

Site Water Management Plan
for the
Calga Sand Quarry

Approved

Prepared by:



R. W. CORKERY & CO. PTY. LIMITED

in conjunction with

GSS Environmental

and

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for the
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ACRONYMS USED THROUGHOUT THIS DOCUMENT

AEMR	-	Annual Environmental Management Report
DEC (EPA)	-	Department of Environment and Conservation (Environment Protection Authority)
DIPNR	-	Department of Infrastructure, Planning and Natural Resources
DNR	-	Department of Natural Resources
DoP	-	Department of Planning
EIS	-	Environmental Impact Statement
ESCP	-	Erosion and Sediment Control Plan
GCC	-	Gosford City Council
GWMP	-	Groundwater Monitoring Program
SWMP	-	Site Water Management Plan
SWMonP	-	Surface Water Monitoring Program



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Site Water Management Plan

1 INTRODUCTION

This Site Water Management Plan (SWMP) for the Calga Sand Quarry (“the quarry”), prepared in compliance with *Condition 3(11)* of Development Consent DA 94-4-2004 includes:

- the predicted site water balance (**Section 3**);
- an Erosion and Sediment Control Plan (**Section 4**);
- a Surface Water Monitoring Program (**Section 5**); and
- a Groundwater Monitoring Program (**Section 6**).

The SWMP has been prepared in conjunction with GSS Environmental, who prepared Sections 3, 4 and 5, and Peter Dundon and Associates Pty Ltd, who prepared Section 6. The SWMP builds upon and refines the water management concepts presented in the 2004 Environmental Impact Statement (2004 EIS), an amended proposal to extend the quarry following initial reviews of the 2004 EIS by DIPNR (2005 Amendment Report) and additional documentation prepared for the proposed Calga Sand Quarry extension.

For management purposes, the water within the Quarry Site has been divided into three classes.

1. **“Clean”** - surface runoff from rehabilitated catchments and catchments undisturbed or relatively undisturbed by extraction or related activities.
2. **“Dirty”** - surface runoff from disturbed catchments such as the active extraction area, soil and subsoil stockpiles and rehabilitated areas (until stabilised), all of which could contain sediments.
3. **“Contaminated”** - surface runoff which could potentially contain hydrocarbons.

The following definitions are applicable to this document.

- **“Sediment Fence”** - A temporary sediment barrier consisting of filter fabric buried at the bottom, stretched, and supported by posts. Designed to retain sediment from small disturbed areas by reducing the velocity of sheet flows to allow sediment deposition.



- “**Stage 3**” – The area approved for the extension of the quarry under DA 94-4-2004.
- “**Silt Cells**” – The large shallow settling basins that are designed to accumulate sediment/silt, and once dewatered, rehabilitated through the placement of overburden, soil and revegetation over the consolidated sediment.
- “**Water Management System**” – The series of structural controls (including the drains, pipelines, silt cells, storage dams) that are used to manage the “dirty” water and supply water for quarry activities (primarily the wash plant).

2 OBJECTIVES

The principal objectives of site water management are as follows.

- (i) To ensure sufficient quantities of water can be obtained through the capture of surface water and groundwater to meet the operational and dust suppression requirements of the quarry.
- (ii) To ensure the segregation of “dirty” water from “clean” water, and maximise the retention time of “dirty” water such that any discharge from the quarry meets the water quality objectives as follows:
 - pH +/- 1 unit from background;
 - Electrical Conductivity < 1 500µs/cm;
 - Total Grease < 10mg/L; and
 - Suspended Solids < 50mg/L.
- (iii) To minimise the volume of water discharged from the Quarry Site but, should the discharge of water prove necessary, ensure sufficient settlement time is provided prior to discharge such that concentration of suspended sediment within the water meets the objectives identified above (point (ii)).
- (iv) To minimise erosion and sedimentation from all active and rehabilitated areas of the Quarry Site.
- (v) To monitor the effectiveness of surface water controls and ensure all relevant surface and groundwater quality criteria are met.
- (vi) To monitor the impact on groundwater level, quality and availability.
- (vii) To minimise any impacts on the availability of surface water or groundwater to surrounding residents and landholders.
- (viii) To establish a method of assessing the level of impact on groundwater supply attributable to the quarry.



3 SITE WATER BALANCE

3.1 Introduction

The Calga Sand Quarry is situated within the Cabbage Tree Creek catchment, which is an ephemeral stream (first order stream under the Strahler System (Ref: Strahler, 1957)) that eventually discharges into the Hawkesbury River. Stage 3 of the quarry represents about 8% of the total catchment area of Cabbage Tree Creek of 385ha.

Water is required at the quarry for use in the wash plant and for dust suppression. For Stage 1 and 2 operations, the quarry drew water for these processes from the various storage dams (Dams 1, 6, 7a, 7b, 7c, 10 and 12) within the quarry. This practice will continue in Stage 3. Water is also lost through evaporation from the storage dams and silt cells on site. Water use is described in greater detail in Section 3.2.

There are three main sources of water for the quarry, namely: groundwater seepage into the pit; rainfall falling directly into the pit; and off-site runoff that enters the Quarry Site via three man-made drains that carry water from Peats Ridge Road and from a small contributing catchment to the northeast of Stage 3. Water availability is described in greater detail in Section 3.3.

3.2 Site Water Use

3.2.1 Sand Washing & Retention of Water in Materials

Approximately 8 000L of process water is required to produce one tonne of sand product. A maximum of 200 000t of washed sand plus 200 000t of mortar sand (50% washed sand plus 50% raw crushed sandstone) will be sold per annum. Therefore based upon this production rate, approximately 300 000t of washed sand will be produced. With the exception of the following, the majority of this process water will be continuously recycled and available for reuse.

- The washed sand product will have a moisture content of 7%. As a consequence, up to **21ML/year** will exit the Quarry Site as water retained in the sand products.
- To produce 300 000t of washed sand, 400 000t of raw feed will be washed which has an average silt content of 25%. Therefore, up to 100 000t of silt will be washed from the raw sand each year and deposited in the quarry silt cells. The silt will bind approximately 1 000L of water per tonne and as a result up to **100ML/year** will be removed from the water cycle and retained in the silt each year.

3.2.2 Dust Suppression

Water is used for dust suppression on the roads, stockpiles and other exposed surfaces around the Quarry Site. It is estimated that the maximum rate of water application will be 13.5kL/hour. Based on an application time of 3.5 hours/day for 250 days/year, this equates to approximately **12ML/year**.



3.2.3 Evaporation

Based on an evaporation rate of 1 500mm/year and an average total water surface area of 30 000 m², the water loss through evaporation from storage dams and silt cells of the quarry will be up to **45ML/year**.

3.2.4 Total Water Use

Based on the calculations above, the estimated water use for the quarry is up to **178 ML/year**, based on the following.

- A maximum of 121ML/year of water lost through the retention of water retention in silt and sand.
- 12 ML/year of water used for dust suppression.
- 45ML/year lost as evaporation from storage dams and silt cells on site.

3.3 Water Availability

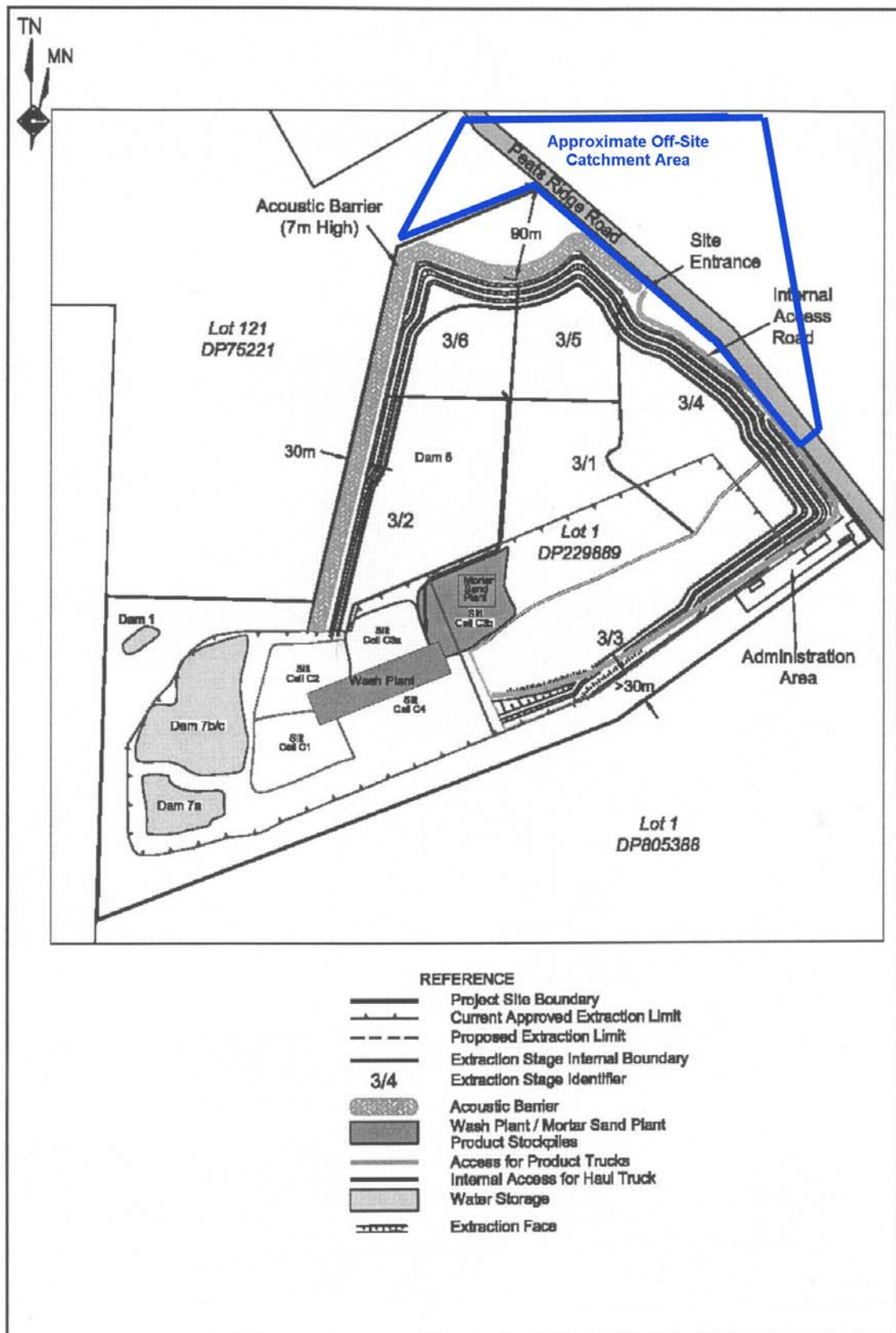
3.3.1 Surface Water Rainfall and Offsite Runoff

The footprint of the existing quarry and Stage 3, combined with a small contributing catchment of approximately 10ha to the northeast of Peats Ridge Road (see **Figure 1**), amounts to a catchment size of approximately 57ha. Given that this catchment consists primarily of a disturbed quarry area with little vegetation and a sealed road (Peats Ridge Road), the annual runoff rate is estimated to be approximately 45% of rainfall. The annual average rainfall for the area is 854mm and therefore annual runoff collected on site is 219ML/year. This assumes 100% capture, however, 50% of runoff from Peats Ridge Road and the contributing catchment to the northeast of the Quarry Site is to be diverted around Stage 3 and onto the adjoining land. This catchment contributes approximately 38ML/year of runoff, and therefore about 19ML/year will be diverted. Thus the annual runoff available for collection is about **200ML/year**.

3.3.2 Groundwater Seepage

A transient analysis of a three-dimensional groundwater model was carried out to predict the water make in Stage 3 (CM Jewell & Associates, 2004). This analysis suggests the maximum seepage from the quarry walls and floor will be **49ML/year**. The predicted seepage depends on the timing of the quarry excavation as well as the model's assessment period, due to the fact that the groundwater seepage rate will change over time. The transient analysis conducted assumes a worst-case scenario, whereby the excavation is considered to be instantaneous and seepage calculated two months after the instantaneous quarry development, where seepage rates are likely to be at their highest. Therefore, whilst a maximum of 49ML/yr is predicted, the long term seepage rate is likely to be substantially lower than this value.





REFERENCE

- Project Site Boundary
- Current Approved Extraction Limit
- Proposed Extraction Limit
- Extraction Stage Internal Boundary
- Extraction Stage Identifier
- Acoustic Barrier
- Wash Plant / Mortar Sand Plant
- Product Stockpiles
- Access for Product Trucks
- Internal Access for Haul Truck
- Water Storage
- Extraction Face

Figure 1 – Site Layout and Off Site Catchment Area



3.3.3 Total Water Availability

Based on the calculations above, the estimated maximum water availability for the Quarry Site is **249ML/year**, based on the following.

- An average of 200ML/year of water captured from rainfall and runoff.
- Up to 49ML/year of groundwater seepage. Although it is noted that water inflow in the quarry walls will be generally be less than predicted as explained in Section 3.3.2.

3.4 Water Balance

Assuming, all water not lost through retention in sand and silt, evaporation or used in dust suppression is available for reuse, the total water use for the quarry is estimated to be a maximum of 178ML/year (Refer Section 3.2), and the total maximum water availability is estimated to be 249ML/year (Refer Section 3.3). Subsequently, the site is expected to have a **net water gain of 71ML/year**, based on an average yearly rainfall. It is acknowledged that there is a large variability in the numbers used to calculate this amount and the actual water loss/make is likely to vary significantly from year to year and be dependent on the local meteorological conditions, production rate, process efficiency, and the accuracy of the assumptions. For example, it is likely there will be operational losses of water through the sand washing process that will reduce the volume of water recycled/reused each year and, due to the worst-case scenario used to model the predicted water inflow, the groundwater seepage rate is likely to be much less than 49ML/year.

As a result, the predicted net water gain is likely to be less than 71ML each year. However, while it is likely that the net water gain will be <71ML/year, experience at the quarry over the recent low rainfall years shows the Quarry Site has not had a water shortage, ie the site has been able to maintain adequate water storages and supply sufficient water for the sand washing process despite drought conditions. The site has a significant water storage capacity, ie. two dams with 100ML combined capacity, and it is anticipated this capacity would allow continued processing operations during extended periods of low rainfall.

In the event that the amount of on-site water storage declines over time, Rocla will need to take actions to increase the available water or reduce the water consumption. The following options would be considered.

- Sourcing water from existing Dam 13 on the adjoining land, which is normally close to or at capacity.
- Purchase water from other neighbouring properties that have existing water entitlements.
- Modify the clean water diversion channel to discharge 100% of this flow in to the quarry, which would equate to an estimated increase in availability of 19ML/year.
- Increase the proportion of sand that is sold unwashed (currently 75% washed) to reduce the amount consumed in the washing process.
- Decrease the rate sand production (ie. less than 400 000tpa) to reduce the amount consumed in the washing process.



- Investigation of potential modification to the washing plant to increase water efficiency.
- Any other alternatives that may become apparent through the operation of the quarry.

In the event that the water captured in a wet year, or consecutive wet years, exceeds the storage capacity of the water storage dams, treated water will be discharged from the Quarry Site into the tributary of Cabbage Tree Creek, during periods of high rainfall. This discharge would occur from the outlet of water storage Dam 7b/c, which subsequently, flows to Dam 1, prior to discharge to tributary of Cabbage Tree Creek. Previous water quality monitoring results indicate that there is very little difference between the quality of water discharging from the Quarry Site and that existing in Cabbage Tree Creek (see **Table 3.1** (based on page 5-8 of EIS)). Subsequently, any increased flows leaving the Quarry Site are not expected to have a negative impact on the receiving waters. Any discharge water will be monitored, as described in **Section 5.3**.

Table 3.1
Surface Water Monitoring Results 2002

Sampling Date #	pH	Electrical Conductivity	Total Grease	Suspended Solids
Units		µs/cm	mg/L	mg/L
EPA Limit	± 1 unit from background	1 500	10	50
Location A[@]				
12/03/2002	6.5	100	4	3
16/04/2002	6.4	90	11	3
22/05/2002	6.2	89	18	10
27/06/2002	6.1	93	<2	3
Location B[@]				
12/03/2002	NF	NF	NF	NF
16/04/2002	NF	NF	NF	NF
22/05/2002	NF	NF	NF	NF
27/06/2002	NF	NF	NF	NF
Location C[@]				
12/03/2002	6.2	120	4	5
16/04/2002	6.0	110	8	2
22/05/2002	6.2	110	16	3
27/06/2002	6.1	110	<2	4
Location D[@]				
12/03/2002	NF	NF	NF	NF
16/04/2002	NF	NF	NF	NF
22/05/2002	NF	NF	NF	NF
27/06/2002	NF	NF	NF	NF
Location E ^{*@}				
NF = No Flow - hence, no sample collected				
[@] see Figure 3 for location				
* Access permission withdrawn				
Source: Sample Collection and Analytical Results by Terratest Pty Ltd, Geotechnical Testing Services (NATA Accreditation No. 541)				



3.5 Water Balance Review

During operation of the quarry, measurements of actual water use and availability will be made so that the water balance can be refined, if necessary. The following information will be collected and used.

- Water levels (related to storage volumes) in the water storage dams.
- Rainfall within the quarry catchment will be recorded by the on-site weather station. Evaporation rates will also be recorded.
- Quantities of water discharged from the Quarry Site.

Based upon an analysis of this information, as well as production rates of sand and silt, Rocla will review and update the water balance appropriately.

The majority of water used at the quarry is through the sand washing process. The majority of the water lost is bound to the silt and clay washed out of the raw sandstone as well as evaporation. Whilst the water balance suggests the quarry has the potential to recover >90% of the water used, any further gains in efficiency could reduce the water consumption at the quarry. The sand washing process will be monitored over time, and any likely improvements to reduce the water consumption will be investigated and implemented where economically feasible and practical.

4 EROSION AND SEDIMENT CONTROL PLAN

4.1 Introduction

In accordance with *Condition 3(13)*, the **Erosion and Sediment Control Plan (ESCP)** has been prepared consistent with the requirements of the Department of Housing's *Managing Urban Stormwater: Soils and Construction Manual* (DoH, 2004). All erosion and sediment control structures will be constructed or erected in accordance with the recommendations identified in the relevant standard drawing and construction notes of DoH (2004).

The **ESCP** has been structured as follows.

- (i) Section 4.2 - identifies activities for the construction and operational phases of the development that could cause soil erosion and generate sediment.
- (ii) Section 4.3 - describes the management principles to be implemented.
- (iii) Section 4.4 - describes the detail on the measures to be employed, including the location, function, and capacity of erosion and sediment control structures.



4.2 Sources of Sediment

4.2.1 Construction

The main potential sources of sediment during construction are:

- clearing and soil stripping activities undertaken to expose the friable sandstone in Stage 3; and
- construction of roads and other infrastructure such as any surface drains and the acoustic bund.

4.2.2 Operations

The main potential sources of sediment during operations are:

- uncontrolled run-off from active extraction areas;
- uncontrolled run-off from roads and drainage areas;
- uncontrolled overflow of sediment-laden water of the silt cells; and
- possible spillages and uncontrolled flows of sediment-laden water used in, or silt produced by, the sand washing process.

4.3 Erosion and Sediment Management Principles

The principal objective of surface water management for the quarry is to ensure that there is no uncontrolled discharge of water from the Quarry Site, and that the water quality leaving the Quarry Site meets the appropriate quality standards. This objective is intrinsic to erosion and sedimentation designs and controls for the quarry, and will be achieved by implementing the following principles.

- Adopting appropriate land clearing procedures for all proposed disturbance areas.
- Separating *undisturbed*, “clean water” runoff from *disturbed*, “dirty water” runoff where possible to minimise and isolate the amount of “dirty water” runoff.
- Directing sediment-laden runoff into designated sediment control retention ponds.
- Diverting “clean water” runoff unaffected by the operations upstream into natural or constructed depressions.
- Constructing the haul road and working quarry face with effective surface drainage that flows to sediment control retention ponds.
- Maintaining sediment control structures to ensure that the designed capacities are maintained for optimum settling of sediments.
- Implementing an effective revegetation and maintenance program for the site.



The principal design aspects of the quarry will be the diversion of “clean water”, containment of dirty water within the extraction / quarry area, and the treatment and recycling of “dirty water” to eliminate any uncontrolled runoff.

4.4 Erosion and Sediment Controls

4.4.1 Minimal Disturbance

Land disturbance will be minimised by clearing one extraction cell at a time ahead of extraction activities and leaving this disturbed for the shortest possible times. This will be achieved by:

- limiting the cleared width to that required to accommodate excavation within the active Stage 3 and other associated structures; and
- programming the works so that only the areas which are actively being excavated are cleared, therefore limiting the time the areas are exposed and limiting the potential for erosion and sedimentation.

General vegetation clearing and soil stripping will not be undertaken until earthwork operations are ready to commence. All proposed erosion and sediment control measures will be implemented in advance of, or in conjunction with, clearing and stripping operations. Prior to clearing commencing, the limits of clearing shall be marked by pegs placed at intervals on each side of the disturbed area. All operations will be planned to ensure that there is no damage to any trees outside the limits to be cleared.

4.4.2 Management of Soil Stockpiles

Topsoil stripping within the disturbed area will be undertaken as far as practicable, when the soil is in a slightly moist condition thus reducing damage to soil structure. The soil materials will be moistened if very dry and will not be stripped in wet conditions. Stripped soil will be placed directly onto the disturbed areas and spread immediately if excavation sequences, equipment scheduling and weather conditions permit.

If longer term stockpiling, ie. greater than 6 months, is required, a maximum stockpile height of two (2) metres will be maintained to preserve biological viability and reduce soil deterioration. Soil stockpiles will be sown with the sterile cover crop (annual species).

Where the stockpile is not wholly contained within the quarrying area and associated “dirty” water management system, temporary sediment control measures such as sand bags and silt fences will be used to prevent sediment from leaving the area. Stockpiles will be placed in areas so as to avoid impediment of natural localised drainage lines and minimise the likelihood of water ponding against the stockpile.



Topsoil will be re-spread in the reverse sequence to its removal, so that the organic layer, containing any seed or vegetation, is returned to the surface. Topsoil will be spread to a minimum depth of 50mm on 3:1 or steeper slopes and to a minimum depth of 100mm on flatter slopes. Re-spreading on the contour will aid runoff control and increases moisture retention for subsequent plant growth.

Re-spread topsoil will be levelled to achieve an even surface, avoiding a compacted or an over-smooth finish.

4.4.3 Clean Water Diversion Works

During periods of heavy rainfall, clean surface water flows onto the Quarry Site via three man-made drains that carry water sourced from Peats Ridge Road and from a small contributing catchment to the northeast of Stage 3 (approximately 10ha). This water will be diverted around Stage 3 to prevent the clean water entering the extraction area and compromising silt cell dewatering activities.

To achieve the clean water diversion, a new channel will be constructed at the base of the earth bund, ie. acoustic barriers, required to be constructed around the perimeter of Stage 3. The new diversion channel will be utilised as a permanent mitigation control on the site to minimise erosion and divert run-on water around the disturbed areas for the life of the Stage 3 quarry. The diversion channel will be constructed during the initial stage of site preparation. The location of the diversion channel is shown on **Figure 2**.

The channel will be trapezoidal in shape with a 3 m base width and 3:1 (H:V) batters. The channel has been designed to convey the 100 year ARI, time of concentration (19 min) event, which is a peak flow for the channel of approximately 1.1 m³/s. All completed banks will be topsoiled and sown with sterile cover crops. **Appendix A** contains the model input data and hydraulic results for the channel design. A piped culvert will be used to convey the channel flows under the site entrance road.

The channel will discharge to two locations, as agreed between Rocla and the affected adjoining land holder. Fifty percent will be discharged into a large agricultural dam (Dam 13) on the neighbouring property (see **Figure 2**). Dam 13 is located to the west of Stage 3, and currently receives overflow from Dam 6. It also receives substantial groundwater inflow and is normally close to or at capacity. Overflows from Dam 13 enter a tributary of Cabbage Tree Creek. The remaining fifty percent of the diverted clean water will be accepted and contained onsite, via a piped discharge from the diversion channel outlet to one of the water storage dams (i.e. 7a or 7b/c). This water will then be used by Rocla, and contained within the quarry water management system. Ultimately, any overflow from the water storage dams will enter the tributary of Cabbage Tree Creek. The outlet of the diversion channel will have a 50/50 dual pipe culvert to split the flows into the two separate flow paths.



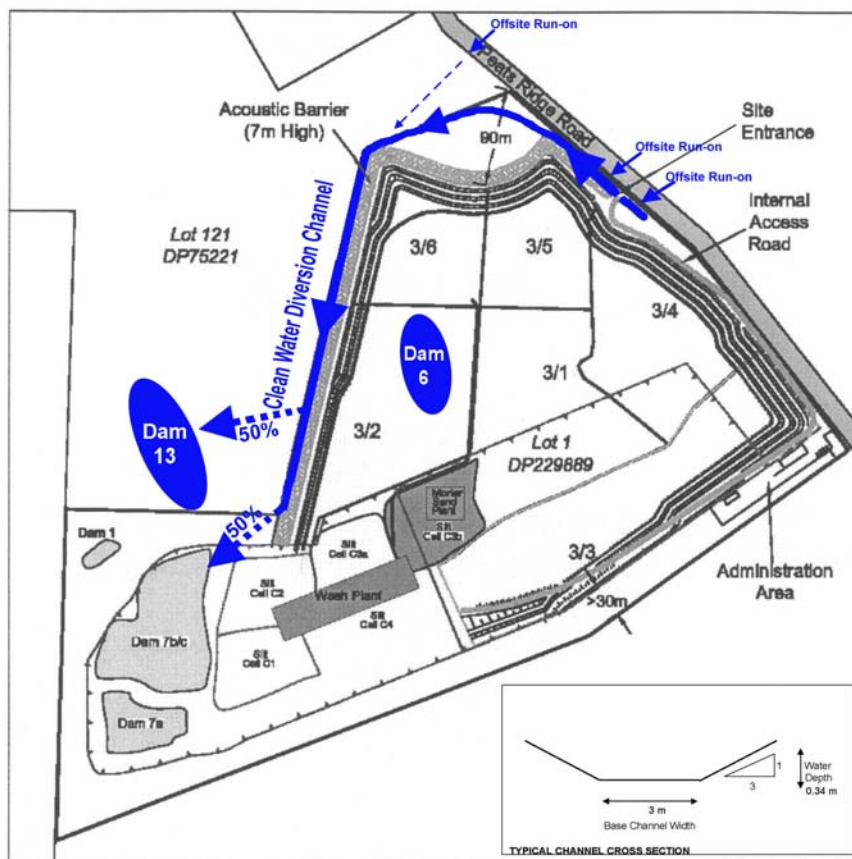


Figure 2 – Location of Clean Water Diversion Channel

4.4.4 In-pit Water Management & Sediment Removal

The quarry has been designed so that all “dirty water” is contained within the quarry extraction area and directed to the internal “dirty water” control system throughout all stages of active extraction. “Dirty water” is directed towards the dams of the southeastern end of the quarry (Dams 7a, b and c) to allow for the settlement of silt prior to this water being recycled through the wash plant, used for dust suppression purposes or, during periods of heavy rainfall, discharged off site.

For Stage 3, the quarry floor will generally be graded so that it drains in a southerly direction towards the existing quarry and dirty water control system. However, the active quarry floor may also be locally graded to sump areas which will allow the controlled pumping of dirty water to specific silt cells, depending on the particular stage of quarrying and condition of silt cells. **Figure 2** shows the location of existing silt cells, with new silt cells to be created as quarrying progresses through Stage 3. The capacity of the silt cells will remain relatively constant as consolidated cells are rehabilitated, new cells are constructed following extraction within each of the Stage 3 and sub-stages.



The series of silt cells allow for the settling and retention of sediment from the dirty water prior to storage in the water storage dams. This system has operated effectively with negligible suspended sediment occurring in the water storage dams. Notwithstanding this, in the event that suspended sediment is observed in the water storage, the use of other options, such as flocculation, will be investigated and implemented.

4.4.5 Quarry Haul Roads

The internal quarry haul roads within the Quarry Site will be constructed to ensure surface drainage is optimised and stabilised, thereby reducing roadside erosion and sedimentation. Cross-fall drainage structures and mitre drainage will be implemented for the entire length of each haul road. Crowning will generally be implemented on any steeper sections of the haul road. Outfall drainage will be constructed where the road traverses small fill batter areas and in-fall drainage will occur where the road traverses larger fill batter areas.

Mitre drains will be constructed to take water from the shoulders or table drains of the internal haul roads to the internal dirty water control system. Road runoff will be intercepted at regular intervals to reduce runoff velocity in each mitre drain. Drain spacing will not exceed 50m.

4.4.6 Additional Erosion & Sediment Controls

Additional control works including, but not limited to, sediment fencing, sand bag sediment filters and revegetation will be employed where suitable. As an example, these controls will be implemented down slope of clearing and soil stripping activities to be undertaken in advance of Stage 3.

Silt-stop fencing and sandbag weirs will be installed in the longitudinal drainage adjoining the roads / disturbed areas and will be in advance of, and in conjunction with, earthworks to prevent contaminated or “dirty water” leaving the site. The weirs will be installed at 50m intervals.

Sand bag sediment filters will be used “as required” during the construction of drainage and road works, however, the use of sand bags will be limited to situations only where erosion and sediment control is required for a short period (i.e. maximum of three (3) months).

Any batters will be constructed to minimise exposed areas, ie. minimise the potential surface for erosion. Batters that may require treatment include those on access roads and other construction areas, as these areas may be steep and erodable. Stabilisation, revegetation and rehabilitation works will be undertaken quickly to minimise erosion. Hydromulching will be used where appropriate to immediately protect underlying fill material from wind and water erosion. Hydromulching applications will typically consist of sterile annual grasses, bitumen or polymer binder, seed and fertiliser. Materials used in hydromulching are biodegradable and decompose to form a beneficial organic humus.



4.4.7 Maintenance of Erosion Control Structures

The Quarry Manager will undertake regular general environmental inspections and following substantial rainfall events to ensure that all the water management controls outlined in **Sections 4.4.1 to 4.4.6** are functioning as designed and required. The Quarry Manager will also ensure that any contractors on site are operating within the environmental controls as required for their activities. Site drainage and sediment control structures will be inspected regularly after runoff events (>20mm of rain) to check for scouring of diversion drains and accumulation of materials in sediment traps (eg. sediment fences & sand bags) and storage dams. Inspection will include the following.

(i) Haul Roads

The haul roads will be visually inspected to ensure that the appropriate mitigation measures are functioning to convey the surface flows from the road surface and work areas without causing excessive erosion to the road or work areas or the adjacent land. The pipe culverts will also be inspected for any signs of erosion around the culvert or in the drainage line immediately downstream of the culvert. Where controls are observed to be not functioning correctly, the surface will be restored to meet the required standard. Where significant erosion is observed to be occurring on a regular basis, additional controls will be constructed, such as additional mitre drains, scour protection of road drainage, and the re-grading of surface.

(ii) Water Diversion Channel

The water diversion channel will be inspected to ensure that it is functioning to divert the surface run-on in accordance with its design. Any signs of erosion along the length of the banks and at the points of discharge will be noted and remedial works undertaken as required. Where significant erosion is observed additional erosion controls will be constructed. Such as establishment of further vegetation cover, armouring of the channel surface and construction of rock scour protection at the entry and discharge locations.

(iii) Sediment Controls

Regular visual checks will be made of the silt cells to ensure that there is no noticeable increased discoloration of the water decanted to the “clean water” storages.

(iv) Water Storage Dams

Visual checks will be regularly made of all the clean water dams on site to ensure that there is no noticeable increased discoloration in the dams.

(v) Additional Sediment Controls

All sediment fencing and sand bag sediment filters will be inspected to ensure that they are functioning adequately.



Where controls are observed not to be functioning correctly, the eroded area will be restored to meet the required standard. Where significant erosion is observed to be occurring on a regular basis, additional controls will be constructed generally in accordance with the Department of Housing's *Managing Urban Stormwater: Soils and Construction Manual* (DoH, 2004).

5 SURFACE WATER MONITORING PROGRAM

5.1 Introduction

This **Surface Water Monitoring Program (SWMonP)** has been prepared in compliance with *Condition 3(14)* and includes the following.

- a) A detailed baseline data on surface water flows and quality in waterbodies that could potentially be impacted by the quarry (see Section 5.2).
- b) A surface water impact assessment criteria (see Section 5.2).
- c) A program to monitor surface water flows and quality (see Section 5.3).
- d) A protocol for the investigation, notification and mitigation of identified exceedances of the surface water impact assessment criteria (see Section 5.4).
- e) a program to monitor the effectiveness of the Erosion and Sediment Control Plan (see Section 5.5).

Rocla has previously conducted a regular program of surface water quality monitoring, with results compiled and reported to Gosford City Council, the Department of Environment and Conservation (Environment Protection Authority) (DEC (EPA)) and DIPNR (now Department of Planning (DoP) and Department of Natural Resources (DNR)) on an annual basis in accordance with *Conditions 5(2)* and *5(3)* of the previous Development Consent No. 10604. The locations of the monitoring sites are shown in **Figure 3**.

5.2 Baseline Water Quality Data for Receiving Waters and Assessment Criteria

The receiving waters that may be potentially affected by discharge from the Quarry Site are Cabbage Tree Creek, and the tributary that directly receives flows from Dam 1. Detailed results of baseline monitoring result recorded in 2002 are presented in **Table 3.1**.

The following DEC (EPA) criteria have been adopted, namely:

- pH – +/- 1 unit from background;
- Electrical Conductivity – <1 500µs/cm;
- Total Grease – <10mg/L; and
- Suspended Solids, <50mg/L.



5.4 Investigation and Reporting of Exceedances

For each sampling event, water quality results will be compared against the assessment criteria in the plan (refer Section 5.2) and any other relevant criteria that may be defined by DEC (EPA). Any exceedance of criteria will trigger an immediate investigation to determine the cause of the exceedance and preparation of a corrective action plan to re-establish or introduce additional appropriate controls as necessary. Initially, however, whenever possible, the water would be re-sampled to verify the result recording an exceedance.

The reporting of all monitoring and measurement data will be undertaken in accordance with the requirements of the development consent, including notification of monitoring/investigation results to external organisations if required. All results will be reported in the Annual Environmental Management Report (AEMR).

Rocla will also report results to the DEC (EPA), as soon as practicable after any incident with actual or potential significant off-site impacts on people or the bio-physical environment.

5.5 Erosion and Sediment Control Monitoring

The measurement of concentrations of suspended solids over time will establish the effectiveness of the various erosion and sediment controls. The water quality monitoring results will be reviewed in conjunction with the visual observations undertaken as part of the routine maintenance (refer Section 4.4.7).

6 GROUNDWATER MONITORING PROGRAM

6.1 Background

The Groundwater Monitoring Program (GWMP) has been prepared to meet part of the requirements of *Condition 3(11)*, which requires Rocla “... prior to carrying out any development, ... to prepare and subsequently implement a Water Management Plan for the development, in consultation with the DNR, and to the satisfaction of the Director-General. This plan ... shall include ... a Groundwater Monitoring Program.”

The requirements of the GWMP are detailed in *Condition 3(15)*, viz:

- “a) a program to collect detailed baseline data, based on sound statistical analysis, to benchmark the pre-quarrying natural variation in groundwater levels, yield and quality in groundwater bores within the predicted drawdown impact zone identified in the Amendment Report;
- b) groundwater impact assessment criteria for monitoring bores and privately-owned bores;
- c) a program to monitor impacts on the groundwater supply of potentially affected landowners, groundwater dependent ecosystems, and on vegetation; and
- d) a protocol for the investigation, notification and mitigation of exceedances of the groundwater impact assessment criteria.”



Condition 3(11) notes that the “... Groundwater Monitoring Program shall be prepared in accordance with the recommendations of the independent groundwater assessment reports ... prepared by Mackie Environmental Research^a ... unless otherwise authorised by the Director-General.”

6.2 Scope Of Groundwater Monitoring Program

6.2.1 Yield Characteristics of Existing Bores/Wells on Neighbouring Properties

Rocla will seek landholder approval to undertake hydraulic testing of all stock and domestic and industrial production bores/wells located on neighbouring properties within a distance of 500m from the approved limit of extraction. These include the bores/wells listed in **Table 6.1**. A survey will be conducted to establish whether any other bores/wells exist within 500m of the approved limit of extraction.

Table 6.1
Existing Private Bores/Wells on Neighbouring Properties Within 500m of Calga Sand Quarry

Bore/Well*	SWL Depth (m)	Groundwater Production Interval (m)	Bore Purpose	Owner
GW101409 (PB1)	NR	NR	Industrial	Gazzana
GW100548 (PB2)	NR	11 – 13 m	Industrial	Gazzana
Uncoded (PB3)	NR	6.5 – 10 m	Industrial	Gazzana
Uncoded (Domestic Bore)	NR	NR	Domestic	Gazzana
GW037925	3.0	4.8 – 39.5m	Stock/Domestic	Kashouli
GW101316	15.0	16.5 – 16.8m 62.7 - 63.0m 76.2 – 76.5m	Stock/Domestic	Kashouli
GW067408	10.0	10.1 – 10.2m 20.4 – 20.5m 38.3 – 38.6m 61.2 – 61.3m	Stock/Domestic	Kashouli
GW066908	20.0	13.9 – 14.1m 27.3 – 27.7m	Stock/Domestic	Kashouli
GW066907	13.0	20.6 – 20.7 m 44.3 – 44.6 m	Stock/Domestic	Rozmanec
Source: DLWC Work Summary Sheets Note * Refer to Figure 4 NR = No Record				

^a Mackie Environmental Research Pty Ltd, 2004. *Review of Additional Groundwater Modelling of Calga Sand Quarry*, dated December 2004.
 Mackie Environmental Research Pty Ltd, 2005. Letter report entitled *Calga Sand Quarry, Amendment to DA 94-4-2004*, dated 21 July 2005.



Subject to landholder approval, each bore/well will be subjected to hydraulic testing, comprising a pumping test of at least 6 hours duration, or if test pumping is not possible due to access constraints, a falling head permeability test, to establish hydraulic performance under current conditions. These tests will aim to establish:

- aquifer hydraulic conductivity;
- specific yield or specific storage^b;
- broad water quality parameters (TDS, EC and pH); and
- an assessment of the yield potential of each bore/well (if possible).

An initial test will be carried out of all bores/wells within six months of the date of the Consent to establish the above parameters under current conditions. It is proposed that subsequent testing of any bore/well would be undertaken at a later date during the extraction project for comparison to the initial testing results, to determine whether it has suffered loss of yield or hydraulic performance, or change in water quality.

At the time of the initial test, the bore depth and other relevant dimensions will be verified. The bore depth will be re-measured prior to each subsequent test. Where possible, subject to landholder approval, at this time an attempt will be made to ensure ongoing physical access down the casing beside the pump in each bore to enable periodic measurement of water levels to be made by manual insertion of a water level probe. Further, an attempt will be made to enable periodic measurement of pumping rate, by an appropriate means.

6.2.2 Installation of New Monitoring Bores

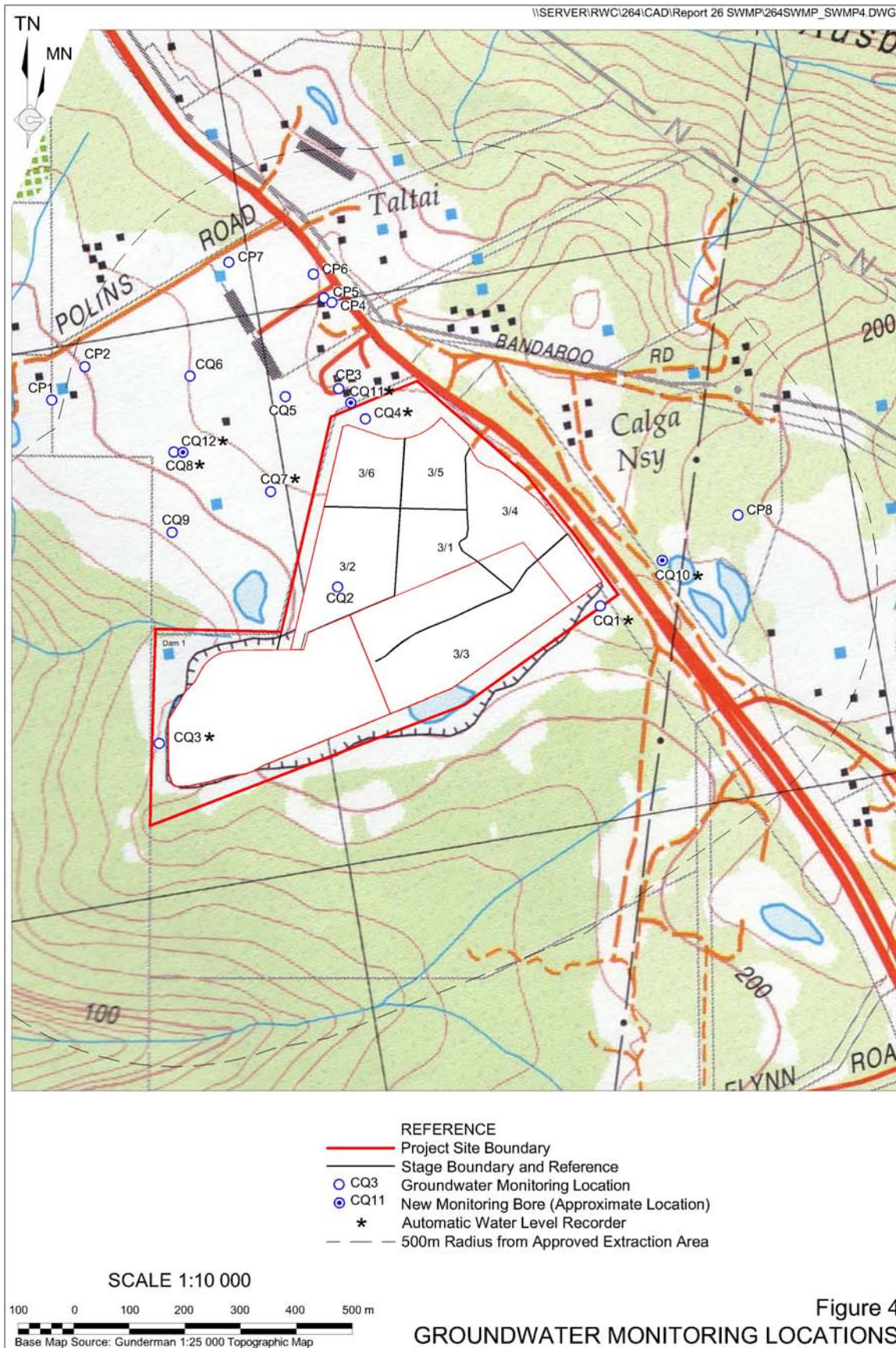
Subject to landholder approval, new monitoring bores will be established approximately at the locations shown on **Figure 4**. Three locations are proposed.

- CQ10 - At an intermediate site between monitoring bore CQ1 and the Rozmanec bore GW066907 (CP8).
- CQ11 - Between CQ4 and the Gazzana domestic bore (CP3).
(Note: each of these two locations (CQ10 and CQ11), two standpipe piezometers are proposed, one to a depth similar in elevation to the water producing zones in the closest neighbouring bores, and the second to a depth nominally 10m below the deepest proposed extraction elevation in the Calga Sand Quarry.
- CQ12 - Immediately adjacent to existing monitoring bore G34 (CQ8) (screened 17-24m), where it is proposed to install a shallow piezometer screened at a depth interval similar to the main producing zone in Gazzana bores PB1 and PB2 (ie. in the range 0-10m).

Precise locations for these bores will be determined on the basis of local access constraints, and negotiations with individual landholders. Precise depths of the piezometers and the screened intervals will depend on the surface elevations at the sites drilled.

^b Note: Specific Yield and Specific Storage cannot readily be determined accurately from pumping tests or falling/rising head permeability tests. Under favourable conditions, indicative values can be determined from drawdown observations on non-pumping bores/wells during a pumping test on a nearby bore/well. However, the values so determined are of questionable accuracy.





The purpose of these new monitoring bores will be to monitor for changes in groundwater levels and/or quality over time, so that potential impacts from the sand extraction operations can be detected, and can be distinguished from climatic effects or other effects not related to sand extraction.

6.2.3 Groundwater Levels

The monitoring of groundwater levels will be undertaken in all monitoring bores located within the Quarry Site, and (subject to landholder approval) in all privately-owned bores on neighbouring properties within a distance of 500m from the approved limit of extraction. Monitoring of Rocla's monitoring bores CQ1, CQ3, CQ4, CQ7, CQ8, CQ10, CQ11 and CQ12 will be undertaken using automatic recorders, with a nominal 6-hourly recording frequency. Monitoring of water levels in the remaining Rocla monitoring bores and privately-owned bores will be undertaken manually using a water level device on a quarterly basis.

The bores to be monitored are as follows.

- Rocla bores CQ1 to CQ4, and CQ5 to CQ9 (formerly known as G31 to G35).
- The new monitoring bores described in **Section 6.2.2** above (to be known as CQ10, CQ11 and CQ12).
- Two Gazzana production bores (CP1^c and CP2).
- Gazzana domestic bore (CP3).
- Four Kashouli stock and domestic bores (CP4 to CP7).
- Rozmanec bore (CP8).

6.2.4 Groundwater Quality

Water samples will be collected every two months from all monitoring bores and existing production bores as listed above in **Section 6.2.3**, for on-site determination of pH and EC.

Every six months, all monitoring bores and existing production bores will be sampled for laboratory analysis of:

- major cations (Ca, Mg, Na, K) and anions (CO₃, HCO₃, SO₄, Cl, F and NO₃); and
- dissolved metals (Al, As, B, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn).

The list of analytes and frequency of testing will be reviewed periodically throughout the life of the quarry.

6.2.5 Rainfall and Evaporation

Rocla will maintain its rainfall gauge on the site and will maintain daily records of rainfall throughout the project. Daily evaporation data would be sourced from the Peats Ridge Bureau of Meteorology Station No. 61351. The location of this monitoring equipment will remain close to the site office.

^c The bore nomenclature proposed is CQ1 to CQ11 for Rocla's monitoring bores; and CP1 to CP8 for the private bores within 500m of the quarry [CQ = Calga Quarry; CP = Calga Private].



6.2.6 Periodic Review of Performance

In accordance with *Condition 3(17)*, it is proposed that an independent audit review of performance will be carried out every 12 months throughout the life of the quarry. These reviews will assess groundwater elevation trends and impacts, and consider other collected monitoring data.

Should it be determined at any review that there is a declining baseline trend, and the component of drawdown attributable to the sand extraction operations exceeds 1.0m at the proposed new monitoring bores (**Figure 4**), then a program would be commenced to determine whether there has been a loss of yield at any of the existing production bores within the 500m zone, subject to landholder approval. This will be determined by carrying out an identical pumping test to that conducted prior to commencement, as proposed above in **Section 6.2.1**.

At each review, the frequency and extent of monitoring will be reviewed, and if considered appropriate, a reduction in either the breadth or frequency of monitoring may be recommended for approval by the Director-General in consultation with the DNR.

The independent annual groundwater audit would be included in the relevant AEMR.

6.2.7 Program of Work to Complete Implementation of GWMP

The works to be completed within six months of the date of the Consent include the following.

- Hydraulic testing of all existing stock and domestic and industrial production bores within 500m of the quarry.
- Water quality sampling from all nominated bores/wells.
- Record depth and other relevant dimensions of all nominated bores/wells.
- Installation of new monitoring bores namely:
 - CQ8 (shallow piezometer);
 - CQ10 (shallow and deep piezometers); and
 - CQ11 (shallow and deep piezometers).
- Hydraulic testing and water quality sampling of the new monitoring bores.
- Installation of automatic water level recorders in Rocla monitoring bores (CQ1, CQ3, CQ4, CQ7, CQ8, CQ10, CQ11 and CQ12).
- Installation of a rain gauge adjacent to the quarry office.
- Commencement of an ongoing water level and water quality monitoring program, involving:
 - bi-monthly sampling for pH, EC and TDS; and
 - six-monthly sampling for comprehensive laboratory analysis.
- Commitment to an annual independent audit review.



6.2.8 Groundwater Dependent Ecosystems and Vegetation

The groundwater dependent ecosystems and vegetation beyond the Quarry Site are to be inspected on an annual basis as part of the overall vegetation management and rehabilitation review. This inspection will form part of the overall vegetation management of the Quarry Site and will be documented in the Rehabilitation and Landscape Management Plan for the quarry.

6.3 Baseline Monitoring Data

6.3.1 Groundwater Levels

Groundwater levels have been recorded in monitoring bores CQ1 to CQ4 since May 2001, using continuous water level recorders, supplemented by quarterly manual measurements. The monitoring data are plotted on **Figures 5 to 8**.

6.3.2 Groundwater Quality

The available water quality data from the monitoring bores CQ1 to CQ4 and nearby private bores will be summarised in **Table 6.2**. The analytes noted are those referred to in Section 6.2.4.

Table 6.2
Quarry Site Water Quality – 18 June 2001

Analyte	Units	CQ1	CQ2	CQ3	CQ4	DUP1†
Sodium (Na)	mg/L	15	9.6	51	16	NA
Potassium (K)	mg/L	1.0	0.4	1.8	0.3	NA
Calcium (Ca)	mg/L	0.6	1.0	2.7	2.8	NA
Magnesium (Mg)	mg/L	0.9	2.8	1.8	1.2	NA
Copper (Cu)	mg/L	<0.001	0.001	<0.001	<0.001	<0.001
Lead (Pb)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (Zn)	mg/L	0.016	0.022	0.035	0.031	0.015
Cadmium (Cd)	mg/L	0.0004	<0.0002	<0.0002	<0.0002	0.0005
Chromium (Cr)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel (Ni)	NA	NA	NA	NA	NA	NA
Selenium (Se)	NA	NA	NA	NA	NA	NA
Iron (Fe)	mg/L	0.69	0.04	1.4	<0.01	0.75
Manganese (Mn)	mg/L	0.05	0.02	0.93	<0.01	0.05
Aluminium	NA	NA	NA	NA	NA	NA
Arsenic (As)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	NA	NA	NA	NA	NA	NA
Mercury (Hg)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chloride (Cl)	mg/L	16	17	20	13	NA
Bicarbonate (HCO ₃) as CaCO ₃	mg/L	8.4	3.65	57.31	24.39	NA
Carbonate (CO ₃) as CaCO ₃	mg/L	<1	<1	<1	<1	NA
Sulphate (SO ₄)	mg/L	13	8	63	12	NA
Nitrate as N	mg/L	0.28	0.42	0.03	0.19	0.25
Fluoride (F)	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1

Notes: * Measured in the field.

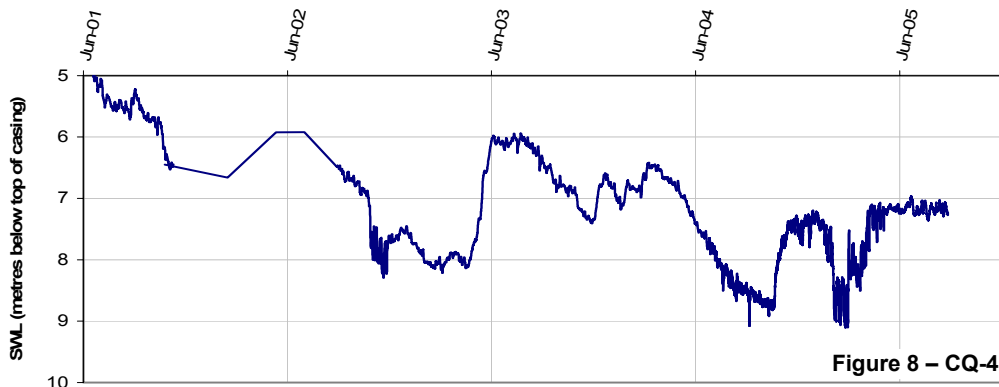
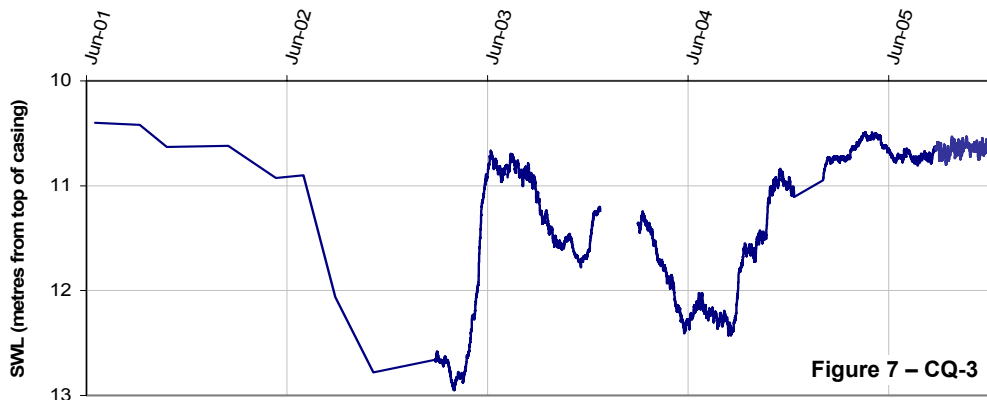
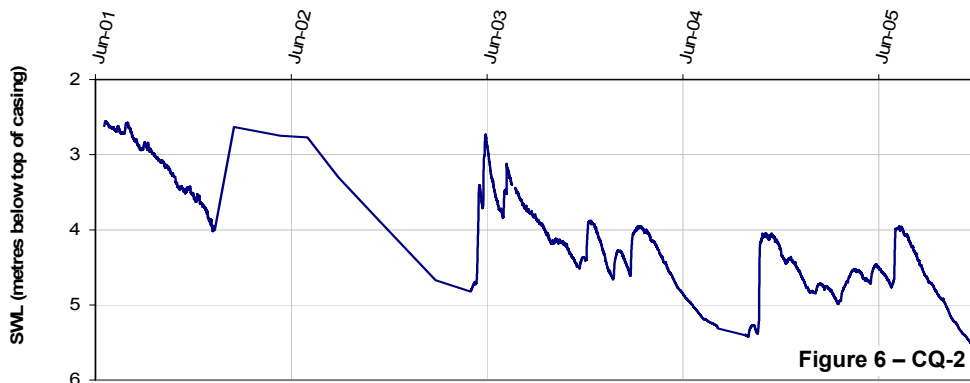
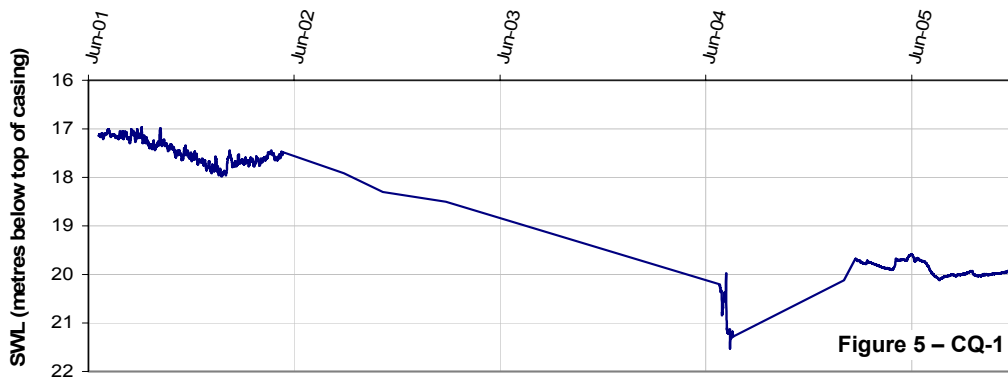
NA

Not analysed

ND

Not detected





Figures 5 to 8: MONITORING BORES - HYDROGRAPHS



6.3.3 Rainfall and Evaporation

Table 6.3 records the rainfall recorded on the Quarry Site between January 1990 and November 2003. For completeness, data for the period from December 2003 to December 2005 has been drawn from the nearby Peats Ridge meteorological station.

Table 6.3
Rainfall Recorded at Calga Sand Quarry (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	56.0	92.0	172.5	84.0	25.0	66.0	17.0	20.0	8.0	39.0	25.0	52.5
1995	208.0	93.5	292.5	19.5	142.0	71.0	1.5	1.5	226.0	31.5	98.0	-
1996	147.0	89.0	64.0	11.5	155.5	98.0	41.5	197.0	87.0	35.5	107.5	58.0
1997	117.0	289.0	19.0	15.5	77.0	67.5	91.0	18.0	86.0	66.5	26.5	19.0
1998	123.0	58.5	3.0	149.5	637.5	112.0	79.0	329.5	21.0	64.5	84.0	27.5
1999	92.5	360.0	42.5	161.5	20.5	109.5	234.5	41.5	30.0	164.0	69.0	83.0
2000	93.6	36.6	326.2	89.2	30.9	22.4	39.0	29.2	43.8	46.6	107.3	83.0
2001	66.5	146.7	188.0	157.0	201.0	4.0	49.0	43.0	26.0	33.0	86.0	94.5
2002	62.5	314.0	112.5	133.5	69.0	28.5	22.0	36.0	29.5	29.5	43.0	103.0
2003	21.5	134.5	79.5	15.0	335.0	31.5	64.5	35.0	3.5	63.0	93.5	71.0
2004	71.2	159.0	105.8	26.0	11.4	9.2	31.2	46.2	63.2	249.0	72.4	114.7
2005	126.8	113.0	150.2	32.4	67.5	127.2	28.8	2.8	57.2	86.0	97.0	40.4
Mean¹	98.8	157.2	129.7	74.6	147.7	62.2	58.2	66.6	56.8	75.7	75.8	69.4
Bureau Of Meteorology Peats Ridge Station (No. 61351) From 1983 – 2002												
Mean²	127	143	150	137	105	79	72	89	71	91	111	91
Note 1: Mean for Rainfall Recorded on site from 1994 to 2005.												
Note 2: Mean for Rainfall recorded at Peats Ridge (24 years)												

Recorded at Peats Ridge Bureau of Meteorology Station No. 61351

6.4 Interim Impact Assessment Criteria

6.4.1 Groundwater Levels

The proposed impact assessment criteria and response actions are as follows.

- If at any annual independent audit review, there is a declining trend in groundwater levels which is not attributable to climatic conditions or other factors not related to the sand extraction activities, and if the groundwater level decline at monitoring bores CQ10 or CQ11 deemed due to sand extraction impacts exceeds 1.0m, then the adjoining landholders will be approached to arrange re-testing of their existing production bore(s). The test results will be compared to pre-extraction tests, and if it is determined that any bore has suffered a reduction in its pumping yield of greater than 10% (in accordance with *Condition 3(10)*), then arrangements will be made with the affected landholder to restore water supply potential, by one of the following means.
 1. Supply of an equivalent water supply by pumping from a production bore on Rocla's property.
 2. Deepening of the affected bore (if feasible).
 3. Drilling a deeper replacement bore.
 4. Another arrangement mutually acceptable to the landholder and Rocla.



- If at any other time, a landholder's bore within 500m of the quarry suffers a reported loss of yield >10% due to declining groundwater levels, the loss of yield would be notified to both the Director-General and the affected landholders (in accordance with *Condition 4(1)*). The Company would also commission an independent hydrogeologist to conduct an investigation regarding the loss of yield. The investigation would include a review of all monitoring data, and if necessary a re-testing of the bore to allow comparison of performance with previous tests. If the investigation reveals that the loss of yield is attributable to the sand extraction activities, then arrangements would be made with the landholder to restore the supply by one of the means described above.

6.4.2 Groundwater Quality

If any private bore within 500m of the quarry experiences a salinity increase (20% increase in EC or TDS), the following response actions would be implemented.

- Resample the bore to verify the quality.
- If the salinity increase is confirmed, immediately notify the Director-General and affected landholder and refer the data to an independent hydrogeologist for investigation.
- If the investigation confirms the sand extraction activities as the likely cause, then arrangements would be made with the landholder to restore the supply by one of the means described above.



7 REFERENCES

C.M. Jewell & Associates, 2004, Hydrogeology Assessment for the Proposed Calga Sand Quarry Extension.

Department of Housing, 2004, *Managing Urban Stormwater: Soils and Construction*.

Mackie Environmental Research Pty Ltd, 2004. *Review of Additional Groundwater Modelling of Calga Sand Quarry*, dated December 2004.

Mackie Environmental Research Pty Ltd, 2005. Letter report entitled *Calga Sand Quarry, Amendment to DA 94-4-2004*, dated 21 July 2005.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. *Transactions of the American Geophysical Union* (38):913-920.

R.W. Corkery & Co, May 2004, Environmental Impact Statement for the Proposed Calga Sand Quarry Extension.

R.W. Corkery & Co, June 2005, Amendment to a Proposal Submitted as Development Application (DA 94-4-2004) for an Extension to the Calga Sand Quarry.



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Appendix 1

Surface Water Flow Calculations

(GSS Environmental Services)

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GSS Environmental
Environmental & Land Management Consultants



PROJECT: Calga Sand Quarry – Northern Extension

COMPUTED BY: Rod Masters

DRAINAGE AREA: 10 ha

DESIGN EVENT: ARI - 1%, DURATION – Tc

**TABLE A1
Data Input**

Parameter	Unit	Output
Discharge	m ³ /sec	1.1
Peak Flow Period	hrs	0.32
Channel Slope	%	1
Channel Bottom Width	m	3
Batter Grade	h:v	3
Material Type	dimensionless	unreinforced vegetation
Retardance	cm	15
Vegetation Type	dimensionless	mixed (sod & bunched)
Vegetation Density	%	50 - 75
Soil Type	dimensionless	Sandy Loam
Manning's Roughness Coefficient	dimensionless	0.05

**TABLE A2
Hydraulic Results**

Parameter	Unit	Output
Flow Velocity	m/sec	0.82
Flow Area	m ²	1.34
Hydraulic Radius	m	0.26
Flow Depth	m	0.34
Permissible Shear Stress	Pa	1.68
Calculated Shear Stress	Pa	1.28
Safety Factor	dimensionless	1.31
RESULT	dimensionless	STABLE



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