Lake Water Quality Management Plan

BORAL Gold Coast Quarry, Reedy Creek

B12119ER003

April 2013
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# Glossary of Terms

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<tr>
<td>AHD</td>
<td>Australian Height Datum</td>
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<tr>
<td>ANZECC</td>
<td>Australia New Zealand Environment Conservation Committee</td>
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<td>BMT WBM</td>
<td>An Engineering and Environmental Consultancy</td>
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<td>Gold Coast Quarry</td>
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EXECUTIVE SUMMARY

The Lake Water Quality Management Plan (LWQMP) forms part of the Environmental Impact Statement (EIS) for a new extractive industry operation (quarry), proposed by Boral Resources (Qld) Pty Limited, on a greenfield site at Old Coach Road, Reedy Creek, Gold Coast.

Lambert & Rehbein was commissioned to provide a LWQMP for the waterbodies, created by the proposed Boral Gold Coast Quarry, as required by Section 2.6 of the Terms of Reference (ToR) for the EIS. As stated by the ToR, the objective of this report is to "prepare a lake water quality management plan, in accordance with the Australia and New Zealand Guidelines for Fresh and Marine Water Quality (2000) and the Queensland Water Quality Guidelines (2009), for where a water body is likely to be created by the proposed quarry."

The request for a lake water quality management plan is in relation to the strategies and methods used for decommissioning and rehabilitation of the quarry. Three (3) waterbodies will exist when quarry operations cease in several decades time, a sediment pond, a quarry dam and a quarry lake. A quarry dam covering approximately 2 ha will be constructed to provide a water supply for the quarry during the operational phase. When no longer required, the quarry dam will be removed as part of the decommissioning process to reduce the potential flooding hazard that could occur if the dam wall had a major failure. A quarry lake will slowly develop within the quarry pit once quarry operations cease. It will take approximately 14 years for precipitation falling into the quarry pit to fill the lake to its final level, at which point the lake will overflow. The quarry lake will be approximately 700 m long, 400 m wide and 90 m deep (25 m to -66 m AHD) and will be a feature of the rehabilitated landscape. Overflow waters from the quarry lake will flow via a channel to the sediment pond which will be used for monitoring and if necessary treatment of lake waters before they are released into the environment.

Artificial lakes that fill mine voids can have poor water quality due to contact between lake water and mineralised rocks or from low quality groundwater seepage, bringing chemical contaminants into the lake. A lake water quality management plan is intended to provide a means of communicating the potential for water quality issues to quarry managers, providing a framework for monitoring lake water quality and presenting options in the event that water quality needs improving. This plan provides a general description of issues that have been experienced in some other artificial lakes and the relevance of these issues to the proposed quarry lake.

As the quarry pit is to be excavated in competent rock, which is almost impermeable to groundwater, little groundwater will flow into the pit. Most of the quarry lake will come from precipitation directly onto the lake surface and from rainwater running off the pit walls. As the stone walls of the quarry will have only trace minerals and will not contain substances such as coal which can impact on water quality, the water quality in the proposed pit lake is likely to be high for an artificial lake. The small inputs of groundwater from the surround rock faces contribute
water that has had a very long residence time and is of low quality, and for this reason the water quality of the quarry lake will need to be monitored. Rock samples retrieved from the quarry resource investigation indicate the presence of traces of both acid forming and acid neutralising minerals. Water sampling at the nearby West Burleigh Quarry, which is located in the same geological resource, indicate that water quality objectives are very likely to be met.

In conclusion, the proposed quarry lake should develop with a water quality suitable for environmental use such as discharge into wetlands. The water quality is likely to fall short of drinking water standards due groundwater inputs and a lack of biological systems in the new lake which can improve and maintain water quality. It is not possible to predict lake water quality in detail, as lakes are complex systems which can both lock up and release the factors which determine water quality, however indications are that the lake water quality should meet the ANZECC water quality guidelines for 95% ecosystem protection. No measures for improvement of lake water quality need to be factored into the design and operational management of the quarry.
1.0 INTRODUCTION

Lambert & Rehbein (SEQ) Pty Ltd (L&R) was commissioned by Boral Resources (Qld) Pty Limited (Boral) in June 2012 to develop a Lake Water Quality Management Plan (LWQMP) for future onsite impoundments/lakes at the proposed Gold Coast Quarry (GCQ) located at Reedy Creek, described as Lot 105 on SP144215 and Road Reserve Lot 901 on RP907357.

The regional context of the proposed project with respect to waterways and localities is shown on Figure 1.

1.1 TERMS OF REFERENCE

L&R has prepared this report in response to the Gold Coast Quarry Project Terms of Reference (ToR) for the Environmental Impact Statement. The section of the ToR pertaining to this report is detailed below:

Decommissioning and rehabilitation (Section 2.6 in ToR)

Describe the options, strategies and methods for progressive and final rehabilitation of the environment disturbed by the project, including:

- Preparing a lake water quality management plan in accordance with the Australia and New Zealand Guidelines for Fresh and Marine Water Quality (2000) and the Queensland Water Quality Guidelines (2009) for where a water body is likely to be created by the proposal.

1.2 OBJECTIVE

The objective of the LWQMP is to ensure that any waterbodies created by the proposed quarry that are retained in the post quarry landscape have a water quality which meets regulatory requirements. A description of any waterbodies that are to be removed during the decommissioning phase will also be provided, including a description of the decommissioning process.

1.3 SCOPE OF REPORT

The scope of this LWQMP includes the following:

- Description of waterbodies present during the decommissioning and rehabilitation (post operational) phase;
- Identification of water quality objectives for waterbodies that are retained in the post decommissioning stage;
- Review of sources of inflows, outflows and lake circulation;
• Establishment of factors involved in long term maintenance of lake water quality;

• Develop, in line with the Australian and New Zealand Environment Conservation Committee (ANZECC) Guidelines for Fresh and Marine Water Quality (ANZECC 2000) and the Queensland Water Quality Guidelines (QWQG 2009), an appropriate suite of water quality parameters for monitoring waterbodies in the post operational phase; and

• List potential interventions that could be undertaken in the event of a water quality issue developing in a post-operational waterbody.
Figure 1: Regional Context of Proposed Quarry

Proposed Gold Coast Quarry

Boral

This plan may only be relied upon in relation to the project and purpose for which it was commissioned.
2.0 PROJECT DESCRIPTION

Boral is proposing to establish a new extractive industry operation on a greenfield site, Lot 105 on SP144215 at Old Coach Road, Reedy Creek as shown in Figure 2, below.
The project is necessary to compensate for the scheduled winding down of Boral’s existing West Burleigh Quarry (the location of this quarry is detailed in Figure 2), which has sufficient reserves for only a further 6.5 to 9 years of production (depending on market conditions). Given the lead times that are involved (in gaining development and environmental approvals; establishing the operation and completing preliminary site works in order to enable full scale production), it has been necessary for Boral to commence the relevant approval processes to ensure that an adequate, uninterrupted and efficient supply of construction materials remains available for critical infrastructure and construction projects in the Gold Coast region.

The Gold Coast Quarry will represent an investment of $140-$160million (2012$\textsuperscript{[1]}$ dollars) by Boral into the economy of the Gold Coast region and is projected to provide continuity of employment for approximately 100 staff across Boral’s integrated quarrying, asphalt, concrete and transport operations. An estimated total of 246 full-time equivalent (FTE) person-years will be directly required for the development and on-site construction of the project. The flow-on benefits of this employment would generate further employment opportunities for the wider Gold Coast region and Queensland, resulting in a total of approximately 480 and 490 full-time equivalent person-years, respectively. Once operational, the proposed Gold Coast Quarry would directly generate 24 FTE positions. The flow-on benefits of this employment would support about 65 FTE positions in Queensland, with 62 positions generated in the Gold Coast. The proposed Gold Coast Quarry would provide a net increase in employment opportunities and help continue quarrying industry jobs within the area once the West Burleigh Quarry resources are exhausted.

The site of the proposed Gold Coast Quarry contains the last and largest known deposit of meta-greywacke quarry rock resources on the southern Gold Coast. Meta-greywacke is of extremely high strength and forms the excavated and processed quarry product. The meta-greywacke resource is located within a deposit that is favourably surrounded by ridgelines (reducing amenity impacts) and has the benefit of having substantial vegetated buffers on land owned by Boral. In developing this proposal, Boral has attempted to balance the need to secure this hard rock resource with the social and environmental factors associated with extractive industry development. After taking into account a range of environmental constraints and providing appropriate separation buffers during the detailed design process for the proposed quarry footprint, it has been estimated that a total of 79 million tonnes of measured, indicated and inferred quarry resources have been delineated on the site (within the optimised pit shell and including the area to be developed for the plant and associated infrastructure). Boral has voluntarily sterilised a significant proportion of the resource which is known to occur on the site in order to achieve an appropriate balance between environmental, economic and community interests.

\[1\] Based on the value of the Australian dollar during 2012
The proposed development will operate as a quarry for the extraction and processing of hard rock primarily for use in concrete, asphalt, drainage materials, road base, bricks/blocks, pavers, pipes and landscape supplies. Investigations indicate that the quality and consistency of the resource at the site is of equal or better quality than the meta-greywacke deposit situated at Boral’s existing West Burleigh Quarry, providing an opportunity to completely replace the current quarry operations at Boral’s existing West Burleigh Quarry due to the diminishing supply of consented resources at that site. The proposed Gold Coast Quarry has the potential to supply the Gold Coast region with high grade construction materials for at least 40 years whilst maintaining continuity of employment across Boral’s integrated quarrying, asphalt, concrete and transport operations.

The greenfield site will be fully developed and operated in accordance with recognised industry best practice. Initial development requires the removal of significant overburden over the first few years of site development, including the introduction of mobile crushing plants to develop the site and value the excavated material. Boral estimates that approximately 5 million tonnes of materials (all types) will be removed from the site to allow the site infrastructure and fixed plant to be built.

Overall, the proposed Gold Coast Quarry’s processing plants and supporting heavy mobile equipment (HME) will comprise:

- **Mobile Crushing Plants**
  Proprietary modular trains from recognised (best practice) manufacturers such as Sandvik or Metso. The 3-stage road base train consists of a Primary Jaw, Secondary and Tertiary Cone Crushers complete with screens, conveyors and stockpiling conveyors. The second train (for aggregates production) will be the same or similar to the first and may include a vertical shaft impactor (VSI) to improve aggregate quality for use in higher specification applications. Each train will be targeting to achieve a minimum of 300 tonnes per hour of aggregate or base course materials. The estimated capital cost of each train is $6 million (2012 dollars).

- **Fixed Plant**
  The plant will be designed as a modern, ‘fit for purpose’ crushing plant which will target the production of aggregates. It is estimated that the production rate will be between 750 - 900 tonnes per hour to achieve an annual production of 2 million tonnes. The estimated cost of the plant is $75 million with a construction timeframe of 18-24 months.

- **Mobile Fleet**
  There will be two distinct fleets, firstly a development fleet which will service the site development and stripping works, through to load and haul service for the mobile crushing trains. The second fleet will be sized to service the 750-900 tonne per hour fixed plant. Over the course of the establishment and operation of the project (refer to Table
1.2), there will be a range of equipment on the site for various periods of time. This equipment includes, amongst others, the following:

- Excavators;
- Graders;
- Front-end Loaders;
- Bulldozers;
- Compactors;
- Articulated Dump Trucks;
- Water Trucks;
- Haulage Trucks; and
- Cranes.

The quarrying process commences with a survey of the rock face and bench to be developed (by drilling and blasting). Laser survey equipment defines the rock mass, and an optimised blast hole pattern is designed and drilled. As production requirements demand, the drilled “shot” is then charged with bulk explosives (from Boral’s key supply partner, Orica), and fired, in accordance with the site blasting model and procedures.

Once the rock has been blasted, fragmented rock will be loaded from the pit floor onto haul trucks, whereas any larger rock fragments (“oversize”) will typically be broken by a rock breaker before loading. The load and haul fleet will generally be operated continuously during the operating hours of the quarry, in order to maintain continuity of supply for processing.

The primary stage of processing involves the use of a jaw crusher and vibratory screens, with crushed product being held in an interim stockpile called a “surge pile”. From this stage, material will be conveyed to several downstream stages of crushing and screening equipment. After processing, the material will be conveyed to individual product stockpiles. The processing plant, including primary and secondary crushers (and screening to separate dust and aggregates) will be located within the plant and infrastructure area, near the individual product stockpiles.

The quarry materials are then either loaded directly by a front end loader (‘sales loader’) from the stockpiles, or via overhead storage bins at the plant (under typical conditions), to road haulage trucks. The road haulage trucks then proceed across the weighbridge and through the wheel wash before exiting the site to deliver quarry materials to the market.

Section 2.0 of the EIS document provides a more detailed description of the various components of the project.

2.1 STAGES OF DEVELOPMENT

The site will be developed in a sequence of discrete stages, each of which will involve a series of phases:
Site establishment (E), development (D), and construction (C) stages (featuring a number of intermediate phases);

Quarry operation stage (Q) (featuring a number of phases) associated with the development of the quarry pit itself; and

Rehabilitation and decommissioning of the site once the operations have concluded.

The timing and rate of progression through the stages associated with the pit development will be defined by market conditions and demand. It is not appropriate to specify timeframes for the development of each respective phase of the project at this early point, but the quarry will have an operational life of at least 40 years.

During the establishment, development and construction stages, the proposed Gold Coast Quarry will operate with mobile plant(s), and be replaced with a permanent fixed plant as soon as practicable after the plant site infrastructure area and initial pit have been established (estimated to occur between 5 to 6 years of the development approval).

The staging plans for the project, as prepared by Lambert & Rehbein, detail how the development of the quarry is intended to progress. Table 1 below provides a general overview of the works undertaken as part of each phase of the development stage.
## Table 1 Quarry Development Stages

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<td><strong>E1</strong></td>
<td>The external access road and associated intersection (from Old Coach Road) will be constructed.</td>
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| **E2** | A portion of the access road, as it enters the site from the intersection constructed as part of Phase E1, will be constructed and sealed (with bitumen).  
Earthworks (cut) associated with the development of the internal road network are undertaken, specifically for the construction of:  
  o the internal road that will ultimately link to the plant facility and ROM pads; and  
  o the access and maintenance road extending to the dam.  
Temporary weighbridge and wheel wash area will be developed.  
The water storage dam embankment wall (requiring 89,300 tonnes of fill) and associated spillway will be constructed.  
Overall, a total of approximately 230,000 tonnes of overburden will be removed from the site as a result of the development of this phase. |
| **E3** | The extent of the internal access road created in Phase E2 will be sealed with bitumen.  
The temporary weighbridges and wheel wash areas will be removed and replaced by the permanent facilities.  
The construction of the facilities pad will be commenced, while the sedimentation pond will also be developed.  
The temporary buildings associated with the (construction) facilities pad will also be constructed.  
Filling works will be completed in an existing gully so as to facilitate the future pad area for the plant equipment.  
Overall, a total of approximately 260,000 tonnes of overburden will be removed from the site as a result of the development of this phase.  
The extent of filling completed as part of this phase equates to 115,900 tonnes. |
### DEVELOPMENT STAGE

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| D1    | - Earthworks associated with the construction of the plant pad will be continuing. These earthworks will be performed in a ‘receding rim’ fashion in order to minimise impacts on nearby sensitive receptors.  
- By this time the quarry dam and sedimentation pond will be operational.  
- Overall, a total of approximately 770,000 tonnes of overburden will be removed from the site as a result of the development of this phase.  
- Furthermore, approximately 280,000 tonnes of quarry product extracted from the site will be utilised and sold as marketable material. |
| D2    | - Earthworks associated with the construction of the plant pad will be continuing.  
- Overall, a total of approximately 750,000 tonnes of overburden will be removed from the site as a result of the development of this phase.  
- Furthermore, approximately 560,000 tonnes of quarry product extracted from the site will be utilised and sold as marketable material. |
| D3    | - Earthworks associated with the construction of the plant pad will be continuing.  
- The ROM pad and ROM ramp will be created, and a small amount of fill will be required to develop this area (24,890 tonne).  
- Overall, a total of approximately 745,000 of overburden will be removed from the site as a result of the development of this phase.  
- Furthermore, approximately 560,000 tonnes of quarry product extracted from the site will be utilised and sold as marketable material. |
| D4    | - Earthworks associated with the construction of the plant pad will be completed.  
- The final ‘floor level’ for the plant area equates to RL 34.0m AHD.  
- The final ‘floor level’ for the ROM pad equates to RL 50m AHD.  
- The stockpile area for the storing of materials will be cleared of its overburden.  
- The stockpile area rock (suitable for product) will be left in place for processing at a more economic rate once the permanent plant has been established.  
- Overall, a total of approximately 215,000 tonnes of overburden will be removed from the site as a result of the development of this phase.  
- Furthermore, approximately 540,000 tonnes of quarry product that can be utilised and sold is extracted. |
### CONSTRUCTION PHASE

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| C1    | The construction / erection of the crushing plant will be commenced.  
|       | All permanent buildings (e.g. site office, employee facilities, workshop etc.) are constructed.  
|       | Earthworks associated with the removal of overburden are commenced with respect to extending into the area that will ultimately become the quarry pit. |
| C2    | The construction / erection of the crushing plant will be completed.  
|       | Earthworks associated with the removal of overburden will be continuing with respect to extending into the area that will ultimately become the quarry pit. |

### QUARRY OPERATION PHASE

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| Q1    | Earthworks associated with Pit Stage 1 will be undertaken.  
|       | The base levels for Pit Stage 1 will range between RL 78.0m AHD (western end of the pit area) and RL 66.0m AHD (eastern end of the pit area, adjacent to the ROM pad). |
| Q2    | Earthworks associated with Pit Stage 2 will be undertaken.  
|       | The base levels for Pit Stage 2 will be RL 54.0m AHD (eastern end of the pit area, adjacent to the ROM pad).  
|       | Rehabilitation of the benches associated with the pit will commence as necessary. |
| Q3    | Earthworks associated with Pit Stage 3 will be undertaken.  
|       | The base levels for Pit Stage 3 will be RL 30.0m AHD (western end of the pit area).  
|       | Rehabilitation of the benches associated with the pit will commence as necessary. |
| Q4    | Earthworks associated with Pit Stage 4 will be undertaken.  
|       | The base levels for Pit Stage 4 will be RL 6.0m AHD (centrally located within the pit area).  
|       | Rehabilitation of the benches associated with the pit will commence as necessary. |
| Q5    | Earthworks associated with Pit Stage 5 will be undertaken.  
|       | The base levels for Pit Stage 5 will be RL -66.0m AHD centrally located within the pit area).  
|       | Rehabilitation of the benches associated with the pit will commence as necessary. |
3.0 DESCRIPTION OF PROPOSED LAKES

This LWQMP covers all of the waterbodies created by the proposed quarry. Three waterbodies are proposed:

1. A sediment pond that will capture stormwater drainage from operational areas;
2. A quarry dam which will provide process water; and
3. A quarry lake that will fill part of the quarry pit after quarrying ceases.

A schematic showing the relative size and locations of these waterbodies is presented in Figure 3.

During the operational life of the quarry, the sediment pond and the quarry dam may discharge after high rainfall events to the site's natural drainage system via drop down structures. The quality and quantity of these discharge waters is covered by a Water Resources and Flood Plain Management Report (BMT WBM 2013).

3.1 SEDIMENT POND

A sediment pond will be constructed to capture stormwater flowing from the processing and stockpiling areas. It is proposed that a sediment pond will extend approximately 100 m along the edge of the operations area and will be approximately 60 m wide at the widest point. To ensure that all stormwater flows into the sediment pond, surfaces will be profiled and drains will be constructed around the perimeter of the processing area and as required, beside haul roads including the haul road descending from the pit.

The sediment pond will be retained when quarry operations cease and used as a controlled overflow point for the quarry lake as per Figure 3. A channel will be excavated from the quarry lake to the sediment pond. Routing lake overflow water through the sediment pond provides a location for monitoring the water quality of overflow waters and if necessary undertaking water quality improvement measures prior to releasing the water to the environment.

In the longer term, should high quarry lake water quality be demonstrated, the sediment pond may be modified to become a free flowing drainage line, rather than a waterbody. Modifying the sediment pond to become free flowing would be undertaken in order to reduce the requirement to monitor and manage the sediment pond waterbody.

3.2 QUARRY DAM

A quarry dam is required to provide water for processing and for use in dust suppression during the operational life of the quarry. Water will be pumped from the quarry dam into a water header tank in close proximity to the processing area and then used for materials processing or used by water trucks for dust suppression on haul roads.
The quarry dam is approximately 200 m long and varies from 80 to 120 m wide. Most of the water held in the quarry dam will be pumped in from the larger quarry pit catchment, rather than originating from within the quarry dam catchment. Even during early quarry operations when the bottom of the quarry is at a relatively high elevation the quarry will be internally draining. A drop cut will be used to create a sump for collecting quarry affected rainwater which will be contribute to the quarry water supply, including the quarry dam.

The quarry dam will likely be decommissioned and removed when quarry operations cease. **Figure 4** shows a quarry with a sump and a quarry dam in the background.

### 3.3 QUARRY LAKE

During the operational phase of the quarry, there will only be a one hectare-sized sump at the bottom of the quarry void. The sump provides a place for stormwater to collect without interfering with quarry operations and facilitates dewatering of the pit.

Approximately 14 years after operations cease, a quarry lake of approximately 700 m long, 400 m wide and 90 m deep with a volume of more than 9,000 megalitres will have formed in the quarry pit. The surface area of the full lake will be between 17 and 21 hectares and the lake will lie within a basin formed by the quarry walls, with a total catchment of 32 hectares. The quarry lake will be retained.

![Figure 3 Indicative View of Full Quarry Lake and Dam](image-url)
Figure 4  Sump/Drop Cut in Pit of an Existing Quarry
4.0 OVERVIEW OF LAKE WATER QUALITY PLAN

4.1 OVERVIEW OF LAKE WATER QUALITY PLAN

4.1.1 REGULATORY FRAMEWORK
This LWQMP has been prepared in accordance with guidelines provided by the Queensland Department of Natural Resources and Mines. The guidelines used include guidelines for water storages and for mine pit lakes. The regulatory framework encourages the use of a process that promotes understanding of the physical, chemical and biological processes within the lake. Development of an understanding of a lake proceeds in several stages including the development of a conceptual model, then a quantitative model if necessary. Routine monitoring occurs as the lake fills revealing actual conditions within the lake and if an issue is detected, there may be corrective action (remediation). Each of these stages is explained in the following sections.

4.1.2 CONCEPTUAL MODEL
Lakes can have complex interactions between physical, chemical and biological factors and the science of predicting lake water quality in advance is still developing. To enable the likely physical, chemical and biological character of an artificial lake to be determined, the first step is to provide a conceptual model of the lake. A conceptual model is a systematic description of the processes that are likely to occur in the lake. As conditions at each lake vary, so will the conceptual models for the lakes. Some lakes have saline bottom waters, freeze in winter or have groundwater flow through, factors which do not apply to the proposed GCQ lake and which do not need to be included in the model for the GCQ Lake. The following section provides a detailed description of the physical, chemical and biological factors that are likely to operate with the proposed lake and how they might interact. This information constitutes a conceptual model of the lake.

4.1.3 QUANTITATIVE MODEL
In lakes such as mine pit lakes where a potential environmental issue has been identified, the conceptual model may be used to create quantitative models, which attempt to predict water quality over time and at various depths. Due to the interaction of physical, chemical and biological systems, modelling lake water quality requires a high level of knowledge about the potential interactions and a great deal of accurate input data. Collecting and processing this amount of information comes at great cost and is only warranted where the potential for significant environmental impacts has been identified by the conceptual model. Potential for environmental impacts usually only occurs where the lake has been used as a receptacle for a waste stream or where the lake has been excavated into ground which releases contaminants on exposure. As the proposed quarry lake does not contain wastes and is not subject to low quality groundwater or mineralised soils, there is little justification to undertake quantitative modelling to predict the...
potential impacts from these sources, and accordingly this step is not proposed by this plan. Experience with quantitative models has also revealed that even the best models may not be accurate and empirical evidence is still the best form of evidence. Empirical evidence is based on continuous and statistically valid water quality monitoring.

4.1.4 MONITORING

Monitoring of water quality in the proposed quarry lake will be undertaken to ensure that the lake remains within the required water quality standards. The Queensland Government has provided a set of comprehensive guidelines for monitoring of water quality in waterbodies such as the proposed GCQ quarry lake.

4.1.5 REMEDIATION

Should the lake water quality or discharges from the lake fall below the applicable standards, then corrective action has to be undertaken. Corrective action usually takes the form of enhancing naturally occurring physical, chemical or biological processes within the lake, which will result in improvements in water quality. A simple example is mixing the lake waters to prevent stratification using a mechanical destratification system. The effectiveness of any remediation strategy will be confirmed by the monitoring program. Whilst remedial actions may never have to be implemented, it is a requirement of a lake water quality management plan that a range of remedial actions be prescribed for the purposes of dealing with contingencies.

4.2 CONCEPTUAL MODEL OF QUARRY LAKE

4.2.1 FINAL LANDFORM

The basin within the final post operation pit void, which could potentially become a pit lake, is approximately 700 m long and 400 m wide. Climate data reveals that rainfall exceeds evaporation and the quarry pit is expected to gradually fill up and eventually overflow into the surrounding watershed during periods of high rainfall. As the lowest point on the perimeter of the pit void is located at RL25 m AHD and the pit void is planned to go a depth of RL-66 m AHD, the potential depth of the pit lake is approximately 91 m. In groundwater modelling undertaken by Australasian Groundwater and Environmental Consultants (AGE Consultants 2013), the final surface level of the quarry lake was taken as RL25 m AHD. A shallow perched aquifer is also present in the top 20 m of regolith and weathered rock. If the lake contacts a section of quarry wall with weathered rock, lake water may leak into the surrounding water table. Rock from greater depths is considered to be tight and to have very low hydraulic conductivity.

High rock walls, which are referred to as quarry faces, will surround the quarry lake on most sides. At the highest point (RL 132 m AHD) the potential height of the surrounding quarry high wall is approximately 85 - 105 m above the final quarry lake level. The high walls will contain a series of benches. As such, the final quarry lake will resemble a volcanic crater with stepped sides and a deep lake at the bottom.
From most directions, the GCQ pit will not be visible from the surrounding landscape. A wide buffer area which includes a natural ring of hills covered with mature native vegetation surrounds the quarry. Additionally, the external slopes of the central hill that is being quarried will retain native vegetation cover. Within the pit, the steep walls will contain horizontal benches, which when provided with soil cover, will be capable of supporting a variety of trees species, including species which may be tall enough to hide any benches which can be seen from the surrounding landscape. As there are no external vantage points that are more elevated than the final quarry lake surface, the quarry lake will not be visible from the surrounding landscape.

### 4.2.2 QUARRY LAKE WATER BALANCE

As groundwater investigations have revealed that the proposed pit will be excavated into a competent rock deposit with little groundwater, the main inputs into the lake will be from precipitation. Competent rock is rock in which any cracks present have not opened to create voids through which groundwater can easily move. The pit will be excavated into the side of a hill starting near its summit, so the surface water catchment surrounding the pit will consist of a very small band of disturbed land around the rim of the pit. Disturbance in this area is likely to be limited to some tree clearing and overburden removal. The small catchment area above the pit will naturally regenerate with grasses and native plants. Inputs from the catchment above the pit will be very small, as the edge of the pit will be very close to the crest of the hill. In wet conditions, seepage from the perched aquifer in the regolith at the top of the hill may seep into the pit, however these inputs are also likely to be very small. Surface water flows from terrain surrounding the pit and from the perched water table are so small that they have not been factored into the water balance model.

A water balance model for the quarry lake, which was produced by Australasian Groundwater and Environmental Consultants (AGE, April 2013), is based on precipitation and evaporation rates measured at the Hinze Dam, which is 15 km north west of the proposed quarry site and which has comparable topography. Records for the Hinze Dam reveal that precipitation exceeds evaporation and implies that the quarry pit will eventually fill with water if there is no significant leakage to groundwater. As the catchment within the pit of the proposed quarry is considerably larger than the surface area of the final quarry lake, there will be significant runoff from the surrounding pit benches into the quarry lake. Factoring in the total catchment area reveals that the lake will fill to final depth in a period of approximately 14 years. During the early years, the rate at which the lake depth increases will be more rapid than in later years, as total evaporation is related to the surface area of the lake which is initially small in relation to the catchment which supplies water to the lake.

Filling of the quarry lake is likely to commence only after cessation of quarrying, as an exposed quarry floor is required to allow the quarry to operate. An appropriately sized sump will be
constructed in the floor of the quarry to allow rainwater to collect, so that it can be pumped up to a storage dam located outside the pit during the operational phase.

During the operational phase of the quarry, only a small waterbody will exist within a basin at the bottom of the quarry pit, referred to as the quarry sump. The sump will measure approximately 100 m by 100 m and will be excavated approximately 12 m into the floor of the quarry. The sump provides a place for stormwater to collect without interfering with quarry operations. Rainwater captured in the pit will be used for process and dust suppression water. During the early years when the pit is smaller, it is likely that all of the water captured will be used for process water or dust suppression. Excess water will be pumped from the sump into the quarry dam, after most of the sediment brought in by stormwaters has settled.

4.2.3 QUARRY LAKE ENVIRONMENT

Quarry lakes tend to be very deep in relation to their size, and this has a large effect on the chemical and biological character of these lakes. Biologically, quarry lakes are oligotrophic, which means a very nutrient poor environment that sustains low levels of primary productivity. As the lake margins tend to be very steep, there are very limited areas of shallow water in which rooted aquatic plant such as waterlilies and rushes can grow. Lake waters also tend to be nutrient poor due to stratification, so do not support significant levels of plankton. During the summer months it is likely that the lake will be thermally stratified, with bottom waters remaining at local winter temperatures (10-12° C) throughout the year and surface waters becoming relatively warm in summer (mid-twenties). Due to stratification, nutrients in surface waters become depleted as dead plankton sinks and carries any contained nutrients into the bottom waters and bottom sediments. It is expected that during winter, the stratification will breakdown and the lake will experience deep circulation, resulting in the return of some nutrients to surface waters. Many nutrients will also become locked into bottom sediments and will be permanently lost from the lake ecosystem. The quarry lake will be too deep to support plant life on the lake bottom.

4.2.4 PIT WATER QUALITY

Greywacke is high-strength durable rock, and samples obtained during the resource mapping for the proposed quarry show only traces of mineralisation. Based on rock samples collected to date, there is very little potential for contamination of quarry lake waters through contact with the rocks that make up the lake basin. Water quality results from sediment dams in the nearby West Burleigh Quarry are almost always within acceptable limits for metals and metalloids, which are routinely measured as required by water quality management plans. Rock in the exposed walls above the lake will be exposed to the prevailing weather and will break down at an accelerated rate, however as the rock is not highly mineralised, it is not expected to release chemical species which create water quality issues. Mineralised areas can release sulphides, heavy metals and metalloids. Oxidation of sulphides results in acid formation and a low pit lake pH, which is a common water quality impact in metal and coal mines.
Despite the low levels of mineralisation, groundwater present in fractures in fresh rock may have had a very long residence time and have absorbed minerals to the extent that it now exceeds ANZECC levels for some metals and metalloids. Similarly, run-off waters that have been in contact with fresh, finely ground material such as dust can absorb metals and metalloids, may occasionally exceed ANZECC water quality levels, particularly if they have been concentrated by evaporation. Run-off or groundwater containing elevated levels of metals and metalloids is related to the exposure of fresh material and will be significantly reduced in the post operational environment. In the case of the proposed GCQ, the volume of groundwater in the surrounding rock is quite limited and the fresh rock is relatively impermeable, so the rate of flow into the pit will also be low (generally 2-4 l/s reaching 8.3 l/s when the pit reaches final size). In fact, it is expected that no pit dewatering will be required, as the majority of groundwater seepage into the pit is expected to evaporate before reaching the bottom of the pit. Much of the seepage also originates from a perched water table in the soil and weathered rock overlying the rock resource, and which is relatively well flushed. Only very small quantities of groundwater exceeding ANZECC thresholds are likely to flow into the pit, even allowing for metals and metalloids deposited on pit walls by evaporating groundwater being washed into the quarry lake by rain. When the quarry lake fills, the rate of groundwater influx will rapidly decrease due to a decreasing hydraulic gradient, decreasing the influx of metals and metalloids. Surfaces which produce run-off with elevated levels of metals and metalloids due to contact with dust or finely ground product are usually rehabilitated with soil and vegetation, which act to capture most contaminants.

In a lake environment, metals and metalloids usually become immobilised in sediments deep within the lake, so concentrations in the water column tend to fall with time. Dilution of run-off water by lake water will result in concentrations of metal and metalloids being reduced to below ANZECC thresholds for 95% species protection in slightly to moderately disturbed systems, based on monitoring results from the nearby West Burleigh Quarry, which also quarries the same rock formation. There are several ANZECC water quality guidelines, including guidelines for drinking water, recreational use and stock use. A final purpose for the quarry lake has not been determined and the most probable destination of waters from the quarry lake is the natural environment, hence the ANZECC guidelines for aquatic ecosystems have been used in this case.

New inputs of nutrients into the lake will mainly be via stormwater or by materials placed within the lake, such as backfilled overburden. Groundwater entering the quarry lake can also bring in dissolved minerals. Currently, it understood that there is relatively little groundwater within the proposed quarry resource, due to the relatively intact nature of the rock that constitutes the resource. In the post quarry environment, it is the low permeability of the rocks surrounding the pit that are expected to prevent quarry waters from leaking out of the quarry lake.

Whilst the quarry lake is not in a mineralised area and the shape of the lake suggests that metals and metalloids will largely become trapped in the bottom sediments with time, there could potentially be water quality impacts when the lake turns over in winter. Turning over is associated
with the equalisation of temperature above and below the thermocline, leading to the breakdown of the thermocline and mixing of lake top and bottom waters. As lake bottom waters have been cut off from access to atmospheric oxygen, these waters may have low oxygen concentrations. A further consequence of low oxygen concentrations is that reducing conditions are created that favour the creation of dissolved metal ions. Surface water quality in lakes in which bottom waters become seasonally depleted of oxygen tend to have oscillating levels of dissolved metals, associated with the seasonal creation and breakdown of the thermocline. Factors which allow metal ions to accumulate in bottom waters include depletion of oxygen, lack of bottom sediments for metals to bind to and lack of dissolved organic carbon in the water column. Absorption of metals into bottom sediments is usually mediated by chemotrophic bacteria which live in the sediments.

Often the limiting nutrient for bacterial growth is organic carbon, which is required by the bacteria for producing cell walls and other structure. Generally organic carbon is supplied by humus from plants growing around the lake shoreline or from dead phytoplankton, however in lakes that are particularly low in leaf litter inputs from around the shoreline and phytoplankton, organic carbon can be in limited supply. Provided that the lake has some bottom sediment and that some organic carbon is supplied by plankton and shore plants, levels of dissolved metal ions in bottom waters should decrease with time, and any jumps in metal concentrations associated with the breakdown of the thermocline should be dampened with time.

4.2.5 LAKE DISCHARGE WATER QUALITY

Local climate records indicate a summer rainfall peak and a winter rainfall deficit. The implication of this rainfall distribution is that the quarry lake is only likely to overflow in summer months when stratification is strongest. Discharge waters will be comprised of waters from above the thermocline which marks the depth of stratification, and these waters will be a mix of:

- rainwater that has fallen directly on the quarry lake;
- stormwater that has drained from the pit walls and any small areas of catchment between the edge of the pit and the catchment boundary; and
- lake water which was resident before the lake reached the overflow level.

Management of water quality of discharge waters from the quarry dam and sediment pond occur mainly during the operational phase, and water quality management for these waterbodies is outlined in the Boral Quarry, Tallebudgera Valley Environmental Impact Assessment: Water Resources and Floodplain Management Report, which was prepared by BMT WBM.

4.2.6 POTENTIAL SOURCES OF CONTAMINATION

The main potential sources of lake water pollutants will be materials introduced to the lake due to human activity. Potential sources include quarry operations where materials used in the quarry remain present in the post quarry environment. These materials may be the results of accidental
release such as fuel spills, or a result of creating quarry product such as materials used to precoat gravel for use in roads. As the environmental aspects all of the materials used by the quarry are explicitly described and managed within the company’s integrated environmental management system, it is unlikely that the quarry process or incidents at the quarry will result in contamination of the pit and future quarry lake. Production of quarry product is almost entirely a mechanical process, so the quantities of chemicals used on site are minimal. Some explosives are used in the pit, however most of the residues would be removed with the broken stone.

A potentially greater issue is unauthorised dumping of contaminants into the quarry lake. There are currently no pipelines within the catchment of the pit and none are likely to be constructed, so there is no risk of burst pipes delivering large loads of material into the quarry lake. Any unauthorised contaminants would have to be brought in by vehicle. Access to the quarry lake will be restricted by fencing and additionally by surrounding steep terrain.

4.2.7 POTENTIAL REMEDIAL ACTIONS

Although no significant water quality problems are expected to develop, this section is included to provide some information on remedial actions that could be implemented to change water quality, should an issue develop.

The most common issues experienced in lakes and impoundments are:

- Blue green algal blooms on the lake surface;
- Depletion of oxygen in bottom waters and subsequent generation of hydrogen sulfide and metal ions; and
- Elevated levels of metals or other chemical species in the water column due to contaminated inflows.

In Queensland, most water quality issues in storages including blue green algae and oxygen depletion in bottom waters are caused by stratification of the water column. Elevated levels of metals and other chemicals are usually associated with tailings dams and are covered here only for completeness. Two main approaches appear to be currently favoured for correcting chemical and biological problems in lakes:

- Mixing lake surface and bottom waters; and
- Improving the level of biological activity in the lake.

Mixing surface waters with bottom waters may prevent hydrogen sulfide build up and release of metals and metalloids from lake sediments, by increasing oxygen levels throughout the water column. Usually air is pumped deep into the lake to bring bottom waters to the surface by air lift. The reverse process of pumping oxygen saturated surface water into the depths is also effective and seems to have the added benefits of higher energy efficiency and of blue green algae control. Blue green algae float on the surface and if piped to depth, cannot obtain enough light to grow.
Improving biological activity in a lake is usually performed by adding in a greater surface for aquatic plants to grow on, such as brush, or by fertilising the waterbody. More productive lakes produce more organic carbon, which in turn facilitates increased growth of chemotrophic bacteria which break down or render insoluble most chemical contaminants. Chemotrophic bacteria do not need carbon as an energy source, however, as they are carbon-based life forms they require it for creating their physical and functional structures. Changing the intrinsic productivity of the lake by fertilising the lake requires a detailed understanding of the biological and chemical processes that take place with the lake to enable specification of the correct type and amount of fertiliser.
5.0 LAKE MANAGEMENT PLAN

5.1 OPERATIONAL PHASE

5.1.1 PIT LAKE

Upper benches of the quarry high wall which surround the future quarry lake will have been progressively rehabilitated for visual impact reasons. No actions directly related to the future quarry lake are required at this stage.

5.2 POST-OPERATIONAL PHASE

5.2.1 SEDIMENT POND

A channel will be excavated from the quarry lake to the sediment pond to allow lake overflow waters to flow through the sediment pond and down the existing drop down structure into the site’s natural drainage system. The sediment pond provides some capacity to hold lake overflow waters before discharge and provides opportunity to monitor the overflow water prior to discharge and if required to undertake water quality improvement measures.

In a rehabilitated environment, stormwaters from the former processing and stockpiling areas would no longer be directed into the sediment pond. The stormwaters which drain from stabilised and vegetated surfaces would be discharged from the perimeter of the rehabilitated site as diffuse overland flow or into natural drainage systems via drop down structures if flows are concentrated.

In the long term, the sediment pond will be cleaned out and, as necessary, the rock basin will be modified or breached to allow the sediment pond to be free draining. This step may be undertaken to reduce the potential for environmental or management issues developing in relation to the sediment pond basin such as provision of habitat for pest species.

5.2.2 QUARRY DAM

The quarry dam will be retained for a period following quarry closure and then be breached or partially removed to allow restoration of the original flows patterns within the drainage system. As the quarry dam holds a significant quantity of water, it could potentially create a flooding hazard if it were ever to fail catastrophically, and for this reason, the dam will be breached to reduce the potential hazard.

During the period following quarry closure, water quality within the dam will be monitored to ensure that the breaching the dam will not result in release of low quality or sediment laden water. The breaching process is likely to be two stages, with a large breach created in the first stage, which reduces the lake size to a small pond which will be further monitored until it is established that water quality objectives are being met.
Removal of the quarry dam in stages also provides opportunity for any wildlife which are resident (turtles, water dragons, fish and water birds) to relocate to other wetland habitats such as wetlands downstream of the site. Once the water quality meets objectives, the remaining dam wall within the breached section will be removed and the quarry dam lake will be replaced by an intermittent stream.

Rehabilitation of land surfaces that have emerged following lowering of water levels will have to be undertaken. The newly exposed ground surface will have to be investigated and a suitable revegetation option selected. The bottom of the quarry dam is likely to be covered with a thick layer of dense sediment and revegetation practices prescribed for the balance of the quarry are unlikely to be suitable. Sowing the ground with a spreading pasture lawn or pasture grass will probably be the best option for stabilising exposed sediments.

5.2.3 QUARRY LAKE

The quarry pit will be allowed to fill with rainwater. Modelling predicts that the pit will take 14 years to fill to overflowing. However the lake will rapidly increase in depth in the first few years and will rise to within about 20 m of overflowing within approximately 8 years.

Monitoring of lake waters throughout this period is recommended. The objectives of the monitoring are described in a previous section. Other than monitoring and securing the site, no other actions are likely to be needed.

Should the GCQ Lake not meet water quality objectives, it will be necessary to conceptually model the lake to determine the source of the issue and whether there are any potential courses of action that could lead to improvement of water quality. Quantitative modelling of the physical and chemical behaviour of the lake could be undertaken if it is important to know the functional characteristics of the lake in detail when designing water quality improvement programs.

The proposed quarry lake will be located within an area of bushland and will have an environmental setting.

5.3 MANAGEMENT OF PEST SPECIES

Pest animals and plants can have major impacts on waterways and water quality. Bottom feeding fish such as catfish, *Tilapia* and carp can continually stir up bottom sediments and make what would otherwise be clear waters very turbid. Waterweeds can choke the waterbody and create very high levels of biomass which decompose, reducing water quality and impacting on the ability to use the water by clogging inlets. Very few native water plants have pest potential. Most waterweeds are escapes from the aquarium trade and a few were deliberately introduced as agricultural species. The majority of waterweeds are declared pests and there is a requirement for the landholder to manage or eradicate these species. Failure to promptly detect and eradicate pests can result in very costly campaigns against large and entrenched pest populations.
The most susceptible waterbody is the quarry dam, as it provides suitable potential habitat for many pest species, particularly aquatic plants that grow in shallows. Even though the quarry dam is to be removed, regulatory issues would occur if release of waters also released pests into the downstream environment. Control of any pest species present within the quarry dam needs to be factored into decommissioning works.

Some plant species which have been subject to eradication campaigns and which could potentially invade the quarry dam include:

- Alligator weed (*Alternanthera phylloxeroides*);
- Hymenachne grass (*Hymenachne amplexicaulis*);
- Salvinia (*Salvinia molesta*);
- Cabomba (*Cabomba caroliniana*); and
- Limnocharis (*Limnocharis flava*).

Invasive species continue to arrive in Australia and the list of species on the declared weed list changes from time to time, so the list of species to search for should be updated periodically. Approximately fifty known water weeds which could create serious issues exist within the region or are on “watch lists” and the list above represents some of the better known examples only.

Pest fish are usually deliberately introduced to waterbodies and have regularly shown up in ponds on golf courses, council gardens and unfortunately natural lakes. There is a legal requirement to control any noxious fish and this generally involves use of a toxin such as rotenone that attacks fish gills but is harmless to other life forms. In practice it can be difficult to mix the toxin in to all parts of the lake and fish may survive in the toxin free parts of the lake. Screens may also need to be fitted to lake outlets to prevent fish from spreading. The best strategy for keeping out noxious fish is to prevent public access to the lakes.
6.0 MONITORING

6.1 SCOPE

This water quality monitoring plan is a template document which will be subject to change as additional requirements become known. This document specifically deals with lake waterbodies created for or by the proposed quarry, however the quarry water monitoring program will also include other surface water features such as creeks. Specific water quality monitoring requirements will be stated in the development approval and this plan will have to be adjusted to be centred on those requirements. Monitoring protocols outlined in this plan are also subordinate to Australian Standards on water sampling and Queensland Government guidelines and policies for water sampling and water management.

The setting of water quality objectives is beyond the scope of this report. Setting of water quality objectives depends on a wide range of factors, including standard ANZECC levels, water quality of receiving waters and increases in sediment and nutrient loading of discharge waters compared with background waters. The setting of water quality objectives is the subject of another technical report, the Water Resources and Floodplain Management Report prepared by BMT WBM. The BMT WBM report's role is determining discharge levels for sediment and contaminants in quarry affected waters and for waters draining from the site in general.

Note that the water quality monitoring program proposed below may have to be adjusted to better coordinate with the requirements of the monitoring program proposed in the BMT WBM report or government regulators.

6.2 SEDIMENT DAM

All water quality monitoring required for the operation and decommissioning of the sediment dam is specified in the Water Resources and Floodplain Management Report (BMT WBM 2013).

6.3 QUARRY DAM

All water quality monitoring required for the operation and decommissioning of the sediment dam is specified in the Water Resources and Floodplain Management Report (BMT WBM 2013). The water quality monitoring program should continue in the post-operational environment. The objective of the monitoring would avoid impacts on the downstream catchment due to water releases from the dam. Impacts on the downstream catchment could result from sources including:

- suspended sediment, particularly during dam decommissioning;
- release of weeds and pests from the dam; or
- cold water impacts due to release of dam bottom waters in summer.
6.4 QUARRY PIT LAKE

6.4.1 MONITORING OBJECTIVES

The objectives of the water quality monitoring plan for the lake are to:

1. Characterise the stratification pattern for a lake;
2. Ensure lake remains with allowable range for water quality parameters; and
3. Determine trigger values for remedial actions (based on reference sites)

Table 2 lists the water quality parameters that should be collected from the developing quarry lake.

Table 2 Water Quality Parameters for New Lakes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lake</th>
<th>Lake outflow</th>
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</thead>
<tbody>
<tr>
<td>Temperature</td>
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</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Profile</td>
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<td>pH</td>
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<td>Yes</td>
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<tr>
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<td>Cyanobacteria</td>
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<td>No</td>
</tr>
<tr>
<td>Total Sulfide</td>
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<td>Yes</td>
</tr>
</tbody>
</table>

6.4.2 MONITORING LOCATIONS AND FREQUENCY

For monitoring relating to characterisation of stratification pattern, a minimum of monthly sampling for three years is recommended. The following requirements are also to apply where appropriate:

- Where measurements and/or samples are required in consecutive months, these should be taken no less than three weeks apart; and
- Where inflow and outflow data are compared to determine impact, measurements and/or samples for all the parameters specified in the relevant table should be taken on the same day where practicable.

All water samples are to be collected in accordance with the Queensland Environmental Protection Agency Water Quality Sampling Manual 2009 (now issued by Qld Environment and Heritage Protection), AS 2031:2001 and AS/NZS 5667.1:1998. Cyanobacteria biomass shall be monitored in the storage pond in accordance with the NRW ‘Blue-Green Algae Monitoring Standard’.
Where water quality profiles are required, these should be taken at depth intervals of one metre throughout the profile to the maximum accessible depth of the storage. Smaller depth intervals should be used if the storage is shallow, or if temperature or dissolved oxygen readings are changing rapidly. One of the sampling points should be in the vicinity of 100 metres upstream of the storage wall along the channel alignment at or near the deepest point where practicable.

The monitoring program should be reviewed annually at a minimum to ensure that the program is adequate in assessing the risk of stratification and the associated potential impacts to the impoundment and receiving ecosystems.

6.4.3 LONG TERM MONITORING FREQUENCY AND SCOPE

The frequency and duration of monitoring should be determined by a risk assessment framework. Where the lake is found to have a low risk of impact, monitoring may be reduced. Lakes defined as having a moderate risk should continue to be monitored in accordance with the above programs. Storages defined as having a high risk should extend the monitoring program, to enable a comprehensive assessment of the potential impact of releases to the downstream environment and the extent of such an impact. A full suite of parameters which have been monitored in a quarry lake where water quality was of concern (PB 2007) is presented below in Table 2. Monitoring which includes all of the parameters in Table 3, should be undertaken at the start of key phases of quarry development (C1, Q1 and Q5).

Table 3 Extended Suite of Water Quality Parameters

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<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Detection Limits</th>
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<tr>
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<td>Redox potential</td>
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<td>Electrical Conductivity</td>
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<td>Temperature</td>
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<td>Suspended Solids</td>
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<td>Magnesium</td>
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<td>Sulphate</td>
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### Parameter Detection Limits

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<th>Unit</th>
<th>Detection Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness as CaCO3</td>
<td>mg/L</td>
<td>-</td>
</tr>
<tr>
<td>Metals (totals)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>mg/L</td>
<td>0.01</td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/L</td>
<td>0.001</td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/L</td>
<td>0.0001</td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/L</td>
<td>0.001</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/L</td>
<td>0.001</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/L</td>
<td>0.001</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/L</td>
<td>0.001</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/L</td>
<td>0.005</td>
</tr>
<tr>
<td>Nutrients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td>0.01</td>
</tr>
<tr>
<td>Nitrite</td>
<td>mg/L</td>
<td>0.01</td>
</tr>
<tr>
<td>Nitrate</td>
<td>mg/L</td>
<td>0.01</td>
</tr>
<tr>
<td>Nitrite and Nitrate as N</td>
<td>mg/L</td>
<td>0.01</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen as N</td>
<td>mg/L</td>
<td>0.1</td>
</tr>
<tr>
<td>Total Nitrogen as N</td>
<td>mg/L</td>
<td>0.1</td>
</tr>
<tr>
<td>Total Phosphorus as P</td>
<td>mg/L</td>
<td>0.01</td>
</tr>
<tr>
<td>Reactive Phosphorus as P-Tot</td>
<td>mg/L</td>
<td>0.01</td>
</tr>
</tbody>
</table>

### 6.5 REPORTING

Results of the survey shall be provided in a concise report suitable for submission to the administering authority within fourteen (14) days of monitoring. Records will be retained for the period stated in the Boral IEMS, generally seven (7) years.

Reporting to government regulators may be required in the event of non-compliance with decision notice conditions or with water quality standards set by policy or legislation.

### 6.5.1 INTERPRETATION OF DATA

According to the Queensland Water Quality Guidelines (QWQG) (DERM 2010), the water type of the proposed quarry lake is a lake in South East Queensland. The purpose of the QWQG is to provide a regionally appropriate set of water quality objectives (WQO) that also recognise differences in water parameters that are associated with each type of waterbody. This allows a set of water quality objectives to be selected that is better suited to the particular application than...
the generic ANZECC 2000 guidelines. However in this case the QWQG defaults back to the ANZECC guidelines, as no local WQO have been developed for lakes in South East Queensland.

The appropriate WQO for the quarry lake are the ANZECC guidelines for slightly to moderately disturbed aquatic ecosystems which is presented in Table 3.4.1 of the guidelines (Trigger values for toxicants at alternative levels of protection).

The ANZECC guidelines are generic and are probably suitable for the purpose of setting trigger levels for WQO. However both the ANZECC guidelines and the QWQG provide a mechanism where trigger levels for water parameters can be based on site specific WQO. Site specific WQO are appropriate in situations that are dissimilar to conditions for which the generic values were established. Setting of site specific WQO is impractical for most developments and generic ANZECC trigger values are generally used.

Where water quality parameters have exceeded ANZECC trigger values or agreed site specific trigger values, these exceedences are to be highlighted and explained. Any other matters of note are to be highlighted in the report and, if they are potential issues that have not previously been encountered or are encountered following implementation on mitigation measures, then additional mitigation measures are to be proposed.
7.0 REFERENCES


