Appendix I
Soil and Water Management Plan

FINAL REPORT

Reavill Farm Pty Ltd and Tucki Hills Pty Ltd

Champions Quarry 1586 Wyrallah Road, Tuckurimba NSW
Soil and Water Management

February 2010

Reference: 0098287

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Champions Quarry,
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Soil and Water Management

For: Champions Quarry

November 2009

For and on behalf of:
Environmental Resources Management Australia

Approved by: Murray Curtis

Signed:

Position: Partner

Date: 23 February 2010

CONTENTS

CONTENTS

ANNEXURES

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 BACKGROUND

Environmental Resources Management Australia (ERM) was commissioned by Reavill Farm Pty Ltd and Tucki Hills Pty Ltd to prepare a Soil and Water Management Plan (SWMP) for the proposed expansion of its sandstone quarry (Champions Quarry) located on Wyrallah Road, Tuckurimba, approximately 16km south of Lismore, NSW. The Project Site location and Project Area is shown on ***Error! Reference source not found.*** below.

Champions Quarry has an existing 2006 development consent to extract sandstone at the Project Site, limiting its production to 29,600 cubic metres per annum (approximately 64,000 tonnes per annum) over a period of 15 years. Champions Quarry is seeking approval for the expansion of the quarry under Part 3A of *Environmental Planning and Assessment Act, 1979.* The proposed expansion will involve the extraction up to 6.25 million tonnes of sandstone resource at an extraction rate of 250,000 tonnes per annum over a period of 25 years, and importantly, the implementation of a sand washing plant.

The SWMP addresses the Director-General's requirements for the Environmental Assessment (EA) of the proposed quarry expansion and issues raised by the relevant regulatory authorities.

The extraction of the sandstone resource will take place within an *operational area* of approximately 16 hectares (herein referred to as the Project Area), which is divided into two separate extraction areas (referred to as the *Central* and *Southern Sections*). The sequential extraction and rehabilitation within 'section areas' will take place in up to three '*work cells*' that will have a maximum area of 3 hectares each. The proposed Project Area layout is presented in *Figure* below.

ERM has considered data and information provided by Champions Quarry during the preparation of this SWMP including the results of geological investigations, groundwater and surface water quality testing data, and hydrogeological field testing data.

The hydrological data obtained in this investigation assisted in the development of a water balance model for the proposed quarry operations.

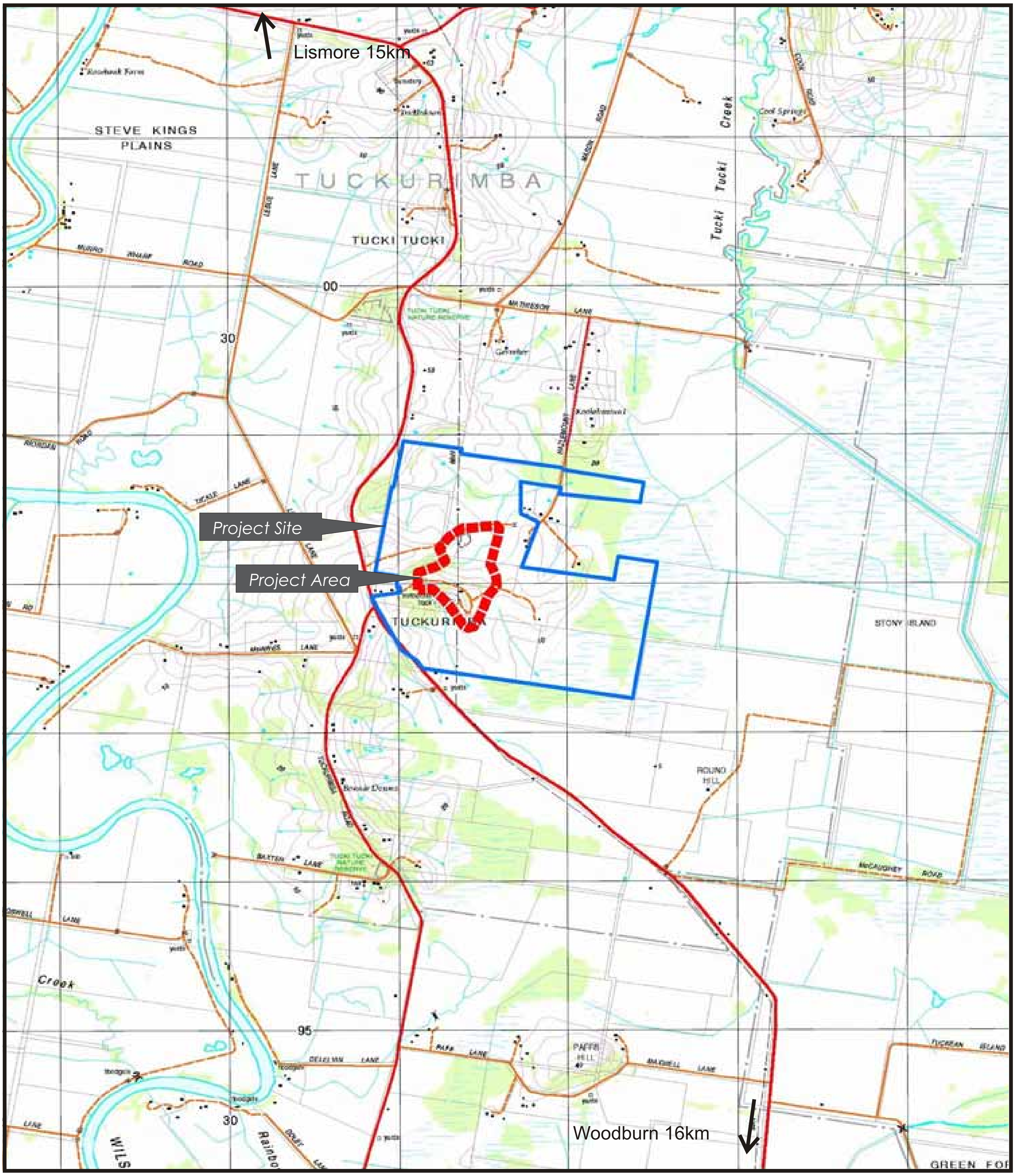

Figure 1.1

Project Locality Plan

Client:	Champions Quarry		
Project:	Champions Quarry Expansion		
Drawing No:	0098287pm_01		
Date:	12/08/09	Drawing size:	A4
Drawn by:	AM	Reviewed by:	WW
Source:	Department of Lands		
Scale:	Refer to Scale Bar		

N

0 0.5 1km

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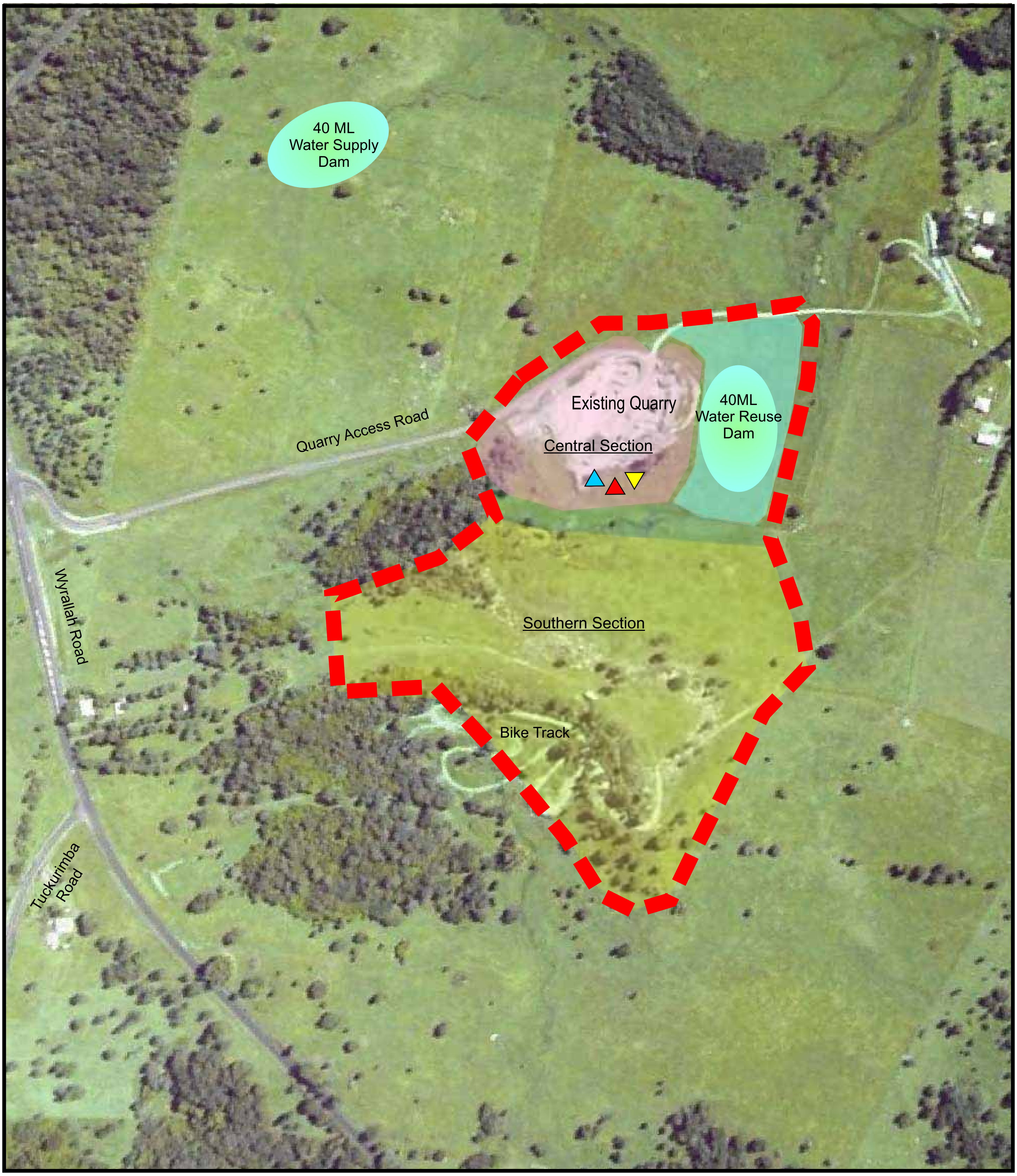

Legend

- Extent of Quarry Extraction and Operations (Project Area)
- Washing Plant
- Processing Plant
- Service Area and Temporary Stockpile Holding Area
- Water Management Dam
- Central Section
- Southern Section
- Water Management (Non-quarrying area)

Client:	Champions Quarry		
Project:	Champions Quarry Expansion		
Drawing No:	0098287pm_03	Suffix No:	V4
Date:	12/08/09	Drawing size:	A4
Drawn by:	AM	Reviewed by:	WW
Source:	-		
Scale:	Refer to Scale Bar		

N 0 50 100 150 200 m

Figure 1.2

Proposed Project Area Layout

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2 SOIL AND LANDFORMS

2.1 EXISTING SOILS AND LANDFORMS

2.1.1 *Geology*

The 1:250,000 geological map of Tweed Heads (SH56-2) shows that the site is underlain by the Jurassic age Kangaroo Creek Sandstone which is described as quartz sandstone and conglomerate. The higher elevations and western portions of the site are overlain by basaltic rocks of the Lismore Basalt, which is a Tertiary age member of the Lamington Volcanics. Site observations of outcrop towards the southern extent of the site indicate that the basaltic rocks are limited to an area west of the Project Area and as a thin clay soil veneer above RL50m inside Project Area. The basal contact of the basalt appears to be sub horizontal, although regional experience indicates that lateral prediction of this contact for any great distance is unreliable (Coffey Geotechnics, 2008).

Geotechnical drilling undertaken by Coffey Geotechnics (refer *Appendix B of EA report*) has demonstrated that the geology of the Champions Quarry expansion area is underlain by Kangaroo Creek Sandstone which is the premier sandstone aggregate parent material in the Far North Coast of NSW. Typically this sandstone contains coarse quartz sandstone and conglomerate of varying characteristics.

Several thin coal seams and weathered siltstone interbeds were observed in the drill cores. Two thin bands of material containing sulphide (pyrite) were encountered at one of the test drilling locations (BH5) undertaken by Coffey Geotechnics. These occurred at 12.15m depth below ground surface (50mm thick) and at 27.5m depth (20mm thick).

Pyrite (FeS_2) is commonly associated with coal and metal ore deposits. Its oxidation occurs spontaneously in nature and can cause Acid Mine Drainage (AMD) and mine tailing leachate containing heavy metals (WA DMP, 2009). The overall chemical reaction governing pyrite oxidation is:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_20) \text{ --> } Fe(OH)_3 + 2SO_4$$

Based on the small amounts of pyrite observed in the drilling cores the potential for AMD is considered to be low. Management measures should however been considered to mitigate against the generation of AMD and potential for discharge of AMD from the Project Area. This is discussed further in *Section 2.2.3*.

2.1.2 *Soils*

Geological site investigations undertaken at the Champions Quarry Project Site by Coffey Geotechniques (2007) indicated that the shallow topsoil and residual soil ranges from sand to sandy clay between 0.5 to 1.3 metres depth in the investigation areas. The sandy soil is described as medium grained orange brown with traces of clay and organic materials, while the sandy clay is described as medium plasticity, dark brown firm to stiff.

The *Soil Landscape of the Lismore-Ballina 1:100,000 Sheet* (Morand, 1994) identifies two soil landscapes occurring in the vicinity of the Project Site comprising a variant of the 'Wollongbar' erosional and a variant of the 'Coffee Camp' colluvial landscapes. The erosional 'Wollongbar' soils are typically derived from basalts and are mostly deep (>200cm) Krasnozems and stonier Krasnozems on crest/ upper slope boundaries.

The colluvial 'Coffee Camp' soil landscape comprises footslopes and low hills on Kangaroo Creek sandstone. Soils are likely to comprise of shallow (<100cm), moderately well drained lithosols on ridges and crests; moderately deep to deep (60-150cm) Yellow Podzolic soils, with Red Podzolic and brownish Red Podzolic soils on slopes; and, deep (>150cm), rapidly drained Earthy Sands and deep (>100cm), well drained Red Earths on lower footslopes and depositional areas.

The latter 'Coffee Camp' soil landscape is the dominant soil landscape within the defined operational area, which is consistent with the soil types encountered during the geological site investigations.

Agricultural land classification mapping has been undertaken for the region and indicates that the relative suitability of the land for agriculture is classified as *Class 3* in accordance with the *Agricultural Land Classification Map* (NSW Agriculture, 2001). However, it is important to note that the land suitability mapping has been developed for the primary purpose of planning at the strategic level and direct application to the site specific level, without ground-truthing, can be inaccurate.

Class 3 lands are defined as grazing lands or lands well suited to pasture improvement. It may be cultivated or cropped in rotation with sown pasture. The overall production level is moderate due to edaphic or environmental constraints. Erosion hazard, soil structural breakdown, or other factors, including climate, may limit the capacity of the land for cultivation and soil conservation or drainage works may be required.

2.1.3 *Acid Sulphate Soils*

A review of available former Department of Land and Water Conservation (DLWC) Potential Acid Sulphate Soils (PASS) Risk mapping (1998) indicates PASS are not expected to occur within the proposed extents of the expanded quarrying operation. An area to the east of the central and southern quarry sections had been classified a *low probability of occurrence* between 2 – 4m Australian Height Datum (mAHD), while a large region denoted as high probability occurrence of ASS at between 1 - 2m AHD is located further to the east. An acquired digital version of the DLWC 1998 mapping layered onto an aerial photograph with the proposed Project Area is shown in *Figure* .

The corresponding PASS mapping provided in the Lismore City Council Local Environment Plan (refer *Annex J*) indicates that the proposed quarry development is to be undertaken within *Class 5* lands for works within 500m of *Class 1-4* lands. However, the proposed works are not expected to lower the water table in *Class 1-4* lands to below 1m AHD, as the quarry floor will not be below 8m AHD.

2.1.4 Landforms

The Project Area is located off a ridgeline system running north-south between the Wilsons River to the west and low lying flood plain to the east (refer *Figure 1.1*). The elevation ranges from approximately 50 metres Australian Height Datum (mAHD) in the proposed southern extraction area to approximately 6mAHD at the eastern and north eastern boundary of the Project Area. A gully depression occurs between the southern and central extraction areas draining east, then north along the eastern boundary of the Project Area. Land to the north of the main Project Site access road area generally slopes to the north toward an ephemeral drainage depression and northeast toward the ephemeral drainage depression on the eastern Project Site boundary.

Legend

Project Area

NSW Acid Sulfate Soil Risk

High probability of occurrence (1-2m)

Low probability of occurrence (2-4m)

Client:	Champions Quarry		
Project:	Champions Quarry Expansion		
Drawing No:	0098287_GIS05	Suffix No:	A0
Date:	12/08/09	Drawing size:	A4
Drawn by:	AM	Reviewed by:	WW
Source:	LPI 2007		
Scale:	Refer Scale Bar		

N

0 0.15 0.3 0.6 km

Figure 2.1

Tuckurimba Acid Sulphate Soils Risk Map

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2.2 *POTENTIAL IMPACTS OF THE PROPOSAL*

2.2.1 *Soils*

There are a number of potential impacts that could arise from quarry operations, which in the absence of appropriate mitigation measures, could adversely affect soils.

There is a potential for soil erosion from quarry pit, stockpiles and unsealed access roads. If this takes the form of wind erosion, topsoil could potentially be transported off-site. However, a significant portion of the Project Area is already denuded of vegetation and topsoil covering as a result of current quarry operations and as a result the extent of erosion is not expected to show any significant increase.

Heavy vehicle movements can cause soil compaction which would be most likely to manifest itself as a cumulative impact.

The Project Area will be returned to an agricultural use following rehabilitation. As the Project Area soils have been identified as having limited capacity to support long-term cropping, the impact of the proposed continuation of quarrying activities would not significantly degrade this resource any further.

2.2.2 *Acid Sulphate Soils*

Impact Assessment

As the proposed quarry excavation depth for the *Central* and *Southern* sections will be limited to a maximum depth of approximately 8mAHD, no direct impacts to PASS are expected as a result of the proposed quarry expansion. The base of the proposed *Water Reuse Dam* and proposed *Water Supply Dam* (refer *Figure*) will not be excavated to a depth that will lower the water table below 1mAHD in adjacent Class 1-4 lands, and the Dams are not located within the region identified as *low probability of occurrence* of PASS, and as such are not expected to encounter PASS.

It is noted that the geological drilling undertaken across the Project Site by Coffey Geotechnics for resource assessment purposes (refer *Appendix B* of EA report) encountered sandstone bedrock to depths of greater than 9mAHD in all test bores and to a maximum of approximately 6mAHD in one location. The test bores were all terminated in sandstone bedrock suggesting the sandstone geological unit would likely extend to greater than the test depths. ERM also understands that test pits undertaken by Champions Quarry in lower portions of the Project Area in the vicinity of the existing quarry have only encountered shallow sand and sandstone bedrock with no typical PASS soils identified.

Seepage and spring activity are considered likely to dominate low flow conditions in the lower reaches of the watercourses downstream of the proposed quarry extension. These factors would limit any impact of the loss of surface water catchment due to the proposed quarry extension and associated dams and subsequently is not expected to impact on PASS in low lying lands to the east of the Project Area.

As the proposed quarry excavations are outside of the areas mapped as PASS and that such excavation would be above the maximum elevation of PASS in nearby mapped areas, and above the local groundwater table, no impact to PASS are expected from the proposed quarry expansion.

Mitigation Measures

As a precautionary measure it is proposed that prior to excavation of the *Water Reuse Dam* a number of targeted test pits (minimum of 2 pending final Dam design) will be advanced in low lying land in order to assess the in-situ soil conditions and to collect samples for PASS assessment. Should PASS be identified changes to the dam design would be undertaken to ensure that no excavation of PASS will occur.

The principal national body responsible for the development of Acid Sulphate Soils assessment and management guidelines in Australia and NSW has been the Acid Sulphate Soils Management and Advisory Committee (ASSMAC). ASSMAC was established in 1994 to coordinate government response to acid sulphate soils issues. ASSMAC recommendations are designed to support Local Environmental Plans (LEP's), which provide a key regulatory mechanism to enable sustainable management of acid sulphate soils in the coastal zone. The ASSMAC assessment guidelines, (August 1998) provide recommendations on the assessment and management of Acid Sulphate Soils in NSW, and may be used in combination with Acid Sulphate Soil Planning Maps and risk maps.

Soil samples collected from the proposed test pits will be submitted to a NATA registered laboratory for Suspended Peroxide Oxidation Combined Acidity and Sulphate (SPOCAS) analysis. The results of the testing will be used to evaluate the required limit to the extent of excavation in the *Water Reuse Dam* area. All fieldwork and laboratory testing will be undertaken in accordance with the ASSMAC *Guidelines for Sampling and Analysis of Lowland Acid Sulphate Soils* (ASS) *in New South Wales* (1998).

PASS are not expected to be impacted as a result of the proposed quarry expansion or the construction of on-site dams. The latter will be confirmed by a precautionary targeted assessment prior to construction to ensure PASS will not be exposed during the excavation of the *Water Reuse Dam*.

2.2.3 *Acid Mine Drainage*

Impact Assessment

As previously discussed in *Section 2.1.1* there exists what is expected to be minor potential for AMD at the site. The identified veins containing pyrite at the site are considered very minor (to insignificant) due to their thickness in relation to the total sandstone resource. In addition, they were only identified in one of the four drilling cores located in the proposed Southern Section extraction area (at BH5 to the west). It is noted that heavy metals are not a feature of the sandstone resource and as such are not expected to present a significant issue with regard to mobilisation of same.

Mitigation Measures

As all operational site runoff is to be contained within the Project Area, the Water Reuse Dam will provide a means for capturing and treating (if required) any AMD. In order to prevent the generation of AMD, where possible material from the very thin veins containing pyrite will be separated, excavated and stockpiled for treatment. Given the inconsistency and thinness of these veins, this may not always be practical, however the simple extraction methods utilised at the quarry does allow for this management strategy to be implemented where possible.

Where pyrite material can be separated it will be stored with the Project Area (and hence within the Water Management System) and be immediately covered with clay overburden sourced from the Project Area. This will limit the potential for oxidation and aim to prevent the production of AMD. The storage area, to be contained with the quarry pit, will be monitored and where AMD is detected Aglime (or equivalent) will be used to neutralise the materials.

In addition to the above, the Water Reuse Dam will be regularly monitored for pH to ensure AMD is not creating acidic conditions. If the pH of the Water Reuse Dam is outside relevant discharge criteria, Aglime (or equivalent) will need to be broadcast over the dam in order to raise the pH. Monitoring of the Water Reuse Dam is discussed further in *Section 4.6*. To retain design capacity, options for discharge from the Water Reuse Dam include on-site irrigation over the wider Project Site, and/or discharge downstream once monitoring confirms dam water is shown to meet DECCW discharge criteria. Management of the Water Reuse Dam is discussed in *Section 4.3*.

2.2.4 *Landforms*

The proposed quarry expansion will impact on the topography of the Project Area via excavation of the sandstone resource and assembly of in-pit and out-of-pit emplacement areas for overburden and excess product. Construction of infrastructure, namely new internal access roads, processing area and weighbridge (including levelling) and water management structures, will result in minor impacts upon landform. Landform alterations will be confined to the operational area of quarry operations and the remainder of the surrounding rural holdings will be unaffected.

Following rehabilitation, the areas used for stockpiling of materials and access would be returned to grazing land, with soil stockpiles reallocated over the benches of the quarry pit to allow for revegetation. The final proposed landform is displayed in *Figure* below.

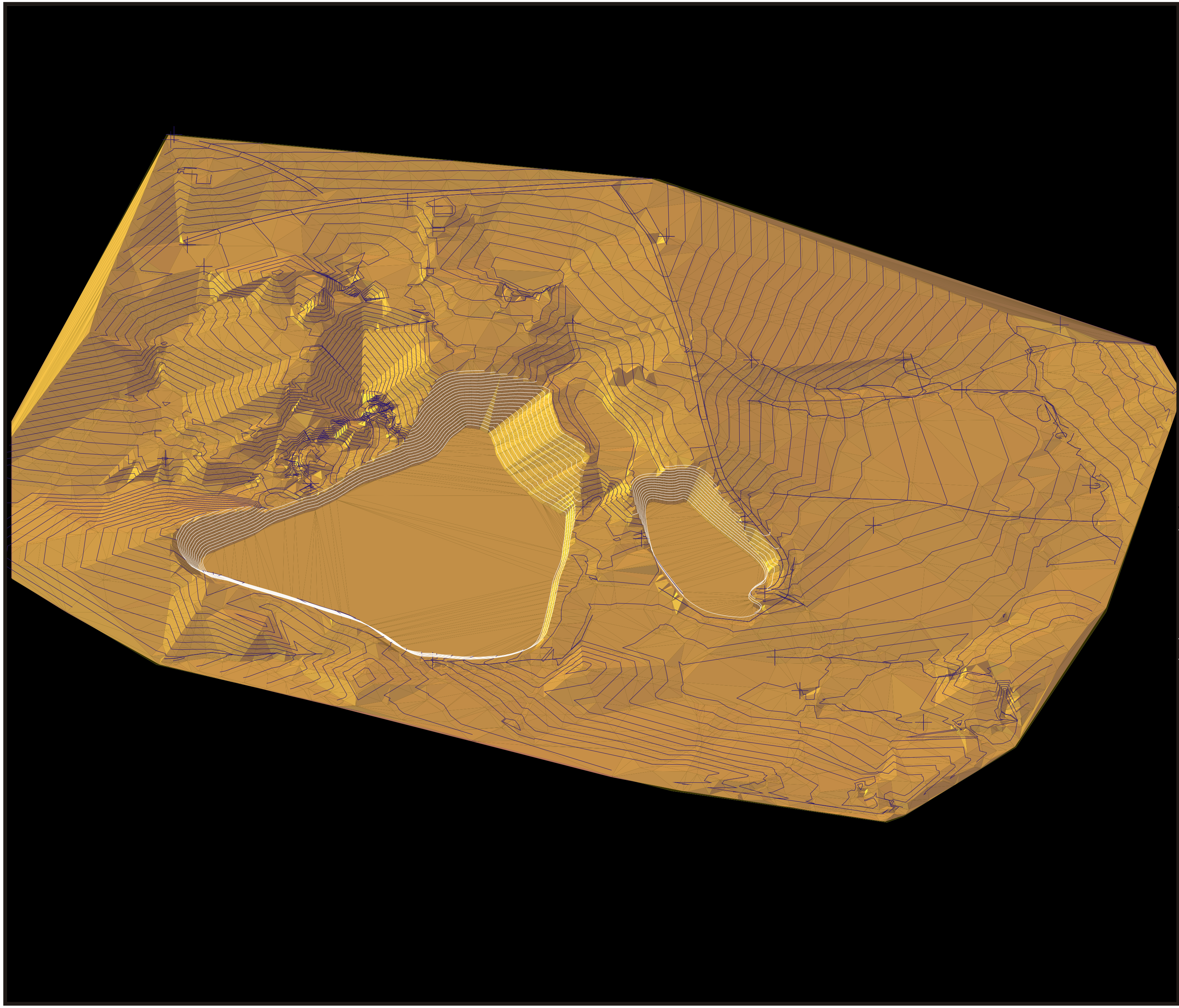

Figure 2.2

Three Dimensional - Final Landform

Client:	Champions Quarry		
Project:	Champions Quarry Expansion		
Drawing No:	0098287_06_SWMP_3D		
Date:	13/08/09	Drawing size:	A4
Drawn by:	AM	Reviewed by:	WW
Source:	VGT		
Scale:	-		

N

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3 WATER RESOURCES

3.1 EXISTING ENVIRONMENT

3.1.1 *Rainfall and Evaporation*

Long term climate data is available from Bureau of Meteorology (BoM) weather stations located in Lismore and Alstonville, approximately 16 km north and northeast of the Project Area respectively.

On average, January is the warmest month in Lismore with a mean daily maximum of 29.9ºC. The coolest month is July with a mean daily minimum temperature of 6.5ºC.

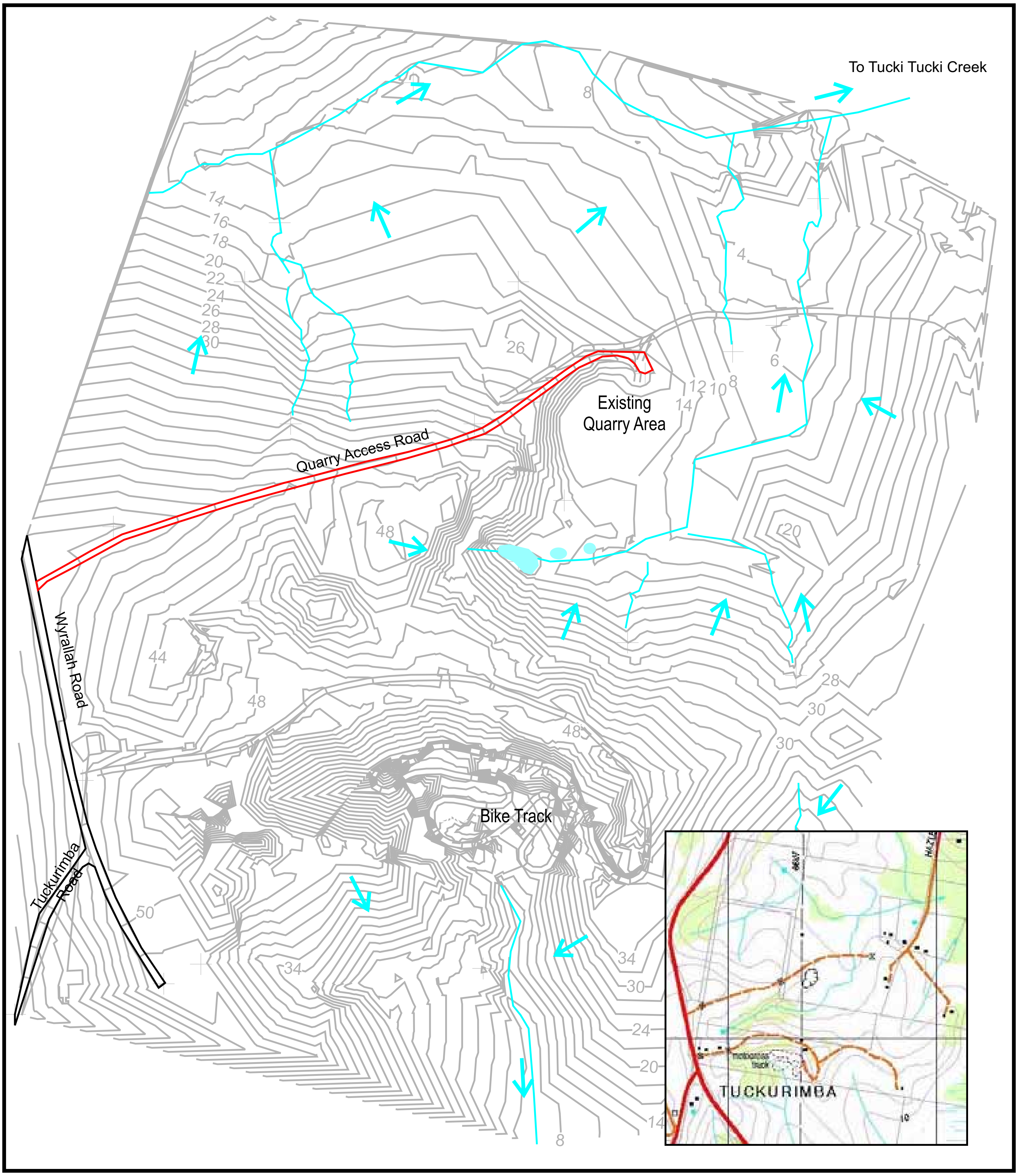
The mean annual rainfall at Lismore is 1343.1 mm. The mean number of rain days annually over this period is 104.4 days. On average, March is the wettest month with a mean monthly rainfall of 188.4 mm, whilst September is the driest month with an average of 50.4 mm. The following table provides summary annual rainfall and evaporation data for the region. Evaporation exceeds rainfall for seven months of the year.

Table 3.1 Rainfall & Evaporation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Mean monthly rainfall (mm)[1]	155	184	188	129	115	97	80	55	50	73	94	121	1343
Mean monthly evaporation (mm) [2]	177	140	136	105	84	72	84	102	140	150	167	177	1533

3.1.2 *Catchment Description*

The proposed Champions Quarry operational Project Area occupies approximately 16 hectares within the headwaters of 1st Order ephemeral tributaries that flow to a low lying floodplain and Tucki Tucki Creek. A catchment drainage plan is shown in *Figure* below.



Legend

- Access & Haul Rds
- Ephemeral Creeks
- Direction of Surface Drainage
- 2 metre contours
- Existing dams

Client:	Champions Quarry		
Project:	Champions Quarry Expansion		
Drawing No:	0098287pm_05		
Date:	20/08/08	Drawing size:	A4
Drawn by:	AM	Reviewed by:	WW
Source:	Inset - Department of Lands (2006)		
Scale:	Refer to Scale Bar		

N

0 40 80 120 160 200m

Figure 3.1

Existing Project Site Surface Water

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The tributaries and Tuck Tucki Creek predominantly flow through agricultural land. The catchment is characterised by undulating topography to the west draining toward flat country to the east.

3.1.3 *Drainage*

The Project Area generally drains to the northeast towards low lying floodplain lands via several ephemeral drainage depressions into an unnamed intermittent water course along the eastern boundary of the Project Area. The flood plain is located approximately one kilometre from the eastern boundary of the Project Area, which in turn drains into Tucki Tucki Creek approximately 2.5 kilometres from the Project Area. During flood events these drains can be breached, with site water mixing with flood waters of Tucki Tucki Creek that in turn flow across adjoining properties.

An area in the south of the Project Area (the motocross track) naturally drains to the south. Proposed extraction activities in this area will result some diversion of this surface flow back to the north. A constructed drain exists from the floor of the existing quarry to two small sediment ponds to the east of the quarry pit. No large dams are currently present on the Project Area or Project Site. Further downstream the water is currently channelled through an established reed bed before discharging off-site.

3.1.4 *Environmental Value of Receiving Waters*

Tucki Tucki Creek is the primary receiving waters for any discharges or runoff from the Project Area. The waterway is affected by variable quality runoff from agricultural and urban sub-catchments.

EAL laboratories of Lismore have undertaken preliminary surface water sampling on behalf of Champions Quarry during February 2007, with samples collected from Tucki Tucki Creek. The samples were collected at locations within the upper tributary to the east of the existing quarry and both up and down hydraulic gradient of the main intersection with Tucki Tucki Creek (refer *Figure* below).

The analytical results appear typical of a disturbed watercourse within a rural catchment. The pH of the water in the creek is generally slightly acidic (consistent with the local soil pH), while the presence of slightly elevated levels of nutrients and ammonia are consistent with what would be expected given the surrounding agricultural (cattle grazing and sugar cane) land usage.

It is noted that in the first round of data collected that Total Petroleum Hydrocarbons (TPH) were detected at sampling location SW3. This was also the case for groundwater samples collected during the same sampling event. As this was considered to be an anomaly at the time, EAL re-sampled the bores and surface water sampling location SW3 at a later date. The subsequent result did not identify TPH in the groundwater and surface water samples with the exception of very low levels (<100µg/L) detected bore and BH3. The analytical reports for surface water samples and groundwater samples are provided in *Annex H*.

Legend

(red dashed line)	Extent of Quarry Extraction and Operations (Project Area)
Bh3	Bore Hole Location
SW3	Surface Water Sample Location
Windmill	Windmill Water Sample Location

Client:	Champions Quarry		
Project:	Champions Quarry Expansion		
Drawing No:	0098287pm_GIS_Boreholes_v2		
Date:	14/08/2009	Drawing size:	A4
Drawn by:	AM	Reviewed by:	WW
Source:	-		
Scale:	Refer to Scale Bar		

N

0 100 200 300 400 500m

Figure 3.2

Surface Water and Groundwater Sampling Locations

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3.1.5 *Existing Pollution Control Measures*

The existing quarry operations utilise a newly constructed sedimentation pond and the two original settling ponds below the quarry pit to prevent sediment discharges to the tributary. The discharge from these ponds is not currently monitored, and as such the efficacy of the ponds and quality of water leaving the quarry is unknown. However, Champions Quarry has indicated that over the many years of operation of the existing quarry they have not needed to remove silt from the ponds. Further downstream, water from the ponds naturally drain through an established reed bed, which will further enhance water quality leaving the Project Site.

Swales have been formed down-gradient of the quarry and stockpile area, along the eastern and southern edges, to direct surface water from these areas towards the settling ponds.

There is currently no fuel storage on the Project Area including the existing quarry.

3.1.6 *Existing Water Use and Supply*

There is currently no town water connection to the Project Area, however connection is available if needed. Water is collected in a small depression located to the east of the existing quarry. This water is currently made available for dust suppression and for adding moisture to the extracted resource when required.

3.1.7 *Sewage Effluent*

Currently, quarry staff utilise toilets at the nearby residence contained within the Project Site. There are currently no sewage connections or on-site sewage treatment systems in the Project Area. Small volumes of potable site water are brought onto the existing quarry for human consumption only.

3.2 GROUNDWATER

Groundwater Bore Search

A search of NSW Department of Water and Energy (DWE) registered groundwater bore licences identified 23 licensed bores within approximately 3km of the *Project Area* (refer *Table 3.2* below). The detailed groundwater bore logs and bore location plan are provided in *Annex B*.

Table 3.2 Groundwater Bores within 3km of Quarry Project Area

Bore Reference	Distance / Direction	Location	Authorised Purposes	Final Drilled Depth	Standing Water Level	Yield (L/sec)	Water Bearing Zones
GW034200	3.0km N	N6801348 E531839	Stock	11.0m	-	-	-
GW037211	2.5km SE	N6796575 E532855	Stock	3.7m	-	0.25	3.0m to3.6m
GW037579	2.8km SE	N6796174 E533151	Stock	3.7m	1.5m	-	2.7m-3.6m
GW037580	2.8km SE	N6796451 E533152	Stock	3.7m	1.5m	-	2.7m to 3.6m
GW038487	1.8km SE	N6796976 E532666	Stock	3.7m	0.7m	-	3.00m-3.6m
GW038540	1.5km NW	N6799905 E530698	Stock	1.5m	0.3m	0.25	0.9m to 1.5m
GW038541	1.0km W	N6798675 E530397	Stock	1.8m	0.6m	0.19	1.2m to 1.8m
GW043088	2.0km NE	N6800147 E532242	Stock	3.0m	1.2m	0.25	2.4m to3.0m
GW43089	2.0km N	N6800210 E531782	Domestic Farming Stock	1.2m	1.5m	0.38	0.9m to 1.2m
GW046137	1.5km S	N6797041 E531367	Stock	2.4m	1.8m	0.06	2.1m to 2.1m
GW046138	1.5km SW	N6797258 E530799	Stock	2.5m	2.1m	-	2.4m to 2.4m
GW046139	2.0km SE	N6796238 E532285	Stock	5.5m	-	0.05	4.9m to 5.5m
GW046148	3.0km SE	N6795590 E533068	Stock	3.7m	0.00	0.38	3.4m to 3.7m
GW046151	3.0km SE	N6795744 E532988	Stock	4.0m	-	0.38	3.7m to 4.0m
GW046341	3.0km SE	N6795591 E532825	Stock	4.3m	-	-	4.3m to 4.3m
GW047403	0.5km N	N6798949 E531318	Stock	7.5m	-	-	-
GW052250	2.7km N	N6800856 E531675	Stock	3.0m	2.5m	-	2.1m to 2.3m
GW058862	1.7km NE	N6799655 E531159	Stock	30.0m	-	0.25 0.38 1.89	10.0m to 10.0m 20.0m to 20.0m 28.0m to 28.0m
GW061503	0.7km NE	N6799255 E532104	Domestic Stock	50.0m	-	0.13 0.78	25.0m to 27.0m 40.0m to 48.0m
GW063949	1.8km NE	N6800421 E533353	Domestic Stock	25.0m	-	0.60	20.0m to 21.0m

Bore Reference	Distance / Direction	Location	Authorised Purposes	Final Drilled Depth	Standing Water Level	Yield (L/sec)	Water Bearing Zones
GW065451	0.5km NE	N6798886	Domestic	41.0m	-	0.1	7.0m to 8.0m
		E532049				0.1	27.0m-28.0m
						0.1	37.0m to 38.0m
GW067108	0.6km NE	N6799439	Domestic	-	18.50	0.9	22.0m to 30.0m
		E5321132	Stock				
GW300053	2.8km N	N6801301	Stock	36.0m	9.0m	6.6	23.0m to 30.0
		E531847					
GW300375	0.6km NE	N6799334	Domestic	40.0m	25.0m	1.5	0.0m to 40.0m
		E532124	Stock				
GW302233	2.9km SW	N6795953	Stock	-	-	-	-
		E530360					
GW302234	2.9km SW	N6795891	Stock	-	-	-	-
		E530389					
GW303341	2.0km NE	N6800574	Stock	-	-	-	-
		E531935					

The logs reported shallow and deep water bearing zones depending on the location of the bores. The shallow water bearing zones were generally reported in low lying areas (i.e. <10mAHD). Groundwater bores located along Hazlemount Lane to the north east of the Project Area appear to access a water bearing zone in excess of 20m depth (i.e. <10mAHD).

An existing wind mill and well is located on the Project Site adjoining the intermittent watercourse approximately 250m to the north east of the existing quarry and is at elevation less than 10mAHD. During all seasonal conditions ERM understands that the water in the well stands at approximately 0.5m below ground surface.

3.2.1 *Hydrogeological Assessment*

Geological investigations undertaken encountered groundwater in six boreholes advanced across and adjacent to the Project Area (Coffey Geotechnics, 2007). Relatively high standing water levels were recorded, following a significant rainfall event in excess of 500mm, in the three boreholes that were converted to monitoring wells (BH3, BH5 and BH6, *Figure* and to Coffey Geotechnics borelogs in *Annex C)*. A summary of the water level gauging undertaken is provided in *Annex D*.

Slug testing and Rising Head Testing was undertaken by Champions Quarry Environmental Officer in all four on-site groundwater monitoring bores. This involved initially gauging the standing water level in the bores then pumping water from the bores. Following pumping a groundwater depth probe was used to measure the depth increase of water in the bores over time as they recharged. The hydraulic testing sheets are provided in *Annex E*.

The data collected from the above Rising Head Tests was analysed by ERM using *AquiferTest*™ software to calculate the hydraulic conductivity (K) for each bore. The software analysis slug test data for unconfined aquifers using the Bouwer-Rice (1976) method and the Hvorslev (1951) method. As a result the Bouwer-Rice method may provide a more accurate calculation of the hydraulic conductivity. However, in practice, the results from both tests are often quite close.

The following *Table 3.3* contains the result of the hydraulic conductivity analysis for bores BH3 BH5 and BH6. The *AquiferTest*™ graphical output for each bore and test are provided in *Annex F*.

Table 3.3 Hydraulic Conductivities

	Conductivity (K, m/s)	
Borehole	**Hvorslev**	**Bouwer-Rice**
3	2.15E-07	1.24 to 2.3E-7
5	2.83E-07	1.12E-07
6	4.55E-08	1.55E-08

The overall results indicate very low recharge rates and low calculated conductivity (K = E^{-7}m/s to E^{-8}m/s) in the three monitoring bores. This suggests that the groundwater encountered is likely to represent shallow perched seepage water in the sandstone. It is noted that the monitoring, while screened at depth are sand-packed to near ground surface (refer bore logs in *Annex C*).

It is also noted that the groundwater gauging and slug testing events occurred immediately following significant rainfall in January 2008, which led to local and regional flooding. ERM understands that groundwater was also observed flowing from surface seepages at higher elevations on the southern ridgeline within the Project Area at this time.

In the absence of information or groundwater flow data for the Project Area, it can be reasonably assumed that shallow perched groundwater will generally follow the landform and flow in an east to north easterly direction towards Tucki Tucki Creek.

3.2.2 *Groundwater Quality*

The groundwater borelogs indicate that the deeper aquifer beneath the region (<10mAHD) is generally suitable for stock purposed and domestic applications.

EAL laboratories of Lismore have undertaken preliminary groundwater sampling on behalf of Champions Quarry during February 2007, with samples collected from monitoring bores BH3, BH5 and BH6. The EAL analytical reports for BH3, BH5 and BH6 are provided in *Annex H*.

The analytical data indicates that the pH of shallow perched groundwater across the Project Site is slightly to mildly acidic (consistent with the soil pH) and contains low levels of nutrients and non-organics. It is noted that in the first round of data collected that elevated Total Petroleum Hydrocarbons (TPH) were detected at sampling location BH6. As this was considered anomaly at the time, or perhaps caused by the drilling activities, EAL re-sampled after further developing the bores. The subsequent results did not identify significant levels of TPH in the groundwater water samples as previously discussed in *Section 3.1.4* above. The potential source of the recorded TPH levels was not determined, however it is considered possible they may have resulted from the drilling activities (i.e. hydraulic or lubricating oils). There is currently no bulk storage of fuel or oils on-site.

3.3 POTENTIAL WATER RESOURCES IMPACTS

3.3.1 Water Quality and Environmental Flows

Appropriate soil and water management will ensure there are minimal impacts on water quality and on the quantity of runoff.

Discharges from the pits and other disturbed areas have the potential to adversely affect water quality unless the water is adequately treated. The primary concern for water quality is in relation to increased sediment loads in Tucki Tucki Creek.

All water used as part of the quarry and sand washing operations is to be diverted via formed catch drains to a series of linked settling ponds. Sediment control devices will be installed between the sediment ponds in the form of rock filters (refer *Figure*). This will allow the removal of sediment from the catch drains, adjacent to each rock filter as part of routine maintenance.

Plant filters and a pond–riffle system of channel design will also be used upslope of the recycling dam (refer *Figure*).

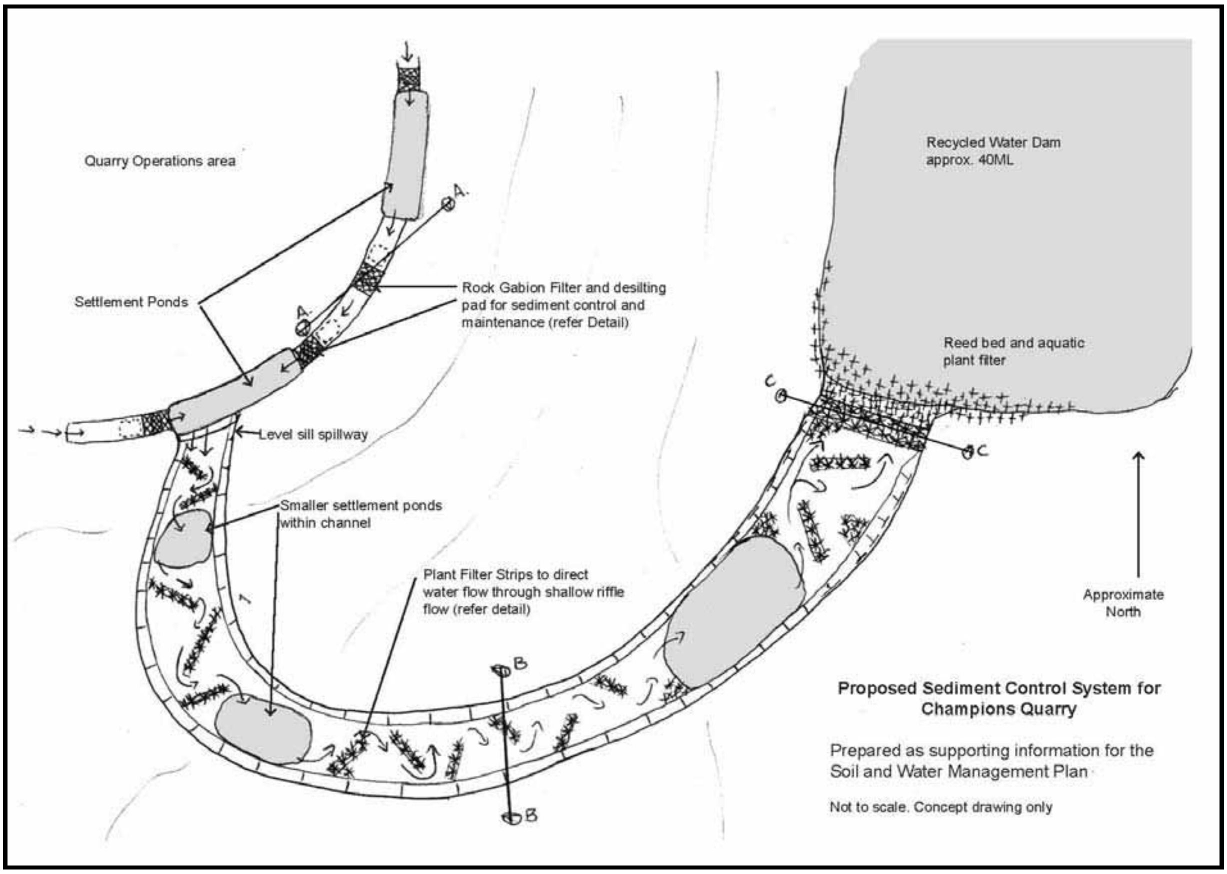


Figure 3.3 ***Indicative Proposed Sediment Control System*** ***(source: Champions Quarry)***

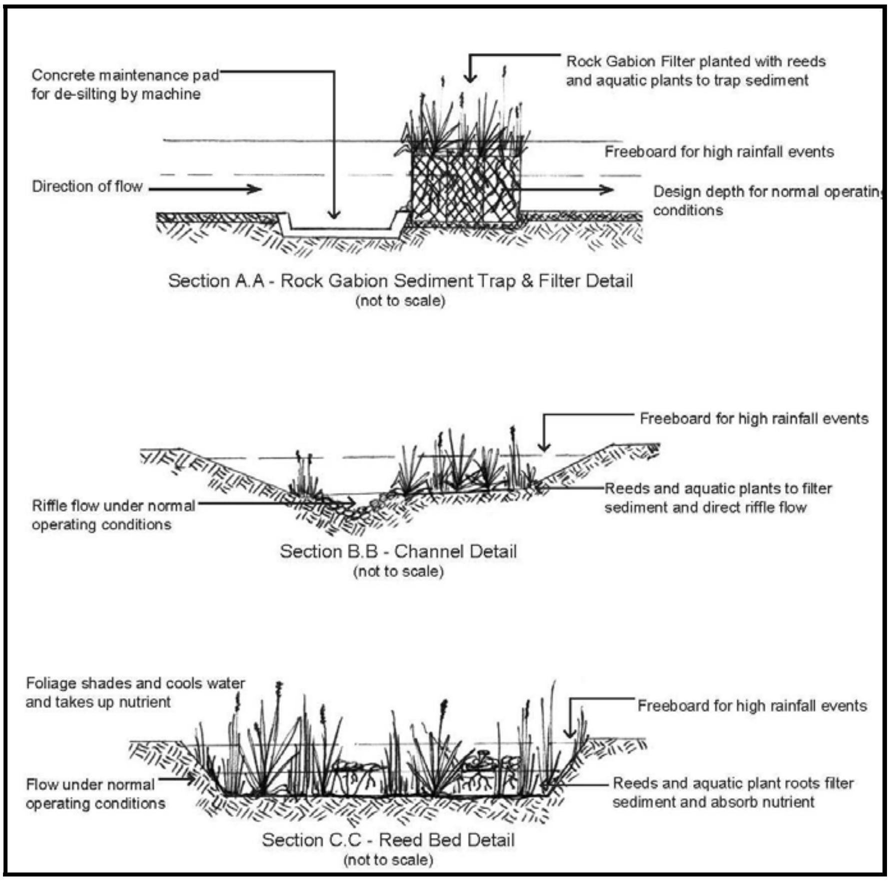


Figure 3.4 ***Indicative Proposed Plant Filters*** ***(source: Champions Quarry)***

Given the location of the Project Area within the upper reaches of the catchment, and the limited area to be disturbed for the quarry operations, it is unlikely that the quarry will cause significant changes to the environmental flows in the tributaries or Tucki Tucki Creek.

3.3.2 *Diversions and Downstream Drainage*

Clean water will be diverted around disturbed areas in contour drains or modified channels. This will have minor effects to local flows. Appropriate design in accordance with Landcom, NSW (2004) *Managing Urban Stormwater - Soils and Construction* and management of contour drains will minimise potential for erosion as well as off-site transport of suspended sediments. Dirty water will be retained in settling ponds located at the toe of each of the active 3 hectare 'work cells' and then directed into the reuse dam.

All clean water flowing from the Project Area will pass through existing established reed beds within the Project Site before leaving the proponents property and reaching Tucki Tucki Creek (and floodplain). This will be further expected enhance the quality of waters flowing from the Project Area.

3.3.3 *Groundwater Interception*

As the quarry expands laterally and vertically it is not expected to intercept the groundwater table. The average proposed depth of extraction of 12mAHD in the central section and 8mAHD in the southern section will ensure that the deeper regional aquifer beneath the Project Area is not intercepted. Based on the hydrogeological properties encountered during the investigations discussed in *Section 3.2* above, shallow perched groundwater identified within the extraction zones is not expected to result in significant levels of seepage into the quarry pits. This is further supported by the conditions experienced in the existing quarry pit where significant seepage is not encountered.

It is considered likely that the extraction of the sandstone resource will result in a lowering of the perched water table profile, with any minor seepage from quarry walls likely to be lost via evaporation.

3.3.4 *Water Supply*

The proposed quarry expansion and operations will significantly increase the annual water demand as discussed in *Section 4 below*.

4 WATER MANAGEMENT

A water management plan for the quarry has been developed to:

- ensure adequate water supplies under most climatic conditions, and
- safeguard the integrity of downstream watercourses and lowlands.

The following sections assess water requirements, available water sources and management controls.

4.1 WATER DEMANDS

Water will be required in the following areas:

4.1.1 *Employee Use*

Water will be required for toilet and hand basin use with smaller quantities being used for personal consumption. An average of 50 litres per person per working day has been assumed for design purposes. A workforce of 10 will have a daily demand of 500 L and an annual demand of up to 0.25 megalitres (ML).

4.1.2 *Process Water*

The proposal would see water used in the processing plant during screening and washing, and for dust suppression at conveyor transfer points. Water would also be used during crushing, however as crushing is expected to occur only infrequently the quantities of water used would be low compared with other processes, and are ignored within the water balance.

Conservative estimates of process water consumption were made in consultation with the quarry operator and are summarised in *Table 4.1* below. The estimates are based on a worst-case scenario. It is also noted that a high recycle percentage (estimate at 90% efficiency) is achievable by collecting, treating and reusing wash water and this is included in the water balance.

In round figures it is conservatively estimated that up to 44 ML of process water would be used annually, the majority of this consumed during production of washed sand.

Table 4.1 Process Water Consumption

Process Description	Annual Production Rate*	Production rate	Water Use	Water Use	Water Use	Water Throughput Annually	Re-Use	Water Usage Annually
	(t)	(t/hr)	(L/hr)	(L/min)	(L/t)	(L/year)	%	(L/year)
Washed Sand Screening Dampening	87500	120	10800	180	90	7875000	0.9	787500
Washed Sand Screen Head Washing	87500	120	36000	600	300	26250000	0.9	2625000
Washed Sand Bucket and Spiral Washing	62500	86	428571	7143	5000	312500000	0.9	31250000
Washed Oversize Screen Discharge Dampening	3000	34	7800	130	228	684000	0	684000
TOTAL						**347309000**		**35346500**
Loam Screening Feed Dampening	18750	150	10800	180	72	1350000	0	1350000
Loam Screen Discharge Dampening 1	12500	100	7800	130	78	975000	0	975000
Loam Screen Discharge Dampening 2	6250	50	7800	130	156	975000	0	975000
TOTAL						**3300000**		**3300000**
Soil Screen Feed Dampening	37500	200	10800	180	54	2025000	0	2025000
Soil Screen Discharge Dampening 1	25000	133	7800	130	59	1475000	0	1475000
Soil Screen Discharge Dampening 2	12500	67	7800	130	117	1462500	0	1462500
TOTAL						**4962500**		**4962500**

Note: * - some materials go through a number of processes

4.1.3 *Dust Suppression*

Water will be required for dust suppression on internal access roads, haul roads and on stockpiles within the quarry. Demand has been estimated (this is based on a worst case scenario whereby internal roads aren't sealed, however it is noted that the project description provides for the tar sealing of the majority of the internal road system) by the quarry operator on the basis of past experience, and the following factors:

- total area requiring dust control equals 11,000m^2 (7,000m^2 of roads; 4,000m^2 of stockpiles);
- 200 days requiring dust control per year (expected worse case scenario);
- use of a water truck with boom sprays, making 3 passes per day; and
- water truck applying approximately 1 mm of water per pass (i.e. 3 mm per day, or 3 L/m^2/day).

Water throughout for dust suppression is estimated at 33,000 L/day, or 6.6 ML/year.

4.1.4 *Product Moisture*

Certain types of material such as road bases and washed sand are required to have a moisture content of around five to seven per cent. Quarried material is wetted during screening and washing and in most cases this will supply the necessary moisture content. Nevertheless, an allowance is made for a worst-case scenario where the washed sand is stockpiled, dries completely and needs rewetting to 5% moisture. At an annual washed sand production rate of 50,000 tonnes the required volume of water to obtain 5% moisture is 2.5 ML.

4.1.5 *Truck Washing Facilities*

Mobile plant used in quarry operations will need to be cleaned as part of general maintenance and prior to servicing. Water used in vehicle washing will be treated to remove coarse grit before being recycled back into the quarry water system by discharging to the process area sediment dam. A nominal conservative allowance of 10,000 litres a month (0.12 ML/year) was made to allow for water lost through evaporation and vehicle wetting.

4.1.6 *Total Water Demand*

The total water demand for processing, dust suppression, adding product moisture, and truck washing is conservatively estimated at approximately 53.5 ML/year. Water of different qualities can be used to meet quarry demands. Drinkable quality water (potable) will be used for domestic and employee uses while poorer quality water (non-potable) will be used for all other purposes. The majority of demand is for non-potable water that could be sourced from stormwater harvesting, or pumped from groundwater. A very small component is potable water (0.12 ML/year) that could be sourced from roof water collection in tanks, or purchased.

4.1.7 *Potable Water Supplies*

Champions Quarry is not currently connected to mains water supply, however connection is available if required. Drinking water for quarry staff will be supplied through bottled water stored at the quarry office.

4.1.8 *Non-Potable Water Supply*

Non-potable demands will be supplied from on-site storages, both sediment basins and a large clean water catchment dam. These will serve all non-potable water requirements for the quarry including product washing, dust control, vehicle washing and product moisture control. Groundwater may be sourced form an existing bore in situations where supply of non-potable water is low, e.g. during extended dry weather periods.

4.2 *WATER STORAGES*

Two major storages are proposed (yet to be constructed), one being situated within a natural drainage paths comprising largely undisturbed (clean water) catchments, the second being an off stream dam. They are referred to as the *Water Supply Dam* and the *Water Reuse Dam* with approximate sizes of 40ML each. The objective is to construct the *Water Reuse Dam* first, building the *Water Supply Dam* when required as the quarry develops.

Additional storage will be provided by quarry pit sediment basins, whose number and size will vary throughout the operation. At any one time there may be between 3ML and 6ML of storage available in sediment basins.

4.2.1 *Catchment Yields*

Annual catchment yields were estimated for the *Water Reuse Dam* and *Water Supply Dam* for dry, normal and wet years, using long term annual rainfall statistics from Lismore (Bureau of Meteorology station No. 058037). The 10-percentile annual rainfall at Lismore (a dry year) is 900 mm; the 50-percentile annual rainfall (a normal year) is 1270 mm and the 90-percentile annual rainfall (a wet year) is 1922 mm.

Catchment yields were estimated by multiplying catchment areas by rainfall depth by an annualised volumetric runoff coefficient (Cv). Data on long term volumetric runoff coefficients is scant and so an estimate has been made with reference to Landcom (2004) and also the regional runoff coefficient adopted by NSW Department of Water and Energy (DWE) when assessing harvestable rights for farm dams. From Table F2 in Landcom (2004), Cv ranges from 0.01 for small rain events on rapidly drained soils, to 0.79 for large rain events on impermeable soils. However, these runoff coefficients are for short-term rain events and are significantly higher than occurs annually. By comparison, harvestable rights calculations for this area adopt an annual runoff coefficient of 0.09 (i.e. 9% of volumetric rainfall converts to runoff annually).

For undisturbed, grassed catchments (the majority of *Water Supply Dam* catchment area) a Cv of 0.09 is adopted. For roads and quarry floors (the majority of *Water Reuse Dam* catchment area) a Cv of 0.2 is adopted. There is a high degree of uncertainty over the actual volumetric runoff coefficient; however, the estimations made here are sufficient for the purpose of this analysis. It is probable that Cv is higher than 0.2 from disturbed quarry areas, providing a factor of safety within the water balance.

The results are summarised in *Table 4.2*.

Table 4.2 Catchment Yields for Major Storages

	Water Supply Dam	***Water Reuse Dam***	**Total**
Catchment Area (ha)	19	13	32
Annual Runoff Coefficient (Cv)	0.09	0.2	
		Catchment Yields (ML)	
10%ile rain year (900mm)	15.4	23.4	38.8
50%ile rain year (1270mm)	21.7	33.0	54.7
90%ile rain year (1922mm)	32.9	50.0	82.8

The Farm Dams Policy implemented by DWE includes a process for calculating harvestable rights. Under this policy the rural harvestable right for this area is 0.12 ML/hectare, i.e. for every hectare of land up to 0.12 ML of storage may be provided in dams without the need for dams to be licensed. For dams exceeding the harvestable right a license must be obtained.

Harvestable rights are generally allocated to each separate allotment; however contiguous allotments under the same ownership may combine the harvestable rights to allow larger centralised storage subject to DWE approval.

Dams that are exempt from harvestable rights calculations include those specifically sized for control or prevention of soil erosion, and dams for the capture, containment, recirculation of drainage and or effluent. This is applicable to the proposed treatment and reuse of water from the small sand washing plant as part of the proposed commercial quarrying operation.

ERM have consulted the former DWE in relation to water harvest rights and licensing of the proposed water storage and harvesting dams. These discussions have clarified the Maximum Harvestable Right Dam Capacity (MHRDC) for the Project Site; licensing requirements and exemptions for proposed dams; and rights and responsibilities under the *Water Act 1912* (the "Water Act") and *Water Management Act 2000* (the "WM Act"). The water management strategy outlined in this SWMP incorporates the advice given by DWE, which confirmed the following:

- the MHRDC for the properties "Reavill Farm Pty Ltd" and "Tucki Hills Pty Ltd" are 27.2ML and 12.68ML, respectively;

- the proposed 40 ML *Water Reuse Dam* that would be used for collection and recirculation of quarry stormwater runoff is exempt from licensing and calculation of harvestable right use;

- the proposed 40 ML *Water Supply Dam* must be considered in the calculation of harvestable right use and must be licensed to be constructed larger than the MHRDC capacity. However, a pipe should be installed to set the top water level at the MHRDC;

- to utilise the full capacity of the *Water Supply Dam* an annual volumetric entitlement must be obtained by purchasing an existing water license to the satisfaction of DWE and the top water level set to the aggregate of the available MHRDC and purchased allocation; or

- the two properties Reavill Farm Pty Ltd and Tucki Hills Pty Ltd can be treated as one for MHRDC calculations provided Reavill Farm Pty Ltd takes a lease out over the Tucki Hills Pty Ltd property.

It is proposed that Reavill Farm Pty Ltd will lease the property from Tucki Hills Pty Ltd so that the MHRDC of the two properties can be combined. The combined MHRDC is 39.88 ML. This is approximately equal to the capacity of proposed *Water Supply Dam* (40 ML). The volume of existing storages on both properties is minimal, therefore, the available harvestable rights dam capacity is 39.88 ML.

4.2.2 *Dam Construction*

Water Supply Dam

The *Water Supply Dam* (40 ML) is to be constructed at the confluence of two intermittently flowing first-order streams to the north of the main access road. It would have a catchment area of approximately 19 ha comprising moderately sloping bush and grassland. The opportunity exists to construct a contour bank around the hillside to the north of the Dam to increase its catchment area. This work would be undertaken in the future should the need arise.

Harvested water would be delivered from the *Water Supply Dam* to the *Water Reuse Dam* either by gravity pipeline, if the levels permit, or if necessary by pumping using a high flow diesel pump.

Construction of the *Water Supply Dam* and any associated contour banks would not trigger the "controlled activity" provisions of the WM Act. The watercourse on which The Water Dam is to be located is a "minor stream" which does not meet the definition of "waterfront land" under the WM Act.

The *Water Supply Dam* would require a water license with the DWE under the Water Act. The licensing provisions of the WM Act do not yet apply to the area as a Water Sharing Plan is not in place. Once a Water Sharing Plan for the catchment is gazetted the water license would be converted to a water access license under the WM Act.

Water Reuse Dam

The *Water Reuse Dam* (40 ML) is to be constructed "off-line" in a position down hydraulic gradient of the proposed *Central* section quarry pit. The function of the *Water Reuse Dam* is to collect and recycle process water and stormwater runoff from the central and southern quarry pits. Process water for the crushing and washing plants and for dust suppression would be pumped from the *Water Reuse Dam* to the processing plant.

A contour bank would be constructed around the hillside downslope of the main access road and central quarry pit, to the northwest of the *Water Reuse Dam*, to capture and divert into the *Central* section quarry water that overflows the central quarry pit sediment basins. The *Water Reuse Dam* will then provide additional sediment capture and water quality control, particularly during peak storm events that may exceed the collection and treatment capacity of the smaller sediment basins. The sediment basins and associated sediment control devices will provide the primary means sediment capture and water quality control

A gravity contour bank and pipeline would be constructed between the sediment basins at the lower end of the southern pit, and the *Water Reuse Dam*. Water collected in the basins would undergo primary desilting prior to draining through the series of sediment control devices comprising rock filters and plant filter strips for additional water quality control prior to reaching the to the *Water Reuse Dam*. It is the intention to use this *Water Reuse Dam* to mediate between recycling and using runoff, to manage water levels at around 50% capacity such that during peak rainfall events the smaller sediment basins will drain to the *Water Reuse Dam* and not discharge into the water courses.

It is considered that the *Water Reuse Dam* qualifies as "excluded works" under *Schedule 1, Section 3,* of the WM Act, being a dam "*solely for the capture, containment and recirculation of drainage and/or effluent*". As such the *Water Reuse Dam* is exempt from licensing and calculation of harvestable right use.

Construction of the *Water Reuse Dam* would not trigger the "controlled activity" provisions of the Water Management Act 2000 as the works would not occur on or within the prescribed distance of waterfront land.

4.3 PRELIMINARY WATER BALANCE

A simple annual water balance was initially used to compare quarry water demands with the volume of water which could be realistically collected within the Project Site, and is used to predict the security of supply and the magnitude of any water surplus, or deficit.

The catchment yields estimated above may be greater than the effective yields due to factors like storage overflow when full, and seepage losses from poorly sealed storages. Additional losses may occur where there is net evaporation from the storage surface. In this water balance we have assumed that any dams would be well sealed and seepage losses would be negligible. We have also assumed that storages would be sufficiently large to ensure overflow losses are negligible. Further, it is assumed that there are no net evaporation losses, with annual rainfall generally exceeding annual evaporation within this area.

The data in *Table 4.1* indicates that the annual water demand would be met in a median (50-percentile) rain year with a predicted yield of 54.7 ML. During wetter years there will be a surplus of water, however during drier years there may be a shortfall of water that might need to be supplemented from alternative supplies or production practices modified to conserve water. Based on the preliminary water balance the overall security of water supply under this proposal is deemed to be acceptable.

A more detailed water balance has been conducted by Strategic Environmental and Engineering Consulting (SEEC, refer *Section 4.6*) to confirm the findings and ensure the quarry has sufficient security of supply to meet demands while also minimising discharges to downstream waters from the operational quarry areas.

Water quality of discharges from the Water Reuse Dam will be managed through a program of monitoring and implementation of controls such as pH adjustment and sediment flocculation. Discharges will be managed via irrigation to land within the Project Site and/or discharges downstream when required. It is noted that the natural water quality conditions both on-site and for receiving waters are typically tending toward slightly acidic. Sediment is to be removed from the Sediment Dams and the *Water Reuse Dam* periodically as required to maximise the available water storage volume.

4.3.1 Pit Seepage

As previously discussed, groundwater seepage is not expected to add significantly to the overall water balance at the quarry. This is primarily due to the nature of the shallow unconfined groundwater stored within the porous sandstone. The excavation of the sandstone resource is considered likely to result in a lowering of the shallow sandstone groundwater profile thus limiting storage of water above any confining layers (i.e. siltstone). The recharge rates identified in the on-site groundwater bores are not considered typical of a confined aquifer or significant source of groundwater.

4.4 IMPACT ON CATCHMENT HYDROLOGY

The *Water Supply Dam* has a total catchment area of approximately 19ha and would be constructed at the confluence of two first order watercourses. The second order watercourse downstream of the *Water Supply Dam* (denoted watercourse 1) is mostly dry, with water flowing only after significant rainfall events. Watercourse 1 is joined downstream by several first order watercourses and is then piped beneath Hazlemount Lane, approximately 800m east of the *Water Reuse Dam*. Thereafter, flows along watercourse 1 become indistinct as the watercourse enters very flat, partially cleared lands to the east of Hazlemount Lane. This land area adjoins Tucki Tucki Creek approximately 1.5km east of Hazlemount Lane. During flood events water flows generally south east over adjoining flood prone lands.

At the culvert crossing of Hazlemount Lane watercourse 1 has a catchment area of approximately 140ha. A reduction of approximately 32ha from its surface catchment area due to construction of the *Water Supply* and *Water Reuse Dams* would be expected to have a minor impact on the magnitude and frequency of sub-catchment surface water flows (i.e. for small storm events) within watercourse 1.

The *Water Reuse Dam* is to be constructed off-line and next to an unnamed first order watercourse (denoted watercourse 2), with a catchment area of approximately 13 ha measured at its downstream confluence with watercourse 1. Construction of the *Water Reuse Dam* would result in the loss of approximately 4ha of the catchment area of watercourse 1. This would have a negligible impact on the magnitude and frequency of sub-catchment surface water flows within watercourse 2.

It is further noted that watercourse 1 and watercourse 2 are located in cleared grazing land with limited habitat value. These streams are both influenced by seepage and spring activity which is likely to dominate low flow conditions in the lower reaches of the watercourses downstream of the proposed quarry expansion. These factors would limit the impact of the loss of surface water catchment due to the proposed quarry extension and associated dams.

4.5 WATER QUALITY MANAGEMENT

Management of water quality will minimise potential impacts of the operations on watercourses and Tucki Tucki Creek.

During construction and operation of the quarry, drainage facilities will convey water from areas of disturbed ground to sediment basins which will then drain to the *Water Reuse Dam* to prevent sediment laden or potentially contaminated runoff leaving the Project Area. Details of drainage from undisturbed and disturbed areas of the Project Area and Project Site are provided in *Sections 4.5.1* and *4.5.2* respectively.

Water quality will be monitored as outlined in *Section 4.6* to confirm the efficiency of the drainage system. Water quality devices will be inspected and cleaned regularly.

4.5.1 Surface Drainage from Undisturbed Areas

In general, runoff from undisturbed areas will be diverted around areas disturbed or affected by quarry activities. This will reduce the potential for clean runoff to be polluted by quarry activities. Diversion of clean water will be affected by diversion drains, contour drains and, where necessary, bunds, and pipe culverts designed in accordance with the *Managing Urban Stormwater - Soils and Construction 'Blue Book'* (Landcom, NSW 2004). Examples of typical construction methods including temporary erosion sediment control measures to be used are provided in *Annex G*.

All permanent diversion elements will be designed with capacity to convey critical flows from a 1 in 20 year Average Recurrence Interval (ARI) storm event. Temporary drains may be designed for smaller storm events depending on their design life – typically, elements that will be in place for less than 6 months would be designed for a 1 in 5 year ARI storm. Diversion elements that will be in place for more than 2 years should be considered "permanent".

Diversion drains and contour drains will be constructed as channels and/or banks depending on topography. Where practical, drains will be lined or vegetated and longitudinal gradients will be limited to 1% to minimise the risk of erosion. Where necessary, check dams and sediment basins will be constructed at intervals along diversion drains at locations with greater erosion potential. At points of concentrated or high velocity flows, spreaders, lining and dissipaters will be constructed.

A conceptual drainage plan is provided in *Figure* . There are two main points to note in regards to drainage from undisturbed areas:

1. Quarrying will operate in a maximum of three by three hectare 'work cells' allowing for staged rehabilitation of the quarry pits. Therefore, sediment ponds have been designed to treat runoff from this operational scenario.

2. Treated water from the sediment ponds will be discharged either via overland flow (i.e. via level spreaders), or by water directing into the proposed on-site recycling water storage for reuse on-site as discussed above.

4.5.2 Pit Water and Runoff from Disturbed Areas

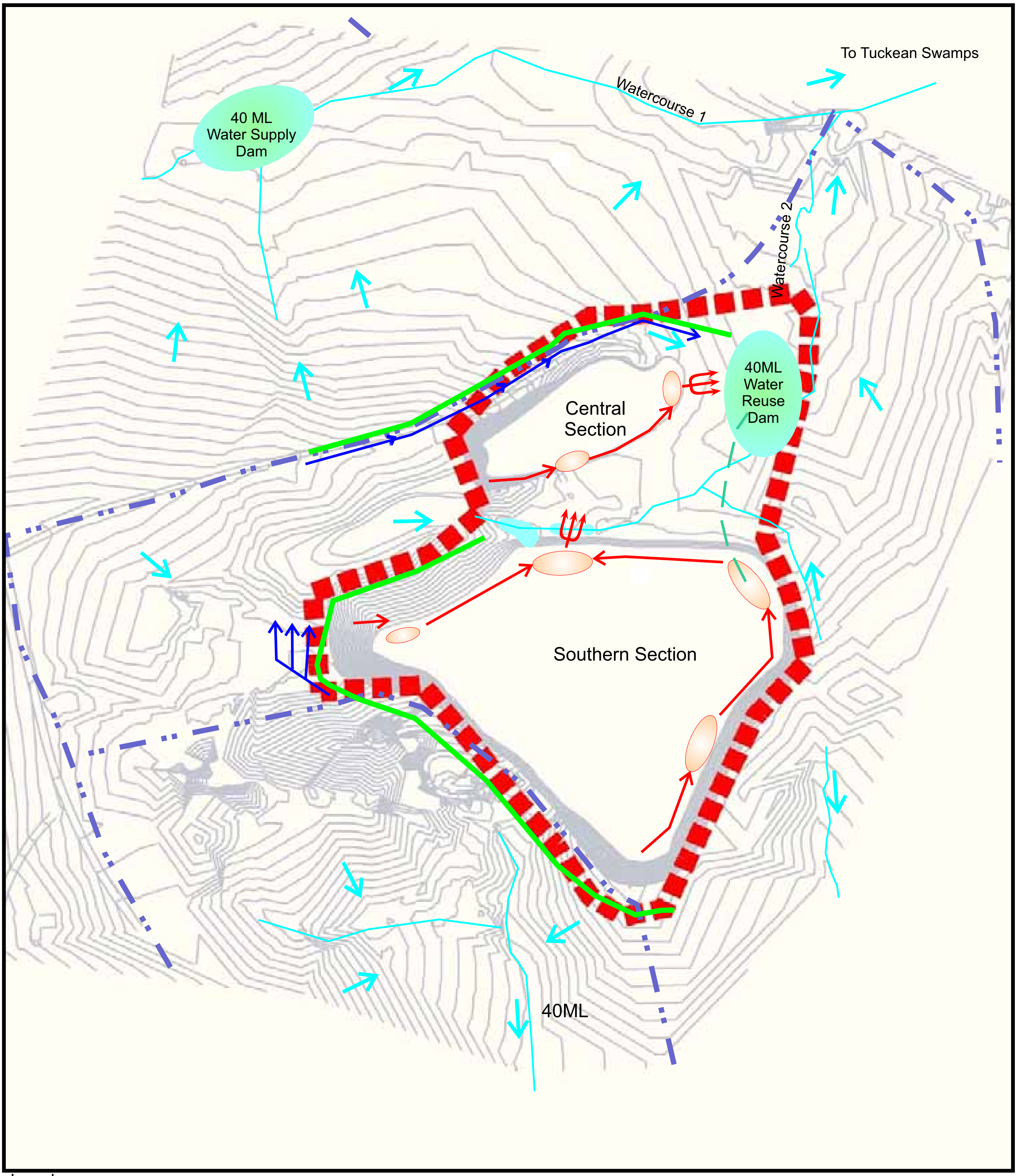
As far as possible, all water runoff within the pit, including any minor seepage groundwater inflow, will be directed to a series of settling basins to be constructed in the bottom of the active quarry pit.

The capacity of the sediments basins to control runoff from each 3ha cells (up to 3 cells) has been assessed and the results are provided below. Relevant calculations are shown in *Annex A*.

The capacities of the proposed sediment ponds were calculated for sediment capture to retain the 5-day, 80th percentile rainfall event as calculated using the revised Universal Soil Loss Equation (RUSLE) (Landcom, 2004). This is based on the assumption that all soil in the catchments including stockpiles are permanently disturbed.

The sediment settling pond volumes were calculated assuming conservative conditions (i.e. Type F Soils) to account for topsoil stripping and sand washing. Actual ground conditions are not expected to be as dispersive, particularly once topsoil and overburden stockpiles have been stabilised. Based on the conservative assumptions, the required pond volumes to treat sediment for one hectare and three by three hectare sites are 312m^3 and 2,808m^3 respectively.

All settling ponds will be required to be regularly de-silted to ensure that they are operating effectively.



Legend

- Access & Haul Roads
- New Dams
- Existing Dams
- Sediment Basins (Indicative)
- 2 metre contours
- Ephemeral Creeks
- Contour Bank
- Gravity pipeline
- Subcatchment Boundary
- Direction of Surface Drainage
- Catch Drain (dirty water)
- Level Spreader
- Level Spreader
- Upslope Clean Water Diversion

Figure 4.1

Conceptual Drainage Plan

Client:	Champions Quarry		
Project:	Champions Quarry Expansion		
Drawing No:	0098287pm_GIS04		
Date:	25/08/09	Drawing size:	A4
Drawn by:	AM	Reviewed by:	WW
Source:	VGT		
Scale:	Refer to Scale Bar		

N

0 40 80 120 160 200m

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ERM

Sediment control devices in the form of rock filters will be installed at regular intervals between the settlement ponds. These rock filters will be designed and installed to allow regular desilting maintenance to ensure that they are operating effectively. Additional sediment control devices including plant filter strips and smaller settling ponds, designed as a pond-riffle flow system are to be installed upslope of the *Water Reuse Dam*.

Long-term material stockpiles (i.e. topsoil and overburden) will be stabilised by seeding with seasonal grasses. All shorter term material stockpiles will be bunded to reduce run-on and to capture runoff. Appropriate sediment control measures (i.e. silt fencing, check dams etc.) will be established in accordance with *Managing Urban Stormwater - Soils and Construction 'Blue Book'* (Landcom, NSW 2004) where necessary to reduce the potential for sediment run-off. Examples of typical construction methods for temporary and long term erosion sediment control measures to be used are provided in *Annex D*.

4.5.3 Spill Response

It is important that all potentially contaminating materials used or stored on the Project Area during quarrying activities should be prevented from entering the groundwater or surface water systems. This will be achieved through storage in designated bunded areas (i.e. internally bunded shipping containers).

Provision of spill kits and training of quarry personnel in their use will ensure that in the event of any spills appropriate action can be taken rapidly to prevent and minimise impacts to surface waters or groundwater. Wherever possible, activities that have potential for spills will be located in areas that drain to the pit; otherwise appropriate safeguards and spill containment facilities will be installed.

4.5.4 Potable Water Supplies

Champions Quarry is not connected to mains water supply, however as previously discussed connection is available if required. Drinking water for quarry staff will be supplied through the bottled water cooler.

4.5.5 Sewage Effluent

A toilet, either composting or on-site septic disposal system, will be provided in the vicinity of the quarry office.

4.6 VERIFICATION WATER MODELLING

In order to confirm the findings of the preliminary water balance and adequacy of the proposed water management system a detailed water balance

(MUSIC) model were prepared by SEEC. The scope of the modelling exercise was as follows:

- to model the *Project Area* in 12-monthly periods of dry and wet weather to evaluate:
    - the confidence of water supply (i.e. surface water capture), providing graphical output of predicted storage fluctuations;
    - the predicted outflow from the *Project Area* (mean annual volume and time series);
    - the predicted mean annual nutrient and sediment loads and cumulative concentrations.

4.6.1 *Music Model Inputs*

MUSIC is an computer modelling software package designed to simulate urban stormwater systems operating at a range of temporal and spatial scales, catchments from 0.01 km^2 to 100km^2 and modelling time steps ranging from 6 minutes to 24 hours to match the catchment scale.

The MUSIC modelling of the *Project Area* and proposed quarrying activities was undertaken for two scenarios as follows:

- at approximately half the proposed open quarry area (i.e. during early expansion stages) being 4.5ha of disturbed land; and
- at the maximum proposed open quarry area of 9ha.

The modelling assumes 50ML and 53ML are required for operational purposes for the start-up and maximum open quarry area scenarios respectively.

The two operational scenarios have been modelled using three Bureau of Meteorology (BoM) rainfall data sets in six minute time steps as follows:

1. Lismore (2003) – a relatively dry year with 761mm of rainfall;
2. Lismore (2004) – a relatively normal year with 945mm of rainfall; and
3. Alstonville (1979) – to represent a wet year of 1,474mm of rainfall.

Daily time steps were also used to evaluate storage capacity requirements and levels. The following figures graphically represents the rainfall data sets used by SEEC.

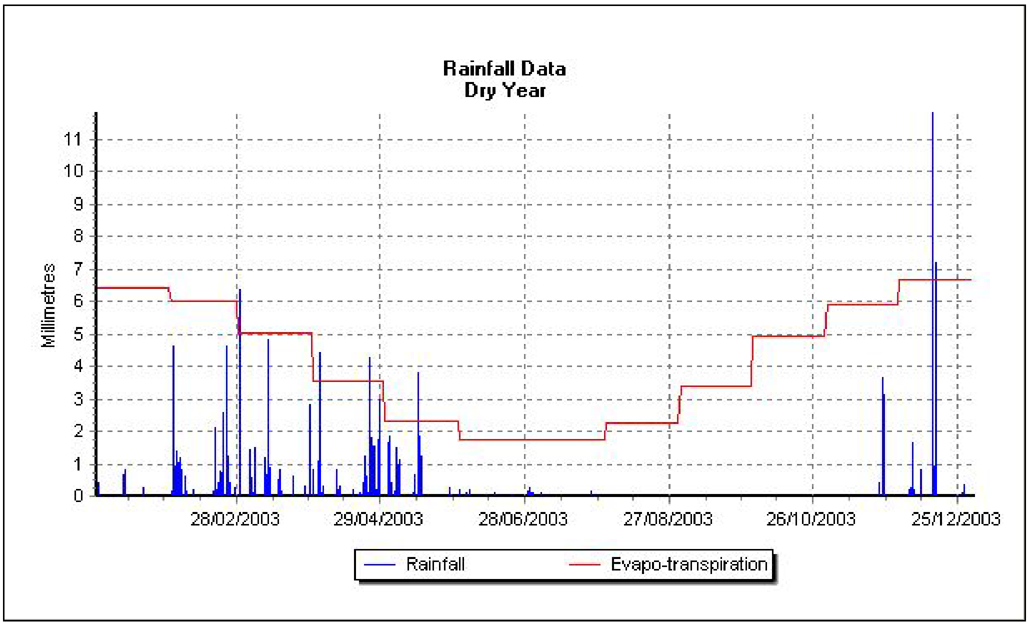

Figure 4.2 Lismore (2003) – Dry Year Rainfall Data (BoM)

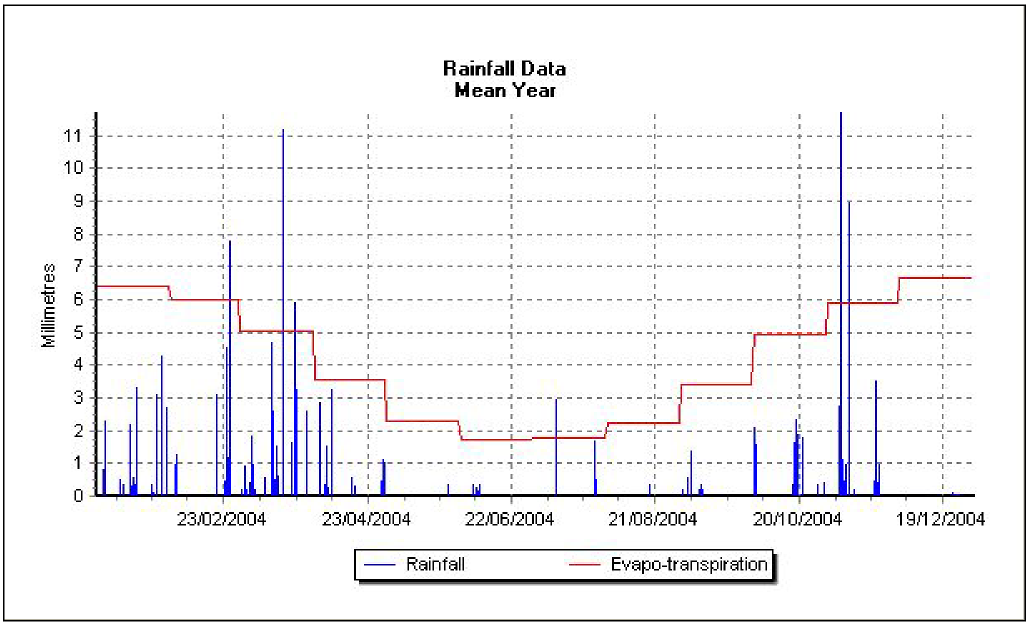

Figure 4.3 Lismore (2004) – Mean Year Rainfall Data (BoM)

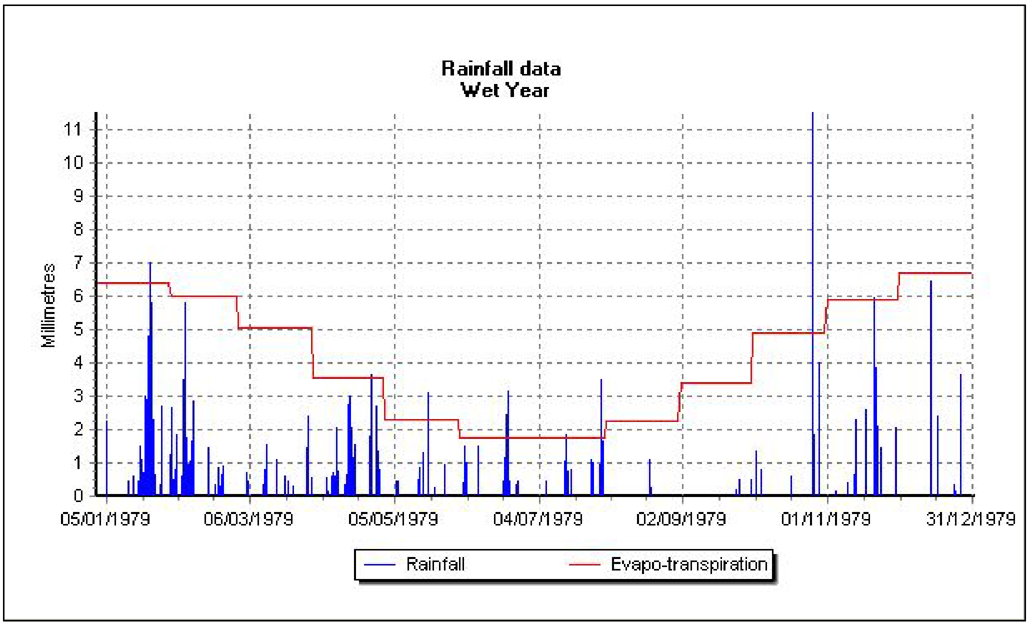

Figure 4.4 ***Astoneville (1979) – Wet Year Rainfall Data (BoM)***

Note, as there was insufficient data from the Lismore weather station to draw a representative wet year, data from the Alstonville station was used. Pan evaporation taken from the Lismore data set is 1,515mm per year, which equates to a Areal Potential Evapotranspiration (PET) value of approximately 1350mm per year, as input into the MUSIC model.

The modelling included pervious surfaces (soil) calibrated for 200mm of sandy loam over 300mm of light to medium clay, based on the soil landscape data for the Coffey Camp soil landscape. This equates to an average 500mm of estimated rooting depth of pasture. Actively quarried surfaces were modelled as impervious with a rainfall threshold of 3mm (i.e. 3mm of rainfall falling before runoff occurs).

To verify the adequacy of the proposed water management system the MUSIC model included the sediment basins as described in *Section 4.5.2* and the 40ML *Water Reuse Dam.* The Reuse Dam is to comprise of 34ML of permanent storage and 6ML of temporary detention. The 6ML of temporary detention is the approximate requirement for capturing *Project Area* runoff from the 95th percentile 5-day rainfall depth as is required by Volume 2e of *Managing Urban Stormwater* (DECC, 2009).

For the purpose of modelling, the area of the *Water Reuse Dam* is assumed to be 12 000m^2, being approximately 4m deep with 2:1 side batters.

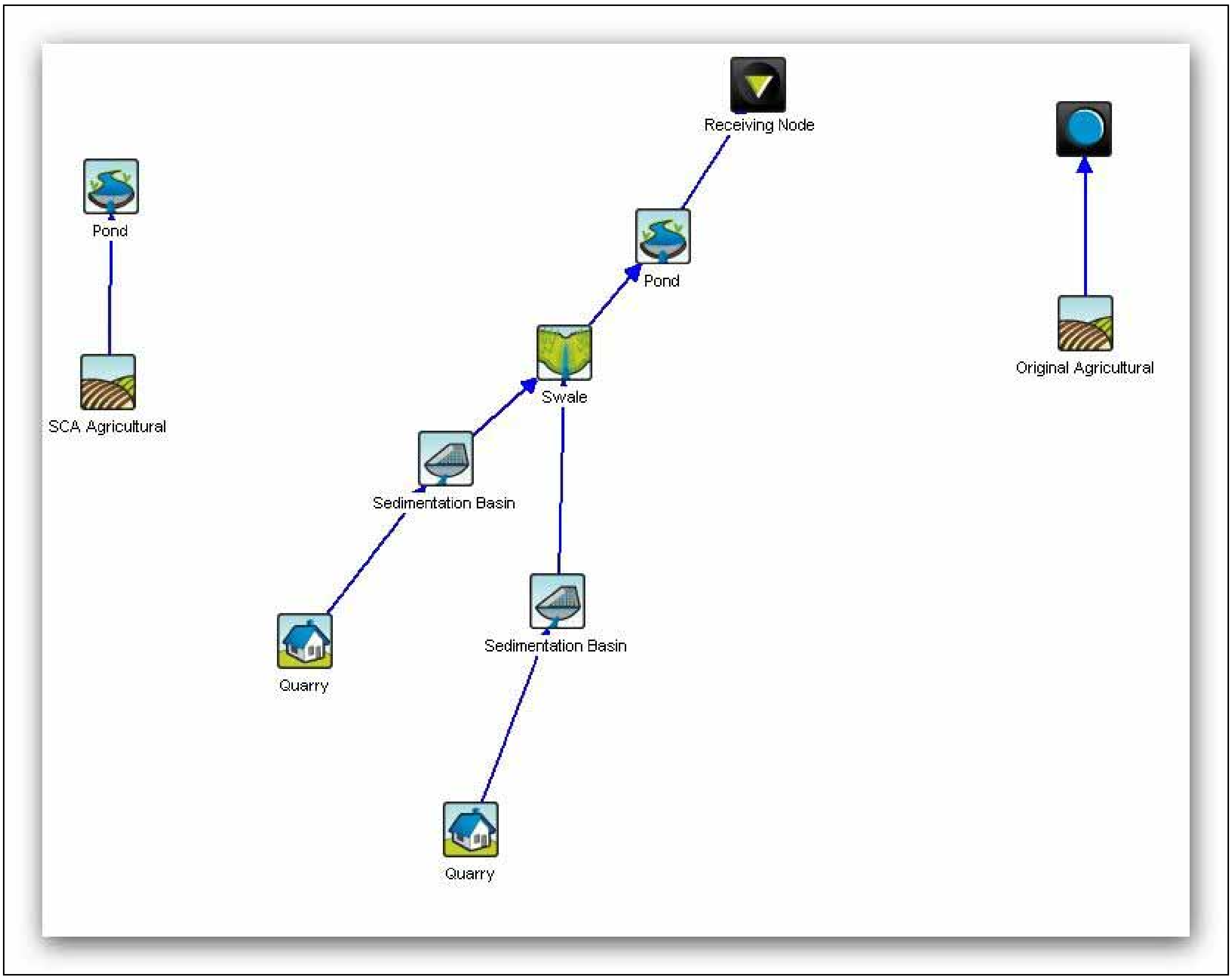

Figure 4.5 MUSIC Modelling Nodes (SEEC)

4.6.2 *Music Model Outputs*

The following information was obtained from the MUSIC modelling exercises:

- a time series flow-graph for the pond outlet in all models;
- an indication of volume of flows through the weir (i.e. maximum capacity) and volume of flows through the 150mm low flow orifice (i.e. set at 6ML temporary detention level);
- a graph of pond level for each model;
- a graph of pond storage for each model; and
- a prediction of mean annual pollutant loads from the pre-existing agricultural land use and the half and fully open quarrying operations.

All graphs are provided in *Annex K* and are summarised in the following sections.

4.6.3 *Water Supply Confidence*

The MUSIC models predict that the water supply confidence, with consideration of the 40ML *Water Reuse Dam* only (i.e. 36ML permanent storage), will meet almost all demand with little requirement to draw on other sources of water. The water supply confidence is summarised as follows:

- 88% in a dry year when the quarry is only half open;
- 98% in a dry year when the quarry is fully open;
- 97% in a mean rainfall year when the quarry is only half open; and
- 100% in all other modelling scenarios.

4.6.4 *Water Discharges from the Project Area*

The modelling undertaken by SEEC predicts that the *Water Reuse Dam* would rarely be expected to overflow when a minimum 6ML of freeboard is maintained for temporary storage. The dry and mean models demonstrate no weir overflow at all, with all discharge being via the low-flow orifice only.

Figure 4.6 provides the summary of MUSIC modelling predicted water discharges from the *Project Area*.

Dry fully open	**Pre**	**Pre**	**Post**	**Post**
	Flow (ML/yr)	19.20	Flow (ML/yr)	4.39
	Total Suspended Solids (kg/yr)	4760.00	Total Suspended Solids (kg/yr)	58.40
	Total Phosphorus (kg/yr)	11.00	Total Phosphorus (kg/yr)	0.40
	Total Nitrogen (kg/yr)	48.90	Total Nitrogen (kg/yr)	4.85
Dry half open	**Pre**	**Pre**	**Post**	**Post**
	Flow (ML/yr)	19.20	Flow (ML/yr)	0.00
	Total Suspended Solids (kg/yr)	2720.00	Total Suspended Solids (kg/yr)	0.00
	Total Phosphorus (kg/yr)	10.40	Total Phosphorus (kg/yr)	0.00
	Total Nitrogen (kg/yr)	54.60	Total Nitrogen (kg/yr)	0.00
Mean fully open	**Pre**	**Pre**	**Post**	**Post**
	Flow (ML/yr)	20.00	Flow (ML/yr)	25.50
	Total Suspended Solids (kg/yr)	2600.00	Total Suspended Solids (kg/yr)	365.00
	Total Phosphorus (kg/yr)	10.60	Total Phosphorus (kg/yr)	2.39
	Total Nitrogen (kg/yr)	51.00	Total Nitrogen (kg/yr)	31.30
Mean half open	**Pre**	**Pre**	**Post**	**Post**
	Flow (ML/yr)	20.00	Flow (ML/yr)	12.30
	Total Suspended Solids (kg/yr)	2000.00	Total Suspended Solids (kg/yr)	160.00
	Total Phosphorus (kg/yr)	9.89	Total Phosphorus (kg/yr)	1.13
	Total Nitrogen (kg/yr)	53.00	Total Nitrogen (kg/yr)	14.20
			Gross Pollutants (kg/yr)	0.00
Wet fully open	**Pre**	**Pre**	**Post**	**Post**
	Flow (ML/yr)	70.40	Flow (ML/yr)	65.00
	Total Suspended Solids (kg/yr)	10000.00	Total Suspended Solids (kg/yr)	1540.00
	Total Phosphorus (kg/yr)	44.70	Total Phosphorus (kg/yr)	6.56
	Total Nitrogen (kg/yr)	225.00	Total Nitrogen (kg/yr)	82.60
Wet half open	**Pre**	**Pre**	**Post**	**Post**
	Flow (ML/yr)	70.40	Flow (ML/yr)	48.50
	Total Suspended Solids (kg/yr)	10000.00	Total Suspended Solids (kg/yr)	1150.00
	Total Phosphorus (kg/yr)	44.80	Total Phosphorus (kg/yr)	4.88
	Total Nitrogen (kg/yr)	213.00	Total Nitrogen (kg/yr)	60.60

Figure 4.6 MUSIC Modelling Predicted Discharge Volumes and Pollutant Loads (SEEC)

In terms of discharge flow rates there will be little change from the half developed quarry to the fully open quarry area.

The MUSIC modelling indicates that there is expected to be a clear beneficial effect in terms of mean annual pollutants loads in all models from the pre-development runoff from agricultural grazing lands to the proposed controlled water management system. In addition the pollutant loads are predicted to be less or no worse than under existing conditions. As previously discussed other potential contaminants such as heavy metals or hydrocarbons are not expected to occur in runoff from the *Project Area*. This discussed further in *Section 4.7.3*.

It is noted that field observations made both during and immediately after high rainfall events have demonstrated that flows from the *Project Area* in its current form, including the existing quarry, that runoff from the *Project Area* is significantly less turbid than the nearest receiving water confluence at the culvert on Hazelmount Lane.

4.6.5 *Sediment Detention*

In order to meet the requirements of Volume 2e of *Managing Urban Stormwater* (DECC, 2008), 6ML of freeboard capacity will need to be available to capture the required 95th percentile, 5-day rainfall depth (95.3 mm). The extended detention was set in the MUSIC model to drain in 5 days via the 150mm orifice pipe. To ensure settlement of entrained sediments a management regime including flocculation may be required. The extended detention volume in the *Water Reuse Dam* could be increased to extend the residence time, if necessary. This will be achievable on the basis of ample water supply for operations from the *Water Supply Dam*. In the event that flocculation is required, water can be discharged at a slower rate via an automatic flocculater or a smaller-volume flocculation pond could be integrated into the *Water Reuse Dam* design.

Finally, it is noted that excess water is proposed to be applied over land within the *Project Site* during favourable climactic conditions (i.e. dry ground). This will enable water to be disposed appropriately while maximising freeboard storage. Given that the verification modelling did not included any input from the proposed *Water Supply Dam* there exists adequate surety of supply to enable a range of options to be considered for the final engineering design of the *Water Reuse Dam* for the treatment and disposal of any water emanating from the active *Project Area*.

Final detailed engineering design of the *Water Reuse Dam*, including discharge points and storage levels will be able to adequately accommodate the needs for management of operational water and *Project Area* runoff working within the modelled site parameters.

4.7 *SURFACE WATER MONITORING*

An operational surface water monitoring program will be designed and implemented as part of the quarry environmental management procedures. Water quality monitoring is proposed to be undertaken as outlined below on an ongoing basis. This monitoring should be refined where necessary based on the results of previous monitoring and ongoing quarry operations.

4.7.1 *Objectives*

Surface water quality monitoring will comprise sample collection and testing by a National Association of Testing Authorities (NATA) registered laboratory and will provide a mechanism to:

- ensure the quarry is operating as anticipated with respect to water quality protection;
- assess the effectiveness of water management strategies in protecting downstream water quality;

- identify any unforseen impacts from the quarry operations;
- implement measures to prevent any as yet unforseen impacts from the scheme; and
- verify that the quarry is achieving its environmental objectives.

4.7.2 *Sampling Locations and Frequency*

Water quality monitoring should be undertaken within the tributary of Tucki Tucki Creek or within Tucki Tucki Creek itself at a point immediately upstream and downstream of Tucki Tucki Creek to confirm that quarry operations are not impacting receiving waters.

Monitoring should initially be undertaken on a regular (i.e. quarterly) basis with additional monitoring following rainfall events and/or known discharges from the *Project Area*. It is likely, given the dry conditions of the drainage channel on-site, that samples would only be able to be collected following rain events. After an initial sampling period to understand the existing water quality, monitoring frequency may be reduced to (say) half yearly, provided water quality meets the performance criteria.

Monitoring should be commenced immediately upon Project Approval to gain an ongoing understanding of water quality in the tributary from the proposed quarry operations.

The *Water Reuse Dam* will be monitored regularly (i.e. weekly at minimum) for pH to identify any trends toward acidic conditions. Discharge water quality monitoring will also be conducted in the dam and the downstream reed beds. This will be undertaken to ensure all water discharged from the Project Area meets the relevant DECCW water quality criteria (i.e. for pH and suspended solids). *Table 4.3* provides a summary of the proposed specific surface water monitoring points and sampling details:

Table 4.3 Surface Water Monitoring Locations

Monitoring Point	Type of Monitoring Point	Type of Discharge Point	Description of location
1	Surface water monitoring - Upstream	NA	SW1 on *Figure 3.2*
2	Surface water monitoring – Downstream	NA	SW2 on *Figure 3.2*
3	Surface water monitoring – On-site watercourse	NA	SW3 on *Figure 3.2*
4	Surface water monitoring – Downstream of operational quarry	NA	Culvert on *Figure 3.2*
5	Water Reuse Dam	Dam discharge point	Near discharge point.
6	Effluent Quality	Recycling dam effluent discharge point – final reed bed	Stormwater overflow monitoring point for *Water Reuse Dam*

4.7.3 *Surface Water Monitoring Parameters*

A comprehensive suite of water quality parameters will be monitored initially to assist in gaining a comprehensive understanding of existing water quality conditions. Once the critical water quality parameters have been determined, regular monitoring will focus on these and the frequency of comprehensive monitoring will be reduced. The key water quality parameters for testing will to include pH, electrical conductivity (salinity), total suspended solids, and oil and grease (hydrocarbons) and selected heavy metals.

It is noted that heavy metals are not an expected feature of the identified sandstone resource. Geochemical investigation undertaken on sand materials from the site (refer Appendix B of EA, ERM 2010) have demonstrated the presence of iron oxide coated grains of sand. Some of this may be displaced during sand washing and returned to the *Water Reuse Dam* where it will be expected to settle out in sediments. As such, iron levels in any water discharges would not be expected to be in exceedance of the relevant water quality criteria for the protection of receiving waters.

As previously noted, the presence of thin veins of material containing pyrite in one core sample (refer Coffey Geotechnics, 2008 as provided in *Appendix B* of *EA*) is a potential very minor source for generation of AMD. Given the relatively small amount material potentially containing pyrite in relation to the whole sandstone resource, and as all Project Area water is to be collected for reuse, monitoring and treatment (if required), it is concluded that AMD will not be a significant issue at the quarry.

Specific parameters (i.e. pH) may need to be reviewed during the monitoring program to evaluate the optimum outcome for the water quality of discharge waters. It is noted that the pH of nearby soil and receiving waters are mildly acidic.

As discussed in a letter from Professor Ian White FTSE the natural acidic soil conditions encountered at the Project Site and the subsequent influence on runoff may require that maintenance of ambient condition is the preferred water quality goal (refer *Annex I* for letter and Soiltec soil testing report). As stated in the letter adjusting the pH to neutral conditions may result in unintended impacts on down stream aquatic ecosystems.

4.7.4 Performance Criteria

Results of the surface water quality monitoring will be compared to guideline values provided in *Australian and New Zealand Guidelines for Fresh and Marine Waters Quality* (ANZECC & ARMCANZ, 2000). Should any sample fail to meet these guidelines further assessment and/or quarry management may be required to ascertain the reason(s) for failure and initiate remedial measures to correct any problems identified. Additional testing may also be required to confirm the effectiveness of remedial actions. It is noted that in some cases (i.e. pH) the performance criteria may need to be established on a site specific basis to reflect source and receiving water and soil conditions.

4.8 GROUNDWATER MONITORING

4.8.1 Objectives

Groundwater quality monitoring will comprise water level gauging along with sample collection and testing by a National Association of Testing Authorities (NATA) registered laboratory and will provide a mechanism to:

- ensure the quarry is operating as anticipated with respect to groundwater quality protection;
- to gauge the impact (if any) of the groundwater level across the Project Site.;
- identify any unforseen impacts from the quarry operations;
- implement measures to prevent any as yet unforseen impacts from the scheme; and
- verify that the quarry is achieving its environmental objectives.

4.8.2 Sampling Locations and Frequency

Groundwater quality monitoring should be undertaken in the three existing cased groundwater bores adjacent to the *Central* and *Southern Section*. If bores are destroyed during the quarrying activities, alternative groundwater testing location may need to be established.

Monitoring should initially be undertaken on a regular (i.e. quarterly) basis to evaluate the influence of rainfall and quarrying activities on groundwater levels and quality. After an initial sampling period to understand the existing water quality, monitoring frequency may be reduced to (say) half yearly, provided water quality meets the performance criteria.

Monitoring should be commenced immediately upon receipt of Project Approval to gain an ongoing understanding of water quality in the tributary from the existing quarry operations.

Table 4.4 provides a summary of the proposed specific monitoring points and sampling details:

Table 4.4 ***Groundwater Monitoring Locations***

Monitoring Point	Type of Monitoring Point	Type of Discharge Point	Description of location
7	Groundwater quality monitoring	NA	BH3 on *Figure 3.2*
8	Groundwater quality monitoring	NA	BH5 on *Figure 3.2*
9	Groundwater quality monitoring	NA	BH6 on *Figure 3.2*

4.8.3 Groundwater Monitoring Parameters

A comprehensive suite of water quality parameters will be monitored initially to assist in gaining a comprehensive and ongoing understanding of existing water quality conditions. Once the critical water quality parameters have been determined, regular monitoring will focus on these and the frequency of comprehensive monitoring will be reduced. The key water quality parameters are expected to include pH, electrical conductivity (salinity), and oil and grease (hydrocarbons).

4.8.4 Performance Criteria

Results of the water quality monitoring will be compared to background water quality data. Should the groundwater quality change significantly from the background conditions quarry management will be required to ascertain the reason(s) for failure and initiate remedial measures to correct any problems identified. Additional testing may be required to confirm the effectiveness of remedial actions.

4.9 *EFFLUENT DISCHARGE*

The discharge of stormwater from the *Water Reuse Dam* (monitoring point 9) will not exceed a total suspended solids concentration (TSS) of 50mg/L, once the stormwater management system is constructed and operational. However, exceedance of this condition should be permitted at the overflow point for the duration of the overflow whenever a wet weather overflow is occurring due to stormwater events greater than or equal to 71mm in total falling over any consecutive 5 day period.

The ANZECC (2000) water quality guidelines provide default trigger levels for Turbidity for slightly disturbed ecosystem in south eastern Australia for upland and lowland rivers of between 10 and 20 NTU. While the minor order ephemeral streams on-site and down stream receiving waters at Tucki Tucki Creek are likely best described as highly modified ecosystems, this range will be considered to evaluate site conditions. Turbidity levels will be recorded alongside TSS for effluent discharge in order to determine a site specific correlation. Turbidity levels measured in-situ will be used to estimate TSS levels once sufficient data has been collected to determine the correlation.

As local receiving waters are expected to be slightly acidic, the specific discharge limit for pH may need to be reviewed after a period of ongoing monitoring. The pH of any discharge waters from the sediment basins or the *Water Reuse Dam* will initially be compared to the neutral range of pH6.5 to 8.5 for the purpose of evaluating site conditions. However, as discussed in the letter from Professor Ian White FTSE as provided in *Annex I,* the natural acidic soil conditions encountered at the Project Site of pH4.5 to 5.3 and the subsequent influence on runoff may require that maintenance of ambient condition is the preferred water quality objective. As stated in the letter adjusting the pH of discharge waters to neutral conditions may result in unintended impacts on down stream aquatic ecosystems.

4.10 *REHABILITATION DRAINAGE*

Contour drains will be installed on rehabilitated slopes to minimise the potential for scouring. Runoff will be directed to sediment traps and settling ponds before flowing to the on-site tributaries. Where necessary, scour protection and dissipaters will be installed and rehabilitated slopes will be vegetated to reduce surface erosion. Rock batters will be benched to reduce erosion potential. Flows collected on each bench will be directed to contour drains or natural waterways.

4.11 CONCLUSION

The proposed Water Management System has been designed taking into account the regional setting and climatic conditions, the *Project Area* and *Project Site* conditions, operational factors and consideration for relevant guidelines, policies and legislation. A conservative approach was taken throughout the design process particularly with regard to the control and detainment of on-site water. The design underwent verification modelling to confirm it will be adequate to meet the water quality and supply requirements for the *Project Area*. The following provides a summary of the system:

- the *Water Storage Dam* will only collect 'clean' water (i.e. not from the *Project Area*) for the purpose of supplementing quarry operational water needs during dryer periods, and as such will be treated as any other on-farm harvestable rights dam;

- the *Water Reuse Dam* will only collect water from the disturbed quarry and operational areas, including all water harvested from the smaller sedimentation ponds located in the *Central Section* and *Southern Section* quarry pits;

- the water balance and verification modelling undertaken demonstrates that water demand of the quarry for the majority of the recorded range of local annual rainfall can be met via water collected in the *Water Reuse Dam,* which is to be further supplemented by the *Water Supply Dam*;

- the smaller settlement ponds (designed for the 3ha operational areas) have been conservatively designed for primary treatment for the removal of sediment up to the 80th percentile, 5 day rainfall event beyond which drain to the *Water Reuse Dam*. The performance of the settling ponds is to be optimised via harvesting of water from the *Water Reuse Dam* and by regularly removing sediment;

- the water levels in the *Water Reuse Dam* will be managed via operational reuse (including processing and dust suppression), and also via land application on the *Project Site* during favourable climactic conditions. This will be undertaken as required to ensure a minimum 6ML of freeboard is available to receive stormwater runoff from the operational site. Under most operating conditions all operational site water is expected to be detained on-site for reuse or for land application;

- it is noted that if water quality objectives are satisfied that it is appropriate for water to discharge to the environment (if required);

- based on the need to harvest water for operational purposes and to treat *Project Area* runoff, the proposed *Water Reuse Dam* has been shown to be sufficient to control and treat all runoff from the *Project Area*. It is considered that water quality in terms of mean annual loads and pollutant concentrations will carry lower pollutant loads or will be no worse off than under existing conditions; and

- the system for treating *Project Area* runoff has been conservatively modelled and designed assuming 13ha of disturbed area. It is noted that in the early operational stages and as quarry cells are progressively rehabilitated that the actual disturbed area will likely be significantly less at any one time. Where possible runoff from undisturbed or rehabilitated sections of the *Project Area* will be diverted where possible around the *Water Management Systems*.

Based on the above information the proposed Water Management System is considered to be adequate, as it not only accounts for site operational water needs, but provides for conservative design measures for the detaining and treatment of *Project Area* runoff and washing plant reuse water.

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