ZERO HARM TODAY

# Dunmore Quarry

## Annual Review

## 2016-2017

ZERO HARM TODAY

| Document Control | | | |
|---|---|---|---|
| Version | Prepared by | Date | Distribution |
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# 1. Introduction

## *1.1. Purpose/Scope*

This report has been prepared to address Annual Review requirements in accordance with Condition 9, of Schedule 5 in Development Consent DA 470-11-2003 for Boral Dunmore Quarry. The review and associated report accounts for the period between 1 July 2016 and 30 June 2017. Condition 9(5) and all other relevant conditions required as part of the Annual Review are outlined in Table 1 with reference to the section of this report where each has been addressed.

**Table 1: Relevant Conditions of Approval**

| Condition of Approval | Condition Requirements | Location within this report |
|---|---|---|
| 9(5) | By the end of September each year, or other timing as may be agreed by the Secretary, the Applicant must submit a report to the Department reviewing the environmental performance of the development to the satisfaction of the Secretary. The review must:<br>a) Describe the development (including rehabilitation) that was carried out in the previous financial year, and the development that is proposed to be carried out over the current financial year;<br>b) Include a comprehensive review of the ,monitoring results and complaints records of the development over the previous financial year, which includes a comparison of these results against the:<br>• Relevant statutory requirements, limits or performance measures/criteria;<br>• Requirements of any plan or program required under this consent;<br>• Monitor results of previous years; and<br>• Relevant predictions in the document listed in condition 2 of schedule 3;<br>c) Identify any non-compliance over the last financial year, and describe what actions were (or are being) taken to ensure compliance;<br>d) Identify any trends in the monitoring data over the life of the development;<br>e) Identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and<br>f) Describe what measures will be implemented over the current financial year to improve the environmental performance of the development.<br>The Applicant must ensure that copies of the Annual Review are submitted to Council and are available to the Community Consultative Committee (see condition 6 of Schedule 5) and any interested person upon request. | Section 2.1 & 2.5<br>Section 1.2, 2.4, 3.1, 4.1, 4.2, 4.3, 4.4 & 4.5<br>Section 5<br>Sections 3 & 4<br>Sections 3 & 4<br>Sections 2, 3 & 4 |
| 4(30) | In each Annual Review, the Applicant must:<br>a) Recalculate the site water balance for the development; and<br>b) Provide information on evaporative losses, dust suppression, | Section 2.3 |

| | | |
|---|---|---|
| | dam storage levels and implications of obtaining any water supplies from off-site; and<br>c) Evaluate water take against licencing requirements. | |
| 4(51) | The Applicant must include a progress report on the implementation of the Flora and Fauna Management Plan in the Annual Review. | Section 2.4 |
| 4(58) | The Applicant must include a progress report on the Rehabilitation Management Plan in the Annual Review. | Section 2.5 |
| 4(72) | The Applicant must describe what measures have been implemented to minimise the amount of waste generated by the development in the Annual Review. | Section 2.6.1 |
| 4(78) | The Applicant must:<br>(a) provide annual production data to the DRE using the standard form for that purpose; and<br>(b) include a copy of this data in the Annual Review. | (Provided to the DRE)<br>Section 2.2.1 |

## *1.2. Background and Site Description*

The Dunmore Hard Rock Quarry, owned and operated by Boral Resources (NSW) Pty Ltd, is located at Tabbita Road Dunmore, approximately 12 kilometres north-west of Kiama in the Shellharbour Local Government Area. The Quarry produces hard rock from Bumbo Latite Member, a fine-grained intermediate volcanic rock similar to basalt, which is crushed to produce coarse aggregates, road construction materials and fines.

Development Consent (DA 470-11-2003), issued 19 November 2004 by the Minister for Infrastructure and Planning, allows Boral to produce up to 2.5 million tonnes of quarry product a calendar year (Mtpa), and transport it offsite by road and rail to local and regional markets.

Dunmore Hard Rock Quarry (the site) covers approximately 248 hectares and is surrounded by private property, predominantly agricultural grazing land and tracts of remnant native vegetation, to the south, north and west (The Boral owned and operated Dunmore Lakes Sand Project adjoins the site to the east).

The extraction method involves drilling and blasting to produce broken rock, that is transported to the primary crusher feed bin. The primary-crushed rock is further reduced in size in a series of crushers, before being conveyed to the tertiary screen house where the crushed rock is sized according to product specifications. The sized products are then stockpiled within the various stockpile areas on site, until they are transported to local and regional markets.

Extraction has occurred in an area known as Original Dunmore Quarry and Rail Infrastructure Corporation (RIC) Slot. Extraction operations are currently centred on the Croome Farm Pit. A layout of the site is illustrated in Figure 1.

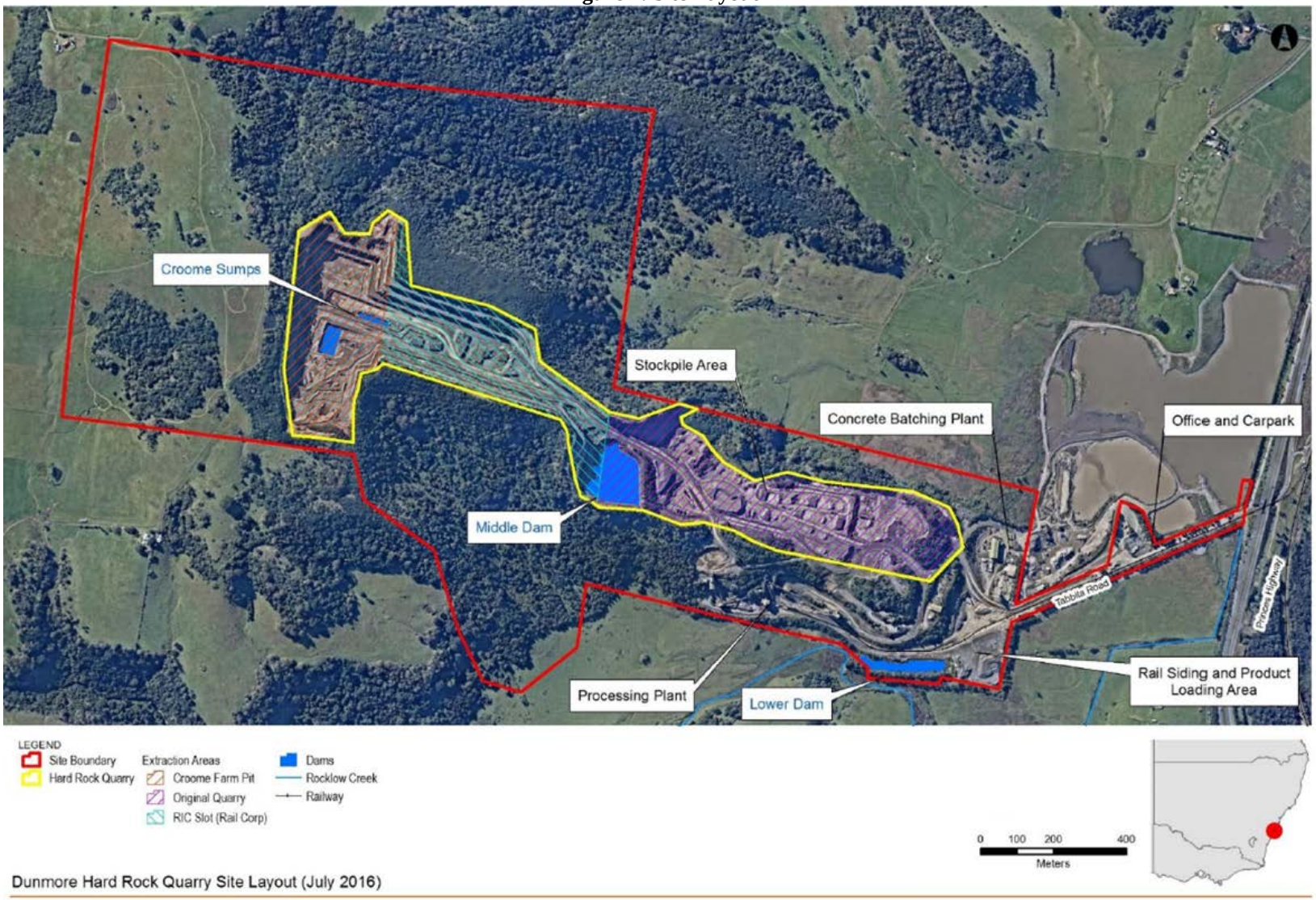
A summary of all the approvals relevant to the Dunmore Quarry are provided in Table 2.

**Table 2: Summary of Approvals**

| Approval Type | Approval Authority | Approval No. | Date Granted |
|---|---|---|---|
| Development Consent | Department of Planning & Environment | 470-11-2003 | 30/09/2004 |
| Environment Protection Licence (EPL) | Environment Protection Authority | 77 | 31/08/05 |
| Water Extraction Licence | Department of Primary Industries – Water | Water Access Licence No: WAL25152<br>Approval No: 10WA103611 | 01/07/2011 |

Approval of modification 8 of the development consent was granted in November 2016. This modification relates primarily to the approval and installation of the earth bund located at Croome West. Further approval of modification 10 of the development consent was granted in June 2017. This modification relates to wording around water storage capacity across the site.

**Figure 1: Site Layout**



# 2. Quarry Operations

## *2.1. Quarry Development*

### 2.1.1. Last 12 Months

Throughout this reporting period, the site focused on quarrying the remaining resources within the Croome Farm extraction area, with the majority of extraction taking place within the South Croome Farm extraction area. As the consented resource is reaching depletion levels, the site focused on tidying up all areas and ensured the full extent of material was quarried at all extraction limits that have been reached.

### 2.1.2. Next 12 Months

The next 12 months will focus on quarrying all remaining resource left, which is predominantly in the South Croome region. Pending approval of planned development consent modifications for expansion to the West, works will begin for the further development. At this preliminary stage expansion works will include completion of the construction of the required noise and visual bund, and the commencement of quarrying in the Croome West Expansion area.

## *2.2. Production, Sales & Transport*

### 2.2.1. Last 12 Months

Table 3 details the calendar year production figures for the reporting period. In total the quarry produced 1,660,559 tonnes during the reporting period. This is below the potential consented capacity of the quarry of 2.5 million tonnes of quarry product per calendar year. A total of 1,303,335 tonnes of quarry product was sold via road, whilst 303,985 tonnes was transferred to the adjacent Boral owned Dunmore Lakes Sand Project for blending with sand products and internal application. It should be noted that natural sand product is transferred to the quarry for distribution via rail. This product mass has not been represented in Table 3. Table 4 provides the production data as it will be reported to the Division of Resources and Geoscience (DRG) within the Department of Planning and Environment (DPE).

**Table 3: Calendar Year Production Data**

| Month | Production (t) | Sales (t) | |
|---|---|---|---|
| | | Road | Transfers |
| Jan-2016 | 89,720 | 62,580 | 22,549 |
| Feb-2016 | 123,392 | 114,595 | 28,067 |
| Mar-2016 | 113,075 | 103,182 | 25,408 |
| Apr-2016 | 117,011 | 113,052 | 28,799 |
| May-2016 | 152,519 | 130,458 | 26,409 |
| Jun2016 | 141,664 | 103,824 | 25,701 |
| Jul-2016 | 161,479 | 97,313 | 31,917 |
| Aug-2016 | 208,594 | 103,114 | 24,124 |
| Sep-2016 | 153,490 | 119,486 | 18,477 |
| Oct-2016 | 154,313 | 118,841 | 30,793 |
| Nov-2016 | 145,574 | 142,456 | 20,432 |
| Dec-2016 | 99,728 | 94,434 | 21,309 |
| **Total** | 1,660,559 | 1,303,335 | 303,985 |
| | | 1,607,320 | |

**Table 4: Production Data (DRE Annual Return Format)**

| | | Total Sales / Disposals | |
|---|---|---|---|
| **Product** | **Type of Material** | **Quantity (Tonnes)** | **$ Value of Sale*** |
| Virgin Materials<br>Crushed Coarse Aggregates | | | |
| Over 75mm | Latite | 6,350 | * |
| Over 30mm to 75mm | Latite | 4,072 | * |
| 5mm to 30mm | Latite | 903,071 | * |
| Under 5mm | Latite | 391,124** | * |
| Natural sand | Latite | | * |
| Manufactured Sand | Latite | | * |
| Prepared Road Base & Sub Base | Latite | 277,004 | * |
| Other Unprocessed Materials | Latite | | * |
| Total | | 1,581,621 | * |

*Note: This data is an approximation of FY17 production data and is subject to change. *This information is commercially sensitive and has been omitted. ** This product is not part of the total sales.*

### 2.2.2. Next 12 Months

Overall production is dependent on the outcome of planned development consent modifications for quarry expansion into the Croome Farm West area. Pending approval, it is expected that production volumes will increase slightly during the 2017-2018 reporting period production.

## 2.3. *Water Management*

### 2.3.1. Site Water Balance Review

The site water balance is currently under review by consultants Royal Haskoning DHV and is being prepared as part of Condition 30 of Schedule 4 of the development consent. Figure 2 outlines the existing water management system, dam capacities and water transfers. The site water demands are presented in Table 5 below.

**Table 5: Process Water Use Profiles**

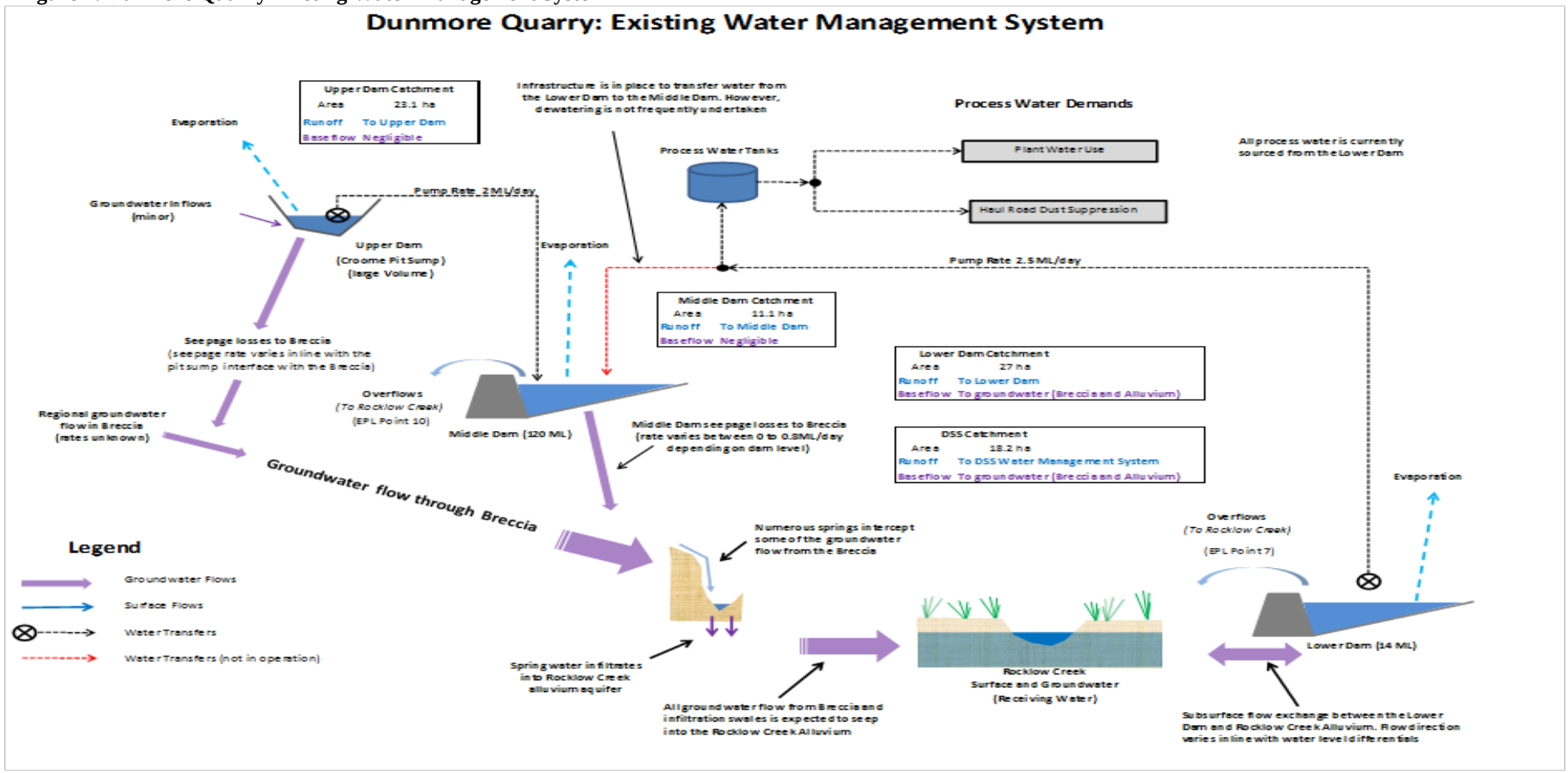
| Process Water Use | Description | Annual Water Use[1] |
|---|---|---|
| Haul road dust suppression | The site operates a 50KL water cart five and a half days per week. Typical daily use rates during dry conditions are:<br>• 1.6ML day in summer (2-3 loads an hour over a 13 hour period)<br>• 0.8 ML/day in winter (2 loads an hour over a 8 hour period) | Between 264 to 291 ML/year for wet and dry years respectively. |
| Dust suppression within processing plant | Water is used for conveyor and stockpile dust suppression within the plant. Water meter readings indicate an average daily use rate of 75KL/day | Constant at 27ML/year. |

**Note 1:** The annual water use volumes have been calculated using the site water balance. The annualised figures for haul road dust suppression account for reduced application during wet weather, reduced application rates on Saturdays and no application on Sunday.

The site water balance will be reviewed and updated annually using data obtained from metered pumping locations. To improve data management and reporting for use in future water balance updates, within the next 12 months the quarry will:

- Investigate placing metered pumping stations associated with the site water balance on an online recording system to capture site water movement.

**Figure 2: Dunmore Quarry Existing Water Management System**



## 2.4. *Flora and Fauna Management*

### 2.4.1. Flora and Fauna Management Plan

#### *2.4.1.1. Summary*

In accordance with Condition 4(47), a Flora and Fauna Management Plan (FFMP) was prepared by Arcadis for Boral in 2016 and approved on the 18th of January 2017. This FFMP incorporated a Vegetation Clearing Protocol, a Compensatory Habitat Management Plan and a Remnant Vegetation Conservation Plan. A review of the FFMP commenced in this reporting period. Please refer to Appendix 7 for an overview of the associated conservation areas for the site. The FFMP will be reviewed during the FY18 reporting period.

#### *2.4.1.2. Vegetation Offset Area*

As a result of the vegetation being cleared for the southern extension of the Croome Farm extraction area, and in recognition of Condition 4(46) of DA 470-11-2003, a Vegetation Offset Strategy was prepared to set out how the impacts of the clearing would be offset.

A Conservation Agreement between the Minister administering the National Parks and Wildlife Act (1974) and Boral Resources for Dunmore Quarry was signed by NSW Minister for the Environment on February 2011. The NSW Minister for the Environment confirmed signing the Dunmore Quarry Conservation Agreement acknowledged that the Conservation Agreement satisfied condition 46(a) of DA 470-11-2003, for the long term security of the biodiversity offset.

The Offset Area has been fenced to exclude cattle and facilitate natural regeneration outside of the active management zone. A number of actions have been identified to manage conservation values of the Offset Area. These actions include weed management, feral animal control, bushfire management, and restoration and maintenance of native vegetation.

On the 4th of April 2017 a vegetation species survey was conducted by Good Bush Pty Ltd (Appendix 10). The survey identified 85 native plant species and 30 weed species. Of the 85 native plant species identified, 1 threatened species was identified (*Zieria granulate*). Of the 30 weed species identified, 4 were identified to be both a noxious weed (NW) and a weed of national significance (WoNS) while 1 was a weed of national significance only. The weeds are as follows:

1. *Senecio madagascarensi* – Fireweed (NW, WoNS),
2. *Anredera cordifolia* – Madeira Vine (WoNS),
3. *Opuntia stricta* – Common Prickly Pear (NW, WoNS),
4. Rubus fruticosis – Blackberry (NW, WoNS); and

5. Lantana camara – Lantana (NW, WoNS)

Three vegetation communities were identified within this survey area, and they are:

1. Illawarra Lowlands Grassy Woodlands,
2. Illawarra Subtropical Rainforest; and
3. Melaleuca armillaris Tall Shrubland.

All three vegetation communities have been classified as an endangered ecological community. A restoration plan has been developed to provide recommendations to address weed management issues that assists and encourages the regeneration of the natural vegetation communities. The initial stage of the restoration in the Offset Area will be of 12 months duration and will be reassessed to determine the scale of rehabilitation and effectiveness and management controls.

#### *2.4.1.3. Compensatory Habitat Management*

The primary management objectives of the Compensatory Habitat are to:

- Establish at least twice the area of EECs cleared for the quarry extension in nearby areas of modified vegetation that support similar geology/soil type and landform.
- Improve the connectivity of native vegetation communities by establishing vegetation on land that has previously been cleared for grazing activities. Isolated patches of remnant vegetation will be linked by revegetating areas of cleared grazing (predominantly exotic grassland) land between remnant patches.

On the 18th of April 2017 a vegetation species survey was conducted by Good Bush Pty Ltd (Appendix 10). The survey identified 60 native plant species and 17 weed species. Of the 60 native plant species two have been found to be threatened species, and they are:

1. *Cynanchum elegans*; and
2. *Zieria granulate*

Of the 17 weed species identified one has been classified as a noxious weed and a weed of national significance, and that is *Lantana camara*. The vegetation communities identified for this survey include:

1. Illawarra Subtropical Rainforest; and
2. Melaleuca armillaris Tall Shrubland

Both communities have been classified as an endangered ecological community.

#### *2.4.1.4. Remnant Vegetation Conservation Area*

The remnant vegetation conservation area contains 33.25 hectares of Illawarra Subtropical Rainforest (ISR) EEC. Cumberland Ecology (2009) identified weed invasion and degradation of native vegetation

resulting from edge effects as potential risks to ISR EEC within the remnant vegetation conservation area.

The primary management objectives of the Remnant Vegetation Conservation Area are to:

- Remove dense infestations of noxious and environmental weeds, including *Lantana camara* (Lantana), *Araujia sericifera* (Moth Vine), *Delairea odoratam* (Cape Ivy) and *Passiflora subpeltata* (White Passionfruit).
- Reconstruct ISR EEC in the kikuyu pasture adjoining the south-east of Remnant Vegetation Conservation Area,

In this reporting period, Dunmore Quarry undertook weed management tasks in the grazing paddock directly adjacent the remnant vegetation conservation. This weed management campaign focused on noxious weeds with the aim to reduce potential edge effects leading to weed invasion and degradation of native vegetation.

On the 28th of March 2017 a vegetation species survey was conducted by Good Bush Pty Ltd (Appendix 10). The survey identified 70 native plant species and 11 weed species. Of the 70 native plant species identified, 1 threatened species was identified (Cynanchum *elegans*). Of the 11 weed species identified, 2 were identified to be both a noxious weed and a weed of national significance. These are *Rubus fruticosis* and *Lantana camara*. The vegetation community was defined as the Illawarra Subtropical Rainforest which is defined as an endangered ecological community.

Over the next reporting period, a range of management actions plan to be undertaken to continue conserving, maintaining and enhancing existing vegetation within the Remnant Vegetation Conservation Area. These include weed management, monitoring of revegetated areas, and increasing the condition and extent of the ISR EEC and repairing/maintaining exclusion fencing.

#### *2.4.1.5. Vegetation Clearing*

During the reporting period the noise and visual bund construction commenced and included the clearing of approximately 1.603 hectares of vegetation. The vegetation cleared includes such species as:

- Black Wattle (Acacia spp.),
- Parramatta Wattle (Acacia parramattensis),
- Coastal White Box (Eucalyptus quadrangulata)
- Sydney Blue Gum (*Eucalyptus saligna*),
- Bracelet Honey Myrtle (*Melaleuca armillaris*)
- Sweet Pittosporum (Pittosporum undulatum),

- Narrow-leaved Bottlebrush (*Callistemon linearis*),
- Prickly-leaved Tea Tree (*Melaleuca styphelioides*),
- Heath-leaved Banksia (*Banksia ericifolia*),
- Two-veined Hickory (*Acacia binervata*)
- Blackwood (*Acacia melanoxylon*),
- Foam Bark Tree (*Jagera pseudorhus*),
- Coffee Bush (*Coffea spp*.),
- Cherry Ballart (*Exocarpos cupressiformis*),
- Red Ash (*Alphitonia excelsa),*
- Lantana *(Lantana camara*),
- Wombat Berry *(Eustrephus latifolius),*
- Sickle Fern *(Pellaea falcate),*
- Prickly Beard Heath *(Leucopogon juniperinus*),
- Wallaby Apple *(Pittosporum spinescens),*
- Cranesbill *(Geranium homeanum),*
- Twining Glycine *(Glycine clandestina),*
- Monkey Rope *(Parsonsia straminea),*
- Raspberry *(Rubus parvifolius),*
- Guinea Flower *(Hibbertia scandens),*
- African Olive *(Olea europaea);* and
- Small and large-leaved Privet *(Ligustrum sinense)*

It is expected that the noise and visual bund be completed during FY18 which may require an additional 0.376 hectares of vegetation clearing. As per the sites Flora and Fauna Management Plan, clearing is conducted utilising the sites clearing protocol with prior assessments conducted and completed by a qualified ecologist.

Over the next reporting period, vegetation clearing is expected to occur at level 4 site (see figure 3) to increase stockpile area for specialised products. The vegetation being cleared in this area is approximately 0.912 hectares in size and is dominated by dense exotic species Lantana (*Lantana camara*). Other exotic species include:

- Eastern Cassia (*Senna pendula*),
- Castor Oil Plant (*Ricinus communis*),
- Cobbler's Pegs (*Bidens pilosa*),
- Purpletop (*Verbena bonariensis*),
- Caterpillar Grass (*Paspalum dilatatum*); and
- Rhodes Grass (*Chloris gayana*).

Native vegetation has commenced regeneration to the western boundary of this site and includes the following:

- Forest Red Gum (*Eucalyptus tereticornis*),
- Late Black Wattle (*Acacia mearnsii*); and
- Sallow Wattle (*Acacia longifolia*).

**Figure 3: Dunmore Quarry Proposed Clearing for Specialty Stockpile**

## *2.5. Rehabilitation Management*

### 2.5.1. Summary

Dunmore Quarry aims to progressively encourage a sustainable vegetative cover in accordance with the rehabilitation objectives for the site, as outlined in the site Rehabilitation Management Plan. Progressive rehabilitation work will be undertaken when reshaped, benched and topsoiled areas become available. Only small areas can currently be rehabilitated to avoid conflict with future extraction and sterilisation of resource production potential.

### 2.5.2. Rehabilitation Management Progress Report

Most areas of the site are currently operational and as such rehabilitation is not able to commence on the majority of areas until the completion of extraction activities. When practical, progressive rehabilitation of the site will be undertaken in conjunction with on-going quarrying works. Rehabilitation activities undertaken to date have been in accordance with the updated Flora and Fauna Management and Rehabilitation Management Plan prepared by Arcadis (2016) and include soil alignment to the west of Middle Dam. Natural establishment of vegetation has occurred within this rehabilitation and management of weeds will continue across the entire site. Current locations of extraction include Croome Farm Pit South and Croome Farm Pit North.

### 2.5.3. Next 12 Months

Over the next reporting period Dunmore Quarry intends to, where possible commence rehabilitation of the North Croome benches through establishing the final trim and alignment to the mining plan. This will include the placement of soil and vegetation establishment. Rehabilitation of the southern entrance to the RIC cut will be included in the site management of weeds.

## *2.6. Waste Management*

### 2.6.1. Waste Minimisation Measures

Boral is committed to ensuring its extraction and processing activities produces minimal waste rock material. Approximately 30% of the hard rock processed at Dunmore Quarry becomes material of less than 4mm in diameter, which is known as quarry fines. In the past, quarry fines were considered a product waste and stockpiled due to having no steady market, however the material is now used in manufactured sand (as opposed to natural sand) production. Dunmore Quarry transfers quarry fines to the Boral owned Dunmore Lakes Sand Project site for blending to produce manufactured sand.

At the end of this reporting the stock level of quarry fines was approximately 233,380 tonnes. On average throughout the reporting period 23,748 tonnes was transferred to the DLSP site for manufactured sand production.

Boral is committed to continuing non-production waste management minimisation in accordance with the waste hierarchy, and minimising the amount of waste sent to landfill. To achieve this, all liquid and solid wastes are classified and sorted so they can be appropriately re-used or recycled. Table 6 below outlines the waste totals and waste types for the reporting period.

**Table 6: FY17 Waste Streams and Total**

| | General Waste Tonnes | Cardboard Tonnes | Timber Tonnes | Oil/Oily Waters Litres | Effluent Litres | Other Litres |
|---|---|---|---|---|---|---|
| Jul-2016 | 4.984 | 0.069 | 0 | 3100 | 0 | 0 |
| Aug-2016 | 3.106 | 0.136 | 1.62 | 1700 | 3000 | 0 |
| Sep-2016 | 4.018 | 0.276 | 0.6 | 5300 | 6000 | 0 |
| Oct-2016 | 1.417 | 0.106 | 0 | 2300 | 0 | 0 |
| Nov-2016 | 3.844 | 0.05 | 0.78 | 2500 | 7000 | 0 |
| Dec-2016 | 2.418 | 0 | 1.24 | 3000 | 5000 | 0 |
| Jan-2017 | 1.05 | 0.199 | 0 | 1600 | 3000 | 0 |
| Feb-2017 | 5.766 | 0.427 | 0.96 | 1000 | 5000 | 0 |
| Mar-2017 | 4.672 | 0.201 | 0.52 | 4500 | 16000 | 0 |
| Apr-2017 | 5.098 | 0 | 0.4 | 200 | 6000 | 200 |
| May-2017 | 4.872 | 0.54 | 0.5 | 0 | 5000 | 0 |
| Jun-2017 | 3.878 | 0.148 | 1.52 | 200 | 4000 | 200 |
| Total | 45.123 | 2.152 | 8.14 | 25400 | 60000 | 400 |

These waste management practices will continue over the next 12 months, with a particular focus on managing quarry fines stock levels and maximising quarry fines transfers for manufactured sand production.

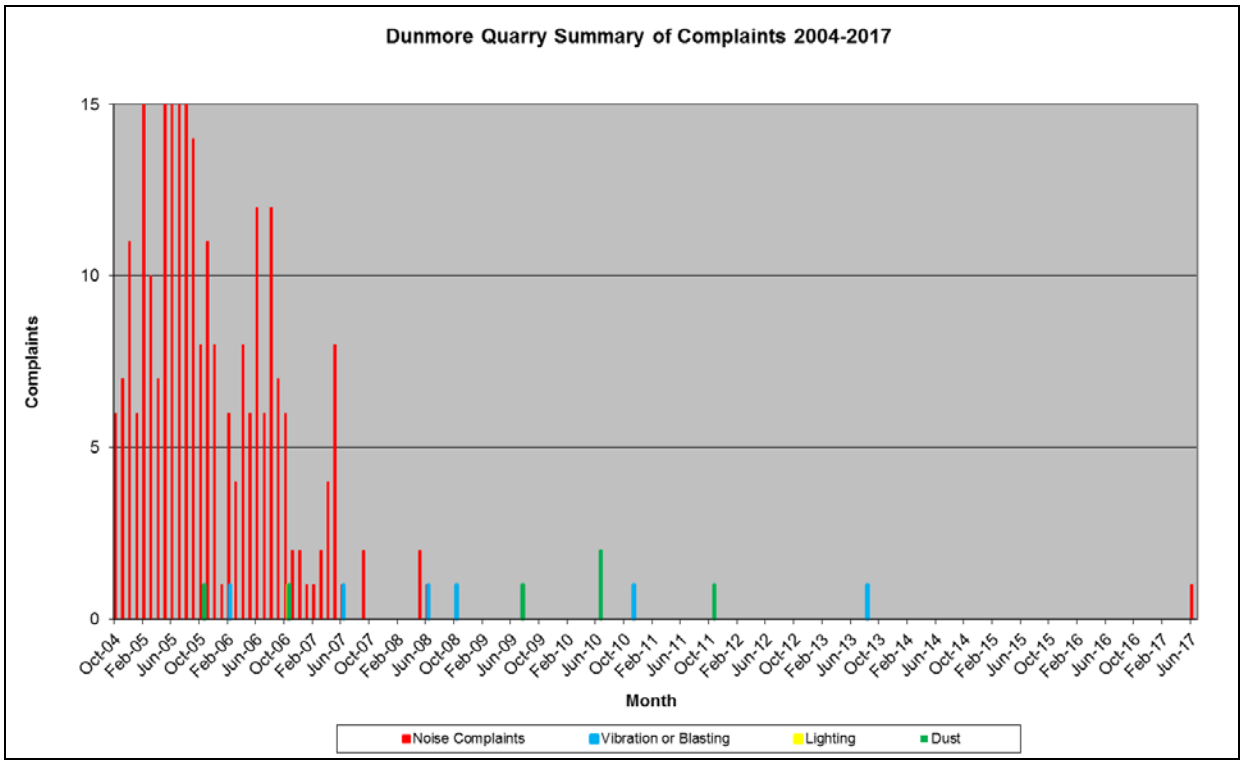
# 3. Complaints and Community Management

## *3.1. Complaints Summary and Analysis*

Dunmore Quarry maintains a complaints register that identifies actions required to resolve issues and concerns raised by the community. The complaints register is also published on the Boral website.

One complaint (noise complaint) was received for the 2016-2017 reporting period. After completing internal investigations, site was found to be operating within its consent conditions. During the reporting period the Environmental Protection Agency (EPA) made an enquiry regarding blasting. After reviewing blasting records it was deemed that site was within its licenced blasting limits and as such this was recorded as an enquiry and not a complaint. Figure 4 provides an overview of the noise, vibration and dust complaints received since 2004. It is clear that in recent years there have been minimal complaints.

**Figure 4**




## *3.2. Community*

The Dunmore Quarry Community Consultative Committee (CCC) continues to serve as a valuable dialogue between Boral and the local community with valuable input and feedback being provided by the community regarding quarry operations and plans. Members are informed of the environmental performance of the site, provided with an update on operations and given a chance to tour the site and ask questions they may have regarding the operation. CCC members have also been diligent in disseminating the information from the meetings to other interested community members in the local area. The minutes of each meeting is published in the Boral website.

The CCC met twice during the 2016-2017 reporting period (August 2016 and February 2017) and no community contributions were undertaken during the reporting period.

# 4. Environmental Monitoring

## *4.1. Noise*

A noise monitoring program was prepared in recognition of Condition 4(14) to monitor noise at the three receiver locations specified in the consent and EPL. These locations are displayed in Appendix 1. The noise monitoring program includes:

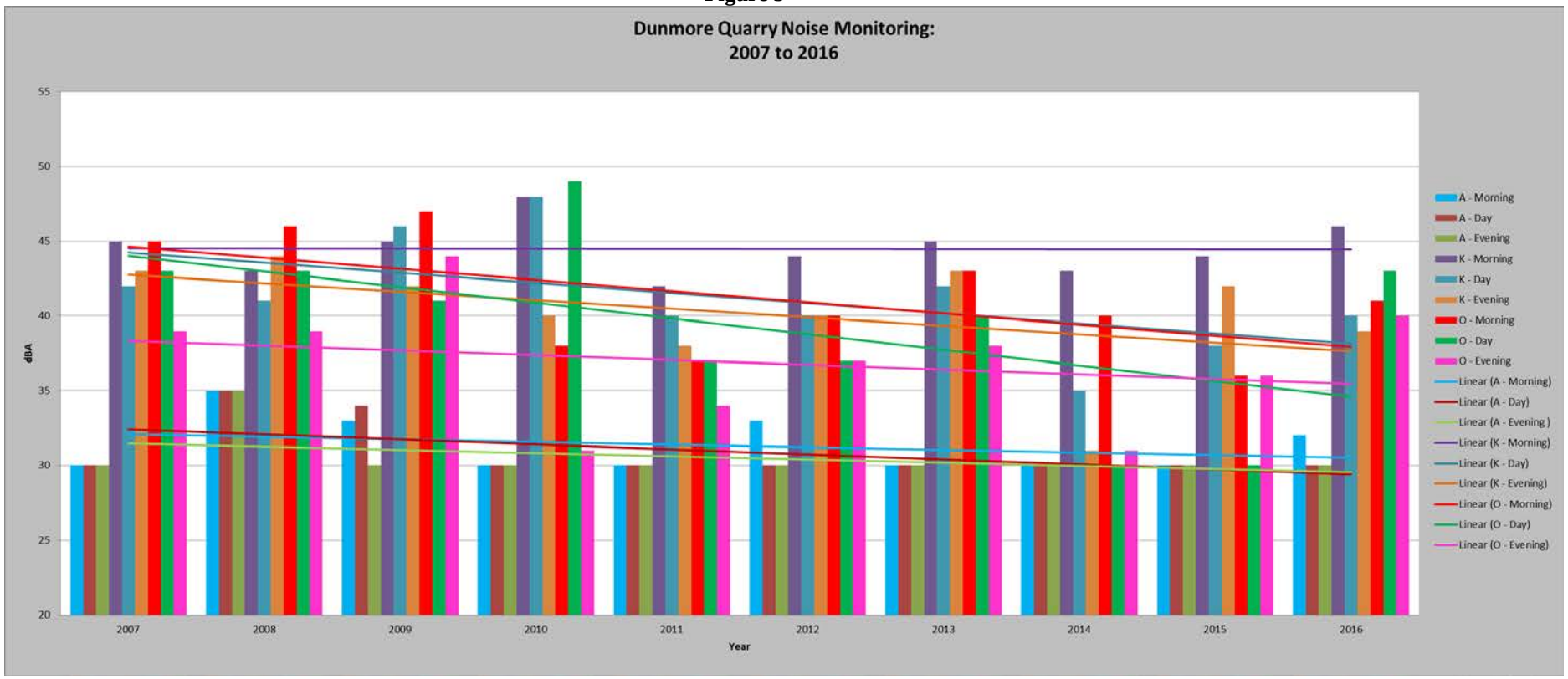
Annual attended noise monitoring surveys were conducted at all receiver locations during winter by a specialist noise consultant (Condition 4(13)).

A Noise Compliance Assessment Report was prepared by SLR Consulting Australia and presents results of attended noise monitoring surveys undertaken during the FY17 reporting period in August 2016 at receiver locations A (McParland), K (Stocker) and O (Dunmore Lakes Estate).

The report found that the quarry achieved compliance with the licence noise limits at all locations during all monitoring periods. This is in line with previous reporting periods. The noise levels monitored are consistent with the majority of EIS predictions, with only Location O noise levels slightly higher than predicted. It should be noted however the Annual Noise Compliance assessment reports that noise generated from road traffic was the dominant noise source at this residential location. Quarry operations were only observed to be audible during the morning shoulder and evening noise monitoring periods. A copy of the Noise Compliance Assessment Report is attached as Appendix 6 of this report.

Figure 5 provides a graphical representation of the noise monitoring results (estimated Quarry $LA_{eq}$ [15 minute] contribution sourced from Annual Noise Monitoring Assessments) for the life of the project, including linear trend patterns. It is clear that the monitoring results have remained generally consistent with neutral or decreasing trend patterns over the life of the project.

**Figure 5**


Dunmore Quarry Noise Monitoring:
2007 to 2016
55
50
45
40
35
30
25
20
dBA
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year
A - Morning
A - Day
A - Evening
K - Morning
K - Day
K - Evening
O - Morning
O - Day
O - Evening
Linear (A - Morning)
Linear (A - Day)
Linear (A - Evening )
Linear (K - Morning)
Linear (K - Day)
Linear (K - Evening)
Linear (O - Morning)
Linear (O - Day)
Linear (O - Evening)

## 4.2. Blasting

A total of 60 blasts were conducted throughout the 2016-2017 reporting period. All blasts were compliant with Airblast Overpressure and Ground Vibration blasting criteria generally below the EIS predictions. Figure 6 and Figure 7 provide a graphical representation of the blast monitoring results. The location of the blasting monitor is displayed in Appendix 2.

Four blasts did not exceed trigger levels set on the monitoring instruments indicating they are of low level and in compliance with the assessment criteria. These blasts are represented as absent bars in Figure 6 and 7.

Figure 8 and 9 provide a graphical representation of the blast monitoring results for the life of the project. It is clear that for both parameters that the results for this reporting period are consistent with previous years. Additionally, trend analysis depicts that over the life of the project airblast overpressure has increased as has ground vibration trend analysis has increased. This increase is considered a result of the Quarry operations, and therefore blast locations, progressing west and closer to the nearest affected resident.

**Figure 6**

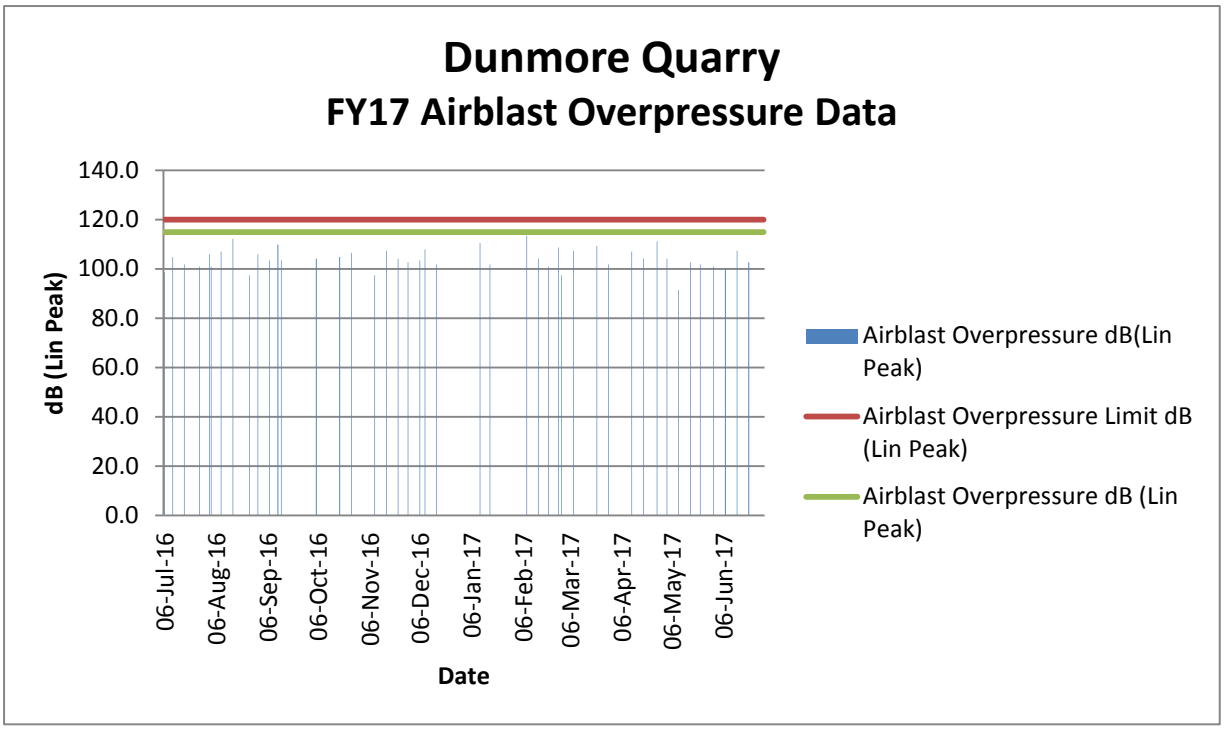


**Figure 7**

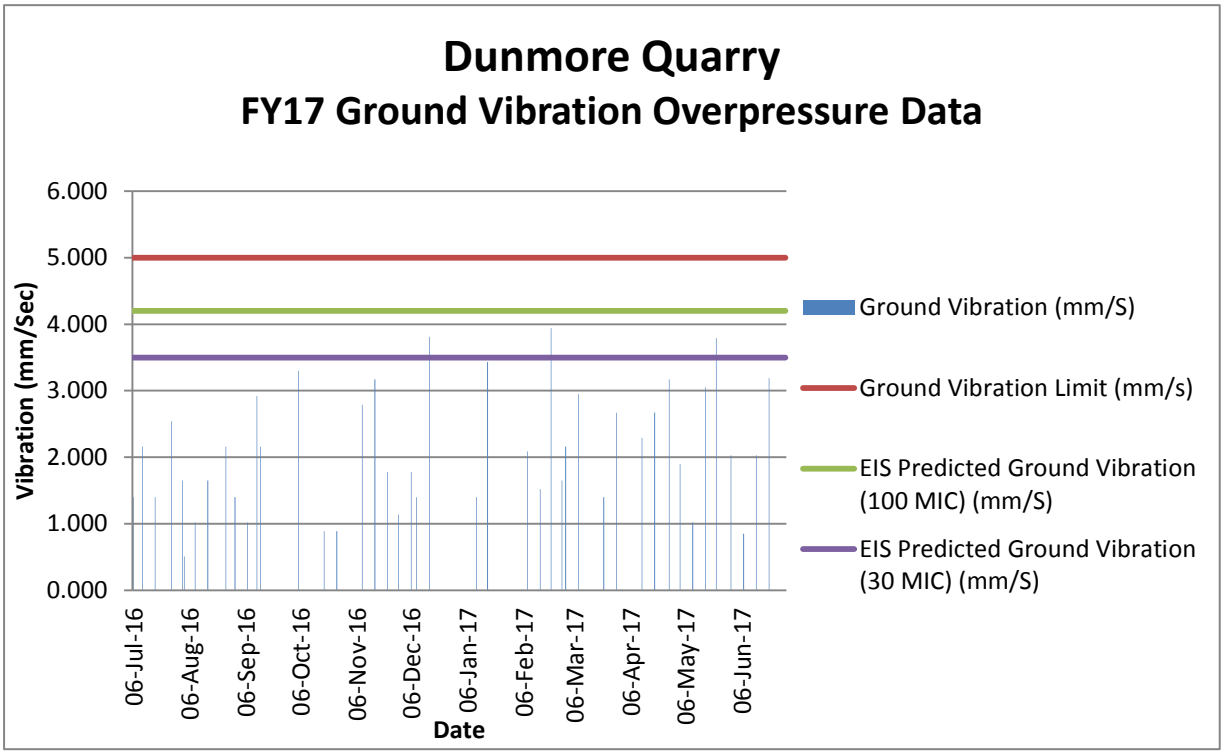

Dunmore Quarry
FY17 Ground Vibration Overpressure Data
Vibration (mm/Sec)
6.000
5.000
4.000
3.000
2.000
1.000
0.000
06-Jul-16
06-Aug-16
06-Sep-16
06-Oct-16
06-Nov-16
06-Dec-16
06-Jan-17
06-Feb-17
06-Mar-17
06-Apr-17
06-May-17
06-Jun-17
Date
Ground Vibration (mm/S)
Ground Vibration Limit (mm/s)
EIS Predicted Ground Vibration (100 MIC) (mm/S)
EIS Predicted Ground Vibration (30 MIC) (mm/S)

**Figure 8**

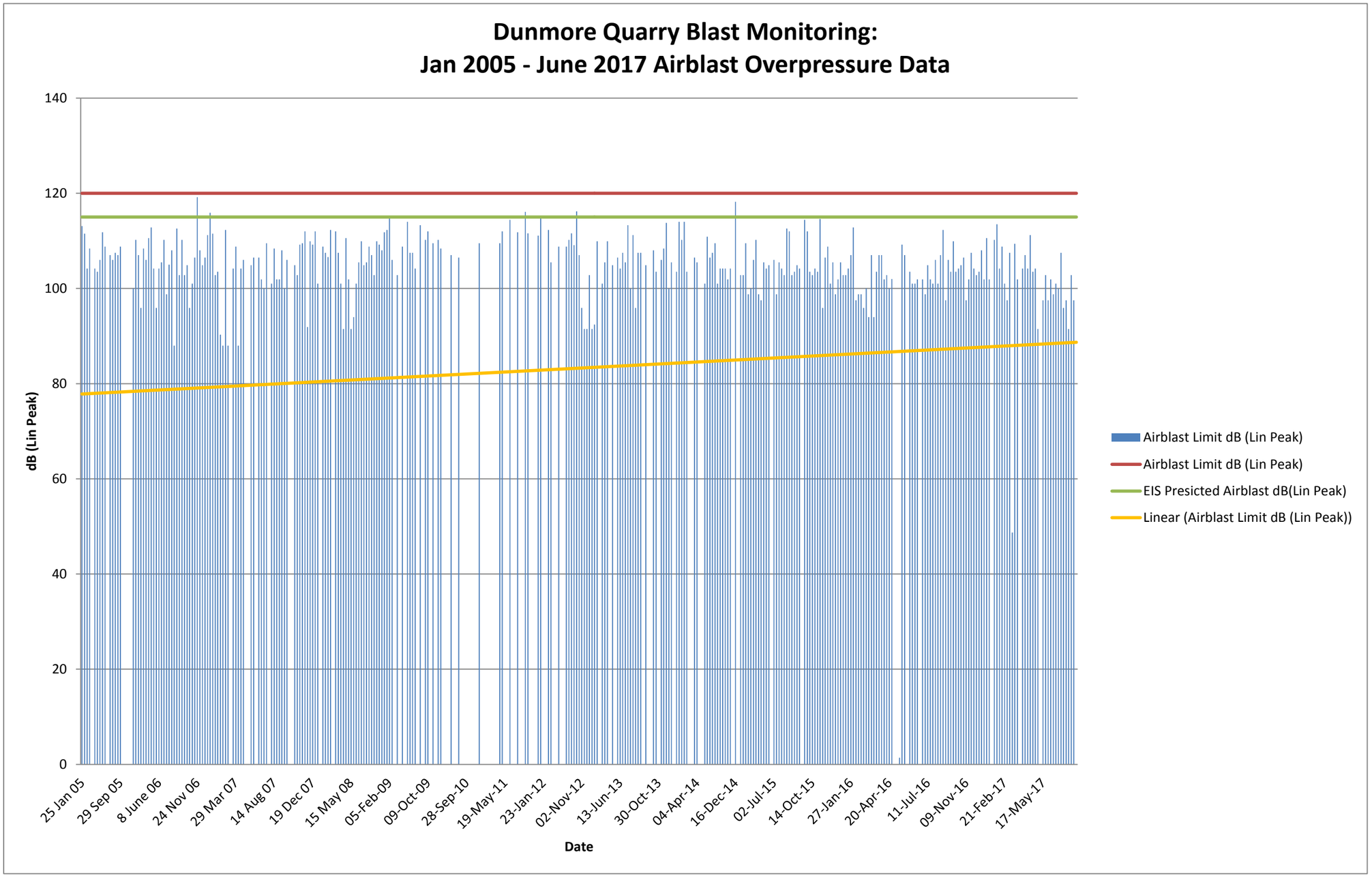
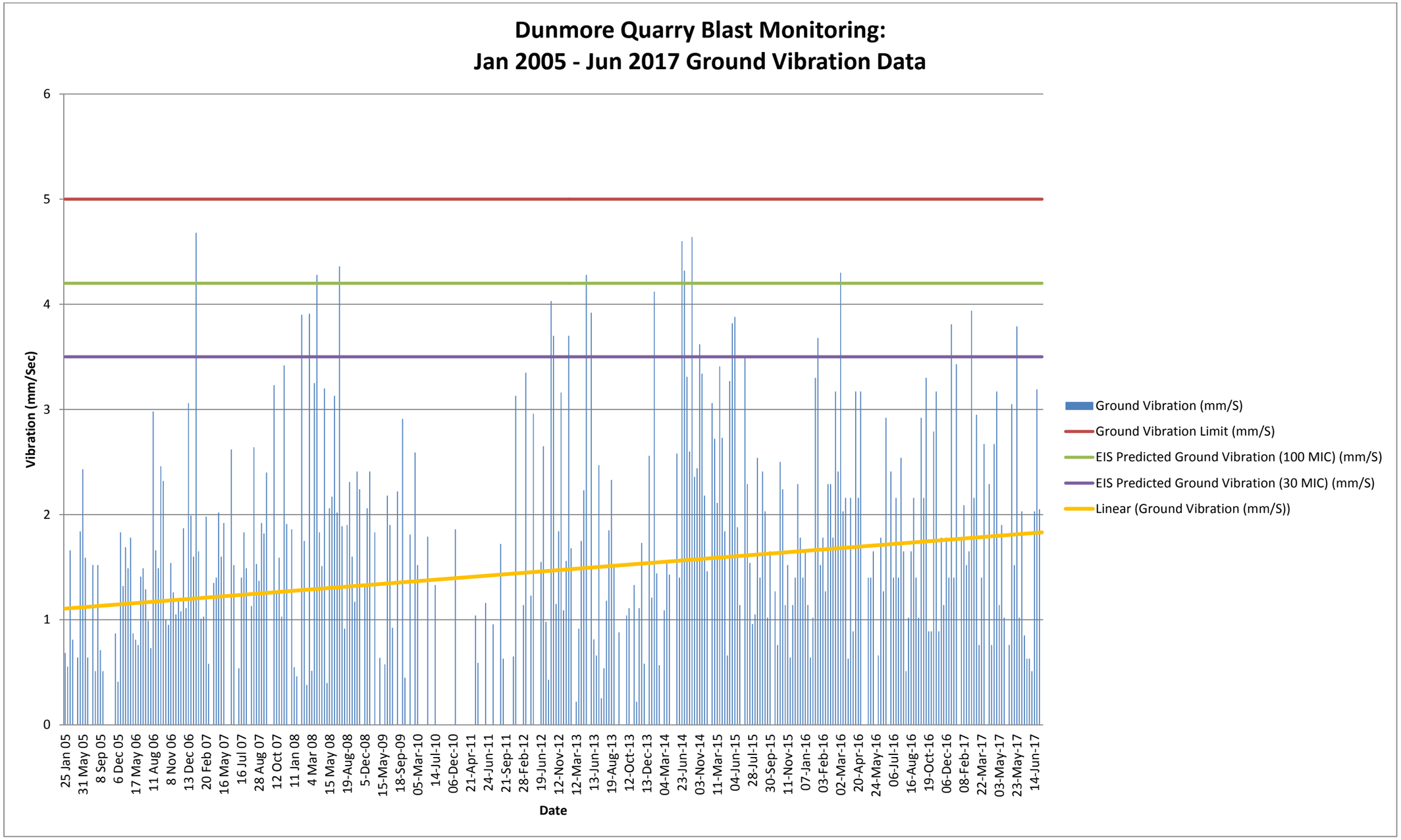

Dunmore Quarry Blast Monitoring:
Jan 2005 - June 2017 Airblast Overpressure Data
dB (Lin Peak)
140
120
100
80
60
40
20
0
25 Jan 05
29 Sep 05
8 June 06
24 Nov 06
29 Mar 07
14 Aug 07
19 Dec 07
15 May 08
05-Feb-09
09-Oct-09
28-Sep-10
19-May-11
23-Jan-12
02-Nov-12
13-Jun-13
30-Oct-13
04-Apr-14
16-Dec-14
02-Jul-15
14-Oct-15
27-Jan-16
20-Apr-16
11-Jul-16
09-Nov-16
21-Feb-17
17-May-17
Date
Airblast Limit dB (Lin Peak)
Airblast Limit dB (Lin Peak)
EIS Presicted Airblast dB(Lin Peak)
Linear (Airblast Limit dB (Lin Peak))

**Figure 9**


Dunmore Quarry Blast Monitoring:
Jan 2005 - Jun 2017 Ground Vibration Data
Vibration (mm/Sec)
0
1
2
3
4
5
6
Date
25 Jan 05
31 May 05
8 Sep 05
6 Dec 05
17 May 06
11 Aug 06
8 Nov 06
13 Dec 06
20 Feb 07
16 May 07
16 Jul 07
28 Aug 07
12 Oct 07
11 Jan 08
4 Mar 08
15 May 08
19-Aug-08
5-Dec-08
15-May-09
18-Sep-09
05-Mar-10
14-Jul-10
06-Dec-10
21-Apr-11
24-Jun-11
21-Sep-11
28-Feb-12
19-Jun-12
12-Nov-12
12-Mar-13
13-Jun-13
19-Aug-13
12-Oct-13
13-Dec-13
04-Mar-14
23-Jun-14
03-Nov-14
11-Mar-15
04-Jun-15
28-Jul-15
30-Sep-15
11-Nov-15
07-Jan-16
03-Feb-16
02-Mar-16
20-Apr-16
24-May-16
06-Jul-16
16-Aug-16
19-Oct-16
06-Dec-16
08-Feb-17
22-Mar-17
03-May-17
23-May-17
14-Jun-17
Ground Vibration (mm/S)
Ground Vibration Limit (mm/S)
EIS Predicted Ground Vibration (100 MIC) (mm/S)
EIS Predicted Ground Vibration (30 MIC) (mm/S)
Linear (Ground Vibration (mm/S))

## *4.3. Air Quality*

### 4.3.1. Deposited Dust

The air quality monitoring program includes 4 deposited dust gauges that have been in operation for 11+ years. The location of these dust gauges can be seen Appendix 3. Table 7 present the results of deposited dust monitoring during the reporting period content as well as averages for previous reporting periods. Figure 14 provides a graphical representation of the annual averages and linear trend patterns for the life of the project at each monitoring location.

#### *4.3.1.1. Site 1*

During the reporting period site 1 yielded an annual average of 2.20 g/m2/month insoluble solids, with an average ash content of 1.42 g/m2/month. The assessment criteria for insoluble solids was exceeded on two (2) occasions over the reporting period, however of these occasions there was no ash content greater than 4g/m2/month (Insoluble Impact Assessment Criteria).

Figure 10

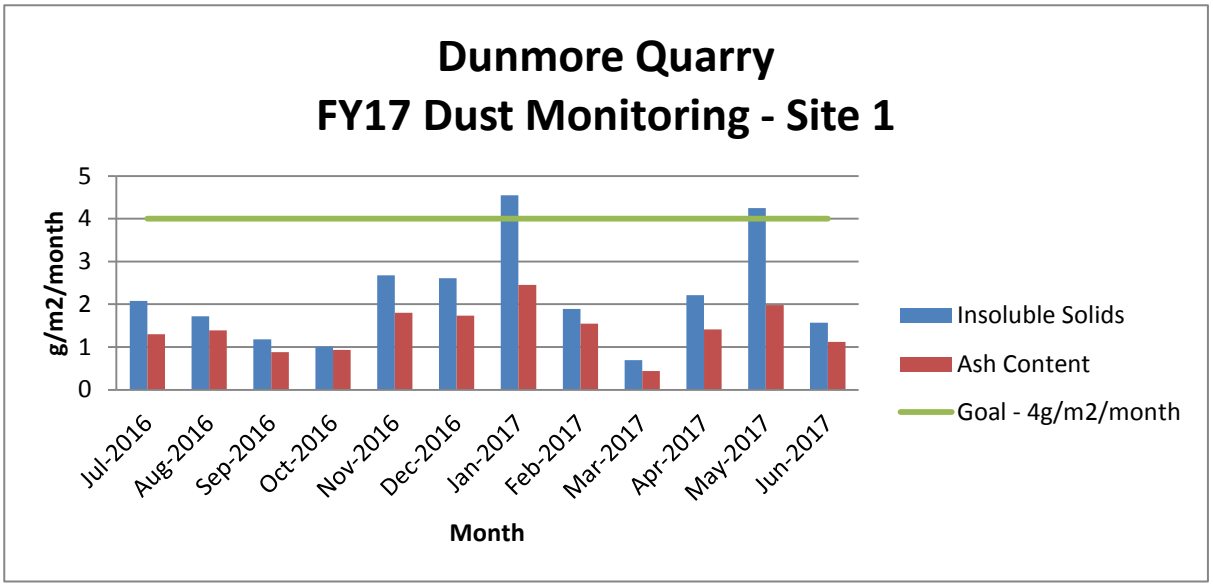



Table 7 indicates the dominant wind direction and the direction of strongest winds for each month. The months in which the criteria was exceeded, the dominant wind directions were primarily WNW and SSE (January 2017) and W, S, WNW (May 2017. The general wind direction of the quarry is SSE which indicates that the quarry contribution to the location is minor. Over the life of the project, Site 1 has a slight increasing trend for insoluble solids; however FY17 reporting period has seen a slight decrease for both insoluble solids and ash content, whilst it remains slightly higher in comparison to Dunmore Quarry EIS predicted annual dust deposition.

#### *4.3.1.2. Site 2*

During the reporting period site 2 yielded an adjusted annual average insoluble solid content of 3.36 g/m$^2$/month and annual average ash content of 1.96 g/m$^2$/month. During the month of August site 2 produced outlier results which were removed from the reporting data. Laboratory results suggest with a high insoluble solids level of 17.22 g/m$^2$/month and a similarly high ash content of 11.26 g/m$^2$/month that the site was influenced by organic matter such as insects and plant matter. The assessment criteria for insoluble solids for exceeded on four (4) occasions and on one (1) occasion where ash content exceeded 4g/m$^2$/month.

Figure 11

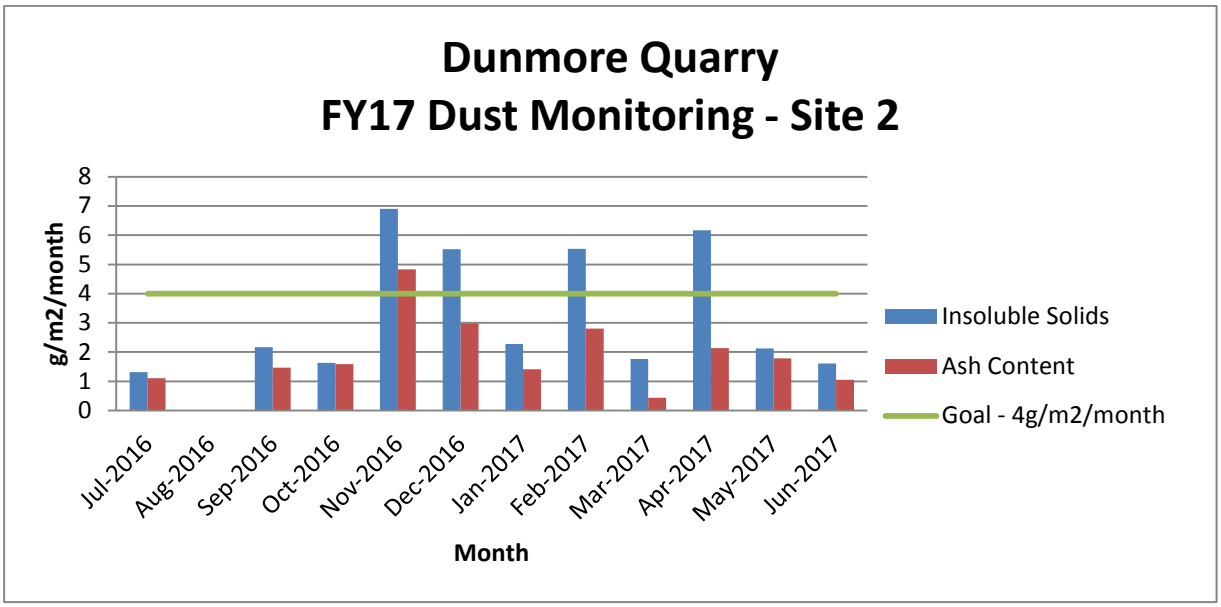


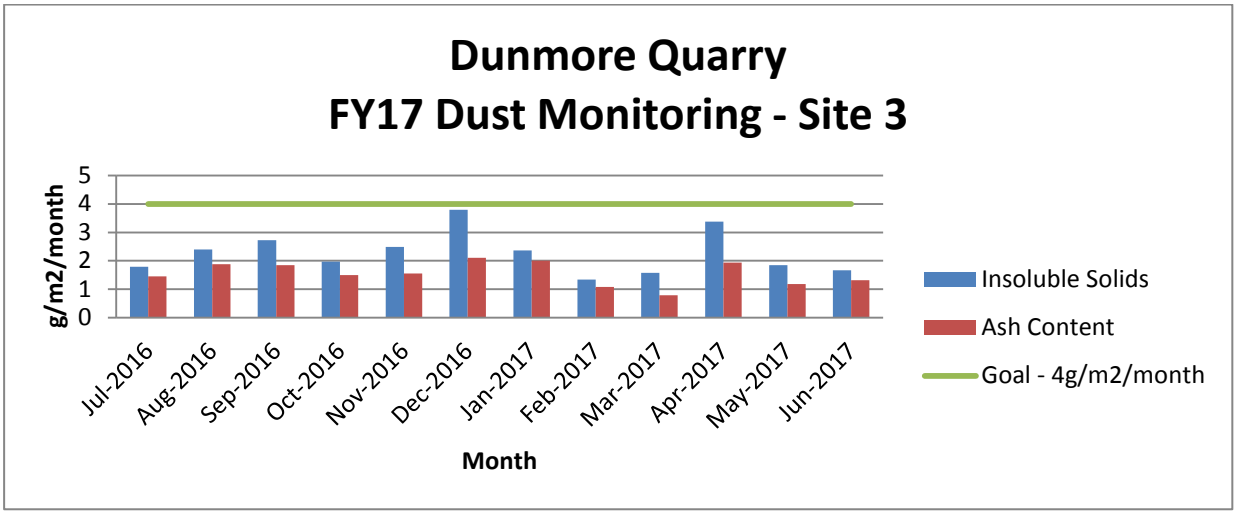

Table 7 indicates that the dominant wind direction and the direction of strongest winds for each month. The months in which criteria was exceeded the dominant wind directions were WSW, W (November 2016), W (December 2016), SSW, W, NE (February 2017) and W, S (April 2017). The general wind direction of the quarry is NE, which indicates that the quarry contributions are minor during the reporting period. It is noted that during February 2017 site 2 received dominant wind from the direction of NE, however this was combined with winds from SSW and W. The strongest direction of wind came from the SSW during this month. The trend patterns over the life of the project for site 2 have remained relatively neutral, however the reporting period FY17 has seen a slight increase for both insoluble solids and ash content The site results continue to remain slightly higher in comparison to Dunmore Quarry EIS predicted annual dust deposition.

#### *4.3.1.3. Site 3*

At the commencement of the reporting period site 3 deposited dust gauge was relocated further south of the site (see appendix 3) as per the Dunmore Quarry Air Quality Monitoring Program and is shared

between the Quarry and Dunmore Sand and Soil. Site 3 reporting period results yielded an annual average of insoluble solids of 2.28 g/m2/month, with an average ash content of 1.56 g/m2/month. Over the reporting period no monthly results exceeded the insoluble impact assessment criteria of 4g/m2/month.

Figure 12

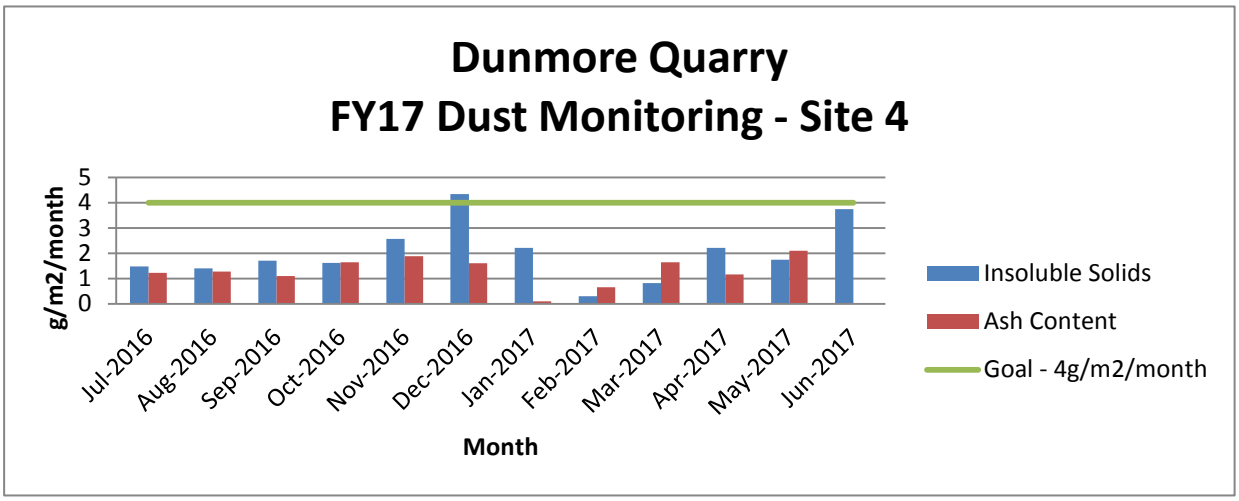



Over the life of the project, site 3 had maintained a relatively stable results and has continued during the FY17 reporting period, the site, however remains slightly higher in comparison to Dunmore Quarry EIS predicted annual dust deposition.

#### *4.3.1.4. Site 4*

At the commencement of the reporting period site 4 was relocated further north of the site (See appendix 3) towards the nearest privately owned land where the deposited dust gauge is shared between the Quarry and Dunmore Sand and Soil. Site 4 reporting period results yielded an average insoluble solid of 2.01 g/m$^2$/month with an average ash content of 1.30 g/m$^2$/month. The assessment criteria was exceeded once during December 2016 with an insoluble solids results recorded as 4.34 g/m2/month, however the ash content was reported as 1.89 g/m2/month which is considered a better representation of the potential site impacts.

Figure 13

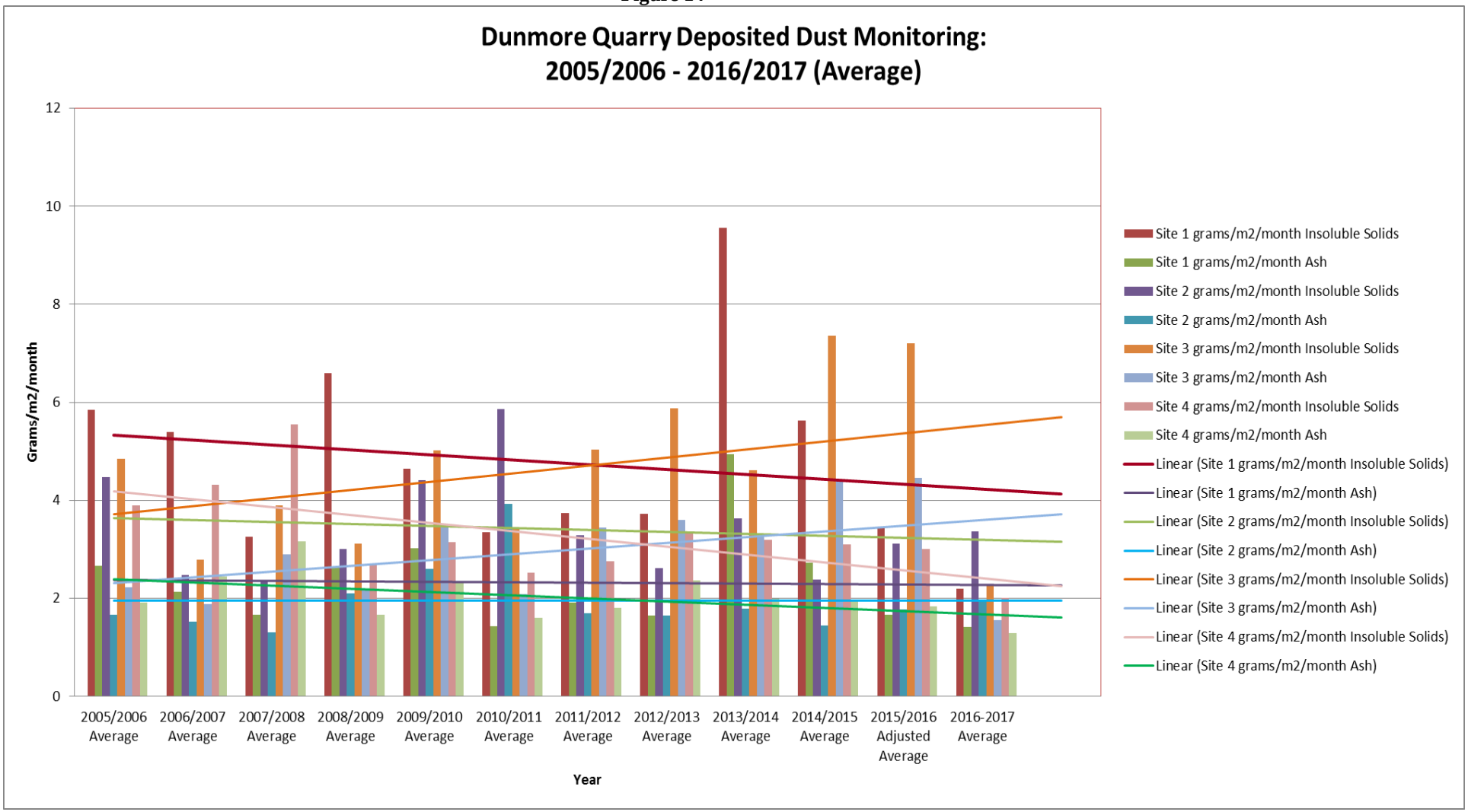



The trend patterns over the life of the project, for both insoluble solids and ash content Site 4, remained relatively neutral with a slight decrease in reporting period averages. The site results continue to remain slightly higher in comparison to Dunmore Quarry EIS predicted dust deposition. It should be noted that this gauge is located adjacent the Stage 2 operations of the Dunmore Lakes Sand Project.

**Table 5: Deposited Dust Measurements**

| Month | Site 1 grams/m$^2$/month | | Site 2 grams/m$^2$/month | | Site 3 grams/m$^2$/month | | Site 4 grams/m$^2$/month | | Dominant Wind Direction | Direction of Strongest Winds | Production Tonnes (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Insoluble Solids | Ash | Insoluble Solids | Ash | Insoluble Solids | Ash | Insoluble Solids | Ash | | | |
| **2005/2006 Average** | *5.85* | *2.66* | *4.48* | *1.67* | *4.85* | *2.22* | *3.9* | *1.92* | | | |
| **2006/2007 Average** | *5.4* | *2.13* | *2.48* | *1.53* | *2.79* | *1.89* | *4.31* | *2.44* | | | |
| **2007/2008 Average** | *3.26* | *1.67* | *2.37* | *1.3* | *3.89* | *2.9* | *5.55* | *3.17* | | | |
| **2008/2009 Average** | *6.6* | *2.63* | *3.01* | *2.1* | *3.12* | *2.17* | *2.71* | *1.66* | | | |
| **2009/2010 Average** | *4.65* | *3.03* | *4.41* | *2.6* | *5.02* | *3.49* | *3.15* | *2.33* | | | |
| **2010/2011 Average** | 3.35 | 1.43 | 5.86 | 3.92 | 3.43 | 2.09 | 2.53 | 1.6 | | | |
| **2011/2012 Average** | 3.74 | 1.92 | 3.28 | 1.7 | 5.03 | 3.44 | 2.75 | 1.81 | | | |
| **2012/2013 Average** | 3.73 | 1.65 | 2.61 | 1.65 | 5.87 | 3.6 | 3.36 | 2.36 | | | |
| **2013/2014 Average** | 9.56 | 4.94 | 3.63 | 1.79 | 4.61 | 3.28 | 3.2 | 2 | | | |
| **2014/2015 Average** | 5.63 | 2.72 | 2.38 | 1.44 | 7.36 | 4.42 | 3.1 | 1.98 | | | |
| **2015/2016 Average** | 5.75 | 2.09 | 3.12 | 1.77 | 8.25 | 5.53 | 3.01 | 1.84 | | | |
| **2015/2016 Adjusted Average** | 3.46 | 1.66 | 3.12 | 1.77 | 7.2 | 4.45 | 3.01 | 1.84 | | | |
| **Jul-2016** | 2.08 | 1.3 | 1.31 | 1.11 | 1.79 | 1.45 | 1.48 | 1.13 | WSW | WSW | 161,479 |
| **Aug-2016** | 1.72 | 1.39 | - | - | 2.4 | 1.88 | 1.4 | 1.23 | W, SSW | W | 208,594 |
| **Sep-2016** | 1.18 | 0.88 | 2.17 | 1.47 | 2.72 | 1.85 | 1.71 | 1.28 | WNW, W | WNW | 153,490 |
| **Oct-2016** | 1.01 | 0.93 | 1.63 | 1.59 | 1.97 | 1.5 | 1.62 | 1.1 | WNW, W | W | 154,313 |
| **Nov-2016** | 2.68 | 1.8 | 6.9 | 4.83 | 2.49 | 1.55 | 2.57 | 1.65 | WSW, W | WSW | 145,574 |
| **Dec-2016** | 2.61 | 1.73 | 5.52 | 2.98 | 3.79 | 2.11 | 4.34 | 1.89 | W | W | 99,728 |
| **Jan-2017** | 4.55 | 2.45 | 2.28 | 1.41 | 2.37 | 2.01 | 2.22 | 1.61 | WNW, SSE | WNW | 124,023 |
| **Feb-2017** | 1.89 | 1.55 | 5.53 | 2.8 | 1.34 | 1.08 | 0.31 | 0.1 | SSW, W, NE | SSW | 160,131 |
| **Mar-2017** | 0.69 | 0.44 | 1.76 | 0.44 | 1.58 | 0.79 | 0.82 | 0.66 | SW, SSW, S | SW | 183,042 |
| **Apr-2017** | 2.21 | 1.41 | 6.17 | 2.14 | 3.38 | 1.94 | 2.22 | 1.64 | W, S | W | 117,185 |
| **May-2017** | 4.25 | 1.98 | 2.13 | 1.79 | 1.85 | 1.18 | 1.74 | 1.16 | W, S, WNW | W | 172,358 |
| **Jun-2017** | 1.57 | 1.12 | 1.61 | 1.05 | 1.67 | 1.32 | 3.74 | 2.1 | SSW, WSW | SSW | 153,000 |
| **2016-2017 Average** | 2.20 | 1.42 | 3.36 | 1.96 | 2.28 | 1.56 | 2.01 | 1.30 | | | |

**Figure 14**


Dunmore Quarry Deposited Dust Monitoring:
2005/2006 - 2016/2017 (Average)
Grams/m2/month
0
2
4
6
8
10
12
2005/2006 Average
2006/2007 Average
2007/2008 Average
2008/2009 Average
2009/2010 Average
2010/2011 Average
2011/2012 Average
2012/2013 Average
2013/2014 Average
2014/2015 Average
2015/2016 Adjusted Average
2016-2017 Average
Year
Site 1 grams/m2/month Insoluble Solids
Site 1 grams/m2/month Ash
Site 2 grams/m2/month Insoluble Solids
Site 2 grams/m2/month Ash
Site 3 grams/m2/month Insoluble Solids
Site 3 grams/m2/month Ash
Site 4 grams/m2/month Insoluble Solids
Site 4 grams/m2/month Ash
Linear (Site 1 grams/m2/month Insoluble Solids)
Linear (Site 1 grams/m2/month Ash)
Linear (Site 2 grams/m2/month Insoluble Solids)
Linear (Site 2 grams/m2/month Ash)
Linear (Site 3 grams/m2/month Insoluble Solids)
Linear (Site 3 grams/m2/month Ash)
Linear (Site 4 grams/m2/month Insoluble Solids)
Linear (Site 4 grams/m2/month Ash)

#### *4.3.1.5. Deposited Dust Summary and Opportunities for Improvement*

Analysis of the deposited dust records suggest that whilst there were exceedances recorded at sites 1, 2 and 4 during monthly monitoring, it is evident that the quarry contribution may be limited.

To continue managing air quality and dust levels the site will continue dust management; via maintained dust suppression sprays throughout the processing plant area; application of the water cart on haulage roads and the entrance road and the use of the wheel wash for exiting vehicles. Further, the site will continue to actively manage dust on site through supervisor inspections and control room video surveillance to monitor dust emissions from the plant to slow or stop production until the issue is resolved.

Measures planned for the coming year include:

- Management and maintenance of light vehicle wheel wash facilities
- Continual upgrades of product transfer points (dust baffle & micro spray installation)
- Investigate in early warning network to predict wind strength and direction

### 4.3.2. $PM_{10}$

The monitoring program for finer particulates includes monitoring of dust finer than 10 micron through use of a high volume air sampler (HVAS). The HVAS runs for a 24 hour period every 6 days in accordance with EPL conditions. Please refer to Appendix 3 for an indication of the where the HVAS is located (identified as monitoring point 5).

The $PM_{10}$ monitoring results for the 2016-2017 reporting period are represented graphically in Figure 15 and monitoring results for the life of the project are represented in Figure 16.

The annual average of recorded results of was 11.98 µg/m$^3$. The lowest recorded result was 0.24µg/m$^3$ on 02 September 2016 and the highest being 54.43µg/m$^3$ on 30 January 2017. It was noted that on the 30$^{th}$ of January 2017 severe fire danger was forecast within the Illawarra which may have impacted on the higher than normal results. As a result, the short term impact assessment criterion of 50µg/m3 was exceeded once during the reporting period. These results indicate that $PM_{10}$ dust levels are well below long term impact assessment criteria; consistent with previous years reporting; and consistent with the EIS predicted maximum 24 hour $PM_{10}$ concentration and predicted annual average. Furthermore, trend analysis indicates that over the life of the project the sample average has decreased.

**Figure 15**

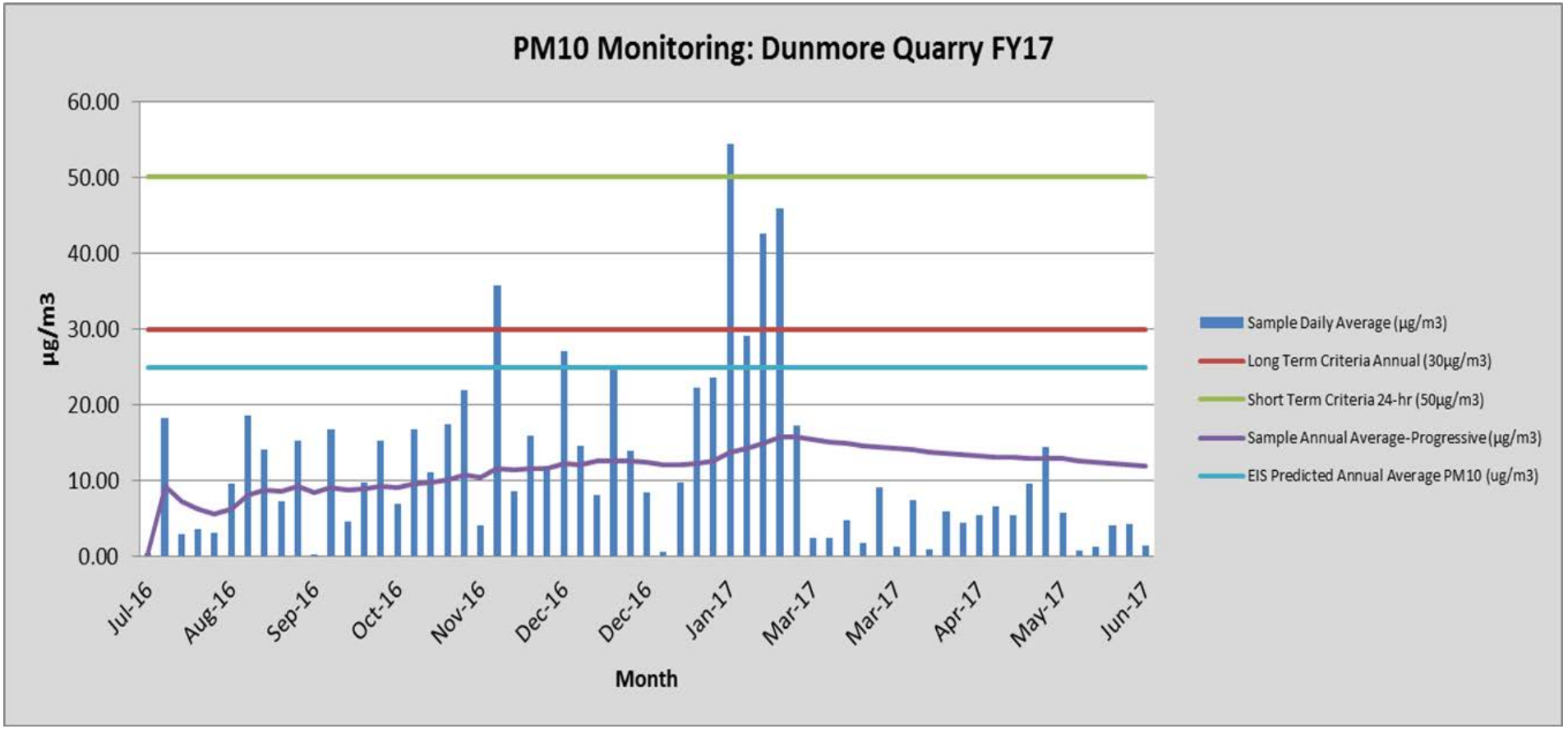
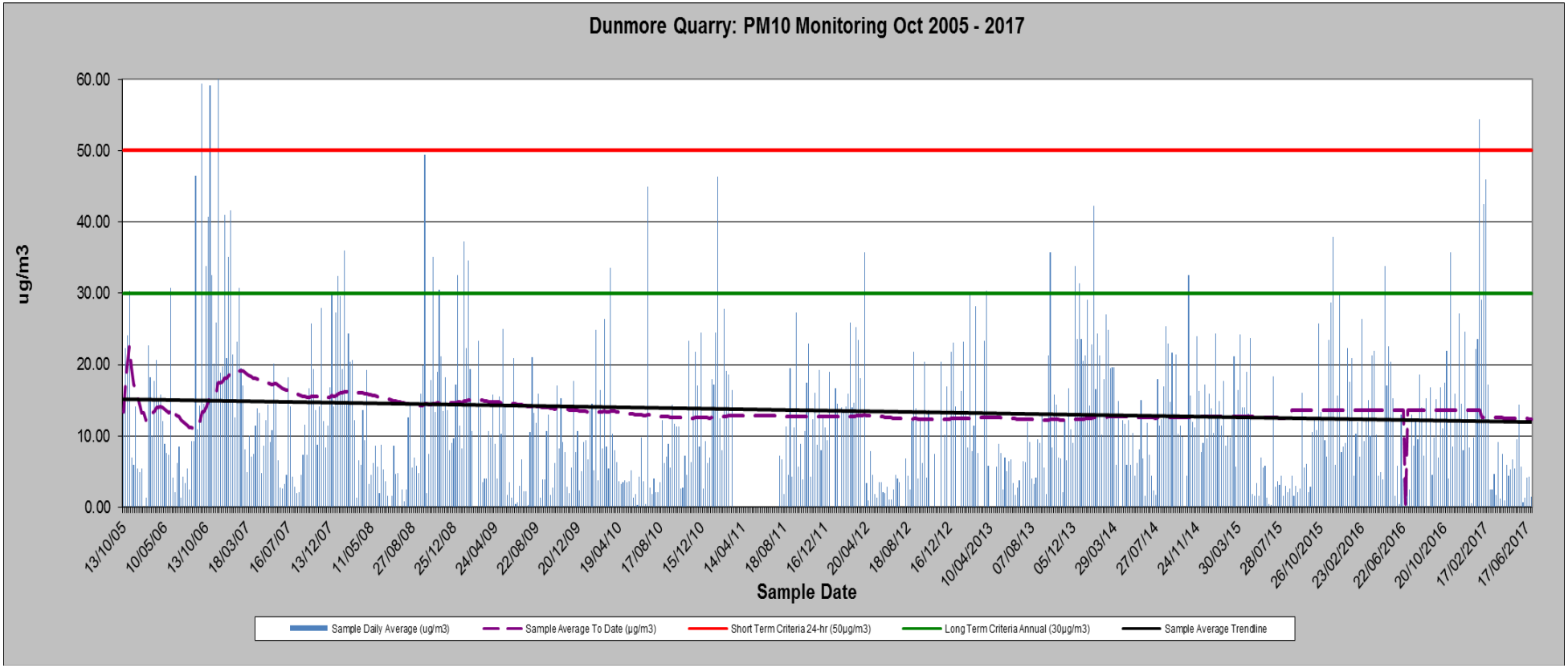

PM10 Monitoring: Dunmore Quarry FY17
60.00
50.00
40.00
30.00
20.00
10.00
0.00
µg/m3
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Dec-16
Jan-17
Mar-17
Mar-17
Apr-17
May-17
Jun-17
Month
Sample Daily Average (µg/m3)
Long Term Criteria Annual (30µg/m3)
Short Term Criteria 24-hr (50µg/m3)
Sample Annual Average-Progressive (µg/m3)
EIS Predicted Annual Average PM10 (ug/m3)

**Figure 26**


Dunmore Quarry: PM10 Monitoring Oct 2005 - 2017
ug/m3
60.00
50.00
40.00
30.00
20.00
10.00
0.00
13/10/05
10/05/06
13/10/06
18/03/07
16/07/07
13/12/07
11/05/08
27/08/08
25/12/08
24/04/09
22/08/09
20/12/09
19/04/10
17/08/10
15/12/10
14/04/11
18/08/11
16/12/11
20/04/12
18/08/12
16/12/12
10/04/2013
07/08/13
05/12/13
29/03/14
27/07/14
24/11/14
30/03/15
28/07/15
26/10/2015
23/02/2016
22/06/2016
20/10/2016
17/02/2017
17/06/2017
Sample Date
Sample Daily Average (ug/m3)
Sample Average To Date (µg/m3)
Short Term Criteria 24-hr (50µg/m3)
Long Term Criteria Annual (30µg/m3)
Sample Average Trendline

## 4.4. Meteorology

A meteorological monitoring station has been operating at Dunmore Quarry since 2002. Table 8 below displays the annual rainfall since FY11 to FY17. Seasonal wind roses showing the local wind movements are available in Appendix 5.

**Table 6: Rainfall Data**

| Month | Rainfall (mm) | | | | | | | Regional FY17 Averages** (mm) |
|---|---|---|---|---|---|---|---|---|
| | 2010-11 | 2011- 12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | |
| **July** | 78 | 194 | 39 | 57.9 | 5 | 48 | 97.5 | 64.6 |
| **August** | 72 | 85.5 | 4.5 | 17 | 252 | 327 | 76 | 57 |
| **September** | 145.5 | 58.5 | 11.5 | 85.5 | 150.5 | 82 | 51 | 54.2 |
| **October** | 126 | 124.5 | 83.5 | 6.5 | 102.5 | 36.5 | 32 | 18.8 |
| **November** | 198 | 165.5 | 25 | 173 | 24 | 48 | 33 | 31.4 |
| **December** | 147.5 | 60.5 | 32 | 71.5 | 232.5 | 116.5 | 58 | 40.4 |
| **January** | 59.5 | 52 | 183 | 42.5 | 192.5 | 155.5 | 32.5 | 2.4 |
| **February** | 48 | 307.5 | 142.5 | 59 | 99.5 | 29.5 | 283 | 248 |
| **March** | 362.5 | 146.5 | 23.5 | 326 | 57 | 145 | 441 | 376.6 |
| **April** | 37.4* | 85 | 136 | 64.5 | 308.5 | 37.5 | 40.5 | 37.4 |
| **May** | 58.3* | 9.5 | 81 | 13 | 49 | 35.5 | 51.5 | 30.8 |
| **June** | 74 | 88 | 239 | 34 | 76 | 429 | 57 | 42.2 |
| **Total** | **1407** | **1377** | **1000.5** | **950.4** | **1549** | **1490** | **1253** | **1003.8** |

** Source: Bureau of Meteorology, Climate Statistics for Australian Location, Wollongong University*
*** Source: Bureau of Meteorology, Climate Statistics for Australian Location, Albion Park (Wollongong Airport. Red) values indicate month received higher than the regional average rainfall.*

## 4.5. Water

### 4.5.1. Surface Water

Water quality results were taken from the lower dam at point 8 on a monthly basis over the reporting period. Water quality in the lower dam was analysed for turbidity, pH, total suspended solids (TSS), conductivity and a visual inspection for oil and grease as part of the monthly sampling routine. Table 9 provides summary monitoring results for the lower dam during this reporting period and for averages for the life of the project. Figures 17 to20 provide a comparison of the monitoring results for this reporting

period with monitoring results of previous reporting periods, and indicate any trends in the monitoring data over the life of the project.

**Table 7: Lower Dam Summary**

| | Year / Month | pH | Turbidity (NTU) | TSS (mg/L) | Oil and Grease |
|---|---|---|---|---|---|
| Annual Averages (Background Averages) | 2004-2005* | 7.9 | 21 | 18.4 | - |
| | 2005-2006* | 8.1 | 3 | 7.4 | - |
| | 2006-2007* | 7.2 | 84 | 67.2 | - |
| | 2007-2008* | 7.5 | 62 | 40.3 | - |
| | 2008-2009* | 7.6 | 38 | 14.1 | - |
| | 2009-2010 | 7.6 | 35.7 | 18 | - |
| | 2010-2011 | 7.2 | 131.3 | 38.4 | - |
| | 2011-2012 | 7.6 | 144.7 | 43.8 | - |
| | 2012-2013 | 7.7 | 340.6 | 85.9 | - |
| | 2013-2014 | 7.7 | 215.1 | 87.4 | - |
| | 2014-2015 | 7.9 | 71.7 | 32 | - |
| | 2015-2016 | 8.0 | 153.2 | 70.7 | Not Visible |
| 2015-2016 Reporting Period Results | Jul-16 | 8.3 | 43 | 32 | Not Visible |
| | Aug-16 | 8.3 | 65 | 37 | Not Visible |
| | Sep-16 | 8.2 | 110 | 85 | Not Visible |
| | Oct-16 | 8.3 | 80 | 61 | Not Visible |
| | Nov-16 | 8.1 | 120 | 87 | Not Visible |
| | Dec-16 | 8.2 | 60 | 53 | Not Visible |
| | Jan-17 | 8.3 | 65 | 58 | Not Visible |
| | Feb-17 | 8.1 | 27 | 28 | Not Visible |
| | Mar-17 | 7.2 | 110 | 62 | Not Visible |
| | Apr-17 | 8.2 | 33 | 29 | Not Visible |
| | May-17 | 8.3 | 90 | 130 | Not Visible |
| | Jun-17 | 8.2 | 120 | 88 | Not Visible |
| 2016-2017 Average | | 8.1 | 76.92 | 62.5 | Not Visible |

**Figure 37**

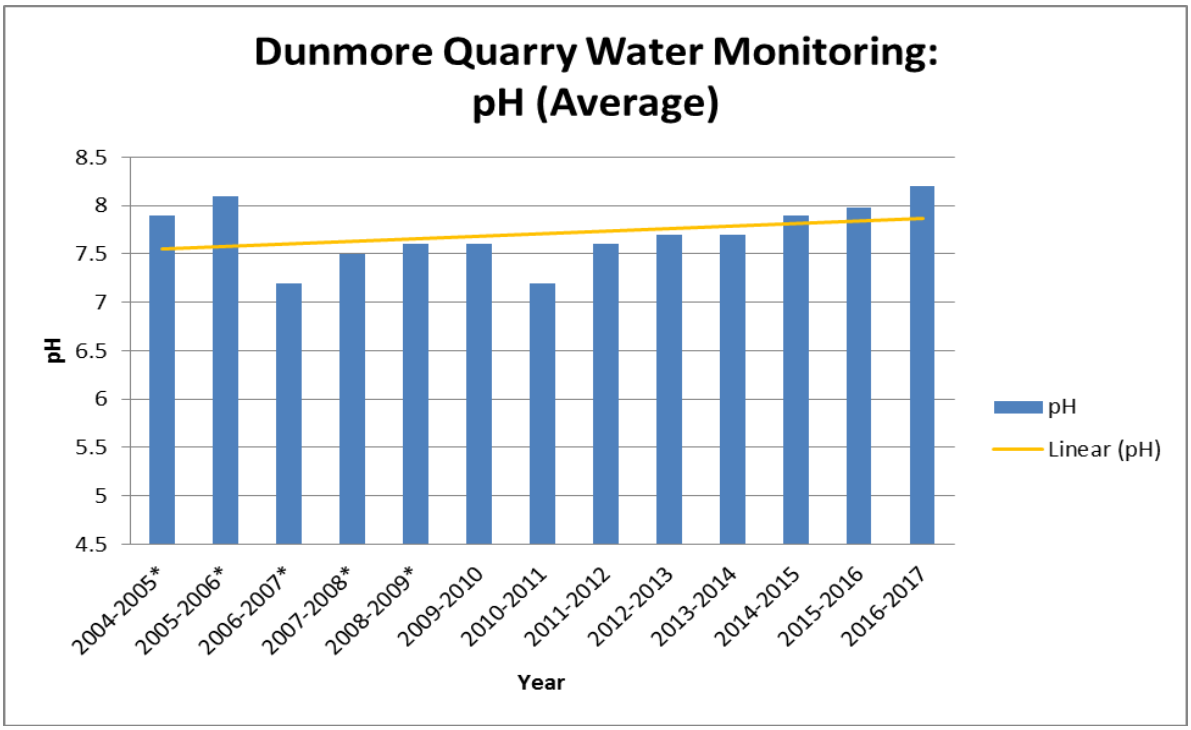



Figure 16 indicates the pH levels in the lower dam have remained relatively consistent since the 04/05 reporting period with a slight increase in annual average between FY16 and FY17 reporting period.

**Figure 18**

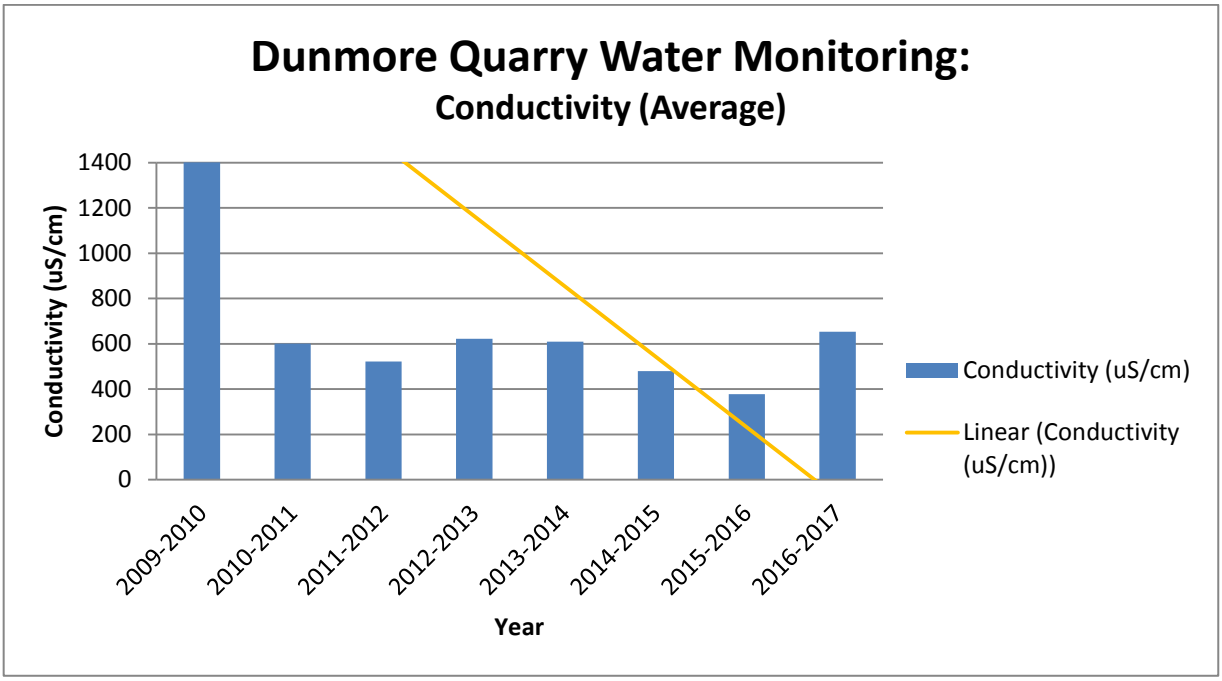


Figure 17 indicates the conductivity levels in the lower dam have remained consistent with previous reporting periods, excluding the 09/10 anomaly.

**Figure 19**

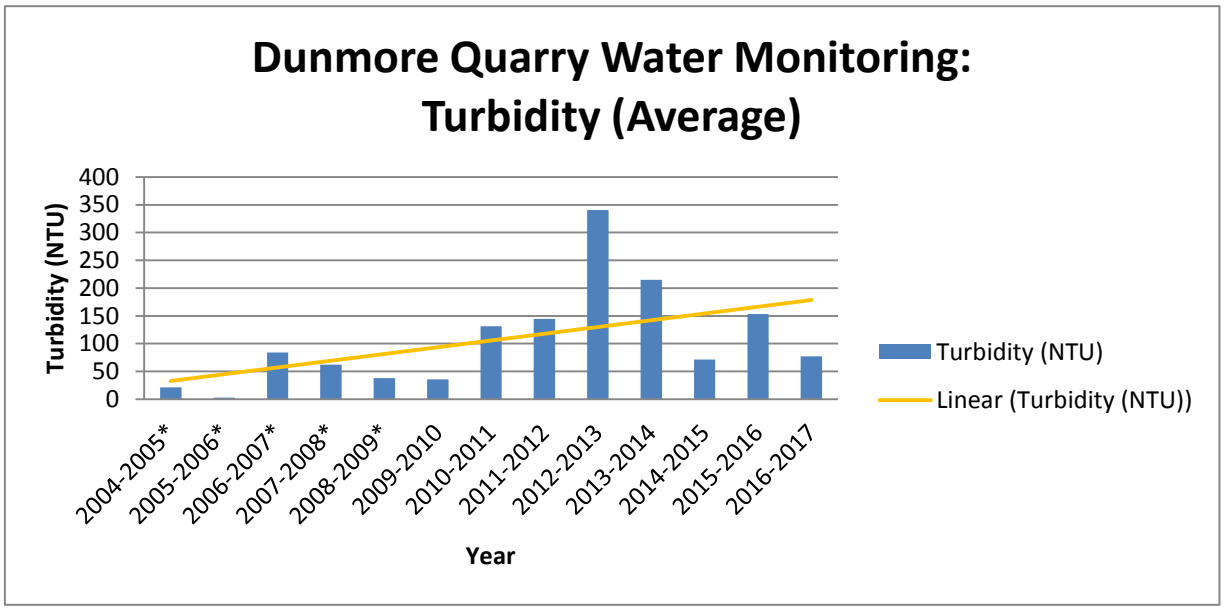



Figure 18 indicates the average turbidity levels have decreased over the FY17 reporting period, although have remained consisted with previous year averages.

**Figure 20**

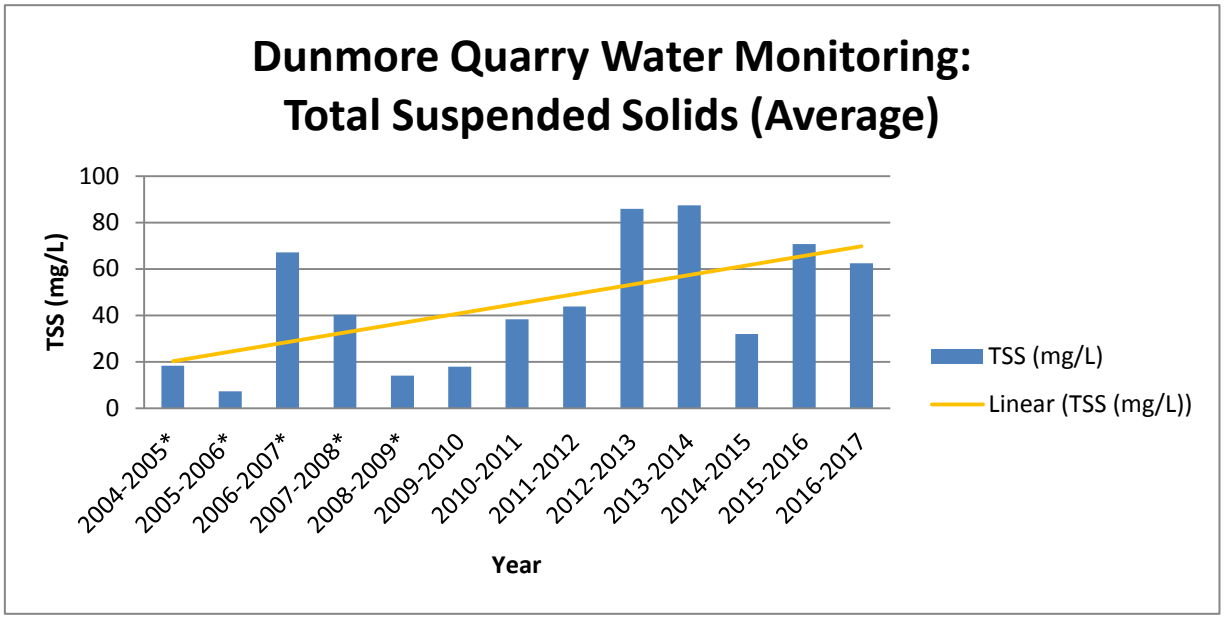


Figure 20 indicates the average TSS levels have decrease from FY 16 to FY17; again these remain relatively consistent with the previous year averages. Note: there are no relevant predictions provided in the EIS to provide a comparison.

Over the reporting period there were three (3) uncontrolled discharge instances from the lower dam. The monitoring results of these events indicate that the TSS at the uncontrolled discharge point (point 7) was greater than the controlled water discharge limit outlined in the development consent. The rainfalls recorded at the site meteorological station indicate large events leading to the uncontrolled discharge. On the 08/02/2017 198.5mm of rainfall was recorded in the previous 5-day period, and on the 17/03/2017 and 18/03/2017, 218.5mm and 232.5mm of rainfall were recorded in the respective previous 5-day periods. Further, it is noted that in the 24 hour period leading up to the 17/0/2017, 190mm of rainfall was recorded resulting in Rocklow Creek floodwaters rising up and over the spillway in to the dam, which in turn has filled up and spilled over. Due to site flooding at the upstream Rocklow Creek sampling point, not all samples could be collected associated with uncontrolled discharge from point 7. Where results have been obtained and assessed from both up and downstream sampling associated with the uncontrolled discharge, results indicated minimal impact to Rocklow Creek water quality has occurred. The location of relevant surface water monitoring locations is displayed in Appendix 4.

Table10 provides the results for the discharge events at monitoring location points 7; upstream Rocklow Creek and downstream Rocklow Creek.

In order to prevent uncontrolled discharge, when required, water is transferred from the lower dam to the middle storage dam to allow for maximum water storage onsite. In addition to this, water is pumped from the lower dam to the water cart for dust suppression and to the crusher plant for use in water sprays.

**Table 8**

| Date of Uncontrolled discharge | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Parameter | 8/02/2017 | | | 17/03/2017 | | | 18/03/2017 | | |
| | Discharge Point (EPL#7) | Upstream Rocklow | Downstream Rocklow | Discharge Point (EPL#7) | Upstream Rocklow | Downstream Rocklow | Discharge Point (EPL#7) | Upstream Rocklow | Downstream Rocklow |
| pH | 8 | 6.7 | 6.8 | 7.05 | No access to site due to flooding. | 6.7 | 6.9 | No access to site due to flooding. | 6.6 |
| Conductivity (µS/cm) | 883 | 387 | 421 | 280 | | 180 | 320 | | 290 |
| Turbidity (NTU) | 90 | 25 | 90 | 430 | | 58 | 290 | | 19 |
| TSS (mg/L) | 69 | 34 | 53 | 219 | | 10 | 140 | | 7.2 |
| Oil and Grease | Not visible | - | - | Not visible | | Not visible | Not visible | | Not visible |

### 4.5.2. Ground Water

The existing water management plans for Dunmore Quarry stipulate that data from the Boral owned Dunmore Sand and Soil groundwater monitoring program be reviewed to determine if there is a significant impact on groundwater levels or quality as a result of both operations. Environmental Earth Sciences NSW were engaged by Boral to undertake a review of the surface and groundwater environmental monitoring data undertaken during the 2016 – 2017 reporting period (Appendix 8).

The analysis completed by Environmental Earth Sciences NSW indicates that groundwater levels have remained stable, including from bores located directly adjacent to and down-gradient of mining activities and that there were no observable impacts in the form of dewatering from extraction activities on the groundwater.

As part of the Dunmore Quarry Western Expansion proposal, EMM Consulting Pty Ltd has undertaken groundwater assessment and groundwater monitoring (Appendix 9). The monitoring bores are located up hydraulic gradient from current quarrying activities and are therefore considered representative of baseline conditions (both water levels and quality). Groundwater quality and level monitoring was undertaken from the established groundwater monitoring network at the Quarry. This data will contribute to inform future site assessment for the proposed Quarry extension. The main findings from the monitoring indicate there is a delay in response to high rainfall as recharge is slow and delayed, however this is consistent with the conceptual model. The water quality results indicate the groundwater is dominated by sodium and bicarbonate with elevated levels of silica which reflects the mineralogy of the host rock. The annual groundwater quality results are overall comparable to results from previous monitoring years. Note: there are no relevant predictions provided in the EIS to provide a comparison.

# 5. Compliance

## *5.1. Independent Audit Summary*

An independent environmental audit was conducted in response to Condition 5(10) of the Development Consent. The audit considered conditions of the Development Consent and Environment Protection Licence (EPL), reviewed the adequacy of strategies, plans and programs prepared under the consent and EPL, assessed the environmental performance of development and recommended actions and measures to improve environmental performance. The audit was completed in May 2017 with the associated report issued in August 2017. A summary of non-compliances determined are outlined below:

- Four (4) conditions of the development consent were found to be non-compliant. These are addressed in section 5.2.
- Since 2013/2014, three (3) non-compliances have been recorded across a range of EPL conditions, of which none resulted in the issue of a penalty notice. Most of the non-compliances related to deficiencies in monitoring and reporting, rather than exceedances of limits. There were no EPL non-compliances in the 2016-2017 reporting period.
- The majority of strategies, plans and programs were reviewed and updated in 2016. The revised documents are considered adequate for the purposes as they meet the conditioned requirements, follow a relatively consistent structure and are operational documents. Several documents have not been reviewed and revised in accordance with the conditions of consent and are considered to be inadequate. A number of recommendations are made to improve the project documents and to help ensure they remain current.

## 5.2. *Response to Non-Compliance*

| Non-Compliance Item | | Identified Non-Compliance | Response to Non-Compliance |
|---|---|---|---|
| Development Consent (470-11-2003) | Condition 4(14) | In October 2016, the Secretary requested the noise monitoring program be reviewed and revised. No evidence provided that the Noise Monitoring Program has been reviewed in response to this request. | As per the consent a Noise Management Plan will be developed during FY18. |
| | Condition 4 (63) | At the time of audit an incident had occurred at Dunmore Sand and Soil which involved the dredge being out of operation. This resulted in large amounts of water being tracked over the access road which subsequently created a significant amount of mud. The wheel-wash was in operation; however, it was not sufficient to properly clean trucks prior to them leaving site. A truck operator was observed attempting to manually dislodge mud with a rubber mallet. Photographs are included in Appendix 1(ix). Interviews with staff suggest that under normal operating conditions, this mud-tracking does not occur. | The site Pollution Incident Management Plan has been updated to include and manage the potential for unexpected mud generation on site. |
| | Condition 5(4) | While this condition was updated in Modification 8, the requirement for review following every AEMR review remains. The document control tables within the all the plans, strategies and programs required under this consent do not reflect the reviews have occurred. Some plans (e.g. the Flora and Fauna Management Plan) contain information regarding review requirements, but the information is inconsistent with this condition. | All management plans to be reviewed in accordance with the consent. |
| | Condition 5(11) | The previous response to recommendations was submitted in 2017, three years after the submission of the previous audit. | The Environmental Permit Planner has been developed to ensure compliance with the site environment protection licence and consent conditions. |

# 6. Conclusion

Dunmore Quarry has continued to focus on ensuring the environment and neighbouring community are not adversely impacted by quarry operations.

Throughout this reporting period extraction and processing of quarry materials has remained consistent with previous years. As consented resource is reaching final volumes, the operation focused on ensuring the full extent of material was quarried at all extraction limits that have been reached.

Approval of modification 8 and 10 of the development consent was granted within the reporting period. This modification related primarily to install the noise and visual bund associated with the proposed modification 9 approvals associated with the Croome West Expansion.

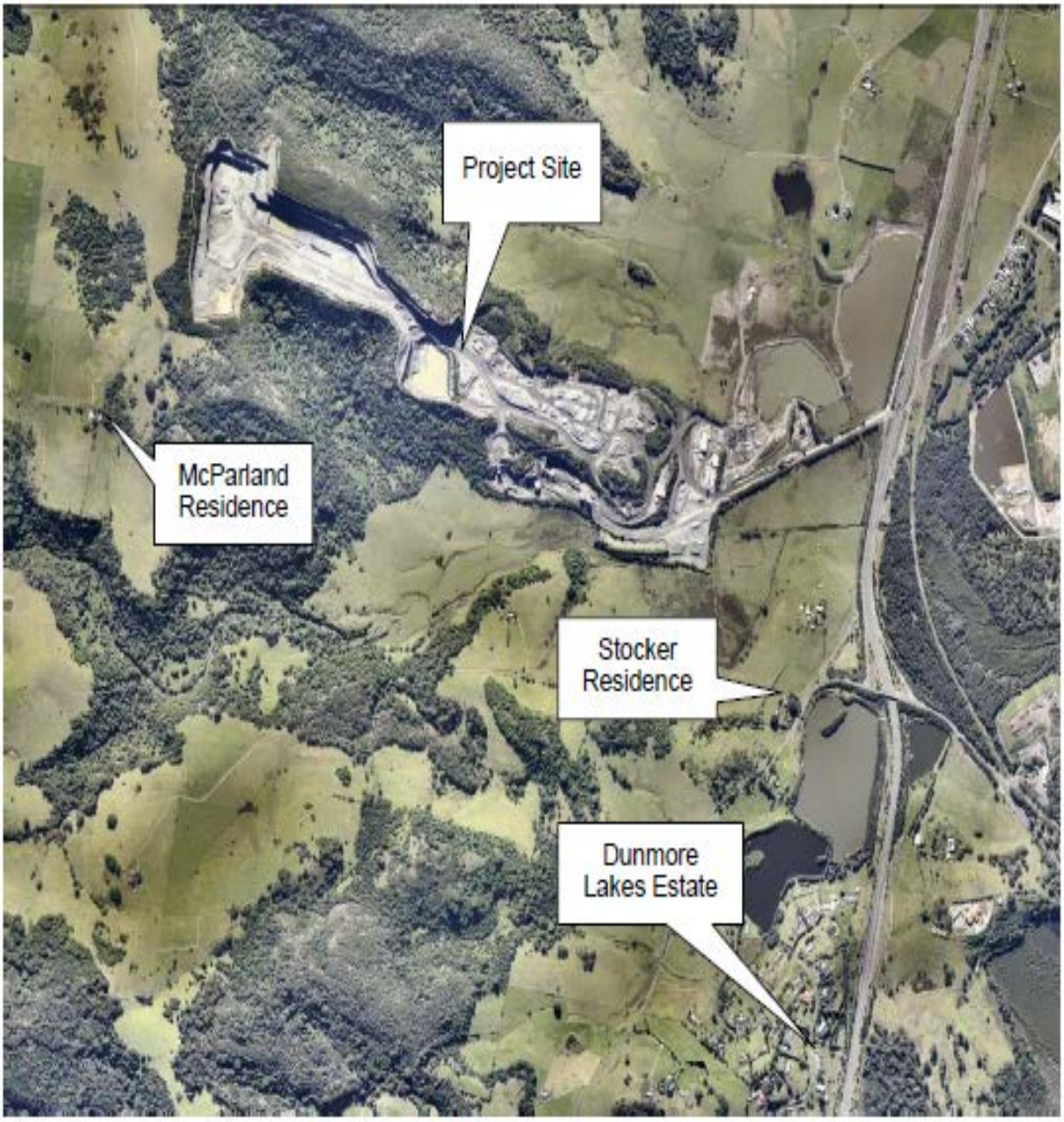
The 2016-2017 reporting period also contained a strong focus on maintaining regulatory compliance. A number of opportunities for improvement were identified from the Independent Environmental Audit and will be addressed and implemented during the FY18 reporting period.

# Appendix 1 – Noise Monitoring Locations

Table 1 Monitoring Locations

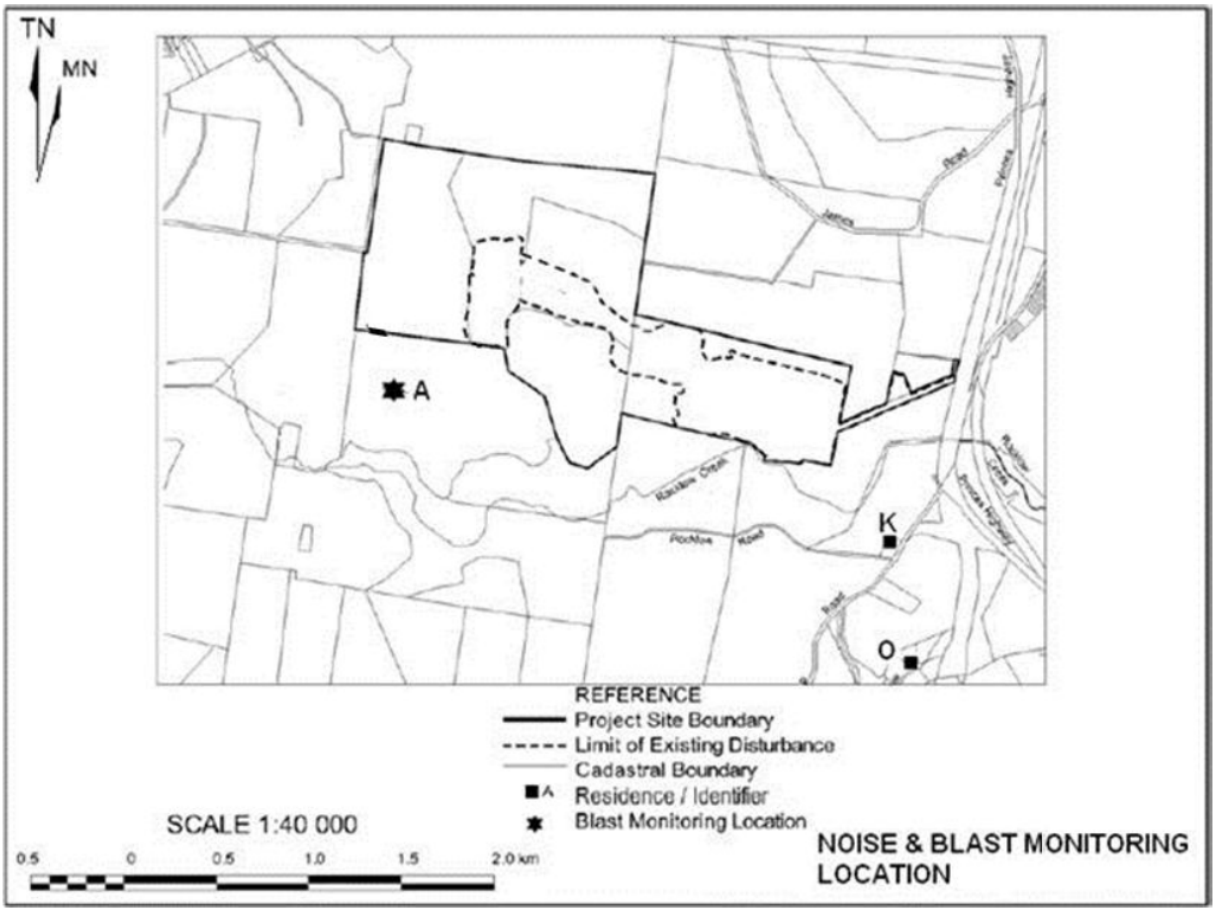
| Location | Description |
|---|---|
| A | McParland Residence |
| K | Stocker Residence |
| O | Dunmore Lakes Estate |

Figure 1 Noise Monitoring Locations




Note: Image courtesy of Neamap (dated 21 June 2014).

# Appendix 2 – Blast Monitoring Location


TN
MN
A
K
O
REFERENCE
Project Site Boundary
Limit of Existing Disturbance
Cadastral Boundary
Residence / Identifier
Blast Monitoring Location
SCALE 1:40 000
0.5
0
0.5
1.0
1.5
2.0 km
NOISE & BLAST MONITORING LOCATION

# Appendix 3 – Air Quality Monitoring Locations

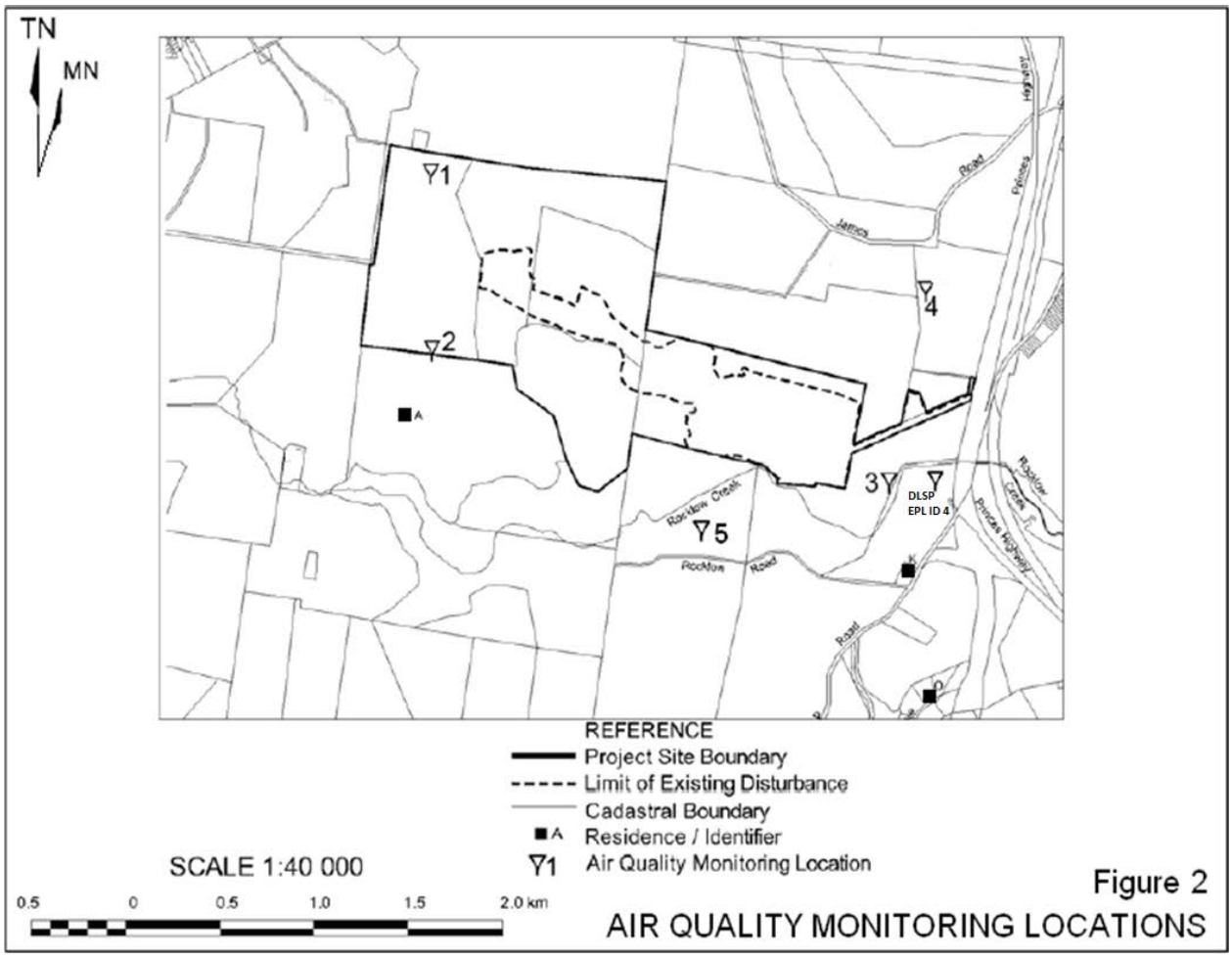


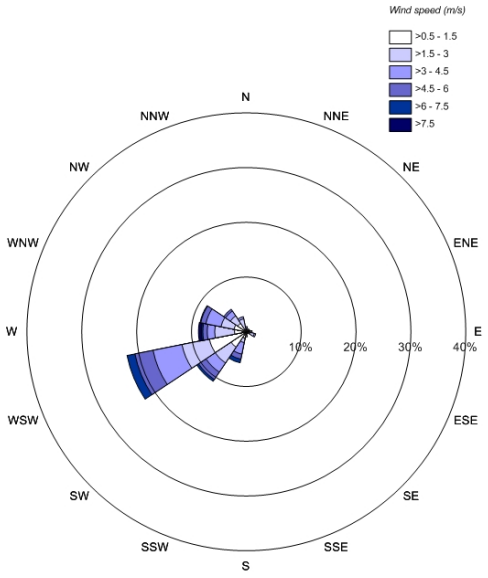

Figure 2
AIR QUALITY MONITORING LOCATIONS

# Appendix 4 – Surface Water Quality Monitoring Locations


EPL#7
Rocklow Upstream
EPL#8
Rocklow Downstream

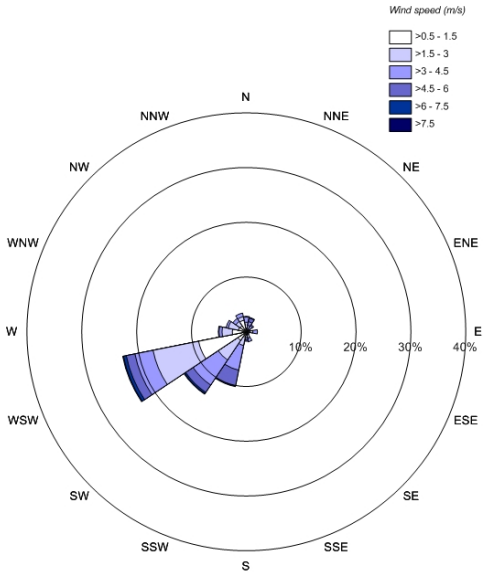
# Appendix 5 – Wind Roses

**July 2016**



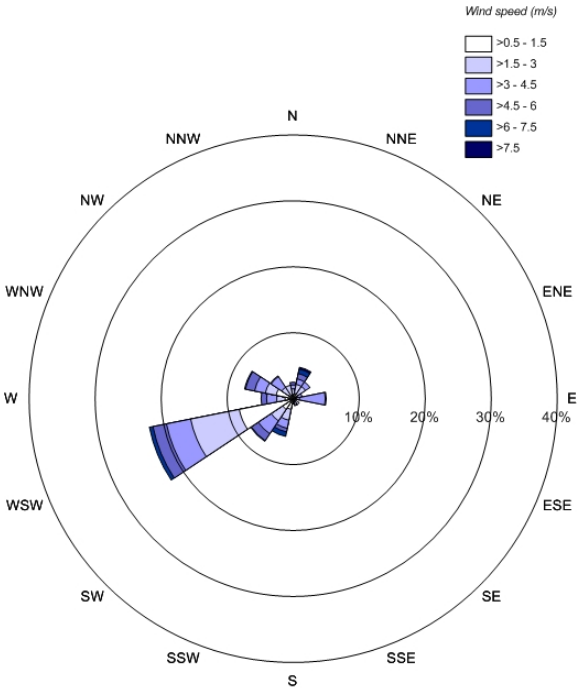

Calms = 29.2%

**August 2016**



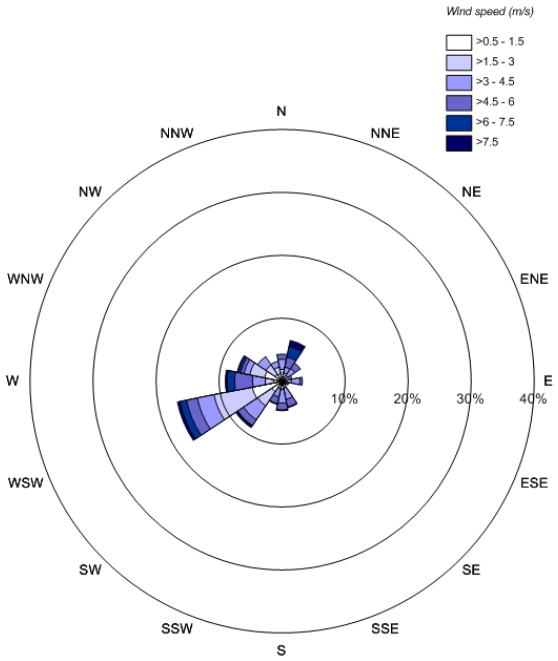

Calms = 23.1%

**September 2016**



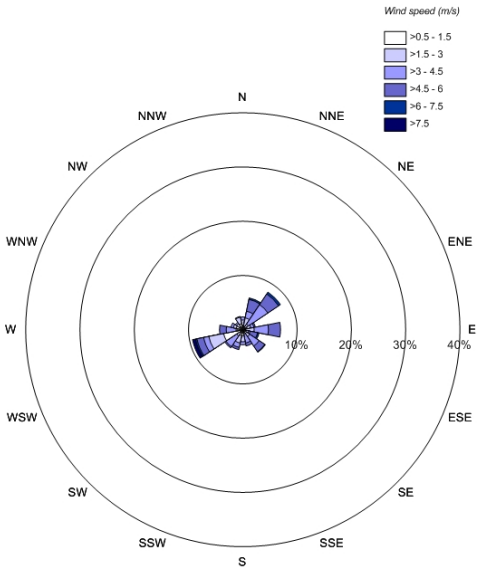

Calms = 25.1%

**October 2016**



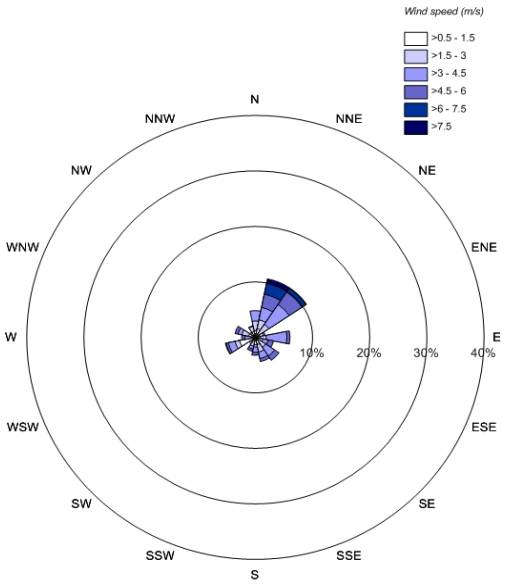

Calms = 16.0%

**November 2016**



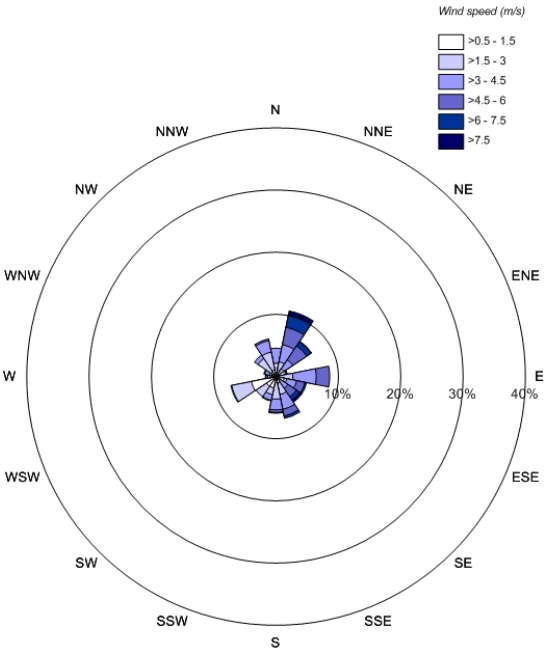

Calms = 32.1%

**December 2016**



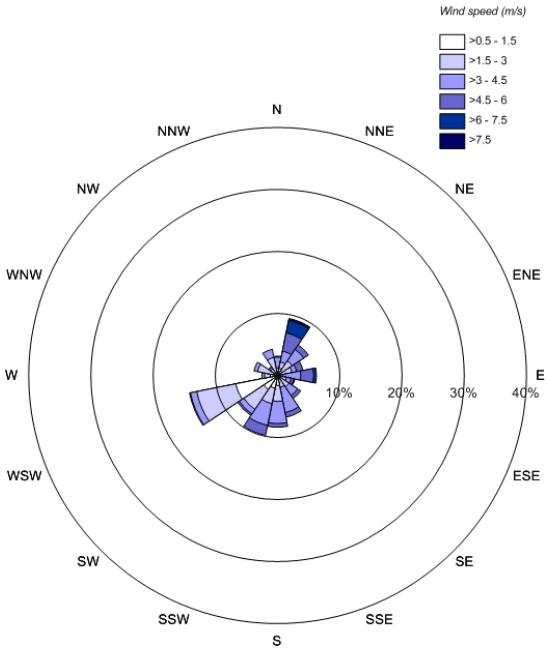

Calms = 31.3%

**January 2017**



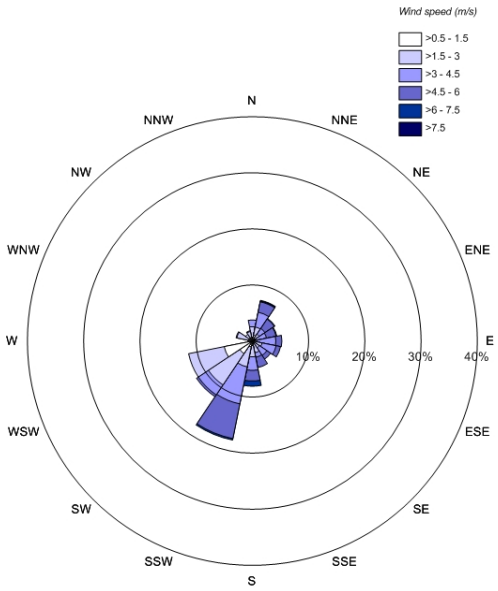

Calms = 15.2%

**February 2017**



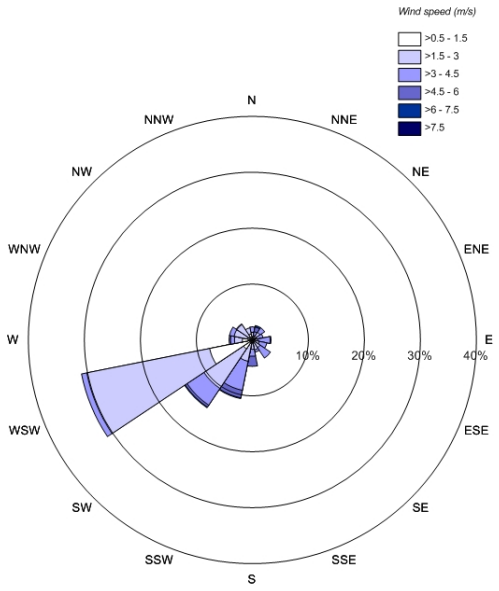

Calms = 3.9%

## March 2017



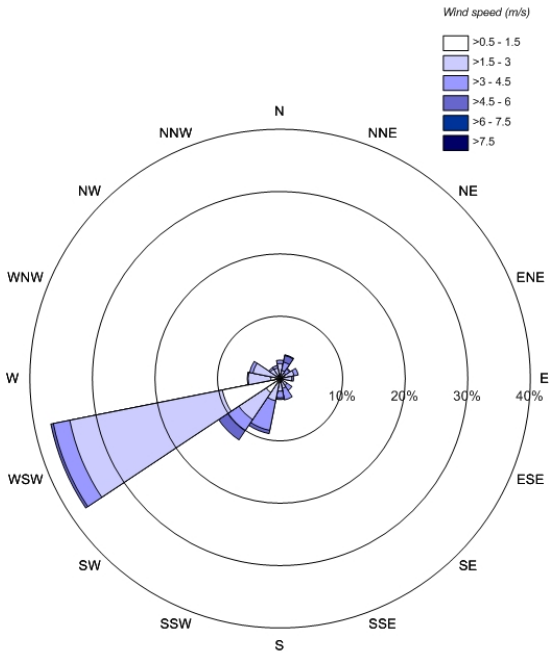

Calms = 3.8%

## April 2017



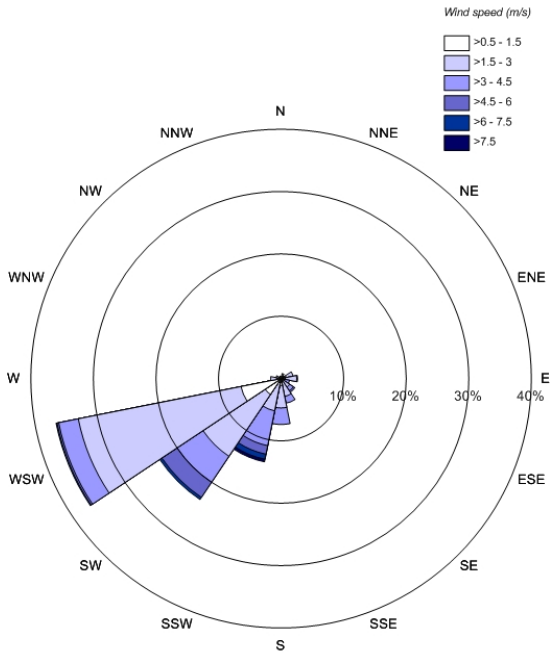

Calms = 3.1%

## May 2017




Calms = 3.6%

## June 2017




Calms = 1.5%

# Appendix 6 – Annual Noise Assessment Report

SLR

global environmental solutions

# Annual Compliance Noise Monitoring 2016

## Dunmore Quarry

## Tabbita Road, Dunmore NSW

Report Number 610.11631-R8

9 September 2016

Boral Property Group
38 Tabbita Road
DUNMORE NSW 2259

Version: Revision 0

# Annual Compliance Noise Monitoring 2016

## Dunmore Quarry

## Tabbita Road, Dunmore NSW

PREPARED BY:

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**DOCUMENT CONTROL**

| Reference | Status | Date | Prepared | Checked | Authorised |
|---|---|---|---|---|---|
| 610.11631-R8 | Revision 0 | 30 August 2016 | Nicholas Vandenberg | Dick Godson | Dick Godson |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

# Table of Contents



**TABLES**



**FIGURES**

# 1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) conducted a noise assessment of the operations at Dunmore Quarry during August 2016. The assessment comprised of operator attended noise monitoring at the McParland residence, the Stocker residence and the Dunmore Lakes Estate.

The purpose of the assessment was to determine the quarry noise contribution at Location A (McParland residence), Location K (Stocker residence) and Location O (Dunmore Lakes Estate) in relation to the Development Consent DA 470-11-2003 (DA) and Environment Protection Licence (EPL) limits for the Dunmore Quarry operation.

An explanation of acoustic terminology and descriptors discussed throughout the report is included in **Appendix A**.

# 2 METHODOLOGY

Noise measurements and assessments in this report have been prepared in accordance with Australian Standard AS 1055-1997 "*Description and Measurement of Environmental Noise*" Part 1, 2 and 3 and with reference to the NSW Industrial Noise Policy (INP) .

All acoustic instrumentation employed throughout the monitoring programme has been designed to comply with the requirements of IEC 61672.1-2004 *"Electroacoustics – Sound Level Metres – Specifications"* and carries current NATA or manufacturer calibration certificates.

The objectives of the noise monitoring assessment were as follows:

- Measure the quarry noise contribution at the McParland, Stocker and Dunmore Lakes Estate residential locations. Noise surveys consisted of operator-attended monitoring.
- Qualify all sources of noise within each of the attended surveys, including estimated contribution or maximum level of each source.
- Assess the noise emissions of Dunmore Quarry in relation to the DA/EPL limits for the site with regard to wind speed and direction during the noise surveys.

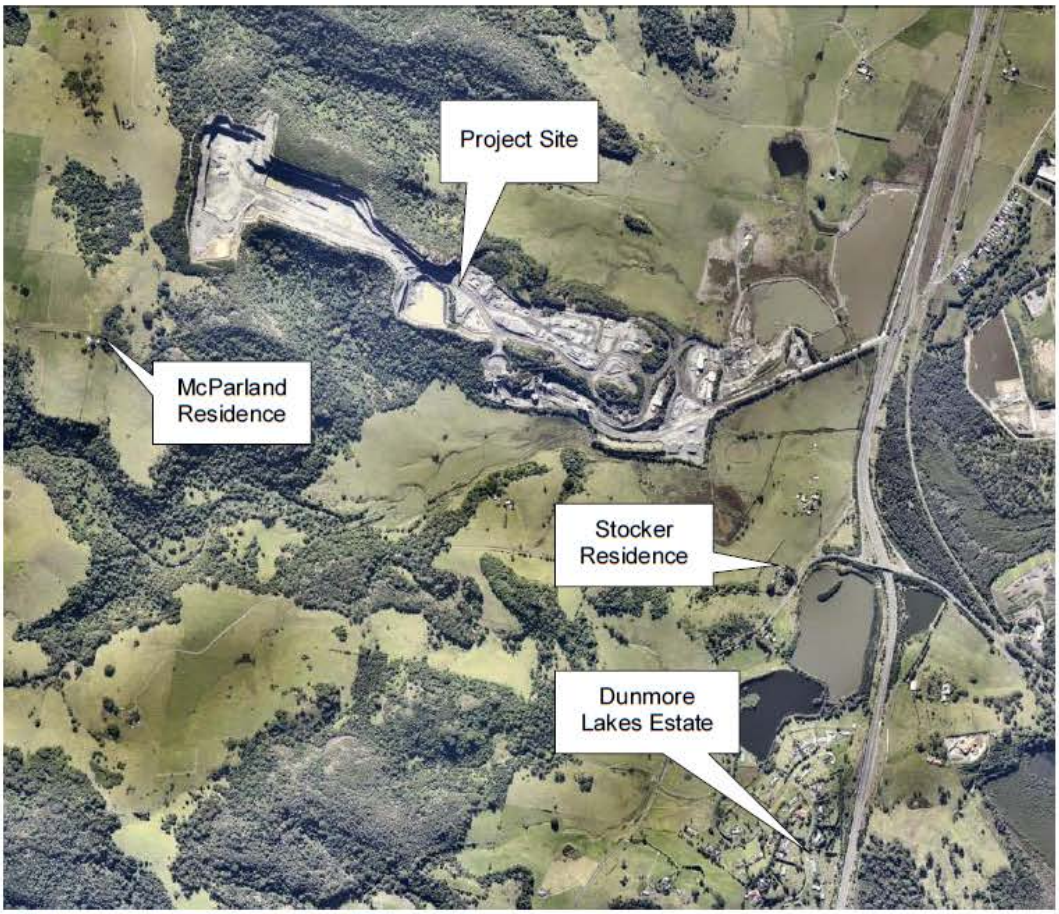
## 2.1 Monitoring Locations

Operator attended noise measurements were conducted at the locations provided in **Table 1** and depicted in **Figure 1**.

**Table 1 Monitoring Locations**

| Location | Description |
|---|---|
| A | McParland Residence |
| K | Stocker Residence |
| O | Dunmore Lakes Estate |

**Figure 1 Noise Monitoring Locations**




Note: Image courtesy of Nearmap (dated 21 June 2014).

## 2.2 Operator Attended Noise Monitoring

Operator-attended surveys were conducted at each monitoring location in order to determine the character and contribution of the noise sources, including quarry noise, to the overall ambient noise level. Operator attended noise measurements were conducted using a one-third octave integrating Brüel & Kjær 2270 Type 1 sound level meter (S/N 3008204).

# 3 OPERATOR ATTENDED NOISE MONITORING

## 3.1 Compliance Monitoring

Operator attended noise measurements were conducted during the morning shoulder period (6:00 am to 7:00 am) on both 9 August 2016 and 18 August 2016, during the daytime period on 17 August 2016 and during the evening period on 17 August 2016.

A summary of the operator-attended measurements presenting the estimated contribution of quarry noise sources is contained within **Table 2** to **Table 4**.

The tables provide the following information:

- Monitoring location.
- Date and time.
- Wind velocity (m/s) at 1.5 m above the ground.
- Temperature (Temp) in degrees Celsius.
- Estimated Quarry contribution - $L_{Aeq(15minute)}$.
- DA/EPL Limit $L_{Aeq(15minute)}$.

**Table 2 Attended Noise Survey Results – Location A - McParland**

| Period<br>DA/EPL Limit<br>LAeq(15minute) | Date/Start Time/ Weather | Primary Noise Descriptor (dBA re 20 µPa) | | | | | Description of Noise Emissions and Typical Maximum Noise Levels (dBA) |
|---|---|---|---|---|---|---|---|
| | | $L_{Amax}$ | $L_{A1}$ | $L_{A10}$ | $L_{A90}$ | $L_{Aeq}$ | |
| Morning Shoulder<br>35 dBA | 18-08-2016<br>06:00 7°C<br>1 m/s NW | 59 | 51 | 43 | 32 | 41 | Dist Taffic - <30 to 40 dBA<br>Insects 33 dBA<br>Birds 36 to 59 dBA<br>**Quarry Audible**<br>Trucks – 31 to 36 dBA<br>Beeper <30 |
| | | **Estimated Quarry LAeq(15minute) Contribution ~ 32 dBA** | | | | | |
| Day<br>35 dBA | 17-08-2016<br>16:09 20°C,<br>1 m/s NNW | 58 | 45 | 37 | <30 | 36 | Birds – 40 to 58 dBA<br>Dog 36 to 59 dBA<br>Dist Traffic <30 to 43 dBA<br>Plane – 37 to 42 dBA<br>Chain Saw 33 to 41 dBA<br>**Quarry Not Audible** |
| | | **Estimated Quarry LAeq(15minute) Contribution - < 30 dBA** | | | | | |
| Evening<br>35 dBA | 17-08-2016<br>18:00 18°C,<br>1 m/s NW | 67 | 52 | 43 | 32 | 41 | Insects – 33 to 35 dBA<br>Plane – 35 to 55 dBA<br>Dist Traffic 31 to 36 dBA<br>Dog barking – 36 to 67 dBA<br>**Quarry Not Audible** |
| | | **Estimated Quarry LAeq(15minute) Contribution - < 30 dBA** | | | | | |

**Table 3 Attended Noise Survey Results – Location K - Stocker**

| Period<br>DA/EPL Limit<br>LAeq(15minute) | Date/Start Time/ Weather | Primary Noise Descriptor (dBA re 20 µPa) | | | | | Description of Noise Emissions and Typical Maximum Noise Levels (dBA) |
|---|---|---|---|---|---|---|---|
| | | $L_{Amax}$ | $L_{A1}$ | $L_{A10}$ | $L_{A90}$ | $L_{Aeq}$ | |
| Morning Shoulder<br>47 dBA | 9-08-2016<br>06:45 5° C<br>0.5 m/s NW | 63 | 61 | 59 | 56 | 58 | Princes Hwy – 58 to 59 dBA<br>Birds 59 to 62 dBA<br>Local Traffic 58 to 60 dBA<br>**Quarry Audible at times**<br>Truck Rev Tone<br>Bang 55<br>Faint hum ~47 to 50 dBA[1] |
| | | **Estimated Quarry LAeq(15minute) Contribution - <46 dBA** | | | | | |
| Day<br>49 dBA | 17-08-2016<br>17:09 20° C<br>1m/s NNW | 60 | 55 | 52 | 46 | 49 | Local Traffic – 53 to 58 dBA<br>Princes Hwy – 45 to 50 dBA<br>Birds 60 dBA<br>**Quarry Trucks Audible at times**<br>Quarry Trucks - <39 to 43 dBA<br>Faint hum - <36 dBA |
| | | **Estimated Quarry LAeq(15minute) Contribution - <40 dBA** | | | | | |
| Evening<br>44 dBA | 17-08-2016<br>19:19 18° C<br>1 m/s NW | 63 | 57 | 53 | 45 | 50 | Traffic – 48 to 51 dBA<br>Local Traffic – 54 to 62 dBA<br>Dog 57 dBA<br>Train Horn – 54 to 55 dBA[2]<br>**Quarry Audible**<br>Trucks faintly Audible - <36 dBA<br>Air breaks 43 dBA<br>Horn – 42 dBA<br>Faint Hum - <36 dBA |
| | | **Estimated Quarry LAeq(15minute) Contribution - <39 dBA** | | | | | |

Note 1: Further noise measurements and calculations were performed to confirm the contribution from the quarry.
Note 2: The train horn was not related to trains associated with the quarry.

**Table 4 Attended Noise Survey Results – Location O – Dunmore Lakes Estate**

| Period<br>DA/EPL Limit<br>LAeq(15minute) | Date/Start Time/ Weather Stability Class | Primary Noise Descriptor (dBA re 20 µPa) | | | | | Description of Noise Emissions and Typical Maximum Noise Levels (dBA) |
|---|---|---|---|---|---|---|---|
| | | $L_{Amax}$ | $L_{A1}$ | $L_{A10}$ | $L_{A90}$ | $L_{Aeq}$ | |
| Morning Shoulder<br>47 dBA | 18-08-2016<br>06:39 7° C,<br>1 m/s NW | 73 | 66 | 56 | 49 | 55 | Swamp Road Traffic – 53 dBA<br>Princes Hwy – 47 to 62 dBA<br>Local Traffic – 67 to72 dBA<br>Birds – 50 to 66 dBA<br>Train Horn – 67 dBA[1]<br>**Quarry Audible at times**<br>Trucks ~ <41 dBA |
| | | **Estimated Quarry LAeq(15minute) Contribution - <41 dBA** | | | | | |
| Day<br>49 dBA | 17-08-2016<br>16:49 20° C,<br>1 m/s NNW | 66 | 61 | 58 | 53 | 56 | Traffic 53 to 61 dBA<br>Birds <45 to 53 dBA<br>Helicopter 55 to 66 dBA<br>**Quarry Not Audible** |
| | | **Estimated Quarry LAeq(15minute) Contribution - < 43 dBA** | | | | | |
| Evening<br>44 dBA | 17-08-2016<br>19:00 18° C,<br>1 m/s NW | 72 | 54 | 50 | 43 | 49 | Swamp Road Traffic – 53 dBA<br>Pricnes Hwy – 48 to 56 dBA<br>Dog 50 54 dBA<br>Local traffic – 72 dBA<br>Plane 51 to 53 dBA<br>**Quarry Audible Intermittently**<br>Trucks audible in lulls <36<br>Hum - <40 dBA |
| | | **Estimated Quarry LAeq(15minute) Contribution - < 40 dBA** | | | | | |

Note 1: the train horn was not related to trains associated with the quarry.

# 4 COMPLIANCE ASSESSMENT AND DISCUSSION

A summary of the operator attended noise survey results are provided in **Table 5**.

**Table 5 Compliance Noise Assessment - Operations**

| Location | Estimated Contribution | | | Consent Conditions | | | Compliance Achieved | | |
|---|---|---|---|---|---|---|---|---|---|
| | Morning Shoulder | Day | Evening | Morning Shoulder | Day | Evening | Morning Shoulder | Day | Evening |
| McParland | ~32 | <30 | <30 | 35 | 35 | 35 | Yes | Yes | Yes |
| Stocker | <46 | <40 | <39 | 47 | 49 | 44 | Yes | Yes | Yes |
| Dunmore Lakes | <41 | <43 | <40 | 47 | 49 | 44 | Yes | Yes | Yes |

A review of **Table 5** indicates that compliance with the consent conditions was achieved at all locations during the operator attended noise surveys. Further discussion with regard to each monitoring location is provided below.

## 4.1 Location A – McParland Residence

This location represents receptors located to the west of the Dunmore Quarry. Noise generated from ambient noise sources such as birds and insects as well as noise generated from residents were the dominant noise sources at this location.

Noise contributions from the quarry at the McParland residence were estimated to be:

- ~30 dB $L_{Aeq(15minute)}$ during the morning shoulder period.
- <30 dB $L_{Aeq(15minute)}$ during the daytime period.
- <30 dB $L_{Aeq(15minute)}$ during the evening period.

Quarry operations were only observed to be audible during the morning shoulder period at this location.

## 4.2 Location K – Stocker Residence

This location represents receptors located to the southeast of Dunmore Quarry. Noise generated from road traffic and birds were the dominant noise source at this location.

The evening period has been identified in previous noise surveys and assessments as the most likely to contain noise enhancing conditions. The Stocker residence is the closest noise sensitive receiver.

Noise contributions from the quarry at the Stocker residence were estimated to be:

- <46 dB $L_{Aeq(15minute)}$ during the morning shoulder period.
- <40 dB $L_{Aeq(15minute)}$ during the daytime period.
- <39 dB $L_{Aeq(15minute)}$ during the evening period.

Quarry operations were audible during all monitoring periods at this location. Quarry operations which contributed to the estimated noise level included truck loading and movement and a low frequency hum. This low frequency hum was observed to be quite prominent during morning shoulder period, however further measurements were conducted on site and at various distances from the quarry.

A measurement of 75 dBA was taken at a distance of approximately 40 meters from the Jaw Crusher, which has been extrapolated to be 45 dBA at the receiver location. However, it has been calculated that there is approximately 6 dB to 8 dB of reduction provided by the earth mound. Therefore it is calculated that the resultant noise level is approximately 37 dBA to 39 dBA.

It should be noted that the noise level at the Stocker Residence is dominated by road traffic noise (particularly during the morning shoulder period), and although audible, the Quarry is not likely to have an impact on the overall noise level at the receiver location.

### 4.3 Location O – Dunmore Lakes Estate

This location represents receptors located to the east-southeast of Dunmore Quarry. Noise generated from road traffic was the dominant noise source at this residential location.

Noise contributions from the quarry at the Dunmore Lakes residence were estimated to be:

- <41 dB $L_{Aeq(15minute)}$ during the morning shoulder period.
- <43 dB $L_{Aeq(15minute)}$ during the daytime period.
- <40 dB $L_{Aeq(15minute)}$ during the evening period.

Quarry operations were only observed to be audible during the morning shoulder and evening noise monitoring periods. Quarry operations which contributed to the estimated noise level included truck movement and loading noise.

## 5 CONCLUSION

SLR was engaged by the Boral Property Group to conduct a noise compliance monitoring survey of the operations of the Dunmore Quarry. Operator attended noise measurements were conducted at three (3) locations in order to determine the estimated noise contribution from the Quarry.

The results of noise monitoring indicate that compliance is achieved at all locations during all monitoring periods.

## 1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or $L_P$ are commonly used to represent Sound Pressure Level. The symbol $L_A$ represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is $2 \times 10^{-5}$ Pa.

## 2 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

| Sound Pressure Level (dBA) | Typical Source | Subjective Evaluation |
|---|---|---|
| 130 | Threshold of pain | Intolerable |
| 120 | Heavy rock concert | Extremely noisy |
| 110 | Grinding on steel | |
| 100 | Loud car horn at 3 m | Very noisy |
| 90 | Construction site with pneumatic hammering | |
| 80 | Kerbside of busy street | Loud |
| 70 | Loud radio or television | |
| 60 | Department store | Moderate to quiet |
| 50 | General Office | |
| 40 | Inside private office | Quiet to very quiet |
| 30 | Inside bedroom | |
| 20 | Recording studio | Almost silent |

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

## 3 Sound Power Level

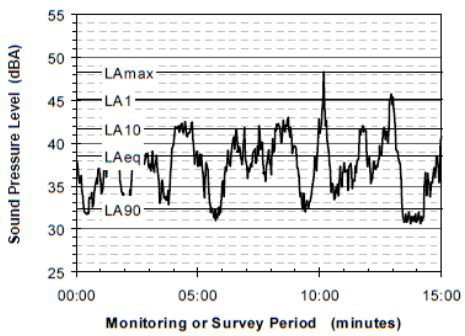
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or Lw, or by the reference unit $10^{-12}$ W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

## 4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels $L_{AN}$, where $L_{AN}$ is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the $L_{A1}$ is the noise level exceeded for 1% of the time, $L_{A10}$ the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.




Of particular relevance, are:

$L_{A1}$ The noise level exceeded for 1% of the 15 minute interval.

$L_{A10}$ The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

$L_{A90}$ The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

$L_{Aeq}$ The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' $L_{A90}$ noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or 'average' levels representative of the other descriptors ($L_{Aeq}$, $L_{A10}$, etc).

## 5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise.

## 6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

## 7 Frequency Analysis

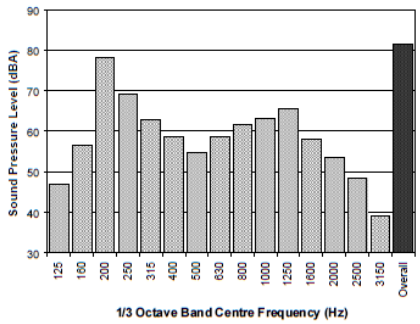
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.




## 8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log ($V/V_o$), where $V_o$ is the reference level ($10^{-9}$ m/s). Care is required in this regard, as other reference levels may be used by some organizations.

## 9 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

## 10 Over-Pressure

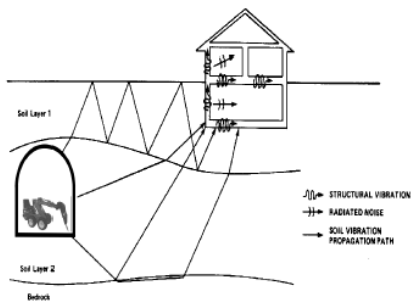
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

## 11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

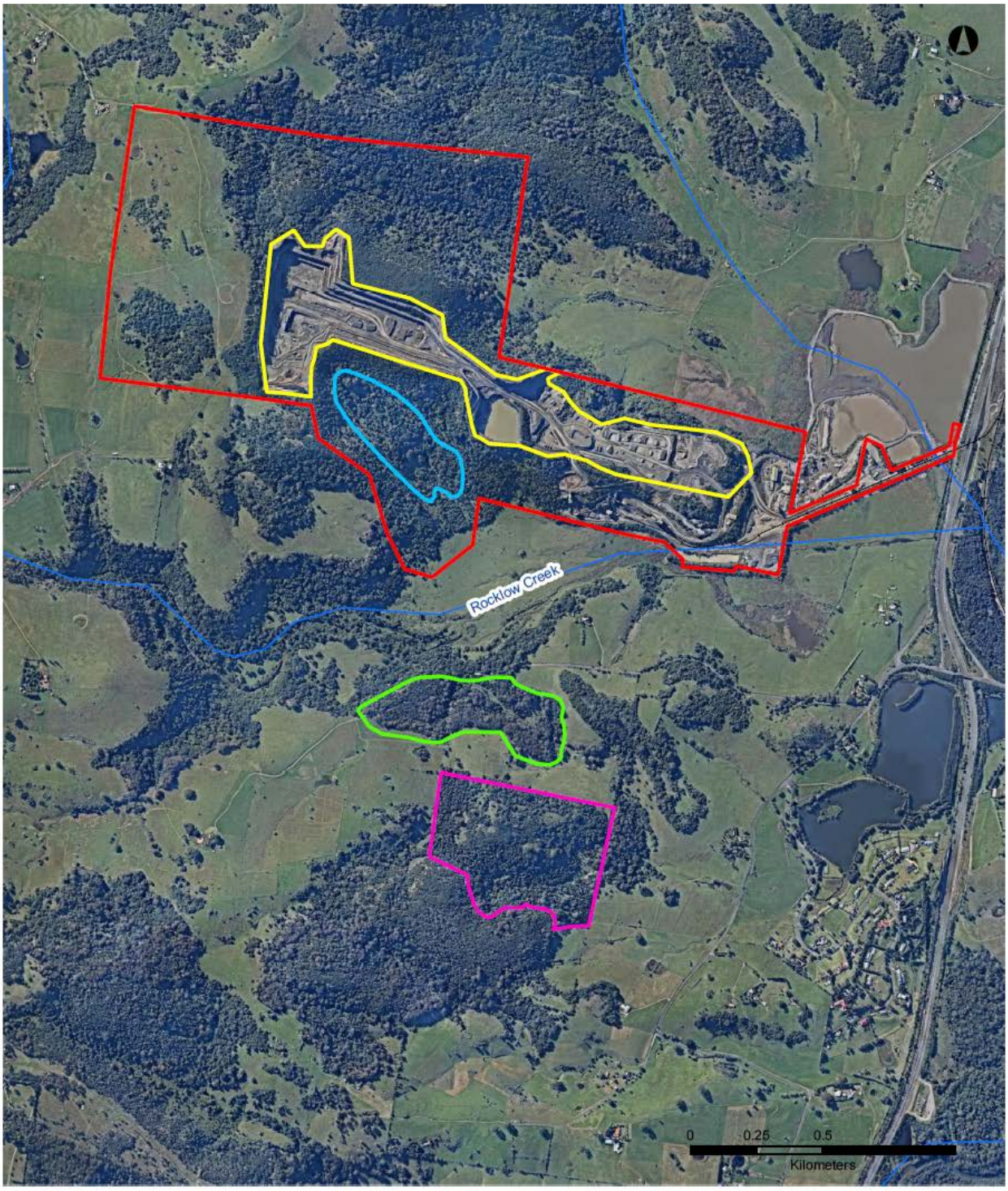
Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.




The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

# Appendix 7 – Map of Conservation Areas




LEGEND

- Site Boundary
- Hard Rock Quarry
- Watercourse

**Conservation Areas**

- Compensatory Habitat Area
- Offset Area
- Remnant Vegetation Conservation Area

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Conservation Areas (April 2016)

# Appendix 8 – Annual Monitoring Report at 38 Tabbita Road, Dunmore, NSW

13 July 2017

**Dunmore Sand & Soil Pty Ltd**
c/- Boral Quarries
38 Tabbita Road
Dunmore NSW 2529

Attention: **Ellie Randall**
Environmental Coordinator

Dear Ellie

**Annual report on groundwater level monitoring at the Swamp Road Quarry, Dunmore NSW – May 2016 to May 2017**

## 1.0 Introduction

Environmental Earth Sciences NSW was engaged by Dunmore Sand & Soil Pty Ltd (DS&S) to monitor groundwater levels at Swamp Road Quarry, Dunmore, NSW (see Figure 1 for a locality plan), between May 2016 and May 2017. The objective of this report is to assess whether former and on-going sand extraction activities are impacting groundwater levels in line with the Development Consents for Stage 2 – 4 as well as the Environmental Management Plan (EMP) (DS&S, 2006) and the Water Management Plan (WMP) (Arcadis, 2016).

Data loggers (pressure transducer sensors) are programmed to measure groundwater levels at 60 minute intervals and have been installed within the following groundwater bores (see Attachment 1, Figures 1 and 2 for bore locations):

- DG1 (removed in May 2017) and DG5 (missing in May 2017);
- BHA (removed in August 2016), BHD (missing February 2016) and BHF; and
- DG31 (installed in May 2016) and DG59 (installed in February 2017).

The scope of works undertaken to achieve this objective as outlined in proposal number PO116092 included:

- downloading data from the loggers;
- water level measurement to calibrate water levels (i.e convert head to mAHD); and
- review water level data from the data loggers located in the vicinity of Swamp Road Quarry and the Stage 3 sand dredging area.

## 2.0 Fieldwork and data downloading

Water level data from each location (bores DG1, DG5, BHA, BHD, BHF, DG31 and DG59) was downloaded from pressure transducer data loggers ('divers') at quarterly intervals by Environmental Earth Sciences personnel on 18 August 2016, 9 November 2016, 15 February 2017 and 10 May 2017.

Water level data from May 2016 to May 2017 for bores DG1, DG5, BHA, BHD, BHF, DG31 and DG59 has been compared to rainfall totals in Attachment 2, Chart 1 and tidal data in Attachment 2, Chart 2. Water level data from bores DG1 and DG5 compared to rainfall and tidal data is displayed separately in Attachment 2, Chart 3.

### 2.1 Water level calibration

Water levels are manually measured from the top of casing (TOC) of each monitoring bore with the TOCs surveyed to the Australian Height Datum (mAHD). To assess groundwater levels these measurements from TOC are converted into relative levels to calibrate datalogger measurements. Subtracting the bore dip from the surveyed TOC level provides a water level in mAHD that can be used to calibrate the datalogger pressure reading.

The data logging of this piezometric pressure (water pressure) in the monitoring bores is undertaken at 60 minute intervals, with readings compensated for barometric changes. The data from the loggers is downloaded quarterly at each location, and used to compare the piezometric head with tidal influence and rainfall.

### 2.2 Rainfall data

Local daily rainfall data was obtained from the Bureau of Meteorology (BOM) weather station 068242 located at Kiama (Bombo Headland) approximately 4.6 km away from site. The majority of rainfall during both 2016 and 2017 occurred in later summer and throughout autumn, with three significant rainfall events totalling 80 mm (February 2017) and 130 mm (May 2016 and March 2017), respectively. Rainfall totals compared to water level data at DS&S are presented Attachment 2, Chart 1.

### 2.3 Tidal data

Tidal data from the Minnamurra River tidal monitoring station (214442) was purchased from Manly Hydraulics Laboratory for the period between 31 May 2016 and 1 June 2017 for the purpose of comparing the water level data to tidal movements (Attachment 2, Chart 2).

## 3.0 Data interpretation and discussion

A review of the water level data collected during the 2016/ 2017 monitoring period indicates no observable impact in the form of dewatering from extraction activities on groundwater, with water levels up gradient (bore BH31) and down gradient (DG5) having remained consistent when compared to historical level data (Attachment 2, Chart 1).

The relationship between bores DG5, BHF, DG59 and BH31 indicates that groundwater flow is in an easterly direction towards bore DG5, and locally towards bore BHF, as dredging works continue in Stage 3 (Attachment 1, Figure 3). Bore BHF displayed a particularly variable SWL during the period since November 2016 and these fluctuations are expected to

be a product dewatering and other disturbances associated with sand dredging activities (see Attachment 2, Chart 1).

### 3.1 Groundwater level response and rainfall analysis

The aquifer beneath site has historically responded rapidly to local rainfall events (Environmental Earth Sciences 2009-2016), a trend which was repeated during 2016/ 2017 monitoring period at all locations (Attachment 2, Chart 1).

Bore BHF displayed a particularly variable SWL during the period since November 2016 and these fluctuations are expected to be a product of dewatering associated with sand dredging activities which have commenced within Stage 3.

The groundwater in bore BH31 although affected by rainfall (late 2017), had a dampened response (lower overall fluctuations) during 2016 when compared to the other bores onsite. This likely as result of a reduced sensitivity to rainfall totals <20mm, reduced tidal influences and being located further up the catchment and closer to the edge of the aquifer/ unconsolidated sediments (Attachment 2, Chart 1).

Bore BHD (prior to November 2016) and newly installed diver in bore DG59 both shared a similar rapid rainfall response pattern and appeared to be more easily influenced by minor rainfall events <20 mm (Attachment 2, Chart 1). Fluctuations in the water-table level up to one metre AHD can be seen during rainfall events up to 150 mm. This observation fits the conceptual site model (CSM) of aquifer effective porosity being close to 30% and recharge from rainfall being close to 100% of total recharge at the water-table level (Environmental Earth Sciences, 2013b).

### 3.2 Groundwater level response and tide analysis

The unconfined aquifer which is intercepted by all bore locations is susceptible to tidal influences, however at relatively low amplitudes. Tidal characteristics of the aquifer are shown in Attachment 2, Chart 2.

Groundwater fluctuations in response to tidal influxes in bore DG5 have historically been larger (approximately double) compared to bore DG1 (Attachment 2, Chart 3) while the tidal amplitudes at bores BHA, BHD and BHF are very similar. This indicates a reduced tidal impact on groundwater levels further up the Rocklow Creek catchment.

Groundwater levels responsiveness to tidal fluctuations (high and low tides) is as follows for each bore and graphically displayed in Attachment 2, Chart 2:

- Bore DG5: ±0.03-0.05 m;
- Bore DG1: ±0.03 m;
- Bores BHA, BHD and BHF: ±0.015-0.020 m;
- Bore DG59: ±0.01-0.02 m.

### 3.3 Hydraulic gradient and groundwater flow direction

The groundwater hydraulic gradient at each location is determined by comparing the average standing water level (SWL, converted to mAHD) in the unconfined aquifer at each location to down-gradient bore DG5 between May 2016 and May 2017. The inferred groundwater contours (Figure 3) indicate that over the last monitoring year groundwater flow

continues to be influenced by both tidal movements and localised dredging activities in Stage 3, but showed a consistent south easterly pressure gradient towards Rocklow Creek, the Minnamurra River and the coast.

## 4.0 Recommendations for future monitoring

Groundwater monitoring should continue in line with the Development Consents for Stage 2 – 4 as well as the EMP (DS&S, 2006) and the WMP (Arcadis, 2016). It is understood that DS&S ceased Stage 1 dredging activities at the Swamp Road site in March 2009, and the site is currently a rehabilitated pond. Sand dredging of Stage 2 is complete, however some sand maybe excavated in the future during the clean-up process with the western portion. Dredging operations have commenced within Stage 3.

Quarterly groundwater level monitoring is still required at DS&S however the location, density and frequency of monitoring is reviewed on an annual basis to provide the most useful and pertinent data. Based on a review of the 2016/ 2017 monitoring data the following adjustments are recommended to the program:

- Monitoring of representative water level diver locations within (bores BHF and DG59) and adjacent (bores DG5 and DG31) to Stage 3 should continue at quarterly intervals;
    - Replace the missing diver within bore DG5;
    - Once bore BHF is destroyed by sand dredging operations the diver can be moved to bore BHA;
    - Bores DG59 and DG60 (historically dry) should be replaced with new bores outside of the Stage 3 footprint as the dredging front advances; and
    - Install a diver in the proposed new bore DG7 (located 250m north of DG6).

## 5.0 Conclusions

Groundwater levels continue to remain stable indicating that there has been little to no impact from sand dredging activities. The data obtained from the data loggers installed in bores DG59, DG31, DG5 and BHF indicates that over the past monitoring year natural fluctuations in water levels were occurring in response to rainfall and tide as illustrated in Attachment 2, Charts 1 and 2. This is consistent with previous findings dating back to 2003 (Environmental Earth Sciences 2009, 2010, 2011, 2012, 2013a, 2014, 2015, 2016).

The groundwater-monitoring program over the past monitoring year (May 2016 to May 2017) showed that bores DG59, DG31, DG5 and BHF all had increased in groundwater levels in May 2016, February 2017 and April 2017 in response to rainfall totals exceeding 80 mm. The aquifer was subsequently fully recharged with any additional smaller rainfall events resulting in fluctuations in the water table.

Bore BHF displayed a particularly variable SWL during the period since November 2016 and these fluctuations are expected to be a product of dewatering associated with sand dredging activities. Monitoring at bore BHF should continue until it is destroyed by dredging activities at which point the diver should be moved to bore DG17 to continue to provide representative on-site water level data from within Stage 3.

All data obtained from the bores monitored strongly indicate the following:

- that influences on groundwater levels are related to recharge from rainfall and more minor tidal influx (this finding is supported by chemical monitoring of tidal seawater intrusion from Rocklow Creek);
- reductions in groundwater levels are related to periods of low rainfall (i.e. not to minor recharge) where the aquifer is slowly draining from Rocklow Creek and the south-east aquifer boundary; and
- water-table fluctuations are therefore naturally occurring and cannot be seen to be impacted by dredging activities in the area (except immediately around bore BHF).

It is recommended that groundwater monitoring be continued at bores DG59, DG31 and DG5 (reinstall missing diver), an additional diver be installed at bore DG60, and bores BH31 and DG59 both be surveyed to provide exact relative level data.

## 6.0 Limitations

This report has been prepared by Environmental Earth Sciences NSW ACN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from Dunmore Sand and Soil Pty Ltd;
2. The specific scope of works set out in PO116092 issued by instructing company for and on behalf of Dunmore Sand and Soil Pty Ltd, is included in Section 3 (Scope of Work) of this report;
3. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);
4. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
5. The report only relates to the site referred to in the scope of works being located at 38 Tabbita Road, Dunmore, NSW, 2529 (“the site”);
6. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
7. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;
8. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill, excavated natural material (ENM) or virgin excavated natural material (VENM) if deposited off site;
9. This report is not a geotechnical or planning report suitable for planning or zoning purposes; and
10. Our General Limitations set out at the back of the body of this report.

Should you have any queries, please contact us on (02) 9922 1777 or (07) 3852 6666.

On behalf of
**Environmental Earth Sciences NSW**

**Project Manager**
Max Setchfield
Soil Scientist

**Project Director / Internal Reviewer**
Mark Stuckey
Principal Soil Scientist, Hydrogeolgoist and Risk Assessor
Contaminated Land Auditor (NSW, QLD, VIC)

Attachment 1 FIGURES
Attachment 2 HYDROGRAPHS

## 7.0 References

Arcadis (2016). *Dunmore Sand and Soil Project – Water Management Plan*. Report to Boral date 26 August 2016.

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Environmental Earth Sciences (2016) *Groundwater Level Monitoring May 2015 to May 2016 – Swamp Road Sand Quarry,* Dunmore, NSW, Report No. 115069

# ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

## Scope of services

The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

## Data should not be separated from the report

A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

## Subsurface conditions change

Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

## Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

## Obtain regulatory approval

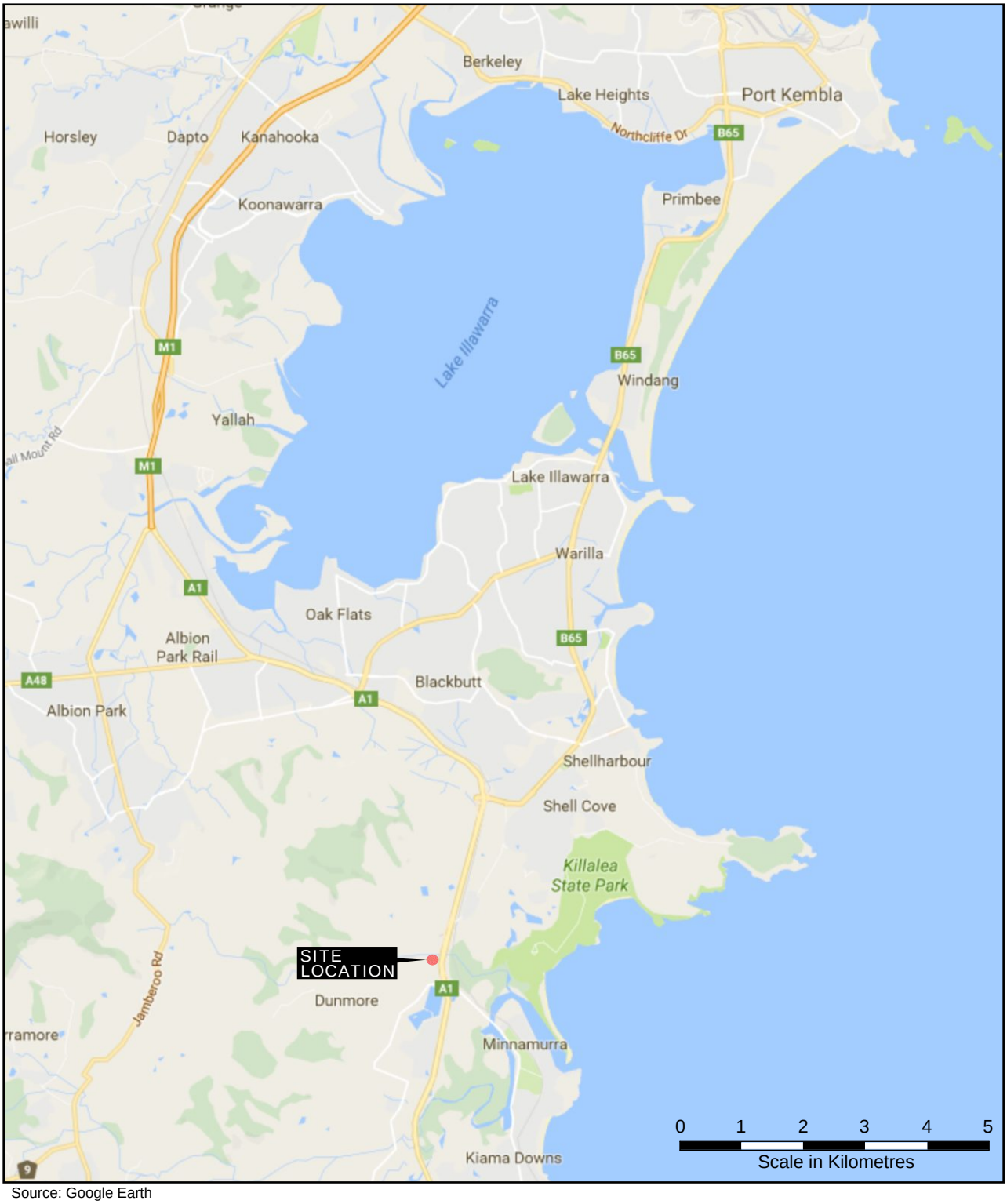
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

## Limit of liability

This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

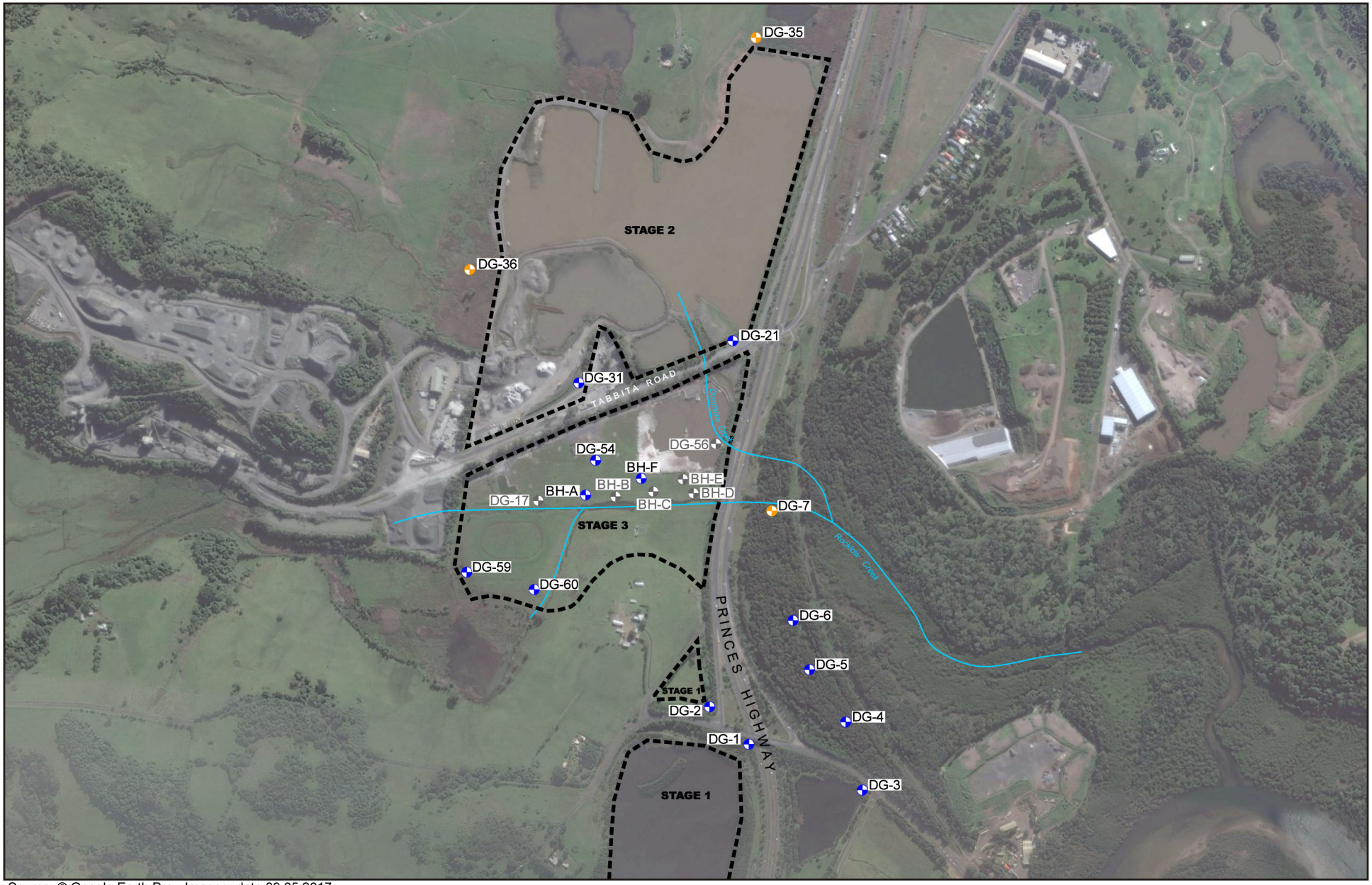
To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

# ATTACHMENT 1 FIGURES




Source: Google Earth


| | | |
|---|---|---|
| ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW | Title: **Site Locality Map** | |
| | Location: **Dunmore, Shellharbour, NSW** | |
| Client: **Dunmore Sand and Soil Pty Ltd** | | Job No: **116085** |
| Project Man: **MX** | Scale: **As Shown** | **Figure 1** |
| Drawn By: **LB** | Date: **June 2017** | |




Source: © Google Earth Pro - Imagery date 09.05.2017

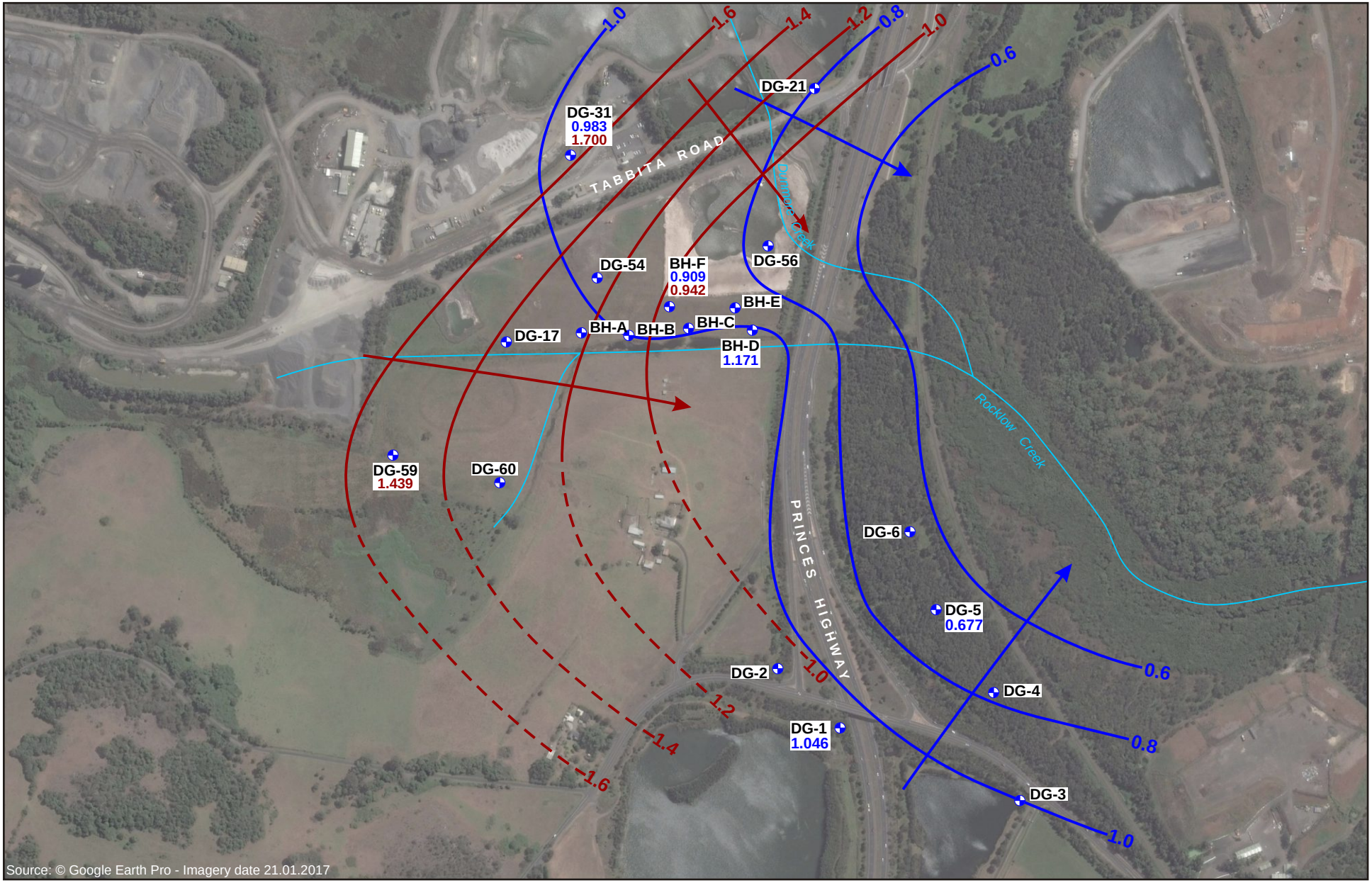
LEGEND:

- Bore location
- Decomissioned bore
- Proposed monitoring location

0 100 200 300 400 500
Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

| | | | |
|---|---|---|---|
| Title: | Site Layout and Bore Locations | | |
| Location: | Dunmore, Shellharbour, NSW | | |
| Client: | Dunmore Sand and Soil Pty Ltd | | Job No: 116085 |
| Project Man: | MX | Scale: As Shown | Figure 2 |
| Drawn By: | LB | Date: July 2017 | |




LEGEND:

- Bore location
- Inferred groundwater contour - May 2016 (mAHD)
- Inferred groundwater flow direction - May 2016
- 0.983 SWL (mAHD)
- Inferred groundwater contour - April 2017 (mAHD)
- Inferred groundwater flow direction - April 2017
- 1.700 SWL (mAHD)

0 100 200 300 400 500

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

| | |
|---|---|
| Title: | Inferred Groundwater Contours - May 2016 and April 2017 |
| Location: | Dunmore, Shellharbour, NSW |
| Client: | Dunmore Sand and Soil Pty Ltd |
| Job No: | 116085 |
| Project Man: | MX |
| Scale: | As Shown |
| Drawn By: | LB |
| Date: | June 2017 |
| Figure | 3 |

# ATTACHMENT 2 HYDROGRAPHS

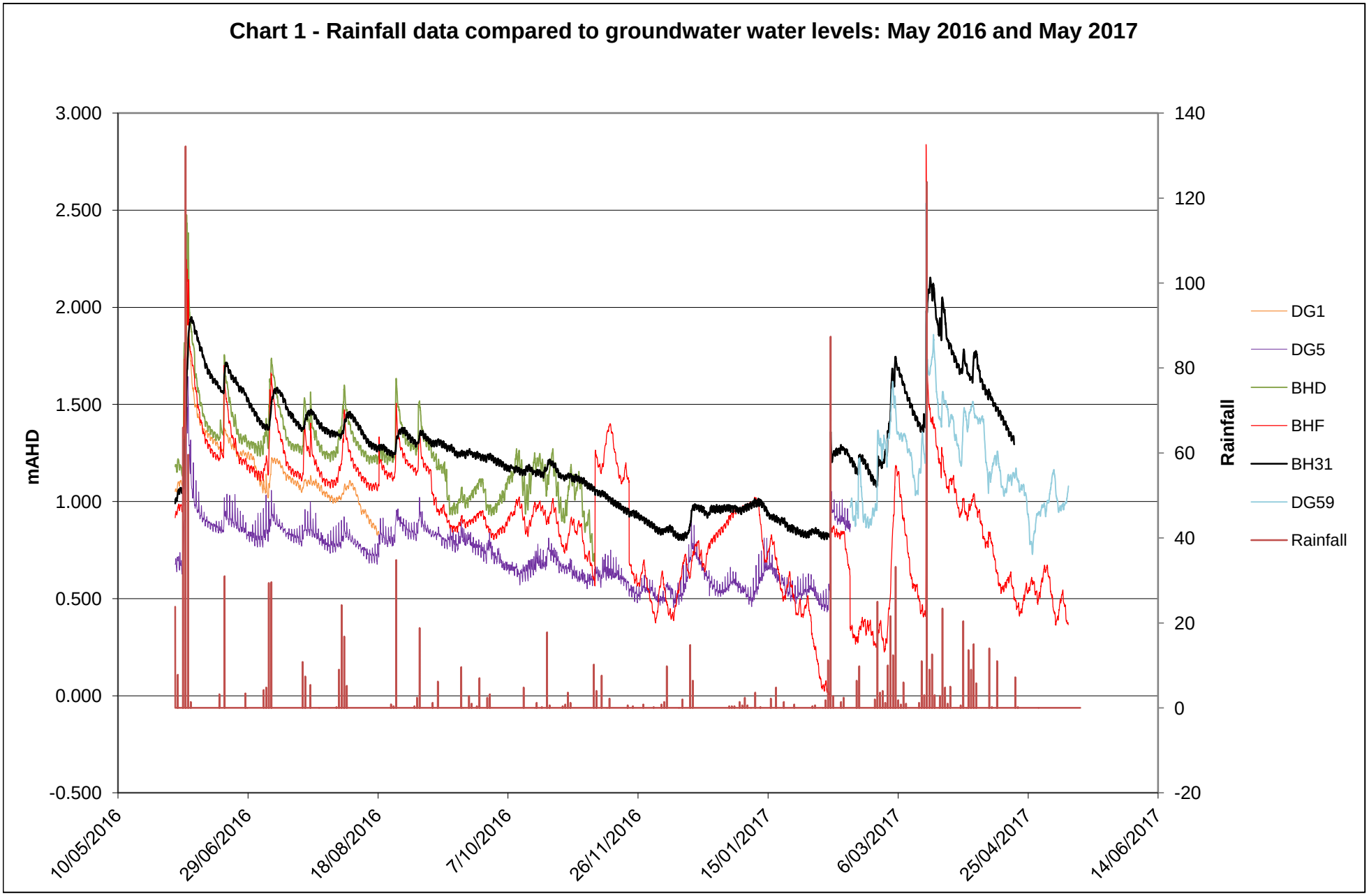


Chart 1 - Rainfall data compared to groundwater water levels: May 2016 and May 2017
mAHD
Rainfall
3.000
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
140
120
100
80
60
40
20
0
-20
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
DG1
DG5
BHD
BHF
BH31
DG59
Rainfall

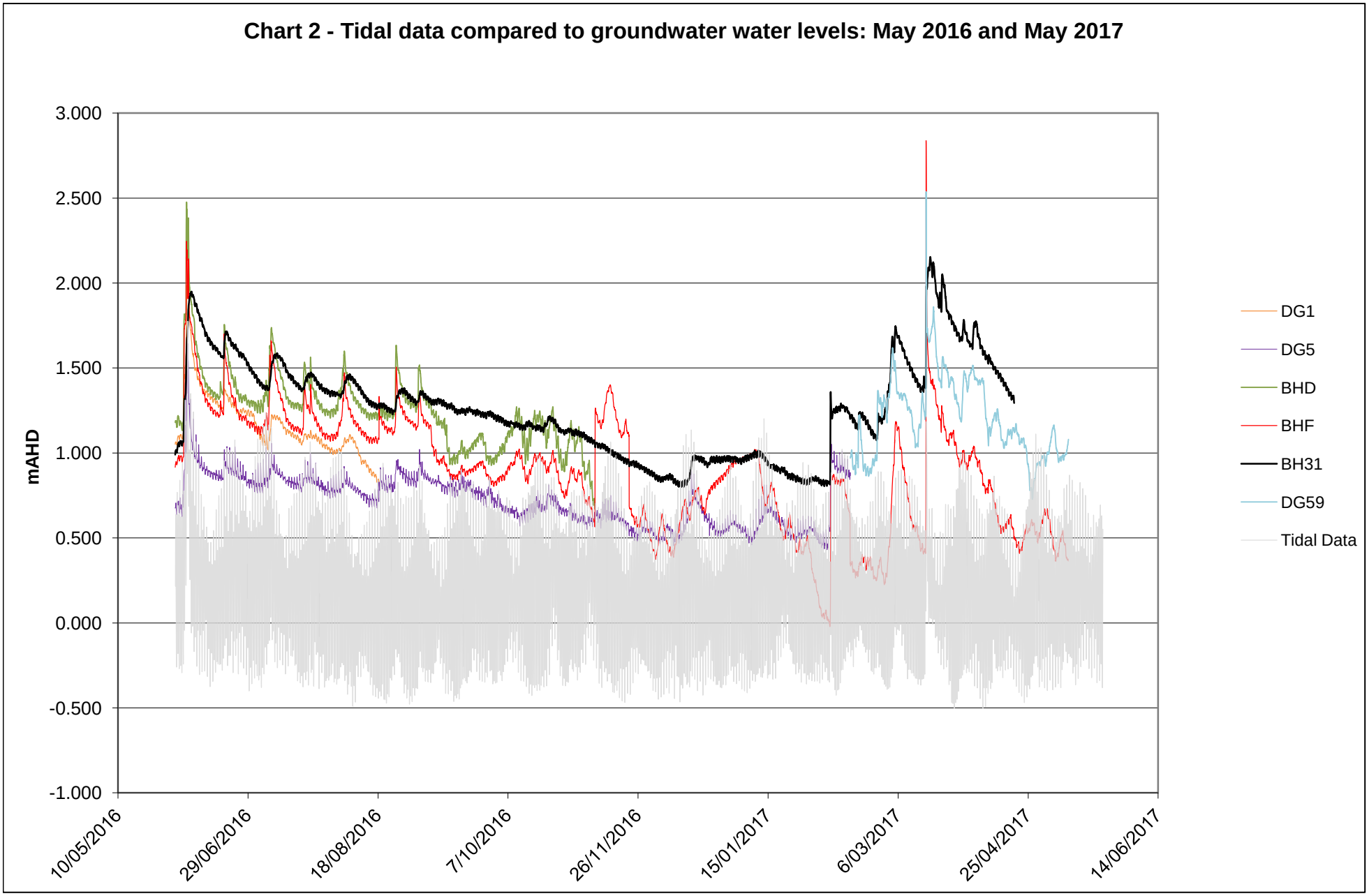


Chart 2 - Tidal data compared to groundwater water levels: May 2016 and May 2017
mAHD
3.000
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
DG1
DG5
BHD
BHF
BH31
DG59
Tidal Data

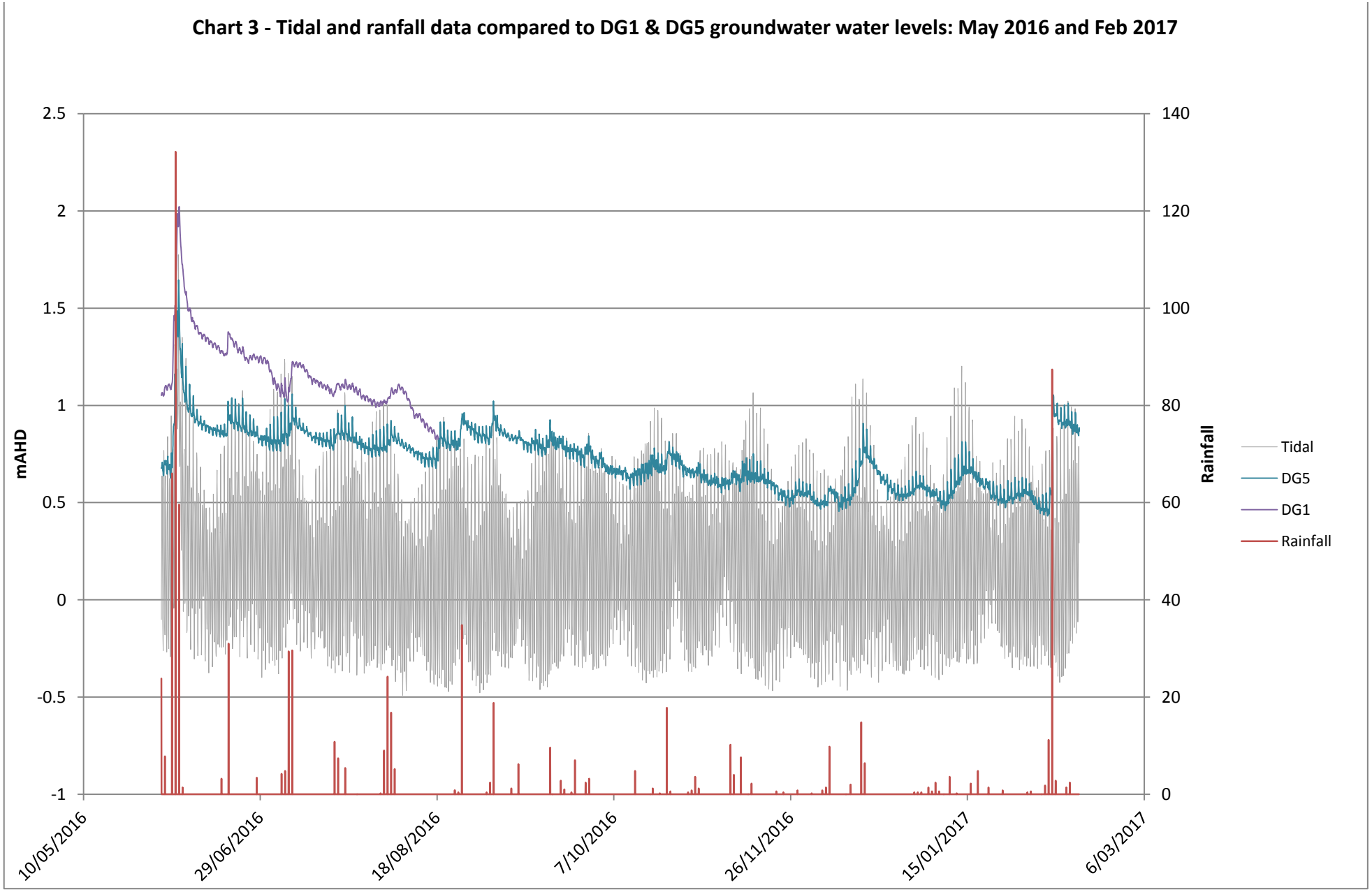


Chart 3 - Tidal and ranfall data compared to DG1 & DG5 groundwater water levels: May 2016 and Feb 2017
mAHD
Rainfall
2.5
2
1.5
1
0.5
0
-0.5
-1
140
120
100
80
60
40
20
0
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
Tidal
DG5
DG1
Rainfall

# Appendix 9 – Annual groundwater monitoring report

# 2016 - 2017 Annual Groundwater Monitoring Report

Dunmore Quarry

Prepared for Boral Resources (NSW) Pty Ltd | 28 August 2017

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# 2016 - 2017 Annual Groundwater Monitoring Report

Draft Report

Report J14050RP3 | Prepared for Boral Resources (NSW) Pty Ltd | 28 August 2017

| | | | |
|---|---|---|---|
| Prepared by | **Carolina Sardella** | Approved by | **James Duggleby** |
| Position | Senior Hydrogeologist | Position | Principal Hydrogeologist |
| Signature | | Signature | |
| Date | 28 August 2017 | Date | 28 August 2017 |



**Document Control**

| Version | Date | Prepared by | Reviewed by |
|---|---|---|---|
| V1 | 28 August 2017 | Carolina Sardella | James Duggleby |

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## Appendices



## Tables



## Figures

# 1 Introduction

Dunmore Hard Rock Quarry (the quarry) is located at the end of Tabbita Road, in the Shellharbour local government area (LGA). The quarry is owned and operated by Boral Resources (NSW) Pty Ltd (Boral).

The quarry supplies construction materials to markets in the Illawarra, Southern Highland and Sydney regions. It is estimated that approved rock reserves at the quarry will be exhausted by November 2017. A western expansion of the quarry is proposed to enable the continued delivery of aggregate until about 2034.

Hard rock extraction commenced at the quarry in the early twentieth century. The quarry comprises one elongated open cut pit with an approved disturbance area of about 100 hectares (ha) (Figure 1.1). Site infrastructure includes a crushing and screening plant, product stockpiles, workshop and site offices located east of the pit.

The proposed modification extends the existing pit to the west with the additional area referred to as the proposed Croome West pit (Figure 1.1). Staged extraction is proposed according to the forecasted demand for hard rock. The final pit will be extended both laterally and vertically with a maximum proposed pit depth of 60 metres (m) Australian Height Datum (AHD).

Water management at the quarry comprises routine groundwater monitoring and the capture of intercepted surface runoff. Captured runoff is directed into dedicated stormwater dams for storage. Stored water is utilised for site operations (dust suppression) and excess water is directed back to one of the storage dams, which has a holding capacity of 120 to 150 ML (Arcadis 2016).

EMM Consulting Pty Ltd (EMM) was engaged by Boral to characterise the hydrogeological environment and conduct groundwater monitoring and interpretation in relation to the proposed western expansion.

## 1.1 Scope of works

This annual groundwater monitoring report has been prepared as a requirement of the groundwater monitoring program (GMP) (EMM 2016). It includes analysis and interpretation of groundwater quality and groundwater level data collected since monitoring began at the Croome West monitoring bores, with emphasis on the data obtained during the last 12 months (1 July 2016 to 30 June 2017).

The scope of works was to:

- conduct groundwater monitoring, including six-hourly groundwater level measurements and six-monthly groundwater sampling events at the Croome West monitoring bores (Figure 1.1);
- analyse and interpret water level and water quality data obtained from the Croome West monitoring bores with reference to the conceptual model where relevant; and
- analyse and interpret water level and water quality data obtained from the Dunmore Sand & Soil (DSS) quarry monitoring bores located down hydraulic gradient from the current quarrying activities (Figure 1.1) (data collected by Environmental Earth Sciences).

This report also includes a review of the current monitoring network design and provides recommendations for ongoing monitoring.


Source: EMM (2017); GA (2017)

T:\Jobs\2014\J14050 - Boral Dunmore groundwater monitoring\GIS\02_Maps\G010_MonitoringBores_20170823_02.mxd 24/08/2017

KEY

- Croome West monitoring bore
- Dunmore Sand and Soil monitoring bores
- Watercourse
- Acoustic / visual bund (Mod 8)
- Mod 8 disturbance boundary
- Proposed Croome West pit extension
- Approved extraction boundary

Site location and monitoring bores

Boral Dunmore Quarry
Annual Groundwater Monitoring Report
Figure 2.1

EMM

# 2 Environmental setting

## 2.1 Site setting and topography

The regional topography rises from coastal flats in the east to a ridge which then descends to a shallow and broad valley at the foot of a larger rise to the Southern Highlands region of the Great Dividing Range in the west.

The quarry is set on a north south-west trending range. The peak is named Locking Hill, and is partially incised by the existing pit. The ridge extends along the current western quarry highwall and has an elevation of approximately 164 mAHD. The elevation of the south-east processing area is 10 mAHD.

The project area is surrounded by small agricultural plots, with cattle and horse grazing, and rural residential properties. Historically the area has been used for dairy farming. Remnant native vegetation lines the top of the prominent ridge line and exists in isolated pockets in the lower lying areas.

The DSS quarry and the Dunmore Concrete Batching Plant (CBP) are generally east of the quarry. Quaternary alluvium sediments associated with the Minnamurra River system are extracted and processed at the DSS quarry.

Approximately 1.5 kilometres (km) to the north is the Cleary Bros Bombo Pty Ltd (Cleary Bros) Albion Park Quarry. The quarry is approved to produce 900,000 tonnes per annum (tpa) and has extracted and processed hard rock from the Bumbo Latite since the 1950s (MMJ 2013). Holcim Australia Pty Ltd (Holcim) operates the Readymix Albion Park Quarry immediately west of the Cleary Bros Albion Park Quarry. This hard rock quarry also extracts a hard rock resource from the Bumbo Latite.

## 2.2 Climate

The project area is part of the Illawarra region, which is characterised by a mild/temperate climate described as warm and humid. Rainfall and climate data was obtained from the Bureau of Meteorology, Albion Park weather station (BoM 068241), which is approximately 10 km north of the quarry. Temperature and rainfall data have been collected at this monitoring station since 1999.

Temperature fluctuates throughout the year. January is the warmest month and July the coldest month. The mean, maximum, and minimum temperatures are shown in Table 3.1. The average annual rainfall is 932 mm (BoM 068241) with the most significant rainfall events generally experienced in late summer (February and March) and the lowest rainfall in late winter (August).

No evaporation data is available for the quarry. Mean monthly evaporation for the BoM Goulburn Tafe station (070263) is 105 mm and the BoM Sydney Observatory station (066062) is 89 mm. These regional evaporation results are comparable, and the average of these results suggests evaporation exceeds rainfall all year, except for May, June and July.

The cumulative deviation of monthly rainfall from the mean (from 1999 to mid 2017, Albion Park) is plotted in Figure 2.1. The long-term CDFM is generated by subtracting the long-term average monthly rainfall for the recorded period from the actual monthly rainfall and then accumulating these residuals over the assessment period. Periods of below average rainfall are represented as downward trending slopes while periods of above average rainfall are represented as upward trending slopes.

The cumulative deviation plot for Albion Park shows a period of predominantly below average or average rainfall from 1999 until late 2007, followed by a brief above average rainfall period. Since 2010 rainfall has been mostly above average (Figure 2.1).

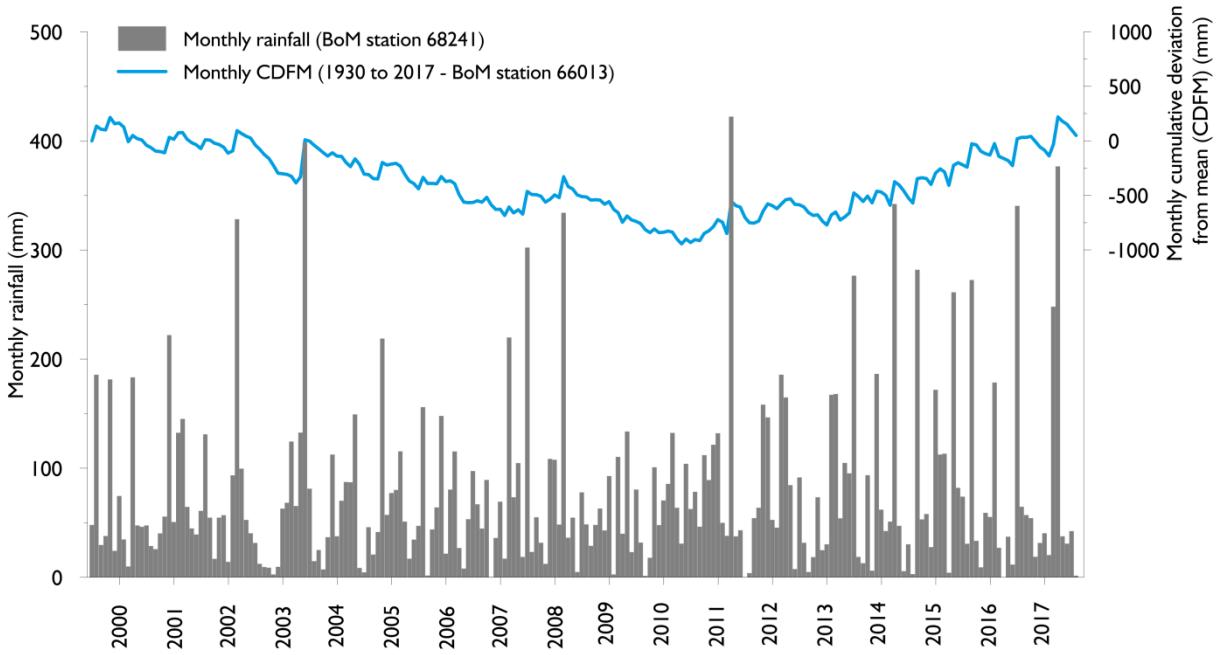



**Figure 2.1 Cumulative deviation from long term monthly mean rainfall**

Total monthly rainfall for the 2016/17 monitoring year differed from the long-term average, with a period of below average rainfall observed from July 2016 to January 2017, followed by a period of above average rainfall in February and March 2017, after which rainfall returned to be below average (Figure 2.2).

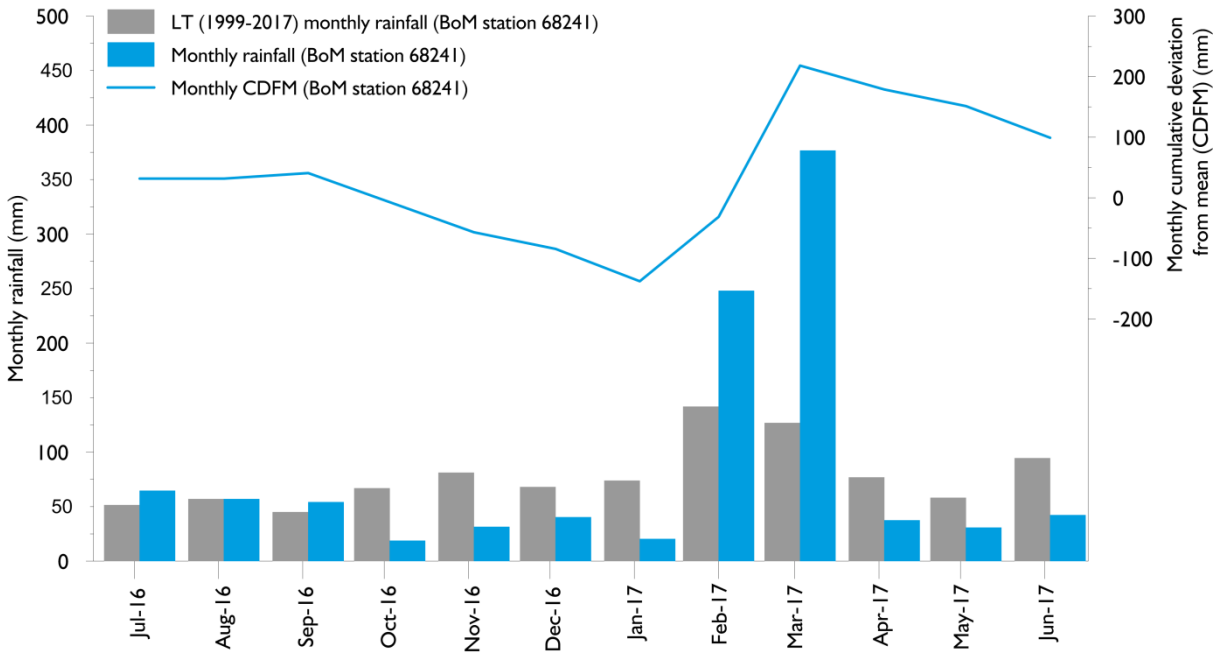



**Figure 2.2 Monthly rainfall for the 2016/17 monitoring year (June 2016 to May 2017**

## 2.3 Surface water

The quarry is in the Rocklow Creek catchment area, which forms part of the Minnamurra River Catchment. The Minnamurra River discharges into the Pacific Ocean approximately 8 km south east of the project area.

Rocklow creek is south of the quarry, flowing to the east and draining to the Minnamurra River. The Rocklow Creek catchment (21 $km^2$) originates in the Illawarra Range, 3 km west of the project area (Arcadis 2016). All clean water runoff from the project area flows into Rocklow Creek. Boral have a surface water extraction licence (No. 10SL050221 under Section 12 of the Water Act) to extract 227 ML of surface water from Rocklow Creek.

To the north of the project area is the Frasers Creek catchment area which drains to Lake Illawarra. Frasers Creek is an ephemeral system and forms disconnected pools during dry periods.

## 2.4 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$^{\circ}$ (Evans and Peck 2006; MMJ 2013).

The Gerringong Volcanics facies comprise nine latite members, and three volcanic sandstones or tuff members. 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 Gerringong Volcanics were deposited in a shallow marine environment, which was then uplifted above sea level. The area has since been eroded via river action to form the present landscape (Cohen 2006). Geological outcrop for the project area is shown in Figure 2.3.

The Bumbo Latite 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. The Bumbo Latite Member is divided into three flows: upper, middle and lower. The Bumbo Latite is a grey to dark grey, very hard dense rock with light coloured phenocrysts of feldspar (Cohen 2006). Weathered latite is generally softer with a brownish, yellow colour. The latite can be jointed and fractured, with the dominant jointing close to vertical, however jointing is not widespread (MMJ 2013).

A breccia layer was deposited between the middle and lower Bumbo Latite Member flows. This breccia layer, also comprising volcanic material, ranges in thickness between 5 to 22 m (Cohen 2006). It comprises a softer layer of fragmental, angular materials cemented in a fine grained matrix (Department of Mines 1974).

The Bumbo Latite Member overlies the Kiama Sandstone Member at the quarry. Although to the west of the quarry the Kiama Sandstone outcrops. The Kiama Sandstone has a maximum thickness of 90 m (Evans and Peck 2006). The Kiama Sandstone Member comprises tuff, and interbedded volcanic and lithic sandstones and shales. The sandstones are typically moderately sorted and the lithic material comprises

mainly andesitic to basaltic material (Department of Mines 1974). This sandstone is easily weathered and therefore not extracted for quarrying activities.

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.

## 2.5 Hydrogeology

The regional groundwater system flows south-east, governed by 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. 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.

Groundwater flow is minimal and predominantly occurs along fractures and contacts between volcanic rock and the underlying sandstone (MMJ 2013). Cleary Bros report that groundwater inflows are observed and collected in the pit sump when quarrying intersects the contact between the Bumbo Latite and Kiama Sandstone (2003).

Information from Boral suggests that the breccia layer is partially saturated and more permeable than the surrounding Bumbo Latite. Breccia generally exhibits a variable porosity with areas of higher permeability common however generally limited in their extent. There is no visual evidence of groundwater seepages to the pit with the rockface remaining dry throughout the year.

Cohen (2006) reports that there is no active mine dewatering at the two Albion Park quarries which also intersect the Bumbo Latite. Water use at these quarries constitutes only collected rainwater runoff.

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). Cohen (2006) identified the Locking Hill peak, within the project area, as a recharge area for the Bumbo Latite. Discharge from the local groundwater system occurs in the valleys and includes ephemeral springs.

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.

## 2.6 Conceptual hydrogeological model

### 2.6.1 Groundwater flow

Groundwater within the Bumbo Latite flows from 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 gives 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 are coincident with the dip of the strata.

### 2.6.2 Recharge and discharge

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

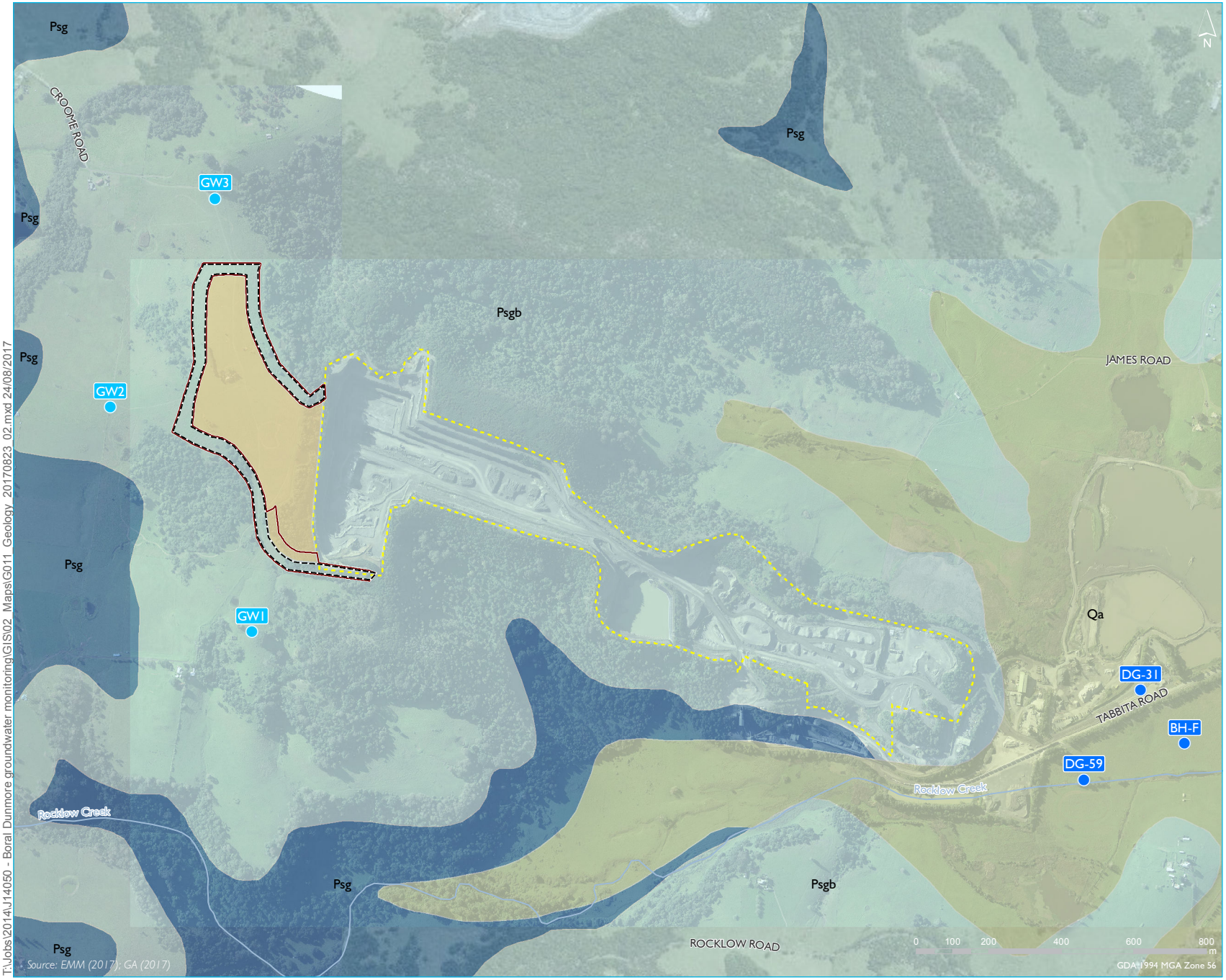
Groundwater from the shallow latite is largely thought to discharge to the Minumurra River and Rocklow Creek, which form the main drainage systems in the vicinity of the quarry.

### 2.6.3 Groundwater-surface water connectivity

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

The surface water systems to the east of the quarry in the lower parts of the ladscape (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 groundwater within the shallow latite flows through to the alluvium in the east, the volume of this flux is likely to be insignificant in comparison to the recharge from the overlying rivers.




Source: EMM (2017); GA (2017)

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KEY

- Croome West monitoring bores
- Dunmore Sand and Soil monitoring bores
- Watercourse
- Acoustic / visual bund (Mod 8)
- Mod 8 disturbance boundary
- Proposed Croome West pit extension
- Approved extraction boundary

Lithology

- Quaternary Alluvium (Qa)
- Shoalhaven Group, Bumbo Latite (Psgb)
- Shoalhaven Group, undifferentiated siltstone (Psg)

Surface geology

Boral Dunmore Quarry
Annual Groundwater Monitoring Report
Figure 2.3

EMM

# 3 Groundwater monitoring program

## 3.1 Monitoring network design

The monitoring network consists of a total of six monitoring bores (Figure 1.1 and Table 3.1). In summary:

- three deep monitoring bores were completed within the Bumbo Latite in July 2014. One monitoring bore (GW1) is screened across the latite and the top of the underlying sandstone, and one monitoring bore (GW3) is screened across the latite and the breccia. These bores are located up hydraulic gradient from current quarrying activities; and
- three shallow monitoring bores were installed and monitored as part of the DSS operations. These monitoring bores are screened in the alluvium and are located down hydraulic gradient from current quarrying activities.

Table 3.1 provides an overview of the completion details for the monitoring network.

**Table 3.1 Groundwater monitoring bore construction details**

| Monitoring bore | Total depth (mbgl) | Total depth (m AHD) | Screened interval (mbgl) | Screened interval (mAHD) | 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-F | 5.2 | 3.0 | 2.1 – 5.2 | 0.1 – -3.0 | Sand | Alluvium |
| DG-31 | tbc | tbc | tbc | tbc | Sand | Alluvium |
| DG-59 | tbc | tbc | tbc | tbc | Sand | Alluvium |

*Notes: mbgl = meters below ground level, mAHD = meters Australian Height Datum.*
*tbc – to be confirmed by Boral.*

## 3.2 Groundwater quality

Groundwater quality sampling is undertaken at the frequency detailed in Table 3.2.

**Table 3.2 Water quality monitoring program**

| Monitoring bores | Monitoring events | Monitored by |
|---|---|---|
| GW1, GW2, GW3 | December 2016 and June 2017 | EMM |
| BH-F, DG-31, DG-59 | August 2016, April and June 2017 | Environmental Earth Sciences (EES) |

### 3.2.1 Sampling technique

A low-flow sampling technique (stainless steel double-check bailer) was used to obtain groundwater quality samples from the deep monitoring bores due to the low permeability of the Bumbo Latite. A submersible pump or a bailer was used to obtain groundwater quality samples from the higher permeability shallow alluvial monitoring bores.

Physicochemical parameters (pH, electrical conductivity (EC), temperature, total dissolved solids (TDS), dissolved oxygen (DO) and oxidation reduction potential (ORP)) were measured during and following purging using a calibrated hand-held water quality meter.

### 3.2.2 Chemical analysis

Water quality samples collected from the monitoring network were analysed for a broad chemical suite designed specifically to assess the chemical characteristics of the different water bearing zones at the monitoring sites. Table 3.3 details the analytical suite.

**Table 3.3 Water quality suite of analysis**

| Grouping | Parameters | |
|---|---|---|
| Physicochemical parameters (field) | EC | Temperature |
| | pH | TDS |
| | DO | ORP |
| Major ions | Calcium[1] | Chloride |
| | Magnesium | Total alkalinity |
| | Sodium | Sulphate |
| | Potassium | Silica[1] |
| Dissolved metals | Aluminium[1] | Iron |
| | Arsenic[1] | Manganese[1] |
| | Cadmium[1] | Nickel[1] |
| | Chromium[1] | Zinc[1] |
| | Copper[1] | |
| Nutrients | Ammonia | Total nitrogen |
| | Nitrate | Total phosphorus |
| | Nitrite | |

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

The samples collected by EMM were analysed by Australian Laboratory Services (ALS) in Smithfield, while the samples collected by EES were analysed by the Boral Construction Materials Technical Services in Winston Hills, both NATA accredited laboratories.

Water samples for laboratory analysis were collected in sample bottles specified by the laboratory, with appropriate preservation where required. Samples undergoing total or dissolved metal analysis were filtered through 0.45 µm filters in the field prior to collection.

### 3.2.3 Quality assurance and quality control (QA/QC)

Field sampling procedures conformed to EMM's QA/QC protocols to prevent cross-contamination and preserve sample integrity. The following QA/QC procedures were applied:

- samples were collected in clearly labelled bottles with appropriate preservation solutions;
- samples were delivered to the laboratories within the specified holding times; and
- unstable parameters were analysed in the field (physiochemical parameters).

### i Laboratory QA/QC

The laboratories conduct their own internal QA/QC program to assess the repeatability of the analytical procedures and instrument accuracy. These programs include analysis of laboratory sample duplicates, spike samples, certified reference standards, surrogate standards/spikes and laboratory blanks. In addition, a duplicate sample is collected in the field for every ten samples collected to assess sampling and laboratory analysis accuracy.

## 3.3 Groundwater levels

Following completion of the deep monitoring bores in July 2014, pressure transducers (Solinst dataloggers) were installed in the water column and programmed to record a groundwater level every six hours. To verify the level recorded by the dataloggers, manual measurements were recorded during each six-monthly monitoring event (December 2016 and June 2017) using an electronic dip meter.

Dataloggers were installed by EES in monitoring bores BH-F in October 2013, in DG-31 in May 2016 and in DG-59 in February 2017. These dataloggers were programmed to record a groundwater level every hour. Manual measurements were recorded periodically since installation.

# 4 Groundwater levels

Hydrographs showing groundwater levels and rainfall from the start of monitoring until June 2017 are presented in Figure 4.1. Individual hydrographs for each monitoring bore are included in Appendix A.

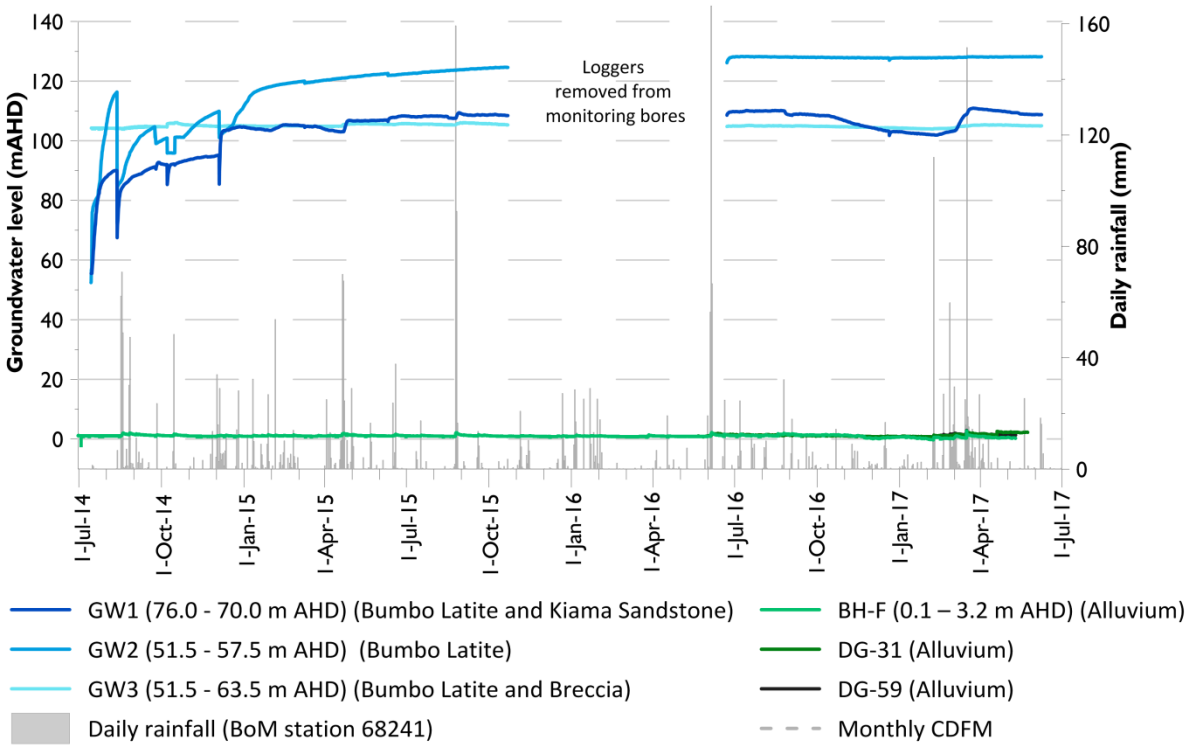



**Figure 4.1 Groundwater levels**

## 4.1.1 Alluvium

Groundwater levels in the alluvium (BH-F, DG-31 and DG-59) are shallow (less than 1 mbgl (3 mAHD)) and show a direct response to rainfall and minor tidal influx (EES 2017) (Figure 4.2).

During the monitoring year, groundwater levels increased in response to the high rainfall events in March 2017, after which they receded to pre-rainfall levels. The water levels receded to pre-rainfall levels in less than a month at BH-F and DG-59 and over a period of up to two months at DG-31 (Figure 4.2).

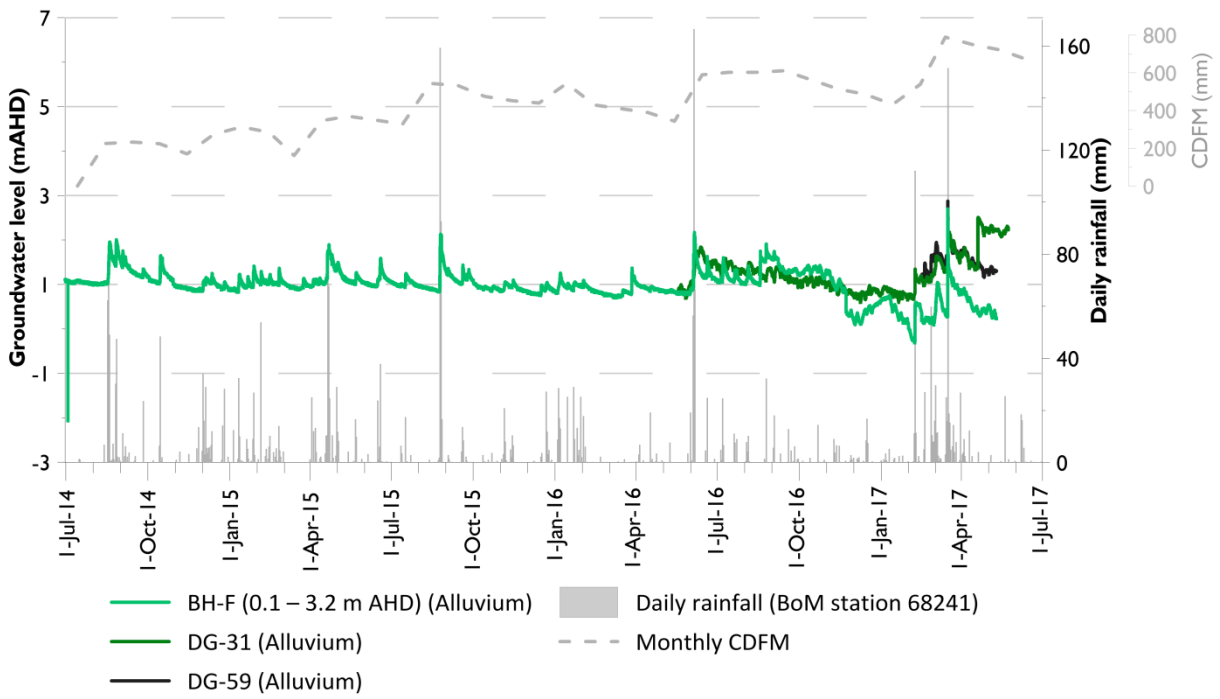



**Figure 4.2 Groundwater levels in the alluvium**

### 4.1.2 Bumbo Latite

Groundwater levels in the Bumbo Latite monitoring bores vary spatially between the three monitoring bores. The groundwater level elevation is the highest at monitoring bore GW2 (128 mAHD) and lower at monitoring bores GW1 (between 100 mAHD and 110 mAHD) and GW3 (105 m AHD). This suggests that there is a potential downward hydraulic gradient form the Bumbo Latite to the underlying Kiama Sandstone and towards the Breccia.

The groundwater levels at GW1 (partially screened in the underlying Kiama Sandstone) and GW2 (screened entirely in the Bumbo Latite) show a very slow recovery (longer than 1 year) after installation. This slow recovery is due to the very low permeability of the Bumbo Latite formation at these locations (between $1.93 \times 10^{-8}$ m/day and $6.39 \times 10^{-8}$ m/day (EMM 2014)).

The groundwater level at monitoring bore GW2 (partially screened in the Breccia) recovered immediately after installation. This is consistent with the permeability measured at this locations ($8.93 \times 10^{-7}$ m/day (EMM 2014)) information from Boral which suggests that the Breccia is more permeable than the surrounding Bumbo Latite (Section 2.5).

A pronounced and delayed response to rainfall is observed at monitoring bores GW1 and GW3, with an increase of approximately 7 m and 2 m respectively in response to the March 2017 rainfall events, followed by a decrease in groundwater levels over a period of two months. The response to rainfall indicates slow and delayed recharge after high rainfall periods consistent with the conceptual model.

Monitoring bore GW2 shows little apparent response to individual rainfall events (approximately 0.4 m increase).

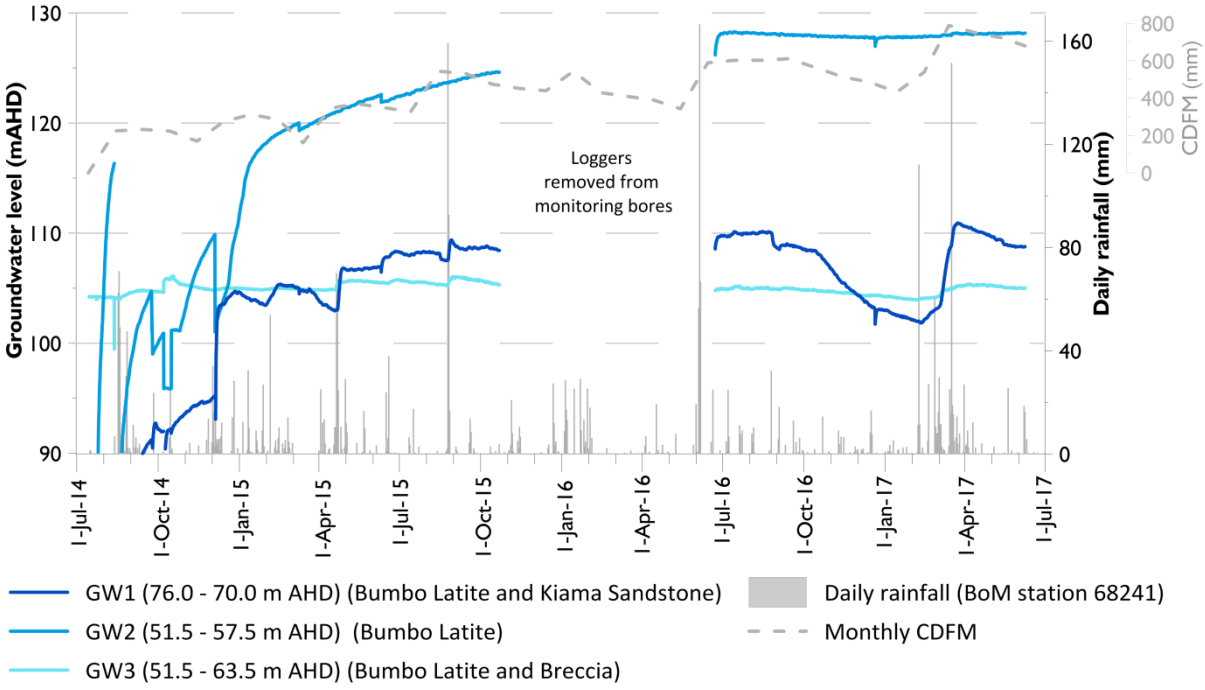



**Figure 4.3 Groundwater levels in the Bubmo Latite**

## 4.2 Spatial trends

The data collected to date suggest that the groundwater within the Bumbo Latite flows from areas of high relief towards the valleys and low lying plains where it discharges to the alluvium and surface watercourses in accordance with the conceptual model (Section 2.6).

Groundwater flow within the alluvium is in an easterly direction, locally towards BH-F and regionally towards the ocean.

# 5 Groundwater quality

Water quality results for the 2016/17 monitoring year are summarised in this chapter and are compared to previous monitoring years. The 2016/17 monitoring year full water quality results are presented in Appendix B and laboratory results in Appendix C.

## 5.1 Groundwater quality

### 5.1.1 Field parameters

Time series of field EC and pH are presented in Figure 5.1 and Figure 5.2.

Groundwater sampled from the alluvial monitoring bores is fresh (BH-F) to brackish (DG-31 and DG-59) and has slightly acidic (BH-F) to slightly basic pH (DG-59).

Groundwater sampled from the Bumbo Latite monitoring bores is marginal (GW3) to brackish (GW1 and GW2) and has near neutral to alkaline pH.

Groundwater EC and pH were overall comparable to previous monitoring years.

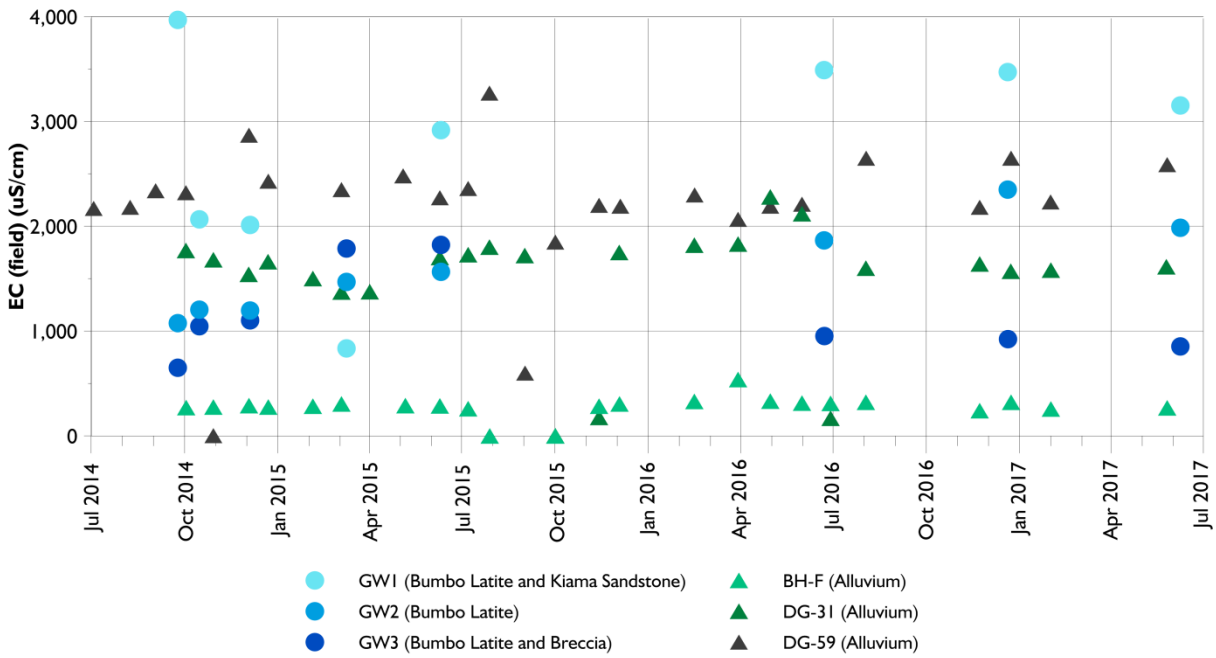



**Figure 5.1 EC time series for the alluvium and Bumbo Latite monitoring bores**

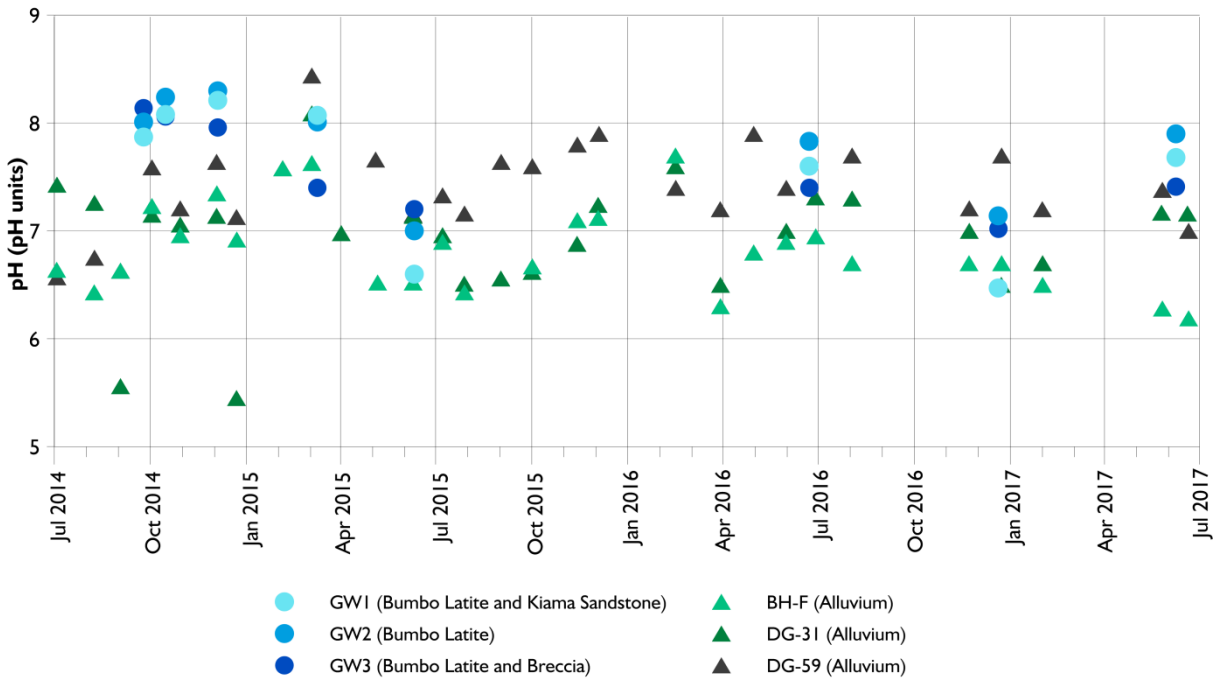



**Figure 5.2 pH time series for the alluvium and Bumbo Latite monitoring bores**

### 5.1.2 Major ions

The major ion characteristics of groundwater samples for the Bumbo Latite monitoring bores for this monitoring year are shown in a piper diagram Figure 5.3. A piper diagram is a graphical representation of the relative concentrations of major ions ($Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $K^{+}$, $Cl^{-}$, $HCO_3^{-}$, $CO_3^{2-}$ and $SO_4^{2-}$). Not all major ions were analysed for the DSS quarry monitoring bores, therefore it was not possible to include these results on the piper plot.

Groundwater at the majority of monitoring sites is typically dominated by sodium and bicarbonate, although, groundwater at the GW3 is a mixed ion, Na-Mg--$HCO_3$ type water. Groundwater with sodium and bicarbonate dominant ions is typically found in deeper portions of aquifers.

Silica concentrations at the Bumbo Latite monitoring bores are elevated, reflecting the mineralogy of the host rock.

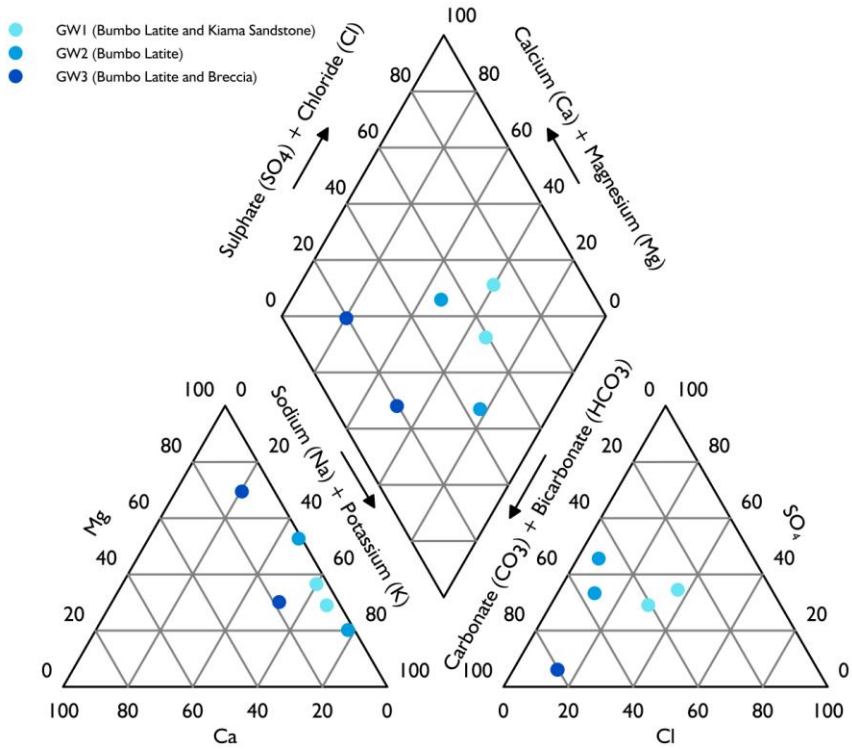



**Figure 5.3 Piper plot of groundwater for the Bumbo Latite monitoring bores (2016/17 monitoring year)**

### 5.1.3 Dissolved metals

Concentrations of dissolved metals in groundwater are presented in Figure 5.4. The major findings for dissolved metals for this monitoring year are as follows:

- dissolved metal concentrations in the alluvium were comparable to previous years and are generally the highest at monitoring bores BH-F and DG-31; and
- dissolved metal concentrations in the Bumbo Latite were comparable to previous monitoring years and overall comparable amongst the thee monitoring bores.

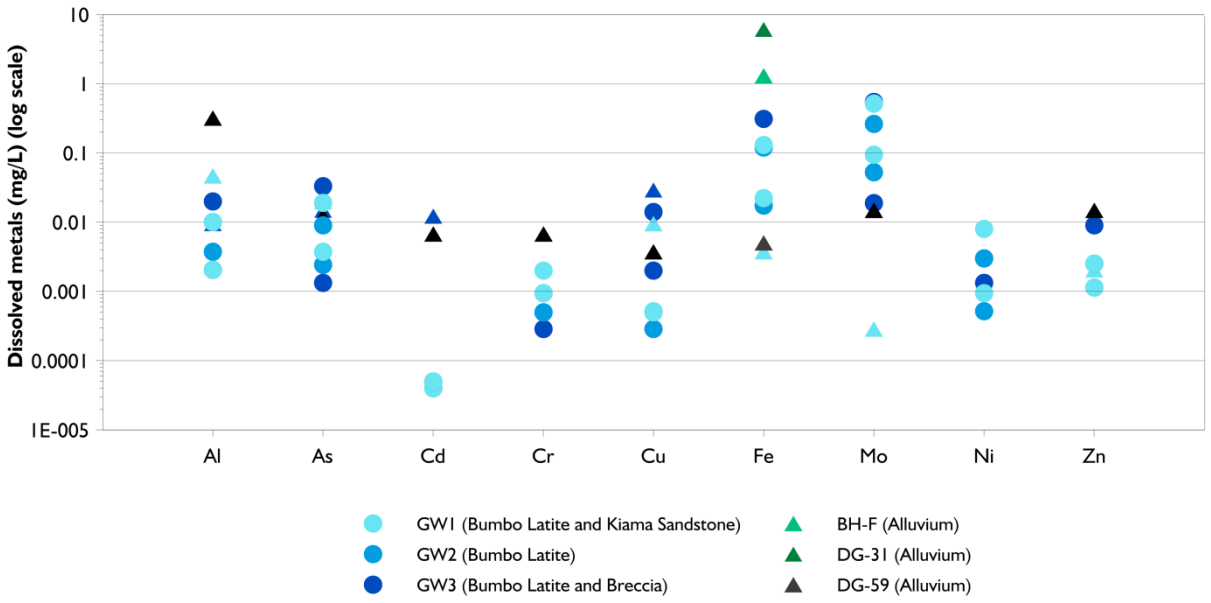



**Figure 5.4** **Dissolved metal concentrations for the alluvium and Bumbo Latite monitoring bores (2016/17 monitoring year)**

### 5.1.4 Nutrients

Time series of nitrate and total phosphorous concentrations are presented in Figure 5.5 and Figure 5.6 respectively.

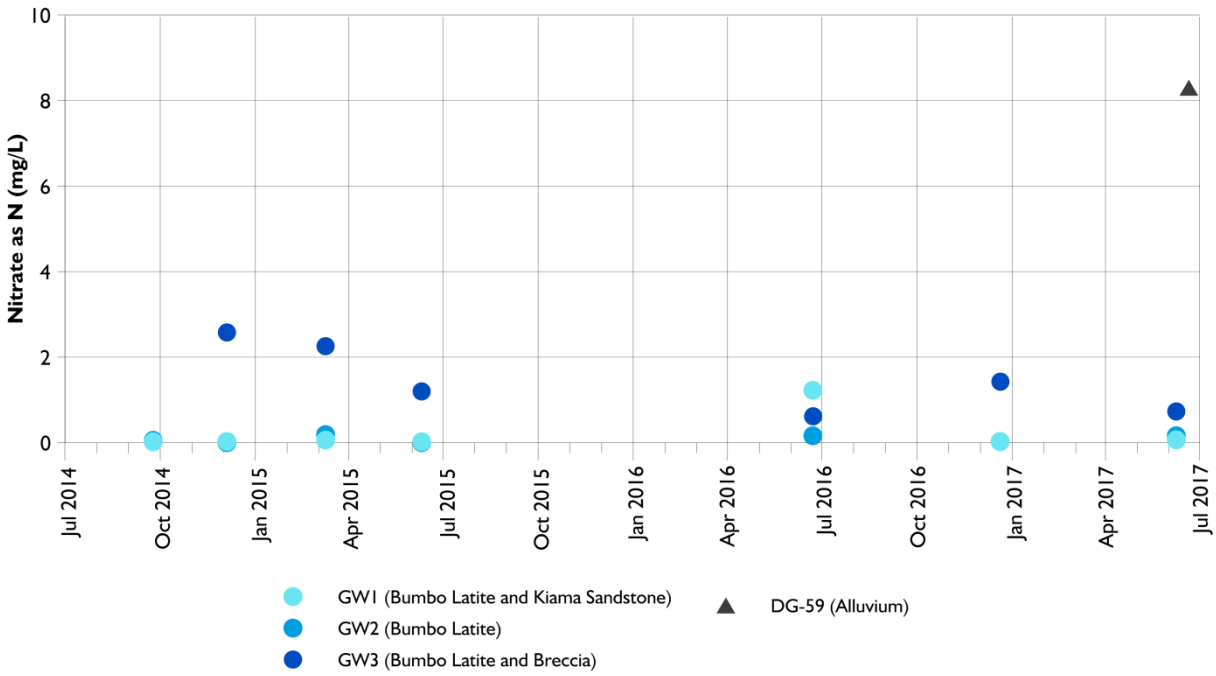



**Figure 5.5** **Nitrate time series for alluvial monitoring bore DG-59 and Bumbo Latite monitoring bores**

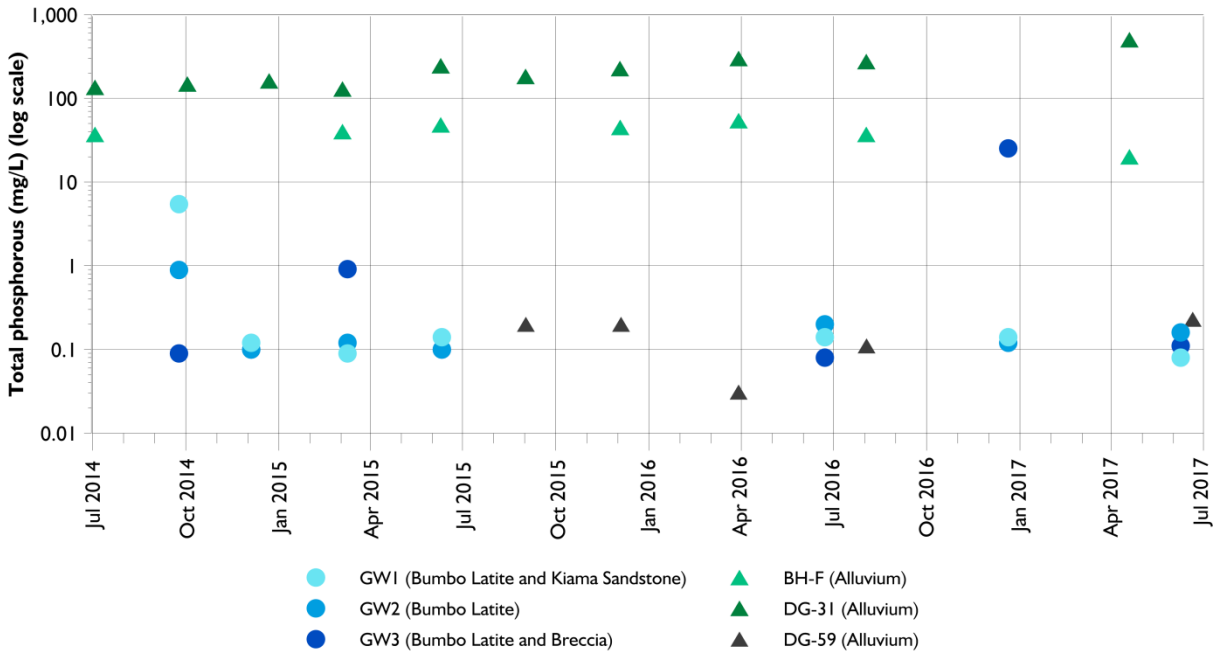



**Figure 5.6 Total phosphorous time series for the alluvium and Bumbo Latite monitoring bores**

The major findings for nutrients are as follows:

- nutrient concentrations are generally detected at higher concentrations in the alluvium compared to the Bumbo Latite;
- nitrate concentrations at the Bumbo Latite monitoring bores were comparable to previous monitoring years, with the highest concentrations detected at GW3. Only one measurement of nitrate concentrations is available for the alluvial monitoring bores (DG-59 in June 2017) indicating nitrate concentrations of an order of magnitude higher than in the Bumbo Latite;
- total phosphorous concentrations were comparable to previous monitoring years, with the exception of GW3, where concentrations were the highest recorded since monitoring commenced in the Bumbo Latite. Overall the highest concentrations were detected at alluvial monitoring bores BH-F and DG-31; and
- ammonia concentrations were overall comparable to previous monitoring years, with the exception of DG-59, where ammonia concentrations were an order of magnitude higher than previously measured.

# 6 Conclusions and recommendations

Groundwater levels are recorded every six-hours allowing water level trends to be identified in the alluvium and the Bumbo Latite. Six monthly sampling of water quality at all sites also established useful trends.

The main findings for the 2016/17 monitoring year in regards to **water levels** are:

- groundwater levels in the alluvium at the DSS site are less than 1 mbgl and show a direct response to rainfall and minor tidal influences;

- groundwater levels in the Bumbo Latite monitoring bores vary spatially between the three monitoring bores. Groundwater levels are the highest at monitoring bore GW2 (128 mAHD) and lower at monitoring bores GW1 (between 100 mAHD and 110 mAHD) and GW3 (105 m AHD). A pronounced and delayed response to rainfall is observed at monitoring bores GW1 and GW3, with an increase of approximately 7 m and 2 m respectively in response to the March 2017 rainfall events, followed by a decrease in groundwater levels over a period of two months. The response to rainfall indicates slow and delayed recharge after high rainfall periods consistent with the conceptual model.

The main findings for this monitoring year in regards to **water quality** are:

- groundwater quality in the alluvium at the DSS site is fresh to brackish and of slightly acidic to slightly basic pH. Dissolved metals are detected at overall low concentrations and nutrients are detected at slightly elevated concentrations. Groundwater quality was overall comparable to results from the previous monitoring years; and

- groundwater quality in the Bumbo Latite is marginal to brackish, of near neutral to alkaline pH. Groundwater in the latite is dominated by sodium and bicarbonate and is elevated in silica reflecting the mineralogy of the host rock. Dissolved metals and nutrients are detected at overall low concentrations. Groundwater quality was overall comparable to results from the previous monitoring years.

The results for the 2016/17 monitoring year are in agreement with the conceptual model for the project.

It is recommended that groundwater level monitoring continues at current six-hourly frequency and that groundwater quality monitoring continues at the six-monthly frequency at the Croome West and the DSS monitoring bores.

# References


Arcadis 2016, *Dunmore Hard Rock Quarry Project, Water Management Plan*.

Cohen 2006, *Shellharbour/Kiama regional hard rock resource review groundwater assessment study*, NSW Government – Department of Planning.

Department of Mine 1974, *Geology of the Wollongong, Kiama and Robertson 1:50,000 Sheets*.

EES 2017, *Annual report on groundwater level monitoring at the Swamp Road Quarry, Dunmore NSW – May 2016 to May 2017*. Prepared for Boral Dunmore Sand and Soils Pty Ltd, dated 16 June 2017.

EMM 2016, *Groundwater Monitoring Program for Dunmore Hard Rock Quarry*, Prepared for Boral Dunmore Quarry, dated 18 November 2016.

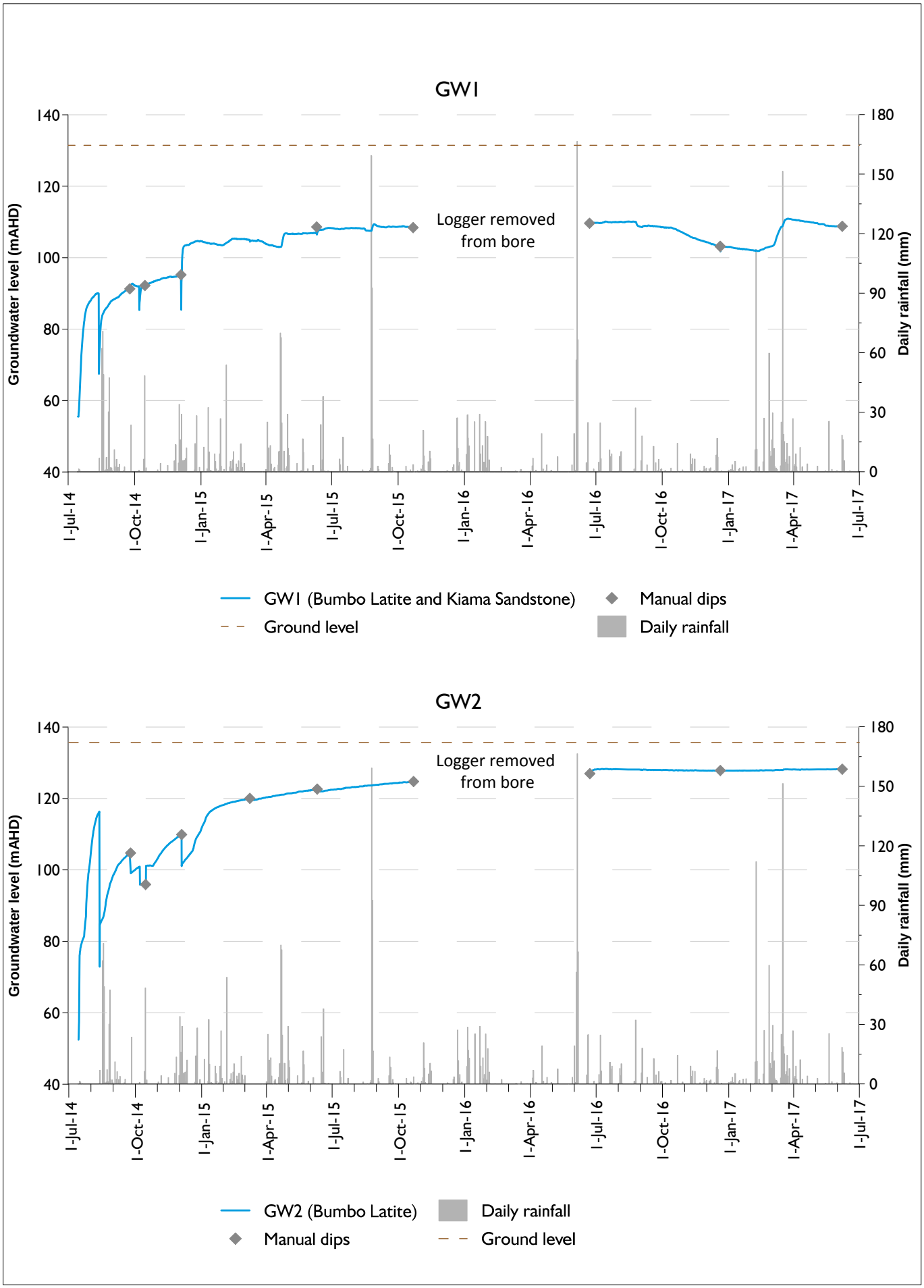
Evans and Peck 2006, *Statement of Environmental Effects, Section 4 Water Management, Dunmore Hardrock Quarry extension*.

MMJ Wollongong (MMJ) 2013, *Environmental Assessment, Modification of Development Consent 10639 of 2005 Albion Park Quarry*.

Walker G., Gilfedder M., Evans R., Dyson P., Stauffacher M. 2003, *Groundwater Flow Systems Framework – Essential Tools for Planning Salinity Management*, Murray Darling Basin Commission and CSIRO Land and Water.

# Appendix A

## Groundwater hydrographs




**GW1 and GW2 hydrographs**

Boral Dunmore Quarry
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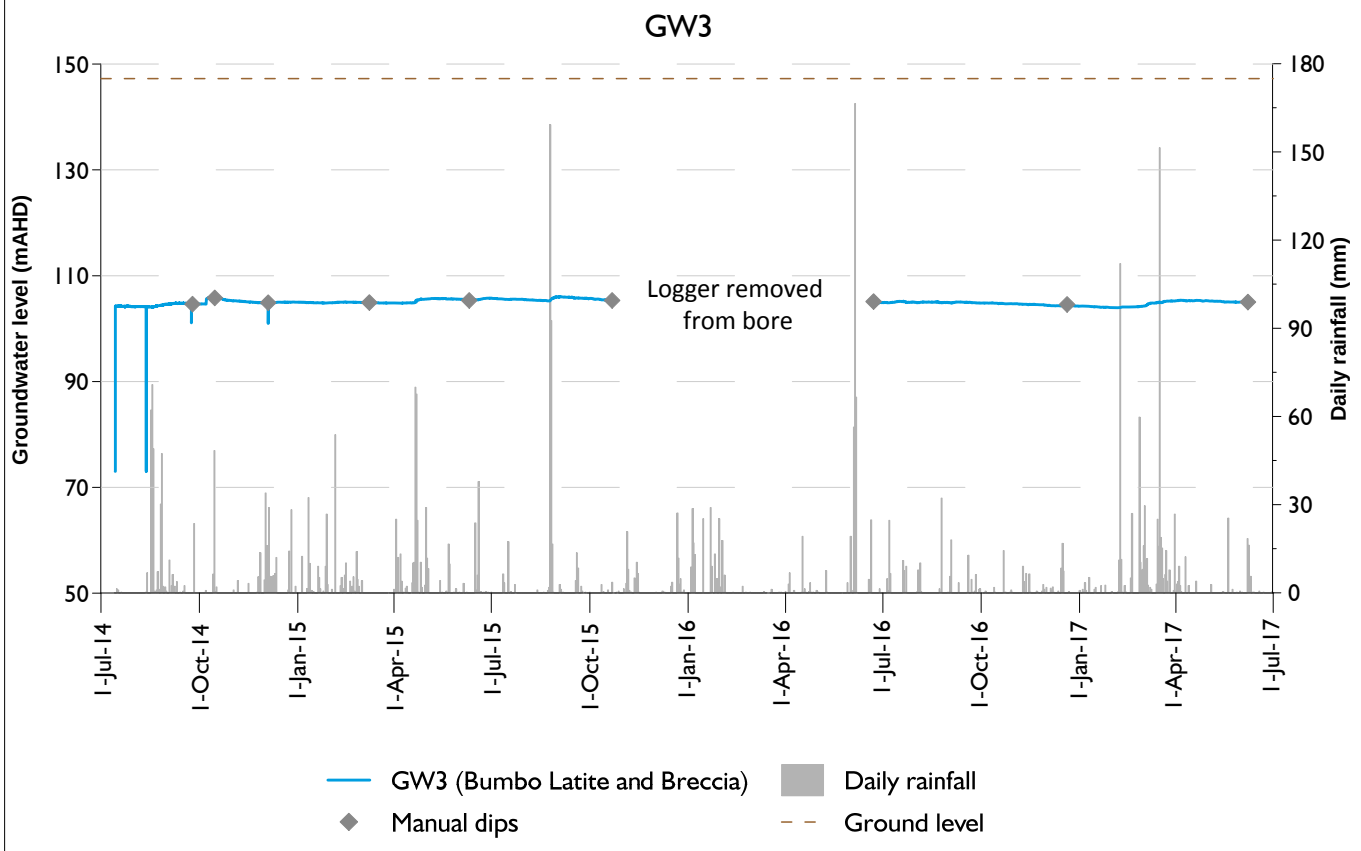
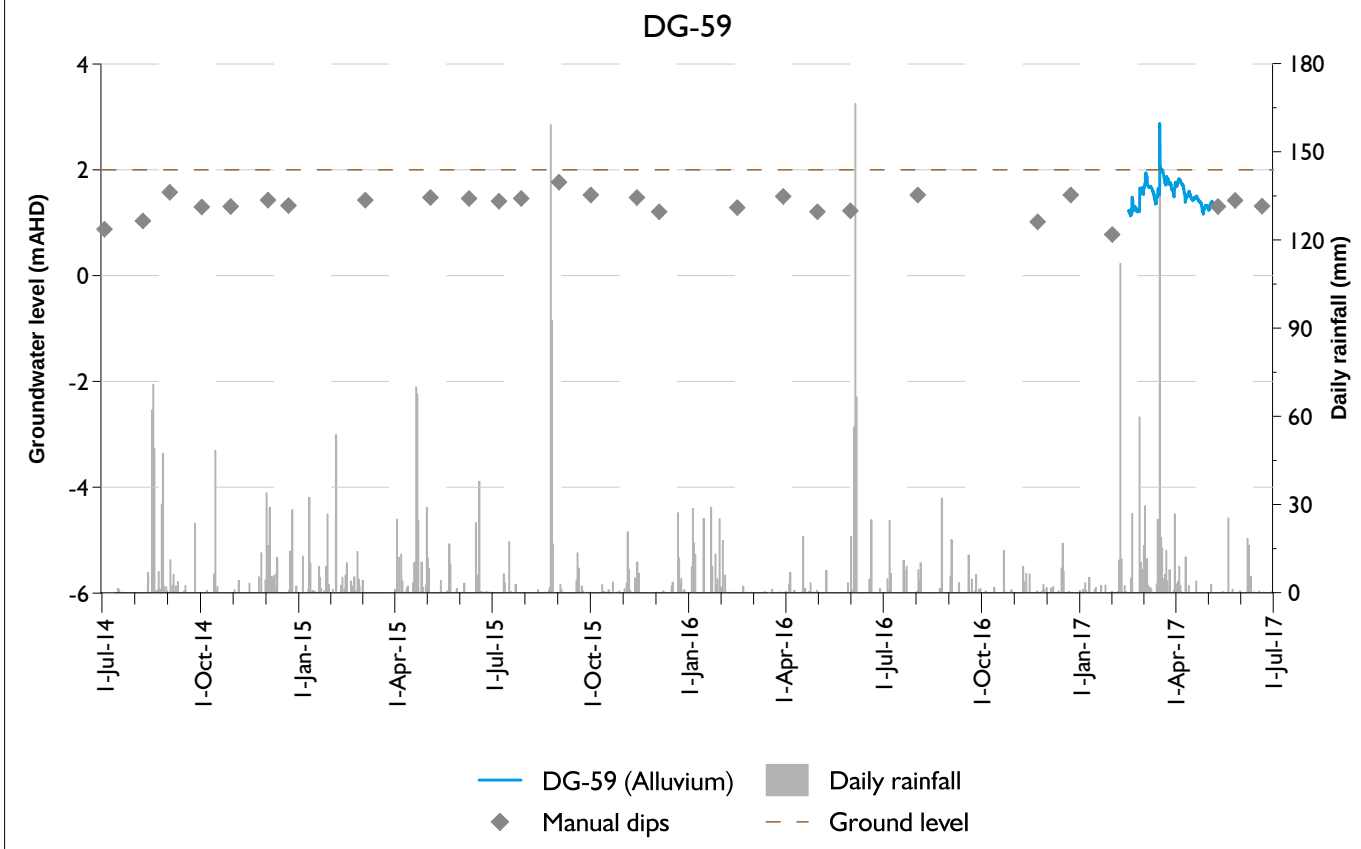
Figure A.1



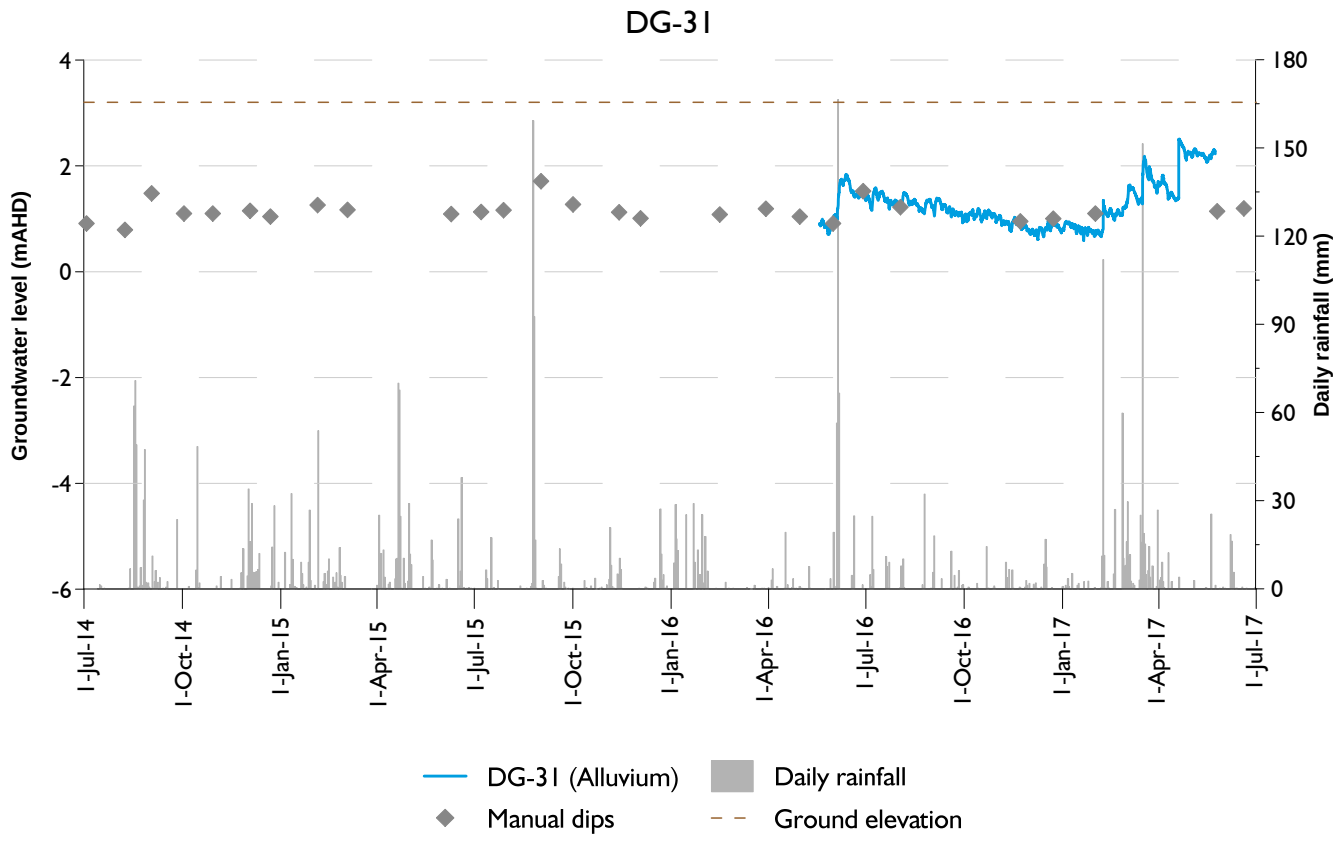



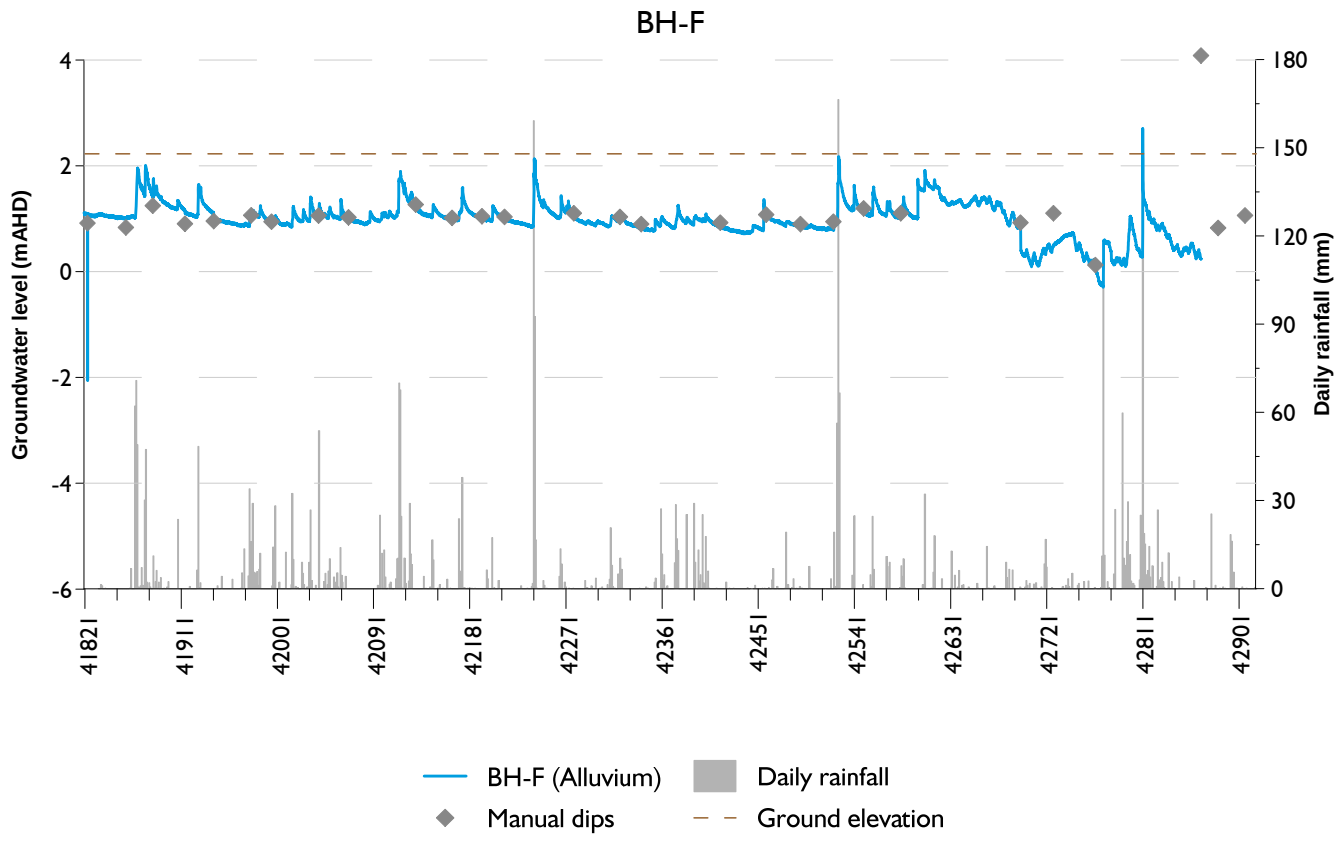

**GW3 and DG-59 hydrographs**

Boral Dunmore Quarry

2016-2017 Annual Groundwater Monitoring Report

Figure A.2




**DG-31 and BH-F hydrographs**

Boral Dunmore Quarry
2016-2017 Annual Groundwater Monitoring Report
Figure A.3

# Appendix B

## Water quality summary tables

## Appendix B.1 - Water quality results for the Croome West monitoring bores

| | | | Sample ID | GW1 | GW1 | GW2 | GW2 | GW3 | GW3 |
|---|---|---|---|---|---|---|---|---|---|
| | | | Date | 20/12/2016 | 8/06/2017 | 20/12/2016 | 8/06/2017 | 20/12/2016 | 8/06/2017 |
| **Chem_Grou** | **ChemName** | **Units** | **EQL** | | | | | | |
| Field | pH (field) | pH units | | 6.47 | 7.68 | 7.14 | 7.9 | 7.02 | 7.41 |
| | Electrical conductivity (field) | uS/cm | | 3470 | 3154 | 2350 | 1987 | 923 | 852 |
| | Temperature (field) | °C | | 19 | 16.4 | 20.8 | 18.1 | 20.6 | 17.9 |
| | Dissolved oxygen (field) | % | | 15.1 | 23.7 | 18.4 | 20.8 | 19.3 | 27.3 |
| | Dissolved oxygen | mg/L | | 1.38 | 2.3 | 1.63 | 1.95 | 1.78 | 2.58 |
| | Total dissolved solids (field) | mg/L | | 2255 | 2047 | 1527 | 1293 | 598 | 552 |
| | Redox (field) | mV | | -142.8 | -147.2 | -112 | -170.4 | 3.2 | 17.3 |
| | Total dissolved solids (lab) | mg/L | | 2255 | - | 1527 | - | 598 | - |
| Laboratory | Alkalinity (Hydroxide) as CaCO3 | mg/L | 1 | <1 | <1 | <1 | <1 | <1 | <1 |
| | Alkalinity (total) as CaCO3 | mg/L | 1 | 403 | 428 | 376 | 342 | 262 | 247 |
| | Bicarbonate Alkalinity-mg CaCO3/L | mg/L | 1 | 403 | 428 | 376 | 342 | 262 | 247 |
| | Calcium | mg/L | 1 | 384 | 195 | 100 | 83 | 62 | 49 |
| | Carbonate Alkalinity-mg CaCO3/L | mg/L | 1 | <1 | <1 | <1 | <1 | <1 | <1 |
| | Chloride | mg/L | 1 | 719 | 448 | 73 | 100 | 63 | 59 |
| | Magnesium | mg/L | 1 | 24 | 17 | 4 | 5 | 23 | 18 |
| | Potassium | mg/L | 1 | 3 | 2 | 1 | 2 | <1 | <1 |
| | Silicon as SiO2 | mg/L | 0.1 | 21.9 | 27.1 | 25 | 24.6 | 33.4 | 34 |
| | Sodium | mg/L | 1 | 755 | 514 | 378 | 365 | 88 | 96 |
| | Sulfate as SO4 - Turbidimetric | mg/L | 1 | 921 | 586 | 690 | 396 | 38 | 36 |
| Dissolved | Aluminium | mg/L | 0.01 | 0.01 | <0.01 | 0.01 | 0.01 | 0.02 | <0.01 |
| | Arsenic | mg/L | 0.001 | 0.019 | 0.01 | 0.009 | 0.006 | 0.033 | 0.003 |
| | Cadmium | mg/L | 0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | Chromium | mg/L | 0.001 | 0.002 | 0.002 | <0.001 | 0.002 | <0.001 | <0.001 |
| | Copper | mg/L | 0.001 | <0.001 | 0.001 | <0.001 | <0.001 | 0.002 | 0.047 |
| | Iron | mg/L | 0.05 | 0.13 | 0.08 | 0.12 | 0.06 | 0.31 | <0.05 |
| | Manganese | mg/L | 0.001 | 0.514 | 0.433 | 0.263 | 0.219 | 0.544 | 0.066 |
| | Nickel | mg/L | 0.001 | 0.008 | 0.002 | 0.003 | 0.001 | 0.003 | 0.003 |
| | Zinc | mg/L | 0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.028 |
| Nutrients | Ammonia (as N) | mg/L | 0.01 | 0.26 | 0.3 | 0.18 | 0.31 | 0.17 | 0.01 |
| | Nitrite (as N) | mg/L | 0.01 | <0.01 | 0.02 | <0.01 | <0.01 | 0.01 | <0.01 |
| | Nitrate (as N) | mg/L | 0.01 | 0.02 | 0.07 | 0.03 | 0.16 | 1.43 | 0.73 |
| | Nitrite + Nitrate as N | mg/L | 0.01 | 0.02 | 0.09 | 0.03 | 0.16 | 1.44 | 0.73 |
| | Nitrogen (Total) | mg/L | 0.1 | 1 | 0.7 | 0.6 | 1 | 8.8 | 1.1 |
| | Kjeldahl Nitrogen Total | µg/L | 100 | 1000 | 600 | 600 | 800 | 7400 | 400 |
| | Total phosphorus | mg/L | 0.01 | 0.13 | 0.08 | 0.12 | 0.16 | 25.2 | 0.11 |
| Additional | Ionic Balance | % | 0.01 | 6.44 | 0.22 | 4.7 | 6.73 | 5.4 | 4.88 |
| | Anions Total | meq/L | 0.01 | 47.5 | 33.4 | 23.9 | 17.9 | 7.91 | 7.35 |
| | Cations Total | meq/L | 0.01 | 54 | 33.5 | 21.8 | 20.5 | 8.81 | 8.1 |

*Note: samples collected by EMM Consulting; EQL - laboratory estimated quantitation limit.*

## Appendix B.2 - Water quality results for the Dunmore Sand and Soil monitoring bores

| | | | Sample ID | BH-F | BH-F | BH-F | DG-31 | DG-31 | DG-31 | DG-59 | DG-59 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Date | 2/08/2016 | 19/04/2017 | 20/06/2017 | 2/08/2016 | 19/04/2017 | 19/06/2017 | 2/08/2016 | 20/06/2017 |
| **Chem_Grou** | **ChemName** | **Units** | **EQL** | | | | | | | | |
| Field | pH (field) | pH units | | 6.7 | - | 6.19 | 7.3 | - | 7.16 | 7.7 | 7 |
| | Electrical conductivity (field) | uS/cm | | 320 | - | 0.284 | 1600 | - | 1.51 | 2650 | 607 |
| | Temperature (field) | °C | | 14 | - | 20.9 | 14.6 | - | 21.68 | 13.7 | 19.1 |
| | Dissolved oxygen (field) | % | | 42 | - | 17.7 | 52.3 | - | 27.2 | 51.3 | 16.5 |
| | Dissolved oxygen | mg/L | | 5.6 | - | 1.59 | 5.6 | - | 2.35 | 5.9 | 1.6 |
| | Total dissolved solids (field) | mg/L | | - | - | - | - | - | - | - | - |
| | Redox (field) | mV | | 123 | - | 212 | 159 | - | 427 | 181 | 143 |
| | Total dissolved solids (lab) | mg/L | | - | - | - | - | - | - | - | - |
| Laboratory | Alkalinity (Hydroxide) as CaCO3 | mg/L | 1 | - | - | - | - | - | - | - | - |
| | Alkalinity (total) as CaCO3 | mg/L | 1 | 73 | 27 | - | 139 | 138 | - | 705 | - |
| | Bicarbonate Alkalinity-mg CaCO3/L | mg/L | 1 | - | - | - | - | - | - | - | - |
| | Calcium | mg/L | 1 | - | - | 16 | - | - | 1112 | - | 224 |
| | Carbonate Alkalinity-mg CaCO3/L | mg/L | 1 | - | - | - | - | - | - | - | - |
| | Chloride | mg/L | 1 | 6.2 | 20 | - | 409 | 64 | - | 468 | 1396 |
| | Magnesium | mg/L | 1 | 33 | 17 | - | 92 | 86 | - | 55 | 129 |
| | Potassium | mg/L | 1 | 4.1 | 3.9 | - | 42 | 34 | - | 25 | 101 |
| | Silicon as SiO2 | mg/L | 0.1 | - | - | - | - | - | - | - | - |
| | Sodium | mg/L | 1 | 0.01 | 0.05 | - | 0.04 | 0.02 | - | 214 | 463 |
| | Sulfate as SO4 - Turbidimetric | mg/L | 1 | 0.12 | 0.13 | - | 0.02 | 0.08 | - | 98 | 509 |
| Dissolved | Aluminium | mg/L | 0.01 | - | - | 1.8 | - | - | 0.03 | - | 0.19 |
| | Arsenic | mg/L | 0.001 | - | - | 0.04 | - | - | 0.05 | - | 0.07 |
| | Cadmium | mg/L | 0.0001 | - | - | 0.02 | - | - | 0.04 | - | 0.04 |
| | Chromium | mg/L | 0.001 | - | - | 0.02 | - | - | 0.02 | - | 0.02 |
| | Copper | mg/L | 0.001 | - | - | 0.01 | - | - | 0.11 | - | 0.03 |
| | Iron | mg/L | 0.05 | 1.3 | 0.68 | - | 6.1 | 13 | - | <0.01 | 0.01 |
| | Manganese | mg/L | 0.001 | - | - | 0.05 | - | - | 0.05 | - | <0.001 |
| | Nickel | mg/L | 0.001 | - | - | - | - | - | - | - | - |
| | Zinc | mg/L | 0.005 | - | - | <0.1 | - | - | <0.1 | - | <0.01 |
| Nutrients | Ammonia (as N) | mg/L | 0.01 | <0.01 | 0.07 | - | <0.01 | 0.95 | - | <0.01 | 7.33 |
| | Nitrite (as N) | mg/L | 0.01 | - | - | - | - | - | - | - | <0.01 |
| | Nitrate (as N) | mg/L | 0.01 | - | - | - | - | - | - | - | 8.3 |
| | Nitrite + Nitrate as N | mg/L | 0.01 | - | - | - | - | - | - | - | - |
| | Nitrogen (Total) | mg/L | 0.1 | - | - | - | - | - | - | - | 20.4 |
| | Kjeldahl Nitrogen Total | µg/L | 100 | 440 | 650 | - | 1030 | 920 | - | 1100 | 12,100 |
| | Total phosphorus | mg/L | 0.01 | 37 | 20 | - | 274 | 502 | - | 0.11 | 0.23 |
| Additional | Ionic Balance | % | 0.01 | - | - | - | - | - | - | - | - |
| | Anions Total | meq/L | 0.01 | - | - | - | - | - | - | - | - |
| | Cations Total | meq/L | 0.01 | - | - | - | - | - | - | - | - |

*Note: samples collected by EMM Consulting; EQL - laboratory estimated quantitation limit.*

# Appendix C

## Laboratory reports

ALS Environmental

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Work Order** | : **ES1629492** | Page | : 1 of 4 |
| Client | : **EMM CONSULTING PTY LTD** | Laboratory | : Environmental Division Sydney |
| Contact | : MS CAROLINA SARDELLA | Contact | : Customer Services ES |
| Address | : Ground Floor Suite 1 20 Chandos Street St Leonards NSW 2065 | Address | : 277-289 Woodpark Road Smithfield NSW Australia 2164 |
| Telephone | : +61 02 9493 9500 | Telephone | : +61-2-8784 8555 |
| Project | : DUNMORE | Date Samples Received | : 21-Dec-2016 14:00 |
| Order number | : J14050 | Date Analysis Commenced | : 21-Dec-2016 |
| C-O-C number | : ---- | Issue Date | : 04-Jan-2017 15:11 |
| Sampler | : CAROLINA SARDELLA | | |
| Site | : ---- | | |
| Quote number | : SYBQ/202/15 | | |
| No. of samples received | : 4 | | |
| No. of samples analysed | : 4 | | |

ilac-MRA NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

**Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.**

## *Signatories*

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

| *Signatories* | *Position* | *Accreditation Category* |
|---|---|---|
| Ankit Joshi | Inorganic Chemist | Sydney Inorganics, Smithfield, NSW |
| Celine Conceicao | Senior Spectroscopist | Sydney Inorganics, Smithfield, NSW |
| Wisam Marassa | Inorganics Coordinator | Sydney Inorganics, Smithfield, NSW |

## General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

## Analytical Results

| Sub-Matrix: WATER (Matrix: WATER) | | | Client sample ID | GW1 | GW2 | GW3 | QA1 | ---- |
|---|---|---|---|---|---|---|---|---|
| | | | Client sampling date / time | 20-Dec-2016 08:40 | 20-Dec-2016 09:30 | 20-Dec-2016 10:15 | 20-Dec-2016 00:00 | ---- |
| Compound | CAS Number | LOR | Unit | ES1629492-001 | ES1629492-002 | ES1629492-003 | ES1629492-004 | -------- |
| | | | | Result | Result | Result | Result | ---- |
| **ED037P: Alkalinity by PC Titrator** | | | | | | | | |
| Hydroxide Alkalinity as CaCO3 | DMO-210-001 | 1 | mg/L | <1 | <1 | <1 | <1 | ---- |
| Carbonate Alkalinity as CaCO3 | 3812-32-6 | 1 | mg/L | <1 | <1 | <1 | <1 | ---- |
| Bicarbonate Alkalinity as CaCO3 | 71-52-3 | 1 | mg/L | 403 | 376 | 262 | 411 | ---- |
| Total Alkalinity as CaCO3 | ---- | 1 | mg/L | 403 | 376 | 262 | 411 | ---- |
| **ED040F: Dissolved Major Anions** | | | | | | | | |
| Silicon as SiO2 | 14464-46-1 | 0.1 | mg/L | 21.9 | 25.0 | 33.4 | 26.0 | ---- |
| **ED041G: Sulfate (Turbidimetric) as SO4 2- by DA** | | | | | | | | |
| Sulfate as SO4 - Turbidimetric | 14808-79-8 | 1 | mg/L | 921 | 690 | 38 | 648 | ---- |
| **ED045G: Chloride by Discrete Analyser** | | | | | | | | |
| Chloride | 16887-00-6 | 1 | mg/L | 719 | 73 | 63 | 466 | ---- |
| **ED093F: Dissolved Major Cations** | | | | | | | | |
| Calcium | 7440-70-2 | 1 | mg/L | 384 | 100 | 62 | 221 | ---- |
| Magnesium | 7439-95-4 | 1 | mg/L | 24 | 4 | 23 | 18 | ---- |
| Sodium | 7440-23-5 | 1 | mg/L | 755 | 378 | 88 | 582 | ---- |
| Potassium | 7440-09-7 | 1 | mg/L | 3 | 1 | <1 | 4 | ---- |
| **EG020F: Dissolved Metals by ICP-MS** | | | | | | | | |
| Aluminium | 7429-90-5 | 0.01 | mg/L | 0.01 | 0.01 | 0.02 | 0.01 | ---- |
| Arsenic | 7440-38-2 | 0.001 | mg/L | 0.019 | 0.009 | 0.033 | 0.018 | ---- |
| Cadmium | 7440-43-9 | 0.0001 | mg/L | <0.0001 | <0.0001 | <0.0001 | <0.0001 | ---- |
| Chromium | 7440-47-3 | 0.001 | mg/L | 0.002 | <0.001 | <0.001 | 0.002 | ---- |
| Copper | 7440-50-8 | 0.001 | mg/L | <0.001 | <0.001 | 0.002 | <0.001 | ---- |
| Manganese | 7439-96-5 | 0.001 | mg/L | 0.514 | 0.263 | 0.544 | 0.503 | ---- |
| Nickel | 7440-02-0 | 0.001 | mg/L | 0.008 | 0.003 | 0.003 | 0.008 | ---- |
| Zinc | 7440-66-6 | 0.005 | mg/L | <0.005 | <0.005 | <0.005 | <0.005 | ---- |
| Iron | 7439-89-6 | 0.05 | mg/L | 0.13 | 0.12 | 0.31 | <0.05 | ---- |
| **EK055G: Ammonia as N by Discrete Analyser** | | | | | | | | |
| Ammonia as N | 7664-41-7 | 0.01 | mg/L | 0.26 | 0.18 | 0.17 | 0.26 | ---- |
| **EK057G: Nitrite as N by Discrete Analyser** | | | | | | | | |
| Nitrite as N | 14797-65-0 | 0.01 | mg/L | <0.01 | <0.01 | 0.01 | 0.03 | ---- |
| **EK058G: Nitrate as N by Discrete Analyser** | | | | | | | | |
| Nitrate as N | 14797-55-8 | 0.01 | mg/L | 0.02 | 0.03 | 1.43 | 0.03 | ---- |
| **EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser** | | | | | | | | |
| Nitrite + Nitrate as N | ---- | 0.01 | mg/L | 0.02 | 0.03 | 1.44 | 0.06 | ---- |

## Analytical Results

| Sub-Matrix: WATER (Matrix: WATER) | | | Client sample ID | GW1 | GW2 | GW3 | QA1 | ---- |
|---|---|---|---|---|---|---|---|---|
| | | | Client sampling date / time | 20-Dec-2016 08:40 | 20-Dec-2016 09:30 | 20-Dec-2016 10:15 | 20-Dec-2016 00:00 | ---- |
| Compound | CAS Number | LOR | Unit | ES1629492-001 | ES1629492-002 | ES1629492-003 | ES1629492-004 | -------- |
| | | | | Result | Result | Result | Result | ---- |
| **EK061G: Total Kjeldahl Nitrogen By Discrete Analyser** | | | | | | | | |
| Total Kjeldahl Nitrogen as N | ---- | 0.1 | mg/L | 1.0 | 0.6 | 7.4 | 0.9 | ---- |
| **EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser** | | | | | | | | |
| ^ Total Nitrogen as N | ---- | 0.1 | mg/L | 1.0 | 0.6 | 8.8 | 1.0 | ---- |
| **EK067G: Total Phosphorus as P by Discrete Analyser** | | | | | | | | |
| Total Phosphorus as P | ---- | 0.01 | mg/L | 0.13 | 0.12 | 25.2 | 0.14 | ---- |
| **EN055: Ionic Balance** | | | | | | | | |
| Total Anions | ---- | 0.01 | meq/L | ---- | ---- | 7.91 | ---- | ---- |
| Total Anions | ---- | 0.01 | meq/L | 47.5 | 23.9 | ---- | 34.8 | ---- |
| Total Cations | ---- | 0.01 | meq/L | 54.0 | 21.8 | 8.81 | 37.9 | ---- |
| Ionic Balance | ---- | 0.01 | % | ---- | ---- | 5.40 | ---- | ---- |
| Ionic Balance | ---- | 0.01 | % | 6.44 | 4.70 | ---- | 4.23 | ---- |

ALS Environmental

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Work Order** | : **ES1714012** | Page | : 1 of 4 |
| Client | : **EMM CONSULTING PTY LTD** | Laboratory | : Environmental Division Sydney |
| Contact | : MS CAROLINA SARDELLA | Contact | : Customer Services ES |
| Address | : Ground Floor Suite 1 20 Chandos Street St Leonards NSW 2065 | Address | : 277-289 Woodpark Road Smithfield NSW Australia 2164 |
| Telephone | : +61 02 9493 9500 | Telephone | : +61-2-8784 8555 |
| Project | : Dunmore | Date Samples Received | : 08-Jun-2017 18:45 |
| Order number | : J14050 | Date Analysis Commenced | : 09-Jun-2017 |
| C-O-C number | : ---- | Issue Date | : 16-Jun-2017 16:12 |
| Sampler | : CAROLINA SARDELLA | | |
| Site | : ---- | | |
| Quote number | : SYBQ/202/16 | | |
| No. of samples received | : 3 | | |
| No. of samples analysed | : 3 | | |

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

**Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.**

## *Signatories*

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

| *Signatories* | *Position* | *Accreditation Category* |
|---|---|---|
| Ankit Joshi | Inorganic Chemist | Sydney Inorganics, Smithfield, NSW |
| Celine Conceicao | Senior Spectroscopist | Sydney Inorganics, Smithfield, NSW |

## General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

## Analytical Results

| Sub-Matrix: WATER (Matrix: WATER) | | | Client sample ID | GW1 | GW2 | GW3 | ---- | ---- |
|---|---|---|---|---|---|---|---|---|
| | | | Client sampling date / time | 08-Jun-2017 09:30 | 08-Jun-2017 10:30 | 08-Jun-2017 11:30 | ---- | ---- |
| Compound | CAS Number | LOR | Unit | ES1714012-001 | ES1714012-002 | ES1714012-003 | -------- | -------- |
| | | | | Result | Result | Result | ---- | ---- |
| **ED037P: Alkalinity by PC Titrator** | | | | | | | | |
| Hydroxide Alkalinity as CaCO3 | DMO-210-001 | 1 | mg/L | <1 | <1 | <1 | ---- | ---- |
| Carbonate Alkalinity as CaCO3 | 3812-32-6 | 1 | mg/L | <1 | <1 | <1 | ---- | ---- |
| Bicarbonate Alkalinity as CaCO3 | 71-52-3 | 1 | mg/L | 428 | 342 | 247 | ---- | ---- |
| Total Alkalinity as CaCO3 | ---- | 1 | mg/L | 428 | 342 | 247 | ---- | ---- |
| **ED040F: Dissolved Major Anions** | | | | | | | | |
| Silicon as SiO2 | 14464-46-1 | 0.1 | mg/L | 27.1 | 24.6 | 34.0 | ---- | ---- |
| **ED041G: Sulfate (Turbidimetric) as SO4 2- by DA** | | | | | | | | |
| Sulfate as SO4 - Turbidimetric | 14808-79-8 | 1 | mg/L | 586 | 396 | 36 | ---- | ---- |
| **ED045G: Chloride by Discrete Analyser** | | | | | | | | |
| Chloride | 16887-00-6 | 1 | mg/L | 448 | 100 | 59 | ---- | ---- |
| **ED093F: Dissolved Major Cations** | | | | | | | | |
| Calcium | 7440-70-2 | 1 | mg/L | 195 | 83 | 49 | ---- | ---- |
| Magnesium | 7439-95-4 | 1 | mg/L | 17 | 5 | 18 | ---- | ---- |
| Sodium | 7440-23-5 | 1 | mg/L | 514 | 365 | 96 | ---- | ---- |
| Potassium | 7440-09-7 | 1 | mg/L | 2 | 2 | <1 | ---- | ---- |
| **EG020F: Dissolved Metals by ICP-MS** | | | | | | | | |
| Aluminium | 7429-90-5 | 0.01 | mg/L | <0.01 | 0.01 | <0.01 | ---- | ---- |
| Arsenic | 7440-38-2 | 0.001 | mg/L | 0.010 | 0.006 | 0.003 | ---- | ---- |
| Cadmium | 7440-43-9 | 0.0001 | mg/L | <0.0001 | <0.0001 | <0.0001 | ---- | ---- |
| Chromium | 7440-47-3 | 0.001 | mg/L | 0.002 | 0.002 | <0.001 | ---- | ---- |
| Copper | 7440-50-8 | 0.001 | mg/L | 0.001 | <0.001 | 0.047 | ---- | ---- |
| Manganese | 7439-96-5 | 0.001 | mg/L | 0.433 | 0.219 | 0.066 | ---- | ---- |
| Nickel | 7440-02-0 | 0.001 | mg/L | 0.002 | 0.001 | 0.003 | ---- | ---- |
| Zinc | 7440-66-6 | 0.005 | mg/L | <0.005 | <0.005 | 0.028 | ---- | ---- |
| Iron | 7439-89-6 | 0.05 | mg/L | 0.08 | 0.06 | <0.05 | ---- | ---- |
| **EK055G: Ammonia as N by Discrete Analyser** | | | | | | | | |
| Ammonia as N | 7664-41-7 | 0.01 | mg/L | 0.30 | 0.31 | 0.01 | ---- | ---- |
| **EK057G: Nitrite as N by Discrete Analyser** | | | | | | | | |
| Nitrite as N | 14797-65-0 | 0.01 | mg/L | 0.02 | <0.01 | <0.01 | ---- | ---- |
| **EK058G: Nitrate as N by Discrete Analyser** | | | | | | | | |
| Nitrate as N | 14797-55-8 | 0.01 | mg/L | 0.07 | 0.16 | 0.73 | ---- | ---- |
| **EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser** | | | | | | | | |
| Nitrite + Nitrate as N | ---- | 0.01 | mg/L | 0.09 | 0.16 | 0.73 | ---- | ---- |

## Analytical Results

| Sub-Matrix: WATER (Matrix: WATER) | | | Client sample ID | GW1 | GW2 | GW3 | ---- | ---- |
|---|---|---|---|---|---|---|---|---|
| | | | Client sampling date / time | 08-Jun-2017 09:30 | 08-Jun-2017 10:30 | 08-Jun-2017 11:30 | ---- | ---- |
| Compound | CAS Number | LOR | Unit | ES1714012-001 | ES1714012-002 | ES1714012-003 | -------- | -------- |
| | | | | Result | Result | Result | ---- | ---- |
| **EK061G: Total Kjeldahl Nitrogen By Discrete Analyser** | | | | | | | | |
| Total Kjeldahl Nitrogen as N | ---- | 0.1 | mg/L | 0.6 | 0.8 | 0.4 | ---- | ---- |
| **EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser** | | | | | | | | |
| ^ Total Nitrogen as N | ---- | 0.1 | mg/L | 0.7 | 1.0 | 1.1 | ---- | ---- |
| **EK067G: Total Phosphorus as P by Discrete Analyser** | | | | | | | | |
| Total Phosphorus as P | ---- | 0.01 | mg/L | 0.08 | 0.16 | 0.11 | ---- | ---- |
| **EN055: Ionic Balance** | | | | | | | | |
| Total Anions | ---- | 0.01 | meq/L | 33.4 | 17.9 | 7.35 | ---- | ---- |
| Total Cations | ---- | 0.01 | meq/L | 33.5 | 20.5 | 8.10 | ---- | ---- |
| Ionic Balance | ---- | 0.01 | % | 0.22 | 6.73 | 4.88 | ---- | ---- |

**Boral Construction Materials**
**Materials Technical Services**

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# Test Report

CLIENT: DUNMORE SAND & SOIL PTY LTD
Greystanes House PROSPECT NSW 2148

FILE No.: 457/16

PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of August 2016.

REQUEST No.: 68784

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| Laboratory Sample No.: | 181316 | 181317 | 181318 | 181319 |
|---|---|---|---|---|
| Date Sampled: | 2/08/2016 | 2/08/2016 | 2/08/2016 | 2/08/2016 |
| Date Received: | 4/08/2016 | 4/08/2016 | 4/08/2016 | 4/08/2016 |
| Sample Description: | Water - DG4 Deep | Water - DG4 Shallow | Water - DG5 Deep | Water - DG5 Shallow |
| Field No.: | DG4d | DG4s | DG5d | DG5s |

## TEST RESULTS

| | | | | |
|---|---|---|---|---|
| pH*1 | 7.5 | 7.4 | 7.4 | 7.6 |
| Ammonia - N (mg/L) | <0.01 | <0.01 | <0.01 | <0.01 |
| Conductivity (µS/cm) | 4270 | 2220 | 257 | 767 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 208 | 123 | 18 | 72 |
| Chloride as $Cl^-$ (mg/L) | 1577 | 683 | 60 | 131 |
| Iron (mg/L) | 0.01 | 0.06 | 0.16 | < 0.01 |
| Potassium (mg/L) | 54 | 9.8 | 4.0 | 21 |
| Magnesium (mg/L) | 120 | 49 | 7.4 | 19 |
| Sodium (mg/L) | 349 | 192 | 29 | 54 |
| Total Phosphorus (mg/L) *2 | 1.36 | 0.05 | 0.16 | 0.05 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Approved Signatory Nanthini Selvadurai

Date 31-08-16 Serial No. 149438

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025

NATA Accredited Laboratory
Number: 9968

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APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 181320 | 181321 | 181322 | 181323 |
| Date Sampled: | 2/08/2016 | 2/08/2016 | 2/08/2016 | 2/08/2016 |
| Date Received: | 4/08/2016 | 4/08/2016 | 4/08/2016 | 4/08/2016 |
| Sample Description: | Water - DG6 Deep | Water - DG6 Shallow | Water - DG21 Deep | Water - DG31 Shallow |
| Field No.: | DG6d | DG6s | DG21 | DG31 |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | 7.1 | 6.9 | 7.4 | 7.2 |
| Ammonia - N (mg/L) | <0.01 | <0.01 | <0.01 | <0.01 |
| Conductivity (µS/cm) | 10610 | 10000 | 519 | 1344 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 550 | 545 | 69 | 409 |
| Chloride as $Cl^-$ (mg/L) | 5100 | 4087 | 68 | 139 |
| Iron (mg/L) | 0.01 | 0.27 | 0.07 | 0.02 |
| Potassium (mg/L) | 113 | 112 | 4.4 | 6.1 |
| Magnesium (mg/L) | 268 | 275 | 19 | 42 |
| Sodium (mg/L) | 935 | 932 | 76 | 92 |
| Total Phosphorus (mg/L) *2 | 0.05 | 0.06 | 0.07 | 0.04 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini Selvadurai

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**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 181324 | 181325 | 181326 | 181327 |
| Date Sampled: | 2/08/2016 | 2/08/2016 | 2/08/2016 | 2/08/2016 |
| Date Received: | 4/08/2016 | 4/08/2016 | 4/08/2016 | 4/08/2016 |
| Sample Description: | Water - DG54 | Water - DG56 | Water - DG59 | Water - BH@DW17 |
| Field No.: | DG54 | DG56 | DG59 | BH17 |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | 6.5 | 7.5 | 7.2 | 7.3 |
| Ammonia - N (mg/L) | < 0.01 | 0.01 | < 0.01 | < 0.01 |
| Conductivity (µS/cm) | 298 | 965 | 2280 | 724 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 35 | 80 | 98 | 149 |
| Chloride as $Cl^-$ (mg/L) | 44 | 188 | 468 | 64 |
| Iron (mg/L) | 0.44 | 0.06 | < 0.01 | 0.01 |
| Potassium (mg/L) | 3.3 | 5.9 | 25 | 4.6 |
| Magnesium (mg/L) | 5.6 | 17 | 55 | 20 |
| Sodium (mg/L) | 31 | 52 | 214 | 71 |
| Total Phosphorus (mg/L) *2 | 0.03 | 0.02 | 0.11 | 0.05 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini Selvadurai

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## Test Report

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FILE No.: 457/16

PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of August 2016.

REQUEST No.: 68784

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 181328 | 181329 | 181330 | 181332 |
| Date Sampled: | 2/08/2016 | 2/08/2016 | 2/08/2016 | 2/08/2016 |
| Date Received: | 4/08/2016 | 4/08/2016 | 4/08/2016 | 4/08/2016 |
| Sample Description: | Water - BH-A | Water - BH-B | Water- BH-C | Water - BH -E |
| Field No.: | BHA | BHB | BHC | BHE |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | 6.1 | 6.7 | 6.6 | 6.5 |
| Ammonia - N (mg/L) | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| Conductivity (µS/cm) | 208 | 479 | 219 | 378 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 30 | 79 | 12 | 2.1 |
| Chloride as $Cl^-$ (mg/L) | 46 | 73 | 46 | 63 |
| Iron (mg/L) | 0.16 | 0.02 | 0.62 | 1.63 |
| Potassium (mg/L) | 1.3 | 2.5 | 1.9 | 1.3 |
| Magnesium (mg/L) | 3.0 | 8.7 | 2.9 | 9.2 |
| Sodium (mg/L) | 20 | 22 | 21 | 23 |
| Total Phosphorus (mg/L) *2 | 0.02 | 0.01 | 0.06 | 0.09 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini Selvadurai

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REQUEST No.: 68784

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| | |
|---|---|
| Laboratory Sample No.: | 181333 |
| Date Sampled: | 02/08/2016 |
| Date Received: | 04/08/2016 |
| Sample Description: | Water - BH-F |
| Field No.: | BHF |

**TEST RESULTS**

| | |
|---|---|
| pH*1 | 5.9 |
| Ammonia - N (mg/L) | < 0.01 |
| Conductivity (µS/cm) | 257 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 6.2 |
| Chloride as $Cl^-$ (mg/L) | 73 |
| Iron (mg/L) | 0.12 |
| Potassium (mg/L) | 1.3 |
| Magnesium (mg/L) | 4.1 |
| Sodium (mg/L) | 33 |
| Total Phosphorus (mg/L) *2 | 0.01 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini Selvadurai

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# Test Report

CLIENT: DUNMORE SAND & SOIL PTY LTD

FILE No.: 457/16

Greystanes House PROSPECT NSW 2148

PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of August 2016.

REQUEST No.: 68784

**TEST PROCEDURE:** APHA 2320 B - Alkalinity Titration Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method
APHA 2580 B - Oxidation/Reduction Potential Measurement in Clean Water

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 181316 | 181317 | 181318 | 181319 |
| Date Sampled: | 2/08/2016 | 2/08/2016 | 2/08/2016 | 2/08/2016 |
| Date Received: | 4/08/2016 | 4/08/2016 | 4/08/2016 | 4/08/2016 |
| Sample Description: | Water - DG4 Deep | Water - DG4 Shallow | Water - DG5 Deep | Water - DG5 Shallow |
| Field No.: | DG4d | DG4s | DG5d | DG5s |

## TEST RESULTS

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 186 | 250 | 64 | 200 |
| TKN (mg/L) | 0.55 | 0.89 | 0.01 | 0.26 |
| ORP (mV) | 302 | 298 | 303 | 310 |

Samples submitted by the Client.

Cynthia Tjiam
Analytical Chemist
30th August 2016
R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

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APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method
APHA 2580 B - Oxidation/Reduction Potential Measurement in Clean Water

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 181320 | 181321 | 181322 | 181323 |
| Date Sampled: | 2/08/2016 | 2/08/2016 | 2/08/2016 | 2/08/2016 |
| Date Received: | 4/08/2016 | 4/08/2016 | 4/08/2016 | 4/08/2016 |
| Sample Description: | Water - DG6 Deep | Water - DG6 Shallow | Water - DG21 Deep | Water - DG31 Shallow |
| Field No.: | DG6d | DG6s | DG21 | DG31 |

## TEST RESULTS

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 235 | 278 | 163 | 274 |
| TKN (mg/L) | 0.51 | 0.69 | 1.05 | 1.03 |
| ORP (mV) | 333 | 328 | 300 | 303 |

Samples submitted by the Client.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Cynthia T

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APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method
APHA 2580 B - Oxidation/Reduction Potential Measurement in Clean Water

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 181324 | 181325 | 181326 | 181327 |
| Date Sampled: | 2/08/2016 | 2/08/2016 | 2/08/2016 | 2/08/2016 |
| Date Received: | 4/08/2016 | 4/08/2016 | 4/08/2016 | 4/08/2016 |
| Sample Description: | Water - DG54 | Water - DG56 | Water - DG59 | Water - BH@DW17 |
| Field No.: | DG54 | DG56 | DG59 | BH17 |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 76 | 229 | 705 | 192 |
| TKN (mg/L) | 1.48 | 1.51 | 1.10 | 2.37 |
| ORP (mV) | 311 | 322 | 312 | 309 |

Samples submitted by the Client.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Cynthia T

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REQUEST No.: 68784

**TEST PROCEDURE:** APHA 2320 B - Alkalinity Titration Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method
APHA 2580 B - Oxidation/Reduction Potential Measurement in Clean Water

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 181328 | 181329 | 181330 | 181332 |
| Date Sampled: | 2/08/2016 | 2/08/2016 | 2/08/2016 | 2/08/2016 |
| Date Received: | 4/08/2016 | 4/08/2016 | 4/08/2016 | 4/08/2016 |
| Sample Description: | Water - BH-A | Water - BH-B | Water- BH-C | Water - BH -E |
| Field No.: | BHA | BHB | BHC | BHE |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 29 | 95 | 54 | 128 |
| TKN (mg/L) | 1.48 | 0.50 | 1.19 | 1.62 |
| ORP (mV) | 332 | 331 | 328 | 333 |

Samples submitted by the Client.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Cynthia T

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PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of August 2016.

REQUEST No.: 68784

**TEST PROCEDURE:** APHA 2320 B - Alkalinity Titration Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method
APHA 2580 B - Oxidation/Reduction Potential Measurement in Clean Water

| | |
|---|---|
| Laboratory Sample No.: | 181333 |
| Date Sampled: | 02/08/2016 |
| Date Received: | 04/08/2016 |
| Sample Description: | Water - BH-F |
| Field No.: | BHF |

**TEST RESULTS**

| | |
|---|---|
| Alkalinity (mg $CaCO_3$/L) | 37 |
| TKN (mg/L) | 0.44 |
| ORP (mV) | 326 |

Samples submitted by the Client.

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Cynthia T

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# Test Report

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Greystanes House PROSPECT NSW 2148

FILE No.: 457/16

PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of March 2016.

REQUEST No.: 66850

**TEST PROCEDURE:**

APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 176486 | 176487 | 176488 | 176489 |
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG1 Deep | Water - DG1 Shallow | Water - DG2 Deep | Water - DG2 Shallow |
| Field No.: | DG1d | DG1s | DG2d | DG2s |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | 7.6 | 7.9 | 6.9 | 6.7 |
| Ammonia - N (mg/L) | <0.01 | <0.01 | <0.01 | <0.01 |
| Conductivity (µS/cm) | 551 | 1861 | 369 | 496 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 3.7 | 149 | 27 | 43 |
| Chloride as $Cl^-$ (mg/L) | 47 | 417 | 56 | 57 |
| Iron (mg/L) | 0.19 | 0.002 | 2.8 | 0.029 |
| Potassium (mg/L) | 4.6 | 21 | 1.6 | 2.7 |
| Magnesium (mg/L) | 13 | 32 | 13 | 9.4 |
| Sodium (mg/L) | 41 | 234 | 30 | 44 |
| Total Phosphorus (mg/L) *2 | 0.049 | 0.027 | 0.18 | 0.009 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Approved Signatory Nanthini Selvadurai

Date 19 - 05 - 16 Serial No. 146436

NATA Accredited Laboratory
Number: 9968

ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025

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## Test Report

CLIENT: DUNMORE SAND & SOIL PTY LTD
Greystanes House PROSPECT NSW 2148

FILE No.: 457/15

PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of March 2016.

REQUEST No.: 66850

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| Laboratory Sample No.: | 176490 | 176491 | 176492 | 176493 |
|---|---|---|---|---|
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG3 Deep | Water - DG3 Shallow | Water - DG4 Deep | Water - DG4 Shallow |
| Field No.: | DG3d | DG3s | DG4d | DG4s |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | 8.4 | 7.5 | 7.7 | 8.0 |
| Ammonia - N (mg/L) | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| Conductivity (µS/cm) | 630 | 672 | 6020 | 2680 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 18 | 11 | 251 | 122 |
| Chloride as $Cl^-$ (mg/L) | 109 | 107 | 2116 | 733 |
| Iron (mg/L) | 0.07 | 0.027 | 0.005 | 0.068 |
| Potassium (mg/L) | 4.02 | 3.5 | 70 | 14 |
| Magnesium (mg/L) | 14 | 13 | 210 | 51 |
| Sodium (mg/L) | 67 | 71 | 1274 | 310 |
| Total Phosphorus (mg/L) *2 | 0.15 | 0.094 | 0.096 | 0.014 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini Selvadurai

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## Test Report

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FILE No.: 457/15

PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of March 2016.

REQUEST No.: 66850

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| Laboratory Sample No.: | 176494 | 176495 | 176496 | 176497 |
|---|---|---|---|---|
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG5 Shallow | Water - DG 5 Deep | Water - DG6 Shallow | Water - DG6 Shallow |
| Field No.: | DG5d | DG5s | DG6d | DG6s |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | 7.8 | 8.1 | 7.2 | 6.6 |
| Ammonia - N (mg/L) | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| Conductivity (µS/cm) | 11850 | 1041 | 19530 | 11800 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 512 | 74 | 1057 | 615 |
| Chloride as $Cl^-$ (mg/L) | 4062 | 165 | 8747 | 4540 |
| Iron (mg/L) | 0.001 | 0.02 | 0.009 | 0.59 |
| Potassium (mg/L) | 99 | 7.7 | 167 | 90 |
| Magnesium (mg/L) | 290 | 27 | 405 | 346 |
| Sodium (mg/L) | 2175 | 107 | 4146 | 2327 |
| Total Phosphorus (mg/L) *2 | 0.11 | 0.02 | 0.027 | 0.06 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

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FILE No.: 457/15

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REQUEST No.: 66850

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| Laboratory Sample No.: | 176498 | 176499 | 176500 | 176501 |
|---|---|---|---|---|
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG21 Deep | Water - DG31 Shallow | Water - DG54 | Water - DG56 |
| Field No.: | DG21 | DG31 | DG54 | DG56 |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | 7.3 | 6.9 | 6.6 | 7.3 |
| Ammonia - N (mg/L) | < 0.01 | < 0.01 | < 0.01 | 0.78 |
| Conductivity (µS/cm) | 434 | 1704 | 645 | 1590 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 25 | 435 | 67 | 140 |
| Chloride as $Cl^-$ (mg/L) | 62 | 171 | 112 | 324 |
| Iron (mg/L) | 0.22 | 0.029 | 0.86 | 0.013 |
| Potassium (mg/L) | 4.2 | 8.9 | 5.5 | 12 |
| Magnesium (mg/L) | 24 | 44 | 22 | 24 |
| Sodium (mg/L) | 148 | 157 | 67 | 109 |
| Total Phosphorus (mg/L) *2 | 0.071 | 0.018 | 0.027 | < 0.001 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

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REQUEST No.: 66850

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| Laboratory Sample No.: | 176502 | 176503 | 176504 | 176505 |
|---|---|---|---|---|
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG59 | Water - BH@DW17 | Water - BH-A | Water - BH-B |
| Field No.: | DG59 | BH17 | BHA | BHB |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | 7.8 | 8.1 | 6.1 | 7.0 |
| Ammonia - N (mg/L) | < 0.01 | 0.04 | < 0.01 | < 0.01 |
| Conductivity (µS/cm) | 2390 | 835 | 337 | 507 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 59 | 82 | 37 | 48 |
| Chloride as $Cl^-$ (mg/L) | 393 | 86 | 61 | 73 |
| Iron (mg/L) | 0.005 | 0.007 | 0.16 | 0.18 |
| Potassium (mg/L) | 21 | 2.5 | 0.88 | 2.8 |
| Magnesium (mg/L) | 53 | 22 | 4.7 | 8.4 |
| Sodium (mg/L) | 317 | 84 | 35 | 26 |
| Total Phosphorus (mg/L) *2 | 0.031 | 0.093 | 0.01 | 0.02 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

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FILE No.: 457/15

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REQUEST No.: 66850

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method

| | | | |
|---|---|---|---|
| Laboratory Sample No.: | 176506 | 176508 | 176509 |
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - BH-C | Water - BH-E | Water - BH-F |
| Field No.: | BHC | BHE | BHF |

**TEST RESULTS**

| | | | |
|---|---|---|---|
| pH*1 | 7.7 | 8.0 | 6.5 |
| Ammonia - N (mg/L) | 0.03 | < 0.01 | 0.11 |
| Conductivity (µS/cm) | 197 | 395 | 286 |
| Sulphate as $SO_4^{2-}$ (mg/L) | 3.3 | 4.1 | 13 |
| Chloride as $Cl^-$ (mg/L) | 36 | 58 | 57 |
| Iron (mg/L) | 1.6 | 0.10 | 0.79 |
| Potassium (mg/L) | 1.2 | 1.04 | 1.2 |
| Magnesium (mg/L) | 2.8 | 4.8 | 5.4 |
| Sodium (mg/L) | 26 | 32 | 30 |
| Total Phosphorus (mg/L) *2 | 0.13 | 0.014 | 0.041 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

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REQUEST No.: 66850

**TEST PROCEDURE:** APHA 2320 B - Alkalinity Titration Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 176486 | 176487 | 176488 | 176489 |
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG1 Deep | Water - DG1 Shallow | Water - DG2 Deep | Water - DG2 Shallow |
| Field No.: | DG1d | DG1s | DG2d | DG2s |

## TEST RESULTS

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 223 | 245 | 78 | 111 |
| TKN (mg/L) | < 0.01 | 0.01 | <0.01 | < 0.01 |

Samples submitted by the Client.

Nanthini S
Analytical Chemist
5th May 2016
R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

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# Test Report

CLIENT: DUNMORE SAND & SOIL PTY LTD

FILE No.: 457/16

Greystanes House PROSPECT NSW 2148

PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of March 2016.

REQUEST No.: 66850

**TEST PROCEDURE:** APHA 2320 B - Alkalinity Titration Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 176490 | 176491 | 176492 | 176493 |
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG3 Deep | Water - DG3 Shallow | Water - DG4 Deep | Water - DG4 Shallow |
| Field No.: | DG3d | DG3s | DG4d | DG4s |

## TEST RESULTS

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 142 | 134 | 175 | 214 |
| TKN (mg/L) | < 0.01 | < 0.01 | < 0.01 | < 0.01 |

Samples submitted by the Client.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini S

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REQUEST No.: 66850

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APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 176494 | 176495 | 176496 | 176497 |
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG5 Deep | Water - DG5 Shallow | Water - DG6 Deep | Water - DG6 Shallow |
| Field No.: | DG5d | DG5s | DG6d | DG6s |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 181 | 239 | 375 | 289 |
| TKN (mg/L) | < 0.01 | < 0.01 | <0.01 | < 0.01 |

Samples submitted by the Client.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

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FILE No.: 457/16

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PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of March 2016.

REQUEST No.: 66850

**TEST PROCEDURE:** APHA 2320 B - Alkalinity Titration Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 176498 | 176499 | 176500 | 176501 |
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG21 Deep | Water - DG31 Shallow | Water - DG54 | Water - DG56 |
| Field No.: | DG21 | DG31 | DG54 | DG56 |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 124 | 299 | 91 | 194 |
| TKN (mg/L) | < 0.01 | < 0.01 | < 0.01 | < 0.01 |

Samples submitted by the Client.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini .S

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PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of March 2016.

REQUEST No.: 66850

**TEST PROCEDURE:** APHA 2320 B - Alkalinity Titration Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 176502 | 176503 | 176504 | 176505 |
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - DG59 | Water - BH@DW17 | Water - BH-A | Water - BH-B |
| Field No.: | DG59 | BH17 | BHA | BHB |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 734 | 247 | 50 | 107 |
| TKN (mg/L) | < 0.01 | < 0.01 | < 0.01 | < 0.01 |

Samples submitted by the Client.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini S

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## Test Report

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FILE No.: 457/16

Greystanes House PROSPECT NSW 2148

PROJECT: Testing of Groundwater Samples from Dunmore Sand & Soil for the Month of March 2016.

REQUEST No.: 66850

**TEST PROCEDURE:** APHA 2320 B - Alkalinity Titration Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method

| | | | |
|---|---|---|---|
| Laboratory Sample No.: | 176506 | 176508 | 176509 |
| Date Sampled: | 29/03/2016 | 29/03/2016 | 29/03/2016 |
| Date Received: | 1/04/2016 | 1/04/2016 | 1/04/2016 |
| Sample Description: | Water - BH-C | Water - BH-E | Water - BH-F |
| Field No.: | BHC | BHE | BHF |

**TEST RESULTS**

| | | | |
|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | 50 | 128 | 54 |
| TKN (mg/L) | < 0.01 | < 0.01 | < 0.01 |

Samples submitted by the Client.

R. Johnson, P. Paterson, B. Subotic, C. Potts, S. McLean, R. Lawton, Mat.File, File.

Nanthini S

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# Test Report

CLIENT: DUNMORE SAND & SOIL PTY LTD (WATER) FILE No.: 457/17
ADDRESS: 39 Delhi Road NORTH RYDE NSW 2113
PROJECT: Annual and 6 Monthly Testing of Groundwater Samples from Dunmore Sand & Soil. REQUEST No.: 73628

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 2540 C - Total Dissolved Solids Dried at 180°C
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method

| Laboratory Sample No.: | 193424 | 193425 | 193426 | 193427 |
|---|---|---|---|---|
| Date Sampled: | 19/06/2017 | 19/06/2017 | 19/06/2017 | 19/06/2017 |
| Date Received: | 21/06/2017 | 21/06/2017 | 21/06/2017 | 21/06/2017 |
| Sample Description: | Water – DG5d | Water – DG5s | Water – DG6d | Water – DG6s |
| Field No.: | DG5d | DG5s | DG6d | DG6s |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | - | - | - | - |
| Total Dissolved Solids (mg/L) | 106 | 554 | 12092 | 9336 |
| Ammonia - N (mg/L) | - | - | - | - |
| Conductivity (µS/cm) | - | - | - | - |
| Sulphate as $SO_4^{2-}$ (mg/L) | - | - | - | - |
| Chloride as $Cl^-$ (mg/L) | - | - | - | - |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.

R. Johnson, P. Paterson, B.Subotic, E. Randall, C.Potts, S. McLean, R. Lawton, Mat. File, File.

Approved Signatory Nanthini Selvadurai

Date 04-08-17. Serial No. 159807

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025

NATA Accredited Laboratory
Number: 9968

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**Materials Technical Services**

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## Test Report

CLIENT: DUNMORE SAND & SOIL PTY LTD (WATER) FILE No.: 457/17
ADDRESS: 39 Delhi Road NORTH RYDE NSW 2113
PROJECT: Annual and 6 Monthly Testing of Groundwater samples from Dunmore Sand & Soil. REQUEST No.: 73628

**TEST PROCEDURE:** APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method
APHA 4500 –P B/D Total reactive phosphorus – stannous chloride method.

| Laboratory Sample No.: | 193424 | 193425 | 193426 | 193427 |
|---|---|---|---|---|
| Date Sampled: | 19/06/2017 | 19/06/2017 | 19/06/2017 | 19/06/17 |
| Date Received: | 21/06/2017 | 21/06/2017 | 21/06/2017 | 21/06/17 |
| Sample Description: | Water – DG5d | Water – DG5s | Water – DG6d | Water – DG6s |
| Field No.: | 1 | 2 | 3 | 4 |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| Aluminium (m/L) | 0.03 | 0.03 | 0.03 | 0.03 |
| Arsenic (mg/L) | 0.04 | 0.04 | 0.06 | 0.08 |
| Cadmium (mg/L) | 0.02 | 0.04 | 0.04 | 0.02 |
| Calcium (m/L) | 9.4 | 108 | 195 | 150 |
| Chromium (mg/L) | 0.02 | 0.02 | 0.02 | 0.02 |
| Copper (mg/L) | 0.29 | 0.05 | 0.03 | 0.03 |
| Iron (mg/L) | - | - | - | - |
| Lead (mg/L) | 0.05 | 0.07 | 0.08 | 0.06 |
| Magnesium (mg/L) | - | - | - | - |
| Manganese (mg/L) | 0.01 | 0.02 | 0.06 | 0.22 |
| Mercury (mg/L) | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Potassium (mg/L) | - | - | - | - |
| Sodium (mg/L) | - | - | - | - |
| Total Phosphorus (mg/L) *1 | - | - | - | - |
| Zinc (mg/L) | 0.02 | 0.01 | 0.04 | 0.04 |

Samples submitted by the Client.

NOTE:
*1 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B.Subotic, E. Randall, C.Potts, S. McLean, R. Lawton, Mat. File, File.

Nanthini Selvadurai

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PROJECT: Annual and 6 Monthly Testing of Groundwater Samples from Dunmore Sand & Soil. REQUEST No.: 73628

**TEST PROCEDURE:** APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 2540 C - Total Dissolved Solids Dried at 180°C
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method
APHA 4500 $NO_3^-$ D - Nitrate Electrode Method
APHA 4500 $NO_2^-$ B – Nitrite – Colorimetric Method
APHA 4500 - $N_{org}$ B/D - Organic Nitrogen Ammonia Macro-Kjeldahl and Selective Electrode Method - Total Nitrogen

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 193428 | 193429 | 193430 | 193431 |
| Date Sampled: | 19/06/2017 | 19/06/2017 | 20/06/2017 | 20/06/2017 |
| Date Received: | 21/06/2017 | 21/06/2017 | 21/06/2017 | 21/06/2017 |
| Sample Description: | Water – DG21d | Water – DG31s | Water – DG55 | Water – DG59 |
| Field No.: | DG21d | DG31s | DG55 | DG59 |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| pH*1 | - | - | - | 7.0 |
| Total Dissolved Solids (mg/L) | 214 | 830 | 1492 | 3396 |
| Ammonia – N (mg/L) | - | - | - | 7.33 |
| Conductivity (µS/cm) | - | - | - | 5140 |
| Sulphate as $SO_4^{2-}$ (mg/L) | - | - | - | 509 |
| Chloride as $Cl^-$ (mg/L) | - | - | - | 1396 |
| Nitrate -N (mg/L) | - | - | - | 8.30 |
| Nitrite -N (mg/L) | - | - | - | < 0.01 |
| TKN (mg/L) *2 | - | - | - | 12.10 |
| Total Nitrogen (mg/L) *2 | - | - | - | 20.40 |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.
*2 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B.Subotic, E. Randall, C.Potts, S. McLean, R. Lawton, Mat. File, File.

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**TEST PROCEDURE:** APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method
APHA 4500 –P B/D Total reactive phosphorus – stannous chloride method.

| | | | | |
|---|---|---|---|---|
| Laboratory Sample No.: | 193428 | 193429 | 193430 | 193431 |
| Date Sampled: | 19/06/2017 | 19/06/2017 | 20/06/2017 | 20/06/2017 |
| Date Received: | 21/06/2017 | 21/06/2017 | 21/06/2017 | 21/06/17 |
| Sample Description: | Water – DG21d | Water – DG31s | Water – DG55 | Water – DG59 |
| Field No.: | 5 | 6 | 7 | 8 |

**TEST RESULTS**

| | | | | |
|---|---|---|---|---|
| Aluminium (m/L) | 0.03 | 0.03 | 0.10 | 0.19 |
| Arsenic (mg/L) | 0.04 | 0.05 | 0.04 | 0.07 |
| Cadmium (mg/L) | 0.02 | 0.04 | 0.02 | 0.04 |
| Calcium (m/L) | 34 | 1112 | 77 | 224 |
| Chromium (mg/L) | 0.02 | 0.02 | 0.02 | 0.02 |
| Copper (mg/L) | 0.03 | 0.11 | 0.04 | 0.03 |
| Iron (mg/L) | - | - | - | 0.01 |
| Lead (mg/L) | 0.06 | 0.05 | 0.06 | 0.06 |
| Magnesium (mg/L) | - | - | - | 129 |
| Manganese (mg/L) | < 0.01 | < 0.01 | 0.27 | < 0.01 |
| Mercury (mg/L) | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Potassium (mg/L) | - | - | - | 101 |
| Sodium (mg/L) | - | - | - | 463 |
| Total Phosphorus (mg/L) *1 | - | - | - | 0.23 |
| Zinc (mg/L) | < 0.01 | 0.01 | 0.04 | < 0.01 |

Samples submitted by the Client.

NOTE:
*1 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B.Subotic, E. Randall, C.Potts, S. McLean, R. Lawton, Mat. File, File.

Nanthini Selvadurai

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FILE No.: 457/17

REQUEST No.: 73628

**TEST PROCEDURE:**
APHA 4500 $H^+$ B - pH Value - Electrometric Method
APHA 2540 C - Total Dissolved Solids Dried at 180°C
APHA 4500 $NH_3$ D - Ammonia - Selective Electrode Method
APHA 2510 B - Conductivity - Laboratory Method
APHA 4500 $SO_4^{2-}$ C - Sulphate - Gravimetric Method with Ignition of Residue
APHA 4500 $Cl^-$ D - Chloride - Potentiometric Method

| | | |
|---|---|---|
| Laboratory Sample No.: | 193432 | 193433 |
| Date Sampled: | 20/06/2017 | 20/06/2017 |
| Date Received: | 21/06/2017 | 21/06/2017 |
| Sample Description: | Water – BHA | Water – BHF |
| Field No.: | BHA | BHF |

**TEST RESULTS**

| | | |
|---|---|---|
| pH*1 | - | - |
| Total Dissolved Solids (mg/L) | 154 | 144 |
| Ammonia - N (mg/L) | - | - |
| Conductivity (µS/cm) | - | - |
| Sulphate as $SO_4^{2-}$ (mg/L) | - | - |
| Chloride as $Cl^-$ (mg/L) | - | - |

Samples submitted by the Client.

NOTE: *1 Sample for this test has not met the specified holding time.

R. Johnson, P. Paterson, B.Subotic, E. Randall, C.Potts, S. McLean, R. Lawton, Mat. File, File.

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**TEST PROCEDURE:** APHA 3120 B - Metals - Inductively Coupled Plasma (ICP) Method
APHA 4500 –P B/D Total reactive phosphorus – stannous chloride method.

| | | |
|---|---|---|
| Laboratory Sample No.: | 193432 | 193433 |
| Date Sampled: | 20/06/2017 | 20/06/2017 |
| Date Received: | 21/06/2017 | 21/06/2017 |
| Sample Description: | Water – BHA | Water – BHF |
| Field No.: | BHA | BHF |

**TEST RESULTS**

| | | |
|---|---|---|
| Aluminium (m/L) | 0.74 | 1.8 |
| Arsenic (mg/L) | 0.04 | 0.04 |
| Cadmium (mg/L) | 0.04 | 0.02 |
| Calcium (m/L) | 13 | 16 |
| Chromium (mg/L) | 0.02 | 0.02 |
| Copper (mg/L) | 0.12 | 0.01 |
| Iron (mg/L) | - | - |
| Lead (mg/L) | 0.06 | 0.05 |
| Magnesium (mg/L) | - | - |
| Manganese (mg/L) | 0.03 | 0.14 |
| Mercury (mg/L) | < 0.1 | < 0.1 |
| Potassium (mg/L) | - | - |
| Sodium (mg/L) | - | - |
| Total Phosphorus (mg/L) *1 | - | - |
| Zinc (mg/L) | 0.03 | 0.03 |

Samples submitted by the Client.

NOTE:
*1 Test method not covered by laboratory's current scope of accreditation.

R. Johnson, P. Paterson, B.Subotic, E. Randall, C.Potts, S. McLean, R. Lawton, Mat. File, File.

Nanthini Selvadurai

# Appendix 10 – Vegetation Assessment

# Vegetation Assessment
# Boral Dunmore Quarry

**Report prepared by: Marcus Burgess**

**29/04/2017**

| | |
|---|---|
| Client: | Boral Dunmore Quarry |
| Site: | Dunmore Hills, Tabbita Road, Dunmore |
| Report Prepared by: | Marcus Burgess |
| Field Work by: | Marcus Burgess, Djimon Bishop |
| Date: | March - April 2017 |

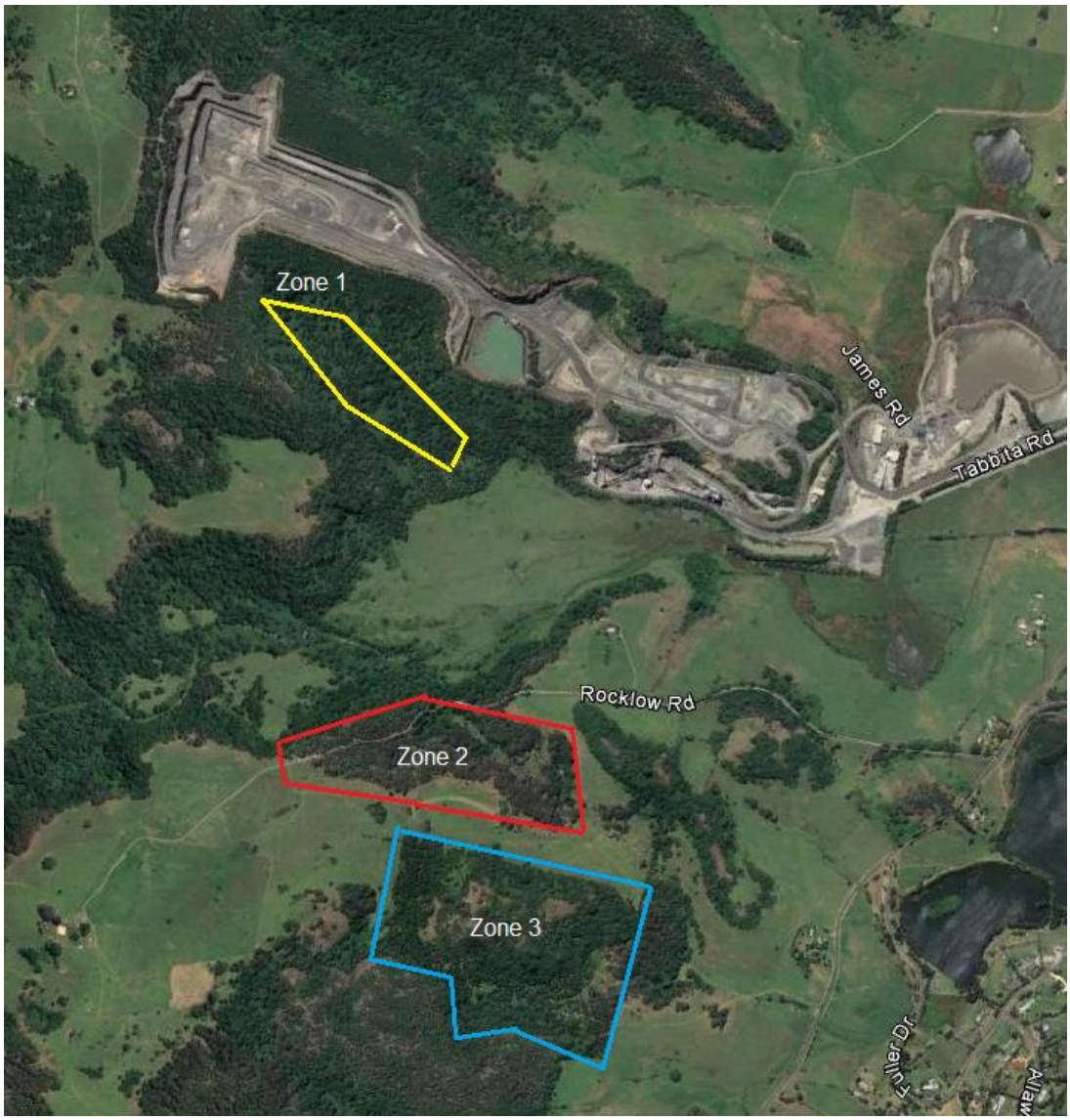
Good Bush Pty ltd
ABN 94 169 923 246
41 Gloucester Crescent Dapto, NSW 2530
Email: brookscreekdapto@gmail.com
Phone: 0406 215 823

## Contents

## Introduction

This report has been prepared for Boral Dunmore Quarry and includes an assessment of the natural and planted vegetation within three zones surrounding the hard rock quarry at Tabbitta Road, Dunmore.

## Location Map




**Zone 1 – Remnant Vegetation Conservation Area**
**Zone 2 – Offset Area**
**Zone 3 – Compensatory Habitat Area**

# Zone 1 Remnant Conservation Area

## Site Map


## Site Description

This site consists of a large gully with a south easterly aspect with a drainage line that forms part of the Rocklow Creek catchment. The total site area of this zone is approximately 15 hectares. The gully is framed by basalt cliffs on the northern and western boundaries and large basalt boulders dominate the ground layer throughout much of this gully. The south eastern corner at the lower end of the gully has been cleared for pasture and grazing and a waterfall exists at the high end within the north western corner. Immediately west of the waterfall the Dunmore hard rock quarry dominates the landscape.
The basalt at this site erodes to a fine grained highly fertile soil that supports a diverse subtropical rainforest remnant that has remained largely intact despite the clearing of vegetation that was carried out here and within the surrounding areas in the mid 1800's.

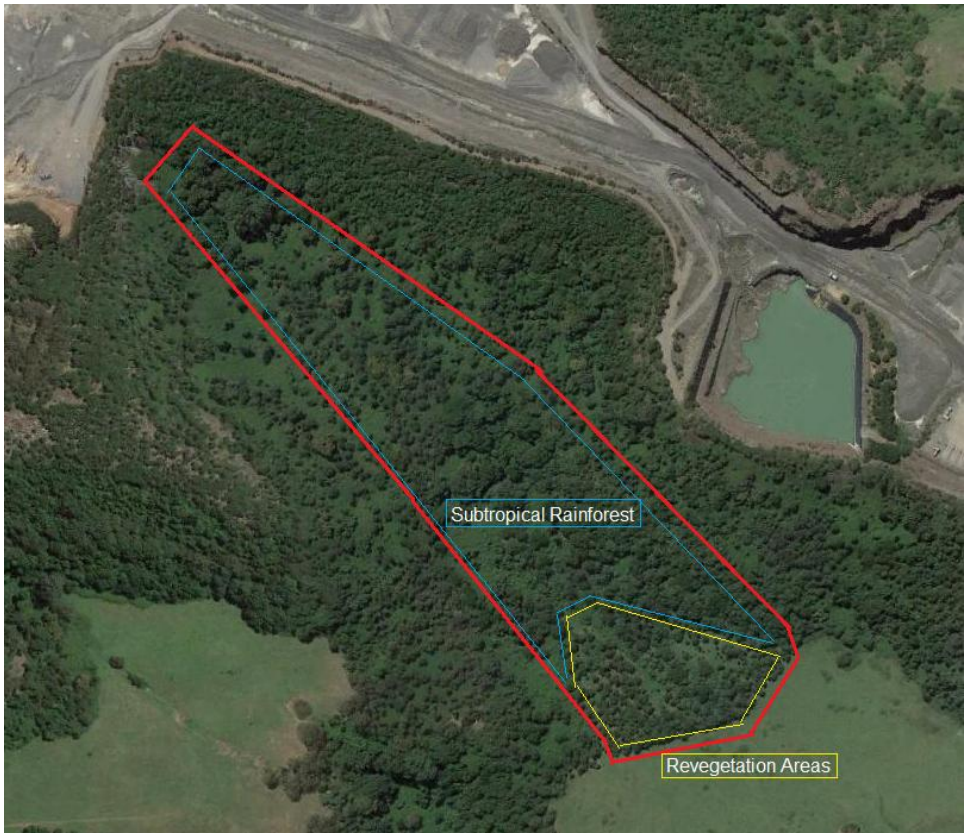
## Vegetation Description

The vegetation at this site consists of subtropical rainforest within the deep shaded and wet areas at the top of the gully and planted woodland at the lower end of the gully.
The subtropical rainforest within this zone consists of diverse rainforest remnant that has remained intact due to the rocky nature of the site, difficulty of removing timber species and low value of timber species present. A diverse range of canopy species exists within this gully including Sassafras (*Doryphora sassafras*), Myrtle Ebony (*Diospyros pentamera*) and all five of the local Fig (*Ficus sp*.) species. An abundance of vines exist within this remnant including Round Vine (*Legnephora moorei*), Kangaroo Grape (*Cissus antarctica*) and Milk Vine (*Marsdenia spp*.) and many species of ferns are present as epiphytes, lithophytes and within the ground layer.
Where gaps in the canopy occur the gully has been invaded by woody weeds and a large percentage of the open areas on the slopes of the gully are dominated by Lantana.
The lower end of the gully has been revegetated within the last ten years using a range of local native tree species, some of which are not entirely relevant to this site. The revegetated areas are also subjected to grazing by cattle and woody weeds have colonised these areas.

A diverse example of intact Illawarra Subtropical Rainforest community within Zone 1

## Vegetation Mapping

The following site map shows the approximate boundaries of the different vegetation communities found within this zone:



## Vegetation Survey

## Native Species List

The following list is a representation of species found within this zone. This is not intended to be a complete list of all species found within this gully rather an overview of species to assist the determination of the vegetation community found on site.
The survey was carried out on 28/03/2017 and identified 70 native plant species:

| | | |
|---|---|---|
| I | Isolated specimens | Usually only 1 individual plant |
| U | Uncommon | 2 to 10 plants throughout the site |
| M | Moderately Common | 10 to 50 plants throughout the site |
| C | Common | 50 + plants throughout the site |
| TS | Threatened Species | Plants listed as 'Threatened Species' (EPBC Act 1999) |

| FAMILY | BOTANICAL NAME | COMMON NAME | Freq. |
|---|---|---|---|
| ADIANTACEAE | *Adiantum aethiopicum* | Common Haiden Hair | C |
| ADIANTACEAE | *Adiantum formosum* | Giant Maiden Hair | C |
| ADIANTACEAE | *Adiantum hispidulum* | Rough Maiden Hair | C |
| APOCYNACEAE | *Parsonsia straminea* | Common Silk Pod | C |
| ARACEAE | *Gymnostachys anceps* | Settlers Flax | C |
| ARECACEAE | *Livistona australis* | Cabbage Palm | C |
| APOCYNACEAE | *Cynanchum elegans* | White Wax Flower | U, TS |
| APOCYNACEAE | *Marsdenia flavescens* | Hairy Milk Vine | C |
| APOCYNACEAE | *Marsdenia rostrata* | Common Milk Vine | C |
| ASPLENIACEAE | *Asplenium australasicum* | Birds Nest Fern | C |
| ASPLENIACEAE | *Asplenium flabellifolium* | Necklace Fern | C |
| ATHEROSPERMATACEAE | *Doryphora sassafras* | Sassafras | C |
| BIGNONIACEAE | *Pandorea pandorana* | Wonga Vine | C |
| BLECHNACEAE | *Doodia aspera* | Rasp Fern | C |
| CELASTRACEAE | *Cassine australis* | Red Fruit Olive-plum | C |
| CUNONIACEAE | *Aphaneopetalum resinosum* | Gum Vine | C |
| EBENACEAE | *Diospyros australis* | Black Plum | C |
| EBENACEAE | *Diospyros pentamera* | Myrtle Ebony | U |
| EHRETIACEAE | *Ehretia accuminata* | Koda | C |
| ELEOCARPACEAE | *Eleocarpus kirtonii* | White Quandong | I |
| EUPHORBIACEAE | *Alchornea ilicifolia* | Native Holly | U |
| EUPHORBIACEAE | *Baloghia inophylla* | Brush Bloodwood | C |
| EUPHORBIACEAE | *Claoxylon australe* | Brittle Wood | C |
| EUPHORBIACEAE | *Croton verreauxii* | Native Cascarilla | C |
| EUPOMATIACEAE | *Eupomatia laurina* | Bolwarra | U |
| FABACEAE | *Acacia maidenii* | Maidens Wattle | C |
| FABACEAE | *Acacia mearnsii* | Black Wattle | C |
| ICACINACEAE | *Citronella moorei* | Churnwood | U |
| ICACINACEAE | *Pennantia cunninghamiana* | Brown Beech | C |
| LAURACEAE | *Cryptocarya glaucescens* | Native Laurel | M |
| LAURACEAE | *Cryptocarya microneura* | Murrogun | M |

| | | | |
|---|---|---|---|
| MALVACEAE | *Hibiscus heterophyllus* | Native Hibiscus | C |
| MELIACEAE | *Melia azedarach* | White Cedar | C |
| MELIACEAE | *Toona ciliata* | Red Cedar | C |
| MENISPERMACEAE | *Legnephora moorei* | Round Vine | C |
| MONIMIACEAE | *Wilkiea huegeliana* | Wilkiea | C |
| MORACEAE | *Ficus coronata* | Sandpaper Fig | C |
| MORACEAE | *Ficus macrophylla* | Moreton Bay Fig | C |
| MORACEAE | *Ficus obliqua* | Small Leaf Fig | M |
| MORACEAE | *Ficus rubiginosa* | Port Jackson Fig | M |
| MORACEAE | *Ficus superba* | Deciduous Fig | I |
| MORACEAE | *Maclura cochinchinensis* | Cockspur Thorn | C |
| MORACEAE | *Streblus brunonianus* | Whalebone Tree | C |
| MORACEAE | *Trophis scandens* | Burney Vine | C |
| MYRTACEAE | *Acmena smithii* | Lilly Pilly | C |
| MYRTACEAE | *Syzygium australe* | Brush Cherry | C |
| OLEACEAE | *Notelaea venosa* | Mock Olive | C |
| PEPEROMIACEAE | *Peperomia blanda var floribunda* | Peperomia | C |
| PHILESIACEAE | *Eustrephus latifolius* | Wombat Berry | C |
| PHILESIACEAE | *Geitonoplesium cymosum* | Scrambling Lily | C |
| PIPERACEAE | *Piper novaehollandiae* | Giant Pepper Vine | C |
| PITTOSPORACEAE | *Pittosporum revolutum* | Hairy Pittosporum | C |
| PITTOSPORACEAE | *Pittosporum undulatum* | Sweet Daphne | C |
| PODOCARPACEAE | *Podocarpus elatus* | Plum Pine | U |
| RHAMNACEAE | *Alphitonia excelsa* | Red Ash | C |
| RUTACEAE | *Acronychia oblongifolia* | Acronychia | M |
| RUTACEAE | *Geijera salicifolia* | Brush Wilga | M |
| RUTACEAE | *Melicope micrococca* | Melicope | U |
| SAPINDACEAE | *Alectryon subcinereus* | Native Quince | C |
| SAPINDACEAE | *Diploglottis australis* | Native Tamarind | U |
| SAPINDACEAE | *Guioa semiglauca* | Guioa | C |
| SAPOTACEAE | *Pouteria australis* | Black Apple | M |
| SINOPTERIDACEAE | *Pellaea falcata* | Sickle Fern | C |
| SMILACACEAE | *Smilax australis* | Smilax | C |
| STERCULIACEAE | *Brachychiton acerifolius* | Illawarra Flame Tree | U |
| URTICACEAE | *Dendrocnide excelsa* | Giant Stinging Tree | C |
| URTICACEAE | *Urtica incisa* | Stinging Nettle | C |
| VERBENACEAE | *Clerodendrum tomentosum* | Hairy Clerodendron | C |
| VITACEAE | *Cissus antarctica* | Kangaroo Grape | C |
| VITACEAE | *Cissus hypoglauca* | Water Vine | C |

## Weed Species List

The survey was carried out on 28/03/2017 and identified 11 weed species present within this zone:

| | | |
|---|---|---|
| I | Isolated specimens | Usually only 1 individual plant |
| U | Uncommon | 2 to 10 plants throughout the site |
| M | Moderately Common | 10 to 50 plants throughout the site |
| C | Common | 50 + plants throughout the site |
| NW | Noxious Weeds | Weeds declared as Noxious Weeds |
| WoNS | Weeds of National Significance | Weeds declared as WoNS |

| FAMILY | BOTANICAL NAME | COMMON NAME | Freq. |
|---|---|---|---|
| APOCYNACEAE | *Araujia sericifera* | Moth Vine | C |
| ASTERACEAE | *Ageratina riparia* | Mist Flower | C |
| ASTERACEAE | *Bidens pilosa* | Cobblers Pegs | C |
| ASTERACEAE | *Cirsium vulgare* | Spear Thistle | C |
| ASTERACEAE | *Conyza sumatrensis* | Fleabane | C |
| ASTERACEAE | *Delairea odorata* | Cape Ivy | C |
| FABACEAE | *Senna septemtrionalis* | Arsenic Bush | C |
| MALVACEAE | *Sida rhombifolia* | Paddys Lucerne | C |
| ROSACEAE | *Rubus fruticosis* | Blackberry | U, NW, WoNS |
| SOLANCEAE | *Physalis peruviana* | Cape Gooseberry | C |
| SOLANCEAE | *Solanum mauritianum* | Wild Tobacco | C |
| VERBENACEAE | *Lantana camara* | Lantana | C, NW, WoNS |

## Noxious Weeds and WoNS

The following Noxious weeds (Illawarra District Noxious Weeds Authority) and WoNS (Weeds of National Significance) were identified within this zone:

| Botanical Name / Common Name | Listing | Local Requirements | Control Methods |
|---|---|---|---|
| *Rubus fruticosis*<br>*Blackberry* | • Noxious Class 4<br>• WoNS | The growth of the plant must not be sold, propagated or knowingly distributed. | Scrape and paint ascending stems, spray with Metsylfuron or Starane to control spread |
| *Lantana camara*<br>Lantana | • Noxious Class 4<br>• WoNS | The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread | Cut and mulch all plant materials on site after removal of viable propagules. Apply undiluted herbicide immediately to the cut stump. |

## Vegetation Community Determination

Based on the assemblage of native species within this gully the following vegetation communities have been identified at this site:

| Vegetation Community | Key Species | Endangered Ecological Community | Notes |
|---|---|---|---|
| Illawarra Subtropical Rainforest | *Ficus spp. Toona ciliata, Pouteria australis, Diospyros australis, Doryphora sassafrass* | Yes | This community is easily identifiable by the assemblage of rainforest species and the tall intact closed canopy within this site. |

## Threatened Species

The following threatened species listed under THE EPBC Act 1999 were identified on this site:

| | |
|---|---|
| **Family** | Apocynaceae |
| **Common Name** | White Flower Wax Plant |
| **Genus / Species** | *Cynanchum elegans* |
| **Date** | 28/03/2017 |
| **Site Description** | Zone 1 Remnant Conservation Area, Boral Dunmore Hills |
| **GPS Co-ordinates** | Northing: 6168217<br>Easting: 02997123 |
| **Number of Plants / Stems** | 3 |
| **Size / Age of Plants** | Immature seedlings or suckers. No mature plants observed |
| **Vegetation Community** | Illawarra Subtropical Rainforest |
| **Growing in association with** | *Streblus brunonianus, Croton verauxii, Notelea venosa, Alchornea ilicifolia* |
| **Weeds Present** | *Lantana camara, Araujia sericifera, Bidens pilosa* |

Immature White Wax Flower(*Cynanchum elegans*) within Zone 1

## Revegetation Assessment

The revegetated areas of this site are located within the lower south eastern corner of the gully adjacent to the open paddocks. Some of the species selected for revegetation within this area are not specifically relevant to this site based on their natural growth requirements. For example Bracelet Honey Myrtle (*Melaleuca armillaris*) has been extensively planted within this area but is a tree species that specifically occurs naturally on the caps of the hills and ridge lines within this area. Several other species planted within this area are also outside of their natural range. The following is a list of all species used for revegetation within this gully:

| Botnaical Name | Common Name | Notes |
|---|---|---|
| *Acacia binervata* | Two Vein Hickory | |
| *Acacia maidenii* | Maidens Wattle | |
| *Eucalyptus saligna x botryoides* | Bastard Blue Gum | Inappropriate planting location |
| *Ficus coronata* | Sandpaper Fig | Heavily grazed |
| *Hibiscus heterophyllus* | Native Hibiscus | Heavily grazed |
| *Melaleuca armillaris* | Bracelet Honey Myrtle | Inappropriate planting location |
| *Mlelaleuca decora* | White Feather Honey Myrtle | |
| *Scolopia braunii* | Flintwood | Heavily grazed |
| *Syzygium australe* | Brush Cherry | Heavily grazed |

The following observations and management recommendations have been identified within the revegetation area:

| Observations | Management Recommendations |
|---|---|
| Maintenance of these plantings has been minimal and evidence of this can be observed by trees that have been constricted by the plant guards that should have been removed once the tree had exceeded the requirements of the guards.<br>Many plant guards have been broken from the trees and have been wind blown throughout the gully | Remove all core flute guards and dispose of appropriately |
| The planting density used within this area is appropriate for restoring a woodland community but is not sufficient for creating a connected canopy that will assist weed / pasture suppression and natural regeneration<br>Weeds such as Lantana, Blackberry and Thistles have colonised the planted areas due to the sparse planting of canopy species | Additional infill planting may be required to fill the gaps in the canopy to assist weed suppression.<br>Infill planting should be carried out at 1 plant per 2 square metres to create canopy connectivity and assist weed suppression |
| Regeneration of weed species within the planted areas | Weed control will be required within the planted areas to reduce competition and assist plant establishment |
| Use of inappropriate tree species in the planting program | Planting species specific to the site conditions.<br>(See appendix 1 for suitable species planting list) |
| Several of the species used within the planting areas have been heavily grazed by stock | Exclusion of stock using fencing and ensuring gates are closed |

Revegetated area at the lower end of the gully showing sparse plantings of woodland species. Infill planting of rainforest pioneer species will create a closed canopy to assist weed suppression

Sandpaper Fig (*Ficus coronata*) suffering from heavy grazing

Brush Cherry (*Syzygium australe*) suffering from heavy grazing and with old worn plant guard still intact

# Zone 2 Offset Area

## Site Map


## Site Description

This zone is located south of Rocklow Road and consists of a large bushland remnant with a creek line flowing through the middle. The total site area of this zone covers approximately 18.3 hectares. The majority of this zone is perched on the rocky hillside immediately adjacent to Rocklow Road and supports *Melalecua armillaris* tall shrubland. The creekline drops toward the eastern end of the site forming a gully which is well defined by the presence of rainforest species. The creek flows close to Rocklow Road at one point where dumping of rubbish and weed material has introduced several highly invasive weed species. On the southern side of the gully a tall intact canopy of Forest Red Gum (*Eucalyptus tereticornis*) exists that defines the Grassy Woodland community on site.
The 'Pulpit Rock' is located within this zone which is a large basalt column projecting from the creek bank that has eluded the processes of erosion. Pulpit Rock and Whispering Gallery some 1.5 km to the west were both popular tourist destinations in the late 19$^{th}$ and early 20$^{th}$ centuries. Tourists would travel by train to Dunmore railway station and walk to these destinations for day trips and picnics but the rising popularity of motor vehicles as a means of transport allowed tourists to travel much further afield and these destinations ceased to be visited and have since become overgrown with weeds and lost to the ages.

Pulpit Rock basalt column projecting from the creek bed within Zone 2

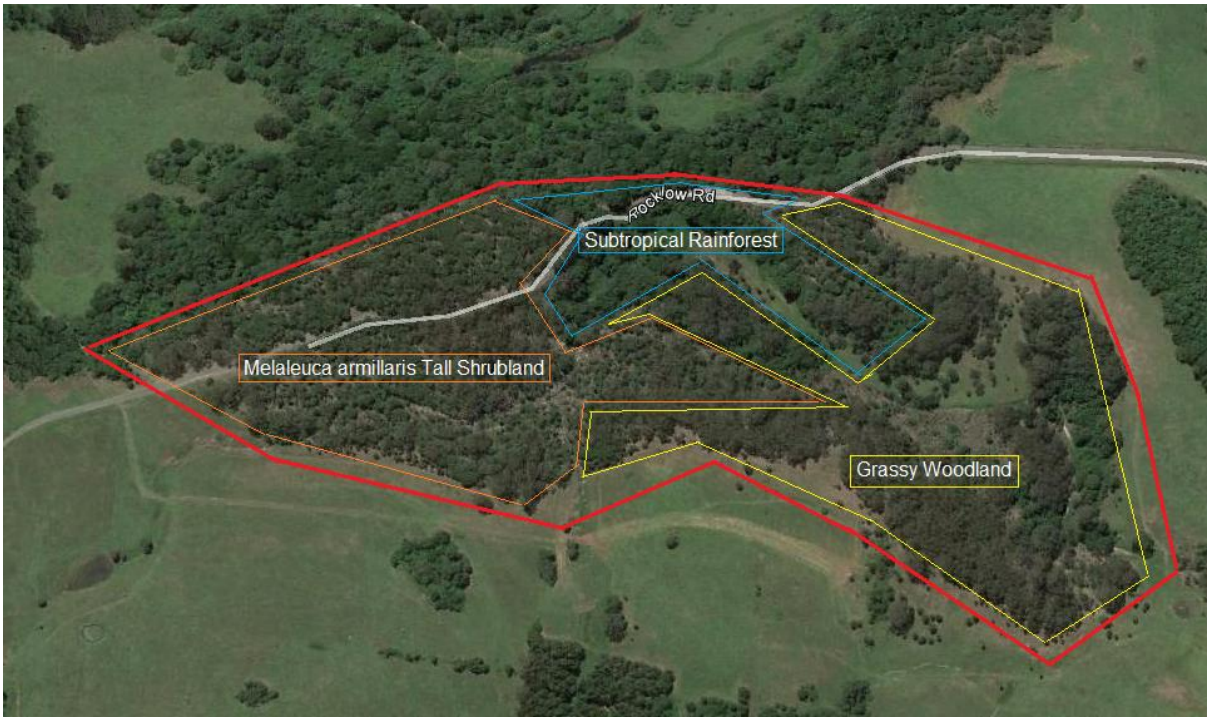
The area Below Pulpit Rock was once a popular picninc destination and swimming hole

## Vegetation Description

The vegetation within this zone consists of Melaleuca armillaris Tall Shrubland on the hill tops adjacent to Rocklow Road. This community remains intact but has been subjected to pressures form grazing and weed invasion. Dumping of various weeds has resulted in the ground layer within this area comprising approximately 75% weed species including *Ehrharta erecta*, Kikuyu and Bidens pilosa. Woody weeds such as Lantana are threatening to dominate the shrub layer and tree weeds such as African Olive will become problematic in the future.
Downstream of the 'Pulpit Rock' the creek drops into a gully which is well defined by the presence of an intact canopy of subtropical rainforest species. The creek flows close to the roadside within this area and a range of weeds have become established due to dumping of vegetative material from the road side. Madiera Vine is now spreading throughout this area and due to the tubers ability to float in flood waters has spread over a large area downstream from this point. Madiera Vine is a notoriously difficult and expensive weed to control and can be detrimental to rainforest regeneration and measures should be put in place to control the spread of this highly invasive weed. Various other weeds such as Cassia, Blackberry, Privet and African Olive are also thriving within this area and will require difficult and expensive control measures to treat.
The southern side of the creek supports and intact canopy of Forest Red Gum indicating the presence of Illawarra Grassy Woodland but the shrub layer is almost entirely dominated by Lantana and other woody weeds.

## Vegetation Mapping

The following site map shows the approximate boundaries of the different vegetation communities found within this zone:



## Vegetation Survey

### Native Species List

The following list is a representation of species found within this zone. This is not intended to be a complete list of all species found within this zone rather an overview of species to assist the determination of the vegetation community found on site.
The survey was carried out on 4/04/2017 and identified 85 native plant species:

| | | |
|---|---|---|
| I | Isolated specimens | Usually only 1 individual plant |
| U | Uncommon | 2 to 10 plants throughout the site |
| M | Moderately Common | 10 to 50 plants throughout the site |
| C | Common | 50 + plants throughout the site |
| TS | Threatened Species | Plants listed as 'Threatened Species' (EPBC Act 1999) |

| FAMILY | BOTANICAL NAME | COMMON NAME | Freq. |
|---|---|---|---|
| ADIANTACEAE | *Adiantum aethiopicum* | Common Haiden Hair | C |
| ADIANTACEAE | *Adiantum hispidulum* | Rough Maiden Hair | C |
| APOCYNACEAE | *Parsonsia straminea* | Common Silk Pod | C |
| ARACEAE | *Gymnostachys anceps* | Settlers Flax | C |
| ARALIACEAE | *Polyscias elegans* | Celerywood | U |
| ARECACEAE | *Livistona australis* | Cabbage Palm | U |
| ASCLEPEDIACEAE | *Marsdenia rostrata* | Common Milk Vine | C |
| ASCLEPEDIACEAE | *Tylophora barbata* | Bearded Tylophora | U |
| ASTERACEAE | *Sigesbeckia orientalis* | Indian Weed | C |
| BIGNONIACEAE | *Pandorea pandorana* | Wonga Vine | C |
| BLECHNACEAE | *Doodia aspera* | Rasp Fern | C |
| CELASTRACEAE | *Cassine australis* | Red Fruit Olive-plum | C |
| COMMELINACEAE | *Commelina cyanea* | Scurvy Weed | C |
| CONVOLVULACEAE | *Dichondra repens* | Kidney Weed | C |
| CRASSULACEAE | *Crassula sieberana subsp. Sieberana* | Austral Stonecrop | C |
| CUNONIACEAE | *Aphaneopetalum resinosum* | Gum Vine | C |
| CYPERACEAE | *Carex appressa* | Carex | U |
| CYPERACEAE | *Carex longebrachiata* | Drooping Carex | C |
| CYPERACEAE | *Cyperus tetraphyllus* | Cyperus | U |
| DAVALLIACEAE | *Arthropteris tenella* | Climbing Fern | M |
| EBENACEAE | *Diospyros australis* | Black Plum | C |
| EHRETIACEAE | *Ehretia accuminata* | Koda | C |
| EUPHORBIACEAE | *Alchornea ilicifolia* | Native Holly | M |
| EUPHORBIACEAE | *Breynia oblongifolia* | Coffee Bush | U |
| EUPHORBIACEAE | *Claoxylon australe* | Brittle Wood | C |
| EUPHORBIACEAE | *Croton verreauxii* | Native Cascarilla | C |
| EUPHORBIACEAE | *Glochidion ferdinandi* | Cheese Tree | C |
| FABACEAE | *Acacia implexa* | Hickory | U |
| FABACEAE | *Acacia maidenii* | Maidens Wattle | M |
| FABACEAE | *Acacia mearnsii* | Black Wattle | M |

| | | | |
|---|---|---|---|
| FABACEAE | *Desmodium varians* | Desmodium | U |
| FLACOURTIACEAE | *Scolopia braunii* | Flintwood | U |
| GENTIANACEAE | *Geranium homeanum* | Native Geranium | C |
| LAURACEAE | *Cryptocarya glaucescens* | Native Laurel | M |
| LAURACEAE | *Cryptocarya microneura* | Murrogun | M |
| LILIACEAE | *Dianella longifolia* | Flax Lily | U |
| MALVACEAE | *Abutilon oxycarpum* | Chinese Lanterns | C |
| MELIACEAE | *Melia azedarach* | White Cedar | C |
| MELIACEAE | *Toona ciliata* | Red Cedar | C |
| MENISPERMACEAE | *Legnephora moorei* | Round Vine | C |
| MENISPERMACEAE | *Stephania japonica* | Snake Vine | C |
| MONIMIACEAE | *Wilkiea huegeliana* | Wilkiea | I |
| MORACEAE | *Ficus coronata* | Sandpaper Fig | C |
| MORACEAE | *Ficus macrophylla* | Moreton Bay Fig | M |
| MORACEAE | *Ficus obliqua* | Small Leaf Fig | M |
| MORACEAE | *Ficus rubiginosa* | Port Jackson Fig | C |
| MORACEAE | *Ficus superba* | Deciduous Fig | U |
| MORACEAE | *Maclura cochinchinensis* | Cockspur Thorn | M |
| MYRTACEAE | *Acmena smithii* | Lilly Pilly | M |
| MYRTACEAE | *Backhousia myrtifolia* | Grey Myrtle | C |
| MYRTACEAE | *Eucalyptus amplifolia* | Cabbage Gum | U |
| MYRTACEAE | *Eucalyptus quadrangulata* | White Top Box | U |
| MYRTACEAE | *Eucalyptus tereticornis* | Forest Red Gum | C |
| MYRTACEAE | *Melaleuca armillaris* | Bracelet Honey-myrtle | C |
| MYRTACEAE | *Syzygium australe* | Brush Cherry | C |
| OLEACEAE | *Notelaea venosa* | Mock Olive | C |
| PEPEROMIACEAE | *Peperomia blanda var floribunda* | Peperomia | C |
| PHILESIACEAE | *Eustrephus latifolius* | Wombat Berry | C |
| PITTOSPORACEAE | *Bursaria spinosa* | Australian Blackthorn | U |
| PITTOSPORACEAE | *Citriobatus pauciflorus* | Orange Thorn | U |
| PITTOSPORACEAE | *Pittosporum multiflorum* | Citirobatus, Orange Thorn | C |
| PITTOSPORACEAE | *Pittosporum undulatum* | Sweet Daphne | M |
| POACEAE | *Cymbopogon refractus* | Barb Wire Grass | U |
| POACEAE | *Echinopogon caespitosus* | Tufted Hedgehog Grass | U |
| POACEAE | *Microlaena stipoides* | Weeping rice grass | C |
| POACEAE | *Poa labillardieri* | Tussock Grass | C |
| PROTEACEAE | *Stenocarpus salignus* | Scrub Beefwood | C |
| RHAMNACEAE | *Alphitonia excelsa* | Red Ash | C |
| ROSACEAE | *Rubus rosifolius* | Native Raspberry | U |
| RUTACEAE | *Geijera salicifolia* | Brush Wilga | M |
| RUTACEAE | *Sarcomelicope simplicifolia* | Sarcomelicope | U |
| RUTACEAE | *Zieria granulata* | Illawarra Zieria | C, TS |
| SAPINDACEAE | *Alectryon subcinereus* | Native Quince | M |
| SAPINDACEAE | *Diploglottis australis* | Native Tamarind | U |
| SAPINDACEAE | *Dodonaea viscosa var angustifolia* | Hop Bush | C |
| SAPINDACEAE | *Guioa semiglauca* | Guioa | C |

| | | | |
|---|---|---|---|
| SAPOTACEAE | *Pouteria australis* | Black Apple | U |
| SINOPTERIDACEAE | *Pellaea falcata* | Sickle Fern | C |
| STERCULIACEAE | *Brachychiton acerifolius* | Illawarra Flame Tree | U |
| STERCULIACEAE | *Commersonia fraseri* | Brown Kurrajong | M |
| URTICACEAE | *Dendrocnide excelsa* | Giant Stinging Tree | U |
| URTICACEAE | *Urtica incisa* | Stinging Nettle | C |
| VERBENACEAE | *Clerodendrum tomentosum* | Hairy Clerodendron | C |
| VITACEAE | *Cayratia clematidea* | Native Grape | C |
| XANTHOREACEAE | *Lomandra longifolia* | Mat Rush | M |

## Weed Species List

The survey was carried out on 4/04/2017 and identified 30 weed species present within this zone:

| | | |
|---|---|---|
| I | Isolated specimens | Usually only 1 individual plant |
| U | Uncommon | 2 to 10 plants throughout the site |
| M | Moderately Common | 10 to 50 plants throughout the site |
| C | Common | 50 + plants throughout the site |
| NW | Noxious Weeds | Weeds declared as Noxious Weeds |
| WoNS | Weeds of National Significance | Weeds declared as WoNS |

| FAMILY | BOTANICAL NAME | COMMON NAME | FREQ. |
|---|---|---|---|
| ASCLEPEDIACEAE | *Araujia sericifera* | Moth Vine | M |
| ASCLEPEDIACEAE | *Gomphocarpus fruticosis* | Cotton Bush | M |
| ASTERACEAE | *Ageratina adenophora* | Crofton Weed | M |
| ASTERACEAE | *Ageratina riparia* | Mist Flower | C |
| ASTERACEAE | *Bidens pilosa* | Cobblers Pegs | C |
| ASTERACEAE | *Cirsium vulgare* | Spear Thistle | M |
| ASTERACEAE | *Conyza sumatrensis* | Tall Fleabane | C |
| ASTERACEAE | *Cotula coronopifolia* | Yellow Buttons | C |
| ASTERACEAE | *Delairea odorata* | Cape Ivy | C |
| ASTERACEAE | *Senecio madagascarensis* | Fire Weed | C, NW, WoNS |
| ASTERACEAE | *Sonchus asper* | Prickly Sowthistle | M |
| ASTERACEAE | *Tagetes minuta* | Stinking Roger | C |
| BASSELLACEAE | *Anredera cordifolia* | Madiera Vine | C, WoNS |
| CAESALPINIACEAE | *Senna pendula var. glabrata* | Cassia | M |
| CYPERACEAE | *Cyperus brevifolius* | Mulumbimby Couch | C |
| FABACEAE | *Erythrina x sykesii* | Coral Tree | I |
| MALVACEAE | *Sida rhombifolia* | Paddys Lucerne | C |
| OLEACEAE | *Ligustrum sinensis* | Small Leaf Privet | U |
| OLEACEAE | *Olea europaea subsp. cuspidata* | African Olive | C |
| OPUNTIACAE | *Opuntia stricta* | Prickly Pear | U, NW, WoNS |
| POACEAE | *Cenchrus clandestinus* | Kikuyu | C |
| POACEAE | *Ehrharta erecta* | Panic Veldt Grass | C |
| POACEAE | *Paspalum dilatatum* | Paspalum | C |
| POACEAE | *Sporobolus africanus* | Parramatta Grass | C |
| POLYGONACEAE | *Rumex crispus* | Dock | C |
| ROSACEAE | *Rubus fruticosus (agg. spp.)* | Blackberry | C, NW, WoNS |
| SOLANACEAE | *Solanum mauritianum* | Wild Tobacco | M |
| SOLANACEAE | *Solanum nigrum* | Blackberry Nightshade | U |
| VERBENACEAE | *Lantana camara* | Lantana | C, NW, WoNS |
| VERBENACEAE | *Verbena rigida* | Rough Purple Top | M |

## Noxious Weeds and WoNS

The following Noxious weeds (Illawarra District Noxious Weeds Authority) and WoNS (Weeds of National Significance) were identified within this zone:

| **Botanical Name / Common Name** | **Listing** | **Local Requirements** | **Control Methods** |
|---|---|---|---|
| *Rubus fruticosis*<br>*Blackberry* | • Noxious Class 4<br>• WoNS | The growth of the plant must not be sold, propagated or knowingly distributed. | Scrape and paint ascending stems, spray with Metsylfuron or Starane to control spread |
| *Lantana camara*<br>Lantana | • Noxious Class 4<br>• WoNS | The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread | Cut and mulch all plant materials on site after removal of viable propagules. Apply undiluted herbicide immediately to the cut stump. |
| *Opuntia spp.*<br>Prickly Pear | • Noxious Class 4<br>• WoNS | The growth of the plant must not be sold, propagated or knowingly distributed. | Hand remove and bag all materials including leaves, stems and fruit |
| *Senecio madagascarensis*<br>Fireweed | • Noxious Class 4<br>• WoNS | The growth of the plant must not be sold, propagated or knowingly distributed. | Remove and bag mature seed heads, hand remove remaining plant material and compost on site |
| *Anredera cordifolia*<br>Madiera Vine | • WoNS | Land owners and managers at all levels are responsible for managing WoNS | Remove all aerial tubers where possible, use scrape and paint method to treat out of reach aerial tubers, control spread using Starane spray, hand remove and bag tubers stored in soil |

## Vegetation Community Determination

Based on the assemblage of native species within this gully the vegetation at this site the following vegetation communities have been identified at this site:

| Vegetation Community | Key Species | Endangered Ecological Community | Notes |
|---|---|---|---|
| Illawarra Lowlands Grassy Woodland | *Eucalyptus tereticornis, Acacia mearnsii, Dodonea viscosa* subsp. *angustifolia* | Yes | Intact canopy present but the shrub layer heavily infested with woody weeds |
| Illawarra Subtropical Rainforest | *Ficus spp. Toona ciliata, Pouteria australis* | Yes | Intact canopy present. Community facing pressure from highly invasive weeds such as Madiera Vine |
| Melaleuca armillaris Tall Shrubland | *Melaluca armillaris, Zieria granulate, Crassula sieberiana* | Yes | Intact canopy present but the shrub layer and ground layer heavily infested with woody and herbaceous weeds |

## Threatened Species

The following threatened species listed under THE EPBC Act 1999 were identified on this site:

| | |
|---|---|
| **Family** | Rutaceae |
| **Common Name** | Illawara Zieria |
| **Genus / Species** | *Zieria granulata* |
| **Date** | 4/04/2017 |
| **Site Description** | Zone 2 Offset Area, Boral Dunmore Hills |
| **GPS Co-ordinates** | Too many plants to list |
| **Number of Plants / Stems** | Many hundreds |
| **Size / Age of Plants** | Mature plants and seedlings present and in good condition |
| **Vegetation Community** | *Melaleuca armillaris* Tall Shrubland |
| **Growing in association with** | *Melaleuca armillaris, Indigofera australis, Dodonea viscose* var. *angustifolia* |
| **Weeds Present** | *Lantana camara, Ehrharta erecta, Bidens pilosa* |

## Revegetation Assessment

No revegetation is evident within this zone

## Restoration Plan

The purpose of this restoration plan is to provide recommendations to address weed management issues in a way that assists and encourages the regeneration of the natural vegetation communities present within this site.

### Bushland Restoration Objectives

The objectives of the bushland restoration plan are as follows:

- Protect existing natural vegetation using weed management methods and revegetation where necessary
- Treat Noxious Weeds and WoNS as per legal requirements
- Intervention weeding of highly invasive weed species to limit further spread
- Regeneration of natural vegetation communities working from areas of highest resilience toward areas of least natural resilience
- Undertake a staged weeding program over a number of years to assist natural regeneration while ensuring minimal disturbance to habitat
- Maintain worked areas to assist regeneration before clearing of additional unworked areas

### Protection of Existing Vegetation

Protecting existing vegetation is the highest priority activity within this restoration plan. Measures of protecting existing vegetation at this site are as follows:

- Install and maintain fencing surrounding areas of natural vegetation to minimise stock entry and grazing within natural areas
- Use buffer plantings around existing remnants to provide protection from adverse weather and wind borne weed seeds and other propagules blowing into the intact vegetation remnants
- Use a range of measures to reduce the incidence of vegetation dumping on the road side including cameras, signage and additional fencing
- Manage weeds within the different vegetation communities to allow natural regeneration of plant species specific to each community
- Treat highly invasive weed species that can have an adverse impact on the overall health of the natural vegetation communities

### Managing Weed Encroachment

Managing weeds within this site requires a range of different strategies to target particular weed species. The following table lists all weed species present within this site and the removal method and management techniques required to treat these weeds (refer to Appendix 2 for weed removal methods definitions):

| Botanical Name | Common Name | Weed Control method | Long Term Management |
|---|---|---|---|
| **Woody Weeds** | | | |
| *Erythrina x sykesii* | Coral Tree | Frill large trees | One population of approximately 30 stems exists within the subtropical rainforest remnant. Once effectively treated will not require any further management |
| *Lantana camara* | Lantana | Cut and paint mature plants, hand removal of seedlings | Treat areas of approximately 500 – 1000m² at a time in a mosaic pattern and maintain for six months before treating next area |
| *Ligustrum sinensis* | Small Leaf Privet | Cut and paint mature plants, hand removal of seedlings, Frill large trees | Monitor seedling growth and treat prior to flowering and fruiting |
| *Olea europaea subsp. cuspidata* | African Olive | Cut and paint mature plants, hand removal of seedlings, Frill large trees | Monitor seedling growth and treat prior to flowering and fruiting |
| *Rubus fruticosus (agg. spp.)* | Blackberry | Scrape and paint, spraying | Monitor seedling growth and treat prior to flowering and fruiting |
| *Senna pendula var. glabrata* | Cassia | Cut and paint mature plants, hand removal of seedlings | Monitor seedling growth and treat prior to flowering and fruiting |
| *Solanum mauritianum* | Wild Tobacco | Cut and paint mature plants, hand removal of seedlings | Monitor seedling growth and treat prior to flowering and fruiting |
| **Invasive Vines** | | | |
| *Anredera cordifolia* | Madiera Vine | Hand remove and bag all plant materials | Monitor and remove all tubers and plants from the point of initial infestation and all areas downstream of this point |
| *Araujia sericifera* | Moth Vine | Cut and paint mature plants, hand removal of seedlings | Monitor seedling growth and treat prior to flowering and fruiting, bag and remove seeds in June |
| *Delairea odorata* | Cape Ivy | Hand remove and bag all plant materials | Monitor seedling growth and treat prior to flowering and fruiting |
| **Annual and Herbaceous Weeds** | | | |
| *Ageratina adenophora* | Crofton Weed | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, |
| *Ageratina riparia* | Mist Flower | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, |
| *Bidens pilosa* | Cobblers Pegs | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Cirsium vulgare* | Spear Thistle | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Conyza sumatrensis* | Tall Fleabane | Hand removal, spraying | Monitor seedling growth and treat prior to flowering |

| | | | |
|---|---|---|---|
| | | | and fruiting, use planting to establish canopy and out compete |
| *Cotula coronopifolia* | Yellow Buttons | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Gomphocarpus fruticosis* | Cotton Bush | Cut and paint mature plants, hand removal of seedlings | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Opuntia stricta* | Prickly Pear | Hand remove and bag all plant materials | Monitor and removal l plant materials |
| *Rumex crispus* | Dock | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Senecio madagascarensis* | Fire Weed | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Sida rhombifolia* | Paddys Lucerne | Cut and paint mature plants, hand removal of seedlings | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Solanum nigrum* | Blackberry Nightshade | Cut and paint mature plants, hand removal of seedlings | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Sonchus asper* | Prickly Sowthistle | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Tagetes minuta* | Stinking Roger | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| *Verbena rigida* | Rough Purple Top | Hand removal, spraying | Monitor seedling growth and treat prior to flowering and fruiting, use planting to establish canopy and out compete |
| **Grasses** | | | |
| *Cenchrus clandestinus* | Kikuyu | Hand removal, spraying | Use planting to establish canopy and out compete |
| *Cyperus brevifolius* | Mulumbimby Couch | Hand removal, spraying | Use planting to establish canopy and out compete |
| *Ehrharta erecta* | Panic Veldt Grass | Hand removal, spraying | Exclude plants by assisting regeneration of native groundcovers |
| *Paspalum dilatatum* | Paspalum | Hand removal, spraying | Use planting to establish canopy and out compete |
| *Sporobolus africanus* | Parramatta Grass | Hand removal, spraying | Use planting to establish canopy and out compete |

**Priority Work Areas**

Priority work areas within this zone have been identified within each of the different vegetation communities. All vegetation communities within this zone are listed as endangered ecological communities so each have similar prioritised restoration requirements. The highest priority work activities within each community are as follows in order of priority:

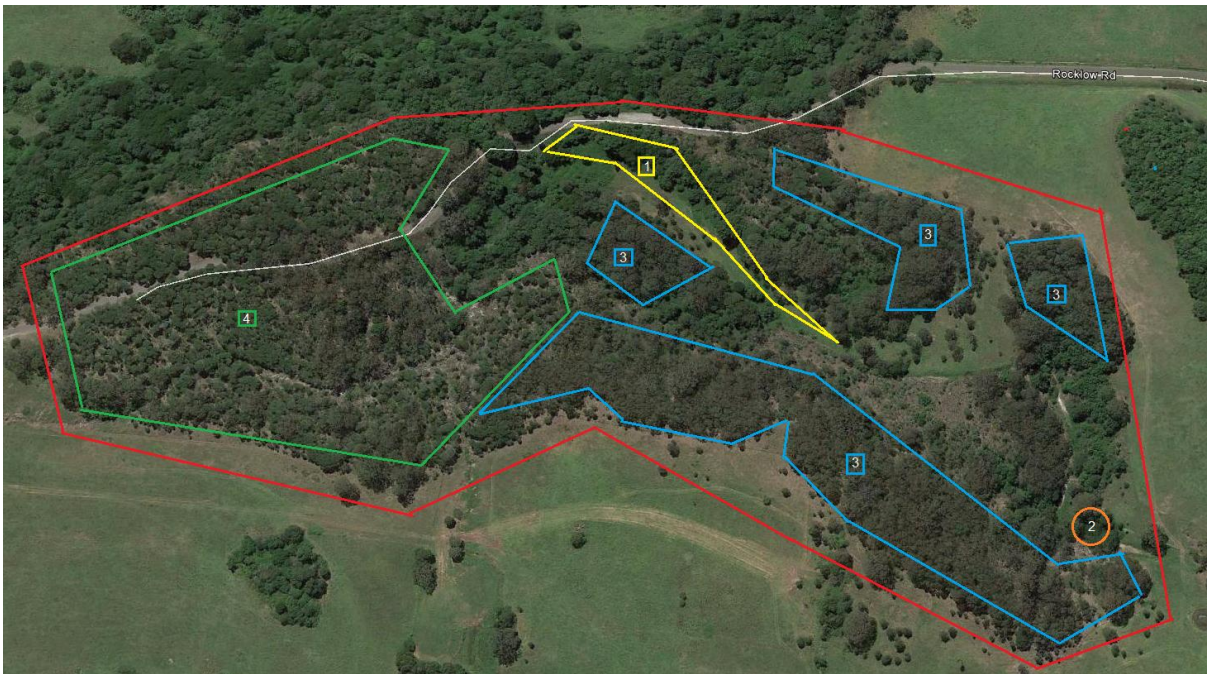
1. Melaleuca armillaris Tall Shrubland
   - Treatment of Noxious Weeds and WoNS
   - Staged treatment of woody weeds such as Lantana, Cassia and African Olive using cut and paint and frilling methods working form areas of highest natural resilience toward areas of least natural resilience
   - Assisting regeneration of native groundcovers to out compete herbaceous weeds and grasses

2. Illawarra Subtropical Rainforest
   - Treatment of Noxious Weeds and WoNS
   - Treatment of Madiera Vine using hand removal and spraying methods from the point of infestation where the creek flows closest to the roadside heading down stream
   - Staged treatment of woody weeds such as Lantana, Cassia and African Olive using cut and paint and frilling methods working form areas of highest natural resilience toward areas of least natural resilience
   - Planting fast growing pioneer within open areas to provide canopy connectivity between rainforest remnant and assist exclusion of weeds

3. Illawarra Lowlands Grassy Woodland
   - Treatment of Noxious Weeds and WoNS
   - Staged treatment of woody weeds such as Lantana, Cassia and African Olive using cut and paint and frilling methods working form areas of highest natural resilience toward areas of least natural resilience
   - Assisting regeneration of native groundcovers to out compete herbaceous weeds such as Cobbler Pegs and grasses such as Panic Veldt Grass, Parramatta Grass

**Priority Work Areas Locations**

The following map identifies the locations of the highest priority work areas within this zone:




1. Madiera vine (*Anredera cordifolia*) population covering approximately 1,500m²
2. Coral Tree (*Erythrina x sykesii*)stand comprising approximately 30 individual stems
3. Grassy Woodland remnant with a dense Lantana understorey covering approximately 26,500m²
4. Melalecua armillaris Tall Shrubland area with many mature individual African Olive (*Olea europa subsp. cuspidata*) plants. The ground layer within this entire community has become infested with annual grassy weeds and planting and assisted regeneration of native groundcovers will be beneficial to help out compete these weeds

**Scope of Works**

The following works will be required within this zone:

- Treatment of Noxious Weeds and WoNS as per legal requirements:
    1. Blackberry – treat large infestations using spray controls, smaller infestations can be treated using the scrape and paint method
    2. Lantana – see below
    3. Prickly Pear – hand remove and bag all plants and remove off site for disposal in an appropriate green waste facility
    4. Fireweed – spray treat Fireweed plants prior to flowering and fruiting
    5. Madiera Vine – see below
- Treatment of dense Lantana in a staged program of clearing approximately 1000m² at a time and assisting regeneration by maintaining weeds over a period of six months before treatment of the next 1000m² area. All woody weed materials generated during these works should be cut and mulched on site using hand tools after careful removal of any viable propagules
- Treatment of African Olive using frilling and cut and paint methods prior to flowering and fruiting to limit further dispersal of seed
- Install and maintain fencing to ensure grazing stock are excluded from the regeneration areas
- Buffer planting around the perimeter of the vegetation remnants to provide an effective screen to limit further dispersal of wind blown weed seeds and other propagules (refer to Appendix 1 for a list of plants appropriate for revegetation within the different vegetation communities)
- Intervention weeding to treat the existing highly invasive Madiera Vine population within the subtropical rainforest remnant. All Madiera vine materials must be bagged and removed off site for disposal in an appropriate green waste facility
- Frilling the small population of Coral Trees on the creek bank within the subtropical rainforest remnant

## Evidence of Pest Fauna

Little evidence of pest fauna was identified during the field survey. The following fauna observations were made at this site:

- Cattle have breached the fencing within this site and have accessed the natural vegetation. Cattle have had the most impact on the natural vegetation by trampling regeneration of native seedlings and random grazing of many plant species.
- Eastern Grey Kangaroos and Swamp Wallabies are present within all of the communities within this zone however their preference for grazing pasture grasses has ensured they have had minimal impact on the health of the natural vegetation
- Foxes are present within this area and while no animals were observed during the survey many scats were identified. Investigation of fox scats identified that the primary food source for foxes in this area was insects however some plant materials were also included within the scats and weed seeds can occasionally be spread by foxes
- Goats are present within the Dunmore Hills area and can be highly detrimental to native vegetation however no evidence of goats was observed within this zone
- Deer are present within the Dunmore Hills area and can be highly detrimental to native vegetation however no evidence of Deer was observed within this zone

Buttress roots of large emergent Moreton Bay fig within Zone 3

# Zone 3 Compensatory Habitat Area

## Site Map


## Site Description

This zone is located south of Rocklow Road and consists of a large bushland remnant on a hilltop with a small ephemeral creek line within a gully to the south of the hill . The total site area of this zone covers approximately 23.1 hectares. The majority of this zone is perched on the rocky hillside and supports the *Melalecua armillaris* tall shrubland vegetation community. The gully drops at the southern end of the zone which is well defined by the presence of rainforest species and some very impressive land large Moreton Bay Fig (*Ficus macrophylla*) trees.
Extensive revegetation has been carried out within this zone within the southern gully and on the eastern and western edges of the zone. Hundreds of thousands of trees have been planted within this zone and are now reaching maturity. Many open areas that have been cleared of vegetation also exist within this zone with the majority of these clearings occurring on the rocky hill tops.

## Vegetation Description

The vegetation within this zone consists of Melaleuca armillaris Tall Shrubland on the hill tops. This community remains mostly intact but has been cleared within some areas for unknown reasons. The rainforest remnants within this zone are much less diverse than the rainforests within zone 1 but still have an intact canopy and a good range of rainforest species. Many large old emergent Moreton Bay Fig trees extend high above the canopy within this zone and are utilised as perching sites for rainforest pigeons and other birds that feed on fleshy fruits. This is evidenced by the assemblage of native and exotic fruit producing species plant growing under the canopy of the fig trees. Fleshy fruited weed species such as African Olive, Green cestrum and Mickey Mouse Plant are particularly abundant within this area.
Actephila (*Actephila lindleyi*) is a small rainforest tree that is common in northern NSW but reaches its southern limit within the Kiama district and is considered regionally rare within the Illawarra region. The rainforest remnants within this zone support a large population of this plant. The threatened species White Wax Flower (*Cynanchum elegans*) is also particularly abundant within these rainforest remnants and mature plants and seedlings were observed during the vegetation survey. Tall Cabbage Palms (*Livistona australis*) are present within the gullies of this zone. These tall trees grow to match the height of the surrounding rainforest canopy to compete for light and when the rainforest is cleared these trees are generally left standing due to their minimal value as a timber species. Tall Cabbage Palms remain as a monument to the once tall rainforest canopy that they initially grew in association with.

Tall Cabbage Palms indicating the clearing of rainforest

## Vegetation Mapping

The following site map shows the approximate boundaries of the different vegetation communities found within this zone:

## Vegetation Survey

## Native Species List

The following list is a representation of species found within this zone. This is not intended to be a complete list of all species found within this zone rather an overview of species to assist the determination of the vegetation community found on site.
The survey was carried out on 18/04/2017 and identified 60 native plant species:

| | | |
|---|---|---|
| I | Isolated specimens | Usually only 1 individual plant |
| U | Uncommon | 2 to 10 plants throughout the site |
| M | Moderately Common | 10 to 50 plants throughout the site |
| C | Common | 50 + plants throughout the site |
| TS | Threatened Species | Plants listed as 'Threatened Species' (EPBC Act 1999) |

| FAMILY | BOTANICAL NAME | COMMON NAME | Freq. |
|---|---|---|---|
| APOCYNACEAE | *Parsonsia straminea* | Common Silk Pod | C |
| ARALIACEAE | *Polyscias elegans* | Celerywood | U |
| ARECACEAE | *Livistona australis* | Cabbage Palm | M |
| APOCYNACEAE | *Cynanchum elegans* | White Wax Flower | U, TS |
| ASTERACEAE | *Bracteantha bracteata* | Paper Daisy | C |
| BIGNONIACEAE | *Pandorea pandorana* | Wonga Vine | C |
| BLECHNACEAE | *Doodia aspera* | Rasp Fern | C |
| CELASTRACEAE | *Cassine australis* | Red Fruit Olive-plum | C |
| CHENOPODIACEAE | *Einadia hastata* | Saloop | C |
| CYPERACEAE | *Gahnia sieberana* | Saw Sedge | U |
| EBENACEAE | *Diospyros australis* | Black Plum | C |
| EBENACEAE | *Diospyros pentamera* | Myrtle Ebony | U |
| EHRETIACEAE | *Ehretia accuminata* | Koda | C |
| ELEOCARPACEAE | *Eleocarpus kirtonii* | White Quandong | I |
| EPACRIDACEAE | *Leucopogon juniperinus* | Prickly Beard Heath | C |
| EUPHORBIACEAE | *Actephila lindleyi* | Actephila | C |
| EUPHORBIACEAE | *Alchornea ilicifolia* | Native Holly | M |
| EUPHORBIACEAE | *Baloghia inophylla* | Brush Bloodwood | C |
| EUPHORBIACEAE | *Breynia oblongifolia* | Coffee Bush | C |
| EUPHORBIACEAE | *Claoxylon australe* | Brittle Wood | C |
| EUPHORBIACEAE | *Croton verreauxii* | Native Cascarilla | C |
| FABACEAE | *Acacia maidenii* | Maidens Wattle | C |
| FABACEAE | *Indigofera australis* | Indigofera | U |
| FLACOURTIACEAE | *Scolopia braunii* | Flintwood | C |
| LAMIACEAE | *Plectranthus graveolens* | Plectranthus | C |
| LAMIACEAE | *Plectranthus parviflorus* | Cockspur Flower | C |
| LAURACEAE | *Cryptocarya microneura* | Murrogun | C |
| MALVACEAE | *Hibiscus heterophyllus* | Native Hibiscus | M |
| MELIACEAE | *Toona ciliata* | Red Cedar | M |
| MONIMIACEAE | *Wilkiea huegeliana* | Wilkiea | U |
| MORACEAE | *Ficus coronata* | Sandpaper Fig | U |

| | | | |
|---|---|---|---|
| MORACEAE | *Ficus macrophylla* | Moreton Bay Fig | C |
| MORACEAE | *Ficus obliqua* | Small Leaf Fig | U |
| MORACEAE | *Ficus rubiginosa* | Port Jackson Fig | M |
| MORACEAE | *Maclura cochinchinensis* | Cockspur Thorn | C |
| MORACEAE | *Streblus brunonianus* | Whalebone Tree | C |
| MYRSINACEAE | *Myrsine variabilis* | Brush Muttonwood | M |
| MYRTACEAE | *Backhousia myrtifolia* | Grey Myrtle | U |
| MYRTACEAE | *Melaleuca armillaris* | Bracelet Honey-myrtle | C |
| MYRTACEAE | *Syzygium australe* | Brush Cherry | M |
| OLEACEAE | *Notelaea venosa* | Mock Olive | C |
| PEPEROMIACEAE | *Peperomia blanda var floribunda* | Peperomia | C |
| PITTOSPORACEAE | *Pittosporum multiflorum* | Citirobatus, Orange Thorn | M |
| PITTOSPORACEAE | *Pittosporum revolutum* | Hairy Pittosporum | C |
| PITTOSPORACEAE | *Pittosporum undulatum* | Sweet Daphne | C |
| POACEAE | *Cymbopogon refractus* | Barb Wire Grass | C |
| POACEAE | *Microlaena stipoides* | Weeping rice grass | C |
| PROTEACEAE | *Stenocarpus salignus* | Scrub Beefwood | U |
| RHAMNACEAE | *Alphitonia excelsa* | Red Ash | C |
| RUTACEAE | *Melicope micrococca* | Melicope | M |
| RUTACEAE | *Zieria granulata* | Illawarra Zieria | C, TS |
| SANTALACEAE | *Exocarpus cupressiformis* | Cherry Ballart | U |
| SAPINDACEAE | *Alectryon subcinereus* | Native Quince | C |
| SAPINDACEAE | *Dodonaea viscosa var angustifolia* | Hop Bush | C |
| SAPINDACEAE | *Guioa semiglauca* | Guioa | C |
| SAPOTACEAE | *Pouteria australis* | Black Apple | C |
| SCHIZAEACEAE | *Cheilanthes sieberi* | Mulga Fern | C |
| STERCULIACEAE | *Brachychiton populneum* | Kurrajong | I |
| URTICACEAE | *Dendrocnide excelsa* | Giant Stinging Tree | C |
| VERBENACEAE | *Clerodendrum tomentosum* | Hairy Clerodendron | C |

Actephila (*Actephila lindleyi*) is a regionally rare tree in the Illawarra region but is well represented within the rainforest remnants in Zone 3

## Weed Species List

The survey was carried out on 4/04/2017 and identified 17 weed species present within this zone:

| | | |
|---|---|---|
| I | Isolated specimens | Usually only 1 individual plant |
| U | Uncommon | 2 to 10 plants throughout the site |
| M | Moderately Common | 10 to 50 plants throughout the site |
| C | Common | 50 + plants throughout the site |
| NW | Noxious Weeds | Weeds declared as Noxious Weeds |
| WoNS | Weeds of National Significance | Weeds declared as WoNS |

| FAMILY | BOTANICAL NAME | COMMON NAME | FREQ. |
|---|---|---|---|
| APOCYNACEAE | *Araujia sericifera* | Moth Vine | C |
| ASTERACEAE | *Ageratina riparia* | Mist Flower | M |
| ASTERACEAE | *Bidens pilosa* | Cobblers Pegs | C |
| ASTERACEAE | *Conyza sumatrensis* | Tall Fleabane | C |
| ASTERACEAE | *Delairea odorata* | Cape Ivy | C |
| ASTERACEAE | *Tagetes minuta* | Stinking Roger | C |
| CARYOPHYLLACEAE | *Stellaria media* | Chickweed | M |
| MALVACEAE | *Sida rhombifolia* | Paddys Lucerne | C |
| OCHNACEAE | *Ochna serrulata* | Mickey Mouse Plant | U |
| OLEACEAE | *Olea europaea* subsp. *cuspidata* | African Olive | C |
| PASSIFLORACEAE | *Passiflora subpeltata* | White Passionfruit | C |
| POACEAE | *Cenchrus clandestinus* | Kikuyu | C |
| POACEAE | *Ehrharta erecta* | Panic Veldt Grass | C |
| SOLANCEAE | *Cestrum parquii* | Green Cestrum | U |
| SOLANCEAE | *Solanum capsicoides* | Devils Apple | U |
| SOLANACEAE | *Solanum mauritianum* | Wild Tobacco | M |
| VERBENACEAE | *Lantana camara* | Lantana | C, NW, WoNS |

## Noxious Weeds and WoNS

The following Noxious weeds (Illawarra District Noxious Weeds Authority) and WoNS (Weeds of National Significance) were identified within this zone:

| Botanical Name / Common Name | Listing | Local Requirements | Control Methods |
|---|---|---|---|
| *Lantana camara*<br>Lantana | • Noxious Class 4<br>• WoNS | The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread | Cut and mulch all plant materials on site after removal of viable propagules. Apply undiluted herbicide immediately to the cut stump. |

## Vegetation Community Determination

Based on the assemblage of native species within this gully the vegetation at this site the following vegetation communities have been identified at this site:

| Vegetation Community | Key Species | Endangered Ecological Community | Notes |
|---|---|---|---|
| Illawarra Subtropical Rainforest | *Ficus spp. Toona ciliata, Pouteria australis* | Yes | This community within this zone is highly fragmented and has suffered from past clearing activities but still retains natural diversity |
| Melaleuca armillaris Tall Shrubland | *Melaluca armillaris, Zieria granulate, Crassula sieberiana* | Yes | This community within this zone is highly fragmented and has suffered from past clearing activities but still retains natural diversity |

## Threatened Species

The following threatened species listed under THE EPBC Act 1999 were identified on this site:

| | |
|---|---|
| **Family** | Apocynaceae |
| **Common Name** | White Flower Wax Plant |
| **Genus / Species** | *Cynanchum elegans* |
| **Date** | 18/04/2017 |
| **Site Description** | Zone 3 Compensatory Habitat Area, Boral Dunmore Hills |
| **GPS Co-ordinates** | Northing: 6166550<br>Easting: 0300179 |
| **Number of Plants / Stems** | 5 |
| **Size / Age of Plants** | Many mature stems ascending into the canopy |
| **Vegetation Community** | Illawarra Subtropical Rainforest |
| **Growing in association with** | *Streblus brunonianus, Croton verauxii, Actephila lindleyi* |
| **Weeds Present** | *Lantana camara* |

| | |
|---|---|
| **Family** | Rutaceae |
| **Common Name** | Illawara Zieria |
| **Genus / Species** | *Zieria granulata* |
| **Date** | 18/04/2017 |
| **Site Description** | Zone 3 Compensatory Habitat Area, Boral Dunmore Hills |
| **GPS Co-ordinates** | Too many plants to list |
| **Number of Plants / Stems** | Many hundreds of individual plants |
| **Size / Age of Plants** | Mature plants and seedlings present and in good condition |
| **Vegetation Community** | *Melaleuca armillaris* Tall Shrubland |
| **Growing in association with** | *Melaleuca armillaris, Indigofera australis, Dodonea viscose* var. *angustifolia* |
| **Weeds Present** | *Lantana camara, Bidens pilosa* |

## Revegetation Assessment

Extensive revegetation has been carried out within this zone comprising the entire western, southern and eastern boundaries of the zone.
The revegetation areas within this zone are contained within fenced areas so have not suffered from heavy grazing by cattle but show minor and much less severe grazing impacts form Wallabies and Kangaroo.
The species selection within this site shows more diversity than zone 1 planted areas and the species are better suited to the vegetative conditions of this area. The planting density within this zone is much higher than other zones and the trees have become well established and have formed a closed canopy which is assisting to out compete weed species. Several shade tolerant weeds have managed to colonise this area and the revegetation areas within this zone would benefit from a quarterly maintenance weed control visits to treat woody weeds and ascending vines that may become detrimental to the health of this planting.
The following is a list of all species used for revegetation within this zone:

| **Botnaical Name** | **Common Name** | **Notes** |
|---|---|---|
| *Acacia binervata* | Two Vein Hickory | |
| *Acacia implexa* | Lightwood | |
| *Acacia maidenii* | Maidens Wattle | |
| *Acacia mearnsii* | Black Wattle | |
| *Acmena smithii* | Lilly Pilly | Matured and naturally regenerating |
| *Commersonia fraseri* | Brown Kurrajong | Suckering profusely and forming dense thickets |
| *Dodnea viscosa* subsp. *angustifolia* | Hop Bush | Matured and naturally regenerating |
| *Ehretia accuminata* | Koda | |
| *Eucalyptus amplifolia* | Cabbage Gum | |
| *Eucalyptus eugenioides* | Thin Leaf Stringybark | |
| *Eucalyptus quadrangulata* | White Top Box | |
| *Eucalyptus saligna x botryoides* | Bastard Blue Gum | |
| *Ficus coronata* | Sandpaper Fig | Matured and naturally regenerating |
| *Glochidion ferdinandi* | Cheese tree | Matured and naturally regenerating |
| *Hakea salcifolia* | Willow Leaf Hakea | Species not appropriate to this area |
| *Hibiscus heterophyllus* | Native Hibiscus | Matured and naturally regenerating |
| *Leptospermum morisonii* | Ti Tree | |
| *Melaleuca armillaris* | Bracelet Honey Myrtle | |
| *Mlelaleuca decora* | White Feather Honey Myrtle | |
| *Scolopia braunii* | Flintwood | |
| *Syzygium australe* | Brush Cherry | Matured and naturally regenerating |
| *Toona australis* | Red Cedar | |

The following observations and management recommendations have been identified within the revegetation area:

| **Observations** | **Management Recommendations** |
|---|---|
| Maintenance of these plantings has been minimal and evidence of this can be observed by trees that have been constricted by the plant guards that should have been removed once the tree had exceeded the requirements of the guards.<br>Many plant guards have been broken from the trees and have been wind blown throughout the gully | Remove all core flute guards and dispose of appropriately |
| Regeneration of weed species within the planted areas. Weeds such as Lantana, Blackberry and Thistles have colonised the planted areas due to the sparse planting of canopy species | Weed control will be required within the planted areas to reduce competition and assist plant establishment |
| Use of inappropriate tree species in the planting program | Planting species specific to the site conditions.<br>(See appendix 1 for suitable species planting list) |

Strangler Fig (Ficus superba) within the lower reaches of Zone 3

## Appendix 1: Species Suitable for Revegetation

The following is a list of plants suitable for planting at this site. This list includes a range of trees, shrubs, grasses and groundcovers species that are generally available from most revegetation specialist nurseries. The right hand columns indicate the vegetation community that each individual species is appropriate to:
RF = Rainforest Communities
WL = Woodland Communities
MA = Melaleuca armillaris Tall Shrubland Community

| BOTANICAL NAME | COMMON NAME | RF | WL | MA |
|---|---|---|---|---|
| **Trees** | | | | |
| *Acacia binervata* | Two Veined Hickory | RF | WL | MA |
| *Acacia implexa* | Hickory | | WL | MA |
| *Acacia maidenii* | Maidens Wattle | RF | | |
| *Acacia mearnsii* | Black Wattle | | WL | MA |
| *Acmena smithii* | Lilly Pilly | RF | | |
| *Alectryon subcinereus* | Native Quince | RF | | |
| *Allocasuarina littoralis* | Black She-oak | | WL | |
| *Alphitonia excelsa* | Red Ash | RF | | |
| *Backhousia myrtifolia* | Grey Myrtle | RF | WL | |
| *Callistemon salignus* | Pink Tips | | WL | |
| *Clerodendrum tomentosum* | Hairy Clerodendron | RF | | MA |
| *Commersonia fraseri* | Brown Kurrajong | RF | WL | MA |
| *Dendrocnide excelsa* | Giant Stinging Tree | RF | | |
| *Diospyros australis* | Black Plum | RF | | |
| *Diploglottis australis* | Native Tamarind | RF | | |
| *Ehretia accuminata* | Koda | RF | | |
| *Eucalyptus amplifolia* | Cabbage Gum | | WL | |
| *Eucalyptus eugenioides* | Thin Leaved Stringybark | | WL | |
| *Eucalyptus longifolia* | Woolybutt | | WL | |
| *Eucalyptus quadrangulata* | White Top Box | RF | WL | |
| *Eucalyptus tereticornis* | Forest Red Gum | | WL | MA |
| *Ficus coronata* | Sandpaper Fig | RF | | |
| *Ficus macrophylla* | Moreton Bay Fig | RF | | |
| *Ficus obliqua* | Small Leaf Fig | RF | | |
| *Ficus rubiginosa* | Port Jackson Fig | RF | | |
| *Ficus superba* | Deciduous Fig | RF | | |
| *Geijera salicifolia* | Brush Wilga | RF | | |
| *Glochidion ferdinandi* | Cheese Tree | RF | | |
| *Guioa semiglauca* | Guioa | RF | | |
| *Hibiscus heterophyllus* | Native Hibiscus | RF | WL | MA |
| *Livistona australis* | Cabbage Palm | RF | | |
| *Melaleuca armillaris* | Bracelet Honey-myrtle | | WL | MA |
| *Melaleuca decora* | White Feather Honetmyrtle | | WL | MA |
| *Melaleuca styphelioides* | Prickly Leaved Paperbark | RF | WL | MA |

| | | | | |
|---|---|---|---|---|
| *Melia azedarach* | White Cedar | RF | | |
| *Melicope micrococca* | Melicope | RF | | |
| *Myrsine howittiana* | Muttonwood | RF | | |
| *Myrsine variabilis* | Brush Muttonwood | RF | | |
| *Notelaea venosa* | Mock Olive | RF | WL | |
| *Omolanthus nutans* | Bleeding Heart | RF | | |
| *Parachidendron pruinosum* | Snow Wood | RF | | |
| *Pittosporum revolutum* | Hairy Pittosporum | | WL | |
| *Polyscias elegans* | Celerywood | RF | | |
| *Scolopia braunii* | Flintwood | RF | | |
| *Synoum glandulosum* | Bastard Rose Wood | RF | | |
| *Syzygium australe* | Brush Cherry | RF | | |
| *Toona ciliata* | Red Cedar | RF | | |
| **Shrubs** | | | | |
| *Abutilon oxycarpum* | Chinese Lanterns | | WL | MA |
| *Acacia falcata* | Sickle Wattle | | WL | MA |
| *Breynia oblongifolia* | Coffee Bush | RF | WL | MA |
| *Bursaria spinosa* | Australian Blackthorn | | WL | MA |
| *Dodonaea viscosa var angustifolia* | Hop Bush | | WL | MA |
| *Goodia lotifolia* | Clover Tree | RF | WL | |
| *Indigofera australis* | Indigofera | | WL | MA |
| *Kunzea ambigua* | Tick Bush | | WL | MA |
| *Ozothamnus diosmifolium* | Everlasting | | WL | MA |
| *Solanum aviculare* | Kangaroo Apple | RF | | |
| *Trema tomentosa* | Native Peach | RF | WL | MA |
| **Grasses** | | | | |
| *Austrostipa ramosissima* | Giant Bamboo Grass | | WL | MA |
| *Carex appressa* | Carex | RF | | |
| *Carex longebrachiata* | Drooping Carex | | WL | MA |
| *Cymbopogon refractus* | Barb Wire Grass | | WL | MA |
| *Dichelachne mircantha* | Short Hair Plume Grass | | WL | MA |
| *Imperata cylindrica* | Blady Grass | | WL | MA |
| *Microlaena stipoides* | Weeping rice grass | | WL | MA |
| *Oplismenus aemulus* | Basket Grass | | WL | MA |
| *Oplismenus imbecillis* | Basket Grass | | WL | MA |
| *Poa labillardieri* | Tussock Grass | | WL | MA |
| *Themeda triandra* | Kangaroo Grass | | WL | MA |
| **Groundcovers** | | | | |
| *Commelina cyanea* | Scurvy Weed | RF | | MA |
| *Dianella caerulea* | Flax Lily | RF | | |
| *Dianella longifolia* | Flax Lily | | WL | MA |
| *Einadia hastata* | Saloop | | WL | MA |
| *Ficinia nodosa* | Knobby Clubrush | RF | WL | |
| *Gahnia sieberana* | Saw Sedge | | WL | MA |
| *Geranium homeanum* | Native Geranium | | WL | MA |
| *Hibbertia scandens* | Guinea Flower | RF | WL | |

| | | | | |
|---|---|---|---|---|
| *Juncus usitatus* | Common Rush | | WL | |
| *Lomandra longifolia* | Mat Rush | RF | WL | MA |
| *Pollia crispata* | Pollia | RF | | |
| *Tetragonia tetragonioides* | Warrigal Greens | | WL | |
| *Viola hederacea* | Native Violet | RF | | MA |

## Appendix 2: Weed Control Method Definitions

The following weed removal methods will be used to complete these works:

**Cut and Paint**

The Cut-and-Paint removal technique involves the cutting of the stem using loppers and saws as low to the ground as possible and immediately applying undiluted Glyphosate to the cut stump. Woody weed materials can be cut and composted on site after removal of any seeds or propagules. Weeds treated using this technique include large woody weeds such as Lantana *(Lantana camara*), Cassia (*Senna pendula var. glabrata*), Privets (*Ligustrum spp.*) and Bitou Bush (*Chrysanthemoides monilifera*). Several smaller annual and perennial weeds will require this treatment when hand removal is not possible or has the potential to create soil erosion.

**Scrape and Paint**

The Scrape-and-Paint removal technique involves scraping a knife along one side of the plant stem covering as much stem surface area as possible. Undiluted Glyphosate is then applied immediately to the scrape. This technique can be effectively utilised to treat weeds with particularly strong root systems and large tap roots such as Mickey Mouse plant (*Ochna serrulata*), Blackberry (*Rubus fruticosis*) and Paddys Lucerne (*Sida rhombifolia*) and difficult to treat invasive vines such as Coastal Morning Glory (*Ipomea cairica*), Madiera Vine (*Anredera cordifolia*) and Honeysuckle (*Lonicera japonica*).

**Hand Removal**

The Hand-Removal technique involves removing the whole plant after careful removal of any propagules and mulching the plant on site. Where the threat of vegetative regrowth is present all parts of the plant will require bagging and removal from the site. This technique is most effective for controlling annual weeds such as Cobblers Pegs (*Bidens pilosa*), Fleabane (*Conyza spp*.) and Stinking Roger (*Tagetes minuta*). Targeting woody weeds prior to seeding using hand removal techniques can reduce future work loads by depleting available seed stored in the soil.

**Frilling**

Frilling of trees can be utilised when the target tree carries too much material for disposal or the dead tree is to be retained as habitat for birds, animals or climbing plants. The frilling technique involves using a sharp chisel to create a series of 20 mm deep cuts at 30mm intervals around the base of the trunk as low to the ground as possible and the immediate application of undiluted Glyphosate to the cut. All Tree weeds such as Privet, Coral Tree, African Olive, Camphor Laurel and Cotoneaster can be successfully treated using this method.

**Herbicide Use**

Use of herbicides must be limited to the use of Round Up Biactive® for cut and paint and scrape and paint applications at all times.
Spraying activities should only be carried out by qualified weed managers with a current Smart Train or Chemcert certificate.
Spraying should only be utilised after careful inspection of spray areas to ensure no naturally occurring species are targeted, and at all times follow the manufacturers specifications.

## Appendix 3: Herbicide Compositions

Spraying activities should only be carried out by qualified weed managers with a current Smart Train or Chemcert certificate. Herbicide compositions for various weed treatments are as follows:

1. For spraying activities targeting Panic veldt grass and various annual weed seedlings use the following herbicide composition:

| Chemical | Mixed Rate per 10 Litres of Water |
|---|---|
| Glyphosate (Round Up®) | 50 mls (0.5 %) |
| Indicator Dye (Tru-Blu®) | 30 mls (0.25%) |

2. For spraying activities targeting annuals, grasses, various woody weeds and weed seedlings use the following herbicide composition:

| Chemical | Mixed Rate per 10 Litres of Water |
|---|---|
| Glyphosate (Round Up®) | 100 mls (1.0 %) |
| Indicator Dye (Tru-Blu®) | 30 mls (0.25%) |

3. For spraying activities targeting Wandering Jew *(Tradescantia flumiensis),* Moth Vine seedlings *(Araujia sericifera.)* and Madiera Vine *(Anredera cordifolia*) use the following herbicide composition:

| Chemical | Mixed Rate per 10 Litres of Water |
|---|---|
| Starane 200® | 150 mls (1.5%) |
| Indicator Dye (Tru-Blu®) | 30 mls (0.25%) |

4. For spraying activities targeting Blackberry (*Rubus fruticosis*), Turkey Rhubarb *(Acetosa sagitatta)* and Asparagus Fern *(Protosparagus aethiopicus*) use the following herbicide composition:

| Chemical | Mixed Rate per 10 Litres of Water |
|---|---|
| Glyphosate (Round Up®) | 100 mls (1 %) |
| Metsolfuron (Brush Off®) | 1 gram (0.1%) |
| Indicator Dye (Tru-Blu®) | 30 mls (0.25%) |
| Synetrol Surfactant (Vegetable Oil Concentrate) | 50 mls (0.5%) |

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