Groundwater monitoring program for Dunmore Hard Rock Quarry

Prepared for Boral Dunmore Quarry | 18 November 2016

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Final

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Date	18/11/2016	Date	18/11/2016

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Document Control

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1 Introduction

EMM Consulting Pty Limited (EMM) is pleased to present the groundwater monitoring program (GMP) for the Dunmore Hard Rock Quarry (the quarry). This GMP ensures compliance with condition 44 of the quarry's current approval, which states:

> 44. The Ground Water Monitoring Program shall include:
>
> a) detailed baseline data on ground water levels and quality, based on statistical analysis;
>
> b) ground water impact assessment criteria; and
>
> c) a program to monitor regional ground water levels and quality.

2 Conceptual groundwater model

2.1 Geology

The project area is situated in the south-eastern corner of the Permo-Triassic Sydney Basin. The Sydney Basin predominantly comprises Permian and Triassic aged sedimentary rocks. In the vicinity of the quarry the Triassic and Late Permian sedimentary rocks have been eroded and early Permian Gerringong Volcanics of the Shoalhaven Group dominate (*Geology of the Wollongong, Kiama and Robertson 1:50,000 Sheet,* Department of Mines 1974).

Volcanic activity in the area has produced a series of flat lying lava flows interspersed with volcaniclastic sandstone members and breccias. The thickness of each successive flow decreases in extent from the volcanic origin, assumed to be off the current coastline to the south (Cohen 2006). At the quarry all geological units exhibit a gentle dip in an easterly direction at approximately 2-3° (Evans and Peck 2006; MMJ 2013).

The Bumbo Latite, one of the nine latite members of the Gerringong Volcanics facies, is the areas greatest and most persistent lava flow, and is the predominant geological unit at the quarry. The Latite has a maximum thickness of 150 m. Latite is a term used to describe the type of basalts along the south coast of NSW, they are also referred to as trachybasalts (Cohen 2006).

The Bumbo Latite Member overlies the Kiama Sandstone Member at the quarry. Further east is Quaternary Alluvium associated with the floodplain areas of the Minnamurra River and its tributaries. This alluvium comprises unconsolidated to loosely consolidated gravels, sands, silts and clays.

2.2 Hydrogeology

The regional groundwater system flows south-east, governed the dip of the strata and topography (Cohen 2006). Recharge to the regional groundwater system (the Kiama Sandstone) is via infiltration from overlying sedimentary units to the west of the project area (Cohen 2006). Regional groundwater in the Kiama Sandstone discharges to the Pacific Ocean (Cohen 2006).

Local groundwater flow systems (horizontal scale of less than 5 km) are present within the Bumbo Latite along the elevated ridgeline (Walker et al 2003). These systems are isolated and have limited connection to the regional flow system. The Bumbo Latite is tight with a low primary and low secondary porosity (Cohen 2006) restricting groundwater flow. The local groundwater systems are recharged by rainfall with infiltration higher in areas where the Bumbo Latite outcrops on the ridgelines and hilltops of the landscape (ie areas with limited soil profile).

Groundwater flow is minimal and predominantly occurs along fractures and contacts between volcanic rock and the underlying sandstone (MMJ 2013).

The Quaternary alluvial sediments associated with the surface water courses form unconfined groundwater systems of varying storage. These systems are recharge by leakage from surface water courses during wet periods. The alluvial systems are depleted during dry periods and are not recharged by underlying porous and fractured rocks (Cohen 2006).

Groundwater at the quarry is fresh to brackish with an average EC of 1,756 µS/cm. The groundwater is neutral to slightly alkaline with an average pH of 7.7. The groundwater is classified as calcium carbonate dominant and typical of groundwater found in igneous rocks.

2.3 Conceptual Hydrogeological model

2.3.1 Groundwater flow

Groundwater within the Bumbo Latite flows from the areas of high relief towards the valleys and low lying plains where it discharges to the alluvium and surface watercourses. The bulk rock mass has a low primary permeability with groundwater flow primarily through fractures and across the contacts between the latite flows and breccia.

In the vicinity of the quarry, groundwater flow is generally towards the south-east discharging to Rocklow Creek and the Minnamurra estuary system. To the north of the quarry the landscape give way to steep valleys that shed surface water and provide limited potential for groundwater recharge.

The deep groundwater systems within the Kiama Sandstone and Berry formation typically flow sub-horizontally towards the east and coincident with the dip of the strata.

2.3.2 Recharge and discharge

The groundwater system is recharged by rainfall and the surface watercourses. The steep relief increases runoff with a smaller percentage of rainfall infiltration in this steeper terrain.

Groundwater from the shallow latite is largely thought to discharge to the Minumurra River and Rocklow Creek, which form the main drainage systems in the vicinity of the quarry.

2.3.3 Groundwater-surface water connectivity

The surface watercourses are hydraulically disconnected from the underlying fractured rock groundwater systems in the elevated parts of the landscape. The surface water systems are ephemeral in nature with the upper reaches drying out during periods of low rainfall. This ephemeral nature indicates minimal the surface water courses are not connected to the groundwater systems.

The surface water systems to the east of the quarry (Illawarra River, Minnamurra River and Rocklow Creek) are connected to shallow, marginal groundwater systems within surficial alluvial systems. Direct rainfall and surface runoff recharges these shallow systems during wet periods which rapidly deplete during the drier periods providing an important source of baseflow for the surface watercourses.

Although the shallow latite flows through to the alluvial in the east, the volume of this flux is likely to be insignificant in comparison to the recharge from the overlying rivers.

3 Groundwater monitoring network

3.1 Monitoring network design

The objectives of the groundwater monitoring network are to gather baseline data in the groundwater systems that the quarry intersection or potentially impacts upon. Based on the conceptual hydrogeological model for the quarry the latite is the main groundwater system to be monitored, with an option to monitor the alluvium immediately downgradient of the quarry. Due to the minimal, if any, flux between the latite and the sandstone, there is no obvious need to monitor the underlying sandstone.

The monitoring network consists of a total of six bores, three deep up hydraulic gradient bores and three shallow down hydraulic gradient bores.

The three deep monitoring bores were completed within the bumbo latite in July 2014, with one bore screened across the latite and the top of the underlying sandstone. These bores are located up hydraulic gradient from current quarrying activities (Figure 3.1).

The three shallow monitoring bores, were installed as part of the Dunmore Sand and Soil operation, and are down hydraulic gradient from current quarrying activities.

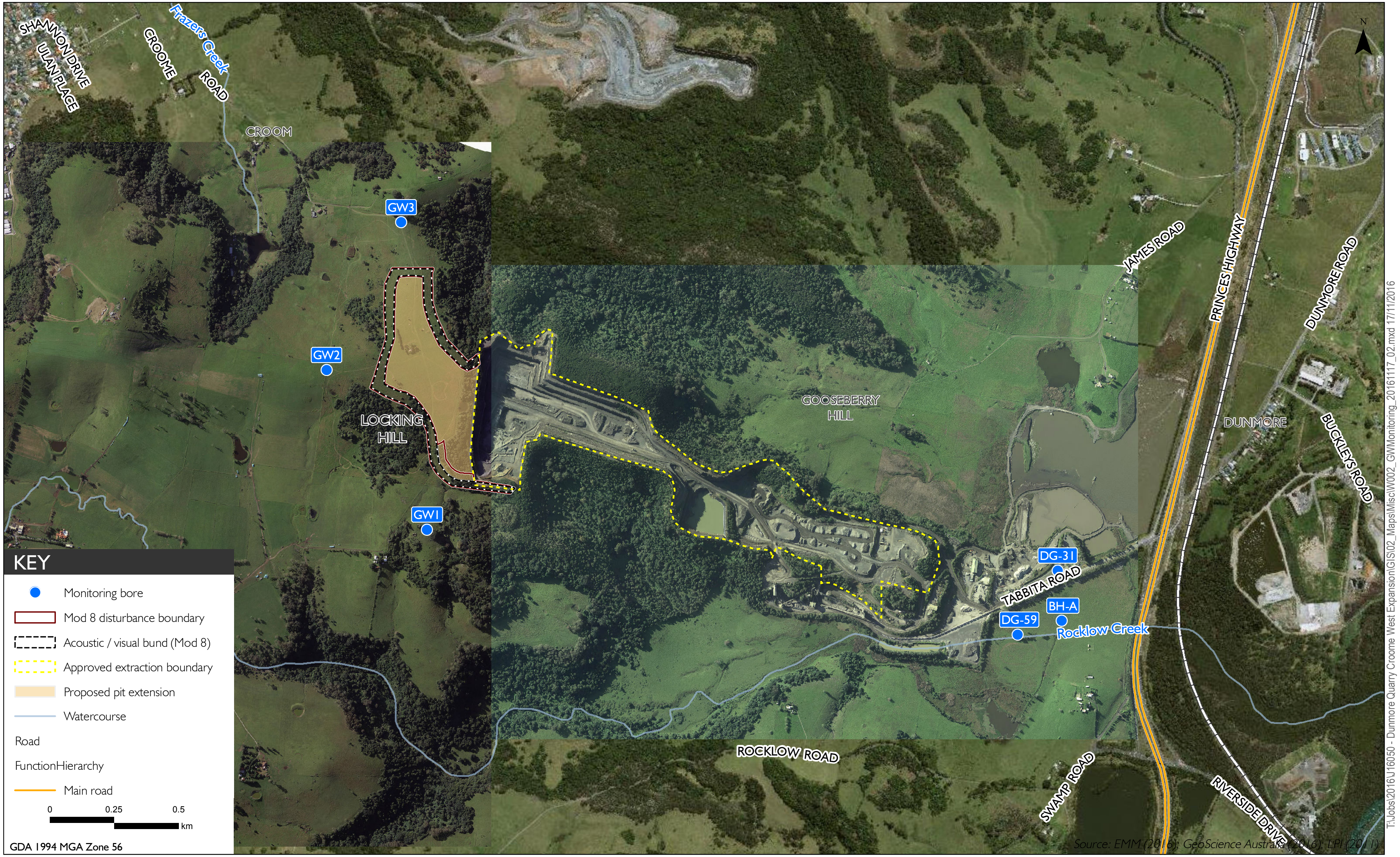
Details of the monitoring bores are listed in Table 3.1.

Table 3.1 Groundwater monitoring bores details

Monitoring bore	Total depth (m bgl)	Total depth (m AHD)	Screened interval (m bgl)	Screened interval (m AHD)	Lithology	Formation
GW1	78.0	70.0	72.0 – 78.0	76.0 – 70.0	Latite / sandstone	Bumbo Latite and Kiama Sandstone
GW2	86.0	51.5	79.0 – 85.0	51.5 – 57.5	Latite	Bumbo Latite
GW3	80.0	51.5	68.0 – 80.0	51.5 – 63.5	Latite / breccia	Bumbo Latite and Breccia
BH-A	tbc	tbc	tbc	tbc	Tbc	tbc
DG-31	tbc	tbc	tbc	tbc	Tbc	tbc
DG-59	tbc	tbc	tbc	tbc	Tbc	tbc

Notes: m bgl = meters below ground level, m AHD = meters Australian Height Datum.

tbc = information to be confirmed.



EMM

Groundwater monitoring bores

Dunmore Quarry
Groundwater Monitoring Program

Figure 1

4 Groundwater monitoring program

4.1 Groundwater quality

Groundwater quality sampling will be undertaken at a six-monthly frequency at all monitoring bores as detailed in Table 4.1.

Table 4.1 Water quality monitoring program

Monitoring bores	Monitoring events	Monitored by
GW1, GW2, GW3	December 2016 and June 2017	EMM
BH-A, DG-31, DG-59	December 2016 and June 2017	Environmental Earth Sciences NSW

Note: tbc = information to be confirmed.

Water quality samples collected from the monitoring network will be analysed for the suite of parameters listed in Table 4.2.

Table 4.2 Water quality suite of analysis

Grouping	Parameters	
Physicochemical parameters (field)	Electrical conductivity pH Dissolved oxygen	Temperature Total dissolved solids Oxidation reduction potential
Major ions	Calcium Magnesium Sodium Potassium	Chloride Total alkalinity Sulphate Silica[1]
Dissolved metals	Aluminium[1] Arsenic[1] Cadmium[1] Chromium[1] Copper[1]	Iron Manganese[1] Nickel[1] Zinc[1]
Nutrients	Ammonia Nitrate Nitrite	Total nitrogen Total phosphorus

Notes: 1. Not analysed in the shallow monitoring bores (BH-A, DG-31 and DG-59).

4.2 Groundwater levels

Following completion of the deep monitoring bores (GW1-3) in July 2014, pressure transducers (dataloggers) were installed in the water column and programmed to record a groundwater level every six hours. A datalogger was installed in monitoring bore BH-A in October 2013 and was programmed to record a groundwater level every hour.

Dataloggers will be installed in monitoring bores DG-31 and DG-59 in December 2016 to record a groundwater level every six hours.

To verify the level recorded by the dataloggers, manual measurements will be recorded during the six-monthly monitoring events (December 2016 and June 2017) using an electronic dip meter.

5 Reporting and review

An annual report will be issued in July 2017, including analysis and interpretation of groundwater quality and groundwater level data collected since monitoring began at all monitoring bores, with emphasis on the data obtained during the last 12 months.

The annual report will also include a review of the monitoring network design and provide recommendations for ongoing monitoring, and also assess the adequecy of the monitoring network design, and whether additional monitoring bores are required.

References

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