

## **Appendix 3**

### **RPS Aquaterra Report**

**GROUNDWATER ASSESSMENT FOR DIXON  
SAND OPERATIONS, LOT 1 AND 2 DP547255,  
MARROOTA NSW**



**GROUNDWATER ASSESSMENT FOR DIXON  
SAND OPERATIONS, LOT 1 AND 2 DP547255,  
MAROOTA NSW**

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Prepared by:

**RPS Aquaterra**

Suite 902, Level 9 North Tower  
1-5 Railway Street, Chatswood NSW 2067  
T: 61 2 9412 4630  
F: 61 2 9412 4805  
E: [water@rpsgroup.com.au](mailto:water@rpsgroup.com.au)  
W: [rpsaquaterra.com.au](http://rpsaquaterra.com.au)

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Prepared for:

**Nexus Environmental Planning on behalf of  
Dixon Sand (Penrith) Pty Ltd**  
PO Box 212  
Concord NSW 2137

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|-------------|------------------|--------------------------|------------------------|------------|
| Author      | Christopher Gill | Senior Hydrogeologist    |                        | 17/08/2012 |
| Contributor | John Fennell     | Project Hydrogeologist   | <i>John Fennell</i>    | 17/08/2012 |
| Reviewer    | Greg Sheppard    | Principal Hydrogeologist | <i>per BS Sheppard</i> | 17/08/2012 |

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## EXECUTIVE SUMMARY

Dixon Sand (Penrith) Pty Ltd owns and operates a sand quarry comprising four separate parcels of land which include the current pits Lots 1 and 2 DP 547255. These lots were approved for a maximum permissible mining depth of 2 metres above the wet weather groundwater level (under the development consent condition 5.2.5).

This groundwater assessment was undertaken to assist with the identification of the 'wet weather' regional groundwater level to justify the proposed modifications to the existing licence consent conditions and extend the maximum depth of extraction on Lots 1 and 2 to two-metres above the regional groundwater table.

- This groundwater assessment was undertaken with a number of aims;
  - To clearly define and delineate the extent of the perched groundwater observed in the Hawkesbury sandstone which was previously incorrectly identified as the regional groundwater level;
  - To define the accurate regional groundwater table level in the Sydney Basin Central Groundwater Source underlying the site;
  - To recommend a depth of mining that would extend 2 meters above the wet weather regional groundwater level;
  - To define the lateral extent of the Maroota Tertiary Sands Groundwater Source; and
  - To assess any potential impacts resulting in the deepening of Lot 1 & 2 pits.

The only gazetted groundwater source found to be underlying the Lot 1 and 2 development areas is the Sydney Basin Central Groundwater Source. Previous investigations involving the installation of shallow groundwater monitoring bores incorrectly identified small perched groundwater levels in the upper unsaturated part of this aquifer as the regional groundwater level. These perched layers are associated with thin shale, clay or ironstone bands that are of limited spatial extent and are not hydraulically connected to the regional groundwater level or the Maroota Tertiary Sands Groundwater source, which is absent from the area.

The Water Sharing Plan for the Greater Metropolitan Region Groundwater Source 2011 identifies the Maroota Tertiary Sands as underlying Lots 1 and 2. Both site specific drilling logs and an independent geological report commissioned conclude that the Maroota Tertiary Sands groundwater source is not present in the development areas. Furthermore, geological logs obtained from a large number of boreholes which have been drilled much further to the east and south east of Lots 1 and 2 do not show any evidence of the Maroota Tertiary Sands Groundwater Source, as it is indicated in the WSP, therefore suggesting that the extent of this source is incorrect and the boundary is much further south than the WSP indicates. A small thin (<0.9m deep) deposit of unsaturated sand is located to the east of the development area. This deposit may represent a thin "feather edge" of the Maroota sands where it has pinched out between the underlying sandstone and the ground surface.

Following detailed site specific investigations the regional groundwater table level was determined to be about 171mAHD in the east and 151mAHD in the west. Therefore, sand extraction in Lot 1 and 2 could extend to a depth of 173mAHD in the east grading to 153mAHD in the west.

The total or partial removal of semi-isolated perched zones is unlikely to have any significant impact on the local hydrogeological regime, other than potentially increasing the rate of rainfall recharge, due to the partial removal of low permeability layers.

The deepening of the quarry pit will not involve contact with, or removal of groundwater from either of the two gazetted groundwater sources in the region (Maroota Tertiary Sands Groundwater Source and the Sydney Basin Central Groundwater Source) and therefore will not impact users abstracting from this source. This includes no impacts to:

- Any registered groundwater abstraction bores. Nine bores are located within 1km of Lot 1 and Lot 2, however all bores are deep and target the Sydney Basin Central Groundwater Source and do not abstract groundwater from the perched groundwater lenses.

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- Local GDEs as the quarrying activities will not intersect either the saturated Maroota sands or the Sydney Basin Central Groundwater source. Therefore no impacts whatsoever on any flow paths or discharges to any local GDEs is possible.

In conclusion, the proposed modification is in accordance with the provisions of the WSP for the Metropolitan Region Groundwater Sources.

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## 1. INTRODUCTION

### 1.1 Background

Dixon Sand (Penrith) Pty Ltd owns and operates a sand quarry off Old Northern Road. The quarry comprises four separate parcels of land identified as Lots 1 and 2 DP547255 and Lot 29 and Lot 196 DP752025.

In 2004, Development Consent No. 250-09-01 was issued by the Land and Environment Court of NSW. The development consent allowed for the operation of extractive industry, water management and rehabilitation on Lots 1 and 2 and the continued use of the existing control processing plant located on Lot 196. The approval for extraction on Lots 1 and 2 is applicable until 24 May 2022 and permits the development of Lot 1 and Lot 2 mine areas down to a depth of 2 metres above the wet-weather groundwater level (under the development consent condition 5.2.5).

RPS Aquaterra was engaged by Nexus Environmental Planning Pty Ltd (on behalf of Dixon Sand (Penrith) Pty Ltd) to undertake a groundwater study in support of the application to amend the existing Development Consent No.250-09-01 on Lots 1 and Lots 2 DP547255. The main objectives of the study were to refine the hydrogeological conceptual model, and more specifically determine the high wet-weather groundwater level.

The amendment also extends to an Endangered Ecological Community (EEC) exclusion area of Shale Sandstone Transition Forest and a delineated buffer zone. In recent times, Dixon Sand Pty Ltd has commissioned an independent investigation of the EEC with a view to determining its current status. Preliminary advice has indicated that the EEC area is most likely not Shale Sandstone Transition Forest. These findings could potentially lead to reclassification and as such, the area might become available for extraction.

In addition, as part of the application for modification, Dixon Sand Pty Ltd is seeking to increase the permitted depth of extraction over Lots 1 and 2 (to also include the EEC and buffer area). The extent of extraction has previously been restricted by the perceived depths to groundwater under Lots 1 and 2. Data obtained from the existing monitoring bore network has indicated the presence of shallow, small and semi-isolated perched lenses of temporarily stored groundwater. These lenses do not represent the regional groundwater table level. As a result, deeper monitoring bores were installed on Lots 1 and 2 (and the surrounding allotments) in order to identify and determine the depth of the deeper regional groundwater table and potentially increase the depth of permitted extraction at Lots 1 and 2.

### 1.2 Key Project Issues

The key technical issues pertinent to Lots 1 and 2 are as follows;

- The total depth of extraction that will be permitted on Lots 1 and 2 will be limited by the depth of the regional water table *“to a depth not exceeding 2 meters above the highest recorded wet weather groundwater level”*, which until recently has not been well defined;
- The current depth of extraction permitted on Lots 1 and 2 was based on the information obtained from shallow monitoring bores which have been monitoring localised perched aquifers and not the regional aquifer system in the Sydney Basin Central Groundwater source; and
- Information obtained from a recent drilling program carried out in areas surrounding Lots 1 and 2, indicated that the regional water table is in fact between 35 and 60m below ground level.

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### 1.3 Project Objectives

The objectives of this assessment were to:

- Review existing hydrogeological studies with reference to the location of Lots 1 and 2 DP547255 and the surrounding area;
- Install two deep monitoring piezometers on Lots 1 and 2 DP547255 to refine the conceptual model of the area that was developed following previous assessments;
- Determine the lateral extent of the perched aquifer in order to ascertain the significance of the system and to provide regulators with sufficient satisfactory information to make informed decisions in relation to the modification of the current consent condition on Lots 1 and 2;
- Determine the wet weather groundwater level beneath Lot 1 and 2, such that the target depth of extraction can be clearly determined; and
- Identify and assess the potential impacts of the proposed amendment to other groundwater users in the area.

### 1.4 Site Description

The quarry site comprises four separate parcels of land identified as Lots 1 and 2 DP547255 and Lot 29 and Lot 196 DP 752025, at 4610 Old Northern Road, Maroota (Figure 1).

The majority of the northern, central and eastern parts of Lots 29 and 196 are being used for extraction operations.

Lots 1 and 2 are two rectangular shaped Lots running parallel to one another occupying an area of approximately 20ha. The current EEC occupies around half of the area that makes up Lots 1 and 2.

## 2. PREVIOUS STUDIES

The hydrogeological system underlying Lots 1 and 2 has been previously assessed by ERM (2005) and more recently by E3 (2010). However, due to the limited amount of site specific groundwater data available, the regional hydrogeological system was not well understood and any potential impacts to groundwater as a result of the proposed extension would have limited site specific emphasis.

In order to address the gaps in the site specific data four monitoring bores were established on Lots 1 and 2 by ERM in 2005, MW1, MW2, MW3 and MW4 (Figure 1) and MW5 located on adjacent Lot 196. These monitoring bores were terminated at relatively shallow depths (ranging from 15.5 to 33.8m). An assessment of groundwater data recorded from the monitoring network has indicated the presence of a shallow 'perched' groundwater table of limited lateral extent, sitting above combinations of shallow confining clay sequences, shale lenses and bands of ironstone. These zones commonly permit the formation of shallow 'perched' aquifer systems well above the deeper regional groundwater level of the Hawkesbury Sandstone. These groundwater bodies generally have limited resource value due to limited extent and storage (DLWC, 2001).

Shallow 'perched' aquifers were also identified in logs of boreholes drilled in the greater Maroota area by Farley and Lewers Ltd (1978) which also reported the presence of shallow clay lenses of limited lateral extent.

An assessment carried out by E3 (2010) concluded that perched groundwater was only present during and shortly after wet periods and that observations from monitoring bores (MW1 to MW4) indicated that the water tables monitored on Lots 1 and 2 were not representative of the depth of water-bearing strata or saturated depth of the regional aquifer system.

For this reason the 'wet-weather' regional groundwater level of the area could not be established from observations recorded from the existing monitoring bore network. In November 2010, Aquaterra Pty Ltd (now RPS Aquaterra) was commissioned to refine the conceptual hydrogeological model of the area, and determine with greater accuracy the depth of the regional groundwater system. This assessment included a review of information obtained from existing licensed bores and the drilling of 3 deep groundwater monitoring bores on nearby allotments (Figure 1). BH1 was installed on the western boundary of Lot 196 DP752025, and BH2 and BH3 were drilled to the east, on Lot 196 DP204159. All three monitoring bores were drilled along an east to west transect, and were completed within the Hawkesbury Sandstone aquifer. The depth of the regional groundwater level was reported to range from 35m in the east to about 60m in the west.

The study also confirmed that the site (and the surrounding area) is underlain by a shallow, narrow, non water bearing, and unconsolidated horizon of weathered clays, sandstones and shales that are likely to be part of the Eluvial Sand unit that grades rapidly to the massive sandstones of the Hawkesbury Sandstone. The weathered clays and shale bands permit the intermittent formation of shallow 'perched' water tables, which are of limited extent and act as temporary storage of groundwater prior to release, by either seepage at topographic lows or by leakage to the deeper underlying aquifers.

### 3. HYDROGEOLOGY

The geological formations present in the Maroota area have variable hydrogeological characteristics (URS, 2006). The high degree of lithological variability (i.e. sands, clays, ironstone, shale and sandstone) and permeability contrasts often result in the establishment of localised perched water tables in both the Maroota Sand and in the Hawkesbury Sandstone; and possibly within the latter, at the base of the weathered profile above fresher sandstone beneath.

Under these conditions, two separate aquifers in the vicinity of the site can be identified, although the extent of their hydraulic separation or, conversely, interconnection, is sometimes uncertain. These aquifer units are the:

- Maroota Sands, gazetted as “The Maroota Tertiary Sands Groundwater Source”; and
- The fresh Hawkesbury Sandstone, gazetted as “The Sydney Basin Central Groundwater Source”.

#### 3.1 The Maroota Tertiary Sands Groundwater Source

The Maroota Tertiary Groundwater Source is a sandy formation of limited areal extent which has been mapped adjacent to Lots 1 and 2 development areas. While there is some evidence of a thin horizon of sands to the east of Lots 1 and 2, the actual groundwater source itself does not underlie the development areas as is identified in the Water Sharing Plan for the Greater Metropolitan Region Groundwater Source 2011 report.

Here, to the east of Lots 1 and 2 the thin unsaturated sands (approximately 0.9m thick), represent the feather edge or pinched out part of the Maroota sands matrix and do not represent the saturated Maroota Tertiary Groundwater Source. An independent report investigating the extent of the Maroota Sand in the vicinity of the site was commissioned by VGT Pty Ltd in August 2012. This report is attached as Appendix C. The report concluded that the 2011 WSP report incorrectly identifies that Lot 1 & 2 sites are underlain by the Maroota Tertiary Groundwater Source. This conclusion is confirmed by site specific and regional drilling data in the area as shown on Figure 2. The correct hydrogeology underlying Lots 1 and 2 consists primarily of unsaturated Hawkesbury Sandstone, with some small thin deposits of sand to the east. This is further discussed in the following sections.

Regionally, the Maroota Tertiary Groundwater Source was deposited mainly in two palaeochannels located to the east of the site which have been eroded into the exposed surface of the Hawkesbury Sandstone (Figure 2).

Away from the palaeochannels, the presence of considerable clay and cemented layers gives rise to localised perched water tables. From a resource viewpoint, the perched water table aquifers have limited value due to their small extent and limited storage. These water bodies are found at variable elevations and depend upon rainfall infiltration for their persistence. The Maroota Sand, where it occurs below the water table such as in the deeper sections of the palaeochannels, constitutes a substantially unconfined water table aquifer open to direct rainfall infiltration.

#### 3.2 Weathered Profile of the Underlying Hawkesbury Sandstone

Small aquifer zones have developed in the eluvial sand, which comprises the leached and weathered profile of the Hawkesbury Sandstone. These zones often form perched aquifer systems above the deeper regional water level of the Hawkesbury Sandstone. In the majority of cases, these perched aquifer systems have limited resource value because, like the Maroota Sand, they have small extent and storage. They act as temporary storage of groundwater prior to release to streams or leakage to underlying aquifers. Dams and large diameter wells constructed into this material can provide a source of farm water supplies, but generally the permeability is too low to yield significant supplies to small diameter boreholes.

### 3.3 Hawkesbury Sandstone

The Hawkesbury Sandstone is generally an impermeable rock, due to the fine grained clayey matrix (generally kaolinite and illite) and large degree of grain cementation resulting from the development of secondary minerals in the interstitial spaces, such as secondary silica and siderite (iron carbonate). Although the rock has very little primary permeability, fracturing and jointing, where open and interconnected, provides secondary permeability and storativity.

A review of the bore records held by the NSW Office for Water, for the Maroota area (including observation bores established during the Stage 2 Maroota Groundwater Study), showed that different water tables are intersected during drilling in the Hawkesbury Sandstone, due to the different degree of fracturing and the presence of confining layers (such as the shale lenses) within the rock mass. Three nested bores (GW075000/1,2,3) located approximately 2.6km to the south of the quarry area are approximately 22m, 43.5m and 110m deep, with corresponding groundwater levels of 14.4m (Maroota Sand), 27.7m (Hawkesbury Sandstone) and 29m (Hawkesbury Sandstone) below ground level respectively. The water level at 14.4m is interpreted to be a localised perched aquifer, while the two deeper levels at 27.7m and 29.0m are considered to represent the regional groundwater aquifer system. The slightly lower level for the deep bore indicates a downward head gradient and is indicative of the variable and layered nature of the aquifer system.

Most of the bores in the area are in elevated locations along the Maroota Ridge which represents a surface drainage divide and a likely groundwater divide.

Groundwater gradients measured in recent investigations in closely spaced bores are variable and steep in places due to the low permeability of the rock mass. Groundwater flow directions are expected to be generally to the northwest, east and south, away from the main axis of the groundwater divides, which coincide with the main topographic divides.

## 4. SITE INVESTIGATIONS

### 4.1 Drilling Programs

Three deep monitoring bores (BH1, BH2 and BH3) were originally drilled along an east to west transect and completed within the Hawkesbury Sandstone Aquifer. BH1 was located on the western boundary of the north western extraction area (Lot 196) and BH2 and BH3 were located on Lot 196 DP204159 (Figure 1).

Drilling was undertaken by Terratest Pty Ltd, using conventional air-rotary hammer techniques. Air hammer drilling uses compressed air, which is used to work a pneumatic down-hole hammer and return drill cuttings to the surface. One of the major advantages of conventional air hammer drilling is that water-bearing zones and yields can be identified when formation water is discharged with the cuttings.

The geological log, water strike information and construction details of BH1, BH2 and BH3 are presented in Appendix A and summarized below in Table 4.1.

The construction of each piezometer comprised of surface casing installed within upper unconsolidated sequence of the sandstone. Each monitoring bore was drilled at 90mm diameter to accommodate 50mm diameter PVC casing to depths of up to 75m.

The screened intervals were 3 to 6m in length and constructed of Class 12, 50mm diameter, machine slotted PVC (0.8mm aperture). Graded gravel pack was installed within the bore annulus and extended 2m above the top of the screens. A 5m bentonite and cement/grout seal was installed into the annulus of the borehole above the gravel packed zone.

Each monitoring bore has been surveyed relative to the Australian Height Datum (AHD).

### 4.2 Additional Drilling Program for Lot 1 and Lot 2

Two additional groundwater monitoring bores (BH6 and BH7) were installed following a subsequent drilling program in the vicinity of Lots 1 and 2 DP547255. Both monitoring bores were drilled to 60m in an attempt to establish the wet weather groundwater level of the regional aquifer underlying Lots 1 and 2.

BH6 was drilled along the northern boundary of Lot 1, and BH7 was drilled along the southern boundary of Lot 2, with both being completed within the Hawkesbury Sandstone (Figure 1). Both monitoring bores were drilled in close proximity to existing shallow monitoring bores (MW1 and MW3). This was done to demonstrate the degree of separation between the perched localised system and the deeper region aquifer identified in previous drilling.

The geological log, water strike information and construction details of BH6 and BH7 are presented in Appendix A.

Both monitoring bores were surveyed relative to the Australian Height Datum (AHD).

A summary of both the deep and key shallow boreholes, relevant to this study have been listed in Tables 4.1 and 4.2.

**Table 4.1: Deep Borehole Summary**

| Monitoring bore | Easting | Northing | Ground RL (mAHD) | Screen interval | Bore Depth (m) | Top of Standpipe (mAHD) | GWL (mAHD) | GWL (mbgl) |
|-----------------|---------|----------|------------------|-----------------|----------------|-------------------------|------------|------------|
| BH1             | 312290  | 6297040  | 166.18           | 68 - 74         | 75             | 166.89                  | 108.95     | 57.2       |
| BH2             | 313426  | 6297209  | 201.88           | 67 - 70         | 70             | 202.33                  | 164.88     | 37.0       |
| BH3             | 313805  | 6297092  | 193.54           | 57 - 60         | 60             | 194.06                  | 160.94     | 32.6       |
| BH6             | 313151  | 6296826  | 195.41           | 54 - 60         | 60             | ~195.91*                | 164.51     | 30.9       |
| BH7             | 313068  | 6296495  | 181.47           | 54 - 60         | 60             | ~181.97*                | 160.77     | 20.77      |
| GW105044        | 312044  | 6297105  | -                | -               | 144.5          | -                       | -          | 61.8       |
| GW105047        | 312504  | 6296897  | -                | -               | 156.8          | -                       | -          | 60.0       |

\*approximate standpipe height. Not surveyed at time of reporting standpipe height above ground level assumed at 0.5m

mbgl – meters below ground level.

**Table 4.2: Shallow Borehole Summary**

| Monitoring bore | Easting | Northing | Ground RL (mAHD) | Screen interval | Bore Depth (m) | Top of Casing (mAHD) | GWL (m AHD) | GWL (m bgl)   |
|-----------------|---------|----------|------------------|-----------------|----------------|----------------------|-------------|---------------|
| MW1             | -       | -        | 182.6            | -               | 15.5           | 182.98               | 175 – 178*  | 4.6 - 7.6     |
| MW2             | -       | -        | 215.49           | -               | 25.3           | 215.8                | 192 – 200*  | 15.49 – 23.49 |
| MW3             | -       | -        | 195.42           | -               | 33.8           | 196.45               | 175 – 178*  | 17.42 – 20.42 |
| MW4             | -       | -        | 187.83           | -               | 29.5           | 188.92               | 171 – 173*  | 14.83 – 16.83 |
| MW5             | -       | -        | -                | -               | -              | 167.44               | 162 – 163*  | 4 - 5         |

\*GWL ranges taken from July 2007 to June 2008 – Annual Environmental Management Report (ERM July 2009)

mbgl – meters below ground level.

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## **5. HYDROGEOLOGICAL ASSESSMENT**

### **5.1 Maroota Tertiary Sands Groundwater Source**

Evidence based on the bore logs and the monitoring wells located on Lots 1 and 2 shows that the Maroota Tertiary Sands Groundwater Source does not underlie these areas. Information from the logs indicate that Lot 1 and Lot 2 and the remainder of the site is underlain by a shallow and narrow non water bearing and unconsolidated horizon of weathered clays, sandstones and shales, which are likely to be part of the Eluvial Sand unit that grades rapidly to massive sandstones of the Hawkesbury Sandstone.

Geological logs obtained from a large number of boreholes which have been drilled further to the east and south east of Lots 1 and 2 do not show any evidence of the Maroota Tertiary Sands Groundwater Source where it is indicated in the WSP, suggesting that the extent of this source is incorrect and the boundary is probably much further south than the WSP indicates (Figure 2).

Table 4.3 presents a summary of the horizons encountered in the boreholes drilled in the proximity of Lots 1 and 2. It should be noted that the Maroota Sands were not encountered in the drilling of these boreholes. The full drilling logs of the boreholes are provided in Appendix A.



**Table 5.1: Summary of the horizons encountered in boreholes near Lot 1 & 2.**

| BH6       |                 | BH7     |                 | GW034628  |                 | MW2        |              | GW48741    |                 |            |            |
|-----------|-----------------|---------|-----------------|-----------|-----------------|------------|--------------|------------|-----------------|------------|------------|
| Horizon   | Depth (mbgl)    | Horizon | Depth (mbgl)    | Horizon   | Depth (mbgl)    | Horizon    | Depth (mbgl) | Horizon    | Depth (mbgl)    |            |            |
| Sands     | Not encountered | Sands   | Not encountered | Sands     | Not encountered | Silty sand | 0 – 0.8      | Sands      | Not encountered |            |            |
| Sandstone | 0 - 60          | Clay    | 0 – 0.1         | Topsoil   | 0 – 1.22        | Sandstone  | 0.8 – 25.3   | Sandy soil | 0 – 0.9         |            |            |
|           |                 |         |                 | Sandstone | 1.22 – 91.44    |            |              |            |                 | Shale clay | 0.9 – 2.4  |
|           |                 |         |                 |           |                 |            |              |            |                 | Sandstone  | 2.4 – 5.6  |
|           |                 |         |                 |           |                 |            |              |            |                 | Clay       | 5.6 – 11.8 |
|           |                 |         |                 |           |                 |            |              |            |                 | Sandstone  | 11.8 - 30  |

Furthermore, an independent report investigating the lateral extent of the Maroota Tertiary Sands Groundwater Source was commissioned by VGT Pty Ltd which also concludes that Lots 1 and 2 development areas are not underlain by the groundwater source. The report identifies a small area to the east of the site where a shallow (0.9m deep) unsaturated sand unit is present at ground surface. This horizon may represent the thin “feather edge” of the Maroota Tertiary Sands where it pinches out between the underlying sandstone and the ground surface.

## 5.2 Sydney Basin Central Groundwater Source

Shallow perched water tables have been found to exist above semi confining layers such as clay lenses, shale or ironstone bands throughout the area. These shallow groundwater lenses are commonly referred to as ‘perched’ aquifers and are defined as ‘an aquifer that forms in the otherwise generally unsaturated zone above the regional aquifer in the saturated zone’. The use of the term ‘perched’ aquifer in this case, can be misleading as it suggests that the perched aquifer could be of significant importance hydrogeologically and from a potential resource perspective. The perched groundwater identified in this area is reported to have limited resource value because of its isolated nature, limited extent and low storage capacity (DWLC, 2001).

MW1, MW2 and MW3 located on Lots 1 and 2 revealed perched water tables at approximately 6 to 19m below ground level (177mAHD). Perched groundwater was also found to exist above thin clay bands at depths of 14 to 18m during the drilling of BH6 and BH7 (Appendix A). It was reported in Aquaterra 2010, that the groundwater levels in MW1 and MW4 did not respond greatly to significant rainfall (i.e. 53mm events). This suggests that the perched aquifers are not extensive and act as temporary storage of groundwater followed by rapid release to the deeper underlying aquifers.

Groundwater elevations for paired groundwater monitoring sites (BH6/MW3) and (BH7/MW1) are shown on Figure 3. They show that the elevation of the regional groundwater level (measured in BH6 and BH7) ranges from 160 to 163mAHD, approximately 14 to 16m deeper than the overlying perched water tables (177mAHD), measured at their respective locations (MW3 and MW1).

Groundwater elevation contours underlying Lots 1 and 2, and the surrounding area are shown on Figure 4. The contouring highlights a groundwater divide, which coincides with the main topographic divide of the Maroota Ridge. The groundwater gradient flows to the east and west (away from the divide) towards the upper tributaries of the Hawkesbury River. At lower elevations, the tributaries represent areas of possible groundwater discharge from the Hawkesbury Sandstone aquifer. The inferred groundwater elevations beneath Lots 1 and 2, range from 170mAHD in the east, to 150mAHD in the west (Figure 4). The groundwater gradients across the area are quite steep, due to flow being controlled predominantly by fracture zones across the sandstone unit.

### 5.2.1 Perched Aquifer Zone Geometry

The lateral extent and depth of the perched groundwater zones can be inferred from the observations made from the drilling program. The drill logs indicate the presence of clay bands across the site at depths ranging from approximately 180 to 165mAHD or around 10 to 20m below ground level (Refer to Table 5.1). The drilling records also indicate that the first water strike (during drilling) was observed between these low permeability layers (Table 5.1). The occurrence of thinly banded clay layers appears to be relatively common across the middle of the site (BH6 and BH7) with two separate bands observed approximately 5m apart. The clay bands do not appear to be as prevalent in BH1 (located to the west) and BH3 (located to the east) indicating that the clay sequence is likely to thin and pinch out to the east and west, reducing the capacity of the layer to retain significant quantities of groundwater. The thinly banded and laterally discontinuous nature of the clay units and the iron stone sequences means that any perched water that is temporarily stored will eventually drain out via topographic lows, leakage into the regional Hawkesbury sandstone or drain slowly through the low permeability unit itself.

**Table 5.2: Perched Aquifer Identification Summary**

| Borehole Number | Semi Impermeable Layer Description | Semi Impermeable Layer Depth (mbgl)       | 1 <sup>st</sup> Water Strike (mbgl) | 2 <sup>nd</sup> Water Strike (mbgl) | Ground RL (mAHD) | Groundwater Depth (mAHD) |
|-----------------|------------------------------------|---|-------------------------------------|-------------------------------------|------------------|--------------------------|
| BH1             | Clay bands                         | 6.0                                       | 7.8 - 10                            | 59.8                                | 166.18           | 108.24*                  |
| BH2             | Harder sandstone bands             | 10.1 – 10.8<br>13.6 – 13.9<br>16.1 – 16.8 | 7.8                                 | 37.7                                | 201.88           | 164.43*                  |
| BH3             | Ironstone Bands                    | 10 and 34                                 | 13.5                                | 34.8                                | 193.54           | 160.42*                  |
| BH6             | Clay bands                         | 5.2 and 21.9                              | 18.2                                | 53.9                                | 195.41           | 164.01*                  |
| BH7             | Clay bands                         | 14.7 and 16.4                             | 18.2                                | 55.5                                | 181.47           | 160.27*                  |
| MW1             | -                                  | -   | -                                   | -                                   | 182.6            | 177.60                   |
| MW2             | -                                  | -   | -                                   | -                                   | 215.49           | 199.00                   |
| MW3             | -                                  | -   | -                                   | -                                   | 195.42           | 176.42                   |
| MW4             | -                                  | -   | -                                   | -                                   | 187.83           | 170.83                   |
| MW5             | -                                  | -   | -                                   | -                                   | 167.44           | 162.00                   |

### 5.2.2 Rainfall

The groundwater levels recently monitored in MW1 and MW4 did not respond greatly to a 53mm rainfall event, which occurred on the 3rd to 5th of November 2010. The flat line hydrographs (Figure 3) supports the theory that the shallow groundwater encountered in this area is not indicative of a significant perched aquifer. Typically, rainfall is the principal mechanism of recharge to a perched system therefore a response to rainfall would normally be apparent following rainfall recharge capture and containment. In this case, it is likely that rainfall recharge gradually drains where the semi-confining layers discontinue or thin out, supporting the interpretation that storage in these shallow groundwater zones is both temporary and of limited capacity.

### 5.2.3 Wet weather groundwater levels

Due to the short duration of groundwater monitoring on BH6 and BH7, it has not been possible to quantify the long term variations in the regional Hawkesbury Sandstone aquifer. However, longer term groundwater monitoring has been carried out on monitoring bores VEL-MW1 to VEL-MW3 at the neighbouring quarry site (PF Formation). The locations of the monitoring bores are presented in Figure 1 and Figure 2 and hydrographs showing the groundwater elevation since 1998 have been reported by URS (2006). The groundwater levels show an annual seasonal fluctuation of up to 1m, with a long-term climate-driven range of 1 to 3m. A receding trend in groundwater levels was indicated as a result of extended periods of below average rainfall.

In the absence of long term groundwater monitoring in the vicinity of Lots 1 and 2, it is expected that the seasonal fluctuations of the Hawkesbury Sandstone aquifer beneath Lots 1 and 2 would also show a seasonal range of about 1m. Based on the inferred groundwater contouring (Figure 4) the 'wet weather high groundwater level' would be at a minimum elevation of about 171mAHD towards the east and 151mAHD in the west. An east to west cross section across Lots 1 and 2, with the proposed extraction depth of the pit is shown for reference purposes as Figure 5.

### 5.3 Conceptual site model

As part of this assessment a conceptual hydrogeological model has been developed to represent the conditions on Lot 1 and 2, and to assist in understanding the groundwater system both locally and at a more regional level. The conceptualisation has been developed based on the information obtained from previous studies (Aquaterra 2010, E3, 2010; and ERM, 2005), licensed bore records, and data sets and drilling records from BH1, 2, 3, 6 and 7 and MW1, 2, 3, 4 and 5.

Diagram 1 (Figure 6) shows the conceptual model section at a more regional scale. The groundwater divide, (which coincides with the topographic divide of the Maroota Ridge) permits groundwater flow both to the east and west towards the upper tributaries of the Hawkesbury River.

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At lower elevations, the tributaries represent areas of possible groundwater discharge from the Hawkesbury Sandstone aquifer. To the west and away from the divide the regional groundwater table exhibits a steep hydraulic gradient (due to low permeability and secondary porosity) towards a topographic low/tributary discharge point. The model also serves to show that the shallow groundwater encountered is representative of semi-isolated pockets of groundwater that accumulate temporarily above discontinuous combinations of low permeability clay bands and iron stone. Due to the limited storage potential of these low permeability layers, the shallow groundwater will gradually drain, providing some slow and low volume recharge to the regional aquifer (Figure 6 - Diagram 2).

## 6. POTENTIAL IMPACTS

### 6.1 Maroota Tertiary Sands Groundwater source

#### 6.1.1 Groundwater Dependent Ecosystems

The development lots are not underlain by, and do not intersect with the Maroota Tertiary Sands Groundwater Source. Therefore, any Groundwater Dependent Ecosystems (GDEs) present in the area which are fed with discharge from this groundwater source will not be impacted by the development.

The thin sands (approx. 0.9m deep) present at the eastern edge of the development lots are unsaturated and therefore do not contribute groundwater to any GDEs in the area. Similarly, the removal of this thin horizon of unsaturated sand will not have any impact on any GDEs in the area.

#### 6.1.2 Local groundwater users

As the site is not underlain by Maroota Tertiary Sands Groundwater Source there will be no impacts to any users abstracting groundwater from this source in the region.

A review of the database has indicated that there are nine registered groundwater abstraction bores within approximately 1km of Lots 1 and 2. All of the bores listed were terminated at depths well below the extent of the low permeability layers observed in the site investigation drilling and from the borehole log review. Therefore none of these production bores would significantly rely on or abstract from groundwater stored above these layers and would therefore not be significantly impacted by an extension of the quarrying activity.

### 6.2 Sydney Basin Central Groundwater Source

The total or partial removal of the shallow horizons which contain some perched groundwater zones is unlikely to have any measurable impacts to the local or regional hydrogeological regime, other than potentially increasing the rate of local rainfall recharge (due to the partial removal of low permeability layers) to the regional aquifer system. As mentioned, the shallow groundwater system will recharge the deeper aquifer via gradual drainage, however, this level of recharge is negligible when compared to the larger scale recharge mechanisms associated with the Hawkesbury sandstone. These mechanisms would include mass infiltration via complex networks of structurally controlled fracturing (secondary porosity) at a more regional level throughout the sandstone unit.

#### 6.2.1 Groundwater Dependent Ecosystems

The development comprises the extension of pits into the unsaturated zone overlying the Sydney Basin Central Groundwater Source. No impact to any wetlands or GDEs in the area is expected to occur because the development remains in the unsaturated zone overlying the regional water table in the Sydney Basin Groundwater source and therefore will not intersect the flow path or hydraulic gradient of the aquifer. No impact on discharge to any local wetland can therefore occur.

#### 6.2.2 Local groundwater Users

The impact of the extended quarrying is expected to have a minimal impact on existing users in the immediate vicinity. A summary review of other registered groundwater bores (using information contained in the NSW Groundwater Archive) in the area is summarised in Table 6.1 and is also shown on Figure 2.

**Table 6.1: Summary of Registered Bores in the Area**

| Registered Borehole Number | Licence Number | Geological Termination and Recorded Depth (mbgl) | Total Bore Depth (mbgl) | Recorded Groundwater Depth (mbgl) |
|----------------------------|----------------|--|-------------------------|-----------------------------------|
| GW060051                   | 10BL130437     | Sandstone (109.7)                                | 172                     | 172                               |
| GW108866                   | 10BL165806     | Not listed                                       | 36.5                    | 18                                |
| GW055962                   | 10BL121786     | Sandstone (9.0)                                  | 22.0                    | -                                 |
| GW048741                   | 10BL107252     | Sandstone (30.0)                                 | 30                      | -                                 |
| GW034628                   | Govt.          | Sandstone (83.52)                                | 91.4                    | 35                                |
| GW105192                   | 10BL161673     | Sandstone (234)                                  | 234                     | 46                                |
| GW102133                   | 10BL159032     | Grey Sandstone (150)                             | 150                     | -                                 |
| GW101528                   | 10BL158453     | Sandstone (108)                                  | 150                     | 20.5                              |
| GW016348                   | 10BL006847     | -  | 73                      | 48                                |

## **7. COMPLIANCE WITH THE WATER SHARING PLAN RULES**

The Sydney Basin Central Groundwater Source is the only gazetted groundwater source underlying the development area. As discussed above, the depth of the development will not extend to the depth of the groundwater level in this aquifer and no impacts are expected. However, for clarity all of the rules and requirements of the Water sharing Plan for Sydney Basin Central Groundwater source are presented in Table 7.1 along with reasons why none of the rules are being impacted.

As mentioned in previous sections of this report, an independent geological investigation by VGT Pty Ltd and site specific drilling data has shown that the Tertiary Sands Groundwater Source is absent from the development area. However, for completeness and because it is the next nearest gazetted groundwater source, reasons why the development does not impact on the rules for this aquifer are presented in this report in Table 7.2.

**Table 7.1: Rules summary sheet for the Maroota Tertiary Sands Groundwater Source**

| Access Rules  | Relevance for this development | Reason why rule is not applicable  |
|---|--------------------------------|--|
| Granting of access licenses may be considered for a listed number of activities | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought. This groundwater source is absent from Lot 1 &amp; 2 and has been confirmed by our study to be further south from Lot 1 &amp; 2 and not present in the location shown by the WSP (<b>Figure 2</b>).</li> </ul>  |
| <b>Rules for managing water allocation accounts</b>                             |                                |  |
| Carryover   | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought and therefore no water allocation accounts need to be amended;</li> <li>No interception whatsoever of the groundwater source will take place.</li> </ul>   |
| <b>Rules for managing access licenses</b>                                       |                                |  |
| Managing surface and groundwater connectivity                                   | Not applicable                 | <ul style="list-style-type: none"> <li>The existing pit is &gt;40m from the high bank of any river or creek;</li> <li>The extension of the pit will not intercept the groundwater source.</li> </ul>   |
| <b>Rules for granting or amending water supply works approvals</b>              |                                |  |
| To minimise interference between neighboring water supply works                 | Not applicable                 | <p>The extent of the Maroota Tertiary Sands Groundwater Source is incorrectly shown in the WSP to be adjacent to Lot 1 &amp; 2. Our study has confirmed that this source is not present where it is shown in the WSP and that Lot 1 &amp; 2 developments are at least 350m from this source and any groundwater licenses that may be associated with it. The closest bore (GW106261) which is located on another landholding, inside the inferred boundary of the Maroota Tertiary Sands Groundwater Source is ~350m from Lot 1 &amp; 2 (Figure 2). However the bore depth (30m) and geological logs obtained from surrounding bores (such as GW048741 &amp; GW105192) confirm that this bore actually targets the Sydney Basin Central Groundwater Source as they do not show any evidence of Maroota Tertiary Sands in this area (Appendix A). It can therefore be said that the development satisfies the following rules:</p> <ul style="list-style-type: none"> <li>The pit extension is &gt;100m from an aquifer access licence bore on another landholding;</li> <li>The pit extension is &gt;1000m from a local or major water utility bore;</li> <li>The pit extension is &gt;200m from a NSW Office of Water monitoring bore;</li> <li>The pit extension is 100m from the closest active groundwater licence. This bore is owned and utilised by Dixon Sand Operations Ltd and targets the underlying Sydney Basin Central Groundwater Source</li> </ul> |
| To protect bores located near contamination                                     | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought;</li> <li>No areas of contamination have been identified within 500m of Lot 1 &amp; 2 development;</li> <li>The development does not intercept or abstract groundwater and therefore will not impact hydraulic gradients, or facilitate the mobilization of any contamination in the vicinity;</li> <li>The development remains entirely in the unsaturated zone.</li> </ul>   |
| To protect bores located near sensitive environmental areas                     | Not applicable                 | <ul style="list-style-type: none"> <li>No water supply works are being carried out as part of the development;</li> <li>No interception of the groundwater source will take place;</li> <li>The development remains entirely in the unsaturated zone and therefore will not impact any discharges to / from sensitive environmental areas.</li> </ul>  |
| To protect groundwater dependent culturally significant sites                   | Not applicable                 | <ul style="list-style-type: none"> <li>The development is &gt;100m from existing bores abstracting from the aquifer;</li> <li>The development does not intercept any groundwater source;</li> </ul>  |



| Access Rules   | Relevance for this development | Reason why rule is not applicable  |
|--|--------------------------------|--|
| Rules for replacement groundwater water supply works   | Not applicable                 | <ul style="list-style-type: none"> <li>No replacement groundwater work is being applied for.</li> </ul>                    |
| Rules for the use of water supply works approvals      |                                |  |
| To manage bores located near contaminated sites        | Not applicable                 | <ul style="list-style-type: none"> <li>No groundwater source is being abstracted or intercepted for any purpose</li> </ul> |
| To manage the use of bores within restricted distances | Not applicable                 | <ul style="list-style-type: none"> <li>No groundwater source is being abstracted or intercepted for any purpose</li> </ul> |
| To manage the impacts of extraction                    | Not applicable                 | <ul style="list-style-type: none"> <li>No groundwater source is being abstracted or intercepted for any purpose</li> </ul> |
| Limits to the availability of water                    |                                |  |
| Available water determinations (AWDs)                  | Not applicable                 | <ul style="list-style-type: none"> <li>No groundwater source is being abstracted or intercepted for any purpose</li> </ul> |

**Table 7.2: Rules summary sheet for the Sydney Basin Central Groundwater Source**

| Access Rules  | Relevance for this development | Reason why rule is not applicable   |
|---|--------------------------------|---|
| Granting of access licenses may be considered for a listed number of activities | Not applicable                 | <ul style="list-style-type: none"> <li>No access licence is being sought as the developments do not intercept the groundwater source;</li> <li>The deepest extent of the pit will remain at least 2m above the elevation of the regional water table level.</li> </ul>                        |
| Rules for managing water allocation accounts                                    |                                |   |
| Carryover   | Not applicable                 | <ul style="list-style-type: none"> <li>No access licence is being sought and therefore no carryover is needed;</li> <li>The lot developments do not intercept the regional water table level.</li> </ul>  |
| Rules for managing access licenses  |                                |   |
| Managing surface and groundwater connectivity                                   | Not applicable                 | <ul style="list-style-type: none"> <li>No access licence is being sought;</li> <li>The pit developments are &gt;40m from the high bank of any river or creek (See Figure 6);</li> <li>The development of the pits will not intercept the groundwater source whatsoever (Figure 6).</li> </ul> |

| Access Rules   | Relevance for this development | Reason why rule is not applicable  |
|--|--------------------------------|--|
| Rules for granting and amending water supply works approvals     |                                |  |
| To minimise interference between neighbouring water supply works | Not applicable                 | <ul style="list-style-type: none"> <li>The developments are &gt;100m from an aquifer access licence bore on another landholding. The closest licensed bore (GW100651) on another land holding is located 350m from Lot 1 &amp; Lot 2 and its status is listed as Active-Current. Neighbouring bores with groundwater licences range from 83mbgl - 200mbgl and target the Sydney Basin Central Groundwater Source (Figure 2);</li> <li>Lot 1 &amp; 2 developments are &gt;1000m from a local or major water utility bore;</li> <li>The pit developments are &gt;200m from a NSW Office of Water monitoring bore;</li> </ul> |
| To protect bores located near contamination                      | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought;</li> <li>No areas of contamination have been identified within 500m of Lot 1 &amp; 2 developments;</li> <li>The developments do not intercept or abstract the groundwater and therefore will not impact hydraulic gradients, or facilitate the mobilisation of any contamination in the vicinity;</li> <li>The developments remain entirely in the unsaturated zone.</li> </ul>   |
| To protect water quality   | Not applicable                 | <ul style="list-style-type: none"> <li>The pit floor will be at least 2m above the regional groundwater level of the aquifer and therefore does not intercept it;</li> <li>The development remains in the unsaturated zone and therefore cannot possibly initiate the onset of saline intrusion to the aquifer.</li> </ul>   |
| To protect bores located near sensitive environmental areas      | Not applicable                 | <ul style="list-style-type: none"> <li>No water supply works are being carried out as part of the development;</li> <li>No interception of the groundwater source will take place;</li> <li>The pit extension remains entirely in the unsaturated zone and therefore will not impact any discharges to / from sensitive environmental areas.</li> </ul>  |
| To protect groundwater dependent culturally significant sites    | Not applicable                 | <ul style="list-style-type: none"> <li>The developments are &gt;500m from existing bores abstracting from the aquifer;</li> <li>The developments do not intercept the groundwater source;</li> <li>The developments remain entirely in the unsaturated zone and does not impact any discharges to / from groundwater dependent culturally significant sites.</li> </ul>  |
| Rules for replacement groundwater works                          | Not applicable                 | <ul style="list-style-type: none"> <li>No replacement groundwater work is being applied for;</li> <li>The developments do not intercept the groundwater source.</li> </ul>   |
| Rules for the use of water supply works approvals                |                                |  |
| To manage bores located near contaminated sites                  | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought and therefore no groundwater abstraction will take place;</li> <li>The developments do not intercept the groundwater source.</li> </ul>  |
| To manage the use of bores within restricted distances           | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought and therefore no groundwater abstraction will take place;</li> <li>The developments do not intercept the groundwater source.</li> </ul>  |
| To manage the impacts of extraction                              | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought and therefore no groundwater abstraction will take place;</li> <li>The developments do not intercept the groundwater source.</li> </ul>  |

| Access Rules                                     | Relevance for this development | Reason why rule is not applicable   |
|--|--------------------------------|---|
| Limits to the availability of water              |                                |   |
| Available water determinations (AWDs)            | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought and therefore no groundwater abstraction will take place;</li> <li>The developments do not intercept the groundwater source.</li> </ul> |
| Trading Rules                                    |                                |   |
| INTO groundwater source                          | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought therefore no groundwater abstraction will take place;</li> <li>The developments do not intercept the groundwater source.</li> </ul>     |
| WITHIN groundwater source                        | Not applicable                 | <ul style="list-style-type: none"> <li>No application licence is being sought therefore no groundwater abstraction will take place;</li> <li>The developments do not intercept the groundwater source.</li> </ul>     |
| Conversion to another category of access license | Not applicable                 | <ul style="list-style-type: none"> <li>No application license is being sought therefore no groundwater abstraction will take place;</li> <li>The developments do not intercept the groundwater source.</li> </ul>     |

## 8. SUMMARY AND CONCLUSIONS

Following a review of the information made available and from the findings made in this assessment the following salient points and conclusions are presented as follows.

- Lot 1, Lot 2 and the remainder of the site is underlain by unsaturated Hawkesbury Sandstone which contains some shallow perched groundwater lenses of limited extent. These temporary perched storages have no significant resource value as they are discontinuous and of limited extent and low storage. They therefore do not contribute to the regional hydrogeological regime.
- The only gazetted aquifer underlying the development area is the Sydney Basin Central Groundwater Source which will not be intersected by the development of Lots 1 and 2.
- The maximum 'wet weather' regional groundwater table level in this aquifer is estimated to be about 171mAHD in the east and 151mAHD in the west. Therefore, sand extraction in Lots 1 and 2 could extend to a depth of 173mAHD in the east grading to 153mAHD in the west.
- As the development of Lot 1 and 2 will extend to a maximum depth of 2 meters above the highest wet weather groundwater level in the Sydney Basin Central Groundwater source, no interception of this aquifer will occur.
- An independent report commissioned by VGT Pty Ltd concludes that Lot 1 and 2 are not underlain by the Maroota Tertiary Sands Groundwater source and the WSP 2011 report incorrectly identifies. This fact is confirmed by drilling data in the vicinity of Lots 1 and 2 which is also presented in Figure 2.
- The proposed modification is considered to be in accordance with the provisions of the WSP for the Metropolitan Region Groundwater Source. Rational for this is presented in the rules summary sheet in Table 7.1 and 7.2.
- There are no wetlands and GDEs present in the area that could be impacted, as neither groundwater source will be intercepted by the extraction at Lots 1 and 2 which remains in unsaturated geology. Therefore no discharges to / from GDEs can possibly be effected.
- The total or partial removal of the shallow perched groundwater zones is unlikely to have any major impacts to the local hydrogeological regime, or to the regional aquifer system, other than potentially locally increasing the rate of rainfall recharge to the regional water table in the vicinity of the project. However, this potential increase in recharge is negligible when compared to the larger scale recharge mechanisms associated with the Hawkesbury sandstone.
- There are nine registered groundwater abstraction bores within approximately 1km of Lots 1 and 2. None of these production bores abstract groundwater from the perched groundwater lenses located in the area, and therefore would not be impacted by deepening of the quarry in Lots 1 and 2.

## **9. REFERENCES**

Aquaterra, 2010. Groundwater Assessment For Dixon Sand Operations Lot 196 DP 752025 Maroota NSW – Aquaterra 19 November 2010.

DWLC, 2001. NSW Department of Land and Water Conservation (2001) Maroota Groundwater Study Technical Status Report.

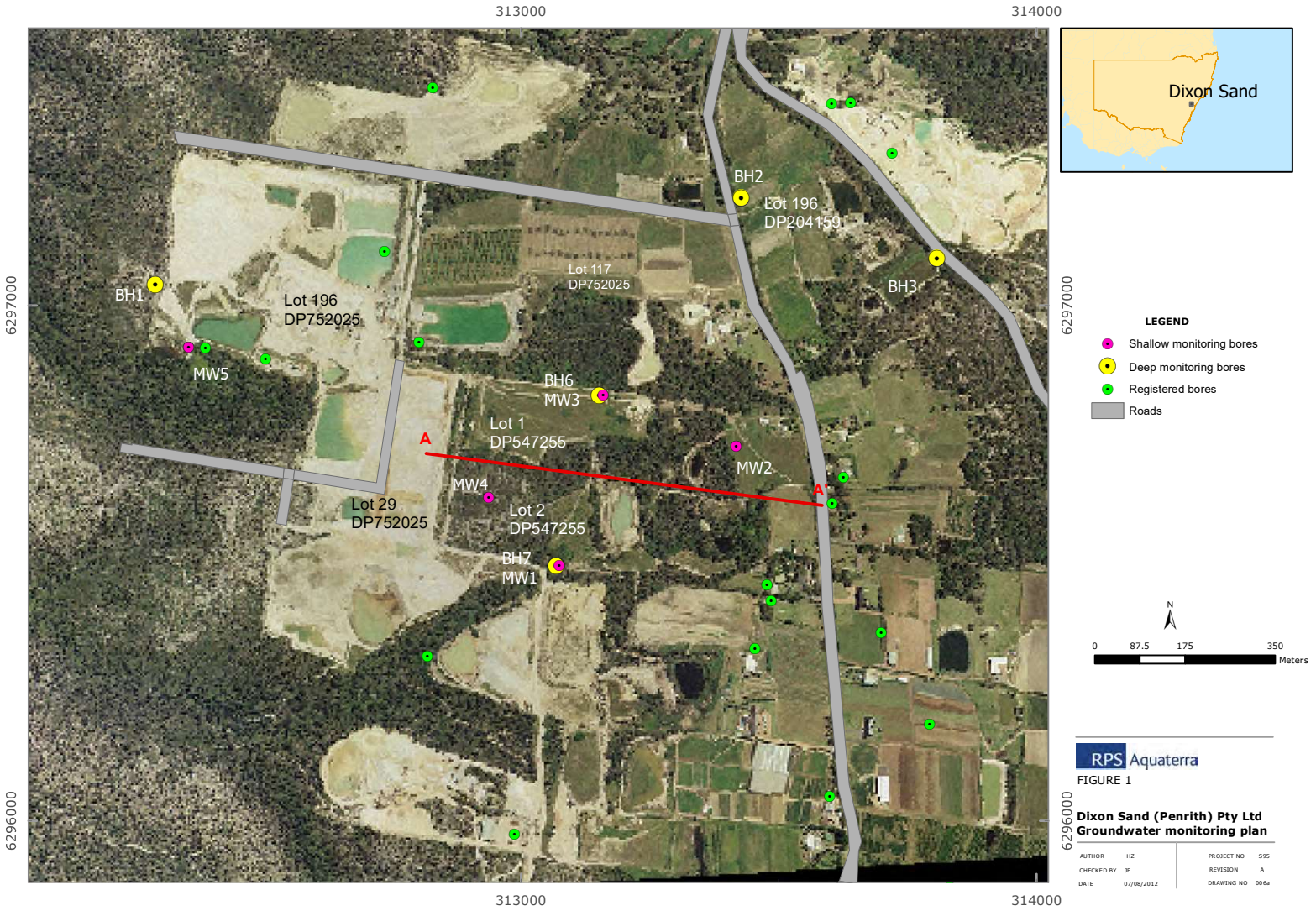
E3, 2010. Preliminary Assessment of Potential Impacts to Groundwater of Proposed Extension of Dixon Sand Operations, Lot 196 DP752025, Maroota NSW – E3 Consult Nexus Environmental Planning 17 June 2010.

URS, 2006. Environmental Assessment of the Hitchcock Road Sand Extraction and Rehabilitation Project. Maroota, NSW. Groundwater Assessment. Prepared for PF Formation 1774 Wisemans Ferry Road Maroota NSW 2756ERM, 2005. Environmental Resources Management Australia (ERM) 14 June 2005.

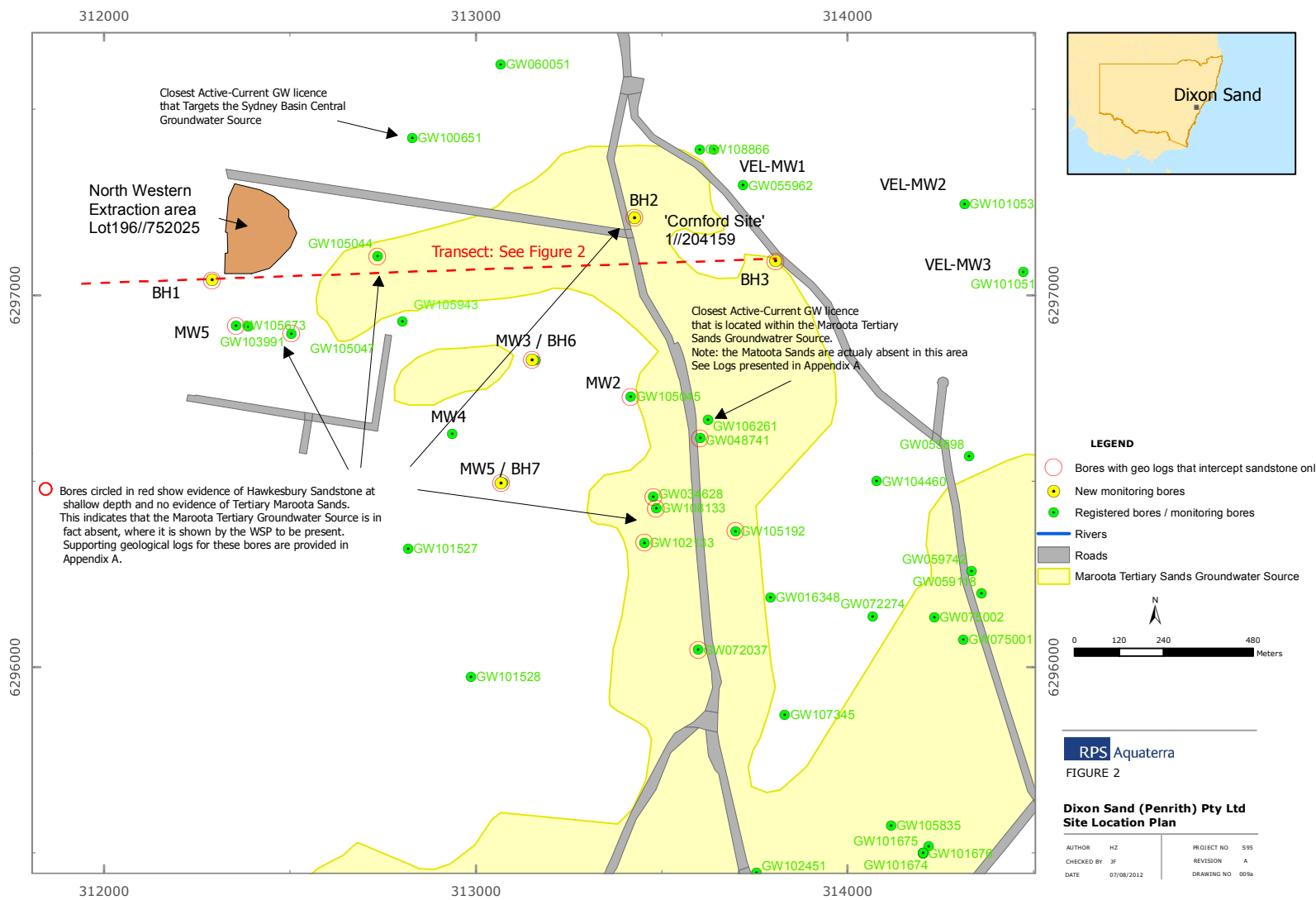
## FIGURES

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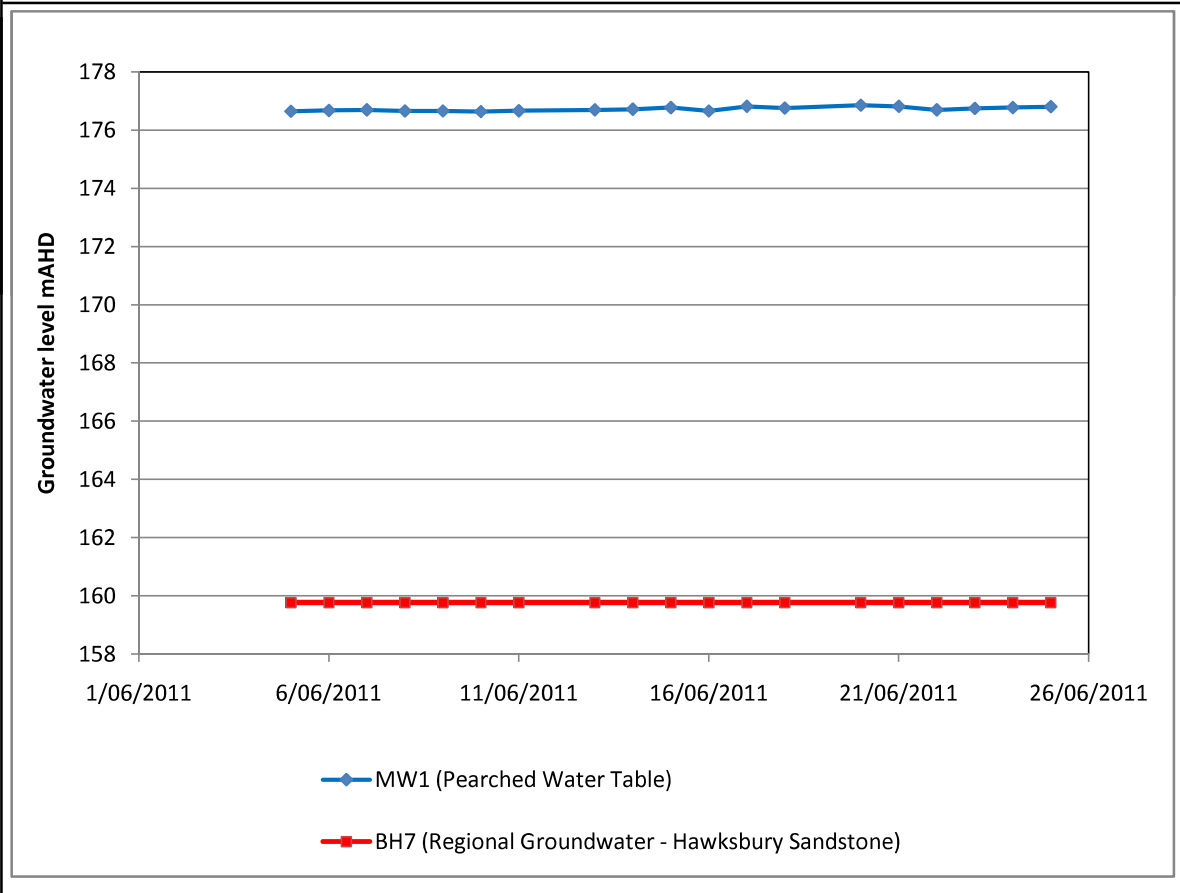
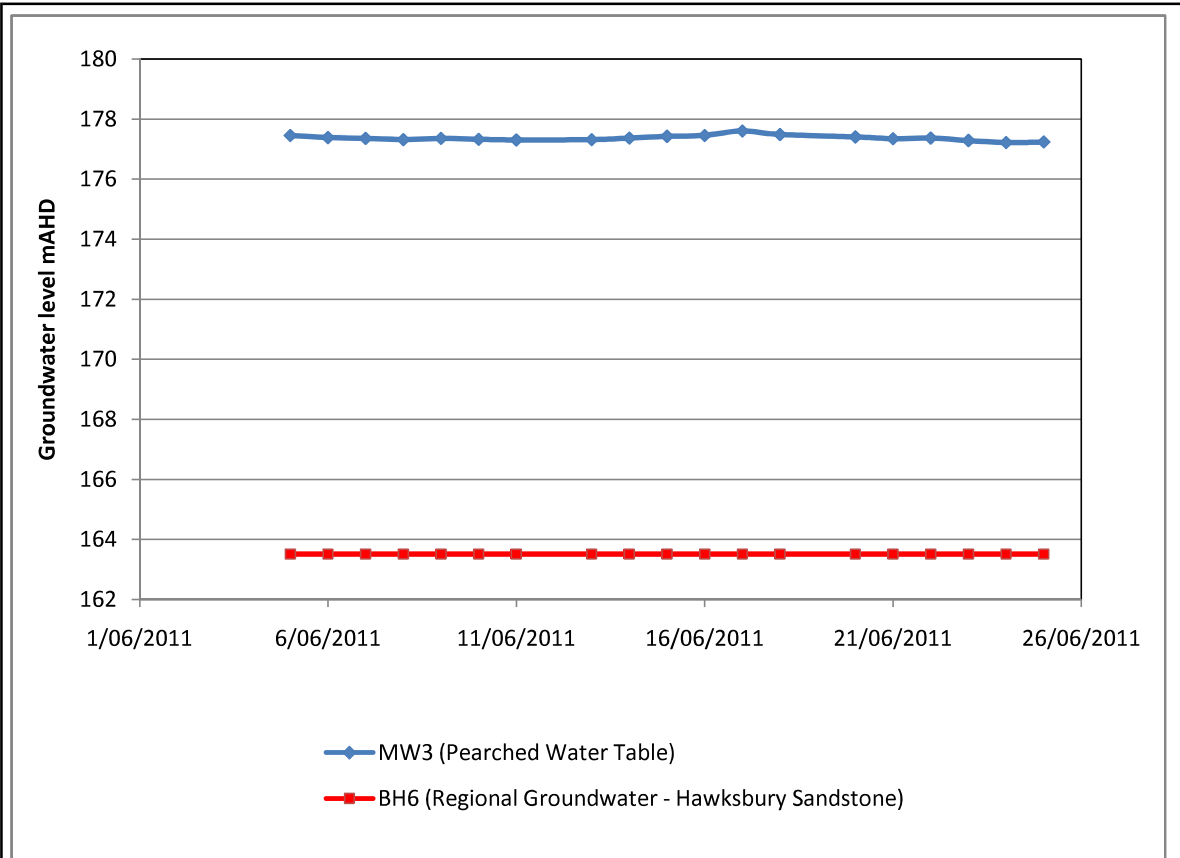
- Figure 1: Site Layout and Groundwater Monitoring Network
- Figure 2: Regional Geology and Registered Bore Summary
- Figure 3: Hydrographs of Paired Monitoring Sites
- Figure 4: Groundwater Elevation
- Figure 5: Cross section of the Extraction Area
- Figure 6: Hydrogeological Conceptual Model

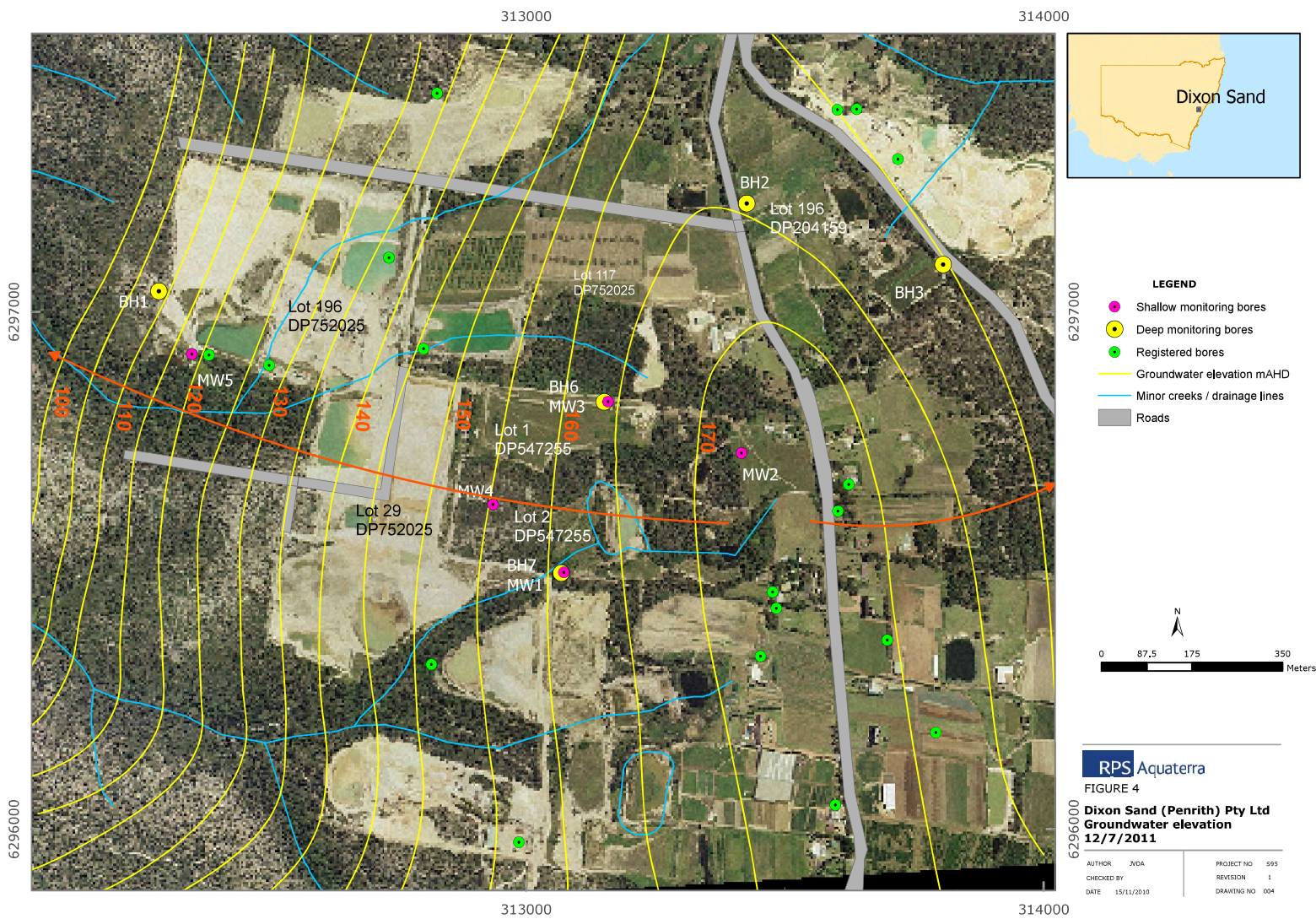


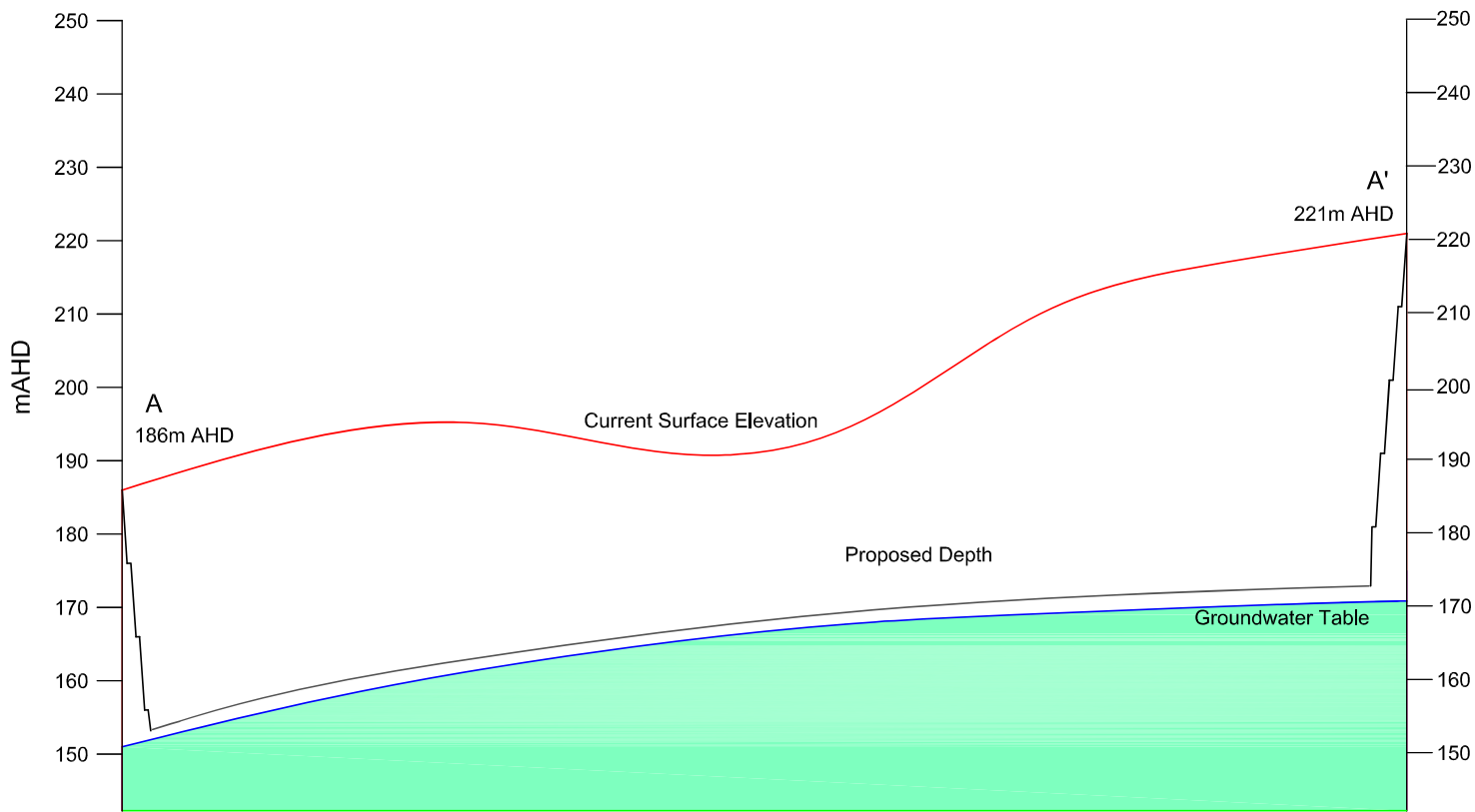












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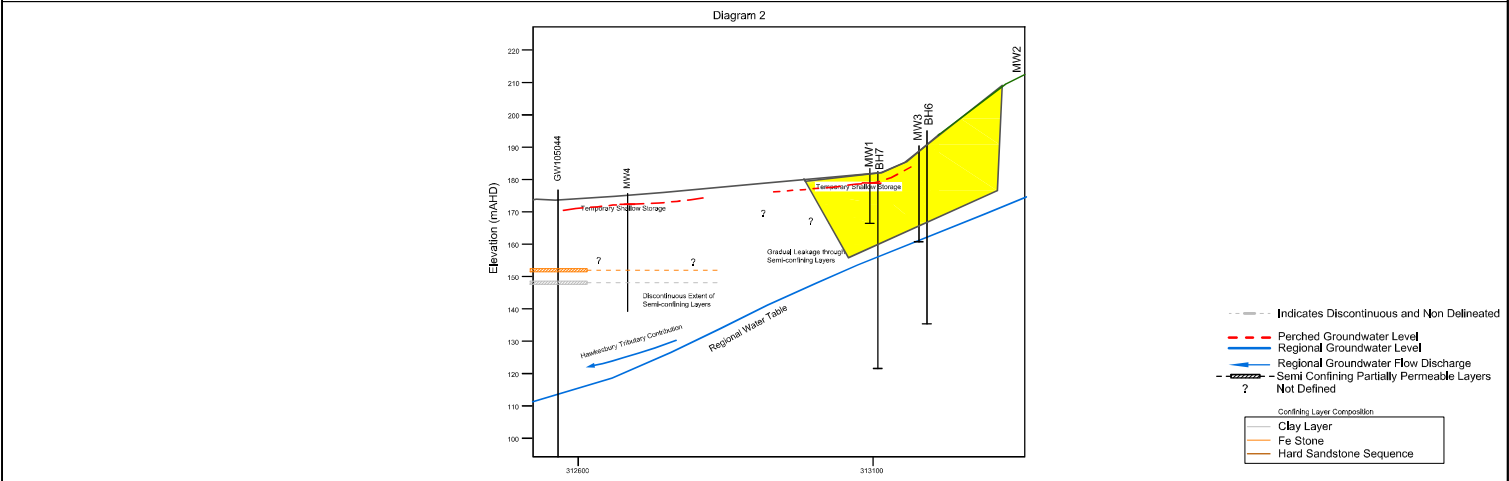
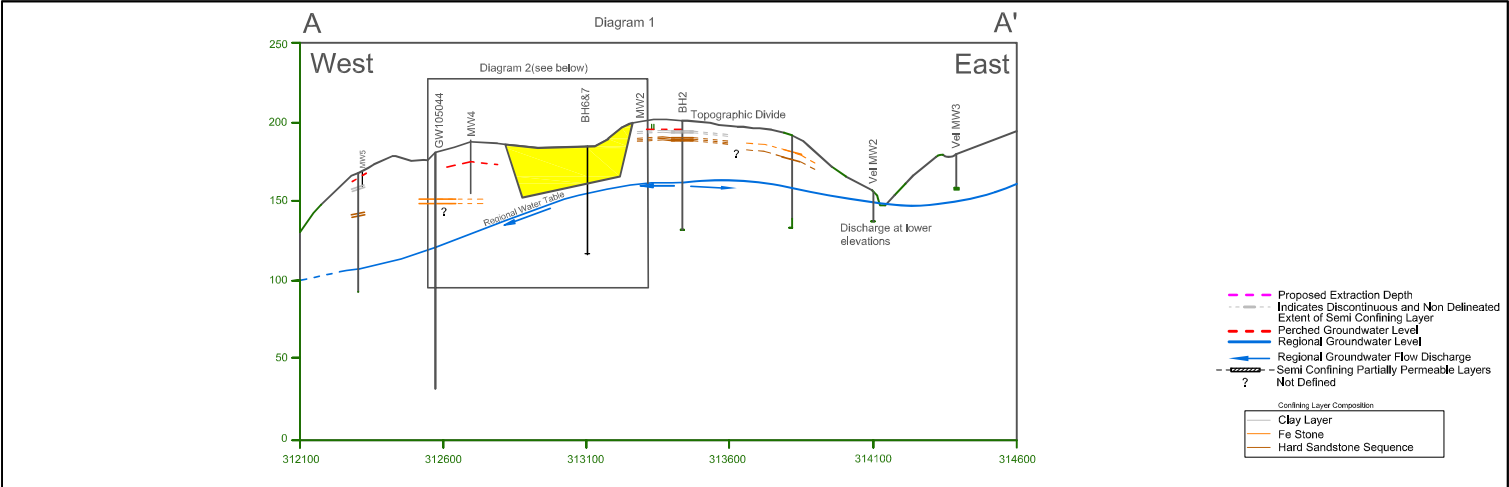
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**RPS Aquaterra**  
Suite 902, Level 9, North Tower  
1-5 Railway Street, Chatswood  
New South Wales, Australia, 2067  
Telephone: (02) 9412 4630  
Facsimile: (02) 9412 4605

| Dixon Sand (Perth) Pty Ltd           |          |         |             |
|--------------------------------------|----------|---------|-------------|
| Cross Section of The Extraction Area |          |         |             |
| SHEET                                | SCALE    | ASB No: | DRAWING No: |
| A4                                   | As Shown | 595     | FIGURE 5    |
|                                      |          |         | REV: A      |



|     |             |      |                       |  |  |                                  |  |  |  |                          |             |                                  |        |  |
|-----|-------------|------|-----------------------|--|--|----------------------------------|--|--|--|--------------------------|-------------|----------------------------------|--------|--|
|     |             |      | GENERAL NOTES:        |  |  | DESIGNED: PROJECT APPROVAL:      |  |  | <div><div>RPS Aquaterra</div><div>Suit 902, Level 9, North Tower<br/>1-5 Railway Street, Chatterbox<br/>New South Wales, Australia, 2067<br/>Telephone: (02) 9412 4630<br/>Facsimile: (08) 9412 4805</div></div> |                          |             | Dixon Sand (Penrith) Pty Ltd     |        |  |
|     |             |      |                       |  |  | A. MUNT MA                       |  |  |  |                          |             | Hydrogeological Conceptual Model |        |  |
|     |             |      |                       |  |  | DESIGN CHECK: CAD REFERENCE:     |  |  |  |                          |             |                                  |        |  |
|     |             |      |                       |  |  | C. GILL SPS-SPS                  |  |  |  |                          |             |                                  |        |  |
|     |             |      |                       |  |  | DRAWN: Date:                     |  |  |  |                          |             |                                  |        |  |
|     |             |      | AB CHATTERBOX         |  |  | New South Wales, Australia, 2067 |  |  |  |                          |             |                                  |        |  |
|     |             |      | DRAWING CHECK: SCALE: |  |  | CS                               |  |  | (02) 9412 4630   |                          |             |                                  |        |  |
|     |             |      |                       |  |  | As Drawn                         |  |  | (08) 9412 4805   |                          |             |                                  |        |  |
| REV | DESCRIPTION | DATE |                       |  |  |                                  |  |  | REV: 44  | SCALE: Schematic diagram | JOB No: 535 | DRAWING No: FIGURE 6             | REV: 4 |  |

**APPENDIX A:**  
**MONITORING BORE LOGS**

---

|  |                    |   |                                     |                               |                            |                  |
|--|--------------------|---|-------------------------------------|-------------------------------|----------------------------|------------------|
| <div>RPS Aquaterra</div> <div>Suit 902, Level 9, North Tower<br/>1-5 Railway Street, Chatswood<br/>NSW, 2067<br/>Australia<br/>Tel: (+61) (02) 9412 4630<br/>Fax: (+61) (02) 9412 4805</div> |                    | <div>COMPOSITE WELL LOG</div>   |                                     | <div>Well No: BH1</div>       |                            |                  |
|  |                    | <div>Client: Dixon Sand (Penrith) Pty Ltd</div>   |                                     | <div>Project: S95</div>       |                            |                  |
| <div>Commenced:</div>  |                    | <div>Method: Rotary Air</div>   |                                     | <div>Area: Maroota</div>      |                            |                  |
| <div>Completed: 22/10/10</div>   |                    | <div>Fluid:</div>   |                                     | <div>East: 312290.45</div>    |                            |                  |
| <div>Drilled: Terratest</div>  |                    | <div>Bit Record:</div>  |                                     | <div>North:6297040.00</div>   |                            |                  |
| <div>Logged By:</div>  |                    |   |                                     | <div>Collar (RL):166.18</div> |                            |                  |
|  |                    | <div>Static Water Level: 57.94</div>  |                                     | <div>Date: 15/11/2010</div>   |                            |                  |
| <div>Depth<br/>(mbgl)</div>  | <div>Bit Log</div> | <div>Graphic<br/>Log</div>  | <div>Lithological Description</div> | <div>Field Notes</div>        | <div>Well Completion</div> |                  |
|  |                    |   |                                     |                               | <div>Diagram</div>         | <div>Notes</div> |
| 0  |                    | <div><div>Sandstone</div><div><div><div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div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|                                     |                               |                            |                  |

Suit 902, Level 9, North Tower  
1-5 Railway Street, Chatswood  
NSW, 2067  
Australia  
Tel: (+61) (02) 9412 4630  
Fax: (+61) (02) 9412 4805

**Client:** Dixon Sand (Penrith) Pty Ltd

**Project:** S95

**Commenced:**

**Completed:** 27/10/10

**Drilled:** Terratest

**Logged By:**

**Static Water Level: 37.35**

**Method:** Rotary Air

**Fluid:**

### Bit Record:

**Area:** Maroota

**East:** 313426.48

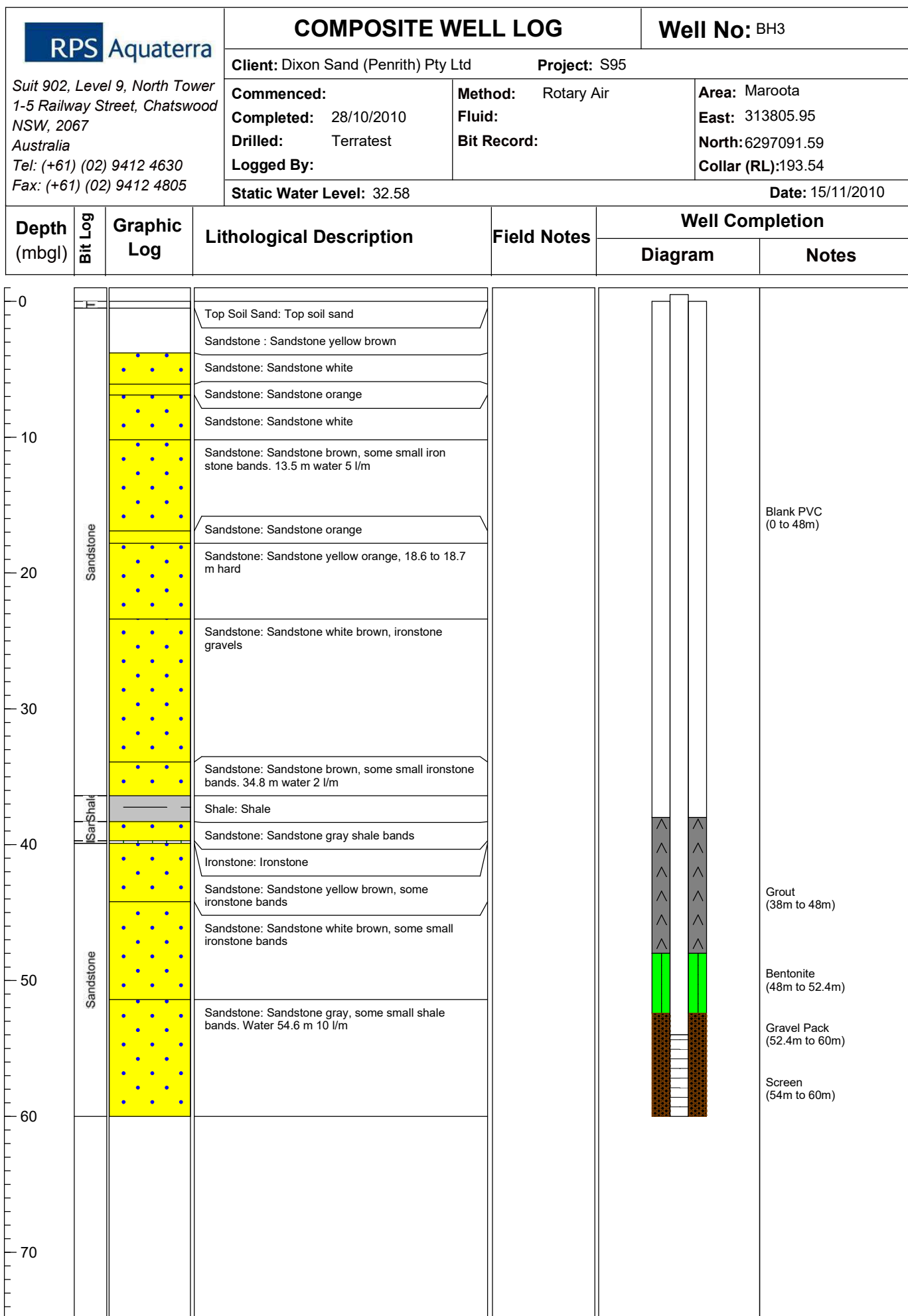
**North: 6297209.18**

Collar (RL):201.88

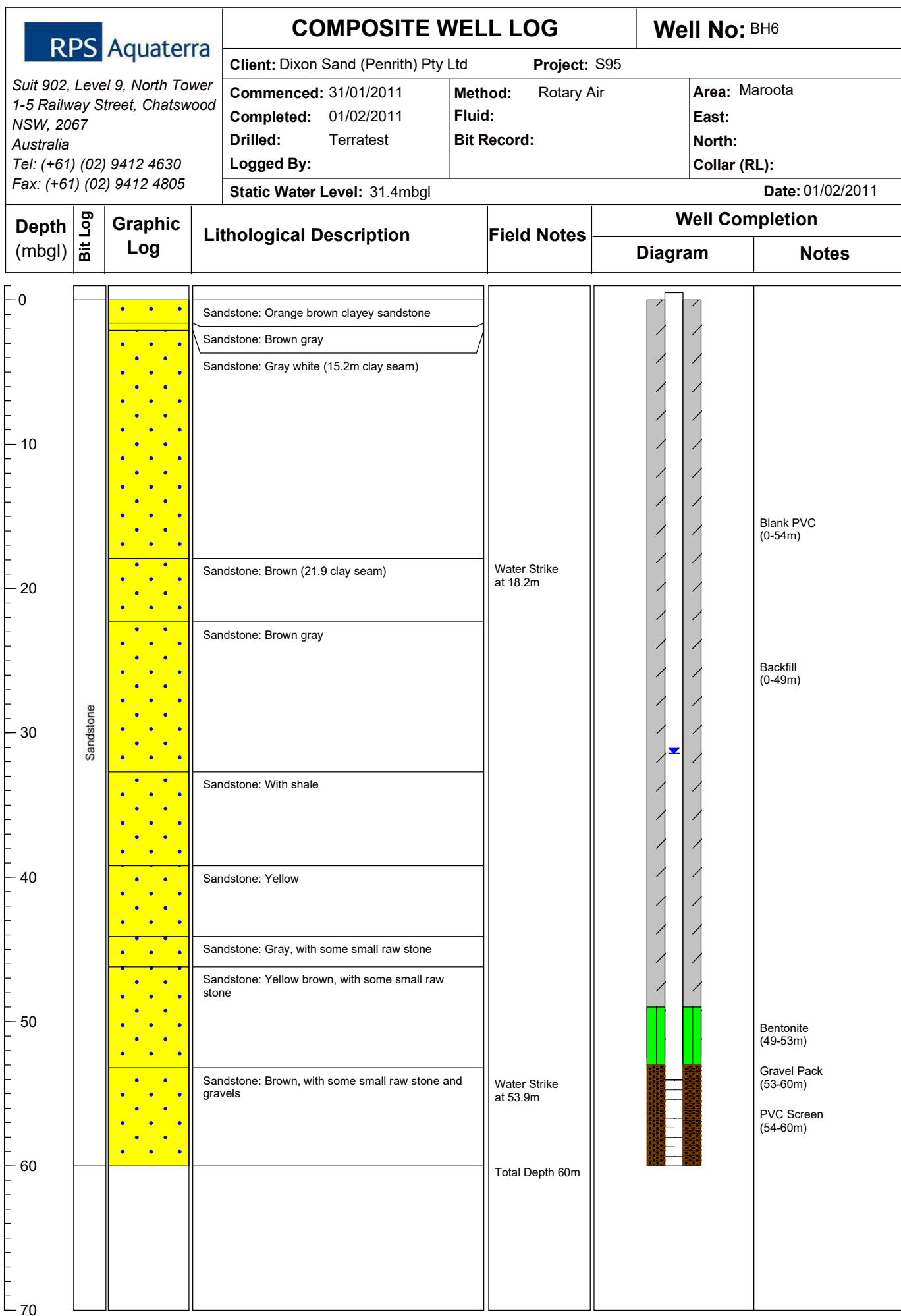
**Date:** 15/11/2010

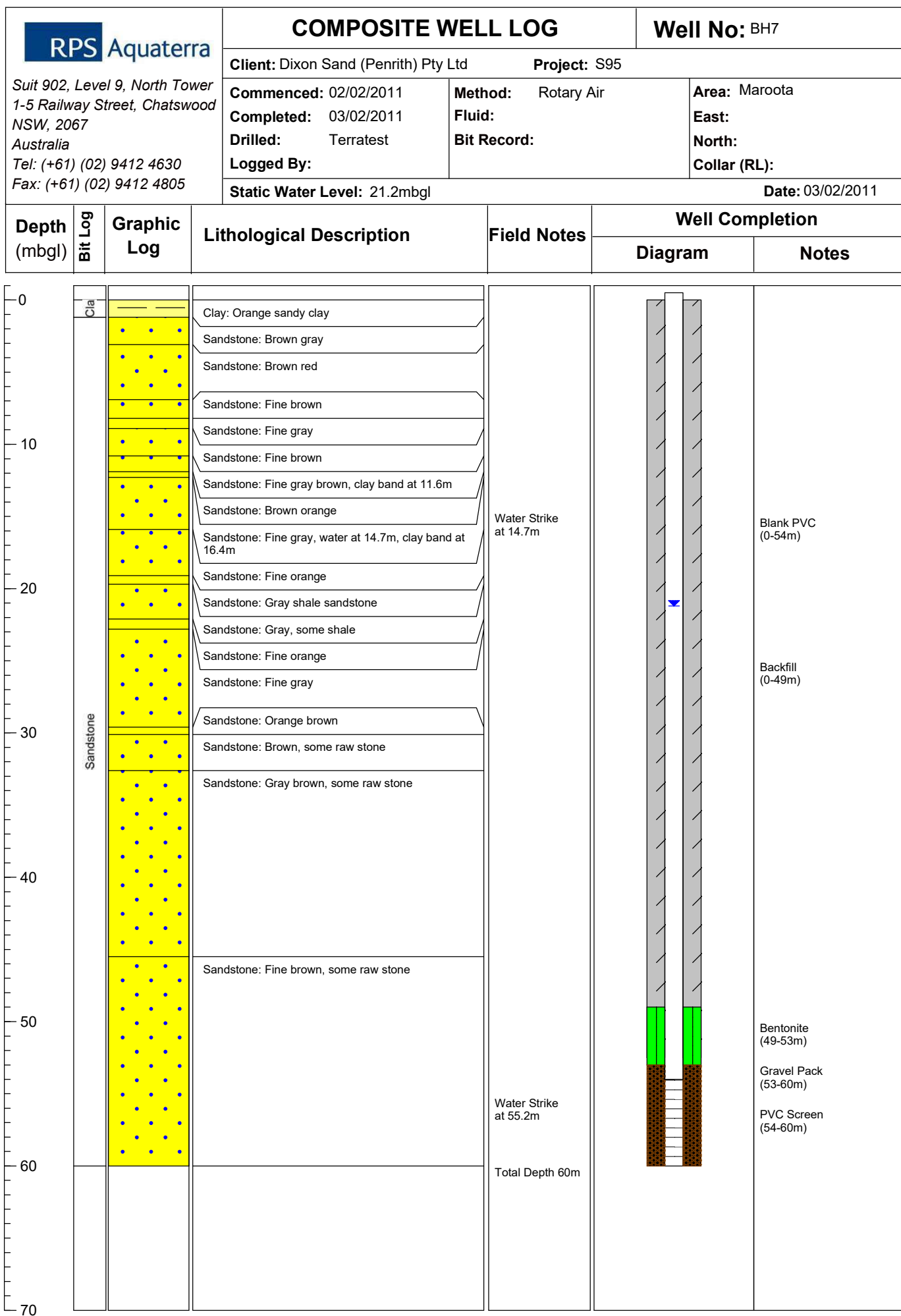
| Depth<br>(mbgl) | Bit Log    | Graphic Log | Lithological Description  | Field Notes | Well Completion |       |
|-----------------|------------|-------------|---|-------------|-----------------|-------|
|                 |            |             |   |             | Diagram         | Notes |
| 0               |            |             | Topsoil: Top Soil Sand  |             |                 |       |
|                 | Sandstone  |             | Sandstone: Sandstone brown yellow gray  |             |                 |       |
|                 |            |             | Sandstone: Sandstone brown yellow clay bands. 8.2 m water 1 l/m                               |             |                 |       |
| 10              | Silty Sand |             | Silty Sand: Silty Sandstone gray<br>Hard Bands 10.1 to 10.8 m, 13.6 to 13.9 m, 16.1 to 16.8 m |             |                 |       |
|                 |            |             | Sandstone: Sandstone red hard   |             |                 |       |
| 20              |            |             | Sandstone: Sandstone brown, small gravel  |             |                 |       |
|                 |            |             | Sandstone: Sandstone yellow white, some gravels. 24.7 m water 6 l/m                           |             |                 |       |
|                 |            |             | Sandstone: Sandstone yellow brown   |             |                 |       |
|                 |            |             | Sandstone: Sandstone gray   |             |                 |       |
| 30              |            |             | Sandstone: Sandstone brown some gravels   |             |                 |       |
|                 |            |             |   |             |                 |       |
| 40              |            |             | Shale: Shale gray   |             |                 |       |
|                 |            |             | Sandstone: Sandstone gray brown small gravels   |             |                 |       |
|                 |            |             | Shale: Shale Sandstone  |             |                 |       |
| 50              |            |             | Sandstone: Sandstone gray some small shale bands, some small gravels                          |             |                 |       |
|                 |            |             | Sandstone: Course grain sandstone some gravels  |             |                 |       |
| 60              |            |             | Shale: Shale  |             |                 |       |
|                 |            |             | Sandstone: Sandstone, shale bands   |             |                 |       |
|                 |            |             | Sandstone: Sandstone course   |             |                 |       |
| 70              |            |             |   |             |                 |       |











**APPENDIX B:  
GEOLOGICAL LOGS OF  
REGISTERED BORES**

---

# Geological Logs of Registered Bores

| Work No  | From Depth | To Depth | Drillers Description        | Rock Type Code | Rock Type |
|----------|------------|----------|-----------------------------|----------------|-----------|
| GW105044 | 0          | 12.5     | SANDSTONE SOFT              | SDSN           | Sandstone |
| GW105044 | 12.5       | 21.8     | SANDSTONE/QUARTZ            | SDSN           | Sandstone |
| GW105044 | 21.8       | 22.8     | SANDSTONE/IRONSTONE BANDS   | SDSN           | Sandstone |
| GW105044 | 22.8       | 24.8     | SANDSTONE                   | SDSN           | Sandstone |
| GW105044 | 24.8       | 25.5     | SHALE                       | SHLE           | Shale     |
| GW105044 | 25.5       | 25.8     | CLAY                        | CLAY           | Clay      |
| GW105044 | 25.8       | 30.5     | SHALE                       | SHLE           | Shale     |
| GW105044 | 30.5       | 38       | SANDSTONE                   | SDSN           | Sandstone |
| GW105044 | 38         | 39       | SANDSTONE/IRONSTONE BANDS   | SDSN           | Sandstone |
| GW105044 | 39         | 52.6     | SANDSTONE LIGHT GREY        | SDSN           | Sandstone |
| GW105044 | 52.6       | 55.7     | SHALE                       | SHLE           | Shale     |
| GW105044 | 55.7       | 57       | SANDSTONE L/GREY/CLAY BANDS | SDSN           | Sandstone |
| GW105044 | 57         | 68.6     | SANDSTONE/QUARTZ            | SDSN           | Sandstone |
| GW105044 | 68.6       | 69       | CLAY                        | CLAY           | Clay      |
| GW105044 | 69         | 73.6     | SANDSTONE/QUARTZ            | SDSN           | Sandstone |
| GW105044 | 73.6       | 89       | SANDSTONE DARK GREY         | SDSN           | Sandstone |
| GW105044 | 89         | 112.5    | SANDSTONE L/GREY            | SDSN           | Sandstone |
| GW105044 | 112.5      | 120.5    | SANDSTONE/QUARTZ            | SDSN           | Sandstone |
| GW105044 | 120.5      | 127.8    | SANDSTONE L/GREY            | SDSN           | Sandstone |
| GW105044 | 127.8      | 135      | SANDSTONE/QUARTZ            | SDSN           | Sandstone |
| GW105044 | 135        | 144.5    | SANDSTONE L/GREY            | SDSN           | Sandstone |

# Geological Logs of Registered Bores

| Work No  | From Depth | To Depth | Drillers Description           | Rock Type Code | Rock Type |
|----------|------------|----------|--------------------------------|----------------|-----------|
| GW105047 | 0          | 0.2      | FILL                           | FILL           | Fill      |
| GW105047 | 0.2        | 5.5      | SHALE/CLAY/SANDSTONE           | SHLE           | Shale     |
| GW105047 | 5.5        | 16       | SANDSTONE WITH IRONSTONE BANDS | SDSN           | Sandstone |
| GW105047 | 16         | 19.3     | SANDSTONE HARDER               | SDSN           | Sandstone |
| GW105047 | 19.3       | 24.3     | SHALE                          | SHLE           | Shale     |
| GW105047 | 24.3       | 26.5     | SANDSTONE AND QUARTZ           | SDSN           | Sandstone |
| GW105047 | 26.5       | 28       | SHALE                          | SHLE           | Shale     |
| GW105047 | 28         | 31.5     | SANDSTONE                      | SDSN           | Sandstone |
| GW105047 | 31.5       | 32.5     | SANDSTONE AND CLAY BANDS       | SDSN           | Sandstone |
| GW105047 | 32.5       | 33       | SANDSTONE AND CLAY FRACTURED   | SDSN           | Sandstone |
| GW105047 | 33         | 35.5     | SANDSTONE                      | SDSN           | Sandstone |
| GW105047 | 35.5       | 35.9     | IRONSTONE                      | IRSN           | Ironstone |
| GW105047 | 35.9       | 51.5     | SANDSTONE L/GREY               | SDSN           | Sandstone |
| GW105047 | 51.5       | 52.5     | SHALE FRACTURED                | SHLE           | Shale     |
| GW105047 | 52.5       | 65.5     | SANDSTONE L/GREY               | SDSN           | Sandstone |
| GW105047 | 65.5       | 81       | SANDSTONE DARK GREY            | SDSN           | Sandstone |
| GW105047 | 81         | 82.5     | SANDSTONE L/GREY               | SDSN           | Sandstone |
| GW105047 | 82.5       | 84.5     | SANDSTONE FRACTURED            | SDSN           | Sandstone |
| GW105047 | 84.5       | 111.6    | SANDSTONE AND QUARTZ           | SDSN           | Sandstone |
| GW105047 | 111.6      | 111.7    | SANDSTONE FRACTURED            | SDSN           | Sandstone |
| GW105047 | 111.7      | 131      | SANDSTONE AND QUARTZ           | SDSN           | Sandstone |
| GW105047 | 131        | 132.8    | SANDSTONE AND QUARTZ FRACTURED | SDSN           | Sandstone |
| GW105047 | 132.8      | 152.3    | SANDSTONE L/GREY               | SDSN           | Sandstone |
| GW105047 | 152.3      | 153.8    | SANDSTONE AND QUARTZ FRACTURED | SDSN           | Sandstone |
| GW105047 | 153.8      | 154.8    | SANDSTONE AND QUARTZ           | SDSN           | Sandstone |
| GW105047 | 154.8      | 155.1    | CAVITY                         | CVTY           | Cavity    |
| GW105047 | 155.1      | 156.8    | SANDSTONE L/GREY               | SDSN           | Sandstone |

### Geological Logs of Registered Bores

| Work No  | From Depth | To Depth | Drillers Description           | Rock Type Code | Rock Type    |
|----------|------------|----------|--------------------------------|----------------|--------------|
| GW105192 | 0          | 0.8      | SANDSTONE SOFT IRONSTONE BANDS | SDSN           | Sandstone    |
| GW105192 | 0.8        | 8.5      | CLAY WHITE                     | CLAY           | Clay         |
| GW105192 | 8.5        | 18       | SANDSTONE FIRM LT BROWN        | SDSN           | Sandstone    |
| GW105192 | 18         | 22       | SANDSTONE IRONSTONE BANDS      | SDSN           | Sandstone    |
| GW105192 | 22         | 22.5     | CLAY                           | CLAY           | Clay         |
| GW105192 | 22.5       | 39       | SANDSTONE LT GREY              | SDSN           | Sandstone    |
| GW105192 | 39         | 42       | SHALE AND CLAY                 | SHLE           | Shale        |
| GW105192 | 42         | 56.5     | SANDSTONE AND QUARTZ           | SDSN           | Sandstone    |
| GW105192 | 56.5       | 57       | CLAY AND SANDSTONE LT BROWN    | CLAY           | Clay         |
| GW105192 | 57         | 58.5     | SHALE                          | SHLE           | Shale        |
| GW105192 | 58.5       | 82.5     | SANDSTONE LT GREY              | SDSN           | Sandstone    |
| GW105192 | 82.5       | 124.5    | AND QUARTZ                     | SDSN           | Sandstone    |
| GW105192 | 124.5      | 147.5    | SANDSTONE GREY                 | SDSN           | Sandstone    |
| GW105192 | 147.5      | 150      | QUARTZ                         | 15             | Invalid Code |
| GW105192 | 150        | 175      | SANDSTONE HARD LT GREY         | SDSN           | Sandstone    |
| GW105192 | 175        | 177      | SHALE                          | SHLE           | Shale        |
| GW105192 | 177        | 198      | SANDSTONE GREY                 | SDSN           | Sandstone    |
| GW105192 | 198        | 201      | SANDSTONE AND QUARTZ           | SDSN           | Sandstone    |
| GW105192 | 201        | 234      | SANDSTONE GREY/LT GREY         | SDSN           | Sandstone    |

### Geological Logs of Registered Bores

| Work No  | From Depth | To Depth | Drillers Description                    | Rock Type Code | Rock Type    |
|----------|------------|----------|---|----------------|--------------|
| GW101527 | 0          | 0.3      | SANDY LOAM                              | 20             | Invalid Code |
| GW101527 | 0.3        | 48.5     | SANDSTONE, RED AND GREEN                | SDSN           | Sandstone    |
| GW101527 | 48.5       | 49       | IRONSTONE                               | IRSN           | Ironstone    |
| GW101527 | 49         | 50.5     | SHALE                                   | SHLE           | Shale        |
| GW101527 | 50.5       | 56.5     | SANDSTONE, GREY, M. GRAIN               | SDSN           | Sandstone    |
| GW101527 | 56.5       | 57.2     | SANDSTONE AND QUARTZ, FRACTURED (WATER) | SDSN           | Sandstone    |
| GW101527 | 57.2       | 58.5     | SANDSTONE, GREY, M. GRAIN               | SDSN           | Sandstone    |
| GW101527 | 58.5       | 60       | SHALE                                   | SHLE           | Shale        |
| GW101527 | 60         | 74       | SANDSTONE, GREY. M. GRAIN               | SDSN           | Sandstone    |
| GW101527 | 74         | 75.5     | SANDSTONE, QUARTZ (WATER)               | SDSN           | Sandstone    |
| GW101527 | 75.5       | 92       | SANDSTONE, GREY. M. GRAIN               | SDSN           | Sandstone    |
| GW101527 | 92         | 138      | SANDSTONE, GREY. M. GRAIN               | SDSN           | Sandstone    |

Geological Logs of Registered Bores

| Work No  | From Depth | To Depth | Drillers Description        | Rock Type Code | Rock Type        |
|----------|------------|----------|-----------------------------|----------------|------------------|
| GW108133 | 0          | 1.5      | SANDY CLAY, L/BROWN         | 20             | Invalid Code     |
| GW108133 | 1.5        | 3.6      | BROWN SANDSTONE WEATHERED   | BNST           | Invalid Code     |
| GW108133 | 3.6        | 5.2      | L/BROWN CLAY                | CLAY           | Clay             |
| GW108133 | 5.2        | 5.8      | RED CLAY                    | CLAY           | Clay             |
| GW108133 | 5.8        | 42.8     | BROWN SANDSTONE             | BNST           | Invalid Code     |
| GW108133 | 42.8       | 43.1     | L/GREY SHALE                | LBIL           | Invalid Code     |
| GW108133 | 43.1       | 44.5     | D/BROWN SANDSTONE WEATHERED | DCIT           | Dacite(Tonalite) |
| GW108133 | 44.5       | 49.4     | PINK SANDSTONE              | PKST           | Invalid Code     |
| GW108133 | 49.4       | 49.7     | GREY CLAY                   | CLAY           | Clay             |
| GW108133 | 49.7       | 53.6     | GREY SANDSTONE              | GYST           | Invalid Code     |
| GW108133 | 53.6       | 53.9     | D/GREY SHALE                | DCIT           | Dacite(Tonalite) |
| GW108133 | 53.9       | 75.6     | L/BROWN SANDSTONE           | LBIL           | Invalid Code     |
| GW108133 | 75.6       | 76       | L/GREY SANDSTONE FRACTURED  | LBIL           | Invalid Code     |
| GW108133 | 76         | 78       | L/GREY SANDSTONE            | LBIL           | Invalid Code     |
| GW108133 | 78         | 79.2     | GREY SHALE                  | GYST           | Invalid Code     |
| GW108133 | 79.2       | 87.8     | BROWN SANDSTONE             | BNST           | Invalid Code     |
| GW108133 | 87.8       | 89.7     | IRONSTONE AND QUARTZ        | IGVL           | Ironstone Gravel |
| GW108133 | 89.7       | 101.2    | L/GREY SANDSTONE            | LBIL           | Invalid Code     |
| GW108133 | 101.2      | 101.5    | GREY SANDSTONE AND QUARTZ   | GYST           | Invalid Code     |
| GW108133 | 101.5      | 101.7    | RED SHALE                   | RDST           | Invalid Code     |
| GW108133 | 101.7      | 105.7    | BROWN SANDSTONE             | BNST           | Invalid Code     |
| GW108133 | 105.7      | 105.8    | QUARTZ                      | 15             | Invalid Code     |
| GW108133 | 105.8      | 108.5    | D/GREY SANDSTONE            | DCIT           | Dacite(Tonalite) |
| GW108133 | 108.5      | 109.3    | DARK GREY SHALE SOFT        | DGRY           | Invalid Code     |
| GW108133 | 109.3      | 139.9    | L/GREY SANDSTONE            | LBIL           | Invalid Code     |
| GW108133 | 139.9      | 149.9    | L/GREY SANDSTONE AND QUARTZ | LBIL           | Invalid Code     |
| GW108133 | 149.9      | 150.6    | L/GREY SANDSTONE            | LBIL           | Invalid Code     |



### Geological Logs of Registered Bores

| Work No  | From Depth | To Depth | Drillers Description                     | Rock Type Code | Rock Type |
|----------|------------|----------|--|----------------|-----------|
| GW034628 | 0          | 1.22     | Topsoil Sandy                            | TPSL           | Topsoil   |
| GW034628 | 1.22       | 3.35     | Sandstone Yellow                         | SDSN           | Sandstone |
| GW034628 | 3.35       | 12.8     | Sandstone Dark Yellow Water Supply       | SDSN           | Sandstone |
| GW034628 | 12.8       | 15.85    | Sandstone White                          | SDSN           | Sandstone |
| GW034628 | 15.85      | 27.43    | Sandstone Yellow                         | SDSN           | Sandstone |
| GW034628 | 27.43      | 38.4     | Sandstone White                          | SDSN           | Sandstone |
| GW034628 | 38.4       | 42.67    | Sandstone Yellow                         | SDSN           | Sandstone |
| GW034628 | 42.67      | 48.77    | Sandstone Dark Yellow                    | SDSN           | Sandstone |
| GW034628 | 48.77      | 60.96    | Sandstone Grey                           | SDSN           | Sandstone |
| GW034628 | 60.96      | 77.72    | Sandstone White                          | SDSN           | Sandstone |
| GW034628 | 77.72      | 82.3     | Sandstone Yellow                         | SDSN           | Sandstone |
| GW034628 | 82.3       | 83.52    | Sandstone Yellow Open Water Supply       | SDSN           | Sandstone |
| GW034628 | 83.52      | 91.44    | Sandstone Yellow                         | SDSN           | Sandstone |
| Work No  | From Depth | To Depth | Drillers Description                     | Rock Type Code | Rock Type |
| GW048741 | 0          | 0.9      | Soil Sandy                               | SOIL           | Soil      |
| GW048741 | 0.9        | 2.4      | Shale Clay                               | SHLE           | Shale     |
| GW048741 | 2.4        | 5.6      | Sandstone Yellow Silty                   | SDSN           | Sandstone |
| GW048741 | 5.6        | 6        | Pipe Clay White                          | CLAY           | Clay      |
| GW048741 | 6          | 8.1      | Clay White Some Fine Gravel Water Supply | CLAY           | Clay      |
| GW048741 | 8.1        | 11.8     | Clay                                     | CLAY           | Clay      |
| GW048741 | 11.8       | 30       | Sandstone Silty Water Supply             | SDSN           | Sandstone |
| GW048741 | 11.8       | 30       | Clay Bands                               | CLAY           | Clay      |

### Geological Logs of Registered Bores

| Work No  | From Depth | To Depth | Drillers Description            | Rock Type Code | Rock Type |
|----------|------------|----------|---------------------------------|----------------|-----------|
| GW102133 | 0          | 6.5      | Brown Clay                      | CLAY           | Clay      |
| GW102133 | 6.5        | 10       | Weathered Sandstone             | SDSN           | Sandstone |
| GW102133 | 10         | 18.5     | Grey Sandstone M.G.             | SDSN           | Sandstone |
| GW102133 | 18.5       | 19       | Grey Clay                       | CLAY           | Clay      |
| GW102133 | 19         | 28       | White Sandstone M.G.            | SDSN           | Sandstone |
| GW102133 | 28         | 29.5     | Ironstone                       | IRSN           | Ironstone |
| GW102133 | 29.5       | 43       | White Sandstone M.G.            | SDSN           | Sandstone |
| GW102133 | 43         | 45.5     | Claystone                       | CLSN           | Claystone |
| GW102133 | 45.5       | 47       | Brown Sandstone M.G.            | SDSN           | Sandstone |
| GW102133 | 47         | 49.5     | Claystone                       | CLSN           | Claystone |
| GW102133 | 49.5       | 54       | Black Shale                     | SHLE           | Shale     |
| GW102133 | 54         | 76       | Grey Sandstone M.G.             | SDSN           | Sandstone |
| GW102133 | 76         | 78       | Ironstone                       | IRSN           | Ironstone |
| GW102133 | 78         | 84       | Brown Sandstone M.G.            | SDSN           | Sandstone |
| GW102133 | 84         | 86.5     | Ironstone                       | IRSN           | Ironstone |
| GW102133 | 86.5       | 114      | Grey Sandstone M.G.             | SDSN           | Sandstone |
| GW102133 | 114        | 118.5    | Sandstone and Quartz            | SDSN           | Sandstone |
| GW102133 | 118.5      | 130      | Grey Sandstone M.G.             | SDSN           | Sandstone |
| GW102133 | 130        | 132      | Sandstone and Quartz, fractured | SDSN           | Sandstone |
| GW102133 | 132        | 150.5    | Grey Sandstone M.G.             | SDSN           | Sandstone |

Geological Logs of Registered Bores

| Work No  | From Depth | To Depth | Drillers Description    | Rock Type Code | Rock Type    |
|----------|------------|----------|-------------------------|----------------|--------------|
| GW105493 | 0          | 1        | SANDY TOPSOIL           | 20             | Invalid Code |
| GW105493 | 1          | 12       | FINE YELLOW SANDSTONE   | FINE           | Invalid Code |
| GW105493 | 12         | 34       | COARSE ORANGE SANDSTONE | CRSE           | Invalid Code |
| GW105493 | 34         | 37       | SILTSTONE               | SLSN           | Siltstone    |
| Work No  | From Depth | To Depth | Drillers Description    | Rock Type Code | Rock Type    |
| GW105673 | 0          | 0.5      | TOPSOIL                 | TPSL           | Topsoil      |
| GW105673 | 0.5        | 1.6      | WEATHERED SANDSTONE     | WRCK           | Invalid Code |
| GW105673 | 8.5        | 10       | SANDSTONE L/GREY        | SDSN           | Sandstone    |
| GW105673 | 1.6        | 8.5      | SANDSTONE L/BROWN       | SDSN           | Sandstone    |
| Work No  | From Depth | To Depth | Drillers Description    | Rock Type Code | Rock Type    |
| GW105673 | 0          | 0.5      | TOPSOIL                 | TPSL           | Topsoil      |
| GW105673 | 8.5        | 10       | SANDSTONE L/GREY        | SDSN           | Sandstone    |
| GW105673 | 1.6        | 8.5      | SANDSTONE L/BROWN       | SDSN           | Sandstone    |
| Work No  | From Depth | To Depth | Drillers Description    | Rock Type Code | Rock Type    |
| GW072037 | 0          | 1.2      | SOIL                    | SOIL           | Soil         |
| GW072037 | 1.2        | 9.1      | SOFT SANDSTONE          | SFBD           | Invalid Code |
| GW072037 | 9.1        | 48.5     | SANDSTONE               | SDSN           | Sandstone    |
| GW072037 | 48.5       | 54.5     | SHALE                   | SHLE           | Shale        |
| GW072037 | 54.5       | 99       | SANDSTONE               | SDSN           | Sandstone    |

**APPENDIX C:  
GEOLOGICAL ASSESSMENT OF  
THE MAROOTA SANDS -  
VGT PTY LTD AUGUST 2012**

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## **Dixon Sand (Penrith) Pty Ltd**

# **Geological Assessment of the Maroota Sand**

## **Maroota**

## **South of Wisemans Ferry**

**August 2012**



Prepared by:

**VGT Pty Ltd**

for:

**Dixon Sand (Penrith) Pty Ltd**

# **Dixon Sand (Penrith) Pty Ltd**

## **Geological Assessment of the Maroota Sand Maroota South of Wisemans Ferry August 2012**

|                      |                        |
|----------------------|------------------------|
| Prepared by:         |                        |
| VGT Pty Ltd          | ph: (02) 4028 6412     |
| 4/30 Glenwood Drive, | fax: (02) 4028 6413    |
| Thornton NSW 2322    | email: greg@vgt.com.au |
| PO Box 2335          | www.vgt.com.au         |
| Greenhills NSW 2323  | ABN: 79 103 636 353    |

|                       |              |      |
|-----------------------|--------------|------|
| Report Date:          |              |      |
| Report Number:        |              |      |
| Copy Number:          |              |      |
| Report Authorised by: |              |      |
|                       | David Dixon  | Date |
|                       | Greg Thomson | Date |

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## Acronyms and Terms Used Throughout the Report

Through this document, a number of Acronyms and reference terms are frequently used. To assist the reader, the following lists are provided.

| ACRONYMS |                                |
|----------|--------------------------------|
| AHD      | Australian Height Datum        |
| EIS      | Environmental Impact Statement |

### Terms

**Alluvial:** Detrital material which is transported by a river and deposited – usually temporarily – at points along the flood plain of a river. Commonly composed of sands and gravels. *D.G.A Whitten with J.R.V. Brooks, The Dictionary of Geology 1982*

**Conformable:** A sequence of beds are said to be conformable when they represent an unbroken period of deposition. *D.G.A Whitten with J.R.V. Brooks, The Dictionary of Geology 1982*

**Disconformably:** The overlying Maroota sands have been placed disconformably over the Hawkesbury Sandstone.

**Eluvial:** Weathered material (float) which is still at, or near, its point of formation. *D.G.A Whitten with J.R.V. Brooks, The Dictionary of Geology 1982*

**Ma:** Million years old.

## **Section 1. Executive Summary**

This report documents the geological assessment of the Maroota area which included a site visit, and reviews of the L.T. Etheridge 1980 report Ref. 2 and the Water Sharing Plan for the Greater Metropolitan Region Groundwater Source 2011, Maroota Sands Groundwater Source (2011 plan).

Upon examination of these it was determined that the 2011 plan has incorrectly identified two key areas to be part of the Maroota Sands and as outlined in this report they are in fact Hawkesbury Sandstone.

As such sand extraction operations in these areas will not affect the Maroota Groundwater source.

## **Section 2. Introduction**

VGT Pty Limited at the request of Dixon Sand (Penrith) Pty Limited (the proponent) have investigated the extent of the Maroota Sand, at Lots 1 and 2 DP 547255 and Lot 1 204159 (the Cornford site), *Figure One* shows these areas.

### **2.1. Purpose of this Investigation**

The proponent is seeking to confirm if Maroota Sands occur on these sites. If Maroota sands do occur then extraction within these areas may affect the localised ground water table.

### **2.2. Site Background**

Dixon Sand has consent, DA 250-09-01, for extraction, processing and rehabilitation activities on Lots 1 and 2 DP 547255. The Cornford site is an area of interest for the proponent and liaison with the land owner is being undertaken.

## Section 3. Field Geological Assessment

### 3.1. Assessment

A field assessment was undertaken on 24<sup>th</sup> July 2012 where existing sand extraction operations were examined on Lots 1 and 2, DP 547255 (Lots 1 and 2) and at Hearses Road. At Lots 1 and 2 it was noted that the material extracted is sandstone and is ripped by a dozer. *Figure Two* shows the geological map prepared by Etheridge Ref. 2 found in his report. The photographs below are for the locations shown on *Figure 2*.

***Photoplate 1 – Dixon Sands Lot 1 Extraction area***



***Photoplate 2 – Dixon Sands Hearses Road area (Maroota Sands)***



Extraction activity at the Hearses Road site is undertaken mostly within the friable Maroota sands.

The Maroota Sands seen in *Photoplate 2* exhibit the red iron colouring which is indicative of water moving through the deposit and the white pea sized gravels showing different stream layers.

Photoplate 3 shows an outcrop adjacent to where Lot 1 meets The Old Northern Road. Geological mapping shows this is Maroota Sand out cropping as evidenced by the iron colouring as well as the occasional white pebble.

***Photoplate 3 - Maroota sands on Old Northern Road***



*Figure Two* shows the lateral extent of the Maroota Sand, Hawkesbury Sandstone and Eluvial deposits.



Large Hawkesbury Sandstone float was found at the location seen on *Figure Two*. Referring to *Photoplate 4* below, logic that dictates “*rocks do not roll up hill*” this sandstone can only have originated from the site it was found (in situ) or further up slope into the Maroota Sand sequence. This sandstone float indicates coupled with the Etheridge mapping, the contact between the Hawkesbury Sandstone and the Maroota Sands is nearby.

***Photoplate 4 - Hawkesbury Sandstone float on Lot 1 130 metres west of Old Northern Road***



***Photoplate 5 - Hawkesbury Sandstone adjacent to Lot 1***



**Photoplate 6 - Hawkesbury Sandstone at Cornford Site**

The mapping confirms the findings outlined in the Etheridge report.

### **3.2. Geology Discussion**

Etheridge has outlined clearly in his report that the Early Tertiary (55 to 65 ma) Maroota Sand deposit was laid down unconformably in a channel formed in the Triassic (237 to 245 ma) Hawkesbury Sandstone. The main Maroota Sand deposit is presented in *Figure Two* which has been sourced from Etheridge.

Etheridge states *"The sequence mainly consists of the Triassic Hawkesbury Sandstone disconformably overlain by the Tertiary Maroota Sand...."*

*"The Maroota Sand comprises a sequence of interbedded clayey gravels, gravels, gravelly sands, pebbly sands, clayey/silty sand, sand, silty clay and clay which range from unconsolidated sand and gravel to partly consolidated clay and clayey sand".*

Although this is a wide ranging description of the materials found in this area he goes on to say more specifically *"The bulk of the Maroota Sand consists of sand sized material"* and *"Overall, the Maroota Sand sediments are poorly sorted"*.

#### **3.2.1. Difference between Eluvial and Alluvial**

The outcrop of the Eluvial and alluvial deposits, as mapped by Etheridge, has been presented in *Figure Two and 2A*.

A diagram has been prepared (see *Figure Three*) which attempts to show the physical difference between these.

As evidenced in *Figure Four* taken from the Etheridge report (which identifies the thickness of the Maroota Sands) the Eluvial deposits at Maroota must be weathered Hawkesbury Sandstone.

The Maroota Sand is an alluvial deposit which is detrital material transported by a river and deposited – usually temporarily – at points along the flood plain of a river. Commonly composed of sands and gravels as defined by Ref. 1 (*Whitten and Brooks*).

The Eluvial sand deposit is defined as weathered material (float) which is still at, or near, its point of formation. Ref. 1 (*Whitten and Brooks*).



These Eluvial deposits were formed (weathered upper portion of the Hawkesbury Sandstone) in the Holocene (1 ma to now), this means these deposits are 50 million years younger than the Maroota Sands.

Structurally these deposits are also different where the Maroota Sands being mostly unconsolidated or loose which is deposited in a stream bed up to 30 metres deep and has a high permeability where water can flow through these with ease. Whereas, the Eluvial material is an insitu sand and clay material which has a lower permeability and is around 1 to 2 metres deep.

### 3.3. Groundwater Discussion

The Etheridge report Ref. 2 has been used by many authorities to determine the extent of the Maroota Sands, including the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 – Maroota Tertiary Sands Ground Water Source.

*Figure Five* shows the plan for the Maroota area and adjacent to this plan is the Etheridge Ref. 2 Geological plan showing the extent of the Maroota Sands. It can be seen that the areas are very similar in shape and size.

*Figure Two A* shows the Etheridge Ref. 2 geology, property details and air photograph to assist with presentation, this clearly illustrates that the western lobe of sand in Lot 1 is actually Eluvial (Hawkesbury sandstone) not Alluvial (Maroota Sand) and the Cornford site is all Eluvial.

### 3.4. North-Eastern Corner of Lot 1, DP 547255

Maroota Sand extraction activities in the north eastern corner of Lot 1, DP 547255 are mostly constrained by the 250 metre buffer from the school. Extrapolating from Google maps and property boundaries, *Figure Six* shows that there is an approximate 40 metre wide and 130 metres long strip that can be accessed by the proponent, which has been identified as the Maroota Sand, by Etheridge.

*Figure Four* shows that the Maroota Sand, identified by Etheridge, in this area of interest could be up to a maximum 2 metres thick and outcropping at the surface. Drill hole GW 048741 is located within the Maroota Sand area, identified by Etheridge, as presented in *Figures 4 and 6*, and the log is presented below.

#### Drill log

| Work No         | From Depth | To Depth   | Drillers Description Rock                |
|-----------------|------------|------------|--|
| GW048741        | 0          | 0.9        | Soil Sandy                               |
| <b>GW048741</b> | <b>0.9</b> | <b>2.4</b> | <b>Shale Clay</b>                        |
| GW048741        | 2.4        | 5.6        | Sandstone Yellow Silty                   |
| GW048741        | 5.6        | 6          | Pipe Clay White                          |
| GW048741        | 6          | 8.1        | Clay White Some Fine Gravel Water Supply |
| GW048741        | 8.1        | 11.8       | Clay                                     |
| GW048741        | 11.8       | 30         | Sandstone Silty Water Supply             |
| GW048741        | 11.8       | 30         | Clay Bands                               |

The drill log is a simplistic drillers log but the identification of Shale / Clay overlying a sandstone unit indicates to the author that at 0.9 metres the Hawkesbury Sandstone commences, which has numerous shale lenses, whereas the Maroota Sands do not.

Etheridge has previously identified the Maroota sand to be 5 metres thick at this location but he was that the time without the benefit of data from drill hole 048741, so interpolating from this point now the area of interest would have a maximum thickness of 0.45 metres of Maroota Sand, as shown on *Figure 6*.

## **Section 4. Conclusion**

A geological assessment was undertaken in the Maroota area on 24<sup>th</sup> July 2012, the aim of this assessment was to confirm the findings of the Etheridge report Ref. 2, with specific regard to the lateral extent of the Maroota Sand deposit.

This report presents the field geological findings, outcomes from reviewing the Etheridge report Ref. 2 and the Water Sharing Plan for the Greater Metropolitan Region Groundwater Source 2011, Maroota Sands Groundwater Source (2011 plan).

Upon examination of these it was determined that the 2011 plan has wrongly identified two key areas to be part of the Maroota Sands when they are in fact Hawkesbury Sandstone.




As such sand extraction operations in these areas will not affect the Maroota Groundwater source.

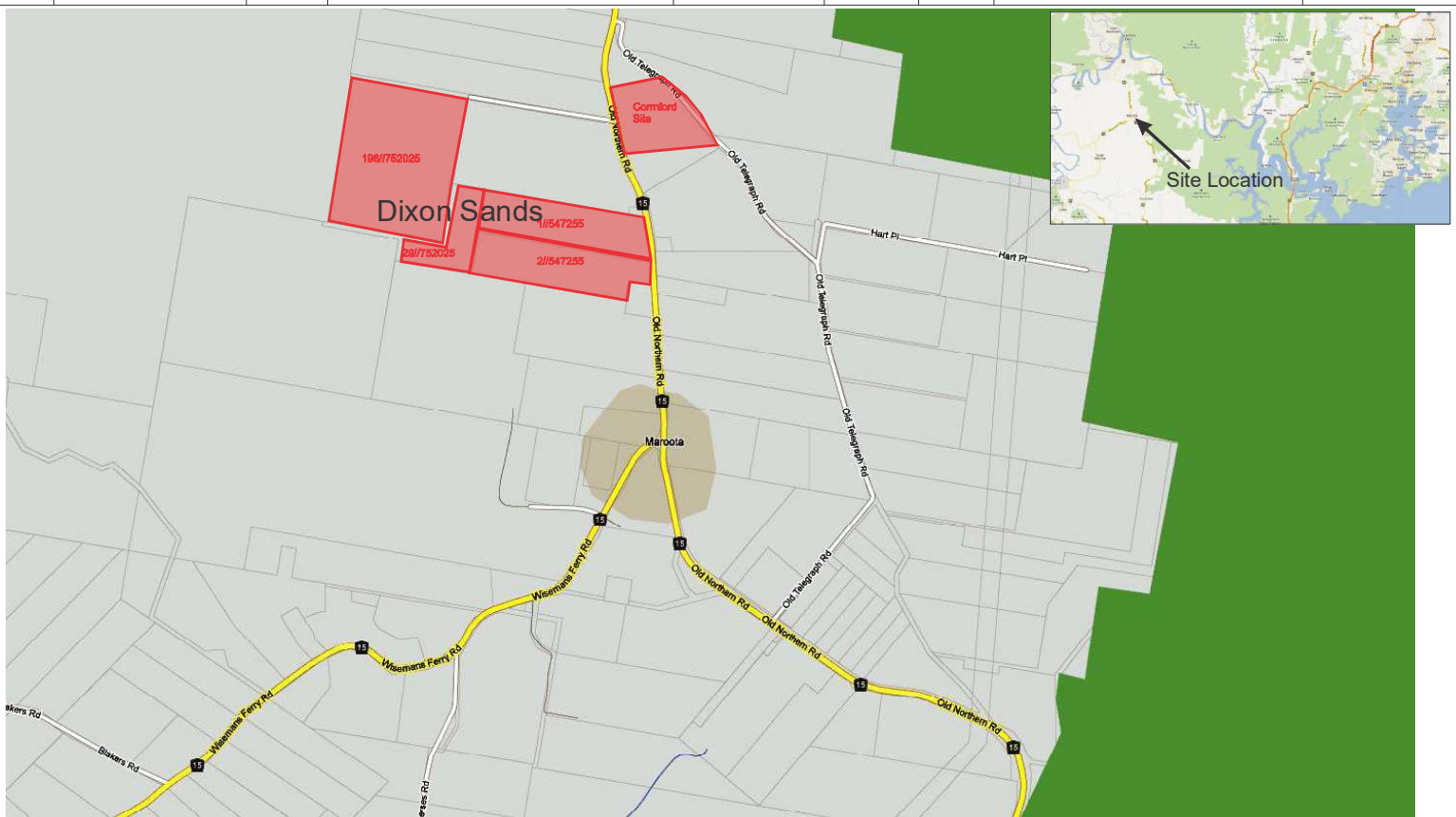
## Section 5. References

**Ref. 1.** *D.G.A Whitten with J.R.V. Brooks, The Dictionary of Geology 1982. D.G.A Whitten with J.R.V. Brooks,*



**Ref. 2.** *L.T. Etheridge - Geological Investigation and Resource Assessment of the Maroota Tertiary Alluvial Deposit" dated August 1980*

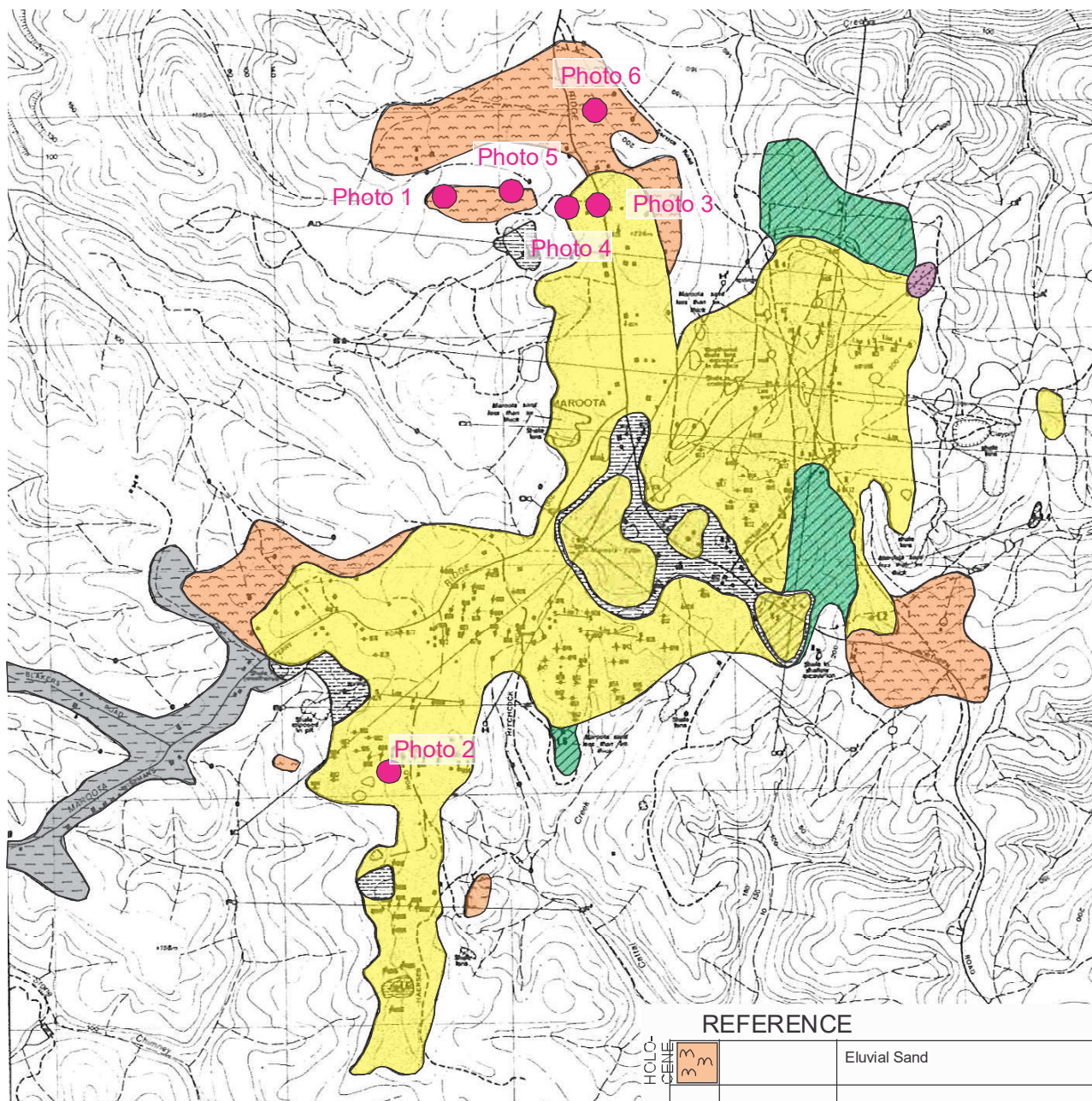
## Figures

|                  |                              |           |   |   |         |          |            |  |             |   |
|------------------|------------------------------|-----------|---|---|---------|----------|------------|--|-------------|---|
| Plan of:         | Maroota Sand-Quarry Location | Location: | Maroota, NSW Australia  | Projection:   | N/A     | Date:    | 31/07/2012 | Version:   | A           |  |
|                  |                              |           |   | Contour Interval:   | N/A     | Sheet:   | 1 of 1     | Source:  | Google Maps |   |
|                  |                              |           |   |  |         | Plan By: | LGT        |  |             |   |
| Project Manager: | GVT                          |           |   |   |         |          |            |  |             |   |
| Figure:          | ONE                          | Council:  | Baulkham Hills  |   |         |          |            |  |             |   |
| Client:          | Dixon Sands Pty Ltd          | Scale:    |  |   | Office: | Thornton | Our Ref:   | V:\Jobs\_Dixon sands\2012\Sand Drafting\Fig1.cdr |             |   |














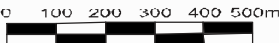
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|-----------------|---------------------|------------------|------------------------|---|-----------------------------|--|
| <b>Plan of:</b> | Maroota Area        | <b>Location:</b> | Maroota, NSW Australia | <b>Date:</b> 31/07/2012   |                             | <br>Environmental<br>Compliance<br>Solutions |
|                 |                     |                  |                        | <b>Version:</b> A   |                             |  |
|                 |                     |                  |                        | <b>Sheet:</b> 1 of 1  |                             |  |
| <b>Figure</b>   | TWO                 | <b>Council:</b>  | Baulkham Hills         |  | <b>Plan By:</b> TO          | <b>Source:</b> Geology of the Maroota Area, L. Etheridge   |
|                 |                     |                  |                        |   | <b>Project Manager:</b> GVT |  |
| <b>Client:</b>  | Dixon Sands Pty Ltd | <b>Scale:</b>    |                        |   | <b>Office:</b> Thornton     | <b>Our Ref:</b> V:\Jobs\_Dixon sands\2012\ Sand Drafting\Fig2.cdr  |



#### REFERENCE


|           |   |                      |   |
|-----------|---|----------------------|---|
| HOLO-CENE |  |                      | Eluvial Sand  |
|           |  |                      | Basalt  |
|           |  | Maroota Sand         | Clayey gravel, gravelly sand, clayey sand, pebbly sand and sand |
|           |  |                      | Clay and silty clay   |
|           |  |                      | Ferruginized sand and pebbly sand                               |
| TRIASSIC  |  | Ashfield Shale       | Shale and laminite  |
|           |  | Hawkesbury Sandstone | Quartzose sandstone with shale lenses                           |

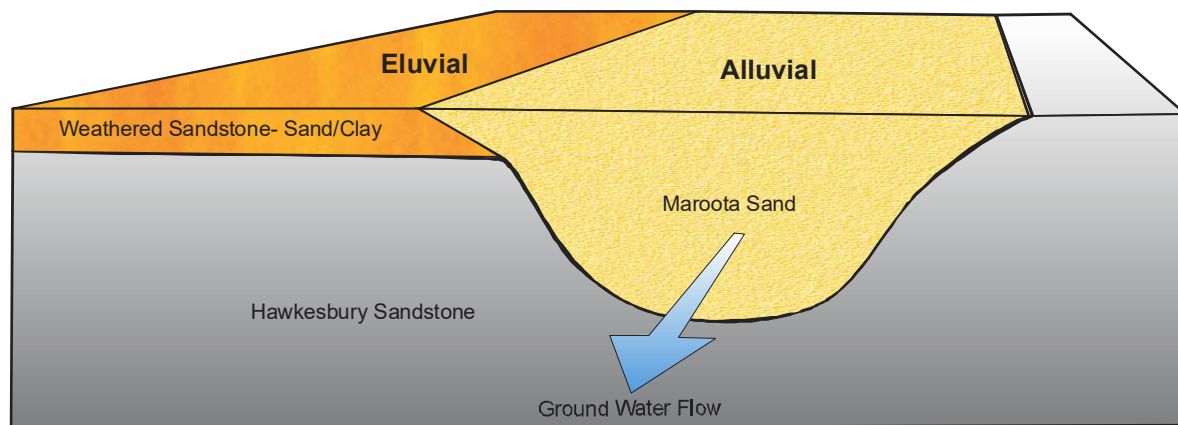




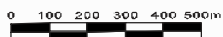
|                 |                     |                  |   |   |                             |  |
|-----------------|---------------------|------------------|---|---|-----------------------------|--|
| <b>Plan of:</b> | Maroota Area        | <b>Location:</b> | Maroota, NSW Australia  | <b>Date:</b> 31/07/2012   |                             |    |
|                 |                     |                  |   | <b>Version:</b> A   |                             |  |
|                 |                     |                  |   | <b>Sheet:</b> 1 of 1  |                             |  |
| <b>Figure</b>   | TWO A               | <b>Council:</b>  | Baulkham Hills  |  | <b>Plan By:</b> LGT         | <b>Source:</b> <a href="#">Air Photo:</a> Google<br><a href="#">Overlay:</a> Geology of the Maroota Area, L. Etheridge<br><a href="#">Property:</a> water.nsw.gov.au |
|                 |                     |                  |   |   | <b>Project Manager:</b> GVT |  |
| <b>Client:</b>  | Dixon Sands Pty Ltd | <b>Scale:</b>    |  |   | <b>Office:</b> Thornton     | <b>Our Ref:</b> V:\Jobs\_Dixon sands\2012\Sand Drafting\Fig2A.cdr  |



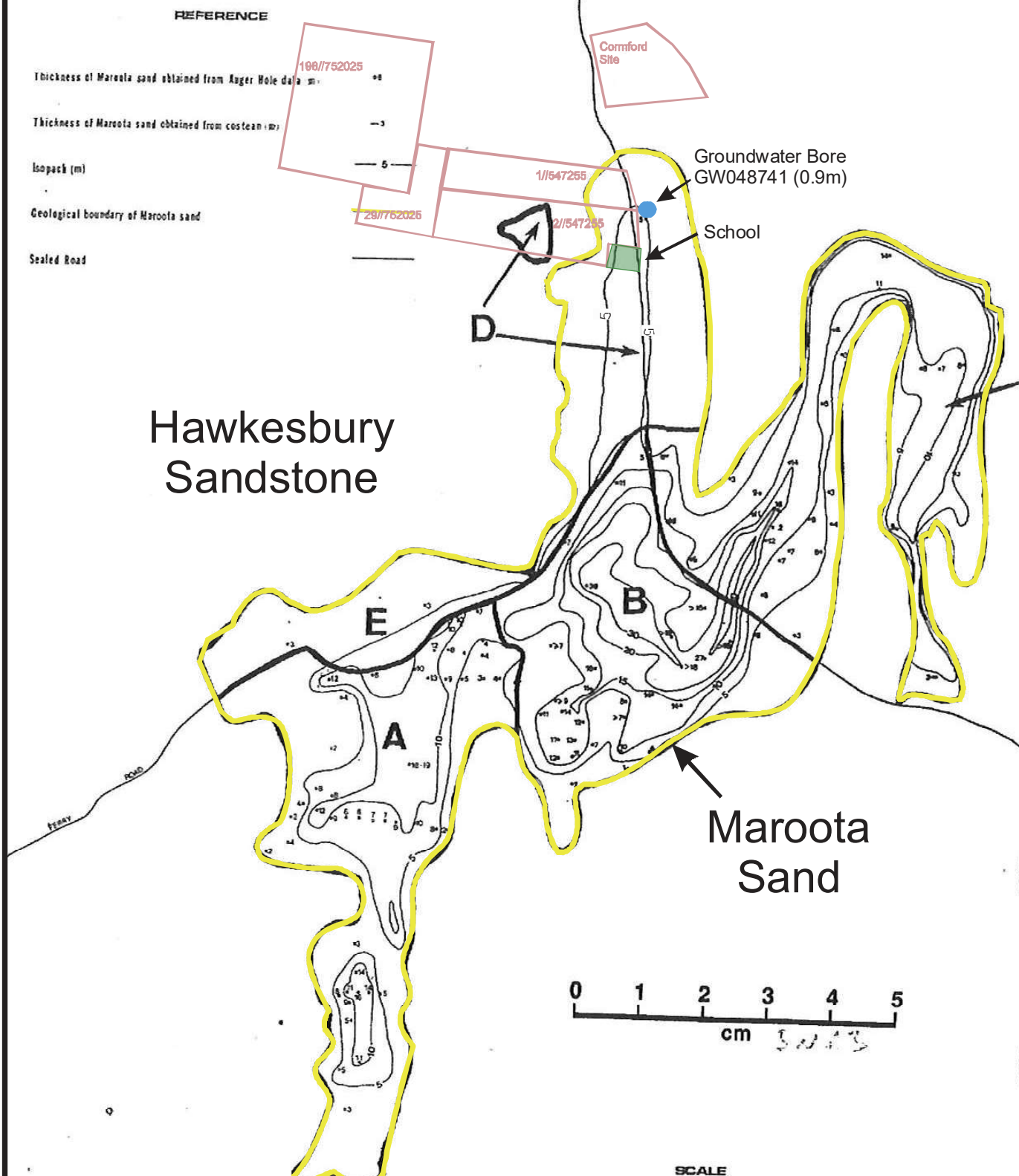





|                 |                                      |                  |                        |                          |     |                         |            |                 |   |   |
|-----------------|--------------------------------------|------------------|------------------------|--------------------------|-----|-------------------------|------------|-----------------|---|---|
| <b>Plan of:</b> | Maroota Representative Cross-Section | <b>Location:</b> | Maroota, NSW Australia | <b>Projection:</b>       | N/A | <b>Date:</b>            | 31/07/2012 | <b>Version:</b> | A   |  |
|                 |                                      |                  |                        | <b>Contour Interval:</b> | N/A | <b>Sheet:</b>           | 1 of 1     | <b>Source:</b>  | VGT Pty Ltd   |   |
|                 |                                      |                  |                        |                          |     | <b>Plan By:</b>         | LGT        |                 |   |   |
| <b>Figure:</b>  | THREE                                | <b>Council:</b>  | Baulkham Hills         |                          |     | <b>Project Manager:</b> | GVT        |                 |   |   |
| <b>Client:</b>  | Dixon Sands Pty Ltd                  | <b>Scale:</b>    | N/A                    |                          |     | <b>Office:</b>          | Thornton   | <b>Our Ref:</b> | V:\Jobs\ Dixon sands\2012\Sand Drafting\Cross section.cdr |   |

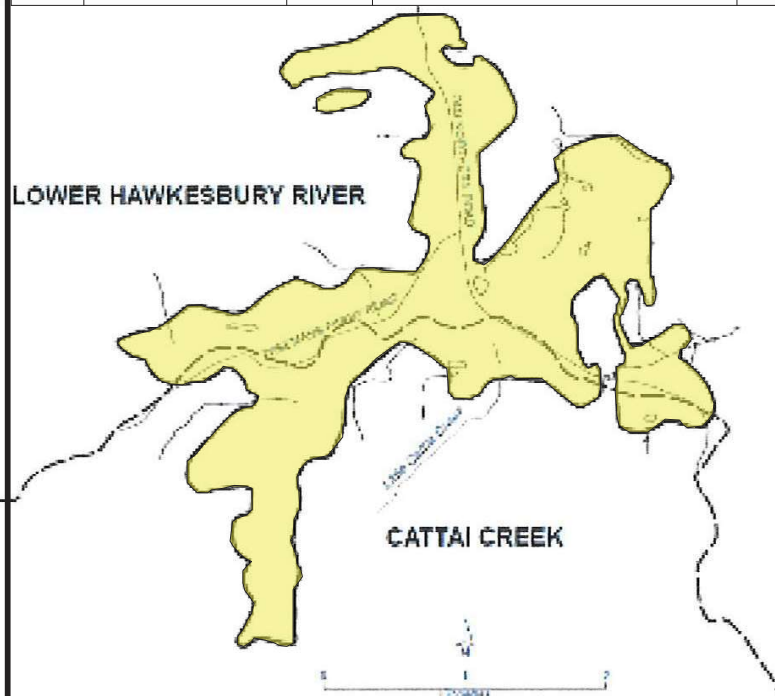


|                  |                     |           |                        |   |          |                 |  |  |
|------------------|---------------------|-----------|------------------------|---|----------|-----------------|--|--|
| Plan of:         | Maroota Area        | Location: | Maroota, NSW Australia | Date:<br>Version:   |          | 31/07/2012<br>A |  |  |
|                  |                     |           |                        | Sheet:  |          | 1 of 1          |  |  |
|                  |                     |           |                        |  | Plan By: | LGT             |  | Source:  |
| Project Manager: | GVT                 |           |                        |   |          |                 |  |  |
| Figure           | FOUR                | Council:  | Baulkham Hills         |  | Office:  | Thornton        | Our Ref:   | V:\Jobs\_Dixon sands\2012\ Sand Drafting\Fig 4.cdr |
| Client:          | Dixon Sands Pty Ltd | Scale:    |                        |   |          |                 |  |  |

Source: Construction Material Resources of the Maroota Area  
POTENTIAL EXTRACTION AREAS  
Figure 5a

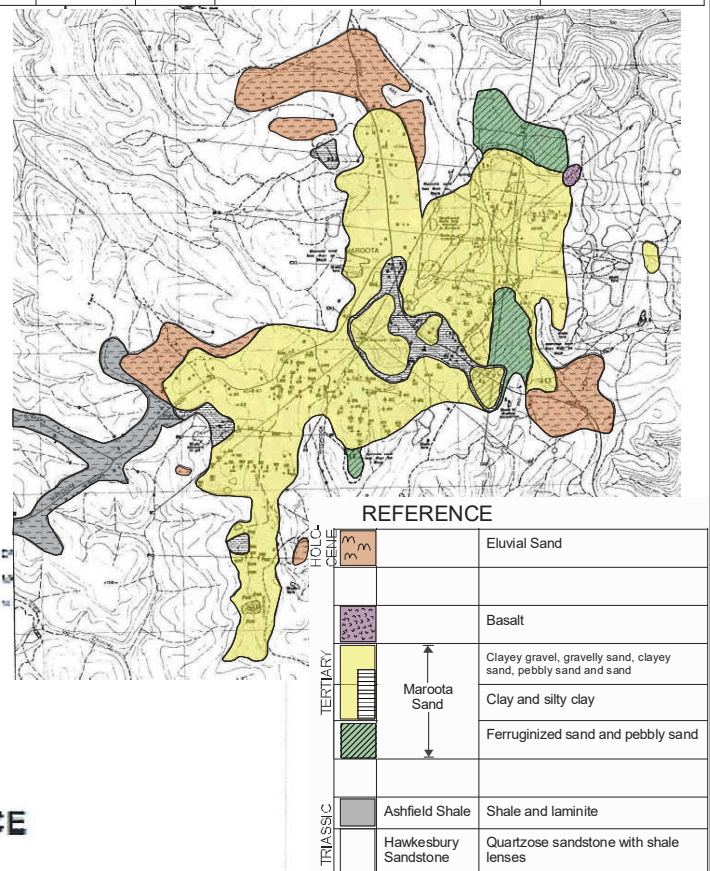


|          |                     |           |   |   |                  |          |            |  |  |   |
|----------|---------------------|-----------|---|---|------------------|----------|------------|--|--|---|
| Plan of: | Maroota Area        | Location: | Maroota, NSW Australia  | Projection:   | MGA              | Date:    | 31/07/2012 | Version:   | A  |  |
|          |                     |           |   | Contour Interval:   | N/A              | Sheet:   | 1 of 1     | Source:  | Left: Water Sharing Plan for the Greater Metropolitan Regional Groundwater Sources, 2011, Appendix 3<br>Right: Geology of the Maroota Area, L. Etheridge |   |
|          |                     |           |   |  | Plan By:         |          | LGT        |  |  |   |
| Figure:  | FIVE                | Council:  | Baulkham Hills  |   | Project Manager: |          | GVT        |  |  |   |
| Client:  | Dixon Sands Pty Ltd | Scale:    |  |   | Office:          | Thornton | Our Ref:   | V:\Jobs\_Dixon sands\2012\Sand Drafting\Fig5.cdr |  |   |






**WATER SHARING PLAN  
FOR THE GREATER METROPOLITAN REGION  
GROUNDWATER SOURCES 2011**

**MAROOTA TERTIARY SANDS GROUNDWATER SOURCE  
showing Surface Water Management Boundaries**





|                  |                     |           |   |   |         |          |            |  |             |   |
|------------------|---------------------|-----------|---|---|---------|----------|------------|--|-------------|---|
| Plan of:         | Maroota Detail      | Location: | Maroota, NSW Australia  | Projection:   | N/A     | Date:    | 31/07/2012 | Version:   | A           |  |
|                  |                     |           |   | Contour Interval:   | N/A     | Sheet:   | 1 of 1     | Source:  | Google Maps |   |
|                  |                     |           |   |  |         | Plan By: | LGT        |  |             |   |
| Project Manager: | GVT                 |           |   |   |         |          |            |  |             |   |
|                  |                     |           |   |   |         |          |            |  |             |   |
| Figure:          | SIX                 | Council:  | Baulkham Hills  |   |         |          |            |  |             |   |
| Client:          | Dixon Sands Pty Ltd | Scale:    |  |   | Office: | Thornton | Our Ref:   | V:\Jobs\_Dixon sands\2012\Sand Drafting\Detail.cdr |             |   |

