FINAL REPORT
RESPONSE TO SUBMISSIONS
(Volume 2: Appendices)

Proposed Relocation of the Voyager Quarry

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

10 December 2004

42905483/DK:582-F6211.1

URS

PROPOSED RELOCATION OF THE VOYAGER QUARRY
RESPONSE TO SUBMISSIONS
VOLUME 2: APPENDICES

Table of Contents

Appendix A

Summary of Submissions Table

Table A1
Summary of Submissions

Legend:
DIA = Department of Indigenous Affairs
DoIR = Department of Industry and Resources
OSLC = Office of Soil and Land Conservation
DEP (LB) = Department of Environmental Protection (Licensing Branch and Swan-Goldfields Regional Office)
DEP (ESB) - Department of Environmental Protection (Ecological Systems Branch)
DEP (ERD) = Department of Environmental Protection (Environmental Regulation Division)
WRC = Water and Rivers Commission
CALM = Department of Conservation and Land Management
CCI = Chamber of Commerce and Industry
AVES = Avon Valley Environmental Society
WS = Wildflower Society of WA
WS (EHB) = Wildflower Society of WA (Eastern Hills Branch)
WBLCDC = Wooroloo Brook Land Conservation District Committee
SoM = Shire of Mundaring
CCWA = Conservation Council of Western Australia
BA = Birds Australia WA Conservation and Research Committee
Earth = Earth
PS = Public Submission

Source	PER Section	Topic	Issues
PS1	1.1	The Proposal	Is this a new quarry or an expansion of an existing quarry?
PS6	1.1	The Proposal	Is this a new quarry or an expansion of an existing quarry?
PS1	1.1	The Proposal	Is the zoning for Lots 11 and 14 the same even though Lot 11 is in the Shire of Mundaring?
PS14	2.1.1	Historical Perspective of the Existing Quarry	The existing quarry started without the knowledge of the EPA.
LAG	2.1.1	Historical Perspective of the Existing Quarry	The existing quarry started without the knowledge of the EPA.
PS2	2.1.2	Site Selection Process	The proposed quarry should be moving away from residences.
AVES	2.1.2	Site Selection Process	It is unlikely that there are no granite reserves located on already cleared land at a suitable distance from the metropolitan area.
WFS (EHB)	2.1.2	Site Selection Process	Why have options for acquisition on nearby land not been investigated?
PS2	2.1.2	Site Selection Process	The proposed quarry should be located on cleared land.
PS10	2.1.2	Site Selection Process	The proposed quarry should be located on cleared land.
PS15	2.1.2	Site Selection Process	The proposed quarry should be located on cleared land.
LAG	2.1.2	Site Selection Process	There are many alternative sites for the quarry that will satisfy BGC's requirements and also have less impact on the environment and amenity of the residents.
PS17	2.1.2	Site Selection Process	A site on Great Northern Highway would be suitable.
LAG	2.1.2	Site Selection Process	The Burgess Road, Gidgegannup site is the best option for the quarry relocation.
PS11	2.1.2	Site Selection Process	The proposed quarry should be located in the North West.
PS9	2.1.2	Site Selection Process	The scale of the operations should be in the Pilbara.
PS15	2.1.2	Site Selection Process	The only solution is for BGC to look for another location.
CCI	2.1.2	Site Selection Process	Quarries occur where the resource exists and cannot occur too far from the metropolitan area as every kilometre that the product has to be transported adds a significant cost.
LAG	2.1.2	Site Selection Process	Why are different criteria used for Tables 2.1 and 2.2?
LAG	2.1.2	Site Selection Process	The results presented in Table 2.1 are questionable.
LAG	2.1.2	Site Selection Process	Was the greatest weighting factor for site location the low cost of establishment as BGC purchased the land prior to development approval?
PS1	2.1.2	Site Selection Process	When was the review of local options carried out?
PS1	2.1.2	Site Selection Process	Was the greatest influencing factor for site location BGC ownership of the land?
PS1	2.1.2	Site Selection Process	Where is the data from a site-specific geological survey to support comments that the bedrock dips away to the north and east?
WFS	2.1.2	Site Selection Process	Why does the proposal involve clearing of native vegetation, when WFS has been told that the quarry could have been sited to the east of the proposed location?
PS1	2.1.2	Site Selection Process	Existing quarries would be able to cope with demand or new quarries would establish if the proposal did not proceed.
PS2	2.1.2	Site Selection Process	Existing quarries would be able to cope with demand or new quarries would establish if the proposal did not proceed.
PS4	2.1.2	Site Selection Process	Existing quarries would be able to cope with demand or new quarries would establish if the proposal did not proceed.
PS15	2.1.2	Site Selection Process	Existing quarries would be able to cope with demand or new quarries would establish if the proposal did not proceed.
LAG	2.2	Project Need	Lot 14 is not a designated Key Extraction Area.
PS4	2.2	Project Need	Lot 14 is not a designated Key Extraction Area.

Table A1 (continued)

Source	PER Section	Topic	Issues
PS5	2.2	Project Need	Lot 14 is not a designated Key Extraction Area.
WBLCDC	2.2	Project Need	Check with the Shire of Northam to see whether the Project Area is a designated Key Extraction Area.
CCI	2.2	Project Need	Hard rock resources at the Voyager Quarry are identified in SPP No. 10, which is in line with their strategic importance.
CCWA	2.3.1	Environmental and Social Benefits	The proponent should demonstrate the environmental benefits that could arise from the project.
CCWA	2.3.1	Environmental and Social Benefits	How does the proposal directly relate to the protection, enhancement and management of the environment?
PS1	2.3.1	Environmental and Social Benefits	Social benefits listed in Section 2.3 of the PER are insignificant as the demand for hard rock supplies would be met by other quarries.
PS4	2.3.1	Environmental and Social Benefits	The presence of the existing quarry has not benefited the local community.
LAG	2.3.1	Environmental and Social Benefits	The presence of the existing quarry has not benefited the local community.
PS5	2.3.1	Environmental and Social Benefits	The Lakes Roadhouse is the only local business that benefits from BGC's presented.
PS1	2.3.1	Environmental and Social Benefits	Which community projects ad groups have received support from BGC? When has this occurred and to what value?
PS2	2.3.1	Environmental and Social Benefits	Which community projects ad groups have received support from BGC? When has this occurred and to what value?
WBLCDC	2.3.1	Environmental and Social Benefits	Which community projects ad groups have received support from BGC? When has this occurred and to what value?
PS2	2.3.1	Environmental and Social Benefits	The employment of people is a social benefit, but jobs would not be lost if the quarry moved to another location.
PS4	2.3.1	Environmental and Social Benefits	Jobs would not be lost if the quarry moved to another location.
PS15	2.3.1	Environmental and Social Benefits	Jobs would not be lost if the quarry moved to another location.
AVES	2.3.2	State Benefits	The statement that BGC carries a substantial cost penalty per tonne contradicts the statement that one of the benefits of the project is the maintenance of low cost supplies of hard rock.
PS2	2.3.2	State Benefits	The statement that BGC carries a substantial cost penalty per tonne contradicts the statement that one of the benefits of the project is the maintenance of low cost supplies of hard rock.
LAG	2.3.2	State Benefits	If the proposed quarry did not proceed, the expansion of quarrying on the Darling Scarp is not an issue as they have excellent rehabilitation programmes.
PS4	2.3.2	State Benefits	If the proposed quarry did not proceed, the expansion of quarrying on the Darling Scarp is not an issue as they have excellent rehabilitation programmes.
AVES	2.3.2	State Benefits	How much royalties are paid to the local and State governments?
PS2	2.3.2	State Benefits	What financial benefits are given to the Shire of Northam besides rates and fees?
PS4	2.3.2	State Benefits	Approximately $150 per annum is given to the Shire of Northam.
PS7	2.3.2	State Benefits	Approximately $150 per annum is given to the Shire of Northam.
WBLCDC	2.3.2	State Benefits	Are royalties paid for hard rock?
PS1	2.3.2	State Benefits	To whom are royalties paid, how much and are royalties paid voluntarily?
LAG	2.3.2	State Benefits	BGC does not pay royalties to the State.
PS4	2.3.2	State Benefits	BGC does not pay royalties to the State.
PS7	2.3.2	State Benefits	BGC does not pay royalties to the State.
PS7	2.3.2	State Benefits	Landowners get royalties and the DEP gets a flat fee and a percentage of the tonnage.
PS4	2.4	Consequences of Not Proceeding	BGC are overstating their importance by claiming that the existing quarry provided 35-40% of crushed rock to the Perth metropolitan area. It is calculated that BGC's market share is less than 25%.
LAG	2.4	Consequences of Not Proceeding	It is calculated that BGC's market share is less than 25%.
CCI	2.4	Consequences of Not Proceeding	The existing Voyager Quarry meets 40% rock demand in the Perth metropolitan area.
CCI	2.4	Consequences of Not Proceeding	Granite is an essential commodity and companies should not have to mount a special case to support an extractive facility.
WFS (EHB)	2.4	Consequences of Not Proceeding	The proposal needs to be subjected to a triple bottom line, where economic, environmental and social costs are given equal weighting.
PS6	3.1	Project Overview	Why is the project called an Expanded Project when there is no increase in the rate of extraction or water consumption?
PS1	3.1	Project Overview	Why doesn't BGC keep digging in a westerly direction?
PS6	3.1	Project Overview	Is the project necessary because the resource is ending or because the owner of the lease does not intend to renew the lease?

Table A1 (continued)

Source	PER Section	Topic	Issues
PS2	3.1	Project Overview	What is meant by "to minimise the potential for off site noise, dust and light emissions"?
PS4	3.1	Proposed Rate of Extraction	There are discrepancies between the daily and annual rates of granite extraction and between the rates and the quarry's licensed throughput.
LAG	3.1	Proposed Rate of Extraction	There are discrepancies between the daily and annual rates of granite extraction and between the rates and the quarry's licensed throughput.
WBLCDC	3.1	Proposed Rate of Extraction	There are discrepancies between the daily and annual rates of granite extraction and between the rates and the quarry's licensed throughput.
AVES	3.1	Proposed Rate of Extraction	Based on the footprint and depth of the proposed quarry, the lifespan of the quarry should be shorter.
WBLCDC	3.1	Proposed Rate of Extraction	Based on the footprint and depth of the proposed quarry, the lifespan of the quarry should be shorter.
PS5	3.1	Proposed Rate of Extraction	If current rates were maintained, the proposed quarry would be mined out in less than 40 years.
AVES	3.1	Proposed Rate of Extraction	How can the proposed and existing rates of extraction be maintained if blasting is halved and hours of operation reduced?
LAG	3.1	Proposed Rate of Extraction	Will the depth of the proposed pit be 50 m from above the 10 m overburden or below it?
LAG	3.1	Proposed Depth of the Pit	Will the floor of the proposed pit be parallel to the slope of level?
PS2	3.1	Proposed Depth of the Pit	Will the depth of the proposed pit be 50 m when the first 30 m are clay and gravel?
PS4	3.2	Construction	The proposed footprint on Figure 1.3 is approximately 70 ha and the PER states 85 ha.
WRC	3.2	Construction	The proposed footprint on Figure 1.3 is approximately 70 ha and the PER states 85 ha.
SoM	3.2	Construction	The proposed footprint on Figure 1.3 is approximately 70 ha and the PER states 85 ha.
PS2	3.2	Construction	Why did the initial licence application to the Shire of Northam request clearing of 98 ha?
LAG	3.2	Construction	Based on LAG's calculation, significantly more clearing would be required than the 85 ha stated in the PER.
PS2	3.2	Construction	Does the 85 ha proposed for clearing include the land already cleared?
AVES	3.2	Construction	Does the 85 ha proposed for clearing include the land already cleared?
PS2	3.2	Construction	Why is 85 ha needed to be cleared for the proposed quarry when the infrastructure is inside the print, whereas the existing quarry footprint is 55 ha and the infrastructure is outside the pit?
PS5	3.2	Construction	Why is 85 ha needed to be cleared for the proposed quarry when the infrastructure is inside the print, whereas the existing quarry footprint is 55 ha and the infrastructure is outside the pit?
SoM	3.2	Construction	Concerned that the clearing would extend beyond the footprint shown in the PER.
S2	3.2	Construction	Is there any guarantee that further clearing outside the designated area would not occur?
AVES	3.2	Construction	The volume of overburden in the proposed pit appears to be greater than the volume of granite.
PS2	3.2	Construction	The volume of overburden in the proposed pit appears to be greater than the volume of granite.
AVES	3.2	Construction	Is the proposed granite quarry actually a clay and gravel pit?
AVES	3.2	Construction	What guarantees are there that the pit will not grow incrementally?
PS2	3.2	Construction	How can the removal of 20 m of granite take 50 years, when the removal of 30 m of overburden only take five to six years?
AVES	3.2	Construction	What noise and dust management will be implemented for the proposed quarry whilst it reaches 30 m belowground?
AVES	3.2	Construction	What is the fate of the overburden material and how will it be managed?
PS2	3.2	Construction	Why is non-degraded vegetation being cleared to stockpile topsoil?
PS14	3.2	Construction	Concerned about the construction activities being conducted for five years in conjunction with the operation of the existing quarry.
PS14	3.2	Construction	More details about the construction phases are needed, including an assessment of impacts on residents during this period.
AVES	3.3.2	Drilling and Blasting	What is the proposed drilling method, conventional or new quieter down hole drilling?
PS4	3.3.2	Drilling and Blasting	The quieter drill would be off-set by its closer proximity to residents.
PS5	3.3.2	Drilling and Blasting	How can BGC maintain the same output if there is a reduction in blasting?
PS1	3.3.2	Drilling and Blasting	Will the frequency of blasting increase with the new operation?
PS5	3.3.4	Crushing and Screening	What kind of crushers would be used for the proposed quarry? How will they be housed and will the conveyors be housed?
PS2	3.3.4	Crushing and Screening	Where does BGC intend to stockpile granite dust?
CCWA	3.3.6	Water Usage and Storage	Will the water storage dam impact hydrology through its connection to the pit and the western stream?
PS5	3.3.6	Water Usage and Storage	More water should be used for dust suppression as dust is not adequately contained at the existing quarry.
LAG	3.3.6	Water Usage and Storage	Claimed that greater than 120 million litres of water at the existing quarry is travelling towards the Wooroloo Brook eastern tributary.

Table A1 (continued)

Source	PER Section	Topic	Issues
LAG	3.3.6	Water Usage and Storage	Claimed that process water from the stockpiles and transfer points is not returned to the water holding dam at the existing quarry and is deliberately channelled to the Wooroloo Brook eastern tributary.
PS4	3.5	Hours of Operation	Hours of operation at the existing quarry on Saturdays is 0700 to 1200 not 0700 to 1300.
PS2	3.5	Hours of Operation	Claimed that the existing quarry operates outside of the hours stated in the PER.
PS5	3.5	Hours of Operation	Claimed that the existing quarry operates outside of the hours stated in the PER.
PS2	3.5	Hours of Operation	Where else in the metropolitan area are quarries allowed to work till 2200, five nights a week?
PS6	3.5	Hours of Operation	Did the Proponent reduce the operating fours for the existing quarry voluntarily?
PS1	3.5	Hours of Operation	Would BGC be providing assurances that the current hours of operation would apply to the proposed quarry?
PS5	3.5	Hours of Operation	Why are the hours of operations for the proposed quarry less if the new quarry is supposed to be more efficient?
PS2	3.7.1	Environmental Licensing	Is BGC admitting that it is not operating within the licence conditions for the existing quarry when the PER stated “operated largely in compliance”? Will this be the case for the proposed quarry?
LAG	3.7.1	Environmental Licensing	Monitoring of groundwater tables and qualities or the Wooroloo Brook has not been conducted by any regulatory authorities or quarry management. This should be conducted.
LAG	3.7.1	Environmental Licensing	Suggested a number of licence conditions.
AVES	3.7.2	Environmental Monitoring	How will compliance be met and how will it be measured? To whom will the data be supplied?
PS2	3.7.2	Environmental Monitoring	Does the proponent agree that its environmental record to date leaves a lot to be desired?
PS1	3.7.3	Complaints Register	The complaints to other organisations about the existing quarry are not presented. These should be provided.
PS4	3.7.3	Complaints Register	Residents had not been aware of the correct format in approaching the Shire and the EPA.
PS5	3.7.3	Complaints Register	Residents had not been aware of the correct format in approaching the Shire and the EPA.
PS4	3.7.3	Complaints Register	Quoted BGC’s General Manager as stating that no complaints register was kept prior to 2000.
PS5	3.7.3	Complaints Register	Quoted BGC’s General Manager as stating that no complaints register was kept prior to 2000.
PS7	3.7.3	Complaints Register	Quoted BGC’s General Manager as stating that no complaints register was kept prior to 2000.
LAG	3.7.3	Complaints Register	Quoted BGC’s General Manager as stating that no complaints register was kept prior to 2000.
PS14	3.7.4	Recent Improvements to BGC’s Operations	The improvements to BGC’s operations are welcome.
WBLCDC	3.7.4	Recent Improvements to BGC’s Operations	The list of improvements presented on Pg ES-3 of the Executive Summary need to be substantiated.
PS5	3.7.4	Recent Improvements to BGC’s Operations	If the new machinery is already in place at the existing quarry, it can still be heard 2.5 km away.
AVES	3.7.5	Environmental Management	Why has BGC not already prepared the EMS for the existing quarry?
PS2	3.7.7	Benchmarking of Existing Operations	Why was the Toodyay quarry not included in the benchmarking exercise?
PS2	3.7.7	Benchmarking of Existing Operations	The Shire of Northam and Toodyay are not in the metropolitan area.
LAG	3.7.7	Benchmarking of Existing Operations	Compared the existing quarry with the Pioneer Quarry at Redhill.
PS1	3.7.7	Benchmarking of Existing Operations	BGC should be benchmarking and seeking accreditation against industry standards.
AVES	3.8	Bonds and Provisioning for Rehabilitation	A sufficient up-front bond is needed to cover the full cost of rehabilitation and closure of the proposed quarry.
WBLCDC	3.8	Bonds and Provisioning for Rehabilitation	A sufficient up-front bond is needed to cover the full cost of rehabilitation and closure of the proposed quarry.
PS4	3.8	Bonds and Provisioning for Rehabilitation	There has never been funding put aside for the closure of the existing quarry.
PS2	3.8	Bonds and Provisioning for Rehabilitation	What is the amount of money that BGC is prepared to allocate for closure of the proposed quarry?
PS6	3.8	Bonds and Provisioning for Rehabilitation	What is the amount of money that BGC is prepared to allocate for closure of the proposed quarry?
AVES	3.8	Bonds and Provisioning for Rehabilitation	What is the amount of money that BGC is prepared to allocate for closure of the proposed quarry?
LAG	3.8	Bonds and Provisioning for Rehabilitation	Rehabilitation bonds under the Shire of Northam are unacceptably low.

Table A1 (continued)

Source	PER Section	Topic	Issues
LAG	3.8	Bonds and Provisioning for Rehabilitation	Up-front bonds for the full cost of rehabilitation should be included in BCG's budget.
AVES	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	What are the details of the landowner's requirements for rehabilitation of the existing quarry?
SoM	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	What are the details of the landowner's requirements for rehabilitation of the existing quarry?
WBLCDC	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	What are the details of the landowner's requirements for rehabilitation of the existing quarry?
PS4	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	The rehabilitation of the existing quarry to the landowner's requirements is totally unacceptable.
SoM	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	The existing quarry should be revegetated upon cessation of quarry activities, regardless of the landowner's requirements.
PS4	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	What equipment is to be sold and what is to be maintained for the proposed quarry?
AVES	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	Will the removal of stockpiles include the dust stockpiles?
PS2	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	Will the removal of stockpiles include the dust stockpiles?
LAG	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	No viable closure plan for the current quarry void has been identified.
LAG	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	The existing void would fill with groundwater after closure.
WBLCDC	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	What would happen to the water in the decommissioned site? What are the implications to hydrology and water quality of the Wooroloo Brook?
WBLCDC	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	What ongoing monitoring and revegetation at the existing quarry would take place?
LAG	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	A formal Rehabilitation Agreement between BGC and the owner of Lot 7, with the approval of DEP/EPA is needed.
LAG	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	The Strategic Framework for Mine Closure (ANZMEC) should be imposed on the current quarry operations.
LAG	3.8.1	Decommissioning and Rehabilitation of the Existing Quarry	The options of the existing quarry void are stark.
AVES	3.8.2	Closure and Rehabilitation of the Proposed Quarry	A draft closure strategy rather than a final closure strategy was not acceptable.
WBLCDC	3.8.2	Closure and Rehabilitation of the Proposed Quarry	A draft closure strategy rather than a final closure strategy was not acceptable.
PS2	3.8.2	Closure and Rehabilitation of the Proposed Quarry	A draft closure strategy rather than a final closure strategy was not acceptable.
PS2	3.8.2	Closure and Rehabilitation of the Proposed Quarry	When will the final closure strategy be presented?
WBLCDC	3.8.2	Closure and Rehabilitation of the Proposed Quarry	Full details and commitments of decommissioning and closure need to be presented.
SoM	3.8.2	Closure and Rehabilitation of the Proposed Quarry	The method and performance of post-closure management will affect environmental acceptability and should be fully assessed in this PER.
LAG	3.8.2	Closure and Rehabilitation of the Proposed Quarry	The Strategic Framework for Mine Closure (ANZMEC) should be imposed on the proposed quarry operations.
LAG	3.8.2	Closure and Rehabilitation of the Proposed Quarry	The group endorses the International Institute for Sustainable Development's observation that a closure plan should precede any discussion of the aspects of the operations.
LAG	3.8.2	Closure and Rehabilitation of the Proposed Quarry	A closure plan should be developed at the outset of the operations.
PS1	3.8.3	Void Closure and Rehabilitation	Information in Table 3.8 of the PER appeared to be qualitative and there was no information on the method for the development of the assessment criteria.

Table A1 (continued)

Source	PER Section	Topic	Issues
PS6	3.8.3	Void Closure and Rehabilitation	In Figure 3.5 of the PER, should the “Will water accumulate?” diamond connect with the “Water storage option analysis” diamond?
PS15	3.8.3	Void Closure and Rehabilitation	It would be ludicrous to leave the void open. What fill would be used for backfill?
PS15	3.8.3	Void Closure and Rehabilitation	Concerned that the void would become a rubbish dump. What would this do to the groundwater?
PS5	3.8.3	Void Closure and Rehabilitation	Options of the closure of the void are unsuitable. No waste should be placed in the void, as it would leach into the Wooroloo Brook, which is to be used as a potable drinking water sources in 2031.
OSLC	3.8.3	Void Closure and Rehabilitation	Analysis of long-term risks of off-site salinisation associated with pit closure should be conducted.
LAG	3.8.3	Void Closure and Rehabilitation	Backfilling with barren rock would negate the environmental problem but would not be a viable option for BGC.
LAG	3.8.3	Void Closure and Rehabilitation	The mix of acidic groundwater, oxygen and the non-reactive waste would cause pollution.
PS1	4.1	Climate	Local weather monitoring should be conducted, as the climate data for Bickley, Chidlow, Mundaring and Northam are unrepresentative.
WRC	4.2	Geology, Landforms and Soils	The land units in the PER do not match the topography of the project area.
PS1	4.2	Geology, Landforms and Soils	A site-specific soil/landscape survey should be conducted at a scale that is suitable for management decisions to be made.
PS1	4.2	Geology, Landforms and Soils	The Churchward and McArthur soil/landscape information used in the surface water and vegetation surveys in the PER is not suitable data and these sections are compromised as a result.
PS1	4.2	Geology, Landforms and Soils	The PER did not identify regolith features.
PS1	4.3	Surface Water	A detailed land assessment of stream conditions for the site needs to be carried out.
PS1	4.3	Surface Water	Data utilised in the surface water assessment was insufficient for the scale of the proposal.
PS1	4.3	Surface Water	The water balance is useful for calculating groundwater recharge rather than surface water movement.
CCWA	4.3	Surface Water	Why are the relative sizes of the Project Area and the catchments relevant?
WBLCDC	4.3	Surface Water	The clearing of 85 ha is large compared to the amount of native vegetation left in the catchment.
PS2	4.3	Surface Water	The clearing of 85 ha is large compared to the amount of native vegetation left in the catchment.
PS4	4.3	Surface Water	The clearing of 85 ha is 35-36% of the vegetation protecting the headwaters of the Wooroloo Brook.
LAG	4.3	Surface Water	The clearing of 85 ha I 35-36% of the vegetation protecting the headwaters of the Wooroloo Brook.
AVES	4.3	Surface Water	The headwaters of the Wooroloo Brook originate within the Project Area and the streams in the area already show problems of salinity and waterlogging.
LAG	4.3	Surface Water	The current quarry requires a surface water monitoring programme to be established.
PS5	4.3	Surface Water	A number of properties already have a salinity problem and sections of the Wooroloo Brook area saline.
PS2	4.3	Surface Water	Excess water has been released into the Wooroloo Brook from the current operations and this exacerbates waterlogging problems.
LAG	4.3	Surface Water	Measurements of the pH of waters around the quarry found that it was acidic in some places.
PS1	4.3	Surface Water	The data on water quality in the existing sediment ponds is misleading as it was sampled in winter.
PS5	4.3	Surface Water	The WRC has allocated the Wooroloo Brook to be used as a potable water source in 2031.
Earth	4.3	Surface Water	The WRC has allocated the Wooroloo Brook to be used as a potable water source in 2031.
CCWA	4.3	Surface Water	Is there a contradiction in the area being a Priority 3 Drinking Water Source Area, but not a Proclaimed Groundwater Area?
CCWA	4.4	Groundwater	Does the proponent agree that Figure 4.10 illustrates how the salinity of groundwater progressively increases from Mundaring Catchment towards the wheatbelt?
LAG	4.4	Groundwater	Lot 7 is showing evidence of salt scalds.
PS1	4.4	Groundwater	Is there any evidence that the current quarry is causing groundwater drawdown on neighbouring bores?
LAG	4.4	Groundwater	Hydrogeological data have not been collected to assess artificial recharge of groundwater beneath the existing operations.
PS1	4.4	Groundwater	Regional groundwater is brackish to saline. BGC should establish monitoring bores to determine water depth, quality and movement.

Table A1 (continued)

Source	PER Section	Topic	Issues
LAG	4.4	Groundwater	BGC should install peizometers for monitoring in early 2002.
LAG	4.4	Groundwater	The current quarry requires a groundwater monitoring programme to be established.
PS1	4.4	Groundwater	Bore data presented in the PER only represented a single sampling period.
PS1	4.4	Groundwater	The study does not highlight that any hydrogeological survey has been conducted.
PS5	4.4	Groundwater	URS started a water survey but did not finalise it.
LAG	4.4	Groundwater	On Figure 4.4 of the PER, BGC1 and BGC2 bores are incorrectly plotted.
PS1	4.5	Flora and Vegetation	What is the difference between "vegetation" and "flora"?
CCWA	4.5	Survey Timing and Methodology	Did the DEP/WRC ask for a biological survey of ecological values of the bulldozed area in spring 2002 and 2003?
CCWA	4.5	Survey Timing and Methodology	It is inappropriate that the first vegetation survey was conducted in summer.
PS2	4.5	Survey Timing and Methodology	The first vegetation survey was conducted in mid-summer.
WFS (EHB)	4.5	Survey Timing and Methodology	Why were there only two vegetation survey conducted?
LAG	4.5	Survey Timing and Methodology	Why were there only two vegetation survey conducted?
PS2	4.5	Survey Timing and Methodology	Why were there only two vegetation survey conducted?
PS7	4.5	Survey Timing and Methodology	The flora survey should have been conducted over a 12 month period.
PS5	4.5	Survey Timing and Methodology	Is conducting only two field vegetation surveys acceptable practice?
AVES	4.5	Survey Timing and Methodology	At least four vegetation flora surveys are required to be sufficient.
CCWA	4.5	Survey Timing and Methodology	Further information on the number of field days spent during the October 2002 vegetation survey is needed.
PS2	4.5	Survey Findings	Were grasses, lichens, fungi and mosses surveyed?
PS5	4.5	Survey Findings	How can the statement about no Declared Rare Flora be made only after two surveys?
LAG	4.5	Survey Findings	There is no flora list in the PER or appendices.
AVES	4.5	Survey Findings	There is no flora list in the PER or appendices.
PS2	4.5	Survey Findings	There is no flora list in the PER or appendices.
WBLCDC	4.5	Survey Findings	The LAG survey recorded a large number of trees with visible hollows.
PS5	4.5	Survey Findings	The LAG survey recorded a large number of trees with visible hollows.
PS14	4.5	Survey Findings	The LAG survey recorded a large number of trees with visible hollows.
LAG	4.5	Survey Findings	Only 15 Wandoo trees were found during the Survey of Significant Trees. Majority of these were in the footprint of the proposed quarry.
CALM	4.5	Survey Findings	The data for the *Hemigenia viscida* population should be supplied to CALM.
PS6	4.5	Survey Findings	Do granite outcrops attract special plant communities as described in Nilkulinsky and Hopper?
PS1	4.5	Survey Findings	There is alack of baseline monitoring data for vegetation for the current quarry.
CCWA	4.5	Survey Findings	Why has the work to map the south-west forest region at a site-vegetation type level not been commissioned by the proponent?
CCWA	4.5	Survey Findings	Where are the vegetation statistics for the remaining vegetation type within the catchment defined in Figure 3.1 of Appendix G? Why have the CALM statistics for the vegetation complexes from October 2002 not been presented?
CALM	4.5	Survey Findings	To the Department's knowledge, all flora species are well represented in land managed within the conservation reserve system.
CCWA	4.5	Survey Findings	Are vegetation types used as an indicator for general biodiversity?
CCWA	4.5	Fire History	Where is the validating information to support the statement that the vegetation has been burnt within the last five years?
LAG	4.5	Fire History	The Project Area has not been burnt within the past five years.
PS2	4.5	Fire History	The Project Area has not been burnt within the past five years.
PS4	4.5	Fire History	The Project Area has not been burnt within the past five years.
PS5	4.5	Fire History	The Project Area has not been burnt within the past five years.
PS14	4.5	Fire History	The Project Area has not been burnt within the past five years.
PS2	4.5	Fire History	The local fire authorities have confirmed that the Project Area has not been burnt within the last five years.
PS4	4.5	Fire History	The local fire authorities have confirmed that the Project Area has not been burnt within the last five years.
LAG	4.5	Logging History	Although the Project Area has been logged, this is not different to any adjacent bushland.
PS5	4.5	Logging History	Although the Project Area has been logged, this is not different to any adjacent bushland.
PS2	4.5	Logging History	Although the Project Area has been logged, this is not different to any adjacent bushland.

Table A1 (continued)

Source	PER Section	Topic	Issues
LAG	4.6	2002 Desktop Study and Site Inspection	Who wrote the "Vertebrate Fauna Study"?
WFS (EHB)	4.6	2002 Desktop Study and Site Inspection	A desktop study on vertebrate fauna and brief site inspection is not sufficient. Why was a field survey not conducted?
AVES	4.6	2002 Desktop Study and Site Inspection	A desktop study on vertebrate fauna and brief site inspection is not sufficient. Why was a field survey not conducted?
PS1	4.6	2002 Desktop Study and Site Inspection	A desktop study on vertebrate fauna and brief site inspection is not sufficient. Why was a field survey not conducted?
PS2	4.6	2002 Desktop Study and Site Inspection	A desktop study on vertebrate fauna and brief site inspection is not sufficient. Why was a field survey not conducted?
PS5	4.6	2002 Desktop Study and Site Inspection	A desktop study on vertebrate fauna and brief site inspection is not sufficient. Why was a field survey not conducted?
PS6	4.6	2002 Desktop Study and Site Inspection	A desktop study on vertebrate fauna and brief site inspection is not sufficient. Why was a field survey not conducted?
CCWA	4.6	2002 Desktop Study and Site Inspection	Biological survey work should cover an extended period of time.
PS1	4.6	2002 Desktop Study and Site Inspection	Would a fauna survey involving trapping and releasing of animals be appropriate for determining the species present, their habitat and their population densities?
PS6	4.6	2002 Desktop Study and Site Inspection	How can the presence of rare and endangered fauna be made in the absence of site-specific survey data?
DEP (ESB)	4.6	2002 Desktop Study and Site Inspection	The hollows for nesting could be used by smaller species.
DEP (ESB)	4.6	2002 Desktop Study and Site Inspection	The five species listed under the EPBC Act are tabulated but the text only indicated three.
BA	4.6	2002 Desktop Study and Site Inspection	Heathlands may be important for a range of insectivorous and nectarivorous birds.
PS4	4.6	2002 Desktop Study and Site Inspection	There are hundreds of suitable habitat trees in the Project Area.
PS6	4.6	2002 Desktop Study and Site Inspection	There are hundreds of suitable habitat trees in the Project Area.
LAG	4.6	2003 Targeted Field Survey	Is the Biota report a substitute for the Ninox report?
PS7	4.6	2003 Targeted Field Survey	Should the fauna survey be conducted over a 1 month period to be accurate?
AVES	4.6	2003 Targeted Field Survey	The field fauna survey is only relevant to the time of the year in which it was undertaken.
PS2	4.6	2003 Targeted Field Survey	The field fauna survey is only relevant to the time of the year in which it was undertaken.
PS7	4.6	2003 Targeted Field Survey	The field fauna survey is only relevant to the time of the year in which it was undertaken.
PS12	4.6	2003 Targeted Field Survey	The field fauna survey is only relevant to the time of the year in which it was undertaken.
AVES	4.6	2003 Targeted Field Survey	The field fauna survey would need to cover all seasons to be complete.
LAG	4.6	2003 Targeted Field Survey	How can assumptions be made on fauna on sampling 2.5% of the year?
PS17	4.6	2003 Targeted Field Survey	A fauna survey has to be seasonal.
PS11	4.6	2003 Targeted Field Survey	The season and time of day has not been taken into account during the fauna survey.
PS12	4.6	2003 Targeted Field Survey	The survey did not document the weather conditions at the time of the survey.
LAG	4.6	2003 Targeted Field Survey	The survey did not document the weather conditions at the time of the survey.
PS1	4.6	2003 Targeted Field Survey	Marri trees were not fruiting and this may have resulted in a lower number of Black Cockatoos in the area.
PS11	4.6	2003 Targeted Field Survey	How had the 25 inch Elliott traps been modified?
PS11	4.6	2003 Targeted Field Survey	How extensive was the censusing fro Carnaby's Black Cockatoo?
PS11	4.6	2003 Targeted Field Survey	How extensive were the visual searches for Dell's skink?
PS11	4.6	2003 Targeted Field Survey	How were visual searches done for herpetofauna?
PS17	4.6	2003 Targeted Field Survey	It appears that the wrong-sized traps were used in the field fauna survey.
PS9	4.6	2003 Targeted Field Survey	How can the modified Elliott trap let a Chuditch escape?
PS1	4.6	2003 Targeted Field Survey	The Biota report needs to detail the survey methodology and the expected outcomes.
PS1	4.6	2003 Targeted Field Survey	Has BGC applied the CSIRO's avifauna habitat criteria to the proposed site?
LAG	4.6	2003 Targeted Field Survey - Findings	The Biota report did not document details of the trapping results?
PS10	4.6	2003 Targeted Field Survey - Findings	Why has Carnaby's Cockatoo been excluded from the Avifauna list?
PS1	4.6	2003 Targeted Field Survey – Findings	If the quarry proceeds, then Black Cockatoos would not visit the area.
PS1	4.6	2003 Targeted Field Survey - Findings	There is no mention of critical habitat size for any of the targeted species.
PS11	4.6	2003 Targeted Field Survey - Findings	There are a few hundred suitable hollows rather than a few, as stated in the Biota report.
PS17	4.6	2003 Targeted Field Survey - Findings	The LAG survey showed that there were 696 suitable trees with hollows.

Table A1 (continued)

Source	PER Section	Topic	Issues
PS10	4.6	2003 Targeted Field Survey - Findings	The project area is an important habitat for native fauna and that the Carnaby's Cockatoo feeds on the plants in the area as does the Red-tailed Cockatoo.
PS18	4.6	2003 Targeted Field Survey - Findings	The feeding habitats of the Baudin's Black Cockatoo have not been adequately considered.
PS2	4.6	2003 Targeted Field Survey - Findings	The feeding and roosting areas for Carnaby's Black Cockatoo, Baudin's Black Cockatoo and the Forest Red-tailed Black Cockatoo are important.
PS1	4.6	2003 Targeted Field Survey – Findings	The survey results indicated that foxes were presented in the area, but no recommendations were made to reduce their numbers to protect native fauna.
PS1	4.6	2003 Targeted Field Survey – Findings	There is no recommendation to limit fauna deaths from traffic and suggested that a driver education programme, speed restrictions and night traffic movement limitation be implemented.
PS11	4.6	2003 Targeted Field Survey - Findings	How low are the numbers of Dell's Skink expected to be?
LAG	4.6	2003 Targeted Field Survey - Findings	Biota's estimate of the kangaroo population is low by a factor of two.
PS9	4.6	2003 Targeted Field Survey - Findings	How many spotlighting excursions for the Carpet Python were conducted? Were there for spotlighting excursions for Carpet Pythons occur during times when there was noise and vibration from the quarry?
PS11	4.6	2003 Targeted Field Survey - Findings	How many spotlighting excursions for the Carpet Python were conducted? Were there for spotlighting excursions for Carpet Pythons occur during times when there was noise and vibration from the quarry?
PS10	4.6	2003 Targeted Field Survey - Findings	More spotlighting excursions for the Carpet Python were needed in summer.
LAG	4.6	2003 Targeted Field Survey - Findings	A Carpet Snake was found on a property in 2000.
CCWA	4.7	Invertebrate Fauna	Why is it reasonable to assume that if the distribution of a vegetation type is not restricted that other components of the region's biodiversity, such as soil microorganisms will also not be restricted?
LAG	4.7	Invertebrate Fauna	The timing of the land snail survey is questionable.
PS5	4.7	Invertebrate Fauna	There was not enough time for comprehensive studies of trapdoor spider and land snails.
PS10	4.7	Invertebrate Fauna	The PER emphasised snails and spiders and commented little on species that were going to be displaced or killed.
PS1	4.7	Invertebrate Fauna	Does the burrowing method of the species suggest the presence of a new sub-species?
DEP (ESB)	4.7	Invertebrate Fauna	The significance of the *Gaius* sp. is still conjecture.
LAG	4.7	Invertebrate Fauna	Why has further work not been conducted on the three unnamed and snails?
PS1	4.7	Invertebrate Fauna	How many trapdoor spiders were located in the area already cleared by BGC?
DEP (ESB)	4.7	Invertebrate Fauna	What studies are being undertaken to determine whether *Gaius* sp. occurs at other Darling Range sites?
LAG	4.7	Invertebrate Fauna	When would BGC conduct the follow-up trapdoor spider work?
PS2	4.8	Social Setting	There are more residences in the affected area than the six identified in the PER.
PS5	4.8	Social Setting	There are more residences in the affected area than the six identified in the PER.
PS16	4.8	Social Setting	There are more residences in the affected area than the six identified in the PER.
PS4	4.8	Social Setting	There are 15 residences within 2 km.
LAG	4.8	Social Setting	There are 19 residences impacted by the existing quarry.
LAG	4.8	Social Setting	The existing quarry is located between 1.1 and 2 km from a cluster of homes.
PS2	4.8	Social Setting	The proposed buffer to the nearest residence is 0.5 km compared to 3 km for the Pioneer quarry.
AVES	4.8	Social Setting	The proposed buffer to the nearest residence is 0.5 km compared to 3 km for the Pioneer quarry.
PS4	4.8	Social Setting	The Pioneer quarry had to mover 2.5 km from residents to place a 4 km buffer between the quarry and the residents.
PS8	4.9	Noise	Noise (drilling, blasting, carting, crushing and trucking) is one of the key problems of the existing quarry.
PS5	4.9	Noise	Noise could be heard from the crushers, rock drill, rock breaker and all the moving machinery. Some residents are recording >50 dB on their sound monitors.
PS9	4.9	Noise	The residents living close to the quarry are impacted by noise 22 hours per day.
LAG	4.9	Noise	The machinery used in quarry is offensive and intrusive.
PS3	4.9	Noise	The constant noise of the crusher is punctuated by the noise of blasting.
PS1	4.9	Noise	BGC has installed noise loggers but not weather station.
PS5	4.9	Noise	The BGC noise loggers are positioned in bushland.
PS7	4.9	Noise	The locations of the BGC noise logger are questionable.
PS1	4.9	Noise	Recognised criteria should be applied to help in the decision-making about blasting times.
LAG	5.0	Community and Government Consultation	LAG suggested that a CLG be set-up in December 2001 but BGC rejected the concept.

Table A1 (continued)

Source	PER Section	Topic	Issues
WBLCDC	5.0	Community and Government Consultation	The structure of the CLG does not have full community support.
PS4	5.0	Community and Government Consultation	A draft terms of reference has been suggested by LAG.
LAG	5.0	Community and Government Consultation	LAG, Shire of Northam and WBLCDC set the terms of reference for the CLG.
PS5	5.0	Community and Government Consultation	BGC refused to work out the terms of reference and would not appoint and independent chairperson.
PS4	5.0	Community and Government Consultation	The CLG was never formed and would not operate until BGC is open an honest with residents.
AVES	5.0	Community and Government Consultation	What are the powers of the CLG?
WBLCDC	5.0	Community and Government Consultation	The terms of reference have not been agreed. How would the group operate?
AVES	5.0	Community and Government Consultation	Would the CLG apply to the existing or proposed quarry? Would the group have the right to inspect the project at any time?
AVES	5.0	Community and Government Consultation	If the CLG were formed, it would be essential that it be independently chaired.
PS6	6.1	Identification of Environmental Effects	Why were BGC site personnel involved with the environmental risk assessment?
PS2	6.1	Identification of Environmental Effects	Why were BGC site personnel involved with the environmental risk assessment?
PS6	7.1	General Environmental Issue	BGC should employ and environmental officer.
OSLC	7.2	Landform and Soils	How does BGC intend to manage those erosion issues?
AVES	7.2	Landform and Soils	Major erosion is likely to occur during summer storms.
WBLCDC	7.2	Landform and Soils	Major erosion is likely to occur during summer storms.
PS4	7.2	Landform and Soils	Rain erosion would occur for six months of the year and wind erosion for the other six months.
WRC	7.2	Landform and Soils	Major erosion is likely to occur during summer storms.
PS1	7.2	Landform and Soils	Significant earthworks would be required to minimise water movement from the unvegetated slope surrounding the proposed quarry.
PS4	7.2	Landform and Soils	What soil conservation techniques would be implemented?
PS2	7.2	Landform and Soils	When would the final Soil Management Plan be released?
WBLCDC	7.3	Surface Water – Existing Situation	Will the sealing of the road changed the water use for dust suppression? Will excess water be discharged to the Wooroloo Brook?
PS4	7.3	Surface Water – Existing Situation	There is no evidence to show that the existing quarry has not contributed to salinity of the Wooroloo Brook.
PS5	7.3	Surface Water – Existing Situation	The property to the north of the project area has salt starting in the paddocks.
PS1	7.3	Surface Water – Existing Situation	Aerial photos show downstream degradation from the current operation, caused by the release of quarry water.
WFS (EHB)	7.3	Surface Water – Existing Situation	Where is the data to support the statement that discharge from the current quarry has reduced salinity levels in the streams near the quarry?
PS1	7.3	Surface Water – Existing Situation	As there are no data presented prior to 1991, there is no evidence that agriculture has contributed to local degradation issues.
LAG	7.3	Surface Water – Existing Situation	Salinisation of creeks due to agriculture had occurred prior to quarrying, but salt scalds downstream of the quarry may be a result of the quarry.
LAG	7.3	Surface Water – Existing Situation	The current quarry discharge introduces excessive salt loads into the Wooroloo Brook.
WFS (EHB)	7.3	Surface Water Studies Conducted for the PER	What is the reference to the data sources for Figures 4.1a, 4.1b, 4.2a and 4.2b in Appendix G?
CCWA	7.3	Surface Water Studies Conducted for the PER	Is SWAT modelling two-dimensional and thus unable to cope with residual salt in the unsaturated zone?
CCWA	7.3	Surface Water Studies Conducted for the PER	Should Table 4.1 of Appendix G be titled "Predicted Water Balance for the Proposed Project Area"?
CCWA	7.3	Surface Water Studies Conducted for the PER	Why is there no inflow shown for the forested area prior to development?
CCWA	7.3	Surface Water Studies Conducted for the PER	Does the proponent expect less rain to fall during the construction phase?
CCWA	7.3	Surface Water Studies Conducted for the PER	Could the water balance be broken down further as there is not enough detail about the water balance during the pit construction?
CCWA	7.3	Surface Water Studies Conducted for the PER	Why were there no allowances for 'runoff' and 'process water' in relation to outflow in Table 4.1 of Appendix G?

Table A1 (continued)

Source	PER Section	Topic	Issues
CCWA	7.3	Surface Water Studies Conducted for the PER	Should Table 4.2 of Appendix G be titled "Predicted Salt Balance for the Proposed Project Area"?
CCWA	7.3	Surface Water Studies Conducted for the PER	Why does the table assume that the only salt inflow will come from salt in rainfall and disregards the residual salt mobilisation into the groundwater?
CCWA	7.3	Surface Water Studies Conducted for the PER	Why are salt tonnages not listed under outflows prior to development and during construction?
CCWA	7.3	Surface Water Studies Conducted for the PER	How can seven tonnes of salt be deposited annually if the forested area does not receive rainfall as shown in the tables?
CCWA	7.3	Surface Water Studies Conducted for the PER	Why would less salt be deposited by rainfall during construction than before construction and after construction?
CCWA	7.3	Surface Water Studies Conducted for the PER	Would 6-7 tonnes of salt per year be removed from the project area and transferred to other properties in the Wooroloo Brook Catchment?
CCWA	7.3	Surface Water Studies Conducted for the PER	Would salt in the groundwater be unlikely t cross the property boundary if the project was not approved?
CCWA	7.3	Surface Water Studies Conducted for the PER	Why were there no allowances for 'runoff' and 'process water' in relation to outflow in Table 4.2 of Appendix G?
CCWA	7.3	Surface Water Studies Conducted for the PER	Does the predicted variation in salt load take into account extra sources of salt such as salt leached from stockpiles?
CCWA	7.3	Surface Water Studies Conducted for the PER	For Figure 4.2 of Appendix G, would an additional curve for 'pre-quarry' (forest) be useful?
LAG	7.3	Proposed Water Usage and Disposal	The proposed quarry should not be located in the uppermost catchment basin of the Wooroloo Brook, as it is a high water-usage operation.
PS11	7.3	Proposed Water Usage and Disposal	The use of water in the area is not sustainable. The use of water for dust suppression is not acceptable.
WFS (EHB)	7.3	Proposed Water Usage and Disposal	What are the proportions of water that will be used for processing versus water that will be released?
OSLC	7.3	Proposed Water Usage and Disposal	What is the likely quantities and duration of release of stored water from the quarry?
PS1	7.3	Proposed Water Usage and Disposal	What are the criteria for releasing water into the Wooroloo Brook?
SoM	7.3	Proposed Water Usage and Disposal	Additional information about the level of treatment to achieve release criteria is required.
PS2	7.3	Proposed Water Usage and Disposal	What tests would be conducted on the water prior to release?
PS2	7.3	Proposed Water Usage and Disposal	Who would conduct the tests and what qualifications would they have?
CCWA	7.3	Proposed Water Usage and Disposal	What happens to stored water that is released after it leaves the project area?
PS2	7.3	Proposed Water Usage and Disposal	What would happen to the water if it were unsuitable for release?
WFS (EHB)	7.3	Proposed Reconstruction of the Western Stream	What will the physical plan look like for the reconstruction of the western stream?
SoM	7.3	Proposed Reconstruction of the Western Stream	Additional information for the method of drainage reconstruction is required.
CCWA	7.3	Proposed Reconstruction of the Western Stream	Will the proposed modification to the western stream contradict the EPA guidelines relating to the integrity, function and environmental value of the stream?
CCWA	7.3	Water and Salt Balances	Will the clearing of the Project Area add 150,000 m^3 of runoff water into the catchment?
WRC	7.3	Water and Salt Balances	What is the depth of the salt stores in the soil profile? What will happen to the salt during clearing?
PS1	7.3	Water and Salt Balances	What is the net effect of the proposed quarry and the Shire of Mundaring's gravel pit on the catchment water balance?
PS1	7.3	Water and Salt Balances	How would assessments be made of the amount of water already existing in the catchment if the rainfall data used water from outside the site?
CCWA	7.3	Water and Salt Balances	Would the total amount of salt carried by the catchment increase the pre-quarry salt levels?
CCWA	7.3	Water and Salt Balances	What physical mechanism leads to salt accumulation if there is no water flow in summer?
CCWA	7.3	Water and Salt Balances	Would the proposed discharge lead to an increased salt load in the Wooroloo Brook catchment?
CCWA	7.3	Water and Salt Balances	Will eight tonnes of salt per year be removed from the project area and be transferred to other properties in the Wooroloo Brook catchment in the release groundwater?
WBLCDC	7.3	Effects on Catchment Salinity and Salinisation	Disagreed with the statement that the proposed quarry would not contributed to local catchment salinisation.
AVES	7.3	Effects on Catchment Salinity and Salinisation	Concerned that the proposed clearing would aggravate the salinity and waterlogging of streams.

Table A1 (continued)

Source	PER Section	Topic	Issues
PS11	7.3	Effects on Catchment Salinity and Salinisation	Concerned that the proposed clearing would aggravate the salinity and waterlogging of streams.
PS10	7.3	Effects on Catchment Salinity and Salinisation	Land clearing contributes to salinity.
PS1	7.3	Effects on Catchment Salinity and Salinisation	The surface water report was concerned with on-site water, but not off-site impacts.
OSLC	7.3	Effects on Catchment Salinity and Salinisation	Analysis of the risks of on-site or off-site salinity occurring due to clearing and site development.
WBLCDC	7.3	Effects on Catchment Salinity and Salinisation	What would be the effect would clearing of 30% of native vegetation in the sub-catchment?
CCWA	7.3	Effects on Catchment Salinity and Salinisation	Why will clearing for the quarry not have the same impact as clearing for agriculture in terms of salinity?
WFS (EHB)	7.3	Effects on Catchment Salinity and Salinisation	How will saline water from the stockpiles be separated from run-off from buildings?
WFS (EHB)	7.3	Effects on Catchment Salinity and Salinisation	What would happen if the volume of “salty water” exceeds the requirements or storage capacity?
PS1	7.3	Effects on Catchment Salinity and Salinisation	If saline groundwater quantities exceed the requirements for dust suppression, how will the on and offsite impacts be managed for the removal of this water?
OSLC	7.3	Effects on Catchment Salinity and Salinisation	Information on the effect of increased discharge on the downstream environment is needed.
PS1	7.3	Effects on Catchment Salinity and Salinisation	Impacts on the local catchment form the current and proposed quarries need to be further investigated.
CCWA	7.3	Effects on Catchment Salinity and Salinisation	Would the proposed quarry contribute to salinisation as a result of water release?
CCWA	7.3	Effects on Catchment Salinity and Salinisation	The proposed quarry has the potential to mobilise salt from the unsaturated zone and increase water salinity and land salinisation downstream from the quarry.
PS4	7.3	Effects on Catchment Salinity and Salinisation	The term “likely” should be more definite in relation to the effect of the increased on the downstream environment.
PS4	7.3	Effects on Catchment Salinity and Salinisation	The term “likely” should be more definite in relation to streamflows in the local catchment returning to levels that occurred prior to the development of either quarries.
CCWA	7.3	Effects on Catchment Salinity and Salinisation	Will the increased runoff have the potential to increase the salt content of the groundwater as the runoff water percolates through the upper salt-laden unsaturated soils?
CCWA	7.3	Effects on Catchment Salinity and Salinisation	How will the Proponent guarantee reduced streamflow salinity downstream if it does not control the management of the downstream portion of the Wooroloo Brook catchment?
AVES	7.3	Effects on Catchment Salinity and Salinisation	There is no guarantee that the less saline water discharged from the mine would compensate for the increased salinity caused by clearing.
PS1	7.3	Effects on Catchment Salinity and Salinisation	The suggestion that the proposed quarry would decrease stream salinity is questionable.
PS1	7.3	Surface Water Management Plan	Further information is required n sump management.
PS1	7.3	Surface Water Management Plan	How will surface water runoff be managed from watering the site with saline groundwater?
CCWA	7.3	Surface Water Management Plan	How would residual salt leaching into the topsoil stockpiles be prevented?
WRC	7.3	Surface Water Management Plan	What contingencies are proposed for special events such as storms, leaks and where monitoring detects problems?
WBLCDC	7.3	Surface Water Management Plan	The Surface Water Management Plan should include the establishment of arrays of observation monitoring bores across the valley downstream from the quarry.
CCWA	7.3	Surface Water Management Plan	The Surface Water Management Plan should address downstream flows outside the project Area.
CCWA	7.3	Surface Water Management Plan	The Surface Water Management Plan should allow for the removal of water from the sump in the pit.
CCWA	7.3	Surface Water Management Plan	The Surface Water Management Plan should address the potential shifting of the salinity problem off-site to other landholders.
WBLCDC	7.3	Surface Water Management Plan	The Surface Water Management should be endorsed by the Shires of Mundaring and Northam.
SoM	7.3	Surface Water Management Plan	The Surface Water Management Plan should be endorsed by the Shires and relevant State government agencies.
PS2	7.3	Surface Water Management Plan	When would the final Surface Water Management Plan be released?
LAG	7.4	Groundwater – Current Situation	The current quarry is likely to have depleted the Horton Hill.
LAG	7.4	Groundwater – Current Situation	The current quarry dewatering could be dewatering the Helena Valley catchment groundwater.

Table A1 (continued)

Source	PER Section	Topic	Issues
LAG	7.4	Groundwater – Current Situation	Fracture zones beneath the Wooroloo Brook may be the reason fro the dewatering of the Horton Hill aquifer.
LAG	7.4	Groundwater – Current Situation	Rainfall recharge is flowing away from the resident farms.
LAG	7.4	Groundwater – Current Situation	Artificial recharge to the Wooroloo Brook is attributable to current quarry operations.
LAG	7.4	Groundwater – Current Situation	Current quarry discharge rates are calculated to be double natural flows and pose a serious threat of increasing the rate of groundwater rise under the Wooroloo Brook.
LAG	7.4	Groundwater – Current Situation	The current quarry holding dam discharges water to the Wooroloo Brook all year round and this has not be measured.
LAG	7.4	Groundwater – Current Situation	Two artesian bores at the existing quarry contribute water to the groundwater table beneath Wooroloo Brook.
LAG	7.4	Groundwater – Current Situation	The PER stated that the holding dam at the existing quarry was lined, however BGC's General Manager told members of LAG that it was not lined.
LAG	7.4	Groundwater – Current Situation	The multiple fracture zones in the upper 10-15 m will resume their function when the quarry fills with water.
LAG	7.4	Groundwater – Current Situation	Collection of detailed baseline data is required to determine the effects of the existing operations on the local groundwater table.
PS1	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	Information on the dewatering rates from the current and proposed pits is required.
LAG	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	There is a possibility that hydrological modelling of the proposed quarry has underestimated rates of seepage into the quarry.
LAG	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	The proposed quarry would discharge saline water for eight months of the year, resulting in a large volume of salt in the Wooroloo Brook.
WRC	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	What would the shape of the cone of groundwater drawdown be during clearing, mining and closure?
CCWA	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	Rising groundwater levels are expected in the remaining area of Lot 14 are expected.
PS1	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	How will wastewater be managed if dewatering of the pit is greater than the holding capacity of the dam?
LAG	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	A viable rehabilitation solution for the drawdown effect of the quarry has not been provided.
LAG	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	Extensive pumping tests and related hydrogeological programmes are needed.
LAG	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	The proposed quarry faces would allow groundwater from Horton Hill to drain away.
WFS (EHB)	7.4	Proposed Pit Dewatering and Predicted Groundwater Drawdown	Further information on the lateral and vertical extends of fracture zones from the edge of the proposed pit is required. What is the long term impact of the fracture zones on the moisture retention capacity of the soil?
AVES	7.4	Potential Impacts of Groundwater Drawdown on Vegetation	How will groundwater drawdown affect surrounding vegetation?
WFS (EHB)	7.4	Potential Impacts of Groundwater Drawdown on Vegetation	What are the potential impacts on the remnant plant communities near the new pit if the soil moisture profile changes?
CCWA	7.4	Potential Impacts of Groundwater Drawdown on Vegetation	Will a fall in groundwater levels have a negative impact on the remaining vegetation in Lot 14 and the heath community 5 of *Hemigenia viscida*?
PS2	7.4	Potential Impacts of Groundwater Drawdown on Vegetation	How would the proponent overcome the problem of vegetation death due to the lowering of groundwater around the rim of the pit?
PS1	7.4	Potential Impacts on Local Water Supplies	Would the pit be responsible for domestic bore drawdown?
WRC	7.4	Potential Impacts on Local Water Supplies	How does a reduction in groundwater levels affect other users in the area?
PS7	7.4	Potential Impacts on Local Water Supplies	How does a reduction in groundwater levels affect other users in the area?

Table A1 (continued)

Source	PER Section	Topic	Issues
PS15	7.4	Potential Impacts on Local Water Supplies	How does a reduction in groundwater levels affect other users in the area?
PS5	7.4	Potential Impacts on Local Water Supplies	The decrease in groundwater levels is a real concern as properties do not have scheme water.
LAG	7.4	Potential Impacts on Local Water Supplies	The quantity of water used by the current quarry has caused a depletion of the groundwater aquifers that the local community relies upon.
PS4	7.4	Potential Impacts on Local Water Supplies	Would the proposed quarry reduce the bore water and would BGC be liable?
PS7	7.4	Potential Impacts on Local Water Supplies	Would clearing of trees cause the water table to drop?
CCWA	7.4	Potential Impacts on Catchment Salinity and Salinisation	Does the proposed quarry lie in a groundwater recharge area, which was not cleared to ensure better groundwater down-catchment?
PS1	7.4	Potential Impacts on Catchment Salinity and Salinisation	Off-site impacts from surface and groundwater movement would be greater than the impacts at the quarry site.
LAG	7.4	Potential Impacts on Catchment Salinity and Salinisation	Increased salinisation of the Wooroloo Brook would be caused by quarrying processes.
CCWA	7.4	Potential Impacts on Catchment Salinity and Salinisation	What is meant by the term “off-set any soil salinisation as the project area is in a forested recharge area?
LAG	7.4	Potential Impacts on Catchment Salinity and Salinisation	The current quarry poses irreversible salinisation problems as the void will fill with groundwater and evaporation will cause it to be become saline.
CCWA	7.4	Groundwater Management Plan	The Groundwater Management Plan should address downstream flows outside the project Area.
CCWA	7.4	Groundwater Management Plan	The Groundwater Management Plan should allow for the removal of water from the sump in the pit.
CCWA	7.4	Groundwater Management Plan	The Groundwater Management Plan should address the potential shifting of the salinity problem off-site to other landholders.
PS5	7.4	Groundwater Management Plan	Independent monitoring of groundwater is required as there is concern for the existing groundwater and proposed water use in the quarry expansion.
PS2	7.4	Groundwater Management Plan	When would the final Groundwater Management Plan be released?
AVES	7.5	Vegetation Clearing in December 2001	Questioned BGC’s ignorance of the law when it conducted clearing in December 2001.
WBLCDC	7.5	Vegetation Clearing in December 2001	Questioned BGC’s ignorance of the law when it conducted clearing in December 2001.
WFS (EHB)	7.5	Vegetation Clearing in December 2001	Questioned BGC’s ignorance of the law when it conducted clearing in December 2001.
PS2	7.5	Vegetation Clearing in December 2001	Questioned BGC’s ignorance of the law when it conducted clearing in December 2001.
PS4	7.5	Vegetation Clearing in December 2001	Questioned BGC’s ignorance of the law when it conducted clearing in December 2001.
AVES	7.5	Vegetation Clearing in December 2001	Part of the land already cleared goes beyond the area intended for the proposal.
PS11	7.5	Vegetation Clearing in December 2001	The land already cleared should be immediately revegetated.
PS6	7.5	Vegetation Clearing in December 2001	The land already cleared should be revegetated to demonstrate that BGC can rehabilitate land.
PS1	7.5	Potential Impacts of Proposed Vegetation Clearing	Why would 85 ha of native vegetation be cleared when a significant amount has already been cleared?
PS2	7.5	Potential Impacts of Proposed Vegetation Clearing	Clearing of 85 ha of vegetation in the Shire of Northam is unacceptable as there is already less than 30% of the vegetation type in the shire.
PS5	7.5	Potential Impacts of Proposed Vegetation Clearing	Clearing of 85 ha of vegetation in the Shire of Northam is unacceptable as there is already less than 30% of the vegetation type in the shire.
PS15	7.5	Potential Impacts of Proposed Vegetation Clearing	Clearing of 85 ha of vegetation in the Shire of Northam is unacceptable as there is already less than 30% of the vegetation type in the shire.
AVES	7.5	Potential Impacts of Proposed Vegetation Clearing	Clearing of 85 ha of vegetation in the Shire of Northam is unacceptable as there is already less than 30% of the vegetation type in the shire.

Table A1 (continued)

Source	PER Section	Topic	Issues
LAG	7.5	Potential Impacts of Proposed Vegetation Clearing	Clearing of 85 ha of vegetation in the Shire of Northam is unacceptable as there is already less than 30% of the vegetation type in the shire.
PS2	7.5	Potential Impacts of Proposed Vegetation Clearing	Why does the Biota report state that an additional 10 ha were required for clearing?
PS6	7.5	Potential Impacts of Proposed Vegetation Clearing	The argument that there is no site-vegetation type present that is not represented in the wider conservation estate, is illogical.
AVES	7.5	Potential Impacts of Proposed Vegetation Clearing	What is the percentage of the remaining vegetation type that the 85 ha represents in the Shire of Northam?
PS6	7.5	Potential Impacts of Proposed Vegetation Clearing	Why should any wandoo be cleared as this vegetation type is below 30%?
LAG	7.5	Potential Impacts of Proposed Vegetation Clearing	The clearing would remove 36% of the remnant vegetation protecting the Wooroloo Brook.
CCWA	7.5	Potential Impacts of Proposed Vegetation Clearing	The proposal would lead to the clearing of 25% of vegetation in the catchment.
CCWA	7.5	Potential Impacts of Proposed Vegetation Clearing	Why is it acceptable to state that all vegetation complexes in the project area exceed 10% in reserves when the EPA's statement states 30%?
CCWA	7.5	Potential Impacts of Proposed Vegetation Clearing	The proposal does not meet the requirements of the EPA's Position Statement on the Environmental Protection of Native Vegetation.
CCWA	7.5	Potential Impacts of Proposed Vegetation Clearing	If the proposal is implemented, it would place WA in breach of the objectives of the Natural Heritage Act.
CCWA	7.5	Potential Impacts of Proposed Vegetation Clearing	How does the proposal meet the no net loss of native vegetation requirement in the Government's biodiversity conservation policy?
CCWA	7.5	Potential Impacts of Proposed Vegetation Clearing	The proponent should meet the terms of the criteria developed by Safstrom and Craig (1996) for clearing land.
PS2	7.5	Potential Impacts of Proposed Vegetation Clearing	What guarantees are there that the vegetation to the north of the Great Southern Highway that is within the water catchment would not be damaged?
AVES	7.5	Potential Impacts of Proposed Vegetation Clearing	Topsoil would deteriorate if left for a long period.
PS1	7.5	Potential Impacts on *Hemigenia viscida*	How many *Hemigenia viscida* plants were estimated to be lost in the clearing undertaken in December 2001?
WBLCDC	7.5	Potential Impacts on *Hemigenia viscida*	The downgrading of *Hemigenia viscida* to Priority 4 does not change BGC's legal obligations under the Act in relation to the species.
PS2	7.5	Potential Impacts on *Hemigenia viscida*	Will *Hemigenia viscida* be placed on the Declared Rare Flora list if clearing for the proposal is carried out?
LAG	7.5	Potential Impacts on *Hemigenia viscida*	Will *Hemigenia viscida* be placed on the Declared Rare Flora list if clearing for the proposal is carried out?
WFS	7.5	Potential Impacts on *Hemigenia viscida*	The protection of 95% of the *Hemigenia viscida* population is welcomed.
PS1	7.5	Potential Impacts on *Hemigenia viscida*	Is the 50 m buffer for the protection of the *Hemigenia viscida* population sufficient?
PS1	7.5	Potential Impacts on *Hemigenia viscida*	What would the buffer comprise of?
PS1	7.5	Potential Impacts on *Hemigenia viscida*	*Hemigenia viscida* would be threatened by ongoing clearing.
LAG	7.5	Dieback	Disagree with the suggested location of the dieback clean down station.
LAG	7.5	Dieback	BCG has not implemented the recommendation from the Dieback Assessment conducted in December 2001.
LAG	7.5	Dieback	The PER does not make any commitment to do anything about the dieback infestation before commencing the work on the proposed quarry.
CALM	7.5	Vegetation and Dieback Management Plans	The Vegetation and Dieback Management plans should outline the objectives and outcomes.

Table A1 (continued)

Source	PER Section	Topic	Issues
CALM	7.5	Vegetation and Dieback Management Plans	The description of how certain actions would be implemented should also be included.
PS1	7.5	Vegetation and Dieback Management Plans	What is the fire management strategy for the remaining vegetation?
PS2	7.5	Vegetation and Dieback Management Plans	When would the final Vegetation and Dieback Management plans be released?
WFS	7.5	Vegetation and Dieback Management Plans	The Vegetation and Dieback Management plans should e approved by the CALM.
CALM	7.5	Vegetation and Dieback Management Plans	The department would provide further comment on the Vegetation and Dieback Management plans following stakeholder consultation.
CALM	7.5	Vegetation and Dieback Management Plans	The redrafted Vegetation and Dieback Management plans should be reviewed to the requirements of the EPA.
PS2	7.6	Trees as Fauna Habitat	There are hundreds of breeding hollows in the area.
PS9	7.6	Trees as Fauna Habitat	There are hundreds of breeding hollows in the area.
AVES	7.6	Trees as Fauna Habitat	There are hollows available for small birds and reptiles.
LAG	7.6	Trees as Fauna Habitat	There are some 700 trees with appropriate hollows based on their height and their hollows.
Earth	7.6	Trees as Fauna Habitat	The clearing of hollows displaces hundreds of species.
PS11	7.6	Trees as Fauna Habitat	What guidelines would be used to determine whether a hollow-bearing tree would be left undisturbed?
AVES	7.6	Trees as Fauna Habitat	How many bat species are using Wandoo spouts? How many Boobook, Barking and Barn owls use the tree hollows? Are Black Cockatoos using the tree hollows?
AVES	7.6	Trees as Fauna Habitat	The use of nesting boxes has not proved to be effective.
PS2	7.6	Trees as Fauna Habitat	The use of nesting boxes has not proved to be effective.
PS9	7.6	Trees as Fauna Habitat	The use of nesting boxes has not proved to be effective.
PS11	7.6	Trees as Fauna Habitat	The use of nesting boxes has not proved to be effective.
PS14	7.6	Trees as Fauna Habitat	The use of nesting boxes has not proved to be effective.
PS18	7.6	Trees as Fauna Habitat	The use of nesting boxes has not proved to be effective.
BA	7.6	Vertebrate Fauna - Impacts	Concerned about the loss of a large area of habitat that is regionally important for a range of birds.
BA	7.6	Vertebrate Fauna - Impacts	Encourages the retention of this native habitat, particularly the heathland the wandoo.
PS10	7.6	Vertebrate Fauna - Impacts	Food dispersion due to clearing means that birds cannot supply enough food for their young.
PS6	7.6	Vertebrate Fauna - Impacts	Why does BGC believe that reducing the likelihood of impact to threatened and migratory birds was adequate?
CCWA	7.6	Vertebrate Fauna - Impacts	What is the conservation status of Numbats and why should the proposal be allowed when it could potentially impact on their conservation status?
PS18	7.6	Vertebrate Fauna - Impacts	The proponent is meant to identify its actions under the Act in terms of endangered or vulnerable fauna.
PS18	7.6	Vertebrate Fauna - Impacts	Concerned that a lack of attention has been paid to the endangered and threatened fauna habitat.
Earth	7.6	Vertebrate Fauna - Impacts	There is a lack of attention to protecting the Priority 3 Phascogales.
PS2	7.6	Vertebrate Fauna - Impacts	Knowing that the Chuditch occurs in the area should be sufficient reason to disallow any further clearing.
PS6	7.6	Vertebrate Fauna - Impacts	What does BGC propose to do about less mobile fauna species?
PS15	7.6	Vertebrate Fauna - Impacts	Where would mobile fauna move to?
PS1	7.6	Vertebrate Fauna - Impacts	The current impacts from the existing quarry on target species have not been described.
AVES	7.6	Vertebrate Fauna - Impacts	Continual blasting would have a deleterious effect on fauna.
PS9	7.6	Vertebrate Fauna - Impacts	The quarry extension would create a pool of water inaccessible to wildlife yet contribute to an explosion of mosquitoes and feral bees.
AVES	7.6	Vertebrate Fauna - Impacts	Kangaroo populations would be unbalanced by 50 years of quarrying and will cause problems to nearby properties.
AVES	7.6	Vertebrate Fauna - Impacts	If animals move to other areas, the habitats already occupied will be defended and result in death of an animal.
DEP (ESB)	7.6	Vertebrate Fauna - Impacts	The example of the Honey Possum is a poor example, as it has not been recorded within the Project Area.
Earth	7.6	Recommendations from the Targeted Vertebrate Fauna Survey Report	Recommendation 1 of the Biota report is inadequate.
Earth	7.6	Recommendations from the Targeted Vertebrate Fauna Survey Report	Recommendations in the Biota report are limited and did not discuss the enhancement of remaining habitat, protection and relocation of species threatened with habitat destruction.

Table A1 (continued)

Source	PER Section	Topic	Issues
PS1	7.6	Recommendations from the Targeted Vertebrate Fauna Survey Report	There is no recommendation for relocating the remaining animals to suitable habitats when clearing is carried out.
PS11	7.6	Recommendations from the Targeted Vertebrate Fauna Survey Report	When would the fauna habitat in rehabilitation area be enhanced with logs, as 50 years would be too late?
PS14	7.6	Recommendations from the Targeted Vertebrate Fauna Survey Report	The ability of logs to be used for fauna habitat may be lessened as felled timber was removed after land clearing in 2001.
LAG	7.6	Recommendations from the Targeted Vertebrate Fauna Survey Report	What commitment are BGC going to make in relation to the information presented in the Biota report?
CALM	7.6	Fauna Management Plan	The Fauna Management Plan should clearly outline the objectives and outcomes.
WFS	7.6	Fauna Management Plan	The Fauna Management Plan should clearly outline the objectives and outcomes.
CALM	7.6	Fauna Management Plan	The description of how certain actions would be implemented should also be included.
PS2	7.6	Fauna Management Plan	When would the final Fauna Management plan be released?
CALM	7.5	Fauna Management Plan	The department would provide further comment on the Fauna Management Plan following stakeholder consultation.
CALM	7.5	Fauna Management Plan	The redrafted Fauna Management Plan should be reviewed to the requirements of the EPA.
WBLCDC	7.7	Invertebrate Fauna	The discovery of the *Gaius* sp. is significant and the percentage to be affected is a concern.
AVES	7.7	Invertebrate Fauna	The discovery of the *Gaius* sp. is significant and the percentage to be affected is a concern.
LAG	7.7	Invertebrate Fauna	It is irresponsible to commence quarrying prior to fully documenting the new *Gaius* sp.
DEP (ESB)	7.7	Invertebrate Fauna	The trapdoor spider is an unresolved situation.
WBLCDC	7.7	Invertebrate Fauna	A successful method of spider relocation is necessary before development proceeds.
DEP (ESB)	7.7	Invertebrate Fauna	What is the previous success of trapdoor spider relocations?
PS1	7.7	Invertebrate Fauna	If the spiders require more than the uncleared area to maintain viable breeding populations, their ability to do this would be hampered by the proposed quarry.
LAG	7.7	Invertebrate Fauna	URS changed the meaning of the trapdoor spider report.
SoM	7.7	Invertebrate Fauna	Clarification on the classification of the invertebrate fauna species identified at the site is necessary.
WBLCDC	7.7	Invertebrate Fauna	What would be the impact to the land snail population outside of the proposed footprint?
PS8	7.7	Invertebrate Fauna	The PER disregarded the recommendations of the land snail study.
LAG	7.7	Invertebrate Fauna	Why was the recommendation to conducted further investigation in adjacent areas not mentioned in the PER?
LAG	7.7	Invertebrate Fauna	The land snail researcher did not state that the molluscan population in the survey area was impoverished.
WBLCDC	7.7	Invertebrate Fauna	What condition would the molluscan population be in once the development begins if it is already impoverished?
LAG	7.7	Invertebrate Fauna	The draft Fauna Management Plan did not include management measures for trapdoor spiders or land snails.
CALM	7.8	Local and Regional Biodiversity Conservation	The clearing of 85 ha would have some impact on biodiversity values, but this loss could be mitigated to some extent by the commitments made in the PER.
WBLCDC	7.8	Local and Regional Biodiversity Conservation	The statement that there will be no biodiversity loss contradicts the statement that there will be loss of species.
PS6	7.8	Local and Regional Biodiversity Conservation	Does the proponent claim that localised loss of habitat does not result in localised loss of biodiversity?
WFS (EHB)	7.8	Local and Regional Biodiversity Conservation	Where are the references to support that degraded areas in the catchment can be restored to intact bushland status?
PS2	7.8	Local and Regional Biodiversity Conservation	Revegetation in other tributary catchments will not stop salinity and waterlogging.
LAG	7.8	Local and Regional Biodiversity Conservation	The proposed revegetation is unlikely to stop rising water tables.
WFS	7.8	Local and Regional Biodiversity Conservation	Rehabilitating 170 ha will benefit salinity but would not address the loss of intact vegetation.
CALM	7.8	Local and Regional Biodiversity Conservation	The loss of biodiversity from clearing 85 ha of vegetation cannot be replaced in the short to medium term by replanting 170 ha. It is not clear whether this could be achieved in the long term.
WBLCDC	7.8	Local and Regional Biodiversity Conservation	What is the evidence to show that 2:1 ratio of revegetation would be effective?
WFS (EHB)	7.8	Local and Regional Biodiversity Conservation	Why should the community accept that 85 ha of intact bushland be given up for parcels of bushland of unknown quality and location?

Table A1 (continued)

Source	PER Section	Topic	Issues
AVES	7.8	Local and Regional Biodiversity Conservation	Why have options for revegetation not already been determined?
AVES	7.8	Local and Regional Biodiversity Conservation	What would happen if only private land was available and the land owners won't sell?
PS6	7.8	Local and Regional Biodiversity Conservation	Could the proponent indicate the location of cleared crown land on Figure ES2?
WBLCDC	7.8	Local and Regional Biodiversity Conservation	More details of the proposed revegetation programme are needed.
LAG	7.8	Local and Regional Biodiversity Conservation	More details of the proposed revegetation programme are needed.
AVES	7.8	Local and Regional Biodiversity Conservation	More details of the proposed revegetation programme are needed.
PS1	7.8	Local and Regional Biodiversity Conservation	More details of the proposed revegetation programme are needed.
PS4	7.8	Local and Regional Biodiversity Conservation	More details of the proposed revegetation programme are needed.
CALM	7.8	Local and Regional Biodiversity Conservation	More details of the proposed revegetation programme are needed.
SoM	7.8	Local and Regional Biodiversity Conservation	More details of the proposed revegetation programme are needed.
CALM	7.8	Local and Regional Biodiversity Conservation	The objectives and outcomes of the revegetation strategy should be clearing outlined.
WBLCDC	7.8	Local and Regional Biodiversity Conservation	The revegetation should occur in the immediate catchment area.
SoM	7.8	Local and Regional Biodiversity Conservation	The revegetation should occur in the White Cum Gully catchment.
PS1	7.8	Local and Regional Biodiversity Conservation	The revegetation in the Shire of Northam is questionable as downstream effects are felt in the Shire of Mundaring.
AVES	7.8	Local and Regional Biodiversity Conservation	It is not possible to return cleared land to its natural state if there is a large weed or pasture burden.
WFS	7.8	Local and Regional Biodiversity Conservation	The proponent should be committed to the production of revegetation strategy before the commencement of the proposed quarry.
PS4	7.8	Local and Regional Biodiversity Conservation	The revegetation should be conducted beforehand because it would take many years of growth to compensate the loss of 85 ha.
AVES	7.8	Local and Regional Biodiversity Conservation	The proposal to complete the revegetation by the time the existing operations cease is not acceptable because the cessation of the existing operations is flexible.
WBLCDC	7.8	Local and Regional Biodiversity Conservation	There should be continuous infilling for the life of the proposal.
CALM	7.8	Local and Regional Biodiversity Conservation	The revegetation strategy requires a stated objective of rehabilitation the land to provide habitat that mimics the floristic structure of nearby native vegetation.
WFS	7.8	Local and Regional Biodiversity Conservation	The revegetation would only be worthwhile if it mimics the floristic structure of the nearby native vegetation.
WBLCDC	7.8	Local and Regional Biodiversity Conservation	The revegetated sites would not have the same diversity of plants as intact bushland.
WFS	7.8	Local and Regional Biodiversity Conservation	BGC should buy and donate 85 ha of good quality native vegetation to the conservation estate in addition to the revegetation programme.
PS6	7.9	Greenhouse Gas Emissions	Is the proposed revegetation to compensate for the loss of native vegetation or to get carbon credits?
PS6	7.9	Greenhouse Gas Emissions	Why were truck movements not considered in terms of greenhouse emissions?
LAG	7.10	Dust – Current Situation	There is a continual fallout of dust from the existing quarry.
PS2	7.10	Dust – Current Situation	Dust from the existing quarry covers the inside and outside of the property.
LAG	7.10	Dust – Current Situation	Vehicular movement causes dust generation and sprinklers are not controlling dust at the existing quarry.
PS3	7.10	Dust – Current Situation	Dust is one of the reasons that the author does not go to their property.
PS4	7.10	Dust – Current Situation	Current dust suppression measures are inadequate.
PS5	7.10	Dust – Current Situation	Dust at the existing quarry is caused from blasting, stockpiles and moving machinery.
PS7	7.10	Dust – Current Situation	Dust from the existing quarry blows down the valley.
PS14	7.10	Dust – Current Situation	The size of the current quarry makes it impossible to control dust.
LAG	7.10	Dust – Current Situation	The logistics of keeping 85 ha wet enough day and night to prevent dust has not been addressed.
PS8	7.10	Dust – Current Situation	Complaints about dust have been made to the Shire, DEP and the local Minister.
PS16	7.10	Dust – Current Situation	Letters have been written to BGC and the Shire of Northam about dust from the existing quarry.
DEP (LB)	7.10	Dust – Current Situation	Dust generated during blasting at the existing quarry was subjected to community complaint.

Table A1 (continued)

Source	PER Section	Topic	Issues
DEP (LB)	7.10	Dust – Current Situation	The removal of the vegetation buffer between the existing quarry and the local residences in 2001 has increased the issue of dust fallout from the existing quarry.
DEP (LB)	7.10.1	Dust – Objectives and Standards	The statement that the DEP licence specifies that dust should not leave the boundary of the premises is incorrect.
DEP (LB)	7.10.1	Dust – Objectives and Standards	Blasting is not covered in the regulations.
LAG	7.10.1	Dust – Objectives and Standards	Why does the PER refer to NEPM guidelines for ambient air quality when these were not designed for measuring site boundary information?
LAG	7.10.1	Dust – Objectives and Standards	No boundary dust monitoring has been carried out at the existing quarry.
LAG	7.10.1	Dust – Objectives and Standards	The existing quarry is not meeting the appropriate criteria for dust.
WFS (EHB)	7.10.1	Dust – Objectives and Standards	Why does the PER refer to NEPM guidelines for ambient air quality when these were not designed for measuring site boundary information?
LAG	7.10	Dust - Impacts	Dust reduces the amenity for living, farming and other activities.
LAG	7.10	Dust - Impacts	Silica dust reduces the quality of locally grown fruit.
PS7	7.10	Dust - Impacts	If the expansion proceeds, the dust levels would increase due to increased machinery movement.
LAG	7.10	Dust - Impacts	Dust generation occurs during general quarrying operations, not just during blasting activities.
DEP (LB)	7.10	Dust – Health Concerns	Health concerns about the dust have been raised by residents.
PS2	7.10	Dust – Health Concerns	Concerned about the potential for dust to cause silicosis.
PS3	7.10	Dust – Health Concerns	Concerned about the potential for dust to cause silicosis.
PS8	7.10	Dust – Health Concerns	Concerned about the potential for dust to cause silicosis.
PS14	7.10	Dust – Health Concerns	Concerned about the potential for dust to cause silicosis.
LAG	7.10	Dust – Health Concerns	A number of residents are asthmatic and any increase in airborne pollutants will exacerbate their condition.
LAG	7.10	Dust – Health Concerns	The PER does not detail the silica type, content and particle size in the dust.
PS7	7.10	Dust – Health Concerns	No testing of the dust emissions or health effects of the dust has occurred.
PS5	7.10	Dust – Health Concerns	The silica content of the dust blown onto houses was 82%.
DoIR	7.10	Dust Management	Public safety and associated issues such as dust have been adequately addressed in the PER.
LAG	7.10	Dust Management	Dust generated during clearing activities would be impossible to control.
PS3	7.10	Dust Management	Wind causes dust to erupt from the pit due to the 'Venturi Effect'.
PS4	7.10	Dust Management	Dust suppression has not been addressed adequately.
WFS (EHB)	7.10	Dust Management	How will dust loads from the proposed quarry be monitored?
LAG	7.10	Dust Management	There are problems associated with the dust management measures proposed in the PER.
LAG	7.10	Dust Management	The Pioneer Quarry has additional dust control measures that BGC have not considered.
PS2	7.10	Dust Management	When would the final Dust Management Plan be released?
PS5	7.11	Noise – Current Situation	The noise from the existing quarry has increased since the clearing in December 2001.
LAG	7.11	Noise – Current Situation	The noise from the existing quarry has increased since the clearing in December 2001.
DEP (LB)	7.11	Noise – Current Situation	Residents feel that they are unreasonably impacted on by noise in the early morning and evenings.
DEP (ERD)	7.11	Noise Monitoring and Modelling	Modelling of the current operation shows the possibility of non-compliance.
DEP (ERD)	7.11	Noise Monitoring and Modelling	What measures will be undertaken to ensure that the current operation is in compliance?
PS11	7.11	Noise Monitoring and Modelling	Who is conducting the noise monitoring? When and how is it being conducted?
PS5	7.11	Noise Monitoring and Modelling	The location of BGC's noise logger is questionable.
PS7	7.11	Noise Monitoring and Modelling	The location of BGC's noise logger is questionable.
LAG	7.11	Noise Monitoring and Modelling	The location of BGC's noise logger is questionable.
LAG	7.11	Noise Monitoring and Modelling	The monitoring station located to the north of the existing quarry should be moved 50 m east.
PS1	7.11	Noise Monitoring and Modelling	BGC have installed noise logger but not weather stations.
PS5	7.11	Noise Monitoring and Modelling	Rain was received on the day that the noise assessment was conducted.
PS7	7.11	Noise Monitoring and Modelling	Rain was received on the day that the noise assessment was conducted.

Table A1 (continued)

Source	PER Section	Topic	Issues
PS16	7.11	Noise Monitoring and Modelling	Rain was received on the day that the noise assessment was conducted.
LAG	7.11	Noise Monitoring and Modelling	The humidity reading for the period that noise monitoring occurred was not mentioned.
LAG	7.11	Noise Monitoring and Modelling	The wind direction for 1 November 2002 that was quoted by Herring Storer Acoustics was incorrect.
LAG	7.11	Noise Monitoring and Modelling	The area has its own “macro-climates” and temperature inversions are common.
LAG	7.11	Noise Monitoring and Modelling	The existing quarry exceeds EPA noise regulations at four residences.
LAG	7.11	Noise Monitoring and Modelling	Were the reduced tree buffer and prevailing winds taken into account for the noise impact assessment?
DEP (ERD)	7.11	Noise Monitoring and Modelling	There is no mention of meteorological parameters used for modelling of the worst-case conditions.
DEP (ERD)	7.11	Noise Monitoring and Modelling	Did the parameters used in the modelling follow the default value defined in the EPA’s “Draft Guidance for the Assessment of Environmental Factors No. 8, Environmental Noise”?
PS5	7.11	Noise Monitoring and Modelling	How can a project with a life of 50 years be based on two days of fieldwork?
PS16	7.11	Noise Monitoring and Modelling	It is important to have acoustic data collected over a 12 month period.
PS1	7.11	Noise Monitoring and Modelling	Noise level trends should be presented from 1991 from periods of 24 hour operation.
DEP (ERD)	7.11	Noise Monitoring and Modelling	Additional data are needed to support the assumption that making by noise generated by wind in the trees occurs and that tonality is not present.
LAG	7.11	Noise Monitoring and Modelling	Adjustments for tonality, modulation and impulsiveness have not been made in the noise modelling.
DEP (ERD)	7.11	Noise Monitoring and Modelling	The rockbreaker has not been included in the modelling of the existing or new operations.
DEP (ERD)	7.11	Noise Monitoring and Modelling	Road trucks are not included in the sound power list and are assumed to not be included in the modelling.
DEP (ERD)	7.11	Noise Monitoring and Modelling	For the transition operations, it was not clear at what depth below ground level, the new operations were modelled.
DEP (ERD)	7.11	Noise Monitoring and Modelling	The proposed operation should be re-modelled to represent worst-case conditions.
LAG	7.11	Noise Monitoring and Modelling	The computer model results from the Noise Impact Assessment shows incorrect sound propagation analyses.
LAG	7.11	Noise Monitoring and Modelling	The noise modelling is flawed and shows considerable bias towards the proposal.
LAG	7.11	Noise Monitoring and Modelling	BGC placed a sound monitor on selected residences and it was noted at the time that readings were exceeding limits. Where is this data?
PS4	7.11	Noise - Impacts	What is the definition of day time operations?
PS4	7.11	Noise - Impacts	Locating the infrastructure 30 m below ground would do little to alleviate noise.
PS5	7.11	Noise - Impacts	Locating the infrastructure 30 m below ground would do little to alleviate noise.
LAG	7.11	Noise - Impacts	Locating the infrastructure 30 m below ground would do little to alleviate noise.
PS7	7.11	Noise - Impacts	Mining of weathered granite would increase noise and the valley acts as an amphitheatre.
CCI	7.11	Noise - Impacts	Noise from the current operation comes from ground level, however noise would be reduced with the proposed operations because it would be from 30 m below ground.
DoIR	7.11	Noise - Impacts	Public Safety issues relating to blast noise have been adequately addressed.
DEP (ERD)	7.11	Noise - Impacts	There is not enough information to show that the transition operation can be managed to comply with the noise regulations.
DEP (ERD)	7.11	Noise - Impacts	The noise impact of the construction and operation activities should be considered separately.
DEP (ERD)	7.11	Noise - Impacts	The removal of overburden in the form of topsoil could be regarded as construction.
DEP (ERD)	7.11	Noise - Impacts	The removal and sale of gravel and clay layers could not be considered as construction noise.
LAG	7.11	Noise - Impacts	The clause for construction noise in the regulation was not designed to cover long-term land clearing projects.
AVES	7.11	Noise - Impacts	Why will the primary crusher be housed “if required”?
DEP (ERD)	7.11	Noise - Impacts	The primary crusher is likely to generate noise that contains modulation characteristics. There has not been an assessment to show that noise from the crusher has lost this characteristic.
PS8	7.11	Noise – Impacts	The PER did not address the effect of noise on livestock production.
LAG	7.11	Noise – Impacts	Further information is needed on the effect of mining noise on livestock.
PS2	7.11	Noise Management Plan	When would the final Noise Management Plan be released?

Table A1 (continued)

Source	PER Section	Topic	Issues
PS7	7.12	Ground Vibration and Airblast	Actual blasting practices were not consistent with information presented in the PER.
PS15	7.12	Ground Vibration and Airblast	Actual blasting practices were not consistent with information presented in the PER.
PS4	7.12	Ground Vibration and Airblast	Are the vibration levels in the Australian Standard for surface or below ground levels?
LAG	7.12	Ground Vibration and Airblast	The noise monitoring performed by ABT was not conducted using the correct methodology, as the ground transducer was attached to a small rock barely buried in the ground.
PS4	7.12	Ground Vibration and Airblast	What is the guarantee that BGC will use Maximum Instantaneous Charges (MICs) around 130 kg?
AVES	7.12	Ground Vibration and Airblast	What is the guarantee that BGC will use MICs around 130 kg?
LAG	7.12	Ground Vibration and Airblast	Where is the airblast and vibration data from 1990 to 1993 for the existing quarry?
LAG	7.12	Ground Vibration and Airblast	It is unreasonable for the airblast level to be so close to the maximum limit.
PS4	7.12	Ground Vibration and Airblast	What are the comfort criteria for airblasts?
DEP (ERD)	7.12	Ground Vibration and Airblast	There was variability in the vibration levels during the early stages of the existing quarry. There is a possibility if exceedance of the DEP limits at the proposed quarry
LAG	7.12	Ground Vibration and Airblast	The damage reported in the McDowell Affleck structural survey was of a type and degree unlike that found in other comparable residences.
LAG	7.12	Ground Vibration and Airblast	The structural survey was incomplete and until these omissions have been rectified, there is a lack of baseline data.
PS5	7.12	Ground Vibration and Airblast	The structural survey on six residences acknowledges that there is a potential for significant impacts to occur.
AVES	7.12	Ground Vibration and Airblast	No information is available on the cumulative effects of continuous blasting on the environment, buildings and residences.
PS11	7.12	Ground Vibration and Airblast	Blasting affects fauna, damages structures and water bodies.
LAG	7.12	Ground Vibration and Airblast	Further information is required on the effects of blasting on livestock.
AVES	7.12	Ground Vibration and Airblast	The wall between the existing and proposed pits may fractures as a results of continual blasting.
LAG	7.12	Ground Vibration and Airblast	The wall between the existing and proposed pits may fracture as a results of continual blasting.
LAG	7.12	Ground Vibration and Airblast	The existing quarry face is extensively fractured.
LAG	7.12	Ground Vibration and Airblast	Geotechnical consultants should be employed to determine how ground vibrations are transferred through fracture zones.
AVES	7.12	Ground Vibration and Airblast - Management and Monitoring	Even though the study showed that blasting can be managed to comply with comfort criteria, there is no evidence that this is the objective.
PS6	7.12	Ground Vibration and Airblast - Management and Monitoring	The monitoring stations for airblast and ground vibration should be located close to the proposed quarry.
PS15	7.12	Ground Vibration and Airblast - Management and Monitoring	The monitoring stations for airblast and ground vibration should be located close to the proposed quarry.
PS5	7.12	Ground Vibration and Airblast - Management and Monitoring	Monitoring of vibration should be conducted on each person's property.
DEP (ERD)	7.12	Ground Vibration and Airblast - Management and Monitoring	Blasts are controllable as lower charge masses can be used.
DEP (ERD)	7.12	Ground Vibration and Airblast - Management and Monitoring	The Airblast and Ground Vibration Management Plan should include information on how the impacts of blasting will be managed.
PS2	7.12	Ground Vibration and Airblast - Management and Monitoring	When would the final Airblast and Ground Vibration Management Plan be released?
PS2	7.13	Flyrock	Flyrock has been a problem n the past.
PS2	7.13	Flyrock	The ability of cameras to capture the flight and extent of flyrock distance is questionable.
PS4	7.13	Flyrock	The ability of cameras to capture the flight and extent of flyrock distance is questionable.
PS5	7.13	Flyrock	The ability of cameras to capture the flight and extent of flyrock distance is questionable.

Table A1 (continued)

Source	PER Section	Topic	Issues
PS4	7.13	Flyrock	The new operation would be unable to contain flyrock.
PS5	7.13	Flyrock	The new operation would be unable to contain flyrock.
PS14	7.13	Flyrock	The new operation would be unable to contain flyrock.
LAG	7.13	Flyrock	The new operation would be unable to contain flyrock.
PS4	7.13	Flyrock	What are the new techniques that prevented flyrock from occurring?
DoIR	7.13	Flyrock	Public safety and associated issues such as flyrock have been adequately addressed in the PER.
LAG	7.14	Site Access and Transport	There are 140-200 trucks a day used at the existing quarry.
PS10	7.14	Site Access and Transport	The number of trucks (200/day) is unacceptable for fauna and humans.
Earth	7.14	Site Access and Transport	There are approximately 300 trucks are currently leaving the existing site each day.
PS11	7.14	Site Access and Transport	Heavy road trains on Great Eastern Highway degrade the surface.
AVES	7.14	Site Access and Transport	The wetting of the loads increases the load on the truck and reduces the payload. Does this mean that that there are more truck movements or are the trucks being overloaded?
PS1	7.14	Site Access and Transport	Data on the volume of traffic from the current quarry is required to see if this has increased or decreased over the life of the quarry.
PS1	7.14	Site Access and Transport	Further information on the expected truck traffic from the proposed quarry is required. This data should be presented to the Department of Planning and Infrastructure to assess the acceptability of truck volume.
PS1	7.14	Site Access and Transport	There needs to be a guarantee that the main access road to the quarry will be from Great Southern Highway, not Horton Road.
PS4	7.15	Visual Amenity	Properties to the north and east have line of sight to the existing and proposed quarries.
PS2	7.15	Visual Amenity	The proposed quarry site is visible from the author’s property.
PS4	7.15	Visual Amenity	The pit wall of the proposed quarry would be as unsightly as the plant and equipment.
PS4	7.15	Visual Amenity	Distance is not a solution to visual impact.
PS4	7.15	Visual Amenity	The term “likely” should be more definite in relation to the vegetation buffer and visibility of the proposed project.
AVES	7.15	Visual Amenity	The lighting type should have already been determined.
PS2	7.15	Visual Amenity	The existing quarry produces nightglow. If the proposed quarry is allowed to operate at night, then the actual lights would be visible.
PS4	7.15	Visual Amenity	Nightglow has detrimental effects on livestock and interferes with the author’s hobby of astronomy.
PS3	7.15	Visual Amenity	During the early years of operation at the new quarry, there will be light overspill.
PS4	7.15	Visual Amenity	The granite would reflect the light back upwards even if the lights are below ground.
PS2	7.15	Visual Amenity	When would the final Visual Impact Management Plan be released?
DIA	7.16	Aboriginal Heritage	BGC has addressed the *Aboriginal Heritage Act* in undertaking the heritage surveys. If any cultural material is unearthed, all work should cease and the DIA should be notified.

Appendix B

Surface Water Study

REPORT

Additional Surface Water Studies Conducted Since the PER in Response to Submissions Related to the Proposed Expansion of BGC Voyager Quarry

Prepared for

BGC Quarries

PO Box 1257
MIDLAND WA 6936

9 December 2004

42905483/50846-008-562

URS

Prepared By	…………………………………..	URS Australia Pty Ltd
	R Connolly	Level 3, The Hyatt Centre
	Associate Hydrologist	20 Terrace Road
		East Perth, WA 6004 Australia
		Tel: 61 8 9221 1630
		Fax: 61 8 9221 1639
Reviewed By	…………………………………..	
	J Barnett	
	Principal Hydrologeologist	

Authorised By	…………………………………..	Date:	**9 December 2004**
	Ian LeProvost	Reference:	42905483 Swtr.doc
	Senior Principal Environment	Status:	Revision 1

Contents

List of Tables, Figures, Plates & Appendices

Tables

Figures

Appendices

1.1 Background

1.1.1 Aim of this Document

The aim of this document is to provide technical detail to support BGC's response to issues raised by the community in relation to surface water, erosion and salinity management at the proposed expansion to the Voyager Quarry. The original public environmental review (PER) documents are given in URS (2003). The submissions are dealt with individually in a response to submission document (URS 2004a) and are not repeated in detail in this document.

1.1.2 Summary of Issues

Submissions from the PER process and subsequent community meetings indicate that issues regarding surface water relate to:

- the nature of the water balance of the existing quarry and what impact the existing quarry is having on downstream flows and salinity;
- release of water from the proposed quarry, particularly how far downstream will be impacted and what the impacts will be on stream flow, salinity, erosion, and local water-table levels as a result of infiltration from the stream beds;
- management of sediment and erosion on-site during the life of the quarry;
- accuracy of the water balance for the proposed quarry, particularly relating to the amount of seepage inflow to the pit from surrounding groundwater and outflow to groundwater from the pit during the life of the project; and
- the level of surface water monitoring at the existing quarry.

2.1 Introduction

The issues raised by the community relating to surface water (see Section 1.1.2) were addressed by instigating a number of more detailed studies during 2004 to extend the original work presented in the PER. The original work related to surface water is given in Appendix G of the PER and summarised throughout the PER documents.

The following additional work was undertaken:

- implementation of a monitoring programme to characterise the water balance of the existing quarry, particularly seepage inflows to the existing pit, seepage outflows from the quarry dam and stockpiles, and stream flows at and downstream of the existing quarry;
- evaluating downstream impacts of water release in more detail, including expansion of the water balance model for the existing operations, updating the water balance model for the new quarry and the catchment simulations to account for new information received, and simulation of a pre-quarry – forest stream flow scenario; and
- enhancing the description of the monitoring and management plan for the proposed quarry, including more details on how stormwater and erosion will be managed, characterisation of the impact of water release on downstream flows, salinity and groundwater levels; and more details of the proposed reshaping of the western stream.

A summary of methods used in these investigations is given below. Results of the investigation are presented in Section 3.

2.2 Characterisation of the Existing Operations

A monitoring programme was developed to further quantify local stream flows and of the water balance of the existing quarry. The monitoring is being undertaken by BGC. A summary of the monitoring plan is given in Section 3.4.1.

Seepage inflows to the Quarry Sump and Quarry Dam were quantified by observing change in water levels at strategic times (over weekends and public holidays) when inputs and outputs could be controlled and key components measured. Seepage tests were conducted over the periods: 24-26 January 2004; 9-12 April 2004; and 5-8 June 2004. These supplemented estimates of seepage made for the Quarry Sump in March and July 2002.

Any rainfall during the test periods was recorded on site and evaporation during the test periods was generated from the Bureau of Meteorology for the quarry site (using the Patched Point Database, BOM 2004). There were no rainfall or runoff inflows to the sump during the time of measurement (except for the June 2004 sampling) and evaporation was the only outflow during the time of measurement. Water was not pumped for process use or watering during the seepage test period. Neither the Quarry Sump nor dam overtopped during the test periods.

Seepage inflows to the Quarry Sump during the June 2004 test period could not be adequately characterised due to high runoff inflow during the observation period. A water balance was constructed for the two storages based on the test observations and used to calculate seepage rates during each test period.

Results are presented in Section 3.2.2

2.3 Downstream Impacts of Water Release

Characterisation of the impact of the release of water from the proposed quarry on downstream flows, salinity, erosion, and local groundwater levels was undertaken using site inspections, review of mapping data, evaluation of observed stream flow data (there are several stream flow sites on Wooroloo Brook operated by the Department of Environment) and modelling.

The modelling framework was used to simulate the existing and proposed quarries and the local catchment. The existing model framework, described in Appendix G of the PER, was expanded to encompass the additional detail needed for the existing quarry, to allow prediction of impacts downstream for a greater distance (for the entire Wooroloo Brook catchment), and updated to include new data received.

Existing flow and water quality in streamlines in the area of the quarry was characterised during site visits in January and April 2004, building on previous site visits and observations presented in Appendix G of the PER. Transects were made along the Eastern and Western Streams near and north of the quarry as far as the boundary with Lot 13 (B Dibble). Issues related to erosion, ponding causing evaporative concentration of salts, recharge of groundwater along streamlines and impacts on dams and farmland were investigated.

Potential for recharge of the shallow watertable in agricultural areas north of the quarry as a result of increased stream flow was evaluated by inspecting the existing geology and hydrogeology of the streams and by interpreting the flow and salinity transects.

Results are presented in Section 3.3.

2.4 Enhanced Monitoring and Management Plans

The existing monitoring and management plans for the proposed quarry, given in Appendix G of the PER, were updated.

A detailed Erosion Management Plan was prepared based on best-practice erosion management techniques and conforming with relevant guidelines.

Figures showing the alignment and typical sections for drainage works throughout the quarry area were developed. This drainage network ultimately drains to the reshaped Western Stream.

More detailed plans showing the alignment and typical cross-sections for the proposed reshaping of the western stream were developed, building on the alignment and conceptual design given in Appendix G of the PER. The stream alignment design was based on the existing alignment and meander guidelines given in Torre (2001). Existing topography restricts the location, size and number of meanders, but the guidelines were followed as closely as possible.

The maximum of the planned rate of release of excess water from the quarry and the existing 100-year ARI event discharge was used as the design discharge. The 100-year ARI discharge was calculated using the Rational method, with parameters adjusted using local stream flow gauging data. Calculations to determine the planned rate of release of excess water from the quarry are given in Appendix G of the PER.

The enhanced monitoring and management plans are presented in Section 3.4.

3.1 Introduction

This section outlines the results of the investigations to address issues raised by the community. Detailed monitoring results are given in Appendix A.

3.2 Characterisation of Existing Operations

Several submissions requested more information on the nature of the water balance of the existing quarry and what impact the existing quarry is having on downstream flows and salinity. To address this issue, an enhanced monitoring program for the existing quarry has been put in place. Results of monitoring and analysis of data collected to date are presented in this section.

3.2.1 Enhanced Monitoring Program

Table 1 summarises an enhanced monitoring program for the existing quarry. A detailed monitoring plan, including monitoring procedures, has been prepared as a separate document (URS 2004b). Figure 1 shows the location of monitoring and observation points.

Monitoring data collected to date are summarised in Appendix A.

Table 1

Monitoring Methodology – Existing Quarry

Sample location	Sample method and frequency	Analysis Required	Comments
Pit sump (Q1).	Hand sample for water quality, monthly.	TDS, TSS, pH.	Required to characterise the pit and site water balance.
	Record depth of water in pit from gauge board, weekly.	Water depth.	
	Seepage tests in January, April, July and November 2004.	Record change in water level daily during a 2-5 day period when there are no pumped inflows or outflows.	
Quarry dam (Q2).	Hand sample for water quality, monthly when no release to the environment, daily when releasing to the environment.	TDS, TSS, pH.	Required to characterise the pit and site water balance and the quantity and quality of water released to the environment.
	Record depth of water in pit from gauge board and water area, weekly.	Water depth, surface area.	
	Record volume released to the environment via the dam spillway, daily when discharging.	Daily volume.	
	Seepage tests in January, April, July and November 2004.	Record change in water level daily during a 2-5 day period when there are no pumped inflows or outflows.	
Stream flow monitoring sites E2, W1 and S2.	Hand sample, monthly; when flowing; daily when water is being released from the quarry dam.	TDS, TSS, pH.	Required to characterise impacts of the quarry on stream flows.
	Record depth of water in stream at time of hand sampling.	Water depth.	
Weather	Daily using a manual rain gauge or an automatic weather station.	Daily rainfall.	Required to characterise local rainfall conditions.
Operations	Record general water management operations, including.	Diary notes.	Required to characterise site water balance and general site operations.

3.2.2 Quarry Sump and Dam Water Balance

An evaluation of the water balance components of the existing Quarry Sump and Dam and general observations of site drainage were undertaken on several occasions from 2002 to 2004. The investigations involved identifying inflow and outflow pathways and conducting tests to characterise seepage inflow and outflow rates.

Quarry Sump

A conceptual water-balance model for the existing Quarry Sump is shown in Figure 2. Estimated flow rate ranges for the various inputs and outputs and average annual totals are shown in Table 2. Observations of seepage inflow rates are listed in Table 3.

The overall water balance for the sump is dominated by runoff inflows and pumping outflows. Runoff inflows are episodic, but can reach 150 L/s. Pumping is at a relatively low rate, 4 L/s, but consistent pumping over time easily removes excess water from the sump. Seepage inflows are small and contribute a small component of the sump water balance.

Table 2

Water Balance for the Quarry Sump

Water Balance - Component	Description	Typical Flow Rates (L/s)	Average Total (ML/year)
Inflows:			
Rainfall	Rainfall directly onto the water surface.	0-0.4	0.4
Runoff	Runoff from the pit area, collecting in the sump.	0-150	155.7
Seepage	Seepage into the pit from surrounding rock, collecting in the sump.	0-0.7	13.1
Outflows:			
Evaporation	Evaporation directly from the water surface.	0.002-0.06	8.3
Seepage	Seepage out to the surrounding rock.	0.0	0.0
Pumping	Pumping to the Quarry Dam for process use and watering.	0-4	160.9
Release via spillway	No release via spillway or overtopping.	0.0	0.0

Seepage inflow occurs from several locations around the walls of the quarry. Estimates of seepage inflow rates to the sump for the various site investigations are given in Table 3. These rates are consistent with the rates used in the water-balance modelling given in the Public Environmental Review documents (an average 0.35 L/s).

Accordingly, the original water-balance modelling was considered to be accurate and is not repeated here.

Table 3

Observed Seepage Inflow Rates for the Quarry Sump

Date	Inflow Rate (L/s)
	Quarry Sump
Mar-02	0.0
Jul-02	0.3
Jan-04	0.2
Apr-04	0.7
Average	**0.3**

Quarry Dam

The main components of the water balance for the Quarry Dam are described in Table 4 and details of observations of seepage inflow are given in Table 5. A conceptual water-balance model for the Quarry Dam is shown diagrammatically in Figure 2.

Table 4

Water Balance for the Quarry Dam

Water Balance - Component	Description	Typical Flow Rates (L/s)	Average Total (ML/year)
Inflows:			
Rainfall	Rainfall directly onto the water surface.	0-11	11.8
Runoff	Runoff from the quarry processing area and the upslope agricultural area.	0-40	39.8
Seepage	Groundwater inflow to the dam. Two artesian bores to the south of the dam discharge water onto the ground and in the direction of the dam, but it is likely that most of this infiltrates or evaporates prior to reaching the dam.	1.5-3.0	63.1
Pumping	Pumped from the Quarry Sump.	0-10	160.9
Outflows:			
Evaporation	Evaporation directly from the water surface.	0.2-2	19.9
Seepage	Seepage from the down-slope edge of the dam. Assumed to be zero after repairs to leaking parts of the dam wall and installation of a seepage collection sump in the northeastern corner of the quarry.	0.0	0.0
Pumping	Pumping for process use and watering.	0.8-4.3	61.6
Release via spillway	Release over a spillway to the Eastern Stream during wet periods	0-30	194.1

Table 5

Observed Seepage Inflow and Outflow Rates for the Quarry Dam

Date	Inflow Rate (L/s)	Outflow Rate (L/s)
Mar-02	-*	-*
Jul-02	-*	-*
Jan-04	1.6	0.5
Apr-04	2.7	0
Jun-04	**4.7**	0
Average/typical	**3.0**	**0.0**

* not measured.

The water balance in the Quarry Dam was more complex than the Quarry Sump with evidence of simultaneous seepage inflows and outflows during some of the tests.

At the time of the January 2004 measurement, a strong seepage outflow (0.5 L/s) was observed in the stockpile area, down slope of the dam. It is understood that this seepage was a result of disturbance to the dam wall, below the waterline, incurred during excavation. Some of this seepage water, after losses to evaporation and infiltration, entered the Eastern Stream in the vicinity of monitoring point E2.

This level of seepage is unusually high. The leak was subsequently repaired and no visible seepage outflow was recorded at the April 2004 sampling. A seepage collection sump was also been installed in mid 2004 in the northeastern corner of the quarry. Any seepage from the Quarry Dam reaching the northeastern area of the quarry will be intercepted by this sump and pumped back to the Quarry Dam.

A mass-balance of inflows and outflows during the test periods indicated a significant seepage inflow, varying from averaging 1.5 to 3 L/s (Table 4). At the January 2004 sampling, seepage inflow matched the outflows to evaporation and seepage downslope. It is likely that the seepage is from downslope movement of shallow groundwater from the agricultural catchment to the south. A subsurface restriction (e.g. dolerite dyke) just upstream of the dam may impede groundwater flow, forcing the water to the near surface and increasing the rate of flow to the dam. Some of the overflow from the artesian bores may contribute to this seepage flow, though much is likely to be lost to evaporation before reaching the dam.

Release via spillway to the Eastern Stream occurs during winter in periods of high rainfall. Observations of flow rate and water quality from May to November 2003 are given in Figure 3. The water released was of good quality: salinity was low, averaging 850 mg/L TDS, and sediment load averaged 16 mg/L TSS.

3.2.3 Site Drainage

Drainage conditions at the existing quarry site are shown in Figure 4. Runoff from the main processing area and some upslope catchment drains to the Quarry Dam via overland flow, drains and pipes. The Quarry Dam also receives runoff and seepage from the agricultural catchment to the south. When the Quarry Dam is full, water flows over a spillway to the Eastern Stream.

Water left over from processing drains to the Quarry Dam via a settling pond.

All runoff from the northeastern area of the quarry, containing rock stockpiles, collects in a sump and is pumped back to the Quarry Dam. In the past this water was released to the Eastern Stream after passing through a settling pond, but this exit is now closed.

An underground drain runs beneath the stockpiles in the northeastern corner of the quarry, discharging to a new sump in the northeast corner of the quarry. A new underground drain has been constructed north of the Quarry Dam, draining to the same sump. Drainage water collecting in the sump is pumped to the Quarry Dam.

Runoff from the pit area collects in the pit sump. This water is pumped to the Quarry Dam, from where it is used for processing, wash down of vehicles, and road watering.

Runoff from soil stockpiles to the south of the pit runs down the western side of the pit and enters the Western Stream.

3.2.4 Stream Flow

A number of transects along the streams north of the quarry have been taken between 2002 and 2004 (Figure 5).

The transect taken on 9 July 2002 illustrates the cumulative impact of seepage flows from salt scalds north of the quarry. These data are discussed in Appendix G of the Public Environmental Review documents. The data indicate that the main source of seepage and salt in the streams north of the quarry is a result of a rising groundwater levels from clearing for agriculture.

The transect taken in January and April 2004 show a decline in stream flow and steady increase in salinity with distance downstream. In these cases, the stream flow was sourced from the area near the northeastern corner of the quarry. Stream flow declined with distance downstream because of losses to evaporation, particularly from the small farm dam north (D2) of the quarry. No infiltration into or seepage was evident from the stream bed and banks north of the quarry.

The Western Stream at the time of the March 2002 and January and April 2004 samplings was dry.

3.3 Predicted Downstream Impacts of Water Release, Existing and Proposed Quarries

Concern has been raised about the impact of the release of water from the proposed quarry on downstream flows, salinity, erosion, and local groundwater levels. The community indicated that more work was needed to characterise how far downstream the water from the quarry is likely to have an impact, to place the volume of water and salt released in the context of the wider Wooroloo Brook catchment, and to characterise any potential impact of the additional water on groundwater levels along the streamlines.

This section outlines the results of an evaluation of the impact of the release of water on downstream flows.

3.3.1 Characteristics of Local Streams

The local streams just north of the quarry are small, flowing mainly in winter as a result of seepage from the surrounding hillsides and overland flow sourced mainly from the quarry area, salt scalds and waterlogged areas. The soils along the streamlines are sandy clay (weathered granite) overlying granite.

The catchment in which the quarry is located is heavily influenced by salinity, caused by rising groundwater as a result of clearing for agriculture. The extent and causes of salinity were discussed in Appendix G of the Public Environmental Review documents. The extent of salinity in the context of the existing quarry is also indicated by historical aerial photography (Figure 6). The photo taken on 10 February 1989, before the quarry began, shows clear evidence of saline seepage and salt scalds. The photo taken in January 2003 shows the quarry in place.

Observations of local geology and stream flow transects indicate that the streams tend to gain water from seepage from the surrounding hill slopes. Any seepage water sourced from the quarry area tends to be lost to evaporation from the streamlines or collected in small dams and used by stock or lost to evaporation.

Local streams in the context of the wider Wooroloo Brook catchment are shown in Figure 7. The main stream line near the quarry merges with another tributary about 2 km north of the quarry, then with Chinganning Gully about 6 km north of the quarry. From there a series of tributaries join Wooroloo Brook before it flows into the Avon River, some 30 km northwest of the quarry.

3.3.2 Impacts of Quarry Operations on Local Streams

Figure 8 presents predicted stream flow for the immediate quarry catchment (to point D3 in Figure 1). These data are the same as in Figure 4.2 in Appendix G of the PER documents, but with predictions of stream flow from a pre-disturbed, forested catchment (pre-quarry forest) scenario added.

Salinity levels in stream flow with the pre-quarry forest scenario are considerably lower than most of the other scenarios. High salt levels with the other scenarios are a result of increased saline outflows associated with clearing for agriculture. Low salt levels in winter with the quarry in operation (Operation, year 20-50 scenario) are a result of dilution of saline stream flows with fresh water released from the quarry.

3.3.3 Impacts of Quarry Operations on Wooroloo Brook

Figure 9 summarises the predicted downstream impact of water release on stream flow and salinity in Woorooloo Brook. Compared with the existing situation (i.e. cleared farmland and existing quarry), average annual stream flow up to about the intersection of Wooroloo Brook and Coates Gully will increase and salinity will decrease. The magnitude of impact is greatest near the quarry, decreasing downstream as a result of increasing catchment area, hence increasing stream flow. Compared to predicted flows and salinity pre-clearing for agriculture (i.e. pre-quarry, forest scenario), the existing quarry has increased stream flows and reduced salinity, mainly within about 2-4 km of the quarry.

Clearing for agriculture has substantially increased stream flows and salinity along the whole length of Woorooloo Brook. The impact of clearing is much greater than the existing and proposed quarry operations because the extent of clearing is much greater than the extent of disturbance from quarrying.

After closure, assuming a deep final void and no increase in the extent of land salinisation as a result of clearing for agriculture, stream flows will reduce and salinity will increase marginally within 2-4 km of the quarry. Stream flow decreases because no water will be released from the void. Salinity increases because there will be no water released from the proposed quarry to dilute saline seepage from agricultural land. Should salinisation as a result of land clearing for agriculture increase, salinity of stream flow will increase. Should the final void be managed differently, impacts may also vary slightly.

Regardless of final void management, impacts are not likely to extend further than 2-4 km downstream.

3.4 Enhanced Monitoring and Management Plan for the Proposed Quarry

Several submissions asked for more details of water management, including an enhanced Erosion Management Plan. This section presents more details of stormwater and erosion management, including a layout map showing the location of erosion management works.

3.4.1 Monitoring

The monitoring program for the proposed quarry is summarised in Table 6.

Table 6

Monitoring Program – Proposed Quarry

Sample location	Sample method and frequency	Analysis Required	Comments
Quarry sump.	Hand sample for water quality, monthly, and prior to release to the environment.	TDS, TSS, pH.	Required to ensure water is of a suitable quality for release and to characterise the pit and site water balance.
	Record depth of water in pit from gauge board, weekly.	Water depth.	
	Record volume pumped for discharge to the environment, daily when releasing.	Daily volume.	
	Representative seepage tests at intervals during the life of the quarry.	Record change in water level daily during a 2-5 day period when there are no pumped inflows or outflows.	
Process dam.	Hand sample for water quality, monthly.	TDS, TSS, pH.	Required to characterise the pit and site water balance.
	Record depth of water in pit from gauge board and water area, weekly.	Water depth.	
	Representative seepage tests at intervals during the life of the quarry.	Record change in water level daily during a 2-5 day period when there are no pumped inflows or outflows.	
Stream flow monitoring sites E2, W1 and S2 (Figure 1).	Hand sample, monthly; when flowing; daily when water is being released from the quarry dam.	TDS, TSS, pH.	Required to characterise impacts of the quarry on stream flows.
	Record depth of water in stream using a ruler or gauge board at time of hand sampling.	Water depth.	
Quarry area, perimeter drain and Western Stream.	Visual observation of erosion, water pollution and channel condition, monthly and after larger runoff events.	Visual assessment.	Required for rapid assessment of gross pollution potential or any inadequacy of management systems.

Table 6 (continued)

Sample location	Sample method and frequency	Analysis Required	Comments
Weather	Daily using a manual rain gauge or an automatic weather station.	Daily rainfall.	Required to characterise local rainfall conditions.
Operations	Record general water management operations at the proposed quarry and rehabilitation/land management at old quarry.	Diary notes.	Required to characterise site water balance and general site operations.

3.4.2 Stormwater Management

Additional details of channels, bunds and water flow paths for the proposed quarry are shown in Figures 10A and 10B.

3.4.3 Erosion Management Plan

Issues

The main erosion issues related to operations at the proposed quarry are:

- erosion from bare areas, particularly during the development of the quarry in years 1 to 5;
- elevated turbidity levels in water released to the environment; and
- erosion of the stream receiving water discharged from the quarry.

Vegetation in the pit area will be progressively cleared during the first 5 years and topsoil removed and stockpiled during the first 10 years. Erosion risk is highest during the early stages of the project, when vegetation is cleared and topsoil removed. Slope through the project area is about 7%, which is high enough for surface water flows over unprotected soil to cause erosion. Erosion risk from stockpiles is also an issue during the early stages of the quarry, until the stockpiles have been stabilised. Erosion risk from roads and plant areas and turbidity in process water are other risks that will be present during the quarry's life.

After year 5, the footprint of the quarry will have been established down to rock. The rock is not erodible, so erosion risk through the quarry area will be substantially diminished and limited mainly to the erosion risk from roads and plant areas and turbidity in process water.

Water in excess of quarry processing and watering requirements will be released, by pumping, to the stream to the north of the quarry (the Western Stream). Currently this stream is degraded, erosionally unstable and has limited capacity to carry water discharged from the quarry. The stream's capacity will be upgraded (by reshaping and enlarging) so that it can safely carry both runoff from the general catchment and water released from the quarry.

Objective

The objective of the erosion management plan is to manage on-site erosion and drainage and release of water from the quarry so that there is no adverse impact on streams below the quarry.

Implementation

Erosion will be managed on-site, during all stages of the project, using the following principles:

- protecting bare soil, slopes, topsoil stockpiles and stream lines from erosion by employing soil conservation and drainage techniques;
- using sediment traps and settling areas to trap sediment; and
- using a monitoring and management plan to ensure water released to the environment is of suitable quality and released in such a way as to not cause downstream erosion.

Erosion on-site will be managed by employing appropriate soil conservation and drainage measures. These measures are spelt out in detail in Appendix G of the Public Environmental Review documents. Figures 10A, 10B and 11 show the proposed site layout and erosion and drainage management works at the end of year 2. These works will be progressively modified as mining proceeds and the area of topsoil is reduced. Drainage structures in the processing area will remain in place during the life of the quarry.

Sediment traps will be located upstream of the Quarry Dam, Quarry Sump and in the crushing area to filter and collect coarse sediment. The traps will consist of a pond where sediment collects and a pipe, coarse rock or spillway outlet. Sediment will be removed from the pond annually and either sold as soil product or used on site for revegetation or landscaping.

Erosion off-site will be managed by controlling releases from the quarry and reshaping and enlarging the existing, degraded, Western Stream. Details of proposed upgrades to the Western Stream are given in Section 3.4.4.

Water in excess of quarry requirements will be released in a controlled fashion and in such a way as to cause no adverse impacts on the receiving environment. The monitoring plan and release criteria that will be used are described in Appendix G of the Public Environmental Review documents. Note that the quarry operations will be located within the quarry pit, i.e. below ground level, so all runoff from within the quarry area will drain to sumps and dams inside the quarry and cannot drain by gravity to the environment. As a result, accidental release of runoff cannot occur. When releasing to the environment, control over pumping rates, timing and quality of water at the time of pumping will ensure the downstream environment is not adversely impacted.

3.4.4 Stream Reshaping

The proposed alignment and cross-section for the reshaped Western Stream is given in Figure 11. Design specifications used are summarised in Table 7.

Table 7

Design Parameters for the Reshaped Western Stream

Design component	Comment
Alignment	To follow the existing stream north of the pit to the confluence with to the Eastern Stream.
Meanders	Meanders in the stream north of the pit: meander multiplier = 20; curve radius multiplier = 1.5*.
Cross-section	Broad V-section stabilised with waterlogging tolerant, runner grass (e.g. couch).
Design flows	Design discharge = 0.37 m^3/s for 100 year ARI; design flow depth = 0.24 m; velocity = 0.7 m/s; freeboard = 0.26 m.

* meander design described in Torre (2001).

The stream was designed to safely accommodate a 100-year ARI event from the existing total catchment (i.e. including the area of the proposed quarry). The area of the quarry will not contribute water directly to the stream during the life of the quarry or after closure if the pit remains, so the estimate of design discharge is conservative. A generous freeboard has been allowed to account for flow variations along the length of the channel. Discharge during a 100-year event (0.37 m^3/s) is greater than peak flows during controlled release from the quarry (0.1 m^3/s), so releases can be safely received in the reshaped stream.

A design velocity of 0.7 m/s was used, which will ensure no erosion even of the bare, freshly constructed channel. The bed material is likely to consist of sandy-clays, clays and gravels, with a maximum permissible velocity of 0.7-1.8 m/s (Concrete Pipe Association, 1991). When grassed, maximum permissible velocity is expected to be 1.6 m/s. Accordingly, the design of the channel, with regard to erosion resistance, is conservative.

Release from the quarry is expected to occur at up to 0.18 m^3/s, well below the design capacity of the stream. Release will not occur during runoff events. Even if release occurred at maximum rate during a 100 year ARI flow, the resulting flow (0.55 m^3/s) would not exceed the channel capacity nor cause erosion (predicted velocity = 0.8 m/s).

Conclusions

From the additional work undertaken, the following broad conclusions can be drawn:

- the original information presented, particularly relating to the water balance of the proposed pit and potential impacts on the downstream environment was broadly correct;
- the volumes of water to be released have increased compared to the volumes given in the original PER due to an increase in the proposed quarry footprint, but this does not cause adverse impacts and can be accommodated within the original management plans;
- the water and erosion management plans remains essentially the same, but more details have been given in this document;
- the quarry will not adversely impact on salinity in streams north of the quarry and may reduce stream flow salinity by releasing fresh water.

BOM (2004). SILO Patched Point Dataset. http://www.bom.gov.au/silo/. Bureau of Meteorology, Canberra.

Concrete Pipe Association of Australasia (1991) Hydraulics of Precaste Concrete Conduits. Concrete Pipe Association of Australasia, Technical Committee.

Torre, A. (2001). Stream Stabilisation. River restoration Report No. RR 10. Water and Rivers Commission: Perth.

URS (2003). Public Environmental Review. Land Clearing and Quarry Expansion, Avon Loc. 1881, Lot 14 Horton Road, The Lakes. Volumes 1, 2 and 3. EPA Assessment No. 1413. Report prepared by URS Australia Pty Ltd for BGC Quarries, Job Number: 50846-001, Perth.

URS (2004a). Response to Submissions. Proposed Relocation of the Voyager Quarry Land Clearing and Quarry Expansion, Avon Loc 1881, Lot 14 Horton Road, The Lakes. EPA Assessment Number 1413. Report prepared by URS Australia Pty Ltd for BGC Quarries, Job Number: 50846-008, Perth.

URS (2004b). Surface Water Monitoring Plan – Existing Voyager Operations. Unpublished report prepared by URS Australia Pty Ltd for BGC Quarries, Job Number: 50846-008, Perth.

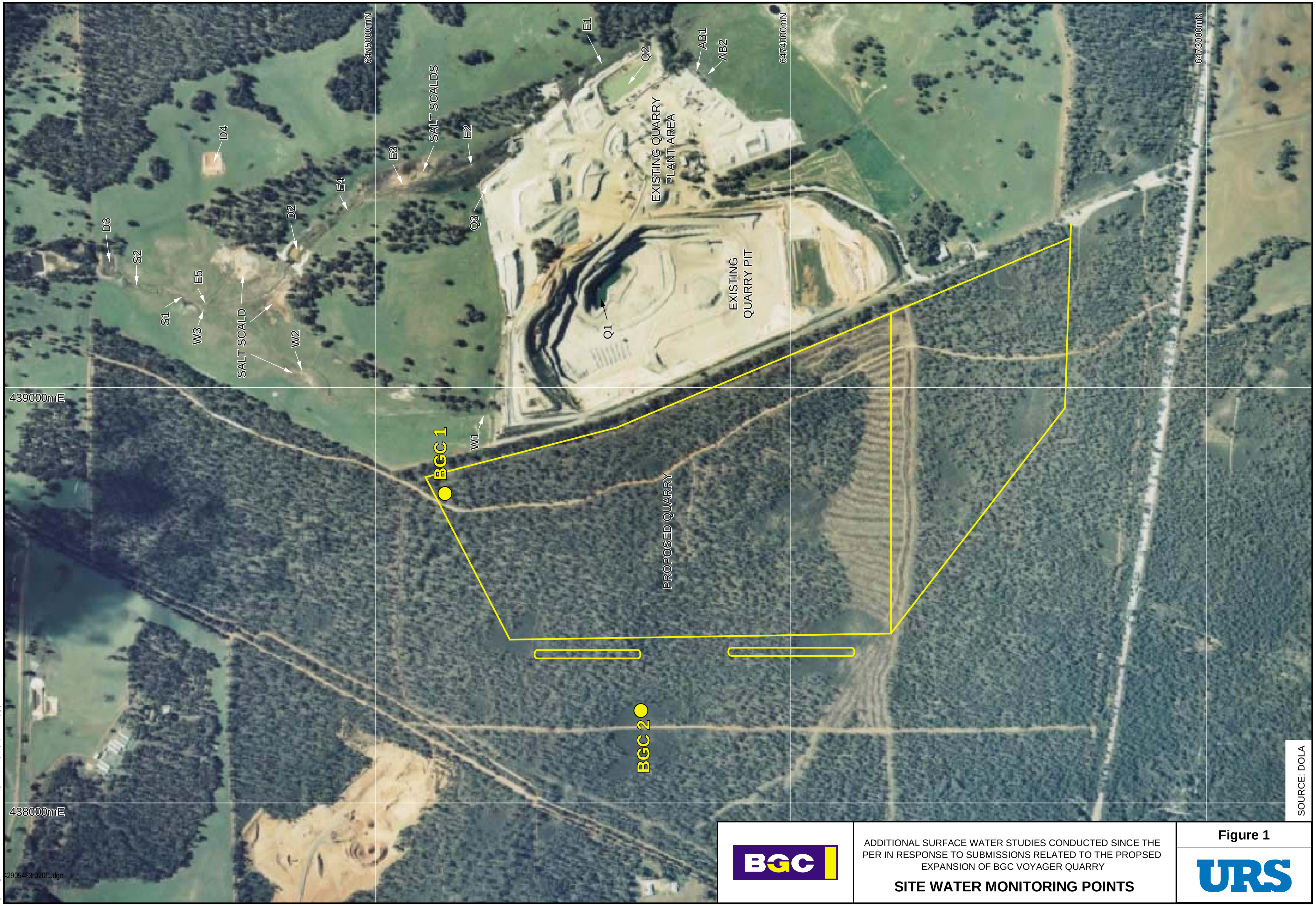
Limitations

URS Australia Pty Ltd (URS) has prepared this report for the use of BGC Quarries in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the proposal dated 4 December 2003.

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

This report was prepared between 4 December 2003 and 27 October 2004 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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



ADDITIONAL SURFACE WATER STUDIES CONDUCTED SINCE THE PER IN RESPONSE TO SUBMISSIONS RELATED TO THE PROPSED EXPANSION OF BGC VOYAGER QUARRY

SITE WATER MONITORING POINTS

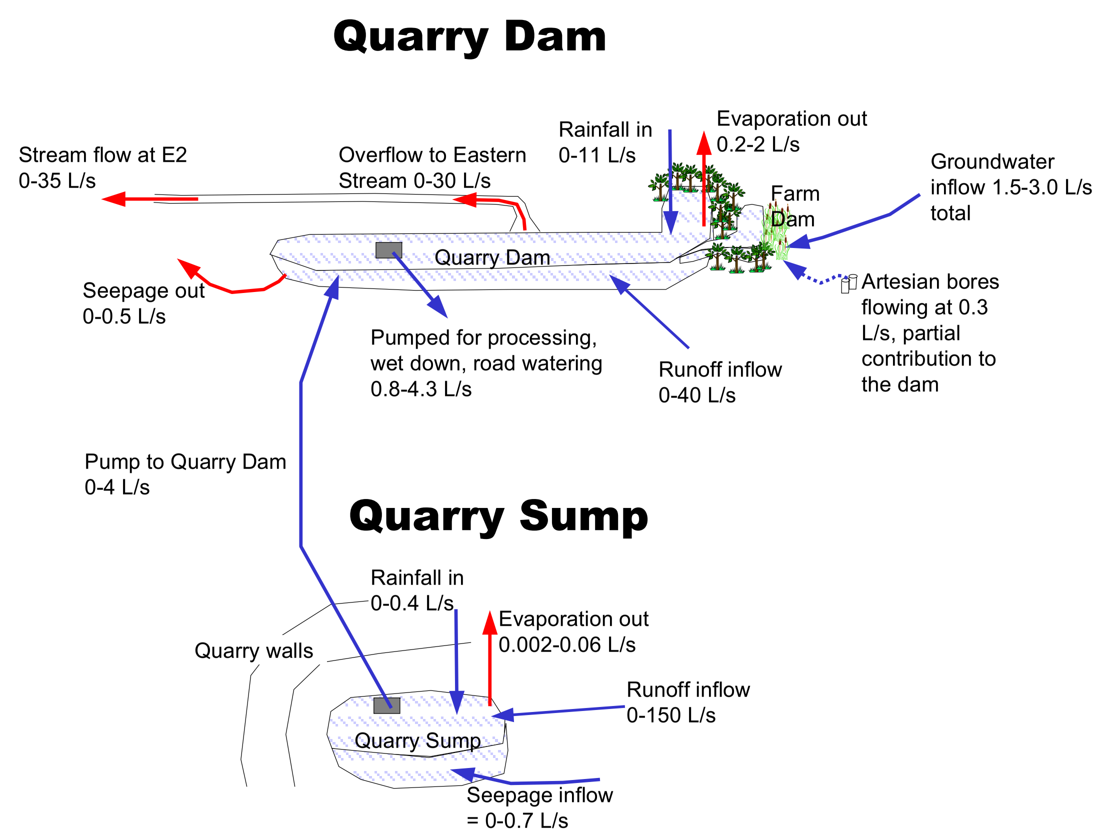
Figure 1

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

42905483r020f1.dgn

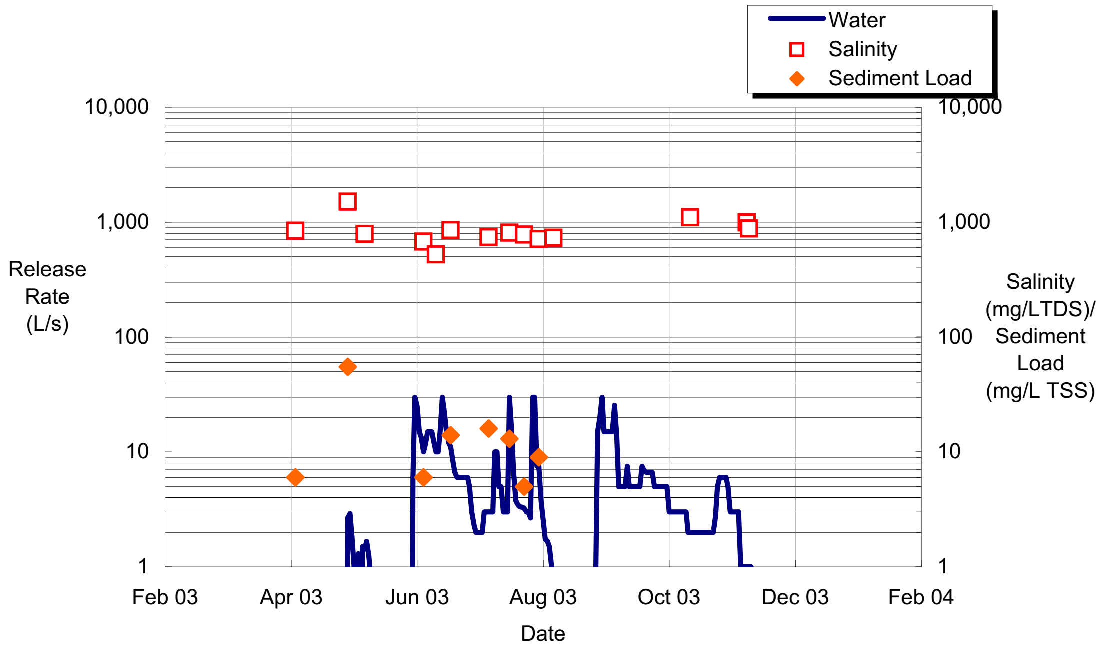
J:\Jobs\42905483\drawings\r020\42905483r020f1.dgn

Wed 08 Dec 04



Flow rates are indicative and based on daily data.
Rainfall and runoff are based on 10-year ARI.

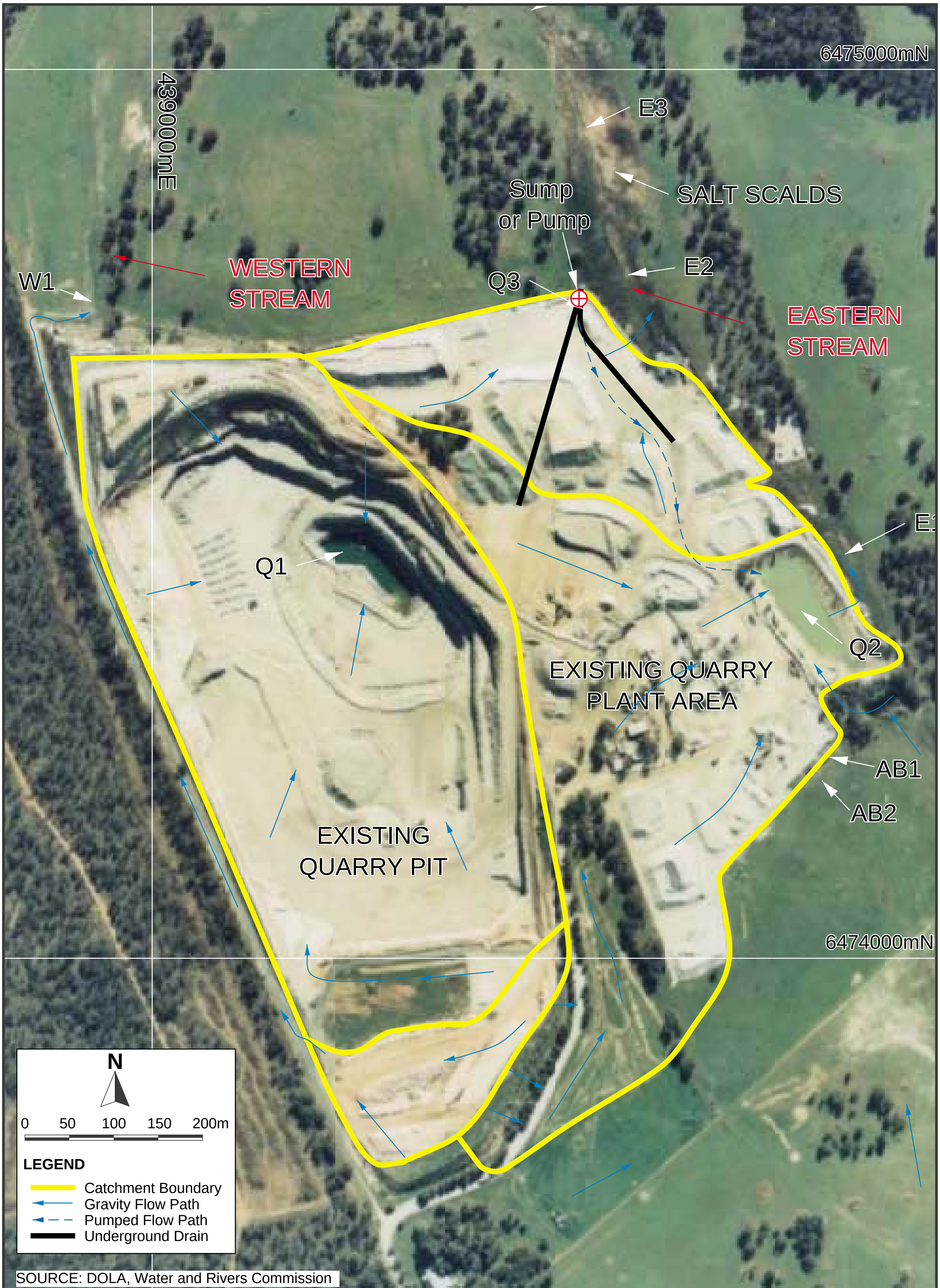
Job No	50846-008-562		BGC Quarries Response to Submissions related to the Proposed Expansion of BGC Voyager Quarry - Surface Water Issues	Figure 2
Prep. by	RC	1 Sep 04		URS
Chkd by	JB	31 Aug 04	**CONCEPTUAL WATER BALANCE FOR QUARRY SUMP AND DAM**	
Revision No.		0		



Data source: BGC

Job No.	50846-008-562		BGC Quarries Response to Submissions related to the Proposed Expansion of BGC Voyager Quarry - Surface Water Issues **RELEASE OF WATER FROM THE QUARRY DAM IN 2003**	**Figure 3**
Prep. By	RC	31 Aug 04		URS
Chk'd By	JB	31 Aug 04		
Revision No.		0		

Thu 09 Dec 04

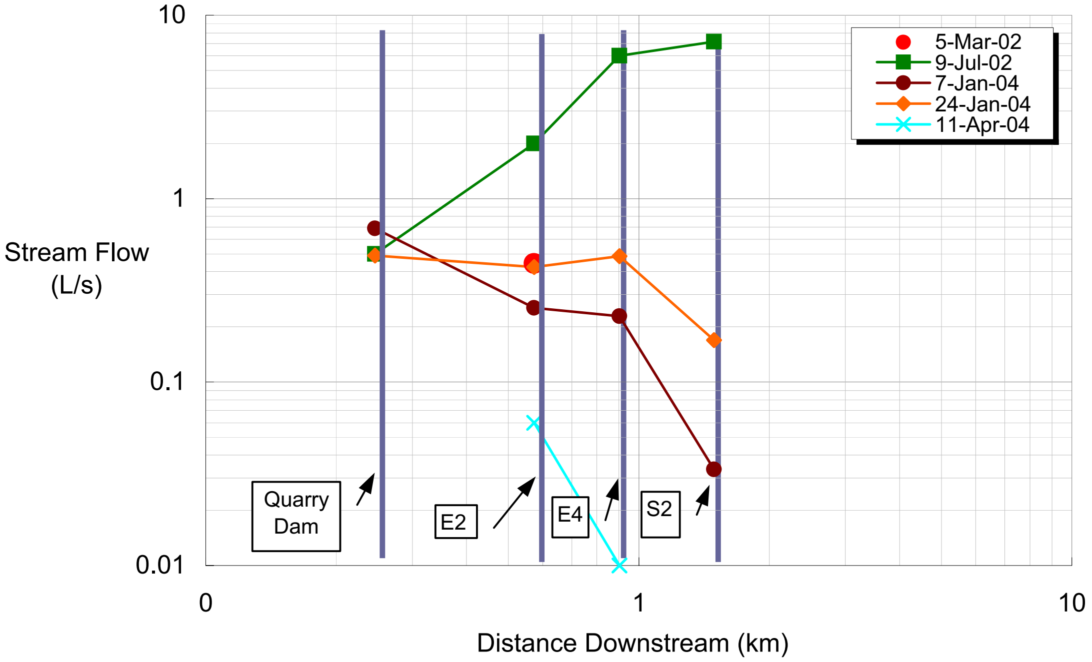


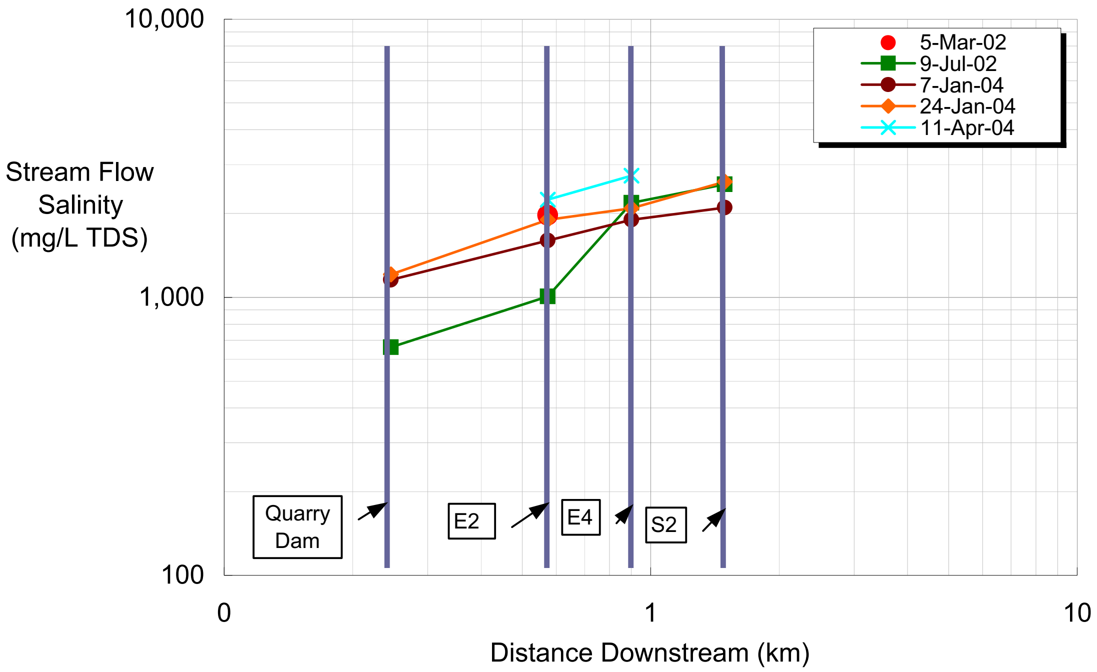
RESPONSE TO SUBMISSIONS RELATED TO THE
PROPOSED EXPANSION OF BGC VOYAGER QUARRY
- SURFACE WATER ISSUES

DRAINAGE AT THE EXISTING QUARRY

Figure 4

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630
J:\Jobs\42905483\drawings\R019\42905483R019F4.dgn

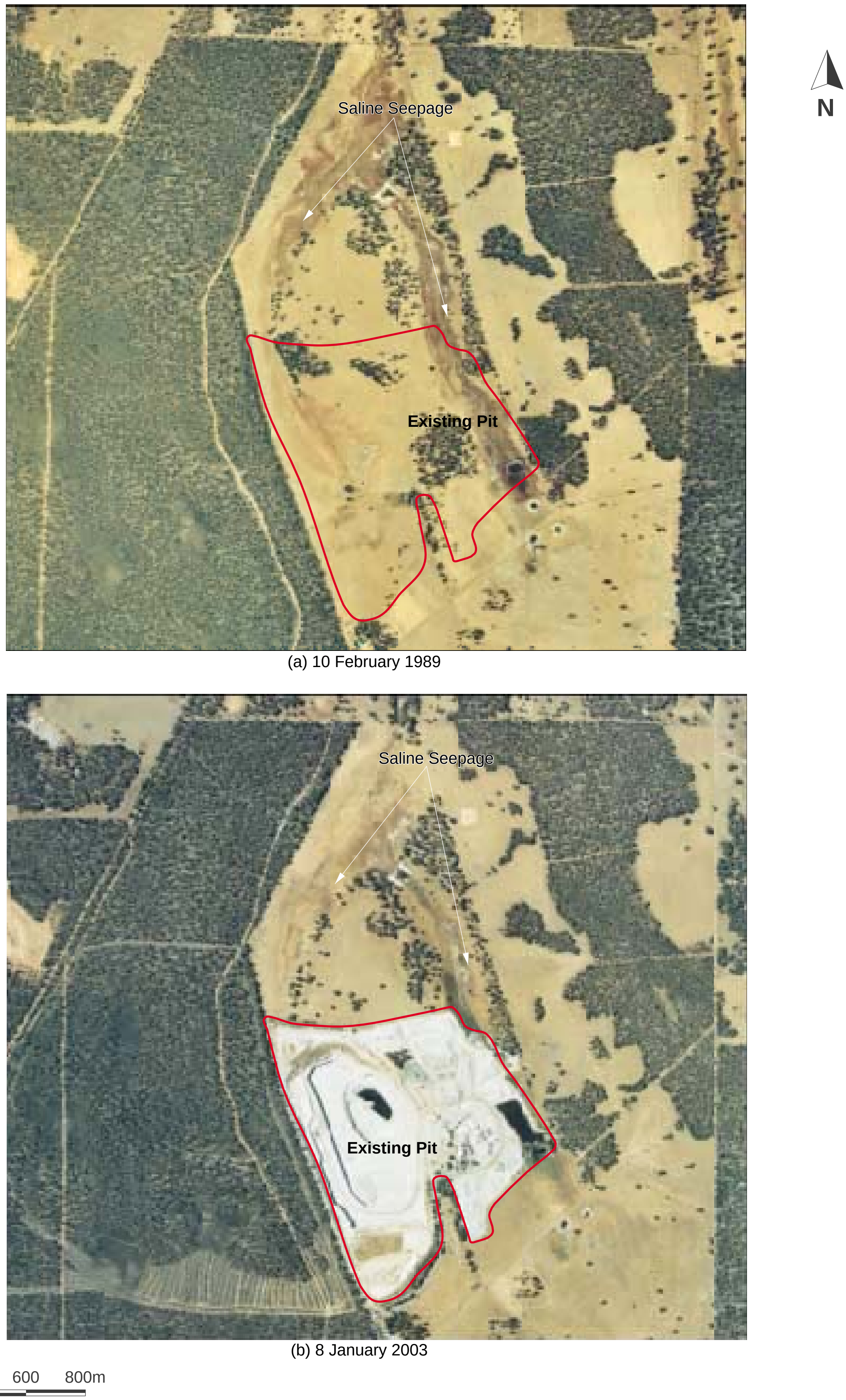




Job No.	50846-008-562		BGC Quarries Response to Submissions related to the Proposed Expansion of BGC Voyager Quarry - Surface Water Issues **OBSERVED STREAM FLOW** **NORTH OF EXISTING QUARRY**	**Figure 5**
Prep. By	RC	30 Aug 04		URS
Chk'd By	JB	31 Aug 04		
Revision No.		0		

URS Australia Ltd Perth Office +61 8 9221 1630

BGC Voyager response to sub surface water figs.xls



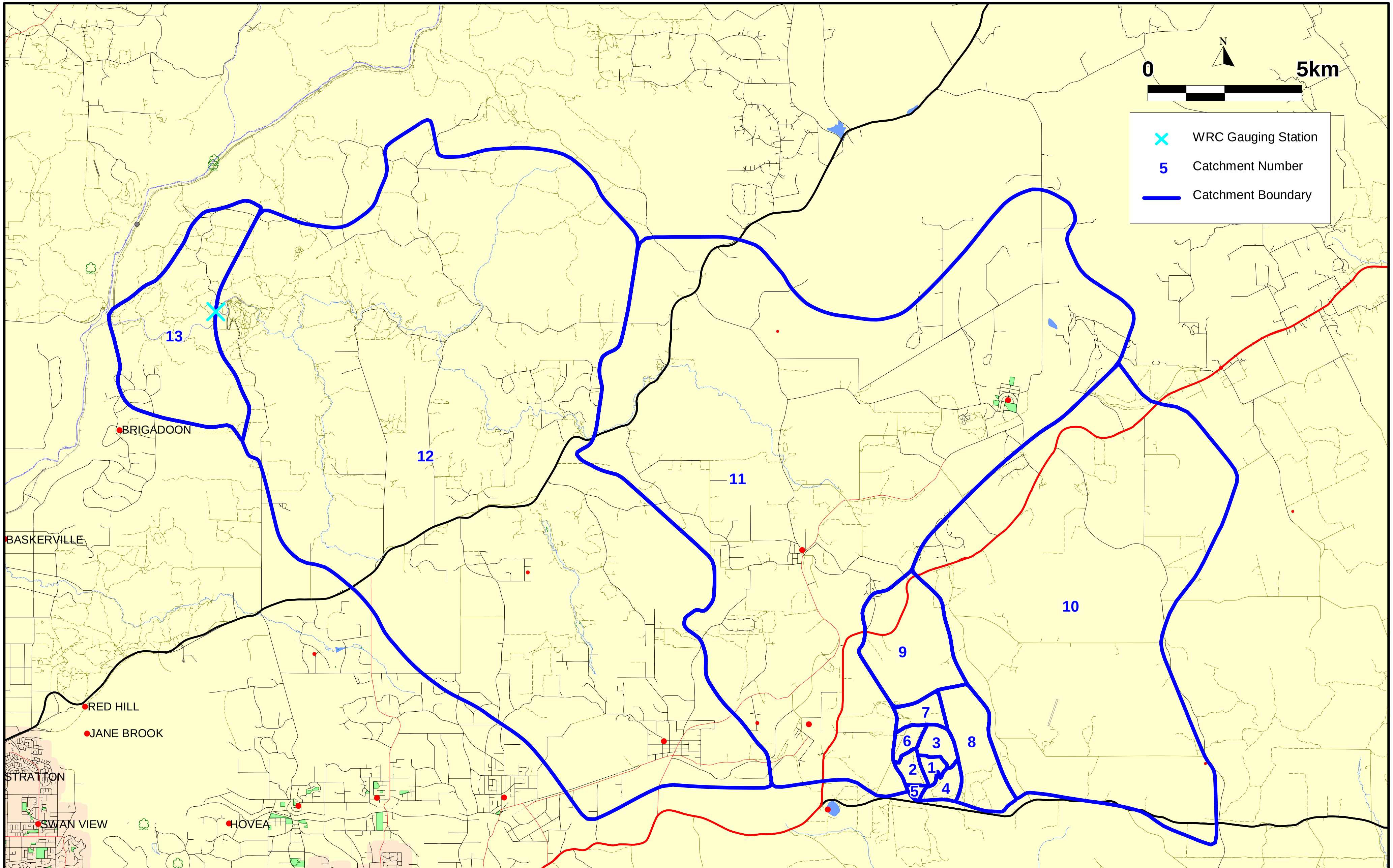
Job No.	42905483	
Prep. By	RC	1 Nov 04
Chk'd By	KA	1 Nov 04
Revision No.		0

ADDITIONAL SURFACE WATER STUDIES CONDUCTED SINCE THE PER IN RESPONSE TO SUBMISSIONS RELATED TO THE PROPOSED EXPANSION OF BGC VOYAGER QUARRY

HISTORICAL AERIAL PHOTOGRAPHY FOR THE QUARRY SITE

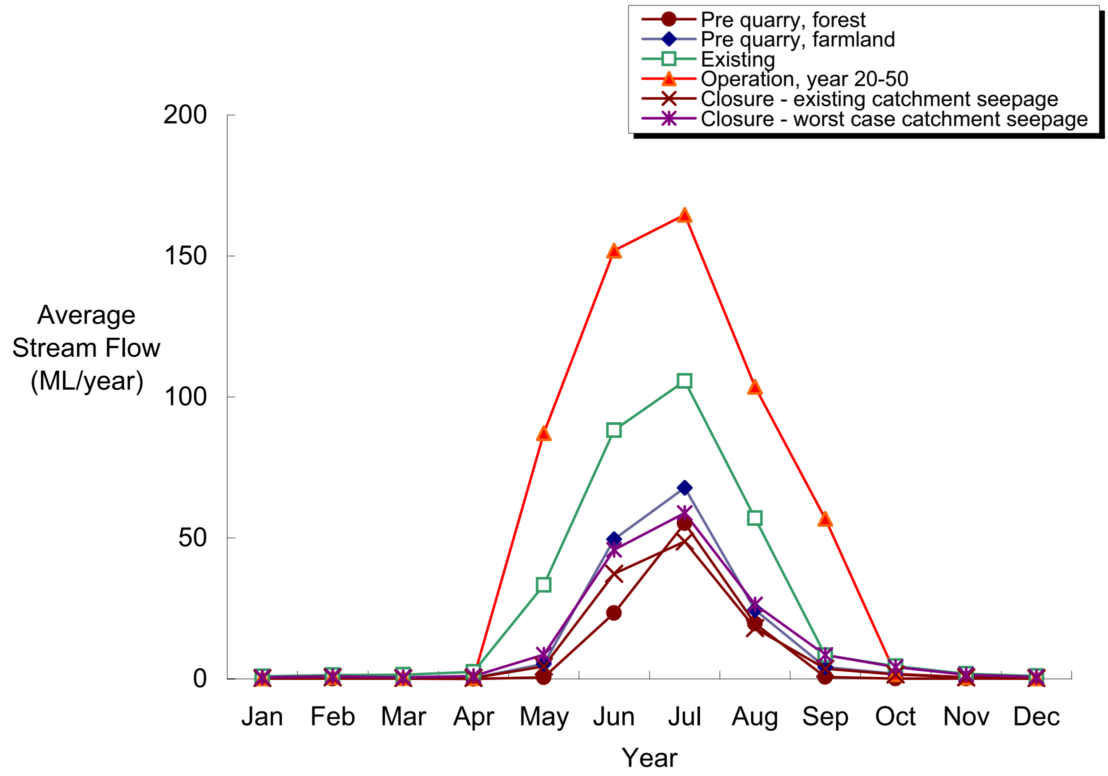
Figure 6

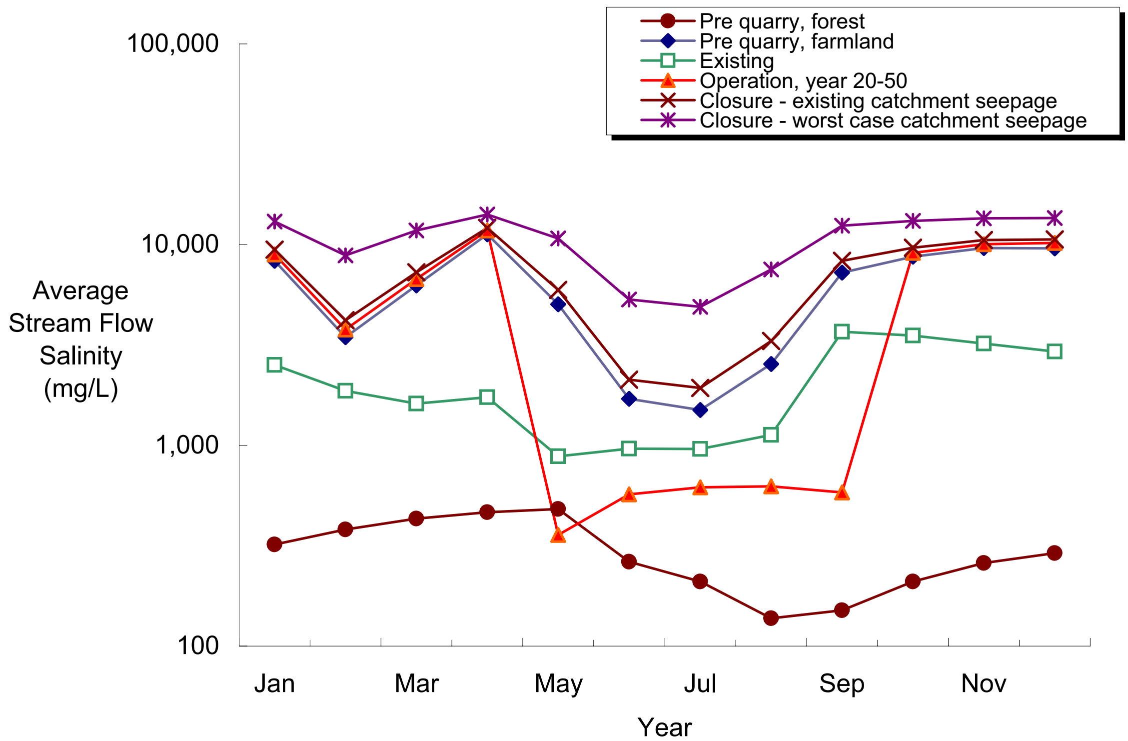
URS



			BGC QUARRIES ADDITIONAL SURFACE WATER STUDIES CONDUCTED SINCE THE PER IN RESONSE TO SUBMISSIONS RELATED TO THE PROPOSED EXPANSION OF BGC VOYAGER QUARRY **SURFACE WATER CATCHMENTS, WOOROLOO BROOK**	**Figure 7** URS
Job No.	42905483			
Prep. By	RC	1 Nov 04		
Chk'd By	KA	1 Nov 04		
Office	Perth, Western Australia Phone: +61 8 9221 1630			

J:\jobs\42905483\drawings\r020\42905483r020f7.wor





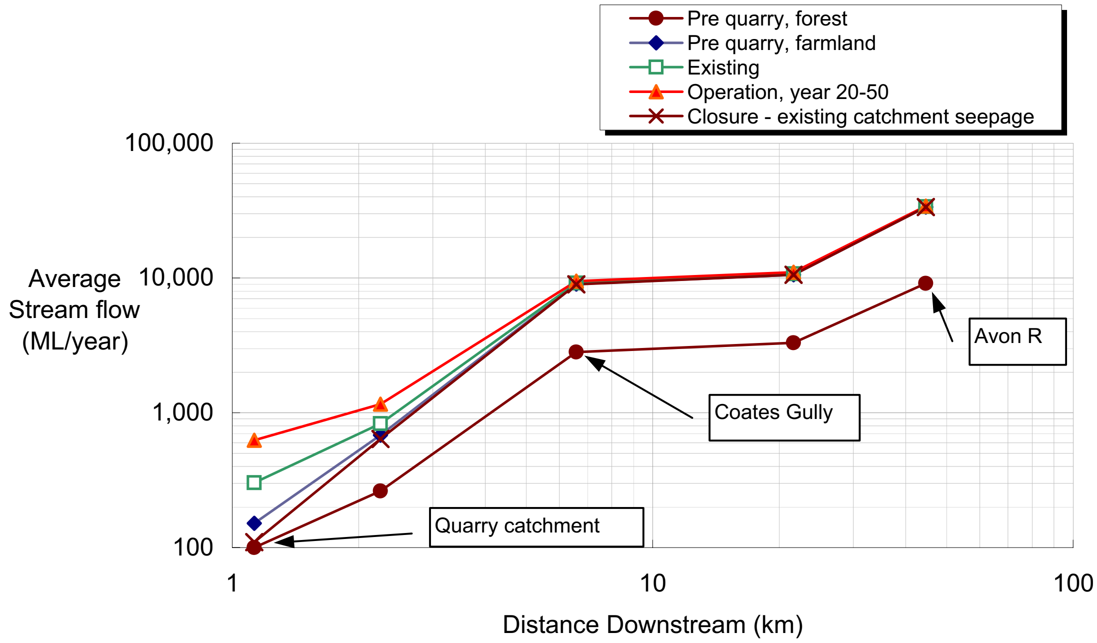
Job No.	50846-008-562	
Prep. By	RC	30 Aug 04
Chk'd By	JB	31 Aug 04
Revision No.		0

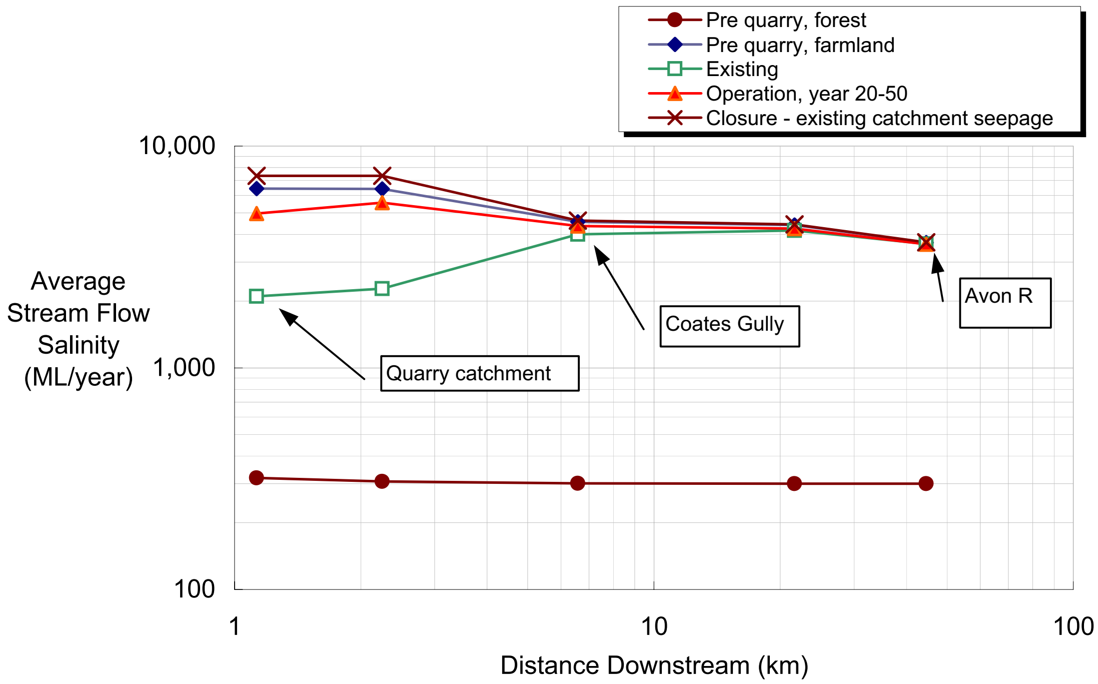
BGC Quarries
Response to Submissions related to the Proposed Expansion of BGC Voyager Quarry - Surface Water Issues

PREDICTED AVERAGE MONTHLY STREAM FLOW FOR THE LOCAL CATCHMENT

Figure 8

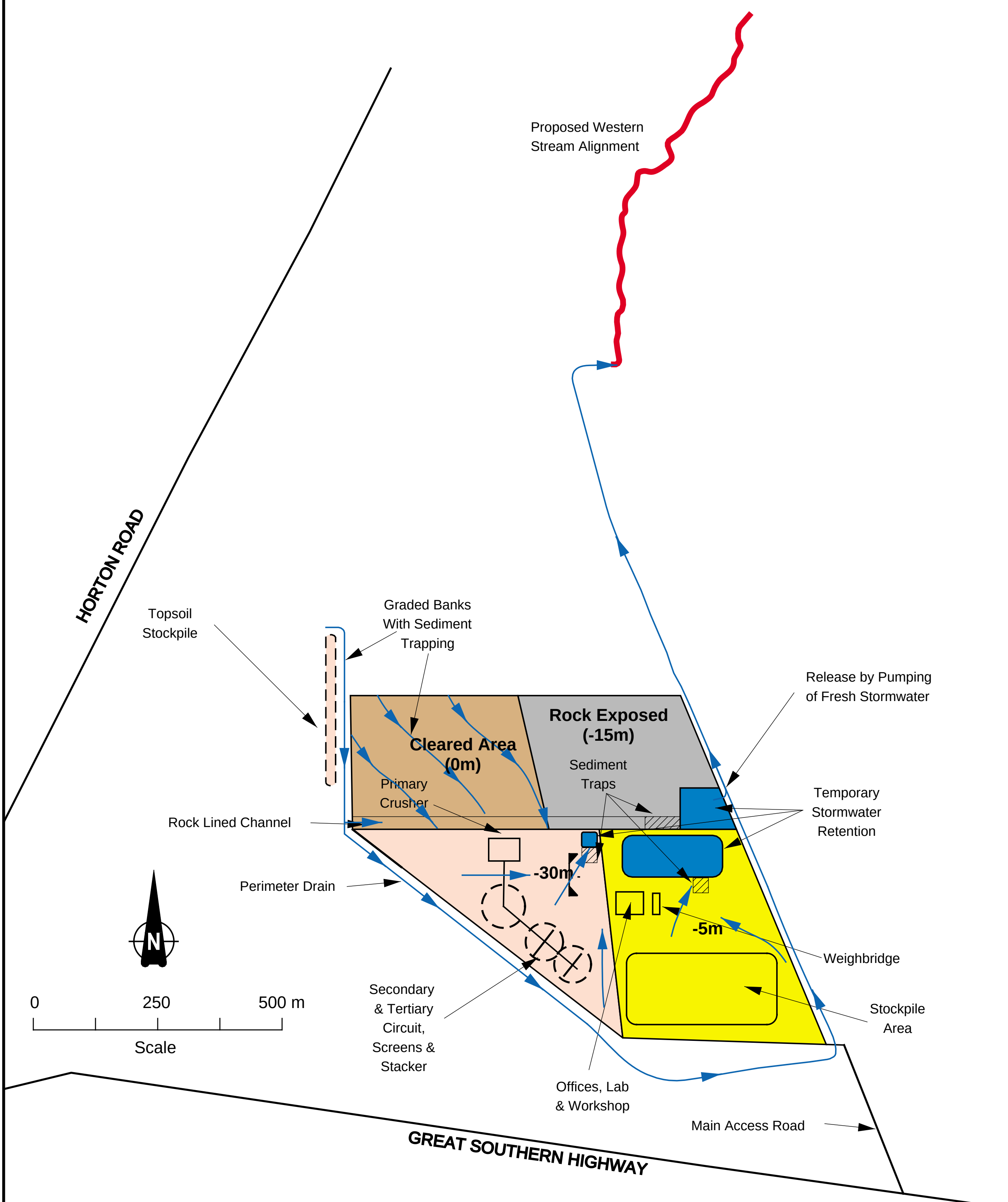
URS





Job No.	50846-008-562		BGC Quarries Response to Submissions related to the Proposed Expansion of BGC Voyager Quarry - Surface Water Issues **PREDICTED AVERAGE ANNUAL STREAM FLOW FOR WOOROOLOO BROOK**	**Figure 9**
Prep. By	RC	30 Aug 04		URS
Chk'd By	JB	31 Aug 04		
Revision No.		0		

BGC Voyager response to sub surface water figs.xls



Refer to figure 10B for
Typical Sections

END OF YEAR 5

Source: Site Layout-BGC

BGC

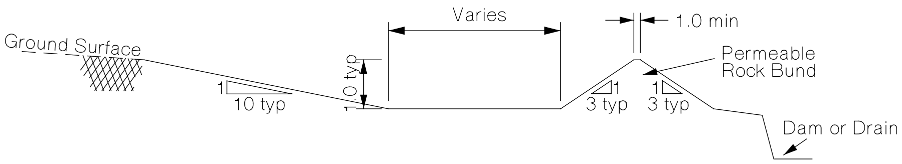
RESPONSE TO SUBMISSIONS RELATED TO THE
PROPOSED EXPANSION OF BGC VOYAGER QUARRY
- SURFACE WATER ISSUES

SURFACE WATER MANAGEMENT PLAN - END OF YEAR 5

Figure 10A

URS

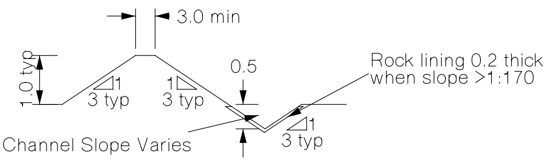
Tue 31 Aug 04



TYPICAL SECTION - SEDIMENT TRAP

Scale H 1:75
V 1:150

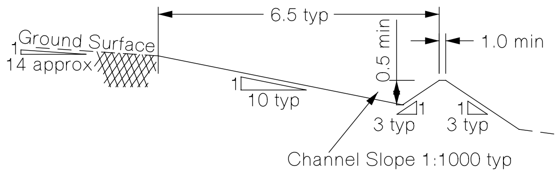
Dimensions in metres



TYPICAL SECTION - PERIMETER DRAIN

Scale H 1:75
V 1:150

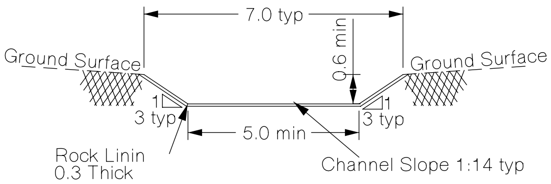
Dimensions in metres



TYPICAL SECTION - GRADED BANK

Scale H 1:75
V 1:150

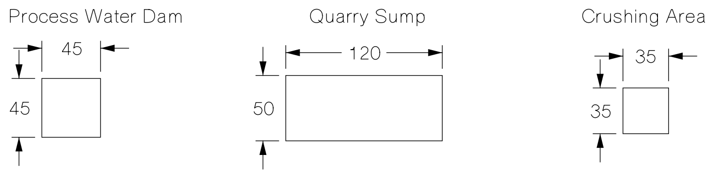
Dimensions in metres



TYPICAL SECTION - ROCKLINED CHANNEL

Scale H 1:75
V 1:150

Dimensions in metres



SEDIMENT TRAP PLANS

Scale H 1:6000

Dimensions in metres

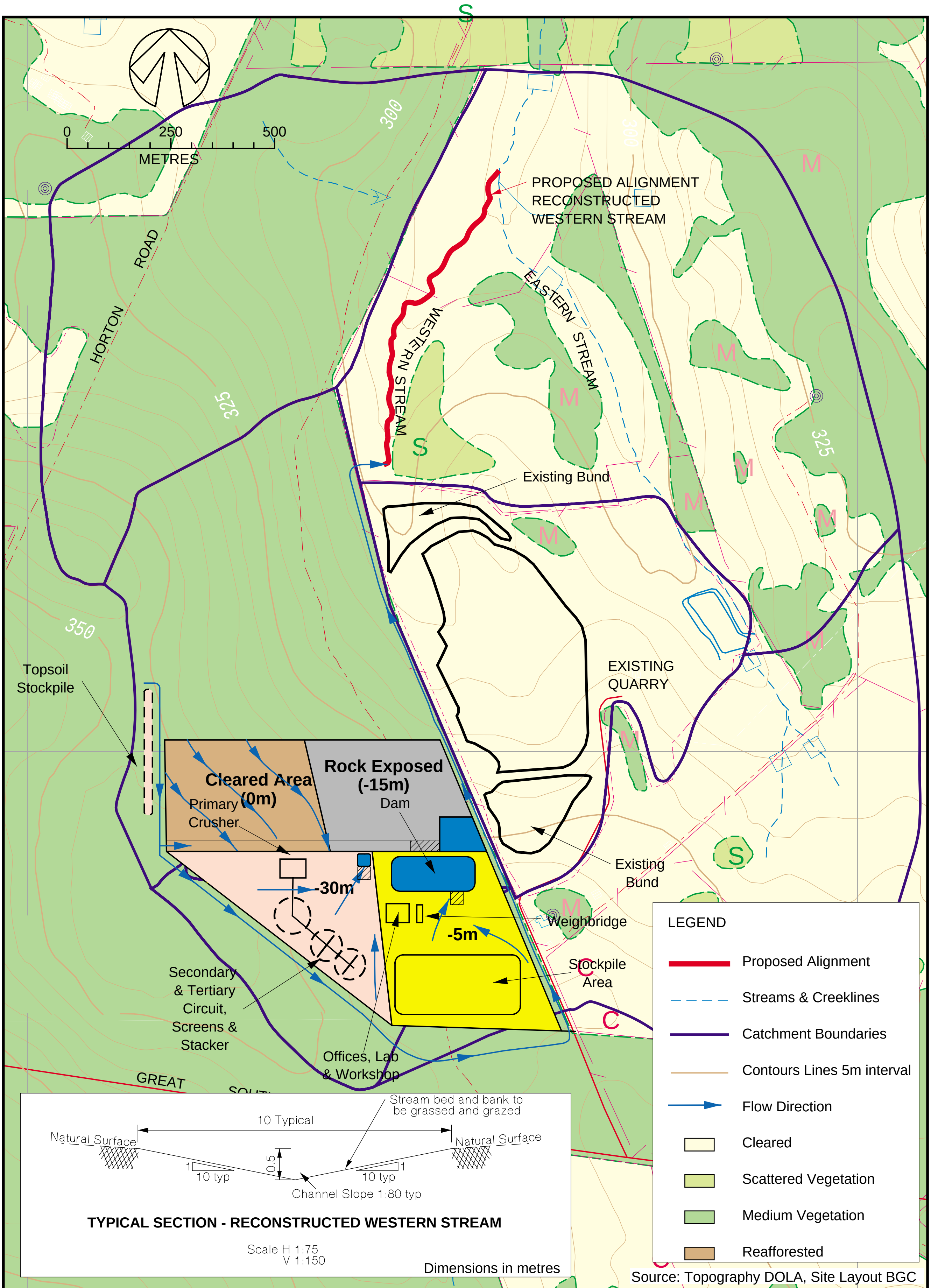
RESPONSE TO SUBMISSIONS RELATED TO THE
PROPOSED EXPANSION OF BGC VOYAGER QUARRY
- SURFACE WATER ISSUES

TYPICAL SECTIONS AND SEDIMENT TRAP PLANS

Figure 10B

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

S:\Environmental\BGC Quarries\50846-008\drawings\r013\50846008r013f10B.dgn



Source: Topography DOLA, Site Layout BGC

Thu 09 Dec 04

RESPONSE TO SUBMISSIONS RELATED TO THE PROPOSED EXPANSION OF BGC VOYAGER QUARRY - SURFACE WATER ISSUES

PROPOSED ALIGNMENT - WESTERN STREAM

Figure 11

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

J:\Jobs\42905483\drawings\R019\42905483R019F11.dgn

Appendix A: Monitoring Results

Table A1

Water Quality Observations for the Quarry Sump, Site Q1

Date	EC Field	EC Lab.	TDS Lab.	TDS Calc.[1]	TDS composite[2]	TSS Lab.	Turbidity	Oil & Grease	pH	Sampler	Lab #	Comment
	(µS/cm)	(µS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(NTU)	(mg/L)	(pH units)			
17/01/02			1,200		1,200	<5				BGC	AEL 62384	
5/03/02		2,300	1,300		1,300					URS	AEL 63380	
25/05/02			1,700		1,700	<5				BGC	AEL 65022	
11/07/02			1,100		1,100	14				BGC	AEL 65939	
3/09/02			480		480	14				BGC	AEL 66983	
22/10/02			780		780	<5		<5		BGC	AEL 67669	
4/03/03	1,400			787	787	<5				BGC	AEL 70708	
1/04/03	1,400			787	787	7				BGC	AEL 71359	
1/05/03	1,600			897	897	<5				BGC	AEL 71982	
3/06/03	1,500			842	842	<5				BGC	AEL 72735	
1/07/03	470			276	276	10				BGC	AEL 73445	
1/08/03			410		410	6				BGC	AEL 74197	
1/09/03			510		510	<5				BGC	AEL 75723	
5/11/03	850			485	485	<5				BGC	AEL 68353	
7/01/04			1,700		1,700	<5	3	<5	8.2	BGC	AEL 77831	
8/01/04	3,090	3,000	1,800		1,800	3				URS	AEL 77826	Sump water level low.
2/02/2004			2,400		2,400	<5				BGC		
2/03/2004			2,600		2,600	<5				BGC		
1/04/2004			560		560	20			7.1	BGC		
11/04/2004	4,850			2,685	2,685					URS		Sump water level pumped low for seepage test
1/05/2004			800		800	5			7.0	BGC		

Date	EC Field	EC Lab.	TDS Lab.	TDS Calc.[1]	TDS composite[2]	TSS Lab.	Turbidity	Oil & Grease	pH	Sampler	Lab #	Comment
1/07/2004			560		560	20			7.1	BGC		
4/08/2004			750		750	6			6.7	BGC		
30/08/2004			570		570	11			7.4	BGC		
29/09/2004			660		660	<5			7.7	BGC		

[1] – calculated from *EC* using the relationship *EC**0.55+17; 2 – composite record using, in order of priority –TDS Lab, TDS Calc.; TDS - total dissolved solids (grav.); TSS - total suspended solids.

Table A2

Monitoring Results, Quarry Dam, Site Q2

Date	EC Field	EC Lab.	TDS Lab.	TDS Calc.[1]	TDS composite[2]	TSS Lab.	Turbidity	Oil & Grease	pH	Sampler	Lab #	Comment
	(µS/cm)	(µS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(NTU)	(mg/L)	(pH units)			
17/01/02			1,800		1,800	19				BGC	AEL 62384	
5/03/02	2,500		1,300	1,392	1,300					URS	AEL 63380	
25/05/02			1,800		1,800	15				BGC	AEL 65022	
9/07/02	1,170			661	661					URS	AEL 65943	
11/07/02			1,400		1,400	61				BGC	AEL 65939	
3/09/02			1,200		1,200	40				BGC	AEL 66983	
22/10/02			1,100		1,100	8		<5		BGC	AEL 67669	
4/03/03	1,500				842	<5				BGC	AEL 70708	
1/04/03	1,500				842	14				BGC	AEL 71359	
1/05/03	1,500				842	6				BGC	AEL 71982	
26/05/03			1,500		1,500	55				BGC	AEL 72538	Dam just starting to discharge to E Stream.
3/06/03	1,400				787	<5				BGC	AEL 72735	Dam.
3/06/03	1,400				787	<5				BGC	AEL 72735	Discharge from dam to E Stream.
1/07/03	1,200				677	6				BGC	AEL 73445	Dam discharging to E Stream.
1/07/03	1,200				677	9				BGC	AEL 73445	Dam discharging to E Stream.
7/07/03	920				523					BGC	AEL 73561	
14/07/03			850		850	14		<5		BGC	AEL 73750	
1/08/03			740		740	16		<5		BGC	AEL 74197	
1/08/03			730		730	15		<5		BGC	AEL 74197	
11/08/03			810		810	13		<5		BGC	AEL 74709	
18/08/03			780		780	5		<5		BGC	AEL 74709	
25/08/03			710		710	9		<5		BGC	AEL 74709	
1/09/03			730		730	<5		<5		BGC	AEL 75723	
1/09/03			1,200		1,200	<5		<5		BGC	AEL 75723	
5/11/03	1,100		1,100		1,100	<5				BGC	AEL 68353	
2/12/03			990		990	<5		<5		BGC	AEL 77140	Process dam overflow.

Date	EC Field	EC Lab.	TDS Lab.	TDS Calc.[1]	TDS composite[2]	TSS Lab.	Turbidity	Oil & Grease	pH	Sampler	Lab #	Comment
	(µS/cm)	(µS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(NTU)	(mg/L)	(pH units)			
3/12/03			880		880	<5		<5		BGC	AEL 77140	Process dam overflow.
7/01/04			1,000		1,000	<5		<5		BGC	AEL 77831	
8/01/04	1,788				1,000					URS		Dam close to full & recently overtopping
24/01/04	1,870				1,046					URS		Seepage test.
2/02/2004			1,100		1,100	<5				BGC		
2/03/2004			1,400		1,400	<5				BGC		
1/04/2004			1,400		1,400	<5		<5		BGC		
11/04/2004	3,200			1,777	1,777					URS		Dam in process of being enlarged. Water level low.
1/05/2004			2,100		2,100	<5		<5	6.7	BGC		
1/06/2004					17					BGC		
1/07/2004			1,100		1,100	10		<5	7.2	BGC		
4/08/2004			1,200		1,200	10		95	6.8	BGC		
30/08/2004			920		920	7		5	7.3	BGC		
29/09/2004			990		990	6		15	7.3	BGC		

[1] – calculated from *EC* using the relationship *EC**0.55+17; 2 – composite record using, in order of priority –TDS Lab, TDS Calc.; TDS - total dissolved solids (grav.); TSS - total suspended solids.

Table A3

Monitoring Results, Eastern Stream, Site E2

Date	EC Field	EC Lab.	TDS Lab.	TDS Calc.[1]	TDS composite[2]	TSS Lab.	Turbidity	Oil & Grease	pH	Stream flow	Sampler	Lab #	Comment
	(µS/cm)	(µS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(NTU)	(mg/L)	(pH units)	(L/s)			
5/03/02	2,450			1,365	1,365					0.4	URS		Measured using hand probe, trickle flow from seepage from farmland & quarry.
9/07/02	1,800			1,007	1,007					2.0	URS		Measured using hand probe, trickle flow from seepage from farmland & quarry.
7/01/04	3,340	2,800	1,600	1,854	1,600	540	260		8.3	0.3	URS	AEL 77826	Strong trickle flow from seepage from Quarry Dam; high turbidity due to disturbance by cattle.
24/01/04	3,280	3,100	1,900	1,821	1,900	2	2		7.4	0.4	URS	AEL 78247	Strong trickle flow from seepage from leach drain & Quarry Dam.
11/04/2004	4,050			2,245	2,245					0.1	URS		Trickle flow from seepage on nthn edge of quarry.
10/06/2004	4,580			2,536	2,536				7.4	14.85	URS		Strong from flow from seepage.
30/08/2004			1,100		1,100	12			7		BGC		Taken at E1.
29/09/2004			1,800		1,800	33			7		BGC		Taken at E1.

[1] – calculated from *EC* using the relationship *EC**0.55+17; 2 – composite record using, in order of priority –TDS Lab, TDS Calc.; TDS - total dissolved solids (grav.); TSS - total suspended solids.

Table A4

Monitoring Results, Western Stream, Site W1

Date	EC Field	EC Lab.	TDS Lab.	TDS Calc.[1]	TDS composite[2]	TSS Lab.	Turbidity	Oil & Grease	pH	Stream flow	Sampler	Lab #	Comment
	(µS/cm)	(µS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(NTU)	(mg/L)	(pH units)	(L/s)			
5/03/02										0.0	URS		Assumed dry.
9/07/02	1,865			1,043	1,043					4.0	URS		Measured using hand probe; puddles & some trickle flow from seepage.
7/01/04										0.0	URS		Dry.
24/01/04										0.0	URS		Dry.
11/04/2004										0.0	URS		Dry.
10/06/2004										0.0	URS		Assumed dry.

[1] – calculated from *EC* using the relationship *EC**0.55+17; 2 – composite record using, in order of priority –TDS Lab, TDS Calc.; TDS - total dissolved solids (grav.); TSS - total suspended solids.

Table A5

Monitoring Results, Wooroloo Brook, Site S2

Date	EC Field[1] (µS/cm)	EC Lab.[2] (µS/cm)	TDS Lab. (mg/L)	TDS Calc.[1] (mg/L)	TDS composite[2] (mg/L)	TSS Lab. (mg/L)	Turbidity (NTU)	Oil & Grease (mg/L)	pH (pH units)	Stream flow (L/s)	Sampler	Lab #	Comment
5/03/02										0.0			Dry
9/07/02	4,290			2,377	2,377					7.2	URS		Measured using hand probe; stream flowing strongly from seepage from farmland
7/01/04	3,900	3,800	2,100	2,162	2,100	<5	4		8.2	0.0	URS	AEL 77826	Strong trickle flow from seepage from Quarry Dam; many small fish
24/01/04	4,380	4,500	2,600	2,426	2,600	2	2		7.1	0.2	URS	AEL 78247	Strong trickle flow from seepage from leach drain & Quarry Dam
11/04/2004										0.0	URS		Dry.
10/06/2004	7,570			4,181	4,181				7.2	92.9	URS		Strong from flow from seepage.

[1] – field = measured in the field using a hand probe; [2] – lab = measured in the laboratory on a sample taken in the field; [3] -calculated from *EC* using the relationship *EC**0.55+17; 2 – composite record using, in order of priority –TDS Lab, TDS Calc.; TDS - total dissolved solids (grav.); TSS - total suspended solids.

Appendix C

Groundwater Study

R E P O R T

Groundwater Investigations at Voyager Quarry

Prepared for

BGC (Australia) Pty Ltd

PO Box 1257
MIDLAND WA 6936

8 December 2004

42905483 / 507-F6775.1

URS

Project Manager:	…………………………………..	URS Australia Pty Ltd
	John Barnett	Level 3, The Hyatt Centre
	Principal Hydrogeologist	20 Terrace Road
		East Perth, WA 6004 Australia
		Tel: 61 8 9221 1630
Reviewed by:	…………………………………..	Fax: 61 8 9221 1639
	George Domahidy	
	Principal Hydrogeologist	

Author:	…………………………………..	Date:	**8 December 2004**
	John Barnett	Reference:	42905483/507-F6775.1
	Principal Hydrogeologist	Status:	Revision 1

Contents

List of Tables, Figures & Attachments

Tables

Figures

Attachments

Introduction

A Public Environmental Review (PER) was prepared for the proposed expansion of the Voyager Quarry in January 2003. The quarry is on the north side of the Great Southern Highway, about 16 km east of Mundaring.

Public submissions in response to the PER raised a number of groundwater issues which were considered to require further evaluation. The main issues of concern were as follows:

- Water-level drawdown caused by the existing quarry, depleting local aquifers and adversely affecting private water-supplies.
- Localised recharge to groundwater caused by quarry operations, causing local rise in water-table leading in turn to salinisation of surface soils.
- Inadequate characterisation of groundwater inflows to existing quarry.

Although these issues largely refer to the existing quarry, similar problems were envisaged with the proposed expansion, by those making the submissions.

A groundwater investigation programme was agreed in principle with the DoE, at a meeting on 9 July 2003, to address the issues raised by the public submissions. The programme was to include:

- Census of private bores, wells, soaks and spring-fed dams.
- Survey of elevations of water-points identified by census, to define shape of water-table and groundwater flow directions.
- Map distribution of regional fracture zones and dolerite dykes.
- Improve measurement of seasonal groundwater inflows into existing quarry and flow from artesian bores near process dam. This data would enable refinement of water-balance estimates for the existing quarry.
- Drilling of additional monitoring bores, following completion of census, if considered necessary to fill any gaps in water-level coverage.

The programme was completed in 2004, and included drilling and construction of eleven monitor bores, in addition to pre-existing Bores BGC1 and BGC2. The results of all investigations are described in this report, and applied to the issues of concern raised by public submissions.

2.1 General

The programme of investigation has included:

- Census of private water-points and survey of elevations.
- Construction of eleven monitor bores.
- Interpretation of air-photographs.
- Measurement of water-balance of quarry pit sump and process dam.
- Measurement of flow from artesian bores AB1 and AB2.
- Monitoring of water-levels.

These various components are described below.

2.2 Private Bore Census and Survey

Bores, wells, soaks, and spring-fed dams were visited on all properties for which permission was obtained from landholders, within at least 2 km from the existing quarry.

Depths, salinity (as electrical conductivity), and water-levels were measured where accessible, and background information on history and construction was obtained where possible. The results of the census are summarised in Table 1, and all sites are shown on Figure 1.

The census points were subsequently surveyed by Automated Surveys Pty Ltd.

2.3 Construction of Monitor Bores

Eleven monitor bores were constructed at six sites, to enable measurement of water-quality and water-levels at both shallow and deep intervals within the aquifer profile.

This programme has been reported on separately; the report and borehole logs are included as Attachment A. The results are summarised on Table 2, together with the details of pre-existing monitor bores BGC1 and BGC2. The sites are shown on Figure 1.

Table 1

Groundwater Census– May/June 2004

Source	Owner/ Property	Coordinates		Elevation (mAHD)	Cons-tructed	EC (µS/cm @ 25°C)	Temp. (°C)	PH	Water Level (m below casing top)	Depth (m)	Use	Yield (m^3/day)	Pump	Comments
		East	North											
House Bore	Sorokine	437796	6474272	328.05	1994	1,114	18.4	-	15.0	24	Disused	Low	-	Original domestic use – dried up last 3 yrs. Well to granite at 10 m continues as bore to 24m. Adjacent 27 m bore.
Shed Bore	Sorokine	437784	6474202	325.69	1993	724	18.7	-	~13	23	Orchard	Low	Windmill	Granite at 14-15 m. Dries up in January since 2002.
Horton Rd Bore	Sorokine	437748	6474101	325.28	2002	4,340	19.7	-	14.4	27	Disused	Good	-	
Dam Bore	Sorokine	437539	6474267	310.44	Pre-1988	2,120	20.1	-	6.1	18	Stock	Low	Pneu-matic	Used after 23 m deep bore above dries up. Iron taste.
Dam	Sorokine	437481	6474266	305.83	Pre-1988	1,510	10.2	-	-	-	Stock	-	-	Permanent soak, overflows in winter.
Salty Bore	Harken	437036	6475760	269.61	1997	4,490	19.7	-	Flowing	40	Disused	-	-	Granite at 25 m.
Racetrack Dam	Harken	437903	6475982	297.64	Pre-1984	1,678	13.3	-	-	-	Stock	Low	-	Permanent soak, never dries up.
Big Dam	Harken	437540	6476057	287.67	1998	1,279	14.9	-	-	-	Stock	Good	-	Permanent soak, overflows in winter.
South Dam	Dibble	439226	6475772	278.68	Pre-2001	7,110-7,330	14.5-15.0	8.8	-	-	Stock	-	-	Fed by soak, winter spillway.
North Dam	Dibble	439039	6476213	276.49	Pre-2001	4,780	14.8	8.5	-	-	Stock	-	-	Does not dry up. Fed by soak.
Bore	Pederick	437107	6473988	289.96	Pre-1989	1,284	14.7	-	-	>7.5	Garden	Low	Jet	Supply declines every summer.
Soak No. 1	Pederick	436965	6474276	275.94	1998	4,860	14.9	-	-	~2	Stock	Low	-	Never dries up. Level fluctuates ~1 m.

Table 1 (continued)

Source	Owner/ Property	Coordinates East	Coordinates North	Elevation (mAHD)	Cons-tructed	EC (µS/cm @ 25°C)	Temp. (°C)	pH	Water Level (m below casing top)	Depth (m)	Use	Yield (m^3/day)	Pump	Comments
Soak No. 2	Pederick	436886	6474148	277.05	1998	2,380	15.0	-	-	~2	Stock	Low	-	Never dries up. Level fluctuates ~1 m.
Main Dam	Pederick	437044	6474102	281.32	Pre-1989	4,080	14.6	-	-	~5	Stock	Good	-	Spring fed; never dries – drops only 1.3 m in summer. Overflows in winter.
Driveway Dam	Pederick	436788	6474024	281.36	Pre-1989	450	10.1	-	-	-	Stock	Good	-	Spring fed; never dries up.
Dam	Reeves	436708	6474051	-	-	265	12.7	-	-	-	Vineyard	Good	-	Perennial, spring-fed.
Bore	Hoyle	438043	6475358	301.27	1984	2,780	17.2	4.9	-	20-21	Hydropo n-ics	Good (~20)	Helical Rotor	Reported EC 800-1,200µS/cm until 1995-1996.
Back Dam	Hoyle	438190	6475777	303.83	1993	4,960	13.7	4.5	-	~4	-	Good	-	Never dries up, salinity and yield consistent over time.
Bore	Carter	440563	6474633	296.98	Pre-1996	3,130	14.6	5.3	-		Stock	-	Centrifug al	Summer use only. Shandy with dam water.
Dam	Carter	440580	6474635	295.11	-	1,133	13.5	8.8	-	-	Stock	-	-	Never dries up.
Bore MB010	Carter	440405	6475532	285.88	-	2,950	18.6	6.2	1.58	2.5	Monitor	-	-	50 mm PVC, 0.73 m stick-up.
Bore PB010	Carter	440402	6475532	285.65	-	8,660	17.5	2.9	0.80	7.0	Monitor	-	-	50 mm PVC, 0.82 m stick-up.
Bore PB009	Carter	440313	6475955	280.40	-	6,380	16.7	3.5	0.43	5.5	Monitor	-	-	50 mm PVC, 0.43 m stick-up.
Dam	Carter	440386	6475627	283.93	-	3,090	13.7	6.0	-	-	Stock	-	-	Spring-fed.
Well	House	436838	6474221	273.90	-	3,890	15.3	6.1	0.80	2.6	Disused	-	-	Water level below ground level. 3m x 1m, timber lining.
Dam	House	436880	6474220	274.67	-	3,930	14.0	7.4	-	-	Stock	-	-	Spring-fed.
Spring	House	436882	6474156	276.70	-	1,939	14.4	6.2	-	-	Stock	~80	-	Fed by soak upgradient in Pederick property (Soak No. 2).
House Bore	Guy	436228	6474561	272.67	-	6,160	14.1	4.8	-	-	Garden	Good	Jet	
East Bore	Guy	436362	6474652	265.05	-	5,440	20.1	6.6	2.30	-	Disused	-	-	Pump jammed in bore.
West Bore	Guy	436138	6474681	267.72	-	383	20.0	3.8	6.50	21.0	Disused	-	-	

Table 1 (continued)

Source	Owner/ Property	Coordinates		Elevation (mAHD)	Cons-tructed	EC (µS/cm @ 25°C)	Temp. (°C)	pH	Water Level (m below casing top)	Depth (m)	Use	Yield (m^3/day)	Pump	Comments
		East	North											
North Dam	Guy	436290	6474755	262.28	-	3,720	13.8	7.1	-	-	Stock	-	-	Spring-fed, overflows in winter.
South Dam	Guy	436301	6474725	265.32	-	2,140	14.0	6.5	-	-	Stock	-	-	Spring-fed, overflows in winter.
Bore	Boase	439369	6477695	282.56	-	8,750	14.2	5.8	-	-	Stock	Good	Windmill	
Soak	Boase	439523	6477333	274.16	-	3,510	14.1	4.4	-	-	Disused	-	-	
Wooroloo Brook	Boase	439369	6476802	268.18	-	7,450	14.9	6.6	-	-	-	-	-	

Table 2

Monitor Bores

Bore No	Location		Collar RL (mAHD)	Collar Stickup	Status	Date Completed	Depth Drilled	Casing Details						Field EC	Water Level	Water Level
	Northing	Easting		(m above ground level)			(m)	Backfill	Blank	Slotted	Gravel	Bentonite	Cement	(µS/cm)	(m, relative to casing top)+ 26/05/04	(m btc) 10/06/04
BGC1	6474785	438598	314.54	0.42	Mon	03/02	60	2-4.5	+0.42-5.2 23.2-29.2 53.2-59.2	5.2-23.2 29.2-53.2	5-60	4.5-5.0	Sifoam 0-2	5,800		41.50
BGC2	6474141	438027	350.23	0.49	Mon	03/02	50.5		+0.49-3.1 44.1-50.1	3.1-44.1	2.5-50.5	-	Sifoam 0-2	-		11.20
MB1D*	6475393	439120	282.69	0.5	mon	24/05/2004	19	-	+0.5-10.46	10.46-16.46	Nil	Nil	0-2m	12,300	13.06	0
MB1S	6475393	439118	282.80	0.5	mon	12/05/2004	5	-	+0.5-1.45	1.45-4.45	1.2-4.45	0.8-1.2	0-0.8	14,100	1.94	1.22
MB2Da**	-	-	-	-	**	18/05/2004	32	0-32	-	-	-	-	-	-	-	-
MB2D	6474657	439262	302.64	0.53	mon	25/05/2004	30	0-18	+0.53-12	12-18	-	-	0-1	-	7.71	7.58
MB2S	6474666	439304	300.83	0.51	mon	13/05/2004	36	7-36	+0.51-3.9	3.9-6.9	3.7-6.9	2.8-3.7	0-2.8	12,300	6.24	6.11
MB3D	6475566	439275	282.75	0.5	mon	18/05/2004	27	-	+0.5-13.95	13.95-25.95	6-25.95	3.8-6	0-3.8	-	3.61	3.05
MB3S	6475566	439273	282.66	0.51	mon	19/05/2004	4	-	+0.51-1.8	1.8-3.8	0.8-4	0.5-0.8	0-0.5	1,200	3.45	2.91
MB4D	6475364	439305	286.42	0.5	mon	19/05/2004	27	-	+0.5-15.04	15.04-27.04	13.8-27	12.8-13.8	0-12.8	16,100	+2.57	Flowing
MB4S	6475364	439303	286.36	0.48	mon	19/05/2004	4	-	+0.48-1.57	1.57-3.57	0.2-3.57	-	0-0.2	15.800	1.12	0.97
MB5D	6474716	439556	297.98	0.55	mon	20/05/2004	25	-	+0.55-11.1	11.1-23.1	9.2-23.1	8.2-9.2	0-8.2	11,900	1.98	1.68
MB5S	6474716	439558	298.11	0.51	mon	20/05/2004	6	-	+0.5-3.83	3.83-5.83	0.7-5.83	0.5-0.7	0-0.5	4,100	2.24	1.99
MB6S	6474688	439395	295.69	0.6	mon	25/05/2004	33	6.5-33	+0.6-3.1	3.1-6.1	2-3.1	1-2	0-1	9,900	1.24	1.23
MB6D**	-	-	-	-	**	24/05/2004	32	0-32	-	-	-	-	-	-	-	-

Notes:
* BGCM1D Clays swelled preventing gravel pack/seal installation
** Abandoned holes due to swelling clays - not constructed.
+ mbtc – metres below top of casing

2.4 Air Photograph Interpretation

Air photographs at 1:20 000 scale were obtained for February 1989, before construction of the existing quarry, and for January 2003, as follows:

- Series WA2690(c), Darling Range Catchments, 10/2/89:
  - Run 11/Nos. 5209-5212.
- Series WA 4843(c), Metro Regional Area, 08/01/03:
  - Run 22/Nos. 5118-5122
  - Run 23/Nos. 5065-5069
  - Run 24/Nos. 5088-5092

The photographs have been used to identify major fracture lineaments and dolerite dykes in the granite bedrock, and to compare surface expressions of soil salinity before and after the excavation of the existing quarry.

2.5 Water-Balance, Quarry Pit Sump and Process Dam

Water levels were measured in the quarry pit sump and process dam during periods when the quarry was not in operation. The cross-sectional area of both water-storages was measured at the same time, to enable the water-balance of each to be quantified.

The water-balances are given in full in the URS report "Additional Surface Water Studies Conducted Since the PER, in Response to Submissions Related to the Proposed Expansion of BGC Voyager Quarry, 28 October 2004" (Surface Water Report), and are not repeated here, although the results are cited below.

2.6 Measurement of Artesian Flow

The flow from the two artesian bores has been measured on two occasions, by siphoning into a container of known volume. The results are included in Attachment B.

2.7 Monitoring of Water Levels

Water levels have been monitored approximately weekly in Bores BGC1 and BGC2 since they were constructed in March 2002. The eleven new monitor bores have also been monitored weekly since their installation in May 2004. The results are included as Attachment B.

3.1 Geology

The general area in the vicinity of the existing and proposed quarries is underlain by granite bedrock, weathered to depths ranging from surface to over 30 m.

The complete weathered profile is as follows:

Thickness	*Lithology*
0 – 2 m	Lateritic gravel and clay
3 – 20 m	Kaolin clay and quartz sand (clayey sand and sandy clay)
20 – 25 m	Weathered and decomposed granite
25 – 30 m	Fractured granite, fresh to slightly weathered
30 m	Fresh granite bedrock, hard, rare fractures

In fact, the thickness of the individual layers is highly variable, and any or all of the upper layers may be very thin or absent at a particular site. Representative cross-sections are shown in Figures 2, 3 and 4.

There are a number of lineaments visible in the air photographs which reflect dolerite dykes or regional fracture zones. These are on Figure 1. The most prominent set is west-northwest in orientation; in the existing quarry this set corresponds with sub-vertical dolerite dykes. The margins of the dykes are fractured, except for the northern margin of the dyke in the north wall of the quarry, which is annealed. Individual fracture zones close with depth, and are unlikely to be open below 50-60 m from surface.

3.2 Hydrogeology

The most permeable aquifer zone is the weathered zone just above fresh bedrock, and the upper few metres of fractured bedrock. The regional lineaments, and the margins of associated dolerite dykes, may be particularly fractured. The fresh bedrock, where unfractured, is essentially impermeable.

Water-levels in the monitor bores constructed in 2004 show an upward hydraulic head from the base of the profile to the water-table, except at the most northerly site, MB3. Two of the deep bores (M1D, M4D) have winter water-levels above ground surface. A similar upward head is shown by the artesian bores AB1 and AB2. This upward head reflects the greater permeability of the base of the weathered profile, transmitting hydraulic head caused by recharge in the uppermost part of the catchment. This upward head, coupled with the shallow water-table, prevents significant recharge along the floor of the valley.

3.3 Water-Table Configuration and Groundwater Flow

The regional water-table and groundwater flow directions are shown on Figure 5, compiled by contouring all surveyed water-levels in bores, wells, soaks and dams; a representative cross-section is shown on Figure 4. The water-table contours have been interpolated between data points to correspond to the surface topography. Bore BGC1 encountered fresh unfractured granite from 13.5 to 60 m, was dry when drilled, and took approximately 2 years to rise to its current level; the current level is within the unfractured impermeable fresh granite and probably does not reflect the water table.

The water-table shows a restricted steep depression in the vicinity of the current quarry, reflecting the very low permeability of the fresh bedrock. There is no evidence of any drawdown effect on the nearest private bores, over 1 km to the west. The water level in these bores in June 2004 was similar to the original ground level at the quarry site.

Similarly there is no indication of a recharge mound downgradient from the quarry. The upward hydraulic head in the valley containing the quarry, and the already shallow water-table, would prevent the formation of such a mound.

3.4 Water-Balance of Quarry Pit Sump and Process Dam

The detailed records and analysis of the water-balance for the quarry pit sump and process dam are included in the Surface Water Report.

Estimates of inflow for the quarry pit sump were as follows:

March 2002	-	0 L/s
July 2002	-	0.3 L/s
January 2004	-	0.2 L/s
April 2004	-	0.7 L/s

The average of 0.3 L/s is very similar to the estimated inflow rate of 0.35 L/s to the quarry in the original PER.

The process dam was shown to be receiving net inflow of 2.7 L/s in April 2004 and 4.7 L/s in June 2004, over long weekends when the quarry was not in operation. This inflow was derived from return dust suppression, crushing and processing water, and possibly partly from groundwater inflow. The dam is excavated to 8m, which is several metres below the water table, so that some groundwater inflow is possible if the clay-lining is not completely impermeable.

Measured flows from the artesian bores AB1 and AB2 have been as follows:

January 2004: AB1: 0.08 L/s; AB2: 0.22 L/s

April 2004: AB2: 0.06 L/s; AB2: 0.18 L/s

Most of this is probably lost in evapotranspiration in overland flow between the bores and the process dam.

3.5 Groundwater Quality

Samples were taken from all monitor bores, and from five private bores, in May and June 2004, and submitted to SGS Australia Pty for analysis of pH, Electrical Conductivity (EC) and Total Dissolved Solids (TDS), see Table 3. The analyses are included as Attachment C.

Table 3

Groundwater Quality

	pH	EC (µS/cm @ 25°C)	TDS (mg/L)
BGC1	7.5	5,600	3,500
BGC2	7.7	240	140
MBIS	5.7	16,000	9,600
MBID	5.7	13,000	7,300
MB2S	4.9	8,600	4,700
MB2D	4.8	1,200	700
MB3S	4.4	1,700	1,400
MB3D	7.3	2,100	1,100
MB4S	6.6	16,000	8,900
MB4D	5.4	16,000	9,500
MB5S	5.1	4,100	2,400
MB5D	6.8	11,000	6,200
MB6S	4.8	12,000	6,700
Hoyle	4.6	2,800	1,500
Carter	5.4	3,100	1,800
House	3.5	4,000	2,300
Boase	5.6	9,200	5,300
Guy	3.9	6,400	3,500

The groundwater, whether from shallow or deep parts of the profile, is generally brackish to saline, except for BGC2 and MB2D, which are fresh (less than 1,000 mg/L TDS). BGC2 is affected by perched groundwater resulting from local winter recharge from rainfall and so does not represent the general groundwater salinity. MB2D is on the eastern flank of the uncleared part of Horton Hill, and may reflect local fresh recharge.

The salinity of the shallow groundwater is higher or similar to the deeper groundwater at each of the paired monitor bore sites, with one exception. The exception is Site MB5; as the groundwater also has an upward head at this site, the reason for this anomaly is not evident. This salinity pattern is probably due to solution of salt in the upper part of the soil profile, as the deeper groundwater rises through the weathered profile under upward hydraulic head.

The ratio of TDS to EC is generally in the range 0.55 – 0.60.

The groundwater in all the cleared agricultural areas is almost exclusively acid, in all private and monitor bores, ranging in pH from 3.5 – 5.7. The shallow groundwater is more acid than the deeper groundwater, indicating the presence of acid sulphate soils. Two of the deeper monitor bore sites are almost neutral in pH, MB3D and MB5D. In contrast the surface water, including the creeks downstream from the quarry, is generally neutral to alkaline. When the groundwater discharges to the surface, the discharge of dissolved gases, such as carbon dioxide and hydrogen sulphide, may contribute to this increase in pH, or the increased alkalinity may be derived from surface runoff.

The EC of the artesian bores, measured in January and April 2004, was 2,730 – 2,770 µS/cm for Bore AB1, corresponding to TDS of about 1,550 mg/L TDS, and 4,730 – 4,850 µS/cm for Bore AB2, equivalent to about 2,750 mg/L TDS.

The EC distribution is plotted on Figure 6. There appears to be a general tendency of increasing EC downgradient, although there are many exceptions to this trend, probably because of local variations in recharge. The EC values in the valley north of the quarry are generally higher than elsewhere, probably because of the greater area of clearing in the upper part of this valley.

3.6 Soil Salinity and Salt Scalds

Aerial photography taken before and after the construction of the existing quarry clearly shows the presence of salt-affected soils before the quarry was constructed (Figure 7). Indeed the extent of surface salt-affected ground appears to have been greater in 1989.

During construction of the monitor bores drilling samples at 1 m intervals were mixed at 1:5 ratio with deionised water, shaken by hand for two minutes, and the EC measured, to investigate the relative distribution of salt in the weathered profile. The results are included as Attachment D.

The results show generally higher values in the top 10 m, and increasing levels at depths beyond 25 m. The upper zone of increased salinity represents salt accumulated below the root zones of native vegetation before the land was cleared. The deeper level of increased salt corresponds with the saline groundwater above fresh bedrock.

Six samples were also taken from various depths in Bore MB2D, and analysed by SGS for content of Total Soluble Salts. The concentration showed a general increase with depth, from 53-61 mg/kg at 1-3 m, to 440 mg/kg at 25-26 m, a similar pattern to the field samples in this particular bore. The laboratory analyses are included as Attachment E.

3.7 Extent of Groundwater Drawdown due to Quarrying

The water-level contours show very little drawdown in the vicinity of the quarry to the east and north. The two monitor bores to the west, BGC1 and BGC2, which were constructed in 2002, have not provided an accurate indication of water-levels in that direction. Bore BGC1 encountered essentially impermeable rock below 13.5 m, and the water-level in this bore took 2 years to reach its current level of about 40 m below ground. Bore BGC2 contains very fresh groundwater, and rises very rapidly to within 3 m of the surface at the beginning of each winter, and is clearly affected by perched groundwater above the main water-table.

There is little published data on permeability of weathered and fresh granite in the Darling Range, with values of hydraulic conductivity of 0.01 – 1 m/day from pumping tests being quoted by Wilkes et al (2004), and an average transmissivity of 0.6 m^2/day by Briese (1979).

The granite profile can in fact be expected to show a wide range in transmissivity, from 0 – 10 m^2/day, being essentially impermeable in fresh unfractured rock, with the highest values along major fracture zones.

Storativity may be similarly expected to range from 0 to 0.05 between unfractured granite and decomposed granite.

The radius of effect of drawdown can be estimated from a derivation of the Theis non-equilibrium formula:

$$r = \sqrt{\frac{2.25\ Tt}{S}}$$

where: r = radius of drawdown influence (m)

T = transmissivity (m^2/day)

t = time (days)

S = storativity (dimensionless)

Adopting 200 days as the likely maximum period between recharge periods, estimates of drawdown influence can be made for the bulk profile, and the ‘worst case’ of highest transmissivity and low storativity along a major fracture zone, as follows:

- Bulk Profile (transmissivity 0.1 m^2/day, storativity 0.005)

$$r = \sqrt{\frac{2.25 \;\; x \;\; 0.1 \;\; x \;\; 200}{0.005}} = 95m$$

- Major Fracture Zone (transmissivity 10 m^2/day, storativity 0.005)

$$r = \sqrt{\frac{2.25 \;\; x \;\; 10 \;\; 200}{0.005}} = 950m$$

Thus, in general, drawdown effects are likely to be limited to within 100 m of the quarry itself, except along any major fracture zones which intersect the quarry, along which drawdown could extend up to about 1 km away.

During the census, it was reported that Shed and House Bores, 1,200 m west of the quarry, have dried up in summer in the last few years. The calculations above indicate that this is not related to quarry operations; it may be due to reduced rainfall, which has been about 9 percent below average for the last 5 years, or to increased abstraction. The standing water-level in these two bores in winter is similar to the original ground level at the quarry.

Another bore, at 437107E; 6473988N, some 1,800 m to the west of the quarry, was also reported to decline in supply every summer. This bore is too far away to be affected by the quarry.

None of the other bores, wells, soaks or springs were reported to fail in summer.

Conclusions

- There is no evidence that the quarry has affected the water-levels of any private bores or other water-sources in the vicinity.

  The net groundwater abstraction associated with the quarry is in the range 0.5 – 1 L/s, estimated from measured inflow to the quarry pit sump and discharge from the two artesian bores to the south of the process dam. There may also be some minor groundwater inflow to the process dam, which is excavated to several metres below the water table, but is lined with clay.

- Groundwater inflow to the quarry itself has a measured average of 0.3 L/s, similar to the value of 0.35 L/s adopted in the original PER.

- There is no evidence of local groundwater mounding contributing to salinity in the catchment downstream from the process dam.

  The salt-affected soils have been caused by rising groundwater-levels consequent on clearing of the catchment for agriculture, and are evident on air photography taken in 1989 before the quarry was constructed.

  There is an upward hydraulic head from deeper groundwater levels, maintaining the shallow-water-table in the valley downstream from the dam. This prevents any significant recharge taking place along the floor of the valley.

- The two monitor bores constructed in 2002 are not believed to accurately reflect groundwater-levels to the west of the quarry.

Recommendation

1. Two new paired monitor bores should be constructed to the west of the proposed new quarry, to accurately monitor groundwater levels between the quarry and private bores and water sources to the west of Horton Hill.

   At each site, one bore should be slotted against the weathered/fractured granite at the base of the profile, and one at the water-table, or expected water-table level. The bores should be sited on the two west-northwest fracture lineaments which intersect the quarry.

   The bores should be constructed before the new quarry extension is started, to provide baseline information, and should then be added to the monitoring programme.

2. The Groundwater Management Plan (Attachment F) should be followed through the planning, construction and operational phases of the quarry expansion.

Briese, E.H. 1979. A Reassessment of the Effects of Bauxite Mining on Groundwater Hydrology at Del Park. GSWA Record 1979/13.

Wilkes, S.M., Clement, T.P. & Otto, C.J. Characterisation of the Hydrogeology of the Augustus River Catchment, Western Australia Hydrogeology Journal, Vol. 12, No. 2, April 2004.

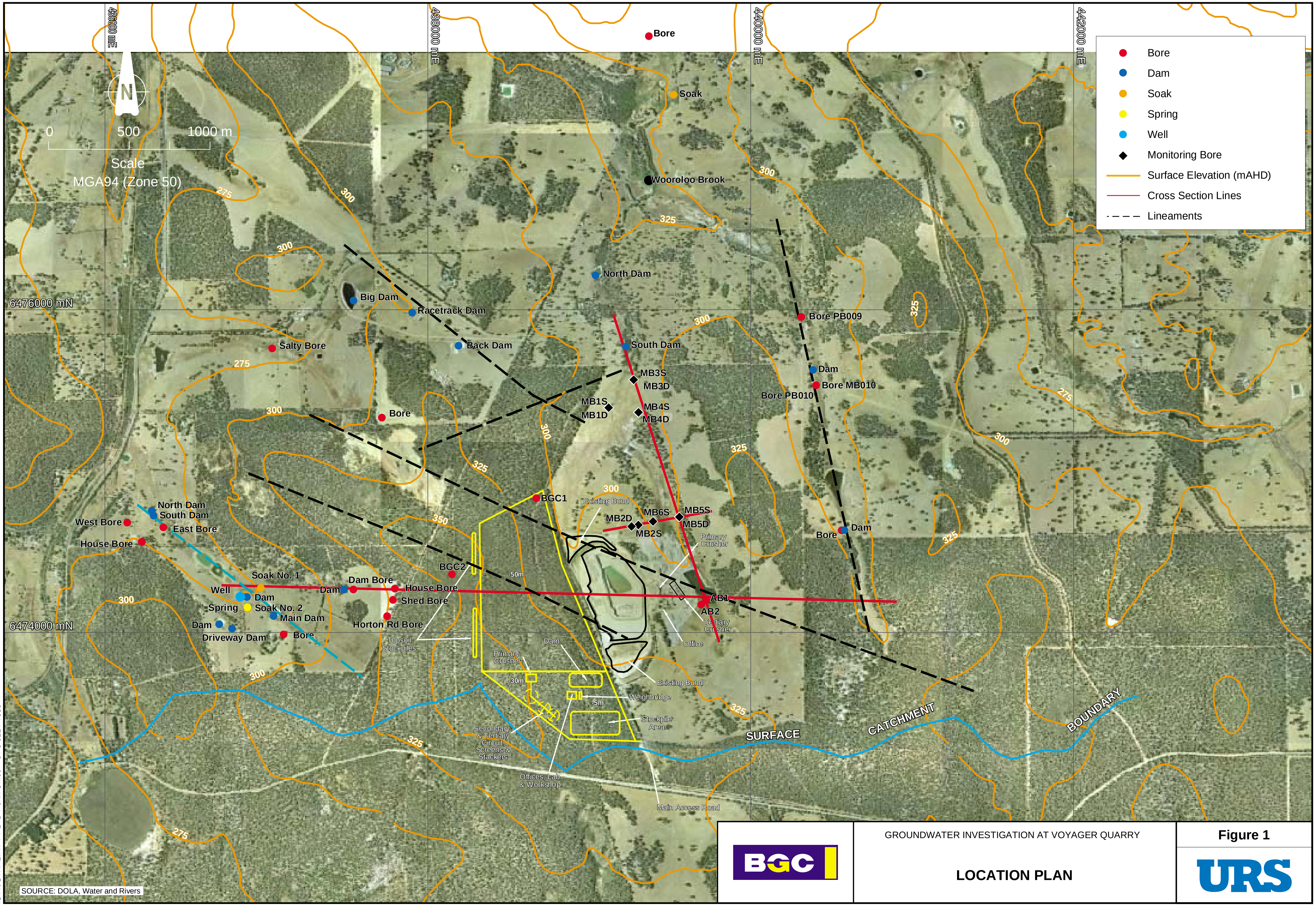
Limitations

URS Australia Pty Ltd (URS) has prepared this report for the use of BGC (Australia) Pty Ltd in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 4 December 2003.

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

This report was prepared between April and November 2004 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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



BGC

GROUNDWATER INVESTIGATION AT VOYAGER QUARRY

LOCATION PLAN

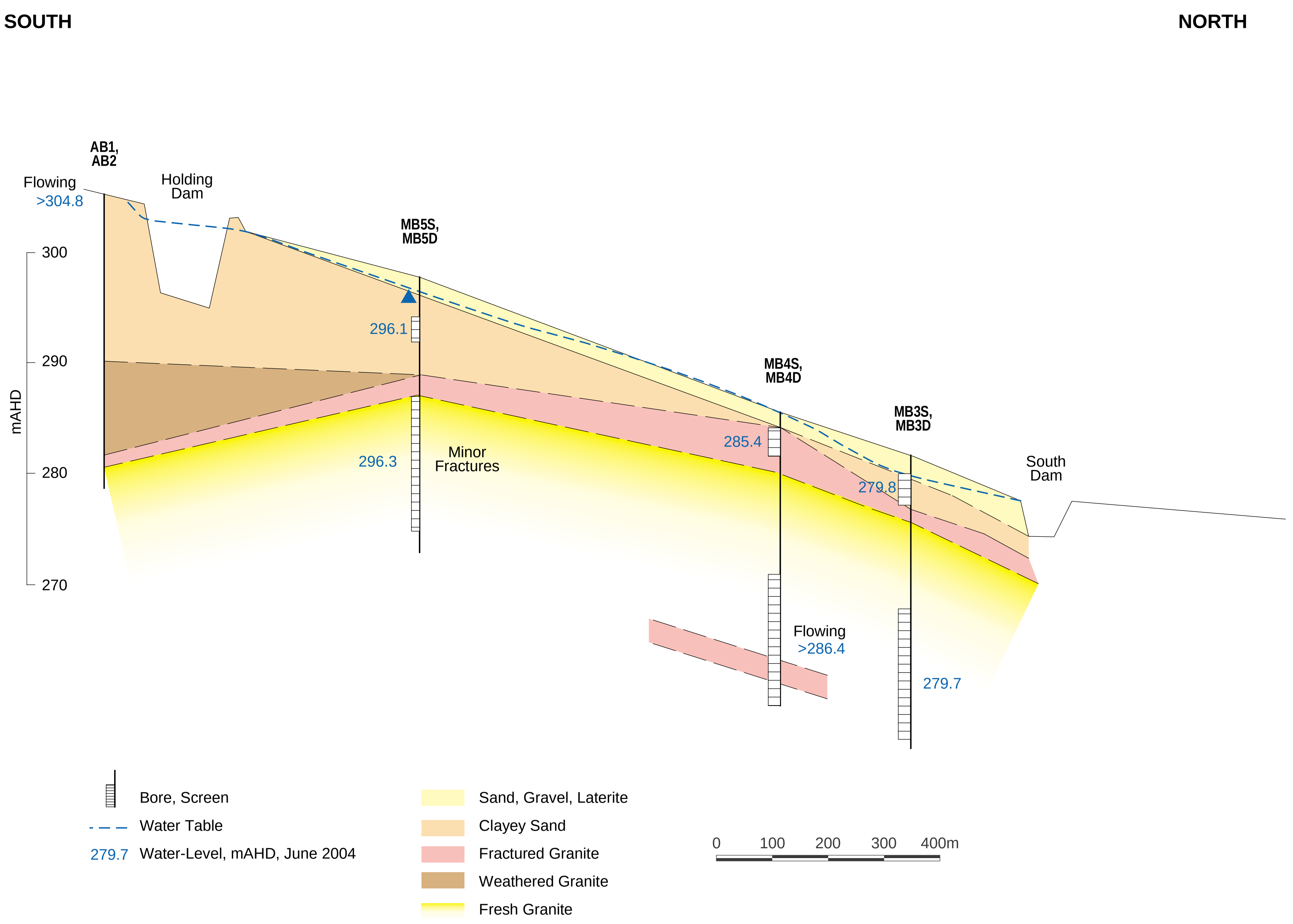
Figure 1

URS

Thu 09 Dec 04

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

J:\Jobs\42905483\drawings\r021\42905483r021f1.dgn



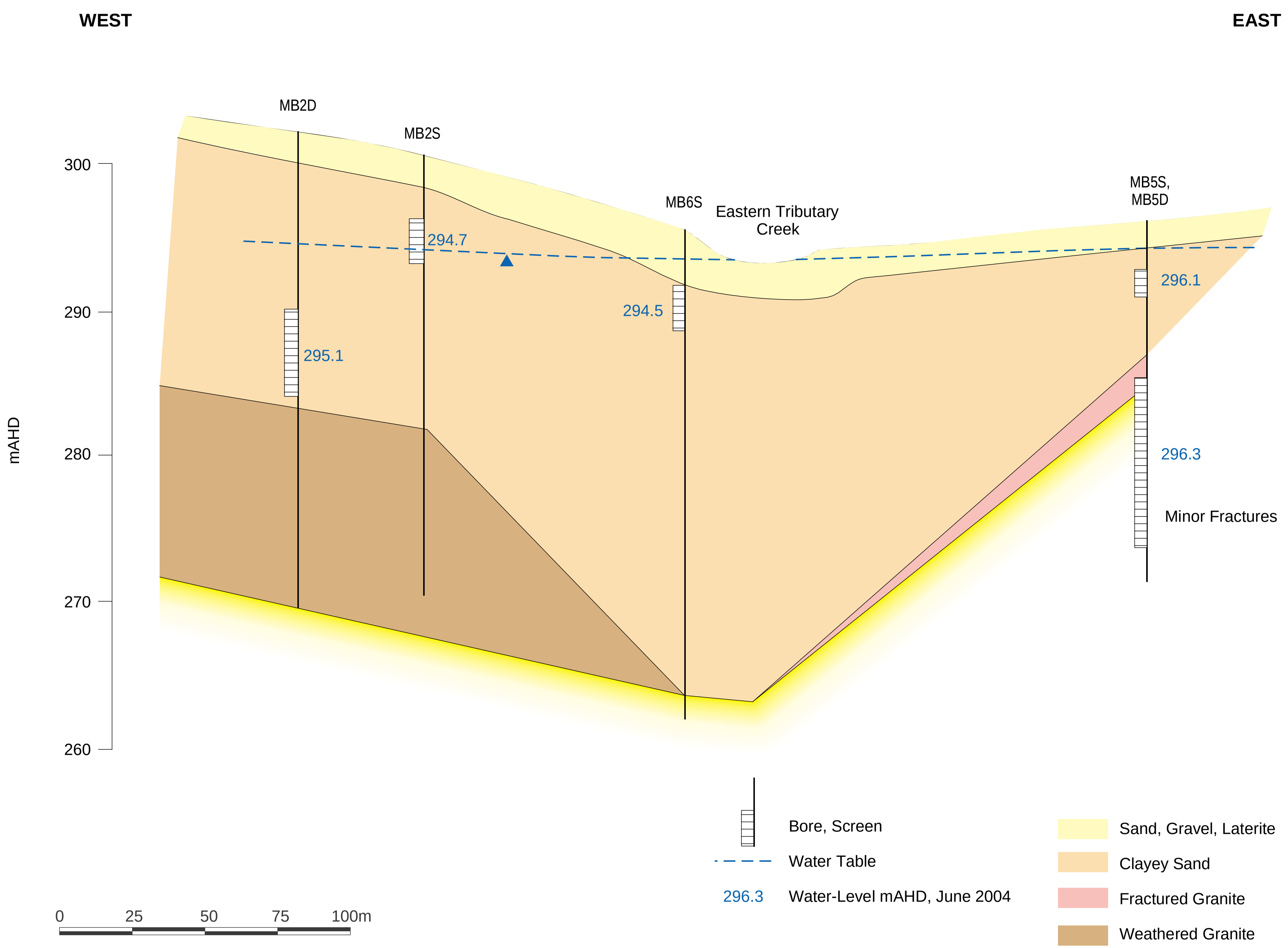
Job No.	42905483	
Prep. By	JCB	10 Nov 04
Chk'd By	KA	10 Nov 04
Revision No.		0

BGC
GROUNDWATER INVESTIGATION AT VOYAGER QUARRY

NORTH-SOUTH SECTION, MONITORING BORES

Figure 2

URS



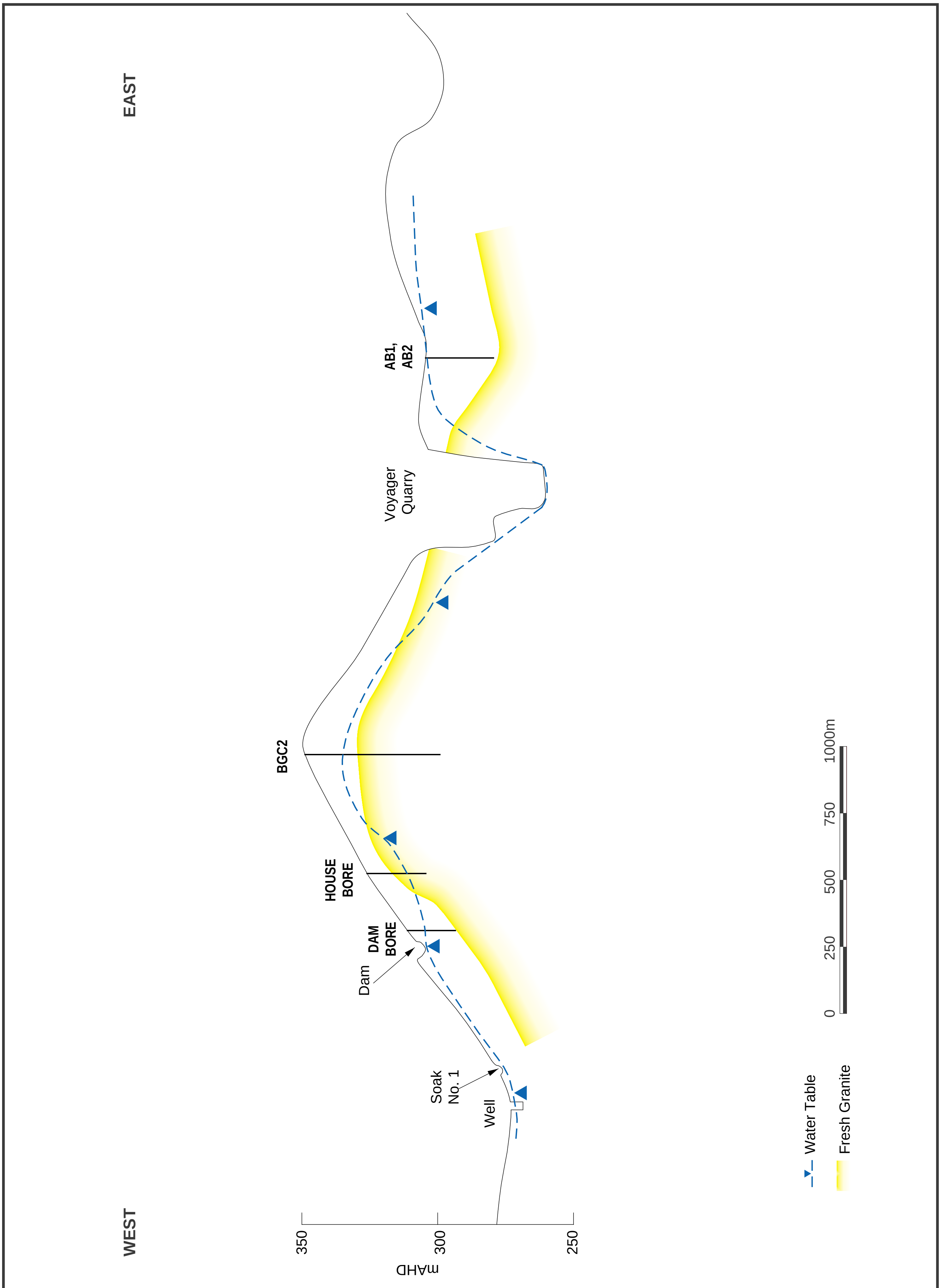
Job No.	42905483	
Prep. By	JCB	10 Nov 04
Chk'd By	KA	10 Nov 04
Revision No.		0

BGC
GROUNDWATER INVESTIGATION AT VOYAGER QUARRY

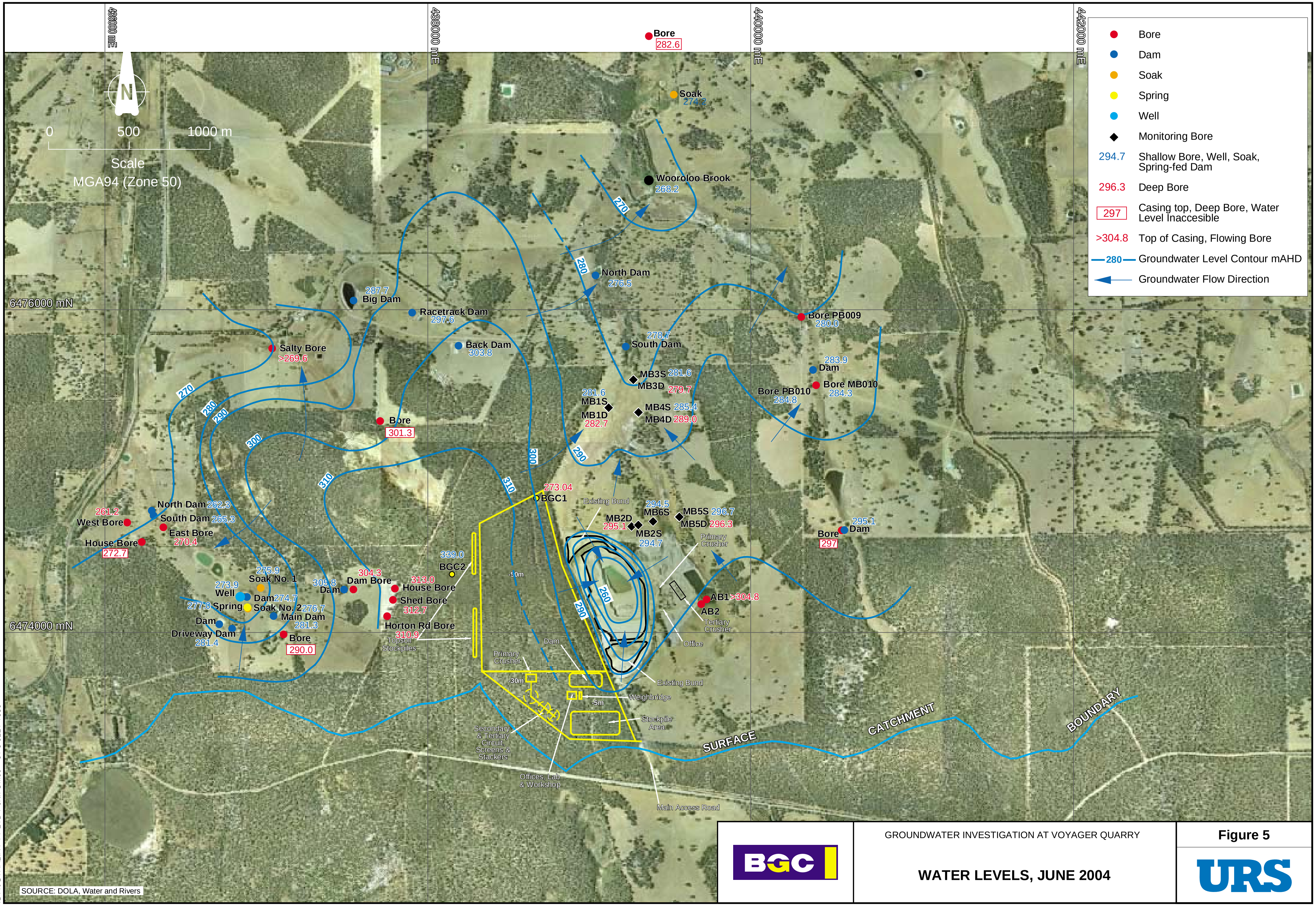
EAST - WEST SECTION, MONITORING BORES

Figure 3

URS



Job No.	42905483		BGC GROUNDWATER INVESTIGATION AT VOYAGER QUARRY **REGIONAL CROSS SECTION**	**Figure 4** URS
Prep. By	JCB	10 Nov 04		
Chk'd By	KA	10 Nov 04		
Revision No.		0		



BGC

GROUNDWATER INVESTIGATION AT VOYAGER QUARRY

WATER LEVELS, JUNE 2004

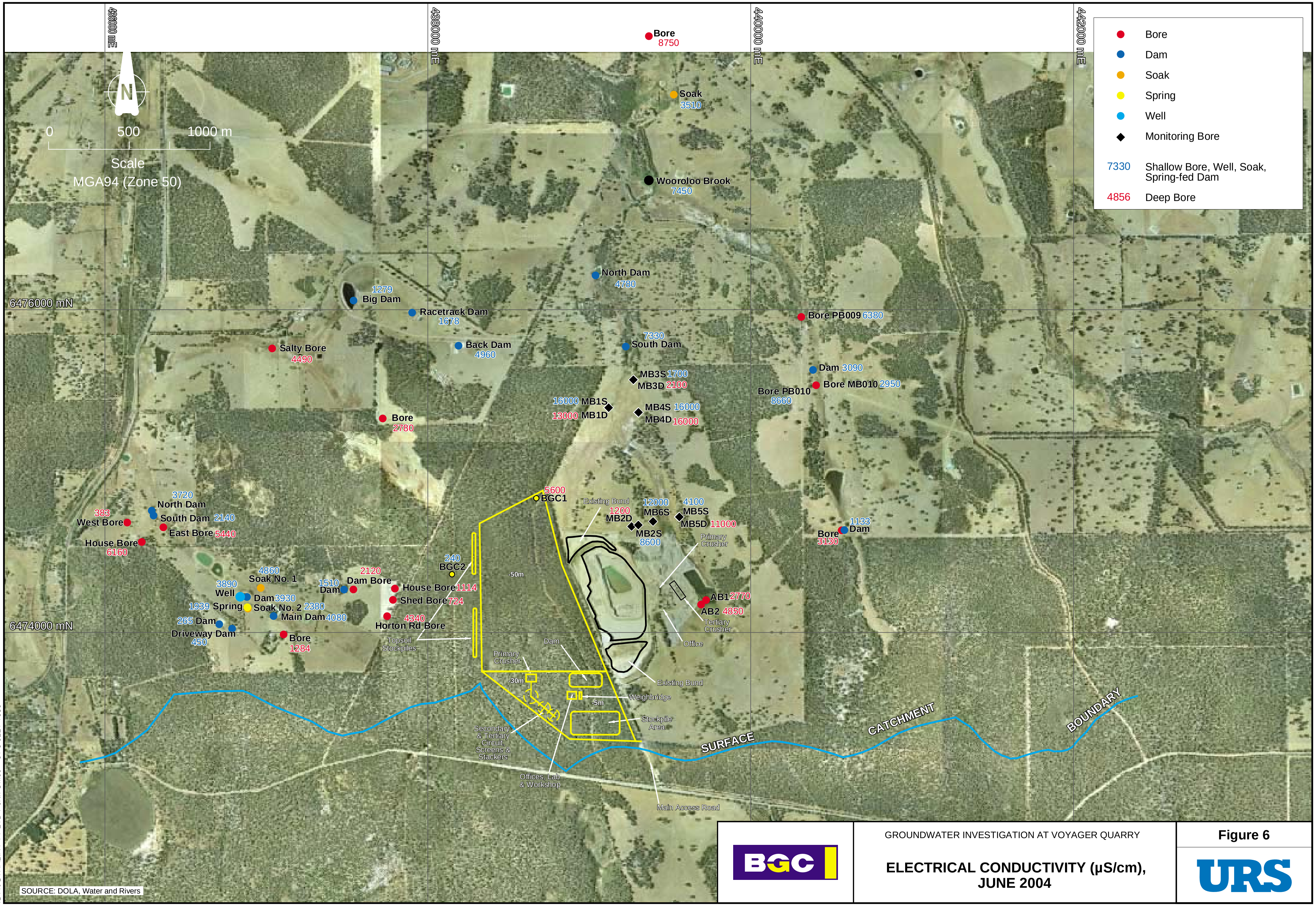
Figure 5

URS

Thu 09 Dec 04

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

J:\Jobs\42905483\drawings\r021\42905483r021f5.dgn



GROUNDWATER INVESTIGATION AT VOYAGER QUARRY

ELECTRICAL CONDUCTIVITY (µS/cm), JUNE 2004

Figure 6

Fri 12 Nov 04

(a) 10 February 1989

(b) 8 January 2003

N

0 200 400 600 800m

			BGC GROUNDWATER INVESTIGATION AT VOYAGER QUARRY	Figure 7
Job No.	42905483			
Prep. By	JCB	10 Nov 04	**HISTORICAL AERIAL PHOTOGRAPHY FOR THE QUARRY SITE**	URS
Chk'd By	KA	10 Nov 04		
Revision No.		0		

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

J:\Jobs\42905483\drawings\r021\42905483r021f7.dgn

Attachment A
Voyager Quarry Monitoring Bore Installation Summary Report, June 2004

BGC - Voyager Quarry Monitoring Bore Installation Summary Report

June 2004

It was proposed to construct two groundwater monitoring bores, one deep and one shallow, at each of the 6 locations adjacent to BGC's Voyager Quarry located near The Lakes, about 60km from Perth.

Drilling and construction were undertaken between the 12th and 25th of May 2004. A total of 13 holes were drilled, 11 being constructed as monitoring bores. The shallow bores were installed to monitor groundwater levels and salinity within the shallow lateritic sands and clays, while the deep ones targeted the deeper weathered bedrock profile.

All holes were drilled using air rotary and/or air core methods at 90mm diameter with depths ranging between 4 and 36m. Bores were constructed using 55mm ID, 60mm OD, Class 9, uPVC casing. A slotted interval of up to 12m was installed at the base of each bore using machine slotted uPVC (1mm slot aperture). The bores were gravel packed to cover the slotted interval and the annulus was cement grouted to surface to provide a seal between the two aquifer zones being investigated. All constructed bores were airlift-developed and completed with lockable steel caps. Summary details of bore construction are presented in Table 1.

As part of the investigation, all holes were lithologically logged and field measurements of soil Electrical Conductivity (1:5 soil/water extract) were conducted at 1m intervals during drilling. Water samples were collected from each completed bore during airlift development or by bailing and sent for laboratory analysis.

The lithological sequence at the location generally proved to be a typical laterite profile of varying thickness, having shallow topsoil overlaying a thin laterite duricrust, a mottled sandy clay zone and a soft white kaolinitic pallid clay zone. Below this was a zone of partially weathered and moderately fractured granite bedrock (saprolite) and then fresh granite. The site proved to be extremely variable in this lithological sequence causing some drilling difficulties.

The most northern sites (i.e. BGCM1 and BCGM4) intersected fresh bedrock (granite) between 0.5m and 6m. At the more southern sites (i.e. BGCM2 and BGCM6), adjacent to the quarry boundary, a thick section of up to 30m of swelling kaolinitic clays/saprolite was intersected. In order to successfully construct monitoring bores at these locations, attempts were made using different drilling techniques. Commonly the most successful method is to case the swelling clays off using larger diameter casing, but this method proved unsuccessful due to a combination of factors including drilling rig breakdowns. Two holes, BGCM2Da and BGCM6D, had to be abandoned and no deep monitoring bore could be constructed at either of these sites, although a medium depth bore (18m) was completed at BGCM2D.

Preliminary results show water levels (measured 26/05/04) in the shallow bores range from 0.97 – 6.11 m below top of collar. The deep monitoring bores water levels ranged between a flowing bore (BGCM4D), having a water level of 2.57 m above top of collar, to 2.91m below top of collar. Bore BGCM4D intersected fresh granite from 0.5m with a fractured zone between 23-25m.

Field electrical conductivity measurements (EC) ranged between 1.2 and 15.8mS/cm for the shallow bores and 11.9 up to 12.3mS/cm for the deeper bores. Water flowing from BGCM4D had a field EC measurement of 16.1mS/cm; this bore has being sealed to prevent contamination of soil and surface water.

BGC - Voyager Quarry
Monitoring Bore Summary Table
May 2004

Bore No	Location		Collar RL	Collar stickup	Status	Date Completed	Depth Drilled	Casing Details						Field EC	Water Level	Water Level
	Northing	Easting		(m AGL)			(m)	Backfill	Blank	Slotted	Gravel	Bentonite	Cement	(mS/cm)	(m btc) 26/05/2004	(m btc) 10/06/04
BGCM1D*	6475393	439120		0.5	mon	24/05/2004	19	-	+0.5-10.46	10.46-16.46	Nil	Nil	0-2m	12.3	13.06	0
BGCM1S	6475393	439118		0.5	mon	12/05/2004	5	-	+0.5-1.45	1.45-4.45	1.2-4.45	0.8-1.2	0-0.8	14.1	1.94	1.22
BGCM2Da**	-	-	-	-	Ab	18/05/2004	32	0-32	-	-	-	-	-	-	-	-
BGCM2D	6474657	439262		0.53	mon	25/05/2004	30	0-18	+0.53-12	12-18	-	-	0-1		7.71	7.58
BGCM2S	6474666	439304		0.51	mon	13/05/2004	36	7-36	+0.51-3.9	3.9-6.9	3.7-6.9	2.8-3.7	0-2.8	12.3	6.24	6.11
BGCM3D	6475566	439275		0.5	mon	18/05/2004	27	-	+0.5-13.95	13.95-25.95	6-25.95	3.8-6	0-3.8		3.61	3.05
BGCM3S	6475566	439273		0.51	mon	19/05/2004	4	-	+0.51-1.8	1.8-3.8	0.8-4	0.5-0.8	0-0.5	1.2	3.45	2.91
BGCM4D	6475364	439305		0.5	mon	19/05/2004	27	-	+0.5-15.04	15.04-27.04	13.8-27	12.8-13.8	0-12.8	16.1	+2.57	Flowing
BGCM4S	6475364	439303		0.48	mon	19/05/2004	4	-	+0.48-1.57	1.57-3.57	0.2-3.57	-	0-0.2	15.8	1.12	0.97
BGCM5D	6474716	439556		0.55	mon	20/05/2004	25	-	+0.55-11.1	11.1-23.1	9.2-23.1	8.2-9.2	0-8.2	11.9	1.98	1.68
BGCM5S	6474716	439558		0.51	mon	20/05/2004	6	-	+0.5-3.83	3.83-5.83	0.7-5.83	0.5-0.7	0-0.5	4.1	2.24	1.99
BGCM6S	6474688	439395		0.6	mon	25/05/2004	33	6.5-33	+0.6-3.1	3.1-6.1	2-3.1	1-2	0-1	9.9	1.24	1.23
BGCM6D**	-	-	-	-	Ab	24/05/2004	32	0-32	-	-	-	-	-	-	-	-

* BGCM1D Clays swelled preventing gravel pack/seal installation
** Abandoned holes due to swelling clays - not constructed.

BORE COMPLETION REPORT

BOREHOLE: BGCM1

URS Australia Pty Ltd — Phone 08 92211630
20 Terrace Rd, East Perth, 6004 — Fax 08 92211639

DRILLING CO:	**Orbit Drilling Pty Ltd**
DRILL METHOD:	**Air Hammer, Air Rotary**
PROJECT NAME:	**Voyager Quarry**
PROJECT NUMBER:	**42905484**
CLIENT:	**BGC Quarries**
LOCATION:	**The Lakes, Western Australia**

	BGCM1S	BGCM1D
DATE COMPLETED:	24/05/04	12/05/04
COLLAR HEIGHT:	0.5	0.5
DATE OF MEASUREMENT:	26/05/04	26/05/04
FINAL EC (mS/cm):	16	13

	BGCM1S	BGCM1D
COLLAR RL:	282.80	282.69
COORDINATES:	439114.96 6475392.09	439117.33 6475391.59
DATUM:	Top of Collar	Top of Collar
SWL (mbgl):	1.44	12.56

LOGGED BY: **GRB**

BORE CONSTRUCTION	DEPTH (m)	LITHOLOGY	DESCRIPTION	FORMATION

Cement Block

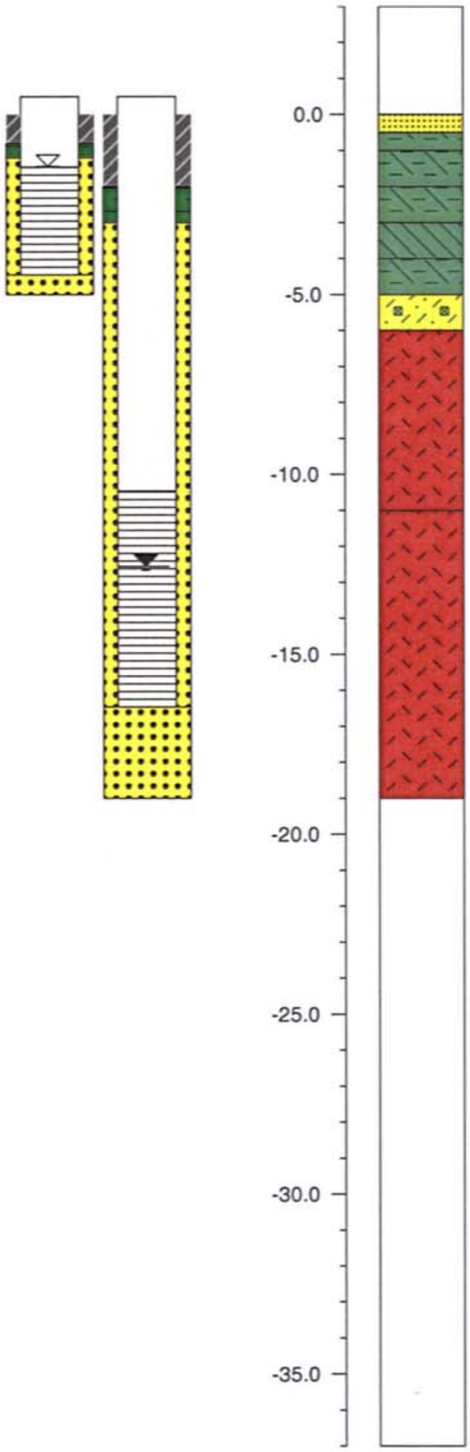
Bentonite Seal

5m End of Shallow Hole

Class 9 uPVC 55mm ID, 60mm OD

Slotted Class 9 uPVC 55mm ID, 60mm OD

19m End of Deep Hole



DESCRIPTION	FORMATION
SAND: Grey, medium grained, sub angular, minor ferruginous gravel	
CLAY AND SAND: White/yellow lateritic nodules, yellow red oxides, loamy	
CLAY AND SAND: Pink brown, medium to well sorted, well cemented red laterite bands, ferrugnous minor pale grey sand clay mottles, loamy	Pallid Clay
CLAY AND SAND: grey green, slightly plastic	
CLAY: Ferruginous, brown-yellow clay, well cemented ferricrete, hard, kaolinite/goethite	
CLAY AND SAND: White grey, dry, angular, medium quartz	
SAPROLITE: Yellow brown, tightly weathered granite, clayey	
GRANITE: White grey, fresh, poorly fractured, dry, minor black mineral (biotite)	
GRANITE: Greenish grey, fresh, hard, minor iron stained, fractured, dry	Bedrock

DRAWN BY: GRB	DATE: 28/09/04	
CHECKED BY:GRB	DATE: 30/09/04	

BORE COMPLETION REPORT

BOREHOLE: BGCM2

URS Australia Pty Ltd — Phone 08 92211630
20 Terrace Rd, East Perth, 6004 — Fax 08 92211639

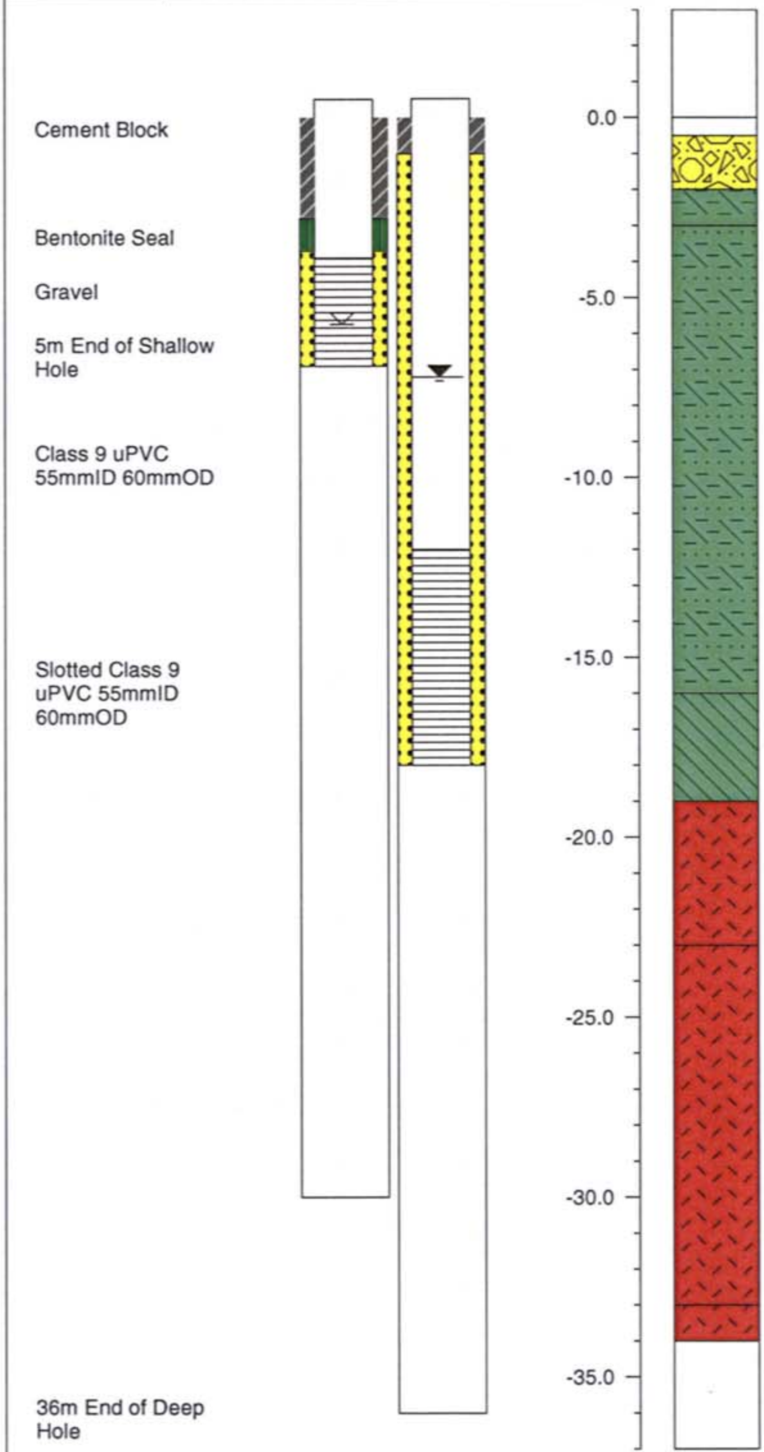
DRILLING CO:	**Orbit Drilling Pty Ltd**
DRILL METHOD:	**Air Hammer, Air Rotary**
PROJECT NAME:	**Voyager Quarry**
PROJECT NUMBER:	**42905484**
CLIENT:	**BGC Quarries**
LOCATION:	**The Lakes, Western Australia**

	BGCM2S	BGCM2D
DATE COMPLETED:	13/05/04	25/05/04
COLLAR HEIGHT:	0.51	0.53
DATE OF MEASUREMENT:	26/05/04	26/05/04
FINAL EC (mS/cm):	NA	NA

	BGCM2S	BGCM2D
COLLAR RL:	300.83	302.64
COORDINATES:	439302.17 6474667.22	439259.41 6474657.65
DATUM:	Top of Collar	Top of Collar
SWL (mbgl):	5.74	7.21

LOGGED BY: **GRB**

BORE CONSTRUCTION	DEPTH (m)	LITHOLOGY	DESCRIPTION	FORMATION



DESCRIPTION	FORMATION
SANDY GRAVEL: Grey sandy quartz, lateritic, gravel nodules, loamy.	
GRAVEL: Ferruginous, yellow brown, hard, well cemented duricrust laterite/ferricrete nodules.	
CLAY AND SAND: Pale yellow to white, medium quartz, mottled kaolinite clay.	Pallid Clay
CLAY AND SAND: White grey medium to coarse quartz, 30% sand, white kaolinite clay.	Pallid Clay
CLAY: Red brown, dark, soft, minor medium sand (10%), hematitic.	Pallid Clay
GRANITE: Weathered, yellow brown to dark red, highly weathered granite, coarse quartz, angular.	Saprolite
GRANITE: Green brown, clayey, soft, moderately weathered feldspar, grains clayey white, yellow iron stained quartz sand.	Saprolite
GRANITE: Green to yellow brown, moderately fractured becoming fresh, hard, iron stained clumps.	Bedrock

DRAWN BY: GRB	DATE: 28/09/04	
CHECKED BY: GRB	DATE: 30/09/04	

BORE COMPLETION REPORT

URS — BOREHOLE: BGCM3

URS Australia Pty Ltd — Phone 08 92211630
20 Terrace Rd, East Perth, 6004 — Fax 08 92211639

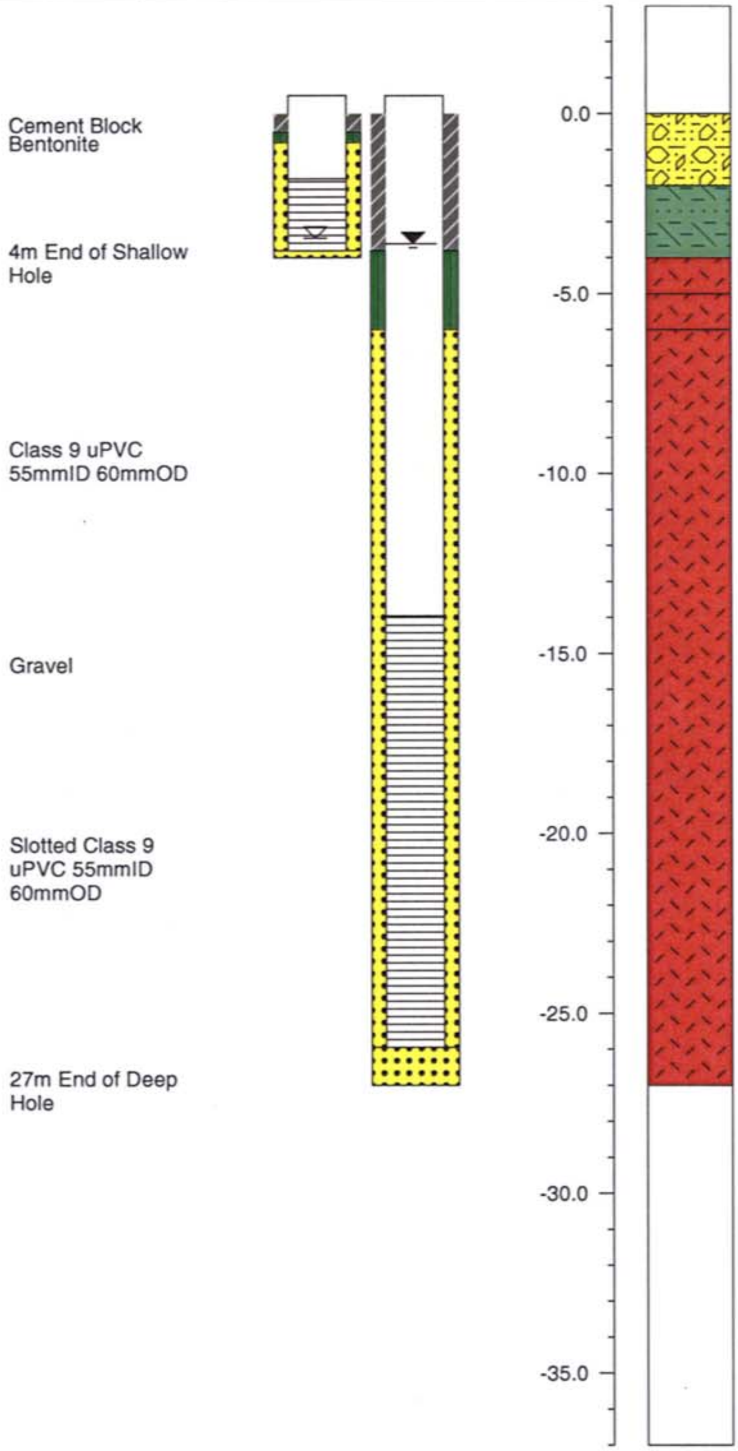
DRILLING CO:	**Orbit Drilling Pty Ltd**
DRILL METHOD:	**Air Hammer, Air Rotary**
PROJECT NAME:	**Voyager Quarry**
PROJECT NUMBER:	**42905484**
CLIENT:	**BGC Quarries**
LOCATION:	**The Lakes, Western Australia**

	BGCM3S	BGCM3D
DATE COMPLETED:	19/05/04	1805/04
COLLAR HEIGHT:	0.51	0.5
DATE OF MEASUREMENT:	26/05/04	26/05/04
FINAL EC (mS/cm):	1.2	NA

	BGCM3S	BGCM3D
COLLAR RL:	282.66	282.75
COORDINATES:	439271.80 6475569.79	439274.06 6475569.48
DATUM:	Top of Collar	Top of Collar
SWL (mbgl):	2.95	3.11

LOGGED BY: **GRB**

BORE CONSTRUCTION	DEPTH (m)	LITHOLOGY	DESCRIPTION	FORMATION



GRAVEL AND SAND: Yellow brown ferricrete gravel in clayey sand, medium grained gravel up to 20mm diameter, moderately hard.

CLAY AND SAND: Pale yellow to brown, medium sand, less clayey.

GRANITE: Weathered, brown, sandy clay to dark yellow brown ferruginous bands, minor nodules of grey clayey granite.

GRANITE: Fresh, grey, hard, iron-fractured, high in black mineral (biotite).

GRANITE: Green-grey, black fresh, hard, very minor fractures, hard, dry.

Bedrock

DRAWN BY: GRB — DATE: 28/09/04

CHECKED BY: GRB — DATE: 30/09/04

BORE COMPLETION REPORT

BOREHOLE: BGCM4

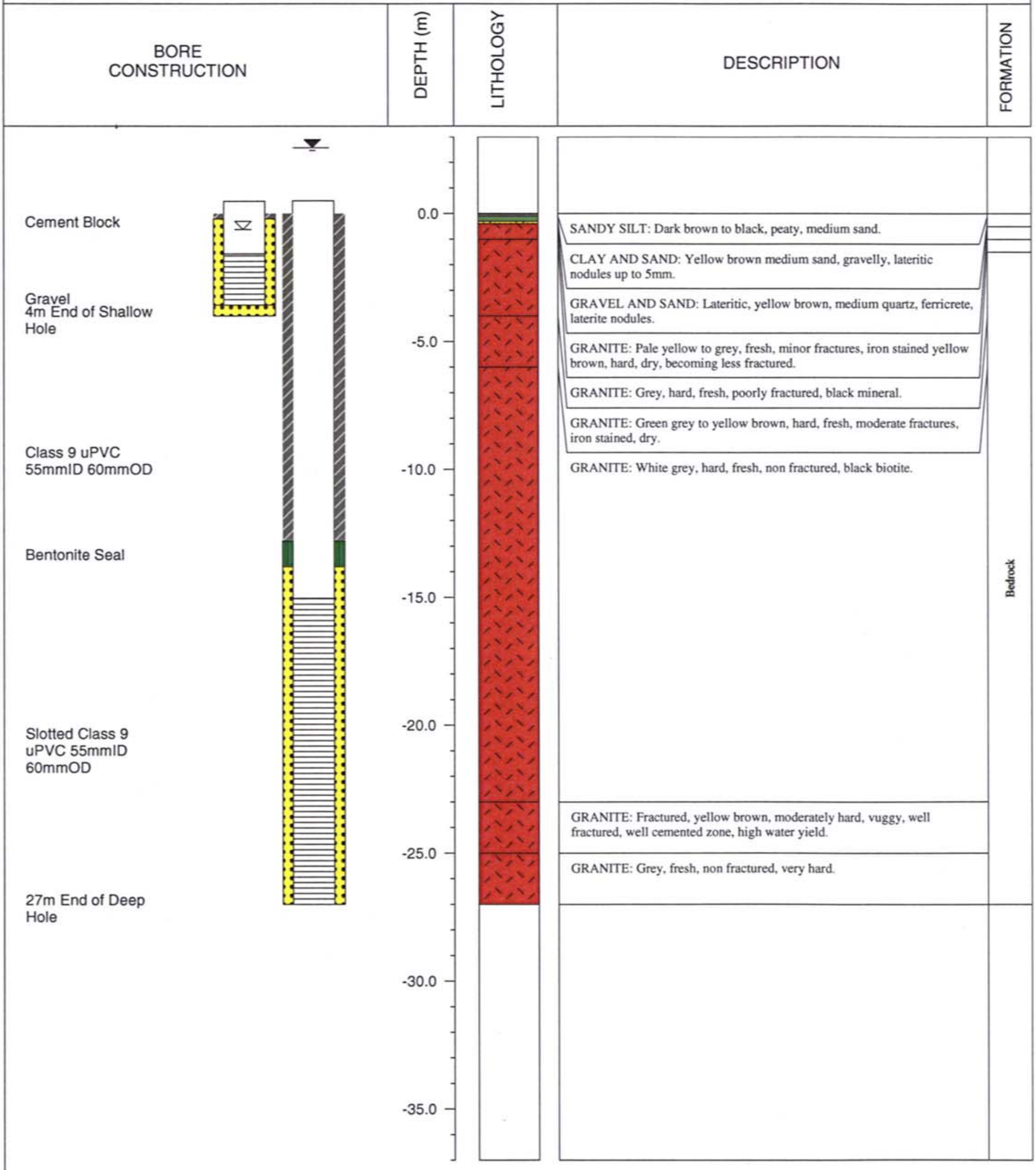
URS Australia Pty Ltd
20 Terrace Rd, East Perth, 6004
Phone 08 92211630
Fax 08 92211639

PROJECT NAME:	Voyager Quarry
PROJECT NUMBER:	42905484
CLIENT:	BGC Quarries
LOCATION:	The Lakes, Western Australia
DRILLING CO:	Orbit Drilling Pty Ltd
DRILL METHOD:	Air Hammer, Air Rotary

	BGCM4S	BGCM4D
DATE COMPLETED:	19/05/04	19/05/04
COLLAR HEIGHT:	0.48	0.5
DATE OF MEASUREMENT:	26/05/04	26/05/04
FINAL EC (mS/cm):	16	16

	BGCM4S	BGCM4D
COLLAR RL:	286.36	286.42
COORDINATES:	439300.64 6475365.47	439303.01 6475366.63
DATUM:	Top of Collar	Top of Collar
SWL (mbgl):	0.62	+2.57

LOGGED BY: GRB



DRAWN BY: GRB	DATE: 28/09/04
CHECKED BY: GRB	DATE: 30/09/04

BORE COMPLETION REPORT

BOREHOLE: BGCM5

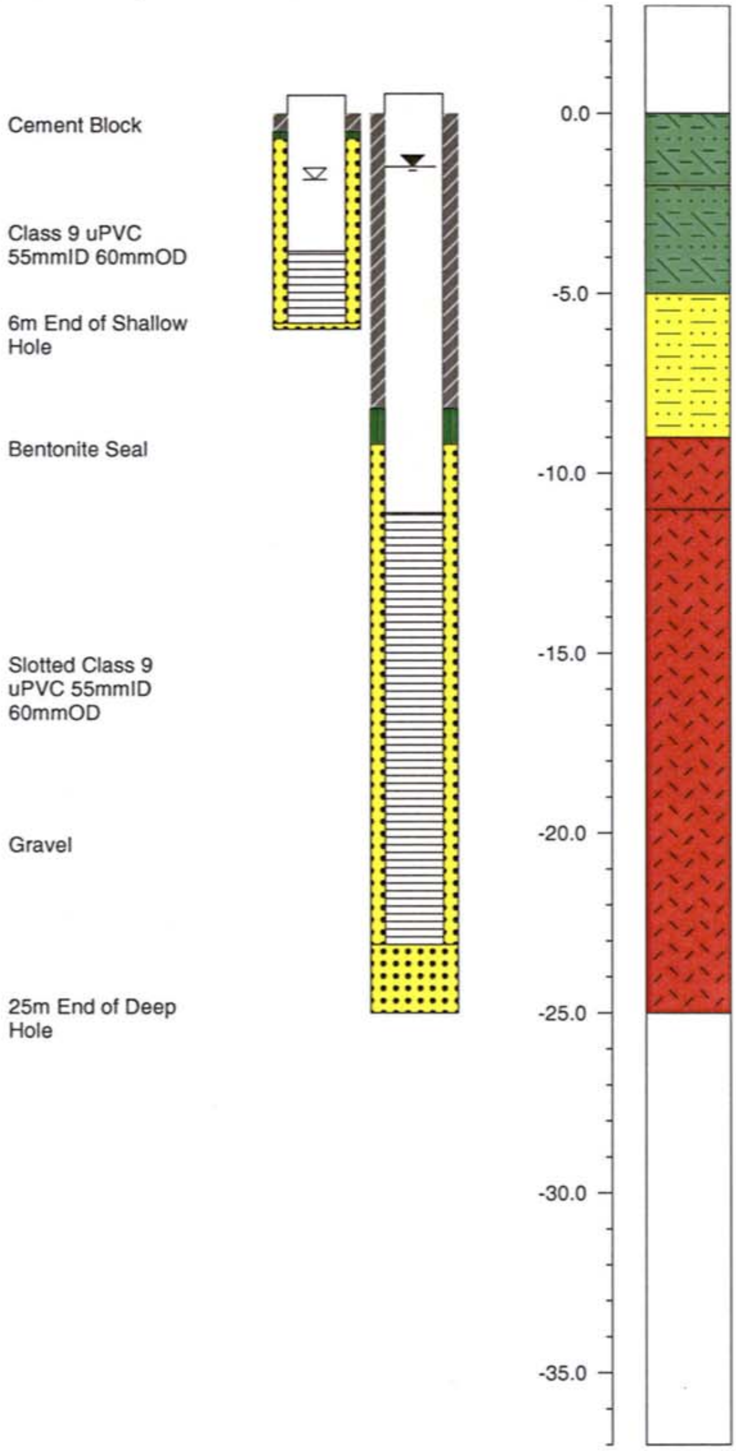
URS Australia Pty Ltd — 20 Terrace Rd, East Perth, 6004 — Phone 08 92211630 — Fax 08 92211639

PROJECT NAME:	**Voyager Quarry**
PROJECT NUMBER:	**42905484**
CLIENT:	**BGC Quarries**
LOCATION:	**The Lakes, Western Australia**
DRILLING CO:	**Orbit Drilling Pty Ltd**
DRILL METHOD:	**Air Hammer, Air Rotary**

	BGCM5S	BGCM5D
DATE COMPLETED:	20/05/04	20/05/04
COLLAR HEIGHT:	0.51	297.98
DATE OF MEASUREMENT:	26/05/04	26/05/04
FINAL EC (mS/cm):	4.1	11

	BGCM5S	BGCM5D
COLLAR RL:	286.36	NA
COORDINATES:	439300.64 6475365.47	439551.14 6474720.59
DATUM:	Top of Collar	Top of Collar
SWL (mbgl):	1.74	1.48

LOGGED BY: **GRB**



DESCRIPTION	FORMATION
CLAY AND SAND: Laterite sandy clay, yellow brown, laterite nodules, minor ferruginous bands.	Pallid Clays
CLAY AND SAND: Pale pink to cream white, soft, dry, minor quartz, sand.	Pallid Clays
CLAYEY SAND: White grey medium to coarse quartz sand, silty kaolinite, white clay.	Pallid Clays
GRANITE: White grey medium quartz, moderate fractures, moderately hard weathered granite.	Bedrock
GRANITE: White grey, very minor fractures, hard, minor yellow iron stained on poor fractures.	Bedrock

DRAWN BY: GRB — DATE: 28/09/04
CHECKED BY: GRB — DATE: 30/09/04

URS | **BORE COMPLETION REPORT** | BOREHOLE: BGCM6

URS Australia Pty Ltd 20 Terrace Rd, East Perth, 6004	Phone 08 92211630 Fax 08 92211639	PROJECT NAME:	**Voyager Quarry**
		PROJECT NUMBER:	**42905484**
DRILLING CO:	**Orbit Drilling Pty Ltd**	CLIENT:	**BGC Quarries**
DRILL METHOD:	**Air Hammer, Air Rotary**	LOCATION:	**The Lakes, Western Australia**

	BGCM6S	BGCM6D
DATE COMPLETED:	25/05/04	24/05/04
COLLAR HEIGHT:	0.6	NA
DATE OF MEASUREMENT:	26/05/04	NA
FINAL EC (mS/cm):	12	NA

BGCM6S		BGCM6D	
COLLAR RL:	295.69	COLLAR RL:	NA
COORDINATES:	439392.92 6474686.81	COORDINATES:	NA NA
DATUM:	Top of Collar	DATUM:	NA
SWL (mbgl):	0.74	SWL (mbgl):	NA

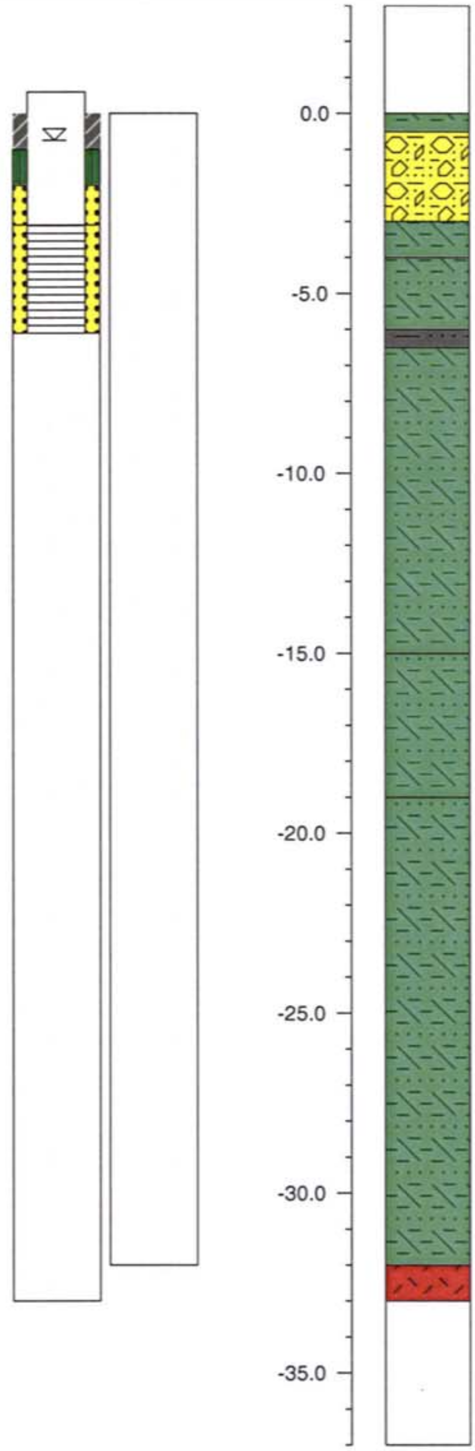
LOGGED BY: **GRB**

BORE CONSTRUCTION	DEPTH (m)	LITHOLOGY	DESCRIPTION	FORMATION

Cement Block
Bentonite
Class 9 uPVC 55mmID 60mmOD
Slotted Class 9 uPVC 55mmID 60mmOD
Gravel

Fallback

33m End of Hole



DESCRIPTION	FORMATION
CLAY AND SAND: Dark brown, medium sandy loam, laterite gravel.	
GRAVEL AND SAND: Yellow brown medium sandy clay, lateritic sand.	
CLAY AND SAND: White to red brown, medium sand, angular, soft, kaolinite.	Pallid Clays
CLAY AND SAND: White, soft, kaolinite, minor red sand.	Pallid Clays
SANDY SILT: Brown to black, peaty, odorous.	Pallid Clays
CLAY AND SAND: White, soft, kaolinitic, minor red coarse sand, becoming more clayey.	Pallid Clays
CLAY AND SAND: Red brown, silty, minor red sand, hematitic, soft.	Pallid Clays
CLAY AND SAND: Green brown, highly weathered granite, clayey, soft, granitic fracture, moderately weathered feldspar grains, yellow iron stained quartz sand.	Saprolite
GRANITE: Fresh, hard, yellow brown iron stained.	

DRAWN BY: GRB	DATE: 28/09/04	
CHECKED BY:GRB	DATE: 30/09/04	Page 1 of 1

Attachment B
Monitoring Bore Water Levels

Lot 14 Monitor Bore Results

	Bore Hole	BGC 1				BGC 2	
		Water Level mBC	Relative Level	Pit Water RL		Water Level mBC	Relative Level
	Level top of collar	314.54				350.23	
		269.21					
Date	20/03/2002	57.58	256.96	264.00		50.00	300.23
	4/04/2002	54.52	260.02	264.00		50.00	300.23
	18/04/2002	54.44	260.10	264.00		50.00	300.23
	28/06/2002	51.70	262.84	265.00		50.55	299.68
	5/07/2002	51.52	263.02	265.00		50.46	299.77
	9/07/2002	51.40	263.14	266.00		50.44	299.79
	12/07/2002	51.33	263.21	266.00		50.42	299.81
	19/07/2002	51.13	263.41	267.00		50.30	299.93
	26/07/2002	50.96	263.58	267.50		49.17	301.06
	2/08/2002	50.79	263.75	268.00		38.94	311.29
	9/08/2002	50.60	263.94	268.50		38.60	311.63
	16/08/2002	50.40	264.14	269.00		36.70	313.53
	23/08/2002	50.25	264.29	269.50		36.60	313.63
	30/08/2002	50.00	264.54	270.00		34.30	315.93
	6/09/2002	49.90	264.64	270.50		29.40	320.83
	13/09/2002	49.70	264.84	271.00		29.10	321.13
	20/09/2002	49.60	264.94	271.00		28.80	321.43
	27/09/2002	49.40	265.14	270.75		28.80	321.43
	4/10/2002	49.25	265.29	270.50		28.80	321.43
	11/10/2002	49.00	265.54	270.25		28.60	321.63
	18/10/2002	48.86	265.68	270.15		28.58	321.65
	25/10/2002	48.60	265.94	270.00		28.60	321.63
	1/11/2002	48.20	266.34	270.00		28.60	321.63
	8/11/2002	48.15	266.39	269.75		28.60	321.63
	15/11/2002	48.10	266.44	269.50		28.60	321.63
	22/11/2002	47.90	266.64	269.25		28.60	321.63
	29/11/2002	47.70	266.84	269.00		28.60	321.63
	6/12/2002	47.40	267.14	268.50		28.60	321.63
	13/12/2002	47.30	267.24	268.50		28.50	321.73
	7/01/2003	46.70	267.84	268.50		28.50	321.73
	17/01/2003	46.30	268.24	268.50		28.50	321.73
	24/01/2003	46.10	268.44	268.00		28.50	321.73
	31/01/2003	45.70	268.84	268.00		28.50	321.73
	7/02/2003	45.90	268.64	267.50		28.50	321.73
	14/02/2003	45.70	268.84	267.00		28.60	321.63
	21/02/2003	45.60	268.94	266.50		28.60	321.63
	28/02/2003	45.30	269.24	265.50		28.50	321.73
	7/03/2003	45.00	269.54	262.00		28.50	321.73
	14/03/2003	44.90	269.64	260.00		28.50	321.73
	21/03/2003	44.80	269.74	258.00		28.50	321.73
	28/03/2003	44.70	269.84	256.00		28.50	321.73
	7/04/2003	44.40	270.14	255.00		28.50	321.73
	14/04/2003	44.20	270.34	253.00		28.50	321.73
	23/04/2003	44.00	270.54	252.00		28.50	321.73
	1/05/2003	43.90	270.64	250.00		28.60	321.63
	9/05/2003	43.60	270.94	250.00	MT	28.60	321.63
	16/05/2003	43.40	271.14	250.00		28.60	321.63
	23/05/2003	43.30	271.24	250.00		28.60	321.63
	30/05/2003	43.10	271.44	250.00		28.50	321.73
	6/06/2003	43.00	271.54	250.00		28.50	321.73
	13/06/2003	42.90	271.64	250.00		28.50	321.73
	20/06/2003	42.80	271.74	250.00		28.50	321.73
	27/06/2003	42.60	271.94	255.00		28.50	321.73
	4/07/2003	42.40	272.14	255.00		2.60	347.63
	11/07/2003	42.30	272.24	260.00		2.60	347.63
	18/07/2003	42.20	272.34	263.00		2.60	347.63
	25/07/2003	42.10	272.44	265.00		2.50	347.73
	1/08/2003	41.90	272.64	266.00		2.50	347.73

8/08/2003	41.70	272.84	267.00		2.50	347.73
15/08/2003	41.70	272.84	267.50		2.50	347.73
22/08/2003	41.60	272.94	268.00		2.60	347.63
29/08/2003	41.40	273.14	268.00		2.70	347.53
05/09/2003	41.30	273.24	268.50		2.80	347.43
12/09/2003	41.15	273.39	268.50		2.80	347.43
19/09/2003	41.00	273.54	268.50		2.80	347.43
26/09/2003	40.90	273.64	268.50		2.80	347.43
03/10/2003	40.80	273.74	268.00		2.80	347.43
10/10/2003	40.70	273.84	266.50		2.90	347.33
17/10/2003	40.60	273.94	265.00		3.10	347.13
24/10/2003	40.50	274.04	262.00		3.20	347.03
31/10/2003	40.40	274.14	261.00		3.30	346.93
07/11/2003	40.30	274.24	260.00		3.40	346.83
14/11/2003	40.20	274.34	258.00		3.50	346.73
21/11/2003	40.15	274.39	257.00		3.60	346.63
28/11/2003	40.10	274.44	257.00		3.70	346.53
5/12/2003	40.00	274.54	256.00		3.80	346.43
12/12/2003	39.90	274.64	255.00		3.80	346.43
19/12/2003	39.80	274.74	254.00		3.80	346.43
26/12/2003	39.70	274.84	253.00		3.80	346.43
2/01/2004	39.60	274.94	252.00		3.90	346.33
9/01/2004	39.50	275.04	251.00		3.90	346.33
16/01/2004	39.40	275.14	250.00	MT	3.90	346.33
23/01/2004	39.30	275.24	250.00		3.90	346.33
30/01/2004	39.20	275.34	250.00		4.60	345.63
6/02/2004	39.10	275.44	250.00		4.70	345.53
13/02/2004	39.00	275.54	250.00		4.80	345.43
20/02/2004	39.00	275.54	250.00		4.90	345.33
27/02/2004	38.90	275.64	250.00		5.00	345.23
5/03/2004	38.80	275.74	250.00		5.10	345.13
12/03/2004	38.70	275.84	250.00		5.20	345.03
19/03/2004	38.70	275.84	250.00		5.30	344.93
26/03/2004	38.60	275.94	251.00		5.40	344.83
13/04/2004	38.40	276.14	250.00		5.60	344.63
23/04/2004	38.30	276.24	250.00		5.70	344.53
30/04/2004	38.20	276.34	250.00		5.90	344.33
7/05/2004	38.10	276.44	250.00		5.90	344.33
14/05/2004	38.00	276.54	250.00		6.00	344.23
21/05/2004	37.90	276.64	250.00		6.10	344.13
28/05/2004	42.70	271.84	250.00		11.40	338.83
4/06/2004	42.51	272.03	250.00		11.30	338.93
11/06/2004	42.25	272.29	250.00		11.47	338.76
18/06/2004	42.50	272.04	251.00		11.42	338.81
28/06/2004	41.91	272.63	252.00		11.50	338.73
9/07/2004	41.58	272.96	252.00		11.47	338.76
16/07/2004	41.47	273.07	252.50		11.30	338.93
23/07/2004	41.50	273.04	253.00		11.20	339.03
30/07/2004	41.25	273.29	253.50		11.10	339.13
6/08/2004	41.02	273.52	254.00		11.05	339.18
12/08/2004	40.05	274.49	254.50		11.00	339.23
25/08/2004	40.70	273.84	255.00		9.00	341.23
30/08/2004	40.67	273.87	255.00		2.45	347.78
3/09/2004	40.60	273.94	255.00		2.50	347.73
10/09/2004	40.50	274.04	255.00		2.67	347.56
17/09/2004	40.40	274.14	255.00		2.70	347.53
28/09/2004	40.88	273.66	255.00		2.80	347.43
11/10/2004	40.13	274.41	255.00		3.14	347.09
18/10/2004	40.00	274.54			3.26	346.97
22/10/2004	39.80	274.74			3.18	347.05
29/10/2004	39.86	274.68			3.68	346.55
5/11/2004	39.78	274.76			3.57	346.66
12/11/2004	39.90	274.64			3.40	346.83
19/11/2004	39.60	274.94			3.76	346.47
26/11/2004	39.56	274.98			3.80	346.43
3/11/2004	39.51	275.03			3.95	346.28

URS Bore Levels - Bennett Lease

	Bore Identification & Depth Measurement - Linear Metres												
Date	**M1S**	**M1D**	**M2S**	**M2D**	**M3S**	**M3D**	**M4S**	**M4D**	**M5S**	**M5D**	**M6S**	**BGC1**	**BGC2**
28.6.04	1.20	Surface	5.80	7.49	2.40	2.35	0.60	O/Flow	1.86	1.55	1.26	41.50	11.20
9.7.04	1.10	O/Flow	5.40	7.10	1.75	1.82	0.60	O/Flow	1.70	1.50	1.40	41.25	11.10
26.7.04	1.20	Surface	5.70	6.64	1.87	1.90	0.70	O/Flow	1.50	1.20	1.34	41.47	11.50
6.8.04	1.06	Surface	5.20	6.70	1.81	1.88	0.57	O/Flow	1.50	1.20	1.15	41.02	11.45
12.8.05												40.05	11.00
25.8.04	1.00	Surface	4.40	5.95	1.75	1.82	0.50	Surface	1.70	1.00	1.00	40.70	9.00
30.8.04												40.67	2.45
3.09.04	1.14	Surface	3.33	4.52	1.62	1.67	0.56	Surface	1.00	0.70	0.90	40.60	2.50
10.9.04												40.50	2.67
17.9.04	1.16	Surface	3.42	4.67	1.86	1.90	0.70	Surface	1.30	1.00	0.82	40.40	2.70
28.9.04												40.88	2.80
18.10.04	1.30	Surface	4.40	5.66	2.42	2.43	0.98	Surface	1.70	0.77	0.86	40.00	3.26
22.10.04												39.80	3.18
29.10.04	1.42	Surface	4.73	5.98	2.63	2.65	1.05	Surface	1.80	0.86	0.96	39.86	3.68
5.11.04												39.78	3.57
12.11.04	1.46	Surface	4.81	5.91	2.69	2.68	1.10	Surface	1.87	0.91	1.00	39.90	3.40
19.11.04												39.60	3.76
26.11.04	1.54	Surface	5.01	6.40	3.10	3.06	0.90	Surface	1.37	1.01	1.01	39.56	3.80
verage Dept	1.23455	#DIV/0!	4.74527	6.0927273	2.1727273	2.196364	0.7509091	#DIV/0!	1.5729091	1.0631818	1.0632727		
Deviation	0.17415	#DIV/0!	0.8204	0.9209244	0.4932766	0.458242	0.2165389	#DIV/0!	0.2688737	0.2755383	0.1962901		

Author: Carlson Daniels

19/04/2005

Attachment C
Groundwater Analyses

SGS

REG No. 162004-703				
DATE 2-7-04				
NAME	INFO	ACTION	Complete (Sign)	DATE
John Barnett				

LABORATORY REPORT COVERSHEET

DATE: 30 June 2004

TO: URS Corporation

Level 3, The Hyatt Centre
20 Terrace Road

EAST PERTH WA 6004

ATTENTION: Mr John Barnett

YOUR REFERENCE: 50846-009-1002

OUR REFERENCE: 81229

SAMPLES RECEIVED: 26/05/04

SAMPLES/QUANTITY: 13 Waters

The above samples were received intact and analysed according to your written instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

NATA Accredited Laboratory
Number: 2562(1705)

NATA ENDORSED TEST REPORT
This document shall not be reproduced, except in full.

JANICE VENNING
Manager, Perth

LIEN TANG
Manager Reporting Systems

This report supersedes our preliminary results that were reported by facsimile.
This report must not be reproduced except in full.

SGS Australia Pty Ltd ABN 44 000 964 278 | Environmental Services t +61 (0)8 9458 7278 | 52 Murray Road f +61 (0)8 9451 3505 | Welshpool 6106 | Western Australia | www.au.sgs.com

Member of the SGS Group

CLIENT: URS Corporation
PROJECT: 50846-009-1002

OUR REFERENCE: 81229

LABORATORY REPORT

		BGC 1	M3D	BGC 2	M6S	M1S
Your Reference Our Reference	Units	GW 001 _25/ 05/04 81229-1	GW 002 _25/ 05/04 81229-2	GW 003 _25/ 05/04 81229-3	GW 004 _25/ 05/04 81229-4	GW 005 _25/ 05/04 81229-5
pH	pH Units	7.5	7.3	7.7	4.8	5.7
Electrical Conductivity @ 25 oC	μS/cm	5600	2100	240	12000	16000
Total Dissolved Solids (grav) @ 180°C	mg/L	3500	1100	140	6700	9600

		M4D	M4S	M5S	M5D	M1D
Your Reference Our Reference	Units	GW 006 _25/ 05/04 81229-6	GW 007 _25/ 05/04 81229-7	GW 008 _25/ 05/04 81229-8	GW 009 _25/ 05/04 81229-9	GW 010 _25/ 05/04 81229-10
pH	pH Units	5.4	6.6	5.1	6.8	5.7(5.7)
Electrical Conductivity @ 25 oC	μS/cm	16000	16000	4100	11000	13000
Total Dissolved Solids (grav) @ 180°C	mg/L	9500	8900	2200(2400)	6200	7300

		BLANK (DISTILLED)	M3S	M2S
Your Reference Our Reference	Units	GW 011 _25/ 05/04 81229-11	GW 012 _25/ 05/04 81229-12	GW 013 _25/ 05/04 81229-13
pH	pH Units	7.3	4.4	4.9
Electrical Conductivity @ 25 oC	μS/cm	11	1700	8600(8600)
Total Dissolved Solids (grav) @ 180°C	mg/L	<10*	1400	4700

CLIENT: URS Corporation

PROJECT: 50846-009-1002

OUR REFERENCE: 81229

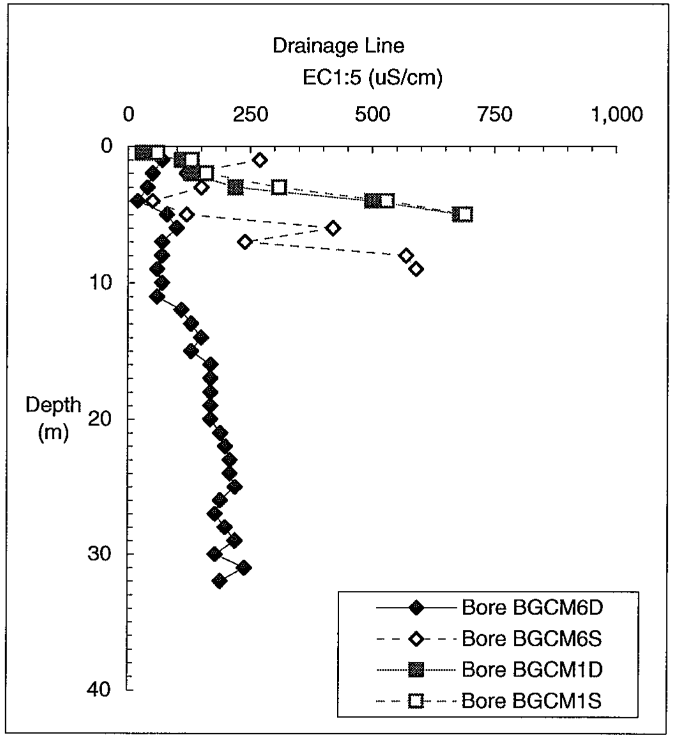
LABORATORY REPORT

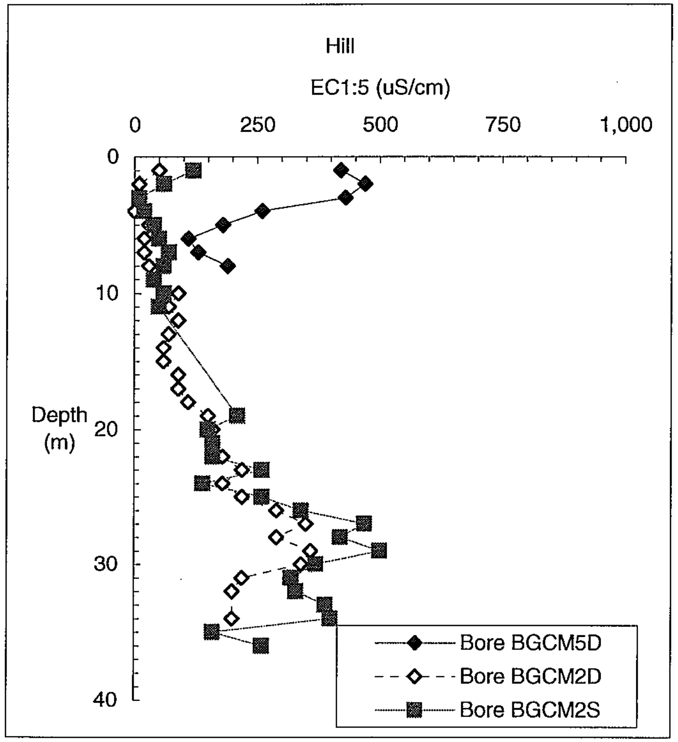
TEST PARAMETERS	UNITS	LOR	METHOD
--------			
pH	pH Units	0.1	PEI-001
Electrical Conductivity @ 25°C	μS/cm	1	PEI-032
Total Dissolved Solids (grav) @ 180°C	mg/L	10	PEI-002

NOTES:
LOR - Limit of Reporting.
Bracketed results are from duplicate analysis.
*Calculated TDS.

Attachment D
Field Soil Salinity Measurements

BGC Voyager - PER responses
R Connolly
26/10/2004
Evaluation of soil salinity
Recorded by G Brophy while drilling piezo's. 1 part rock plus 5 parts water, shaken by hand for 2 min, meas with TDS20 pocket EC meter





Attachment E
Soil Analyses

SGS

LABORATORY REPORT COVERSHEET

DATE:	22 June 2004
TO:	URS Corporation Level 3, The Hyatt Centre 20 Terrace Road EAST PERTH WA 6004
ATTENTION:	Mr John Barnett
YOUR REFERENCE:	50846-009-1002
OUR REFERENCE:	81230
SAMPLES RECEIVED:	26/05/04
SAMPLES/QUANTITY:	6 Soils

The above samples were received intact and analysed according to your written instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

JANICE VENNING
Manager, Perth

LIEN TANG
Manager Reporting Systems

This report supersedes preliminary results that were reported by E-Mail.
This report must not be reproduced except in full.

SGS Australia Pty Ltd ABN 44 000 964 278 | Environmental Services t +61 (0)8 9458 7278 | 52 Murray Road f +61 (0)8 9451 3505 | Welshpool 6106 | Western Australia | www.au.sgs.com

Member of the SGS Group

SGS

CLIENT: URS Corporation

PROJECT: 50846-009-1002

OUR REFERENCE: 81230

LABORATORY REPORT

		1-2m	2-3m	11-12m	17-18m	22-23m
Your Reference	Units	SS001_21/05/04	SS002_21/05/04	SS003_21/05/04	SS004_21/05/04	SS005_21/05/04
Our Reference		81230-1	81230-2	81230-3	81230-4	81230-5
Date Sampled		21/05/2004	21/05/2004	21/05/2004	21/05/2004	21/05/2004
Type of Sample		Soil	Soil	Soil	Soil	Soil
Electrical Conductivity @ 25 oC (1:5)	μS/cm	17	14	16	29	45
Total Soluble Salts(Calc)	mg/kg	61	53	64	120	180

		25-26m
Your Reference	Units	SS006_21/05/04
Our Reference		81230-6
Date Sampled		21/05/2004
Type of Sample		Soil
Electrical Conductivity @ 25 oC (1:5)	μS/cm	110
Total Soluble Salts(Calc)	mg/kg	440

TEST PARAMETERS	UNITS	LOR	METHOD

Electrical Conductivity @ 25°C (1:5)	μS/cm	5	PEI-032
Total Soluble Salts(Calc)	mg/kg	25	PEI-032

CLIENT: URS Corporation

PROJECT: 50846-009-1002

OUR REFERENCE: 81230

LABORATORY REPORT

QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate
Electrical Conductivity @ 25°C (1:5)	μS/cm	<5	81230-1	17 || 17 || RPD: 0
Total Soluble Salts(Calc)	mg/kg	<25	81230-1	61 || 60 || RPD: 2

NOTES:

LOR - Limit of Reporting.

Electrical Conductivity was determined from a 1:5 as received sample to deionised water extract with results reported on the extract basis. Total Soluble Salts was calculated from the Conductivity with results reported back to the dry weight basis.

Attachment F
Groundwater Management Plan

Proposed Relocation of the Voyager Quarry

Groundwater Management Plan

Management Tools	Responsibility for Implementation and Management	Action	Monitoring and Internal Audits
Planning Phase			
Installation of additional monitor bores at two sites	Quarry General Manager, Quarry Operations Manager	Construction of paired monitor bores at two sites on fracture lineaments to west of proposed quarry site. One bore at each site to be slotted against base of weathering profile, one bore at water table.	Produce baseline report on results of drilling and construction.
Groundwater Monitoring Programme	Quarry General Manager, Quarry Operations Manager	Weekly monitoring of groundwater-levels in Bores MB Nos 1S, 1D, 2S, 2D, 3S, 3D, 4S, 4D, 5S, 5D, 6S, BG1, BGC2 and two planned additional monitoring sites. Annual water sampling from each monitor bore, and from pit sump; analysis for pH, EC, TDS. Record any groundwater abstraction from the pit.	Audit the data management system and review the results. Regulatory reporting of results will occur in accordance with site licence conditions. Reports will be distributed to the relevant government bodies, however the results will be available to the public on request.
Construction and Operational Phases			
Complaints Register	Quarry Operations Manager	Record all complaints regarding groundwater received directly from residents or via councils. Details to be recorded are: • Complainant; • Address of complainant; • Time of complaint; and • Nature of complaint.	Audit implementation of the complaints response procedure.
Groundwater Monitoring Programme	Quarry General Manager, Quarry Operations Manager	Continue groundwater monitoring programme in accordance with licence conditions	As for planning phase.

Appendix D

Preliminary Closure Plan – Voyager Quarry Relocation

DRAFT REPORT

Preliminary Closure Plan - Relocated Voyager Quarry

Prepared for

BGC (Australia) Pty Ltd

Lot 4 Stirling Crescent
HAZELMERE WA 6055

28 October 2004

42905483/582-F6477.0

URS

Project Manager:	…………………………………..	URS Australia Pty Ltd
	Karen Ariyaratnam	Level 3, The Hyatt Centre
	Project Environmental Scientist	20 Terrace Road
		East Perth, WA 6004 Australia
		Tel: 61 8 9221 1630
Project Director:	…………………………………..	Fax: 61 8 9221 1639
	Ian LeProvost	
	Senior Principal, Environment	

Date:	28 October 2004
Reference:	582-F6477.0
Status:	Draft

Contents

Contents

List of Tables, Figures, Plates & Appendices

Tables

Diagrams

Figures

1.1 Accountability for Closure

1.1.1 Plan Approval

This Preliminary Closure Plan has been prepared for the proposed Voyager Quarry site, which is planned to be located on Lot 14, Horton Road, The Lakes. This plan has been approved by:

______________________________ **Date:** ____________________

Frank Italiano
General Manager - BGC Asphalt and Quarries

1.1.2 Financial and Management Responsibility

BGC (Australia) Pty Ltd (BGC) is committed to ensuring that there is clear accountability and adequate resources, for the implementation of this Preliminary Closure Plan. Responsibility for managing the technical and financial implementation of this Plan is outlined below.

Table 1.1

Roles and Responsibilities of the Voyager Quarry Closure Team

Position	Description of Role
General Manager	• Advise on preliminary closure planning and review process for the Voyager Quarry • Lead Preliminary Closure Plan development and review process • Develop and review Preliminary Closure Plan and implementation management
Quarry Manager	• Develop and review Preliminary Closure Plan and implementation management • Implement rehabilitation portion of Preliminary Closure Plan • Oversee rehabilitation activities

1.1.3 Ownership

BGC's proposed Voyager Quarry is located on Lot 14 Horton Road, approximately 47 km southwest of the town of Northam and 20 km east of the town of Mundaring, Western Australia (Figure 1.1). BGC owns Lot 14.

1.2 Context

BGC currently operates the Voyager Quarry located on Lot 7 Great Southern Highway, approximately 47 km southwest of Northam and approximately 20 km east of Mundaring. This quarry has been operating since 1990 to provide crushed granite for the manufacture of concrete, road base and other building products.

As BGC are currently proposing to relocate the Voyager Quarry to Lot 14 Horton Road, it was determined that a Preliminary Closure Plan was required. This Preliminary Closure Plan is the first stage of the closure planning process and should be viewed as a working document.

1.3 Purpose and Structure of this Plan

1.3.1 Objective of this Plan

The Australian and New Zealand Minerals and Energy Council (ANZMEC) 2000 guidelines for mine closure suggests that planning for closure should be undertaken during the design of the mine (quarry). Therefore, this Preliminary Closure Plan has been developed at this stage of the process.

The objective of the plan is to provide a framework for closure planning for the proposed relocation of the Voyager Quarry and to identify issues that need to be addressed as the closure planning continues.

1.3.2 Status of this Plan

This plan is a working draft of the Preliminary Closure Plan. It has been produced for discussion purposes during the Response to Submissions process for the environmental assessment of the Proposed Relocation of the Voyager Quarry.

1.3.3 Structure of this Plan

This report is structured as follows:

Section 1	Introduction	Identifies the Preliminary Closure Plan structure, BGC management and financial accountability for the development and implementation of the plan, defines the ownership of the Project Area and establishes the context within which the closure will be effected.

Section 2	Project Description	Provides a description of the relocated Voyager Quarry, including details on land tenure, site history and environmental characteristics.
Section 3	Legal and Other Requirements	Summarises the key legislative, company and other requirements relevant to the closure of the relocated Voyager Quarry.
Section 4	Stakeholder Consultation	Identifies the Government departments, landowners and other parties that should be consulted as part of the conceptual closure planning process for the relocated Voyager Quarry.
Section 5	Closure Issues	Summarises the key closure issues identified during the preparation of this Preliminary Closure Plan.
Section 6	Closure Action Plan	Describes the preliminary closure objectives for the site and identifies the actions that will contribute to site closure during the operational phase of the site (rehabilitation) and closure of the site (decommissioning).
Section 7	Documentation	Identifies the environmental documentation required in relation to the different stages of planning for, and implementing, site closure. Allocates accountability for reviewing and approving this Preliminary Closure Plan.
Section 8	References	Lists the references cited in this report.

1.3.4 Development of this Plan

This Preliminary Closure Plan was prepared by URS in accordance with Proposal No. 03-210 (Revision 4) dated 4 December 2003.

Principally, the development of the plan involved the following tasks:

- A review of the environmental setting at the existing Voyager Quarry site.
- Identification of significant closure issues based on existing available information.
- Identification of significant knowledge gaps associated with the Preliminary Closure Plan.
- Rehabilitation and decommissioning planning.

2.1 Facility Description

This Preliminary Closure Plan covers the following components of the relocated Voyager Quarry:

- quarry pit
- primary crusher
- secondary crusher
- tertiary crusher
- screens 1
- screens 2
- screens 3
- screens 4
- product stockpiles
- water storage dam
- administration buildings and workshop
- support infrastructure (roads, power and communications).

The layout of the proposed Voyager Quarry operations is presented as Figure 2.1.

2.2 Land Tenure

The proposed Voyager Quarry is located on Lot 14 Horton Road, which is owned by BGC. Lot 14 is located within the Shire of Northam and adjacent to the Shire of Mundaring (Figure 2.2). The zoning classification for Lot 14 is Rural Zone 3. The Rural Zone 3 classification means that Council will not support further subdivision of the land, except where this may by necessary for the protection of the natural and rural environment or the acquisition of additional reserves.

2.3 Site History

Lots 11 and 14 are remnant bushland within the Shires of Mundaring and Northam, respectively. Logging had consistently been undertaken on these properties in the past prior to BGC acquiring this land.

2.4 Existing Environmental Characteristics

2.4.1 Landforms and Soils

The proposed site for the Voyager Quarry relocation 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 proposed site. The Archaean 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, 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)
- 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 at the proposed site for the Voyager Quarry are typical of the ‘lateritic uplands’, with a small portion on the eastern section of the proposed site located in a ‘minor valley’.

The land units within the proposed site are listed below (Churchward and McArthur, 1980; King and Wells, 1990):

- **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 proposed site include Goonaping and Murray. Goonaping is located south-east of the proposed site. 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 proposed site. The Murray land unit comprises of deeply incised valleys, which have red and yellow soils on the slopes (Churchward and McArthur, 1980).

2.4.2 Surface Hydrology

The proposed quarry relocation site is located near the top of the local catchment divide. 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 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.

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.

There are several obvious areas of salinisation in the pasture land downstream of the existing quarry site (URS, 2002). 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.

2.4.3 Groundwater Hydrology

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 kL/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
- 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.

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 licence is therefore not required to extract groundwater in this area.

2.4.4 Vegetation and Flora

Vegetation

A vegetation survey of the proposed quarry relocation site was conducted in January 2002 by Mattiske Consulting Pty Ltd.

In total, 11 site-vegetation types were defined and mapped for the survey area. These plant communities are described in Table 2.1. All of these site-vegetation types 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 within the proposed relocation site is presented in Table 2.1.

Flora

Two flora surveys were conducted at the proposed quarry relocation site 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.

No Declared Rare Flora (DRF) species gazetted under the *Wildlife Conservation Act* 1950 were recorded 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 *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) was recorded at the site. This species, *Hemigenia viscida,* was recorded in four of the 17 areas of heath present in the Project Area (Mattiske Consulting Pty Ltd, 2002). Almost 95% of *Hemigenia viscida* plants within Lots 11 and 14, Horton Road, (1,612 plants) were recorded in one heath community (H5).

A survey to identify other locations or potential locations for *Hemigenia viscida* populations beyond the immediate site was conducted by Mattiske Consulting Pty Ltd in February 2002. 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 Shire of Mundaring land to the west of Horton Road, and south of a Shire of Mundaring 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.

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).

Table 2.1

Local and Regional Significance of Vegetation Types in the Project Area

Code	Vegetation Type	Known Occurrence	
		Locally (Proposed Site 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 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 at the proposed site 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 at the proposed site 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 at the proposed site 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 at the proposed site 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 at the proposed site and surrounds.	Not restricted. Occurs in conservation areas, both within the eastern and northern parts of the Jarrah forest.

Table 2.1 (continued)

Code	Vegetation Type	Known Occurrence	
		Locally (Proposed Site 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 at the proposed site 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 at the proposed site 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 at the proposed site 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 at the proposed site 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 site. *Hemigenia viscida* (Priority 4 species) occurs in this vegetation type at the proposed site.	Restricted in distribution within the northern Jarrah forest, but is well represented in conservation estates (e.g. near Mt Cooke and Mt Windsor).

Dieback

A field survey was conducted by Glevan Dieback Consultancy Services in December 2001 to assess the presence of *Phytophthora* spp. at the proposed site. *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). It is important to note that the *Phytophthora cinnamomi* infested area is not within the operational area.

2.4.5 Fauna

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. 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 site location. 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 1950*).
- Baudin's Black Cockatoo, *Calyptorhynchus baudinii* (which is listed as Vulnerable under the EPBC Act and as Threatened under the State *Wildlife Conservation Act 1950*).
- the Chuditch, *Dasyurus geoffroii* (which is listed as Vulnerable under the EPBC Act and as Threatened under the State *Wildlife Conservation Act 1950*).
- 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.

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 and 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. However, 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 that offer appropriate nest hollows for cockatoos 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.

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).

2.4.6 Social Environment

The proposed quarry site is located within the Shire of Northam, which is adjacent to the Shire of Mundaring, Shire of Toodyay, Shire of Goomalling, Shire of Cunderdin and Shire of York. The Shire of Northam covers an area of 1,400 km^2 and had a population of 3,500 in 2001-2002.

The nearest residence to the proposed quarry site 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.

2.5 Post-Operation Environment

2.5.1 Built Environment

At the time of site closure for the relocated Voyager Quarry, it is assumed that all buildings and infrastructure will be decommissioned and removed from the site. The decommissioning and rehabilitation activities for the relocated quarry would involve the following:

- Decommissioning the primary, secondary and tertiary crushers. These components of the plant will be sold or salvaged as scrap material.
- Decommissioning and selling the screens.
- Removing the offices, workshops and weighbridge.
- Removing any stockpiled material.
- Capping and plugging monitoring bores.
- Rehabilitating any roads that are not required for the future land use.
- Monitoring the progress of surface rehabilitation against completion criteria.

2.5.2 Landform and Soils

Following the completion of the quarrying activities at the relocated Voyager Quarry, the landform would be altered. The main change in the landform would be the presence of a quarry void, instead of the original granite outcrop. The void will be approximately 900 m long, 450 m wide and 50 m deep. Based on the drilling results within the proposed pit area, it is expected that the top 18 m is fractured. This is associated with the saprolitic zone of the weathered granite profile. Due to the presence of this zone, there is potential for some surface slumping or slippage at the edge of the open pit, if the pit is not backfilled. If the pit is not backfilled, a geotechnical study needs to be undertaken prior to closure to assess the risk of slumping of the pit edge. Abandonment bunds will also need to be constructed at a nominated distance based on the results of the geotechnical study.

At the completion of the operations at the relocated quarry, the only created landforms will be abandonment bunds if the pit is not going to be backfilled, as all stockpiles will be removed and the stockpile areas will be rehabilitated with native vegetation.

2.5.3 Surface Hydrology

The cessation of the proposed quarry will result in a return of the streamflows and water quality to levels experienced prior to the development of the existing and relocated Voyager quarries. The operation of the relocated quarry will increase the streamflow in the local catchment because of the controlled discharge of water from the quarry. The operation of the relocated Voyager Quarry will also decrease the downstream salinity of the water in the local catchment, as the discharged water will have much lower salt concentration than the existing streamflow. Therefore, the closure of the relocated quarry will reduce the streamflow and increase salinity of watercourses downstream of the quarry.

2.5.4 Groundwater Hydrology

The groundwater levels within the local area are expected to return to levels prior to the development of the existing and relocated Voyager quarries. As both of the quarry operations require the dewatering of groundwater to allow quarrying activities to be conducted below the water table, this results in the lowering of groundwater levels immediately adjacent to the quarry.

The quality of the groundwater will not be affected by the closure of the proposed quarry.

If the pit void is left empty, seepage would flow into the pit, however if runoff is directed away from the pit, the seepage and direct rainfall collected within the pit will evaporate and a permanent water body will not form in the void.

2.5.5 Vegetation and Flora

Rehabilitation will be conducted for any surface disturbances, such as roads that are not required for the future land use and stockpile areas. These areas will be rehabilitated with native vegetation.

2.5.6 Fauna

Potential risks to the fauna caused by the closure of the quarrying operations will be addressed. For example, the monitoring bores will be plugged and capped to ensure that fauna do not become trapped and perish in these structures. Access to the pit void will be fenced to prevent fauna from entering the pit.

2.5.7 Social Environment

The closure of the proposed Voyager Quarry will result in a decrease in financial support for local businesses and the social environment will return to the pre-quarrying scenario.

3.1 Overview

The required framework for the closure of the relocated Voyager Quarry site is provided by:

- BGC policies, guidelines and procedures
- legislation
- environmental commitments made in the Public Environmental Review (PER)
- government and industry guidelines.

These requirements are discussed in Sections 3.2 - 3.5.

3.2 BGC Policies, Guidelines and Procedures

The framework for the closure of the relocated Voyager Quarry is defined in the following documents:

- BGC Contracting – Environment Policy
- BGC – Environmental Management System.

These document BGC's commitment to managing its activities in an environmentally responsible manner.

3.3 Legislation

Legislation relevant to the closure of the relocated Voyager Quarry site include:

- *Environmental Protection Act 1986*
- *Mining Act 1978*
- *Mines Safety and Inspection Act 1994*
- *Soil and Land Conservation Act 1945*
- *Rights in Water and Irrigation Act 1914*
- *Contaminated Sites Act 2003.*

The Department of Environment (DoE) and the Department of Industry and Resources (DoIR) would be the primary regulatory authorities responsible for overseeing the closure of the proposed Voyager Quarry.

3.4 Environmental Commitments

The commitments made in the 2003 PER relevant to the decommissioning, rehabilitation and closure of the relocated Voyager Quarry are presented in Table 3.1. There may be additional commitments issued by the Minister of the Environment, should approval of the proposed project be obtained. Any Ministerial Conditions relating to the decommissioning, rehabilitation and closure of the relocated Voyager Quarry should be added to the revised version of this closure plan.

Table 3.1

Environmental Commitments for the Closure of the Relocated Voyager Quarry

Topic	Commitment	Reference
Closure planning	Prior to the 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).	Section 3.8.3, PER (URS, 2003).
	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.	Section 7.2.3, PER (URS, 2003).

3.5 Government and Industry Guidelines

In addition to legislative regulation, Western Australian and Commonwealth government departments have issued, or contributed to, a number of guidelines to reflect the statutory requirements of current legislation and the expectation of government regulators. Organisations consisting of mining industry representatives have also been proactive in developing guidelines for the closure of mining operations.

This Preliminary Closure Plan was developed with reference to the following government and industry guidelines:

- Strategic Framework for Mine Closure (ANZMEC/MCA, 2000).
- Mine Closure Guideline for Minerals Operations in Western Australia (Chamber of Minerals and Energy of Western Australia, 1999).

- The Commonwealth Environmental Protection Agency Series 'Best Practice Environmental Management in Mining' (1995).

4.1 Identification of Key Stakeholders

According to the ANZMEC/MCA (2000), "stakeholders [in the mine closure process] are those parties with the potential to be affected by the mine closure process". Interested parties are those groups that have an interest in the process or outcomes of mine closure.

BGC recognises the importance of consulting stakeholders in the closure planning process. A preliminary list of stakeholders has been prepared and is provided below.

- **State Government**
  - Department of Environment
  - Department of Industry and Resources
  - Office of Soil and Land Conservation
  - Department of Conservation and Land Management.
- **Local Government**
  - Shire of Northam.
- **Non-Government Organisations**
  - Wooroloo Brook Land Conservation District Committee
  - Lakes Action Group.

4.2 Stakeholder Consultation Process

BGC will commence the consultation process early in the life of the relocated Voyager Quarry. This consultation will continue to occur during the life of the quarry through to the closure of the relocated quarry. At this stage, the consultation process would involve:

- Confirming that all stakeholders have been identified.
- Information about the proposed closure plan would be presented to the stakeholders.
- Comments and feedback received from the stakeholders will be recorded.
- Amendments to the closure plan that have been made in response to feedback received will be communicated to the stakeholders.
- The results of studies relating the closure of the relocated quarry will be communicated to the stakeholders.

5.1 Overview

Closure planning for the proposed Voyager Quarry should consider those issues that require additional management to achieve the desired future land use of the site. The issues that could influence the closure of the relocated Voyager Quarry are discussed in the following sections.

5.2 Future Land Use

The future land use for the proposed quarry has not yet been decided, however there are a number of options available. These are discussed in Sections 5.2.1-5.2.8.

5.2.1 Empty Void

BGC may wish to leave the quarry as an empty void, following the cessation of quarrying activities. The post-operational void would be suitable to be left empty because the walls would be stable as granite is a competent rock, not susceptible to major slumping, however due to the presence of a saprolitic zone of the weathered granite profile, there is the potential for some slumping to occur. Abandonment bunds will be required to prevent access to the pits. A fence would also be required to prevent fauna from entering the void and becoming trapped in the pit.

The main environmental issue related to the future land use of the quarry being an empty void, is whether a water body will form in the void and what the nature of that water body would be.

Based on the preliminary hydrogeological work, it is unlikely that water will accumulate within the void even though seepage will flow into the pit. If surface runoff is prevented from entering the void and only direct rainfall and groundwater seepage enters the pit, this water will evaporate and a permanent water body will not form. Prior to the selection of the land use after the closure of the quarry, a hydrogeological study will be conducted to verify these predictions.

5.2.2 Water Supply for Human Consumption

The feasibility of using the quarry as a water supply for human consumption depends on the quality of the water within the void, because the water quality needs to be suitable for human consumption. For this land use to be feasible, surface water runoff will need to be channelled into the pit and the rate of abstraction for water supply will have to be lower than the inflow of water into the pit. Prior to the selection of this option as a final land use for the quarry, the following information will be required:

- water balance results for the final void
- water quality analysis
- water supply requirements

- design of the water supply pipes.

5.2.3 Water Supply for Watering of Stock

Based on the results of surface water and hydrogeological studies, a permanent water body will accumulate in the pit if surface water is diverted into the pit. The results also suggest that the quality of the water is likely to meet the requirements for the watering of stock, however further analyses would be required to confirm these results.

It is unlikely that BGC will clear the land for agricultural use, however the water collected in the pit could be provided to adjacent landholders for the watering of stock or BGC may sell the land and the future owner may wish to run stock on the land.

5.2.4 Water Supply for Crop Irrigation

The quarry could be used for the supply of water for crop irrigation. As mentioned in Section 5.2.3, a permanent water body will accumulate in the void if water is diverted to the pit. This stored water could be used for irrigation if the salinity is low, because this future land use option would not be environmentally acceptable if the irrigation contributed to salinisation within the catchment. Further analyses of the water within the pit is required to verify whether it will be acceptable for irrigation. The design for the network of irrigation lines would also need to be developed.

5.2.5 Recreational Use

If the quarry was to be used for recreational purposes, the following activities may be possible at the site:

- rock climbing
- abseiling
- swimming
- picnicking
- camping
- bush walking
- bird watching.

If rock climbing and abseiling were considered feasible land uses for the quarry, the long-term stability of the pit walls would need to be assessed to confirm that these activities could be safely undertaken at the site. It is also likely that the quarry walls would need to be re-shaped if these recreational activities were to be conducted at the site.

5.2.6 Storage for Waste Rock

Following the closure of the relocated Voyager Quarry, the void would provide an ideal space for the storage of inert waste rock. The use of this material in the pit would help to reduce the risk of slumping or slippage. There would be minimal risk to the environment if inert material was used to backfill the pit.

If this option was selected as the final land use, the main issue that will need to be considered is the issue of subsidence within the pit. Subsidence will occur if the waste material being deposited in the void has a uniform particle size distribution. The best result would be achieved by having material with a wide particle size distribution. Further advice on backfilling the pit with waste rock is required from geotechnical experts to ensure that subsidence does not occur.

5.2.7 Storage for Municipal Waste

The pit void would provide storage for municipal waste, as the local councils may wish to utilise the void instead of constructing new landfills. If the quarry were to be used for the storage of municipal waste, an assessment on the permeability of the pit walls would need to be conducted. Liners or other membranes may be required to prevent leachates from the material stored in the void reaching the groundwater.

5.2.8 Aquaculture

Directing surface water runoff towards the pit is likely to result in the creation of a permanent water body, however additional sources of water may be required to maintain required levels in the pit for aquaculture. Depending on the nature of the water body, it may be suitable for the pit to be used for aquaculture. A study should be undertaken to assess this land use option, as this option would be sustainable and environmental acceptable.

5.3 Soil Contamination Issues

Soil contamination may occur at the relocated Voyager Quarry site, as hydrocarbon spills may occur within the workshop areas. These spills are unlikely to reach the groundwater because the spills will be cleaned up immediately.

5.4 Geotechnical Stability Issues

The geotechnical stability of the pit walls would need to be assessed to ensure that they safe and stable.

If the pit is not backfilled, abandonment bunds will need to be established. These bunds will be designed to ensure that they are stable and erosion is minimal.

Other disturbed surfaces that require rehabilitation will be contoured and rehabilitated so that erosion and dust generation from these surfaces is minimised.

5.5 Unplanned Closure

There may be a number of unforeseen circumstances that can lead to unplanned closure. These include economic and operational factors that may result in the permanent or temporary closure of the relocated quarry. If there is no possibility that the site will re-open in the foreseeable future, then an accelerated closure process will need to be implemented. A decommissioning plan will need to be prepared and implemented based on the most current closure plan for the site.

The planning and provisioning for the closure of the relocated Voyager Quarry will be undertaken based on the assumption that the operation will be closed in a planned and systematic manner. No allowance will be made for:

- temporary closure that develops into permanent closure

or

- sudden (unplanned) and permanent closure.

Where provisioning is inadequate to fund the full closure requirements, other company resources may be needed to provide the required funds.

6.1 Closure Planning Process

The Chamber of Minerals and Energy of Western Australia has produced a structure for the closure planning process. It is recommended that a similar approach to the closure planning process presented in Diagram 6.1 be implemented for the closure of the relocated Voyager Quarry.

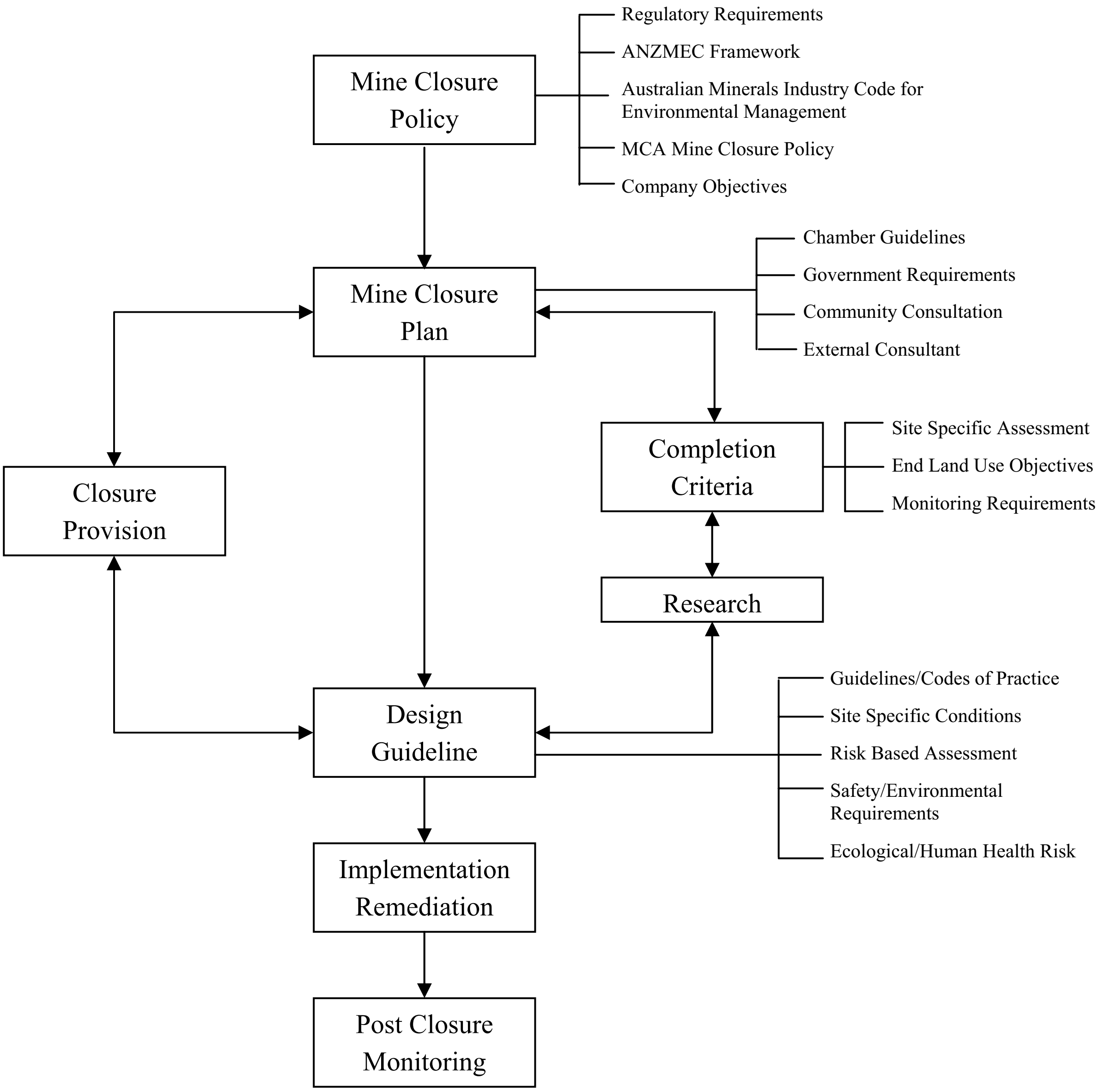


Diagram 6.1: Closure Planning Process (Chamber of Minerals and Energy of Western Australia, 1999)

6.2 Overview of the Closure Process

There are five activities associated with the closure of the relocated Voyager Quarry as listed below:

- Decommissioning and Deconstruction – removal of infrastructure and other services that are no longer required;
- Remediation – clean-up of contaminated areas of soil and/or water;
- Rehabilitation – re-contouring and revegetating on land that has been disturbed by the quarrying operations;
- Maintenance – management of the site after closure; and
- Monitoring – gathering and evaluation of information to determine whether the completion criteria have been met.

These activities can be undertaken during the life of the Project, at the cessation of operations or after the cessation of operations (post-operations).

For the purposes of this preliminary closure plan, it is assumed that the works to be conducted for the closure of the relocated Voyager Quarry are as defined in Table 6.1.

Table 6.1

Summary of Closure Activities for the Proposed Voyager Quarry

During Operations	At the Cessation of Operations	Post-operations
• Investigations to address any data gaps. • Remediation of any hydrocarbon spills. • Groundwater monitoring. • Monitoring of surface water that is being released. • Rehabilitation of disturbed areas that are available.	• Decommissioning and removal of unwanted infrastructure and services. • Potential remediation of hydrocarbon contaminated soil. • Potential establishment of abandonment bunds. • Rehabilitation of stockpile areas. • Potential rehabilitation of abandonment bunds. • Groundwater monitoring.	• Monitoring of groundwater. • Monitoring or rehabilitation. • Maintenance of rehabilitation. • Maintenance of any roads that are left open.

6.3 Decommissioning and Deconstruction

The methods for the disposal of infrastructure and services should be determined prior to the closure of the quarry. The following tasks relating to the decommissioning and deconstruction of the site should be conducted:

- Identify and document all infrastructure and services that BGC is responsible for;

- Identify the safety issues associated with the removal of infrastructure; and
- Determine if there are any legal requirements for the disposal of any of the items.

Decommissioning and deconstruction activities will mainly relate to the crushing and screening plant at the site.

6.4 Remediation

To achieve operational closure, remediation of any contaminated areas would be required to ensure that the completion criteria are achieved. The remediation would mainly be related to the cleanup of any hydrocarbon contaminated soil. It is not envisaged that any other contamination will be present at the site.

6.5 Rehabilitation

The rehabilitation phase of the Project will be conducted throughout the life of the Project, should disturbed areas become available for rehabilitation. There will be some areas that will require rehabilitation following the cessation of the quarrying operations. Activities associated with the rehabilitation include:

- Ripping of compacted hardstand areas;
- Re-profiling and contouring the surface, including the development of appropriate natural drainage systems to control surface water runoff;
- Spreading of topsoil; and
- Seedbed preparation and seeding.

6.6 Maintenance

It is identified within this closure plan that maintenance activities may be necessary, as not all closure activities would be successful and further work may be required to ensure that the completion criteria are met.

The maintenance activities associated with the rehabilitated areas. It is recognised that infilling of revegetated areas may be required if plants do not become established or weeds become prevalent in these areas.

6.7 Monitoring

Following closure, monitoring of environmental conditions is required to demonstrate that agreed completion criteria have been met and that the site is safe and stable. It is envisaged that the time required to demonstrate that the completion criteria have been met is likely to be five years following the closure of the site.

The resources required to manage this phase of the closure process should be identified. It is assumed that the following aspects of the relocated quarry would require monitoring:

- rehabilitation
- groundwater – only if the pit is backfilled to above the weathered granite layer.

6.8 Completion Criteria

Completion criteria are an agreed set of environmental indicators which, upon being met, would demonstrate successful rehabilitation of the site. Completion criteria are specific to the operation being closed and reflect the unique set of environmental, social and economic circumstances of the site. Where possible, the criteria should be quantitative and capable of objective verification.

Completion criteria should be developed in consultation with stakeholders. This provides certainty about the process and the outcome. Completion criteria should also be flexible enough to adapt to the changing circumstances. To facilitate these changes, there should be an agreed process for the periodic review and modification of completion criteria in light of improved knowledge or changed circumstance.

Completion criteria have not been defined for the relocated Voyager Quarry site as part of the development of this plan. It is recommended that completion criteria be developed for the site during the next phase of closure planning.

6.9 Closure Costs

Closure costs include the expenses associated with decommissioning and deconstruction, remediation, rehabilitation, maintenance and monitoring. These costs will be incurred at the time of closure of the site. BGC anticipate that the method that it will use for provisioning for closure will be adequate to cover the actual cost of closure. The ANZMEC/MCA (2000) recognise the following methods of provisioning:

(i) Expense as Incurred: This method involves expending all costs as they are incurred. This method is not recommended, because it not in accordance with the principles of the international framework for accounting practices;

(ii) Incremental Method: Closure costs can be accrued by gradually increasing the provision over the life of the project. Periodic provisions are made by estimating the future cost of rehabilitation and building up the cost over the life of the project; and

(iii) Full Liability Method: The total present value of the future cost of rehabilitation is provided as soon as the commitment is incurred. The amount capitalised under this method is re-paid over the life of the project.

Where provisioning is inadequate to fund the full closure requirements, other company resources may be needed to provide the required funds.

6.10 Reporting and Documentation

As this is the preliminary closure plan, it is essential that an actual closure plan be developed once the Project becomes better defined, most likely during the operational phase of the Project. A closure plan should be prepared and submitted to the DoIR and DoE well in advance of decommissioning to allow time for the plan to be reviewed and approved.

The closure plan should be reviewed annually or more frequently if required, due to changing circumstances or other factors. Review of the closure plan is the responsibility of the General Manager, BGC Asphalt and Quarries.

Arnold, J.G., Williams, J.R., Srinivasan, R., King, K.W. and Griggs, R.H. (1994) SWAT: Soil and Water Assessment Tool. USDA-ARS, Temple TX.

Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (2000) Strategic Framework for Mine Closure. ANZMEC and MCA, Canberra.

Biggs, E.R. and Wilde, S.A. (1980) Geology, Mineral Resources and Hydrogeology of the Darling System, Western Australia. In: Atlas of Natural Resources Darling System, Western Australia. Department of Conservation and Environment, Perth.

Chamber of Minerals and Energy of Western Australia (1999) Mine Closure Guidelines for Minerals Operations in Western Australia. November, 1999.

Christian, C.S. and Stewart, G.A. (1953) Methodology of Integrated Surveys. In: Aerial Surveys and Integrated Studies. UNESCO, Paris: 233-280.

Churchward, H.M. and McArthur, W.M. (1980) Landform and Soils of the Darling System Western Australia. In Atlas of Natural Resources Darling System, Western Australia. Department of Conservation and Environment, Perth.

Commonwealth Environmental Protection Authority (1995) Overview of Best Practice Environmental Management in Mining. One module in the Best Practice Environmental Management in Mining Series. Commonwealth Environmental Protection Authority, Canberra.

Glevan Dieback Consultancy Services (2001) Proposed Extension to Voyager Farm Quarry. Assessment for the Presence of *Phytophthora* sp. Unpublished report prepared for BGC Quarries, December 2001.

Heddle, E.M., Havel, J.J. and Loneragan, O.W. (1980) Vegetation Complexes of the Darling System, Western Australia. In: Atlas of Natural Resources Darling System, Western Australia. Department of Conservation and Environment, Perth.

Hussey, B.M.J., Keighery, G.J., Cousens, R.D., Dodd, J. and Lloyd, S.G. (1997) Western Weeds – A Guide to the Weeds of Western Australia. The Plant Protection Society of Western Australia (Inc), Victoria Park, WA.

King, P.D. and Wells, M.R. (1990) Darling Range Rural Land Capability Study. Ed. by D.A.W, Johnston and L.J. Snell. Land Resources Series No 3. Perth, Western Australian Department of Agriculture.

Kirchner, L. (2002) Hydrology of the Upper Wooroloo Brook Catchment. Report prepared for the Wooroloo Brook Land Conservation District Committee and the Eastern Hills Catchment Management Project, May 2002.

Mattiske Consulting Pty Ltd (2002) Flora and Vegetation on Avon Loc 1881 – Lots 11 and 14 Horton Road, The Lakes – Mundaring. Unpublished report prepared for BGC Quarries, November 2002.

Ninox Wildlife Consulting (2002) The Vertebrate Fauna of Avon Loc 1881 Lots 11 and 14 Horton Road The Lakes – Mundaring. Unpublished report prepared for BGC Quarries, July 2002.

URS Australia Pty Ltd (2002) An Evaluation of Surface Water Issues Related to the Proposed Expansion of BGC Voyager Quarry. Unpublished report prepared for BGC Quarries, November 2002.

URS Australia Pty Ltd (2003) Public Environmental Review Proposed Relocation of the Voyager Quarry. Land Clearing and Quarry Expansion, Avon Loc 1881, Lot 14 Horton Road, The Lakes. Unpublished report prepared for BGC Quarries, January 2003.

Wilde, S.A. and Low, G.H. (1978) Perth 1:250,000 Sheet Geological Series – Explanatory Notes. Geological Survey of Western Australia.

Williams, I.R. (1975) Southwestern Province. In: Geology of Western Australia. West. Australia Geol. Survey, Mem. **2**: 65-71.

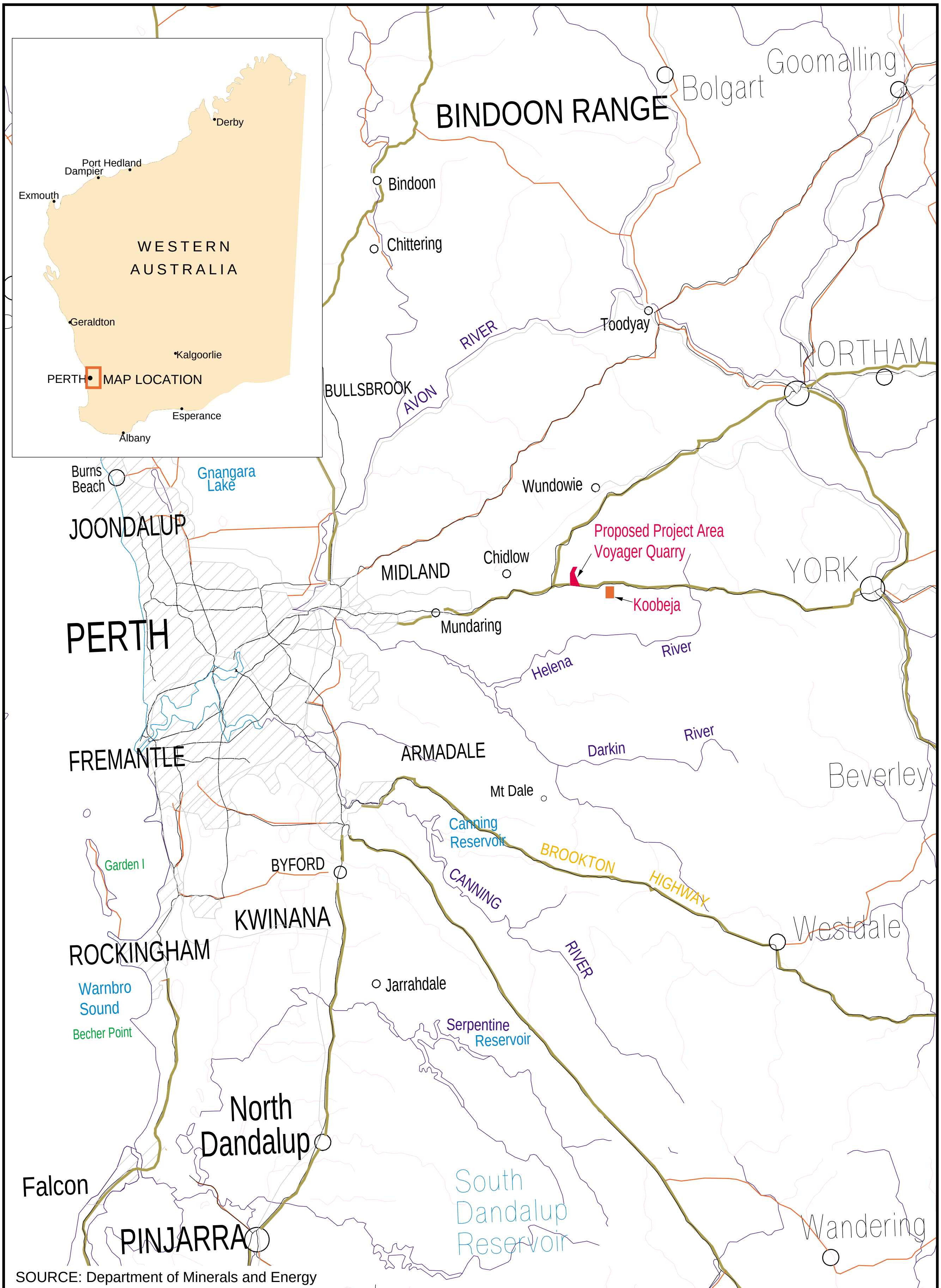
Limitations

URS Australia Pty Ltd (URS) has prepared this report for the use of BGC Asphalt and Quarries in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 4 December 2003.

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

This report was prepared between 23 January and 14 September 2004 and is based on the information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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



SOURCE: Department of Minerals and Energy

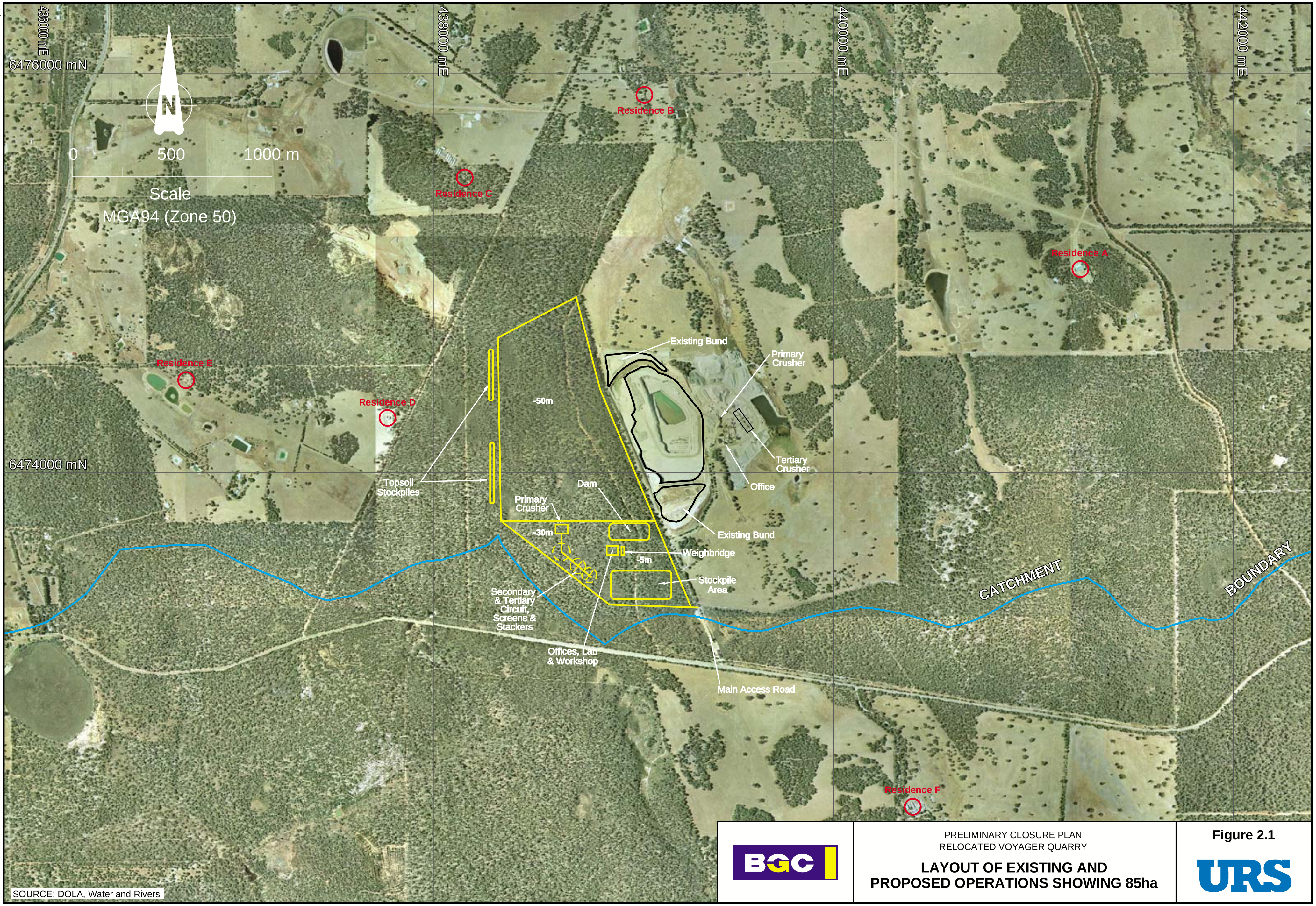
Figure 1.1

PRELIMINARY CLOSURE PLAN
RELOCATED VOYAGER QUARRY

REGIONAL LOCATION MAP

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

j:\jobs\42905483\drawings\r019\42905483r019f1.1.dgn



BGC

PRELIMINARY CLOSURE PLAN
RELOCATED VOYAGER QUARRY

LAYOUT OF EXISTING AND PROPOSED OPERATIONS SHOWING 85ha

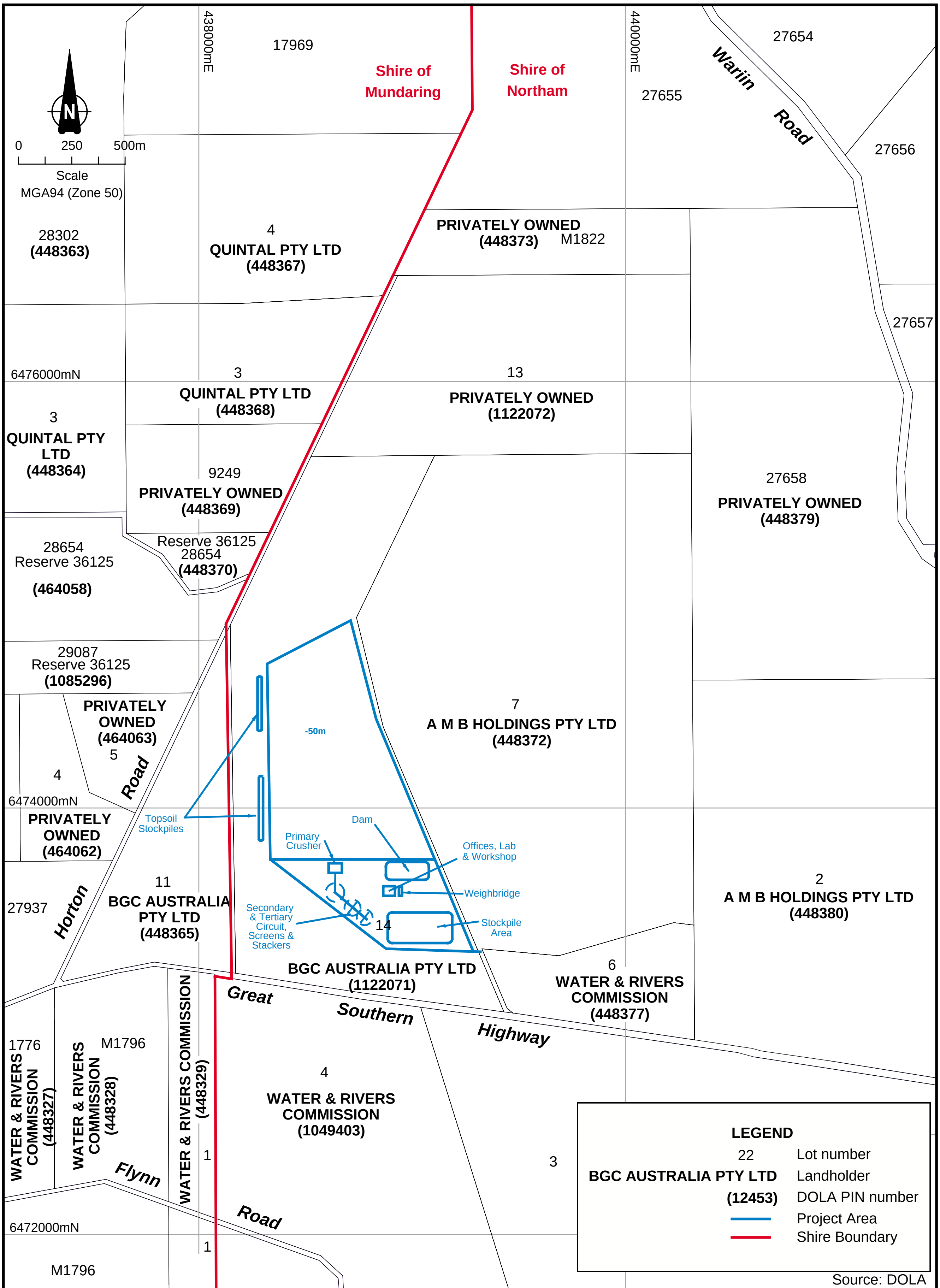
Figure 2.1

URS

Wed 20 Apr 05

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

j:\jobs\42905483\drawings\r019\42905483r019f2.1.dgn



Wed 20 Apr 05

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

BGC

PRELIMINARY CLOSURE PLAN
RELOCATED VOYAGER QUARRY

LAND TENURE

Figure 2.2

URS

j:\jobs\42905483\drawings\r019\42905483r019f2.2.dgn

Appendix E

Flora lists for the Survey Area - January and October 2002

APPENDIX E: SUMMARY OF VASCULAR PLANT SPECIES RECORDED WITHIN THE SURVEY AREA, JANUARY 2002

Note: * denotes introduced (weed) species

		Site-vegetation Types										
Family	**Species**	**D**	**H**	**HS**	**HG**	**P**	**PS**	**PG**	**Y**	**YG**	**MG**	**G**
ZAMIACEAE	*Macrozamia riedlei*				+		+					
CUPRESSACEAE	*Actinostrobus pyramidalis*											+
POACEAE	*Amphipogon laguroides*		+									
	Austrodanthonia caespitosa		+	+								+
	* *Briza maxima*		+			+						
	* *Lagarus ovatus*				+							
	* *Ehrharta longifolia*					+						
	Neurachne alopecuroidea				+							
	Tetrarrhena laevis		+	+	+	+	+	+				
CYPERACEAE	*Cyathochaeta avenacea*		+		+	+	+	+				+
	Lepidosperma gracilis		+		+	+		+				+
	Lepidosperma squamatum	+	+	+	+	+	+	+	+		+	+
	Lepidosperma tenue	+	+	+	+	+	+	+			+	+
	Mesomelaena pseudostygia			+								+
	Mesomelaena tetragona	+	+	+	+	+		+	+			+
	Tetraria capillaris	+	+		+							+
	Tetraria octandra	+	+	+	+	+						+
RESTIONACEAE	*Desmocladus fasciculatus*		+		+	+						
	Lepidobolus preissianus		+					+				+
	Loxocarya cinerea	+	+		+	+						
DASYPOGONACEAE	*Kingia australis*											+
	Lomandra drummondii		+	+	+		+	+				
	Lomandra hermaphrodita		+	+	+	+		+				
	Lomandra micrantha		+		+							
	Lomandra sonderi				+	+	+	+				
	Lomandra spartea		+		+						+	
XANTHORRHOEACEAE	*Xanthorrhoea gracilis*	+	+	+	+	+	+	+	+			+
	Xanthorrhoea preissii	+	+	+	+	+	+	+	+	+	+	+
PHORMIACEAE	*Dianella revoluta*				+							+
ANTHERICACEAE	*Laxmannia squarrosa*	+	+		+	+						+
	Thysanotus dichotomus		+				+	+				+
	Thysanotus sp.		+		+							
	Tricoryne elatior		+		+							
BORYACEAE	*Borya sphaerocephala*		+		+			+				+
HAEMODORACEAE	*Conostylis setigera*	+	+		+	+						+
	Conostylis setosa		+	+	+	+	+					+
	Haemodorum laxum				+							
	Haemodorum sp.		+									+
IRIDACEAE	*Patersonia occidentalis*	+	+	+	+	+	+	+	+	+		+
	Patersonia pygmaea		+		+		+	+				
	Patersonia rudis					+						
CASUARINACEAE	*Allocasuarina fraseriana*		+			+	+	+				+
	Allocasuarina huegeliana							+				+
	Allocasuarina humilis	+	+		+	+		+			+	+
	Allocasuarina microstachya										+	

APPENDIX E: SUMMARY OF VASCULAR PLANT SPECIES RECORDED WITHIN THE SURVEY AREA, JANUARY 2002

Note: * denotes introduced (weed) species

		Site-vegetation Types										
Family	**Species**	**D**	**H**	**HS**	**HG**	**P**	**PS**	**PG**	**Y**	**YG**	**MG**	**G**
PROTEACEAE	*Adenanthos barbiger*		+			+	+					
	Adenanthos cygnorum subsp. *cygnorum*		+		+	+		+		+		+
	Banksia grandis		+	+	+		+	+				
	Conospermum stoechadis		+		+	+	+	+				+
	Dryandra armata		+		+			+			+	+
	Dryandra bipinnatifida	+	+		+	+		+	+			
	Dryandra lindleyana	+	+	+	+	+	+	+		+	+	
	Dryandra sessilis		+	+	+	+		+		+	+	
	Dryandra squarrosa subsp. *squarrosa*	+		+	+	+	+	+		+		+
	Grevillea bipinnatifida	+	+		+			+			+	+
	Grevillea synapheae	+	+		+	+		+				
	Grevillea wilsonii				+	+	+					
	Hakea cyclocarpa				+							+
	Hakea incrassata		+		+		+	+			+	+
	Hakea lissocarpha	+	+	+	+	+	+	+			+	
	Hakea prostrata	+			+	+						
	Hakea ruscifolia	+	+	+	+	+		+				+
	Hakea spathulata		+									
	Hakea stenocarpa		+		+	+		+			+	+
	Hakea trifurcata						+					
	Hakea undulata		+		+			+			+	+
	Isopogon dubius											+
	Isopogon formosus subsp. *formosus*				+							+
	Isopogon sphaerocephalus		+	+	+	+		+				+
	Persoonia elliptica		+			+		+				+
	Persoonia longifolia			+		+	+					
	Petrophile serruriae				+			+				+
	Petrophile striata		+		+	+		+				
	Stirlingia latifolia		+	+								
	Synaphea petiolaris	+	+	+	+	+	+	+		+		+
	Synaphea sp.					+						
AMARANTHACEAE	*Ptilotus drummondii*		+		+	+		+				
	Ptilotus manglesii	+	+	+	+	+	+	+				+
LAURACEAE	*Cassytha glabella*		+		+	+		+				+
PITTOSPORACEAE	*Billardiera variifolia*		+		+							
	Pronaya fraseri		+					+				
MIMOSACEAE	*Acacia alata*	+		+	+	+		+				
	Acacia barbinervis		+	+	+	+						
	Acacia browniana				+	+						
	Acacia celastrifolia					+						
	Acacia lateriticola						+					+
	Acacia nervosa		+						+	+		
	Acacia preissiana	+	+	+	+	+	+	+		+		+
	Acacia pulchella		+								+	
	Acacia stenoptera		+				+					
	Acacia urophylla		+									
	Acacia willdenowiana				+							
CAESALPINACEAE	*Labichea punctata*		+		+	+					+	+

APPENDIX E: SUMMARY OF VASCULAR PLANT SPECIES RECORDED WITHIN THE SURVEY AREA, JANUARY 2002

Note: * denotes introduced (weed) species

		Site-vegetation Types										
Family	**Species**	**D**	**H**	**HS**	**HG**	**P**	**PS**	**PG**	**Y**	**YG**	**MG**	**G**
PAPILIONACEAE	*Bossiaea eriocarpa*					+						
	Bossiaea ornata		+	+	+	+	+	+		+	+	+
	* *Chamaecytisus palmensis*					+						
	Daviesia decurrens		+		+	+					+	
	Daviesia preissii	+	+	+	+		+	+				+
	Daviesia rhombifolia	+	+		+	+		+	+			+
	Gastrolobium bilobum											+
	Gastrolobium calycinum								+	+		
	Gompholobium confertum				+							+
	Gompholobium knightianum		+	+	+	+		+				
	Gompholobium marginatum		+		+	+						
	Gompholobium polymorphum		+			+						
	Hovea chorizemifolia		+		+	+	+				+	
	Jacksonia epiphyllum (ms)		+									
	Jacksonia restionoides				+			+				+
	Kennedia coccinea		+									
	Nemcia capitata					+						
	Sphaerolobium vimineum				+							+
	Viminaria juncea				+							
RUTACEAE	*Boronia fastigiata*				+		+				+	
	Philotheca spicata						+	+				
TREMANDRACEAE	*Tetratheca confertifolia*						+					
	Tetratheca hirsuta		+		+							
POLYGALACEAE	*Comesperma virgatum*	+	+		+	+	+	+				+
EUPHORBIACEAE	*Monotaxis occidentalis*				+	+		+	+			
	Phyllanthus calycinus					+					+	
	Poranthera ericoides					+						
STACKHOUSIACEAE	*Stackhousia monogyna*		+		+							
RHAMNACEAE	*Trymalium ledifolium*					+						
STERCULIACEAE	*Lasiopetalum floribundum*											+
	Thomasia grandiflora										+	
DILLENIACEAE	*Hibbertia acerosa*		+	+	+	+	+	+		+		+
	Hibbertia commutata		+			+	+	+	+			
	Hibbertia huegelii	+	+	+	+	+	+	+	+	+		+
	Hibbertia hypericoides	+	+		+	+	+	+		+	+	+
	Hibbertia lasiopus			+	+	+	+	+				
	Hibbertia rhadinopoda				+							+
	Hibbertia sp.	+	+	+	+	+		+				+
THYMELAEACEAE	*Pimelea ciliatum*				+			+				
	Pimelea suaveolens		+		+	+						

APPENDIX E: SUMMARY OF VASCULAR PLANT SPECIES RECORDED WITHIN THE SURVEY AREA, JANUARY 2002

Note: * denotes introduced (weed) species

		Site-vegetation Types										
Family	**Species**	**D**	**H**	**HS**	**HG**	**P**	**PS**	**PG**	**Y**	**YG**	**MG**	**G**
MYRTACEAE	*Baeckea camphorosmae*	+	+	+	+			+				+
	Beaufortia macrostema		+		+			+				+
	Calothamnus quadrifidus				+			+				
	Calothamnus sanguineus		+		+	+		+	+			+
	Calytrix depressa					+	+					
	Corymbia calophylla	+	+	+	+	+	+	+			+	+
	Eucalyptus drummondii											+
	Eucalyptus marginata subsp. *thalassica*	+	+	+	+	+	+	+	+	+	+	+
	Eucalyptus wandoo								+	+	+	
	Leptospermum spinescens											+
	Melaleuca aspalathoides				+			+				+
	Melaleuca scabra				+							
	Pericalymma ellipticum		+		+			+				+
	Verticordia densiflora											+
HALORAGACEAE	*Glischrocaryon aureum*				+	+	+					+
	Gonocarpus cordiger		+	+		+						+
APIACEAE	*Pentapeltis peltigera*		+	+	+	+	+	+				
	Xanthosia atkinsoniana					+						
EPACRIDACEAE	*Astroloma ciliatum*		+			+						
	Astroloma pallidum		+		+	+		+	+			
	Leucopogon capitellatus						+	+				
	Leucopogon nutans	+	+	+	+	+	+	+				+
	Leucopogon propinquus	+	+		+	+	+	+				
	Leucopogon pulchellus				+			+			+	
	Leucopogon strictus		+	+	+	+	+	+	+		+	+
	Leucopogon sp.											+
	Styphelia tenuiflora		+	+	+	+	+	+				+
PRIMULACEAE	* *Anagalis arvensis*		+			+						
LOGANIACEAE	*Logania micrantha*		+			+	+	+				+
LAMIACEAE	*Hemiandra pungens*				+							
	Hemigenia viscida (P4)				+			+				+
	Pityrodia bartlingii				+							
GOODENIACEAE	*Dampiera alata*				+			+		+		+
	Dampiera linearis		+		+	+						+
	Lechenaultia biloba		+		+	+		+				+
	Scaevola calliptera		+	+	+	+						
STYLIDIACEAE	*Stylidium amoenum*		+			+	+					
	Stylidium brunonianum subsp. *brunonianum*		+			+						
	Stylidium piliferum	+	+	+	+	+						+
ASTERACEAE	*Angianthus tomentosus*			+								+
	* *Conyza bonariensis*		+	+								
	Lagenophora huegelii						+					
	* *Pseudognaphalium luteoalbum*				+							
	Trichocline spathulata		+				+					
	Waitzia acuminata		+			+		+				
	Waitzia suaveolens				+							

APPENDIX E: SUMMARY OF RARE, PRIORITY AND THREATENED VASCULAR PLANT SPECIES POTENTIALLY NEAR THE SURVEY AREA, JANUARY 2002

SCC - as defined by the Wildlife and Conservation Act (1950)

FCC - as defined by the Environmental Protection and Biodiversity Conservation Act (1999)

Data extracted from records and listings held by the Department of Conservation and Land Management (2002)

Family	Species	SCC	FCC
ORCHIDACEAE	*Cyanicula ixioides* subsp. *candida* (ms)	P2	
	Thelymitra manginii (ms)	R	E
	Thelymitra sp. Crystal Brook Star Orchid (F. Humphreys)	P2	
PROTEACEAE	*Adenanthos cygnorum* subsp. *chamaephyton*	P3	
	Grevillea flexuosa	R	V
	Grevillea manglesii subsp. *ornithopoda*	P2	
	Grevillea pimeleoides	P4	
	Lambertia multiflora var. *darlingensis*	P3	
DROSERACEAE	*Drosera occidentalis* subsp. *occidentalis*	P4	
MIMOSACEAE	*Acacia aphylla*	R	V
	Acacia drummondii subsp. *affinis*	P3	
	Acacia horridula	P3	
	Acacia oncinophylla subsp. *oncinophylla*	P3	
PAPILIONACEAE	*Aotus cordifolia*	P3	
	Daviesia oxylobium	P4	
	Templetonia drummondii	P4	
RUTACEAE	*Boronia tenuis*	P4	
TREMANDRACEAE	*Tetratheca pilifera*	P3	
	Tetratheca similis	P3	
RHAMNACEAE	*Stenanthemum coronatum*	P3	
STERCULIACEAE	*Lasiopetalum bracteatum*	P4	
THYMELAEACEAE	*Pimelea rara*	P4	V

APPENDIX E: SUMMARY OF RARE, PRIORITY AND THREATENED VASCULAR PLANT SPECIES POTENTIALLY NEAR THE SURVEY AREA, JANUARY 2002

SCC - as defined by the Wildlife and Conservation Act (1950)

FCC - as defined by the Environmental Protection and Biodiversity Conservation Act (1999)

Data extracted from records and listings held by the Department of Conservation and Land Management (2002)

Family	Species	SCC	FCC
MYRTACEAE	*Eucalyptus loxophleba* x *wandoo*	P4	
	Verticordia citrella	P2	
	Verticordia venusta	P3	
HALORAGACEAE	*Haloragis tenuifolia*	P3	
BORAGINACEAE	*Halgania corymbosa*	P3	
LAMIACEAE	*Hemigenia viscida*	P4	V
SOLANACEAE	*Anthocercis gracilis*	R	V
STYLIDIACEAE	*Stylidium rigidifolium*	P2	
ASTERACEAE	*Senecio gilbertii*	P1	
	Senecio leucoglossus	P4	
PARMELIACEAE	*Xanthoparmelia darlingensis*	P1	

Appendix F

Survey of Significant Trees within Proposed Voyager Quarry Site

SURVEY OF SIGNIFICANT TREES WITHIN PROPOSED EXPANSION AREA (LOTS 11 & 14) OF THE VOYAGER QUARRY SITE.

R.E. & C. JOHNSTONE AND T. KIRKBY

INTRODUCTION

The purpose of this survey was to assess tree hollow resources, especially trees that appeared to offer appropriate hollows for nesting cockatoos (i.e. Carnaby's Cockatoo *Calyptorhynchus latirostris,* Baudin's Cockatoo *Calyptorhynchus baudinii* and Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*). A further aim was to check for evidence of hollow use by other vertebrates of conservation significance e.g. Chuditch and Phascogale.

The site was visited on 20, 21 and 22 December 2003. Trees with large hollows deemed 'significant' trees were inspected for signs of use by cockatoos e.g. wear around hollow, chewing, scarring and scratch marks on trunks and branches. Trees deemed 'significant' were also scratched and raked with a pole to flush any sitting birds from hollows and we listened for calls of chicks from within hollows.

A total of 130 trees with large hollows were visually inspected with binolculars from several angles for signs of use by cockatoos, and a subset of these (33 in total) with hollows that we considered most appropriate for nesting cockatoos were climbed, checked, measured and mapped using GPS pick up. From some of these we also took a sample of the hollow floor contents to identify egg shell fragments, feathers, bones, scats, fur and wood chips etc. Most black cockatoo nest hollows have a characteristic worn and chewed walkway down the inside of the hollow formed by the coming and going of the adult female. Small cigar-shaped wood chips are chewed from the sides of hollow and form a thick mat on the floor space, providing a clean and dry base for the eggs and chick. Cockatoos also regularly visit or prospect and sometimes chew the entrance of hollows not suitable for breeding and also drink at hollows (especially Jarrah and Marri hollows) that store water. From the ground some of the latter may appear to be breeding hollows.

Hollows were accessed using extension ladders, wire cave ladders and ropes with julmar ascenders. Details of the climbed trees include latitude and longitude (with GPS pick up), tree type, senescence scale (using Whitford scale), circumference at breast height, position in landscape, surrounding vegetation, tree height, hollow type, depth of hollow, hollow entrance width, hollow entrance length or height, hollow floor width, hollow floor length, height to hollow, hollow entrance facing and remarks (see attached table and maps).

Judging from information in the Storr-Johnstone Bird Data Bank from Bindoon - Chittering and Mundaring Weir catchment two species of black Cockatoo namely; Carnaby's Cockatoo and the Forest Red-tailed Black Cockatoo could occur as breeding in the Voyager site. Carnaby's Cockatoo begins breeding in this region in October - November and nests would contain feathered chicks in late December and Forest Red-tailed Black Cockatoos breed in October - December and some also in autumn. Both of these species prefer large top entry hollows in marri and wandoo.

During the survey we also logged areas where we found evidence of cockatoos feeding, details of these are given below. Breeding success for cockatoos is largely dependent on suitable feeding habitat adjacent to the site to provide the necessary food for survival of chick.

RESULTS

A total of 163 trees with large hollows were visually inspected and mapped using GPS (see attached). Of these a subset of 33 trees with hollows that appeared to be most appropriate for cockatoos or showed signs from ground of recent use etc. were climbed, checked, measured and mapped (see tables). Of the 33 trees climbed 3 were identified as having hollows that had evidence of use by cockatoos (probably Forest Red-tailed Black Cockatoo) over the past 1 - 3 years. None of these hollows were used during the current breeding season. All three of these trees were large Marris, one in the north-east section of the site and the others near the southern boundary close to the Great Southern Highway (see map). All three were also noted in our visual inspection from ground as being possible cockatoo breeding hollows.

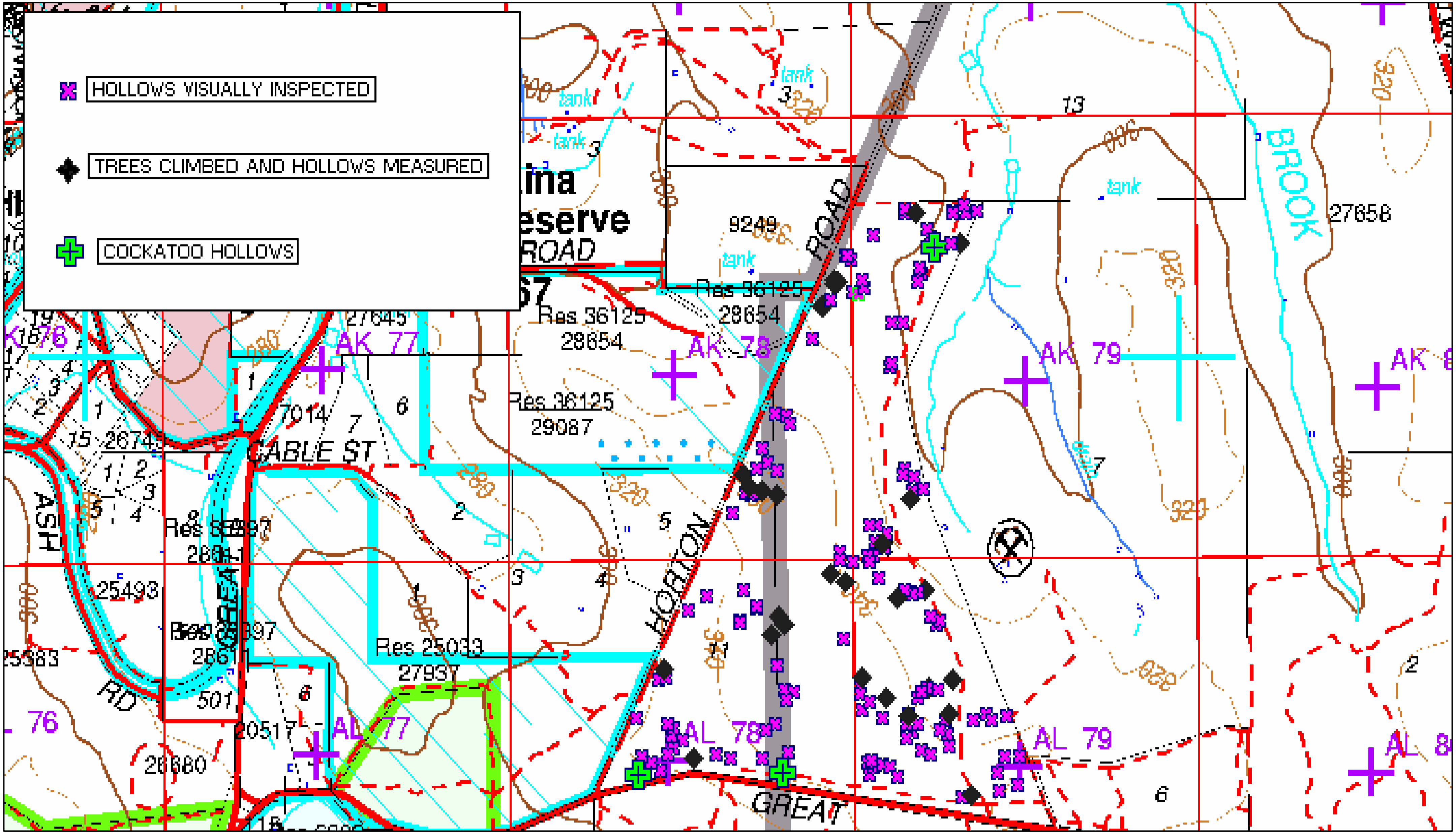
Overall the site contained very few trees that would offer appropriate nest hollows for cockatoos.

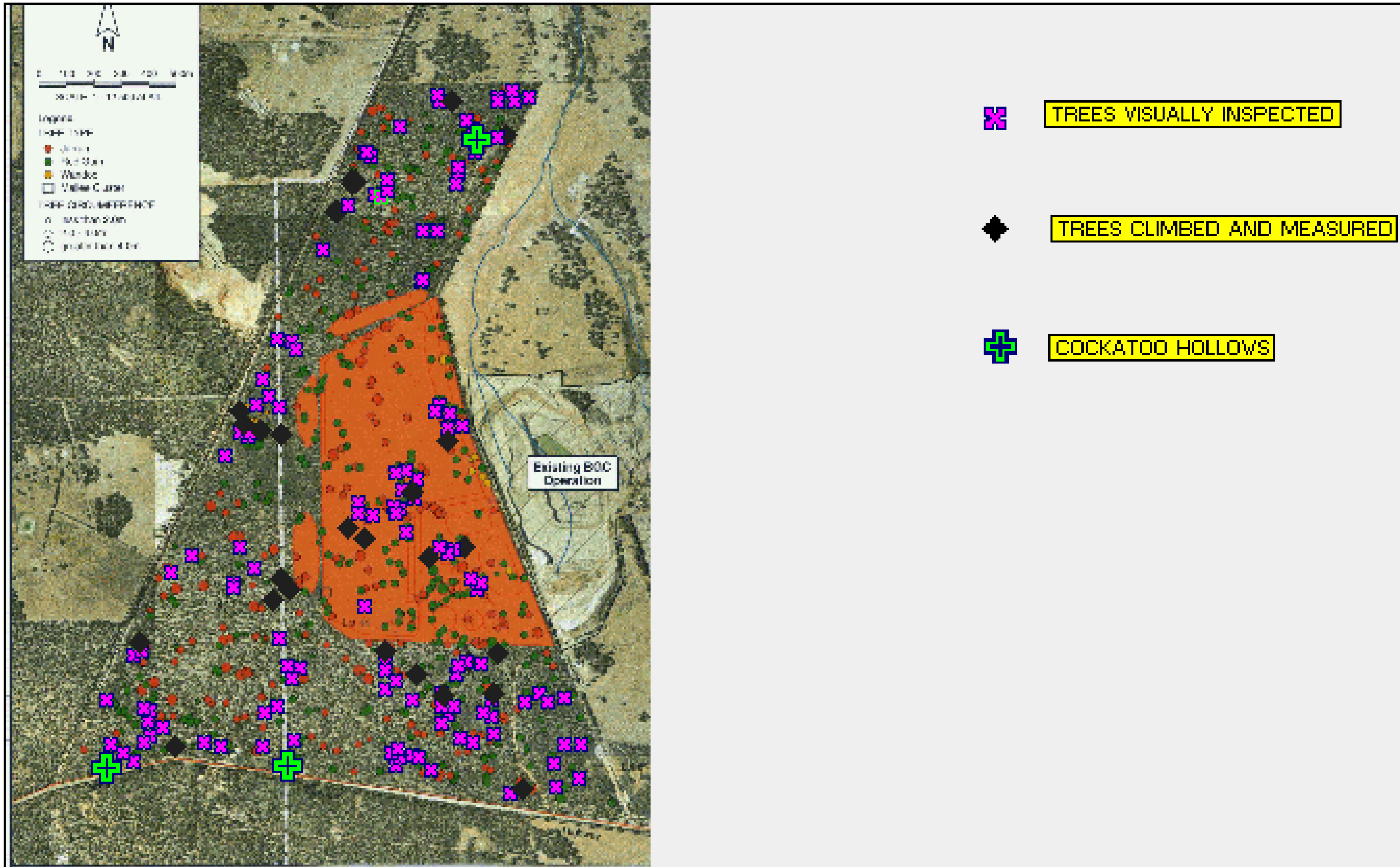
Details of the other climbed trees are as follows: 2 hollows (tree numbers 1 and 23) had been used recently by Australian Wood Duck *Chenonetta jubata* (egg fragments, down and feathers in hollow); 4 hollows (tree numbers 2, 3 and 9) contained fur and scats of Brushtail Possum; 1 hollow (tree number 4) had what appeared to be a Sacred Kingfisher *Todiramphus sanctus* tunnel going into a termite mound in the hollow; 3 hollows (tree numbers 6 and 7) had been used by owls (probably Boobook Owl *Ninox novaehollandiae*) for breeding or roosting, hollow contained pellets, small bones and insect fragments; 1 hollow (tree number 10) had been used as a roost by a small hawk; 1 hollow (tree number 11) was possibly used by a small parrot; 1 hollow (tree number 15) contained a recently used nest of the Grey Shrike-thrush *Colluricincla harmonica*; 1 hollow (tree number 20) contained scats of a small mammal ? *Antechinus*; and 1 hollow (tree number 28) appeared to be a water holding hollow. The remainder of the climbed and checked hollows were empty and showed no signs of use.

Of the unclimbed trees, one at 31. 52. 29.6. S, 116. 21. 7.5. E contained a hollow that appeared to have been used by cockatoos in the past. One other hollow at 31. 51. 13.1. S, 116. 21. 19.8.E was scarred by Galahs. A number of hollows that appeared suitable for cockatoos had been taken over by feral bees (see table). We found no evidence of hollow usage by Chuditch and Phascogale.

FEEDING SITES

During this survey we found evidence that both Baudin’s Cockatoo and the Forest Red-tailed Black Cockatoo had been feeding on Marri nuts in the north-western area of the site at
31. 51. 22. S, 116. 20. 01. E.


HOLLOWS VISUALLY INSPECTED
TREES CLIMBED AND HOLLOWS MEASURED
COCKATOO HOLLOWS
BROOK
ROAD
HORTON
GREAT
CABLE ST
ASH
RD
AK 77
AK 78
AK 79
AL 77
AL 78
AL 79
76
Res 36125
28654
Res 36125
29087
Res 25033
27937
9249
27658
27645
7014
25493
20517
26680
tank



SIGNIFICANT TREES

Figure 6

Lakes Action Group

Appendix G

Voyager Quarry Relocation Fauna Management Plan

Voyager Quarry Relocation Fauna Management Plan

URS Australia Pty Ltd | BGC Quarries

Fauna Management Plan

October 2004

ABN 49 092 687 119
2 / 186 Scarborough Beach Rd
Mt Hawthorn WA 6016
Ph: (08) 9201 9955 Fax: (08) 9201 9599

Project No.:	168	
Prepared by:	Lee Mould	
Checked by:	Garth Humphreys	Roy Teale

Voyager Quarry Relocation – Fauna Management Plan

Contents

Tables

Figures

1.0 Introduction

1.1 Project Background and Current Status

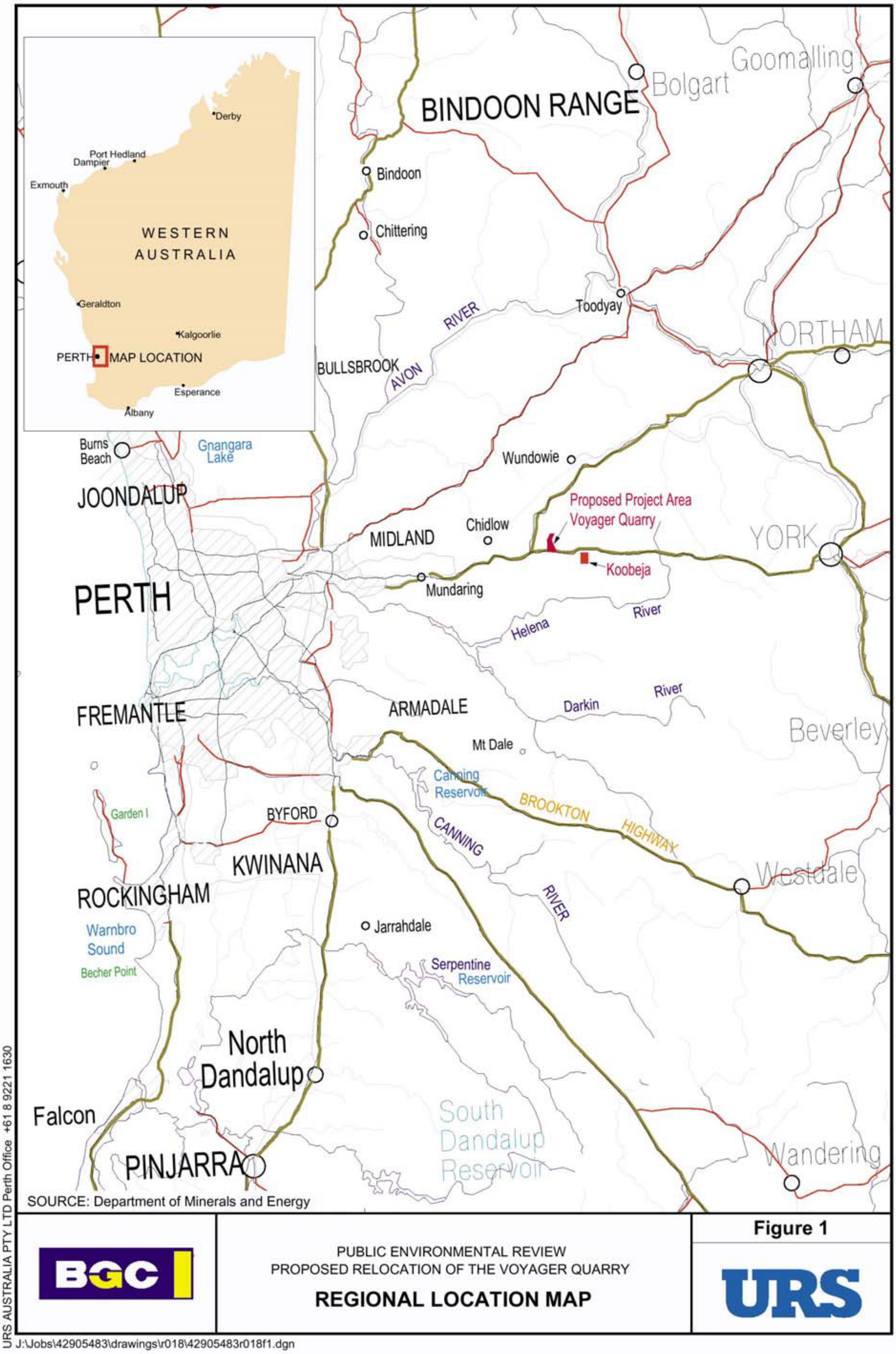
The Voyager Quarry site is owned and operated by BGC Australia Pty Ltd (BGC). It is located on the Great Southern Highway, approximately 47 km southwest of the town of Northam and 20 km east of the town of Mundaring. BGC proposes to extend its operation to an adjacent property on Lot 14 Horton Road, west of the existing quarry. The proposal involves the development of an open pit and the construction of a crushing and screening plant within the pit. The proposal to extend quarry operations at this site was assessed at the level of a Public Environmental Review (PER). The Department of Environment (DoE) requested additional information on fauna following the review of a report prepared by Ninox Wildlife Consulting in July 2002. Targeted fauna surveys to obtain information on the fauna of the site were undertaken by Biota Environmental Sciences (2002) and Johnstone and Kirkby (2003).

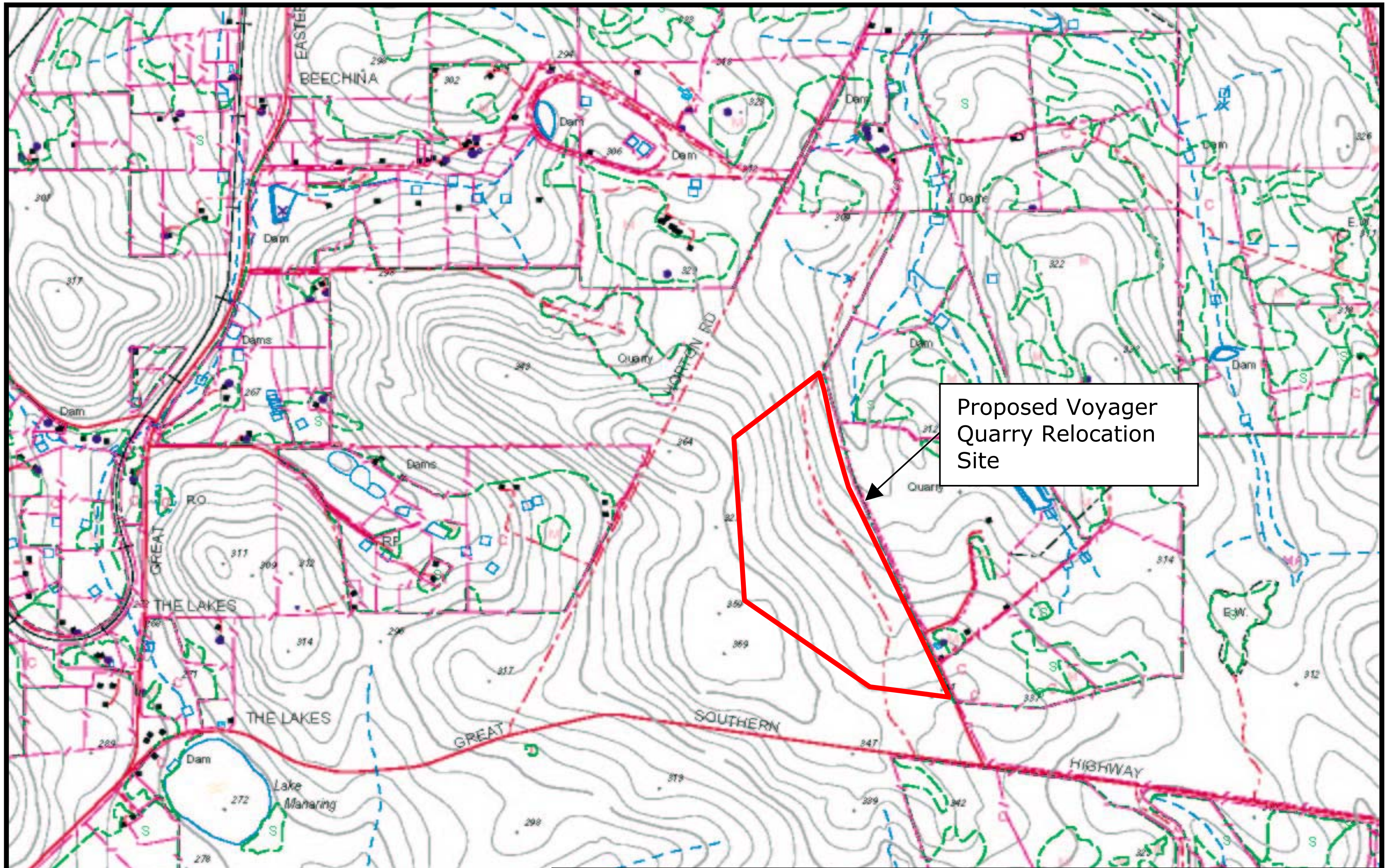
The proponent is presently submitting a Response to Submissions to the DoE to gain approval to relocate the quarry to Lot 14. This Fauna Management Plan (FMP) fulfils a proponent commitment as part of the proposal and sets out working methods for fauna protection, habitat rehabilitation and enhancement.

1.2 Regional Context and Layout

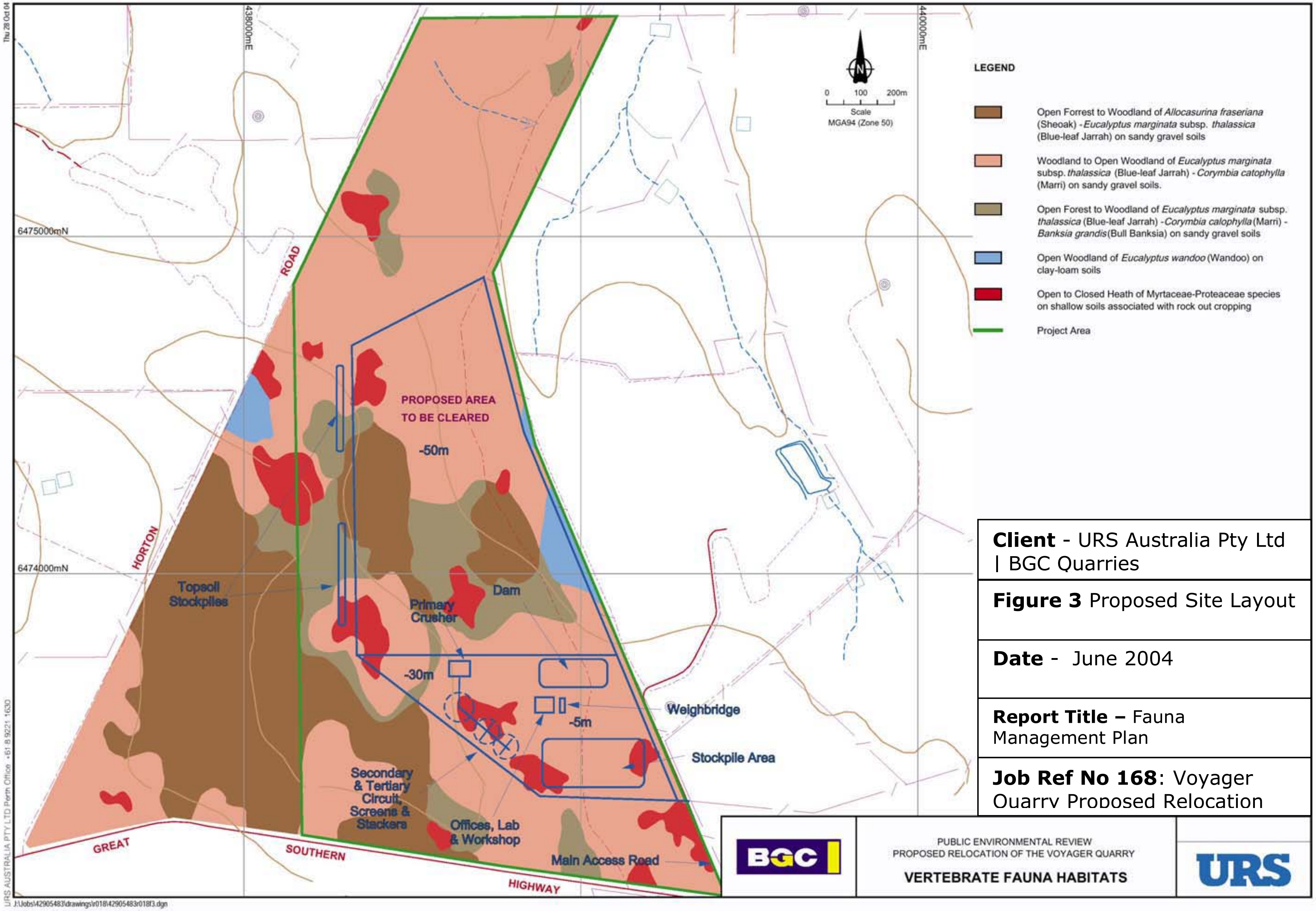
The site area is located within the Shire of Northam (438500E, 6474000N GDA94 datum). The proposal area is bordered by the Great Southern Highway to the south, Horton Road to the west, the existing quarry to the east and farmland to the north. The area is surrounded by a mixture of cleared land, grazed open pasture and mixed Banksia/Eucalypt woodland (see Figure 1 for the location of the site within a regional context). The area is also shown within a local context on Figure 2.

The quarry site is currently active and has been in operation since 1991. Quarrying is expected to continue for a further five years until 2009, with the planned site layout shown in Figure 3. A 30 m buffer will be created between the access road to the existing works to the east and the development footprint on its western aspect. All infrastructure will be located below ground level, in the southeast corner of the proposed pit. The stockpile area and dam will be located on the western side of the infrastructure area. An office, laboratory and weighbridge are proposed for the central area of the infrastructure footprint. Processing machinery such as screens, stackers and crusher, are proposed for the southern side of the site, along with a surge pile. The scale of operations proposed is equal to the level of works currently undertaken on adjacent land. The proposed quarrying activities are due to run for approximately 50 years after commencement.


BINDOON RANGE
Bolgart
Goomalling
Bindoon
Chittering
WESTERN AUSTRALIA
Derby
Port Hedland
Dampier
Exmouth
Geraldton
Kalgoorlie
PERTH
MAP LOCATION
Esperance
Albany
RIVER
AVON
Toodyay
NORTHAM
BULLSBROOK
Burns Beach
Gnangara Lake
Wundowie
JOONDALUP
Proposed Project Area
Voyager Quarry
Chidlow
MIDLAND
YORK
Koobeja
Mundaring
PERTH
Helena
River
Darkin
River
FREMANTLE
ARMADALE
Beverley
Mt Dale
Canning Reservoir
BROOKTON
HIGHWAY
Garden I
BYFORD
CANNING
KWINANA
ROCKINGHAM
RIVER
Westdale
Warnbro Sound
Becher Point
Jarrahdale
Serpentine Reservoir
North Dandalup
Falcon
South Dandalup Reservoir
PINJARRA
Wandering
SOURCE: Department of Minerals and Energy
URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630
BGC
PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY
REGIONAL LOCATION MAP
Figure 1
URS
J:\Jobs\42905483\drawings\r018\42905483r018f1.dgn



Client	URS Australia Pty Ltd | BGC Quarries	**Job Ref No 168**	Voyager Quarry site – Proposed Relocation Works
Figure 2	Topography of Site in context with local environment	**Report Title**	Fauna Management Plan
Date	June 2004		


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
0 100 200m
Scale
MGA94 (Zone 50)
N
438000mE
440000mE
6475000mN
6474000mN
PROPOSED AREA TO BE CLEARED
-50m
-30m
-5m
Dam
Primary Crusher
Topsoil Stockpiles
Secondary & Tertiary Circuit, Screens & Stackers
Offices, Lab & Workshop
Main Access Road
Weighbridge
Stockpile Area
ROAD
HORTON
GREAT
SOUTHERN
HIGHWAY
Client - URS Australia Pty Ltd | BGC Quarries
Figure 3 Proposed Site Layout
Date - June 2004
Report Title – Fauna Management Plan
Job Ref No 168: Voyager Quarry Proposed Relocation
BGC
PUBLIC ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF THE VOYAGER QUARRY
VERTEBRATE FAUNA HABITATS
URS
URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630
J:\Jobs\42905483\drawings\r018\42905483r018f3.dgn

1.3 Scope and Responsibility

This FMP addresses the proposed construction and site clearance working methods to be implemented as part of the quarry relocation. It sets out management methods to be implemented with regards to minimising impacts to, and the protection of, native fauna. This FMP also documents:

1. the stage of the project that actions are to be implemented;
2. management actions to be undertaken; and
3. organisation or individual responsible for management actions.

BGC is ultimately responsible for the project proceeding in an environmentally appropriate fashion. This includes ensuring that all personnel adhere to environmental controls that apply to their activities, as documented in this FMP, to the approval of BGC.

1.4 Aims and Structure of Plan

The aim of this document is to minimise impacts on vertebrate fauna, throughout and subsequent to the proposed habitat clearance on site. This is to be achieved through a series of management strategies relating to fauna on site. In accordance with the EPA's objectives for the formal assessment of the Voyager Quarry site proposal; the aim of the FMP is:

- To maintain the abundance, species diversity and geographical distribution of fauna in the vicinity of the proposed the Voyager Quarry relocation area (ie. Lot 11 and remainder of Lot 14).

The FMP is divided into three main sections as follows:

Pre-construction (Section 3.0 of this FMP)

- Sets out pre-clearance surveys to ensure a method of best practice is adhered to, in avoiding injury to native fauna and fauna habitat within the proposed development area (ie. quarry boundary).

Construction/Operation (Section 4.0 of this FMP)

- Define working methods to minimise and wherever possible eliminate construction and operational impacts on native fauna within the proposed development area.

Post-construction (Section 5.0 of this FMP)

- Advocate an on-going approach to valid fauna management and monitoring, open to future review and adaptation.

However, prior to detailing the management actions required to achieve the objectives of this plan, it is useful to review the background to the plan. This is done in Section 2.0, which briefly describes the biological environment of the proposed project area, defines the species targets for management and outlines information sources useful to their management.

2.0 Background

2.1 Introduction

This section provides a summary of the features of the biological environment of the project area of relevance to fauna management. Detailed information on the following aspects is given in Appendix 2; vegetation and flora, hydrology, temperature, rainfall, geological and geographical features. Data obtained from previous fauna survey work on site is provided in Appendix 3.

2.2 Target Management Species

Whilst the bulk of this FMP addresses general habitat management and actions to minimise impacts on all vertebrates, some species of elevated conservation significance also occur on the site. These were primarily the taxa identified by the DEP as being of potential concern for the targeted fauna survey (Biota 2002). A subset of these species has been carried forward for specific consideration in this FMP. These were the species that surveys indicated actual or probable occurrence on the site, and which are amenable to specific management measures. These are:

- Carnaby's Black Cockatoo *Calyptorhynchus latirostris* (Schedule 1);
- Baudin's Cockatoo *Calyptorhynchus baudinii* (Schedule 1);
- Chuditch *Dasyurus geoffroii* (Schedule 1);
- Carpet Python *Morelia spilota imbricata* (Schedule 4);
- Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* (Priority 3); and
- Brush-tailed Phascogale *Phascogale tapoatafa* (Priority 3).

The biology and local occurrence of these species were addressed in previous site surveys and this is summarised in Appendix 3 of this document.

2.3 Review of other Fauna Management Documentation

Two broader regional management plans are of contextual relevance to fauna management of the site. These plans are both developed and administered by the Department of Conservation and Land Management (CALM).

2.3.1 Chuditch Recovery Plan

The following information is taken from the Chuditch recovery plan (Orell and Morris 1994). The Chuditch is listed as Endangered (ANZECC 1991); Endangered (Schedule 1 of *Endangered Species Protection Act 1992*); Threatened species (WA *Wildlife Conservation Act 1950*). The Chuditch had a distribution covering 70% of the Australian continent at the time of European settlement. It is currently estimated that fewer than 6,000 Chuditch now remain in the south-west of Western Australia, mostly in the Jarrah forest but also scattered through the southern and eastern wheatbelt. The Chuditch is considered vulnerable to local extinction because of the low population densities and the scattered distribution of populations (Orell and Morris 1994). The recovery plan was initially established to run for a term of 10 years from 1992 to 2001 inclusive. The objective of this Recovery Plan was to achieve downlisting of Chuditch status from endangered to vulnerable (ANZECC 1991) within 10 years by ensuring that the species persists within its present range and increasing population numbers by expansion into former range. The criteria for successfully achieving this objective was that the average daily trap success rates for Chuditch at selected monitoring sites in the Jarrah forest, using standard trapping techniques remained at or increased above 1%. (*the average of the number of animals caught each day per 100 traps in one trapping period). Six primary strategies were pursued during this term and are presented below:

- Habitat management in the Jarrah forest. Research into the effect of prescribed burning regimes and timber harvesting practices commenced in 1992. Results of this research will be incorporated into fire prescription and silviculture guidelines.

- Research into the effect of the fox and fox baiting programmes on Chuditch in the Jarrah forest. This was carried out in 1991-1992. The findings from this research demonstrates that modifications to operational fox baiting procedures were not necessary.

- Monitoring of Chuditch populations and habitat at representative sites, initially in the Jarrah forest and later in semi-arid areas. Population monitoring is ongoing and habitat monitoring will be implemented as soon as possible. Results of this programme will be used initially to assess the well-being of the Jarrah forest Chuditch populations, and at a later date, populations in semi-arid areas.

- Undertake further research into Chuditch distribution and habitat requirements, particularly in semi-arid areas. Fauna trapping surveys are now being carried out in the Jarrah forest by CALM district operations staff and Alcoa, providing additional information on Chuditch distribution. Further research in semi-arid areas will commence in 1994.

- Continuation of captive breeding. A captive breeding programme at Perth Zoo was in operation until 2001. Chuditch from this programme were being bred from stock obtained from the Jarrah forest, and were used for the translocation project in 1992 and 1993. A separate colony will be established from Chuditch obtained from semi-arid areas for translocation to a suitable semi-arid area outside the present range. A total of 315 Chuditch were released at a number of sites within the Swan Coastal Plain over a nine year period between 1992 and 2001, as part of the Chuditch Recovery Programme (Pers comm Perth Zoo, 4 May 2004). The release areas and corresponding animals numbers at each site are Mount Lindsay 63, Kalbarri 49, Julimar Conservation Park 62, Lake Magenta 80 and Cape Arid 61. The last animals to be released were at the kalbarri site in March 2001.

- Translocation to areas of vacant, suitable habitat. An experimental translocation to Julimar Conservation Park was undertaken in 1992 to develop techniques for successfully translocating Chuditch. This project was successful and a subsequent translocation to a semi-arid site will be undertaken in 1996 following further research and monitoring of extant semi-arid populations.

A Chuditch Recovery Team was appointed in 1992 to coordinate the research and management of the Chuditch, as outlined in this Recovery Plan. The team comprised representatives from CALM Science and Information Division, Nature Conservation Division and relevant Regions, Perth Zoo, World Wide Fund for Nature Australia and Alcoa. The Recovery Team report to CALM's Corporate Executive and to funding agencies.

A Chuditch was recorded from the proposed Voyager Quarry site (Biota 2003) and management measures are contained in this plan to address minimising impacts on this species.

2.3.2 Western Shield Programme

The Western Shield Programme focuses on the control of the exotic Red Fox *Vulpes vulpes* and Feral Cat *Felis catus* populations and translocations of native species into areas where control of feral predators has been achieved. Initial efforts of the Western Shield Programme began in 1996. The method of control involves placing or dropping by air poison baited meats, injected with indigenous plant extracts (native animals have an immunity to this extract) to kill exotic, predatory animals.

Since 1996, CALM has carried out more than 60 translocations of 16 animal species. The species are:

- Chuditch *Dasyurus geoffroii;*
- Dibbler *Parantechnus apicalis;*
- Numbat *Myrmecobius fasciatus;*
- Bilby *Macrotis lagotis;*
- Quenda *Isoodon obeselus;*
- Western Barred Bandicoot *Perameles bougainville;*
- Woylie *Bettongia penicillata;*
- Mala *Lagorchestes hirsutus;*
- Tammar Wallaby *Macropus eugenii;*
- Western Ringtail Possum *Pseudocheirus occidentalis;*
- Shark Bay Mouse *Psuedomys fieldi;*
- Thevenard Island mouse *Leggadina lakedownensis;*
- Noisy scrub-bird *Atrichornis clamosus;*
- Western Bristlebird *Dasyornis longirostris;*
- Malleefowl *Leipoa ocellata;* and
- Western Swamp Tortoise *Pseudemydura umbrina.*

The species of concern regarding the project area are the Numbat, and the Chuditch. The latter was recorded during the 2003 Biota survey works undertaken within the survey area (Biota 2003).

3.0 Pre-construction Management

3.1 Access and Signage

Objective: To minimise vehicle impacts on fauna habitat and minimise the likelihood of road kills.

Vehicles needing to access the site prior to the commencement of construction activities are to use existing tracks, sealed road surfaces and other hard landscape features. All staff accessing the site are to be briefed on access requirements as part of environmental inductions for the planned quarry operations. This is to include the locations of formalised access points and the importance of not driving on uncleared vegetation. 'Fauna aware' signs should also be installed at key access points, alerting vehicle drivers entering the area to the potential presence of Threatened fauna such as the Chuditch and Carpet Python (see Appendix 3).

Management Action	Responsibility
Vehicles to use existing tracks only, with no off-road driving on uncleared areas	All staff
Access and driving procedures to be included in environmental induction	Environmental Officer, Site Manager
'Fauna Aware' signage to be erected at key vehicle access points	Site Manager

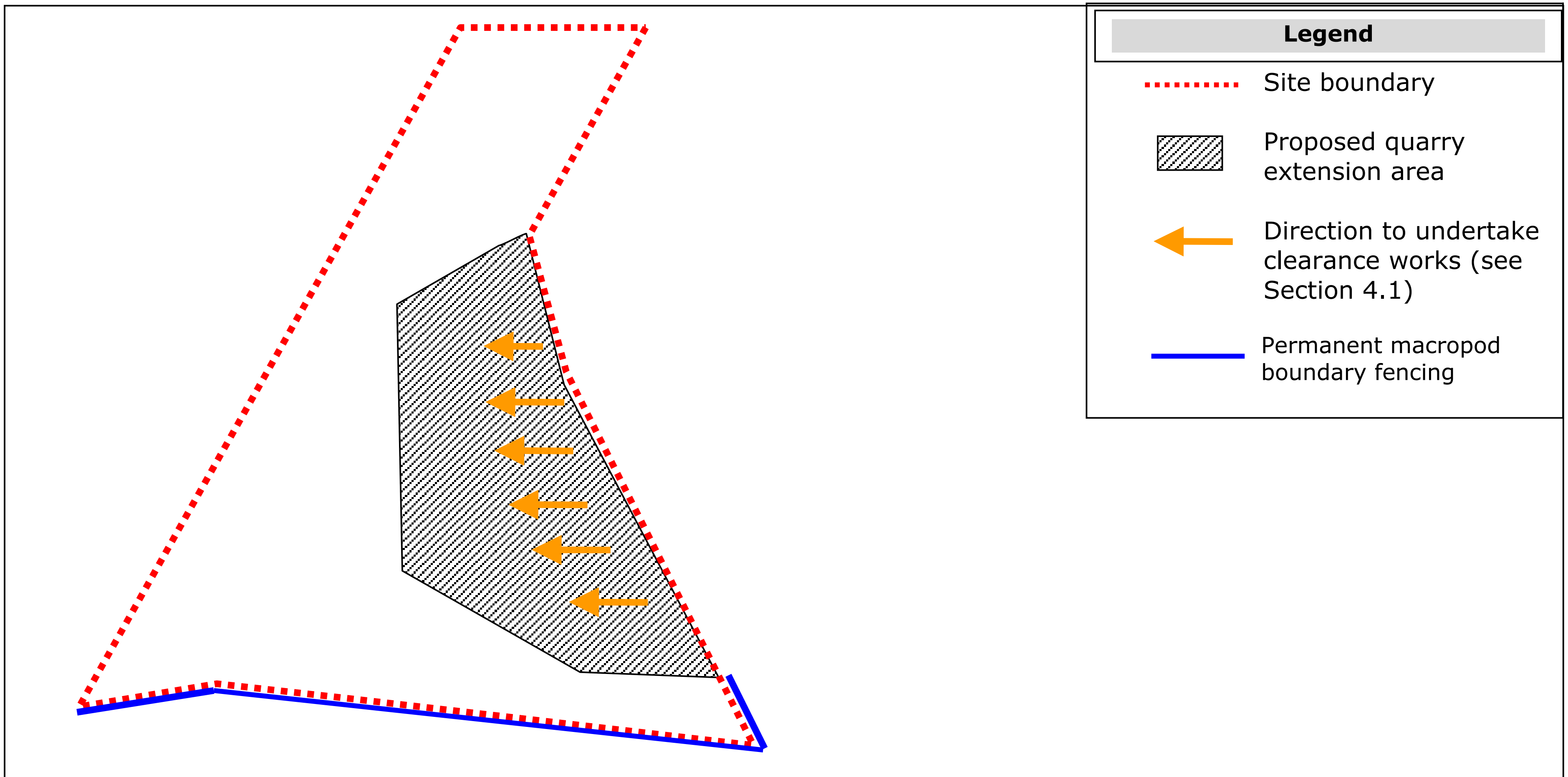
3.2 Fencing

Objective: To allow the escape of ground fauna from the quarry area during clearing works and to minimise the entry or re-entry of fauna into the works area.

Standard cyclone mesh fencing is to be installed along the southern boundary of the site as shown on Figure 4. The installation of this permanent boundary fencing will serve to reduce the likelihood of macropods displaced by quarrying works being struck by vehicles on the Great Southern Highway.

There are a number of locations being accessed by macropods along the perimeters of the site. These were observed during site survey works undertaken in 2002 and 2003. An updated survey should be undertaken prior to clearance works to determine the exact locations of these crossing points. Once these areas have been identified, fencing designs can be modified to allow continued access to these areas once the initial proposed clearance works have been undertaken.

Management Action	Responsibility
Cyclone mesh boundary fencing along southern boundary to minimise kangaroo road kills on Great Southern Highway	Environmental Officer, Site Manager



Client	URS Australia Pty Ltd | BGC Quarries	**Job Ref No 168**	Voyager Quarry Site – Proposed Relocation
Detail	**Figure 4** Fencing works	**Report Title**	Fauna Management Plan
Date	June 2004	**Scale**	(not to scale – schematic only)

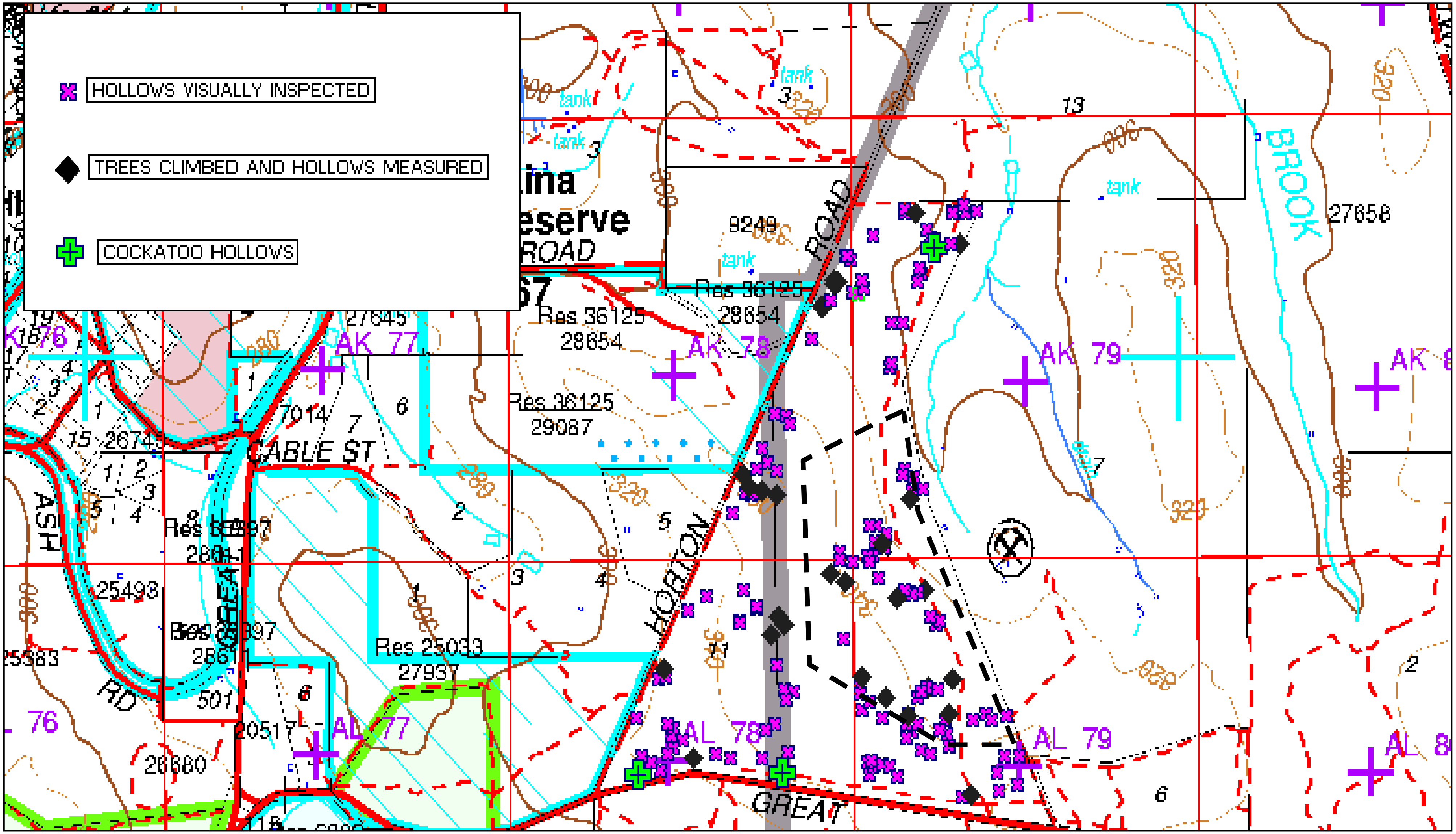


Figure 5: **Locations of significant habitat trees with potential cockatoo breeding hollows (source: Johnstone and Kirkby 2003).**

3.3 Identification and Protection of Significant Hollow Breeding Trees

Objective: To ensure that trees that may provide breeding resources for Threatened fauna are retained.

The proposed quarry site has previously been subject to a detailed evaluation to assess tress for both actual and potential use by hollow-breeding Threatened fauna species, primarily the black cockatoo species (Johnstone and Kirkby 2003). The outcomes of this work are shown on Figure 5, whereby most trees on the site did not have hollows of sufficient size to be of potential breeding utility to these regionally threatened taxa. The three trees that were identified as providing these hollow breeding resources are shown as green crosses on Figure 5.

The significant habitat trees are located outside of the proposed areas to be cleared and will therefore be retained. These trees are to be clearly marked with high visibility tape and a sign signifying the importance of the tree. If the tree is in close proximity to the area subject to clearance then the tree should be fenced with semi-permanent fencing, to a minimum distance of 5 m in diameter. This fencing should remain in place until the completion of all clearance and other initial works on site. In addition, site environmental inductions should highlight the importance of retaining these trees, and that the fencing, tape and sign identifies trees to be left undisturbed.

Management Action	Responsibility
Semi-permanent fencing to be erected around significant breeding resource trees to prevent clearing	Environmental Officer
Environmental inductions to inform all personnel of requirement to protect these trees	Environmental Officer, all personnel

3.4 Threatened Fauna Clearance Surveys

Objective: To ensure that no ground-dwelling Threatened fauna remain within the area to be cleared for quarrying activities.

3.4.1 Targeted Threatened Fauna Confirmation Survey

Prior to the commencement of clearance on site, a targeted trapping and survey exercise to cage trap and relocate threatened fauna is to be undertaken. This exercise will target the threatened species that:

- previous survey work, CALM, WA Museum and data records have shown to be potentially present;
- have large home ranges and may have entered the area since the previous surveys;
- and are amenable to this type of survey and management.

The species targeted by this exercise will comprise the Threatened mammal and reptile fauna listed in Section 2.2. That is the Chuditch, Carpet Python, Numbat and Phascogale. Threatened fauna clearance trapping will be conducted for six nights immediately prior to vegetation clearing work commencing. Trapping is to be conducted by methods appropriate for each species (primarily cage trapping, with spotlight searches for carpet pythons). If capture of the target species are still being recorded at the end of the six-night period, the exercise may need to be extended.

3.4.2 Threatened Fauna Relocation

If any Threatened fauna taxa are captured within the area to be cleared for quarrying these will need to be relocated to an appropriate location outside of the disturbance area. There are several considerations, including CALM's statutory role in management of Threatened fauna, displacement effects and other potential ramifications of fauna relocation.

Selection of the appropriate receptor site for species is crucial, as displacement of existing populations can occur if population densities within the recipient site are already at carrying capacity. Other issues such as food and shelter/nesting competition, disease and predation should also be considered. The selection process for the relocation site needs to be addressed in consultation with and to the approval of CALM. Relocation site options would need to be agreed upon prior to the commencement of survey works between the environmental officer of BGC and the CALM officer responsible for the management of native wildlife in the area. Due to the proximity of the remaining suitable habitat in ownership of the proponent, in the surrounding adjacent land, the default position will be that any Threatened fauna found throughout proposed works should be relocated to within adjacent intact areas. This should serve to minimise displacement effects, out of home range issues and stress on relocated animals. Measures for the temporary storage and handling of native fauna are outlined in Section 4.5.

3.4.3 Bat Tree Hollow Use

It is estimated that 43 of the known 65 Microchiroptera (microbat) species (66%) use tree hollows in Australia (Gibbons and Lindenmayer 2000). An inspection of trees within the proposed quarry area for hollow and crevice dwelling microbat species should be undertaken to ensure that no trees are occupied by bats (this exercise could be completed as part of the targeted fauna survey set out in Section 3.4.1). The primary target species would be *Falsistrellus mackenziei* (Priority 4). If a maternity bat roost is located with young unable to fly these would need to be collected and placed within a hot box and immediately transported to a wildlife carer (see Appendix 1, Section 4.4). If possible the tree should be protected (in accordance with the procedures outlined in Section 3.3) until the young are able to leave the maternity roost.

Management Action	Responsibility
Targeted Threatened Fauna clearance surveys of quarry area immediately prior to habitat clearing work commencing	Environmental Officer
Liaison with CALM regarding the relocation of any Threatened Fauna recorded from the quarry area	Environmental Officer
CALM statutory permits to be obtained for these aspects of the management plan	Environmental Officer

4.0 Construction/Operations Management

4.1 Systematic Habitat Clearance

Objective: To maximise the potential for fauna to escape the quarry area as habitat is progressively cleared.

The clearing activities should be executed immediately after the completion of the Threatened fauna clearance surveys (see Section 3.4). This would ensure that best possible effort has been made to ensure that Threatened fauna species are not present within the area to be cleared.

A systematic working method is necessary to ensure the minimisation of fauna mortality whilst vegetation clearance is undertaken. Clearance should be commenced at the eastern most aspect of the site, and continuing systematically through the development footprint to the west (see Figure 4). The intent here is for fauna that are mobilised by the approach of machinery to be driven westward into intact habitat outside of the clearing boundaries. Whilst pre-clearing surveys (Section 3.4) should minimise the risks of any Threatened fauna remaining inside the clearing envelope, a protocol has been developed to respond to any injured fauna recovered from the works area (Section 4.4).

Clearing works should ideally be conducted outside of the spring – summer period when many native bird species (including the Threatened black cockatoo species) are nesting. This would minimise the risk of nesting birds being impacted by tree clearing on the site.

Management Action	Responsibility
Vegetation clearing to commence from eastern boundary and proceed systematically in a westerly direction.	Site Manager, Plant Operators
Timing of vegetation clearing works to be reviewed to avoid main bird nesting periods	Environmental Officer, Site Manager

4.2 General Site Management

Objective: To manage the general operations of the quarry to a best practice standard to minimise impacts on local fauna.

Daily site management would include the monitoring of general work activities, ensuring that any unavoidable impacts upon fauna are managed, minimised and, where possible, eliminated. All staff should be prohibited from bringing pets, traps or firearms into the project area. Putrescible waste should also be managed in accordance with Shire requirements to minimise feral fauna spread and the potential for Salmonella introduction into native fauna. Liaison between site staff and the environmental officer should take place, in order to review work practices in relation to any new fauna issue that may emerge as the operation progresses.

Management Action	Responsibility
Review the general management of the site on an ongoing basis from the perspective of fauna protection	Environmental Officer

4.3 Fire Management

Objective: To ensure that the risks of bushfire are minimised during construction and that adequate bushfire response equipment is available in the event of a fire.

There is an increased risk of bushfire within the bushland and surrounding area during clearance and/or construction activities. To address this, the following Bushfire Management Plan is to be implemented during these operations (see Table 5.6).

Table 4.1: Bushfire Management Plan.

1. No fires are to be lit within the works area at any time.
2. Construction plant is to be fitted with appropriate fire prevention equipment such as spark arresters and spark shields. All vehicles and plant are to be in good working order and fuel systems are to be inspected for leaks prior to operation. Exhaust systems are to be shielded such that contact with vegetation is not possible.
3. Welding and grinding activities are to be carried out on cleared areas assigned for construction, or behind spark shields, and only when fire-fighting equipment is available for bushfire response.
4. Should a bushfire start as a result of construction activities, plant equipment are to be made available to assist with controlling the fire.
5. The contractor is to liaise with the Shire of Northam Ranger's office to identify the appropriate contact names, radio communication and phone numbers for notification and response to bushfire events in the project area.

The Shire of Northam fire officer and/or the relevant CALM officer is to be consulted if there are any queries regarding wider land operation fire management issues.

Management Action	Responsibility
No fires to be lit at any time within the works area	Site Manager
All machinery or other equipment to be maintained in good working order	Site Manager
The Shire of Northam Ranger's office is to be contacted to identify names and numbers for bushfire notification and response	Site Manager
Plant equipment to be made available to assist with fire control in the event of a bushfire	Site Manager, Plant Operators

4.4 Injured/Orphaned Fauna Protocol

Objective: To ensure that any injured fauna that may be found during habitat clearing are appropriately treated.

All staff of BGC and contractors involved with clearing activities on site should be briefed on the correct protocol to follow if injured or orphaned animals are found. Contact numbers and the appropriate course of action should be made available to all staff to access, including a contact list of wildlife carers and emergency animal rescue centres (see Useful Contacts Lists, Appendix 1). Contractors or other site clearance staff should use the following protocol given in Table 4.2, in the event of finding inured, orphaned or displaced animals:

Table 4.2: Injured/Orphaned Fauna Protocol.

1. Animal found.
2. Discontinue work, switch machine off.
3. Identify animal, if possible (determine if potentially venomous).
4. Contact Environmental Officer or Site Manager.
5. If unable to stay with the animal, clearly mark its position so it is visible to all personnel that approach the site.
6. Follow handling and temporary holding instructions provided in this FMP (Section 4.5).
7. If in any doubt about whether the animal is venomous, do not under any circumstances handle. Instead, monitor the location of the animal and await arrival of experienced wildlife officer or reptile handler.
8. Environmental Officer or Site Manager to contact CALM or Wildlife Carers as appropriate with reference to Appendix 1 of this FMP.

Management Action	Responsibility
Be aware of the potential for injured or orphaned native fauna around the site	All personnel
Follow protocol in the event of locating injured or orphaned fauna	All personnel, Environmental Officer
Contact CALM or Wildlife Carers, as necessary, in accordance with this FMP	Environmental Officer, Site Manager

4.5 Fauna Handling and Temporary Holding

Objective: To minimise stress on any native fauna that require temporary storage, handling or relocation.

Native fauna, and mammals in particular, can be significantly affected by handling and relocation stress. The relocation of any native wildlife should only be undertaken with a Regulation 17 permit issued by CALM (allowing the taking and removal of native fauna species) and only by personnel experienced in the handling of native fauna. Relocation requirements are also discussed further in Section 3.4. Handling and relocation methods vary for herpetofauna, avifauna and mammals.

Herpetofauna
Reptiles can, in most cases, be transported within calico bags of varying size to suit the animal. Plastic carry boxes can also be used with some air holes, leaf litter and sand within them. The animals should always be placed within an area of shade in hot weather so that they do not overheat.

Avifauna
Nesting birds (and all avifauna) are protected by the *Wildlife Conservation Act 1950-1979* and should be left undisturbed until an appropriate course of action has been followed (see Section 4.4). Young birds found within a nest should only be removed if considered by a specialist to be abandoned or injured.

Mammals
Any mammals found throughout the undertaking of works on site the best method of storage and transportation would be within hessian sacks. Mammals may become stressed and agitated in traps or hard containers, some times resulting in injury. Mammals transported in hessian sacks remain calmer due to the dark environment and if kept in the shade and on a soft, secure surface can be transported with relatively limited stress and injury.

4.6 Cockatoo Nesting Boxes

Objective: To supplement nesting opportunities for Threatened black cockatoo species in the locality.

The installation of nesting boxes for cockatoo and owls should be undertaken in positions to be negotiated with Mr Ron Johnstone of the Western Australian Museum. These nest boxes are over a metre tall, made of external plywood and topped with a natural wood hollow for an entrance. The inside of the nesting box is lined with wire mesh to prevent the box from being excessively chewed. The exterior is weatherproofed with a coat of undercoat and *Gripset*, a waterproof, non-toxic adhesive paint. A piece of *Shelltox Pest Strip* attached to the inside of each box deters feral honey bees from taking over, whilst a bottom layer of potting charcoal and a second layer of blended sawdust and German peat provide drainage and a soft nesting surface, respectively. By the use of heavy chains or brackets, the nest boxes are attached to the trunks of large trees at least 14 m above the ground, using a cherry picker or ladder. Other smaller nest boxes could also be installed in addition to the boxes for the black cockatoos to help with the conservation of a range of bird species. The boxes should be monitored for use during the operational life of the quarry. The potential breeding trees identified on the site (Section 3.3) could also be checked for use as part of this annual cycle. This monitoring work would make a valuable contribution to current field trials of cockatoo nesting boxes in WA being undertaken by the Cockatoo Care Programme Team, in association with the Water Corporation.

Management Action	Responsibility
Install cockatoo nesting boxes in surrounding bushland in liaison with WA Museum	Environmental Officer
Carry out annual monitoring of nesting box usage by target species in liaison with WA Museum	Environmental Officer

4.7 Incident Reporting

Objective: To track and document all incidents on site which may affect native fauna and ensure that this provides feedback into site management.

An incident reporting system should be in place prior to the commencement of any activities on site. This system should aim to ensure that all incidents that may result in impacts on native fauna throughout the works are reported, acted upon and feedback into the management of the site. Examples of these may be fauna injury or roadkill, chemical spillages or accidental vegetation damage. The Environmental Officer should review this on an on-going basis, either reporting to the Site Manager, or directly resolving more minor incidents.

Management Action	Responsibility
Document fauna impact related occurrences in the site incident reporting system	Site Manager, Environmental Officer, all personnel
Review fauna related incidents on an ongoing basis to determine if management changes are required	Environmental Officer

4.8 Revision of Plan

Objective: To review the effectiveness and currency of the fauna management measures included in this document during the operational life of the quarry.

The FMP should be reviewed after five years to allow for future revisions and adaptations to made to ensure the highest level of fauna management is employed. Approved methodologies, practices, and legislation for fauna can change over time. It is therefore essential that the appropriate management of fauna within the Voyager Quarry site is open for review and strategic adaptation or change. A review of the document at five-year intervals would also enable management techniques employed to be assessed, through analysing data recorded during monitoring activities.

Management Action	Responsibility
Fauna management actions and incidents on site to be reviewed against the FMP on a five-yearly basis	Environmental Officer, Site Manager
Update and modify FMP, as necessary, to reflect improved practices, legislative changes, etc	Environmental Officer

5.0 Post-construction Management

5.1 Habitat Reconstruction

Objective: To maximise the re-establishment of microhabitats for native fauna species as part of site rehabilitation works.

Once quarrying operations are complete, the site will be subject to rehabilitation works. For the purposes of this FMP it is assumed that a separate topsoil management and rehabilitation plan will address the majority of this requirement. The specifications provided here are intended to maximise the outcomes of revegetation work in terms of fauna habitat reconstruction. The key elements of this are:

- exclusion zones/conservation areas;
- log habitat piles;
- buffer zones; and
- re-vegetation.

5.1.1 Exclusion Zones/Conservation Areas

The provision of exclusion zones or conservation areas immediately outside of the proposed site area should be considered. There are no plans at present to carry out further clearance works on the remaining land surrounding the development footprint that is owned by the proponent. However, this issue would need to be reviewed if further activities and/or clearance works were proposed for the surrounding area, due to the in-combination or cumulative effects of clearance or development. Habitat requirements of the Chuditch and other key target species are discussed in earlier reports (Biota 2003; Appendix 3) and should be considered in this context.

5.1.2 Log Habitat Piles

The retention of cleared timber from the site area is an important measure in helping to maintain local fauna diversity. These log habitat piles should vary from collections of single seasoned and hollowed or hollowing/decomposing logs, such as tree trunks, and branches to collective piles of stacked timber. The log piles will form both instantaneous and future habitat for a diverse fauna, ranging from wood decomposing invertebrates to reptiles, amphibians and the larger mammalian fauna. The location of these wood piles should aim to create a food source, shelter and linkage throughout the remaining site area, not proposed for clearance. The Numbat and the Chuditch, which is known to occur on site, would greatly benefit from these features. Both of these species require hollow logs for refuge, and the Numbats exclusive food source is White Ants or termites, which can be found within decomposing wood. The presence of wood decomposing insects also creates a food source for other foraging mammals and reptiles.

Management Action	Responsibility
Consideration be given to the establishment of exclusions conservation zones in any further development of adjoining land owned by the proponent	Environmental officer, Site Manager
Re-establishment of log piles and other fauna habitat reconstruction as part of site rehabilitation works	Environmental Officer

5.2 Revegetation

Objective: To maximise the use of locally occurring flora species in revegetation works that will be of future habitat value for native fauna species.

It is assumed that a dedicated rehabilitation plan will be prepared separately, with the specification in this Section intended as an adjunct to this to maximise the outcomes of revegetation work for fauna utilisation.

Tall Trees
The following tree species, when in a mature, over-mature or senescent state, and bearing hollows, are used by Carnaby's Cockatoo specifically and other species of cockatoo for nesting purposes;

- Salmon Gum *Eucalyptus salmonophloia*
- Wandoo or White Gum *Eucalyptus wandoo*
- Red Morrell *Eucalyptus longicornis*
- York Gum *Eucalyptus loxophleba*
- Marri or Red Gum *Corymbia calophylla*
- Tuart *Eucalyptus gomphocephala*
- Swamp Yate *Eucalyptus occidentalis*

These tree species should be reviewed against the planned revegetation species list for flora that occur locally. Targeting of species that provide hollows at maturity will improve the long-term value of rehabilitation efforts on the site for hollow breeding fauna.

Low Trees and Shrubs
Low tree and shrub species that will favour the use of the rehabilitation site by target management species should be included in the revegetation plan. Table 5.1 provides a list of plant species that are used as a food source for foraging Carnaby's Cockatoo. This list should be reviewed against locally occurring flora list to provide focus to revegetation plans.

Table 5.1: Plants Species Utilised by Carnaby's Cockatoo.

Family	Genus	Species	Plant part eaten
Protaceae	*Banksia*	*ashbyi*	seeds, flowers
		attenuata	seeds, flowers
		grandis	seeds, flowers
		littoralis	seeds, flowers
		menziesii	seeds, flowers
		verticillata	seeds, flowers
		tricuspis	seeds, flowers
	Dryandra	aff *incirioides*	Seeds
		fraseri	Seeds, flowers
		nivea	seeds, flowers
		nobilis	seeds
		praemorsa	seeds, flowers
		sessilis	seeds, flowers
		speciosa	seeds, flowers
	Grevilliea	*apiciloba*	seeds, flowers
		armigera	seeds, flowers
		paniculata	seeds
		paradoxa	seeds
		petrophiloides	seeds
	Hakea	*auriculata*	seeds
		curcumalata	seeds
		conchifolia	seeds

Family	Genus	Species	Plant part eaten
		crassifolia	seeds
		cyclocarpa	seeds
		falcata	seeds
		gilbertii	seeds
		incrassata	seeds
		lissocarpha	seeds
		multilineata	seeds
		obliqua	seeds
		prostrata	seeds
		ruscifolia	seeds
		scoparia	seeds
		sulcata	seeds
		trifurcata	seeds
		undulata	seeds
		varia	seeds
	Isopogon	*scabriuscula*	seeds
	Lambertia	*multiflora*	seeds, flowers
Myrtaceae	*Eucalyptus*	*marginata*	seeds
		todtiana	seeds
		wandoo	flowers
	Corymbia	*calophylla*	flowers, seeds, nectar
	Callistemon	*viminalis*	nectar
Pinaceae	*Pinus*	*pinaster*	seeds
		pinea	seeds
		radiata	seeds
Araliaceae	*Brassia*	*actinophylla*	fruit
Casuarinaceae	*Casuarina*	sp	seeds
Fabaceae	*Lupinus*	sp	seeds
Geraniaceae	*Erodium*	*botrys*	seeds
Polygonaceae	*Emex*	*australis*	seeds
Rosaceae	*Prunus*	*dulices*	seeds

Management Action	**Responsibility**
Review the native flora species outlined in this Section against those specified for the revegetation works to maximise the value of rehabilitated area as native fauna habitat	Environmental Officer

6.0 References

ANZECC (1991) *Australian and New Zealand Environment and Conservation Council*

Biota and Jhonstone R.E & C. (2003) Voyager Quarry Extension –Targeted Fauna Survey. Unpublished report for BGC Quarries, Perth.

Bush et al (1995) *A Guide to the Reptiles and Frogs of the Perth Region*. University of Western Australian Press, Nedlands, WA.

Gibbons, P. and Lindenmayer, D. (2000) *Tree hollows and Wildlife Conservation in Australia*, CSIRO Publishing.

Johnstone, R and Kirkby, T. (2003) Survey of Significant Trees Within the Proposed Expansion Area (Lots 11 and 14) of the Voyager Quarry Site. Unpublished report for BGC Quarries, Perth.

Orell, P. and Morris, K. (1994) *Chuditch Recovery Plan,* Western Australia Wildlife Management Programme No. 13, CALM.

Seabrook, J. (1988) *Collection of Seed of Australian Native Plants*. The Wildflower Society of WA.

Scheltema M, Harris, J. (1995) *Managing Perth's Bushlands.* Greening Western Australia.

Nichols O.G. and Bamford, M.J. (1985) Reptile and Frog utilisation of rehabilitated bauxite mine sites and dieback-affected sites in Western Australia's Jarrah *Eucalyptus marginata* forest. *Biol. Cons*. 34:227-249.

Internet Source, www.watercorporation.com.au/cockatoocare/carnabys.cfm Cockatoo Care Programme Information.

Ninox Wildlife Consuting (2002). Vertebrate Fauna Habitat Assessment, Avon Loc 1881- Lots 11 & 14 Horton Road, The Lakes, Mundaring. Unpublished report for BGC Quarries, Perth.

Useful Contacts List

Appendix 1

BIOTA

Centre or individual	Specialism	Contact details
Kanyana Wildlife Rehabilitation Centre	Native fauna rehabilitation and care + captive breeding	(08) 92931416 Fax 92572306
CALM	Natural Resource Management	(08) 93340333
Perth Zoo	Captive breeding/species advice	(08) 93677988
Armadale Reptile Centre	Volunteer Snake Catchers	(08) 93996927
Independent Carers	Fauna rehabilitation	Advised through Kanyana

Information on Site Biophyscial Features

Appendix 2

Vegetation & Flora

The vegetation and flora of the site area has been mapped and described by Mattiske Consulting (2002) and fauna habitats superimposed by Ninox Wildlife Consulting (2002). Ninox Wildlife Consulting (2002) recognised five main habitat types within the study area.

- Open Forest to Woodland of *Allocasuarina fraseriana* (Sheoak) – *Eucalyptus marginata* subsp. *thalassica* (Blue-leafed Jarrah) on sandy gravel soils.
- Woodland to Open Woodland of *E. marginata* subsp. *thalassica* – *Corymbia calophylla* (Marri) on sandy gravel soils.
- Open Forest to Woodland of *E. marginata* subsp. *thalassica* – *C. calophylla* – *Banksia grandis* (Bull Banksia) on sandy gravel soils.
- Open to Closed Heath of Myrtaceae – Proteaceae species on shallow soils associated with rock outcropping.
- Open Woodland of *E. wandoo* (Wandoo) on clay – loam soils.

Climate and Micro-climate

Rainfall

Annual rainfall averages and totals for the area are given for each month in 2003, also given are long-term averages aver a 98 year period, see Table 1 (Bureau of Meteorology, Western Australia 2004). These figures were recorded at the weather station at Chidlow approximately 24 km from the site area and are represented in millimetres.

Table 6.1: Annual Rainfall Averages for Site Area

Month	Mean Maximum Long Term Average mm	Actual mm 2003
January	12.0	0
February	16.2	3.8
March	19.4	41.4
April	41.6	73.6
May	112.3	103.6
June	178.8	183.2
July	183.8	129.0
August	140.6	119.4
September	89.7	124.6
October	56.0	21.6
November	25.8	34.2
December	13.3	3.4
Total	887.1	837.8

MMLTA = mean max long term average (calculated over 98 years)

Temperature

Annual temperature averages and totals for the area are given for each month in 2003 Table 2.2 (Bureau of Meteorology, 2004). These figures were recorded at the weather station located at Bickley, which lies 27 km southwest of the site area.

Table 6.2: Annual Temperature Averages for Site Area

Month	Long Term Mean Maximum Averages	Long Term Mean Minimum Averages	Mean Maximum Temperature 2003	Mean Minimum Temperature 2003
January	30.4	15.1	30.4	14.5
February	30.5	15.5	30.3	15.8
March	27.9	14.4	29.4	15.1
April	23.8	12.8	23.4	13.0
May	19.4	10.3	20.6	11.3
June	16.0	8.1	15.9	7.3
July	15.0	7.3	14.5	7.5
August	15.7	7.3	15.5	6.7
September	17.5	8.3	17.0	8.0
October	21.0	9.2	20.6	8.7
November	24.9	11.6	26.1	11.9
December	28.2	13.6	28.0	12.9
Avg totals	22.5	11.1	22.6	11.1

Hydrology
There are no natural bodies of standing water within the proposed site area. The Mundaring Lakes are located approximately 4.0Km to the southwest of the proposed development site.

Geological and Geographical Features
The site survey area is predominantly limestone and the landscape within the survey area has very few topographical features with the exception of minor undulations.

Supplementary Fauna Information

Appendix 3

Introduction

A desktop data search for the site area was undertaken, as part of the 2003 Biota report. Ninox Wildlife Consulting carried out a desktop survey in 2002, following a brief preliminary site survey prior tot he compilation of the report. The following section gives an overview of species diversity recorded on site and within the surrounding area. It is relevant to describe the results of the previous surveys undertaken by Biota in 2002 and 2003 which are given in the sections below, however, the reports should be reviewed for a more detailed knowledge of the fauna representation of the area.

Herpetofauna

Previous surveys recorded 12 species of herpetofauna from the project area comprising four families, including the Agamidae (dragon lizards), Varanidae (monitor lizards), Gekkonidae (geckos) and Scincidae (skinks).

In general, herpetofauna were found to be present in fairly low numbers with few individuals encountered (Table 1). The most frequently recorded species were *Cryptoblepharus plagiocephalus* (n=12) and *Morethia obscura* (n=12). Also recorded were *Pogona m. minor* (n=3), *Egernia napoleonis* (n=2), *Hemiergis i. initialis* (n=1), *Lerista distinguenda* (n=4), *Menetia greyii* (n=2), *Tiliqua r. rugosa* (n=7) and *Varanus gouldii* (n=2). *Crenadactylus o. ocellatus* (n=1), *Oedura reticulata* (n=6) and *Underwoodisaurus milii* (n=1).

Table 1: Herpetofauna species x habitat matrix for the Voyager Quarry Relocation Project (Common names after Bush et al 1995).

Species Name	WW	A/J W	J/M W	Opp	Total
Western bearded dragon *Pogona minor minor*	2	1			3
Clawless gecko *Crenadactylus ocellatus ocellatus*	3	2	1	1	7
Reticulated velvet gecko *Oedura reticulata*	6				6
Barking gecko *Underwoodisaurus milii*	1				1
Fence skink *Cryptoblepharus plagiocephalus*		1	10	1	12
South-western Crevice Egernia *Egernia napoleonis*		1	1		2
Southern five-toed earles skink *Hemiergis initialis initialis*				1	1
South-western four-toed Lerista *Lerista distinguenda*	1	2	1		4
Common dwarf skink *Menetia greyii*		2			2
Southern pale-flecked morethia *Morethia obscura*	1	5	6		12
Bobtail *Tiliqua rugosa rugosa*		2	3	2	7
Gould's monitor *Varanus gouldii*		1		1	2
Number of Species	**6**	**9**	**6**	**5**	**12**

WW = Open Wandoo Woodland; A/J W = Woodland of *Allocasuarina* and Jarrah; J/M W = Jarrah / Marri Woodland; Opp = Opportunistic records.

A list of herpetofauna recorded from an upland jarrah site is given in Nichols and Bamford (1985), who recorded 31 species from localities near Jarrahdale.

Avifauna

The avifauna censusing focused on obtaining evidence of nesting by Rainbow Bee-eaters *Merops ornatus*, Carnaby's Black Cockatoo *Calyptorhynchus latirostris* and the Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*. None of these target species were observed within the study area during the survey, however:

- Rainbow Bee-eaters were recorded nesting in spoil heaps on a Shire of Northam gravel quarry immediately to the north west of the study area;
- Marri fruit collected from several locations showed evidence of foraging by Baudin's Cockatoos (R.E. Johnstone pers comm.);

- Evidence of foraging by either Carnaby's or Baudin's Cockatoo was noted on some larger Jarrah *Eucalyptus marginata* and Marri *Corymbia calophylla* trees in the form of exfoliated bark (the birds were presumably searching for wood-boring grubs); and
- Three Forest Red-tailed Black Cockatoos were noted over The Lakes Roadhouse, 4 km to the west of the project area.

Thirty-six other species of avifauna were recorded from the survey area during the targeted censusing. The five most commonly recorded species in descending order were the Striated Pardalote (n=21), Western Gerygone (n=16), Australian Ringneck Parrot (n=16), Weebill (n=13) and White-cheeked Honeyeater (n=12) (Table 2). Twelve species were recorded from single records only (Table 2). None of these additional birds species currently have any special conservation significance.

Table 2: Avifauna species by habitat matrix for the Voyager Quarry Relocation Project

Common Name	W W	A/J W	J/M W	H	Total
Square-tailed Kite *Hamirostra isura*			1		1
Little Eagle *Aquila morphnoides*		1			1
Australian Kestrel *Falco cenchroides*			1		1
Common Bronzewing *Phaps chalcoptera*			1		1
Baudin's Cockatoo *Calyptorhynchus baudinii*		S			S
Sulphur-crested Cockatoo *Cacatua galerita*		1			1
Regent Parrot *Polytelis anthopeplus*			1		1
Australian Ringneck *Platycercus zonarius*			16		16
Red-capped Parrot *Platycercus spurius*			1		1
Pallid Cuckoo *Cuculus pallidus*			1		1
Horsfield's Bronze Cuckoo *Chrysococcyx basalis*	3				3
Boobook Owl *Ninox novaeseelandiae*	1				1
Australian Owlet-nightjar *Aegotheles cristatus*	1				1
Laughing Kookaburra *Dacelo novaeguineae*			7		7
Rainbow Bee-eater *Merops ornatus*	1		4		5
Splendid Fairy-wren *Malurus splendens*	1				1
Striated Pardalote *Pardalotus striatus*	9	1	11		21
Weebill *Smicrornis brevirostris*	5	1	7		13
Western Gerygone *Gerygone fusca*	5	4	7		16
Broad-tailed Thornbill *Acanthiza apicalis*		4			4
Western Thornbill *Acanthiza inornata*	3		1		4
White-cheeked Honeyeater *Phylidonyris nigra*			12		12
Tawny-crowned Honeyeater *Phylidonyris melanops*		1		3	4
Western Spinebill *Acanthorhynchus superciliosus*		1			1
Red Wattlebird *Anthochaera carunculata*	3	1	3		7
Scarlet Robin *Petroica multicolour*	1		4		5
Western Yellow Robin *Eopsaltria australis*		3			3
Varied Sittella *Daphoenositta chrysoptera*			3		3
Rufous Whistler *Pachycephala rufiventris*		3			3
Grey Fantail *Rhipidura fuliginosa*			4		4
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	1	2			3
Australian Magpie *Cracticus tibicen*		2			2
Australian Raven *Corvus coronoides*	2	1	1		4
Welcome Swallow *Hirundo neoxena*			6		6
Tree Martin *Hirundo nigricans*			7		7
Grey-breasted White-eye *Zosterops lateralis*	1	1			2
Number of Species	**14**	**16**	**21**	**1**	**36**

WW = Open Wandoo Woodland; A/J W = Woodland of *Allocasuarina* and Jarrah; J/M W = Jarrah / Marri Woodland; H = Open to closed heath of Myrtaceae - Proteaceae.

Some 16 species of obligate hollow nesters may potentially occur in the study area given their occurrence nearby and / or habitat preferences. R.E. and C. Johnstone (2003).

Mammals

The survey works undertaken in 2003 within the site area recorded eight species of mammal including six native and two introduced taxa. The native species comprised the Echidna *Tachyglossus aculeatus*, Mardo (Yellow-footed Antechinus) *Antechinus flavipes*, Chuditch *Dasyurus geoffroii*, Western Grey Kangaroo *Macropus fuliginosus*, Western Brush Wallaby *Macropus irma* and Common Brushtail Possum *Trichosurus vulpecula*. The two introduced species included the Rabbit *Oryctolagus cuniculus* and Red Fox *Vulpes vulpes*.

Although no Phascogales were seen during the survey, two specimens (both road kills) have recently been lodged with the WA Museum from the area. The single Western Brush Wallaby noted during the survey was a road kill close to the entrance of the quarry. Details are given in the original report ref (Biota 2003).

Threatened Fauna

This section details the current conservation and protection status that applies to species recorded on site, and species that are known to be present within the surrounding area, or whose ranges and habitat overlap with the site.

In WA, all native fauna species are protected under the *Wildlife Conservation Act* 1950-1979. Fauna species that are considered rare, threatened with extinction or have high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan & Australia Migratory Bird Agreement (JAMBA) and the China & Australia Migratory Bird Agreement (CAMBA).

Classification of rare and endangered fauna under the *Wildlife Conservation (Specially Protected Fauna) Notice* 1998 recognises four distinct schedules of taxa (see Table 3).

Table 3 Schedules of conservation significance for fauna species.

1. Schedule 1 taxa are fauna that are rare or likely to become extinct and are declared to be fauna in need of special protection;

2. Schedule 2 taxa are fauna that are presumed to be extinct and are declared to be fauna in need of special protection;

3. Schedule 3 taxa are birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction which are declared to be fauna in need of special protection; and

4. Schedule 4 taxa are fauna that are in need of special protection, otherwise than for the reasons mentioned in paragraphs (1), (2) and (3).

In addition to the above, CALM classifies fauna under four Priority codes (Table 4).

Table 4 Priority conservation codes for fauna species.

1. Priority One Taxa with few, poorly known populations on threatened lands.

   Taxa that are known from few specimens or sight records from one or a few localities on lands not managed for conservation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

2. Priority Two Taxa with few, poorly known populations on conservation lands, or taxa with several, poorly known populations not on conservation lands.

   Taxa that are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

3. Priority Three Taxa with several, poorly known populations, some on conservation land.

Taxa that are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

4. Priority Four Taxa in need of monitoring.

Taxa which are considered to have been adequately surveyed or for which sufficient knowledge is available and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands. Taxa that are declining significantly but are not yet threatened.

Threatened fauna are also listed in any one of the following categories as defined in Section 179 of the *Environment Protection and Biodiversity Conservation Act 1999*: Extinct; Extinct in the wild; Critically endangered, Endangered; Vulnerable; and Conservation dependent (http://www.ea.gov.au/biodiversity/threatened/species/index.html).

An account of the Threatened species know or suspected to occur on the site follows.

Schedule Fauna

Carnaby's Cockatoo *Calyptorhynchus latirostris* (Schedule 1)
Confined to the southwest of Western Australia, ranging north to the lower Murchison and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noongar, Lake Cronin, Oldfield River and Cape Arid. Most breeding occurring between the 350 mm and 700 mm rainfall isohyets (Garnett 1992).

Listed as Endangered in Action Plan for Australian Birds (Garnett and Crowley 2000). Uncommon to common in wetter parts of range, scarce and patchily distributed in driest parts of range. Usually in pairs or small flocks, occasionally in large flocks up to 7000 in non-breeding season especially at pine plantations. It is a postnuptial nomad, tending to move coastward after breeding into higher rainfall areas. This species has declined greatly since World War II because of widespread clearing of semiarid sand plains for agriculture and removal of its principal nesting tree (salmon gum) from the Wheatbelt (Garnett 1992, Johnstone and Storr 1998). It has shown a reduction in its range, especially in the northern and eastern areas of the Wheatbelt and there is an apparent shift in its distribution further west and south since the middle of the century. This species is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act* 1999.

Habitat comprises mainly proteaceous scrubs and heaths, and eucalypt woodlands and forests; also plantations of *Pinus* spp. since the early 1930s. Generally favours salmon gums *Eucalyptus salmonophloia* and wandoo *E. wandoo*, and shrubland or kwongan heaths dominated by *Hakea*, *Dryandra* and *Banksia* species. A close association between feeding areas and the woodlands for nesting habitat are important for the breeding success of this cockatoo (Saunders 1977). Attracted to seeding *Banksia*, *Dryandra*, *Hakea*, *Eucalyptus*, *Corymbia*, *Grevillea*, *Pinus* and *Allocasuarina* spp., flowering *Dryandra sessilis*, *D. quercifolia*, *Lambertia inermis*, *Banksia*, *Eucalyptus*, *Grevillea* and *Callistemon*, also fruiting almonds and the seeds of corkscrews *Erodium* spp., and accessible water and trees around watercourses that provide shade in summer. Carnaby's Cockatoo occurs less frequently in jarrah - marri and karri forests than does Baudin's Cockatoo.

In the Voyager Quarry area this species appears to be generally scarce. Recorded in small flocks in neighbouring areas including Wooroloo, Chidlow, The Lakes, upper Helena River (Flynn Road area), Mt. Helena, Mundaring and lower Darkin River.

Breeding is recorded mainly in semiarid and subhumid interior, from Three Springs south to the Stirling Range and west to Cockleshell Gully, Cataby, Regans Ford, Gingin, Yanchep, Walyunga, The Lakes area, Boddington and Tone River. Nests in hollows of live or dead eucalypts, primarily the smooth-barked salmon gum and wandoo, also red morrell, York gum, tuart, flooded gum, gimlet, swamp yate and marri. Nest hollows range from 2–12 m above ground, size of entrance from 23–30 cm and depth of hollows from 1–2.5 m. Both adults prepare the hollow, stripping chips from the sides of the entrance and inside of the hollow, and raking the bottom. Eggs laid on wood chips at the bottom of the hollow from early July to mid October, clutch one or two (mostly two, but usually only one young is reared). Prior to the breeding season the flocks break up into smaller units and return to their breeding areas, pairs often using the same hollow that was used the previous season.

There is strong competition for the use of hollows with Australian Shelducks *Tadorna tadornoides*, Australian Wood Ducks *Chenonetta jubata*, Grey Teal *Anas gracilis*, Black Ducks *Anas superciliosa*, Barn Owls *Tyto alba*, Boobook Owls *Ninox novaeseelandiae*, Corellas *Cacatua* spp., Galahs *Cacatua roseicapilla*, Australian Ringnecks *Platycercus zonarius*, Brushtail Possums *Trichosurus vulpecula* and feral bees *Apis mellifera*. Tree hollows are also lost as a result of clearing, tree fall, fire, and collapse of the chamber floor or damage to the hollow by other parrots or humans.

The Voyager Quarry site contains very few suitable breeding hollows for this species (i.e. large top entry hollows in wandoo, marri or jarrah). The closest recorded breeding sites to Voyager are at Flynn Road (near The Lakes), Walyunga National Park and near Bindoon.

Baudin's Cockatoo *Calyptorhynchus baudinii* (Schedule 1)
Confined to the south-west of Western Australia, in humid and subhumid zones, ranging north to Gidgegannup, east to The Lakes, Mt. Helena, Christmas Tree Well, Wandering, Williams, Kojonup, near Cranbrook, King River, and west to the Swan Coastal Plain including West Midland, Byford, North Dandalup, Yarloop, Wokalup, Yalgorup and Bunbury; also the Stirling and Porongurup Ranges and east to Waychinicup. Occurs mainly in eucalypt forests especially jarrah *Eucalyptus marginata* - marri *Corymbia calophylla* forest but also karri *E. diversicolor*, wandoo *E. wandoo* and tuart *E. gomphocephala*, also orchards and farmlands (see also Blakers et al. 1984). Forage at all levels in forest; attracted to seeding marri, also *Banksia* and *Hakea*, to seeding *Erodium botrys* and to fruiting apples and pears; and strip bark and wood from trees, especially dead trees in search of insect larvae.

Listed as Near Threatened in Action Plan for Australian Birds (Garnett and Crowley 2000). It is scarce to moderately common (most numerous in deep south-west); usually in small flocks (up to 50), occasionally in large flocks (up to 900) at roosting sites. Estimate of total population in WA 15–20,000, but breeding population is small, possibly only 10-20%. It is a postnuptial nomad, movements including visits between March and September to central and northern Darling Range and adjacent far west of Swan Coastal Plain. It has declined greatly in the last 50 years, its low rate of reproduction (0.6 chick per year) precluding it from replacing the large number shot by orchardists and those lost through other causes (e.g. habitat destruction). Over a quarter of its original habitat has been cleared for agriculture. This species is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act* 1999.

In the Voyager Quarry area this species appears to be generally scarce. Recorded in small parties at Gidgegannup, Chidlow, The Lakes area, Mt. Helena, Flynn Road and the northern end of Yarra Road. Mainly reported in family parties (male, female and juvenile or immature), occasionally in small flocks (up to 20), rarely larger flocks (up to 50), not recorded for the quarry site but small numbers had recently been feeding on the seeds of several large marri trees near north-eastern boundary of the site. Some dead trees also showed signs of cockatoo feeding (Baudin's or Carnaby's) (i.e. stripped bark where birds had been searching for insect larvae).

Breeding recorded in October - November. Little is known about their breeding biology especially tree hollow requirements and breeding site characteristics. Only 10 nests are recorded for the entire southwest. Research undertaken by Johnstone et al (2000) shows that birds become mature and begin to breed at about four years of age. Nests are in very large, old eucalypts, especially marri but also jarrah, wandoo, karri and tuart. Favours top entry hollows with entrances ranging from 15–48 cm in diameter and depth of hollow ranging from 0.46–2 m. Clutch 1 (rarely 2, but only one young reared). Most nests appear to be thinly dispersed through the available feeding habitat but in some areas (e.g. Serpentine and Kojonup) are as close as 100 m. Overall in the southwest there appears to be a lack of suitable nest hollows and strong competition for available nest sites, especially from feral bees.

Nearly all the Voyager Quarry site had been logged or partly logged, greatly reducing nesting and feeding habitat. The closest recorded breeding site is on Yarra Road on lower Darkin River (31° 12' S, 116° 26' E).

There are very few suitable hollows available for this species (i.e. large top-entry chimney stack hollows in marri trees) at the Voyager Quarry site.

Chuditch *Dasyurus geoffroii* (Schedule 1)
A chuditch release programme was undertaken by CALM in 1998 at several sites within the Mundaring area to the north and south of the Mundaring weir. Results based upon monitoring exercises recorded in 1999 showed that there were no records of Chuditch to the south, but there was a 14% capture peak recorded in the northern sites, dropping to between 4-8% over the course of the year (Orell P, CALM 2004). . Evidence of Chuditch was recorded from an Elliott trap (VO01) within the development footprint (Biota 2003). No further details on Chuditch are available for this area.

Numbat *Myrmecobius fasciatus* (Schedule 1)
No records of Numbat were recorded for the survey area, however a Numbat release programme for the Mundaring area was undertaken in the Nochine Forest Block, between Pool road and Bericine road area in 1999 (Orell P, CALM 2004). A radio collar monitoring exercise was undertaken in 2000 with reasonable results, showing Numbat still to be present within the area. In September 2003, a search of the area was conducted in order to find scats and diggings indicative of use of the area by Numbat. As reported within the monitoring report no evidence of use of the area by Numbat were recorded at this time. This may be due to the following:

- The numbat population released within the Mundaring area has moved into, and populated other areas that have as yet had no evidence recorded of Numbat.
- The Numbat population released within the Mundaring area has perished due to lack either lack of White Ant availability, competition for habitat or predation.

The quarry relocation area is considered by CALM to be within the expected expansion range for Numbat populations, based upon known Numbat ranges and the localised suitable habitat.

Carpet Python ***Morelia spilota imbricata*** **(Schedule 4)**
This sub-species is broadly distributed across much of the southwest, but has been given its protected status due to the fact that it is not common anywhere in its range. Individuals would probably shelter amongst rock piles and in hollow branches and logs on site. None were recorded from the study site during the survey but the species is known to occur in the locality.

Priority Fauna

Forest Red-tailed Black Cockatoo ***Calyptorhynchus banksii naso*** **(Priority 3)**
Endemic to Western Australia. This subspecies occurs in the humid and subhumid south-west, mainly in hilly interiors, north to Gingin (formerly to Dandaragan), Gidgegannup, and east to Mt. Helena (formerly to Toodyay), Chidlow, Wooroloo, Wundowie, The Lakes, Christmas Tree Well, North Bannister (formerly to Wandering), Mt. Saddleback, Kojonup, Rocky Gully, the upper King River and Porongurup Range.

Occurs mainly in jarrah *Eucalyptus marginata* - marri *C. calophylla* and karri *E. diversicolor* forests. Attracted to seeding marri, jarrah, blackbutt *E. patens*, Albany blackbutt *E. staeri*, karri, sheoak *Allocasuarina fraseriana* and snottygobble *Persoonia longifolia* (Johnstone and Kirkby 1999). Higgins (1999) notes that this subspecies feeds arboreally in fruiting marri.

A Priority 3 species, the Forest Red-tailed Black Cockatoo has seriously declined in numbers since European settlement (Saunders and Ingram 1995). Listed as Near Threatened in Action Plan for Australian Birds (Garnett and Crowley 2000). Storr (1991) reports that the species was formerly common but is now uncommon and patchily distributed over a range which has become markedly reduced. Causes include clear-felling and 80 year cut rotation forestry practices, which can significantly reduce the number of large tree hollows (Saunders and Ingram 1995). Usually in pairs or small flocks, seldom-large flocks (up to 200). Estimate of total population 10–15,000 birds but breeding population is small (possibly only 10–20%). Flocks consist of juveniles (birds of the year), immature (up to 4 years old), adult non-breeders and breeding adults. Some of the non-breeding birds may be still too young to breed (i.e. sub-adult) or could be old senescent birds. Although not recorded from the study area, three birds (adult male, adult female and a young bird) were noted over The Lakes, four kilometres to the West.

Few breeding reports. Nesting in large old eucalypts, mainly marri but also jarrah, karri, wandoo and bullich. Favours top entry hollows with entrances ranging from 12–14 cm in diameter, hollow depth 1–5 m, and height of entrance 8–30 m above ground. Breeding may be tied to the heavy nutting cycle of the marri. Clutch one (very rarely two) laid on wood chips at bottom of hollow. Incubation period 29–31 days and only the female incubates and broods. Generally most breed in October - December, but one pair nested in May in 1999, four pairs were recorded nesting in April–May–June 2000 near Bedfordale, Serpentine and Collie, and many pairs were recorded breeding in April–May 2001. The summer and autumn of 2000–2001 were the driest on record in much of the southwest of the State and this appears to have affected the breeding cycle. Most pairs appear to breed every second year, although one pair in Collie was recorded breeding every year for three years (but the chick may not have survived). It is believed that these birds nest in loose colonies with nest trees as close as 50–60 m. This is probably because most members of the flock are closely related and return to their natal area to breed. Breeding fairly close together may also help the flock keep contact.

Research on this subspecies shows that suitable hollows within the breeding areas are at a premium, as most of the study sites have been previously logged or mined. They do not breed until at least four years of age and the breeding population is small. For example, one of our study flocks of 50 birds contains only 3–4 breeding pairs and another of around 100 birds has only 10–12 breeding pairs. Johnstone et al. (unpublished data) have surveyed and documented six nests in Bungendore Park (ca. 500 ha), 10 nests in ca. 1,000 ha near Serpentine, and six nests fairly close together at a study site 19 km east of Collie.

Brush-tailed Phascogale *Phascogale tapoatafa* (Priority 3)
The Brush-tailed Phascogale is a largely arboreal, carnivorous dasyurid that occurs in a variety of regions in Australia with open, dry sclerophyll forests and reliable rainfall patterns (Cuttle 1982). The southwest populations of *Phascogale tapoatafa* are listed by Department of Conservation and Land Management as Priority 3.

Two specimens from the vicinity of the project area have been recently lodged with the Western Australian Museum. The first (a female M49940) was recorded from a road kill adjacent to the quarry (116.3522°E 31.8758°S) on the 20/12/01 and the second (a male M49941, also a road kill) from adjacent to the quarry (116.3194°E 31.8785°S) on the 07/01/02.

Appendix H

Summary of Trapdoor Spider Study and Trapdoor Spider Reports

APPENDIX H: TRAPDOOR SPIDER SURVEYS

Table of Contents

Summary of the Findings of the *Gaius* sp. Trapdoor Spider March 2004 Survey

1.0 INTRODUCTION

A survey of the *Gaius* sp. trapdoor spider population within lots 11 and 14 (Avon Location 1881), Horton Road, was conducted by B. York Main and S. Trent between 10 and 24 March 2004. This survey was conducted as a follow-up to work undertaken in July and August 2002, which revealed an undescribed trapdoor spider species (*Gaius* sp) (Main, 2002).

A regional survey was also undertaken to ascertain whether the species has a wider geographic occurrence. This survey involved searching the area between lots 11 and 14 and the intersection between Brookton Highway and Beraking Pool Road, which are known locations for *Gaius* sp. The regional survey was conducted over four days during the survey period of 10 and 24 March 2004.

2.0 OBJECTIVES

As defined in the scope prepared by B. York Main, the key objectives of the survey work undertaken in March 2004 were:

1. To determine the population size and distribution in lots 11 and 14 of *Gaius* sp. spiders and to describe their habitat preferences.
2. To collect male specimens and thereby assist with diagnosis of species and confirm generic placement.
3. To conduct a comprehensive survey outside the above location to ascertain whether the species has a wider geographic occurrence in adjacent land and on sites with similar habitat and topographic position within the Darling Range southward from the above location.
4. Consideration to be given during the above surveys of the likelihood of favourable sites in lots 11 and 14, in neighbouring land holdings and in the wider region for possible relocation of selected spiders at a later date.

3.0 METHODS

3.1 Spot-checks

To determine the distribution of *Gaius* sp. within lots 11 and 14, spot checks were conducted semi-randomly. The search area covered a 15 m radius at each site and a 15 minute sampling time was allocated for each site. At each site the occupation or evidence of occupation by the spiders was determined. If the area was occupied the following observations were made:

- the number of viable burrows;
- GPS coordinates;
- soil type; and
- field notes on basic vegetation structure.

To assess the accuracy of the spot-checks in determining occupation, five sites where no spiders were found within the 15 minute sampling time, were re-examined for an additional 30 minutes.

Based on the number of burrows located during each spot-check, the following density categories were determined:

- Evidence of occupation or 1 burrow – low density;
- 2 to 3 burrows – medium density;

- 4 to 5 burrows – medium/high density; and
- ≥ 6 burrows – high density.

3.2 Detailed Survey of Selected Site

A detailed survey was undertaken within the proposed quarry site area, due to the relatively dense subpopulation along the ecotone of intersecting heath and open woodland of jarrah (*Eucalyptus marginata*) and sheoak (*Allocasuarina fraseriana*) that was identified during the 2002 survey.

During this detailed survey, individual burrows within the study area were initially found and marked with metal pegs and flagging tape. The diameter of the opening of each burrow was measured and recorded, or if a burrow was sealed, then the diameter of the trapdoor was measured. The position of the burrow in relation to the surrounding understorey vegetation was recorded (ie. directly under cover, semi-exposed and exposed).

Using the data collected in this detailed survey, the following three size classes were determined:

1. large trapdoor spider burrow: 26-35 mm
2. medium trapdoor spider burrow: 16-25 mm
3. small trapdoor spider burrow: 0-15 mm

These provide an indication of the age of the trapdoor spider.

3.3 Pitfall Traps

Six pitfall traps were positioned next to burrows that were estimated to be about the size of a burrow for a male, within the proposed quarry site area. The pitfall traps comprised of two litre plastic ice-cream containers with about 10 cm of anti-freeze liquid (ethyl glycol) in the base. Ethyl-glycol is a standard preservative used in long-term biodiversity sampling for invertebrates.

Traps were installed below the ground surface so that the top of the container was flush with the soil surface.

3.4 Sampling for Taxonomic Specimens

Several burrows were selected for excavation to obtain specimens for morphological/taxonomic examination and assessment. This involved digging a pit adjacent to a burrow and making a longitudinal section of the burrow. The spider was collected from the base of the burrow using forceps and placed in a jar.

3.5 Regional Survey

A search for the presence of the *Gaius* sp. trapdoor spider outside of the proposed quarry area was undertaken. Sites were selected using:

- Information on vegetation type and structure provided by Dr L. Mattiske; and
- Previous experience of B. York Main.

The sites were traversed by vehicle, and at some 17 potential sites, spot-checks were conducted to ascertain whether or not the species was present. At each site, the following information was recorded:

- whether the site was occupied or unoccupied by the species;
- sampling time (usually 15 minutes on average, but up to 30 minutes);

- vegetation/soil field notes; and
- GPS coordinates.

4.0 RESULTS

4.1 Population Size and Distribution of *Gaius* sp. in Lots 11 and 14

The population distribution and density of *Gaius* sp. spiders in the vicinity of lots 11 and 14 is shown on Figure 1. Spiders were estimated to occupy approximately 33% of the area of lots 11 and 14. Most of the occupied areas that were located during the spot-checks had a medium density of burrows (2-3 burrows).

The densest aggregation of burrows was located within the proposed quarry relocation area (Figure 1). This area was located along the ecotone between heath and open Jarrah woodland and was the focus of the detailed survey (Figures 2 and 3). The extremely dense population at this site is considered to be the core population for the area from which other spiders have migrated outward.

The total number of burrows that were recorded in lots 11 and 14 during spot-checks and the detailed survey was 178 burrows (including 1 defunct burrow) of which 79 burrows were recorded in the detailed survey of the ecotone. Of this total, 124 burrows[1] were located within the proposed quarry relocation area. It should be noted that this population size estimate has been obtained using two different methods. The numbers obtained from the detailed survey are reliable. However, those obtained during the spot-checks may be an underestimate.

4.2 Habitat Preference of *Gaius* sp.

It is apparent that an upper canopy structure consisting of open woodland or open forest dominated by jarrah (*Eucalyptus marginata subsp. thalassica*) with scattered marri (*Corymbia calophylla*) and sheoak (*Allocasuarina fraseriana*) is the preferred habitat for the *Gaius* sp. (Figure 4). At all of the occupied sites, an understorey comprising shrubs of predominantly *Hakea, Lepidosperma* and *Dryandra* spp. formed a low semi-closed canopy.

The substrate of occupied sites consisted of sand or sandy clay (loam) soils (<10% clay) and usually with a small to large amount of pisolitic gravel present. The results of the survey work indicated that soils consisting of predominantly large gravel pebbles were not favourable for the establishment of the *Gaius* sp. burrows. Burrows were also absent from areas where there was a lateritic cap or where granite was close to the surface.

Burrows were generally located directly under cover or partially covered areas. There was an observed relationship between the size of the burrow and the position of the burrow in relation to the surrounding understorey vegetation (Figure 5). For the smallest size category (0-15 mm), 63% of burrows were located directly under cover, 32% semi-covered and 5% were exposed. For the largest size category (26-35 mm), only 37% were located under cover, whilst 48% were semi-covered and 15% were exposed. The higher percentage of individuals in larger size classes occupying semi-exposes areas might be due to the death of vegetation under which they were initially sheltered.

4.3 Collection and Identification of Specimens

A male specimen was collected from Burrow 14. Examination of the male shows that it has some similarities with Collie specimens, which in turn have similarities with an unnamed species that

---

[1] Following the completion of trapdoor spider study, BGC confirmed that 85 ha of clearing will be required for the proposed quarry and therefore the southern boundary was extended. Subsequently, there are an additional 8 burrows (including 1 defunct burrow) within the proposed quarry footprint. Therefore, there are actually 132 burrows within the proposed new quarry footprint.

extends from Tambellup and disparate localities between Ravensthorpe and Esperance. However, it should be noted that these specimens and the specimen from the study area have markedly different palpal structures and other secondary features from specimens on the plateau.

4.4 Regional Survey

No populations in addition to the already known populations were observed during the survey. The known populations are located in:

- lots 11 and 14;
- adjacent land vested in the Water and Rivers Commission located to the west and south of lots 11 and 14 and considered to be a sub-population therefrom (Sites 106,118 and 127, Figure 6); and
- a site at the intersection of Beraking Pool Road and Brookton Highway (Inset 2, Figure 6).

The locations where spot-checks were conducted are presented in Figure 6. No spiders were found at any of these sites after a 15 minute inspection, except at the known location at the intersection of Beraking Pool Road and Brookton Highway.

5.0 DISCUSSION

The results of the 2004 survey indicated that there were high concentrations of *Gaius* sp. burrows in the proposed quarry area. This distribution was related to the presence of the ecotone between the woodland and heath. This area was selected for a demographic assessment of the population due to the extensive aggregation of burrow and range of burrow sizes. The results of the demographic assessment indicated that there were fewer individuals in the smallest category size (0-15 mm) than the medium to larger size categories. This may be partly accounted for by the summer mortality of the previous winter's recruitment. There were high proportions of juveniles and mature spiders.

The *Gaius* sp. originally found in lots 11 and 14, Horton Road, is of biogeographic interest because it does not appear to have morphological affiliations with the populations east of the Avon. From prior records, there is a gap in the distribution of *Gaius* within the southern part of the Mortlock River drainages, as there are no records in the area east of York and south of Kellerberrin. The absence of *Gaius* from these areas could reflect a geohistorical environment that is unfavourable for occupation by *Gaius*.

The site within lots 11 and 14 represents a relictual upland area, which also forms part of the divide between inland and western drainage lines along which remnants of old landscapes persist. Prior to the uplift of the old plateau (Western Australian Shield), the course of the Avon River was directed along the Darkin-Talbot Divide and westward through the Helena Valley. Therefore, the site within lots 11 and 14 could be the relictual northerly point of an essentially southern distribution of the spider.

The survey team did not record evidence of (recent) fire within the detailed study site. It should be noted that the *Gaius* sp. spider population is likely to be adversely affected by fire because the species does not make a soil plug at the burrow entrance. Hence, lots 11 and 14 should not be burned and should be protected from bushfires.

The vegetation at the Brookton Highway/Beraking Pool Road site is a degraded jarrah/redgum dominated woodland with open shrubby understorey. The site has been heavily logged in the past but has some regrowth coppicing. During the 2004 survey, it was observed that there has been recent logging in the area with the stockpiling of timber along the edge of the spider site, which has interfered with the spider habitat. The interference to this site has rendered it unsuitable for the translocation and long-term preservation of the *Gaius* sp. from the proposed quarry area (Lot 14).

There is only one documented case of a spider being successfully translocated. This translocation exercise involved one adult female specimen of *Idiosoma sigillatum* which was translocated from a Nedlands garden to bushland at the Department of Conservation and Land Management Wildlife

Research Centre at Woodvale (Prince, 2003). Although it is possible to translocate an individual spider, the translocation of a population of spiders would require a long-term commitment.

6.0 CONCLUSIONS

The main findings of the 2004 trapdoor spider survey of lots 11 and 14 and the surrounding area are:

- The core population (containing approximately 79 burrows) is located within the proposed quarry relocation area. The long-term persistence of the other spiders within the vicinity of this area may be dependent on this core population. Main (1987) noted that *Anidiops villosus* (Rainbow) (=*Gaius villosus* Rainbow) can persist in remnant bush provided about 20 matriarchs (reproductive age females), representing about 25% of a given subpopulation, are present in a group of closely aggregated clusters and with additional aggregations (of similar representative age structure) scattered in proximity in continuous bush. Thus, extrapolating from other studies and considering the disparate distribution of low density clusters of the *Gaius* sp. in lots 11 and 14 outside the dense aggregation in the proposed Voyager Quarry relocation area (and that minimal size of reproductive females is not known), it is unlikely that the population of *Gaius* sp. will be able to persist in the long-term if this “core” population is destroyed.
- Should the quarry relocation proceed, approximately 54 burrows (including 1 defunct burrow)[2] will not be disturbed on the remaining areas of lots 11 and 14. Whilst these spiders are likely to survive in the short- to medium-term, their long-term persistence without the core population providing regular recruits is questionable.
- The *Gaius* sp. spider population is likely to be highly sensitive to fire because the species does not make a soil plug at the burrow entrance. Therefore, fire management should be a critical component of any land management plan for lots 11 and 14.
- The male specimen of *Gaius* sp. spider from lot 14 differs morphologically from other male specimens of *Gaius* spider populations that have been found to the east of the Avon.
- The *Gaius* sp. population from lots 11 and 14 appears to be the northern extent of the southerly distribution of *Gaius* spider populations. The Voyager (male) specimen does have some morphological affinity with “southern” spiders. The Voyager species may be either the same or a different species (derived from a possibly once continuous population) as the species farther south. More morphological comparisons need to be made. For example, comparisons on samples of internal genitalia of females and comparisons of additional male specimens (from Voyager) and Collie need to be made. The specific status is still not conclusive.
- The *Gaius* sp. spider has been found in low numbers on land adjacent to lots 11 and 14, and in a degraded area near the intersection of Brookton Highway and Beraking Pool Road.
- Whilst trapdoor spiders can be readily translocated into artificial accommodation such as flower pots of soil maintained in a laboratory, translocation of large populations in the field has not yet been attempted and the likely success of such translocation is unknown.

7.0 RECOMMENDATIONS

The main recommendations based on the results of the 2004 survey are:

- If the proposed quarry proceeds, fire management strategies should be implemented to protect the remaining spiders, as the *Gaius* sp. is likely to be sensitive to fire.

---

[2] As the southern boundary of the proposed quarry has been extended to reflect 85 ha of clearing for the Project, there will 46 burrows that will not be disturbed by the proposed project.

- Given the uncertainty of long-term survival of the spider in this area if the quarry relocation proceeds, further investigation is desirable to locate a dense population within the conservation estate nearby so that there is confidence that the *Gaius* sp. will persist in the long-term.

The requirements for translocation of the *Gaius* sp. from Lot 14 at a population level would involve:

- identification of a suitable habitat for the translocation of spiders;
- excavation and removal of the specimens, which is a labour intensive process;
- establishment of artificial burrows at the new site; and
- implementation of a monitoring programme for the first three years, then at 10 and 20 years.

Once the translocation exercise has been completed, the monitoring programme needs to include an assessment of the following:

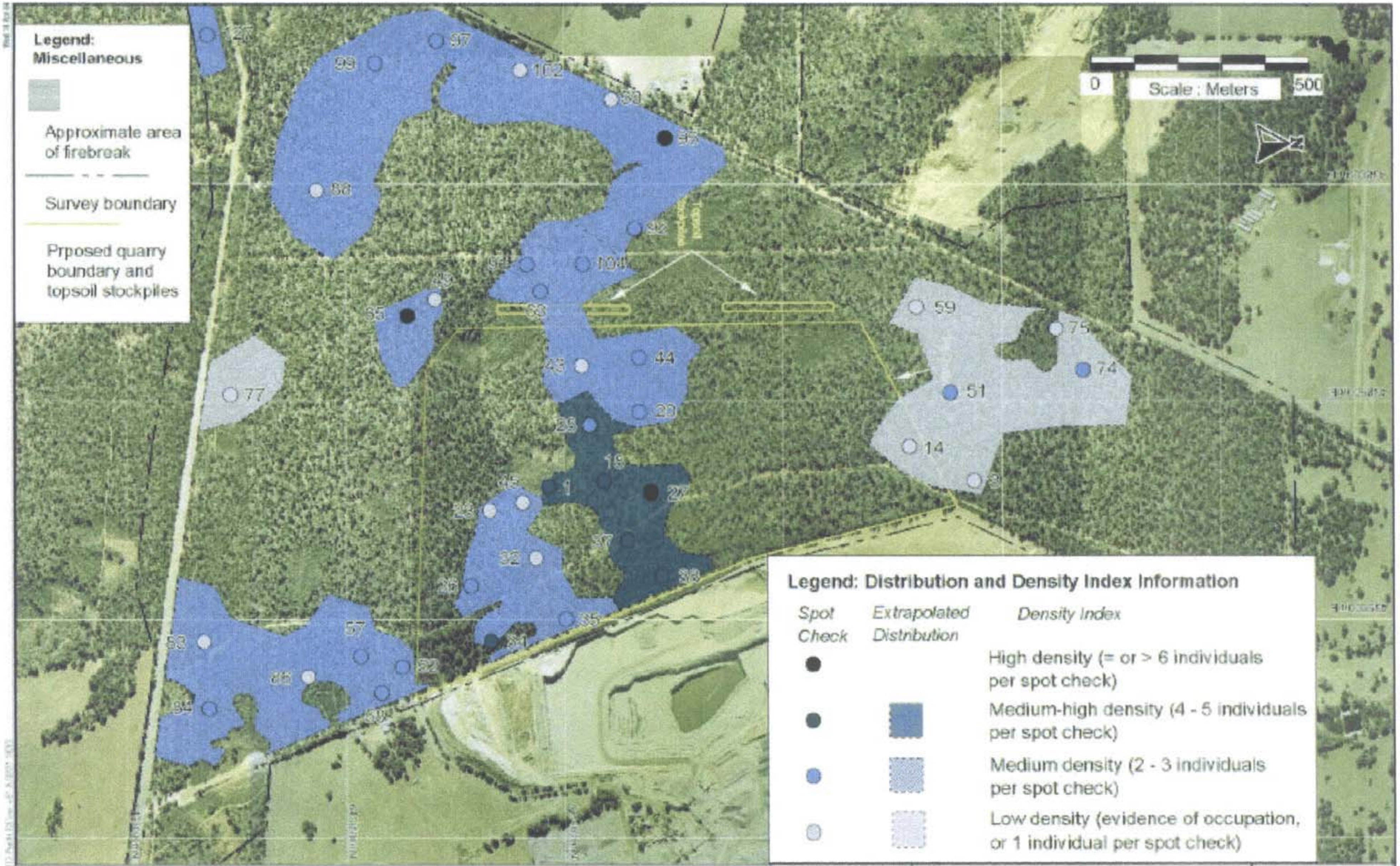
- establishment of spiders;
- reproductive success as measured by establishment of recruits; and
- generational turnover (i.e. continuing reproductive success and maintenance of an ongoing viable population).

8.0 REFERENCES

Main, B.Y. (1987). Persistence of invertebrates in small areas: Case studies of trapdoor spiders in Western Australia. In: *Nature Conservation: The role of remnants of native vegetation.* (Ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.) Surrey Beatty & Sons, CSIRO and CALM.

Main, B.Y. (2002). *Survey of Trapdoor Spiders Occurring in Avon Location 1881, Lots 11 and 14, Including an Area for Proposer Relocation of the Voyager Quarry.* Unpublished report prepared for BGC Quarry and Asphalt, October 2002.

Prince, R.I.T (2003). Successful translocation of a mature female ridge-back trapdoor spider (Idiopidae: *Idiosoma sigillatum*). *The Western Australian Naturalist.* 24(2) 10-103.



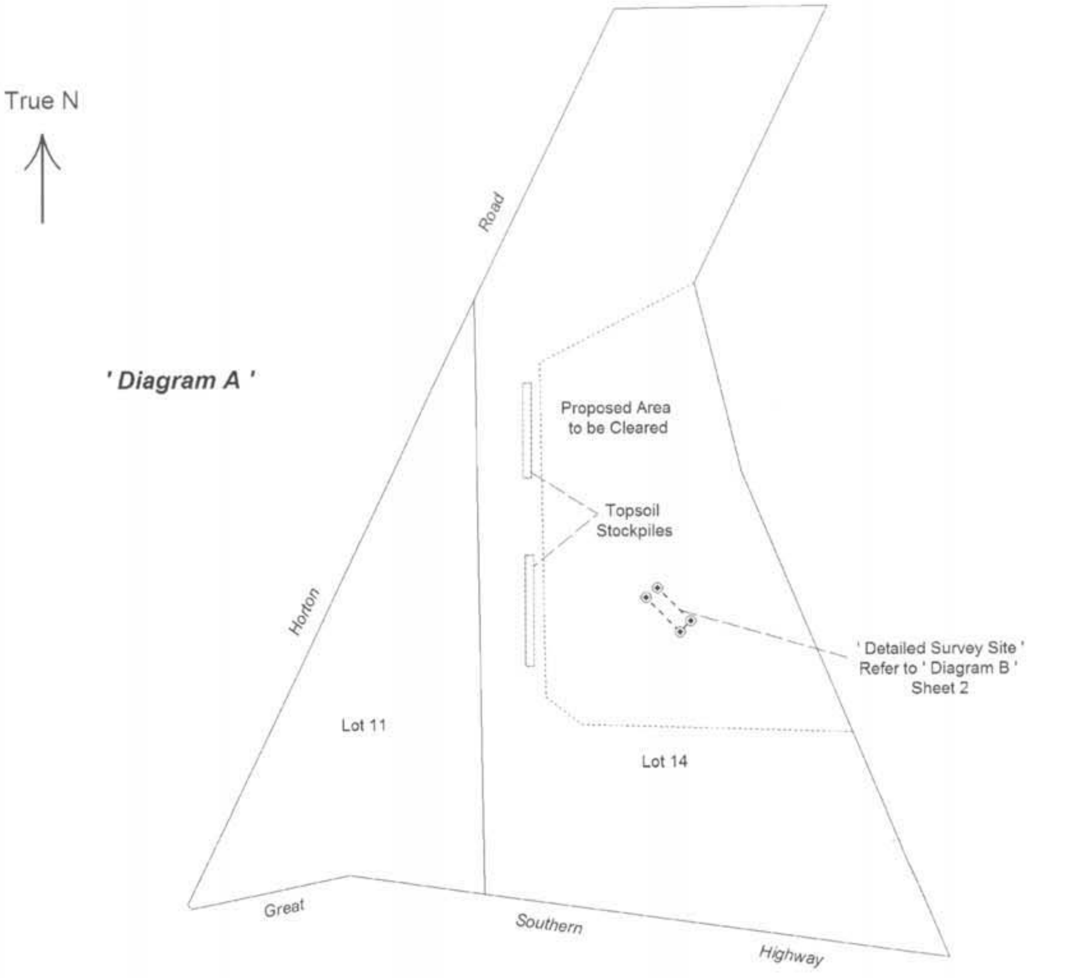
Distribution of the Trapdoor Spider (Genus: Gaius) in Lots 11 and 14 (Landholder - BGC Australia)

BGC

RESPONSE TO PUBLIC SUBMISSIONS
PROPOSED RELOCATION OF THE VOYAGER QUARRY

Figure 1

URS



LEGEND

Survey Control Mark

Survey Area Boundary

Proposed Quarry Boundary

Lot Boundary

Date: 30/3/2004	" Layout Sketch of Trapdoor Spider Burrows Within the ' Detailed Survey Site '. "	Scale: 0 250 500 meters
Mapped by: Stephen Trent in association with Barbara York Main (UWA)	Avon Location 1881, Lots 11 and 14, Mundaring and Northam Shires respectively	Figure 2

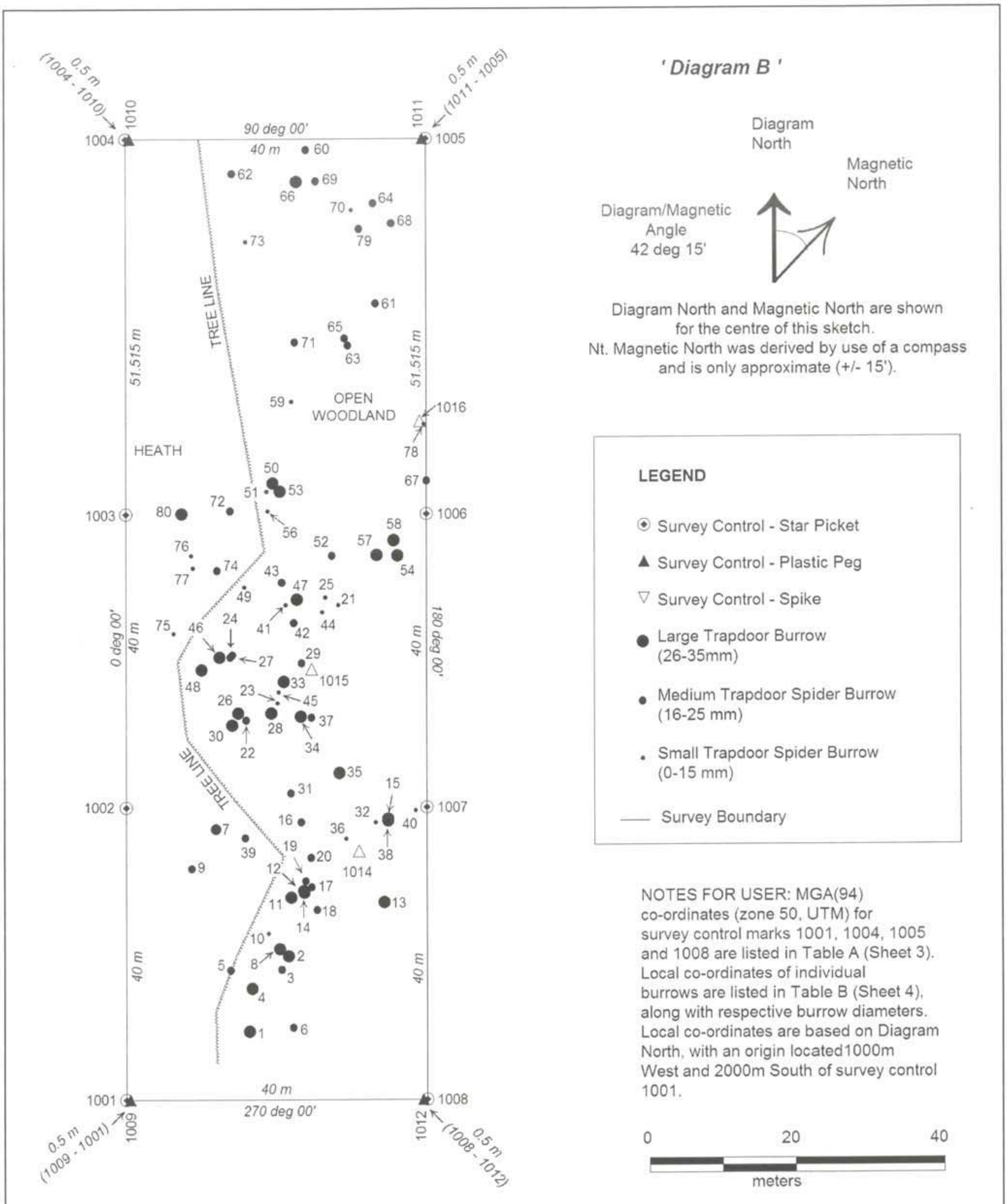
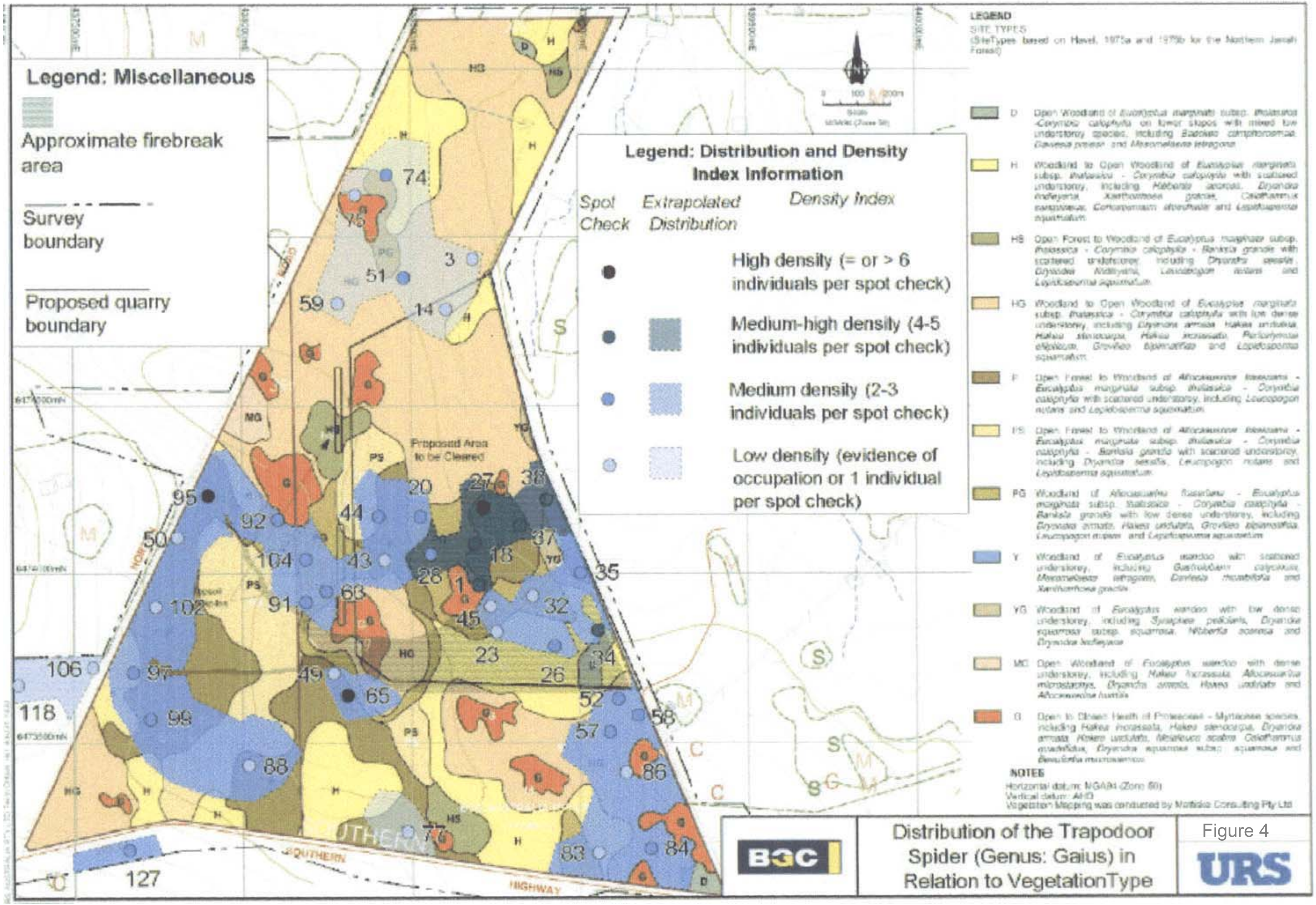

'Diagram B'
Diagram North
Magnetic North
Diagram/Magnetic Angle 42 deg 15'
Diagram North and Magnetic North are shown for the centre of this sketch.
Nt. Magnetic North was derived by use of a compass and is only approximate (+/- 15').
LEGEND
Survey Control - Star Picket
Survey Control - Plastic Peg
Survey Control - Spike
Large Trapdoor Burrow (26-35mm)
Medium Trapdoor Spider Burrow (16-25 mm)
Small Trapdoor Spider Burrow (0-15 mm)
Survey Boundary
NOTES FOR USER: MGA(94) co-ordinates (zone 50, UTM) for survey control marks 1001, 1004, 1005 and 1008 are listed in Table A (Sheet 3). Local co-ordinates of individual burrows are listed in Table B (Sheet 4), along with respective burrow diameters. Local co-ordinates are based on Diagram North, with an origin located1000m West and 2000m South of survey control 1001.
0
20
40
meters
HEATH
OPEN WOODLAND
TREE LINE
TREE LINE
90 deg 00'
40 m
270 deg 00'
40 m
0 deg 00'
180 deg 00'
51.515 m
51.515 m
40 m
40 m
40 m
40 m
1004
1005
1003
1006
1002
1007
1001
1008
1010
1011
1009
1012
1014
1015
1016
0.5 m (1004 - 1010)
0.5 m (1011 - 1005)
0.5 m (1009 - 1001)
0.5 m (1008 - 1012)

Figure 3



Distribution of the Trapodoor Spider (Genus: Gaius) in Relation to VegetationType

Figure 4

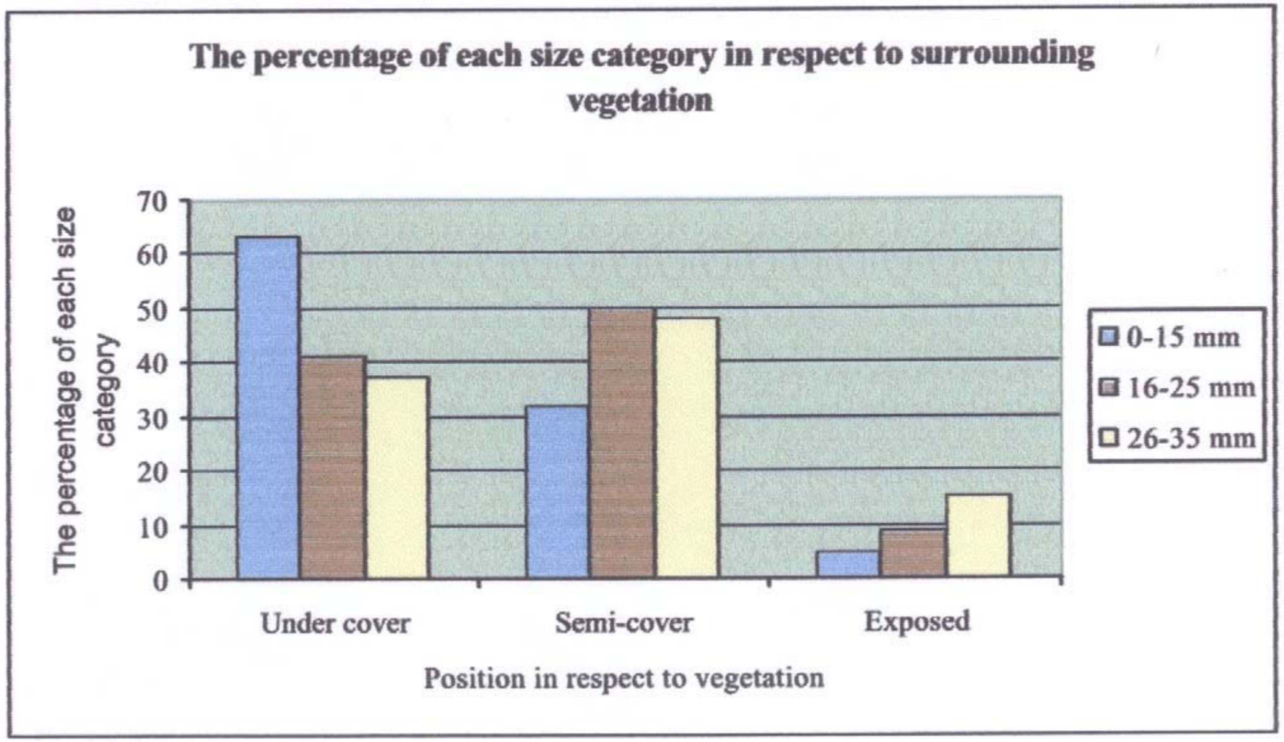
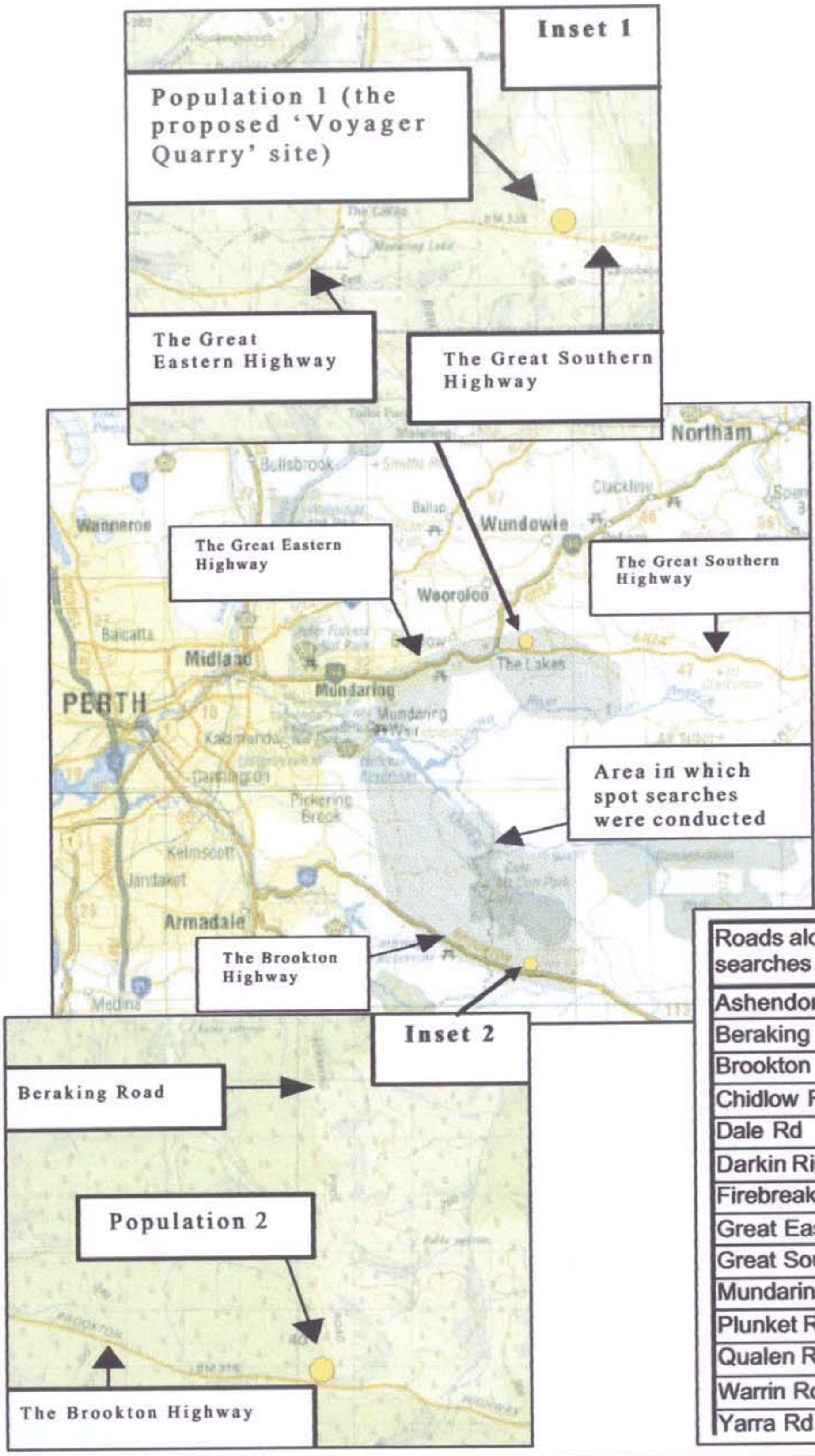

The percentage of each size category in respect to surrounding vegetation
The percentage of each size category
70
60
50
40
30
20
10
0
Under cover
Semi-cover
Exposed
Position in respect to vegetation
0-15 mm
16-25 mm
26-35 mm

Figure 5

Current Known Locations of *Gaius* sp. Populations



Roads along which searches were conducted
Ashendon Rd
Beraking Pool Rd
Brookton Highway
Chidlow Rd
Dale Rd
Darkin Ridge Rd
Firebreak Rd
Great Eastern Highway
Great Southern Highway
Mundaring Weir Rd
Plunket Rd
Qualen Rd
Warrin Rd
Yarra Rd

Figure 6 **(Sources: Key Map - Hema Maps, Australia Road Atlas 4th edition, 2004; Insets– Natmap, 1:100 000 topo series { inset 1 and inset 2, 2133 Jarrahdale & 2134 Wooroloo respectively}).**

REPORT (1)

A FURTHER SURVEY INCLUDING DEMOGRAPHY OF THE TRAPDOOR SPIDER *GAIUS* sp. OCCURRING IN AVON LOCATION 1881, LOTS 11 AND 14 AND ADJOINING LANDHOLDINGS

TABLE OF CONTENTS

SUMMARY

A survey of the population of the trapdoor spider species of *Gaius* occurring in Lots 11 and 14 Avon Location 1881 was conducted during March 2004. It was estimated that the species occupies 33% of the area. One hundred and twentynine spot checks were conducted in the Lots and adjoining wooded areas. Of these, 43 sites were occupied by spiders of which 40 were located in Lots 11 and 14. Of the occupied area in Lots 11 and 14, 24% was located within the proposed quarry relocation where the densest aggregation of burrows occurred.

In a detailed survey of a dense aggregation in an area approximately 131m by 41m (approximately 5992 sqm) along an ecotone of heath and woodland, 79 burrows were marked and the burrow entrance diameters measured. Diameters ranged from 12 to 35mm. Three arbitrary size (age) classes were categorised with the medium (16 - 25mm) burrows forming the largest proportion.

A higher proportion (63%) of the smallest category was found under entire cover (canopy) than the other size classes. All categories were poorly represented in exposed areas (5% of the smallest category and 15% of the largest category). The preferred habitat of the spiders is low heath with some high canopy shade provided by jarrah, marri and *Allocasuarina fraseriana* , with well drained sandy loam soil with pisololitic gravel and some litter cover.

The detailed study area appears not to have been recently burnt. The lower density of burrows of some of the other sites may be related to more recent burning. However, thorough assessment of soil type, canopy cover, potential for water logging and time since burning all need to be considered in interpreting relative density, particularly if translocation becomes an option. Any attempt at translocation would require a long term commitment:

(a) selection for translocation of a mixture of size categories of spiders (as indicated by burrow size) in accordance with the proportions found in the study site and
(b) a commitment of:
(i) in the first instance three years to monitor the success of establishment of translocated burrows followed by
(ii) ten years to assess reproductive success (i.e. recording of recruitment of new burrows) and
(iii) 20 years to assess generational turnover.

1. INTRODUCTION

1.1 Previous study and new proposal

An earlier survey of trapdoor spiders undertaken over three days in July and August 2002 in Avon Location 1881 Lots 11 and 14 revealed the occurrence there of an undescribed species of *Gaius* Rainbow which extended the previously known geographic distribution of the genus (Main 2002). With a generally inland and dry country distribution, occurrence of the genus in the northern Darling Range region appeared surprising. Nevertheless close examination of specimens of *Gaius* in collections of the Western Australian Museum identified two specimens from Collie. However the Voyager Quarry site populations clearly suggested a disparate population warranting further study.

The survey reported on herein of the "Voyager" *Gaius* species at Avon Location 1881, Lots 11 and 14, was conducted at the request of BGC Quarries in relation to the proposed quarry extension and took place between 10th and 24th March 2004.

1.2 General description of site and microhabitats occupied

The terrain has a gradual fall from the highest elevation to a valley floor. Saucer like depressions occur at both the higher levels, down slope and near the base.
The general vegetation of the site (see Mattiske 2002) comprises a mixture of open forest and woodland with three dominant eucalypts, jarrah (*Eucalyptus marginata*) , wandoo (*Eucalyptus wandoo*) and marri (*Corymbia calophylla*). Lower trees include *Banksia grandis* and the sheoak *Allocasuarina fraseriana* and grass trees (*Xanthorrhea*). An understory of open to closed heath of Myrtaceae and Proteaceae species occurs in scattered patches throughout and predominates with no overstory in areas associated with lithic outcroppings or where areas are prone to waterlogging such as in the depressions mentioned above. Soils range from coarse laterite through pisolitic gravel (pea gravel) in a mixture with yellow brown sand to some heavier clay and granite sands, the latter associated with lithic exposures. Litter cover varies from deep permanent litter tending to humus or duff beneath shrubs, grading to scattered and unstable litter with patches of bare ground. The area has been logged, probably at several periods and there has been considerable regrowth of jarrah trees by coppicing. While Mattiske (2002) suggests that there has been fire at least through part of the area within the last five years, it was also conceded that some areas within the open forest of jarrah and sheoak have not been burnt so recently.

In the earlier survey most of the burrows located were in patches of heath and the densest aggregation observed was at the lower edge of a large patch of heath forming an ecotone with the edge of the forest where *Allocasuarina fraseriana* provided an upper canopy. The soil in all areas where burrows were located was a sandy loam with pisolitic gravel. Some burrows were in scattered heath understory beneath eucalypts and sheoak trees. In the few days of the survey there was not time to conduct comprehensive traverses of the locality.

1.3 Taxonomic status of the "Voyager" species of *Gaius*

At the conclusion of the previous survey, conducted during the winter of 2002, only female specimens had been collected. Mature males are available only through mid-late summer or autumn. Final specific identification is generally based on male morphological features of mygalomorphs hence the species status of the "Voyager" population remained unresolved.

2. DISTRIBUTION, BIOLOGY AND LIFE CYCLE OF *GAIUS*

2.1 General distribution, biology and life cycle of *Gaius*

Gauis is distributed widely throughout the central wheatbelt and Goldfields, east of Kalgoorlie to near Caiguna, north east to Wiluna, northwest towards Shark Bay; it extends south to Esperance and Ravensthorpe. It is unknown from coastal areas and no previous records have been made from the Darling Range apart from two specimens from Collie. Hence the discovery of the genus at the Voyager site is of particular biogeographic significance. Likewise another recent record from the Brookton Highway raises the possibility of a metaspecies with scattered distribution in the Darling Range.

At least the type species of *Gaius* , *G. villosus* Rainbow, is extremely long lived and female specimens may live in excess of 27 years (Main 2001). Individual spiders remain in the same burrow (constructed by an emergent spiderling on leaving the mother's burrow) throughout life except adult males which on maturity and under favourable weather conditions of high humidity abandon their burrows and wander in search of a receptive female. Mating takes place in the female's burrow. Prior to egg laying a female seals the burrow entrance below the door with a soil plug which sets hard. Juveniles also seal their burrows during summer, likewise males before going through their final moult. Dispersal of spiderlings takes place after the autumn/early winter rains when the soil is wet.

2.2 Burrow structure of *Gaius* species and behavioural differences of the “Voyager” species.

Inland representatives of *Gaius* generally occur in either sandy loam soils or heavy clay which compacts to a cement-like texture when dry. The vertical burrow of mature spiders may exceed 70cms in depth. A thick plaster overlain with silk is deposited on the wall of the burrow. Defunct burrows (i.e. without a living spider) persist as strong walled “pipes” for many years. Part way down the burrow the silk lining is detached from the wall, with the lower broken part forming a loose collapsible collar (like the top of an open sock) (see Main 1957 Figs 23 B - D, 1985 Figs 209 - 210). Food remains are deposited between the outside of this “sock” and the pocket-like expansion in the soil wall of the burrow.

The burrow of the “Voyager” species differs from the above by not having a plastered wall, the silk lining does not adhere to the soil wall but hangs free like a stocking and a well defined “sock” structure has not been observed in the few excavated burrows.

3. OBJECTIVES OF THE PRESENT SURVEY

- To determine the population size and distribution in Lots 11 and 14 of *Gaius* and to describe the habitat preferences
    - To record with GPS, mark on the ground for future reference and map occurrences of burrows
    - To document demographic details of spiders
    - To note and record habitat details particularly of soil and vegetation
- To collect male specimens to assist with diagnosis of the species and confirm generic placement
    - To set out pitfall traps for capture of wandering males

4. METHODS AND DESCRIPTION OF SITES

4.1 Spot checks and recording methods

To determine the distribution of *Gaius* , one of us (SWT) conducted spot checks semi-randomly but which still ensured adequate coverage of the entire site over Lots 11 and 14, and adjoining areas containing native vegetation. Fifteen minutes sampling time was allocated to each site and the search area contained within approximately a 15m radius. Occupation, or evidence of occupation by spiders was noted at each spot check. In occupied areas the number of viable burrows was recorded to produce an index of density. Handheld GPS coordinates (MGA(94), UTM, Zone 50), soil type (granite outcrop present, sandy soils, small/medium/large-sized gravel pebbles predominant (see Figure 1)) and field notes on basic vegetation structure were recorded for each site.

Sampling effort was slightly greater within the proposed quarry relocation site compared to the remainder of the overall site, so that a more accurate distribution of the species could be ascertained within the area of concern. To assess the accuracy of the spot checks in determining occupation, five sites where no spiders were found during the initial 15 minutes, were reexamined for a further 30 minutes.

The location of the occupied spot check sites and the extrapolated distribution of the spiders (based on the spot checks) were overlaid in MapInfo Professional (6.5) onto an aerial photograph (URS) and a vegetation map (Mattiske Consulting Pty Ltd 2002). Spot checks were separated into density index categories, based on the number of individual located per spot check (evidence of occupation or 1 individual - low density; 2 to 3 individuals - medium density; 4 to 5 individuals - medium/high density; =/> 6 individuals - high density).

Similarly, the distribution was divided up into regions of which each contained six consecutive spot checks (or remainder), or in the case of an isolated distribution with less than six spot checks, the total number of spot checks were used. Each region was then divided up into the above categories based on the average density of the spot checks within that region. The plotted distribution was based on the location of occupied and unoccupied spot check sites, and produced in the same manner that contour lines in relief portrayal are formed (i.e. triangle method - by the formation of consecutive triangles between sets of three adjoining points).

4.2 Description of selected study site

Only a selected section of the species distribution within the quarry site was mapped in detail, due to the time associated with locating and recording the position of individual burrows. The selected site found in the earlier survey (Main 2002), contained a relatively dense subpopulation along the ecotone of intersecting heath and open woodland of jarrah (*Eucalyptus marginata*) and sheoak (*Allocasuarina fraseriana*). This large heath patch is in a saucer like depression which slopes down towards the woodland. The soil, presumably partly due to erosion of the heath site (where the soil is now shallower) forms a band of deeper loamy sand with pisolitic gravel pebbles. This soil type combined with the edge of jarrah and particularly sheoak, which provides an upper canopy of shade, forms an ecotone which appears to be the preferred habitat of the spider.

4.3 Detailed survey of burrows in selected site

Individual spider burrows within the study area were initially found and marked with metal pegs and flagging tape. A surveying theodolite (Sokia SDM3FR) was used to place survey control/reference marks (8 star pickets) around the external perimeter of the area containing the marked burrows. These control points were used to form the basis of a local coordinate system in the shape of a rectangle, approximately 131 m long by 41m wide (nt. 4 star pickets were placed along each of he two longest sies of the rectangle). Handheld GPS co-ordinates (MGA(94), UTM, zone 50) of the four corners of the suveyed area were recorded.

Burrows were then precisely located by use of the theodolite. A number of off set survey control (4 plastic pegs and three steel spikes) were placed to assist in locating the spider burrows. The line of the intersection of the two vegetation associations, heath and open woodland was also recorded (see Diagram B, Sheet 2 and Figure 6).

During the process of locating the individual burrows, the initial metal peg adjacent to each burrow was removed and replaced with a smaller metal peg supporting a numbered tag. The diameter of the opening of each burrow was measured and recorded, or if a burrow was sealed (indicating a possible brooding female or male undergoing its final moult) then the diameter of the trapdoor. The position of a burrow in respect to surrounding understory vegetation (< 1m) was grouped into one of three categories: directly under cover, semi-exposed (i.e. partially covered/surrounded by understory vegetation) and exposed.

Geocomp (9) and MapInfo Professional (6.5) were used to produce sketches showing the position of the detailed survey site in relation to lots 11 and 14 and the distribution of individual burrows within the site. Tables with information pertaining to individual burrows (local and MGA(94) coordinates, size and position relative to vegetation) and survey control marks (coordinates, type) were produced in Microsoft Word 97. Graphs were produced in Microsoft Excel displaying burrow location with respect to vegetation and size frequency distribution of marked individuals within the surveyed area.

4.4 Projected trapping for male specimens

Six pitfall traps were positioned in the soil within the selected study site. These were placed when possible near to burrows estimated to be about the size of a prospective male. Pit traps were two litre plastic ice cream containers with about 10cms of anti-freeze liquid (ethyl glycol) in the base. Traps were sunk flush with the soil and litter surface. Ethyl glycol is a standard preservative/killing agent used in long term biodiversity sampling for invertebrates.

4.5 "Destructive sampling" for taxonomic specimens

Several burrows were selected for excavation to obtain specimens for morphological/taxonomic examination and assessment. This followed the usual procedure by digging a pit adjacent to a burrow and a longitudinal section was made of the burrow (the cut made with a sturdy knife). As a burrow is sectioned, soil waste falls into the pit from where it is scooped up and put aside on the surface. Spiders usually stay at the base of a burrow from where they can be removed with forceps and placed in a collecting jar. Some other species of Mygalomorphae (trapdoor spiders) are more active and run up the burrow if disturbed). Excavation and collection of specimens renders a burrow obsolete hence the overburden is used as fill .

5. RESULTS

5.1 The distribution and density of *Gaius* throughout lots 11 and 14

Figures 3 and 4 display the distribution of *Gaius* over lots 11 and 14 and the adjoining area. One hundred and twenty nine spot checks were conducted over lots 11 and 14 and in adjoining areas with native vegetation. Of these spot checks, 43 were classed as occupied by *Gaius*, of which 40 were in lots 11 or 14 and three were in vegetated areas adjoining these two lots. The number of individuals located per spot check ranged from 0 - 10 (see Table 1).

The trapdoor spider *Gaius* was estimated to occupy approximately 33% of the area of lots 11 and 14 (see Figure 2). Of the occupied area of distribution in lots 11 and 14, 24% was was located within the proposed quarry relocation, which appears to contain the densest aggregations of burrows. Most of the occupied area of distribution was classed as medium density of burrows.

It should be noted that five spot check sites in which no burrows were observed during the initial fifteen-minute search, were re-examined more intensely for an additional half-hour period. During the additional searches at each spot check, one site was redefined as occupied, thus, the extrapolated distribution may be slightly underestimated. However, this was expected due to the variable size of burrows and difficulty of locating all individuals when they occurred under small shrubs and amongst continuous litter.
Most of the immediate area adjoining lots 11 and 14 has been cleared (see Figure 3). In the vegetated areas adjacent to the lots, the spider population from within lots 11 (and 14?) was found to extend into two areas viz. the occupied regions on the southern and western sides of lot 11 (owned by the Waters and Rivers Commission) shown in Figure 3. The density indexes for both of these occupied areas were based on only one or two spot checks, and are not intended to provide accurate comparative estimates.

5.2 Distribution of burrows in relation to vegetation associations and soil type

An upper canopy structure in occupied areas was provided by an open woodland or open forest dominated by jarrah (*Eucalyptus marginata* subsp. *thalassica*) with scattered marri (*Corymbia calophylla*) and sheoak (*Allocasuarina fraseriana*). At all sites an understory comprising shrubs of predominantly *Hakea*, *Lepidosperma* and *Dryandra* spp. formed a low semi-closed canopy (Figure 4).

Based on spot checks and cursory observations, it appears that areas of low heath with no upper canopy present (i.e. indicative of shallow soils with granite or a lateritic cap close to the surface) are unsuitable for occupation by *Gaius*. Nevertheless individual burrows were found to occur along the fringe of such areas.

The substrate of occupied sites consisted of sand or sandy clay (loam) soils (i.e. with a very small clay component < 10%) and usually with a small to large amount of pisolitic gravel (pea gravel) present. During the first 49 spot checks no burrows were found in soils consisting of predominantly large gravel pebbles (see Table 1). These records are supported by observations of B.Y.M. that such soils are generally unfavourable for *Gaius*. Thus, after these initial spot checks, sites with predominantly large gravel pebbles present were only briefly examined.

5.3 Distribution of individual burrows in selected study site

In respect to the ecological survey plan the "Layout Sketch of Trapdoor Spider Burrows Within the Detailed Survey Site" (Sheets 1 to 5), Diagram A (Sheet 1) shows the position of the survey site within lot 14. Diagram B (Sheet 2) shows the position of all marked burrows within the survey site relative to one another and the survey control marks. Table A (Sheet 3) displays the local and MGA(94) co-ordinates of survey control marks. Table B (Sheets 4 and 5) contains the local co-ordinates of individual burrows and their relevant information concerning size and position in relation to vegetation.

A total of 79 individuals were marked and located within the surveyed area. The area of the site is 5392sqm. The mean density of spiders in the surveyed area was 0.0147/sqm . The interior burrow diameter ranged from 12 to 34mm (mean size of 21.09mm). Figure 5 shows the size frequency distribution of all marked and recorded burrows, based on three arbitrary size classes. The population of marked individuals appears skewed towards the two larger size categories, which may reflect a seasonal bias (late summer/early autumn) when the survey was conducted which would not have captured the full cohort of emergents due to summer mortality).

5.4 Size frequencies of burrows within study site and relation to vegetation

Figure 6 shows the ecotone of intersecting heath and woodland, where the detailed survey was conducted and an example of the typical habitat in which spiders were located. Burrows were generally situated directly under cover or partially covered, by understory vegetation.

In the smallest size category of burrows (0 - 10mm), 63% of burrows were located directly under cover, 32% semi-covered and 5% were exposed (see Figure 7). In comparison only 37% of the largest size category was found directly under cover, whilst 48% were semi-covered and 15% were completely exposed. Whether juveniles prefer specific areas for settlement and/or that selection favours individuals that settle in close proximity to understory vegetation is not known. The higher percentage of individuals in larger size classes, might be due to the death of vegetation under which they initially sheltered.

5.5 Collection and identification of specimens

Three burrows were dug out by BYM. Burrow numbers 14 and 38 were excavated to collect specimens for taxonomic identification. Burrow #14 contained an adult male specimen; burrow #38 was abandoned (possibly by a male which had already run). An adult female was collected from an unmarked burrow outside the study site.

In addition to burrow differences noted above (Section 2.2.) eg. unplastered soil wall, loose-hanging silk lining and poorly defined "sock" structure adult spiders do not make a soil ("mud") plug in the opening of the burrow below the door. The male specimen collected had a soil/gravel impregnated silk wadding several centimetres thick blocking the entrance and loosely attached to the lower face of the trapdoor. The abandoned burrow #38 had a similar, but broken, wadding below the door. SWT also noted that burrows #4 and #53 were "sealed". These could be either males waiting to run or brooding females.

Examination of the male shows it to have some similarities with the Collie specimens, which in turn have similarities with an unnamed species which extends from Tambellup and disparate localities along a southern strip between Ravensthorpe and Esperance. All these specimens are markedly different in palpal structure and other secondary male features from the plateau species eg *Gaius villosus* and several unnamed species.

6. DISCUSSION AND CONCLUSIONS

The survey shows that the Voyager population of *Gaius* has a scattered distribution throughout the lots but with higher concentrations in some areas, and absence from areas with a lateritic cap or granite close to the surface. Shade provided by tree and shrub canopy favours survival. Only one area, an ecotone between heath and woodland, at the lower edge of a large heath patch downslope from a lithic area, had a very high density (79 burrows) of spiders in an area approximately 131m by 41m (5392 square metres). Because this area represented a fairly extensive aggregation with a range of burrow sizes it was selected for a demographic assessment of the population. Burrow diameter measurements indicate that the smallest size category (of three size ranges) had fewer individuals than the larger categories. This may be partly accounted for by the summer mortality of the previous winter's recruitment. Also, it is not known at what size female spiders mature hence it cannot be ascertained how many larger burrows represent matriarchs (i.e. reproductively active or capable females) (see Main 1978; 1987). Nevertheless there does seem to be a good range of burrow sizes with a reasonable proportion of what may be considered post emergents (recruits), juveniles and in the larger size category at least some mature spiders.

The selected study site is situated in Lot 14 in a more or less central area of the proposed quarry relocation. Evidence of recent fire was not detected. With some exceptions, particularly open forest of jarrah and sheoak (*Allocasuarina fraseriana*) Mattiske (2002) considered that most of the area showed signs of having been burnt within the last five years. If this is so then such (assumed) recent fire may account for the lower density of *Gaius* in some of the heath spot check sites. Although Main (1978) suggested that some life history stages of *Gaius villosus* (an inland species) may be partially protected against fire because of its habit of plugging the burrow entrance with a soil plug it was also demonstrated that the same species is in fact vulnerable to fire in some habitats and seasons (Main 1995). It should be emphasised that the entire population of the Voyager species which does not make a soil plug at the burrow entrance (at any life history stage) is likely to be sensitive to fire at any season.

The "Voyager" population of *Gaius* is of considerable biogeographic interest in that occupying an area in the northern jarrah forest between the water catchments of the Helena and Avon rivers, it does not have morphological (at least as demonstrated by the single male so far collected) with the populations east of the Avon (as from Dowerin eastward to the central wheatbelt and northerly into the pastoral areas). There appears to be a gap in the distribution of *Gaius* within the southern part of the Mortlock River drainages for example there are no records in an area east of York and south of Kellerberrin. This could reflect a geohistorical environment inimical for occupation by *Gaius* . At present the area is flood prone in many parts.

The Voyager site represents a residual upland i.e. relictual part of the old plateau. As such it also forms part of the divide between inland and western drainage lines along which remnants of old landscapes persist (Mulcahy et al 1972). These authors also suggested prior to uplift of the old plateau (of the Western Australian Shield) the course of the Avon River was directed along the Darkin-Talbot Divide and westward through the present Helena valley. Hence it could be that the Voyager site remains as a relictual northerly point of an essentially southern distribution of the spider.

The "Voyager" species (as at present understood) together with the Brookton Highway/Beraking Road population (located by BYM in May 2003) could represent a northern extension or tongue of a southern species. Hence it is desirable to explore the region more thoroughly southward through the eastern part of the Darling Range to ascertain the extent and fragmentation of the distribution of the species. That is, to evaluate whether the "Voyager" population is (a) an isolated northern outlier of a metapopulation of the southern species (i.e. the Collie and farther south populations) or (b) whether the distribution is more continuous than at present perceived or (c) whether the Voyager/Beraking populations represent a distinct species.

If translocation of specimens is contemplated it must be emphasised that although trapdoor spiders can be readily settled into artificial accommodation such as flower pots of soil (BYM regularly settles and maintains spiders in the laboratory) there is only one documented case of a spider being successfully translocated in the field. This was of an adult female specimen of *Idiosoma sigillatum* disturbed from a Nedlands garden and which was translocated to bushland at the CALM Wildlife Research Centre at Woodvale (Prince 2003). Twentythree months after translocation this spider was still active. **However, even though it is possible to move individual spiders, success at the population level would require a long term commitment.** Obviously suitable habitat for transfer of spiders would need to be located at the outset. The task of translocation would be labour intensive - to excavate, remove and hold specimens and then make artificial burrows at a new site in which to insert the spiders. A monitoring programme of three years, then at ten and twenty years to assess (a) establishment of spiders (b) reproductive success as measured by establishment of recruits (emergents) and finally (c) to assess generational turnover i.e. continuing reproductive success and maintenance of an ongoing viable population.

Such an endeavour would indeed be an interesting experiment and may have justification as a last resort in the saviour of an endangered population.

7. ACKNOWLEDGMENTS

We are grateful for the assistance rendered by the following: K. Ariyaratnam for supplying copies of base maps of the site, E. M. Mattiske for loan of regional maps and helpful discussion, M. Melliner for loan of equipment, R. Phillips and S. Tomlinson for assistance in the field survey, J. Waldock for confirming some data from the earlier survey, and T. Stewart for technical assistance.

8. REFERENCES

Main, B.Y. 1957. Biology of Aganippine trapdoor spiders (Mygalomorphae: Ctenizidae). Australian Journal of Zoology. 5 (4): 402 - 473.

Main,B. Y. 1978. Biology of the arid-adapted Australian trap-door spider *Anidiops villosus* (Rainbow). Bulletin of the British arachnological Society 4 (4): 161-175.

Main, B. Y. 1985. Further studies on the systematics of ctenizid trapdoor spiders: a review of the Australian genera (Araneae: Mygalomorphae: Ctenizidae). Australian Journal of Zoology, Supplementary series No. 108: 1 - 84.

Main, B. Y. 1987. Persistence of invertebrates in small areas. Case studies of trapdoor spiders in Western Australia. In: Nature Conservation: The role of remnants of native vegetation. Eds. Saunders, D. A., Arnold, G. W., Burbidge, A. A. and Hopkins, A. J. M. (Surrey Beatty and Sons. CSIRO and CALM).

Main, B. Y. 1995. Survival of trapdoor spiders during and after fire. Calm Science Supplement. 4: 207-216.

Main, B. Y. 2001. Biography of a mygalomorph trapdoor spider (*Gaius villosus* Rainbow) and demographic implications of longevity: is there an oedipus factor? Abstracts of the 15th International Congress of Arachnology. Baadplas South Africa 26-30 March 2001. ISBN 1 - 86849 - 195 -.

Mattiske, E. M. 2002. Flora and Vegetation on Avon location 1881 - Lots 11 and 14 Horton Road The lakes Mundaring. Report for BGC Quarries. *In* Vol. 3, EPA Assessment No. 1413. Perth, Western Australia.

Main, B. Y. 2002. Survey of Trapdoor Spiders Occurring in Avon Location 1881, Lots 11 and 14 and adjoining Landholdings. Unpublished Report to BGC Quarry and Asphalt, October 2002.

Mulcahey, M. J., Churchward, H. M. and Dimmock, G. M. 1972. Landforms and soils of an uplifted peneplain in the Darling Range, Western Australia. Australian Journal of Soil Research, 10: 1 - 14.

Prince, R. I. T. 2003. Successful translocation of a mature female ridge-back trapdoor spider (Idiopidae: *Idiosoma sigillatum* (Cambridge).

Figure 1: Examples of small, medium and large-sized grained gravel's.

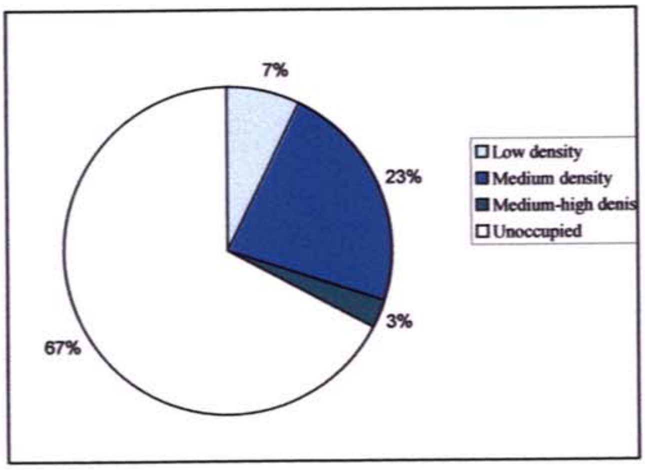


Figure 2.

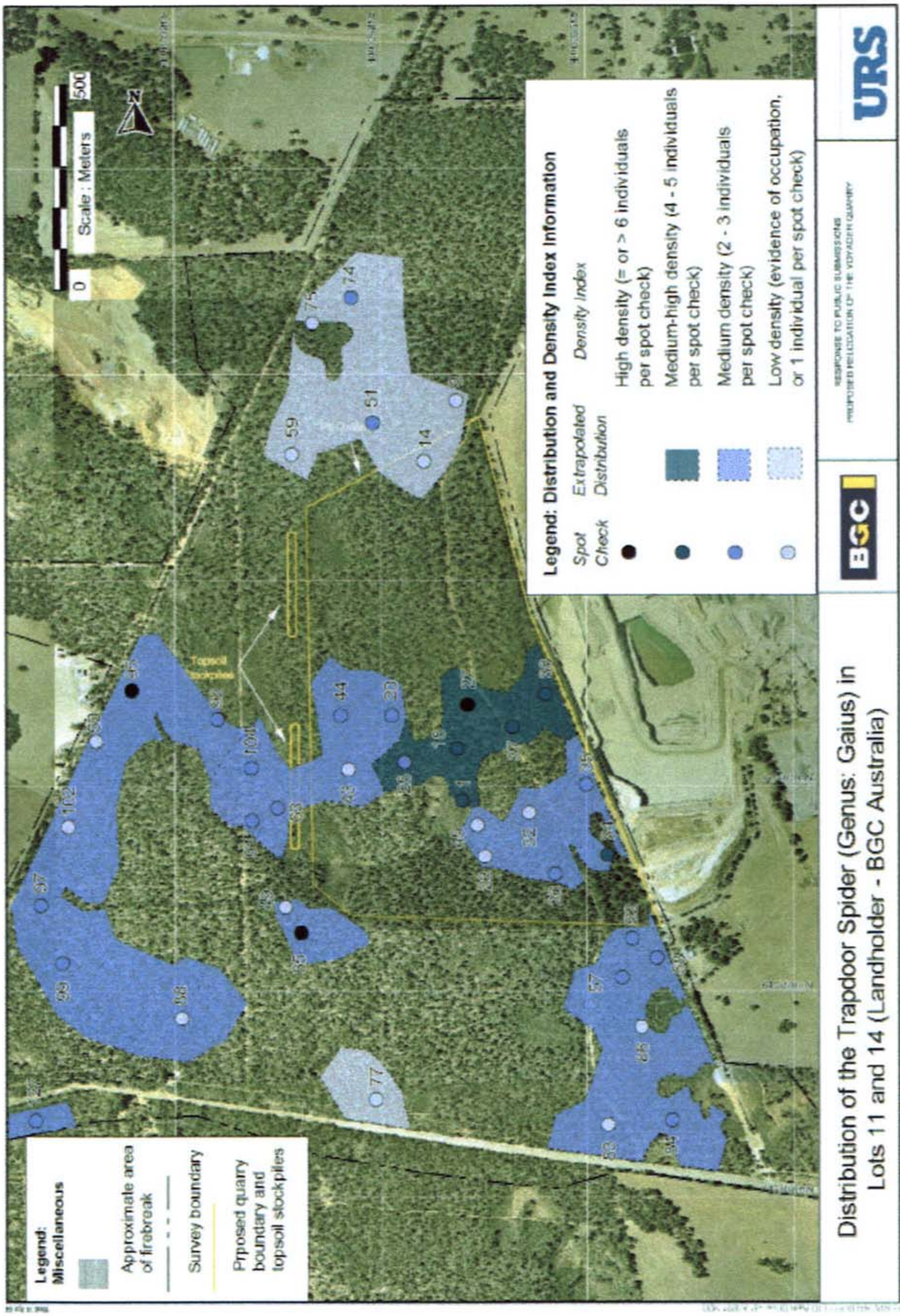

Legend:
Miscellaneous
Approximate area of firebreak
Survey boundary
Prposed quarry boundary and topsoil stockpiles
Scale : Meters
0
500
N
Topsoil Stockpiles
Legend: Distribution and Density Index Information
Spot Check
Extrapolated Distribution
Density Index
High density (= or > 6 individuals per spot check)
Medium-high density (4 - 5 individuals per spot check)
Medium density (2 - 3 individuals per spot check)
Low density (evidence of occupation, or 1 individual per spot check)
BGC
URS
Distribution of the Trapdoor Spider (Genus: Gaius) in Lots 11 and 14 (Landholder - BGC Australia)

Figure 3.

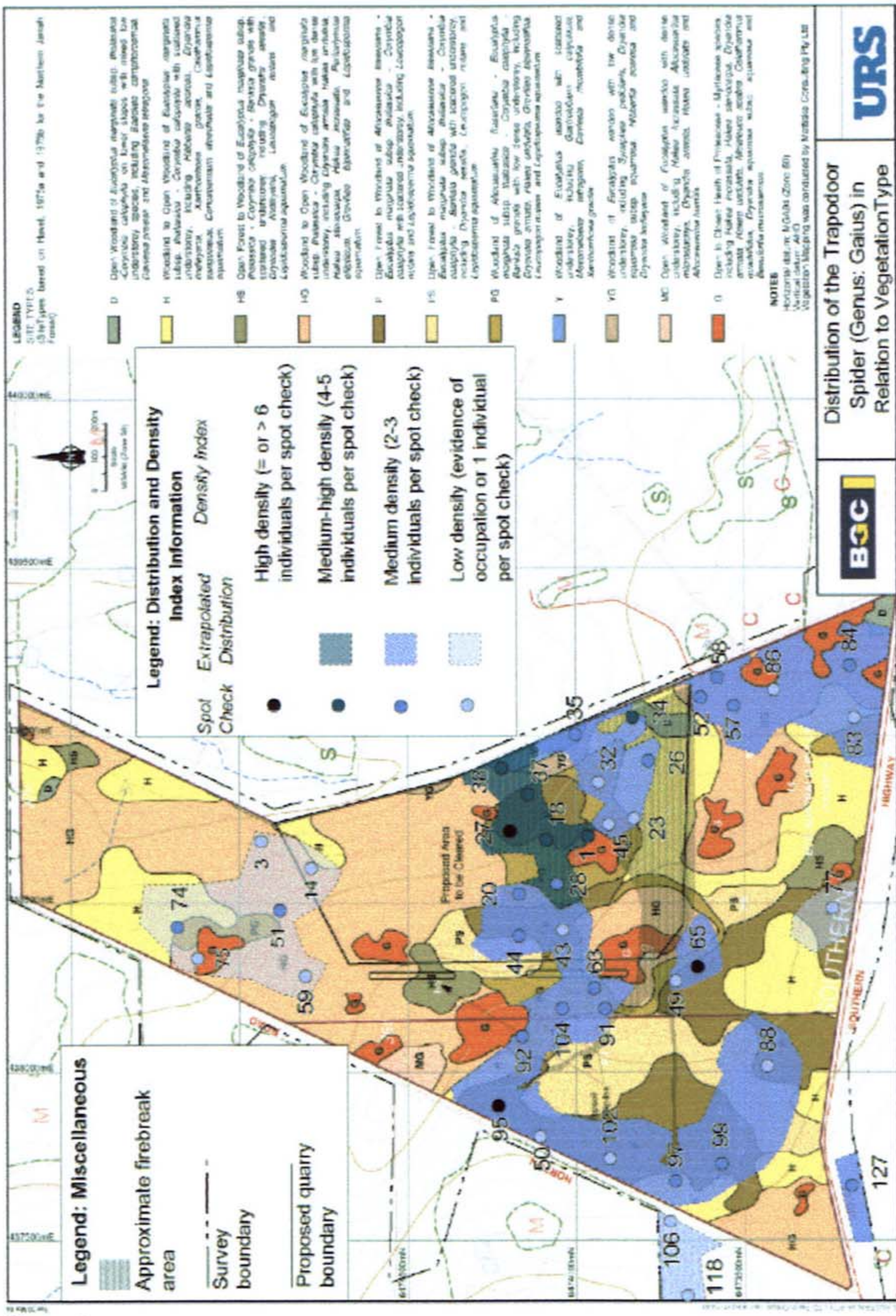
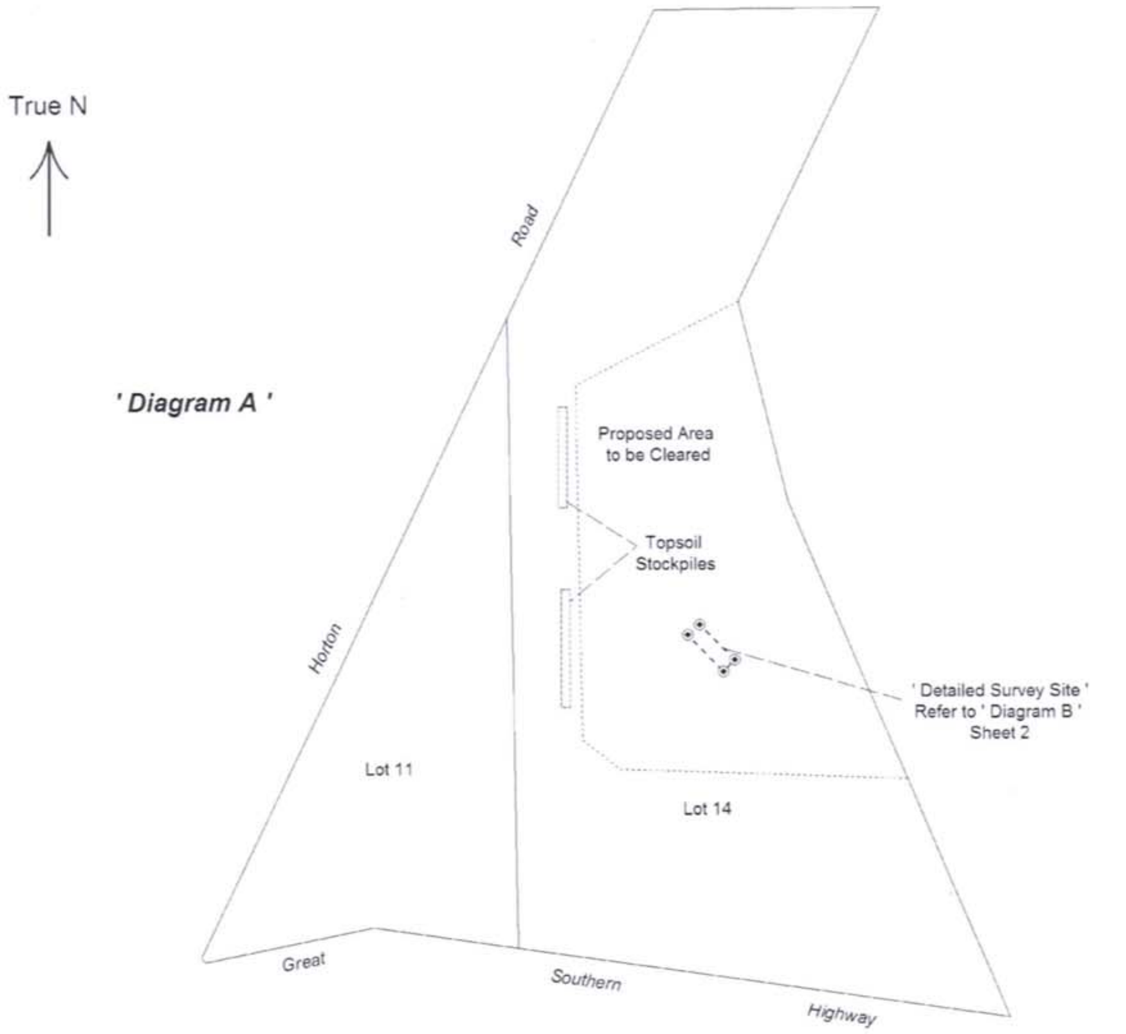

Legend: Miscellaneous
Approximate firebreak area
Survey boundary
Proposed quarry boundary
Legend: Distribution and Density Index Information
Spot Check
Extrapolated Distribution
Density Index
High density (= or > 6 individuals per spot check)
Medium-high density (4-5 individuals per spot check)
Medium density (2-3 individuals per spot check)
Low density (evidence of occupation or 1 individual per spot check)
Proposed Area to be Cleared
SOUTHERN HIGHWAY
Distribution of the Trapodoor Spider (Genus: Gaius) in Relation to VegetationType
URS

Figure 4.



LEGEND

Survey Control Mark

Survey Area Boundary

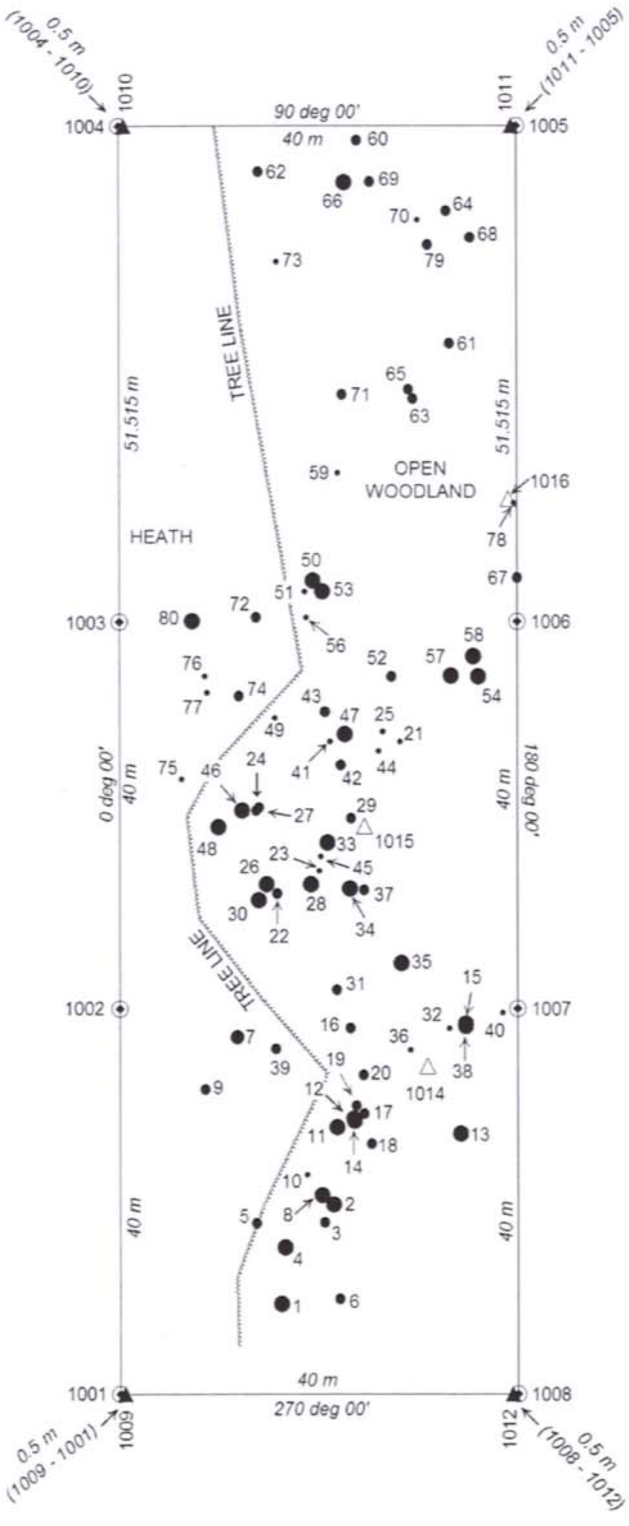
Proposed Quarry Boundary

Lot Boundary

Date: 30/3/2004	" Layout Sketch of Trapdoor Spider Burrows Within the ' Detailed Survey Site '. "	Scale: 0 250 500 meters
Mapped by: Stephen Trent in association with Barbara York Main (UWA)	Avon Location 1881, Lots 11 and 14, Mundaring and Northam Shires respectively	Sheet 1 of 5

'Diagram B'

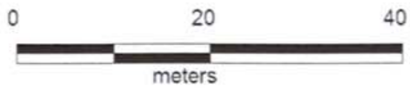
Diagram North and Magnetic North are shown for the centre of this sketch.
Nt. Magnetic North was derived by use of a compass and is only approximate (+/- 15').



LEGEND

- Survey Control - Star Picket
- Survey Control - Plastic Peg
- Survey Control - Spike
- Large Trapdoor Burrow (26-35mm)
- Medium Trapdoor Spider Burrow (16-25 mm)
- Small Trapdoor Spider Burrow (0-15 mm)
- Survey Boundary

NOTES FOR USER: MGA(94) co-ordinates (zone 50, UTM) for survey control marks 1001, 1004, 1005 and 1008 are listed in Table A (Sheet 3). Local co-ordinates of individual burrows are listed in Table B (Sheet 4), along with respective burrow diameters. Local co-ordinates are based on Diagram North, with an origin located1000m West and 2000m South of survey control 1001.



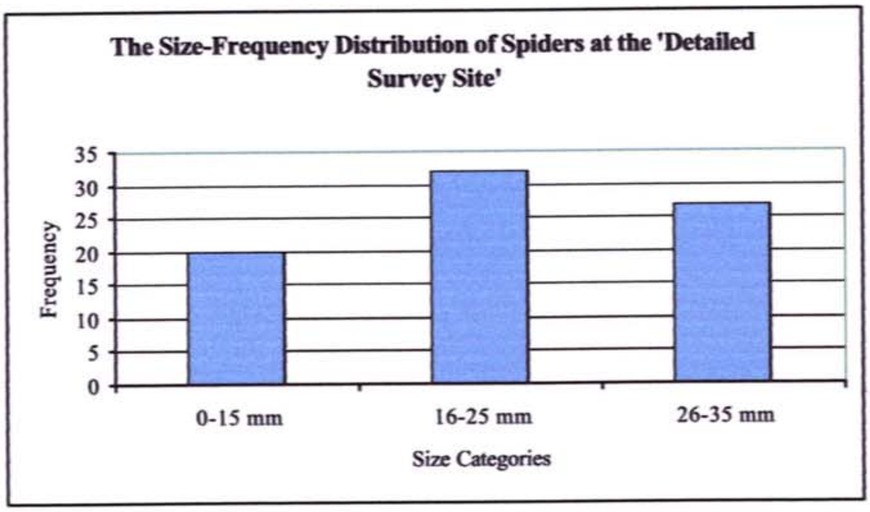
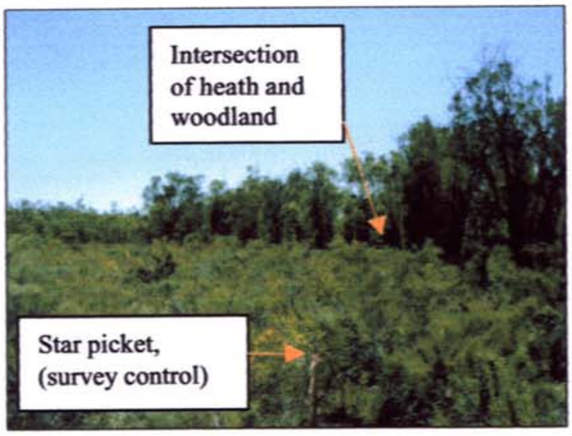


Figure 5.



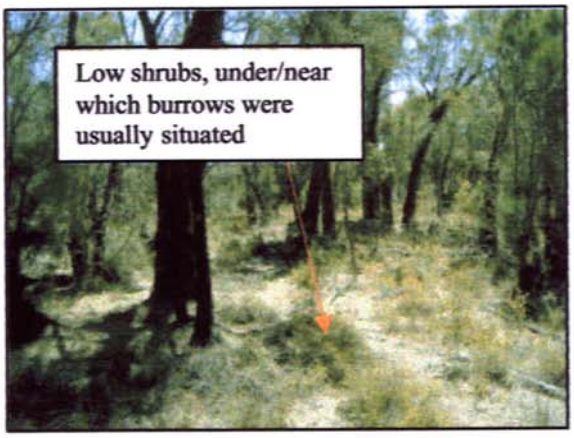


Figure 6: Images recorded at the 'detailed survey site'.

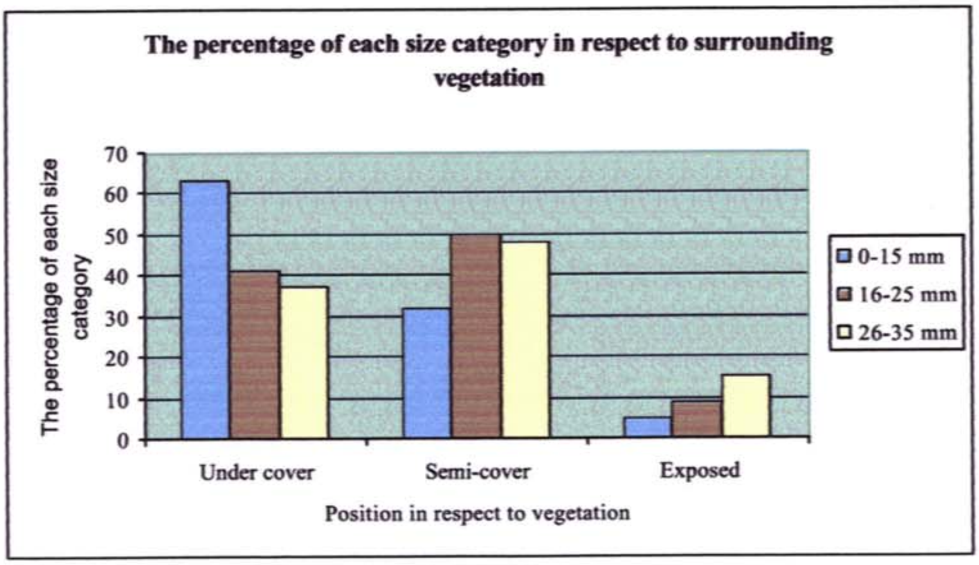


Figure 7.

Table 1: Information pertaining to occupied and unoccupied spot checks conducted within and surrounding lots 11 and 14.

Spot Check Site #	Position in respect to proposed Quarry	Occupied	Easting (MGA 94)	Northing (MGA 94)	The number of individuals, or 'evidence' of occupation	Soil Type (sandy soil (S), light, medium, heavy gravels (LG, MG HG);& exposed granite present EG
1	Within	Y	438697	6473963	4	LG
2	Within	N	438741	6474966	0	MG, EG
3	Outside	Y	438684	6474935	1	LG, EG
4	Within	N	438503	6474652	0	MG, EG
5	Within	N	438416	6474587	0	MG
6	Within	N	438359	6474682	0	MG, EG
7	Within	N	438305	6474593	0	HG, EG
8	Within	N	438360	6474505	0	HG, EG
9	Within	N	438457	6474398	0	HG, EG
10	Within	N	438547	6474428	0	HG,
11	Within	N	438583	6474333	0	HG
12	Within	N	438658	6474386	0	MG
13	Within	N	438638	6474565	0	HG
14	Within	Y	438605	6474787	1	LG
15	Within	N	438710	6474750	0	LG
16	Within	N	438709	6474576	0	MG
17	Within	N	438815	6474056	0	MG, EG
18	Within	Y	438686	6474088	4	LG, EG
19	Within	N	438595	6474162	0	LG
20	Within	Y	438527	6474171	2	LG
21	Within	N	438624	6473758	0	HG
22	Within	N	438691	6473648	0	HG
23	Within	Y	438751	6473828	1	MG
24	Within	N	438776	6473952	0	LG
25	Within	N	438816	6473707	0	HG
26	Within	Y	438923	6473786	2	LG
27	Within	Y	438710	6474195	7	LG
28	Within	Y	438557	6474056	3	LG
29	Within	N	438576	6473939	0	M/HG, EG
30	Within	N	438649	6473910	0	HG
31	Within	N	438635	6473850	0	HG
32	Within	Y	438859	6473933	1	S/LG
33	Within	N	439097	6473741	0	LG;
34	Within	Y	439050	6473831	4	LG
35	Within	Y	439000	6474001	2	S/LG
36	Within	N	438900	6474060	0	LG;
37	Within	Y	438820	6474142	5	
38	Within	Y	438900	6474220	5	LG
39	Within	N	438790	6474320	0	S/LG

40	Within	N	438810	6474451	0	S/LG
41	Within	N	438602	6474622	0	MG
42	Within	N	438479	6474563	0	HG
43	Within	Y	438420	6474040	1	MG, EG
44	Within	Y	438402	6474170	2	LG
45	Within	Y	438733	6473903	1	MG
46	Within	N	438479	6473873	0	MG, EG
47	Within	N	438564	6473758	0	MG
48	Within	N	438313	6473777	0	MG
49	Outside	Y	438267	6473705	1	LG
50	Outside	Y	437806	6474107	1	LG
51	Outside	Y	438480	6474880	2	LG;
52	Outside	Y	439110	6473629	2	MG
53	Outside	N	438975	6473607	0	HG
54	Outside	N	438861	6473582	0	MG
55	Outside	N	438658	6473533	0	HG, EG
56	Outside	N	438634	6473611	0	LG;
57	Outside	Y	439087	6473532	2	LG;
58	Outside	Y	439169	6473580	3	LG;
59	Outside	Y	438284	6474804	1	LG;
60	Outside	N	438415	6474810	0	LG;
61	Outside	N	438300	6474133	0	HG, EG
62	Outside	N	438229	6474298	0	MG, EG
63	Outside	Y	438248	6473946	2	LG;
64	Outside	N	438446	6473484	0	MG, EG
65	Outside	Y	438307	6473640	6	LG;
66	Outside	N	438850	6475212	0	HG
67	Outside	N	438904	6475469	0	MG
68	Outside	N	439070	6475624	0	MG
69	Outside	N	438801	6475619	0	HG
70	Outside	N	438570	6475611	0	HG
71	Outside	N	438457	6475396	0	MG
72	Outside	N	438658	6475366	0	HG
73	Outside	N	438648	6475107	0	LG
74	Outside	Y	438429	6475183	2	LG
75	Outside	Y	438336	6475123	1	LG
76	Outside	N	438160	6474800	0	MG
77	Outside	Y	438485	6473238	1	MG
78	Outside	N	438213	6473334	0	LG
79	Outside	N	438605	6473269	0	MG, EG
80	Outside	N	438523	6473416	0	LG
81	Outside	N	438,816	6,473,214	0	MG, EG
82	Outside	N	438798	6473394	0	MG
83	Outside	Y	439050	6473177	1	LG
84	Outside	Y	439205	6473187	3	LG
85	Outside	N	438930	6473293	0	MG
86	Outside	Y	439133	6473413	Evidence	LG

87	Outside	N	438310	6473483	0	HG, EG
88	Outside	Y	438015	6473434	1	LG
89	Outside	N	438219	6473681	0	MG
90	Outside	N	438045	6473752	0	LG
91	Outside	Y	438187	6473914	2	LG
92	Outside	Y	438104	6474160	3	LG
93	Outside	N	438123	6474372	0	HG, EG
94	Outside	N	438019	6474511	0	HG, EG
95	Outside	Y	437896	6474231	10	LG
96	Outside	N	437975	6474007	0	MG
97	Outside	Y	437673	6473708	2	LG
98	Outside	N	437578	6473536	0	LG
99	Outside	Y	437725	6473569	3	LG
100	Outside	N	437440	6473263	0	LG
101	Outside	N	437685	6473314	0	LG
102	Outside	Y	437740	6473900	1	LG
103	Outside	N	437979	6473689	0	LG
104	Outside	Y	438186	6474042	2	LG
105	Adjoining Lots 11/14	N	437418	6473414	0	MG
106	Adjoining Lots 11/14	Y	437554	6473722	1	LG
107	Adjoining Lots 11/14	N	437449	6474443	0	LG
108	Adjoining Lots 11/14	N	437419	6474529	0	LG
109	Adjoining Lots 11/14	N	437775	6474334	0	LG
110	Adjoining Lots 11/14	N	437809	6474423	0	HG, EG
111	Adjoining Lots 11/14	N	437899	6474511	0	HG, EG
112	Adjoining Lots 11/14	N	437126	6475303	0	MG
113	Adjoining Lots 11/14	N	438068	6475239	0	HG, EG
114	Adjoining Lots 11/14	N	438286	6475246	0	HG, EG
115	Adjoining Lots 11/14	N	438234	6475150	0	MG,EG
116	Adjoining Lots 11/14	N	438152	6474948	0	LG
117	Adjoining Lots 11/14	N	438083	6475039	0	HG, EG
118	Adjoining Lots 11 and 27	Y	437332	6473672	1	LG
119	Adjoining Lots 11 and 28	N	437343	6473581	0	LG
120	Adjoining	N	437306	6473265	0	MG

	Lots 11 and 29					
121	Adjoining Lots 11 and 30	N	439608	6473119	0	LG
122	Adjoining Lots 11 and 31	N	438914	6473041	0	HG, EG
123	Adjoining Lots 11 and 32	N	438678	6473071	0	HG, EG
124	Adjoining Lots 11 and 33	N	438341	6473128	0	MG, EG
125	Adjoining Lots 11 and 34	N	438046	6473226	0	LG
126	Adjoining Lots 11 and 35	N	437822	6473214	0	S
127	Adjoining Lots 11 and 36	Y	437660	6473185	2	LG, EG
128	Adjoining Lots 11 and 37	N	437333	6473113	0	LG
129	Adjoining Lots 11 and 38	N	439461	6473284	0	HG, EG

Table A: Survey control mark coordinates.

Control (Station number)	Local X Co-ord (m)	Local Y Co-ord (m)	Easting (MGA94) – Obtained by handheld GPS	Northing (MGA94) – Obtained by handheld GPS	Control Type
1001	1000.00	2000.00	438701	6473938	Star Picket
1002	1000.00	2040.00			Star Picket
1003	1000.00	2080.00			Star Picket
1004	1000.00	2131.52	438609	6474032	Star Picket
1005	1041.00	2131.52	438643	6474058	Star Picket
1006	1041.00	2080.00			Star Picket
1007	1041.00	2040.00			Star Picket
1008	1041.00	2000.00	438729	6473962	Star Picket
1009	1000.50	2000.00			Plastic Peg
1010	1000.50	2131.52			Plastic Peg
1011	1040.50	2131.52			Plastic Peg
1012	1040.50	2000.00			Plastic Peg
1014	1031.71	2034.03			Nail in ground
1015	1025.27	2058.92			Nail in Ground
1016	1040.11	2092.74			Nail in Ground

Table B: Coordinates, size and positional information pertaining to individual burrows, located in the 'detailed survey site'.

Burrow Number	X Co-ord (m)	Y Co-ord (m)	Diameter of the burrow opening (mm)	The position of each burrow, in respect to the surrounding understory vegetation (i.e. vegetation < 1m)
1	1016.69	2009.24	26	Semi-covered
2	1022.02	2019.57	29.5	Exposed
3	1021.16	2017.80	25	Exposed
4	1017.06	2015.11	Sealed 35	Under cover
5	1014.14	2017.69	25	Under cover
6	1022.73	2009.79	19	Under cover
7	1012.12	2036.90	29.5	Semi-covered
8	1020.86	2020.55	29	Under cover
9	1008.86	2031.68	23	Semi-covered
10	1019.37	2022.63	15	Under cover
11	1022.44	2027.61	28	Under cover
12	1024.10	2028.53	28	Under cover
13	1035.14	2026.93	26	Semi-covered
14	1024.16	2028.28	Sealed 30	Semi-covered; Removed for classification
15	1035.71	2038.34	31	Semi-covered
16	1023.80	2037.98	22	Semi-covered
17	1025.25	2029.12	19.5	Semi-covered
18	1025.96	2026.00	17	Semi-covered
19	1024.42	2029.90	18.5	Semi-covered
20	1025.15	2033.16	22	Under cover
21	1029.00	2067.55	15	Under cover
22	1016.34	2051.89	21	Semi-covered
23	1020.62	2054.11	14	Semi-covered
24	1014.47	2060.85	16	Under cover
25	1027.14	2068.56	15	Under cover
26	1015.18	2052.77	34	Under cover
27	1014.17	2060.56	24	Exposed
28	1019.77	2052.82	28	Under cover
29	1023.91	2059.71	22	Under cover
30	1014.39	2051.12	28	Semi-covered
31	1022.41	2041.92	17.5	Semi-covered
32	1034.03	2037.79	13	Under cover
33	1021.42	2057.13	26	Exposed
34	1023.74	2052.32	26	Under cover
35	1029.06	2044.62	26	Semi-covered
36	1030.00	2035.55	12	Under cover
37	1025.23	2052.23	20	Under cover
38	1035.65	2038.09	26	Semi-covered; Removed for classification
39	1016.14	2035.84	19	Under cover
40	1039.52	2039.44	15	Under cover
41	1036.60	2101.36	14	Under cover
42	1022.88	2065.25	25	Semi-covered
43	1021.23	2070.76	16	Under cover
44	1026.73	2066.58	15	Under cover
45	1020.77	2055.59	14	Semi-covered
46	1012.65	2060.43	28	Under cover
47	1023.26	2068.32	27	Semi-covered
48	1010.20	2058.72	27	Exposed
49	1016.07	2069.97	15	Semi-covered
50	1019.96	2084.25	26	Exposed
51	1019.10	2083.05	14	Under cover

52	1028.05	2074.42	16	Under cover
53	1020.90	2083.12	Sealed 31	Semi-covered
54	1037.02	2074.28	28	Under cover
55				Not Placed
56	1019.31	2080.31	14	Semi-covered
57	1034.14	2074.37	27	Semi-covered
58	1036.51	2076.36	31	Under cover
59	1022.55	2095.36	14	Under cover
60	1024.56	2129.97	24	Under cover
61	1034.13	2108.97	20.5	Semi-covered
62	1014.41	2126.70	16	Semi-covered
63	1030.29	2103.23	16	Under cover
64	1033.80	2122.62	23	Semi-covered
65	1029.90	2104.18	23	Semi-covered
66	1023.27	2125.54	27	Semi-covered
67	1041.13	2084.55	19	Under cover
68	1036.29	2119.91	24	Semi-covered
69	1025.94	2125.67	21	Semi-covered
70	1030.81	2121.61	14.5	Semi-covered
71	1022.98	2103.65	23	Exposed
72	1014.14	2080.52	19	Under cover
73	1016.30	2117.31	13	Under cover
74	1012.39	2072.39	19	Semi-covered
75	1006.48	2063.67	15	Under cover
76	1008.86	2074.28	13	Semi-covered
77	1009.09	2072.62	10	Semi-covered
78	1040.71	2092.24	13	Exposed
79	1031.85	2119.11	22.5	Semi-covered
80	1007.48	2080.05	26	Semi-covered

REPORT 2

SURVEY OF THE TRAPDOOR SPIDER "VOYAGER" *GAIUS* sp. IN NEARBY REGIONAL AREAS TO AVON LOCATION 1881, LOTS 11 AND 14

TABLE OF CONTENTS

1. INTRODUCTION

The regional study was conducted over a broad area occurring between the two known populations of the "Voyager" *Gaius* sp. (see also Report 1 for general background information). These two populations are situated at (1) the Voyager Quarry Site (i.e. Avon Location 1881, Lots 11 and 14) where it is proposed to relocate the present adjacent active quarry to within Lot 14 and (2) the intersection between the Brookton Highway and Beraking Pool Road. These two sites are approximately 35 miles apart. Much of this area is within the headwaters or drainage of the Helena and Darkan Rivers and approximates to the ancestral drainage area of the Avon River. The Voyager site represents a residual area of the old plateau (as does possibly the Warrin Road site). (See report 1 for discussion of the ancestral landscape.)

2. METHODS

Due to the time taken to map the population located in and around the Voyager Quarry, the regional study was conducted over only four days. The area selected for the survey was based partly on consultation with E. M. Mattiske who highlighted possible areas with respect to vegetation type and structure similar to that found at the Voyager Quarry site. Earlier experience of BYM in cursory examination of parts of the area was also taken into account. As a first stage in a regional survey, consideration was given to the need to locate sites as close as possible to the Voyager site in order to locate populations which would be likely to have close genetic affinity. It is thus hoped to be able to extend the area of search in the future.

The area selected for the regional survey was traversed by vehicle. At potential sites, spot searches were conducted to ascertain whether or not the species was present. At each check site, information was recorded concerning whether the site was occupied or unoccupied by the species, sampling effort time at each site, vegetation/soil field notes and MGA(94) coordinates by handheld GPS. A number of secondary spot checks, which were only briefly examined (about five minutes), were conducted whilst travelling between each of the primary searches, but were not recorded. The names of roads along which spot searches or brief spot checks were conducted during the survey period were also recorded.

3. RESULTS

Seventeen spot searches were conducted and recorded over approzimately four days. No populations in addition to the two already known populations were observed during the survey. The map in Figure 1 displays the area in which spot checks were conducted including the two already known locations of *Gaius* occurrence and the names of roads travelled along. Table 1 gives the following information related to the 17 spot check sites: occupation by spiders, coordinates and sampling effort).

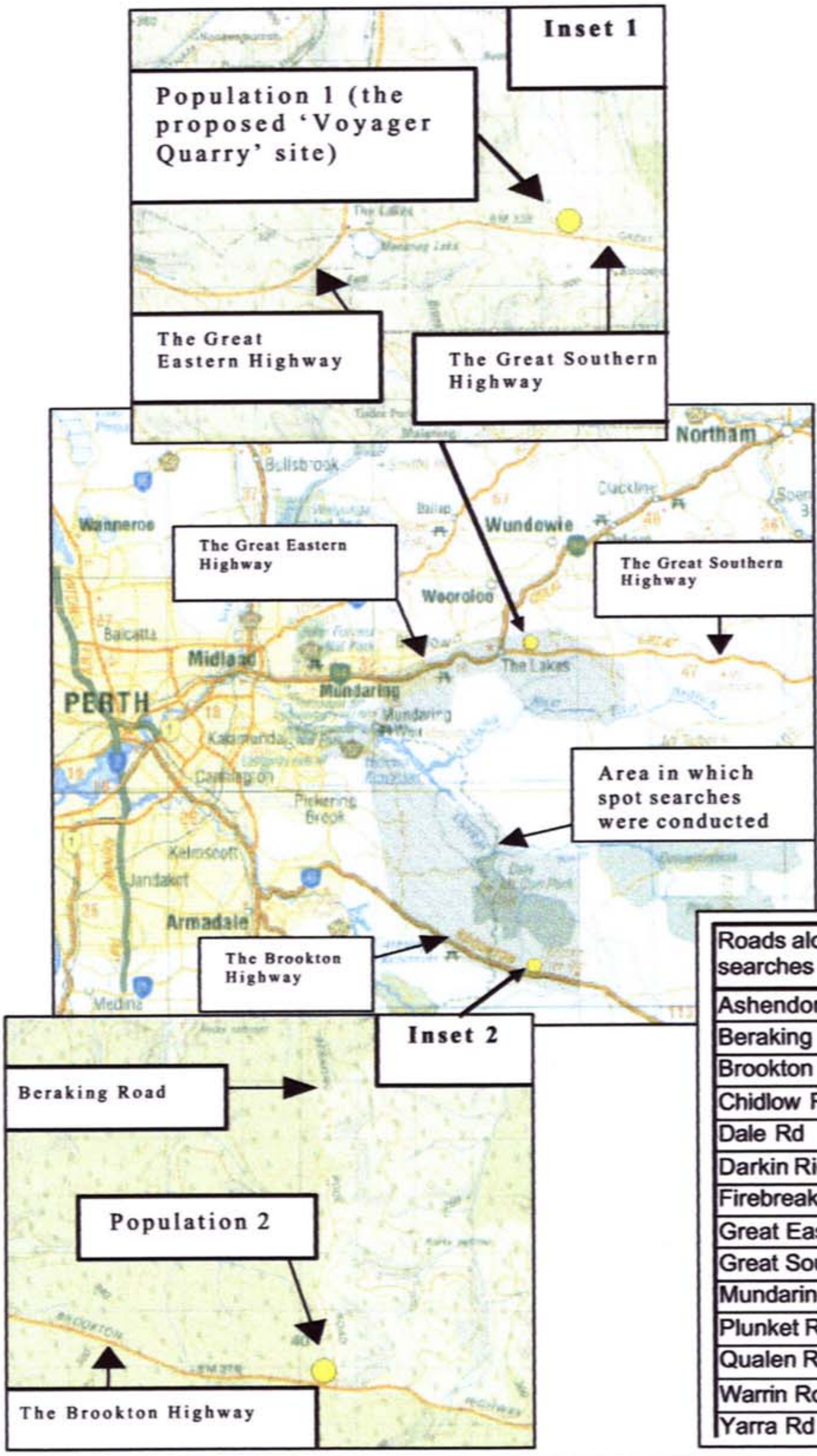
4. DISCUSSION

Some higher points of the landscape were not examined due to time constraints. However, from a distant inspection most such sites appeared to be dominated by wandoo and *Allocasuarina huegeliana* (rock oak) which indicate that the habitat would not be suitable for the "Voyager" species.

The Brookton Highway/Beraking Pool Road site (elevation appoximately 348m ?) has sandy/loam soil and the vegetation is a degraded jarrah/redgum dominated woodland with open shrubby understory. The site shows signs of heavy logging in the past but with regrowth coppicing. There are also indications of disturbance possibly by roadworks- dumps of stock piled soil and heavy vehicle parking. Nevertheless there were small patches of reasonably intact habitat for the spiders when first located in May 2003. However over the recent summer there has been logging of the area (by Forest Products commission) and stacking of cut timber along the edge of the spider site with some serious interference of the habitat. The population did not appear as robust as when first found.

Further investigation and a wider, more intensive search southwards from the above area and also targeting the higher topography along the eastern edge of the Darling Range is required to resolve the problem of the distribution of the species. If other locations can be found a genetic study could also help to elucidate the relationships of the species. Clearly a thorough study of the distribution and taxonomic affinities cannot be made in a short time and requires a longer commitment.

Current Known Locations of *Gaius* sp. Populations



Roads along which searches were conducted
Ashendon Rd
Beraking Pool Rd
Brookton Highway
Chidlow Rd
Dale Rd
Darkin Ridge Rd
Firebreak Rd
Great Eastern Highway
Great Southern Highway
Mundaring Weir Rd
Plunket Rd
Qualen Rd
Warrin Rd
Yarra Rd

Figure 1. (Sources: Key Map - Hema Maps, Australia Road Atlas 4th edition, 2004; Insets– Natmap, 1:100 000 topo series { inset 1 and inset 2, 2133 Jarrahdale & 2134 Wooroloo respectively}).

Table 1: Information pertaining to spot searches conducted during the regional survey.

Site #	Occupied	Easting (MGA (94))	Northing (MGA (94))	Sampling Time (minutes)
1	N	430299	6447868	30
2	N	434518	6448884	30
3	Y	439604	6435009	30
4	N	442194	6473487	25
5	N	448977	6467364	20
6	N	442408	6465930	15
7	N	424073	6469929	15
8	N	429562	6471183	15
9	N	429364	6469339	15
10	N	425473	6466145	15
11	N	420114	6462636	15
12	N	415167	6455716	15
13	N	423790	6448594	15
14	N	428855	6439231	15
15	N	440610	6437090	15
16	N	440781	6437912	15
17	N	438903	6441325	15

Biota Environmental Sciences

14 December 2004

Karen Ariyaratnam
Project Environmental Scientist
URS Australia Pty Ltd
Level 3, Hyatt Centre
20 Terrace Road
East Perth WA 6004
via email

Dear Karen

BGC Voyager Project: Preliminary report of activities related to the Trap-door spider genus, *Gaius*

Further to our recent field survey conducted to assist Professor Barbara York Main search for and collect more specimens of the *Gaius* spider, please find following an account of our findings. This report has been prepared on behalf of Professor York Main, and has been endorsed by her.

Background

A population of trapdoor spiders of the genus *Gaius* was previously located at the Voyager Quarry site (see report by Main and Trent 2004). It is undecided whether the species of *Gaius* at the Voyager Quarry site is an isolated northern outlier of a meta-population of a southern undescribed species (that is, Collie and farther south populations), or whether the Voyager / Brookton Highway populations represent a distinct, more restricted species (Main and Trent 2004). The status of the Voyager population (as part of a group covering a larger range, an isolated remnant population or a distinct taxon), and therefore its biodiversity significance, is uncertain.

Advice received by URS from Mr John Dell of the EPASU after having reviewed Professor York Main's report was that the taxonomic status of the spider should be resolved, either by genetic or morphological analysis.

Aims

To clarify the taxonomic status and conservation significance of the Voyager Quarry *Gaius* population by;

a) locating further populations in the region of the Darling Scarp proximal to the Voyager Quarry area; and

b) collecting individuals from several populations for genetic and morphological analysis.

Methods

Physical searches for *Gaius* populations and collection of individual spiders for analysis were conducted at ten sites on Wednesday the 17th and Friday the 19th November 2004 (Table 1). The sites selected represented, as closely as practicable, similar habitat structure to the Voyager Quarry site: a Jarrah dominated overstorey and *Hibbertia* dominated understorey, approximately 340 m above sea level. The preferred substrate was loamy to sandy type soils containing fine gravel on low sloping hill sides to facilitate drainage.

14 View Street North Perth WA 6006 | t: (08) 9328 1900 | f: (08) 9328 6138 | e: biota@biota.net.au | abn: 49 092 687 119

Specimens recovered from each site were processed to facilitate later morphological and genetic analysis. The third left leg of each specimen was removed and stored in 100% ethanol for genetic analysis. The remainder of each specimen was stored in 75% ethanol for morphological work.

Table 1: Co-ordinates of sites searched in the Darling Scarp for populations of the Mygalomorph spider genus, *Gaius*.

Site Number	Site Location	Northing	Easting
1	Voyager Quarry	See Main and Trent, 2004	
2	Yarra Road 1	6439652	0446784
3	Brookton Highway / Beraking Pool Road (North side)	6435034	04359576
4	Mount Yetar	6465808	0445895
5	West Mount Yetar	6465941	0442501
6	Yarra Road 2	6461904	0445529
7	Yarra Road 3	6455869	0443750
8	West Mount Dale	6446383	0433231
9	North Mount Dale		04
10	Brookton Highway / Beraking Pool Road (South side)	6434930	0439600

Results

Spiders were located at only the two sites previously known to have colonies (Sites 1 and 3/10;Figure 1): the Voyager Quarry site and the Brookton Highway/Beraking Pool Road intersection. Both sites are characterised by a Jarrah overstorey and a mixed shrub understorey in which *Hibbertia* is conspicuous. Leaf litter at both sites is shallow and overlies a sandy loam, which is mixed with fine gravel substrate at Voyager, and a grey sandy substrate at Brookton Highway.

Five individuals were recovered from the Voyager Quarry extension site, of which four – numbers 12, 27, 35 and 37 (see Main and Trent 2004; Table B) – were preserved for subsequent genetic and morphological analysis.

Three more individuals were recovered from the north side of Brookton Highway at the Brookton Highway/Beraking PoolRoad site to provide genetic and morphological comparison against those from the Voyager Quarry extension.

A further 22 specimens were located at the Brookton Highway site and GPS co-ordinates of their burrows recorded. The aggregation of spiders in this second population appeared more dense on the southern side of the highway than on the northern side. A large majority of spiders in these localities were found under the margins of *Hibbertia* bushes. Despite extensive searches at seven other sites with appropriate habitat, including a *Hibbertia* understorey, no further *Gaius* populations were found (see Figure 1 for location of sites searched).

Material from each specimen was placed in storage for later morphological and genetic analysis.

Conclusions

We were able to demonstrate that the Brookton Highway/Beraking Pool Road population is relatively large and robust (some 25 burrows having been recorded). It is considered likely by Professor York Main that the two *Gaius* colonies found contain individuals of the same species, although this requires confirmation via morphological and/or genetic analysis.

We were unable to demonstrate the presence of other *Gaius* populations, nor continuity between the two previously known to exist. On the basis of current knowledge, the distance separating the two populations makes the likelihood of genetic exchange extremely low and they must at this point be considered as isolated. The presence of other populations cannot be discounted, although the lack of evidence of their occurrence during our searches of similar habitat indicates a sparse, restricted distribution at best. The conservation significance of these two *Gaius* colonies must therefore be considered equivalent.

The key issues concerning the two presently known *Gaius* populations are as follows:

- their taxonomic status cannot be conclusively stated until such time as morphological and/or genetic analysis provides confirmation that they are of the same species.
- they should be regarded as isolated populations until other colonies are located in the Darling Scarp, preferably in close proximity to the Voyager Quarry area.

Material has now been collected to enable genetic analyses to proceed. However a male specimen is required from the Beraking Pool road population to enable confirmation of taxonomic affinity with the Voyager population. The best time to collect male specimens is after the first rains in autumn.

It is therefore recommended that:

(1) the samples collected for genetic analyses be forwarded to the South Australian Museum for analysis; and

(2) further pit trapping be conducted in autumn 2005 at the Brookton Highway/Beraking Pool Road population to collect a male specimen for morphological analysis by Professor York Main at the WA Museum.

Please contact us should you wish to discuss any aspect of this work.

Yours sincerely,

Biota Environmental Sciences Pty Ltd

Phil Runham
Zoologist

References

Main BY and SW Trent (2004). A further survey including demography of the trapdoor spider *Gaius* sp. occurring in Avon Location 1881, Lots 11 and 14, and adjoining landholdings. Report no. 1 for BGC Quarries, Perth.

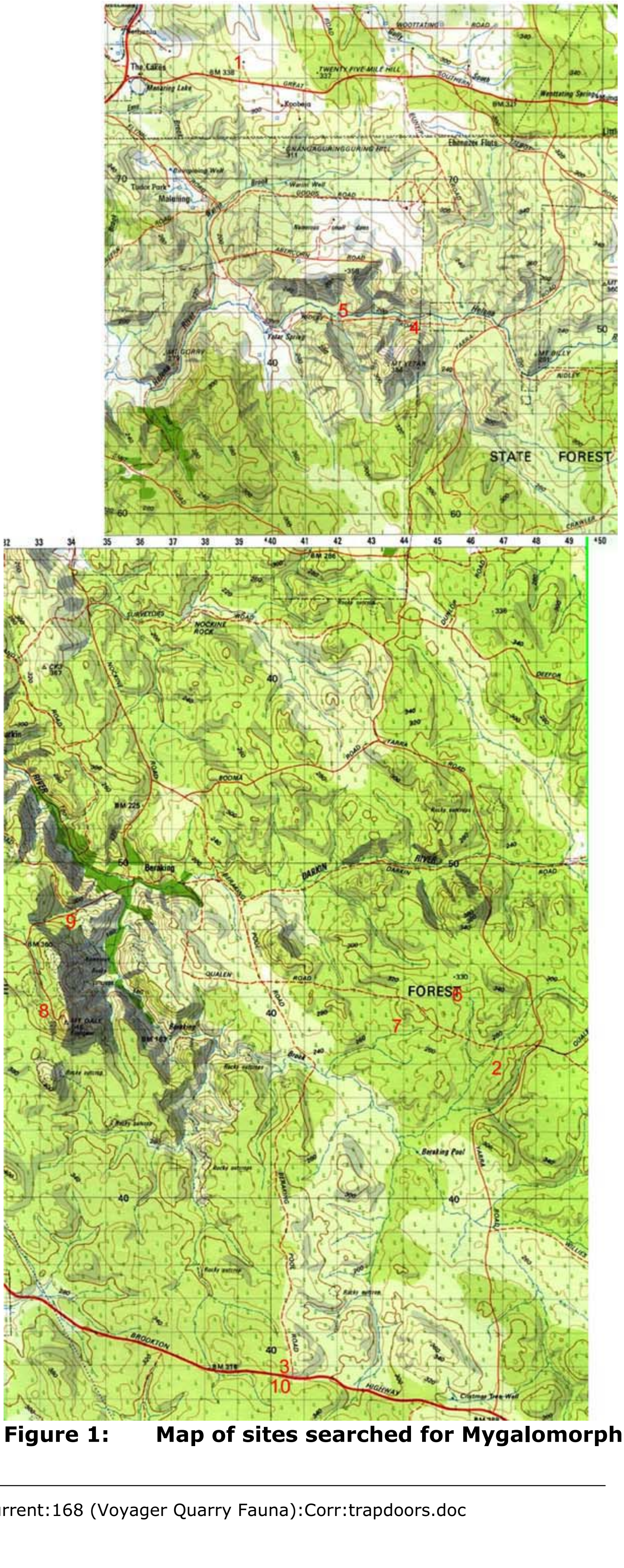


Figure 1: Map of sites searched for Mygalomorph spider genus, *Gaius*.

Appendix I

Land Snail Report

REPORT

ON A SURVEY OF TERRESTRIAL MOLLUSCS

FOR BGC QUARRIES

OF AREAS WITHIN A PROPOSED EXPANSION OF THE VOYAGER QUARRY AND OF NEARBY AREAS OF THE DARLING RANGE, WA

17 & 19 May 2004

S.M. SLACK-SMITH,
WESTERN AUSTRALIAN MUSEUM
June 2004

TABLE OF CONTENTS

Page no.

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

In recent years, terrestrial snails have become recognized by land managers as useful indicators of environmental condition because they are relatively immobile and restricted in distribution.

A survey of Lots 11 and 14 Horton Road, at The Lakes, straddling the border of the Shires of Mundaring and Northam was undertaken during July 2002 to determine if the site for the proposed Voyager quarry relocation supported any populations of endemic land snails. The survey found three poorly known and probably un-named, undescribed species. It was not possible to determine the conservation value of the three snail species in the absence of information about their distribution elsewhere on the Darling Scarp. BGC then commissioned the WA Museum to survey seemingly-suitable habitats in the Darling Scarp region in an effort to determine at least part of the geographical distribution of these species of snails.

A survey of the terrestrial snail populations of areas of the Darling Range within and outside the holdings of the BGC Voyager Quarry was subsequently carried out by S. Slack-Smith and G.W. Kendrick of the Western Australian Museum on May 17, 2004 and by these two people plus J. Dunlop on May 19, 2004.

This survey was an extension of that carried out within the Quarry holdings in 2002, and was aimed at determining whether the geographical distribution of some of the three taxa of native snails found during the 2002 survey extends beyond the holdings.

2.0 PROCEDURES

2.1 Survey Stations

Four Survey Stations within the Quarry holdings (Lot 11 (DOLA PIN #448365) and Lot 14 (DOLA PIN #1122071), located within the Shires of Mundaring and Northam) near to or at which snails of the genus *Bothriembryon* (family Bulimulidae) had been located in the previous survey in July 2002 (see Slack-Smith, 2002) were surveyed on May 17, 2004.

Other areas outside the Quarry holdings and within State Forest No. 13, in which the vegetation had not been significantly disturbed, were also surveyed. These included low-lying areas in gullies associated with the Helena River and its tributaries as well as areas at greater altitudes. Six such Survey Stations were examined on May 17 and another five, generally more distant from the roads, on May 19, 2004. These survey Stations lie to the SE and SSE of the Quarry holdings in the area of Inkpen (=Yarra) Road within the Shire of Northam of Western Australia.

GPS readings of the Eastings and Northings were recorded at each Survey Station site.

Table 1. - giving the co-ordinates, location and vegetation for each Survey Station

Stn No	Latitude /Longitude	Easting/Northing	Station Location	Station Description
VQ1	31°51'13"S 116°21'12"E	50 438815 6475621	Within Voyager Quarry Lots 11 and 14	Jarrah/marri forest with some *Xanthorhea* and *Hakea*; good regrowth after fire;much litter
VQ2	31°51'18"S 116°21'17"E	50 438953 6475465	Within Voyager Quarry Lots 11 and 14	Jarrah/marri forest with some *Xanthorhea, Persoonia, Dryandra* and *Hakea*;
VQ3	31°51'25"S 116°21'13"E	50 438831 6475236	Within Voyager Quarry Lots 11 and 14	Forest of jarrah & marri with wandoo and *Xanthorhea*
VQ4	31°52'02"S 116°21'12"E	50 438819 6474099	Within Voyager Quarry Lots 11 and 14	Forest of jarrah, marri & sparse wandoo; with Dryandra spp., *Xanthorhea* spp. *& Adenanthos*
VQ5	31°53'32"S	50 447110 6471386	Low-lying area	Jarrah/marri forest with

	116°26'27"E		either side of West Talbot Rd W of Inkpen(=Yarra) Rd at crossing of power lines	*Macrozamia* & *Dryandra* spp., merging with wandoo, blackbut & *Xanthorhea* downhill;
VQ6	31°53'37"S 116°26'33"E	50 447292 6471239	Low-lying area either side of West Talbot Rd, W of Inkpen(=Yarra) Rd but E of Station #5	Jarrah & marri with more wandoo & less jarrah downhill; *Dryandra*, *Xanthorhea* & *Macrozamia* spp.;
VQ7	31°53'43"S 116°27'05"E	50 448113 6471045	Low-lying area N of West Talbot Rd just W of Inkpen (=Yarra) Rd;	Jarrah, marri & wandoo forest; *Dryandra*, *Macrozamia* & *Xanthorhea* spp.
VQ8	31°54'21"S 116°27'20"E	50 448524 6469878	Low-lying area on track to N of West Talbot Rd to E of Inkpen (=Yarra) Rd	Uphill – jarrah with *Dryandra* & *Allocasuarina* spp.; lateritic boulders; Downhill sandy loam flat; wandoo & marri with *Hakea* & *Dryandra* spp.
VQ9	31°54'01"S 116°27'14"E	50 448365 6470494	Low-lying area E of Inkpen (=Yarra) Rd;	Jarrah/marri/wandoo woodland with *Hakea* spp.
VQ 10	31°53'18"S 116°27'27"E	50 448707 6471823	Hilltop to W of Inkpen (=Yarra) Rd, S of junction with Great Southern H'way	wandoo, jarrah & few marri with *Xanthorhea* & *Macrozamia*
VQ 11	31°54'40"S 116°27'39"E	50 449023 6469294	Hilltop to E of Inkpen (=Yarra) Rd, S of junction with West Talbot Rd	Wandoo with few jarrah; *Xanthorhea, Dryandra sessilis* & low shrubs
VQ 12	31°54'38"S 116°27'13"E	50 448325 6469353	Hilltop to W of Inkpen (=Yarra) Rd S of junction with West Talbot Rd	Wandoo, jarrah & few marri with *Xanthorhea*;
VQ 13	31°57'25"S 116°25'31"E	50 445693 6464192	Low-lying area W of Inkpen (=Yarra) Rd, S of the Helena River crossing	Granitic outcrop with dolerite nearby; *Xanthorhea*;
VQ 14	31°57'21"S 116°25'51"E	50 446217 6464318	Hilltop to E of Inkpen (=Yarra) Rd to E of survey Station VQ #13	Wandoo, powder bark & jarrah with *Macrozamia* & *Xanthorhea* plus low shrubs
VQ 15	31°57'22"S 116°25'38"E	50 445875 6464287	Downhill to W of Survey Station #14	wandoo and *Xanthorhea* with small shrubs

2.2 Survey Procedures

Survey procedures entailed the surface searching of a designated Survey Station by two people on May 17 and by three on May 19, giving particular attention to shelter sites under boulders and logs and in the litter of leaves and bark which accumulates around the vases of trees and under shrubs. The time spent at each Station, excluding that taken in walking to and from the roadway, was approximately 30 minutes.

Any snails or snail shells detected during the search were placed in vials which were marked with the station number.

A labelled sample of approximately 1 litre in volume of the litter from a variety of situations was taken at each station. These samples were later examined in the laboratory using a stereomicroscope and small dead and living specimens, if present, were collected from each.

The specimens were examined using a stereomicroscope and compared with specimens taken during the 2002 Survey and with related specimens in the collections of the Western Australian Museum.

Data on the snail specimens taken in the field or in the laboratory, including data on locality, vegetation, collectors and date, were later entered in the Specimen Database of the Western Australian Museum as the specimens were registered. A copy of the relevant section of that Database is appended to this report.

3.0 RESULTS

Snails, alive and dead, belonging to an un-named species of the genus *Bothriembryon* (family Bulimulidae) were found at four of the fifteen stations surveyed, as below. The associated laboratory work revealed tiny specimens of a currently unidentified genus and species of the family Punctidae.

Table 2 – giving the dates, collecting personnel and results for each Survey Station (indet. = indeterminate)

Voyager Survey Station	Date	Collectors	Terrestrial Snail Count
VQ#1	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	No snails
VQ#2	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	1 live punctid (genus & species indet.)
VQ#3	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	No snails
VQ#4	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	No snails
VQ#5	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	1 dead punctid (genus & species indet.)
VQ#6	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	7 dead punctids (genus & species indet.)
VQ#7	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	No snails
VQ#8	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	No snails
VQ#9	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	1 dead punctid (genus & species indet.)
VQ#10	17 May 2004	S.M. Slack-Smith and G.W. Kendrick	13 dead punctids (genus & species indet.) 1 dead *Bothriembryon* (species indet.)

VQ#11	19 May 2004	S.M. Slack-Smith G.W. Kendrick & J. Dunlop	5 live, 3 dead *Bothriembryon* (species indet.)
VQ#12	19 May 2004	S.M. Slack-Smith G.W. Kendrick & J. Dunlop	2 dead punctids (genus & species indet.); 1 live, 2 dead *Bothriembryon* (species indet.)
VQ#13	19 May 2004	S.M. Slack-Smith G.W. Kendrick & J. Dunlop	6 dead punctids (genus & species indet.)
VQ#14	19 May 2004	S.M. Slack-Smith G.W. Kendrick & J. Dunlop	8 dead punctids (genus & species indet.) 2 live, 1 dead *Bothriembryon* (species indet.)
VQ#15	19 May 2004	S.M. Slack-Smith G.W. Kendrick & J. Dunlop	No snails

4.0 DISCUSSION

Specimens belonging to the genus *Bothriembryon* taken during this survey of May 2004 appear to be conspecific with those taken in the 2002 survey of the Voyager Lots11 and 14. As detailed in the 2002 report, this taxon cannot currently be identified with any named species and is considered to be currently un-named and undescribed.

This species of *Bothriembryon* appears to be endemic to this area of the Darling Range. It does not seem to be conspecific with other taxa of this genus taken further south on the Darling Range – in, for instance, the area east of Mount Dale or in areas to the north and south of the Brookton Highway. Nor is it conspecific with better-known and named species taken in gullies along the western edge of the Range – most of which also live in suitable habitats on the Swan Coastal Plain.

An interesting feature of its distribution, as demonstrated during this 2004 Survey, is that it appears to be limited to hilltop situations, no specimens being found at lower altitudes. These results are consistent with the taxon's occurrence on the Voyager Quarry lots surveyed in 2002.

As far as can be determined at present the very small punctids taken during the 2004 Survey are also conspecific with those taken during the previous survey. They are thought to belong to the genus *Westralaoma* but cannot with confidence be placed within a named species.

This punctid species appears to inhabit a more diverse range of habitats than does the *Bothriembryon* species, being found at a variety of altitudes at Survey Stations on hills or in valleys.

No specimens of the small charopid taxon (thought to be a species within the genus *Luinodiscus*), two dead shells of which were collected during the 2002 survey, were taken this year.

5.0 CONCLUSIONS

Of those native snail species which live within the holdings of the Voyager Quarry: -

(a). the taxon belonging to the diverse genus *Bothriembryon* inhabits a wider area of the Darling Range, having been found alive in areas of State Forest No. 13. Its distribution is, however, patchy and it is presumed that the populations on isolated hilltops would have little opportunity for contact with one another.

(b). the taxon belonging to the family Punctidae and possibly to the genus *Westralaoma*, is well represented in a variety of habitats on the Darling Range, within (and possibly outside) the State Forest No. 13. Because the sites at which this taxon has been found are varied and apparently not physically separated from one another, there would seem to be opportunities for intermixing and so of interbreeding. Because of their small size, however, snails of this group are rarely collected except during surveys of the type discussed here. A very similar if not conspecific form has been taken to the east near Nangeenan.

(c). the taxon belonging to the family Charopidae (query genus *Luinodiscus*) has not yet been found in other areas of the Darling Range but specimens of what seems to be the same or a very closely-related species have been found at various localities on the Swan Coastal Plain in the Perth/Fremantle area and further south. As with members of the family Punctidae, small charopid snails are rarely taken except during detailed surveying procedures.

5.0 RECOMMENDATIONS

Because of the finding of a number of specimens of snails of the families Bulimulidae (*Bothriembryon* sp.) and Punctidae (? *Westralaoma* sp.) at a number of survey stations within the State Forest, there seems to be a less imperative need for concern about the survival of these taxa within the Voyager Quarry holdings.

However, no specimens belonging to the family Charopidae were found during the survey. The dead charopid shells found during the previous survey appear to belong to the same genus and may be of the same species as (or closely related to) the very few other specimens found on the Swan Coastal Plain and further inland.

I understand that the northern part of lot 14 where the dead charopid shells were found in 2002 will not be cleared but is to remain vegetated in perpetuity. Such a measure would safeguard that habitat and so its resident population of charopids from the effects of the proposed quarry relocation.

However the unexpected lack of further information about the distribution of the charopid species (of which only 2 dead shells were found during the 2002 survey) does still give cause for concern at the lack of knowledge about this taxon.

The lack of specific identities for all three taxa encountered during these surveys does certainly need attention. As with so many terrestrial snail groups, specific differentiation based on external morphological characters is generally unsatisfactory. Anatomical studies, preferably accompanied by electrophoretic

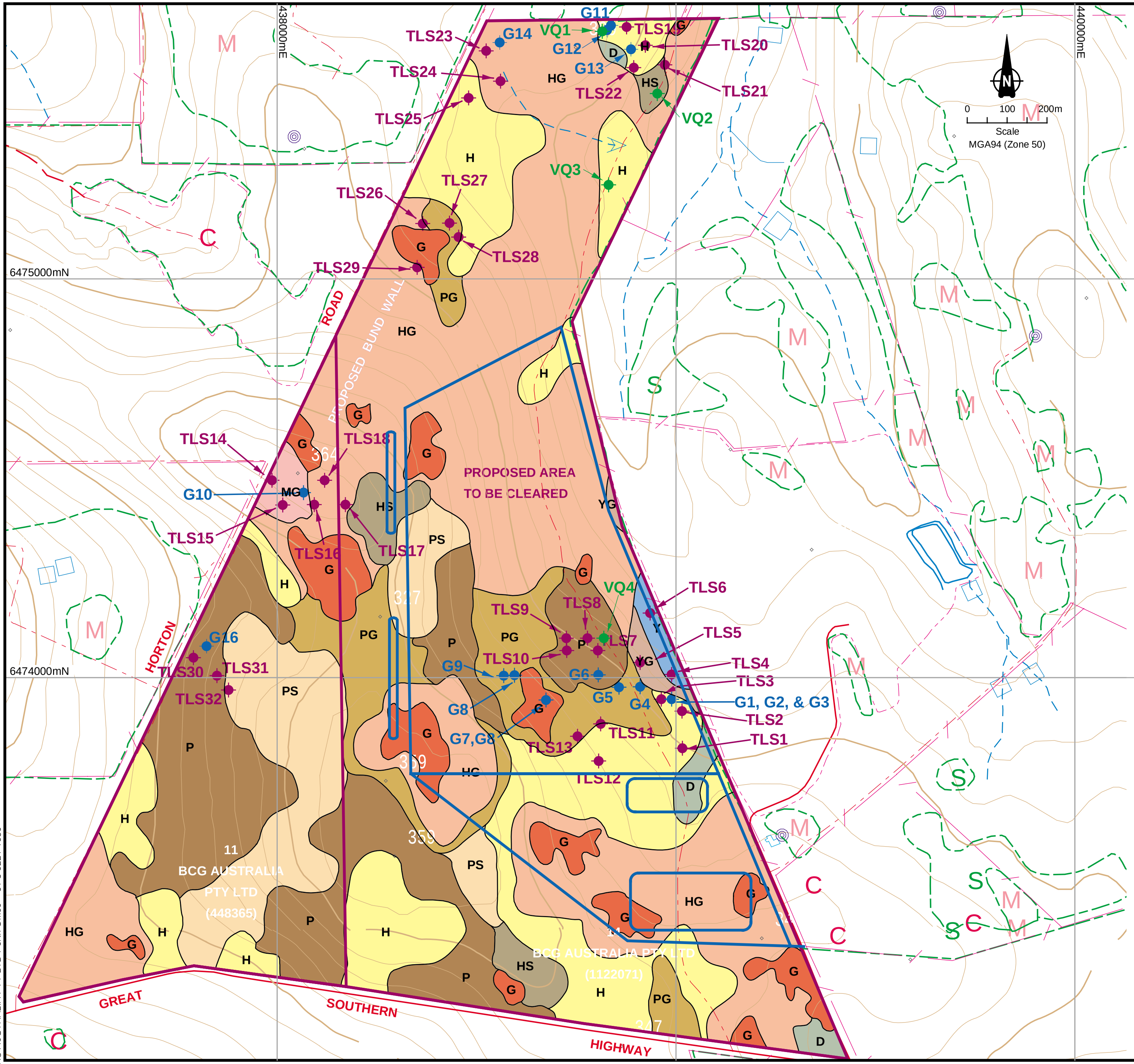
or DNA analysis, need to be carried out by experts in the field – not only on these three taxa but on a variety of taxonomically and geographically related taxa with which they can be meaningfully compared.

In particular, a further field survey to collect some living specimens of this charopid taxon would enable taxonomic work to proceed towards the end point of providing a specific identity for this taxon.

The fieldwork which would be involved in such a survey should not be lengthy. Because of the small size of these charopid snails, surface searching would be of no avail and so only litter samples would need to be collected at each Survey Station to be sieved and searched under a stereoscope in the laboratory.

7.0 REFERENCES

Slack-Smith, S.M., 2002,
Report on a survey of invertebrates (terrestrial molluscs)for BGC Quarries of areas within and adjacent to a proposed expansion of the Voyager Quarry, WA (lot 11 – DOLA Pin #448365; and lot 14 - DOLA Pin #1122071;belonging to BGC Australia Pty Ltd;) July 16th & 28th 2002. Unpublished Report



LEGEND

SITETYPES
(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)
- Landsnail search sites (17 to 19 May 2004)

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

Map 1
MAP OF THE PROJECT AREA SHOWING SAMPLING STATIONS AND VEGETATION TYPES

Appendix J

Proposed Environmental Offsets Package

EVALUATING A SUITABLE ENVIRONMENTAL OFFSETS PACKAGE FOR THE BGC VOYAGER QUARRY EXTENSION

By Frank Batini
(Sub-consultant)

SUMMARY

BGC wish to expand the Voyager quarry on to forested freehold land held by the Company. The proposed expansion will have a "clearing footprint" of 85 hectares and is being assessed by the EPA as a PER. An environmental offsets package based on the rehabilitation of 170 hectares of Crown and private land in the Wooroloo brook catchment was proposed as a suitable environmental offset by BGC and a draft revegetation strategy was prepared by URS for public comment.

However, practical difficulties were encountered with the implementation of such a strategy. In addition, during 2004, the EPA released a preliminary Position Statement on the acceptable use of environmental offsets.

Mr Frank Batini (Consultant in the management of natural resources) was therefore engaged to provide advice on the range of environmental offsets available and to design an offsets package that would meet the EPA's requirements for generating a "net benefit" to the environment

A revised environmental offsets package, based on the findings of Mr Batini's investigations and advice is now proposed by BGC for evaluation by EPA Service Unit, the Wooroloo brook LCDC and the EPA. This revised package consists of three elements:

- The Covenanting, in perpetuity, of about 120 hectares of jarrah-marri woodland in good condition, held as freehold by BGC, to either CALM, Agriculture WA or the National Trust.
- The provision of up to 15 kilometres of fencing materials to the Ministry for Justice, to protect remnant vegetation and the Wooroloo brook from grazing, on land managed by the Ministry as prison farms. Prisoners would then erect this fencing as part of their farm training. It is expected that between 100 and 150 hectares of remnant vegetation would be protected.
- The rehabilitation of about 60 hectares of gravel pits and other degraded lands on land managed by the Shires of Mundaring and Northam, CALM and the Water and Rivers Commission.

1.0 BACKGROUND

BGC wish to expand the Voyager quarry on to forested freehold land held by the Company on Lot 14 Horton Road, The Lakes, Mundaring. The proposed expansion will have a "clearing footprint" of 85 hectares and is now being assessed by the EPA as a PER (Assessment number 1413). To mitigate the loss of 85 hectares from an already over-cleared catchment, BGC proposed in the PER to revegetate some 170 hectares of mainly private land in the Wooroloo brook catchment. The PER was issued for public comment in January 2003 and contained a draft revegetation strategy for rehabilitation of 170 hectares. Since then URS has been investigating ways of finalising the revegetation strategy into a more definitive plan of action.

However, practical difficulties were encountered with the implementation of such a strategy, not the least of which was finding privately owned land to revegetate. Local farmers willing to " donate" this area of land could not be found. Rehabilitation of cleared land is usually more expensive and difficult due to competition from weeds and grazing pressures by domestic animals or rabbits. Fencing is required and the land would need to be protected and managed for conservation in the long-term or "gifted" by BGC to the State.

Then, in June 2004, the EPA issued a Preliminary Position Statement No 9 on its proposed environmental offsets policy for public comment. Though the statement is not final, it indicates the EPA's current thinking on the situations where offsets can be used to mitigate environmental impact, and is a useful guide. The statement covers 33 pages, but is adequately summarised in Figure 2 Decision framework for the use of environmental offsets (Refer figure 1).

On the basis of the guidance provided in the Preliminary Position Statement, the proposed clearing of 85 hectares by BGC is likely to be seen as clearing of a 'high value asset' by the EPA. In the PER, BGC has attempted to reduce the predicted impact by implementing on-site impact mitigation as follows:

- Avoid – avoiding all impacts is not possible, some clearing is essential for the establishment of a quarry.
- Minimise – the PER has attempted to minimise the footprint for clearing to the minimum required for safe and efficient operations, and return on investment.
- Rectify – It is not practical to "repair the site as soon as possible" as the quarry is planned to be operational over the next 50 years.
- Reduce – some of the impacts will be reduced over time, but unlike gravel, bauxite, sand or some coal mine sites, open quarry pit sites are not usually amenable to revegetation.
- Offset – this requires that an offset package be proposed which contains both primary and secondary offsets aimed at generating a "net benefit" to the environment.

The EPA document then discusses examples of primary offsets eg rehabilitation, re-establishment and also of secondary offsets eg acquiring land for conservation. Some of the "offset principles" against which the BGC proposed offsets package would be considered are also listed.

2.0 OBJECTIVES AND SCOPE OF WORKS

At this stage, BGC through its principal consultants (URS Australia Pty Ltd) contacted Mr Frank Batini (Consultant in the management of natural resources) for advice on the range of offset options available including involving Crown land. Ten alternative options were examined initially including revegetation, land purchase, donation of land, Land for Wildlife, covenanting, funding for research into wandoo crown decline, funding of recovery plans for DRF species and fencing of remnant vegetation.

Several alternative options that concentrated primarily on the protection and enhancement of remnant native vegetation were then examined in more detail, as well as the potential for rehabilitation of degraded areas on reserve land, managed by State Departments or by Local Government.

Frank Batini was subsequently engaged to develop an appropriate environmental offsets package that was both feasible and cost-effective and addressed the requirements of the EPA Preliminary Offsets Position Statement.
The specific tasks set to the sub-consultant were to:

- Locate appropriate areas of cleared Crown land that may require rehabilitation and that are reasonably close to the proposed quarry
- Determine the responsible management authority
- Contact these authorities, discuss BGC's proposal and obtain "in principle" support
- Recommend the rehabilitation techniques most appropriate to these sites and suggest some approximate costs.
- Briefly inspect those parts of Lots 11 and 14 being considered for a Covenanting agreement with CALM/ National Trust/Agriculture WA.
- Obtain relevant data related to the establishment of these Covenants, including management responsibilities and approximate costs.
- Locate areas of remnant vegetation on Crown land that may require protection by fencing.
- Estimate the likely cost to protect some 100-150 hectares of remnants.

3.0 FINDINGS

The findings of investigations into each of the specific tasks indicated above are presented below in the same order.

3.1) LAND REHABILITATION

A) Selection of Areas

From an aerial mosaic provided by URS Consultants, a number of areas that were cleared or had sparse vegetation were selected. By reference to a CALM map that showed Tenure, those areas that occurred on Crown land were then inspected in the field. Photographs were taken for relevant areas.

Two areas were found to be naturally open, one on a Nature Reserve due to extensive shallow rock, the other on an open wandoo flat, adjacent to a very small parkland-cleared block (318) of about 15 hectares, surrounded by reserve land. Two areas could not be accessed as they are now part of the Acacia Prison farm complex.

A large gravel pit of about 20 hectares adjacent and to the West of Lot 11, managed by the Shire of Mundaring is reaching the end of its useful life and would be very suitable for rehabilitation. Parts of a rubbish disposal site managed by the Shire of Northam near Wundowie may also be available (possibly 5 hectares). There are also cleared areas in the Helena catchment on land held as freehold by the Water and Rivers Commission as well as un-rehabilitated gravel pits on CALM managed lands. In total, between 60 and 80 hectares of crown land is potentially available in the region of the Voyager quarry.

.

B) Management Authorities

The four key management authorities were the Shires of Northam and Mundaring, the Water and Rivers Commission (with DoE as their management agency) and CALM. Personal contact was made with senior CALM's Hills District staff at Mundaring Weir (Mr Meinema and Mr Pollock) and with the Shire of Mundaring (Mr Noonan). Follow up phone calls were also made with Mr Mick McCarthy, an environmental officer with the Eastern Metropolitan Regional Council who has responsibility for the Shire of Mundaring. Phone contact was made with the Shire of Northam (Mr Middleton and Mr Edwards) and senior staff at DoE, Mr Phil Roberts (with responsibility for implementing policy on the WRC lands) and Forest Products Commission (Mr Donovan).

CALM indicated that they had several small gravel pits on State forest totalling 10-15 hectares that could be rehabilitated and that they had the equipment, staff and desire to be involved. There are also several areas within the Helena catchment that were once farmland (Flynn's, Chambers, Wellbucket) and have been resumed and are managed by DoE on behalf of Water and Rivers Commission. The bulk of these areas have been planted and are managed by CALM and FPC for salinity control and pine production, but CALM's advice is that about 80 hectares are still available for further planting with eucalypts or pine.

Advice from DoE's land Manager is that the bulk of this land could be planted as commercial plantation venture (pines or globulus) jointly with Forest Products but that some 12-25 hectares of cleared land in stream buffer zones need to be planted to native species. As neither the FPC nor DoE wish to expend their money on this non-commercial planting, the DoE are very keen to continue negotiations with BGC. If these negotiations are successful, the planting would most likely be carried out by CALM.

The Shire of Mundaring staff and the environmental officer from the EMRC also considered the proposal as valuable. Mr McCarthy has spoken to others in the Council and will ascertain how much land is available at the gravel pit and the timings for rehabilitation with dieback-free materials from the BGC site. He will also investigate and report back to me on Friday 10th December whether other Shire lands may be available, for example the rubbish transfer site at Chidlow. It appears that a further five sites totalling some 10-15 hectares may be suitable for rehabilitation.

The Shire of Northam was also supportive of the concept, offered to investigate opportunities and to ring back. They later advised that some work on the rubbish disposal site on Inkpen road was desirable.

C) Proposed rehabilitation techniques

The three key useful documents used were:

- The URS draft revegetation plan prepared for the PER
- The CALM guidelines for the management and rehabilitation of gravel pits (undated) and
- Completion criteria as used by Alcoa World Alumina.

Rehabilitation must be designed to be site specific eg gravel pits will have different needs to former farmland sites. The availability or lack of topsoil is a key determinant as is the presence and quantity of weed competition and of grazing. Some sites may favour a production crop of pine or blue gum, but most sites are better suited to native species.

Recommendations for successful revegetation of the various sites and types of land available to BGC for rehabilitation are provided below.

i) Mundaring Shire gravel pit.
This pit is adjacent to BGC's Lots 11 and 14, where BGC will be clearing vegetation and stripping topsoil and overburden. The pit is currently classified as "dieback-free", as is the site of the proposed quarry. The simplest and most effective rehabilitation technique will be to reshape the pit in accordance with CALM's guidelines (ie. pit sides no steeper than 1:4, pit floor not less than 1:100, laterite boulders removed or buried, rip with winged tyne to 0.5-1.0 metres depth at about 1 metre intervals under drysoil conditions) and then spread overburden (50 –100 cms), fresh topsoil (10-20 cms), stockpiled vegetation, logs and organic debris from BGC's clearing operations.

These materials could be carted by BGC haulpack or scraper across Horton road, using a flagman for safety, average haul distance being 2 km round trip. Site preparation and ripping could be done by the Shire or by BGC equipment. BGC staff experienced with earth-moving operations could readily estimate the likely total cost. As the pit is still in use, some areas may not be able to be rehabilitated for a couple of years. For these areas, overburden, topsoil and vegetation could be stockpiled in the gravel pit, with the topsoil stored in long mounds about 3 metres wide and 1-1.5 metres high, so as to maintain seed viability.

ii) Sites where topsoil is old or not available
The more usual situation is that fresh topsoil is not available, or if older topsoil is present it is present in inadequate quantities to fully cover the site. In these situations, after shaping and ripping, the areas are seeded in drysoil conditions with indigenous tree and shrub species at a minimum rate of 1.5 kgs/hectare, supplemented by seed-bearing brush and then tree seedlings are planted in winter at a rate of about 600 stems/hectare. DAP tablets are buried beside each seedling and the area is fertilised at a rate of between 250 and 400 kgs/hectare. The CALM guideline provides a list of suitable plant species.

iii) Former farmland
Farmland soils still retain the valuable topsoil and organic matter and are generally of higher fertility. They do not require reshaping. The main concerns relate to weed competition and possibly to grazing by rabbits and kangaroos. Weed control is usually achieved with glyphosate (one of the chemicals approved for use in water supply catchments). Strip spraying of planting lines is often used since blanket spraying of whole areas within water-supply catchments requires specific approval from the Health Department. Ripping is often useful and the areas are then seeded, planted and fertilised as described above.

D) Monitoring and Completion Criteria

Monitoring will be required to assess the success of revegetation.
CALM's success criteria for gravel pits are given as follows

- Guidelines : more than 30 shrubs and 5 trees/100 m2 (10mx10m) over 90 percent of the area by year 2, ie 3000 shrubs and 500 trees/hectare.

The success criteria suggested by URS/ Mattiske and Associates are as follows:

- 300 trees/hectare at 12 months
- 1 legume plant/ 10 square metres and
- 2 native plants /10 square metres at 12 months, ie 3000 shrubs/hectare

Success criteria currently used by Alcoa rely on monitoring at 9 and 15 months. Alcoa has data that show that areas that meet the criteria at this early stage remain 'on track" in the future. The criteria measured are:

- at 9 months- more than 500 trees and more than 5000 legume plants/hectare
- at 15 months- more than 50% of the species richness of the adjacent forest.
- At age 12- more than 350 trees /hectare and no more weeds than are found in the forest

3.2) COVENANTING SCHEMES

There are currently three covenanting schemes, (see Table), two of which are associated with Government (CALM, and the Department of Agriculture) and the third with an NGO (the National Trust).

The Title remains with the owner and the Covenant usually covers 5-6 pages and takes 3-6 months to set up. A management plan is then prepared in consultation and agreement between the parties, which is advisory (CALM) or obligatory (National Trust).
CALM's criteria for selection of a suitable covenant are listed as follows:

- Area, shape, intactness, pests, diseases, adjacent land use, long-term viability, threatened flora or fauna, regional significance and corridor function (The National Trust criteria are similar).

A brief inspection by the sub-consultant of Lots 11 and Lot 14 Horton Road, adjacent to the public access roads revealed that the site had been heavily logged and consisted of adequately stocked regeneration of jarrah and marri, with some wandoo, established from coppice and advance growth, on both gravelly and sandy soils, with an understorey of *dryandra* and *banksia,* smoke bush, kangaroo paws and *stirlingia* respectively. The crowns appeared to be healthy and the bulk of the area appeared to be dieback-free. These Lots adjoin Reserve land to the West and the South.

The woodland on these lots appeared to fit the criteria listed above and should be considered suitable for covenanting.

3.3) FENCING OF REMNANT VEGETATION

The Ministry for Justice has two properties in the Wooroloo catchment, the Acacia security prison and Wooroloo prison farm. The sub-consultant was advised that there are no opportunities for rehabilitation as all of the available cleared land is required.

However, there are over 1000 hectares of remnant vegetation and of streamlines on these properties and the Ministry would like to protect some of these from grazing (by fencing) and they have been in touch with CALM to try and obtain Natural Heritage Funds for this work. However, NHT funds are limited. The Ministry staff contacted (Ms Blasgund, Mr Cowan, Mr Jolly) would be very pleased to receive funds for the purchase of fencing materials and would then organise for the construction of the fences using prisoners. This would not only provide suitable farm work, but also mean that more fencing would be done.

4.0 RECOMMENDATIONS

On the basis of the above findings, I recommend the following package of environmental offsets be considered as adequate to address the EPA's requirements for generating a "net benefit" to the environment.

1) The Covenanting of about 120 hectares of Lots 11 and 14 Horton Road, and its management for wildlife so as to protect this valuable vegetation in perpetuity. The priorities for Covenanting could be:

I. National Trust or CALM
II. Agriculture WA

The EPA would be advised as soon as the Covenant is signed.

2) The purchase of about 15 km of fencing materials by BGC to protect substantial areas of remnant vegetation on Crown land managed by the Ministry for Justice. BGC responsibility would cease once the materials are paid for. The Ministry would then advise the EPA of the length of fence constructed and the areas of remnant vegetation that were protected, once the fencing program has been completed.

3) The rehabilitation of about 60 hectares of cleared Crown land. The priorities for rehabilitation appear to be:

- Mundaring Shire gravel pit, about 18-20 ha
- Mundaring Shire, other areas, about 10-15 ha
- Shire of Northam, about 5 ha
- Water and Rivers Commission, stream buffers and other, 12-25 ha
- CALM gravel pits in forest areas, 10-15 ha

For scheduling purposes, it would be best if this program of works could be carried out over a period of three to five years.

I recommend that the CALM rehabilitation procedures and completion criteria of 3000 shrubs and 500 trees per hectare at age 2 (as stated in the CALM guideline) be selected as appropriate. Monitoring at 9 months would be desirable to indicate likely success and would allow appropriate intervention if this were required.

The rehabilitation could be carried out by BGC or the Shire of Mundaring (Shire gravel pit), the Shires of Mundaring, Northam or CALM (other Shire managed areas) and by CALM (State forest, reserves and land held by WRC). CALM or the Shire would submit a detailed rehabilitation costing/hectare to BGC whose responsibilities would cease on payment. CALM or the Shire would report annually to EPA on the completion of the program of works for that year and on the success achieved. The Shire of Northam has indicated a desire to outsource the work to CALM.

4) Where to from here?

- Discuss the environmental offsets proposal with EPASU staff, the Wooroloo brook LCDC and EPA
- If agreed, visit the Ministry for Justice sites, determine the location and fencing distances and estimate the area to be protected.
- Visit the remaining sites at Mundaring with the Shire (and possibly CALM) to agree on prescriptions and who will carry out the work
- Obtain written quotes from the Shire and CALM
- Obtain letters of agreement from all parties (CALM, Shires of Mundaring and Northam, Water and Rivers Commission and Ministry for Justice).
- Initiate an application for covenanting land held by BGC.

Frank Batini
8-12-04

ATTACHMENTS
CALM Gravel pit rehabilitation Guidelines
Conservation Covenant Schemes in Western Australia.
EPA Preliminary Position statement No 9 (2004) Figure 2

Draft Applying NNCA BRM Policy for access and mgt of gravel pits within the Conservation Estate Guidelines for Managers & Proponents Oct 1999

Pit life is to be maximized, as far as practical, by:

- ensuring that all areas of suitable gravel are removed, with no islands left in the pit;

- using equipment of adequate horsepower to secure material down to the basement clay;

- mixing basement clay with surface gravel, if quality is not unacceptably compromised and providing material remains in the pit floor which is suitable for subsequent revegetation;

- crushing caprock in the pit floor.

4.2 Pit Rehabilitation

Rehabilitation is to be based on a properly formulated plan, as outlined at 2.6.2 above.

4.2.1 Shaping

The pit sides are shaped to blend with the surrounding terrain, with batter slopes to be no steeper than 1 in 4 (14^0). Secondary filling of batters may occur to assist this objective, using overburden removed in the pit establishment process.

The pit floor should have an overall fall of not less than 1 in 100, to preclude localised ponding and consequent increased dieback risk.

Large laterite boulders may be broken up, removed, or buried in the pit shaping process, or some may be retained to provide faunal habitat and to assist in seed trapping.

4.2.2 Ripping

Ripping is preferably carried out under dry soil conditions, to maximize shattering of the underlying clay. Use of a winged tyne will also increase the zone of subsoil shattering.

The pit floor and batters are ripped on the contour at 1-metre intervals to a depth of 0.5-1.0 metres prior to return of overburden and topsoil. Cross-ripping is carried out on the pit floor only, to the same depth and at the same intervals, following topsoil and overburden return.

In certain situations where deep ripping may bring inferior subsoil to the surface which inhibits revegetation, shallow ripping is preferred. This is likely to apply, in particular, to pits in arid environments.

If presence of caprock prevents ripping to depth, blasting is required.

4.2.3 Topsoil and Overburden Return

Any overburden is spread evenly over the pit floor and batters, followed by even spreading of topsoil. The latter preferably comes directly from the next cell of the gravel pit as this is opened, but otherwise it will be stockpiled material which is returned.

Topsoil return should aim to leave a rough surface for improved drainage, erosion control and germination microclimate.

4.2.4 Soil Amendment

Approval by CALM will be required to advise on any soil amendment which may be required in pit rehabilitation.

On certain soils, gypsum addition for structural improvement or liming for pH correction may be warranted. Chemical fertilizers are also commonly beneficial to correct nutrient deficiencies, with application rates generally between 250 and 400 kg/ha. Proteaceous species are, however, adversely affected by some fertilizers. If these species predominate, fertilizer type and application rate will require careful selection to suit.

If seedlings are introduced they may benefit from addition to the soil of a slow release fertilizer tablet.

4.2.5 Drainage and Erosion Control

If the rehabilitated pit presents long or steep slopes, erosion control banks or drains may be warranted to check overland flow and consequent erosion hazard until vegetation has established.

4.2.6 Litter Return

Stockpiled vegetation, logs and other organic debris removed at the start of operations should be respread over the surface following topsoil return and ripping. This provides a protective surface cover which reduces raindrop impact, and thus surface erosion, as well as reducing evaporation in the summer months. It can also trap seed blowing into the area and offers niches for seedling survival and fauna habitat. Returned branches may also provide a seed source for site regeneration, if they are bearing seed at the time they are harvested.

4.2.7 Plant Establishment

There are several avenues for fostering plant re-establishment on the pit:

- The preferred approach in the conservation estate is to permit natural regeneration from topsoil especially fresh topsoil. This can be encouraged, where practical, by placement of seed-bearing branches harvested from the site or its surrounds. For best results, fruit or pods should be left on these branches rather than being removed from them, and the branches should be laid promptly after they are harvested.

- Seed may be introduced directly, preferably harvesting same within the immediate locality of the pit, but otherwise securing it within the reserve as a whole or from its neighbourhood. Indigenous native species only are to be used, with application rates of at least 1.5kg/ha of mixed native seed, the mix reflecting the species which existed on the site before gravel extraction.

If local seed material is in short supply, CALM should be contacted for advice on a suitable source area.

- If it is believed that regeneration from the topsoil and/or from complementary seeding may prove insufficient, plant introduction may be considered as a back-up in those areas where rainfall is sufficient to permit survival of introduced seedlings. In this event, plants grown from locally harvested seed or vegetative material should be used, adopting a selection of both understorey and overstorey species and determining planting density in consultation with the local CALM office. They must be grown under dieback-free conditions and should come only from CALM-approved nurseries.

4.2.8 Weed and Vermin Control

Weed invasion will require monitoring for at least three growing seasons, with any weeds to be controlled using a CALM-approved herbicide and/or by hand weeding. Control may be required beyond three seasons, if there is a continuing problem of weed invasion.

Rabbit control may be necessary to prevent grazing regenerating seedlings and spread of weeds. The chosen control method will require approval by CALM. Kangaroo foraging should also be monitored. If kangaroos are destroying young seedlings, fencing of the site with ringlock will usually be sufficient to discourage their access until vegetation is well established.

4.2.9 Access Track Closure

When the gravel resource has been exhausted, the access track, unless still required by CALM for management of the reserve, is closed, shaped to original profile, and ripped to 0.5-1.0 metre depth.

Topsoil is spread over the surface and, if it is still available, the vegetation cleared from the track alignment is returned as brush.

A ditch, earth bund, log or other approved barrier is then placed at the entry, to block further access. Signs may also be required, in which event they are to comply to CALM specifications.

4.2.10 Rehabilitation of Old Gravel Pits

If the pit which has been sourced is an old one which has been reactivated, there may be no stockpiled topsoil or vegetation to return in its rehabilitation.

Depending on comparative benefits and drawbacks, such topsoil and vegetation might be secured in consultation with CALM by stripping undisturbed ground around the pit perimeter for a distance at least four times the pit's depth. If this is unacceptable, the pit is simply rehabilitated by shaping and ripping as previously described, but without return of topsoil.

In the latter case, ancillary measures discussed above, such as soil amendment, fertilizing, seeding and planting, are likely to prove necessary to secure satisfactory regeneration, albeit this is still likely to be of poorer standard than in pits where fresh topsoil is available.

5. MONITORING AND MAINTENANCE

In a conservation area where reinstatement of original vegetation is sought, the time scale to achieve this will generally be long term - measured in decades rather than years. This long term result is the prime consideration, rather than any short term outcomes. Pit monitoring and maintenance must be sensitive to this and should not seek dramatic outcomes in a short time span.

The area should be monitored by the proponent for at least the first three seasons following completion of rehabilitation, to check for plant regeneration, weed infestation, and any evidence of dieback infection. Transects will usually be required as an integral component of this monitoring, to assess plant diversity and density.

CALM will consult with the operator on appropriate maintenance measures in response to the findings of this monitoring. This could include such initiatives as weed control, drainage improvement if dieback hazard is evident, or follow-up seeding or planting to assist species return, if particular species deficiencies are evident.

Once CALM is satisfied that the rehabilitation has been successful and that a natural ecosystem is evolving, the proponent will relinquish responsibility for further maintenance of the area. It can then be re-incorporated into the conservation estate.

CONSERVATION COVENANT SCHEMES IN WESTERN AUSTRALIA

Attribute	*Department of Conservation and Land Management*	*National Trust of Australia (WA)*	*Department of Agriculture (WA)*
Nature of Organisation	Government agency	Membership based, non-profit organisation	Government department
Purpose of covenant	Nature Conservation	Natural, Cultural and LandscapeHeritage	Soil and Land Conservation
Type of covenant	Restrictive	Restrictive	Can probably contain positive obligations relating to management
Management advice	Positive recommendations in Management Guidelines	Positive obligations in Deed of Trust which includes a mutually agreed Management Plan	See above
Staff	CALM Officers	National Trust Officers	Department of Agriculture Officers
Term of covenant	Permanent or for a specified time (negotiable)	Permanent or for a specified time (negotiable)	Permanent or for a specified time (30 Years minimum)
Linkages	Other CALM networks, government agencies	Other National Trust programs: education, advocacy, asset management and members	
Can covenant	Private property	Private property	Private and leasehold property
Permanence	Can be revoked or varied by mutual agreement, court order or operation of a town planning scheme.	Can be revoked or varied by mutual agreement, court order or operation of a town planning scheme.	Conservation Covenants (CCs) cannot be revoked by agreement during their term. Agreements to Reserve (ATRs) are covenants that may be revoked or varied by mutual consent or Ministerial appeal if Commissioner will not agree. Both CCs and ATRs may possibly be revoked by court order or by the operation of a town planning scheme.
Criteria for assessing covenant applications	Area, Shape, Intactness, Pests/Diseases, Adjacent Land Use, Long Term Viability, Threatened Flora/Fauna, Regional Significance, Corridor function	Natural Heritage: Area, Shape, Intactness, Pests/Diseases, Adjacent Land Use, Long Term Viability, Threatened Flora/Fauna, Corridor function	Commissioner would consider any reasonable area of native or planted vegetation
Stewardship Program	Yes, annual contact and 3 year management plan review/site visit.	Yes, annual contact and 3 year management plan review/site visit.	No
Covenant details flexible and negotiable	Yes, all or part of property, compatible land use (eg small dwelling) can be negotiated.	Yes, all or part of property, compatible land use (eg dwelling, seed collection etc) can be negotiated.	Can be tailored to achieve mutual management objectives of Commissioner and landholder

CONSERVATION COVENANT SCHEMES IN WESTERN AUSTRALIA (*cont'*)

Incentives	*Department of Conservation and Land Management*	*National Trust of Australia (WA)*	*Department of Agriculture (WA)*
Fencing Assistance	May be available on a case by case basis (Salinity Action Plan)	None	None
Cover Admin. Costs of covenanting (registration, survey etc)	Yes, **unless** the owner is seeking a covenant as a condition of subdivision approval	Yes, **unless** the owner is seeking a covenant as a condition of subdivision approval	Yes, **unless** the owner is seeking a covenant as a condition of subdivision approval. On ground survey not required.
Independent Legal Opinion	Yes, funded up to the value of $500 **unless** the owner is seeking a covenant as a condition of subdivision approval	No	No
Management Advice	Yes, including assistance with grant applications, plus *Land for Wildlife Scheme* membership	Yes, including assistance with grant applications, plus National Trust of Australia (WA) membership	No
Management costs (eg herbicide costs, seeds)	Yes, but on a limited case by case basis	No	No
Assistance with land sale issues (eg property advertising, talking to buyers, real estate agents)	Yes, links with the Real Estate Industry of Western Australia, Bush Brokers, Bush Bank	Yes, links with the Real Estate Industry of Western Australia, Bush Brokers, Bush Bank	No
Rates and taxes	Application to Valuer General's Office on registration of a covenant to seek revaluation of the covenanted land, and subsequent rate reduction through Shire (but not guaranteed)	Application to Valuer General's Office on registration of a covenant to seek revaluation of the covenanted land, and subsequent rate reduction through Shire (but not guaranteed)	Commissioner routinely provides advice to Valuer General's Office on registration of a covenant with a view to possible rate reduction through Shire (but not guaranteed)

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT NATURE CONSERVATION COVENANT PROGRAM

ESTIMATE OF COSTS TO BE CONTRIBUTED BY LANDOWNER

This is to be used as an interim measure to estimate partial cost recovery for commercial covenants.

The following can be used to provide an estimate of the costs likely to be encountered when preparing a covenant. Please note that the figures for officer time and travel are based on a basic covenant in an area that is serviced by a covenant officer. These costs will increase significantly if the covenant requires extensive negotiation or if the travel distance is increased and more than one visit is required.

Item	*Rate*	*Approximate total*	*Charged required?*
Covenant officer time (including assessment visit and preparation of documents)	$50.00/hr (usually 40 hours)	$2000.00	Required for each covenant.
Travel	$0.65c/km (average 260 km)	$169.00	Required for each covenant.
Certificate of Title search	$11.00 per title	$11.00	Required for each title of land, required for each covenant.
Bank Legal Review	$250.00 (approximate)	$250.00*	Only if there is a mortgage and if this is required by the bank.
Release of Certificate of Title by the bank	$250.00 (approximate)	$250.00*	Only if there is a mortgage.
Production fee for the Certificate of Title (charged by Dept. of Land Administration)	$38.50	$38.50*	Only if there is a mortgage.
Map	No charge if done by the Department, up to $450.00 if sourced elsewhere	$0.00	Only required if only a part of the property is to be covenanted. May be produced outside of the Department on request.
Review by Crown Solicitor's office	$200.00 (average)	$200.00	Required for each covenant.
Registration on Certificate of Title	$77.00 per Certificate of Title	$77.00	Required for each Certificate of Title.
Estimated Total		**$2457.00**	(not including figures marked with an asterisk "*"above, and not including 10% GST)

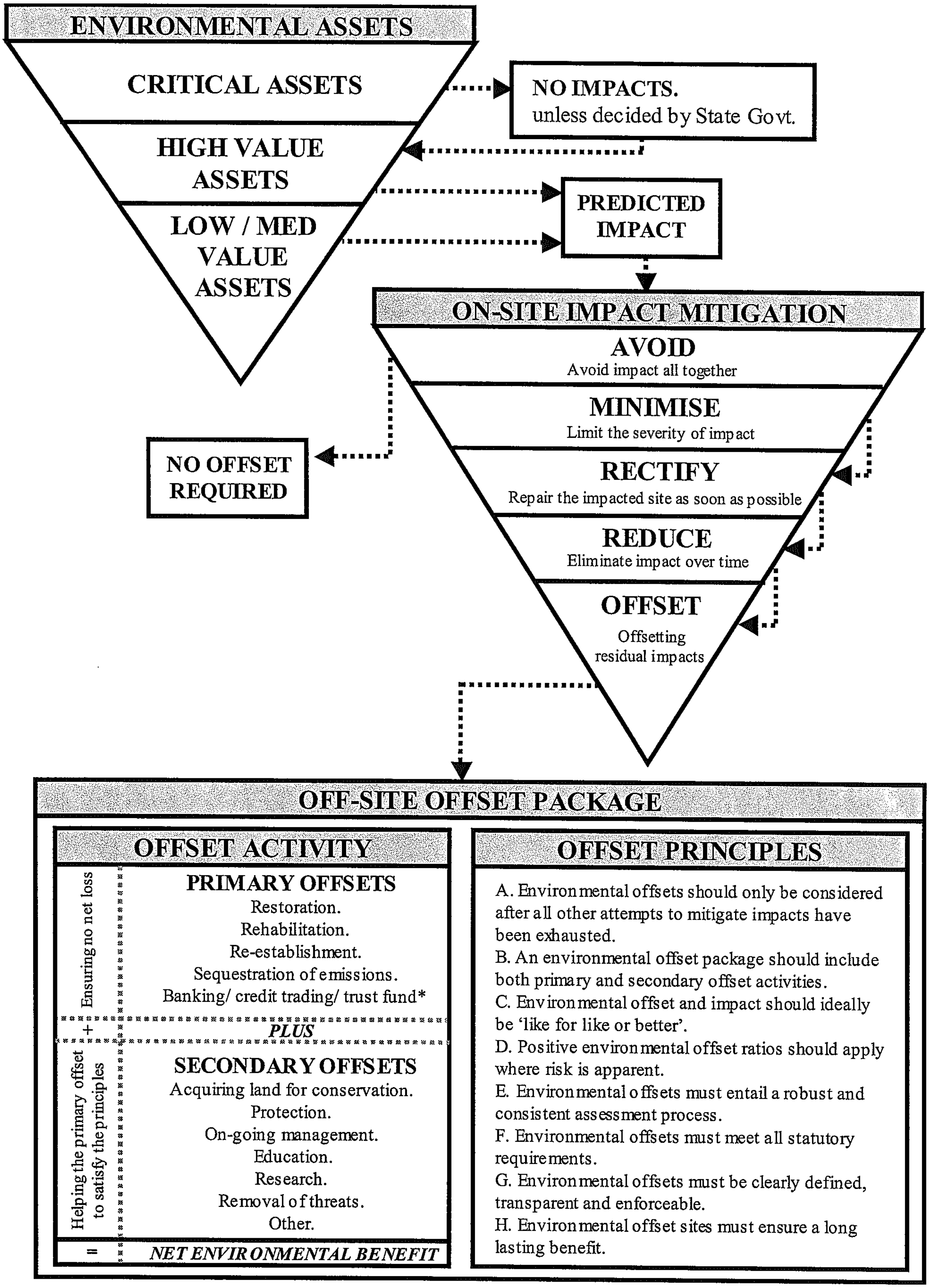


Figure 2: Decision framework for the use of environmental offsets (* as qualified in text)

Appendix K

Noise Study

Rochdale Holdings Pty Ltd A.C.N. 009 049 067 trading as:
HERRING STORER ACOUSTICS
Suite 34, 11 Preston Street, Como, W.A. 6152
P.O. Box 219, Como, W.A. 6952

Telephone: (08) 9367 6200
Facsimile: (08) 9474 2579
Email: hsa@hsacoustics.com.au

ALLAN HERRING M.I.E. AUST. M.A.A.S.
LYNTON STORER M.A.I.E.A., M.A.A.S.
TIM REYNOLDS M.I.E. AUST. M.A.A.S.

NOISE IMPACT ASSESSMENT SUPPLEMENTARY REPORT

BGC AUSTRALIA PTY LTD

RELOCATION OF THE VOYAGER GRANITE HARD ROCK QUARRY

THE LAKES, WESTERN AUSTRALIA

ON BEHALF OF

URS AUSTRALIA PTY LTD

BY

HERRING STORER ACOUSTICS

NOVEMBER 2004

REFERENCE: 3965-3-02184

CONTENTS

APPENDICES

1.0 INTRODUCTION

This report is supplementary to the HSA report reference 1174-4-02184-2 (December 2002) Appendix H, Volume 3 of the URS report of *Land Clearing and Quarry Expansion, Avon Loc 1881, Lot 14 Horton Road, The Lakes* (EPA Assessment Number 1413 – January 2003).

The original report considered the acoustic impact of relocating the existing Voyager Quarry operations. In order to do this, an acoustic model was built to predict the propagation of noise from the proposed quarry to noise sensitive premises. To build this model, detailed information of sources and the surrounds was required, which was facilitated by measurement of the existing operations. The existing operations were modelled in order to calibrate the propagation of noise and hence sources which could then be used in the model for the proposed quarry.

The report was subjected to Public Environmental Review (PER) and evaluated by the Environmental Protection Authority. The review and assessment raised a number of issues requiring further consideration and clarification.

The issues raised were:

1. The need for verification of the reliability of the acoustic model.
2. The need to update the acoustic model to:
   - Include noise from intermittent rockbreaker operations.
   - Include reduced noise arising from the recently completed primary crusher noise control works.
   - Include noise from product haulage off the site.
3. Review and modelling of construction noise emanating from overburden removal at the proposed new quarry location.

Additionally, the modelling was extended to assess the new layout of the proposed quarry, which extends further south that in the PER.

2.0 MODEL VERIFICATION

Validation measurements of the existing quarry operations were undertaken at a number of locations around the site (during the original study). These measurements were shown to reasonably concur with the model predicted levels.

It was considered by the Department of Environment (DoE) that it is primarily the low levels of quarry noise to the west that give rise to concern with respect to modelling accuracies.

Measurements undertaken to the west of the site at the nearest residential location were relatively difficult to interpret in terms of quantifying quarry noise alone, owing to relatively high background noise, particularly under down-wind conditions.

On 24 February 2004, a series of measurements were made at the site when a light easterly breeze was present, (worst-case scenario for residences to the west). This allowed verification measurements to be made generally to the west of the quarry. Recordings were also attempted adjacent Residence D (Site 2, figure 1), however although just intermittently audible, the quarry noise could not be quantified due to background noise.

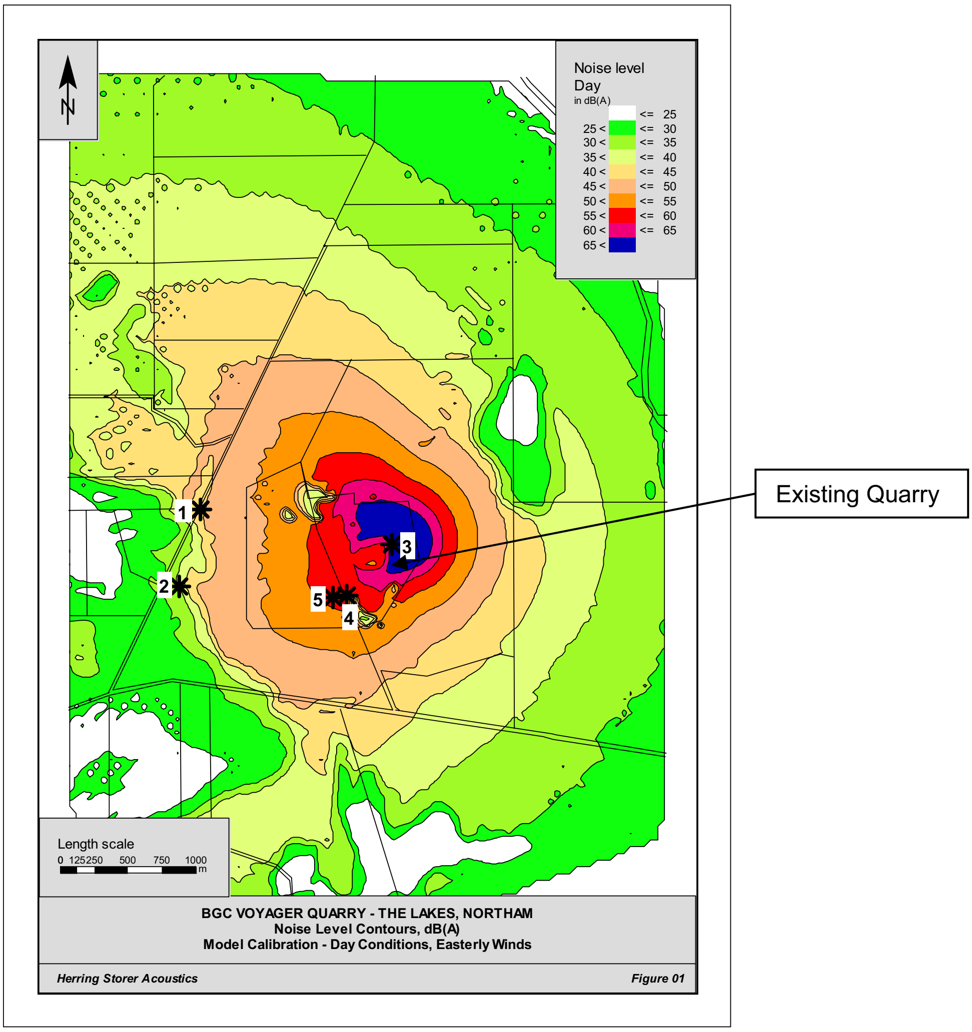
The acoustic model was run for the existing quarry operating conditions and for the meteorological conditions present at the time of measurements. Table 2.1 below compares the measured levels to those predicted (refer to Figure 2.1 for location positions). The modelling results for site 2 confirms the difficulty of obtaining reliable sound measurements to the west of the quarry, in that high levels of attenuation of quarry noise are indicated due to the existing topography.

TABLE 2.1 – PREDICTED/MEASURED SOUND PRESSURE LEVELS, dB(A)

Location	Measured	Predicted
1	40	39
2	<37	29
3	72	71
4	51	52
5	48	51

Noise contours for this scenario are shown in Figure 2.1.

FIGURE 1 – NOISE CONTOUR PLOT: MODEL CALIBRATION & MEASUREMENT LOCATIONS



Based on the results of the above, it is considered that the model is reasonably accurate to the west and given the previous calibrations to the north and east (in PER), the model can be used with confidence to predict the noise impact of the proposed quarry.

3.0 MODEL UPDATE

3.1 Normal Operations

The model of the existing operations has been updated to include additional noise generated by off site haulage trucks and the reduced noise emission level of the enclosed primary crusher.

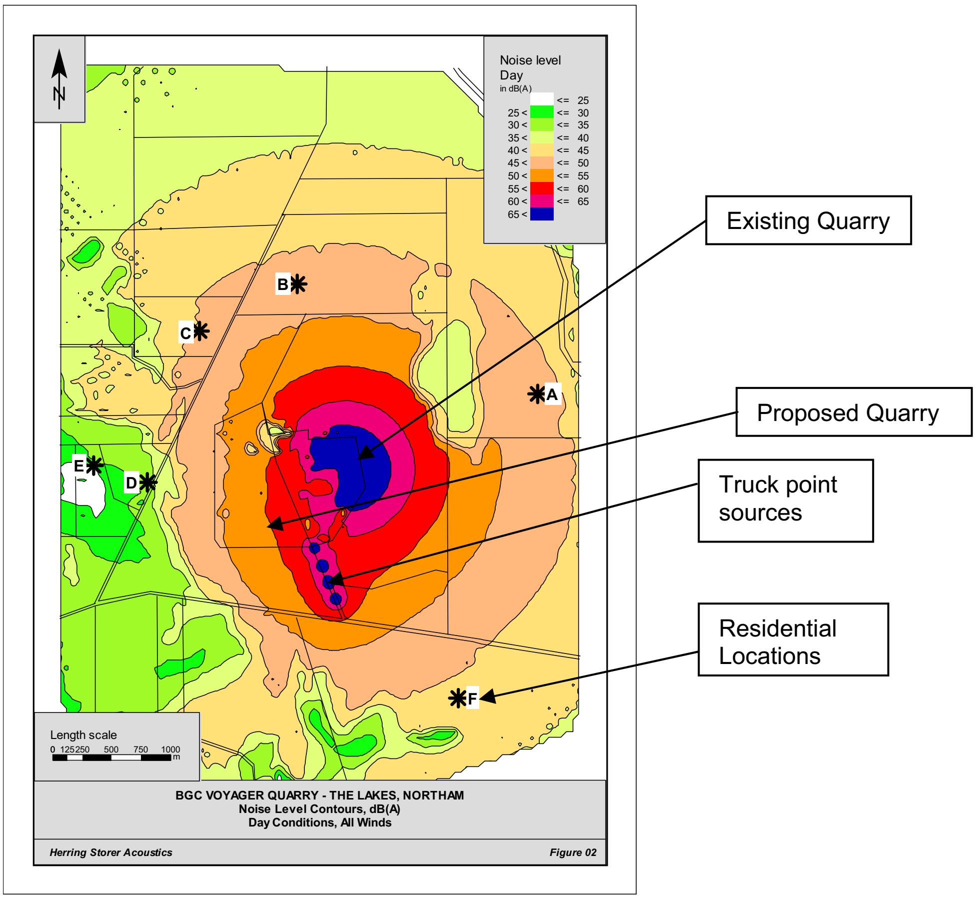
The resultant levels at noise sensitive premises are shown in Table 3.1, assuming worst-case propagation to each location. Also shown are the previously calculated noise levels for comparison.

TABLE 3.1 – WORST CASE NOISE LEVELS AT RESIDENTIAL LOCATIONS

Location	Predicted Sound Pressure Level, dB(A)	
	Previous Model	Updated Model
A	47	46
B	48	47
C	46	45
D	30	31
E	24	25
F	44	43

A noise contour plot of the above scenario is shown in Figure 3.1.

FIGURE 3.1 – NOISE CONTOUR PLOT
EXISTING QUARRY - DAY CONDITIONS



The net result is a reduction of 1 dB(A) at residential locations A, B, C and F, with locations D and E increasing by 1 dB(A). The relative similarity in noise levels between the "previous model" and the "updated model" is understandable given that the additional noise from the haulage trucks has been compensated for by the reduced noise emissions from the primary crusher.

It should be noted that the above modelling applies to the existing quarry operations only.

3.2 Rockbreaking

The rockbreaking operations have been modelled separately, as it is an intermittent operation carried out during the day about 3 times per year, for one week each time. It was requested that the rockbreaker be included in the noise model to allow any impact on residents to be assessed.

The noise generated by the rockbreaker was measured on 12 March 2004. Based on these measurements, the sound power level of the rockbreaker was calculated (Table 3.2 below) and incorporated into the model. The predicted noise levels under worst-case conditions are shown below in Table 3.3 for the rockbreaker alone.

TABLE 3.2 – ROCKBREAKER SOUND POWER LEVEL, dB

One-Third-Octave Band Centre Frequency (Hz)									dB(A)
25 31.5 40	**50 63 80**	**100 125 160**	**200 250 315**	**400 500 630**	**800 1k 1.25k**	**1.6k 2k 2.5k**	**3.15k 4k 5k**	**6.3k 8k 10k**	
101 107 108	114 113 111	112 107 109	106 103 106	108 106 108	108 108 106	109 105 107	104 103 102	101 98 95	118

TABLE 3.3 – ROCKBREAKER AT EXISTING QUARRY
MAXIMUM NOISE LEVELS UNDER WORST CASE PROPOGATION CONDITIONS

Location	Predicted Sound Pressure Level, dB(A)
A	**32**
B	**34**
C	**33**
D	**21**
E	**13**
F	**29**

Since the rockbreaker is such an intermittent operation, it is considered that the applicable assigned noise level is the day L_{A1} parameter of 55 dB. If frequency of use were to increase then the noise immission levels may need to comply with the L_{A10} criteria of 45 dB.

From Table 3.3, it can be seen that the rockbreaker complies with the applicable assigned noise level in terms of the current operations.

In terms of the proposed operations, the rockbreaker predicted noise levels are shown in Table 3.4 below.

**TABLE 3.4 – ROCKBREAKER AT FUTURE QUARRY
MAXIMUM NOISE LEVELS UNDER WORST CASE PROP COND**

Location	SPL, dB(A)
A	**30**
B	**35**
C	**27**
D	**23**
E	**18**
F	**26**

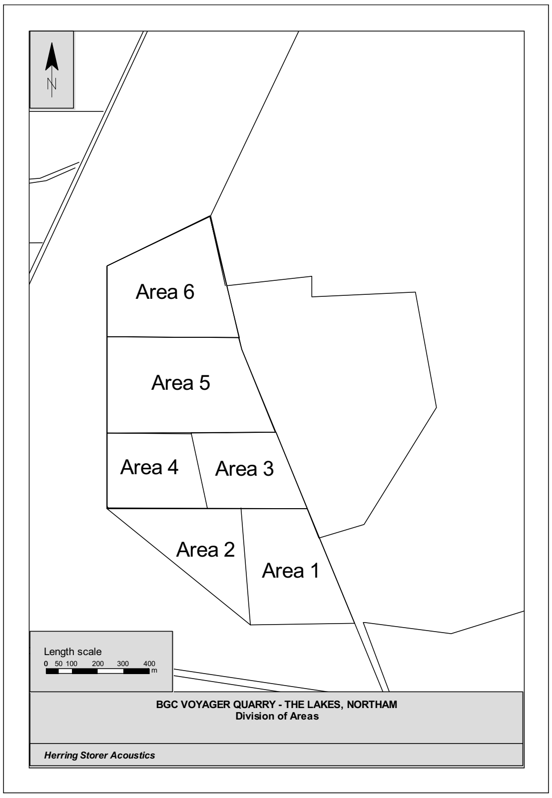
Rockbreaker operations at the proposed quarry are also well below the assigned noise levels of either an L_{A1} of 55 dB or an L_{A10} of 45 dB.

4.0 MINING LAYOUT FOR PROPOSED OPERATIONS

The area intended for mining has been modified from the original submittal and now utilises land to the southern boundary of the lease.

The proposed mining envelope has been divided into 6 areas to allow a balanced management of the overall mining operations and overburden removal. These areas are detailed in Figure 4.1.

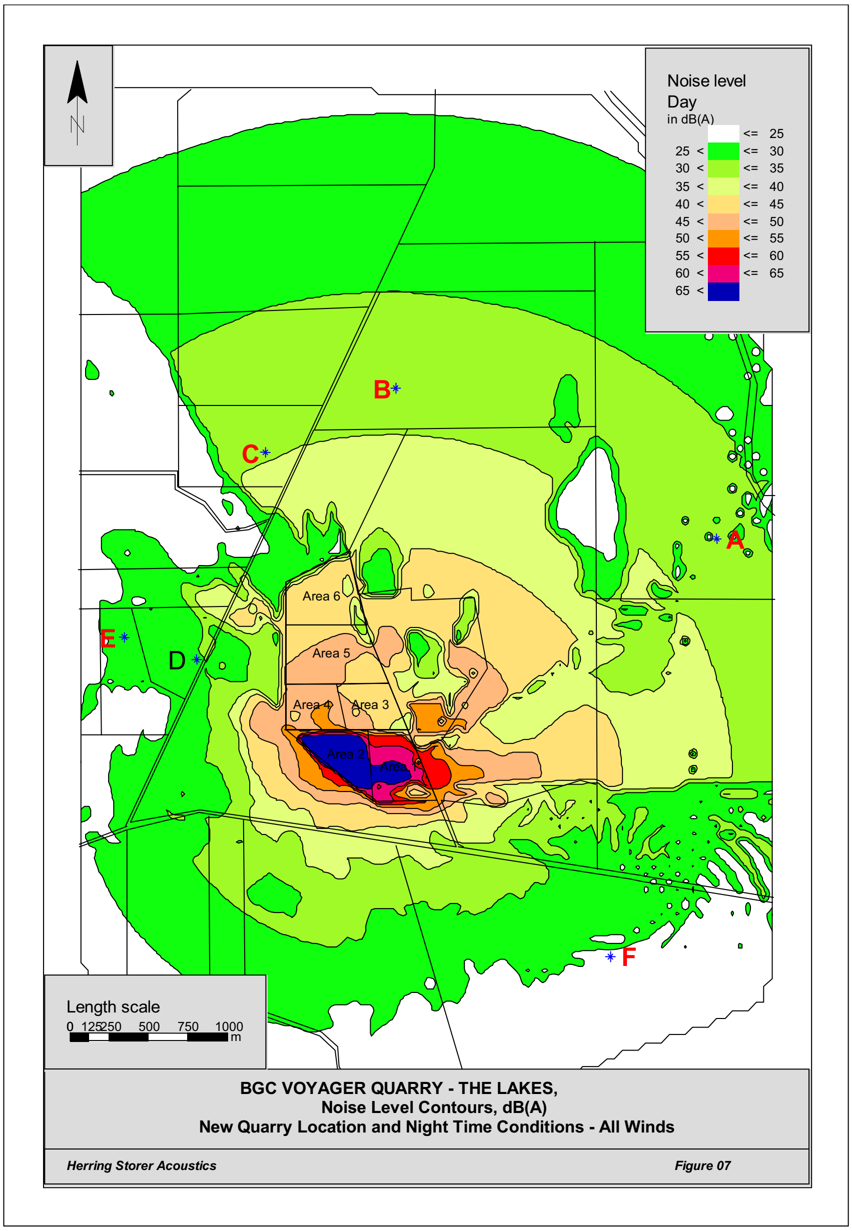
FIGURE 4.1



Area 2 will be the initial rock quarry and will eventually house the crushing and screening plant at a depth of 30 metres. Area 1 will house the infrastructure and stockpiled product at a depth of 5 metres. Mining of future areas will have mobile equipment at benches of 5 metres in depth.

The 'operations' scenario therefore has a different noise footprint than shown in the original study and the current noise contour plot for night time is shown in Figure 4.2. Daytime and evening plots are given in Appendix A.

FIGURE 4.2 – PREDICTED NIGHT TIME NOISE CONTOUR



The results of the noise propagation predictions are summarised in Table 4.1, which shows compliance for all scenarios of operation.

The first scenario is limited to the day period only and involves the mining of Area 2 down to a depth of 30 metres, which will be the depth that the future fixed plant will be located. During this time, product will be hauled to the existing crushing plant. Mining in Area 2 is at its highest point, with mobile plant behind a 5 metre high bench.

The next three scenarios are for the new operations, having the fixed plant relocated to Area 2 (at a depth of 30 metres), stockpiling operations in Area 1 and mining being undertaken at the northern end of Area 4. Again, the mobile equipment is operating behind a 5-metre bench (10 metres below ground level) and the product is being hauled to the new crushing area. Areas 3, 5 & 6 will be managed in the same way and Area 4 is shown as being a typical scenario. The three scenarios represent different periods of plant operation as is current practice at the site.

During the day, all plant is operational. During the evening, the drill does not operate and during the night, only the fixed plant, excluding the primary crusher, operates.

TABLE 4.1 – SUMMARY OF CALCULATIONS

Residence	Scenario			
	Day – Mine Area 2, Haul to Existing	Day – Mine Area 4, Haul to New (Area 2)	Evening – Mine Area 4, Haul to New (Area 2)	Night – Mine Area 4, Haul to New (Area 2)
A	41	39	37	32
B	43	40	40	33
C	39	41	40	35
D	28	37	33	28
E	23	31	29	26
F	42	40	37	24

5.0 CONSTRUCTION NOISE / OVERBURDEN REMOVAL

Construction noise is the noise associated with activities necessary to build, excavate or make ready a project for normal operations. Overburden removal at the proposed site is necessary to expose the area that is to be mined at the site.

Construction noise is essentially exempt from the Regulatory Criteria (Regulation 13) provided it is conducted during the day time, Monday to Saturday and the quietest operations practically available are employed.

The original study, presented in the PER, classified all overburden removal as ‘construction’ noise, and indicated that it would take up to five years to completely remove all overburden This was considered too long a period over which to expose residents to noise levels above the 45 dB(A) limit applicable at the boundary to the property, particularly since clay and gravel components of the overburden are likely to be saleable products. Therefore it has been indicated by the EPA service Unit that the stripping of these products should be considered as normal operational noise, except where the overburden is to be used for construction of noise attenuating barriers or bunds.

The removal of the top layer of overburden material, which is primarily topsoil to be stockpiled, is considered a construction noise activity. Soil and unsaleable overburdens varies in depth between 1 to 5 metres and removal of this will fall under the construction noise Regulations (Regulation 13), which defines “…removal, excavation, …” as construction work.

The balance of the overburden material covers the granite rock sought by up to 20 metres.

Earthmoving equipment used for removal of the initial overburden material will be a daytime activity only and the noise immission levels may exceed the assigned noise level criteria at residential locations from time to time.

Noise immissions associated with the main overburden removal will be managed through the use of the quietest equipment available, restrictions on the number of equipment used at any one time and the restriction of activities when unfavourable wind conditions occur.

In order to manage the overburden removal activities the total mining area has been divided into six sub areas, which will serve to concentrate overburden removal to each area as mining proceeds (from areas 1 and 2). This will be seasonal, hence spreading the activities over many years with 'bursts' of activity occurring as required.

A matrix of overburden material removal noise immission levels has been developed, which demonstrates how these activities can be managed within the assigned noise level criteria of the Regulations. The matrix shows the predicted resultant levels dependant on the area being mined, equipment being used and the variable wind condition. The table showing the results are colour coded, blue being when noise levels exceed the criteria and green when noise levels are less than the criteria.

Table 5.1 shows the predicted noise levels for calm and downwind conditions for 3 scrapers operating in each area. Within each area, the equipment was generally placed in five locations (north, south, east, west and centrally) to determine the change in noise level throughout the area. Table 5.2 is similar, except represents the noise levels for limited numbers of equipment (1 scraper and 1 dozer). Note that the percentage of downwind occurrence is also shown obtained from the Bickley weather station (refer Appendix B).

TABLE 5.1 - RELOCATED QUARRY AREA
PREDICTED LEVELS - OVERBURDEN REMOVAL: MAXIMUM EQUIPMENT

		Downwind						Calm					
Res A													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
3 x Scrapers Central		41.0	39.2	40.4	40.6	40.6		30.4	28.6	29.8	29.9	30.0	
3 x Scrapers East	W to SW	41.6	39.6	41.4	41.3	41.3		31.0	29.0	30.8	30.7	30.7	
3 x Scrapers North	11%	41.1	39.3	40.5	40.6	40.8	39.3	30.5	28.6	29.9	30.0	30.2	28.6
3 x Scrapers South		40.9	39.0	40.3	40.5	40.3	39.0	30.2	28.2	29.6	29.9	29.7	28.3
3 x Scrapers West		40.6	38.7	39.6	39.9	40.0	38.5	29.9	28.0	28.9	29.2	29.3	27.8
Res B													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
3 x Scrapers Central		43.6	43.2	46.0	48.7	41.1		33.2	33.0	35.7	38.5	30.5	
3 x Scrapers East	S to SW	43.7	43.4	46.3	49.2	41.1		33.3	32.9	36.0	39.1	30.5	
3 x Scrapers North	13%	44.3	43.9	46.7	49.5	41.9	41.8	34.0	33.5	36.4	39.4	31.3	31.2
3 x Scrapers South		42.9	42.5	45.2	47.8	40.2	41.0	32.4	32.0	34.8	37.6	29.6	30.4
3 x Scrapers West		43.6	43.1	45.7	48.1	41.1	41.5	33.1	32.6	35.4	38.0	30.5	30.9
Res C													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
3 x Scrapers Central		45.5	46.3	49.3	52.9	42.5		35.3	36.4	39.3	43.3	32.0	
3 x Scrapers East	S to SE	45.3	46.2	48.7	52.5	42.2		35.0	35.9	38.7	42.8	31.7	
3 x Scrapers North	16%	46.4	47.2	50.1	54.1	43.4	44.1	36.2	37.0	40.3	44.7	33.0	33.7
3 x Scrapers South		44.7	45.4	48.3	51.5	41.5	43.2	34.4	35.1	38.3	41.7	30.9	32.8
3 x Scrapers West		45.8	46.5	49.6	53.1	42.8	44.3	35.5	36.3	39.7	43.5	32.4	34.0
Res D													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
3 x Scrapers Central		33.4	54.2	37.2	34.4	39.3		23.9	45.2	28.3	25.3	29.4	
3 x Scrapers East	E to SE	31.4	45.5	34.9	33.0	39.9		21.9	36.1	25.7	23.7	29.8	
3 x Scrapers North	21%	32.7	44.8	36.8	33.9	38.0	42.0	23.3	35.6	28.0	24.7	28.2	32.4
3 x Scrapers South		34.6	53.3	38.4	35.6	36.2	44.7	25.0	43.7	29.5	26.6	26.0	34.8
3 x Scrapers West		35.8	55.5	41.9	36.9	35.6	52.5	26.3	46.2	33.4	28.1	25.7	42.8
Res E													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
3 x Scrapers Central		32.5	49.3	31.3	29.9	32.4		22.6	39.7	21.8	20.3	22.3	
3 x Scrapers East	E to SE	31.1	39.5	29.3	28.5	33.2		21.2	29.4	19.7	18.7	23.1	
3 x Scrapers North	21%	32.0	39.5	30.3	29.7	33.0	35.1	22.2	29.9	20.7	20.0	23.0	25.0
3 x Scrapers South		33.0	48.7	32.3	30.0	33.1	39.9	22.8	38.7	22.8	20.4	22.9	29.7
3 x Scrapers West		34.0	50.1	35.5	31.9	32.5	48.2	24.2	40.3	26.1	22.4	22.5	38.1
Res F													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
3 x Scrapers Central		42.9	41.2	40.1	38.5	45.6		32.4	30.8	29.5	27.8	35.3	
3 x Scrapers East	N to NW	43.3	41.6	40.8	38.9	46.3		32.8	31.1	30.1	28.1	36.0	
3 x Scrapers North	9%	42.2	40.7	39.7	38.1	44.7	43.0	31.7	30.1	29.0	27.3	34.2	32.6
3 x Scrapers South		43.5	41.7	40.6	39.0	46.7	43.6	33.1	31.1	30.0	28.2	36.5	33.1
3 x Scrapers West		42.5	40.7	39.6	38.2	44.8	42.2	32.0	30.1	28.9	27.4	34.5	31.6

TABLE 5.2 - RELOCATED QUARRY AREA
PREDICTED LEVELS - OVERBURDEN REMOVAL: LIMITED EQUIPMENT

		Downwind						Calm					
Res A													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
Scraper & Dozer Central		36.0	34.2	35.4	35.6	35.6		25.4	23.6	24.8	24.9	25.0	
Scraper & Dozer East	W to SW	36.6	34.6	36.4	36.3	36.3		26.0	24.0	25.8	25.7	25.7	
Scraper & Dozer North	0.5 – 5.0 m/s	36.1	34.3	35.5	35.6	35.8	34.3	25.5	23.6	24.9	25.0	25.2	23.6
Scraper & Dozer South	11%	35.9	34.0	35.3	35.5	35.3	34.0	25.2	23.2	24.6	24.9	24.7	23.3
Scraper & Dozer West		35.6	33.7	34.6	34.9	35.0	33.5	24.9	23.0	23.9	24.2	24.3	22.8
Res B													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
Scraper & Dozer Central		38.6	38.2	41.0	43.7	36.1		28.2	28.0	30.7	33.5	25.5	
Scraper & Dozer East	S to SW	38.7	38.4	41.3	44.2	36.1		28.3	27.9	31.0	34.1	25.5	
Scraper & Dozer North	0.5 – 5.0 m/s	39.3	38.9	41.7	44.5	36.9	36.8	29.0	28.5	31.4	34.4	26.3	26.2
Scraper & Dozer South	13%	37.9	37.5	40.2	42.8	35.2	36.0	27.4	27.0	29.8	32.6	24.6	25.4
Scraper & Dozer West		38.6	38.1	40.7	43.1	36.1	36.5	28.1	27.6	30.4	33.0	25.5	25.9
Res C													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
Scraper & Dozer Central		40.5	41.3	44.3	47.9	37.5		30.3	31.4	34.3	38.3	27.0	
Scraper & Dozer East	S to SE	40.3	41.2	43.7	47.5	37.2		30.0	30.9	33.7	37.8	26.7	
Scraper & Dozer North	0.5 – 5.0 m/s	41.4	42.2	45.1	49.1	38.4	39.1	31.2	32.0	35.3	39.7	28.0	28.7
Scraper & Dozer South	16%	39.7	40.4	43.3	46.5	36.5	38.2	29.4	30.1	33.3	36.7	25.9	27.8
Scraper & Dozer West		40.8	41.5	44.6	48.1	37.8	39.3	30.5	31.3	34.7	38.5	27.4	29.0
Res D													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
Scraper & Dozer Central		28.4	49.2	32.2	29.4	34.3		18.9	40.2	23.3	20.3	24.4	
Scraper & Dozer East	E to SE	26.4	40.5	29.9	28.0	34.9		16.9	31.1	20.7	18.7	24.8	
Scraper & Dozer North	0.5 – 5.0 m/s	27.7	39.8	31.8	28.9	33.0	37.0	18.3	30.6	23.0	19.7	23.2	27.4
Scraper & Dozer South	21%	29.6	48.3	33.4	30.6	31.2	39.7	20.0	38.7	24.5	21.6	21.0	29.8
Scraper & Dozer West		30.8	50.5	36.9	31.9	30.6	47.5	21.3	41.2	28.4	23.1	20.7	37.8
Res E													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
Scraper & Dozer Central		27.5	44.3	26.3	24.9	27.4		17.6	34.7	16.8	15.3	17.3	
Scraper & Dozer East	E to SE	26.1	34.5	24.3	23.5	28.2		16.2	24.4	14.7	13.7	18.1	
Scraper & Dozer North	0.5 – 5.0 m/s	27.0	34.5	25.3	24.7	28.0	30.1	17.2	24.9	15.7	15.0	18.0	20.0
Scraper & Dozer South	21%	28.0	43.7	27.3	25.0	28.1	34.9	17.8	33.7	17.8	15.4	17.9	24.7
Scraper & Dozer West		29.0	45.1	30.5	26.9	27.5	43.2	19.2	35.3	21.1	17.4	17.5	33.1
Res F													
Source Loc	**Wind % Occurrence**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area 1**	**Area 2**
Scraper & Dozer Central		37.9	36.2	35.1	33.5	40.6		27.4	25.8	24.5	22.8	30.3	
Scraper & Dozer East	N to NW	38.3	36.6	35.8	33.9	41.3		27.8	26.1	25.1	23.1	31.0	
Scraper & Dozer North	0.5 – 5.0 m/s	37.2	35.7	34.7	33.1	39.7	38.0	26.7	25.1	24.0	22.3	29.2	27.6
Scraper & Dozer South	9%	38.5	36.7	35.6	34.0	41.7	38.6	28.1	26.1	25.0	23.2	31.5	28.1
Scraper & Dozer West		37.5	35.7	34.6	33.2	39.8	37.2	27.0	25.1	23.9	22.4	29.5	26.6

A summary of the matrix is given in Table 5.3 below.

TABLE 5.3 – OVERBURDEN REMOVAL PREDICTED NOISE SUMMARY

Area	Limited Equipment Scenario		Max Equipment Scenario	
	Calm	Downwind	Calm	Downwind
1	OK	Marginal C	OK	Marginal A, B, F Exceeds C
2	Marginal D	Marginal C Exceed D, E	Exceed D	Marginal B, F Exceed C, D, E
3	OK	Marginal B, C	OK	Marginal A, D, F Exceed B, C
4	OK	Marginal B Exceed C	Marginal C	Marginal A Exceed B, C
5	OK	Marginal F	OK	Marginal A, B & C Exceed F
6	OK	Marginal E Exceed D	Marginal D	Marginal B, C & F Exceed D, E

Note: Downwind is for wind speeds 0.5 to 5.0m/s.

From the above, the following is concluded:

Area 1 - If winds are southeast to southwest (through South), use limited equipment.
Area 2 - Always use limited equipment. Cannot operate under southeast to northeast winds (through east).
Area 3 - If winds are southeast to southwest (through south), use limited equipment.
Area 4 - Always use limited equipment. Cannot operate under southeast to southwest (through south).
Area 5 - If winds are from the northwest, use limited equipment.
Area 6 - If winds are from the southeast, do not operate in western most area (on top of hill).

This is considered to be a manageable and practicable method of ensuring mobile equipment noise associated with overburden removal complies with the Regulatory daytime criteria.

6.0 SUMMARY

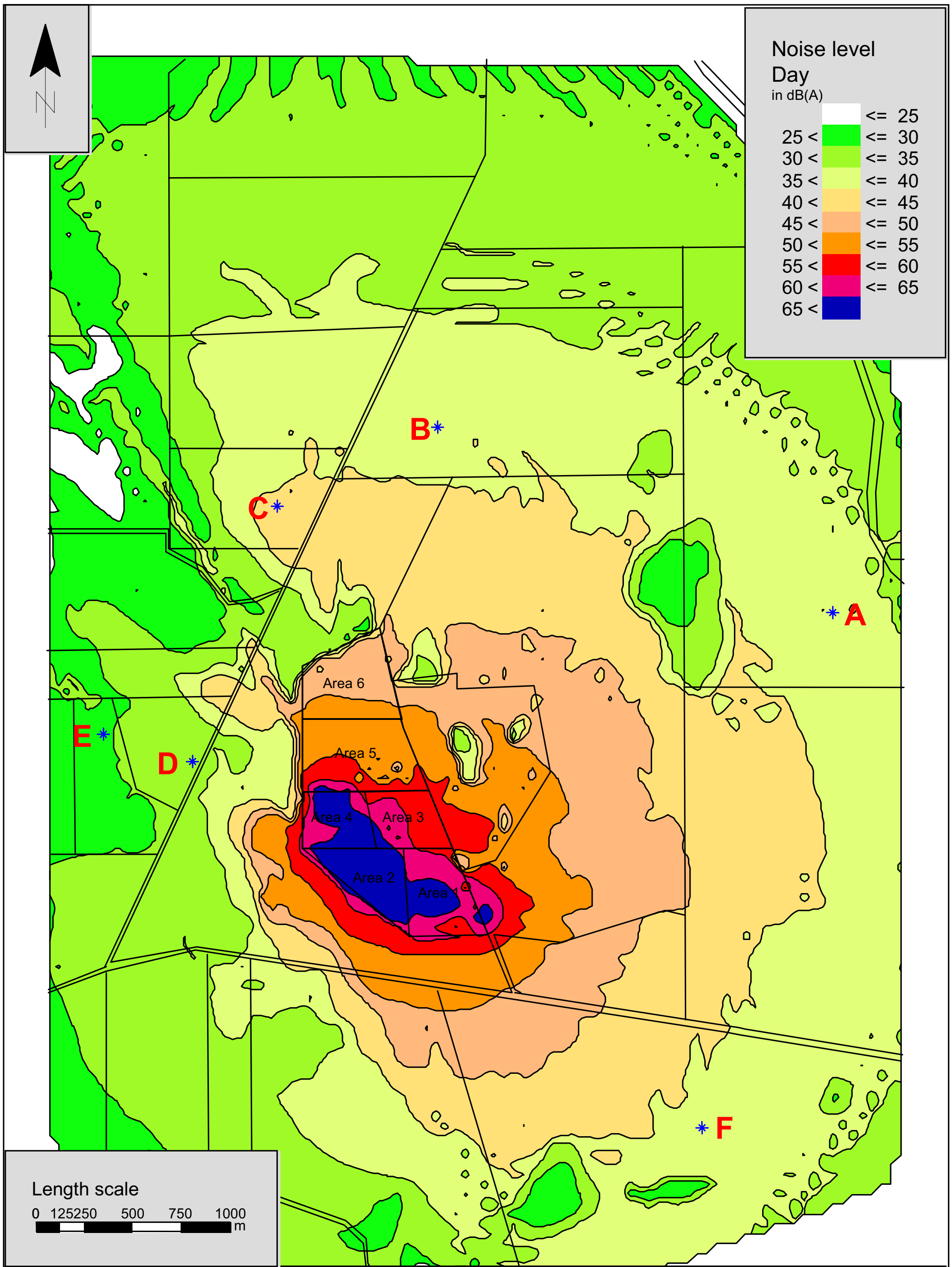
The summary of the above is:

1. Model has been verified and can be used with confidence to predict the noise impact of the proposed quarry operations.
2. Once the overburden has been removed (~ 20m depth), normal quarry operations will comply with the regulatory criteria.
3. Noise levels during the overburden removal phase (5-20m depth) will need to be managed to comply with the regulatory criteria by:
   i. Monitoring the weather forecast,
   ii. Reducing the number of earthmoving plant in operation; and
   iii. Under worst-case conditions, ceasing overburden removal operations.

For: **HERRING STORER ACOUSTICS**

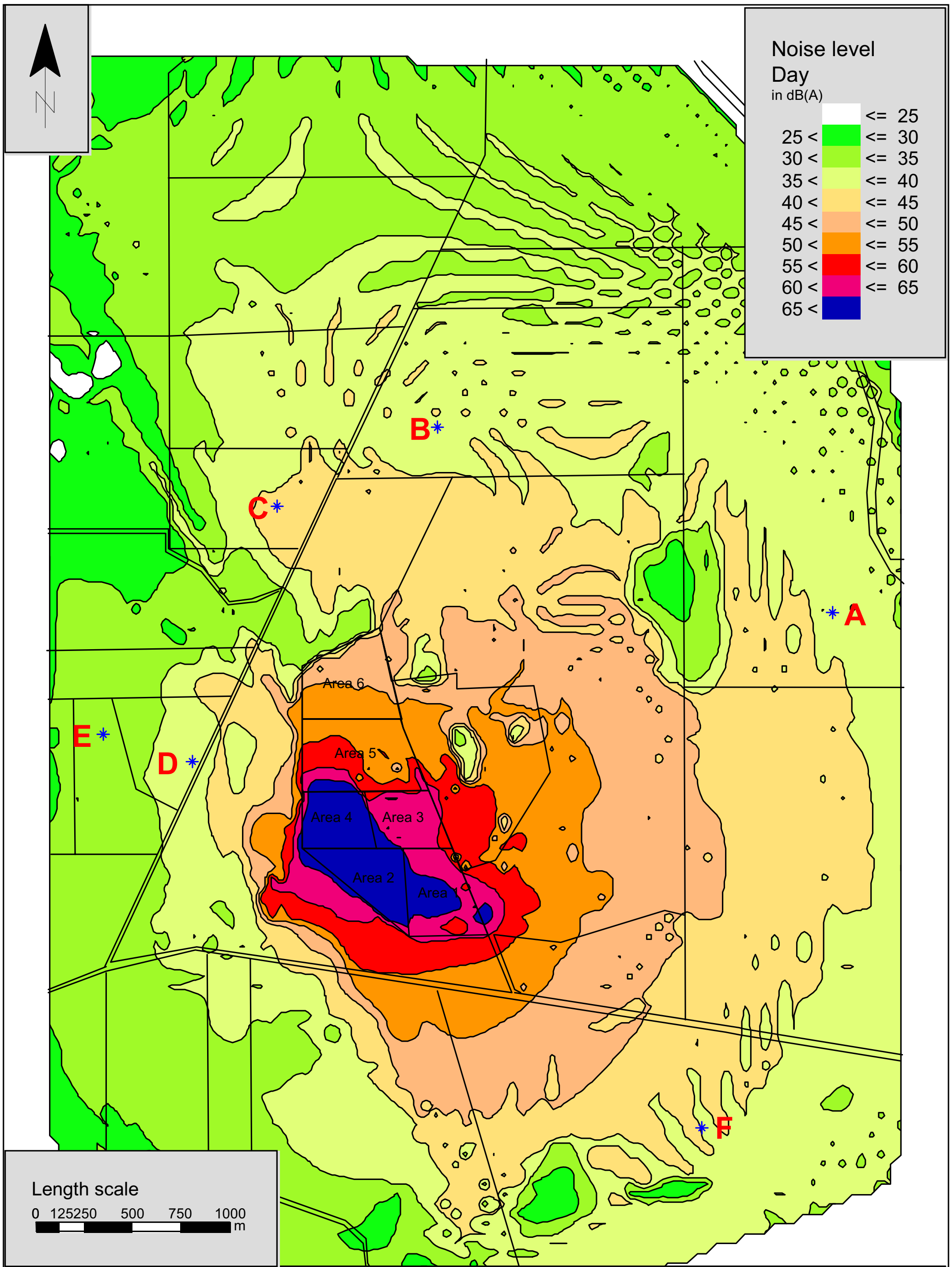
Lynton Storer
10 December 2004

APPENDIX A



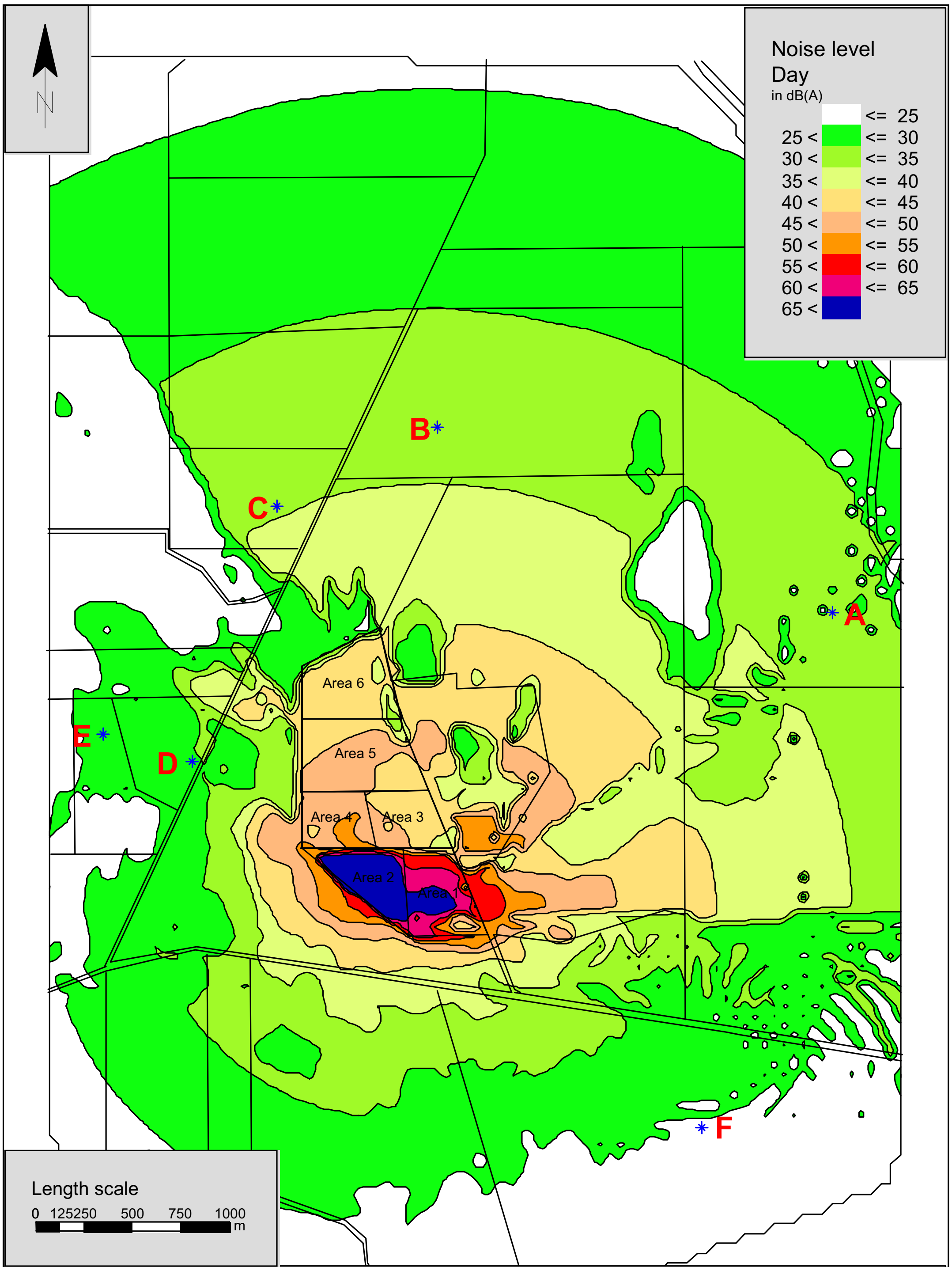
BGC VOYAGER QUARRY - THE LAKES, NORTHAM
Noise Level Contours, dB(A)
New Quarry Location and Evening Time Conditions - All Winds

Herring Storer Acoustics



BGC VOYAGER QUARRY - THE LAKES, NORTHAM
Noise Level Contours, dB(A)
New Quarry Location and Day Time Conditions - All Winds

Herring Storer Acoustics



BGC VOYAGER QUARRY - THE LAKES, NORTHAM
Noise Level Contours, dB(A)
New Quarry Location and Night Time Conditions - All Winds

Herring Storer Acoustics

APPENDIX B

BICKLEY WIND DATA

Direction	Wind Speed (m/s)					
	0.5-2.5	2.5-5.0	5.0-7.5	7.5-10.0	10.0-12.5	>12.5
North	1.24	3.08	1.24	0.63	0.02	0.00
Northeast	1.23	2.57	0.67	0.03	0.02	0.00
East	2.26	10.71	15.79	11.83	0.60	0.02
Southeast	1.29	6.89	4.40	1.39	0.03	0.00
South	1.71	6.01	1.40	0.02	0.00	0.00
Southwest	1.24	3.61	1.47	0.16	0.03	0.00
West	1.50	4.20	2.62	2.19	0.24	0.03
Northwest	1.34	3.23	1.48	0.61	0.06	0.01

LANGFORD ACOUSTICAL SERVICES

ABN 34 849 535 894

93 Goollelal Drive
KINGSLEY WA 6026
Phone: (08) 9408 0081
Fax: (08) 9408 0082
E-mail: langos@iinet.net.au

Peer Review of Environmental Noise Impact Assessment for relocation of the Voyager Granite Hard Rock Quarry at The Lakes, Western Australia

1 Introduction

In July 2004, URS Pty Ltd undertook an environmental impact assessment for the proposed relocation of the BGC (Australia) Pty Ltd Voyager Quarry located in the Shire of Northam, near The Lakes. This re-location involves moving the entire operation in stages some 700 metres to the west of its existing location, over a five year transition period.

The environmental noise assessment study for this impact statement was undertaken, for URS Pty Ltd, by Herring Storer Acoustics. The results of this noise assessment study are presented in Herring Storer Acoustics Reports:

- No 1174-4-02184-2 *Noise & Vibration Impact Assessment for BGC Australia Pty Ltd on Re-location of the Voyager Hard Rock Quarry at The Lakes, Western Australia*, prepared in December 2002 and
- No 3129-4-02184 *Noise Impact Assessment Supplementary Report for BGC Australia Pty Ltd on Re-location of the Voyager Granite Hard Rock Quarry at The Lakes, Western Australia,* prepared in May 2004 (internal report).

Langford Acoustical Services was requested, by BGC (Australia) Pty Ltd, to undertake a peer review of this environmental noise assessment to assist the Department of Environment and the Environmental Protection Authority to assess this proposal in accordance with the requirements of the *Environmental Protection Act 1986*. Langford Acoustical Services presented the results of this peer review in a report dated 8 July 2004.

The proposal was evaluated by the Environmental Protection Authority, at Public Environmental Review standard. A number of issues requiring further consideration and clarification were identified. These issues are:

- The need for adequate verification of the accuracy of the acoustic model;
- The need to modify the model to;
  - include noise from intermittent rock breaker operations;
  - provide for the reduced noise emissions following noise control works on the primary crusher and its building; and
  - include noise from product haulage from the quarry site; and
- Review of the amount of overburden removal work that should be considered as construction work under the regulations.

In addition, the model input data was changed to reflect the changed layout of the proposed quarry, which now extends further south than originally proposed and a decision to manage noise emissions without constructing earth bunds which have previously been shown to be of limited value.

Assessment of vibration and air blast overpressure due to blasting was included in the previous studies undertaken by Herring Storer Acoustics and was reviewed by Langford Acoustical Services. The environmental impact of blasting has now been separately addressed, using specialist consultants. Thus, a review of vibration and air blast overpressure predictions is now not included in this review report.

The noise implications of these issues are discussed in Herring Storer Acoustics report No. 3965-2-02184 *Noise Impact Assessment Supplementary Report for BGC Australia Pty Ltd on Relocation of the Voyager Granite Hard Rock Quarry, The Lakes, Western Australia*, prepared in November 2004.

The proposal being assessed is the staged re-location of the quarry, the rock crushing and screening plant, the run of quarry stockpiles, the finished product stockpiles and truck loading facilities some 700 metres to the west of the present quarry site.

The major environmental noise issues are seen to be:

1. Construction of noise control barriers;

2. Scrapers and bulldozers removing top soil and overburden from the new quarry site;

3. Long hole percussion drilling in the quarry;

4. Blasting;

5. Breaking of freed material that is too large for the primary crusher;

6. Haul trucks carrying material from the quarry to the crushing and screening plant;

7. The crushing and screening plant;
8. Front end loaders loading finished products into trucks; and
9. Trucks conveying finished products from the site.

Items 2, 5, 7 and 9 are the subject of this additional peer review of Herring Storer Acoustics' November 2004 report

2 Environmental noise management in Western Australia

Environmental noise is controlled through the *Environmental Protection Act 1986*. This Act provides for the control of environmental noise in subjective terms and, in summary, requires that no person cause noise emissions that unreasonably interfere with the health, welfare, convenience, comfort or amenity of any person.

To assist in the interpretation of this basic requirement of the Act, and to provide some objectivity to the management of environmental noise, the *Environmental Protection (Noise) Regulations 1997* have been created under the provisions of the Act.

3 Noise requirements of Western Australia's *Environmental Protection Act 1986*

The *Environmental Protection Act 1986* requires that an occupier of premises comply with prescribed standards for the emission of noise and take all reasonable and practicable measures to prevent or minimise the emission of noise (Section 51 of the Act) and not emit an unreasonable emission from his premises (Section 49 of the Act). An unreasonable emission is defined in the Act as an emission of noise which unreasonably interferes with the health, welfare, convenience, comfort or amenity of any person.

Prescribed standards for the emission of noise from premises have been introduced under the Act in the form of the *Environmental Protection (Noise) Regulations 1997*. These regulations specify the manner in which construction work should be carried out and the maximum allowable noise levels that may be received at noise receiving premises due to operational activities on the noise emitting premises. They also prescribe maximum allowable levels for airblast over-pressure due to blasting.

4 Relevant requirements of the *Environmental Protection (Noise) Regulations 1997*

Regulation 7 of the *Environmental Protection (Noise) Regulations 1997* requires that noise emitted from any premises or public place, when received at other premises must not cause or significantly contribute to a level of noise that exceeds the assigned level appropriate for the receiving premises in question. The appropriate assigned levels are established in regulation 8 and schedule 3 of the regulations. This regulation and schedule introduce an influencing factor that is determined from the nature of the land uses that surround the receiving premises and which is added to the levels given in the table in regulation 8. The assigned levels that apply to noise sensitive premises near the quarry are given in Table 1 of this report.

Regulation 9 of the *Environmental Protection (Noise) Regulations 1997* requires that a noise emission be free of tonal, impulsive and modulation characteristics and defines the manner in which the presence or absence of these characteristics is to be determined. This determination provides for adjustments to the measured noise levels where these characteristics cannot be removed in a reasonable and practicable manner. These adjustments are made to the measured sound pressure level and range fro +5 to +15 dB. They are detailed in Table 2 of regulation 9.

Regulation 13 of the *Environmental Protection (Noise) Regulations 1997* requires that the occupier of a construction site follow the environmental noise practices set out in section 6 of Australian Standard AS 2436-1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites* and to use equipment that is the quietest reasonably available. Where construction work is undertaken outside the hours of 7.00 am and 7.00 pm Mondays to Saturdays, or on public holidays, inclusive, the occupier of the construction site (which may, of course, be a portion of the premises under the control of the construction contractor) is also required to prepare a noise management plan, have the plan approved by the Chief Executive Officer of the Department of Environment (or his delegate if appropriate) and to follow the procedures detailed in the plan during the construction phase of the project. The Chief Executive Officer may also require a noise management plan to be prepared, approved and followed, regardless of the times of day when construction work will be carried out, should he consider this to be appropriate.

Construction work is defined in the regulations as meaning;

(a) the construction, erection, installation, alteration, repair, maintenance, cleaning, painting, renewal, removal, excavation, dismantling or demolition of, or addition to, any building or structure, or any work in connection with any of these things, that is done at or adjacent to the place where the building or structure is located;

(b) work on which a hoisting appliance or any scaffold or shoring is used;

(c) work in driving or extracting piles, sheet piles or trench sheet;

(d) work in laying any pipe or work in lining pipe that is done at or adjacent to the place where the pipe is laid or to be laid;

(e) work in sinking or lining or altering, repairing, maintaining, renewing, removing, or dismantling a well or borehole; or

(f) road works, earth works or other similar site works or reclamation.

Application of this definition to removal of overburden as part of the development or construction of a quarry is not clear cut. It is generally accepted that the removal of that overburden which is sold as a by-product to the primary quarry operation is not construction work for the purposes of this definition. However, that overburden which is extracted and moved either to construct noise attenuation barriers, or to provide material for subsequent rehabilitation of the quarry site is accepted to be within the definition of construction work.

Overall, construction activities on the site, other than clearing of vegetation and removal of overburden, if managed within the frame work of an approved Noise Management Plan to follow good engineering construction practice, are not anticipated to result in noise emissions that would unreasonably interfere with the health, welfare, convenience, comfort or amenity of any person living in an existing building that is directly associated with a noise sensitive use.

In contrast, some vegetation clearing and overburden removal may result in noise levels that exceed the assigned levels for the area by up to 10 dB L_A at times, provided this work is carried out only between 7.00 am and 7.00 pm, on Mondays to Saturdays excluding public holidays. Herring Storer Acoustics shows, in its November 2004 report, how the environmental noise impact of this work can be minimized. This approach should be adopted.

5 Assigned noise levels for quarry operations

When in operation, this proposed re-located quarry will be required, by the *Environmental Protection (Noise) Regulations 1997*, to meet the noise levels given in Table 1 at, or within 15 metres of, all buildings directly associated with a noise sensitive use. Those noise sensitive premises most likely to be impacted by re-location of the quarry and crushing and screening plant are shown in figure L01 of the February 2002 Herring Storer Acoustics report. These six residences are identified as Residences A, B, C, D, E and F in this figure. As the quarry and its associated plant will be operating for more than 10% of the time, only the L_{10} assigned levels are considered in this table. Noise emissions from the operation are permitted by the regulations to be higher for brief periods, however, higher noise levels are unlikely whilst the quarry and its associated plant are in normal operation.

Table 1: Assigned noise levels

Location	Influencing factor dB	Assigned noise levels dB L_{A10}		
		Daytime Monday to Saturday (7.00 am to 7.00 pm)	Evening all days (7.00 pm to 10.00 pm) and daytime, Sundays and public holidays (7.00 am to 7.00 pm)	Night time (10.00 pm to 7.00 am Monday to Saturday or 10.00 pm to 9.00 am Sundays and public holidays)
Residence A	0	45	40	35
Residence B	0	45	40	35
Residence C	0	45	40	35
Residence D	0	45	40	35
Residence E	0	45	40	35
Residence F	0	45	40	35

6 Noise emissions when quarry is fully re-located

When the quarry, and crushing and screening facilities, are operating as planned on the new site, the modelling carried out by Herring Storer Acoustics predicts that the requirements of the *Environmental Protection (Noise) Regulations 1997* will be met in full.

These predictions, and other predictions of noise levels for the current operation and transitional situations have been made using the computer modelling programme “SoundPLAN”. This is a programme developed in Europe that is gaining wide acceptance throughout Australia and which is considered an appropriate tool for establishing the predictions made for this proposal. It is generally accepted as having an accuracy of plus or minus about 3 dB and being of a conservative nature in the results it provides. It utilises a range of input data in developing these predictions:

- The sound power levels for all significant noise sources. (Significant noise sources are those which show sound power levels within 10 dB of the highest sound power source, or sources which show unusual noise characteristics such as high levels of tonality or impulsiveness.);

- Weather conditions applicable when the noise is being emitted. Those weather conditions estimated to show worst case enhanced propagation of noise are specified in the Environmental Protection Authority publication *Guidance for the*

Assessment of Environmental Factors – No 8 - Environmental Noise, draft edition June 1998;

- The three dimensional location of all significant sound sources;
- The topographical nature of the surrounding land; and
- The position of buildings, artificial bunds and barriers and the like that will affect noise propagation.

Modelling has been undertaken for worst case weather conditions. Contour maps showing the predictions generated by this modelling are provided in the Herring Storer Acoustics report of November 2004. The sound power data used in the modelling exercise is considered to accurately reflect the sound power levels of the equipment that will be used on the site is considered to be

It should be noted that the worst case scenarios presented in this report do not occur in practice. The contour maps show an artificial situation where the wind is assumed to be blowing away from the noise sources in all directions. This, of course, does not occur in practice. Thus, the predictions provided in these figures should be interpreted in conjunction with wind direction and velocity data for the area. For most of the time, noise levels some 5 dB to 10 dB lower than those shown by the contour maps will be experienced.

Modelling of the relocated quarry and crushing and screening plant shows that a substantial decrease from the predicted and measured noise levels currently being experienced will be evident at the nearer noise sensitive premises. This decrease will be achieved through a number of features:

- The quarry will be moved about 700 metres to the west, making it further away from residences F and A, and giving it greater benefit from the barrier effect provided by the rising ground to the west.
- The crushing and screening plant will be located within the new quarry, on a prepared flat area some 40 metres below the natural ground level. The ground level for the area containing this plant will be 280 metres ref height compared with the current location at 300 metres ref height.
- The current location for the crushing and screening plant is on or very close to the natural ground surface in a flatter area where natural barriers are less effective.
- The primary crusher will be enclosed in a building, as it is at present.

7 Rock breaking activities

Rock breaking is an intermittent operation carried out about three times each year. Blasting results in some fractured rocks being too large to be fed into the primary crusher. These oversize rocks are put to one side in the base of the quarry and are broken, when an adequate quantity of such rocks has accumulated, using a hydraulic pick mounted on an excavator brought onto the site for this purpose.

Modelling of the rock breaker noise emissions shows that this operation complies with the requirements of the regulations as it is currently carried out in the existing quarry and as it is proposed to be carried out in the new quarry. The results of this modelling are presented in tables 3.3 and 3.4 of the Herring Storer Acoustics report of November 2004. They are reproduced in table 2 below. Table 3.2 of the November 2004 report presents the sound power data used to model noise emissions from rock breaking. This sound power level is considered typical for this activity.

Table 2: Predicted noise levels, under worst case weather conditions, for rock breaking operations

Location	Predicted level for existing quarry dB L_A	Predicted level for new quarry dB L_A
Residence A	32	30
Residence B	34	35
Residence C	33	27
Residence D	21	23
Residence E	13	18
Residence F	29	26

The Herring Storer Acoustics reports are not clear on whether or not adjustments have been made to these predicted noise levels for the impulsive character of the rock breaker noise emissions.

If such adjustments have not been applied, as appears to be the case, the predicted levels for worst case weather conditions plus the 10 dB adjustment still remain below the noise levels assigned by the regulations for daytime, between 7.00 am and 7.00 pm Monday to Saturday, other than public holidays.

Although Herring Storer Acoustics proposes that the noise emissions from rock breaking activities can be considered against the requirements of the regulations applicable when the noise emission is present for less than 10% of the time, this is not considered appropriate.

The hydraulic excavator and rock breaking pick would normally be assigned to this work on a campaign basis. An individual campaign is not expected to last less than 4 hours and impulsive noise from the rock breaking pick at work is expected to be present for at least 10% (24 minutes) of this time period. This 4 hour period is the maximum period over which an assessment of the noise can be made under the regulations. It is identified as the "representative assessment period" by the regulations.

Provided that rock breaking activities are confined to day time, Monday to Saturday, other than public holidays, compliance with the requirements of the regulations will be achieved. However, because of the impulsive nature of rock breaking operations, it is considered likely that this operation will be audible and perhaps intrusive at times at some of the nearby residences. Choosing operating periods when weather conditions reduce the audibility of this emission is recommended for adoption as a neighbour friendly practice at the quarry.

8 Noise emissions from trucks hauling crushed products from the quarry

The modelling presented in the Herring Storer Acoustics report of November 2004 provides for the noise contribution made by conventional road trucks moving between the quarry loading area and the Great Southern Highway. The differences attributed to the inclusion of these extra noise sources are plus or minus 1 dB.

In this report, Herring Storer Acoustics advises that its model has been updated to include additional noise generated by trucks hauling products from the site. This, in conjunction with the changes made to the model to allow for the lower noise emissions from the enclosed crushing and screening plant, has resulted in insignificant changes to the predicted noise levels at the 6 key locations around the quarry.

9 Model validation

The accuracy of the modelled results has been verified by on site noise measurements. These measurements have been made at sites generally closer to the quarry and crushing and screening plant to minimise the effect of background noise on the measured levels. The results of this exercise show good correlation between the predicted and modelled values. Table 3, reproduced (with additional information) from the Herring Storer Acoustics report of November 2004, presents these results.

Table 3: Predicted and measured sound pressure levels

Location	Measured level dB L_A	Predicted level db L_A	Difference db L_A
1	40	39	-1
2	37	29	-8
3	72	71	-1
4	51	52	+1
5	48	51	+3

The locations of these sites are given in Figure 1 of the Herring Storer Acoustics report for November 2004. Site 2 is located to the west of the quarry and is thus shielded from quarry noise by the intervening rise in land height. The model has recognised the existence of this rise and correctly predicted that the noise from quarrying operations will be low. The predicted level is thus lower than the ambient noise level actually measured. The quarry activities would most likely not have been audible, or be barely audible, at this site when this measurement was made.

10 Conclusions

- The predictions made in the Herring Storer Acoustics reports are considered to be accurate, within the limitations generally adopted for such modelling and to be derived from realistic and practicable assessment of the current and proposed operations.
- The predictions made in the Herring Storer Acoustics reports indicate that under some weather conditions it is likely that the existing operations are not achieving compliance with the Environmental Protection (Noise) Regulations 1997.
- The predictions made in the Herring Storer Acoustics reports indicate that during the five year transition period in which the new quarry will be developed and the crushing and screening plant will be re-located, compliance with the regulations will not be achieved at all times.
- The most reasonable and practicable solution to this issue is considered to be relocation of the quarry and crushing and screening plant, as proposed by the BGC Group.
- The predictions made in the Herring Storer Acoustics reports indicate that once the quarry and crushing and screening plant have been relocated to the proposed

new site, noise emissions from all activities on the site, except blasting, will meet the requirements of the regulations under all weather conditions. (The environmental impacts of blasting in the quarry are not addressed in the Herring Storer Acoustics report under review. These aspects of the quarry operation have been assessed by other specialist consultants.)

- Noise from rock breaking using a hydraulic pick mounted on an excavator in either the existing or new quarry is predicted to comfortably comply with the requirements of the regulations.
- Herring Storer Acoustics has shown that the inclusion of road trucks moving between the quarry loading area and the Great Southern Highway in the model does not significantly change the modelled noise levels.
- Noise from construction activities (other than possibly overburden removal) is unlikely to result in noise emissions that unreasonably interfere with the health, welfare, convenience comfort or amenity of persons on other premises.

R L Langford

14 December 2004

Appendix L

Blasting Impact Assessment and Monitoring Plan

Voyager Quarry Blast Impact Assessment

Report Prepared for

BGC Quarries

Report Prepared by

SRK Consulting

Engineers and Scientists

October 2004

Steffen Robertson and Kirsten (Australasia) Pty Ltd
Reg No ABN 56 074 271 720
Trading as SRK Consulting

Voyager Quarry Blast Impact Assessment

BGC Quarries

PO Box 1257
Midland WA 6936
Australia

SRK Project Number URS101

SRK Consulting
Level 9, 300 Adelaide Street
Brisbane QLD 4000
Australia

Kevin Holley, MIEAust, RPEQ
Principal Geotechnical Engineer
kholley@srk.com.au

October 2004

Compiled by:

Kevin Holley, MIEAust, RPEQ
Project Consultant

Endorsed by:

Thomas Schrimpf
Principal

Executive Summary

BGC Quarries (BGC) has made an application to extend the operations of the Voyager Quarry. The proposed extension of quarry operations will result in the development of a new quarry pit to the west of the existing pit, which will be approximately 500m from the nearest residence. The local action group have responded to the Environmental Protection Authority (EPA) on the Public Environmental Review (PER) for the proposed relocation of the Voyager Quarry. In their response one of the concerns that have been raised is with respect to perceived and potential blast induced disturbances. Particular concerns that were raised included the potential for blast induced vibrations to cause damage to existing residential structures. To assess the concerns, in relation to blast induced disturbances, BGC has requested independent advice from Steffen Robertson and Kirsten (Australasia) trading as SRK Consulting (SRK) with respect to the potential for causing blast induced damage.

For the purposes of the preparation of this report a visit was made to the quarry, discussions were held with site staff and available information was reviewed and analysed. During the site visit it was noted that the Voyager Quarry is a very tidy operation that attaches high importance to both environmental compliance and operational efficiency.

The current Department of Environment (DoE) Licence requires that ground vibration Peak Particle Velocity (PPV) does not exceed 10mm/sec for any single blast. The nominated ground vibration limits at affected residences are PPV of 5mm/sec for a single blast, and not more than one blast in ten consecutive blasts may cause a disturbance with a PPV of greater than 5mm/sec. In the case of air overpressure, the Voyager Quarry is required to comply with the Environment Protection (Noise) Regulations 1997. This regulation specifies that for blasts between 07h00 and 18h00 on any day other than a Sunday or Public Holiday the airblast must not exceed 125 dBL for any blast, and 120 dBL for nine in any ten consecutive blasts regardless of the interval between them. These environmental blast disturbance limits are consistent with (or more onerous than) those recommended by the Australian Standard AS2187.2-1993.

Vibration and air overpressure monitoring has been carried out by the BGC Voyager Quarry for compliance purposes. The monitoring records show that there is a history of compliance with the environmental limits to which the quarry operation is bound to. For the data that was reviewed the maximum recorded vibration at the nearest residential structure is 4.6mm/sec and the maximum air overpressure is 121.6 dBL. The maximum recorded air over pressure over the life of the quarry is 126 dBL (December 1998), and this was attributed to extenuating circumstances.

There is considerable divergence of opinion as to the levels of disturbance that are likely to cause damage to a residential type structure. However, it is generally considered that a vibration of less that 100mm/sec and air over pressure of less than about 134 dBL are highly unlikely to result in damage (either superficial of structural) to a residential structure. The levels of vibration that are expected to be caused by the Voyager Quarry are therefore unlikely to cause damage to adjacent residential structures.

Regression analysis has been carried out on the results of monitoring data that was filtered to include only those data points with a reliable estimate of distance between the blast and monitor. This regression analysis was used to develop a preliminary site specific vibration attenuation equation with site specific constants ($k = 2557$ and $n = -1.6$). This equation is expected to be updated with the results of further more detailed blast monitoring. In the interim it has been recommended that the preliminary attenuation equation is used as a guide to selecting appropriate blast design parameters.

Additional blast monitoring is considered to be required to develop more reliable attenuation relationships. A monitoring program that is designed to assess blast impact over the range of appropriate distances has been recommended. This program is also designed to allow an assessment of the impact of geology on blast disturbance.

Table of Contents

List of Tables

List of Figures

Disclaimer

The opinions expressed in this report have been based on the information supplied to Steffen Robertson & Kirsten (Australasia) Pty Ltd trading as SRK Consulting (SRK) by BGC Quarries (BGC). The opinions in this report are provided in response to a specific request from BGC to do so. SRK have exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

1 Introduction and Terms of Reference

BGC Quarries (BGC) is seeking to expand their existing Voyager Quarry near Perth in Western Australia. The proposed expansion will require the formation of another pit to the west of the existing quarry operations as shown in **Figure 1-1**. The proposed expansion of operations will mean that quarry activities will be approximately 500 m closer to the nearest residential structure.

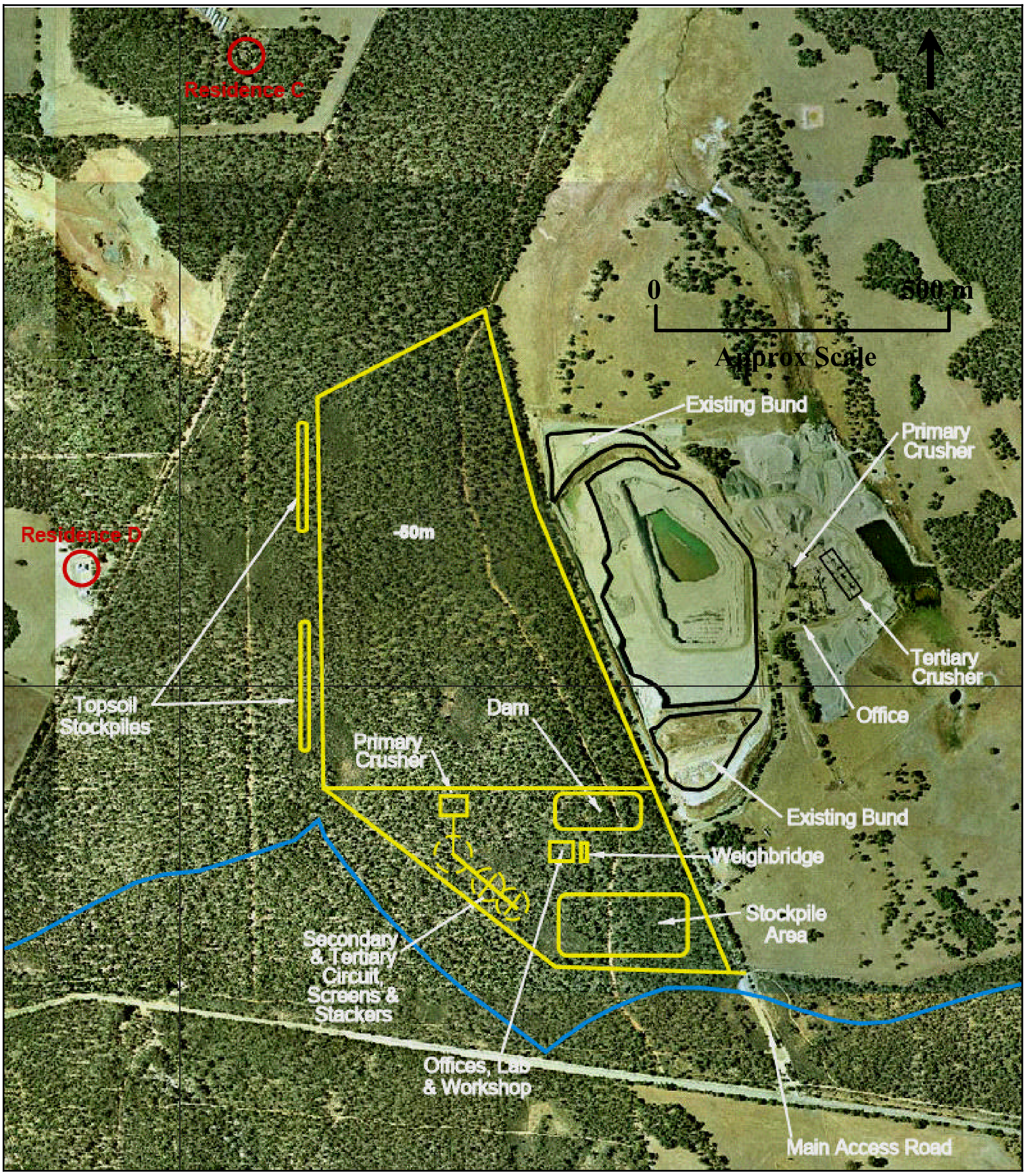


Figure 1-1: BGC Voyager Quarry and Proposed Expansion (after URS, 2004)

Submissions have been made to the Environmental Protection Authority (EPA) in Western Australia for a permit to expand the quarry operation. A local action group has responded to the BGC submission to the EPA during the public consultation period. In this response, the local action group expressed concerns with respect to perceived potential blast induced disturbances. Particular concerns that were raised included the potential for blast induced vibrations to cause damage to existing residential type structures.

To assess the concerns, in relation to blast induced disturbances, that have been brought up by the Local Action Group, BGC has requested independent advice with respect to the potential for causing blast induced damage. The scope of services that were required to be provided in relation to this project were defined in an email from URS addressed to Mr Kevin Holley of Steffen Robertson and Kirsten (Australasia) trading as SRK Consulting (SRK) dated 15 September 2004. SRK provided a proposal to address the issues that were described by URS in a letter dated 16 September 2004. The anticipated scope of work was defined in the SRK proposal. The SRK proposal was accepted by URS, on behalf of BGC in a letter dated 22 September 2004. Following minor clarifications from SRK, BGC issued a Purchase Order (Number Q023807, dated 23 September 2004) authorising SRK to proceed with the defined scope of services.

The results of an assessment of the potential for the Voyager Quarry to cause blast induced disturbances to nearby residents are presented in this report. Preliminary recommendations with respect to blast practices to limit disturbances to the levels that have been stipulated in the current Department of Environment (DoE) Licence to operate are also provided. In addition, recommendations for an Airblast and Ground Vibration Monitoring Plan are provided.

2 Site Visit

Mr Kevin Holley of SRK made a visit to the BGC Voyager Quarry on Monday 27 September 2004. This visit was arranged by the General Manager – BGC Asphalt and Quarries, Mr Frank Italiano. The Quarry Manager, Mr Paul Berkhout and the Manager – Quality, Safety and Environmental Systems, Mr Carlson Daniels met with Kevin Holley at the site and spent the day describing the current and proposed operations. The main purpose of the visit was to:

- gain an appreciation of the existing quarry practices, including blasting and blast monitoring;
- obtain blast design and other monitoring information/records, and;
- assess site specific conditions as they may impact on blast induced disturbances at nearby residences.

During the site visit it was observed that the Voyager Quarry was a very tidy operation and that thorough operations records, not normally maintained by a quarry operation of this size, were easily accessible at the BGC Voyager Quarry operation. It was also noted that these records are routinely reviewed and used by BGC to optimise quarry practices.

A photograph that shows the current quarry pit, as observed on 27 September 2004, is given in **Figure 2-1**. This photograph shows the high level of attention that has been given, by BGC, to both the design and operation of the current quarry.

Figure 2-1: Photograph (towards North) Showing Quarry Pit at 26 September 2004

3 Available Information

The following information was made available, and has been reviewed, for the purposes of this report:

1. McDowall Affleck Pty Ltd (January 2003). Report titled "Structural Survey of 16 Residences, Location: The Lakes, Client: BGC Quarries".
2. URS (January 2003). Portion of Report titled "Land Clearing and Quarry Expansion, Avon Loc 1881, Lot 14 Horton Road, The Lakes (EPA Assessment Number 1413). Volume 2". Chapter 4.2 p43 – 44. Geology, Landforms and Soils.
3. URS (January 2003). Portion of Report titled "Land Clearing and Quarry Expansion, Avon Loc 1881, Lot 14 Horton Road, The Lakes (EPA Assessment Number 1413). Volume 2". Chapter 3 p 19 – 29.
4. URS (January 2003). Portion of Report titled "Land Clearing and Quarry Expansion, Avon Loc 1881, Lot 14 Horton Road, The Lakes (EPA Assessment Number 1413). Volume 2". Chapter 7.12 p 125 – 133.
5. URS (January 2003). Portion of Report titled "Land Clearing and Quarry Expansion, Avon Loc 1881, Lot 14 Horton Road, The Lakes (EPA Assessment Number 1413). Volume 2". Table 8.1 p 143.
6. URS (Undated). Figure 2.2 titled "Preliminary Closure Plan, Relocated Voyager Quarry, Layout of Existing and Proposed Operations".
7. URS (Undated). Figure 1 titled "Response to Submissions Related to the Proposed Relocation of BGC Voyager Quarry, Geological Plan".
8. Lakes Action Group (Undated). Figure 3.7 titled "Geological Plan Showing Major Structures".
9. BGC Quarries (25 March 2002). Drill and Blast Manual.
10. URS (30 September 2004). Draft Borehole logs for borehole numbers BGCM1 to BGCM6.
11. URS (22 March 2002). Borehole Logs for Borehole Numbers BGC1 and BGC2.
12. BGC Quarries. Blast compliance monitoring reports dating back to 1999.
13. BGC Quarries. Printout of Spreadsheet showing Borehole Piezometer Records for the Period Between 20 March 2002 and 10 September 2004.

4 Vibration and Air Pressure Compliance at the Voyager Quarry

4.1 Permit Requirements

The EPA have an objective to "Protect the amenity of nearby residence from noise, airblast overpressure and vibration impacts resulting from activities associated with the proposal by ensuring that noise and vibration levels meet statutory requirements and acceptable standards". To conform with the objective stated above there is a requirement for the BGC Voyager Quarry to comply with the DoE Works Approval and Licence Conditions.

The current DoE Licence requires that ground vibration Peak Particle Velocity (PPV) does not exceed 10mm/sec for any single blast. The nominated ground vibration limits at affected residences are:

- PPV of 5mm/sec for a single blast, and;
- Not more than one blast in ten consecutive blasts may cause a disturbance with a PPV of greater than 5mm/sec.

In the case of air overpressure, the Voyager Quarry is required to comply with the *Environment Protection (Noise) Regulations 1997*. This regulation specifies that for blasts between 07h00 and 18h00 on any day other than a Sunday or Public Holiday the airblast must not exceed:

- 125 dBL for any blast, and;
- 120 dBL for nine in any ten consecutive blasts regardless of the interval between them.

4.2 BGC Documented (Published) Commitments

The BGC Voyager Quarry has committed to complying with the requirements that are described in the above section. In addition to this, BGC undertook to have a condition survey of nearby residences done prior to the commencement of any operations and to provide the results of the survey to the relevant residents. An important objective of the condition survey was to provide a baseline against which claims for damage attributed to blast induced vibration could be assessed. SRK consider that this initiative is appropriate and consistent with "best practice".

BGC Quarries have commissioned McDowall Affleck Pty Ltd to carry out the structural survey of adjacent residences and the survey was completed in January 2003.

5 Potential for Blast Induced Damage to Adjacent Properties

5.1 Damage Due to Vibration

Vibration limits are commonly imposed on blasting operations conducted in proximity to other structures, including residential housing, historical sites, etc., based on the condition of the structure. Vibration limits imposed on structures attempt to account for personal comfort, cosmetic damage, and structural damage. If the human response factor is removed, then substantially higher vibration limits can be imposed while still providing a high factor of safety over the integrity of a structure.

There is, as recognised by Head and Jardine (1992), a considerable difference in opinion as to what constitutes blast vibration damage thresholds as is illustrated in **Figure 5-1** (after Theissen and Wood, 1982). **Figure 5-1** shows that the lowest blast induced vibration that has been attributed to damage (in common residential type structures) is about 100mm/sec. At the Voyager Quarry the objective is to limit vibration to 5mm/sec (i.e. only 5% of the minimum that is attributed to damage).

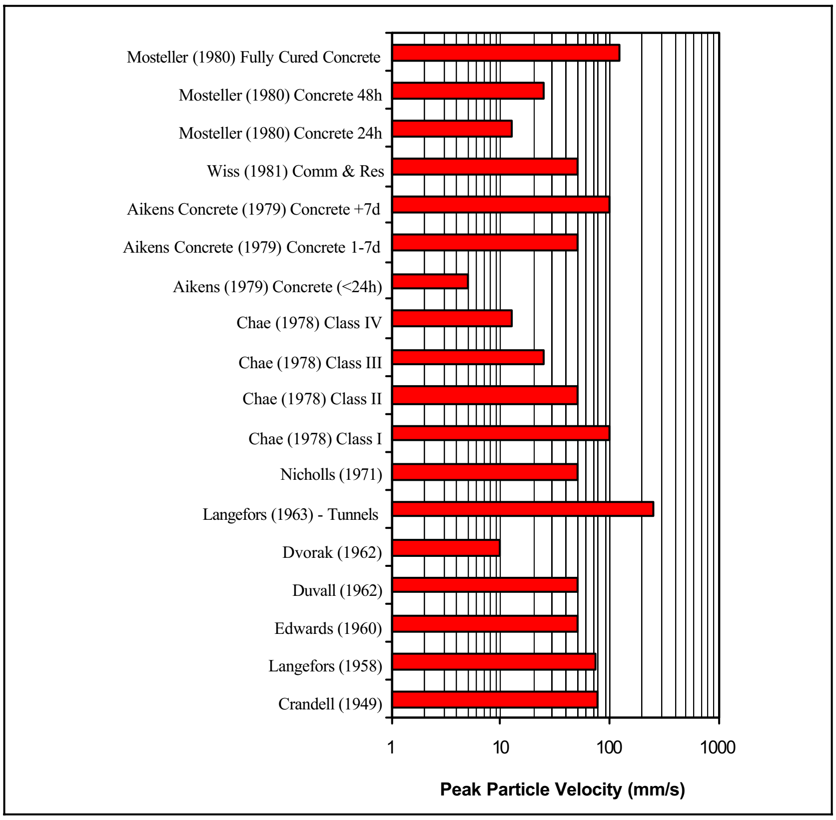


Figure 5-1: Observed and Anticipated Blast Vibration Damage Thresholds

To properly assess the impact of vibration on a structure it is important to understand the units of measurement for vibration. For historic reasons blast vibration is most commonly expressed in terms of peak particle velocity (PPV). The metric units of this measure are mm/s.

Compliance standards are also commonly with reference to the vector sum peak partic le velocity to make allowance for the fact that vibration is three dimensional. The true vector sum is defined as:

$$\sqrt{\nu_R^2+\nu_V^2+\nu_T^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where,

ν = particle velocity for the component shown at time t, the time at which the particle velocity for one of the components was at its maximum.

From the equation given above it can be seen that the vector sum blast induced vibration that is reported is, in actual fact, greater than the maximum of any of the individual components of the blast induced vibration.

It is important to note that the units of vibration are in terms of velocity and not displacement. PPV can be converted to a displacement by integration of the vibration waveform that approximates a sinusoidal wave. For a blast event with a frequency that is typical of a quarry blast, a PPV of 5mm/sec could be expected to equate to a displacement of approximately 3.9 µm (0.0039mm). This is very small, and judged as highly unlikely to cause damage to a residential type structure.

Blast vibration will induce strain. To understand the potential impact of blast induced vibration it useful to compare the equivalent stresses induced in a structure by everyday environmental changes to those induced by blast vibration, as shown in **Figure 5-2** (modified after Stagg et al, 1984).

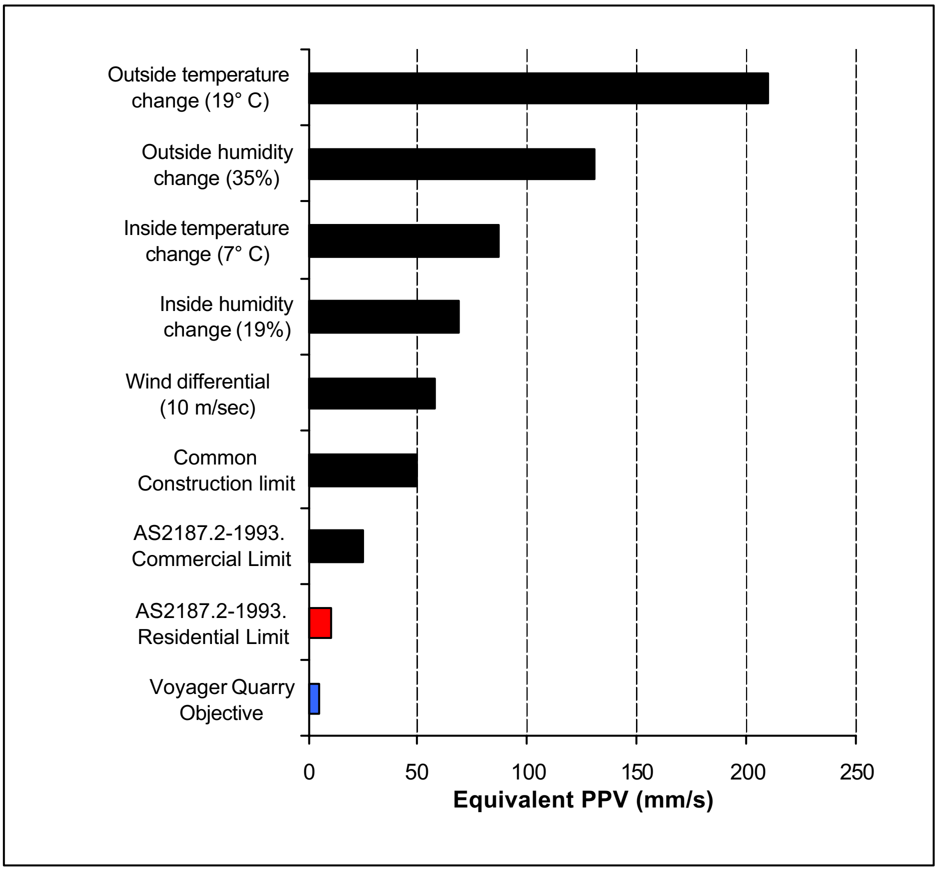


Figure 5-2: Environmental Stresses and Equivalent Peak Particle Velocity

From **Figure 5-3** it can be seen that environmental changes that are quite acceptable, and expected to occur within daily (or even more frequent) cycles, induce greater stress in a structure than does blast induced vibration at commonly accepted limits or the limits to which the Voyager Quarry is striving to achieve.

The Australian Standard AS2187.2-1993 gives allowable levels for both ground vibration and overpressure from blasting activities. The recommended maximum PPV for houses, low rise residential buildings, or commercial buildings is 10mm/s. With regard to AS2187 it should be noted that:

- A PPV of 10mm/s has been selected taking into consideration both human discomfort and structural integrity, including the effect on sensitive equipment located in the buildings;
- The potential for damage to residential type structures increases when ground vibration levels are greater than about 10mm/s (peak particle velocity);
- In the absence of a particular site specific study which may determine the appropriate damage criterion, then a maximum peak particle velocity of 5mm/s is recommended in AS2187, and;
- Documented experience has shown that damage is very unlikely to occur at ground vibration levels below this level.

The BGC Voyager Quarry has a stated objective, and permit requirement, to maintain blast induced vibration to less than 5mm/s. Site specific studies have been carried out at the Voyager Quarry, and there has also been a considerable amount of compliance monitoring that is documented. The blast induced vibration disturbance compliance criteria to be adopted by the BGC Voyager Quarry are therefore at least equivalent to the AS2187.

Compliance with legislative limits or Standards does not necessarily ensure residents will not perceive the vibration from quarry activities. Compliance with these limits does, however, indicate that the effects of blasting are **most unlikely** to be responsible for inducing either structural or superficial damage. The latter is considered to represent hairline cracking, cracking of plaster, or flaking of paint all of which do not diminish the structural integrity of a building.

Humans are very sensitive to vibration. They are, however, poorly equipped to distinguish between different intensity or disturbance. Human perception, and hence personal amenity, is difficult to precisely define in view of the fact that a person's perception and response will vary according to the nature of vibration (duration, amplitude, frequency, and frequency of occurrence), health, state of mind, temperament, and physical attitude of individuals. Consequently, vibration or overpressure on one occasion may be acceptable to a nearby person, although a disturbance at a similar level on another day may be classified as offensive by the same individual. Experience gained from the environmental monitoring of blasting activities has shown that when ground vibration routinely exceeds the threshold of perception (around 1mm/s), the possibility of complaints arises. Given that short duration vibrations of less than 1mm/s are generally considered imperceptible, complaints under these circumstances are more commonly related to alternative sources of annoyance, such as overpressure or noise.

The anticipated Voyager Quarry blast induced vibration at adjacent residential properties (5mm/sec) is extremely unlikely to cause damage to residential type structures.

5.2 Damage Due to Air Overpressure

Overpressure is the air pressure measured on a linear scale, without allowance for human hearing. It represents the ambient pressure state, and is therefore influenced by any factor which causes air pressure fluctuations. These include wind and audible sound sources such as cars or birds.

When an explosive is detonated, airborne vibration or air overpressure is generated. Air overpressure is made up of energy within a wide range of frequencies both above and below the audible range (±20 Hz). The very low frequency (±5 Hz) component of overpressure can induce vibration in a building. Various researchers, for example Anch (1983), have noted that it is possible for air overpressure to generate higher levels of structural vibration than that caused by ground vibration.

Studies in the USA have addressed the level of overpressure generated by wind. These studies are supported by measured data and indicate that an overpressure level of 115 dBL is generated by a wind with a velocity in the range 11 to 16 km per hour (6 to 9 knots). Overpressure levels in excess of 115 dBL are, therefore, easily and frequently exceeded on a daily basis by natural wind occurrences. This is clearly seen in the results of a study by Holley et. al. (2001), where air overpressure was measured over a 14 day period in an upmarket residential area that was not in the vicinity of any blasting activities or excessive traffic disturbance. In this study (see Figure 5-3) 11% of 6,800 measurements made by the authors exceeded the commonly imposed air overpressure limit of 115 dBL for blast generated disturbances. Light winds were observed to be the cause of the overpressure fluctuations.

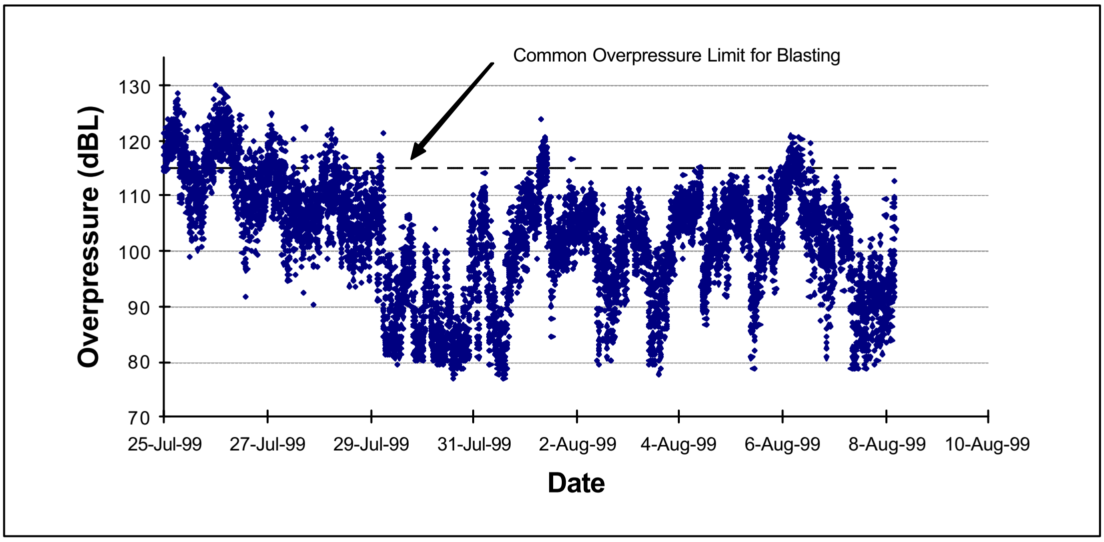


Figure 5-3: Background Air Overpressure (after Holley et al, 2001)

The USBM (Siskind et al, 1980) have carried out extensive studies into the impact of air overpressure, and concluded that a level of 133 dBL (measured with a microphone with 2 Hz cut-off) can be regarded as incapable of causing damage (< 1% probability of even superficial damage) to the typical residential structures studied. The USBM add that the safe air overpressure levels are still high enough to produce secondary vibration effects (rattling of windows etc.). Complaints about rattling are observed to become more common when air overpressure levels exceed approximately 120 dBL. Siskind et al have observed that up to 10% of homes will exhibit rattling once overpressure levels reach 134 dBL.

Reasons for limiting air overpressure can be related to concern for structural integrity, concern over human safety, or a concern over human annoyance. It is generally recognised that the potential for overpressure from normal rock blasting activities to inflict structural damage is very limited. It can be stated that the onset of structural damage from air overpressure is the cracking of glass windows. If windows have not cracked, the likelihood of structural damage is extremely remote.

The AS2187 Standard addresses the effect of air overpressure by noting that it can cause discomfort to persons, and in some cases damage to structures. An air overpressure limit of 120 dBL is commonly used to minimise human discomfort and 133 dBL is adopted to avoid structural damage.

Air overpressure levels less than 115 dBL rarely invoke complaints given that these levels are commonly exceeded by naturally occurring events such as wind. The perception of high overpressure levels is generally through the rattling of loosely fitting windows, often giving the misconception to the resident that the building has been subjected to very high levels of ground vibration.

The levels of air overpressure, that are expected to be generated by blast activities at the Voyager Quarry, are extremely unlikely to cause structural damage to adjacent residences that are more than approximately 500m from the quarry.

6 Blasting Practices at Voyager Quarry

The BGC Voyager Quarry has a comprehensive drill and blast manual. This manual provides a set of procedures for the safe handling of explosives at the site, and also guidance with respect to blast designs that have been proven appropriate and to meet the quarry objectives.

Typical blast design parameters that are used at the Voyager Quarry are summarised in **Table 6-1**.

Table 6-1: Summary of Typical Blast Design Details for BGC Voyager Quarry

Property	Parameter
Bench Height (m)	15
Typical Number of Rows	4
Burden (m)	3 to 3.3
Spacing (m)	3 to 3.3
Front Row Burden (m)	3
Production Hole Diameter (mm)	102
Back Row Hole Diameter (mm)	89
Stemming Length (m)	2 to 2.4
Explosive Type	Powergel NOVA 2560 (Emulsion)
Sub-drill (m)	1
Initiation	Nonel and currently trialling Ikon™

BGC has recently entered into a 'Rock on Ground' contract with Orica, a reputable explosive supplier with considerable experience. One of the intentions of this contract is for the quarry to optimise blast practices from both production and environmental compliance perspectives. Under this contract, Orica are trialling electronic Ikon™ detonators as part of their commitment to reduce environmental impacts and improve production.

Historical blast practices have resulted in compliance with respect to both blast induced vibration and air overpressure. In the records that were reviewed for the purposes of this report (1999 to September 2004) the maximum ground vibration that has been recorded adjacent to the nearest residential structure (Lot 5, Horton Road, The Lakes) is 4.6mm/sec (blast number 473, 9 July 2003, recorded MIC 300 kg). The maximum recorded air overpressure at the same location is 121.6 dBL (Blast Number 489, 23 December 2003, recorded MIC 385 kg). Apparently the maximum recorded air over pressure over the life of the quarry is 126 dBL (December 1998), and this was attributed to extenuating circumstances (external training course).

As a part of the blasting procedures quarry personnel are required to telephone local residents prior to a blast to advise them that a blast has been scheduled. It is understood that BGC Voyager Quarry plans to fire shots at 13h00 on days that blasting is scheduled. Blasts are only fired at other times when unforseen circumstances, usually issues to do with safety, dictate that this is required. From discussions with Mr Paul Berkhout it is understood that the local residents have indicated that they have a preference for more frequent blasts of a smaller size over less frequent larger scale blasts. BGC Voyager Quarry has modified their practice in so far as is practical to conform to the request of the local residents.

Specially prepared stemming material is used by BGC Voyager Quarry. Past experience has shown that a crusher run comprised of a 10/7mm aggregate mix is optimum. With the stemming height that is adopted stemming ejections are not observed. Flyrock has also not been observed for the last 8 to 10 years (pers. comm. Paul Berkhout, 2004). This is evidenced by video records that are maintained by the Voyager Quarry.

SRK are of the opinion that the documented blast procedures and the practices that were observed at the Voyager Quarry are appropriate, and that at distances of greater than 500 m they should not be capable of causing damage to a residential type structure. This opinion is supported by site specific blast compliance monitoring records.

7 Monitoring Records

7.1 Vibration and Air Overpressure Monitoring

It is understood that vibration and air overpressure are monitored for all blasts that are fired at the Voyager Quarry. Prior to December 2003 vibration and air overpressure monitoring was carried out by an independent consulting firm (ABT Engineering Pty Ltd) that was appointed by BGC Voyager Quarry. Post December 2003, blast vibration monitoring has been carried out by Orica.

Vibration and air overpressure monitoring has been carried out at a site near to the residence at Lot 5 Horton Road (closest residence) and also at a site closer to the quarry as a control measure and at the initiative of BGC Voyager Quarry management. The monitoring positions have been permanently established at both locations. At both of the monitoring stations the vibration monitor is mounted on top of a concrete pad that is about 400mm diameter and extends into the ground for up to about 1000mm. The concrete column was formed using a rapid set concrete and it is suspected that it will have a strength of at least 15 MPa. A typical vibration monitor set-up pad is shown in **Figure 7-1**.

Figure 7-1: Vibration Monitoring Pad Near Lot 5 Horton Road

A monitor set up such as that shown in Figure 7-1 will help to reduce the scatter of data by ensuring that the vibration sensor is properly coupled to the ground. SRK consider that the monitor set-up for monitoring that is done for compliance purposes is appropriate.

The vibration monitoring that has been carried out at the Voyager Quarry has been done with a key objective to confirm compliance with the quarry permit requirements. The monitoring program was not designed to allow detailed interpretation and analysis of records. In this regard, the distance to the blast from the monitoring station has not been accurately recorded.

A summary of blast vibration and air overpressure monitoring results, for which blast design information was recorded, is given in Table 7-1. The results of the vibration monitoring, for the period between December 2002 and September 2004) are presented graphically in **Figure 7-2**. Air overpressure monitoring results for the same period are presented graphically in **Figure 7-3**. For the purposes of these figures the distances as quoted on the monitoring record have been used.

Table 7-1: Voyager Quarry Blast Monitoring Records

Blast	Date	Initiation Method	MIC (Kg)	Locaton	Dist (m)	PPV (mm/s)	OP (dBL)
458	19-Dec-02	Nonel	300	Near Lot 5	1000	1.4	116.1
458	19-Dec-02	Nonel	300	BGC Property	500	4.0	115.8
472	20-Jun-03	Nonel	300	Near Lot 5	1000	4.5	113.0
472	20-Jun-03	Nonel	300	BGC Property	500	3.2	119.6
473	9-Jul-03	Nonel	300	Near Lot 5	1000	4.6	105.5
473	9-Jul-03	Nonel	300	BGC Property	500	2.4	109.1
L04	7-Sep-03	Nonel	122 *	Near Lot 5	1000	2.0	109.1
L04	7-Sep-03	Nonel	122 *	BGC Property	500	3.0	114.3
483	28-Oct-03	Nonel	290	Near Lot 5	1000	1.4	98.9
483	28-Oct-03	Nonel	290	BGC Property	500	2.1	107.9
489	23-Dec-03	Nonel	385	Near Lot 5	1000	1.7	121.6
489	23-Dec-03	Nonel	385	BGC Property	500	1.0	118.2
491	13-Jan-04	Nonel	405	Near Lot 5	1000	2.8	112.0
491	13-Jan-04	Nonel	405	BGC Property	500	2.7	108.5
490	13-Jan-04	Nonel	405	Near Lot 5	1000	2.8	112.0
490	13-Jan-04	Nonel	405	BGC Property	500	2.7	108.5
488	4-Mar-04	Nonel	255	BGC Property	500	1.3	110.8
492	4-Mar-04	Nonel	225	Near Lot 5	1000	2.6	102.6
492	4-Mar-04	Nonel	225	BGC Property	500	1.3	110.8
493	10-Mar-04	Nonel	480	Near Lot 5	1000	1.9	118.0
493	10-Mar-04	Nonel	480	Near Lot 5	1000	1.7	112.4
494	17-Mar-04	Nonel	250	Near Lot 5	1000	1.8	103.5
494	17-Mar-04	Nonel	250	BGC Property	500	1.0	111.3
495	23-Mar-04	Nonel	390	Near Lot 5	1000	1.0	92.9
495	23-Mar-04	Nonel	390	BGC Property	500	1.0	108.6
L07	6-Apr-04	Nonel	254	Near Lot 5	1000	2.0	99.8
L09	10-Apr-04	Nonel	300	Near Lot 5	1000	2.0	103.5
L09	10-Apr-04	Nonel	300	BGC Property	500	1.3	110.0
L06	13-Apr-04	Nonel	260	Near Lot 5	1000	1.7	102.3
L06	13-Apr-04	Nonel	260	Near Lot 5	1000	1.4	87.2
L08	20-Apr-04	Nonel	300	Near Lot 5	1000	2.1	104.4
L08	20-Apr-04	Nonel	300	BGC Property	500	2.3	114.8
L13	13-May-04	Nonel	390	Near Lot 5	1000	1.1	114.6
L13	13-May-04	Nonel	390	BGC Property	500	0.6	120.0
L10	18-May-04	Nonel	270	Near Lot 5	1000	1.3	102.5
L10	18-May-04	Nonel	270	BGC Property	500	1.0	108.0
L12	24-May-04	Nonel	252	Near Lot 5	1000	1.0	105.9
L12	24-May-04	Nonel	252	BGC Property	500	1.0	109.7
L14	4-Jun-04	Nonel	312	Near Lot 5	1000	3.1	103.3
L14	4-Jun-04	Nonel	312	BGC Property	500	1.8	112.8
L17	4-Aug-04	Nonel	120	Near Lot 5	1000	1.5	103.9
L18	13-Aug-04	Ikon	240	Near Lot 5	1000	0.4	107.5
L18	13-Aug-04	Ikon	240	BGC Property	500	0.7	117.4
L15	24-Aug-04	Ikon	240	Near Lot 5	1000	1.6	106.4
L15	24-Aug-04	Ikon	240	BGC Property	500	1.9	113.7
L19	31-Aug-04	Nonel	390	Near Lot 5	1000	3.2	101.5
L19	31-Aug-04	Nonel	390	BGC Property	500	2.4	94.7
L20	13-Sep-04	Ikon	360	Near Lot 5	1000	1.4	105.8
L20	13-Sep-04	Ikon	360	BGC Property	500	1.9	112.6
L11	16-Sep-04	Nonel	60	Near Lot 5	1000	0.8	100.2
L11	16-Sep-04	Nonel	60	BGC Property	500	0.7	110.0
L21	22-Sep-04	Ikon	160	Near Lot 5	1000	2.2	101.3
L21	22-Sep-04	Ikon	160	BGC Property	500	1.7	89.3

* Estimated MIC using 12.5m explosive column and assumed explosive density of 1.2 g/cm3

Two distinct clusters of data can be seen in* Figure 7-2 *and* Figure 7-3*. These clusters are attributed to the fact that distance between the monitor and blast has been estimated. These figures also clearly show that, for detailed analysis and development of more reliable attenuation relationships, the distance between the monitor and blast needs to be accurately known.

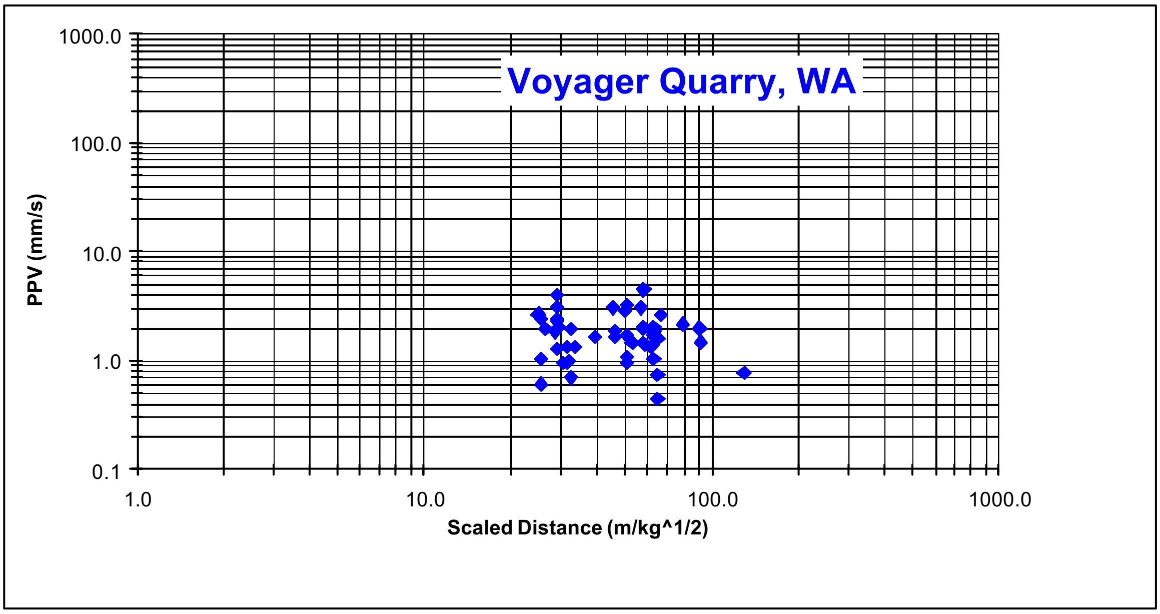


Figure 7-2: Results of Vibration Monitoring

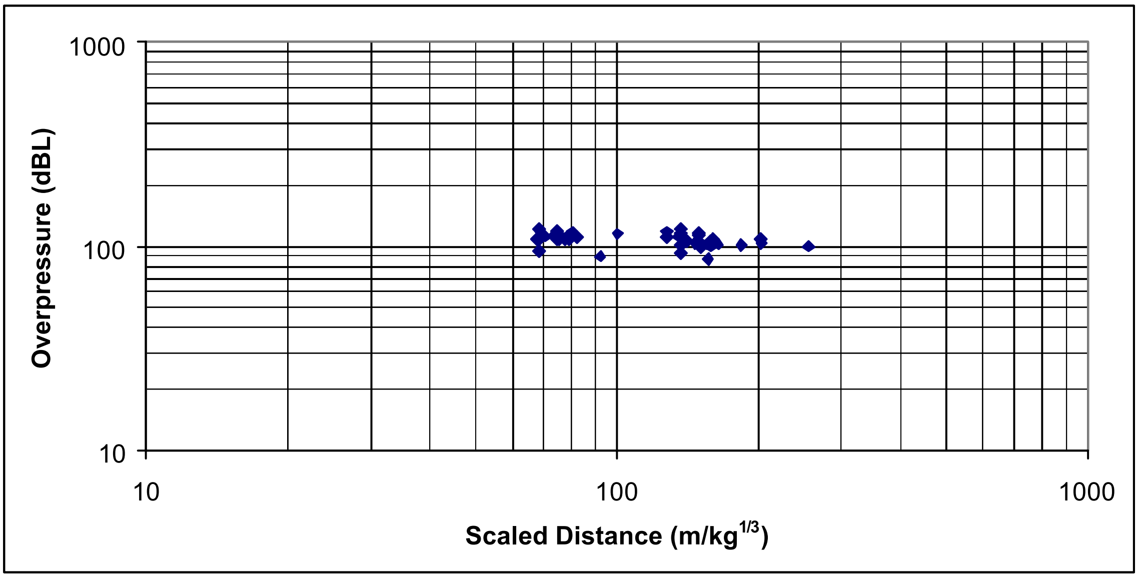


Figure 7-3: Results of Air Overpressure Monitoring

7.2 Survey of Structures on Adjacent Properties

A condition survey of residential properties was carried out by McDowall Affleck Pty Ltd between 23 and 25 January 2003. A summary of the interpreted results of the inspections is given in **Table 7-2**. From this summary it can be seen that cracking was observed in all of the residential structures. The cracking that was observed is of varying severity and is judged by SRK to be the result of “natural” environmentally induced stresses.

Table 7-2: Interpreted Condition Survey Results

Address	Name	Date of Inspection	Type of Structure	Cracking Observed
Lot 3 Cable Street	Pederick	23/01/2003	Steel and timber framed structure with concrete slab and external concrete structures. Extensions observed.	Yes in old structure and external concrete structures.
Lot 6 Gt Eastern Hwy	Harwood	23/01/2003	Double brick.	Yes.
Wariin Rd	Carter	23/01/2003	Brick veneer.	Yes.
200 Carter Rd	Lister & Gregory	23/01/2003	Double brick with framed second storey.	Yes.
Carter Rd	Hoyle	23/01/2003	Double brick.	Yes.
Lot 13 Horton Rd	Dibble	23/01/2003	Framed house, transportable house, sheds, and water tanks.	Not in houses. Cracks in water tanks and shed.
Lot 5 Horton Rd	Sorokine	23/01/2003	Rammed earth. 2 storey.	Yes
C/O Cable St & Gt Eastern Hwy.	Bailey	24/01/2003	Masonry residence and ancillary structures.	Yes.
Lot 5 Gt Eastern Hwy.	N Harwood	24/01/2003	Brick with sheet metal roof, water tanks and shed.	Yes.
Gt. Eastern Hwy.	Harking	24/01/2003	Not known.	Yes.
Lot 4 Horton Rd.	Arkell & Danie	24/01/2003	Framed Construction, and concrete tank.	Yes.
Lot 1 Cable St.	Reeves	24/01/2003	Not known.	Yes.
Lot 6 Cable St.	Brady	24/01/2003	Timber framed house on stumps.	Yes.
284 Wariin Rd.	Boase	24/01/2003	Brick/tile.	Yes.
Chinganning Rd.	Priestly	24/01/2003	2 houses and water tanks.	Yes.
Lot 7 Cable St.	Roberts	25/01/2003	Brick	Yes.

The level of blast induced vibration and air overpressure that has been experienced by the surrounding residences is, in SRK's opinion, highly unlikely to have caused cracking in residential structures such as those that are present around the Voyager Quarry. Strains induced by the recorded blast vibration can be shown to be less than strains that can be expected to be induced by everyday changes in environment.

7.3 Other Relevant Monitoring done by BGC Voyager Quarry

A weather station has been established at the BGC Voyager Quarry. This station provides a record of weather conditions. It should be noted that, according to Mr Paul Berkhout, blasting activities may be modified to take into account the weather conditions. In particular, blasting may be suspended where there is a threat of a thunder storm or when wind conditions are unfavourable with respect to adjacent residences.

Two environmental monitoring stations have been established around the perimeter of the current quarry. These stations monitor weather conditions and also background noise (dBA). These stations are not designed to measure the impact of blasting alone. They measure specific overall impact of quarry activities.

BGC Voyager Quarry routinely carries out the following blast specific monitoring (in addition to overpressure and vibration) to assist in design issues:

- Face Profiling: Laser equipment is used to determine the free face profile and, depending on the actual profile, a blast design may be modified to take account of the surveyed conditions.
- Blasthole Profiling: Used to confirm that actual holes are consistent with design requirements. Where appropriate deviations from design will be accommodated by adjusting the design to optimise the outcome.
- Video Recording: All blasts are recorded using conventional digital technology. Videos are primarily used to assess if there has been any flyrock.

The routine monitoring techniques listed above are not normally done at a quarry operation such as the BGC Voyager Quarry. However, SRK is of the opinion that the initiative is a sound one that indicates the quarry commitment to both environmental compliance and production optimisation.

8 Influence of Geology on Vibration Attenuation

The Voyager Quarry is, according to URS (January 2004), located in the mid-west of the South-western Province of the Yilgarn Block. The Yilgarn Block is comprised of Archean rocks including granite, gneiss, migmatite and intrusive dolerite. The Voyager Quarry is predominantly within medium to widely jointed, strong rock coarse grained granite. A simplified representation of the stratigraphy that has been observed at the Voyager Quarry is given in **Figure 8-1**.

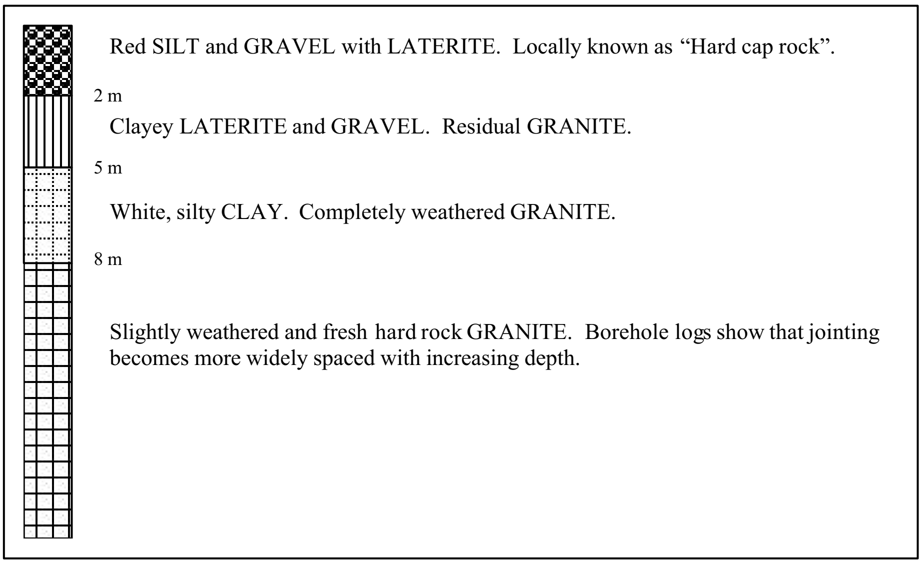


Figure 8-1: Simplified Stratigraphy at Voyager Quarry

From discussions with Mr Paul Berkhout it is understood that the dominant geological structure strikes approximately NW-SE and is steeply dipping. There are also well defined sub-horizontal stress release joints in the fresh granite. These are better developed at depths of less than about 18 m below ground surface. In the south west portion of the existing quarry pit the rock tends to be less fractured.

It is generally recognised that geology has the potential to influence vibration, and in particular the velocity of propagation and the attenuation of vibration with distance from a blast. Factors that have an influence on propagation velocity include degree of jointing, weathering and rock type. Where the geology is less competent the velocity of propagation of blast vibration will be expected to decrease and the rate of attenuation will increase (i.e. the magnitude of vibration will decrease more rapidly with increasing distance from the source).

When blast induced vibration travels across the dominant geological structure (i.e. discontinuities) the vibration will tend to be dampened. It is, therefore, anticipated that the rate of vibration attenuation will be greater towards the west at the Voyager Quarry. The site specific monitoring that has been done to date at the Voyager Quarry has been structured to confirm compliance with the permit requirements. Additional monitoring specifically designed to allow analysis of information is considered to be required to confirm if there is anisotropic attenuation at the Voyager quarry site.

9 Site Specific Attenuation

9.1 Vibration

The most common equation used to predict the amplitude (PPV) of blast induced vibration (in the far field) is the United States Bureau of Mines (Siskind et.al., 1980) empirical propagation law shown below:

$$PPV = K \times \left[\frac{D}{\sqrt{Wt}} \right]^{[-n]} \qquad \text{...2}$$

Where,

PPV	=	instantaneous resultant of the three orthogonal components of peak particle velocity of ground motion (mm/s)
Wt	=	weight of the explosive per delay (kg)
D	=	distance between blast holes and the locality of receiver (m)
K, n	=	site specific parameters relating to local conditions and strength

The term $\left[\frac{D}{\sqrt{Wt}} \right]$ in the above equation is called the square root scaled distance.

The Square root scaled distance is a simple means of comparing the impact of different charge weights, in terms of the expected vibration impact at locations or structures of interest. Experience shows that, at a constant distance from blasting, vibration levels do not increase linearly with increasing charge weight - if weight is doubled, vibration levels do not double. The vibration levels can be expected to increase in proportion to the square root of charge weight - a doubling of charge weight increases vibration levels by only around 50%. By considering the scaled distance, blasts using different charge weights and monitored at various distances can be compared in terms of the vibration impact.

The Blasters' Handbook (DuPont, 1980) and AS2187.2 suggest average values for the site-specific parameters K = 1143 (metric units) and n = 1.6 (metric or US units). In practice, both parameters can vary very considerably, and it is important to collect data from each site and perform simple linear regression analysis to determine the accuracy of assumed parameter values.

The results of site specific compliance monitoring are presented in Section 7.1 of this report. In this Section it was noted that the monitor to blast distance had been estimated, and that this had resulted in distortion of the interpreted data. The µMX vibration monitors (manufactured by Texcel Pty Ltd) that were used for the vibration monitoring have a function that estimates the distance to the blast by considering the difference in arrival times between the vibration (assumed velocity 2000 m/sec) and the air overpressure (speed of sound 344 m/sec). Texcel claim that this method of estimating the distance has a typical accuracy of ±10%. For some of the vibration monitoring records the estimated distance to the blast, as recorded by the vibration monitor, has been documented. A chart showing the documented results of monitoring, where distance to the blast was estimated using the µMX vibration monitor, is presented as **Figure 9-1**. This figure shows that vibration levels have been measured over a small range of scaled distances (approx 70 to 150m/kg $^{0.5}$).

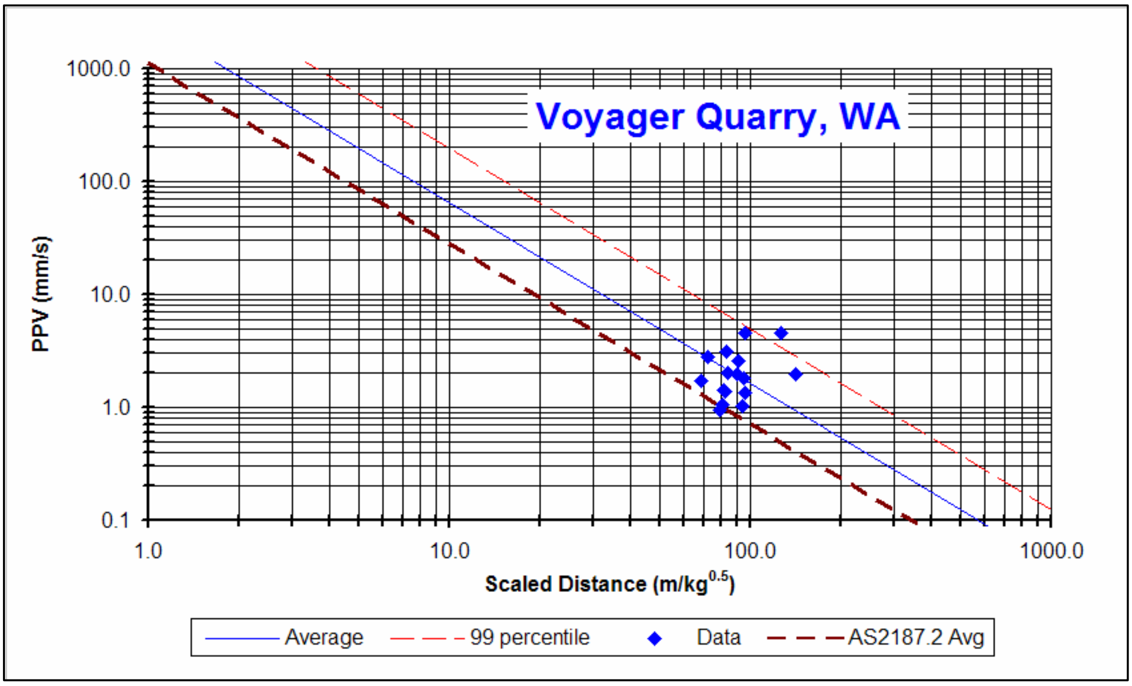


Figure 9-1: Blast Vibration Attenuation Regression Analysis

To provide a ***preliminary indication*** of the likely vibration at various distances from a blast, and with a scaled distance of between say 60 and 100, it is recommended that the data shown in **Figure 9-1** is used for regression analysis. It is anticipated that the attenuation relationship determined using this data will be updated as more site specific data is obtained.

Regression analysis has been carried out for the data shown in **Figure 9-1** to determine the site specific vibration attenuation constants (K and n in Equation 2). The curve recommended by the Australian Standard AS2187.2 is shown in this figure for comparative purposes. The results of the analysis are presented in **Table 9-1**.

Table 9-1: Results of Regression Analysis

Parameter	Average	99 Percentile
K	2557	7763
n	-1.6	-1.6

Whilst additional data is being obtained to develop a more reliable site specific vibration attenuation relationship that is valid over a broader range if scaled distance it is considered to be appropriate for the average parameters quoted in **Table 9-1** to be used to determine the anticipated vibration for a specific blast design. The predicted vibration (using the average parameters as recommended) for various charge weights and distances is shown in **Figure 9-1**. The curves shown in this figure are for scaled distances in the range of 60 to 100.

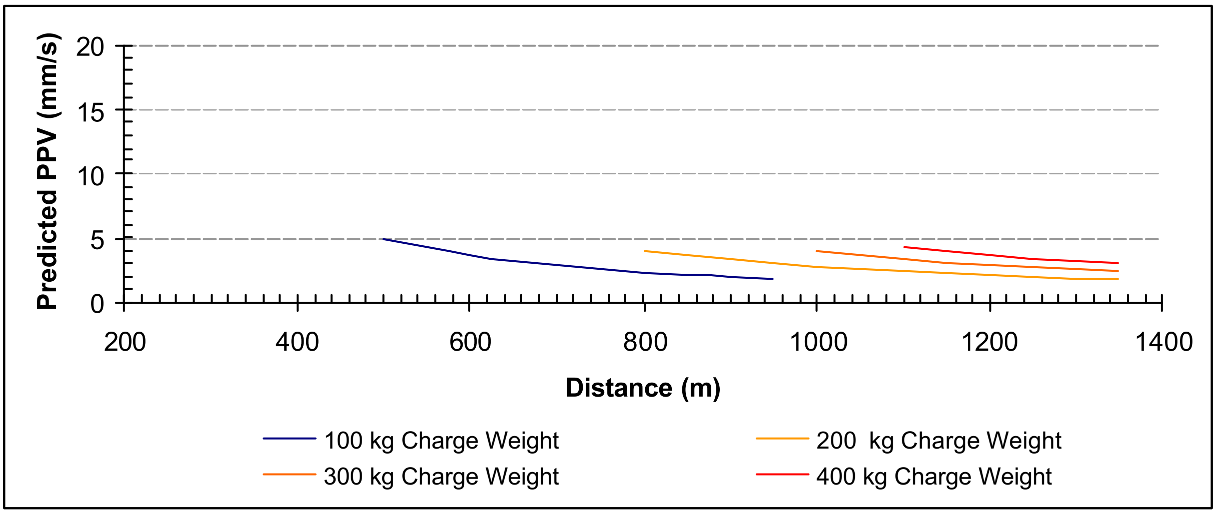


Figure 9-2: Estimated Vibration for Various Charge Weights

Figure 9-2 ***can be used to assist in the Voyager Quarry blast design process. It must, however, be noted that these curves are based on the mean of the data. To improve the reliability of the attenuation relationship additional blast vibration monitoring is required.***

9.2 Air Overpressure

Air overpressure radiates from a blast at a speed of approximately 340 m/s. It generally decays more slowly than ground vibration and is therefore the most likely cause of complaint at large distances from a blast. The rate of decay of air overpressure depends on environmental conditions and is very variable.

Topographical features such as hills, mountains, tree lined ridges, valleys etc. all contribute to reduce overpressure levels. Meteorological factors can have a significant effect on overpressure attenuation. Meteorological influences on overpressure include:

- Wind speed and direction;
- Cloud cover, and;
- Temperature inversions.

Wind tends to concentrate overpressure in exactly the same way as it concentrates noise. Receivers downwind become exposed to a higher pressure than receivers upwind at the same distance. As wind speed increases, downwind pressures become increasingly high. Studies, such as that done by Kamperman (1975), have shown that overpressure can be as much as 10 to 15 dB higher downwind than in similar situations where there is no wind.

Cloud cover, and temperature inversions both tend to reflect sound waves back to ground level, rather than allowing spherical dissipation as normally occurs in clear weather where the air density continuously decreases with altitude.

The prediction of blast induced air overpressure pressure levels is affected by a number of factors including:

- Blast design and face orientation;
- Efficiency of the stemming;
- Surface detonating cord and delays;
- Geological conditions;
- Direction of initiation;
- Variation in detonator delay periods from the nominal; and,
- Meteorological conditions.

Blast generated air overpressure is commonly modelled to attenuate as a cubed root scaled distance function. A commonly used blast air overpressure attenuation relationship is shown in equation 2.

$$AO = 150 - 22.5 \times Log\left[\frac{R}{\sqrt[3]{Q}}\right] \qquad \text{.......} 3$$

Where,

AO	=	Air Overpressure (dBL)
R	=	Distance from Source (m)
Q	=	Charge Weight per Delay (kg)

Whilst the Voyager Quarry continues to develop a blast monitoring database it is recommended that the relationship given in the above equation is used to predict the overpressure at sensitive locations. The anticipated air overpressure attenuation for a range of charge weights is shown in Figure 9-3. As a more extensive database of air overpressure monitoring results is developed for the Voyager Quarry it is anticipated that the constants in the air overpressure attenuation equation will be updated to reflect site specific practices and conditions and to allow the prediction of air overpressure with greater reliability.

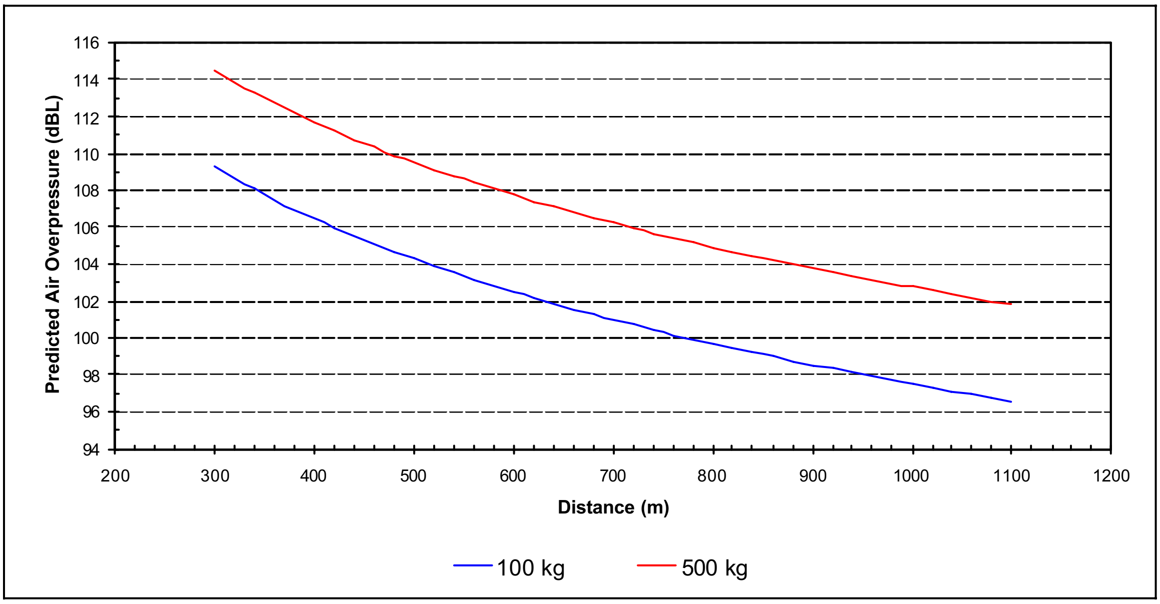


Figure 9-3: Predicted Air Overpressure a Range of Charge Weights

10 Blast Design and Compliance with Environmental Vibration Limits

In Section 9.1 an equation that allows the prediction of vibration as a function of distance from the blast and also the maximum instantaneous charge weight of the blast. This equation should be considered as preliminary at this stage, and it is expected that the site specific constants will be adjusted as the results of further monitoring become available. It is considered most likely that, with additional monitoring that includes records with accurate distance to shot measurements and a wider range of scaled distances, regression analysis will give a lower site specific "K" value. This means that the site specific blast vibration attenuation curve is expected to move closer to that used in the Australian Standard (AS2187.2) and this indicates more rapid vibration attenuation with distance. It is important to note that the most significant reason for lack of confidence in regression analysis using the current data set is lack of accurate distance measurements.

Using the preliminary equation given in Section 9.1 it can be shown that a maximum instantaneous charge weight (MIC) of 100kg will be expected to generate a blast vibration of approximately 4.9mm/sec at a distance of 500 m from the blast. It is, therefore, judged to be feasible to comply with a vibration limit of 5mm/sec at a distance of 500m from the shot. Current practices will, however, most likely be required to be modified as the quarry activities move closer to the nearest residence. Further monitoring to give an attenuation relationship that is perceived to be more reliable will provide guidance as to the type of modification to blast design that is required.

The BGC Voyager Quarry is currently trialling electronic initiation systems. Using electronic initiation it is possible to have very accurate control over the delay interval and some authors claim that this allows the use of a greater MIC. Properly documented trials at the Voyager Quarry should provide guidance to the blasting personnel as to the effect of using electronic detonation systems. SRK are of the opinion that until the attenuation relationship is better understood it is appropriate to base designs on the equation given in Section 9.1.

11 Air Overpressure and Ground Vibration Monitoring Plan

Blast vibration and air overpressure monitoring are required to:

- Demonstrate compliance with maximum levels that are allowed under the DoE Licence;
- Foster better community relations by having detailed records;
- Optimise blast practices, and;
- Demonstrate that significant constraints, that would make the operation unviable, are not imposed on the quarry operation by the environmental limits

To meet the objectives that are defined above it is anticipated that blast monitoring will be conducted in a two stage program that includes:

a) Detailed monitoring at multiple known locations with subsequent interpretation of vibration and air overpressure waveforms to allow development of attenuation relationships that predict vibration and overpressure with a level of confidence that is greater than is currently possible, and;
b) Compliance monitoring at the nearest residential structure to demonstrate that blast induced vibration and overpressure levels are within those permitted.

A blast monitoring plan that addresses the objectives defined above is given in Appendix A.

12 Recommendations

12.1 Vibration and Overpressure Monitoring

Additional blast vibration and air overpressure monitoring is considered to be required to allow the development of reliable site specific attenuation relationships. To provide data across the range of conditions that will be applicable to the site it is recommended that blast vibrations are monitored at distances of between say 200 and 1600m from the blast and that data is obtained for scaled distances of between 10 and 100. An even distribution of data from within the ranges specified above will provide a good basis for regression analysis.

It is important that the vibration monitor sensors are properly coupled to the ground. For the purposes of obtaining data for regression analysis, it is judged to be sufficient to achieve coupling by means of the soil spikes that are supplied with the Texcel µMX monitors that are used by the Voyager Quarry. It is not necessary to mount sensors on a preformed concrete pad for the purposes of obtaining data for regression analysis.

It is understood that there is some concern with respect to the potential for geological conditions to enhance vibration. Whilst it is considered unlikely that the observed geology will “amplify” vibration, this concern should be investigated as a part of the vibration monitoring program and in part as an exercise in community relations. To investigate the impact of geology, monitoring should be carried out in directions to the west and north of the blasts. Sufficient data points will be required to assess the impact of direction on attenuation. As a preliminary guide it is suggested that 8 sets of evenly spaced data are obtained for each direction (i.e. west and north). Depending on the quality of the data additional measurements may be required in order to allow regression analysis.

In addition to assessing the effect of direction on attenuation as described above, it is recommended that a vibration monitor is set up at the location where complaints with respect to high vibration levels have been made (understood to be some 2 to 3km from the blast). A minimum of 3 blasts (vibration and overpressure) should be monitored at this location. It is understood that attempts have previously been made to monitor vibration at this location, but that the monitor failed to trigger at the lowest threshold that it could be set without triggering from background electronic noise. To overcome this problem it is recommended that the Texcel SMS triggering method is used. This method relies on a monitor closer to the blast, triggering a remote monitor by mobile telephone. Orica who are on site providing blast monitoring services do have experience with this technology.

To allow detailed analysis of the monitoring data it is recommended that the following information is recorded for each of the blasts that are monitored:

- Direction to blast.
- Accurate monitor co-ordinates for each monitor.
- Accurate blast hole coordinates.
- Accurately determined distance between monitor and closest blasthole.
- Accurately determined distance between monitor and blasthole with the maximum instantaneous charge.
- General weather conditions at the time of the blast (wind direction, presence/absence of cloud, temperature inversion etc.).
- Full waveforms for vibration in the three orthogonal directions and also for air overpressure.
- Vector Sum PPV (mm/sec) and air overpressure (dBL).

- Frequency of the blast generated vibration and also the air overpressure. The μMX vibration monitor has a reporting function that will allow this to be included in the monitoring report and this is considered to be adequate for this situation.
- The initiation sequence.
- The method of initiation (Nonel or Ikon).
- Maximum instantaneous charge weight.
- Stemming Height and type of material used as stemming.
- Type and density of explosive used.
- Explosive column height.
- Blasthole diameter.
- Any unusual observations such as fly-rock, face blow-outs or stemming ejection.

Blast vibration and air overpressure have historically been monitored at the closest residence to confirm compliance with the permit requirements. It is considered appropriate to continue with this practice. At Lot 5, Horton Road a permanent monitor location has been established by forming a concrete pad in the ground. It is recommended that the monitoring station location is surveyed, and that compliance monitoring is continued at this location. When results of monitoring are reported the distance between the blast and monitoring station should be accurately determined and reported. Other information as described above for data to be collected for regression analysis should be recorded.

BGC Voyager Quarry has established an additional monitoring station that is midway between Lot 5 Horton Road and the current quarry. It is considered that monitoring at this station is not essential and that more useful information would be obtained by moving this monitor location on a blast by blast basis. The location of the monitor should be accurately determined and the details as described above should be recorded for each blast. It is important that the vibration monitor sensors are properly coupled to the ground. For the purposes of obtaining data, it is judged to be sufficient to achieve coupling by means of the soil spikes that are supplied with the Texcel μMX monitors that are used by the Voyager Quarry. It is not necessary to mount sensors on a preformed concrete pad for this monitor station.

12.2 Blast Design

Blast monitoring records that are available at the BGC Voyager Quarry show that the quarry has an impressive history of compliance with the vibration and air overpressure permit requirements. In this report it has been shown that the potential for blast vibration or air overpressure to cause damage at adjacent residential properties where disturbances are within the permit limits is not likely. It has, however, also been pointed out that levels of disturbance that are well below the defined limits will routinely result in complaints due to human perception issues.

From discussions with quarry personnel it is understood that stemming ejection and flyrock are not problematic with the current design criteria and site conditions. It is therefore considered that radical changes to the blast design are not required at this stage.

The results of a monitoring program that has been recommended should be used to optimise blast design in terms of limiting vibration and air overpressure. Whilst the monitoring and analysis are in progress it is considered appropriate to use the attenuation relationships given in Sections 9.1 and 9.2 to provide guidance with respect to appropriate charge weights. In their current form the attenuation relationships that have been provided should be considered as preliminary. It is expected that with more detailed monitoring records the attenuation relationship for ground vibration will be modified and become less restrictive.

12.3 Community Interaction

The BGC Voyager Quarry recognise the importance of community interaction. In this regard Quarry personnel have made considerable effort to modify practices to suit local residents. Modifications that BGC have made include changes to blast frequency and also to blast size. BGC personnel also make an effort to contact each of the nearby residents prior to the blast. This effort is documented by the quarry as a part of their blast recording process.

Continued interaction with the community is recommended. In particular, it is SRK's view that a short demonstration of blast vibration monitoring techniques and the magnitude of disturbances that are being recorded may help to put the local residents concerns into perspective. It is therefore recommended that a blast vibration monitor is taken to the next residents meeting to give a short presentation. This presentation should include a discussion of vibration damage thresholds, a demonstration of what 5mm/sec vibration is, and comment on how BGC Voyager Quarry takes limits into account.

13 Conclusions

BGC Quarries is in the process of applying for environmental approval to relocate their Voyager Quarry operation. The ***proposed project will require the formation of another pit to the west of the existing quarry operations***. During the public consultation period a local action group has responded to the BGC submission to the EPA. One of the issues that the ***local action group has expressed concerns with, is the potential for blast induced disturbances***. Particular concerns that were raised included the potential for blast induced vibrations to cause damage to existing residential type structures. BGC Quarries requested independent advice with respect to blast disturbance and the potential for causing blast induced damage. ***The results of an independent assessment have been documented in this report.***

The current DoE Licence requires that ground vibration PPV does not exceed 10mm/sec for any single blast. The nominated ground vibration limit at affected residences is 5mm/sec for a single blast and not more than one blast in ten may cause a disturbance with a PPV of greater than 5mm/sec. The Voyager Quarry is also required to comply with the Environment Protection (Noise) Regulations 1997. This regulation limits air overpressure to a maximum of 125 dBL for any blast, and 120 dBL for nine in any ten consecutive blasts regardless of the interval between them. ***The vibration and air overpressure limits that the Voyager Quarry is required to comply with are, in general, either consistent or more onerous than that recommended by the Australian Standard AS2187.2-1993***.

Historical blast practices at the Voyager Quarry have resulted in compliance with respect to both blast induced vibration and air overpressure. In the records that were reviewed, the maximum ground vibration that has been recorded adjacent to the nearest residential structure (Lot 5, Horton Road, The Lakes) is 4.6mm/sec. The maximum recorded air overpressure at the same location is 121.6 dBL (Blast Number 489, 23 December 2003, recorded MIC 385kg). Apparently the maximum recorded air overpressure over the life of the quarry is 126 dBL (December 1998), and this was attributed to extenuating circumstances.

There is a large difference in opinion between various specialists with respect to the magnitude of vibration that has potential to cause damage. However, all of the literature (and also SRK experience) indicates that ***damage to a residential type structure is only likely to be caused by ground vibration of greater than about 100mm/sec. The allowable vibration limit at Voyager Quarry is only 5% of this. It is, therefore, highly unlikely that blasting at Voyager Quarry will cause damage to adjacent residential structures***.

A PPV of 5mm/sec can be shown to equate to a displacement of approximately 3.9 µm (0.0039mm). This is very small. Ground vibrations will generate strain in a structure. However, it can be shown that everyday environmental changes are capable of generating equivalent PPVs of more than 10 times that expected to be generated by blasting activities. Taking the above comments into consideration it considered highly unlikely that any blasting activities that are in compliance with the DoE Licence requirements will have the potential to cause damage to a residential structure.

Humans are very sensitive to vibration. They are, however, poorly equipped to distinguish between different intensity or disturbance. Consequently, vibration or overpressure on one occasion may be acceptable to a nearby person, although a disturbance at a similar level on another day may be classified as offensive by the same individual. Experience gained from the environmental monitoring of blasting activities has shown that when ground vibration routinely exceeds the threshold of perception (around 1mm/s), the possibility of complaints arises. Given that short duration vibrations of less than 1mm/s are generally considered imperceptible, complaints under these circumstances are more commonly related to alternative sources of annoyance, such as overpressure or noise. ***Compliance with legislative limits or Standards does not necessarily ensure residents will not perceive the vibration from quarry activities. Compliance with these limits does, however, indicate that the effects of blasting are most unlikely to be responsible for inducing either structural or superficial damage***.

Vibration and air overpressure are monitored for all blasts that are fired at the Voyager Quarry. Monitoring has typically been done at specially prepared permanent blast monitoring stations that have been established adjacent to the quarry. One of these monitoring stations is near the closest residence to the quarry (Lot 5 Horton Road). The monitoring that has been carried out to date has had a key objective of confirming compliance with the environmental limits that the Voyager Quarry is subjected to. The monitoring program was not designed to allow detailed interpretation and analysis of records. In this regard, the distance to the blast from the monitoring station has not been accurately recorded, and for blasts prior to about December 2002 blast design information was not incorporated with the blast monitoring record. ***To allow more detailed analysis to be carried out and to develop site specific attenuation relationships it has been recommended that the accurate distance between the blast and monitor station and a comprehensive record of blast design parameters is recorded for each blast.***

Vibration attenuation is influenced by a number of factors, including site geology. More competent materials generally tend to result in a slower decay in the vibration with increasing distance from the source of disturbance. Less competent (i.e. more weathered or fractured) materials can be expected to cause blast induced vibration to decay more rapidly with distance from the blast. Where blast vibration is transmitted across dominant geological structures it is expected that the vibration would decay more rapidly that when it is transmitted parallel to the structure. ***It is, however, anticipated that geological structures will NOT result in amplification of vibration.***

The available blast monitoring information has been filtered to include only those blasts for which a reliable estimate of distance between blast and monitor was available. A ***preliminary site specific vibration attenuation equation has been developed*** using the technique of regression analysis (site specific constants K = 2557 and n = -1.6). ***This equation will impose quite onerous constraints on the quarry practices when blasting encroaches to within about 600 m of adjacent residences. It has been recommended that this equation is used for the assessment of blast design whilst more detailed monitoring is carried out to provide more reliable information for updating the vibration attenuation equation.***

A blast monitoring program has been recommended, and guidance has been given with respect to the ongoing compliance blast monitoring at the Voyager Quarry. In the short term it is considered important to develop a monitoring database that will allow a reliable attenuation relationship to be developed. A minimum of 16 records is likely to be required. To assess the influence of geology on vibration attenuation it has been recommended that monitoring is done to the west and also to the north of blasts at a range of distances between approximately 200 and 1600m (with 8 data points in each array). Additional data points may be required depending on the data scatter.

It is understood that there is a site well removed from the existing quarry where it has been perceived by the owner that there is significant blast induced vibration. Monitoring has previously been attempted at this site but has not been successful as vibrations have been less than the stable trigger threshold. It is recommended that further monitoring is done at this site to confirm that there is not localised vibration amplification. To ensure triggering of the monitor that is remote from the site it has been recommended that it is triggered by SMS from a monitor located closer to the blast.

Overpressure is the air pressure measured on a linear scale, without allowance for human hearing. It represents the ambient pressure state, and is therefore influenced by any factor which causes air pressure fluctuations. These include wind and audible sound sources such as cars or birds. Various studies have shown wind routinely generates air overpressure of greater than 120 dBL. Studies done in the USA have concluded that a ***blast induced air overpressure of 133 dBL can be regarded as being incapable of causing structural damage***. ***Complaints about rattling are, however, observed to become more common when air overpressure levels exceed approximately 120 dBL. The levels of anticipated air overpressure at the Voyager Quarry are judged to be incapable of causing damage to adjacent residences.***

Air overpressure radiates from a blast at a speed of approximately 340m/s. It generally decays more slowly than ground vibration and is therefore the most likely cause of complaint at large distances from a blast. The rate of decay of air overpressure depends on environmental conditions and is very variable. An equation to allow the prediction of blast induced air overpressure has been given. It is also recommended that a vegetation buffer is maintained between the quarry and adjacent residences.

14 References

- Anch, E, 1983. The Environmental Aspects of Structural Response to Blasting Overpressure. *Institute of Quarrying Transactions. Quarry Management and Products*. July 1983. pp420-425.

- DuPont, 1980. Blasters' Handbook, , 16th edition, pp 425-426

- Head, J M, and Jardine, F M, 1992. Ground-borne vibrations arising from piling. Construction Industry Research and Information Association. TN 142.

- Holley K G, McKenzie CK, Heilig J H and Zoitsas T, 2001. *Towards an Understanding of the Environmental Impact of Blasting*, Explo 2001

- Kamperman, G., (1975), " Quarry blast noise study for the Institute of Environmental Quality", Illinois Institute of Environmental Quality, Springfield, 111.

- Siskind, DE, Stachura, VJ, Stagg, MS & Kopp, JW, (1980). Structure Response and Damage Produced by airblast from Surface Mine Blasting. USBM Report of Investigations 8485.

- Stagg, M S, Siskind, D E, Stevens, M G, and Dowding, C H, 1984. Effects of Repeated Blasting on a Wood-Frame House, Bureau of Mines Report of Investigations 8896.

- Standards Australia AS2187.2-1993, Explosives-Storage, Transport and Use Part 2: Use of Explosives, Appendix J Ground Vibration and Airblast (Informative).

- Theissen, J R and Wood, W C, 1982. Vibrations in Structures Adjacent to Pile Driving, in Dames & Moore Engineering Bulletin, Number 60 (Ed: J Tenney-Groswirth), pp4-21.

APPENDICES

Appendix A
Vibration and Overpressure Monitoring Plan

Proposed Vibration and Overpressure Monitoring Plan

1.0 Objective

A key objective of this Vibration and Overpressure Monitoring Plan is to document the procedures that are to be followed for blast monitoring at the BGC Voyager Quarry. Other important objectives are to:

- Ensure consistency in monitoring procedure;
- Ensure that the data that is collected is accurate and as such useful;
- Ensure that quarry personnel, that are engaged in blasting activities are aware of the requirements for monitoring, and that information collected is used as one of the yardsticks against which performance can be judged ;
- Reduce the potential for non-compliance with respect to blast impact and license requirements, and;
- Provide a mechanism whereby the results of monitoring are communicated to relevant personnel as is appropriate for the efficient operation of the quarry.

2.0 Background Information

The current Voyager Quarry DoE License requires that ground vibration Peak Particle Velocity (PPV) at the nearest residence does not exceed 10 mm/sec for any single blast. In addition to this, the nominated ground vibration limits at affected residences are:

- PPV of 5 mm/sec for a single blast, and;
- Not more than one blast in ten consecutive blasts may cause a disturbance with a PPV of greater than 5mm/sec.

In the case of air overpressure, the Voyager Quarry is required to comply with the Environment Protection (Noise) Regulations 1997. This regulation specifies that for blasts between 07h00 and 18h00 on any day other than a Sunday or Public Holiday the airblast must not exceed:

- 125 dBL for any blast, and;
- 120 dBL for 9 in any ten consecutive blasts regardless of the interval between them.

Currently blast vibration and air overpressure monitoring is done by Orica personnel using µMX blast monitors that are manufactured by Texcel Pty Ltd.

3.0 Other Relevant Information

These procedures should be read in conjunction with:

a) BGC Quarries (25 March 2002). Drill and Blast Manual, and:
b) SRK Consulting Report (October 2004). Voyager Quarry Blast Impact Assessment.

4.0 Blast Design and Safety Considerations

At Voyager Quarry blast design is to be carried out by qualified and experienced personnel as authorized by the Quarry Manager. The blast holes are to be charged in accordance with the design and under the supervision of the person(s) responsible for the design.

All blast procedures and practices are to conform with the Mines Safety and Inspection Regulations 1995, and codes of practice that are adopted by the Voyager Quarry. If there is any contradiction between these documents and this monitoring plan this is to be brought to the immediate attention of the Quarry Manager, and the requirements of Statutory obligations will take preference.

At the Voyager Quarry Boretrac and Laser face profilers are routinely used to confirm that the implementation of a blast design is in accordance with the assumptions that were made for the design. The use of these survey/monitoring tools is at the discretion of the personnel responsible for the blast. Where these tools are used the results of the survey/monitoring should be recorded with the blast details and other monitoring records.

Blasts are to be prepared, charged and fired by qualified shotfirers, which have been trained, assessed and found competent by an appointed person It is the shotfirers responsibility to ensure that appropriate safety procedures are followed, and that equipment and personnel are removed to a safe distance from the blast.

The shotfirer should at all times be in contact with personnel doing blast monitoring to ensure and confirm that immediately prior to initiation:

- Monitors have been established and armed,
- Proper warning has been given in adjacent areas,
- All means of entry to the blasting area have been proper guarded
- Personnel are out of the designated danger area, or have taken proper shelter

5.0 Blast Monitoring

Blast vibration monitoring is to be carried out to:

a) Confirm compliance with permit requirements, and;
b) Provide a database of blast monitoring records that will allow appropriate blast design criteria to be adopted in order to minimize disturbance to adjacent residents/quarry neighbours.

These objectives will require slightly different procedures to be followed for the monitoring as described below.

5.1 Monitor Locations

Compliance Monitoring

When compliance monitoring is done the monitor is to be set up at a permanent monitoring station that will normally be near to the closest residential structure to the blast. At locations where compliance monitoring is to be carried out the monitor sensor is to be mounted on a preformed concrete pad. These pads are used for monitoring multiple blasts and are essentially a 400mm diameter concrete column that is formed to a depth of approximately 1000mm below ground level. The XYZ coordinates of the monitor location are to be determined by survey.

Monitoring for Detailed Analysis

It is anticipated that there will be a requirement to obtain vibration and air overpressure data for more detailed analysis and interpretation. The quarry manager will give instructions as to when this type of monitoring is required.

To obtain this information data is required to be collected from a variety of distances. These distances will be determined on a case by case basis by the personnel responsible for the blast design, with an objective to obtaining information over a broad range of distances as appropriate to the blast design practices. It is anticipated that, depending on the circumstances, monitors may be located at distances of between 200 and 1600 m from the blast. There may also be occasions where blast monitoring is conducted further away from a blast. As a guide for the person responsible for the blast design, it is anticipated that sensors will be mounted at scaled distances of between approximately 10 and 100. The scaled distance is the Distance divided by the square root of the maximum instantaneous charge weight per delay.

Monitor sensors used for collection of data for detailed analysis should be properly coupled to the ground by means of the soil spikes (pegs) that are provided with the instrumentation that is used at Voyager Quarry. Care must be taken to ensure that the sensor is horizontal and that the soil spikes are fully embedded into the soil such that the sensor base plate is firmly in contact with the ground surface. The sensor should be placed on undisturbed ground.

5.2 Monitor Set-up

The monitor set-up for compliance monitoring and monitoring done to collect more detailed information will normally be the same. The vibration and air overpressure monitoring will in most cases be carried out outside of the Voyager Quarry property and it is therefore expected that the instruments will be set-up immediately prior to a blast. Monitors will be removed after the blast.

The following monitor set-up procedures should be adopted:

a) Confirm that the monitor battery is sufficiently charged for the intended monitoring.

b) Test the monitor after connecting it to the appropriate sensors (geophone and microphone). Sensors are calibrated and it is important to confirm that the sensors are matched with the correct data loggers (monitors).
c) Select an appropriate trigger mechanism and trigger threshold for the situation within which the monitoring is being carried out. Under normal circumstances the monitor can be triggered either by means of a user selected vibration or air over pressure threshold. The trigger mechanism considered most likely to record the event being monitored should be used.
d) Adjust the trigger threshold to the lowest level that is practical and at which electronic interference is observed to NOT trigger the instrument.
e) Set the monitor to monitor the blast. The monitor should be kept under observation for several minutes to confirm that it is stable and not triggering randomly.
f) Record the settings at which the instrument was set, and also the time that it was armed.

5.3 Information to be recorded for each blast that is monitored

As a minim, the following information should be recorded for each blast that is monitored:

- Direction to blast.
- Accurate monitor co-ordinates for each monitor.
- Accurate blast hole coordinates.
- Accurately determined distance between monitor and closest blasthole.
- Accurately determined distance between monitor and blasthole with the maximum instantaneous charge.
- General weather conditions at the time of the blast (wind direction, presence/absence of cloud, temperature inversion etc).
- Full waveforms for vibration in the three orthogonal directions and also for air overpressure.
- Vector Sum PPV (mm/sec) and air overpressure (dBL).
- Frequency of the blast generated vibration and also the air overpressure. The µMX vibration monitor has a reporting function that will allow this to be included in the monitoring report and this is considered to be adequate for this situation.
- The initiation sequence.
- The method of initiation (Nonel or Icon).
- Maximum instantaneous charge weight.
- Stemming Height and type of material used as stemming.
- Type and density of explosive used.
- Explosive column height.
- Blasthole diameter.
- Any unusual observations such as fly-rock, face blow-outs or stemming ejection.

The information listed above will be used in the analysis of the vibration data that is recorded. Ultimately it will be used to provide guidance with respect to optimum blast design to minimize blast impact on adjacent residential properties.

6.0 Reporting of Blast Monitoring Results

Monitors are to be retrieved as soon as practical after the blast. When retrieving the monitor check to confirm that the monitor did trigger. Record the vibration and air overpressure results, and the time that the monitor triggered in a notebook. Turn the instrument off. When the monitor is returned to the office ensure that it is placed on charge.

The results of blast monitoring are to be reported as soon as practical, and in any event on the same day that monitoring is done, to the personnel responsible for the blast design and also the shotfirer. A monitoring report is to be submitted to the Quarry Manager within two days of the blast. This report should include the results of monitoring and also all blast design details.

If the measured overpressure or vibration is greater than 120 dBL or 5 mm/sec respectively, the results of monitoring must be reported immediately to the quarry manager, or in his absence the person that has been delegated to act as quarry manager. In the event of a blast causing disturbances that are greater than the permitted level a report that clearly states the circumstances under which the non-compliance resulted is to be prepared and submitted to the quarry manager on the same day that the blast is fired. The Quarry Manager will then action the incident in accordance with the permit and other statutory requirements.

Blast monitoring reports are to be filed for future reference in accordance with the Voyager Quarry document control system. To comply with the permit requirements a summary of the results of blast monitoring will be required to be submitted to the EPD on a routine basis under the direction of the Quarry Manager.

7.0 Analysis and Interpretation of Monitoring Results

It is expected that the results of the blast monitoring will be used to assess the attenuation characteristics and to develop site specific attenuation equations that will allow optimization (with respect to environmental impact) of blast designs. The monitoring data and results of analysis will be especially important when blasting is done within approximately 600 m of a residential structure. To facilitate analysis and interpretation of information a electronic database with the data for each blast will be maintained by the environmental officer.

The monitoring data will be reviewed by a specialist independent consultant appointed by BGC Quarries. The purpose of this review will be to update the site specific attenuation relationships and to provide guidance with respect to the monitoring procedures and locations. This review will be carried out at a frequency considered to be appropriate by the Quarry Manager. During the 2004 to 2005 period this is likely to be at 6 monthly intervals, and thereafter at 12 month intervals.

8.0 Community Interaction

The importance of good community relations cannot be overemphasized. Results of vibration monitoring may be made available to local residents and it is therefore important to ensure that all events are properly documented as described in this document. In the event that a member of staff is approached for copies of monitoring information, the person requesting the information should be referred directly to the quarry manager or the designated person.