctolagus cuniculus*) and the Kookaburra (*Dacelo novaeguineae*) (Ninox Wildlife Consulting, 2002).

A fauna field survey was recently conducted in the proposed Project Area to provide further information for the development of a detailed fauna management plan. The findings of this survey will be provided to the EPA, DEP, CALM and other relevant stakeholders, for review.

4.6.2 Fauna Habitats

The distribution of fauna habitats within the Project Area is shown in Figure 4.14. Due to past logging operations at the site, approximately 80-90% of Jarrah trees in the study area support coppice regrowth (E.M. Mattiske, pers. comm., 2002). Large potential habitat trees, mainly Marri trees, with suitable hollows for nesting or refuge occurred on an estimated 15% of the sites surveyed during the vegetation assessment (E.M. Mattiske, pers. comm., 2002).

4.6.3 Ecological Linkages

The Wandoo woodlands are important for vertebrate fauna as they provide habitat for many animals. In particular the hollows within these woodlands provide refuge and shelter for many species. The Wandoo woodland on the western boundary of Lot 11 (vegetation community MG) had an understorey of heath, which links it with other heath patches and with Jarrah forest with a heath understorey. This habitat continues into the adjacent Mundaring Shire gravel reserve, therefore its significance to fauna is judged to be high and the area will not be disturbed. However, the link through the gravel reserve to other areas of native vegetation is not continuous (Figure 4.15).

The habitats in the southern portion of the Project Area (mainly vegetation types HG, H, P, PG HS, G and D) (Figure 4.11), while separated by Great Southern Highway, are linked to State Forest through native vegetation on private land. This road will form a barrier to the movement of very small terrestrial vertebrates, such as reptiles and mammals, but is unlikely to inhibit the movement of the majority of birds and larger vertebrates (Ninox Wildlife Consulting, 2002). The habitats within the south-eastern corner of the Project Area contains a link with a catchment protection reserve and native vegetation on private land to the east. Wariin Road bisects this link approximately three kilometres to the east of the Project Area, which may form a barrier to small terrestrial vertebrates (Ninox Wildlife Consulting, 2002).

4.7 INVERTEBRATE FAUNA

4.7.1 Introduction

Discussions with the DEP and other government agencies indicated that the invertebrate fauna of interest in relation to the proposed Project Area are trapdoor spiders and land snails. The survey work conducted in relation to these fauna is described in the following sections.

4.7.2 Trapdoor Spiders

A preliminary survey for trapdoor spiders (mygalomorphs) within Lots 11 and 14 was conducted by two personnel from the Western Australian Museum on 16 and 28 July 2002. An additional survey was carried out on 28 August 2002 in the study area and in an area to the south, which is designated for water protection and held by the Water and Rivers Commission. The vegetation map of the Project Area produced by Mattiske Consulting Pty Ltd (2002) was used to guide the selection of search sites.

The objectives, methodology and results of the trapdoor spider surveys are described in Appendix D. The key findings are summarised below.

Three species of trapdoor spiders were collected during the field surveys. These were:

- *Cethegus* sp. (family Dipluridae);
- *Aganippe* sp., probably of the *Aganippe rhaphiduca* group (family Idiopidae); and
- *Gaius* sp. (family Idiopidae).

Of these species, the *Gaius* sp. is of interest as it has not previously been recorded in the Darling Range and may be a relictual taxon.

Gaius is an arid-adapted trapdoor spider known to occur in the Wheatbelt and Goldfields area. It has also been recorded at Collie and possibly on the Swan Coastal Plain (though these records have not been substantiated with field data). The burrow structure of the spiders collected at the proposed quarry site are somewhat different to burrows of Wheatbelt and Goldfields species, mainly in relation to the shape of the burrows (see Appendix E). This may be the result of a lower clay content of the soils at the proposed Project Area compared to the more inland sites.

A total of 36 *Gaius* sp. burrows were recorded at nine of the 59 sites searched within Lot 11 and Lot 14. These were *Gaius* Sites A-D, J10/B10, J29/B15, B16, B21 and B22 (Figure 4.16, Table 4.8). Three of these sites are located within the proposed area to be cleared (J10/B10, J29/B15 and B16). Twenty-two burrows recorded in the northern section of Lot 14 will not be cleared or disturbed by the proposed quarry relocation. Populations of *Gaius* sp. location on the western and eastern sides of Lot 11 will also not be disturbed.

Table 4.8
Number of *Gaius* sp. Nests at Trapdoor Spider Search Sites

Site Number	Number of Burrows	Comments
J10/B10	1	Nest excavated and female spider removed.
Gaius Site A	22	4 adult and 18 juvenile nests. One of the adult nests was excavated and a female spider was removed.
Gaius Site B		
Gaius Site C		
Gaius Site D	1	1 juvenile nest.
J29/B15	7	4 adults and 3 juvenile nests.
B16	3	1 adult and 2 juvenile nests.
B21	1	1 adult nest.
B22	1	1 adult nest.

Gaius sp. appears to prefer heath habitat, much of which will be retained within Lot 14 as well as in Lot 11. Those populations in the footprint of the proposed quarry relation could be translocated, though the success of this action may not be able to be assessed for ten to 20 years.

It is possible that *Gaius* sp. occurs at other sites in the Darling Range, particularly in elevated sites such as the divides between drainage lines towards Mt Dale.

4.7.3 Land Snails

A field survey of Lots 11 and 14 was undertaken on 16 and 28 July 2002 by two personnel from the Mollusc Section of the Western Australian Museum. The objectives, methodology and results of this survey are described in Appendix E. The key findings are summarised below.

Three species of native terrestrial snails were found during the survey. The species are *Bothriembryon* sp., *Westralaoma* sp. and *Luinodiscus* sp., and are native to the area (Slack-Smith, 2002). These species have previously been recorded in the Darling Range, though the records are not extensive. The survey results indicate that the diversity of land snails is low and that there is an impoverished molluscan fauna population in this part of the Darling Range. This could possibly relate to the generally low level of calcium in the granitic and lateritic rocks and soils of the area (Slack-Smith, 2002).

Two live specimens of *Bothriembyron* sp. were found at search site TLS19 (Figure 4.17), which is located near the northern boundary of Lot 14. A dead specimen was found at search site TLS4, which is located in a woodland of *Eucalyptus wandoo* within the proposed area of clearing. This species of *Bothriembryon*, although undescribed and unnamed, is known from a few other localities on the northern part of the Darling Range and in some areas of the Darling Scarp (Slack-Smith, 2002). *Bothriembyron* sp. and other species from the genus *Bothriembryon* are typically distributed within the southern portions of Western Australia and South Australia. Some species also occur (possibly as relict species) in the sheltered habitats in the Pilbara and mountains of Central Australia (Slack-Smith, 2002).

Dead juvenile shell specimens of *Westralaoma* sp. were collected from search sites TLS4 and TLS19. The specimens closely resembled *Westralaoma expicta* but, due to the absence of adult shells, this was only a tentative identification. The shells measured approximately 2 mm in diameter and were found during the examination of the soil/litter samples using a stereomicroscope. The distribution of this species in Western Australia is unknown as investigations into this family (Punctidae) have not been conducted in Western Australia since 1939. However, members of the family are particularly numerous in the south-east of Australia.

Dead shell specimens of *Luinodiscus* sp. (possibly ?*L. cygnea)* were collected from search sites TLS22 and TLS24. These sites were located in the northern section of Lot 14, within a woodland to open woodland of *Eucalyptus marginata*. Species from the genus *Luinodiscus* have been found in south coastal areas of Western Australia.

4.8 SOCIAL SETTING

The proposed site for the relocated quarry is situated at Lot 14 Horton Road, in the Shire of Northam. Lot 14 is owned by BGC (Australia) Pty Ltd (Figure 1.4) and is zoned as Rural Zone 3. The Rural Zone 3 classification implies that Council will not support further subdivision of the land, except where this may be necessary for the protection of the natural and rural environment or the acquisition of additional reserves.

The nearest settlement is a privately owned property in the Shire of Mundaring, which will be approximately 560 m to the west of the site. Other settlements are located to the north and east of the proposed quarry site. The residence to the north is located approximately 1 km

from the proposed quarry pit. The residence to the east of the proposed pit is located approximately 2.4 km from the site.

Lots 44327, 44328 and 44329 are located to the south of the Project Area and are designated areas for water protection held by the WRC (Figure 1.4).

A review of tenure data obtained from the Department of Land Administration (DOLA), indicated that the majority (75%) of residences in the vicinity of the proposed Project Area were purchased after the existing Voyager Quarry had become fully operational in 1991, with 25% of properties purchased prior to 1991.

The transport routes to the distribution centre in Midland are Great Southern Highway and Great Eastern Highway. Approximately 40% of the total volume of material leaving the quarry is distributed to BGC Concrete plants located at Hazelmere, Armadale, Malaga, Rockingham, Quinns Rock and Canning Vale. Approximately 5% of the material is transported to BGC Asphalt with the remaining 55% transported to various locations in the metropolitan area and country locations. Distribution centres in the northern suburbs are accessed using Reid Highway and then Mitchell Freeway. The distribution centres in the southern suburbs are serviced via Roe Highway, then Tonkin Highway and Leach Highway.

4.9 NOISE

4.9.1 Noise-sensitive Premises

Noise-sensitive premises are present in the vicinity of the existing Voyager Quarry and proposed site of the quarry relocation. The location of these premises is indicated on Figure 4.18.

4.9.2 Ambient Noise Levels

Ambient noise levels at five locations in the vicinity of the quarry were measured by ABT when the Voyager Quarry was not operating. These data are presented in Table 4.9.

Table 4.9
Ambient Noise Levels

Measurement Location	Daytime Ambient Noise Level ($L_{90,\ 15\ minutes}$ dBA)	Night-time Ambient Noise Level ($L_{90,\ 15\ minutes}$ dBA)
1	35	35
2	35	35
3	35	35
4	34	35
5	38	33

Note: See Figure 4.18 for measurement locations.
Source: ABT.

The ambient noise level at Location 5 is higher than at the other locations during daytime. This is probably due to the effect of noise from vehicles on the nearby Great Southern Highway. The reason for the ambient noise level at Location 5 being less than at the other locations during night-time is not known.

Measurements made by Herring Storer Acoustics (2002) confirm that ambient noise levels are generally in excess of 35 dB(A) when light wind conditions prevail. Under calm conditions, the ambient noise level can be less than 30 dB(A).

4.9.3 Existing Quarry Noise Sources and Levels

The following activities at the existing quarry operations generate noise:

- drilling blast holes into rock, using a single track-mounted drill rig, in preparation for blasting;
- blasting of rock (blasting occurs once every fortnight);
- excavation and truck transport of blasted rock to the primary crusher;
- primary crushing of excavated rock;
- screening of crushed rock;
- blending of some rock from primary crusher, pugmilling and stockpiling;
- secondary crushing;
- stockpiling of material from secondary crusher;
- tertiary crushing and screening of material from secondary stockpile; and
- transport of product from the site.

Table 4.10 lists the equipment used at the existing site and the operating hours for each of the pieces of equipment.

Table 4.10
List of Equipment Currently Operating at the Voyager Quarry

Plant Type	Item	Number	Operating Hours
Fixed	Baxter Jaw Crusher (Primary Crusher)	1	0700 - 2200
	Symons Cone Crusher (4.25ft) (Secondary Crusher)	1	0700 - 0200
	Symons Cone Crusher (5.5ft) (Tertiary Crushers)	2	0700 - 0400
	Jacques Screen (14ft x 5ft)	2	0700 - 0400
	Jacques Screen (20ft x 8ft)	2	0700 - 0400
	Allis Charmers Screen (20ft x 8ft)	2	0700 - 0400
	Atlas Copco Rock Breaker	1	0800 - 1800
Mobile	Caterpillar 980F Loader	2	0700 - 2200
	Caterpillar 988B Loader	1	0700 - 2200
	Caterpillar 773B Dump Truck	2	0700 - 1700
	Komatsu HD325 Dump Truck	2	0700 - 1700
	Komatsu PC100 SE Excavator	1	0700 - 1700
	Caterpillar 14G Grader	1	0700 - 1700
	Caterpillar 769B Water Cart	1	0700 - 1700
	Tamroc 1100CHA Drill Rig	1	0700 - 1700

ABT reports the results of noise level measurements on Wednesday 23 January 2002 at a number of locations around the existing quarry. The measurements indicate the crushers and screens are the dominant noise source and that other noise sources (such as loaders) are only audible when the crushers and screens are not operating.

As part of the noise impact assessment conducted for the proposed quarry relocation, Herring Storer Acoustics (2002) examined and modelled the existing noise impact on residents around the quarry operations. The results of this modelling are presented in Appendix H and summarised in Table 4.1. It is noted that the resultant noise imission levels at residential

locations were difficult to quantify, mainly due to the masking effect of ambient noise. Therefore, noise level measurements were limited to the relatively near field of boundary locations. The potential exceedances are based on extrapolation of these relatively near field measurements and predictions based on computer modelling.

Table 4.11
Existing Noise Imission Levels
for Worst Case Down-wind and Calm Conditions

Location	Day Scenario dB(A)		Evening Scenario dB(A)		Night Scenario DB(A)	
	Down-wind	Calm	Down-wind	Calm	Down-wind	Calm
Residence A	47 (+2)	38	46 (+6)	38 (+3)	42 (+7)	36 (+6)
Residence B	48 (+3)	40	47 (+7)	39 (+4)	42 (+7)	37 (+7)
Residence C	46 (+1)	36	41 (+1)	32	37 (+2)	31 (+1)
Residence D	30	21	27	18	22	16
Residence E	24	15	20	11	15	9
Residence F	44	35	44 (+4)	35	39 (+4)	34 (+4)
Location A	51	42	49	41	45	39
Location D	45	36	44	36	40	34

Source: Herring Storer Acoustics (2002). See Appendix H.
Note: 1. Figures in brackets indicate the exceedance to the assigned levels and include adjustments for tonality where applicable. 'Assigned levels' are noise levels for noise-receiving locations prescribed under the *Environmental Protection (Noise) Regulations* 1997.
2. See the Location and Area Plan provided in Appendix H for the location of Residences A-F, Location A and Location D.

It is noted that the existing process plant at the Voyager Quarry was designed to meet its original licence conditions (DEP Licence No. 5356, effective up to 1997) stipulated noise limits that are 5 dB(A) more than the current regulatory criteria (Herring Storer Acoustics, 2002). However, BGC has initiated a noise management programme that includes measures to reduce noise emission levels (see Section 3.7.4).

4.10 VISUAL AMENITY

The Darling uplands are characterised by an undulating, dissected land surface with rubbly, pale orange, lateritic soils and pea gravels. Much of this landform is vegetated by tall forest. Domed granite outcrops (monadnocks) and boulders often protrude from the surrounding landscape and deep, steeply sided valleys create contrasting landform to the dominant plateau landscape. The undulating and rolling landform with deep valleys generally restricts view to foreground and midground (CALM, 1994).

A viewshed analysis was conducted for three of the nearest residences to the north, east and west of the Project Area. These sites were deemed to be representative and potentially most likely to be affected by visual impacts. Digital spatial data obtained from the Department of Land Administration (DOLA) were used to determine the visibility of the existing and proposed quarry operations. The structures were modelled at a height of 0 m, which means that all structures present at ground level would be detected in the model. The model allowed for an assumed height of approximately 1.6 m from a selected viewpoint.

The model did not allow for the presence of vegetation, which would be likely to provide screening and reduce the areas visible from each of the residences analysed. Atmospheric conditions also play a role in determining the extent of visibility, and this was not included in the analysis. Therefore, the results provided by the viewshed analysis can be considered as the worst case scenario and are extremely conservative predictions of the visual impact.

Based on the results obtained from the viewshed analysis, the residence to the north of the site has a partial view of the existing operations (Figure 4.19). The main components of the existing operations that are likely to be visible from this residence are the stockpiles, processing plant and workshop/administration areas. However, the extent of this visibility is highly likely to be reduced by vegetation. The presence of features that have a screening effect in close proximity to the viewing point (referred to as 'foreground closure'), will obscure structures in the distance, thereby reducing the visual impact. The residences to the east and west of the Project Area do not have a line-of-sight to the existing operations (Figure 4.19).

The existing quarry is screened from Great Southern Highway and Horton Road by vegetation to the south and east of the quarry, respectively.

4.11 ABORIGINAL HERITAGE

The Department of Indigenous Affairs (DIA) internet site database was searched to determine if any Aboriginal archaeological or ethnographic sites have been recorded in the vicinity of the proposed quarry expansion. No Aboriginal heritage sites were listed on the DIA's Register of Aboriginal Sites for the proposed Project Area.

A desktop review of available data was conducted by McDonald Hales & Associates in April 2002 to determine the likelihood of any Aboriginal sites occurring in the Project Area. MHA concluded that no sites had been previously recorded in the Project Area but advised that this may be due to the lack of survey data for the area.

An archaeological investigation of the proposed quarry expansion area was conducted in July 2002. No archaeological sites were located during the investigation (Quartermaine, 2002).

Consultation with the Combined Metropolitan Working Group of native title claimants and the Ballaruk Aboriginal Corporation was conducted in July 2002 (Hart, 2002; O'Connor, 2002). As a result of the consultation process, it was determined that there are no known burial sites, sacred areas or other areas of significance to the Aboriginal people in the Project Area.

A copy of the archaeological and ethnographic survey reports will be provided to the DIA.

4.12 EUROPEAN HERITAGE

The following databases were searched to identify any European heritage sites located in the vicinity of the proposed quarry expansion:

- Australian Heritage Commission internet site;
- Heritage Council of Western Australia internet site;
- National Trust database; and
- Local Municipal Heritage Inventories.

The search of the Register of the National Estate indicated one place of significance in the vicinity of the Project Area. This is the Traveller's Inn Ruins (Horton's Halfway House) which is located at the junction of Great Eastern Highway and Great Southern Highway, north of the Lakes Roadhouse. The ruins are currently being assessed for heritage listing on the Register.

The Traveller's Inn Ruins are also listed on the Mundaring Municipal Heritage Inventory. This inventory also indicated that the Old Police Station located on Great Southern Highway has historical significance. The building is situated approximately 1.5 km west of the Project. It was restored in the early 1980s and contains some doors and windows from the former Traveller's Inn.

The Traveller's Inn Ruins and the Old Police Station will not be affected by the development of the proposed quarry expansion.

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5. COMMUNITY AND GOVERNMENT CONSULTATION

5.1 CONSULTATION DURING PER PREPARATION

5.1.1 Objective

The environmental approvals process in WA is a public process and the Proponent is expected to consult with the public and government agencies to ensure that updated information about local issues and concerns is used in the environmental and social impact assessment of the proposed Project.

The objective of the consultation programme conducted during the preparation of this PER was to enable all individuals, groups and agencies potentially affected by the proposed quarry relocation to have their interests and concerns considered during the environmental impact assessment process.

5.1.2 Consultation Programme

Overview

The consultation programme comprised the following phases:

1. Identify stakeholders.
2. Disseminate information and identify stakeholder issues.
3. Obtain feedback from stakeholders.
4. Respond to the stakeholder issues.
5. Communicate the Proponent's response.

The scope of these phases is discussed in the following sections.

Identification of Stakeholders

Stakeholders comprise:

- people affected directly by, or concerned about, the environmental assessment and management of the proposed quarry relocation;
- Government agencies with an interest in regulating the proposed operations and management; and
- people with a direct commercial interest in the proposed quarry relocation.

The Government agencies consulted during the preparation of the PER are listed below:

- Environment Australia;
- EPA;
- DEP;
- CALM;
- WRC;
- Department of Agriculture;
- Department of Mineral and Petroleum Resources (MPR);

- Shire of Northam; and
- Shire of Mundaring.

The community and industry groups consulted during the preparation of the PER are listed below:

- the Lakes Action Group;
- the Wooroloo Brook Land Conservation District Committee (LCDC), which was established in 1991 to address land degradation, promote and encourage sustainable land-use and provide environmental education within their catchment area;
- the Extractive Industries Committee, which has the primary role of providing advice to the Chamber of Commerce and Industry's manufacturing, Engineering and Resource Council on all issues impacting on the extractive industries; and
- the Conservation Council of Western Australia.

The Wildflower Society and the Avon Valley Environmental Group were invited to participate in the consultation programme but declined the invitation, preferring to wait until the PER was released for public review before commenting on the proposal.

Consultation was also conducted with the Combined Metropolitan Working Group of native title claimants and the Ballaruk Group of native title claimants.

Most members of the public likely to be affected by, or interested in, the proposed quarry relocation are represented in one or more of the above groups and participated in the consultation programme or, if not directly involved, were informed through secondary processes (see Section 5.1.2.3).

Dissemination of Information and Identification of Issues

Consultation sessions were conducted with a range of Government agencies, community groups and individuals interested in, or affected by, the proposed quarry relocation (see Table 5.1). Each consultation session aimed to:

- inform stakeholders about the proposed quarry relocation;
- identify the ways in which stakeholders may be affected, and their concerns regarding the proposed quarry relocation; and
- identify mechanisms to provide contact with project team members to ask questions or obtain further information.

Those stakeholders belonging to a community group that participated in the consultation programme were also offered the opportunity for an individual meeting if so desired.

During the preparation of this PER, copies of the flora and vegetation survey report, fauna survey report, draft surface water assessment report and the dieback survey report were provided to the Lakes Action Group, Wooroloo Brook LCDC, the Combined Metropolitan Working Group of native title claimants and the Ballaruk Group of native title claimants.

Information about the existing quarry operations and proposed quarry relocation was also provided in the *BGC Quarry Update*, a newsletter aimed at keeping people up to date with activities at BGC's quarry operations at The Lakes. The first and second issues were distributed in May and July 2002, respectively. A third issue will released in conjunction with this PER.

In addition to the above, BGC held an Open Day at the Voyager Quarry on 26 May 2002 which was attended by more than 30 people. Tours of the existing Voyager Quarry were conducted and a display describing the proposed quarry relocation, environmental issues and management strategies was provided. Personnel from BGC and URS were available to answer any questions and to discuss any issues raised by visitors to the quarry.

Feedback and Confirmation of Issues

A summary of the issues raised during each consultation session was prepared and provided to the relevant stakeholder(s) with a request for confirmation of the list of issues. The stakeholders were also invited to provide further input in the event that additional concerns or issues had been identified following the consultation session.

The issues identified during the consultation programme are listed in Table 5.1. The main issues were:

- the potential for impacts on nearby residents due to noise, ground vibration, light overspill, dust and flyrock during construction and operation of the proposed Project;
- the potential for impact on *Hemigenia viscida* (a Priority 4 flora species);
- the potential for impacts due to clearing of vegetation within the proposed Project Area (such as impacts on biodiversity, groundwater levels, surface drainage and catchment salinisation);
- the potential for impacts on fauna due to clearing of vegetation and other construction and operational activities;
- the potential for impacts on groundwater and surface water quality and quantity; and
- the proposed rehabilitation and closure strategy for the proposed Project.

Proponent's Response to the Issues

The comprehensive and ongoing consultation process implemented by BGC has provided the company with a sound understanding of the government and community issues and concerns relevant to the existing project and the proposed quarry relocation. It has also provided the opportunity for these issues to be addressed in the design and management of the proposed quarry relocation as well as the existing operations. The main actions taken in this regard are listed below:

- In response to complaints from nearby residents about noise from the existing primary crusher, BGC has restricted the hours of operation of the existing primary crusher to reduce the impacts on these residents due to noise during evening and night times. In addition, noise control measures at the existing plant have been upgraded to minimise noise generation, including rubber lining of the primary crusher bins and the installation of bunds around the primary crusher.

- Permanent noise monitoring sites have been established around the existing quarry and proposed Project Area to enable BGC to monitor noise levels more effectively and respond to any public complaints.

- To reduce potential sources of noise and dust, the relocated plant will be situated approximately 30 m below ground surface, within the proposed quarry pit.

- The proposed site layout was redesigned to protect heath community H5 which contains approximately 95% of the *Hemigenia viscida* recorded in the Project Area. In addition, BGC proposes to establish a 50 m wide buffer around this community to minimise the risk of direct or indirect impacts.

- The Lakes Action Group has raised concerns about the risk of flyrock exiting the Project Area during blasting. BGC recognises that there have been occurrences in the past when flyrock has been projected some distance (up to 100 m) from the existing quarry pit but changes made to blasting practices in 1999 mean that flyrock does not exit the Project Area. However, to monitor this situation, BGC has been videotaping every blast at the existing operations since August 2002 to confirm that flyrock is being contained within the site boundaries.

- A revegetation strategy has been developed to replace some of the local biodiversity values that will be reduced as a result of clearing approximately 85 ha of vegetation within the Project Area. The strategy comprises planting an area of native vegetation at a 2:1 ratio of the cleared area of vegetation. Revegetation will occur on disturbed areas within the Upper Wooroloo Brook Catchment within the Shire of Northam, over a five year programme. BGC has made a commitment to undertake 50 ha of revegetation within two years of the approval date for the proposed Project.

- BGC is establishing a Community Liaison Group as a key mechanism for continuing government and community consultation and liaison regarding site operations.

- EMS development has been initiated to facilitate continual improvement in environmental performance.

A summary of the issues raised by stakeholders during the consultation programme, and the response developed by the Proponent in relation to these issues, are presented in Table 5.1. The table also indicates where in this PER the reader can find additional information on the issues.

Communicate the Proponent's Response to Issues

BGC's response to the issues raised by the stakeholders is being communicated through the distribution of the PER and follow-up briefings with key stakeholder groups (see Section 5.2).

5.2 CONSULTATION DURING THE PER PUBLIC REVIEW PERIOD

This PER is subject to an eight-week public review period. During this time, the Proposal will undergo further scrutiny by regulators and the community.

BGC will maintain its existing high level of public consultation by continuing its consultation programme during the public review period. The programme will include the following actions:

- information sessions and follow-up consultation with those who were consulted during the preparation of the PER;
- placing the PER on a BGC Quarries website (www.bgc-quarries.com.au);
- producing another issue of the *BGC Quarry Update* newsletter; and
- media releases to provide information on the PER and its availability for review.

5.3 CONSULTATION FOLLOWING PROPOSAL IMPLEMENTATION

In the event that the Project receives environmental approval and is implemented, BGC intends to continue the consultation process throughout the quarry construction, operation and decommissioning phases.

As indicated previously, BGC is establishing a Community Liaison Group to facilitate two-way communication about the site operations. An invitation to register for the group was included in *BGC Quarry Update* newsletter distributed in May and July 2002. Registration for the Community Liaison Group is open to all interested parties and can be made by contacting:

BGC Quarries
PO Box 1257
MIDLAND WA 6936

Tel: (08) 9442 2388
Fax: (08) 9442 2389
Email: info@bgc-quarries.com.au

COMMITMENT

The Proponent will establish a community liaison group to facilitate two-way communication about the site operations.

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Table 5.1
Summary of Environmental Issues Raised by Stakeholders

Interested or Affected Party	Type of Consultation	Issues Raised	Proponent's Response	Reference in PER
Department of Mineral and Petroleum Resources	Briefing on 25 February 2002	The MPR has identified that, as the quarry site is on private land and not covered by a mining tenement, it does not address the environmental issues relating to the quarry operation. However, health and safety aspects are regulated by the *Mines Safety and Inspection Act* 1994 and the *Mines Safety and Inspection Regulations* 1995, which are administered by the MPR.	The Proponent is aware of its responsibility under the *Mines Safety and Inspection Act* 1994 and the *Mines Safety and Inspection Regulations* 1995.	-
Department of Conservation and Land Management	Briefing on 21 March 2002 Site visit on 10 April 2002	The whole of heath community H5, which contains the main population of *Hemigenia viscida* occurring in the Project Area, should be protected by fencing the heath area and establishing an appropriate buffer.	Heath community H5 will not be cleared and a 50 m buffer will be maintained around this community.	Section 7.5.4 Figures 1.2 and 1.3 Section 7.3
		The areas of wandoo woodland contain mature trees with hollows of various sizes that may suit a wide range of animals and birds.	Wandoo communities are mapped on Figure 4.10 as vegetation types Y, YG and MG. One area of vegetation type Y and two areas of vegetation type YG are located on the eastern edge of the Project Area. The area of type Y will be disturbed through the construction of the dam, stockpile area and the quarry pit. The southern area of type YG will also be disturbed through construction of the dam and stockpile area. The northern area of type YG is located within a 30 m wide buffer between the existing and proposed operations, and will not be cleared. The wandoo community mapped as vegetation type MG is located in the northern portion of Lot 11 and will not be disturbed by the Project.	Section 4.5 Figures 1.2 and 1.3 Section 4.6
Water and Rivers Commission	Briefing on 29 April 2002	The Project is located in a proposed Priority 3 Drinking Water Source Area (PDWSA).	To ensure that the potential future usage of the catchment as a drinking water source is not compromised by the implementation of the Proposal, the Project has been designed in accordance with the Water Quality Protection Note: *Extractive Industries within Public Drinking Water Source Areas*.	Section 7.3 Section 7.4
		The Project is located within an area gazetted for the Swan River and tributaries (surface water) and there is a need to obtain a surface water licence.	The Water and Rivers Commission has advised that no licence is required to extract water, because water will not be taken from a watercourse as defined by the *Rights in Water and Irrigation Act* 1914.	Section 7.3
		There are opportunities for revegetation in the Wooroloo Brook catchment area to the north and south-east of the site.	There are a number of areas in the Wooroloo Brook catchment that could be suitable and available for revegetation. A revegetation strategy has been developed to ensure that the plantings are effective and beneficial to the Wooroloo Brook catchment in terms of maintaining biodiversity values.	Section 7.8.4
		Stringent surface water management measures should be implemented on the site.	On-site water movement and releases to the environment will be managed under a site surface water management and monitoring plan. Stormwater runoff and any groundwater seepage will be collected in sumps in the quarry pit. Soil conservation measures will be used on-site to control erosion. Water in excess of processing and dust suppression requirements will be tested for salinity and turbidity and, providing release criteria are met, will be released at a controlled rate during wetter months of the year. The water released will have a lower salinity then the natural catchment flows. Prior to release, the water will pass through settling ponds to minimise the sediment load of the discharge.	Section 7.3.4 Section 7.3.5 Appendix I
		What is the likely quality of water (used for dust suppression and dewatering) leaving the site through surface water expression and recharge?	The water balance prepared for the proposed quarry indicates that there will not be an increase in downslope groundwater recharge as seepage will drain into, rather than out of, the pit. This seepage and any surface water runoff will be collected in the quarry sumps prior to controlled discharge. Criteria for the quality of any water to be released from the site have been proposed. See Section 7.3.5.	Section 7.3 Appendix H

Table 5.1 (continued)

Interested or Affected Party	Type of Consultation	Issues Raised	Proponent's Response	Reference in PER
Department of Agriculture	Briefing on 12 June 2002	There is concern about an increase in groundwater recharge due to clearing.	BGC pumps groundwater from the existing quarry sump for use in the quarry operations. This has lowered the groundwater level in the vicinity of the existing quarry, including the proposed quarry relocation area. This practice will continue during the construction phase of the quarry expansion, so any recharge occurring during this phase should be minimised. During the operation of the relocated quarry, any rainfall and surface water run-off entering the pit will be harvested and used in the quarry operations. Therefore, little or no groundwater recharge is likely to occur as a result of the quarry operations.	Section 7.4 Appendix G
		How will water be managed at the site?	Water will be managed according to a surface water management plan. Water in excess of process requirements will be released in a controlled fashion and is not likely to adversely affect the downstream environment.	Section 7.4 Appendix G Appendix I
		The removal of overburden material decreases the salt store of the soil.	Salt is stored within the overburden present above the granite reserves. Therefore, removal of this material also removes the salt store in the proposed pit area.	Section 7.4 Appendix G
		A site water balance is required for the proposed Project.	A site water balance has been prepared and is presented in Appendix G.	Appendix G
Shire of Mundaring	Briefing on 20 March 2002 and 19 April 2002	Noise and ground vibration are the major social issues relating to the Project.	Noise and ground vibration modelling has been conducted for the proposed operations. The noise modelling conducted by Herring Storer Acoustics indicates that the proposed operations can comply with the regulatory criteria for all conditions and at all times once all operations have been relocated (Herring Storer Acoustics, 2002). Noise management measures to be implemented include locating the plant within the quarry pit. The study of ground-borne vibration and air-borne pressure waves due to blasting in the proposed quarry pit has shown that blasting can be managed to comply with the comfort criteria set down and be well below any criteria relative to damage risk (Herring Storer Acoustics, 2002).	Section 7.11 Section 7.12 Appendix H
		The location and design of noise attenuation bund(s) needs to be validated with data. The Council's current stance is that there is to be no noise attenuation bund on Lot 11.	Results from the noise modelling study indicated that noise attenuation bunds will not be required.	Section 7.11 Figures 1.2 and 1.3
		The Proponent should provide evidence (including a cost benefit analysis) in the PER that they have explored alternative quarrying options in cleared agricultural land. The analysis should not only refer to economic costs but also costs associated with clearing of remnant vegetation.	In selecting the location of the current quarry, BGC investigated a number of other site options. These sites were re-evaluated as part of the site selection process for the current proposal, but it was concluded that it would not be feasible to develop a new quarry at these sites. Therefore, BGC investigated the option of expanding the existing quarry into cleared land to the north, south and east of the pit, or into uncleared land to the west of the pit. The option to expand to north, south or east is constrained as the current landowner is reluctant to allow further development of the quarry on his land and has indicated that BGC's lease will not be renewed when it expires in six years time. Therefore, the most viable option is to expand operations to the west of the existing site, on land owned by the Proponent.	Section 2

Table 5.1 (continued)

Interested or Affected Party	Type of Consultation	Issues Raised	Proponent's Response	Reference in PER
Shire of Mundaring (continued)		Remnant vegetation in the Project Area has biodiversity value.	The proposed Project Area is inhabited by a range of flora and fauna species. A total of 223 vascular plant taxa from 42 plant families and 112 genera were recorded during a baseline survey by Mattiske Consulting Pty Ltd in January 2002 and a follow-up survey in Spring 2002. One plant taxa, *Hemigenia viscida*, is classified as Priority 4 (Rare Taxa) on the State DRF and Priority Flora List and as Vulnerable under the Commonwealth EPBC Act. Vegetation within the Project Area provides habitat for a range of vertebrate and invertebrate fauna species. A desktop review of available data and a brief site inspection conducted by Ninox Wildlife Consulting in January 2002 indicated that 80 native and one bird species, 17 native and five introduced mammal species, nine frog species and 31 reptile species could occur in the Project Area. A recently completed field survey will provide more information on the vertebrate fauna of the Project Area. A survey for trapdoor spiders and land snails in the Project Area was conducted by the WA Museum in July and August 2002. Three species of trapdoor spider were recorded. Of these, an unnamed species of *Gaius* is of interest as it has not previously been recorded in the Darling Range. Three species of land snails were recorded, indicating that diversity is low. Based on available data, it is predicted that no loss of biodiversity will occur as a result of proposal implementation.	Section 7.5-7.8
		If the proposed project is to proceed, off-set mitigation measures should be incorporated into the design of the Project.	A range of mitigation and management measures has been developed to minimise the environmental impact of the proposed quarry relocation, and are documented in draft environmental management plans appended to this PER. These measures include the development of a revegetation strategy to replace some of the local biodiversity values that will be reduced through clearing during project construction.	Section 7.8.4 Appendix I
		A community liaison group should be established to improve communication between the Proponent and the community. The group should involve Shire of Mundaring councillors.	Invitations to join a Community Liaison Group were made in Quarry Update newsletters released in May and July 2002. An invitation is also included in the PER.	Section 5.3
		There is a need to genuinely engage the community and gain their confidence, given that BGC is considering to undertake revegetation activities as part of the off-set management measures at a catchment level. There is also a need to develop criteria to assess the acceptability of areas identified for revegetation as part of the off-site management measures.	BGC has conducted an extensive consultation programme, with consultation occurring through both direct and indirect methods. Topics discussed include the proposed revegetation strategy and issues that need to be considered in its design and implementation. Draft criteria for site selection and species selection have been developed and are provided for review in the PER.	Section 7.8.4
		The impact of additional vegetation clearing arising from the need to relocate the mining infrastructure from the current site needs to be considered.	Approximately 85 ha of vegetation will be cleared during project construction, which 0.32% of the Wooroloo Brook catchment. No additional vegetation clearing will be required for the relocation of mining infrastructure to the current site, as the processing plant will be located within the confines of the proposed quarry pit.	Section 3.2 Section 4.5 Figures 1.2 and 1.3
		The area cleared in the Shire of Mundaring (Lot 11) should be revegetated immediately.	The area cleared within Lot 11 is outside of the Project Area. The rehabilitation of this area will be conducted in consultation with the Shire of Mundaring and advice will be sought from the Department of Agriculture and CALM.	-

Table 5.1 (continued)

Interested or Affected Party	Type of Consultation	Issues Raised	Proponent's Response	Reference in PER
Shire of Northam	Briefing on 15 May 2002	BGC should explore quarrying options in cleared agricultural land immediately to the north and east of the existing quarry.	The granite reserve dips to the north and it would be uneconomical to extract, as there is a large amount of overburden material. The land to the east is not available. See also the above response to the Shire of Mundaring's query in this regard.	Section 2.1
		The Shire considers noise attenuation bunds to be generally ineffective.	If designed, sited and constructed correctly, noise attenuation bunds can be effective in reducing noise impacts. Noise attenuation bunds will be ineffective if insufficient modelling is conducted to determine the location and design of the bunds. The noise modelling study conducted for this Project has indicated that noise attenuation bunds will not be required for the relocated quarry operations.	Section 7.11 Appendix I
		Housing of the crushing plant should be considered for the proposed project in order to reduce noise levels.	To reduce the potential for noise impacts, the processing plant will be located below ground level within the confines of the proposed quarry pit. Other noise management measures include housing the primary crusher, if required.	Section 7.11 Appendix I
		The closure strategy for the proposed project should be discussed in the PER.	Options for a closure strategy have been developed for the Project and are discussed in Section 3.8.	Section 3.8
		The Shire has received complaints about noise and vibration from drilling and blasting.	From the start of quarrying operations in 1991 until 14 December 2001, the Shire of Northam registered a total of three complaints regarding the Voyager Quarry. Since the clearing of vegetation within Lots 11 and 14 on 15 December 2001, up to October 2002, 58 complaints were registered. Noise, dust and the December 2001 clearing were the main issues raised in these complaints (see Table 3.4). Vibration was not identified as a specific issue in the data provided by the Shire, but it is assumed that any complaints about vibration were included under the "noise" or "blasting" categories. The noise modelling conducted for BGC's proposal to relocate its quarry operations indicates that the proposed operations will be able to comply with the regulatory criteria for all conditions and at all times once all operations have been relocated (Herring Storer Acoustics, 2002). The study of ground-borne vibration and air-borne pressure waves due to blasting in the proposed quarry pit has shown that blasting canalso be managed to comply with the comfort criteria set down and be well below any criteria relative to damage risk (Herring Storer Acoustics, 2002).	Section 3.7.3.2 Section 7.11 Section 7.12 Appendix H Appendix I
		The Shire has registered complaints regarding excessive lighting in the pit or operational area.	Lighting impacts will be managed through a number of measures, the most effective being that of intervening topography and vegetation. Lighting will be kept to the minimum necessary for operational needs and safety. Lights will be installed at as low a level as possible and where practicable, lights will be directed away from incoming views. Installation and use of appropriate lighting technology will be investigated to further minimise potential lighting impacts.	Appendix I
		There is concern that the pit will result in increased surface salinity to the north and possible lowering of the water table to the east where bores are a possibility.	Dewatering from the proposed quarry will lower the level of the water table in a cone shaped area called the cone of drawdown. This will result in prevention of any surface salinisation within the perimeter of the cone of drawdown. The lowering of the water table and formation of the cone of drawdown will impact the groundwater level in any private bore located in the cone of drawdown. The Proponent completed a census of privately held bores near the quarry in October 2002. A monitoring bore will be installed between the quarry and the nearest privately held bore.	Table 4.5 Section 7.4 Appendix G

Table 5.1 (continued)

Interested or Affected Party	Type of Consultation	Issues Raised	Proponent's Response	Reference in PER
Wooroloo Brook Land Conservation District Committee	Briefing on 21 March 2002 and follow-up meeting on 19 June 2002	The Project is inappropriate as it is located at the headwaters/recharge of the Wooroloo Brook and will impact on 140 ha of vegetation, with 98 ha being completely cleared.	The Project involves the clearing of approximately 85 ha of vegetation within Lot 14, which approximately 0.32% of the Wooroloo Brook catchment. A revegetation strategy has been developed to replace some of the local biodiversity values that will be reduced through vegetation clearing. There should be little or no increase in groundwater recharge as a result of the quarry construction and operations as all rainfall and surface runoff within the pit area will be harvested as a water supply.	Section 7.8.4
		The Project will result in approximately 25% of the remnant vegetation protecting the upper reaches of the Wooroloo Brook being cleared.	Concern has been raised that clearing of vegetation in the Project Area will result in increased salinisation of the upper Wooroloo Catchment. However, the surface water assessment conducted for this project indicates that this is highly unlikely to occur. BGC's commitment to revegetate areas within the catchment will assist in reducing groundwater recharge in these areas and help protect the catchment.	Section 7.8.4
		The gradient of the site to be cleared is approximately 15°, which will result in excessive erosion and surface water runoff.	Surface water runoff will be managed during the construction of the Project, through the use of contour banks to direct water into settling ponds during the initial clearing operations. During the excavation of the overburden material, the water will be diverted into a sump located in the quarry pit. Any suspended sediment will be allowed to settle. The water will be used in the quarrying and processing operations, or will be tested to ensure quality meets release criteria before being released in a controlled fashion.	Section 7.3 Appendix I
		The Proponent should provide very clear evidence (including cost benefit analysis) in the PER that they have fully explored other quarry options in cleared agricultural land immediately to the north and east of the existing quarry.	The granite reserve dips to the north and it would be uneconomical to extract, as there is a large amount of overburden material. The land to the east is not available. See also the response to the Shire of Mundaring's query in this regard.	Section 2.1
		A minimum buffer of 50 m should be set around heath communities containing *Hemigeneia viscida.*	Almost 95% of *Hemigenia viscida* plants (1,612 plants) were recorded in one heath community (H5). Heath community H5 will not be cleared and a 50 m buffer will be left around this community.	Section 4.5 Figures 1.2 and 1.3 Section 7.3 Section 7.4
		A dieback (*Phytophthora* sp.) survey should be undertaken and a Dieback Management Plan, which includes vehicle hygiene methods and surface water management, should be produced.	The dieback survey identified an area of *Phytophthora cinnamomi* infestation that runs parallel to Great Southern Highway for a distance of approximately 1.65 km. It was suggested that the introduction of the pathogen may have occurred during initial road construction, and the infestation has had an impact on the vegetation, particularly on the species *Banksia grandis*. The remaining area assessed during the study was considered to be free of the symptoms associated with the *Phytophthora* sp. pathogen. A dieback management plan has been drafted and is appended to this PER for review.	Section 7.5.3 Appendix C Appendix I
		Measures to off-set clearing of vegetation should occur within the immediate catchment area and be greater than 3:1 ratio with the area(s) cleared. The strategic placement of off-set measures (eg. revegetation programmes) should be based on best advice from the Department of Conservation and Land Management, Department of Environmental Protection, Department of Agriculture and the Wooroloo Brook Land Conservation District Committee.	Revegetation at a 3:1 ratio planting is considered to be excessive. Discussions with representatives from CALM, DEP and WRC suggested that revegetation at a 2:1 ratio with the area to be cleared would be an adequate off-set measure to replace some of the local botanical values within the Wooroloo Brook catchment reduced through the implementation of the Project. A revegetation strategy has been developed based on advice received from these agencies, the Shire of Mundaring, Department of Agriculture and the Wooroloo Brook LCDC.	Section 7.8.4
		The Proponent should fully detail measures to preserve topsoil and subsoil throughout the duration of the Project.	Topsoil and root-stock will be retained during clearing operations and will be stockpiled for use in rehabilitation. Any surplus topsoil will be made available for rehabilitation of off-site areas to ensure that the viability of the seed bank is maximised. Topsoil will be harvested separately to the subsoil as it is biologically active and has the greatest value for revegetation purposes.	Section 7.2.3 Appendix I
		An extensive hydrogeological field study (including a drilling programme) should be conducted in consultation with local community and the Wooroloo Brook Land Conservation District Committee to determine the hydrological environmental impacts of the Project.	The Proponent will drill a bore near the proposed quarry to allow monitoring of the groundwater levels and the impact of dewatering. The monitoring bore will be drilled in an area selected from geophysical surveys to maximise the potential of intersecting measurable groundwater flows. The design of the geophysical survey and location of the monitoring bores will be determined in consultation with the Wooroloo Brook Land Conservation District Committee. The Proponent will measure groundwater levels on a monthly basis.	Section 7.4 Appendix I

Table 5.1 (continued)

Interested or Affected Party	Type of Consultation	Issues Raised	Proponent's Response	Reference in PER
Conservation Council of Western Australia	Briefing on 17 April 2002	Concern is raised over the clearing of native vegetation and land degradation issues.	The Project involves the clearing of approximately 85 ha of vegetation within Lot 14, which is approximately 0.32% of the Wooroloo Brook catchment. A revegetation strategy has been developed to replace some of the local biodiversity values that will be reduced through vegetation clearing. There should be little or no increase in groundwater recharge and surface salinisation as a result of the quarry construction and operations as all rainfall and surface runoff within the pit area will be harvested as a water supply.	Section 7.8.4 Section 7.3 Appendix I
		Gravel should be quarried from already cleared areas.	The cleared areas adjacent to the existing quarry are under private ownership and are not available for use in the quarry relocation.	Section 2.1
		Off-set measures will not adequately compensate the loss of biodiversity associated with the clearing of native vegetation.	One of the objectives of the revegetation strategy is to replace some of the local biodiversity values that will be reduced through vegetation clearing. It is unlikely that all species present in the area to be cleared will be replaced by the revegetation projects, as native species that are most suited to the site conditions will be used for the revegetation projects. The results from the study conducted by Mattiske Consulting Pty Ltd (2002) will be used for the species selection. BGC is proposing to undertake revegetation at a 2:1 ratio.	Section 7.8.4
		Hydrogeological issues are unlikely to be adequately managed, as the Project will cause serious environmental degradation.	As indicated above, there should be little or no increase in groundwater recharge and surface salinisation as a result of the quarry construction and operations. Any water discharged to the natural environment will need to satisfy stringent criteria before release. The Proponent will also routinely monitor the water environment as follows: • Salinity and flow rate of seepage inflows to the quarry will be measured twice per year (summer and winter). • Groundwater depth in monitoring bores monthly. • Downstream of the water release point will be inspected monthly. • Daily measurement of rainfall.	Section 7.3 Section 7.4
Extractive Industries Committee	Briefing on 5 April 2002	Most bunds in the Perth region have not been designed properly and any bunds to be constructed for the proposed project should have slopes less than 30° and be revegetated.	The noise modelling study conducted for this Project has indicated that noise attenuation bunds will not be required.	Section 7.11
		Rehabilitation projects should be undertaken, such as the projects undertaken by Alcoa in the area.	Options for a closure strategy have been developed for the Project and are discussed in the PER. A revegetation strategy is also described in the PER.	Section 3.8
Lakes Action Group	Briefing on 22 May 2002	Where will the noise attenuation bunds be placed?	The noise modelling study conducted for this Project has indicated that noise attenuation bunds will not be required.	Section 7.11
		Are there any plans for the site access to the Project to be from Horton Road or another entrance from Great Southern Highway, other than the existing entrance?	There is no proposal for any additional access from Horton Road or Great Southern Highway for the proposed quarry relocation. The existing access road has been sealed to make it quieter and safer, and will be used for the relocated quarry.	Section 7.14
		There is concern that flyrock will land on Horton Road and on neighbouring properties.	Blasts will be designed to ensure that all flyrock is contained within the confines of the quarry pit. BGC will monitor blasting by videotaping every blast over a 12-month period. The tapes will be reviewed to confirm that all flyrock is being contained within the site boundary.	Section 7.13
		What are the stages of pit development, particularly in relation to the placement of the processing plant approximately 30 m below ground level?	It is proposed that the pit will be developed in various stages beginning with the clearing of the designated area for the proposed operations. The gravel and clay layers will be removed to a depth of approximately 10 m below the ground surface for the area in the far south-east corner of the pit. This area is the designated location for the primary crusher, surge stockpiles, screens and stackers. The primary crusher, surge stockpile, screens and stackers, weighbridge, surface water dam, and lab offices will be constructed by the end of year five. Pit development will commence to the north of the processing plant and then progress to the west and southwest.	Section 3.2 Section 3.3
		What will the hours of operation be for the Project?	The hours of operation for the Project will be the same as those of the existing operation.	Section 3.5

Table 5.1 (continued)

Interested or Affected Party	Type of Consultation	Issues Raised	Proponent's Response	Reference in PER
Lakes Action Group (continued)		There is concern that there will be light overspill from the proposed operations.	Lighting impacts will be managed through a number of measures, the most effective being that of intervening topography and vegetation. Lighting will be kept to the minimum necessary for operational needs and safety. Lights will be installed at as low a level as possible and, where practicable, lights will be directed away from incoming views. Installation and use of appropriate lighting technology will be investigated to further minimise potential lighting impacts.	Appendix I
		How will blasting of the western wall impact on the residences and will the wall be stable?	The study of ground-borne vibration and air-borne pressure waves due to blasting in the proposed quarry pit has shown that blasting can be managed to comply with the comfort criteria set down and be well below any criteria relative to damage risk (Herring Storer Acoustics, 2002). Granite is a competent rock that is able to stand at vertical or near vertical angles for significant periods of time, depending on the intensity of fracturing. Some slumping or slippage may occur, and a conservative estimate of pit wall set-back distance would be 100 m, which is twice the pit depth. The nearest residence is situated 560 m from the western wall.	Section 3.2 Section 7.12 Appendix H
		There is concern over the displacement of fauna (mainly kangaroos) and the potential for impact of displaced fauna on surrounding properties.	Mobile species such as the Chuditch and Western Brush Wallaby are expected to move away from the impacted area. Some territorial conflicts may occur during the relocation process but populations would be expected to stabilise once these conflicts are resolved. Unpublished data from Ninox Wildlife Consulting show that throughout the interzone of Jarrah forest and agricultural land, from late afternoon onwards, substantial numbers of Western Grey Kangaroos emerge from their daytime rest areas in forest and move into cleared paddocks to feed. Introduced grasses and fresh water have provided Western Grey Kangaroos with additional resources that encourage them to move between forest and cleared land. The recent field fauna survey will provide an indication of the kangaroo population within in the proposed Project Area. The loss of habitat will have an initial impact on non-mobile and/or poorly dispersing species such as reptiles and small mammals. However, the retention and protection of some of the heath habitats in the Project Area will reduce the impact on poorly dispersing species such as the Honey Possum.	Section 7.6 Section 7.8 Appendix D
		Concern about the financial effects of the proposal – damage to properties, devaluation of properties and increase in public liability insurances.	This issue is beyond the scope of the environmental assessment. However, it is noted that the implementation of revegetation projects on properties adjacent to the Project Area and elsewhere in the catchment may enhance visual amenity of the area, which in turn may have a beneficial influence on property values.	-
		Dust is a nuisance.	Blasting activities generate the highest concentration of dust, however atmospheric conditions will be considered prior to blasting. Dust control measures such as the use of water sprays and enclosure of 'dusty' machinery will be implemented.	Section 7.11
		What about the salinity impacts on soil and waterways as a result of the implementation of the Project?	The quarry will have no adverse impact on downstream land or waterways. The proposed quarry will not increase downstream salinity as the water released from the quarry will be fresher than the natural streamflows and will effectively reduce downstream salinity. The small stream immediately to the north east of the proposed quarry, which is already degraded as a result of agriculture and is currently erosionally unstable, will be stabilised and reshaped to accommodate any discharge from the quarry.	Section 7.3 Appendix G Appendix I
		Why does the quarry have to expand at the current location?	Prior to the establishment of the existing Voyager Quarry, investigations were made to find a suitable location for the quarry and it was concluded that the proposed site is the most feasible option. The current location is classified as a Key Extraction Area by the Western Australian Planning Commission.	Section 2.1.2
		There is concern that there will be a loss of groundwater resources, which are vital to the livelihood of the residents, as they do not have access to scheme water.	A bore census of privately held bores on six properties in the vicinity the quarry was conducted in September and November 2002. The results of the census are presented in Table 4.5. A monitoring bore will be installed between the proposed quarry and the nearest privately held bore.	Table 4.5 Section 7.4 Appendix I
		Will oil mallee trees be used for revegetation and runoff control?	The revegetation strategy involves the use of native species, which may include *Eucalyptus* sp., however species best suited to the soil conditions will be selected.	Section 7.8.4 Appendix I

Table 5.1 (continued)

Interested or Affected Party	Type of Consultation	Issues Raised	Proponent's Response	Reference in PER
Combined Metropolitan Working Group of native title claimants	Site inspection and consultation on 3 July 2002 Consultation meeting on 22 July 2002	Why is the operation not located closer to York?	Transport costs are already high for the current site as the quarry is 40 km from Perth.	-
		Have any other groups such as CALM been to the area to check for rare or endangered flora or fauna?	Flora and fauna surveys were conducted in January 2002 and a site inspection was conducted by CALM on 10 April 2002. A follow-up flora survey was conducted in Spring 2002 to identify any additional plant species not recorded during the January 2002 survey. A fauna field survey has also been conducted recently to provide additional information about the vertebrate fauna species in the Project Area.	Section 4.5 Section 4.6
		Has an archaeological survey been done?	An archaeological survey was conducted in July 2002.	Section 7.16
		The group requested a copy of the flora and fauna survey reports, the archaeological survey report, and the salinity report.	A copy of these reports will be provided to this consultation group.	-
Ballaruk Group of Native Title Claimants	Site inspection and consultation on 4 July 2002	No issues were raised.	-	-

6. ENVIRONMENTAL EFFECTS SUMMARY

6.1 IDENTIFICATION OF ENVIRONMENTAL EFFECTS

The environmental issues that may arise from the implementation of the proposed quarry relocation, and the range and scope of studies required to adequately address these issues, were identified through a two-phase process. The first phase comprised:

- a workshop with key staff of BGC to identify the key environmental issues of importance to the proposed operation and to identify whether existing procedures or controls were in place to manage potential environmental impacts;
- a review of the environmental data and other information on the proposed Project Area and surrounds; and
- consultation with pertinent State government agencies (including the DEP, CALM, WRC and Department of Agriculture), local government, community groups and individuals during the period February to May 2002.

A summary of the issues raised during each consultation session was prepared and provided to the relevant stakeholder(s) with a request for confirmation of the list of issues.

The findings of this phase of work were summarised in a Briefing Paper (URS, 2002b) that was submitted to the DEP in May 2002.

The second phase of the process comprised updating information on the potential environmental effects of the proposed quarry relocation through:

- community and government consultation conducted subsequent to the submission of the Briefing Paper;
- review and modification of the project design;
- additional desktop and field investigations; and
- a review of the draft and final EPA Guidelines for the environmental assessment of the proposal.

The way in which BGC has addressed the requirements of the EPA Guidelines is summarised in Table 6.1, which is structured as follows:

- Column 1 lists the environmental factors identified in the EPA Guidelines (Appendix A) as relevant to the proposed quarry relocation.
- Column 2 identifies the work that the EPA considers would be required for the environmental review of the proposal, based on input from regulatory agencies and community groups.
- Column 3 outlines the investigations and other studies conducted by BGC to address the EPA's objectives and work requirements, the key outcomes of this work, and the predicted environmental impacts that may occur as a result of proposal implementation.
- Column 4 provides an overview of the measures proposed to mitigate or manage the predicted environmental impacts.
- Column 5 describes the outcome that is predicted to occur if the mitigation and management measures are implemented successfully.

A summary of how the Proposal has met the requirements of the relevant EPA Guidance and Position statements is presented in Table 6.2.

In summary, and given that the Proposal has been designed to minimises adverse impacts on local residents and the environment, the environmental effects of the Proposal are considered to be as outlined in Sections 6.2–6.4.

Further information is provided in Sections 7 and 8, and a summary of BGC's environmental management commitments is provided in Section 9.

6.2 BIOLOGICAL EFFECTS

The effects of the proposed quarry relocation on the biological environment will be as follows:

- clearing of approximately 85 ha of remnant regrowth native vegetation;
- localised loss of vertebrate and invertebrate fauna habitat as a result of the proposed clearing; and
- localised reduction of some biodiversity values as a result of the clearing of native vegetation.

No loss of regional biodiversity values or species is anticipated because the vegetation associations to be cleared are well represented within the conservation estate, and the vertebrate fauna are widespread in distribution. Eleven burrows of the un-named trapdoor spider (*Gaius* sp.) will be destroyed during clearing, but 25 burrows are located in areas that will not be disturbed by proposal implementation.

Mitigation measures have been developed to replace some of the local biodiversity values lost by clearing. This will involve the rehabilitation of some 170 ha of native vegetation within the Wooroloo Brook Catchment as compensation for the disturbance of 85 ha of vegetation on Lot 14. Hence over time, the area of vegetation within the catchment will actually increase by approximately 85 ha as a result of the project proceeding.

It should be noted that dieback is present in the vegetation bordering the Great Southern Highway. To ensure that the potential spread of *Phytophthora* sp. does not occur into Lot 14, a dieback management plan will be implemented.

6.3 PHYSICAL EFFECTS

The main physical effect of proposal implementation will be to substantially modify the topography of the landform on Lot 14 through the excavation over 50 years of a 50 m deep pit some 900 x 450 m in area. This impact will occur as a result of:

- stripping of vegetation and topsoil;
- excavation and removal of 1-2 Mt of gravel;
- excavation and removal of approximately 12 Mt of clay; and
- excavation and removal of approximately 50 Mt of hard rock.

The proposal will also result in the reconstruction of the "western stream" (Figure 4.7) to restore the shape of the channel and ensure that it is stable.

Clearing of the site will result in increased rainfall runoff from the Project Area. However, this runoff will drain into the pit and be managed such that it will not adversely affect downstream users of the catchment. Such management will result in:

- short term increased streamflow if excess site water is released (in a controlled manner) during the wetter months of the year into the "western stream";
- decrease in streamflow salinity downstream from the proposed quarry due to the release of water into the "western stream" during quarry operations;

Excavation of the pit will also result in a decrease in groundwater levels in the immediate vicinity of the proposed quarry if the pit intersects steeply dipping fractures containing minor amounts of groundwater. This will have the flow-on effect of producing a slight decrease in salinisation of the catchment, as the groundwater in the vicinity of the quarry will seep into, rather than out of, the pit.

It should be noted that there is a potential for erosion of disturbed landforms at the Project Area and immediately downstream during the construction activities, and that a management plan will be implemented to ensure that erosion does not occur offsite.

6.4 SOCIAL EFFECTS

As indicated previously, the Proposal has been designed to minimise potential for adverse impact on adjacent residents, and modelling has confirmed that operational noise, blasting and vibration at the nearest residences will be within acceptable levels as designated by various regulations and standards. In addition, a number of management programmes will be implemented to maintain noise and dust levels to within acceptable limits.

There is very low potential for visual impacts as there will be an existing vegetation buffer to screen the proposed operations and the quarry infrastructure will be located below ground level within the proposed quarry pit.

In summary, there is very low potential for adverse impact on adjacent residents. The main social effects of proposal implementation will in fact be the following benefits to the local and regional economy that will occur if the Project proceeds:

- continued supply of crushed rock for the Western Australian construction industry;
- maintenance of low cost of supplies of hard rock to the Perth metropolitan market;
- maintenance of competition in the Perth metropolitan market;
- continued employment for BGC quarry staff and haulage contractors; and
- revenue for the Local and State governments in the form of royalties, taxes and other charges.

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Table 6.1
Identification of Environmental Factors

Environmental Issues	Objectives and Work Required for the Environmental Review of the Project (as identified by the EPA Guidelines)	Existing Environmental Conditions and Predicted Environmental Impacts	Proposed Mitigation and Management Measures	Predicted Outcome
BIOPHYSICAL				
Vegetation (plant communities)	The EPA Guidelines require that the Proponent maintain the abundance, species diversity, geographic distribution and productivity of plant communities. Work required: • Baseline studies to identify existing flora species and vegetation communities present. • Detail the conservation values, at a local and regional level, of plant communities of the proposal area. • Assess potential impacts (direct and indirect, including from weeds and dieback) on plant communities as a result of development activities. • Propose measures to reduce impacts.	A baseline flora and vegetation survey was conducted in Lots 11 and 14 in January 2002 and a follow-up survey was conducted in Spring 2002. Eleven plant communities have been defined and mapped in the proposed Project Area. The site-vegetation type G (open to closed heath of Proteaceae) is locally significant as includes the Priority 4 species, *Hemigenia viscida.* All of the site-vegetation types present in the proposed Project Area are represented in the wider conservation estate (Mattiske Consulting Pty Ltd, 2002). In general, vegetation occurring in the area proposed for clearing consists predominantly of Jarrah (*E. marginata* subsp. *thalassica*) and Marri (*C. calophylla*) woodland with restricted occurrences of Wandoo (*E. wandoo*). The Project will result in the clearing of approximately 85 ha of native vegetation within Lot 14. Te majority of the proposed Project Area is free from the symptoms associated with *Phytophthora* sp. The main area of infestation is along Great Southern Highway and measures will be implemented to ensure that the spread of the disease does not occur. It is unlikely that the Project will have any further impact on the spread of weeds in the area.	Revegetation of approximately 170 ha within the Wooroloo Brook catchment will be conducted according to the strategy presented in Section 7.8.4 to off-set the clearing. A 50 m buffer will be maintained around Heath community H5, which contains 95% of the *H. viscida* population recorded in the Project Area. This community will be monitored to ensure that it is not adversely affected by the Project. Native vegetation within Lot 14 that will not be cleared during project development, particularly in the northern and southern sections, will be maintained to ensure that the productivity of the remaining vegetation is not adversely affected by the Project. One of the main management measures for the control of *Phytophthora* sp. is to provide training for all personnel to raise awareness of dieback, the areas where it is present and the management practices to be implemented. Signage demarcating the area of infestation will also be erected and the machinery used on-site will be 'clean' (free of mud and soil) prior to entering the site.	The abundance and geographic distribution of vegetation in the region will not be compromised as the revegetation strategy involves the planting of 170 ha of native vegetation within the Wooroloo Brook catchment. It is proposed that native species that are most suited to the site conditions be used for the revegetation projects. The results from the study conducted by Mattiske Consulting Pty Ltd (2002) will provide useful information for species selection. The productivity of the vegetation remaining within the Project Area will be maintained as the disturbance will be contained to the proposed project footprint. Diversity will not be adversely affected by the Project as the plant communities and individual species are well represented in the surrounding areas. The potential for spreading *Phytophthora* sp. is low, particularly as the majority of the Project Area is free from the symptoms associated with the disease. No increase in the spread of weeds is expected as the site has previously been disturbed by logging and fire.
Declared Rare Flora (DRF) and Priority flora; flora of particular conservation significance	The EPA Guidelines require that the Proponent: • Protect DRF and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act* 1950; and • Protect other flora species of particular conservation significance (eg. undescribed taxa, range extensions, outliers). Work required: • Baseline studies, at appropriate seasons (including a Spring flora survey) to identify DRF, Priority Flora or other species of particular conservation significance (including location and number of individuals). • Assess potential impacts (direct and indirect) of the proposal on any DRF, Priority Flora and flora of particular conservation significance in the proposal area. Outline the significance of these potential impacts at a regional level. • Consult with the Department of Conservation and Land Management on impacts to, and management of, DRF, Priority flora, and other flora of particular conservation significance. • Propose measures to ensure protection/rehabilitation of DRF, Priority Flora and other flora species of particular conservation significance.	A baseline flora survey of Lots 11 and 14 was conducted by Mattiske Consulting Pty Ltd in January 2002 and a follow-up survey was conducted in Spring 2002. A Priority 4 species, *Hemigenia viscida,* has been recorded in four of the 17 heath communities in the Project Area, with approximately 95% of the *H.viscida* individuals occurring in one heath community (H5). No other DRF, Priority Flora or other species of conservation significance were identified. A survey to identify potential locations for *Hemigenia viscida* populations beyond the immediate Project Area conducted in February 2002 (Figure 4.13) identified a population of at least 110 plants occurring within a heath community on the Shire of Mundaring land to the west of Horton Road, and south of a Shire of Mundaring gravel quarry pit. The Priority 4 species, *Hemigenia viscida* will not be adversely affected by the Project as the majority of the *H. viscida* population (95%) is located within heath community H5, which will be protected by a 50 m buffer. A briefing meeting was held with representatives from the CALM in March 2002. In addition, two CALM representatives conducted a site visit in April 2002. CALM supports the protection of heath community H5, which contains approximately 95% of the *Hemigenia viscida* population.	Heath community H5, which contains approximately 95% of the population within the Project Area, will be protected. There will be a 50 m buffer of undisturbed vegetation surrounding this community.	A small reduction in the number of individuals of *Hemigenia viscida* will occur as a result of proposal implementation. Heath community H5, which contains approximately 95% of the population within the Project Area, will be protected.

Table 6.1 (continued)

Environmental Issues	Objectives and Work Required for the Environmental Review of the Project (as identified by the EPA Guidelines)	Existing Environmental Conditions and Predicted Environmental Impacts	Proposed Mitigation and Management Measures	Predicted Outcome
Native Fauna	The EPA Guidelines require that the Proponent maintain the abundance, species diversity and geographical distribution of fauna. Work required: • Baseline studies to identify and map fauna habitat on, and adjacent to the proposal area. • Appropriate field surveys to identify fauna present. This should include poorly dispersing invertebrate groups, such as native land snails and trapdoor spiders, as endemic species may be associated with granite outcrops in this area. Outline the conservation values, at a local and regional level, of the fauna present, or likely to be present. The overall assessment should: • assess potential impacts (direct and indirect) on native fauna; • include an assessment of ecological linkages between the proposal area and adjacent vegetated areas (at both a local and regional level), and the effectiveness/viability of the remaining vegetation to provide habitat and linkages; and • propose measures to manage impacts, including to ensure protection (or, if necessary, relocation) of fauna.	A vertebrate fauna study was conducted by Ninox Wildlife Consulting, after an initial site inspection in January 2002 (Section 4.6). The fauna habitats have been mapped (see Figure 4.14) and field survey was completed recently. In addition, consultation with CALM has ben conducted. A list of the fauna species that could potentially occur in the Project Area has been developed. The species likely to occur in the Project Area have recorded elsewhere in the south-west forested area of Western Australia and are not restricted to individual habitats. Therefore, the Project will not result in the loss of any vertebrate fauna species or populations inhabiting the area. The main impact on fauna will be the loss of habitat through vegetation clearing. However, ecological linkages have been considered (Section 4.6) and the creation of a native vegetation corridor to the east of the Project Area will greatly increase the value of the remaining habitats within the Project Area. Field surveys were conducted by the WA Museum in July 2002 to determine the impact of the Project on trapdoor spiders and land snails (Sections 4.7.2 and 4.7.3). Visual searches for spider burrows were conducted at 59 sites (Figure 4.16). Several old webs and trapdoors were observed. Three species of trapdoor spiders were collected, with *Gaius* sp. being of interest, as it has not previously been recorded in the Darling Range. There were approximately 11 *Gaius* sp. burrows within the proposed area to be cleared. Approximately 22 burrows were recorded in the northern section of the Project Area (Lot 14) and will not be cleared or disturbed. Other populations of *Gaius* sp. are located on the western and eastern sides of Lot 11 and will not be disturbed by proposal implementation. The land snail survey revealed that the species diversity was low and there is an impoverished terrestrial molluscan population within the Project Area.	The establishment of a vegetation corridor linking the remaining vegetation within the Project Area to remnant vegetation to the east of Project Area on privately owned land, will be investigated. The impact on the *Gaius* sp. population within the Project Area will be managed by ensuring that the vegetation in the northern section of Lot 14 is not disturbed.	The general abundance and geographic distribution of fauna will not be adversely affected by the Project, as the habitats within the Project Area are well represented in the surrounding areas. Species diversity of vertebrate fauna will not be adversely affected, as the Project will not result in the loss of any vertebrate fauna. Some populations of the trapdoor spider species, *Gaius* sp. (which is a species of scientific interest) will be affected by the clearing operations but viable populations will remain in undisturbed areas of Lots 11 and 14.
Native Fauna – Specially Protected (Threatened) and Priority Fauna, and other fauna species of particular conservation significance.	The EPA Guidelines require that the Proponent: • Protect Specially Protected (Threatened) and Priority Fauna and their habitats, consistent with the provisions of the *Wildlife Conservation Act* 1950; and • Protect other fauna species of particular conservation significance (eg. undescribed taxa, range extensions, outliers). Work required: • Scope of work as for "native fauna" (see above), including consultation with the Department of Conservation and Land Management, and in regard to trapdoor spiders and land snails, the Western Australian Museum, on any impacts to, and management of, Threatened Fauna species and Priority Fauna species.	The work conducted in relation to the assessment of vertebrate and invertebrate fauna is described above. A number of vertebrate fauna listed as threatened or vulnerable under the EPBC Act or the State *Wildlife Conservation Act* 1950 (see Section 4.6) may occur in the Project Area. These animals are generally mobile and able to move away from the Project Area. Therefore, the Project will not result in the loss of any vertebrate fauna species or populations inhabiting the area. Some populations of the trapdoor spider species, *Gaius* sp. (which is a species of scientific interest) will be affected by the clearing operations but viable populations will remain in undisturbed areas of Lots 11 and 14.	The establishment of a vegetation corridor linking the remaining vegetation within the Project Area to remnant vegetation to the east of Project Area on privately owned land, will be investigated. The impact on the *Gaius* sp. population within the Project Area will be managed by ensuring that the vegetation in the northern section of Lot 14 is not disturbed.	The impact on the vertebrate and invertebrate fauna in the Project Area is likely to be low. The main impact will results from the loss of faunal habitat due to the clearing, however it is expected that mobile fauna will be able to move away.

Table 6.1 (continued)

Environmental Issues	Objectives and Work Required for the Environmental Review of the Project (as identified by the EPA Guidelines)	Existing Environmental Conditions and Predicted Environmental Impacts	Proposed Mitigation and Management Measures	Predicted Outcome
Mine planning, decommissioning and rehabilitation	The EPA Guidelines require that the Proponent: • Ensure that mine planning, decommissioning and rehabilitation are carried out in a planned sequential manner consistent with best practice and proposed final land use; • Ensure ecosystem function is maintained following mine closure; and • Avoid State liability. Work required: • Present an integrated mining, decommissioning, and rehabilitation strategy (which, among other things, addresses the issues of monitoring and progressive rehabilitation of disturbed areas); • Present appropriate final land uses for all areas affected by the proposal; and, • Present a description of how the above strategy is consistent with the ANZMEC/Minerals Council of Australia Strategic Framework for Mine Closure, 2000.	The Proponent recognises that appropriate planning and adequate provisioning for rehabilitation and closure is essential to ensure that the process occurs in an orderly, cost-effective and timely manner. A draft closure strategy has been developed. The desired closure outcome is to prevent adverse long-term environmental impacts and to create self-sustaining natural ecosystems or land uses, which are acceptable to the community and other stakeholders. The closure strategy for the proposed quarry relocation is based on the frameworks developed by ANZMEC and MCA (2000) and The Chamber of Minerals and Energy of Western Australia (1999) (Section 3.8). A closure and rehabilitation plan will be prepared for the proposed quarry relocation. It will be submitted to the regulatory authorities and other relevant stakeholders for review prior to site closure.	The mine closure strategy will be continually reviewed and revised. The strategy will include cost estimates for decommissioning and rehabilitation of the Project. A rehabilitation budget will be established to ensure that there are sufficient funds available to conduct the rehabilitation and monitoring.	The State will not be left with a liability following the closure of the Project, as there will be sufficient funds available for rehabilitation and closure.
Landform	The EPA Guidelines require that the Proponent ensure that the post-mining landform is safe, stable, non-erodible, and is, as far as is practicable, integrated into the surrounding environment. Work required: • Assess potential impacts of the proposal on existing landforms, including from erosion caused by run-off and other surface water leaving the site (eg. from dust suppression and dewatering). • Evaluation of the landscape values in the project area and how these will be affected by the proposal and any measures to manage such impacts, including for surface water management. • Propose measures to rehabilitate the impacted areas to an acceptable standard, and that will integrate the post-mining landform with the surrounding environment.	The major land units and soil types present in the Project Area have been identified (Section 4.2). The Project will result in the disturbance of approximately 60 ha of Yalanbee land unit and 15 ha of the Pindalup land unit. The disturbance will involve the clearing of vegetation, the removal of overburden and excavation of the quarry. Most or all of the gravel and clay material will be transported off-site to be sold. Topsoil harvested from the area of disturbance will be stockpiled for rehabilitation of construction phase disturbances and the existing quarry site. Any surplus topsoil will be made available for rehabilitation of off-site areas to ensure that the viability of the seed bank is maximised. In terms of the geotechnical stability of the pit walls, granite is a competent rock that is able to stand at vertical or near vertical angles for significant periods of time, depending upon the intensity of fracturing. During the installation of two groundwater monitoring bores within the Project Area (BGC1 and BGC2, see Section 4.4.3), fracturing was noted in the top 18 m of each bore. This main fractured zone corresponded to the saprolitic zone of the weathered granite profile, a zone which is expected to exist over the entire quarry site. Consequently, there is potential for some surface slumping or slippage to occur at the edge of the open pit edge and within this zone if the pit is not backfilled. The risk of this occurring, and any management measures required, will be assessed during the preparation of the site decommissioning and closure plan.	Any longterm topsoil stockpiles will be revegetated or protected with an appropriate cover material to ensure that erosion does not occur. Following site closure, rehabilitation of disturbed areas within the Project Area will be conducted. In the event that the quarry void is to be left open, BGC will assess the long-term stability of the pit edge and fractured zone as part of its closure process.	Depending on the closure strategy adopted for the Project, the quarry void will remain open, be partially backfilled or fully backfilled. Any remaining stockpiled material will be sold or used for rehabilitation purposes. Surface disturbances such as roads and infrastructure areas will be rehabilitated.

Table 6.1 (continued)

Environmental Issues	Objectives and Work Required for the Environmental Review of the Project (as identified by the EPA Guidelines)	Existing Environmental Conditions and Predicted Environmental Impacts	Proposed Mitigation and Management Measures	Predicted Outcome
Watercourses (Surface Water)	The EPA Guidelines require that the Proponent maintain the integrity, functions and environmental values of watercourses. Work required: • Identify catchments, watercourses, surface lakes and types of surface water flow throughout the areas to be affected by the proposal. • Assess the potential impacts on surface water flow rates, drainage patterns, sediment transport and any dependent vegetation as a result of the proposal. • Propose measures to manage and/or mitigate impacts.	The Project Area is located near the top of the local catchment divide, in the south-east corner of the Wooroloo Brook catchment. There are no substantial drainage lines, wetlands or sensitive water bodies in the Project Area. A small stream passes to the east of the existing quarry pit ("eastern stream"), joining with a small stream from the west ("western stream"). The streams are ephemeral, flowing mainly during winter as a result of seepage from local groundwater or surface runoff. The proposed quarry will increase streamflow in the local catchment but the water discharged will have a low salt load. There will not be any adverse effect on the downstream environment or water users because erosion and turbidity on-site will be minimised and water will be released in a controlled, low-impact fashion during the wetter months of the year. The controlled release should, on average, reduce streamflow salinity downstream of the quarry. Modifications to the "western stream" will be necessary should the Project be approved. At present, the existing "western stream" appears to have been narrowed and straightened by the agricultural land managers. The hydraulic capacity of the stream channel is reduced and appears to be erosionally unstable. The channel should be reconstructed from the base of the existing quarry to the confluence with the "eastern stream". The channel will be restored to its natural hydraulic capacity and be more stable.	The stream that receives discharge water from the proposed quarry will be reconstructed to accommodate the increased flows. This stream has been extensively modified in the past by the agricultural land managers and is currently erosionally unstable. The modifications will result in the restoration of the channel's original hydraulic capacity and improve its stability.	Average salinities in the nearby streams will decrease as a result of dilution with fresh water discharged from the quarry. The quantities of water flow will increase during winter, potentially increasing water supply to downstream water users and the environment. The "western stream", which is erosionally unstable will be stabilised. This is a significant benefit of the proposed Project.
Groundwater Quantity	The EPA Guidelines require that the Proponent ensure that the beneficial uses of groundwater can be maintained. Work required: • Provide details and justification of water requirements for the proposal. • Provide details of the hydrogeological systems of areas that may be affected, existing and potential future uses of groundwater. • Assess implications of planned abstraction on groundwater systems, existing and potential future uses of groundwater, and any groundwater dependent environmental systems. • Address the potential for water recycling and other water minimisation strategies. • Consult with the Water and Rivers Commission regarding groundwater allocation in the area and effects of groundwater drawdown (e.g. on salinity levels) from the proposal. • Propose measures to manage and/or mitigate impacts.	A water balance was developed for the proposed operations. It was predicted that there would be an increase in runoff, which will be collected in the pit. The water will be used for processing, dust suppression and allowed to evaporate. Most of the water will be discharged from the site during five months of the year (likely to be during May and September). The water requirements for the Project are similar to those for the existing operations, which is approximately 377 kL in summer and 77 kL in winter. The water supply source will consist of surface runoff and groundwater seepage. A semi-confined aquifer is located within the Project Area. The salinity of the groundwater in the upper parts of the Wooroloo Brook catchment ranges from 1,000 to 7,000 mg/L TDS. Small amounts of groundwater are available from bores which intersect fractures in the granite bedrock, however yields are low (generally less than 15 kL/day).	To monitor any decline in groundwater levels, the Proponent will measure groundwater levels on a monthly basis. A new monitoring bore will also be installed on the down slope side of the proposed quarry pit to adequately monitor the impact of dewatering on the down gradient portion of the catchment.	There is not expected to be any impact from the dewatering activities on other groundwater users outside of the quarry operations, as the fractured rocks are of low permeability and the cone of depression will be of limited extent. Therefore the groundwater quantity available for other groundwater users will not be affected by the Project.

Table 6.1 (continued)

Environmental Issues	Objectives and Work Required for the Environmental Review of the Project (as identified by the EPA Guidelines)	Existing Environmental Conditions and Predicted Environmental Impacts	Proposed Mitigation and Management Measures	Predicted Outcome
Groundwater Quantity (continued)		The proposed quarry pit will be dewatered using in-pit sumps, as per current practice. Dewatering requirements will be similar to the existing quarry. The proposed quarry pit may intersect steeply dipping fractures containing minor amounts of groundwater, which will be collected in a sump at the base of the pit. A steep cone of drawdown will develop immediately around the proposed quarry as groundwater levels are lowered. A briefing meeting was held with representatives from the WRC in April 2002. A site visit was conducted in September 2002. Due to the low bore yields and generally poor groundwater quality, the Project Area is not within a proclaimed groundwater area under the *Rights in Water and Irrigation Act* 1914. Therefore, there is no requirement to obtain a groundwater well licence to extract groundwater from the area. A survey of private groundwater bores on six properties was conducted in September and November 2002. The results of bore census are provided in Table 4.5.		
POLLUTION MANAGEMENT				
Surface Water Quality	The EPA Guidelines require that the Proponent maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the *Australian and New Zealand Water Quality Guidelines* (ANZECC, 2000). Work required: • Details of site drainage, hydrocarbon use, disposal of plant site waste (including sewage), water use for dust suppression, dewatering, and fate and quality of water used/pumped. • Assess the implications the proposal may have on local surface water quality and salinity, in particular in the Wooroloo Brook catchment. • Propose measures to manage and/or mitigate impacts, including any proposed environmental mitigation measures.	Runoff diversion structures will be designed and constructed so they are stable and do not cause downstream erosion. The drainage system will be adequately designed to cater for intense rainfall events. On-site pollution management will prevent spillages of fuel, oil or other pollutants from being transported to clean runoff water. Excess runoff water will be released only if it meets water quality criteria. The quality of water in streams below the proposed quarry should improve, on average, as a result of dilution with fresh water released from the quarry. There should be no uncontrolled release of polluted water from the quarry because all operations will be located in the quarry, below ground level. The only discharge from the quarry will be in controlled releases by pumping.	A management plan, including regular and strategic monitoring, will be implemented to manage on-site water movement and quality and control the timing and conditions of water release from the site.	There will be a net improvement in downstream water quality.

Table 6.1 (continued)

Environmental Issues	Objectives and Work Required for the Environmental Review of the Project (as identified by the EPA Guidelines)	Existing Environmental Conditions and Predicted Environmental Impacts	Proposed Mitigation and Management Measures	Predicted Outcome
Groundwater Quality	The EPA Guidelines require that the Proponent: • Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the *Australian and New Zealand Water Quality Guidelines* (ANZECC, 2000); and • Ensure that land clearing and quarrying does not cause, or significantly increase, the salinisation of groundwater. Work required: • Describe the water requirements for the proposal. • Describe baseline monitoring of bores, licensing requirements, drainage and fate of water used in on-site processing and quarry operations. • Describe how quarrying and eventual decommissioning and rehabilitation of the site will be undertaken to avoid creating an in-pit saline water body, which may affect the surrounding environment. • Assess impact from any change in groundwater quality, including any salinisation, on the surrounding environment. • Assess potential impacts on regional groundwater quality and other users of the groundwater resource. • Propose measures to manage and/or mitigate impacts.	The water requirements for the Project are similar to those for the existing operations, which is approximately 377 kL in summer and 77 kL in winter. The water supply source will consist of surface runoff and groundwater seepage. Two bores were installed in March 2002, to the west of the existing quarry. One is located in Lot 14, in the middle of the proposed quarry pit and the other is in Lot 11. These were drilled to a depth of 50 m and 60 m, respectively. There was essentially no groundwater intersected by the two new bores drilled in the proposed quarry. Groundwater will be drawn towards the quarry operations as dewatering proceeds. It is then consumed by the plant for mainly dust suppression and washing the rock product. Quarry dewatering operations will lower the level of groundwater in the Project Area. This will offset any soil salinisation which is normally caused by rising groundwater levels. There is not expected to be any impact from dewatering on the water quality for other groundwater users outside of the quarry operations, as the fractured rocks are of low permeability and the cone of depression will be of limited extent. After closure, if the void is deep, salt is likely to accumulate in the void as a result of seepage inflows and concentration by evaporation. This will be confined in the void as there is no seepage outflow. The average increase in salinity will be 22 mg/L/year. If the void is backfilled to a final depth shallower than the local watertable, some seepage outflow could occur. It is likely that the amount of outflow would be small and not contribute to any significant extent on downstream salinity compared to the impact of the widespread clearing for agriculture in the local catchment. Salt accumulation in the pit was predicted to average about 10 mg/L/year. If the void is backfilled to the surface and rehabilitated back to forest, the seepage and runoff rates are likely to return to close to the forested, pre-quarry condition.	The salinity of groundwater discharging to the proposed quarry will be measured twice per year. A bore will be drilled down the catchment slope from the proposed quarry to adequately monitor groundwater levels.	No adverse impact on groundwater quality. Soil salinisation potential in the catchment will be reduced due to lowering of groundwater levels by the quarry dewatering process.

Table 6.1 (continued)

Environmental Issues	Objectives and Work Required for the Environmental Review of the Project (as identified by the EPA Guidelines)	Existing Environmental Conditions and Predicted Environmental Impacts	Proposed Mitigation and Management Measures	Predicted Outcome
Noise and Vibration	The EPA Guidelines require that the Proponent protect the amenity of nearby residents from noise, airblast overpressure and vibration impacts resulting from activities associated with the proposal by ensuring that noise, airblast overpressure and vibration levels meet statutory requirements and acceptable standards. Work required: • Ensure that noise and airblast overpressure levels meet the criteria in the *Environmental Protection (Noise) Regulations* 1997. • Estimation of the noise and vibration levels at sensitive premises arising from the proposal. • In consultation with the DEP, establish best practical measures to manage and/or mitigate noise emissions from the proposal. • Propose measures to manage and/or mitigate noise impacts.	Noise-sensitive premises occur in the vicinity of the existing Voyager Quarry and proposed site for quarry relocation. Complaints regarding impacts due to noise and vibration from the existing operations have been lodged by local residents with the Proponent and the Shire of Northam. Herring Storer Acoustics (2002) has conducted a study of the existing quarry noise emissions and used these data to predict noise propagation from the relocated operations, under various atmospheric conditions. A study was also conducted of overpressure and ground-borne vibration due to blasting. The study conducted by Herring Storer Acoustics found that the proposed quarry operations can comply with regulatory criteria for all conditions and at all times once all operations have been relocated. The study also concluded that blasting can be managed to comply with the comfort criteria set down and be well below any criteria relative to damage risk (Herring Storer Acoustics, 2002).	Noise will primarily be managed by locating the plant site within the proposed quarry pit (approximately 30 m below ground surface) and housing the primary crusher (if required). Airblast overpressure and ground vibration will be monitored for each blast. Good blasting practices will be implemented to ensure that all blasts are confined and meet acceptable standards.	Noise and airblast overpressure levels will meet the criteria in the *Environmental Protection (Noise) Regulations* 1997. Ground vibration levels will also fulfill statutory requirements.
Particulates/Dust	The EPA Guidelines require that the Proponent ensure that particulate/dust emissions, both individually and cumulatively, meet appropriate criteria and do not cause any environmental or human health problem. Work required: • Identify sources of particulates/dust and estimates of project-wide emissions. • Analyse the significance of these emissions with regard to human health and environmental impacts. • Propose measures to manage and/or mitigate impacts.	Dust will be generated by the vegetation clearing activities during the construction of the proposed quarry. During the operational phase of the Project, dust will be generated during blasting and vehicular movement on unsealed roads. Dust may also occur from exposed product stockpiles, however these will be located within the confines of the proposed pit and the dust will not leave the site boundary. The dust generated by the Project will not cause a human health problem or have any adverse effects on the vegetation. Monitoring is conducted for dust levels experienced by site personnel to ensure that the levels do not cause an occupational health hazard. With regards to the health of the surrounding neighbours, dust generated from the site will not cause human health problems, as dust will not cross the site boundary. The Proponent will comply with the DEP licence conditions with respect to this issue. It is unlikely that dust generated from the Project will cause any adverse effects on the vegetation communities.	The main access road is sealed to reduce dust generation. Atmospheric conditions will be considered prior to blasting, so that blasting is conducted when the prevailing winds are away from residential areas. The shotrock is also watered in the pit prior to the being loaded and hauled to he crushing plant. Dust suppression measures, such as the use of water trucks, will be implemented for unsealed roads and within the pit. Sprinklers will be installed for the product stockpiles to reduce dust generation from these exposed surfaces. The Proponent will monitor vegetation condition within the Project Area during the construction and operational phases of the Project. The results from the monitoring programme will provide information on whether dust is adversely affecting the vegetation.	Dust will not adversely affect the environment or cause human health problems.
Visual Amenity	The EPA Guidelines require that the Proponent ensure visual amenity of the area adjacent to the project is not unduly affected by the proposal. Work proposed: • Assess potential impacts on visual amenity of the project area and surrounds from the proposal. • Propose measures to manage impacts.	A viewshed analysis was conducted to assess the visual impact of the Project. Results are presented in Section 8.5. The Project will not be visible from the residence to the west and is unlikely to be visible from residences to the north and east. Vegetation between the residence and the Project and the construction of infrastructure within the confines of the pit will greatly contribute to minimising visibility of the Project. Lighting impacts from the Project were also considered (Section 8.5.3). Light overspill will not occur under normal atmospheric conditions.	Infrastructure will be located within the confines of the pit (below ground level). Appropriate lighting technology will be investigated and implemented at the site.	The visual amenity of the area adjacent to the project will not be unduly affected by the Project.

Table 6.1 (continued)

Environmental Issues	Objectives and Work Required for the Environmental Review of the Project (as identified by the EPA Guidelines)	Existing Environmental Conditions and Predicted Environmental Impacts	Proposed Mitigation and Management Measures	Predicted Outcome
SOCIAL SURROUNDINGS				
Aboriginal Culture and Heritage	The EPA Guidelines require that the Proponent: • Ensure that the proposal complies with the requirements of the *Aboriginal Heritage Act* 1972; and • Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area. Work proposed: • Identify Aboriginal cultural and heritage sites of significance, through consultation with local Aboriginal groups and/or the Department of Indigenous Affairs, and as required, through archaeological and ethnographic surveys of the project area. • Propose measures to manage and/or mitigate impacts.	An archaeological investigation of the proposed quarry relocation area was conducted in July 2002. No archaeological sites were located during the investigation (Section 4.11). Consultation with the Combined Metropolitan Working Group of native title claimants and the Ballaruk Aboriginal Corporation was conducted in July 2002 (Section 4.11). As a result of the consultation process, it was determined that there are no known burial sites, sacred areas or other areas of significance to the Aboriginal people, in the Project Area.	In the event that artefacts or other archaeological material is unearthed during clearing and overburden excavation, the Proponent will seek advice from the DIA.	No impact on Aboriginal culture and heritage anticipated.
Public Health and Safety (Transport)	The EPA Guidelines require that the Proponent ensure that traffic activities resulting from the project can be managed to an adequate level of public safety. Work required: • Describe the types, quantities, and methods of transport for various inputs and products of the quarry and crushing plant, in particular, any hazardous goods. • Assess transport heavy haulage routes, and the implications these may have on public health and safety. • Propose measures to manage and/or mitigate impacts.	Traffic intensity and traffic loading on the surrounding road network is not proposed to change. Access onto Great Southern Highway will remain unchanged (Section 8.4). The traffic conditions resulting from the Project will be similar to those for the existing quarry and will be managed to ensure that an adequate level of public safety is maintained.	No new management measures will be required.	No significant impacts on the level of public safety will be experienced with respect to traffic activities, as traffic is unlikely to change as a result of the Project.
Public Health and Safety (Flyrock)	The EPA Guidelines require that the Proponent ensure that public risk associated with implementation of the proposal is as low as is reasonably achievable; and, is managed to meet the Department of Mineral and Petroleum Resources' requirement in respect of public safety. Work required: • Describe the type, size, and method of blasting conducted at the site. • Assess blasting conducted at the site and the implications this may have on public health and safety. • Propose measures to manage and/or mitigate impacts.	A predetermined drill pattern is marked out on a selected area within the quarry. An average-sized blast consists of approximately 80 to 100 holes. The holes are 102 mm in diameter and are generally 16 m deep (to allow for a 15 m bench height and 1 m for sub drill into the floor to provide an even finish on the quarry floor). The holes are drilled at a rate of approximately 20 holes per ten-hour shift using a hydraulic drill rig. On completion of drilling, the depth of the holes is checked and the holes are loaded with explosives. After the safety checks have been completed, the blast is initiated by a shot-firer. The average amount of explosive used in each blast hole is approximately 120-130 kg. The risk of flyrock will be minimal, as blasts will be designed to ensure that all flyrock is contained within the site boundaries. There is a possibility that flyrock may be projected some distance from the pit if excessive amounts of explosives are used and the drilling pattern is poorly planned. However, the implementation of good blasting practices will prevent this from occurring. BGC has been videotaping every blast at the existing operations since August 2002 to confirm that flyrock is being contained within the site boundaries.	The shot-firer will be properly trained and hold the appropriate qualifications to conduct the blasting. The blasting practices will take into account the burden spacing required for the particular rock type and ensure that the blast pattern is well designed so that the explosives are evenly distributed. The correct blasthole diameters and an effective stemming column will be used for each blast (Orica, 1995). All care will be taken to ensure that there are few misfired shots by using good priming and charging practices. BGC will monitor blasting by videotaping every blast over a 12-month period. The tapes will be reviewed to confirm that all flyrock is being contained within the site boundary.	Flyrock will be contained within the site boundaries and will not adversely affect public health and safety.

Table 6.2
Proposal's Compliance with EPA Guidance and Position Statements

EPA Document	Requirements	Proposal Compliance
Management of Surface Run-off from Industrial and Commercial Sites (Draft Guidance Statement No. 26) (EPA, 1999b)	• A stormwater management plan should be prepared. • A spill prevention and response plan should be developed. • A well-designed vehicle and equipment washdown area. • No discharges of contaminated stormwater to watercourses or waterbodies. • All contaminated stormwater to be retained on-site and treated prior to discharge.	The quarry development will comply with the EPA Guidance Statement No. 26. This will include: • development of a surface water management plan that specifies how stormwater will be treated on-site; • release conditions and controls; • systems for preventing and managing spills; and • systems for managing runoff from wash down, workshop and plant areas.
Environmental Protection of Native Vegetation in Western Australia. Clearing of Native Vegetation, with Particular Reference to the Agricultural Area. EPA Position Statement No. 2 (EPA, 2000)	• The "threshold level" below which species loss appears to accelerate exponentially at the ecosystem level is regarded as being at a level of 30% of the pre-clearing of the vegetation type. • A level of 10% of the original extent is regarded as being a level representing "endangered" and should be avoided.	At the regional scale, all vegetation complexes exceed the 10% (with the exception of Yalanbee 5) on the currently gazetted reserves. With the inclusion of areas within the CAR reserve system, all vegetation complexes are represented in areas greater than 30% of their current extent in public lands. There are no site vegetation types within the proposed Project Area that are not represented in the conservation estate. It is not possible to place percentages on the representation of these vegetation types, as only sections of the south-west have been mapped at the scale of site vegetation type.
Terrestrial Biological Surveys as an Element of Biodiversity Protection. EPA Position Statement No. 3 (EPA, 2002)	• Terrestrial biological surveys should provide sufficient information to address both biodiversity conservation and ecological function values within the context of the proposal. • The terrestrial biological surveys should be made publicly available and contribute to the bank of data available for the particular region. • Demonstration that all reasonable measures have been undertaken to avoid impacts on biodiversity.	Desktop and field studies have been conducted for flora and vegetation, dieback, vertebrate fauna and invertebrate fauna. Reports on these studies (except the recently completed vertebrate field survey) are appended to this PER document (see Appendices B-F) and thus are publicly available. The data collected represent a significant contribution to the scientific information for the region. No significant impact on local or regional biodiversity is expected. Mitigation and management measures have been developed and described in this PER. These include a revegetation strategy which has been developed to replace some of the local botanical and fauna habitat values that will be reduced as a result of the clearing of native vegetation.
EPA Bulletin 966 on Clearing of Native Vegetation (EPA, 1999a)	• Restriction of clearing below 20% of the original on any property. • Restriction of clearing in any Shire where the total amount of remnant vegetation was less than 20% of the Shire area. • Clearing will not cause land degradation or threaten nature conservation values.	The Project involves the clearing of 85 ha on Lot 14, which is approximately 43% of the total area of the lot. Therefore, 57% of the remnant vegetation on Lot 14 will be maintained. Mitigation and management measures will be implemented to ensure that land degradation or loss of nature conservation values do not occur. The Project is located in the Shire of Northam where there is approximately 16.4% of relatively intact native vegetation (Weaving, 1999). Consequently, under the MoU for "The Protection of Remnant Vegetation on Private Land in the Agricultural Region of Western Australia" (Agriculture WA, 1997), there is a presumption against clearing unless it can be demonstrated that loss of biodiversity will not occur. No significant impact on local or regional biodiversity is expected as a result of proposal implementation. To compensate for the loss of 85 ha of native vegetation within the Shire of Northam, BGC has committed to revegetate 170 ha of disturbed areas of remnant vegetation within the Wooroloo Brook Catchment (which has been historically cleared for largely agricultural activities). This revegetation will be undertaken over a five year programme, with a commitment to complete a third of the proposed area within two years from the approval date for the Project. The revegetation projects will be located on cleared Crown land and where feasible, private land through a commitment to allocate support through the Landcare and Catchment groups. Revegetation within the Wooroloo Brook catchment provides the potential to link remnant areas of vegetation and riparian zones with native vegetation on crown land and state forest areas.
Environmental Noise (Draft Guidance Statement No. 8) (EPA, 1998a)	• Measures of existing ambient noise levels should be carried out. • Noise level predications calculated using a computer model or "hand" calculations. • Present the comparison with noise criteria by individual noise receiver or by area, using a map of noise contours. • Present noise reduction measures.	Ambient noise levels in the vicinity of the existing quarry have been measured and a study of existing quarry noise emissions has been made. A computer model has been built to simulate noise propagation from the existing site and predict the resultant imission levels at noise-sensitive premises in the vicinity of the quarry, under various atmospheric conditions. The model was then adjusted by digitally relocating the noise sources to the proposed quarry site and modifying ground contours to allow prediction of noise propagation during and following implementation of the quarry relocation proposal. The findings of this study are presented in Appendix H, along with noise contour maps. Noise reduction measures have been developed and are described in this PER. The key measures are the locating the plant within the pit and housing the primary crusher, if required.
Assessment of Aboriginal Heritage (Draft Guidance Statement No. 41) (EPA, 2001)	• Consult with staff of the Department of Indigenous Affairs and review site records. • Undertake an Aboriginal Heritage Survey (if it is noted from a desktop review that an adequate survey has not been undertaken for an area to be developed) which should include both consultation with appropriate Aboriginal people and/or an archaeological survey as appropriate. • Inform the relevant Aboriginal people about details of the proposed development, including potential environmental impacts. • Consultation with relevant Aboriginal people to enable them to make their concerns in regard to environmental impacts as they affect heritage matters known to the proponent. • Demonstrate that any concerns raised by the Aboriginal people have been adequately considered by the proponent in its management of environmental impacts, and any changes as a result of this process are made known to the relevant Aboriginal people.	A desktop review was conducted by McDonald Hales & Associates (MHA) in April 2002 to determine the likelihood of any Aboriginal sites occurring in the Project Area. MHA concluded that no sites had been previously recorded in the Project Area but advised that this may be due to the lack of survey data for the area. An archaeological investigation of the Project Area was conducted in July 2002. No archaeological sites were located during the investigation. Consultation with the Combined Metropolitan Working Group of native title claimants and the Ballaruk Aboriginal Corporation was conducted in July 2002. As a result of the consultation process, it was determined that there are no known burial sites, sacred areas or other areas of significance to the Aboriginal people, in the Project Area. The concerns raised during the consultation process are presented in Table 5.1.

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7. ENVIRONMENTAL ISSUES AND MANAGEMENT

7.1 GENERAL

This section describes features of the existing local and regional environment, relevant environmental objectives and standards, and potential impacts and their management associated with the proposed Voyager Quarry relocation.

7.2 LANDFORM AND SOILS

7.2.1 Objectives and Standards

EPA Objective

- Ensure that the post-mining landform is safe, stable, non-erodible, and is, as far as is practicable, integrated into the surrounding environment.

Relevant Standards

The relevant standard for the assessment of this factor is the EPA objective.

7.2.2 Definition of Issues

The issue of concern to stakeholders is that the proposed quarry relocation should not cause erosion of stable landforms adjacent to and downstream of, the Project Area.

As described in Section 4.2 and illustrated in Figure 4.5, the Project Area comprises the Yalanbee, Pindalup and Cooke land units. During construction, approximately 60 ha of the Yalanbee land unit and 15 ha of the Pindalup land unit will be disturbed within the Project Area by clearing and removal of overburden. These land units are widespread and well represented throughout the Darling System. Therefore, the disturbance due to the proposed quarry relocation is not considered to be a significant impact.

The portion of the Project Area classified as the Cooke land unit will not be disturbed by the development of the proposed quarry relocation.

During the construction, operation and closure of the Project, there is potential for erosion in high runoff velocity areas. If not appropriately managed, erosional processes may lead to land degradation in the long-term. However, the management strategies outlined in Section 7.2.3 will minimise the potential for erosion to occur. Rehabilitation and stabilisation of the pit edge and the slopes adjacent to the pit will also reduce erosion.

The EPA Guidelines refer to the importance of ensuring that the post-mining landform is safe, stable, non-erodible and, as far as practicable, integrated into the surrounding environment. The long-term stability of the open pit edge depends on a number of factors. DME (1991) notes that the most important of these factors are:

- the presence and orientation of major geological planes of weakness in the rock mass forming the pit walls;
- variation in the strength of the rock mass in the vicinity of the pit walls, both at present and following proposal implementation;

- the geometry of the pit wall; and
- the influence of groundwater, which may cause high pore or joint water pressures within the pit walls.

In terms of the geotechnical stability of the pit walls, granite is a competent rock that is able to stand at vertical or near vertical angles for significant periods of time, depending upon the intensity of fracturing. During the installation of two groundwater monitoring bores within the Project Area (BGC1 and BGC2, see Section 4.4.3), fracturing was noted in the top 18 m of each bore. This main fractured zone corresponded to the saprolitic zone of the weathered granite profile, a zone which was expected to exist over the entire quarry site. Consequently, there is potential for some surface slumping or slippage to occur at the edge of the open pit edge and within this zone if the pit is not backfilled. The risk of this occurring, and any management measures required, will be assessed during the preparation of the site decommissioning and closure plan.

To ensure that any risk to public safety is minimized if the quarry void is left open, methods of preventing inadvertent public access are required. These are discussed in Section 7.2.3.

7.2.3 Management

Erosion Management

Erosion may occur following the clearing of vegetation within the proposed footprint of the proposed quarry operations. Management measures will be implemented by the Proponent to minimise the risk of erosion and include:

- ensuring the area of disturbance is limited to that essential to the practical operation of the quarry (DME, 1994). This will reduce landscape impact, erosion potential and sediment removal by runoff;
- implementing the strategies and procedures developed for the protection of vegetation (Appendix I);
- managing impacts on surface drainage patterns (Section 7.3.4 and Appendix I);
- implementing temporary stabilisation measures before revegetation occurs;
- installing sediment traps;
- implementing dust control measures (Section 8.1.4) and minimising wind erosion on exposed areas;
- progressively clear land to minimise the areas of exposed surface at any one time;
- harvesting the upper 10-20 cm of topsoil separately as it is biologically active and has the greatest values for revegetation purposes;
- harvesting and stockpiling the subsoil material (material to a depth of 0.5 m) separately; and
- progressively rehabilitating disturbed areas.

Further information on soil management strategies is provided in Appendix I. Erosion control strategies in relation to maintenance of surface water quality are also discussed in Section 7.6.4.

COMMITMENT

The Soil Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Soil Management Plan during the construction and operation of the proposed quarry relocation.

Geotechnical Stability Following Site Closure

Rehabilitation of the remaining disturbed areas within the Project Area will be conducted during the decommissioning and closure of the site. In the event that the quarry void is to be left open (i.e. not backfilled), rehabilitation of the pit edge will assist in minimising surface instability.

If the quarry pit is to be left open, BGC will assess the long-term stability of the pit edge and fractured zone as part of its closure planning process. The findings of this assessment, and any management measures required to ensure that any risk to public safety is minimised, will be documented in the site's decommissioning and closure plan. These measures may include methods of preventing inadvertent public access such as the establishment of a revegetated abandonment in accordance with DME guidelines (DME, 1991) and suitable signage clearly stating the risk to public safety and prohibiting public access.

COMMITMENT

In the event that the quarry pit is to be left open (i.e. not backfilled), BGC will assess the long-term stability of the pit edge and fractured rock zone as part of its closure planning process. The findings of this assessment, and any management measures required to ensure that any risk to public safety is minimised, will be documented in the site's decommissioning and closure plan.

7.3 SURFACE WATER

7.3.1 Objectives and Standards

EPA Objectives

- Maintain the integrity, functions and environmental values of watercourses.
- Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the Australian and New Zealand Water Quality Guidelines (ANZECC, 2000).

Relevant Standards

Guidelines for the protection of water resources from stormwater runoff carrying pollutants are provided in the Management of Surface Run-off from Industrial and Commercial Sites (Draft Guidance Statement No. 26) (EPA, 1999b). The statement also outlines the EPA's position on discharges of stormwater to the environment.

Water quality guideline levels can be found in the Australian and New Zealand Water Quality Guidelines (ANZECC, 2000). The guidelines also provide a framework for water quality management and the development of an appropriate monitoring programme.

7.3.2 Definition of Issues

The proposed quarry operations will be located near the top of the local catchment divide. The site occurs in the south east corner of the Wooroloo Brook catchment, which in turn forms part of the Swan-Avon catchment. The site is located in a proposed Priority 3 Drinking

Water Source Area and the catchment is proclaimed under the *Rights in Water and Irrigation Act* 1914.

The proposed quarry site is in the western side of a small valley. Drainage in the valley is from the south to the north, however there are no substantial drainage lines, wetlands or sensitive water bodies in the area that will be disturbed by the proposed quarry. Land slope on the site is around 7% and the general direction of flow is to the north east. Elevation in the quarry area site varies from 300 - 350 m AHD.

There are several obvious areas of salinisation in the pasture land downstream of the existing quarry. Vegetation in these areas is sparse, runoff rates are high and the areas are erosionally unstable. Disturbance and trampling by stock exacerbate the erosion and lead to increased streamflow turbidity. Observations of salinity in the streams, storages and bores over a period of time clearly show that seepage from surrounding agricultural land is the main source of salt load in the local catchment. This seepage is a result of rising watertables caused by clearing of vegetation for agriculture and is not related to the existing quarry operations. Controlled discharge from the current quarry has increased streamflows, but the salinity of the discharge water is low, leading to an overall lowering of salinity levels in the streams near the quarry.

The issues related to hydrology and surface water runoff from the proposed quarry relocation are:

- the potential for erosion during establishment of the new quarry;
- the management of surface runoff diversion and concentration on-site;
- potential impacts on the quantity and quality of downstream flow; and
- implications for downstream salinity.

7.3.3 Impact Assessment

An evaluation of surface water issues related to the proposed relocation of quarry operations is provided as Appendix G. The findings of this evaluation are discussed below.

Erosion During the Construction Phase

Clearing of the existing vegetation to leave bare soil or rock could substantially increase local runoff rates and exposed soil or soil stockpiles may be susceptible to erosion during the construction phase. Problems with erosion are only likely during the wet months of the year (i.e. May to September). Erosion risk will be managed using well-recognised soil conservation techniques and by collecting all runoff water from the site in a pit sump before release. Accordingly, on-site erosion is not expected to impact on the water quality of downstream flow.

Runoff Diversion and Concentration On-site

Runoff movement in the area of the proposed quarry pit and plant area will be affected to some degree, but this is not expected to have any significant effects on-site or at the controlled release point. All on-site diversion drains will be constructed to be non-erosive and silt-traps and other soil conservation works will be used to control stormwater flows.

Runoff from the site will be directed into sump/storages and stored temporarily before use in processing. Excess water will be released after testing to ensure water quality meets release

criteria. The release point from the quarry and the receiving stream will be modified to accommodate the expected flows and will be non-erosive.

Quantity and Quality of Downstream Flow

The proposed quarry will increase streamflow in the local catchment. Figure 7.1 shows predicted average monthly runoff for the existing catchment, including the existing quarry, during operation of the proposed quarry and after closure.

This increased streamflow is not likely to have an adverse effect on the downstream environment or water users as:

- erosion and turbidity on-site will be minimised;
- the water released will have low salinity; and
- water will be released in a controlled, low-impact fashion during the wetter months of the year.

This release will cease after closure of the proposed quarry as water will no longer be pumped from the pit. Streamflows in the local catchment are then likely to return to near the levels that occurred prior to the development of either of the quarries.

There will be no uncontrolled discharge from the quarry, minimizing the chance of an accidental release of water. As the plant area will be located in the quarry pit, all runoff will drain to quarry sumps and must be pumped from the site. On-site management and monitoring should ensure that pumping only occurs when the water released is of an acceptable quality and is unlikely to impact adversely on the downstream environment. Because the water will be pumped, it will be released at a lower rate than likely from a gravity release system and with a higher degree of control.

Salinity

The proposed quarry will not contribute to salinisation in the local catchment and may in fact help ameliorate downstream salinity. For the majority of the quarry life, and most likely after closure, groundwater in the vicinity of the quarry will seep into, rather than out of, the pit. Accordingly, groundwater levels downstream will not rise as a result of the quarry and may even fall in a small area immediately adjacent to the quarry. As water discharged from the site will have a low salt load, this controlled release will, on average, reduce streamflow salinity downstream of the quarry.

It is possible that the saline seepage areas in the local catchment will increase over time as a result of a rising watertable caused by clearing for agriculture. This would cause streamflow and salt load to increase, regardless of the existence of the proposed quarry.

7.3.4 Management

A conceptual management plan has been developed that addresses surface water management, plant water supply and monitoring issues. The objectives of the plan are to:

- minimise erosion on site, particularly during establishment of the new quarry;
- implement appropriate pollution management measures on-site;
- ensure adequate water supply for the quarry operations;

- ensure that water in excess of quarry requirements is of suitable quality by treating it before it is released; and
- ensure that the quarry operations do not adversely impact on downstream flows or water quality.

The surface water management plan addresses these objectives by specifying water management and monitoring procedures. Figures 7.2 and 7.3 show the proposed surface water management system for the plant and quarry areas at the end of year 2 and year 20. As the footprint of the quarry changes over time, particularly in the first 10 years, indicative positioning only of elements of the management system are shown.

The following water management systems will be used:

Erosion

Erosion on-site will be managed by employing appropriate soil conservation measures, including:

- Undertaking activities that may cause erosion or increased turbidity during dry periods, as much as practicable.
- Minimising the area of cleared and/or disturbed land that is susceptible to erosion at any one time.
- Minimising constructed land slopes and/or retaining or adding surface cover on disturbed land and excavations susceptible to erosion.
- Using temporary silt traps and filters such as graded channels, hay bales or shade cloth barriers, revegetation or covering of bare areas. These works should be used throughout the site, adopting a treatment-train approach to managing erosion and water quality.
- Ensuring that discharge points from constructed channels both within the pit and plant areas and at the discharge point from the quarry are stable and do not cause downstream erosion.
- Ensuring that construction of the pit sump, internal drainage channels/bunds, the site discharge point, and modification and stabilisation of downstream channels, are conducted as early as possible in the life of the project.
- Where possible, temporary stockpiles will be stabilised with vegetation or surface cover, by reducing batter slopes, or by constructing stable drainage lines. Stockpiles will not be located close to watercourses. Silt traps will be installed if erosion occurs.
- Runoff from internal and external access roads will be transported in non-eroding channels and discharged without causing erosion.

On-site Runoff Management

Runoff diversion structures will be designed and constructed so they are stable and do not cause downstream erosion. This will be undertaken by:

- ensuring drainage is adequately catered for and drains do not scour or overtop during intense rainfall events (> 50 year average recurrence interval);
- installing on-site storm water drainage systems and settling ponds that temporarily detain storm water and release it at a rate that does not cause flooding or damage to downstream road crossings or erosion of drainage lines;
- ensuring channels are constructed at appropriate slopes or of suitable material to prevent erosion; graded channels should be constructed at a low slope (e.g. 0.1%) and have sufficient capacity to encourage settling of coarse sediment particles and to slow water velocities; and
- ensuring that flow rates at discharge points are reduced to non-erosive velocities.

On-site Pollution Management

To manage the impacts of storm water flows and potential transport of pollutants, plant areas will be designed and constructed to ensure:

- runoff water from the offices, lab and workshop areas will pass through a triple oil separation trap before discharging into the process water dam;
- fuel, hazardous chemical and machinery servicing areas will be located on a concrete pad and bunded to capture any accidental spills;
- runoff water from the plant and stockpile areas will drain to either the process water dam or quarry dam via settling ponds to remove suspended sediment; and
- runoff water released from the quarry area will be done so under controlled conditions to ensure no adverse impact on downstream water quality.

Water Release to the Environment

The proposed controlled release conditions are as following:

- If there is a need to regularly release excess site water to the environment, discharge will be undertaken by pumping from the quarry storages from late autumn to early spring (May – September), though actual timing of release will depend on seasonal conditions. The first regular release from the quarry will not occur until some streamflow has occurred in the stream from natural flow processes. This is to avoid flushing any salt that has accumulated over summer.
- In the event of runoff as a result of summer thunderstorms, water should be released as required when some natural streamflow has occurred.
- Water will be sampled prior to release to ensure the criteria for release are met. If these requirements cannot be met, alternative arrangements for release will be made.
- Water will be released at a rate that allows excess water in the quarry storages to be released without causing downstream flooding, erosion or waterlogging.
- The downstream receiving channel (i.e. the "western stream" in Figure 4.7), will be reconstructed to accommodate the release flow and to more closely match the downstream receiving channel.
- Water will be released when runoff from other parts of the catchment is low to avoid increasing streamflow to the point that erosion or flooding could occur downstream.

Licencing

As it is proposed to reconstruct the Western Stream, a permit to modify bed and banks will be obtained from the WRC prior to construction. A permit is required as the catchment is proclaimed surface water area under the *Rights in Water and Irrigation Act* 1914 and the Western Stream is considered to be a watercourse as defined in the *Rights in Water and Irrigation Act* 1914.

The quarry development will also comply with guidelines for extractive industries in a P3 drinking water source area. This includes complying with buffer distances from streams, fuel and chemical storage systems, and maintaining a surface water management system to ensure water released is of good quality.

The requirements of the EPA Guidance Statement No. 26 are presented in Table 6.2. The Project will comply with these requirements by developing a surface water management plan that specifies how stormwater will be treated on-site. The surface water management plan will also specify release conditions and controls, systems for preventing and managing spills; and systems for managing runoff from wash down, workshop and plant areas.

COMMITMENT

The Surface Water Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Surface Water Management Plan during the construction and operational phases of the Project.

COMMITMENT

The Proponent will obtain a permit from the WRC to modify the bed and banks of the western stream.

7.3.5 Environmental Monitoring

Monitoring will focus on characterising the quality of water to be released from the site, characterising seepage inflow quantity and quality, and managing the occurrence of erosion or other potential sources of water contamination.

Water quality in the storages from which water will be released (the pit sump or plant storage) will be sampled prior to release and results received and water quality verified prior to release. Water will be sampled for, as a minimum TDS, TSS and EC.

The proposed water quality and erosion criteria are listed in Table 7.1, and are based on current water quality in the local catchment and potential impacts on the downstream environment. It is possible that these criteria will be modified in the DEP licence for the site. BGC will ensure that these criteria are met before release of the discharge water.

Table 7.1
Proposed Criteria for Water Release

Measurement	Measurement Method	Acceptable Criteria	Comments
Salinity	Hand sample as required, analysed at accredited laboratory or recorded using portable equipment.	TDS < 1,000 mg/L or EC < 1,800 µS/cm	Based on background stream salinity.
Turbidity	Hand sample as required, analysed at accredited laboratory.	TSS < 80 mg/L	Based on background stream conditions and licence conditions for the existing quarry.
Downstream stability	Visual observation of downstream channels as required.	No obvious stream bank erosion, rilling or sediment fans that can be attributed to releases from the quarry.	Based on the need for a flexible, rapid assessment of gross pollution potential.

Rates and quality of seepage inflow to the pit will be characterised during the life of the project as specified in the proposed monitoring plan (Table 7.2), to help determine the relative contribution of salt into the pit from seepage and manage the quality of water retained on-site and released to the environment. Daily rainfall data will be collected at the site.

Table 7.2
Proposed Monitoring Methodology

Sample location	Sample method and frequency	Minimum Analysis Required	Comments
Pit and plant storages	Hand sample prior to water release.	TDS, TSS, EC as required	Required to ensure water is of a suitable quality for release.
Seepage inflow	Hand sample as required to characterise flows.	EC, flow rates	Required to characterise seepage inflow quality and quantity.
Monitoring bores	Hand sample monthly or more frequently if required for specific purposes.	Depth	Required to characterise local aquifer characteristics, draw down from the quarry operations, and groundwater quality.
Quarry pit and plant area; downstream of release point.	Visual observation of erosion and water pollution, monthly and after runoff events.	Visual assessment	Required for rapid assessment of gross pollution potential or failure of management systems.
Weather	Daily using a manual rain gauge or an automatic weather station.	Daily rainfall	Optional, but useful to characterise local rainfall conditions.

Monitoring data will be retained in a central location. The data will be reviewed annually to ensure that the monitoring plan is adequate and objectives of the management plan are being achieved and to identify any trends that may affect the future performance of the management plan.

COMMITMENT

The Proponent will sample the water in the pit sump and plant storage for TDS, TSS and EC, prior to release. The water quality results for the samples will meet the criteria in the DEP licence prior to release.

COMMITMENT

The Proponent will monitor quantity and quality of seepage inflow and also monitor the depth of water in monitoring bores.

7.4 GROUNDWATER

7.4.1 Objectives and Standards

EPA Objectives

- Ensure that the beneficial uses of groundwater can be maintained.
- Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the Australian and New Zealand Water Quality Guidelines (ANZECC, 2000).
- Ensure that land clearing and quarrying does not cause, or significantly increase, the salinisation of groundwater.

Relevant Standards

The use of groundwater is controlled by the *Rights in Water and Irrigation Act 1914* and applies to the management of water resources.

The quality of groundwater should be maintained or improved to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the *Australian and New Zealand Water Quality Guidelines* (ANZECC, 2000).

7.4.2 Definition of Issue

The proposed BGC Quarry occurs in the Darling Scarp Province of Western Australia. The province has reliable rainfall and is characterised by streams that deeply incise the laterite profile into underlying granite bedrock. Small amounts of potable groundwater are available from bores and wells that intersect fractures within the granite bedrock, but generally yield less than 15 kL/day. Those sited in valleys or on some hill slopes may give larger supplies, but the groundwater salinity is generally higher (Wilde *et al.*, 1978).

The proposed quarry occurs in the very upper-most reaches of the Wooroloo Brook Catchment, immediately adjacent to the catchment divide. Groundwater yield to bores is therefore very small and groundwater salinities are between 1,200 and 3,700 mg/L TDS.

Due to low bore yields and generally poor groundwater quality, the area containing the existing and proposed quarry is not within a proclaimed groundwater area under the *Rights in Water and Irrigation Act* 1914. A WRC groundwater well licence is therefore not required to extract groundwater in this area.

The issue of concern to stakeholders is that groundwater levels and quality in private bores surrounding the Project may be adversely affected.

7.4.3 Impact Assessment

The proposed quarry could intersect steeply dipping fractures containing minor amounts of groundwater which will drain to a sump formed at the base of the quarry. Water will then be pumped for use in the processing operations and for dust suppression. This may further decrease groundwater levels near the proposed quarry.

Groundwater levels surrounding the existing quarry have been lowered due to abstraction of groundwater from the quarry. The shape of the depressed groundwater surface forms a cone of depression in the water table. The shape and width of the cone will depend on the properties of the fractures. Low permeability fractured rock will produce a steeper, less extensive cone than high permeability fractured rock. The existence of two artesian bores within 500 m of the centre of existing dewatering operations indicates that the cone of depression has not extended far in that direction. The cone is considered steep at this location as a consequence of the low permeability of the fractured rock.

In the area outside of the cone of depression, the groundwater levels are not affected by pumping from within the cone. Any bores belonging to other users in the area outside of the cone will not be affected, as groundwater levels in this area will not be impacted.

There is not expected to be any impact from dewatering on other groundwater users, outside of the quarry operations as the fractured rocks are of low permeability and the cone of depression will be of limited extent.

There was essentially no groundwater intersected by the new bores drilled in the proposed quarry area and so the cone of drawdown was not definable in this area. Based on these recent drilling results, the amount of additional groundwater flow to the quarry, due to the proposed quarry relocation will be low and limited to steep fractures in fresh granite and direct rainfall recharge to the saprolite zone.

BGC pumps groundwater from the quarry sump for use in the quarry operations. The removal of groundwater will benefit the local catchment by lowering the level of groundwater and thereby reducing the potential for soil salinisation. Large parts of Australia are subject to salinisation caused by historic land clearing and the subsequent rise in groundwater levels. These levels were once kept lowered by trees and other deep-rooted vegetation that intercepted rainfall before it could recharge the groundwater aquifers and also by vegetation directly abstracting water from the saturated zone. Rising groundwater brings salt from the subsoil to the soil surface. It is well recognised that salinisation can be controlled by re-planting vegetation or by the pumping and disposal of groundwater or surface water. The existing quarry operation is effectively removing over 170 kL/day of groundwater as well as rainfall that directly falls on the quarry and surface water captured by the quarry dam.

7.4.4 Management

The objectives of the management plan for groundwater are:

- To allow dry mining conditions.
- To provide sufficient water for mining and processing activities.
- To protect the groundwater available to other users, including the environment.

To monitor the decline in the level of groundwater that will occur within the area of the relocated quarry, BGC will measure groundwater levels on a periodic basis. Two bores already exist to the south east of the existing operations and two more have recently been installed to the west. In addition, BGC will install a new monitoring bore on the down slope side of the proposed quarry to adequately monitor the impact of dewatering on the down gradient portion of the catchment.

Although it is unlikely that drawdown will impact any of the bores listed in the WRC database, BGC has conducted a census of all privately held bores in the local area to determine their status and their potential to be impacted by declining groundwater levels. BGC will install a monitoring bore at a suitable location between the proposed quarry and the nearest private bore.

COMMITMENT

The Proponent will install a monitoring bore between the proposed quarry and the nearest private bore.

The expected small increase in rate of groundwater and rainwater flowing to the quarry sump will mean increasing the pump rate from the quarry to maintain dry conditions for mining. To monitor the amount of groundwater abstracted, BGC will measure the volume of groundwater pumped from the quarry sump and from any pumps placed in the two south

eastern bores. Further information on the management strategies to be implemented for groundwater are detailed in the Groundwater Management Plan (Appendix I).

COMMITMENT

The Proponent will monitor the amount of groundwater abstracted from the quarry sump and from any pumps placed in the two south-eastern bores.

COMMITMENT

The Groundwater Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Groundwater Management Plan during the construction and operational phases of the Project.

7.5 VEGETATION AND FLORA

7.5.1 Objectives and Standards

EPA Objectives

- Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.
- Protect Declared Rare Flora and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act* 1950.
- Protect other flora species of particular conservation significance (eg. undescribed taxa, range extensions, outliers).

Relevant Standards

Declared Rare Flora are protected under the provisions of the *Wildlife Conservation Act* 1950. Threatened plant communities and species are protected under the provisions of the EPBC Act.

7.5.2 Definition of Issue

The Project Area is located within the eastern section of the Darling Botanical District of the South-western Botanical Province (Beard, 1979, 1980). The two main plant communities of the region are open jarrah-marri forests (*Eucalyptus marginata* subsp. *thalassica* – *C. calophylla*) and wandoo woodlands (*E. wandoo*) (Heddle *et al.*, 1980).

The proposed Project Area comprises 11 site-vegetation types (see Table 4.7, Figure 4.11 and Appendix B). In general, vegetation in the area proposed for clearing consists of jarrah (*E. marginata* subsp. *thalassica*) and marri (*C. calophylla*) woodland with restricted occurrences of wandoo (*E. wandoo*). The frequency of tree stumps and trees with coppice regrowth and the relative lack of large, mature trees in much of the Project Area are indicative of historical logging operations (Mattiske Consulting Pty Ltd, 2002).

All of the site-vegetation types present in the proposed Project Area are represented in the wider conservation estate (Mattiske Consulting Pty Ltd, 2002). Site-vegetation type G (open to closed heath of Proteaceae) is locally significant as it is associated with localised outcropping supporting a range of species and taxa, including the Priority 4 species, *Hemigenia viscida.* Although local variations are noted in composition, this site-vegetation type is well represented in the conservation estate (Heddle *et al.,* 1980).

No DRF species gazetted under the *Wildlife Conservation Act* 1950 have been recorded within the Project Area (Matttiske Consulting Pty Ltd, 2002). One species classified as Priority 4 species (Rare Flora) on the State Declared Rare and Priority Flora List and as Vulnerable under the EPBC Act has been recorded in the Project Area. This species, *Hemigenia viscida*, was recorded in four of the 17 heath communities in the Project Area (Mattiske Consulting Pty Ltd, 2002). Almost 95% of *Hemigenia viscida* plants (1,612 plants) were recorded in one heath community (H5) (Figure 4.12). In Western Australia, *Hemigenia viscida* has been recorded previously on the eastern edge of the jarrah forest and in pockets within the wheatbelt (Appendix B).

The concerns expressed by stakeholders were:

- clearing in the Shire of Northam, which contains less than 20% remnant vegetation;
- loss of remnant vegetation; and
- loss of biodiversity.

7.5.3 Impact Assessment

Approximately 85 ha of native vegetation will be cleared to accommodate the proposed quarry relocation. Most of the area to be cleared has been previously disturbed by logging operations and fire, and consists predominantly of jarrah (*E. marginata* subsp. *thalassica*) and marri (*C. calophylla*) woodland with restricted occurrences of wandoo (*E. wandoo*). Few large, mature trees are present in the Project Area (Mattiske Consulting Pty Ltd, 2002).

Two of the heath communities containing *Hemigenia viscida* plants will be disturbed as a result of proposal implementation (Figure 4.12). However, BGC will establish a 50 m wide no-disturbance buffer to protect heath community H5, which contains around 95% of the *H.viscida* individuals in the Project Area.

Vegetation may also be disturbed as a result of changes to drainage patterns. Natural sheet flow of water across a landscape may be modified by the construction of project infrastructure, potentially resulting in ponding of water upslope and drainage shadows. The exposure of large cleared surface areas to high rainfall events may also cause the transportation of sediment downslope and result in vegetation being blanketed. Groundwater drawdown associated with quarrying operations could have implications for overlying vegetation if it is dependent on water being used. The hydrological impacts of the Project are discussed in greater detail in Sections 7.3 and 7.4.

The majority of the proposed Project Area is free from the symptoms associated with *Phytophthora* sp. infestation. Measures will be implemented to ensure that the spread of the disease does not occur from the main area of infestation, which is located along Great Southern Highway (refer to Appendix C).

A number of weed species have been recorded in the Project Area (see Appendix B). However, the relocation of the quarry is unlikely to have a significant impact on the spread of weeds in the area.

7.5.4 Management

The Proponent has minimised the potential impacts of the Project on significant vegetation types and flora species by modifying the site layout. In addition, the disturbance of flora and vegetation will be managed by implementing the following measures:

- confining temporary work areas to areas previously disturbed wherever practicable;
- retaining topsoil and root stock during clearing operations for use in rehabilitation programmes and for creating microhabitats for fauna;
- parking vehicles and machinery only in designated locations;
- restricting the clearance of *Hemigenia viscida* to approximately 5% of the known population occurring in the Project Area. A 50 m wide buffer around heath community H5, which contains almost 95% of *Hemigenia viscida* plants on-site, will be set for all phases of the operation;
- clearing land in stages over a period of five years rather than all at once to minimise potential impacts on undisturbed vegetation associated with dust generation and erosion;
- raising the awareness of BGC personnel through an induction programme.

The proposed site layout includes the maintenance of uncleared land to the north and south of the proposed quarry relocation within Lot 14 (Figure 1.2)

Further information on the management strategies to be implemented for vegetation and flora are detailed in the Vegetation and Flora Management Plan (Appendix I).

COMMITMENT

The Proponent will not disturb heath community H5 and will maintain a 50 m buffer around this community during all phases of the Project.

COMMITMENT

The Vegetation Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Vegetation Management Plan during the construction and operational phases of the Project.

7.6 TERRESTRIAL FAUNA

7.6.1 Objectives and Standards

EPA Objectives

- Maintain the abundance, species diversity and geographical distribution of fauna.
- Protect Specially Protected (Threatened) and Priority Fauna and their habitats, consistent with the provisions of the *Wildlife Conservation Act* 1950.
- Protect other fauna species of particular conservation significance (eg. undescribed taxa, range extensions, outliers).

Relevant Standards

Threatened fauna are protected by CALM under the provisions of the *Wildlife Conservation Act* 1950. Threatened and migratory fauna are also protected under the provisions of the EPBC Act.

7.6.2 Definition of Issue

The concern raised by stakeholders is that the proposed clearing of vegetation will locally reduce fauna habitat and may result in loss of threatened or endangered species.

A desktop vertebrate fauna review and brief site inspection undertaken by Ninox Wildlife Consulting in January 2002 identified that 80 bird species, 17 native mammal species (including seven bat species), nine frog species and 31 reptile species may occur in the area. Introduced fauna species also expected to occur in the area include the Black Rat (*Rattus rattus*), House Mouse (*Mus musculus*), Red Fox (*Vulpes vulpes*), Feral Cat (*Felis catus*), Rabbit (*Oryctolagus cuniculus*) and the Kookaburra (*Dacelo novaeguineae*) (Ninox Wildlife Consulting, 2002). A list of fauna species expected to occur in the Project Area is provided in Appendix D.

Most of the animals listed have widespread distributions throughout the South-west forested area and are not restricted to individual habitats.

The distribution of fauna habitats within the Project Area are shown in Figure 4.14. Due to past logging operations at the site approximately 80-90% of Jarrah trees in the study area support coppice regrowth (E.M. Mattiske, pers. comm., 2002). Large potential habitat trees, mainly marri trees, with suitable hollows for nesting or refuge occurred on an estimated 15% of the sites surveyed during the vegetation assessment (E.M. Mattiske, pers. comm., 2002).

7.6.3 Impact Assessment

The major impact of the Project on vertebrate fauna relates to the loss of approximately 85 ha of fauna habitat due to clearing. Vegetation occurring in the area proposed for clearing consists predominantly of heath, jarrah (*E. marginata* subsp. *thalassica*) and marri (*C. calophylla*) woodland with restricted occurrences of wandoo (*E. wandoo*). The area has few mature habitat trees present with suitable hollows for nesting or refuge. The relative lack of suitable habitat trees, which can be attributed to historical logging operations, reduces the likelihood that the Project would have a significant impact on threatened or migratory species that may occur in the area. Moreover, mobile species such as the Chuditch and Western Brush Wallaby would be able to move away from the impacted area and attempt to relocate in suitable habitat nearby. During the relocation process some territorial conflicts associated with competition for food resources, shelter and breeding sites may result. However, populations would be expected to stabilise once conflicts are resolved.

The loss of vertebrate fauna habitat will have an initial impact in terms of the loss of non-mobile and/or poorly dispersing species occupying the site, such as reptiles and small mammals. The retention and protection of some of the heath habitats in the Project Area, however, will reduce the impact on poorly dispersing species such as the Honey Possum.

Overall, impacts on the vertebrate fauna as a result of the Project are expected to be minor considering the limited distribution of suitable habitat for many species within the site. Moreover, most of the animals expected to occur at the project site have widespread

distributions throughout the south-west forested area of Western Australia and are not restricted to individual habitats.

7.6.4 Management

The Proponent will manage the impact of the Project on the fauna of the area by implementing the following management measures:

- minimise the extent of disturbance to the vegetation in the Project Area;
- ensure that there is no impact on mature trees and heath communities in undisturbed areas;
- implement off-set measures including the planting of habitat trees in adjacent areas; and
- avoid direct contact with fauna, wherever possible.

A draft Fauna Management Plan (Appendix I) has been prepared based on information obtained during the desktop study conducted by Ninox Wildlife Consulting and from consultation with CALM and other stakeholders. It is recognised that this is a preliminary draft plan, and further detail will be added once the results of the recent field survey are available. This will be conducted in consultation with CALM and other relevant stakeholders.

COMMITMENT

The preliminary Fauna Management Plan will be further developed in consultation with CALM and other relevant stakeholders once the results of the vertebrate fauna field survey are available. The Proponent will implement the Fauna Management Plan during the construction and operational phases of the Project.

7.7 INVERTEBRATE FAUNA

7.7.1 Objectives and Standards

EPA Objectives

- Maintain the abundance, species diversity and geographical distribution of fauna.
- Protect Specially Protected (Threatened) and Priority Fauna and their habitats, consistent with the provisions of the *Wildlife Conservation Act* 1950.
- Protect other fauna species of particular conservation significance (eg. undescribed taxa, range extensions, outliers).

Relevant Standards

The relevant standard for the assessment of this factor is the EPA objective.

7.7.2 Definition of Issue

Some stakeholders raised concerns about the fate of poorly dispersing invertebrate groups as a result of the proposed clearing operations. The EPA Guidelines state that the invertebrate fauna of interest are trapdoor spiders and land snails.

A two day field survey of Lots 11 and 14, undertaken in July 2002 by a team of scientists from the Mollusc Section of the Western Australian Museum, found three native terrestrial snail species, each belonging to a different family. The three species are *Bothriembryon* sp., *Westralaoma* sp. and *Luinodiscus* sp., which are native to the area (Slack-Smith, 2002). These species have previously been recorded in the Darling Range, but the records are not extensive. This low level of diversity of native species appears to be indicative of an impoverished molluscan fauna within the survey area. This is likely to be related to the low level of available calcium in the granite and lateritic rocks and soils in the Darling Range (Slack-Smith, 2002).

A field survey for trapdoor spiders (mygalomorphs) within Lots 11 and 14 was conducted by two personnel from the Western Australian Museum on 16 and 28 July, and 28 August 2002. Several old webs and trapdoors were observed during the site survey and three species of trapdoor spiders were collected. These were:

- *Cethegus* sp. (family Dipluridae);
- *Aganippe* sp., probably of the *Aganippe rhaphiduca* group (family Idiopidae); and
- *Gaius* sp. (family Idiopidae).

Of these species, the *Gaius* sp. is of interest, as it has not previously been recorded in the Darling Range and may be a relictual taxon.

The taxonomy and distribution of trapdoor spiders is poorly known in Australia. However, it is known that many species are habitat specific, and that both makes and females are required for taxonomic identification. A large proportion of trapdoor spiders in WA and elsewhere in Australia are un-named.

7.7.3 Impact Assessment and Management

Some of the suitable habitats for land snails will be cleared during the proposed quarry relocation. However, the three species of land snails were found outside of the proposed footprint of the quarry and will not be disturbed during the proposed operations.

A total of 36 *Gaius* sp. burrows were recorded at nine of the 59 sites searched within Lot 11 and Lot 14. Three of these sites (11 burrows) are located in the area proposed for quarry relocation. These burrows will be destroyed as a result of proposal implementation. The remaining burrows will not be cleared or disturbed by the proposed quarry relocation.

Gaius sp. appears to prefer heath habitat, much of which will be retained within Lot 14 and Lot 11. Those populations in the footprint of the proposed quarry relocation could be translocated, though the success of this action may not be able to be assessed for ten to 20 years.

It is possible that *Gaius* sp. has a wider distribution, even if the geographic distribution is fragmented. It has been suggested that the species may occur on other topographically similar areas such as Mt Dale.

COMMITMENT

The Proponent will conduct a follow-up trapdoor spider survey in topographically similar areas, particularly Mt Dale.

7.8 LOCAL AND REGIONAL BIODIVERSITY CONSERVATION

7.8.1 Objectives and Standards

EPA Objectives

- Maintain the abundance and diversity of species, and geographic distribution and productivity of plant communities.

Relevant Standards

The EPA expects land clearing proposals to demonstrate that vegetation removal would not compromise any vegetation type by taking it below the "threshold level" of 30% of the pre-clearing extent of the vegetation type (Position Statement No. 2 [December 2000], Environmental Protection of Native Vegetation in Western Australia. Clearing of vegetation with particular reference to the agriculture area). A level of 10% of the original extent is regarded as representing "endangered" and should be avoided.

A Memorandum of Understanding (1997) between agencies in Western Australia involved in assessing land clearing applies to proposals to clear more than one hectare of native vegetation on rural land in Southern Western Australia in areas where there is less than 20% of the original vegetation remaining in the main agricultural areas of the shire or less than 20% of the original vegetation remaining on the property.

A Notification of Intention (NOI) to Clear Land is required to be submitted to the Commissioner of Soil Conservation under the *Soil and Land Conservation Act* 1945 if:

- clearing in excess of one hectare of vegetation on any parcel of land is to occur at anytime, and/or
- the proposed clearing will result in a change in land use. This requirement applies to all mining operations.

7.8.2 Definition of Issue

The proposed Project Area is located in the Shire of Northam where there is approximately 16.4% of relatively intact native vegetation (Weaving, 1999). Consequently, under the MoU for "The Protection of Remnant Vegetation on Private Land in the Agricultural Region of Western Australia" (Agriculture WA, 1997), there is a presumption against clearing unless it can be demonstrated that loss of biodiversity will not occur.

7.8.3 Impact Assessment

Vegetation

Approximately 85 ha of native vegetation will be cleared as a result of proposal implementation. This vegetation consists predominantly of jarrah (*E. marginata* subsp. *thalassica*) and marri (*C. calophylla*) woodland with restricted occurrences of wandoo (*E. wandoo*).

At the regional scale, the vegetation complexes present in the Project Area are represented in proposed reserves in more than 10% of their pre-European extent (E.M. Mattiske, pers. comm.., based on data supplied in December 2002 by CALM). The Yalanbee 5 vegetation

complex (Y5) had a pre-European settlement extent of 124,367 ha. Approximately 22.5% of this area is proposed in the Formal Reserve system and 29.6% is proposed in the Formal plus Informal Reserve system (Table 7.3). The Pindalup vegetation complex (Pn) had a pre-European settlement extent of some 166,686 ha. Approximately 26.3% of this area is proposed in the Formal Reserve system and 35.1% of this extent is proposed in the Formal plus Informal Reserve system (Table 7.3).

Table 7.3
Representation of Vegetation Complexes

Area	Vegetation Complexes	
	Pn	Y5
Pre-European Area	166,686 ha	124,367 ha
Existing Reserves Area	14,664 ha	5,523 ha
Gazetted Reserves	8.8%	4.4%
State Forest, Timber Reserve & Executive Director	50,911 ha	22,123 ha
Other Public Land	4,186 ha	3,952 ha
Private Land	14,400 ha	16,059 ha
Total Proposed Formal Reserves	43,824 ha	28,003 ha
Total Proposed Informal Reserves	14,710 ha	8,829 ha
Total Formal and Informal Reserves	58,534 ha	36,833 ha
Formal Reserves	26.3%	22.5%
Formal and Informal Reserves	35.1%	29.6%

Source: EM.M. Mattiske, pers. comm., based on CALM 2002 data.

The Y5 and Pn vegetation complexes are well represented in the reserve system and in a range of other public lands (in State Forest, Timber Reserves, land vested in the Executive Director and in a range of other public reserves) and private lands. A significant proportion of the original extent of these complexes is in currently gazetted reserves, in proposed formal and informal reserves and in a range of other public and private lands where management strategies will assist in protecting the conservation values (Table 7.3). The proposed clearing of the 85 ha will not impinge significantly on the extent of these vegetation complexes.

Many of the management priority areas designated for the northern Jarrah forest in the Forest Management Plan have now been either gazetted as formal reserves or have been included in the proposed reserves under the CAR reserve system through the draft Forest Management Plan. The representation of the site-vegetation types in these respective management priority areas has been highlighted by Heddle *et al.* (1980b).

The site-vegetation types represented in the survey area also occur in sections of the areas previously known as Mt Cooke, Windsor, Russell, Lupton, Wandering and Sullivan. As a result of updating the forest management planning process, the Regional Forest Agreement process and more recently the updating of the Forest Management Plan by the Conservation Commission of Western Australia, several of these areas were merged into reserves or proposed reserves (E.M. Mattiske, pers.comm.). Therefore, at the site-vegetation type level of vegetation community definition there is no site-vegetation type present that is not represented in the wider conservation estate, though it is not feasible to place percentages on representation as only sections of the south-west forest region have been mapped at the scale of site-vegetation type level.

There is some local influences from the vegetation types that are represented in the Cooke (Ce), Goonaping (G) and Murray (My2) systems. These complexes are also represented in the draft Forest Management Plan within total proposed reserves to an extent of 34.9, 57.3% and 27.3% of pre-European area (ha) respectively within the draft Forest Management Plan.

Flora

A total of 223 vascular plant taxa from 42 plant families and 112 genera have been recorded within the survey area (refer to Appendix B). Most of these species are well distributed throughout the Project Area and surrounds. However, *Hemigenia viscida,* which is listed as Priority 4 (Rare Flora) on the State Declared Rare and Priority Flora List and as Vulnerable under the EPBC Act, is limited to four of the 17 areas of heath present in the Project Area. Two of these areas will be disturbed through proposal implementation, but heath community H5 (which contains nearly 95% of the *Hemigenia viscida* plants recorded in the Project Area) will be protected from disturbance.

No loss of flora species diversity or abundance is expected to occur as a result of proposal implementation.

Fauna

A wide range of vertebrate fauna species are expected to utilise the resources of the Project Area and surrounds. These include introduced fauna species including the Black Rat (*Rattus rattus*), House Mouse (*Mus musculus*), Red Fox (*Vulpes vulpes*), Feral Cat (*Felis catus*), Rabbit (*Oryctolagus cuniculus*) and the Kookaburra (*Dacelo novaeguineae*) (Ninox Wildlife Consulting, 2002).

As discussed in Section 7.6, the major impact of the Project on vertebrate fauna relates to the loss of approximately 85 ha of fauna habitat due to clearing. However, no loss of vertebrate fauna species diversity or abundance is expected to occur as a result of proposal implementation.

The land snail survey conducted by Slack-Smith (2002) found that the diversity of native species appears to be indicative of an impoverished molluscan fauna within the survey area. Three species of land snails were recorded during the survey, but were located outside of the proposed footprint of the quarry and will not be disturbed during the proposed operations.

Three species of trapdoor spiders were also recorded in the Project Area. Of these, *Gaius* sp. is of scientific interest as it has not previously been recorded on the Darling Scarp. Although 11 *Gaius* sp. burrows will be destroyed through clearing, viable populations are present elsewhere in the Project Area and will be protected from disturbance due to proposal implementation. It is possible that *Gaius* sp. has a wider distribution, even if the geographic distribution is fragmented. It has been suggested that the species may occur on other topographically similar areas such as Mt Dale.

Regional Processes

An investigation of possible salinity problems from the proposed land clearing and quarrying operations identified that the removal of groundwater for the quarrying will benefit the catchment by lowering the level of groundwater and thereby reducing the potential for soil salinisation (see Appendix G). Large parts of Australia are subject to salinisation caused by historic land clearing and the subsequent rise in groundwater levels. These levels were once kept lowered by trees and other deep rooted vegetation that intercepted rainfall before it could recharge the groundwater aquifers. Rising groundwater brings salt from the subsoil to the soil

surface. It is well recognised that salinisation can be controlled by revegetation or by pumping and disposal of groundwater or surface water. The existing quarry operation is effectively removing over 1.7 ML/day groundwater as well as rainfall that directly falls on the quarry and surface water captured by the quarry dam.

7.8.4 Management

Mitigation Measures

The objectives of the mitigation measures are:

- To replace some of the local botanical values that will be reduced through the implementation of the project as a result of the clearing of native vegetation.
- To ensure that the revegetation sites are sufficiently developed for ecosystem function and newly created ecosystems are resilient.
- To create selected corridors and linkages between remnant vegetation areas to facilitate native fauna movement.
- To replace introduced flora species with local native species in disturbed remnant areas of native vegetation on slopes and ridges and near riparian areas.

The following mitigation options are proposed to compensate for the disturbance and/or loss of native vegetation.

1. Planting an area(s) of native vegetation at a 2:1 ratio of the area of vegetation to be disturbed by the project over a five year programme, with a commitment to undertake a third of the proposed area within two years from the approval date for the project.
2. Revegetation will occur on disturbed areas of remnant vegetation within the Wooroloo Brook Catchment within the Northam Shire (which has been historically cleared for largely agricultural activities).
3. The proposed revegetation will assist in both catchment management issues and assist in the re-establishment of biodiversity values through the planting and seeding of local native species and also through the establishment of corridors and linkages for native fauna movement between areas of remnant vegetation.
4. Revegetation within the Wooroloo Brook catchment provides the potential to link remnant areas of vegetation and riparian zones with native vegetation on crown land and State Forest areas.

Site Selection Criteria

To ensure that the revegetation strategy addresses biodiversity conservation objectives, the following criteria were applied:

- The revegetation projects will be located within the Wooroloo Brook catchment.
- The majority of the revegetation projects will be located within the Shire of Northam, as the Shire only has approximately 16.4% of native vegetation.
- The revegetation projects will be located on cleared Crown land and where feasible private land through a commitment to allocate support through Landcare and Catchment groups to the revegetation of 50 ha within two years of project approval and a further 120 ha within five years of the project approval.
- The sites selected for revegetation projects will be located near degraded riparian areas, in degraded remnant vegetation areas and on proposed corridors and linkages between remnant vegetation areas and nearby crown land and state forest areas.

- Revegetation projects that are located on hillslopes will be situated immediately upslope of any area exhibiting poor drainage (Silberstein *et al*., 2002).
- The angle of slope for the revegetation projects should be less than or equal to 15° as this factor influences the success of revegetation (DME, 1996). At gentle slope angles (0 to 15°), revegetation success tends to be very good as the erosion hazards are slight to moderate on these types of slopes.
- Local native species would be utilised for these plantings. The latter plantings will also provide habitats for native fauna and contributes to managing water flow and velocities (WRC, 2001b).
- Revegetation will be targeted in the immediate vicinity of the Project Area to create ecological linkages as recommended by Ninox Wildlife Consulting (2002).

Guidelines for Species Selection

The following factors will be considered when the species for the revegetation projects are selected (Marcar *et al*., 2002):

- Climatic conditions – species must be suited to the climatic conditions, particularly the rainfall regime (average annual rainfall and the year-to-year and season-to-season variability).
- Soil conditions - soil physical and chemical properties will affect plant growth. Soil texture affects root penetration, water infiltration rates and water availability.
- Water table depth and salinity – waterlogging may occur if the water table is too shallow or poor growth may occur if the groundwater is saline.
- Competition effects – other plants in close proximity will affect the success of the revegetation plantings, as there is likely to be competition for water and nutrients.
- Native species that are most suited to the site conditions will be used for the revegetation projects, to ensure that the probability of the plantings being successful is maximised. The plant species selected will include overstorey and understorey species to contribute to creating a functional ecosystem. Selected native species for revegetation and their suitability for different soil conditions will be based on the information in the following references:

    - Department of Agriculture (2002);
    - Lefroy *et al*. (1991);
    - Marcar *et al*. (2002);
    - Water and Rivers Commission (2001b);
    - Baxter (1996); and
    - Mattiske Consulting Pty Ltd (2002).

COMMITMENT

The Revegetation Strategy will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Revegetation Strategy after the commencement of construction activities.

7.9 GREENHOUSE GAS EMISSIONS

7.9.1 Objectives and Standards

EPA Objectives

The EPA Guidelines do not identify Greenhouse Gas emissions as one of the factors to be addressed in the environmental assessment of the proposed quarry relocation. However, this issue was raised by one of the government agencies consulted during the assessment process.

As the EPA Guidelines did not identify this factor, no EPA objectives have been set in this regard. However, the objectives set for other proposals provide guidance for this proposal. Therefore, for the purposes of this proposal, the environmental assessment objectives are proposed to be as follows:

- To minimise greenhouse gas emissions in absolute terms and reduce emissions per unit product to as low as reasonably practicable.
- To mitigate greenhouse gas emissions in accordance with the Framework Convention on Climate Change 1992, and in accordance with established Commonwealth and State policies including EPA Interim Guidance No 12.

Relevant Standards

There are currently no regulatory standards for greenhouse gas emissions for proposals within Western Australia. However, in assessing proposed developments, the EPA considers that proponents should demonstrate that emissions of greenhouse gases are minimized as far as practicable from new or expanding operations (EPA, 1998b).

The emissions of carbon dioxide (CO_2) from fossil fuel combustion are increasing the concentration of CO_2 in the global atmosphere, which influences the global climate via the enhanced greenhouse effect. Other Greenhouse Gases (GHGs) include methane, nitrous oxide and fluorinated gases, which also influence the enhanced greenhouse effect. Greenhouse gas concentrations in the atmosphere can be minimized by the removal (or 'sequestration') of CO_2 from the atmosphere and stored in vegetation sinks (AGO, 1998).

Although the nature and extent of climate change effects is uncertain, the Kyoto Protocol signals the acceptance by the international community that precautionary measures to control GHG emissions are necessary. Under the Kyoto Protocol, it is proposed that Australia would be required to control its GHG emissions so that the average Australian GHG inventory over 2008-2012 is no more than 108% of the 1990 level; or to offset the excess via carbon sinks (e.g. changing land use from pasture to permanent forest), or to offset the excess via compensatory activities in other countries. Australia is yet to indicate an intent to formally ratify the Kyoto Protocol.

The Commonwealth and State Governments continue to direct support to 'no regrets' measures aimed at reducing GHG emissions, and supplementing these with additional 'beyond no regrets' measures such as those detailed in its 1997 Greenhouse package, *'Safeguarding the Future: Australia's Response to Climate Change'* (AGO, 2000).

7.9.2 Existing Environment

The current Voyager quarry site had minimal woody vegetation cover prior to the initiation of quarry operations by BGC. Therefore the current baseline GHG emissions for the quarry do not address vegetation clearing which are not related to the Project. The current source of

GHG emissions remain combustion of fossil fuels for transport and non-transport related machinery, and power supply.

Existing machinery which is currently operating on-site at Voyager quarry include fixed and mobile plant equipment (as described in Section 8.2), all of which are fuelled by diesel. Using fuel consumption figures provided by BGC, it is calculated that existing machinery on-site have an equivalent GHG emission of 2,400 tpa CO_2 (eq). In addition, there are GHG emissions attributable to current electricity usage as supplied by Western Power. The Carbon intensity of electricity sold to customers is currently reported to be 0.96kg $CO_{2(eq)}$/kWh (Western Power, 2001) which, for the current quarry project equates to approximately 2,300 tpa $CO_{2\ (eq)}$. The current baseline GHG emission for the Project Area is therefore 4,700 tpa $CO_{2\ (eq)}$.

7.9.3 Impacts

The primary sources of GHG in relation to the current project include additional land clearing, the combustion of fossil fuels associated with on-site machinery and equipment, and additional electrical power requirements. Over a sufficiently long period of time, these emissions have the potential to be wholly offset by rehabilitation and reservation of other areas of native vegetation.

The clearing of land required for the Project Area, representing a total disturbance envelope of 85 ha, will inevitably have some impact on the greenhouse inventory attributable to the quarry as a result of removing aboveground biomass.

The Australian Greenhouse Office has published a Vegetation Sinks Workbook to assist in the consistent quantification of carbon stocks in forest vegetation at the project level (AGO, 2000). This can be used to calculate the GHG implications of land clearing associated with the Expansion Project.

On a per hectare basis, the amount of GHGs, as CO_2 equivalent, can be calculated using the following equation:

> $CO_{2\ (eq)}$ = Volume (m^3 of merchantable timber) x density x Harvest Index (ie. ratio of stem wood to above ground biomass) x root-to-shoot ratio (ie. ratio of roots to total above ground volume) x carbon content x 44/12 (ie. ratio of the mass of CO_2 to that of C).

Using this formula assumes the Intergovernmental Panel on Climate Change (IPCC) default that all GHGs are emitted at the time of clearing. Technically this is not the case as carbon may be stored in wood products for many years or slowly released as products decay.

The GHG emissions as a result of clearing land for the 85 ha quarry is therefore estimated to be approximately 1,900-3,700 t $CO_{2\ (eq)}$. This is based on representative values for native vegetation characteristic of the area consisting predominantly of jarrah and marri (as described in Section 4.5.1), and a merchantable volume of timber equivalent to 10-20 m^3 per hectare across the Project Area. This is consistent with the observations of the area having been logged a number of times previously, resulting in a low volume of woody biomass across the Project Area (see Section 5.4 in Appendix B; E.M. Mattiske, pers. comm).

In addition, approximately 2,600 tpa $CO_{2/(eq)}$ are attributable to diesel combustion for machinery and equipment use on-site. BGC estimates that, as a conservative estimate, diesel fuel consumption may increase approximately 10% above current usage, which has been factored into the current assessment. The Expansion Project will involve the replacement of

the existing crushing plant with a new plant, which is expected to demonstrate improved efficiency (and hence greenhouse) benefits over the current base case, however for a conservative assessment this has not been included.

Power consumption for the Expansion Project is anticipated to potentially increase by 10%, which will contribute 2,500 tpa $CO_{2\ (eq)}$ to the predicted GHG inventory.

The total GHG emissions associated with the proposed Expansion Project is therefore 7,000-8,900 t $CO_{2\ (eq)}$. In comparison to the base case, predicted emissions from fossil fuel combustion and power requirements will increase only incrementally, with the primary impact from land clearing. The latest National Greenhouse Gas Inventory released by the Australian Greenhouse Office in April 2001 reports the current best estimate of net emissions to be in the order of 71.7 Mt $CO_{2\ (eq)}$, however it is noted that there still exists a degree of uncertainty relating to the best means of calculating clearing emissions (AGO, 2001). The predicted emissions from the BGC Project, of 7,000-8,900 t $CO_{2\ (eq)}$, represents an increase of around 0.01% from the current National inventory for land clearing. It is therefore concluded that the Project is an extremely minor contributor to Australia's domestic greenhouse inventory.

7.9.4 Management

BGC is currently evaluating suitable measures to compensate for the disturbance of native vegetation associated with the proposed quarry relocation. This will provide the potential to offset the GHG emissions, noting that a sufficiently long time period would be required before an equivalent amount of CO_2 would be sequestered from the atmosphere into vegetation biomass. Preliminary discussions indicate that approximately 170 ha of native vegetation outside the Project Area will be revegetated to provide a significant net Carbon sink in the long term.

Emissions of GHG emissions from fuel combustion will be managed through proper maintenance of on-site equipment to ensure fuel consumption is optimised. BGC will also monitor developments in regulatory and policy developments in carbon trading in Western Australia and also at the Commonwealth level in relation to the company's Statewide operations.

The above assessment has shown that, through quantification of potential greenhouse gas emissions using current Australian methodologies and the potential to completely offset those emissions in the long-term through revegetation measures proposed by the Proponent, the net impact on domestic greenhouse gas emissions will be extremely minor. It can be concluded, therefore, that the quarry relocation proposal satisfies the environmental objective stated in EPA Guidance No.12 to 'ensure that potential greenhouse gas emissions… are adequately addressed and best available technologies are used in Western Australia to minimise Western Australia's greenhouse gas emissions'.

7.10 DUST

7.10.1 Objectives and Standards

EPA Objectives

- Ensure that particulates/dust emissions, both individually and cumulatively, meet appropriate criteria and do not cause an environmental or human health problem.

Relevant Standards

The current DEP licence specifies that visible dust should not leave the boundary of the premises.

Western Australia currently has no air quality criteria set for use in impact assessment studies and instead refers to the National Environment Protection Measure (NEPM) for Ambient Air Quality (NEPC 1998). The National Environmental Protection Measure air quality standard is 50 $\mu g/m^3$ (averaged over 1 day) for particulates with an aerodynamic diameter less than 10 µm (PM_{10}) (NEPC, 2001). This level should not be exceeded on more than 5 days per year. However, when reviewing the standards and goals set out in the NEPM for Ambient Air Quality, it should be noted that they are designed for use in assessing regional air quality and are not intended for use as site boundary criteria. Therefore, for the purpose of monitoring performance against the NEPM, ambient concentrations are to be measured at performance monitoring stations. These are to be located so that they provide a representative measure of the air quality likely to be experienced by the general population in a region or sub-region.

7.10.2 Definition of Issue

Potential sources of dust emissions in the locality of the quarry include vehicular movement on unsealed areas at the existing quarry and along Horton Road.

7.10.3 Impact Assessment

Dust will be generated by the clearing activities, however the clearing will be staged to minimise the areas of exposed soil at any one time. The construction and operation of the quarry will also generate dust through drilling, blasting and vehicular movement. The degree of dust generated will depend on the moisture content of the ground surface.

Dust fallout and suspended particulates are potentially significant issues for the proposed development due to possible nuisance effects on neighbouring properties and the potential for non-compliance with the NEPM goals.

Generally dust emissions consist of two types of particulates: the larger fraction which will settle out relatively quickly and is typically referred to as nuisance dust; and finer particles, which become suspended in the atmosphere for a period of time. The finer particulates are of greater concern as exposure over prolonged periods of time may increase potential health risks.
Dust generation will be highest during blasting activities and this may impact on residents from the surrounding properties. The transportation of quarried material may also generate dust through vehicular movement. This is likely to occur in the drier months when the soil moisture content is low.

The dust generated by the Project will not cause a human health problem or have any adverse effects on the vegetation. Monitoring is conducted for dust levels experienced by site personnel to ensure that the levels do not cause an occupational health hazard. With regards to the health of the surrounding neighbours, dust generated from the site will not cause human health problems, as dust will not cross the site boundary. The Proponent will comply with the DEP licence conditions with respect to this issue.

7.10.4 Management

Dust generation during the transportation of material and the operation of the quarry is unlikely to have a significant impact on nearby land users, as stringent dust control measures will be implemented during the development and operation of the quarry.

The objectives of the dust management plan are:

- to ensure that nuisance dust levels are not experienced by neighbours and do not cause any health problems, such as asthma;
- to ensure that dust generated during the developmental and operational phases of the quarry expansion does not significantly impact on amenity;
- to ensure that the operational layout for the proposed quarry expansion will minimise dust and particulate emissions from the quarry; and
- to ensure the levels of dust and particulate emissions comply with DEP Licence requirements.

Dust generation during the vegetation clearing activities will be managed by undertaking the clearing in stages to minimise the areas of exposed soil at any one time. During the construction and operational phases of the Project dust emissions will be minimised through the implementation of the following management strategies:

- providing a buffer zone of vegetation between the proposed quarry operations and the nearest neighbours to act as windbreaks, reducing wind velocity and dust mobilisation;
- using water sprays and considering atmospheric conditions prior to blasting;
- visually monitoring the level of particulate emissions and using dust suppression techniques, when necessary;
- using sprinkler systems or enclosing 'dusty' machinery, such as conveyors and transfer points, to reduce dust emissions;
- sealing the main access road to reduce dust generated by vehicles travelling on the road; and
- not overloading trucks or conveyors to avoid spillages.

Further information on the management strategies to be implemented for dust is provided in the Dust Management Plan (Appendix I).

COMMITMENT

The Dust Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Dust Management Plan during the construction and operational phases of the Project.

7.11 NOISE

7.11.1 Objectives and Standards

EPA Objectives

- Protect the amenity of nearby residents from noise, airblast overpressure and vibration impacts resulting from activities associated with the proposal by ensuring that noise, airblast overpressure and vibration levels meet statutory requirements and acceptable standards.

Relevant Standards

Criteria for assessing environmental noise in WA are specified in the *Environmental Protection (Noise) Regulations* 1997, which prescribe "assigned noise levels" for noise receiving locations.

Guidance for the assessment of environmental noise is provided in EPA (1998a).

7.11.2 Definition of Issue

Noise-sensitive premises are located in the vicinity of the proposed Project Area and the potential impact of noise from quarry construction and operation is of significant concern to local residents. Noise is the main issue raised in public complaints made to the Shire of Northam and BGC about the existing Voyager Quarry.

7.11.3 Impact Assessment

An assessment of the potential for noise impacts was conducted by Herring Storer Acoustics (2002). The findings of this assessment are provided in Appendix H and summarised below.

BGC proposes a staged implementation of the proposed quarry relocation, whereby the existing Voyager Quarry will continue to operate during the construction of the proposed quarry, and will cease operation once the relocation is completed. Consequently, Herring Storer Acoustics investigated three scenarios, as follows:

- Scenario 1 – Overburden removal and site construction occurs whilst the existing Voyager Quarry continues to operate.
- Scenario 2 – During the transition between the existing and new operations, extraction of hard rock from the new quarry commences whilst crushing continues at the existing Voyager Quarry.
- Scenario 3 – Quarry relocation has been completed, with operations occurring only with the proposed Project Area. No operations occur at the existing Voyager Quarry.

The results of modelling the proposed operations (including the transitional stages) are provided as noise contour plots in Appendix H. The results of single point calculations conducted by Herring Storer Acoustics for these scenarios are provided as Table 7.4.

During construction of the proposed quarry within Lot 14 (Scenario 1), the major noise source during the day will continue to be the existing primary crusher followed by scrapers used for clearing within the proposed quarry footprint. During the night, the main noise

source will continue to be mobile equipment and the tertiary crushing system. No construction of the new quarry will occur at night.

Slightly elevated noise levels of around 2 dB(A) may occur during the day compared to the existing noise levels due to the use of scrapers and dozers for overburden removal. Worst case noise imission levels at residential locations are predicted to be up to 50 dB(A). The scrapers, which result in individual levels of up to 44 dB(A), add to the overall level of 47 dB(A) from existing crushing operations, resulting in the overall level of 50 dB(A).

Overburden removal and associated activities will only occur during the day time. As these construction phase activities are of relatively short duration and are required to prepare the proposed quarry for normal operations, these activities would be classified under Regulation 13 of the *Environmental Protection (Noise) Regulations* as "construction noise". Accordingly, Regulation 7 and the assigned levels of Table 1 in Regulation 8 (see Table 3.1 of Appendix H) do not apply and the noise can be managed in accordance with Regulation 13. Although there are no specific criteria to be met for construction noise, BGC will make every reasonable effort to minimise construction noise emissions.

During the transition from the existing operations to the relocated operations (Scenario 2), the noise imission levels at noise-sensitive premises will be similar to the existing levels (see Section 4.9). Consequently, there is potential for exceedances to occur. However, as part of BGC's commitment to its noise reduction programme, the existing primary crusher is being enclosed. This will lower the risk of exceedeances from this source. However, the most effective means to achieve compliance is to expedite the relocation of the crusher to the proposed quarry site, where it will be located below ground level.

Once the operation has been fully relocated (Scenario 3) and mining is occurring at a level of 15 m or more below natural ground level, noise imission levels are expected to comply with the overall assigned levels at all locations and at all times. Operational noises will be reduced further as mining progresses to lower levels.

Table 7.4
Predicted Transition and Operational Noise Imission Levels

Location	Scenario 1 (Site construction + existing quarry operations)				Scenario 2 (Extraction from new quarry + crushing at existing quarry)				Scenario 3 (Full operations at new quarry only)			
	No Bunds		Bunds		Day		Night		Day		Night	
	Downwind dB(A)	Calm dB(A)	Downwind dB(A)	Calm dB(A)	Downwind dB(A)	Calm dB(A)	Downwind dB(A)	Calm dB(A)	Downwind dB(A)	Calm dB(A)	Downwind dB(A)	Calm dB(A)
Residence A	48 (+3)	39	48 (+3)	39	46 (+1)	38	42 (+7)	36 (+6)	33	23	17	12
Residence B	50 (+5)	41	50 (+5)	41	47 (+2)	39	42 (+7)	37 (+7)	37	28	18	14
Residence C	49 (+4)	40	49 (+4)	40	42	33	37 (+2)	31 (+1)	33	24	13	11
Residence D	36	27	36	22	32	19	22	16	33	25	16	17
Residence E	34	25	34	37	26	14	15	9	27	18	16	17
Residence F	47 (+2)	37	47 (+2)	46 (+1)	44	35	39 (+4)	34 (+4)	36	26	14	13
Location A	52	43	52	43	49	41	5	39	38	29	14	11
Location D	46	37	46	37	44	36	40	34	32	22	16	11

Source: Herring Storer Acoustics (2002) (see Table 6.2 of Appendix H).
Note: Figures in brackets indicate the potential exceedance of assigned levels including tonality adjustments.

7.11.4 Management

The proposed quarry operations have been specifically designed to minimise noise propagation outside of the operating area. To minimise the potential for impacts due to environmental noise, BGC will use of the quietest equipment available, where practicable, and will locate the crushing and screening plant within the proposed quarry pit approximately 30 m below ground surface.

The potential benefit of constructing noise attenuation bunds around the operations as a means of reducing the impact of construction and operational noise has been investigated. However, the predictive modelling conducted by Herring Storer Acoustics (2002) indicates that bunds even up to 15 m in height would not provide any extra attenuation under down-wind conditions. Consequently, noise attenuation bunds have not been included in the project design.

7.12 GROUND VIBRATION AND AIRBLAST

7.12.1 Objectives and Standards

EPA Objectives

- Protect the amenity of nearby residents from noise, airblast overpressure and vibration impacts resulting from activities associated with the proposal by ensuring that noise, airblast overpressure and vibration levels meet statutory requirements and acceptable standards.

Relevant Standards

Ground Vibration

Compliance with the DEP Works Approval and Licence conditions will be required. The site's current DEP Licence states that the ground vibration must not exceed a limit of 10 mm/second peak particle velocity for any single blast.

Nominated limits for ground vibration, at any affected residence as a result of blasting at the Voyager Quarry are:

- The peak particle velocity from any single blast must not exceed 5 mm/s.
- Not more that one blast in any ten consecutive blasts (regardless of the interval between each blast) must exceed a peak particle velocity of 10 mm/s.

Airblast

The *Environmental Protection (Noise) Regulations* 1997 specify that, for blasting carried out between 7am and 6pm on any day not a Sunday or a Public Holiday, the airblast level received on any other premises must not exceed:

- 125 dB(linear, peak) for any blast; and
- 120 dB(linear, peak) for nine in any 10 consecutive blasts, regardless of the interval between blasts.

For blasting on Sundays and public holidays between 7am and 6pm the criteria are:

- 120 dB(linear, peak) for any blast; and
- 115 dB(linear, peak) for nine in any 10 consecutive blasts, regardless of the interval between blasts.

7.12.2 Definition of Issue

Airblast

Blasting is conducted approximately once every fortnight, at approximately 1300 hours. BGC has maintained records for each blast conducted since January 1993. The monitoring is conducted by ABT Engineering Pty Ltd using equipment that has been calibrated by a National Association of Testing Authorities of Australia (NATA) accredited laboratory.

Each blast is measured at the closest property to the quarry at a location approved by the Director of the DEP. This monitoring station is situated approximately 1.5 km west of the existing quarry, near Lot 5 Horton Road. The location of the airblast monitoring site complies with DEP Licence Condition N1(a), which states that each blast shall be measured from the boundary of a premises approved by the Director.

The regulatory levels for blasting are defined in the *Environmental Protection (Noise) Regulations* 1997. The regulations state that the airblast level for any single blast shall not exceed 125 dB (linear peak). During the period from January 1993 to March 2002, there has been only one exceedance of this level (Figure 3.4). This was 126 dB(linear peak), which was recorded in December 1998. The Director of the DEP was notified of the exceedance within six hours of the event as required under the sites licence. A report was also submitted to the Director within seven days of the event, which provided details for the exceedance. The exceedance of the regulatory limit was a result of a shot-firer class conducting the blast at the quarry as practical experience towards their certificate and also due to an increased amount of explosives used for the blast.

The *Environmental Protection (Noise) Regulations* 1997 also require that nine in any ten consecutive blasts does not exceed 120 dB (linear peak). According to the airblast monitoring results, there have not been any two consecutive blasts where the level of 120 dB (linear peak) has been exceeded.

The majority of airblast levels are in the range between 82 - 115 dB (linear peak). Changes were made to improve the blasting technology in 1999 to maintain airblast levels below 115 dB (linear peak), and this level was set as an internal benchmark. These improvements included:

- ensuring the that the burden spacing, which is the distance between the rows of blastholes parallel to the major free face, was adequate;
- decreasing the amount of explosive used for blasting the same amount of rock;
- improving drilling practices by opening up the pattern and drilling straighter holes;
- ensuring that an effective stemming column of suitable height was placed into the blasthole after the main explosives charge; and
- improvements in the manufacturer's products.

Ground Vibration

The ground vibration results for the existing quarry have consistently been below the regulatory limits specified in the DEP Licence limit, which is 10 mm/s. The range of ground vibration values recorded by ABT Engineering at the monitoring station between the period of January 1993 and March 2002 is 0.0 to 4.7 mm/s. These levels are also below the licence limit of one blast in every ten blasts having a ground vibration limit of 5 mm/s. Blasting operations at the Voyager Quarry have complied with the licence conditions relating to ground vibration (Figure 3.3). Improvements in the blasting practices were implemented in 1999, which resulted in a distinct decrease in the ground vibration results. The ground vibration levels have been minimised through the implementation of the following practices:

- increasing the delays on the initiation of the blast;
- improving drilling practices; and
- improvements in the manufacturer's products (initiators and explosives).

7.12.3 Predicted Ground Vibration Levels

Ground vibration can be estimated by the equations in Australian Standard 2187.2-1993, but a prediction graph generated from ground vibration measurements at the site is the most accurate prediction method.

Ground vibration from blasting has been measured adjacent to Residence D since 1993. Results are presented in Appendix H. Table 7.5 presents blast details, measured ground vibration levels, and calculated ground vibration levels at the measurement location using the Australian Standard formulaes.

Table 7.5
Blast Details, Measured Ground Vibration Levels and Calculated Vibration Levels

Parameter	Blast Date	
	15 January 2002	1 February 2002
Measured Ground Vibration (mm/s)	0.1	0.7
Total Mass of charge, Q (kg)	17752	17920
No. Holes	132	156
Calculated MIC (kg)	134.5	114.9
Estimated Distance, R (m)	1400	1400
Calculated Ground Vibration (mm/s)	0.23	0.21

Source: Herring Storer Acoustics (2002).

Herring Storer Acoustics used the higher value (1 February 2002) to calibrate the formula for prediction of ground-borne vibration levels, in accordance with Australian Standard 2187-2:1993 *"Exposure – storage, transport and use Part 2: Use of explosives"*.

The 1 February 2002 value of 0.7 mm/s is considered indicative of the historical vibration recorded levels which actually average around 0.7 mm/s. Using the 0.7 mm/s value to calibrate the AS2187-2 formula resulted in constants of:

K = 1,700
B = 1.6

Using the calibrated formula results in a predicted level of 0.79 mm/s for the 15 January 2002 blast. Therefore, Herring Storer Acoustics concluded that the predicted levels are likely to be conservative.

The formula was then used to predict the ground-borne vibration levels at Residence D, which is located 560 m from the nearest blast point. Based on the blast details of 1 February 2002, the vibration level at Residence D would be around 3 mm/s. This is a significant increase over existing levels but well within the criteria maximum levels.

A summary of the predicted levels at Residence D versus maximum instantaneous charge (MIC) is shown in Table 7.6.

Table 7.6
Calculated Maximum Instantaneous Charges at the Residence Closest to the Project Area

Ground Vibration at 560 m (mm/s)	Calculated MIC (kg)
0.1	2.5
1	54.3
2	136.8
5	464.2
10	1,169.6

Source: Herring Storer Acoustics (2002)

Australian Standard AS2187.2-1993 recommends that vibrations be ≤10 mm/s for houses. The results indicated ground vibration levels of around 2 mm/s can be expected using MICs at the relocated quarry of the same size used at the existing quarry (around 130 kg). A ground vibration level of 2 mm/s is well within the nominated limits above. It should be noted that the Australian standard is conservative. For example, many European standards allow peak particle velocity values of between 20 mm/s and 50 mm/s. Data from the United States Bureau of Mining indicate that structural damage does not occur at peak particle velocity levels of ≤50 mm/s.

The normal MIC used at the Quarry is around 130 kg. This will result in a ground vibration level of around 3.4 mm/s at a distance of 560 m (nearest residence to the proposed site). Such a level is well within the 9 out of 10 blast criteria limit of 5 mm/s.

Excessive ground vibration can result in damage to structures, however much higher levels of ground vibration (such as strong winds, domestic appliances, slamming of doors) are usually experienced and accepted by occupants (Environment Australia, 1998).

COMMITMENT

BGC will undertake building surveys of the nearest residences prior to the commencement of the proposed operations to provide a baseline against which claims of damage due to ground vibration can be evaluated. A copy of the results will be provided to the relevant residents.

In terms of the geotechnical stability of the pit walls, granite is a competent rock that is able to stand at vertical or near vertical angles for significant periods of time, depending upon the intensity of fracturing. A very conservative estimate of pit wall set-back distance (i.e. the distance between the top of the pit and the nearest surface structure) would be 100 m, which is twice the pit depth. As the nearest residence is located approximately 560 m from the proposed western wall of the pit, there will be no adverse effects on the residents.

7.12.4 Predicted Airblast Levels

According to Orica (1995), airblast can be estimated. However, as for ground vibration, the a prediction for a site generated from airblast measurements at that site will be more accurate.

Airblast resulting from blasting at the quarry has been measured adjacent to Residence D since 1993. Results are presented in Appendix H.

Table 7.8 presents blast details, measured airblast levels, and calculated airblast levels at the measurement location using the Orica (1995) formula:

$$PA = 185 (R/W^{1/3})^{-1.2}$$
$$PB = 3.3 (R/W^{1/3})^{-1.2}$$

$$dBL = 20 \log (P/_{P0})$$

PA = Overpressure unconfined charge
PB = Overpressure confined charge
PO = Reference pressure 2×10^{-8kpa}
R = Distance
W = MIC

Table 7.7
Blast Details, Measured Airblast Levels and Calculated Airblast Levels

Date	Airblast, Measured	Total Mass of charge, Q (kg)	No. Holes	Calculated MIC (kg)	Estimated Distance, R (m)	Calculated Airblast, dB(linear)		
						Fully confined		Unconfined
15-Jan-02	108	17752	132	134.5	1400	105.9	to	140.8
1-Feb-02	109	17920	156	114.9	1400	105.3	to	140.3
12-Feb-02	107	9488	79	120.1	1400	105.5	to	140.5
1-Mar-02	108	8770	74	118.5	1400	105.4	to	140.4
12-Apr-02	114	9808	82	119.6	1400	105.5	to	140.4

Source: Herring Storer Acoustics (2002).

The data presented in Table 7.7 indicate that blasts are well confined, as the measured results are similar to the calculated airblast results for a fully confined blast. Adjusting the Orica formula to calibrate against actual measured levels results in a constant factor of 4.5 (Herring Storer Acoustics, 2002).

Table 7.8 presents a range of predicted airblast levels for Residence D for various MICs and ground vibration levels (as used in Table 7.7 based on the calibrated Orica formula).

Table 7.8
Predicted Airblast Levels at 560 m for a Range of MICs

MIC (kg)	Predicted Ground Vibration (mm/s)	Predicted Airblast Level dB (linear)
2	0.1	103
29	1	113
70	2	116
115	3	118
215	5	120
510	10	123

Source: Herring Storer Acoustics (2002).

The actual airblast levels will be slightly higher than the 'confined' airblast levels shownin Table 7.8. Based on the normal MIC of 130 kg, the airblast level will be around 119 dB. This level is within, but at the upper limit, in terms of the 9 out of 10 weekday criteria and well within the maximum recommended value of 125 dB (Herring Storer Acoustics, 2002).

It can be seen that it is likely to be the airblast overpressure that dictates the size and configuration of blasts in order to comply with the criteria for ground vibration and airblast overpressure (Herrring Storer Acoustics, 2002).

7.12.5 Management

Management strategies for controlling airblast and ground vibration are:

- ensuring that the MIC is closely monitored and managed by using hole diameters that are suitable for the rock type. In strong rocks, smaller holes may be needed to distribute the explosives more evenly through the rock mass to improve fragmentation (Orica, 1995);
- using the correct burden spacing, where in strong rock types, smaller burdens and spacings are required (Orica, 1995);
- using the minimum practicable subgrade drilling to ensure that there is not an excessive toe;
- using a staggered drilling pattern, where practical, as this pattern produces better fragmentation and productivity (Orica, 1995); and
- using an effective stemming column of suitable height and consistency to produce better fragmentation (Orica, 1995);

Further information on the management strategies to be implemented for airblast and ground vibration are detailed in the Airblast and Ground Vibration Management Plan (Appendix I).

COMMITMENT

The Airblast and Ground Vibration Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Airblast and Ground Vibration Management Plan during the construction and operational phases of the Project.

7.13 FLYROCK

7.13.1 Objectives and Standards

EPA Objectives

- Ensure that public risk associated with implementation of the proposal is as low as is reasonably achievable; and is managed to meet the MPR's requirements in respect of public safety.

Relevant Standards

The relevant standard for the assessment of this factor is the EPA objective.

7.13.2 Definition of Issue

A predetermined drill pattern is marked out on a selected area within the quarry. An average-sized blast consists of approximately 80 to 100 holes. The holes are 102 mm in diameter and are generally 16 m deep (to allow for a 15 m bench height and 1 m for sub drill into the floor to provide an even finish on the quarry floor).

The holes are drilled at a rate of approximately 20 holes per ten-hour shift using a hydraulic drill rig. On completion of drilling, the depth of the holes is checked and the holes are loaded with explosives. After the safety checks have been completed, the blast is initiated by a shot-firer. The average amount of explosive used in each blast hole is approximately 120-130 kg.

The explosives are purchased in bulk from a supplier and delivered to the site on a pre-designated day. In accordance with Shire of Northam's by-laws relating to extractive industries, blasting operations are only conducted between the hours of 0600 and 1800 on Mondays to Saturdays, inclusive. The Proponent maintains a list of any neighbours who wish to be notified when a blast is scheduled.

Prior to the change in blasting practices in 1999, there were occurrences of flyrock being projected some distance (up to 100 m) from the existing quarry pit. BGC has identified that this was not acceptable and there have been significant improvements in the blasting practices to eliminate flyrock.
The Lakes Action Group has recently indicated that rocks found on a track located to the western edge of the existing pit were flyrock from the existing pit. The track is located approximately 150-300 m west of the pit and BGC contend that it is not possible that flyrock has travelled this distance since implementation of the improved blasting practices in 1999. Plates 6–8 show the sequence of a blast conducted at the existing Voyager Quarry on 8 October 2002. The plates show that rock was forced inwards towards the pit and no flyrock occurred.

Plate 6 Before the blast conducted on 8 October 2002

Plate 7 During the blast conducted on 8 October 2002

Plate 8 After the blast conducted on 8 October 2002. All rock landed within the pit as the blast was designed to force the material inwards towards the pit.

7.13.3 Impact Assessment

Blasting practices employed at the existing site will be used at the proposed operations. The risk of flyrock will be minimal, as blasts will be designed to ensure that all flyrock is contained within the site boundaries. There is a possibility that flyrock may be projected some distance from the pit if excessive amounts of explosives are used and the drilling pattern is poorly planned. However, the implementation of good blasting practices will reduce the likelihood of this occurring.

Since August 2002, BGC has been videotaping all blasts at the existing Voyager Quarry. The tapes are reviewed to verify whether flyrock is leaving the site boundary, however the tapes reveal that all flyrock is contained within the confines of the pit. The absence of flyrock outside of the existing quarry pit is attributed to the improved blasting practices employed at the site. These improvements have included:

- ensuring the that the burden spacing, which is the distance between the rows of blastholes parallel to the major free face, was adequate;
- decreasing the amount of explosive used for blasting the same amount of rock;
- improving drilling practices by opening up the pattern and drilling straighter holes;
- ensuring that an effective stemming column of suitable height was placed into the blasthole after the main explosives charge; and
- improvements in the manufacturer's products.

7.13.4 Management

The principal objective of the blasting management plan for reducing the occurrence of flyrock is to ensure that the public risk associated with blasting is low and flyrock does not endanger the safety of the public.
Flyrock can be managed through a number of measures including:

- BGC will monitor blasting by video-taping every blast over a 12-month period. The tapes will be reviewed to confirm that flyrock does not leave the site boundaries;
- using the correct blasthole diameters, as harder rocks require smaller blast holes to distribute the explosives more evenly through the rock mass (Orica, 1995);
- ensuring that there are few misfired shots by using better priming and charging practices;
- using improved manufacturer's products so that more accurate initiation times can be determined and the detonator delay firing times are more accurate; and
- strictly adhering to the blasting practices.

COMMITMENT

BGC will monitor every blast over a 12-month period by videotaping each blast. The tapes will be reviewed to determine if flyrock is being contained within the site boundaries.

7.14 SITE ACCESS AND TRANSPORT

7.14.1 Objectives and Standards

EPA Objective

- Ensure that traffic activities resulting from the project can be managed to an adequate level of public safety.

7.14.2 Definition of Issue

Access to the existing Voyager Quarry is via a sealed road off Great Southern Highway (Figure 1.2). The access road into the quarry was sealed on 19 May 2002, to reduce dust generation from the site and improve road safety.

At the existing quarry, two 85 t dump trucks are used for the haulage of material from the pit to the primary crusher and on average, each truck takes 30 loads per day.

The transport routes to the distribution centre in Midland are Great Southern Highway and Great Eastern Highway. Approximately 40% of the total volume of material leaving the quarry is distributed to BGC Concrete plants located at Hazelmere, Armadale, Malaga, Rockingham, Quinns Rock and Canning Vale. Approximately 5% of the material is transported to BGC Asphalt with the remaining 55% transported to various locations in the metropolitan area and country locations. Distribution centres in the northern suburbs are accessed using Reid Highway and then Mitchell Freeway. The distribution centres in the southern suburbs are serviced via Roe Highway, then Tonkin Highway and Leach Highway.

7.14.3 Impact Assessment

As the relocated quarry is not expected to begin operation until the existing Voyager Quarry nears completion, the traffic intensity and traffic loading on the surrounding road network is not proposed to change. Access onto Great Southern Highway will not be changed if the proposed quarry relocation is implemented.

The traffic conditions resulting from the Project will be similar to those for the existing quarry and will be managed to ensure that an adequate level of public safety is maintained.

7.15 VISUAL AMENITY

7.15.1 Objectives and Standards

EPA Objective

- Ensure visual amenity of the area adjacent to the project is not unduly affected by the proposal.

Relevant Standards

The relevant standard for the assessment of this factor is the EPA Objective (above).

7.15.2 Definition of Issue

A viewshed analysis was conducted for three of the nearest residences to the north, east and west of the Project Area. These sites were deemed to be representative and potentially most likely to be affected by visual impacts. Digital spatial data obtained from the Department of Land Administration (DOLA) was used to conduct the viewshed modelling to determine the visibility of the existing and proposed quarry operations.

The structures were modelled at a height of 0 m, which means that all structures present at ground level, would be detected in the model. The model allowed for an assumed height of approximately 1.6 m from a selected viewpoint.

The model did not allow for the presence of vegetation, which would be likely to provide screening and reduce the areas visible from each of the residences analysed. Atmospheric conditions also play a role in determining the extent of visibility, and this was not included in

the analysis. Therefore the results provided by the viewshed analysis can be considered as the worst case scenario and are extremely conservative predictions of the visual impact.

Based on the results obtained from the viewshed analysis, the residence to the north of the site has a partial view of the existing operations (Figure 4.19). The main components of the existing operations that are likely to be visible from this residence are the stockpiles, processing plant and workshop/administration areas, however the extent of this visibility is highly likely to be reduced by vegetation. The presence of features that have a screening effect in close proximity to the viewing point (referred to as 'foreground closure'), will obscure structures in the distance, thereby reducing the visual impact. The residences to the east and west of the Project Area do not have a line-of-sight to the existing operations (Figure 4.19).

The existing quarry is screened from Great Southern Highway and Horton Road by vegetation to the south and east of the quarry, respectively.

7.15.3 Impact Assessment

A viewshed model was used to predict the visual impact of the proposed quarry to the neighbouring residents. Three viewing points were selected, being the nearest residences to the north, east and west of the Project Area. The results provided by the viewshed analysis can be considered as the worst case scenario as it assumes that all vegetation between the viewing points and the Project Area has been cleared, and does not allow for atmospheric conditions.

According to the results provided by the viewshed model, the proposed quarry would be visible from the residence located to the east (View Point 1) (Figure 4.19). However there is a vegetation buffer in close proximity to the viewing point, which is likely to obscure the visibility of the proposed project. Distance is another factor that will influence the visual impact experienced from the residence to the east, as it is located approximately 2.4 km from the Project Area, which is the most distant viewing point of those included in this model. The physical detail of the proposed operations, that is form, line, colour and texture, will be reduced as distance from the viewing point increases. This effectively results in a reduction of potential impact.

It was predicted from the viewshed model that the proposed quarry would be partially visible from the residence to the north (View Point 2) (Figure 4.19). The model predicted that the south-east corner of the proposed quarry pit would be visible if there was an absence of screening vegetation, but it is likely that the remnant vegetation within Lot 14 will obscure the view from this residence. As structures were modelled at ground level (0 m) and the processing plant and other infrastructure are to be placed approximately 30 m below ground level, these structures will be effectively screened by the walls of the quarry pit.

The viewshed model predicted that there would be no visual impact on the residence to the west (View Point 3) (Figure 4.19). The topographic features of the landscape naturally screen the proposed operations from this viewing point.

The Project Area will not reduce public amenity, as the proposed operations will not be visible from public roads, such as Great Southern Highway and Horton Road. Photographic records were collected to demonstrate that the vegetation provides an effective screen for the operations. The line-of-sight from Great Southern Highway is presented in Plate 9, which shows that there is relatively dense vegetation to provide effective screening for the proposed operations. The line-of-sight from Horton Road is presented as Plate 10. The Project Area

will be situated approximately 500 m from Great Southern Highway and 250 – 600 m from Horton Road. There will be an adequate vegetative screen to prevent the proposed project from being visible from these public roads. Therefore, it is highly unlikely that the proposed quarry will be visible from users of Great Southern Highway or Horton Road.

Plate 9 Line-of-sight from Great Southern Highway looking north (0°), 1 km west of the main access road

Plate 10 Line-of-sight from Horton Road, looking south-east (130°), 1.5 km north of Great Southern Highway

During the night-time operation of the despatching facilities or during evening operations of the tertiary crusher circuit, lighting is required to allow for safe operation. The areas requiring lighting are the plant facilities, which are to be located approximately 30 m below ground level in the south-east corner of the pit.

The visual effect of lighting will vary depending on the location of the receiver and the type of lighting installed. There are three types of lighting effects that could be experienced with the use of conventional lighting:

- where lighting structures are directly visible and where the light source is directed at the viewer;
- where lighting structures are indirectly visible where the light source is not directed at the viewer; and
- general night-glow which results from light of sufficient strength from a single or multiple source being reflected in the atmosphere. As such it will also be influenced by atmospheric conditions such as fog, low cloud and/or dust particles, which will reflect the light. Conversely, on a clear night this effect would be lessened.

It is considered that there will be an extremely low potential for neighbouring residents to experience lighting impacts as the plant facilities will be located below ground and the lighting would be screened by the walls of the pit. Indirectly visible lighting and general night-glow may be experienced under some atmospheric conditions, such as when fog is present.

7.15.4 Management

The principal objective of the management plan for visual impacts is to ensure that the proposed operations do not compromise the aesthetic value of the surrounding environment.

Lighting impacts can be managed through a number of measures, the most effective being that of intervening topography and vegetation. Other strategies to be implemented include:

- Lighting will be kept to the minimum necessary for operational needs and safety.
- Lights will be installed at as low a level as possible and where possible, lights will be directed away from incoming views.
- Lights will be directed to the ground and work areas and avoid being cast over long distances.
- Where feasible, foreground planting at sensitive view locations such as residences that have direct line of sight to the quarry will be undertaken.
- Installation and use of appropriate lighting technology will be investigated to further minimise potential lighting impacts.

The visual modification of the landscape will be managed through the implementation of the following strategies:

- The topsoil stockpiles will be rehabilitated immediately after they have been constructed. Once the vegetation is established, the stockpiles will act as a screen and reduce the visual impact.
- Vegetation will be retained around the quarry to screen the operations from roads.
- Access routes will screened using native vegetation and roads will be angled away from the quarry to ensure that the line-of-sight is not directly at the quarry.
- The site will be kept tidy through the implementation of good house-keeping practices.
- The quarry pit and other disturbed areas within the site will be rehabilitated on a progressive basis to minimise the period of visually exposed surfaces.

COMMITMENT

The Visual Impact Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Visual Impact Management Plan during the construction and operational phases of the Project.

COMMITMENT

The Proponent will investigate and install appropriate lighting technology to minimise light overspill.

7.16 ABORIGINAL HERITAGE

7.16.1 Objectives and Standards

EPA Objectives

- Ensure that the proposal complies with the requirements of the *Aboriginal Heritage Act* 1972.
- Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.

Relevant Standards

EPA Guidance Statement (No. 41) for the Assessment of Aboriginal Heritage (EPA, 2001) was used to ensure that appropriate attention was given to the *Aboriginal Heritage Act* 1972. According to the Guidance Statement, the EPA will consider Aboriginal heritage matters to the extent that they may be affected by the impacts of the proposal on the physical or biological surroundings.

The assessment standards for Aboriginal heritage are the requirements of the *Aboriginal Heritage Act*.

7.16.2 Definition of Issue

No Aboriginal sites were recorded in the Project Area during the surveys and consultation conducted by Quartermaine (2002), Hart (2002) and O'Connor (2002).

7.16.3 Impact Assessment and Management

No specific management strategies are required as no Aboriginal sites are known to occur in the Project Area. In the event that Aboriginal heritage material is unearthed during proposal implementation, advice would be sought from the DIA.

7.17 EUROPEAN HERITAGE

7.17.1 Objectives and Standards

EPA Objectives

- Comply with the statutory requirements in relation to areas of cultural or historical significance.

Relevant Standards

The management of heritage sites must comply with the *Heritage of Western Australia Act* 1990.

7.17.2 Definition of Issue

The Traveller's Inn Ruins (Horton's Halfway House), is the only European heritage site in the vicinity of the Project Area. The ruins are listed on the Mundaring Municipal Heritage Inventory and are currently being assessed for heritage listing on the Register of the National Estate.

The Traveller's Inn Ruins are also listed on the Mundaring Municipal Heritage Inventory. The search of the inventory also showed that the Old Police Station located on Great Southern Highway has historical significance. The building is situated approximately 1.5 km west of the Project. It was restored in the early 1980s, and contains some doors and windows from the former Traveller's Inn.

7.17.3 Impact Assessment and Management

No specific management strategies are required as the proposed quarry relocation will not affect the Traveller's Inn Ruins or the Old Police Station.

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8. SUMMARY OF ENVIRONMENTAL MANAGEMENT COMMITMENTS

BGC's commitment to sound environmental management is reflected in its development and implementation of an EMS. In addition, the Proponent has developed a number of commitments specific to the environmental management of the proposed quarry relocation. These commitments are listed in Table 8.1.

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Table 8.1
Summary of the Proponent's Environmental Management Commitments

Environmental Factor	Commitment	Objective	Action	Timing (Phase)	Whose Advice	Measurement/Compliance Criteria
Environmental Management	1. Prior to the commencement of operations, the Proponent will develop an Environmental Management System that will address the environmental issues associated with quarrying activities.	To ensure sound and systematic environmental management of the construction, operation and closure of the Project.	The Proponent will prepare an EMS as part of the company's business management strategy. The EMS will include plans for the environmental management of relevant environmental aspects such as: • groundwater; • surface water; • topsoil; • vegetation; • dieback; • fauna; • dust; • noise • airblast and ground vibration; and • visual amenity.	Prior to the commencement of operations.	-	Comments and feedback received from the regulatory authorities.
	2. The Proponent will ensure that all employees and contractors have completed the environmental, health and safety induction training.	To increase the environmental awareness of the personnel on site.	A training programme will be developed and formal inductions will occur for all new employees and contractors. The induction will cover safety, and environmental issues and management.	Development and implementation of the training programme will occur prior to the commencement of operations. Personnel will be required to complete the induction prior to commencing work at the site.	-	-
	3. The Proponent will establish a community liaison group to facilitate two-way communication about the site operations.	To facilitate communication between the Proponent, community and other key stakeholders.	Discussions with members of the Lakes Action Group and the relevant government agencies will facilitate confirmation of the structure of the group. Meetings will be held on a regular basis to ensure that all participants are aware of, and can discuss, the Proponent's plans for the Project.	Commence during the public review period of the PER and continue through life of the Project.	Shire of Northam and other relevant stakeholders	Key aspects of the discussions will be presented in the site's newsletter (Quarry Update).
Vegetation	4. The Proponent will monitor vegetation condition within the Project Area during the construction and operational phases of the Project, as recommended by Environment Australia. The monitoring programme will encompass both woodland and heath communities.	To ensure that the vegetation within the Project Area is adequately protected.	A monitoring programme will be developed to identify any changes in vegetation condition as a result of the proposed operations.	During the operational phase of the Project.	CALM	The results of the monitoring will be reported in the Annual Environmental Report (AER) to the DEP.
	5. The Proponent will not disturb heath community H5 and will maintain a 50 m buffer around this community during all phases of the Project.	To protect the *Hemigenia viscida* within the Project Area is a significant plant species, particularly heath community H5 (which contains 95% of the population with the Project Area)	Avoid disturbing heath community H5 and monitor the health of this community.	Throughout the Project life.	CALM	Internal audits will be conducted and the results from these audits will be reported to the DEP in the AER.
	6. The Vegetation Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Vegetation Management Plan during the construction and operational phases of the Project.	To ensure that vegetation within the Project Area is adequately protected and that significant loss of priority flora does not occur.	The Proponent will adhere to the Vegetation Management Plan.	Throughout the construction and operational phases of the Project.	CALM and other relevant stakeholders	Internal audits will be conducted and the results from these audits will be reported to the DEP in the AER.

Table 8.1 (continued)

Environmental Factor	Commitment	Objective	Action	Timing (Phase)	Whose Advice	Measurement/Compliance Criteria
Fauna	7. The preliminary Fauna Management Plan will be further developed in consultation with CALM and other relevant stakeholders once the results of the vertebrate fauna field survey are available. The Proponent will implement the Fauna Management Plan during the construction and operational phases of the Project.	To minimise adverse impacts on fauna assemblages in the Project Area as a result of proposal implementation.	The Proponent will be reviewed and finalised. The Proponent will adhere to the Fauna Management Plan.	Throughout the construction and operational phases of the Project.	CALM and other relevant stakeholders	Internal audits will be conducted and the results from these audits will be reported to the DEP in the AER.
	8. The Proponent will conduct a follow-up trapdoor spider survey in topographically similar areas, particularly Mt Dale.	To determine whether *Gaius* sp. population exists in other topographically similar areas.	A field trapdoor spider survey will be conducted in areas that are topographically similar to the Project Area, so determine if *Gaius* sp. occurs in these areas.	Prior to the construction of the Project.	WA Museum	The results of these investigations will be reported to the DEP in the AER.
Biodiversity	9. The Revegetation Strategy will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Revegetation Strategy after the commencement of construction activities.	To off-set the clearing of vegetation as a result of the Project and maintain biodiversity within the catchment.	The Proponent will investigate options for revegetation based on the draft strategy and implement the revegetation projects in consultation with stakeholders.	Complete 50 ha of revegetation within two years from the approval date for the Project and the remainder by the time that operations at the existing quarry cease.	CALM	The results of the strategy will be reported to the DEP in the AER.
Landform and Soil	10. The Soil Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Soil Management Plan during the construction and operation of the proposed quarry.	To minimise the risk of land degradation and maintain or improve landscape functionality.	The Soil Management Plan will be reviewed and finalised, and the Proponent will adhere to the plan.	The plan will be finalised prior to construction and implemented throughout the construction and operational phases of the Project.	Department of Agriculture, WRC and other relevant stakeholders	Internal audits will be conducted and the results from these audits will be reported to the DEP in the AER.
Surface Water	11. The Surface Water Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Surface Water Management Plan during the construction and operational phases of the Project.	To minimise erosion on site, particularly during the construction phase of the Project, and to ensure that water in excess of quarry requirements is of suitable quality so that it does not adversely impact downstream flows or water quality.	The Surface Water Management Plan will be reviewed and finalised, and the Proponent will adhere to the plan.	The plan will be finalised prior to construction and implemented throughout the construction and operational phases of the Project.	Department of Agriculture, WRC and other relevant stakeholders	Internal audits will be conducted and the results from these audits will be reported to the DEP in the AER.
	12. The Proponent will obtain a permit from the WRC to modify the bed and banks of the western stream.	To ensure that the modifications to the western stream are acceptable and conducted according to WRC requirements.	The Proponent will liaise with members of Swan Goldfields Agricultural Region (Northam) office to obtain a permit to modify the western stream.	Prior to the commencement of operations.	WRC	The results of the modifications will be reported to the DEP and WRC in the AER.
	13. The Proponent will sample the water in the pit sump and plant storage for TDS, TSS and EC, prior to release. The water quality results for the samples will meet the criteria in the DEP licence prior to release.	To ensure that the quarry operations do not adversely impact on downstream flows or water quality.	The pit water will be sampled and analysed by a National Association of Testing Authorities (NATA) accredited laboratory prior to release to the environment.	Prior to the release of excess water to the environment.	WR	Records of laboratory results will be internally audited on six monthly basis or as required under the DEP licence.

Table 8.1 (continued)

Environmental Factor	Commitment	Objective	Action	Timing (Phase)	Whose Advice	Measurement/Compliance Criteria
Groundwater	14. The Groundwater Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Groundwater Management Plan during the construction and operational phases of the Project.	To protect the quality and quantity of groundwater available to other users, including the environment.	The Groundwater Management Plan will be reviewed and finalised, and the Proponent will adhere to the plan.	The plan will be finalised prior to construction and implemented throughout the construction and operational phases of the Project.	Department of Agriculture, WRC and other relevant stakeholders.	Internal audits will be conducted and the results from these audits will be reported to the DEP and WRC in the AER.
	15. The Proponent will monitor quantity and quality of seepage inflow and the depth of water in monitoring bores.	To develop a sound understanding of the site water balance during various stages of the Project.	Sample any seepage inflow in the pit to characterise flows.	Operational phase.	-	Internal audits will be conducted and the results from these audits will be reported to the DEP in accordance with licence requirements.
	16. The Proponent will install a monitoring bore between the proposed quarry and the nearest private bore.	To monitor variations in groundwater levels within the cone of drawdown and outside the cone-of drawdown.	Install a monitoring bore at a suitable location between the proposed quarry and nearest private bore. Monitor the groundwater levels on a monthly basis.	Install the bore prior to the commencement of construction activities. Monitor water levels throughout the life of the Project.	-	Records of the monitoring data will be kept on site and reviewed on a six monthly basis. Data will be reported to the DEP in the AER.
	17. The Proponent will monitor the amount of groundwater abstracted from the quarry sump and from any pumps placed in the two south-eastern bores.	To provide additional information for the determination of the site water balance during the various stages of the Project.	Record the volumes of water abstracted from the quarry sump.	Operational phase.	WRC	Records of the monitoring data will be kept on site and reviewed on a six monthly basis. Data will be reported to the DEP in the AER.
Noise and Vibration	18. BGC will undertake building surveys of nearest residences prior to the commencement of the proposed operation to provide a baseline against which claims of damage due to ground vibration can be evaluated. A copy of the results will be provided to the relevant residents.	To evaluate damage caused by ground vibration as a result of the blasting conducted at the existing quarry operations.	The Proponent will conduct the building surveys prior to the commencement of the proposed operations and provide a copy of the results to the residents.	Prior to the commencement of operations.	-	Results of the surveys will be provided to the DEP in the AER.
	19. The Airblast and Ground Vibration Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Airblast and Ground Vibration Management Plan during the construction and operational phases of the Project.	To ensure that noise and vibration levels comply with statutory requirements.	The Airblast and Ground Vibration Management Plan will be reviewed and finalised, and the Proponent will adhere to the plan.	The plan will be finalised prior to construction and implemented throughout the construction and operational phases of the Project.	-	Internal audits will be conducted and the results from these audits will be reported to the DEP in accordance with licence conditions.
Dust and Particulates	20. The Dust Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Dust Management Plan during the construction and operational phases of the Project.	To ensure the levels of dust and particulate emissions are miniised.	The Dust Management Plan will be reviewed and finalised, and the Proponent will adhere to the plan.	The plan will be finalised prior to construction and implemented throughout the construction and operational phases of the Project.	-	Internal audits will be conducted and the results from these audits will be reported to the DEP in the AER.
Flyrock	21. BGC will monitor blasting over a 12-month period by videotaping each blast. The tapes will be reviewed to confirm that flyrock is being contained within the site boundaries.	To ensure that flyrock is confined within the quarry pit.	The Proponent will videotape and review the tape for every blast for a 12-month period.	During the fist 12 months of the operational phase of the Project.	MPR	Tapes will kept on record. Results will be reported to the DEP in the AER.

Table 8.1 (continued)

Environmental Factor	Commitment	Objective	Action	Timing (Phase)	Whose Advice	Measurement/Compliance Criteria
Visual Amenity	22. The Visual Impact Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Visual Impact Management Plan during the construction and operational phases of the Project.	To minimise the visual impact of the Project.	The Proponent will adhere to the Visual Impact Management Plan.	Throughout the construction and operational phases of the Project.	-	Internal audits will be conducted and the results from these audits will be reported to the DEP in the AER.
	23. The Proponent will investigate and install appropriate lighting technology to minimise light overspill.	To ensure that the most suitable lighting technology is used for the Project.	The Proponent will investigate and implement the most appropriate lighting technology for the site.	Prior to the commencement of operations.	-	The results of the investigation will be reported to the DEP in the AER.
Site Decommissioning and Closure	24. Prior to closure of the Project, the Proponent will review its planning for the closure, decommissioning and rehabilitation of the Project. This review will address, but will not necessarily be limited to, the following: • the removal of infrastructure; • the rehabilitation of disturbed areas in the Project Area; • the development of a closure solution for the quarry pit, which is acceptable to regulatory authorities; and • the identification and remediation of any contaminated areas (if any exist at the time).	To ensure that the Project Area is left in a safe and stable condition, so there is no future liability for the Proponent or the State.	Planning for the closure, decommissioning and rehabilitation of the Project will be reviewed by the Proponent in consultation with relevant government agencies and other stakeholders.	During the operational phase of the Project.	WRC, CALM and other relevant stakeholders	The findings of the review will be reported through the AER to the DEP.
	25. In the event that the quarry pit is to be left open (i.e. not backfilled), BGC will assess the long-term stability of the pit edge and fractured rock zone as part of its closure planning process. The findings of this assessment and any management measures required to ensure that any risk to public safety is minimised, will be documented in the site's decommissioning and closure plan.	To ensure that the post-mining landform is safe, stable and non-erodible.	If the quarry pit is to be left open, the Proponent will conduct appropriate geotechnical investigations to determine the potential zone of instability and will investigate the management measures (such as construction of an abandonment bund and installation of signage) that would be required.	During the operation of the Project.	DMPR and other relevant stakeholders	Comments from stakeholders on the site's draft decommissioning and closure plan.

9. CONCLUSION

The implementation of the proposed quarry relocation will result in the clearing of approximately 85 ha of native vegetation within the Shire of Northam, which has less than 20% remnant vegetation remaining in its main agricultural area. The 1997 MoU for the Protection of Remnant Vegetation on Private Land in the Agricultural Region of Western Australia states that there is a general presumption against clearing in this shire unless the proponent can demonstrate that land degradation and loss of biodiversity will not occur. The impact assessment conducted for this project, which comprised a range of technical studies and comprehensive community and government consultation, has indicated that land degradation and loss of biodiversity will not occur, though there may be some reduction in botanical values due to the clearing. These issues are discussed below.

Concern has been raised that clearing of vegetation in the Project Area will result in increased salinisation of the Upper Wooroloo Catchment. However, the surface water assessment and water balance prepared for the proposed quarry indicates that this is highly unlikely to occur. BGC's commitment to revegetate areas within the catchment will also help reduce the risk of land degradation due to this or other land uses in the area.

On-site water movement and any releases to the environment will be managed under a site surface water management and monitoring plan. Any groundwater seepage, direct rainfall and stormwater runoff occurring in the quarry pit will be stored for use in processing and dust suppression, and little groundwater recharge is expect to occur. Excess water will only be released if stringent water quality criteria are met, and will be discharged only during the wetter months when natural flow is occurring or likely to occur.

If discharge occurs, this will be directed to the stream located to the west of the existing quarry. This "western stream" has been modified previously and will be reconstructed to restore the shape of the channel and ensure that it is not erosionally unstable. This is an important environmental benefit of the Project.

The Project Area is vegetated by jarrah and marri woodlands with restricted areas of wandoo woodlands. These communities have previously been logged. Heath communities also occur in the Project Area, some of which support *Hemigenia viscida*, a species which is classified as Priority 4 (Rare Taxa) on the State DRF and PF List and as Vulnerable under the Commonwealth EPBC Act. This species was previously classified as DRF by the State, which resulted in its classification under the EPBC Act. However, the conservation status of this species was downgraded to Priority 4 (Rare Taxa) by the State and it is reasonable to assume that its EPBC Act classification will be reviewed in due course. The development of the proposed quarry will result in clearing of approximately 5% of the *Hemigenia viscida* population. However, BGC has made a commitment to protect heath community H5 which contains 95% of the *Hemigenia viscida* population present within the Project Area. This includes the establishment of a 50 m wide buffer around the community.

Clearing of vegetation within the Project Area will result in the localised loss of habitat for vertebrate and invertebrate fauna. This will have an initial impact in terms of the loss of non-mobile and/or poorly dispersing species occupying the site, such as reptiles, small mammals and invertebrates. However, the retention and protection of some of the heath habitats in the Project Area will reduce the impact on poorly dispersing species such as the Honey Possum. Mobile species such as the Chuditch and Western Brush Wallaby are expected to move away from the impacted area and relocate in suitable habitat nearby. During the relocation process some territorial conflicts associated with competition for food resources, shelter and breeding sites may result, but populations would be expected to stabilise once conflicts are resolved.

Overall, the impact on the vertebrate and invertebrate fauna as a result of the Project is expected to be minor considering the limited distribution of suitable habitat for many species within the site. The area has few mature habitat trees present with suitable hollows for nesting or refuge. The relative lack of suitable habitat trees reduces the likelihood that the project would have a significant impact on threatened or migratory species that may occur in the area.

BGC has developed a revegetation strategy to replace some of the local botanical values that will be reduced as a result of clearing approximately 85 ha of vegetation within the Project Area. The strategy comprises planting native vegetation in the Upper Wooroloo Brook Catchment within the Shire of Northam at a ratio of 2:1 for the cleared area of vegetation. BGC has made a commitment to undertake a third of the proposed area within two years of the approval date for the project, and to complete the revegetation programme within five years of project approval. A working group comprising representatives from BGC, the DEP, CALM, the Wooroloo Brook LCDC and other relevant stakeholders will be established to assist BGC in the detailed design of the programme.

The revegetation programme represents a significant environmental benefit to the Upper Wooroloo Brook catchment which is experiencing increasing encroachment of dryland salinity.

Management of noise, airblast and ground vibration, and the minimisation of impacts on nearby residents, are also critical issues that require vigilance and responsive management. Monitoring of noise, airblast and ground vibration at the existing Voyager Quarry has shown that BGC is usually within its licence requirements. However, to reduce potential sources of noise and dust, the plant required for the proposed quarry will be located within the proposed quarry pit approximately 30 m below ground surface, and will be upgraded to reduce potential sources of noise.

BGC is committed to continual improvement of its environmental management of the existing Voyager Quarry. For example, BGC has restricted the hours of operation of the existing primary crusher to reduce the impacts on these residents due to noise during evenings and nights. In addition, noise control measures at the existing plant have been upgraded to minimise noise generation. BGC is also installing permanent noise monitoring sites around the existing and proposed Project Areas to enable BGC to monitor noise levels more effectively and respond to any public complaints.

BGC has also made significant improvements in its blasting techniques, which have reduced the risk of flyrock and ground vibration levels. These include increasing the delays on the initiation of the blast, improved drilling practices and improvements in the manufacturer's products (initiators and explosives). BGC has made a commitment to video-tape every blast over a 12-month period to ensure that flyrock does not exit the Project Area and will also continue to monitor ground vibration.

BGC will carry its commitment to continual improvement in environmental practices through to the proposed quarry relocation through the development and implementation of an EMS as part of its Quality System, which has been developed in accordance with ISO 9002. In addition, BGC is establishing a Community Liaison Group as a key mechanism for continuing government and community consultation and liaison regarding site operations.

Implementation of the proposed quarry relocation, which is proposed for an area identified under the State's Basic Raw Materials Planning Policy as a Key Extraction Area, will result in substantial benefits to:

- the State (through royalties and taxes);
- the local community (through financial support for local businesses and income for the Shire);
- the Perth metropolitan community (through the maintenance of low costs for building and housing materials); and
- BGC owners and employees (through the provision of jobs and profits).

Other benefits include:

- The continued supply of crushed rock for the Western Australian construction industry;
- reduced pressure to develop new quarries in the Darling Scarp area;
- maintenance of low cost of supplies of hard rock to the Perth metropolitan market; and
- maintenance of competition in the Perth metropolitan market.

There would be significant consequences if the proposed quarry relocation does not proceed and these are likely to have widespread ramifications that could adversely impact the Perth Metropolitan Region and elsewhere within WA. These include:

- market implications, as a shortage of crushed rock to meet the demand in the Perth metropolitan region will result in a price increase for the product, which in turn will lead to increased costs for housing;
- increased pressure for existing quarries to expand to provide the quantities of crushed rock that is required for the Perth metropolitan region. The expansion of quarry operations on the Darling Scarp, which are more visible from the Swan Coastal Plain, will reduce the visual amenity of the Scarp;
- a loss of social and financial opportunities within the local community, particularly for those local businesses, sporting clubs and community projects supported by BGC.
- a loss of jobs within BGC and potentially within the suppliers that service the operation.

The findings of the technical and other studies conducted in relation to the assessment of the proposed quarry relocation indicate that, subject to the successful implementation of the environmental management strategies, programmes and commitments documented in this PER, all project activities and environmental impacts are manageable, and that the proposed quarry relocation will not cause significant adverse environmental impact. Therefore, it is submitted that the proposed quarry relocation should be approved.

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10. ACKNOWLEDGEMENTS

10.1 STUDY TEAM

The following personnel contributed to the production of this PER and/or supporting documentation:

BGC (Australia) Pty Ltd

- Mr Frank Italiano, General Manager, BGC Quarries;
- Mr Graham Kierath, Manager, BGC Corporate; and
- Mr Paul Berkhout, Quarry Manager.

URS Australia Pty Ltd

- Mr Ian LeProvost – project advisor and report editor;
- Ms Sonia Finucane – project manager, community and government consultation, report editor;
- Mr Gary Meyer – groundwater aspects;
- Dr Robin Connolly – surface water aspects;
- Mr Larry Clark – noise and ground vibration aspects;
- Mr Jim Singleton – visual aspects;
- Dr Don Burnside - community consultation;
- Ms Lynda Harding - community consultation;
- Mr Tim Mitchell – greenhouse gas aspects;
- Mr Phil Mason – greenhouse gas aspects;
- Ms Karen Lee – data collation, community and government consultation, report production;
- Mr Ross Hamilton – data collation, community and government consultation;
- Ms Katrina Burke – report production;
- Ms Michelle Rigo – report production;
- Mr Will Blackshaw – cartography;
- Mr Justin Dwyer – cartography; and
- Ms Sharmalie Ranjithkumar – report production.

Specialist Subconsultants

- Martine White Consultancy Services;
- Riley Mathewson Public Relations;
- Herring Storer Acoustics;
- Mattiske Consulting Pty Ltd;
- Ninox Wildlife Consulting;
- Glevan Dieback Consultancy Services;
- R & E. O'Connor Pty Ltd;
- Quartermaine Consultants;
- Western Australian Museum; and
- CAD Resources.

10.2 CONSULTATION PROGRAMME PARTICIPANTS

The advice of, and input from, the following persons during the consultation programme and preparation of this document is gratefully acknowledged:

- Ms Amanda Arkell, Member, Lakes Action Group;
- Dr Ken Atkins, Principal Botanist, Department of Conservation and Land Management;
- Ms Deborah Bailey, Member, Lakes Action Group
- Mr Bernard Bowen, Chairman, Environmental Protection Authority;
- Mr Paul Brown, Swan Regional Estate Manager, Department of Conservation and Land Management;
- Ms Shelley Brady, Member, Lakes Action Group;
- Mrs Jackie Carter, Vetters West;
- Mr Peter Carter, Vetter West;
- Ms Kathryn Clarkson, Natural Resource Management Officer, Water and Rivers Commission;
- Mr John Dandie, Member, Lakes Action Group;
- Mr Peter Dans, District Manager, Perth Hills District, Department of Conservation and Land Management;

- Mr John Dell, Environmental Officer, Ecological Systems, Department of Environmental Protection;
- Mr Brian Dibble, Member, Lakes Action Group;
- Mr Stephen Elliott, State Manager WA, Rocla Quarry Products;
- Mr Tony (J.A.) Friend, Principal Research Scientist, Department of Conservation and Land Management
- Mr Tim Gentle, Manager, Mining and Petroleum Assessments, Department of Environmental Protection;
- Mr Brad Gleeson, Manager Planning Service, Shire of Mundaring;
- Ms Jade Gorton, Programme Manager, Environmental Protection, Water and Rivers Commission;
- Mr Mike Grasby, Wooroloo Brook Land Conservation District Committee;
- Ms Pat Guardhouse, Secretary, Chidlow Progress Association;
- Mr Ron Harkan, Member, Lakes Action Group;
- Mrs Toni Harkan, Member, Lakes Action Group;
- Mr Maurice Hoyle, Member, Lakes Action Group;
- Mr Bob Huston, Wooroloo Brook Land Conservation District Committee;
- Mrs Rikki Lister, Member, Lakes Action Group;
- Mr Mick McCarthy, Executive Manager, Environmental Services, Eastern Metropolitan Regional Council;
- Mr Keiran McNamara, Acting Executive Director, Department of Conservation and Land Management;
- Mr Allan Middleton, Chief Executive Officer, Shire of Northam;
- Dr Bob (R.A.) Nulsen, Manager Natural Resources, Department of Agriculture;
- Mrs Sue Pederick, Secretary, Lakes Action Group;
- Mr Peter Popoff-Asotoff, Environmental Officer (Noise), Department of Environmental Protection;
- Ms Caitlin Prowse, Operations Officer, Department of Conservation and Land Management;
- Mr Sri Ramanaphan, Executive Manager, Planning Services, Shire of Mundaring;

- Mr John Rampton, Industry Development Officer, Chamber of Commerce and Industry;
- Mrs Jacky Reeves, Member, Lakes Action Group;
- Mr Michael Reeves, Member, Lakes Action Group;
- Mr Martin Revell, District Manager, Swan Goldfields Agricultural Region, Water and Rivers Commission;
- Mr Neil Roberts, Chair, Lakes Action Group;
- Ms Rachel Siewert, Co-ordinator, Conservation Council of Western Australia;
- Mr Simon Sorokine, Member, Lakes Action Group;
- Mrs Suzanne Sorokine, Member, Lakes Action Group;
- Mr Ben von Perger, Environmental Officer, Department of Environmental Protection;
- Mr Andrew Watson, Deputy Commissioner for Soil and Land Conservation, Department of Agriculture;
- Mr Max Williams, Chief Executive Officer, Shire of Mundaring.

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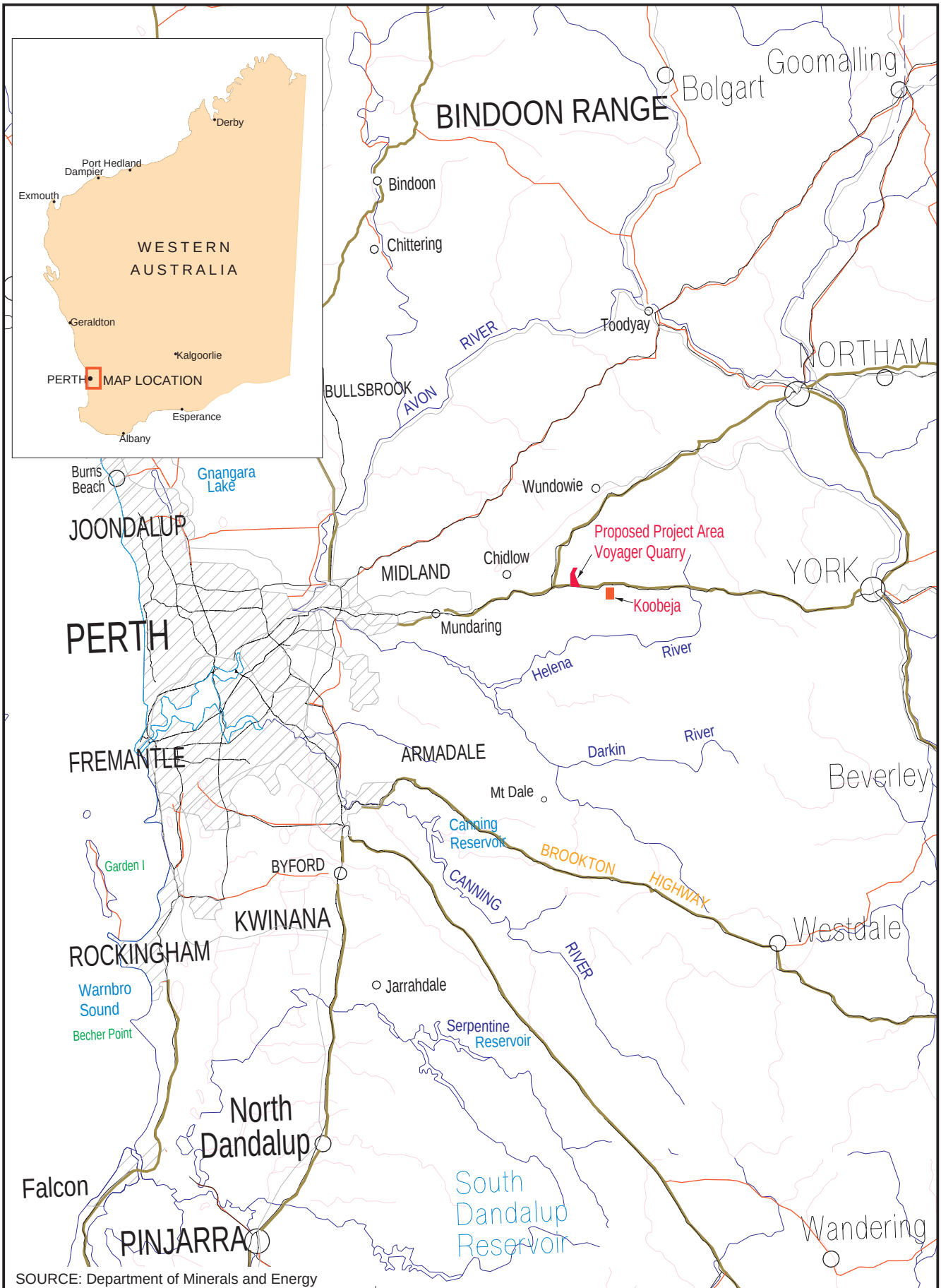
12. ABBREVIATIONS

ABT	Airblast Technology Pty Ltd
AGO	Australian Greenhouse Office
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environmental and Conservation Council
ANZMEC	Australian and New Zealand Minerals and Energy Council
BGC	Buckeridge Group of Companies
°C	Degrees Celcius
CALM	Department of Conservation and Land Management
CAMBA	China Australia Migratory Birds Agreement
dB	Decibels
dBA	Decibels (A-weighted, which is the measure of a sound to approximate the frequency response of the normal human ear)
DEP	Department of Environmental Protection
DME	Department of Minerals and Energy
DOLA	Department of Land Administration
DRF	Declared Rare Flora
EC	Electrical Conductivity
EMS	Environmental Management System
ENM	Environmental Noise Model
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GHG	Greenhouse Gases
ha	Hectares
IPCC	Intergovernmental Panel on Climate Change
JAMBA	Japan Australia Migratory Birds Agreement
kg	Kilograms
kL	Kilolitres
km	Kilometres
m	Metres
m^3	Cubic Metres
mg/L	Milligrams/litre
$\mu g/m^3$	Micrograms per cubic metre
MIC	Maximum Instantaneous Charge
mm	Millimetres
µm	Micrometre
mm/s	Millimetres per seconds
µS/cm	Microseimens per centimetre
MCA	Minerals Council Australia
MHA	McDonald Hales and Associates
MOU	Memorandum of Understanding
MPR	Department of Mineral and Petroleum Resources
Mt	Million tonnes
NATA	National Association of Testing Authorities of Australia
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NES	National Environmental Significance
NOI	Notice of Intention
PER	Public Environmental Review
PDWSA	Public Drinking Water Source Area
RL	Relative Level

sp.	Species (singlular)
spp.	Species (plural)
SWAT	Soil Water Assessment Tool
TDS	Total Dissolved Solids
tpa	Tonnes per annum
WD	Water Depth
WRC	Water and Rivers Commission



SOURCE: Department of Minerals and Energy

Figure 1.1

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

REGIONAL LOCATION MAP

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

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Tue 31 Dec 02

436000 mE
438000 mE
440000 mE
442000 mE
6476000 mN
6474000 mN

N

0 500 1000 m

Scale
MGA94 (Zone 50)

Residence A
Residence B
Residence C
Residence D
Residence E
Residence F

30m Buffer
Existing Bund
Primary Crusher
Dam
Stockpile Area
Tertiary Crusher
Office
Existing Bund
Weighbridge
Screens & Stackers
Surge Pile
Primary Crusher
Offices, Lab & Workshop
Topsoil Stockpiles
Main Access Road

-50m
-5m
-30m
-5m

CATCHMENT BOUNDARY

SOURCE: DOLA, Water and Rivers

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PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

LAYOUT OF EXISTING AND PROPOSED OPERATIONS

Figure 1.2

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Tue 31 Dec 02

440000mE

439000mE

438000mE

6475000mN

6474000mN

6473000mN

Existing Stockpiles

Existing Primary Crusher

Existing Quarry Dam

Existing Tertiary Crusher

Existing Office

Existing Bund

Existing Quarry Bund

Existing Quarry Bund

Existing Quarry Pit

Weighbridge

Screens & Stackers

-5m

-5m

-30m

30m Buffer

Surge Pile

Dam

-50m

Stockpile Area

Offices, Lab & Workshop

Primary Crusher

Topsoil Stockpiles

Approximate Scale: 1: 8000

0 500m

Photo Captured 18 May 2002 by Survey Graphics

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PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

LAYOUT OF EXISTING AND PROPOSED OPERATIONS (CLOSE-UP)

Figure 1.3

URS

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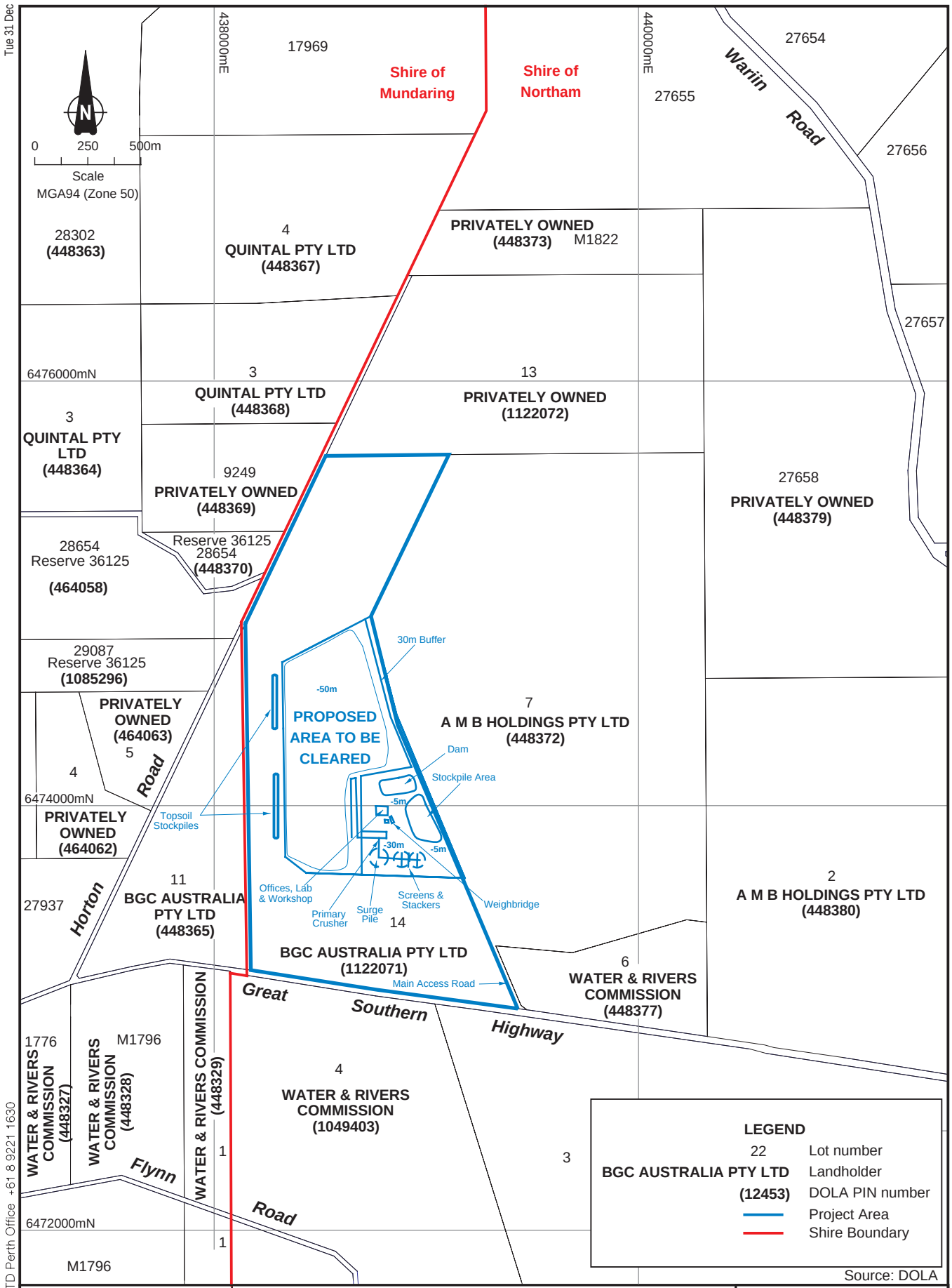

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

LAND TENURE

Figure 1.4

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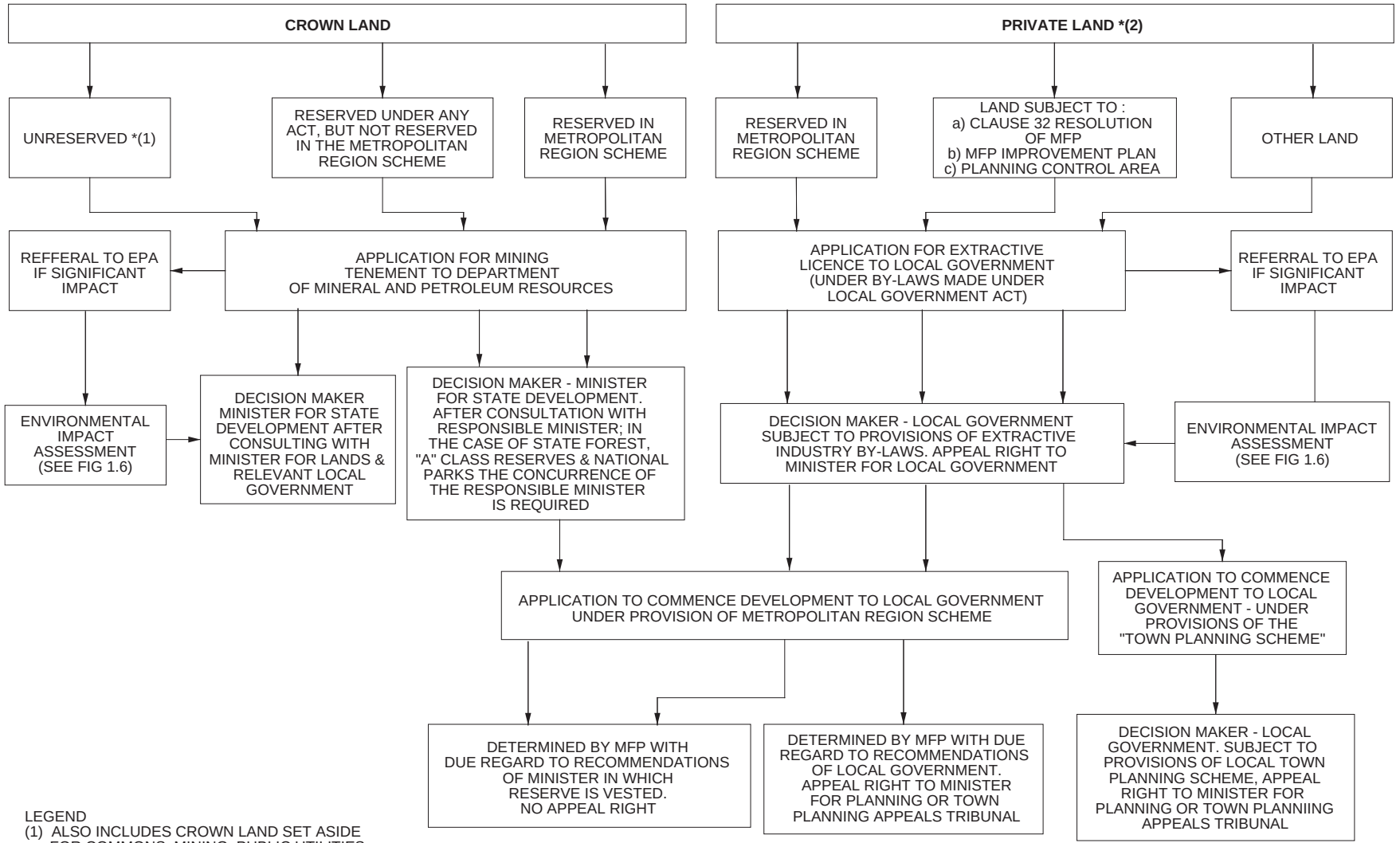
PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

GENERAL PROCEDURE TO OBTAIN CONSENT FOR AN EXTRACTIVE OPERATION

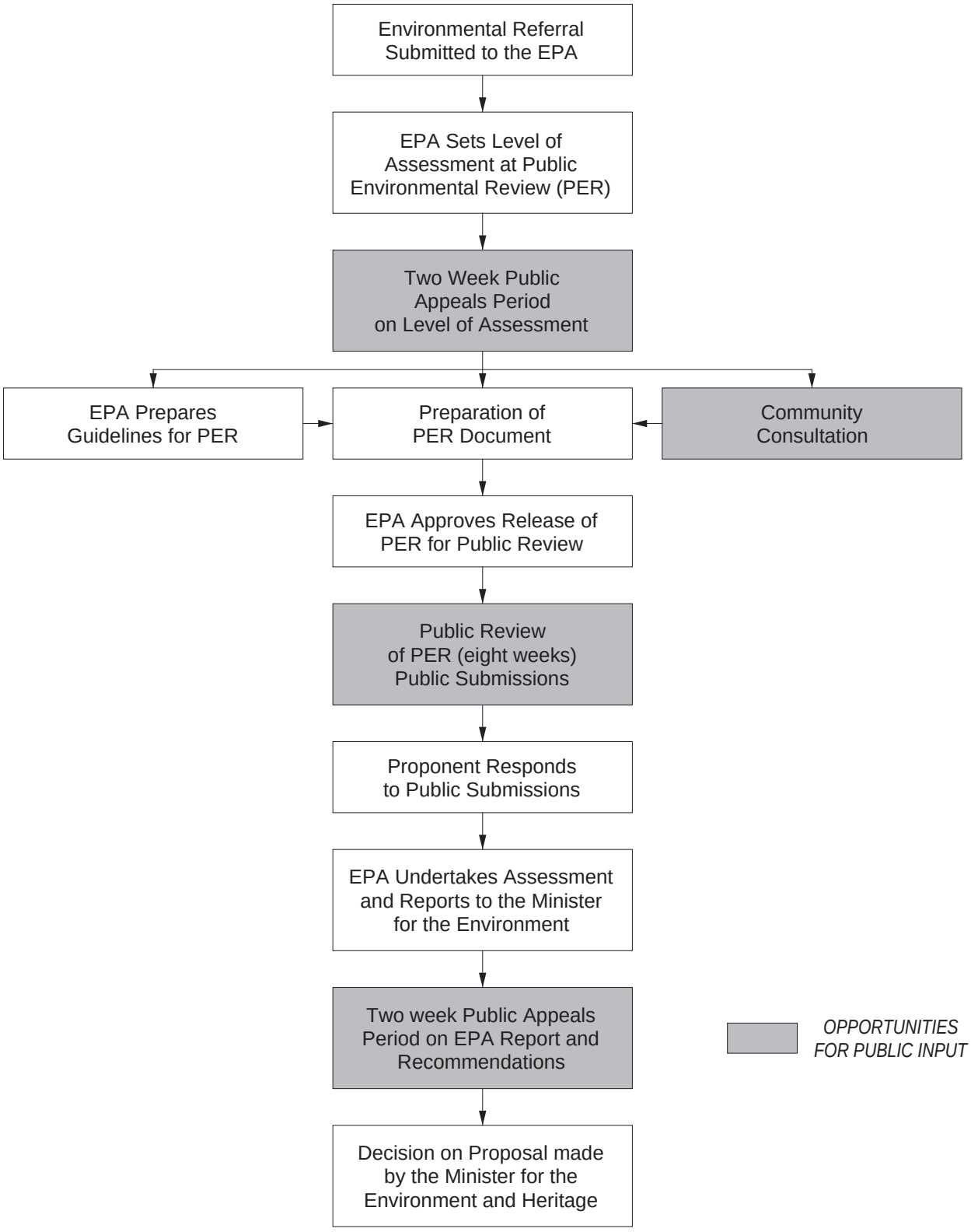


LEGEND
(1) ALSO INCLUDES CROWN LAND SET ASIDE FOR COMMONS, MINING, PUBLIC UTILITIES, TIMER OR LAND UNDER PASTORAL LEASES
(2) ON PRIVATE LAND, THE PRIOR CONSENT OF THE LAND OWNER IS REQUIRED

SOURCE: DME, 1994

URS

Figure 1.5



PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

ENVIRONMENTAL ASSESSMENT PROCESS

Figure 1.6

Tue 31 Dec 02

BORAL QUARRIES
Shire of Toodyay
Key Extraction Area

READYMIX GROUP
City of Swan
Priority Extraction Area

MIDLAND BRICK COMPANY
City of Swan
Priority Resource Area

PIONEER CONCRETE
City of Swan
Key Extraction Area

SHANNON EQUITY
Shire of Northam
Priority Extraction Area

BGC QUARRIES
Shire of Northam
Key Extraction Area

BORAL QUARRIES
City of Gosnells
Key Extraction Area

READYMIX GROUP
City of Gosnells
Key Extraction Area

PIONEER QUARRIES
Shire of Serpentine-Jarrahdale
Key Extraction Area

RANSBURG PTY LTD
Shire of Serpentine-Jarrahdale
Priority Resource Area

Toodyay
Northam
Wanneroo
Midland
PERTH
Mundaring
York
Beverley
Fremantle
Armadale
Kwinana
Rockingham
Rottnest Island
Garden Island

Avon River
Swan River
Canning River
Serpentine River

Brand Highway
Wanneroo Road
Northern Road
Great Eastern Highway
Great Eastern Highway
Toodyay Road
Great Southern Highway
Albany Highway
South Western Highway
Brookton Highway
Mandurah Road

25 km radius
50 km radius
75 km radius
100 km radius

0 10 20 km
SCALE 1 : 400 000 at A3

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

EXISTING HARD ROCK QUARRIES IN PERTH AND SURROUNDS

Figure 2.1

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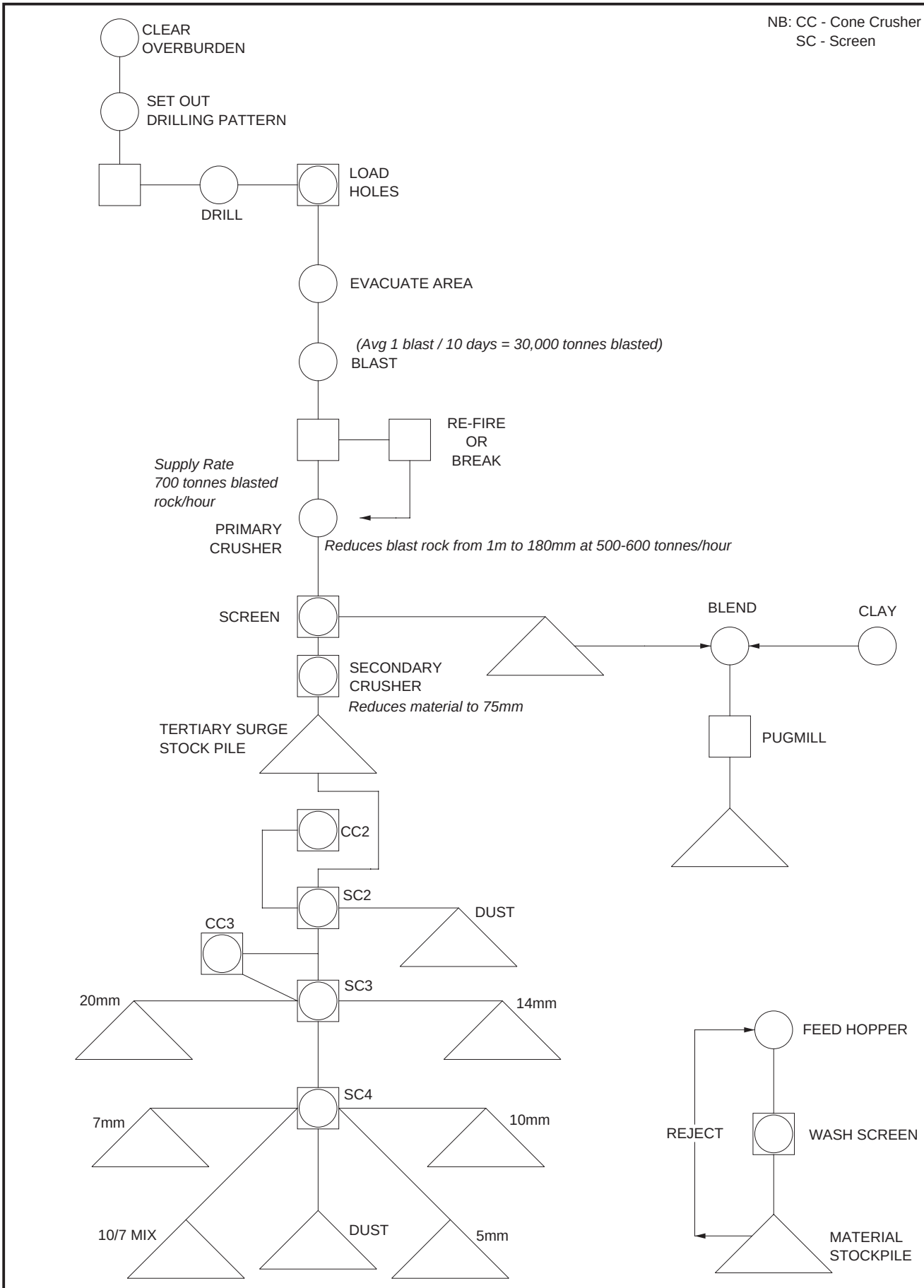
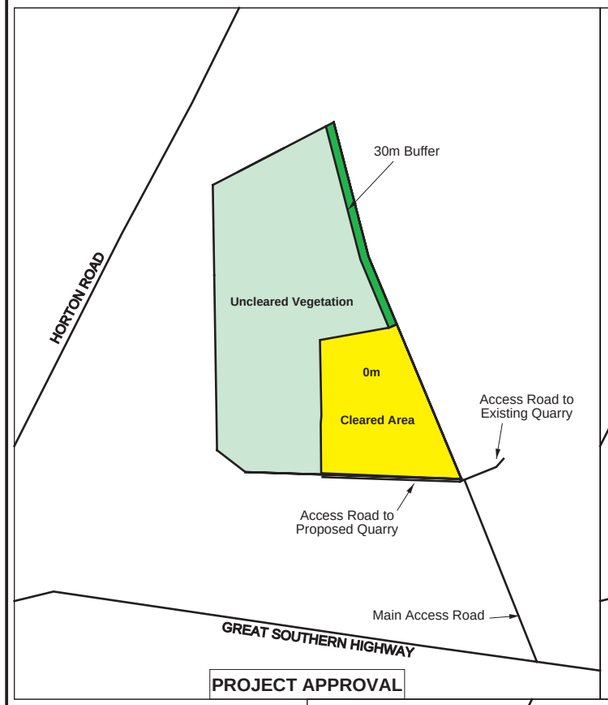


PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

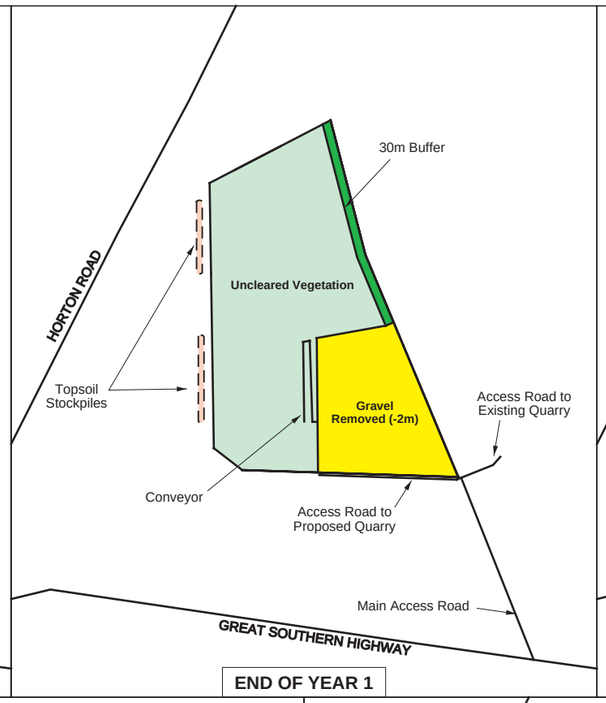
PROCESS FLOW CHART

Figure 3.1

Tue 31 Dec



PROJECT APPROVAL



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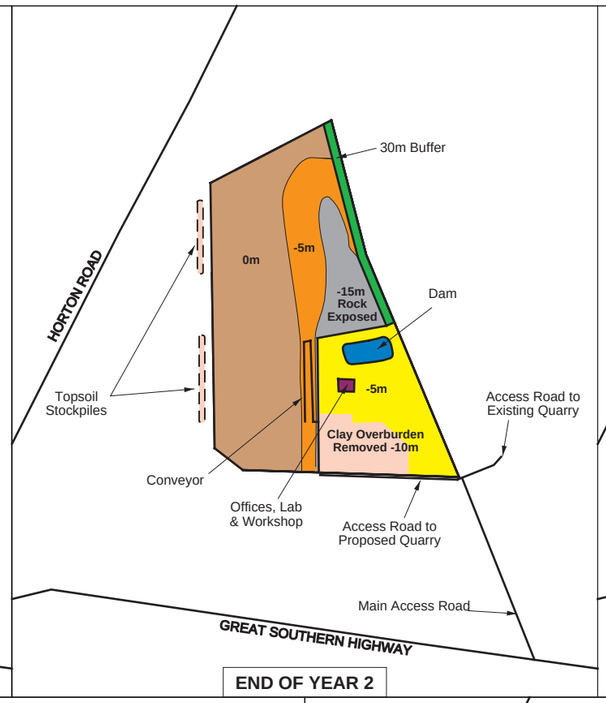

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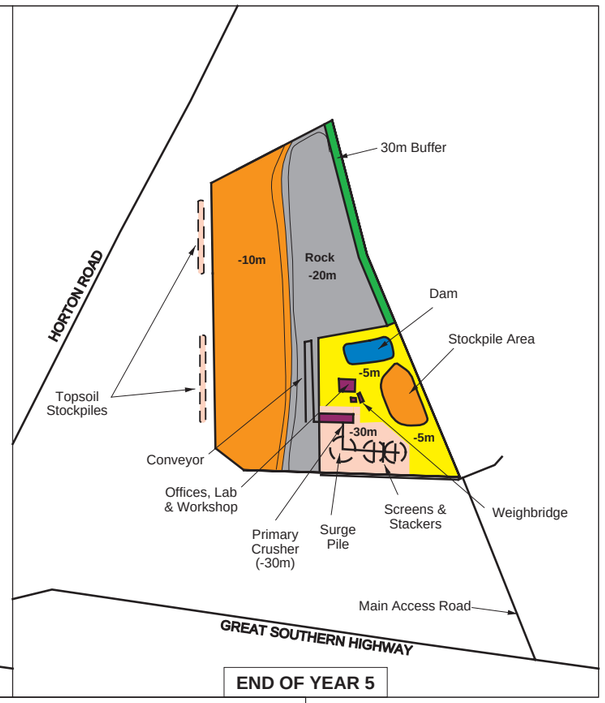

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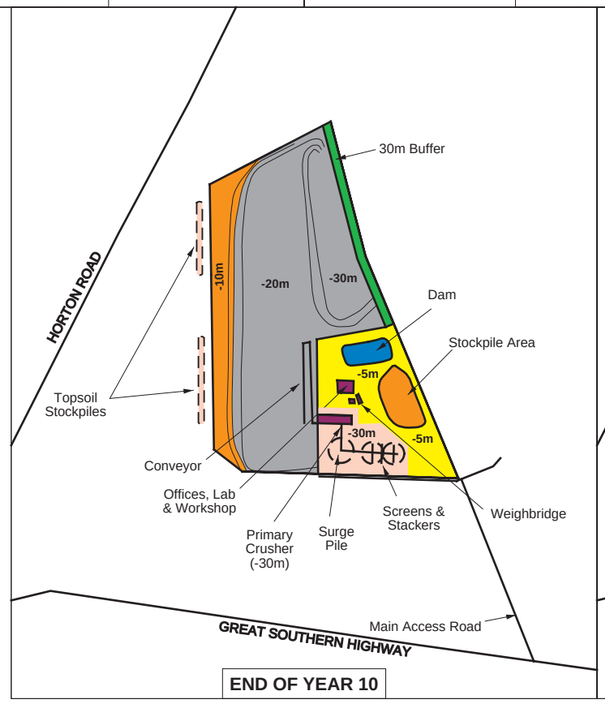
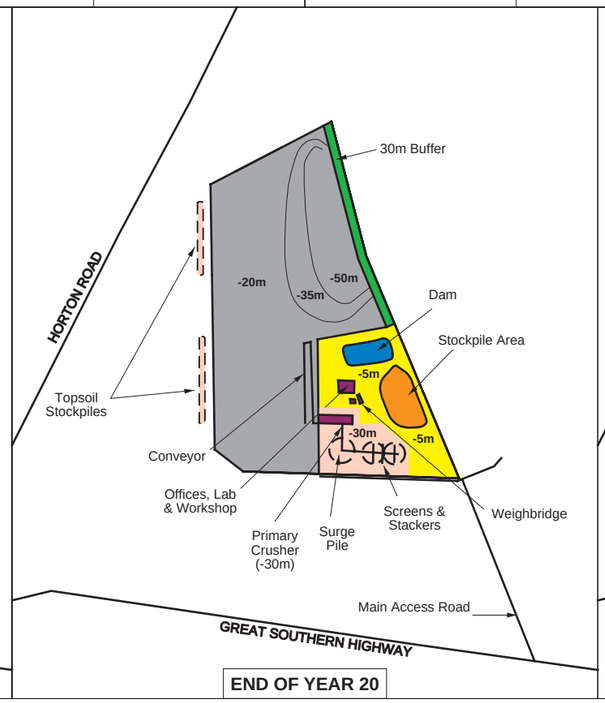


END OF YEAR 10



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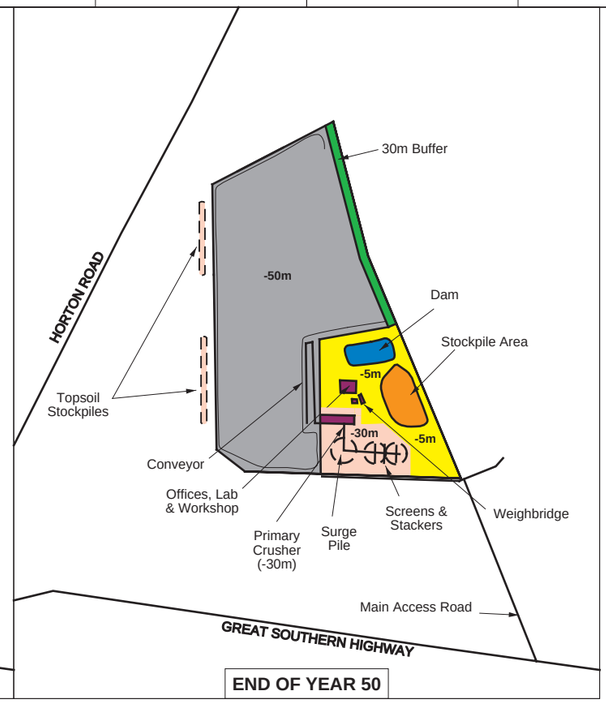

END OF YEAR 50

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PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

INDICATIVE STAGES OF DEVELOPEMENT

Figure 3.2

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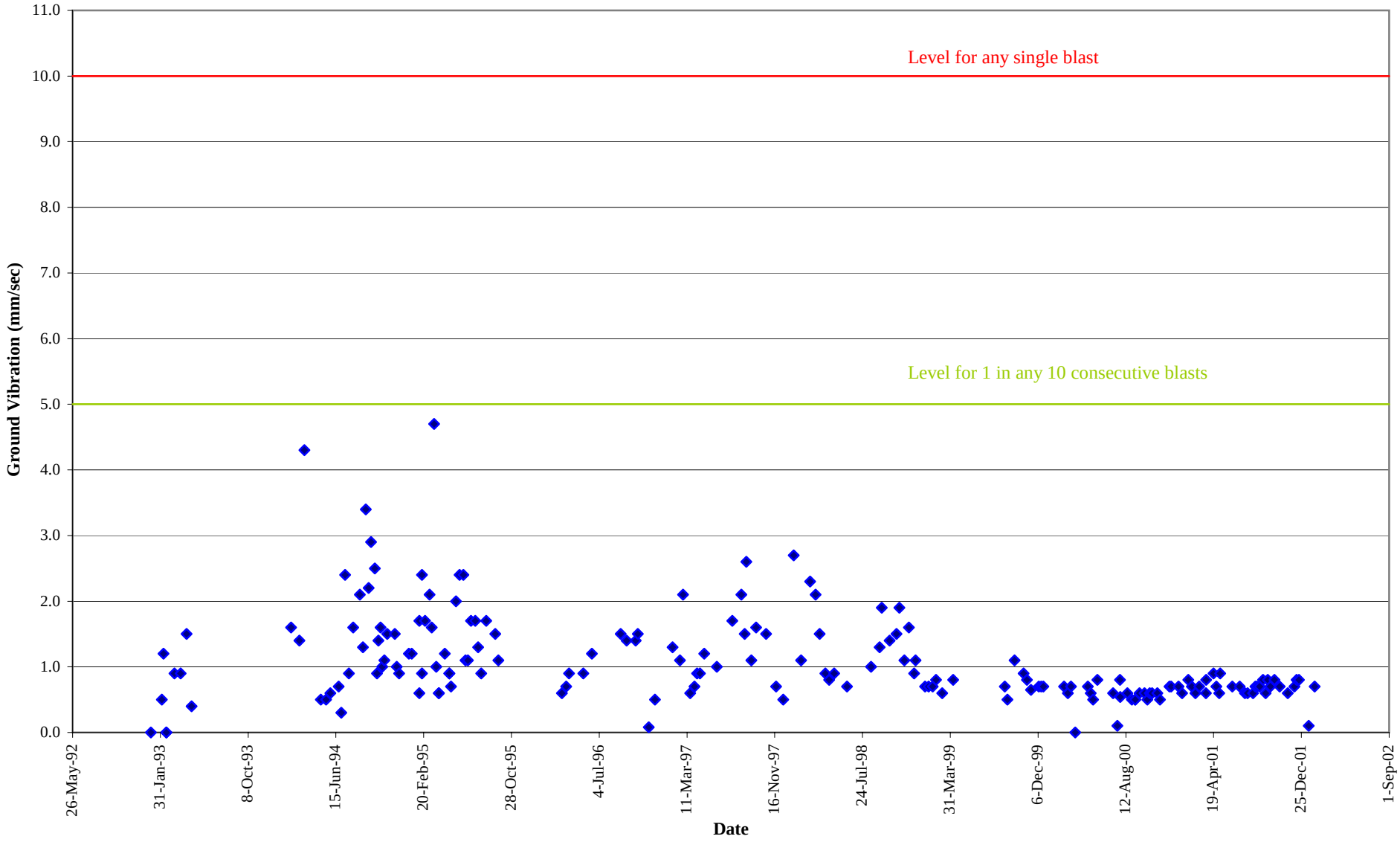
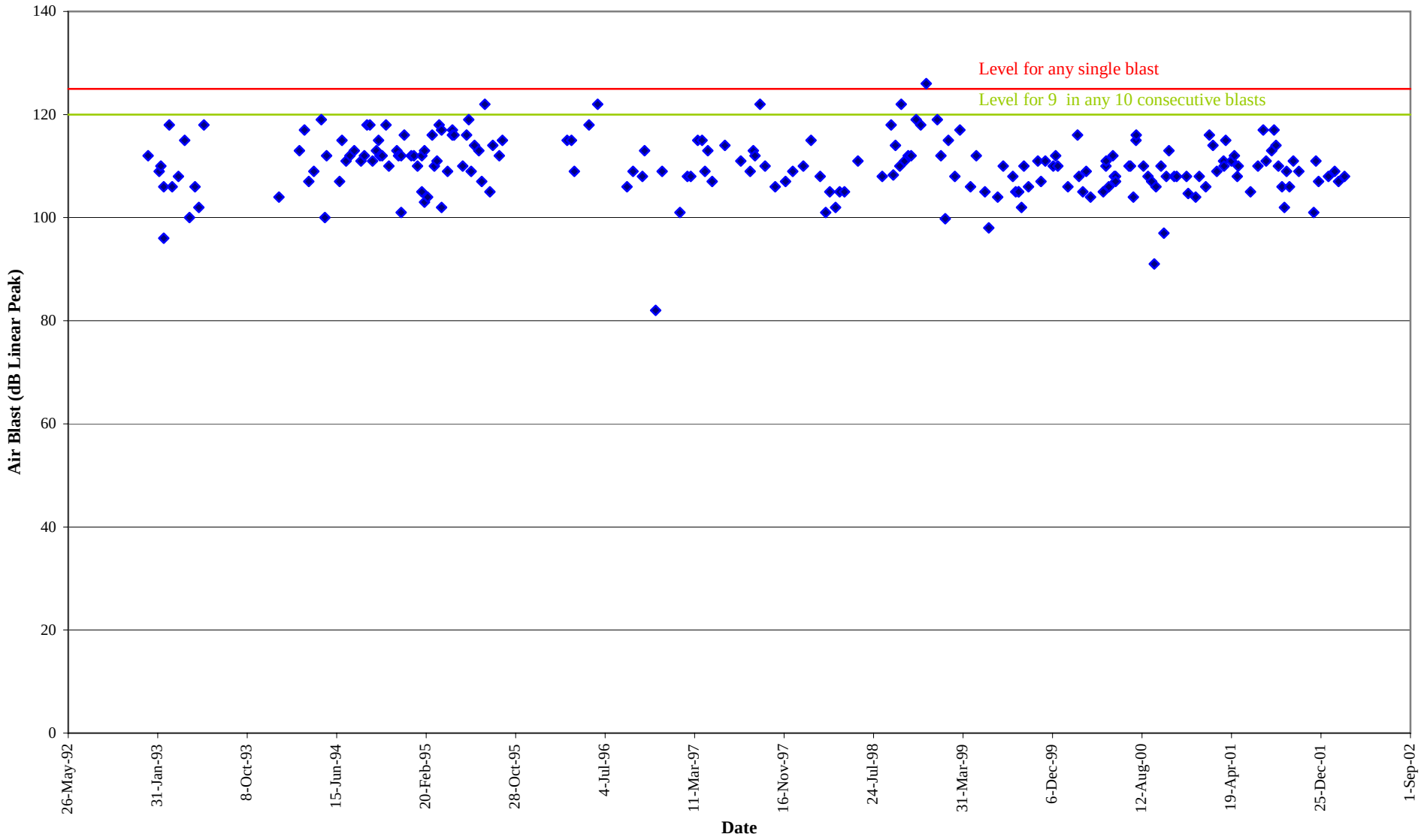


PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

GROUND VIBRATION MONITORING RESULTS FOR THE VOYAGER QUARRY, JANUARY 1993 TO MARCH 2002

Figure 3.3



PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

AIRBLAST MONITORING RESULTS FOR THE VOYAGER QUARRY, JANUARY 1993 TO MARCH 2002

Figure 3.4

START

Final completion plan is required

Is there likely to be remaining resource in the quarry

Yes

No

Water storage option analysis

Waste storage option analysis

Water balance

Catchment, engineering etc

Wastes

Economics

Are there any materials available, such as waste rock or municipal waste?

No

Yes

Rank wastes in order of economic value

Choose most valuable (or next) option

Yes

Water balance

Will water accumulate?

No

Can water be diverted into the quarry?

Yes

Yes

No

No

Geology/geotechnics

Economics

Is quarry suitable for chosen waste disposal?

No

Are there other options?

No

Not an option

Surrounding land use

Yes

Salinity

pH

Limnology

Hydrology

Turbidity

Nutrient concentration

Metal concentration

-N Will water be usable and/or safe for any option? Note 1

No

Has diversion into the quarry been considered?

Yes

Not an option

Yes

Select use requiring the highest water quality

Yes

-N Is the use of the water beneficial? Note 2

No

Option

Option

No

Are there any materials available for use as surface treatments, such as topsoil, subsoil with amendment?

Yes

Preferred option

Preferred option

Yes

Arrange options in order of preference. Select first option.

Leave quarry empty and make safe. Describe longterm configuration of quarry.

No

Select next option

Yes

Are there any options left?

Geology/ geotechnics

Does stability of quarry suit selected option?

No

Yes

Engineering costs

Economics liabilities/risks

Public image (cost or benefit)

Cost - benefit analysis

Economic benefits

Environmental benefits

Regulatory acceptance

Is benefit > cost?

No

Yes

Government approval

No

Yes

STOP

Note 1: Possible uses for pit water could range from human consumption to stock or agricultural use to non consumptive uses such as recreaction. High salinity for example limits consumptive uses but does not make water unsafe for recreation. Acidity, however, limits all uses as does heavy metal contamination.

Note 2: Beneficial uses are those that provide a tangible benefit to the local or regional community or environmental quality. For example, stock watering is a beneficial use in a grazing area whereas non-consumptive recreation may not be if there isn't a population base which will use it.

SOURCE: Modified from Mallet and Mark (1996)

BGC

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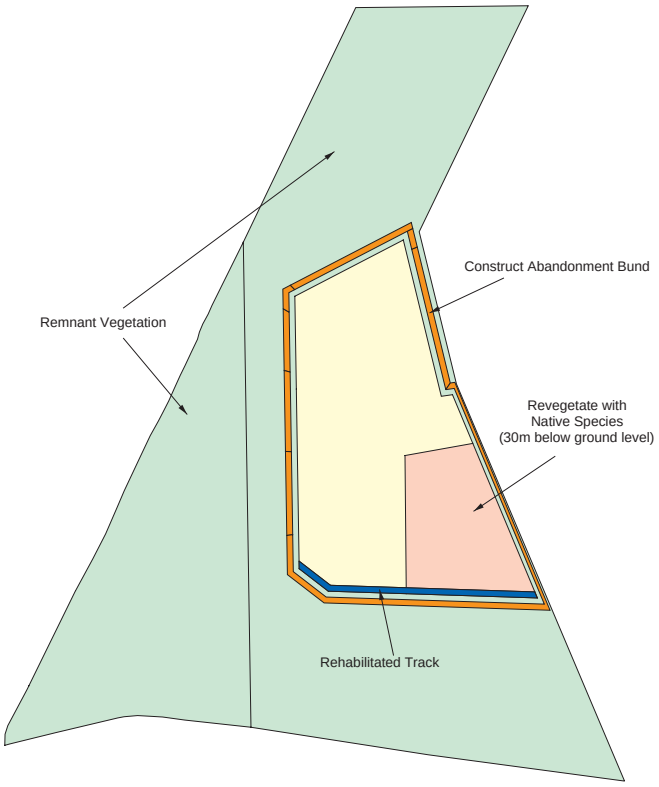
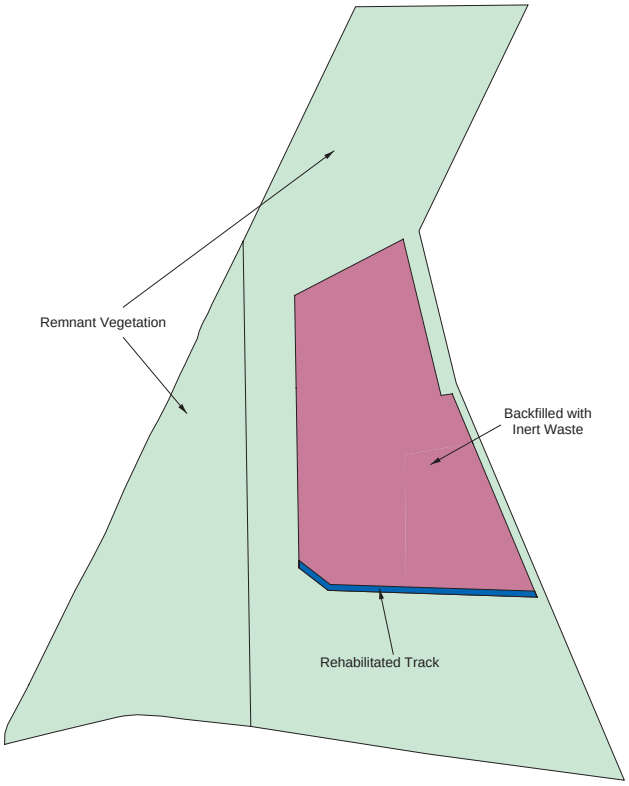
PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

DECISION TREE FOR CLOSURE PLANNING

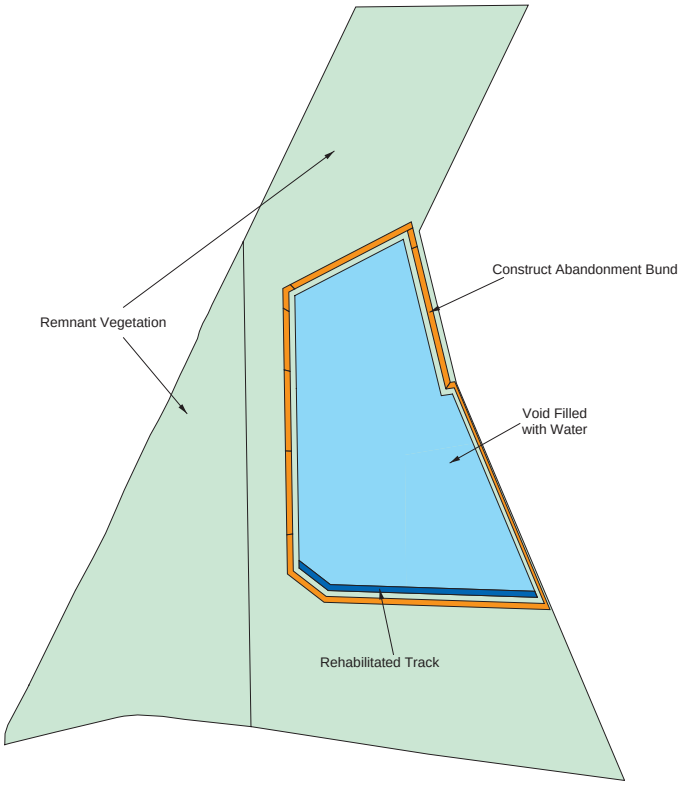
Figure 3.5



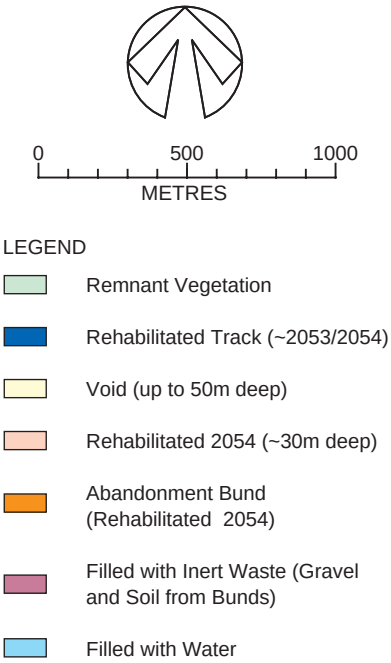
Scenario 1 : Empty Void



Scenario 2 : Partially or Fully Backfilled



Scenario 3 : Filled with Water



PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

CONCEPTUAL MINE CLOSURE PLANS FOR THE RELOCATED QUARRY

Figure 3.6

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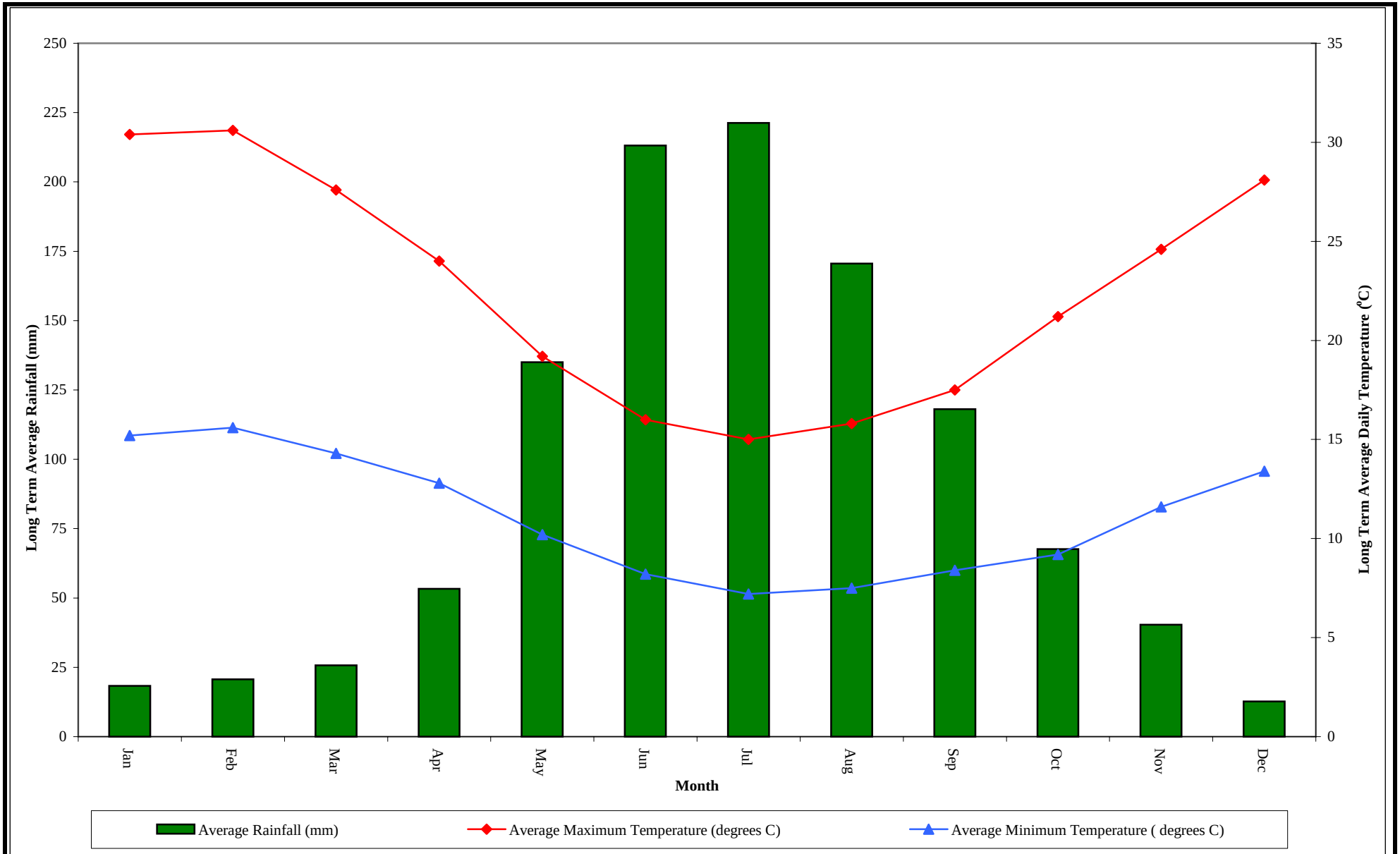


PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

AVERAGE MONTHLY RAINFALL AND AVERAGE DAILY TEMPERATURES AT BICKLEY

Figure 4.1

3am Summer 409 Observations

3am Autumn 317 Observations

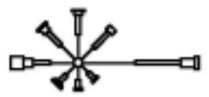
3am Winter 329 Observations

3am Spring 370 Observations

9am Summer 675 Observations

9am Autumn 708 Observations

9am Winter 683 Observations



9am Spring 680 Observations

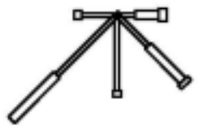
3pm Summer 660 Observations

3pm Autumn 696 Observations

3pm Winter 676 Observations

3pm Spring 662 Observations

9pm Summer 422 Observations

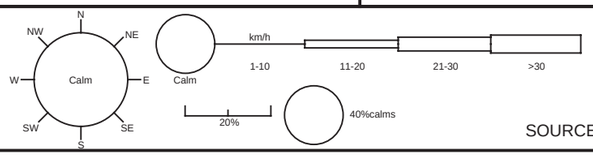


9pm Autumn 349 Observations

9pm Winter 336 Observations

9pm Spring 373 Observations

LEGEND



SOURCE: Bureau of Meteorology, 2002

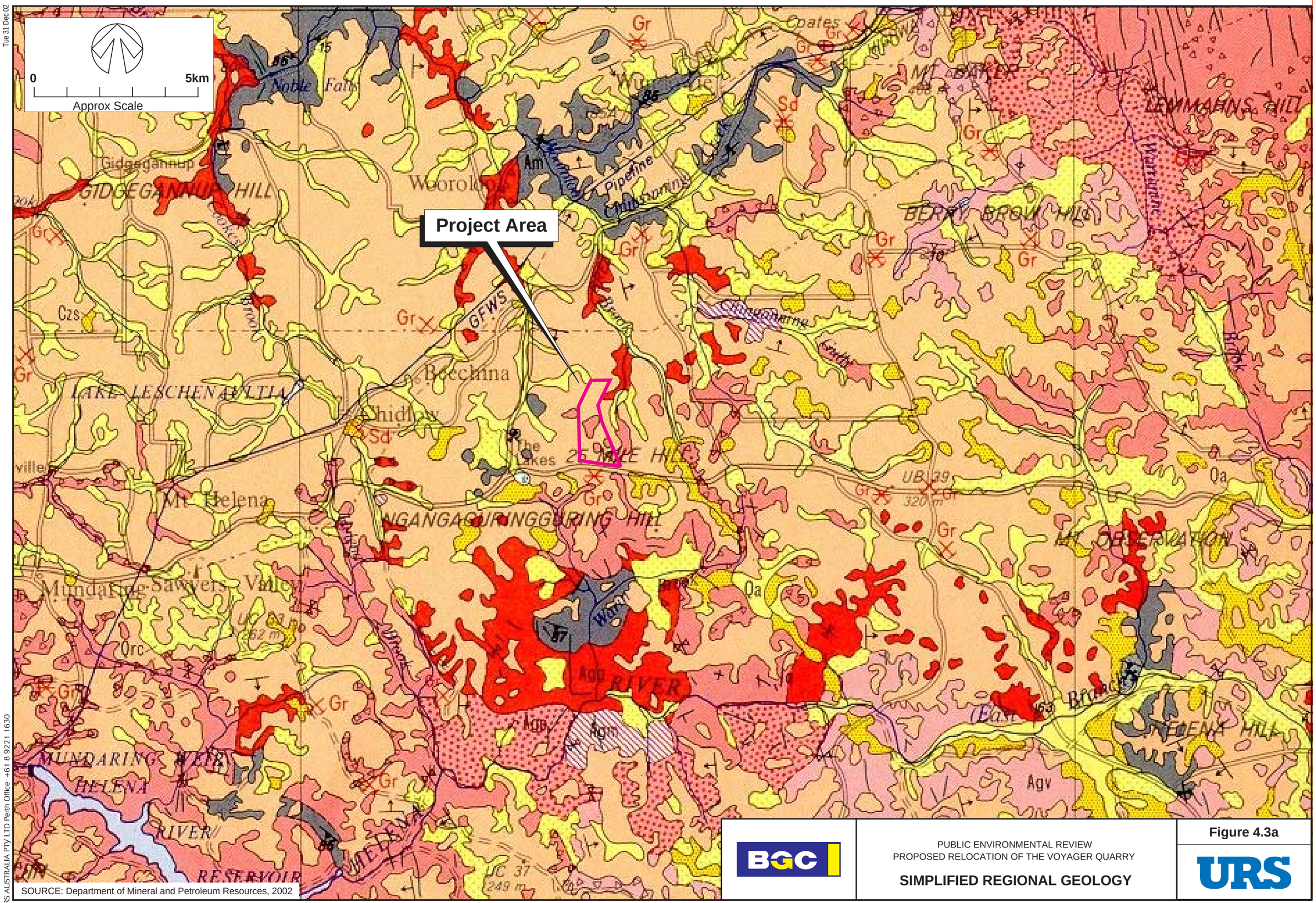
BGC

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

SEASONAL WIND ROSES, BICKLEY

Figure 4.2

URS



SOURCE: Department of Mineral and Petroleum Resources, 2002

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

SIMPLIFIED REGIONAL GEOLOGY

Figure 4.3a

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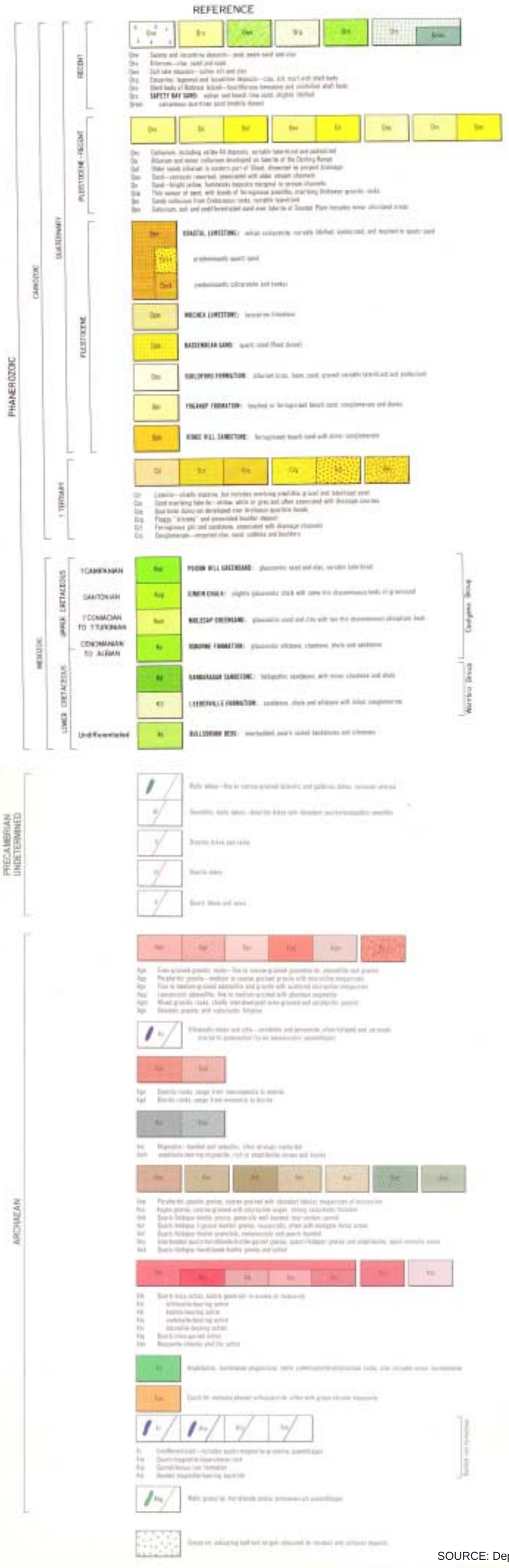


PUBLIC ENVIRONMENTAL REVIEW

PROPOSED RELOCATION OF THE VOYAGER QUARRY

SIMPLIFIED REGIONAL GEOLOGY LEGEND

Figure 4.3b

SOURCE: Department of Mineral and Petroleum Resources, 2002

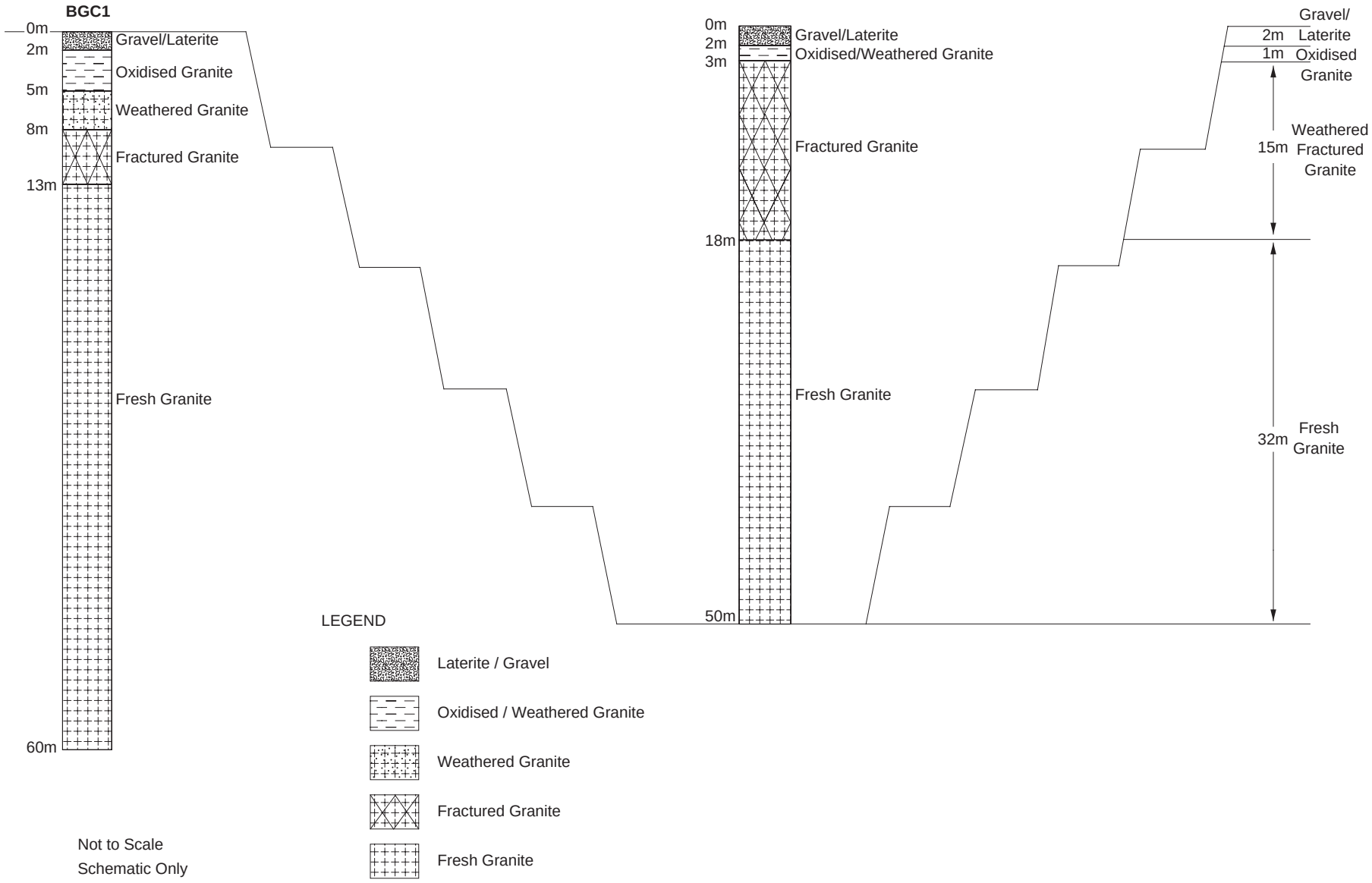
BGC

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

SIMPLIFIED STRATIGRAPHY

URS

Figure 4.4



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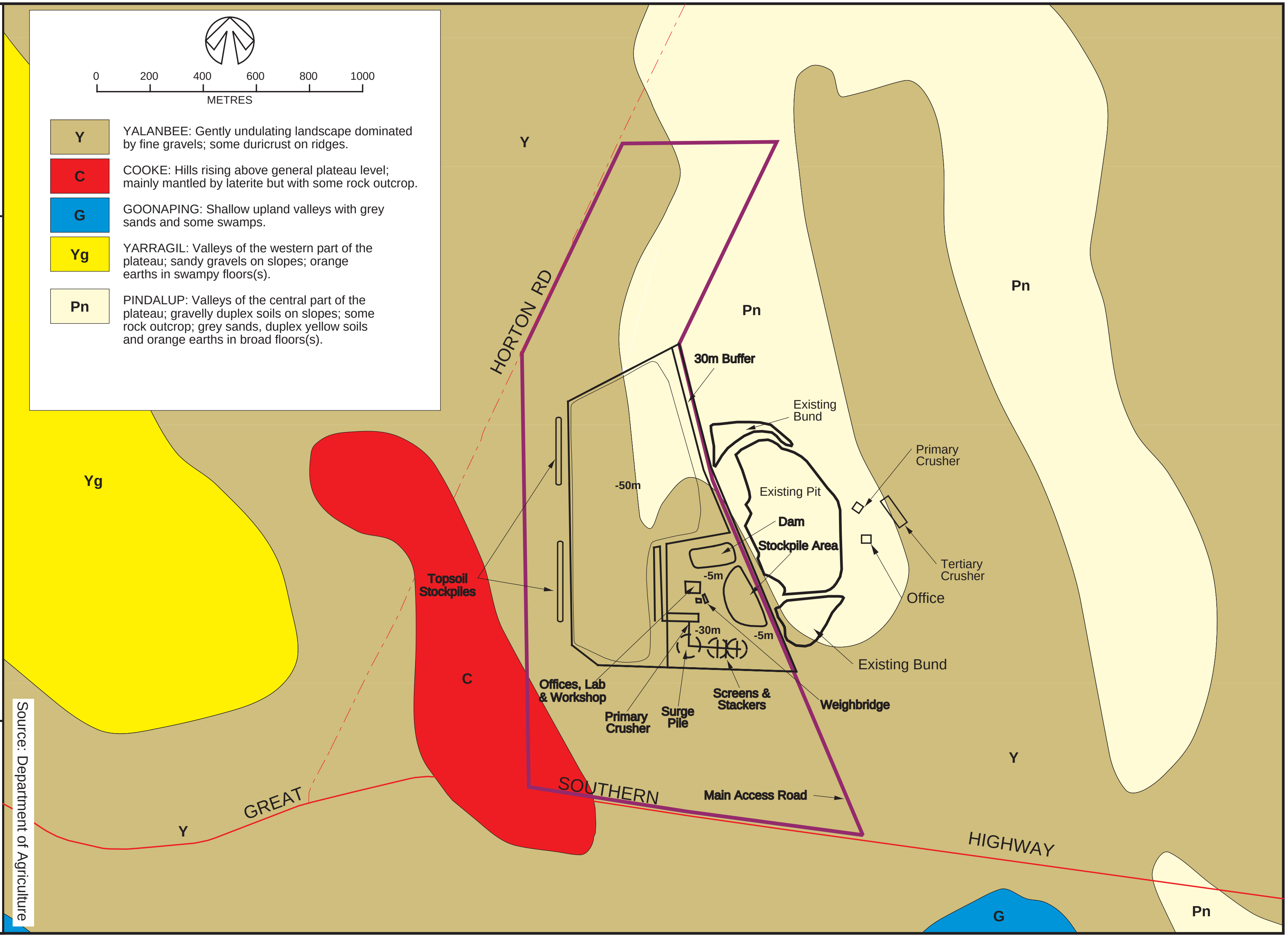
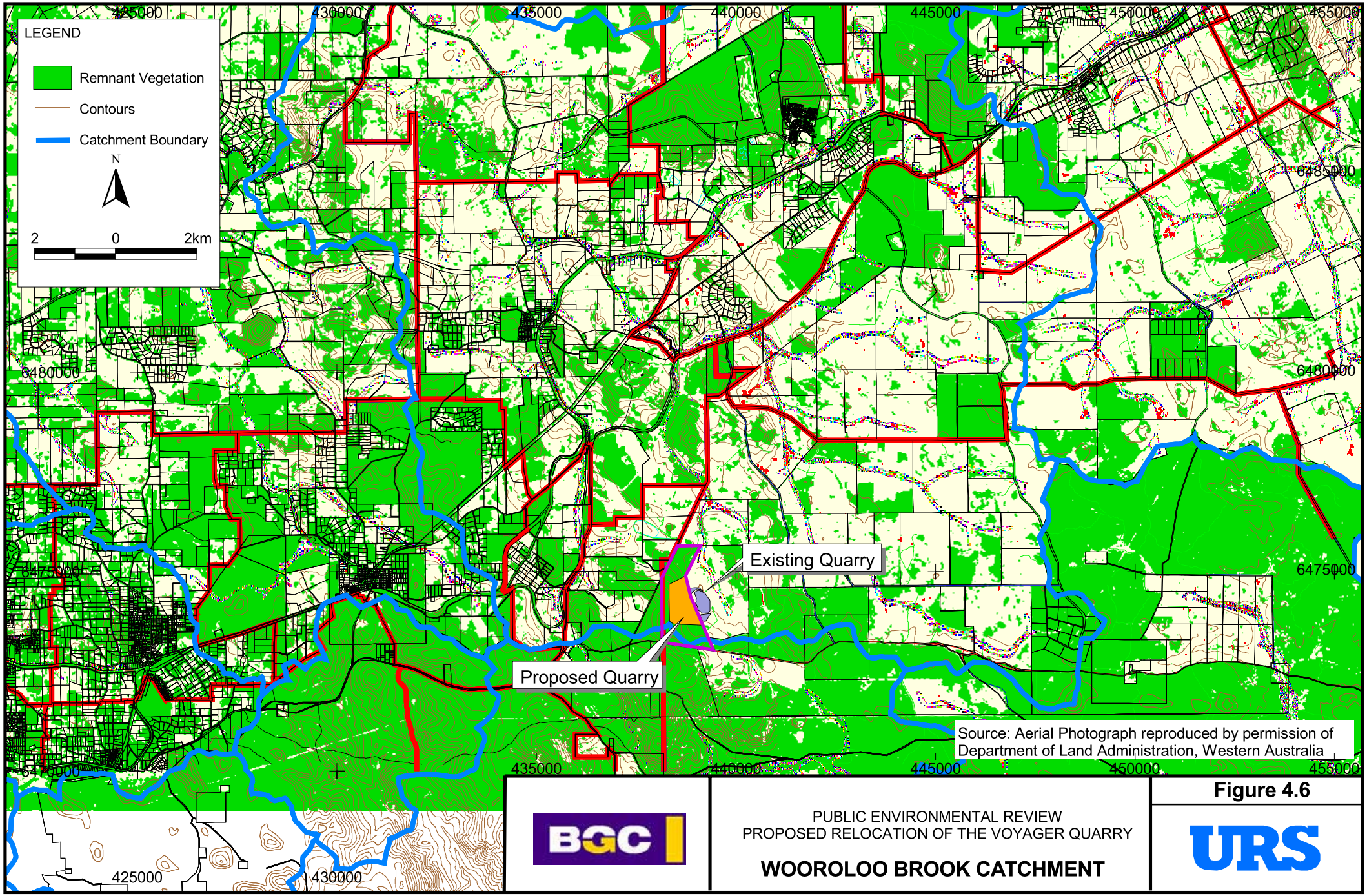
LAND UNITS WITHIN THE PROJECT AREA

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

Figure 4.5



Source: Department of Agriculture



BGC

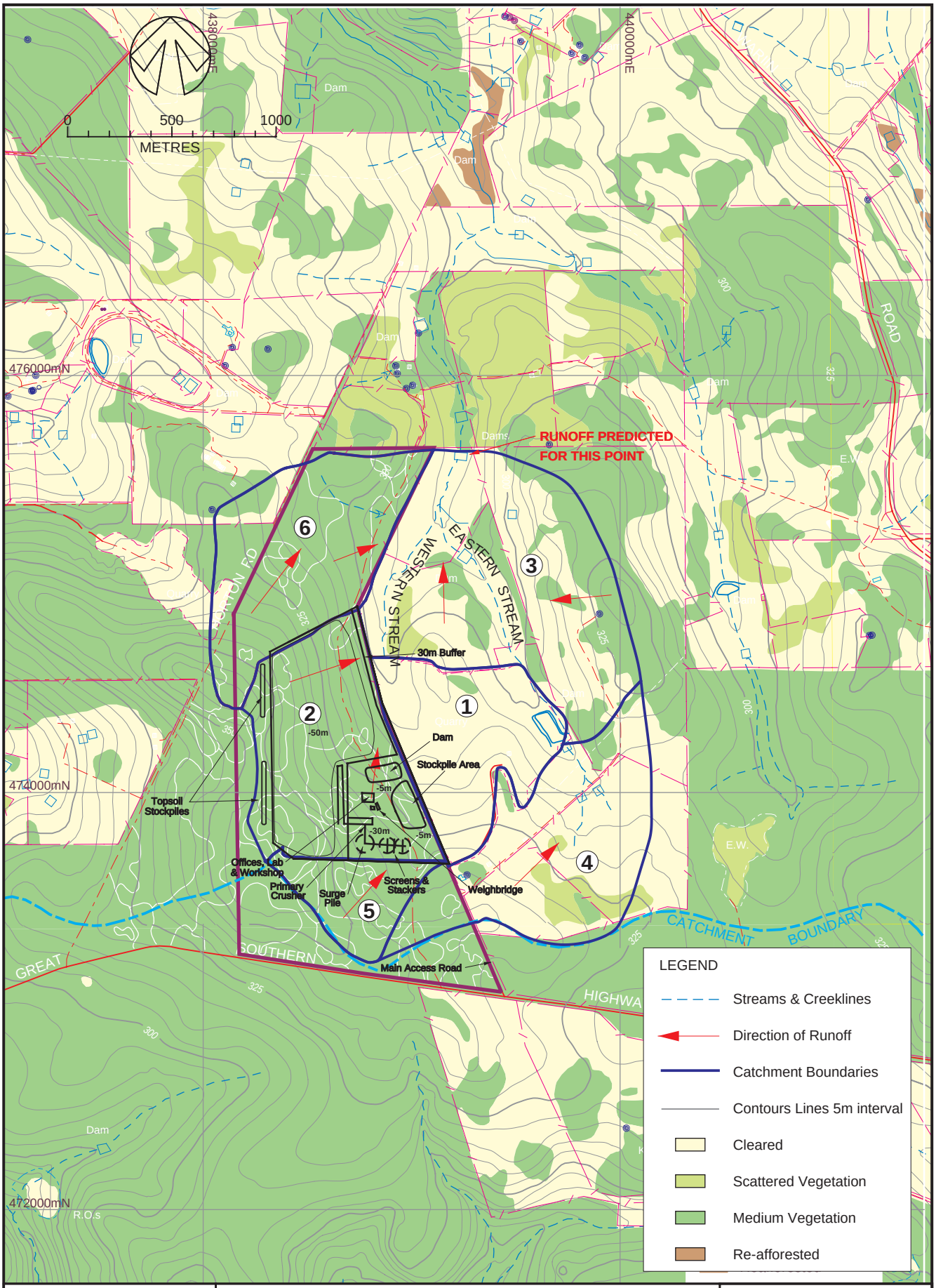
PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

WOOROLOO BROOK CATCHMENT

Figure 4.6

URS

50846001r027f4_6.wor



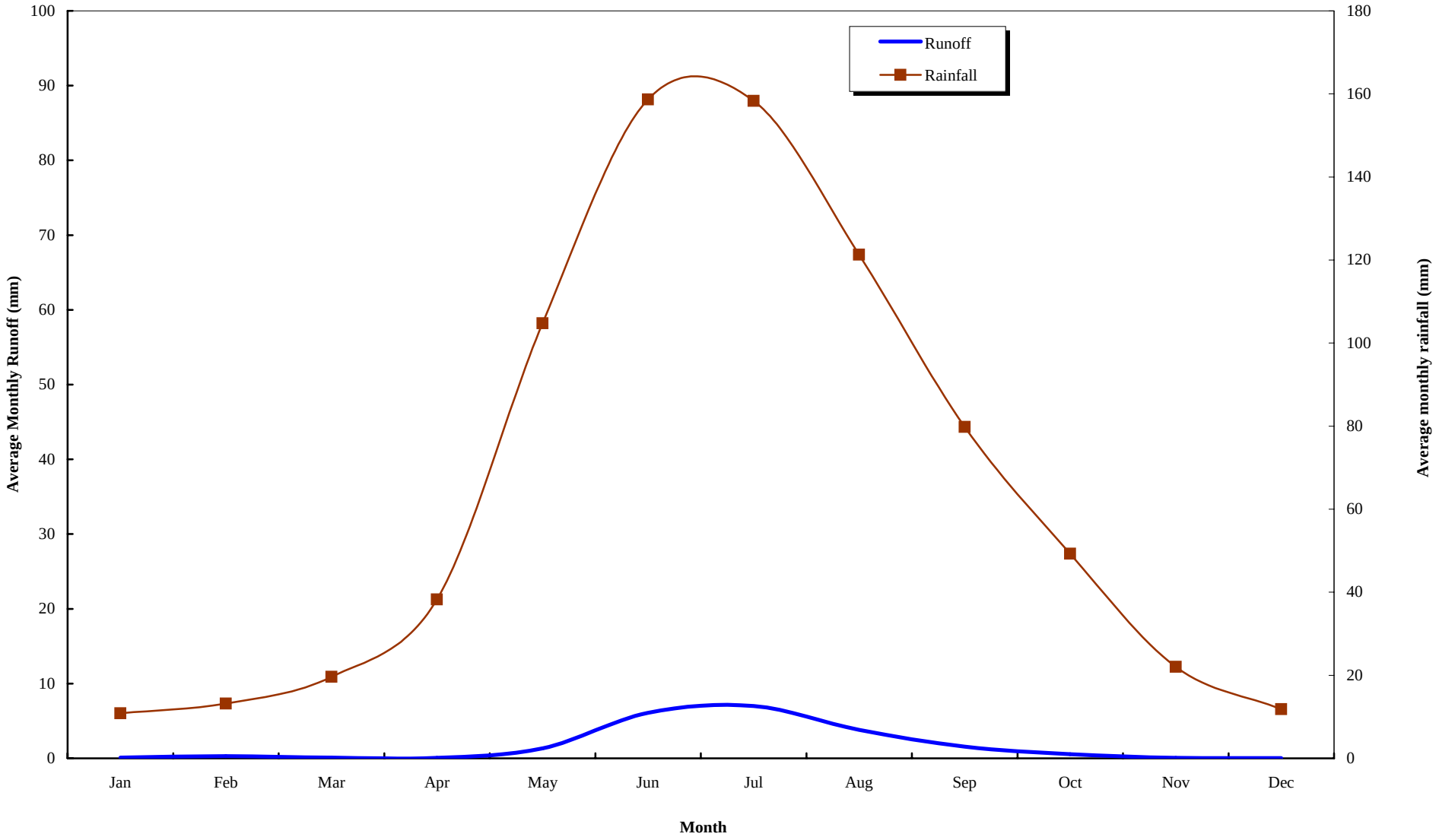
PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

SURFACE WATER CATCHMENTS AND DIRECTION OF RUNOFF

Figure 4.7

BGC

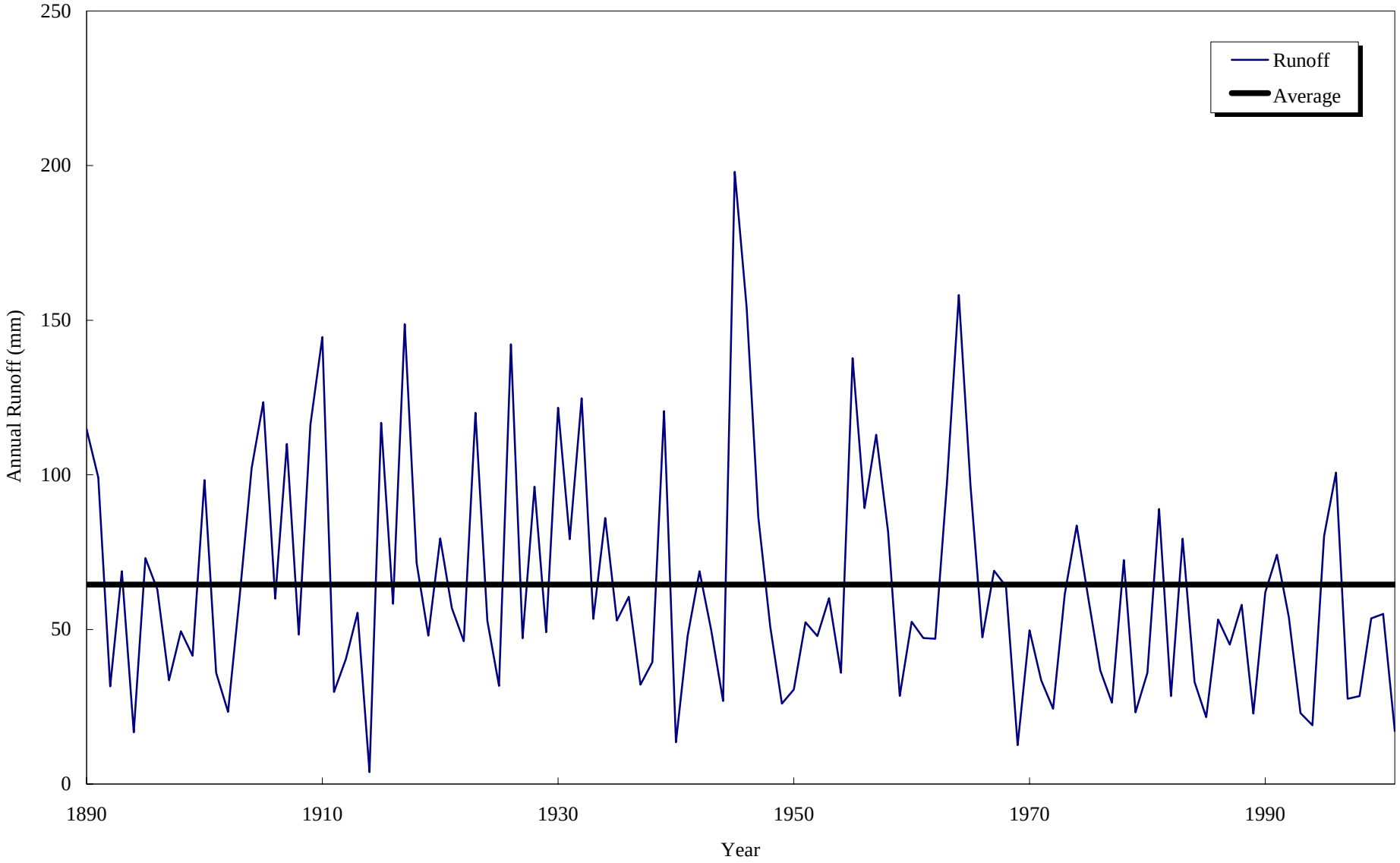
URS



PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

AVERAGE MONTHLY RUNOFF SIMULATED FOR THE CATCHMENT PRIOR TO QUARRY RELOCATION

Figure 4.8



PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

ANNUAL RUNOFF SIMULATED FOR THE CATCHMENT PRIOR TO QUARRY RELOCATION

Figure 4.9

Thu 02 Jan

430000mE

440000mE

450000mE

6490000mN

6480000mN

6470000mN

Werribee

Bakers Hill

Eastern Highway

Great Southern Highway

Mount Helena

N

0 1.5 3km

Scale

MGA94 (Zone 50)

LEGEND

- Project Area
- Catchment boundary
- Waterways
- Roads
- Transmision Line

Groundwater Salinity

(Total Dissolved Solids - mg/L)

- 500 - 1000
- 1000 - 3000
- 3000 - 7000
- 7000 - 14000

SOURCE: DOLA, Agwest, Water & Rivers Commission

BGC

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

SALINITY OF REGIONAL GROUNDWATER

Figure 4.10

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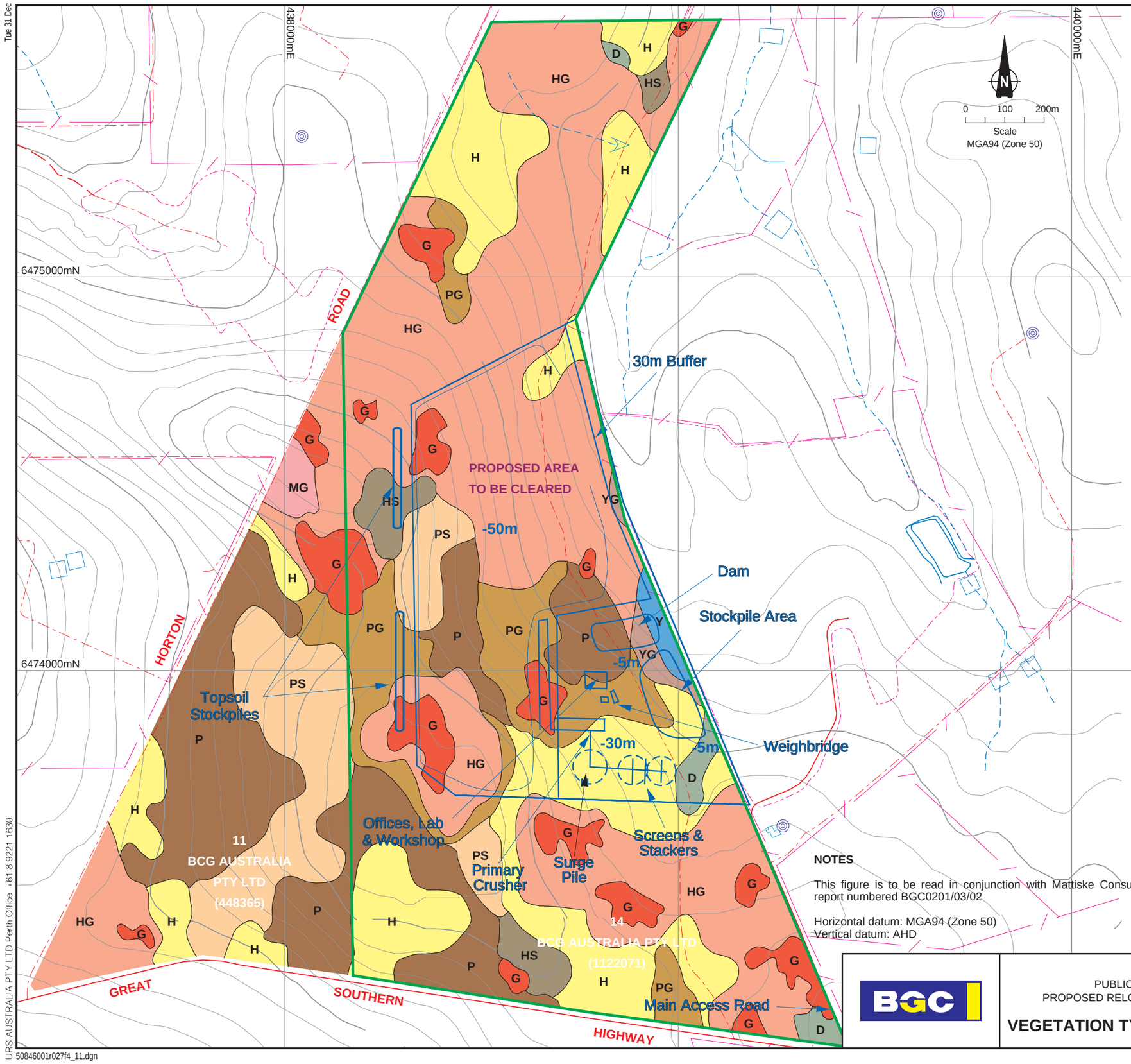

LEGEND

SITE TYPES
(SiteTypes based on Havel, 1975a and 1975b for the Northern Jarrah Forest)

- **D** Open Woodland of *Eucalyptus marginata* subsp. *thalassica -Corymbia calophylla* on lower slopes with mixed low understorey species, including *Baeckea camphorosmae, Daviesia preissii* and *Mesomelaena tetragona.*
- **H** Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with scattered understorey, including *Hibbertia acerosa, Dryandra lindleyana, Xanthorrhoea gracilis, Calothamnus sanguineus, Conospermum stoechadis* and *Lepidosperma squamatum.*
- **HS** Open Forest to Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with scattered understorey, including *Dryandra sessilis*, *Dryandra lindleyana, Leucopogon nutans* and *Lepidosperma squamatum.*
- **HG** Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with low dense understorey, including *Dryandra armata, Hakea undulata, Hakea stenocarpa, Hakea incrassata, Pericalymma ellipticum, Grevillea bipinnatifida* and *Lepidosperma squamatum.*
- **P** Open Forest to Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with scattered understorey, including *Leucopogon nutans* and *Lepidosperma squamatum.*
- **PS** Open Forest to Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with scattered understorey, including *Dryandra sessilis*, *Leucopogon nutans* and *Lepidosperma squamatum.*
- **PG** Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with low dense understorey, including *Dryandra armata, Hakea undulata, Grevillea bipinnatifida, Leucopogon nutans* and *Lepidosperma squamatum.*
- **Y** Woodland of *Eucalyptus wandoo* with scattered understorey, including *Gastrolobium calycinum, Mesomelaena tetragona, Daviesia rhombifolia* and *Xanthorrhoea gracilis.*
- **YG** Woodland of *Eucalyptus wandoo* with low dense understorey, including *Synaphea petiolaris, Dryandra squarrosa* subsp. *squarrosa, Hibbertia acerosa* and *Dryandra lindleyana.*
- **MG** Open Woodland of *Eucalyptus wandoo* with dense understorey, including *Hakea incrassata, Allocasuarina microstachys, Dryandra armata, Hakea undulata* and *Allocasuarina humilis.*
- **G** Open to Closed Heath of Proteaceae - Myrtaceae species, including *Hakea incrassata, Hakea stenocarpa, Dryandra armata, Hakea undulata, Melaleuca scabra, Calothamnus quadrifidus, Dryandra squarrosa* subsp. *squarrosa* and *Beaufortia macrostemon.*
- Project Area

NOTES

This figure is to be read in conjunction with Mattiske Consulting Pty Ltd report numbered BGC0201/03/02

Horizontal datum: MGA94 (Zone 50)
Vertical datum: AHD

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

VEGETATION TYPES IN THE PROJECT AREA

Figure 4.11

Tue 31 Dec

438000mE

440000mE

6475000mN

6474000mN

6473000mN

H16

H1

H3

H4

H2

H17

H5

H14

H10

H9

H15

H12

H13

H7

H11

H8

H6

30m Buffer

-50m

-5m

-30m

-5m

PROPOSED AREA
TO BE CLEARED

Dam

Stockpile Area

Topsoil
Stockpiles

Offices, Lab
& Workshop

Primary
Crusher

Surge
Pile

Screens &
Stackers

Weighbridge

Main Access Road

11
BCG AUSTRALIA
PTY LTD
(448365)

14
BCG AUSTRALIA PTY LTD
(1122071)

N

0 100 200m

Scale
MGA94 (Zone 50)

LEGEND

- Heath area
- Heath area with *Hemigenia viscida*
- **H1/20 plants** Heath area number / number of plants
- Project Area

NOTES

This figure is to be read in conjunction with Mattiske Consulting Pty Ltd report numbered BGC0201/03/02 and provided as Appendix C

Horizontal datum: MGA94 (Zone 50)
Vertical datum: AHD

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

HEATH AREAS WITH *HEMIGENIA VISCIDA*

Figure 4.12

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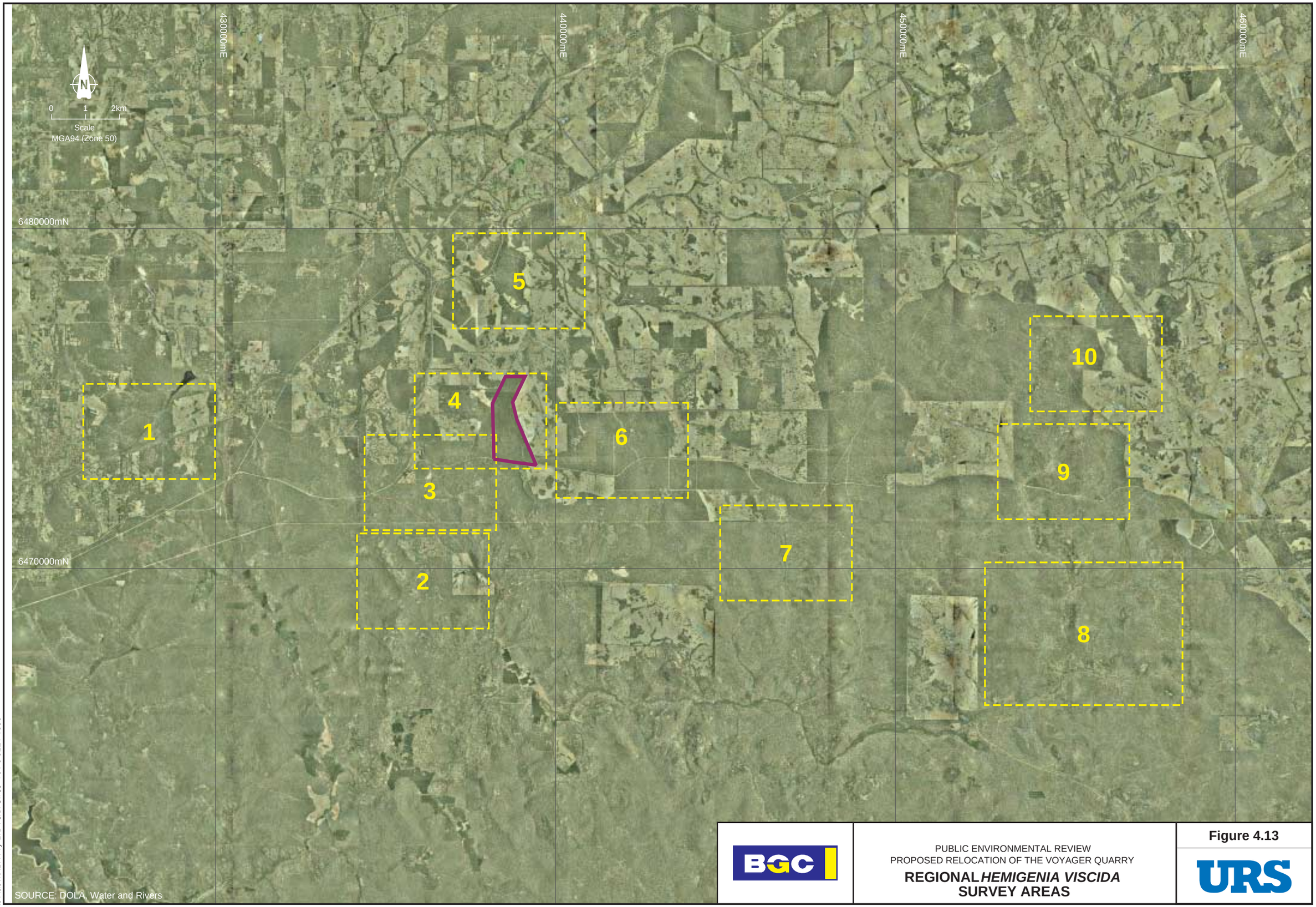
Tue 31 Dec 02



PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

REGIONAL *HEMIGENIA VISCIDA* SURVEY AREAS

Figure 4.13

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Tue 31 Dec

438000mE

440000mE

6475000mN

6474000mN

ROAD

HORTON

GREAT SOUTHERN HIGHWAY

30m Buffer

PROPOSED AREA
TO BE CLEARED

-50m

-30m

-5m

-5m

-5m

Dam

Stockpile Area

Weighbridge

Topsoil
Stockpiles

Offices, Lab
& Workshop

Primary
Crusher

Surge
Pile

Screens &
Stackers

Main Access Road

N

0 100 200m

Scale
MGA94 (Zone 50)

LEGEND

- Open Forrest to Woodland of *Allocasurina fraseriana* (Sheoak) - *Eucalyptus marginata* subsp. *thalassica* (Blue-leaf Jarrah) on sandy gravel soils
- Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica* (Blue-leaf Jarrah) - *Corymbia catophylla* (Marri) on sandy gravel soils.
- Open Forest to Woodland of *Eucalyptus marginata* subsp. *thalassica* (Blue-leaf Jarrah) - *Corymbia calophylla* (Marri) - *Banksia grandis* (Bull Banksia) on sandy gravel soils
- Open Woodland of *Eucalyptus wandoo* (Wandoo) on clay-loam soils
- Open to Closed Heath of Myrtaceae-Proteaceae species on shallow soils associated with rock out cropping
- Project Area

BGC

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

VERTEBRATE FAUNA HABITATS

Figure 4.14

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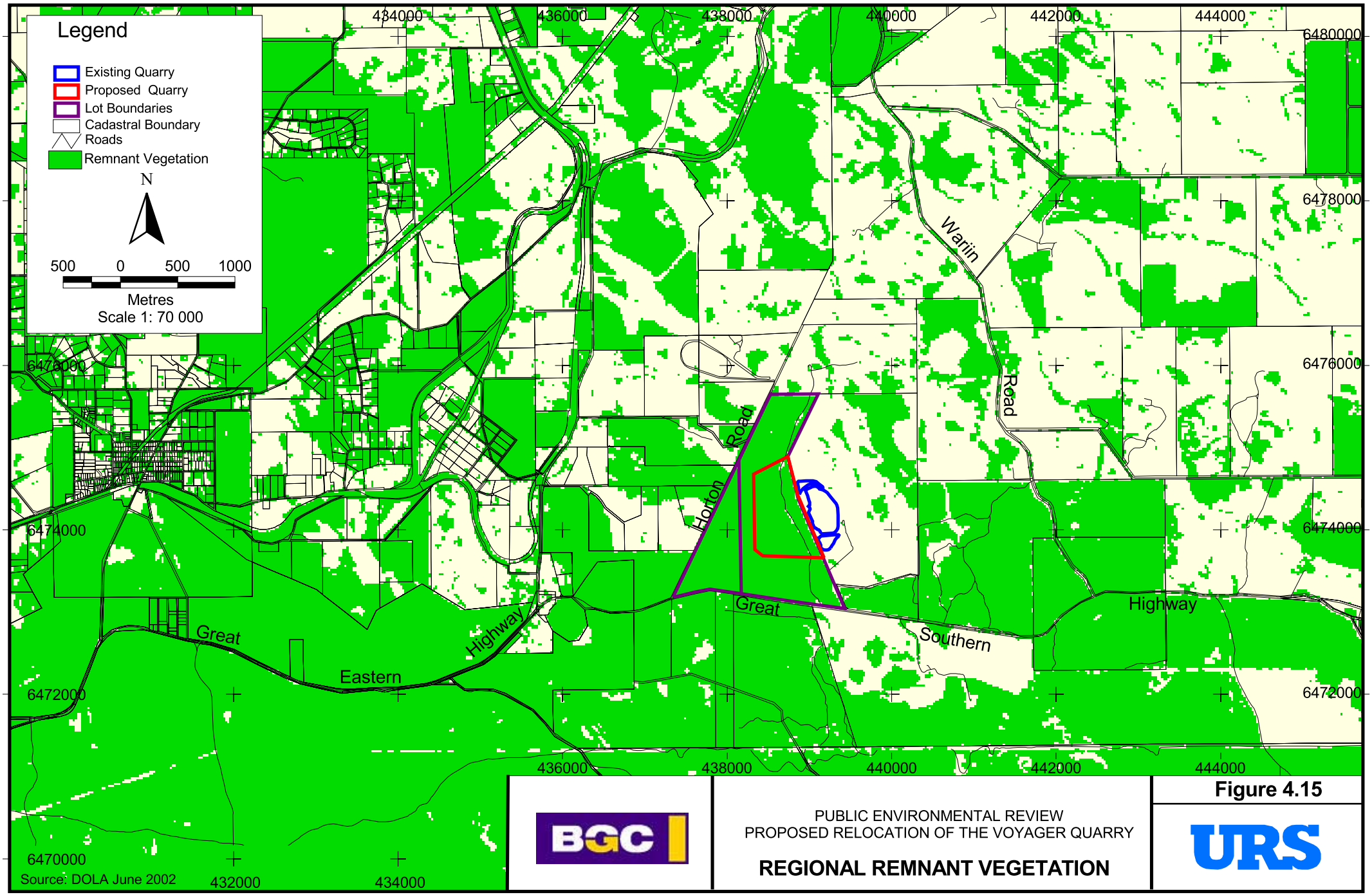

BGC

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

REGIONAL REMNANT VEGETATION

Figure 4.15

URS

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Tue 31 Dec

438000mE

440000mE

6475000mN

6474000mN

B11A B12 B13 B14 J20 J21 J19 J22 J23 J24 J25 J26

Gaius Site A

Gaius Site C

Gaius Site B

B19

ROAD

B24

J28

Gaius Site D

HORTON

J27

Topsoil Stockpiles

J14 J15 & J16 J13 J12 J17 J18 B11

Proposed Area to be Cleared

B18

B20

B2, B6, & J3

J1, J2, & B1

J10, B10

J5, J6, & B3

B4

J4, J7, & B5

J11 J9 B16 B15, J29 B7, & J8 B8 & B9

B21 B22

11 BCG AUSTRALIA PTY LTD (448365)

14 BCG AUSTRALIA PTY LTD (1122071)

B17

B23

GREAT SOUTHERN HIGHWAY

N

0 100 200m

Scale

MGA94 (Zone 50)

LEGEND

SITE TYPES

(SiteTypes based on Havel, 1975a and 1975b for the Northern Jarrah Forest)

Trapdoor Spider search sites (16 and 28 July 2002)

Trapdoor Spider search sites (28 August 2002)

D Open Woodland of *Eucalyptus marginata* subsp. *thalassica -Corymbia calophylla* on lower slopes with mixed low understorey species, including *Baeckea camphorosmae, Daviesia preissii* and *Mesomelaena tetragona.*

H Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with scattered understorey, including *Hibbertia acerosa, Dryandra lindleyana, Xanthorrhoea gracilis, Calothamnus sanguineus, Conospermum stoechadis* and *Lepidosperma squamatum.*

HS Open Forest to Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with scattered understorey, including *Dryandra sessilis*, *Dryandra lindleyana, Leucopogon nutans* and *Lepidosperma squamatum.*

HG Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with low dense understorey, including *Dryandra armata, Hakea undulata, Hakea stenocarpa, Hakea incrassata, Pericalymma ellipticum, Grevillea bipinnatifida* and *Lepidosperma squamatum.*

P Open Forest to Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with scattered understorey, including *Leucopogon nutans* and *Lepidosperma squamatum.*

PS Open Forest to Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with scattered understorey, including *Dryandra sessilis*, *Leucopogon nutans* and *Lepidosperma squamatum.*

PG Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with low dense understorey, including *Dryandra armata, Hakea undulata, Grevillea bipinnatifida, Leucopogon nutans* and *Lepidosperma squamatum.*

Y Woodland of *Eucalyptus wandoo* with scattered understorey, including *Gastrolobium calycinum, Mesomelaena tetragona, Daviesia rhombifolia* and *Xanthorrhoea gracilis.*

YG Woodland of *Eucalyptus wandoo* with low dense understorey, including *Synaphea petiolaris, Dryandra squarrosa* subsp. *squarrosa, Hibbertia acerosa* and *Dryandra lindleyana.*

MG Open Woodland of *Eucalyptus wandoo* with dense understorey, including *Hakea incrassata, Allocasuarina microstachys, Dryandra armata, Hakea undulata* and *Allocasuarina humilis.*

G Open to Closed Heath of Proteaceae - Myrtaceae species, including *Hakea incrassata, Hakea stenocarpa, Dryandra armata, Hakea undulata, Melaleuca scabra, Calothamnus quadrifidus, Dryandra squarrosa* subsp. *squarrosa* and *Beaufortia macrostemon.*

NOTE:
B25, B26, & B27 are located south of the study area at the following locations and are not located on this map

B25 439129,6413121
B26 434635,6471967
B27 441142,6469487

NOTES
Horizontal datum: MGA94 (Zone 50)
Vertical datum: AHD
Vegetation Mapping was conducted by Mattiske Consulting Pty Ltd

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

TRAPDOOR SPIDER SURVEY STATIONS

Figure 4.16

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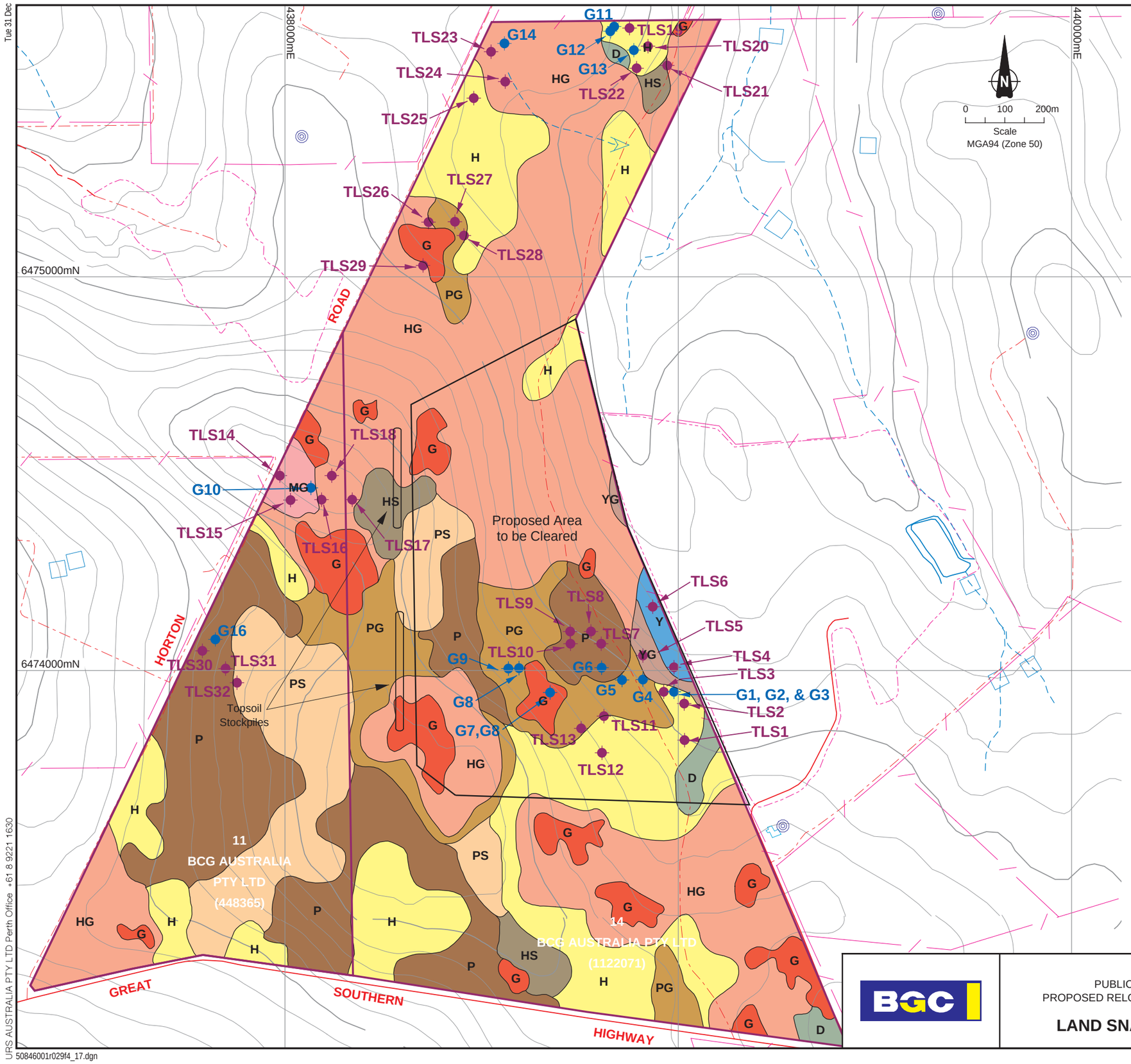

LEGEND

SITE TYPES
(SiteTypes based on Havel, 1975a and 1975b for the Northern Jarrah Forest)

Landsnail search sites including soil / litter samples (16 and 28 July 2002)

Landsnail search sites (16 and 28 July 2002)

D Open Woodland of *Eucalyptus marginata* subsp. *thalassica -Corymbia calophylla* on lower slopes with mixed low understorey species, including *Baeckea camphorosmae, Daviesia preissii* and *Mesomelaena tetragona.*

H Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with scattered understorey, including *Hibbertia acerosa, Dryandra lindleyana, Xanthorrhoea gracilis, Calothamnus sanguineus, Conospermum stoechadis* and *Lepidosperma squamatum.*

HS Open Forest to Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with scattered understorey, including *Dryandra sessilis*, *Dryandra lindleyana, Leucopogon nutans* and *Lepidosperma squamatum.*

HG Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with low dense understorey, including *Dryandra armata, Hakea undulata, Hakea stenocarpa, Hakea incrassata, Pericalymma ellipticum, Grevillea bipinnatifida* and *Lepidosperma squamatum.*

P Open Forest to Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with scattered understorey, including *Leucopogon nutans* and *Lepidosperma squamatum.*

PS Open Forest to Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with scattered understorey, including *Dryandra sessilis*, *Leucopogon nutans* and *Lepidosperma squamatum.*

PG Woodland of *Allocasuarina fraseriana - Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla - Banksia grandis* with low dense understorey, including *Dryandra armata, Hakea undulata, Grevillea bipinnatifida, Leucopogon nutans* and *Lepidosperma squamatum.*

Y Woodland of *Eucalyptus wandoo* with scattered understorey, including *Gastrolobium calycinum, Mesomelaena tetragona, Daviesia rhombifolia* and *Xanthorrhoea gracilis.*

YG Woodland of *Eucalyptus wandoo* with low dense understorey, including *Synaphea petiolaris, Dryandra squarrosa* subsp. *squarrosa, Hibbertia acerosa* and *Dryandra lindleyana.*

MG Open Woodland of *Eucalyptus wandoo* with dense understorey, including *Hakea incrassata, Allocasuarina microstachys, Dryandra armata, Hakea undulata* and *Allocasuarina humilis.*

G Open to Closed Heath of Proteaceae - Myrtaceae species, including *Hakea incrassata, Hakea stenocarpa, Dryandra armata, Hakea undulata, Melaleuca scabra, Calothamnus quadrifidus, Dryandra squarrosa* subsp. *squarrosa* and *Beaufortia macrostemon.*

NOTES

Horizontal datum: MGA94 (Zone 50)
Vertical datum: AHD
Vegetation Mapping was conducted by Mattiske Consulting Pty Ltd

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

LAND SNAIL SURVEY STATIONS

Figure 4.17

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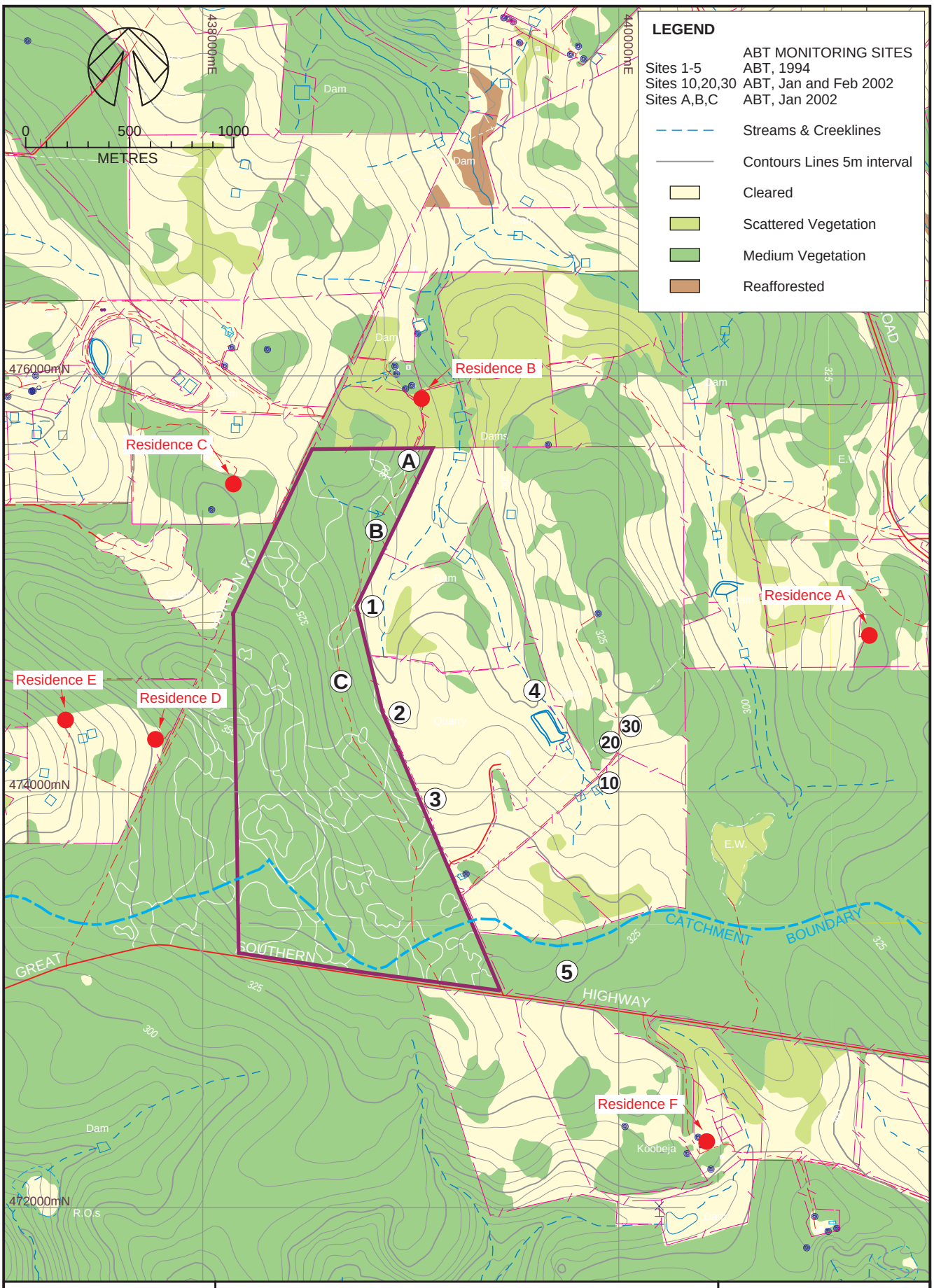

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

LOCATION OF NEAREST RESIDENCES AND NOISE MONITORING SITES

Figure 4.18

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Tue 31 Dec
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Wed 06 Dec

N

0 500 1,000
meters

30m Buffer
Existing Bund
Existing Pit
Primary Crusher
-50m
Dam
Stockpile Area
Tertiary Crusher
Office
-5m
Topsoil Stockpiles
-30m
-5m
Existing Bund
Offices, Lab & Workshop
Screens & Stackers
Weighbridge
Primary Crusher
Surge Pile
Main Access Road

LEGEND
- View Point 1
- View Point 2
- View Point 3
- "Seen" areas from View Point 1
- "Seen" areas from View Point 2
- "Seen" areas from View Point 3

BGC

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

VISUAL IMPACT MAP

Figure 4.19

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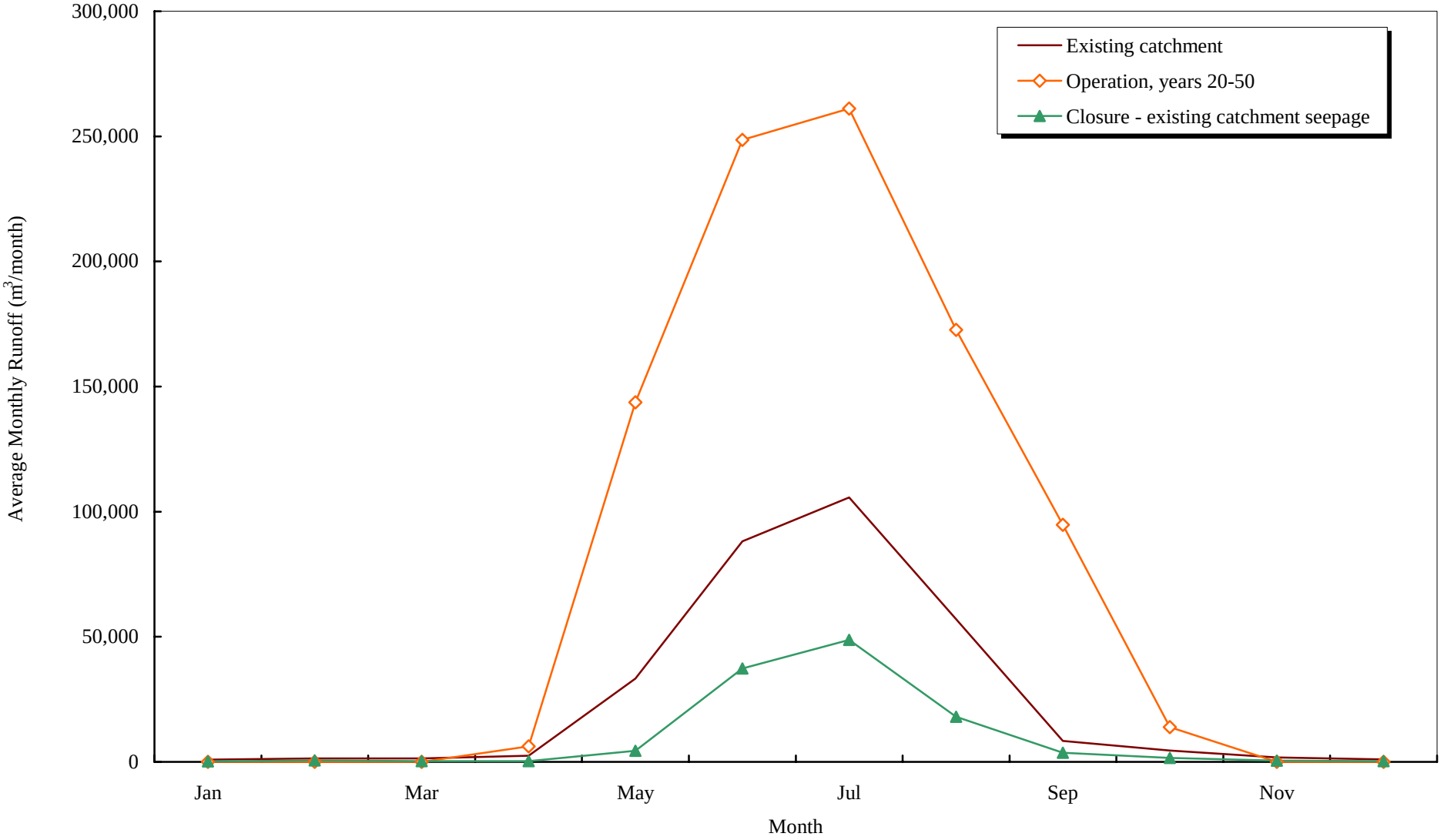
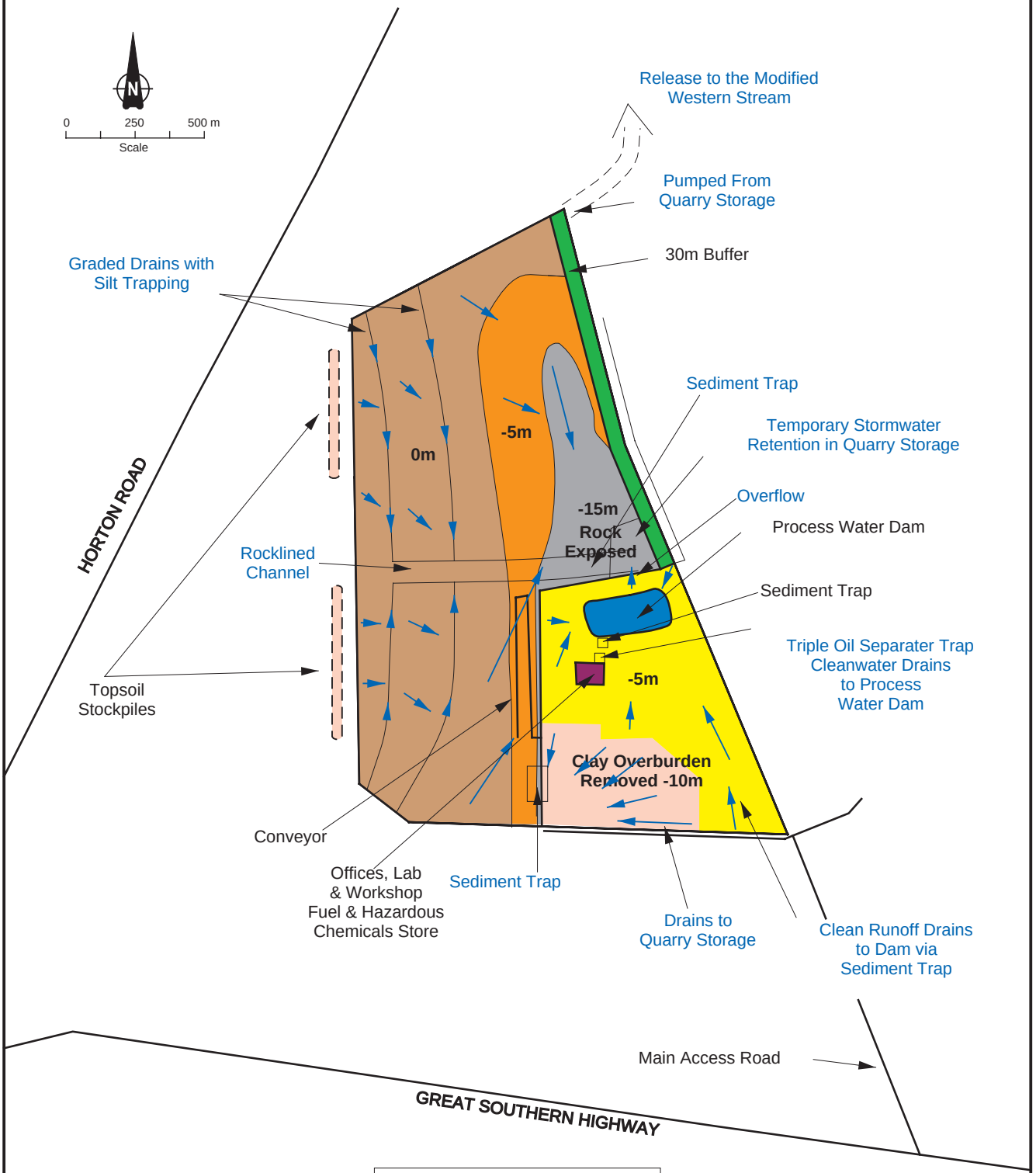


PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

AVERAGE MONTHLY RUNOFF SIMULATED FOR THE CATCHMENT

Figure 7.1



END OF YEAR 2

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

SURFACE WATER MANAGEMENT PLAN - END OF YEAR 2

Figure 7.2

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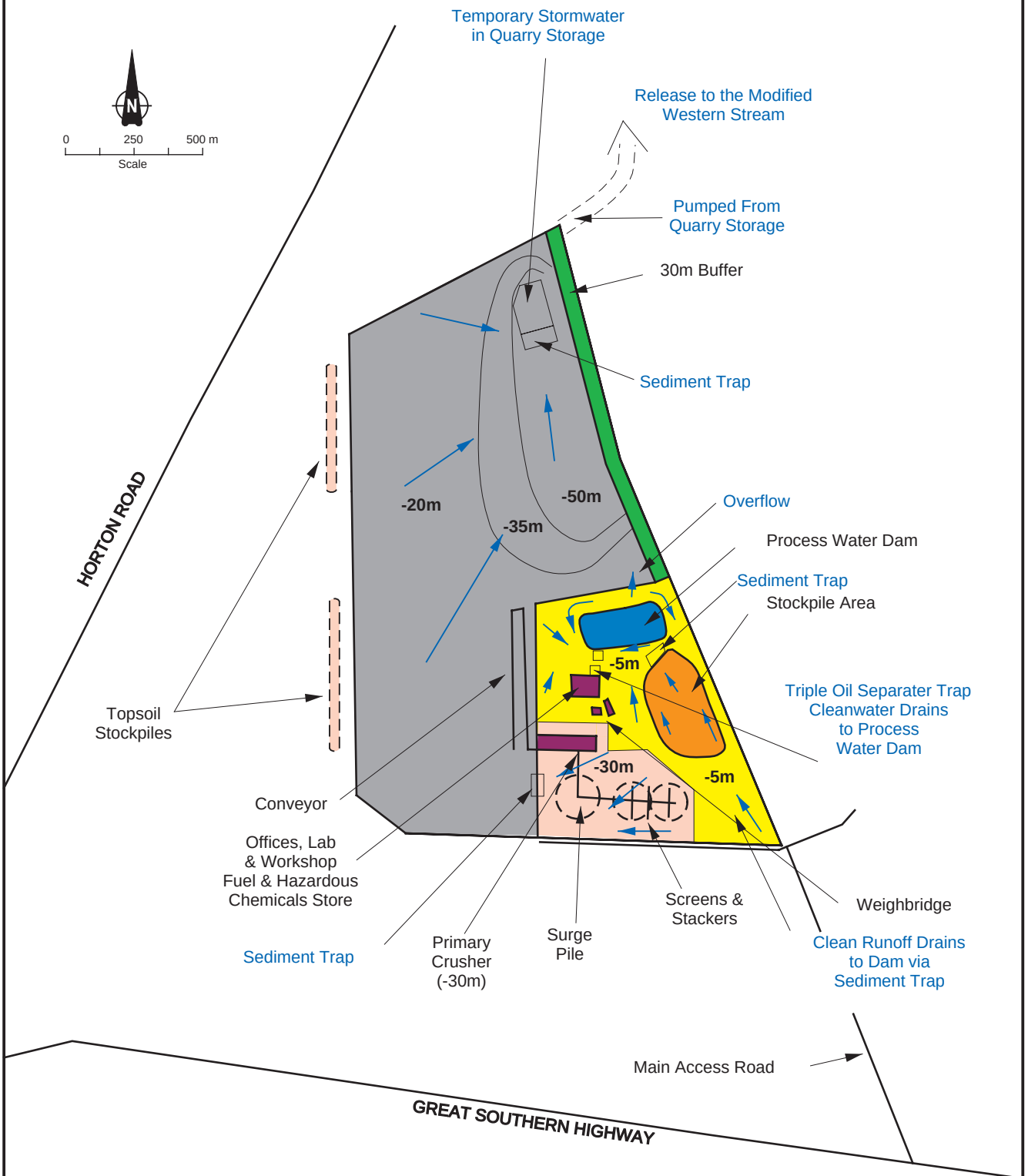

END OF YEAR 20

PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY

SURFACE WATER MANAGEMENT PLAN - END OF YEAR 20

Figure 7.3

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